Acta Biol. Univ. Daugavp., Suppl. 2, 2010
ISSN 1407 - 8953

THE IMPACT OF FARMING SYSTEMS MANAGEMENT AND HABITAT'S ANTHROPOGENIC LEVEL ON PHYTO-DIVERSITY

Ligita Baležentienė

Baležentienė L. 2010. The Impact of farming systems management and habitat's anthropogenic level on phyto-diversity. *Acta Biol. Univ. Daugavp., Suppl. 2: 9 - 16.*

The floristic diversity variation of different anthropogenized habitats in dependence on farming systems was explored during 2006-2007 in Kaunas Region in Central Lithuania. The main goal of this research was to evaluate and compare the impact of organic and traditional farming on floristic diversity. Thirty plots (1 m^2) were selected from different agri-environment backgrounds in crop fields and their margins of organic and of intensive agriculture at the Lithuanian University of Agriculture. The greatest species diversity (71 sp.) was determined in the field margins of organic farming. The intensive farming system emerged with a negative input for floristic diversity due to the use of mineral fertilizers and various pesticides during plant vegetation. Registered plant diversity was represented by 21 plant families of *Magnoliophyta* (*Angiopsermae*) and one family of *Equisetophyta* depending on the farming system and habitat anthropogenic level.

Keywords: floristic diversity, agri-environment, farming system.

Ligita Baležentienė. Environment Institute, Lithuanian University of Agriculture, Studentų 11, LT-65331, Akademija, Kaunas District, Lithuania; E-mail ligita.balezentiene@lzuu.lt

Introduction

Over about 5 000 yrs of agriculture development in Central Europe, the anthropogenic transformation of nature from old–growth woodlands into mosaic landscapes with agricultural and semi-natural habitats has affected the level of species biodiversity (Waldhard et al., 2003). Landscape changes have occurred with acceleration sequences in several stages: a continual increase in the scope and complexity of ecological problems, growing destabilization of natural households and rising irreversible changes (Bastian & Bernhart, 1993).

Increasing land use and other anthropogenic factors during the last 1000 yrs has had a fundamental impact on loss of biodiversity (Piorr, 2003). This particularly concerns species of vascular plants as well as diversity of biocoenoses and ecosystems (Ellenberg, 1996).

In the middle of the 20th century traditional and diverse management of farming were replaced by modern, highly specialized agriculture. Intensification of agriculture was achieved by high cropping technologies which used high-yielding cultivars, mineral fertilizers, pesticides, and irrigation in dry regions. These agricultural measures contributed to a tremendous increases in food production (Matson et al., 1997). On the other hand, large territories with unfavorable climate, topography and poor soils were threatened by abandonment. In consequence, the small-scale mosaic of grassland and arable fields which has maintained the high diversity of habitats was replaced by extensive managed grasslands and forests (Buhler-Natour & Herzog, 1999). The intensive and extensive management of agriculture affects both abiotic (soil, water, air) and biotic (species, communities and biodiversity) resources (Cooper, 1993). As many authors report, floristic cover declined in diversity over the last few decades in arable fields, grasslands and boundary sites (Sutclife & Kay 2000). The main causes for this decrease in plant species diversity are abandonment and intensification of management systems (Korneck at al., 1998).

Today, nearly 40 % of the area of the European Union (EU) is occupied by agriculture for food and raw materials production. Most of the remaining area is forest, settlements and roadways (Bruyas, 2002). It should be stated that agricultural areas in most Central European countries serve not only for agricultural production but also have important additional functions such as preserving abiotic resources, stimulating human recreation and conserving biodiversity (Commission, 1999; Tait, 2001).

In defining the conservation of biodiversity, the assessment and evaluation of biodiversity have become important in agricultural areas. As EC Regulations (EEC, No 2078/92) state, deeper knowledge of the positive and negative impacts of agriculture on biodiversity is required. Therefore, the impact biodiversity of different farming systems (intensive and organic) was investigated and presented in this issue.

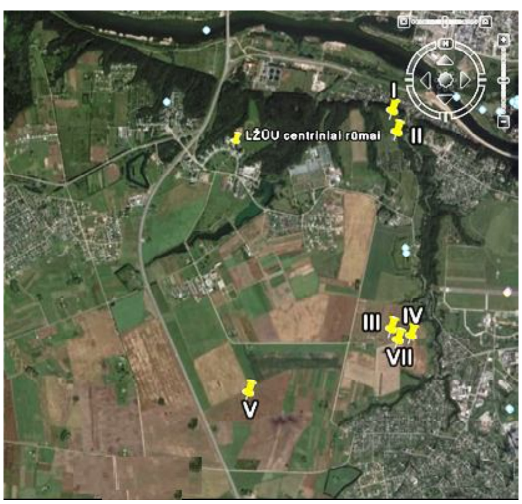

Figure 1. Localization of studied area (54°53'48.32"–54°52'30.92"N, 23°51'40.85"–23°51'40.02"E)

Materials and methods

The usually measured and expressed within habitat-patch-scale ß–diversity of arable plants was investigated in fields of organic (OF) and intensive farming (IF). The 3 clusters of 5 relevés (total 30) of each semi-natural uncropped cultivated margins (UCM) and fully anthropogenized habitats – in crops (winter cereals) communities were applied to determine and to compare the diversity in researched areas (Whittaker, 1975). The initial data of phyto-diversity was obtained in summer (June-July) in crop fields and in uncropped cultivated margins (UCM) both of organic farming (OF) at Ecologic Farm (EF) and of intensive farming (IF) at the Training Farm (TF) and the Research Station (RS) of the Lithuanian University of Agriculture (LUA) during 2006-2007 (Figure 1). The relevés plots size was selected as 0.5 m^2. Relevés were set out along transects in sections of 20-25 m (Kent & Coker, 2003). Stratified sampling was carried out on sandy moraine loam humic horizon of *Calcari-Epihypogleyic Luvisol*, LVg-p-w-cc (Buivydaitė et al., 2001). The soil pH varied from 7.1 to 7.0, humus content was medium – 2.3–2.5 %. The registered plant species were listed and grouped according to commonly used taxonomical interpretation (Jankevičienė, 1998; Gudžinskas, 1999). The species frequencies and abundance were recorded according to the Braun-Blanquet (1964) classification scale. The Shannon–Wiener biodiversity index H' ($H' = - S\ p_i\ ln\ p_i$) of non cultivated species richness or diversity with relative abundance (A), expressed as a proportion of total cover (P) was used (Kent & Coker, 2003).

Additionally the statistical significance of the presentation of each species was recorded by standard deviation (*SD*) for each cluster ($p<0.05$).

Results and discussion

According to Piorr et al. (2003), current land use techniques are responsible for a loss of biodiversity, in contradiction to the fact that increasing land use 1000 yrs ago fostered the development of a high level of species biodiversity in Central Europe. With regard to the data under field conditions for different land use, the maximum average biodiversity (81 species) was determined under sustainable farming conditions at the Organic farm during 2006-2007 (Figure 2).

The most aggressive in terms of habitat environment is the intensive farming system found at the Training Farm of the Lithuanian University of Agriculture, which produced the lowest number (24 sp.) for biodiversity. The conditions at the IF Research Station to a certain extent provided increased of biodiversity (56 sp.) in comparison with the Training Farm. The highly intensive farming system at the Training Farm, involving usage of various pesticides (herbicides, insecticides, fungicides etc.) and doses of chemical fertilizers ($N_{120}P_{90}K_{90}$), led to the minimal plant species diversity in all the researched areas. Interaction between farming type (different cultivation, mineral fertilizers and pesticides) and habitat biodiversity variation is mentioned by some authors (Eiswerth & Haney, 2001). Human activity has changed biodiversity. Twelve perennial species disappeared on the Organic farm due to the dismantling of a water tower and land reclamation in 2006. These actions stipulated changes to habitat conditions and floristic diversity in 2006. On the other hand, the same number (12 species) of new species established and the total number (70 species) of species persisted in 2007, and 81 species were registered in total during 2006-2007. Harmful invasive (EPPO 2000/29/EC) or Red List species were not registered.

Registered plant diversity was represented by 21 plant families of *Magnoliophyta* (*Angiopsermae*) and 1 family of *Equisetophyta* depending on the farming system and habitat (Table 1). *Magnoliopsida* predominated over *Liliopsida*. Diversity of *Liliopsida* (*Monocotyledonae*) produced the least abundance, i.e. 3 families, while the *Poaceae* family was represented by the largest number of genus (4-13) and species (7-16). The following sequence represents the abundance of *Magnoliopsida* (*Dicotyledonae*) families in descending order: *Asteraceae*>*Fabaceae*>*Brassicaceae*> *Caryophyllaceae*> *Rosaceae*> *Polygonaceae*> *Scrophulariacea* > *Onagraceae*> *Apiaceae*> *Lamiaceae*> *Geraniaceae*> *Plantaginaceae*. Remainder families: *Boraginaceae*, *Chenopodiaceae*, *Violaceae, Urticaceae*, *Rubiaceae* and *Equisetaceae* were monotypic. There were no bryophytes species in the cover of all the research areas.

Vegetation spatial analysis of different level anthropogenized areas (arable fields under winter crop and uncropped cultivated field margins) of

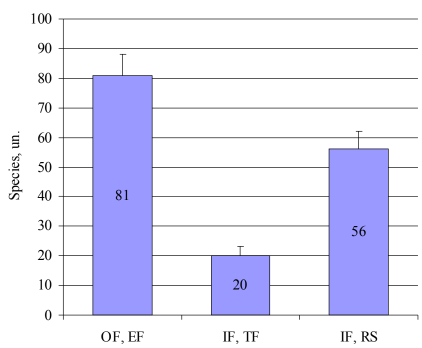

Figure 2. Biodiversity under various land use (mean ± SD intervals, p <0.05)

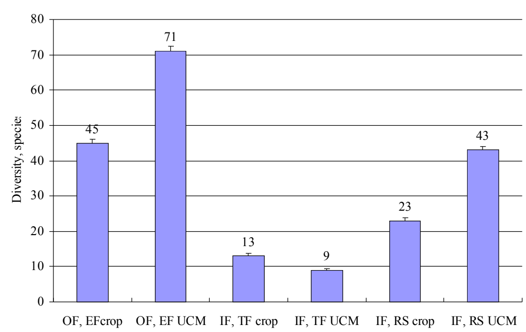

Figure 3. Impact of anthropogenic level and farming type on biodiversity (mean ± SD intervals, p <0.05)

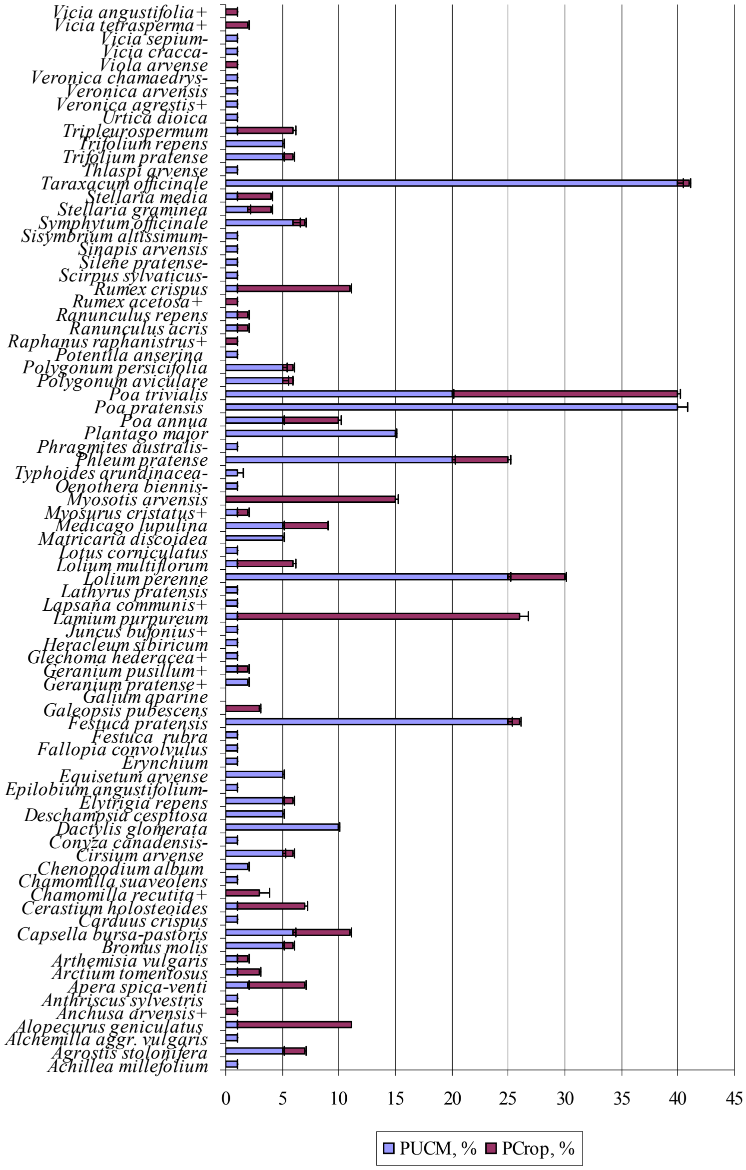

Figure 4. Differences in mean species richness and cover (P) in UCM and in crop of OF (mean ± SD intervals, $p < 0.05$; + added species in 2007, - extinct sp. in 2007)

with higher anthropogenized agro–ecosystems for crops of all investigated farming systems. Plant diversity was generally lower in cropped fields due to competition from the crop.

As Hyvönen (2007) and Büchs (2003) report, the investigation results suggest that despite some benefits for biodiversity, organic farming at early phase cannot recover weed populations to the same level as before application of intensive cropping measures. Therefore the largest diversity was obtained (71 species) in UCM and in crop fields (45 species) of OF LUA.

OF UCM was the most diverse option with the greatest number of grasses and forbs species, as well as ruderal and segetal perennials and annuals. Perennial grasses and forbs predominated in the cover of OF UCM (Figure 4). The cover of some grass (*Poa pratensis* L., *Lolium perenne* L., *Festuca pratensis* L.) and forbs (*Taraxacum officinale* L.) species composed a significant share (25–40%) in cover.

various farming systems (organic (Organic Farm) and intensive farming (Training Farm and Research Station) had different impacts on plant biodiversity (Figure 3). The highest richness of plant species occurred in semi-natural habitats – UCM (with the exception of IF TF) in comparison

The share of different genus of annual and perennial ruderalics and segetalics comprised an insignificant part, often less 5% of total cover, in OF UCM. Their content in OF crops was reliant on the cover density of crops stand. Due to the removal of a water tower and small wetland nearby

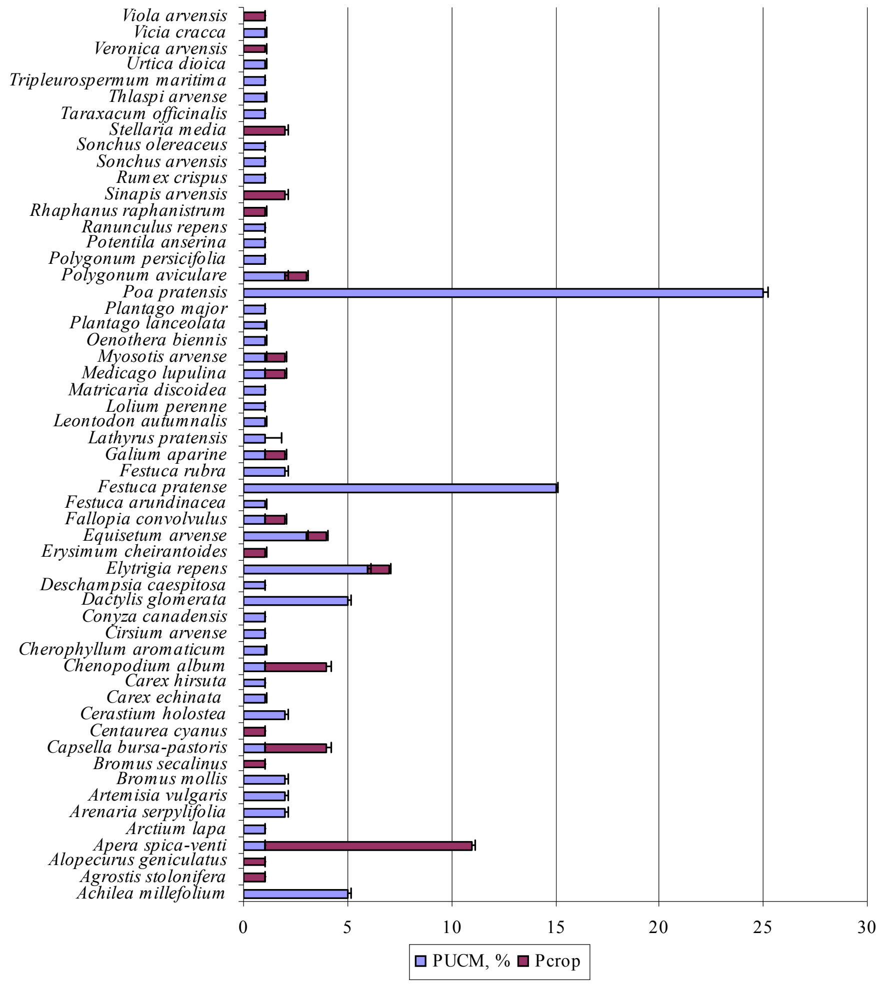

Figure 5. Species richness and cover in crop cover (P) of IF Research Station (mean ± SD intervals, p <0.05)

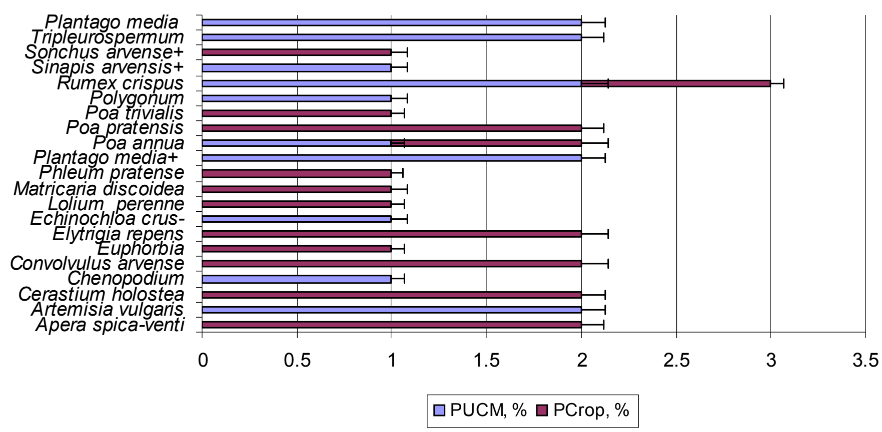

Figure 6. Species richness and cover in UCM of IF Training Farm (mean ± SD intervals, p <0.05; + added species in 2007; - extinct sp. in 2007)

Table 1. Taxonomic diversity in different farming systems

Family / Classes	Genus			Species		
	EF	RS	TF	EF	RS	TF
1. *Poaceae* (*Liliopsida*)	13	10	4	16	12	7
2. *Asteraceae*(*Magnoliopsida*)	10	11	3	12	12	3
3. *Fabaceae* (*Magnoliopsida*)	5	3	-	9	3	-
4. *Brassicaceae* (*Magnoliopsida*)	5	5	-	6	5	-
5. *Caryophyllaceae* (*Magnoliopsida*)	3	3	1	4	3	1
6. *Rosaceae* (*Magnoliopsida*)	3	1	-	3	1	-
7. *Polygonaceae* (*Magnoliopsida*)	3	4	-	5	5	-
8. *Scrophulariaceae* (*Magnoliopsida*)	4	1	1	4	2	1
9. *Onagraceae* (*Magnoliopsida*)	2	1	-	2	1	-
10. *Apiaceae* (*Magnoliopsida*)	2	1	-	2	1	-
11. *Ranunculaceae* (*Magnoliopsida*)	1	1	-	3	1	-
12. *Lamiaceae*(*Magnoliopsida*)	1	-	-	3	-	-
13. *Geraniaceae* (*Magnoliopsida*)	-	-	-	2	-	-
14. *Juncaceae* (*Liliopsida*)	1	-	-	2	-	-
15. *Plantaginaceae* (*Magnoliopsida*)	1	1	-	1	2	-
16. *Cyperaceae* (*Liliopsida*)	1	1	-	1	2	-
Monotypic families and genus						
17. *Chenopodiaceae*(*Magnoliopsida*)	1	1	1	1	1	1
18. *Violaceae*(*Magnoliopsida*)	1	1	-	1	1	-
19. *Urticaceae*(*Magnoliopsida*)	1	-	-	1	1	-
20. *Rubiaceae*(*Magnoliopsida*)	1	1	-	1	1	-
21. *Equisetaceae* (*Equistophyta*)	1	1	-	1	1	-
22. *Boraginaceae* (*Magnoliopsida*)	-	1	-	1	1	-
Total: 22	**61**	**48**	**10**	**81**	**56**	**20**

at OF in the autumn of 2006, some species fluctuation occur in 2007: 12 perennials and synanthropic species became extinct, while the same number of species settle down in accordance with changed environmental conditions.

Variation of diversity of IF RS UCM and crop was in line with the analogous OF habitats. The intermediate number of species (56 sp.) confirmed the less intensive farming in the Research Station of LUA. There were 43 species established in UCM and about half that number, 21 species, in crop fields (Figure 5).

According to Crichley et al. (2004), the removal of field margins from intensive agriculture of Training Farm and Research Station of LUA followed by annual soil cultivation decreased the abundance of diversity. Abiotic measures - pesticides, mineral fertilizers etc. - used in the intensive farming system at the Training Farm led to decreasing diversity both in crop fields (9 species) and UCM (13 species). Cover of non-crop species ranged mostly between 1-2% (Figure 6).

The total plant cover of non-cropped species varied depending on the farming system and anthropogenic level of habitat (Figure 7). The

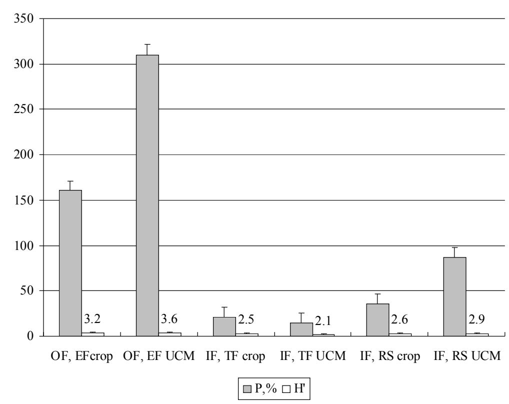

Figure 7. Farming impact on biodiversity index (H') and total plant cover (P) (mean ± SD intervals, $p<0.05$)

cover of non-crop species was highest on OF EF UCM, reaching 310%, and the least (only 15%) was on IF TF UCM. The plant cover of OF UCM was the most closed and even in comparison with IF UCM.

The following sequence represents the total cover in descending order: OF, EF UCM>OF, EF Crop>IF, RS UCM>IF, RS Crop>IF, TF Crop>IF, TF UCM.

Statistically significant ($p<0.05$) differences in Shannon diversity index H' determined overall tested habitats (Figure 6). The highest H' mean determined in OF, EF UCM and in crops, and ranged between 3.6–3.2. Diversity index declined in IF, RS and ranged 2.9–2.6. The least diversity index determined in IF, TF UCM (2.1) and Crop (2.5).

Conclusions

Registered plant taxonomic diversity was represented by 21 plant families of *Magnoliophyta* (*Angiopsermae*) and one family of *Equisetophyta* depending on the farming system and habitat. The agri–environment influenced species diversity in addition to the farming system. Less intensively managed organic farming caused the highest phyto-diversity in the absences of use of mineral fertilizers and various pesticides. Therefore, extensive organic land management has great importance in preserving floristic diversity.

The anthropogenic level of habitat had a great effect on species diversity and composition. Field margins of both intensive and organic farming systems (with the exception of IF, TF UCM) had significantly more phyto-diversity (H' ranged between 2.9-3.6) than conventionally managed cereal crops (H' ranged between 2.5-3.2) due to less usage of agricultural agents. Semi–natural habitats of uncropped field margins are presumably colonization sources for arable field. Grasses and perennials tended to be associated with less cultivation in uncropped margins of organic farms. Annuals of synanthropic vegetation predominated in cereal crops (both IF and OF). A possible explanation for the variation between cultivated (crops) and uncropped (margins) areas might also be differences in land use.

References

Büchs W. 2003. Biotic indicators for biodiversity and sustainable agriculture–introduction and background. Agriculture, Ecosystems & Environment. 98(1–3):1–16.

Bastian O., Bernhardt A. 1993. Anthropogenic landscape changes in Central Europe and the role of bioindication. Landscape ecology. 8(2): 139–151.

Braun-Blanquet J. 1964. Pflanzensoziologie. Grundzüge der Vegetationskunde. 3: 865. Aufl. Springer Verlag, Wien.

Bruyas P. 2002. Land use-land cover: LUCAS 2001 Primary Results. Eurostat,European Community.

Buivydaitė V.V., Juodis J., Motuzas A., Vaičys M. 2001. New classification of Lithuania soils. In: Soils of Lithuania. Vol. 32.Vilnius. Pp. 281–406.

Buhler-Natour C., Herzog F. 1999. Criteria for sustainability and their application at a regional level: the case of clearing islands in the Dubener Heide nature park (Eastern Germany). Landscape and Urban Planning. 46(1): 51–62.

Cooper C. M. 1993. Biological Effects of Agriculturally Derived Surface Water Pollutants on Aquatic Systems-A Review. Journal of Environmental Quality JEVQAA. 22(3): 402–408.

Council directive 92/43/EEC. 1992. The conservation of natural habitats and of wild fauna and flora. Off. J. Eur. Comm. 35: 7–50.

Ccouncil regulation (EEC) No 2078/92. 1992. Agricultural production methods of the countryside. *Official Journal L 215: 0085–0090.*

Crichley C. N. R., Allen D. S., Fowbert J. A., Mole A.. C., Gundrey A. L. 2004. Habitat establishment on arable land: assesment of an agri–environment scheme in England, UK. Biological Conservation. 119: 429–442.

Eiswerth M.E., Haney J.C. 2001. Maximizing conserved biodiversity. Ecol. Econ. 38: 259–274.

Ellenberg H. 1996. Vegetation Mitteleuropas mit den Alpen in ökologischer, dynamischer und historischer Sicht. 5. Stuttgart. 1096.

European Commission. 1999. Contribution of the European Community on themultifunctional character of agriculture. Bruxelles. Pp. 34-62.

Jankevičienė J. (comp.). 1998. Dictionary of plant names. Vilnius. Pp.523. (In Lithuanian).

Gudžinskas Z. Vascular plants of Lithuania. Vilnius, 1999. Pp. 220. (In Lithuanian).

Hyvönen T. 2007. Can conversion to organic farming restore the species composition of arable weed communities? Biological Conservation. 137(3): 382–390.

Kent M., Coker P. 2003. Vegetation description and analysis: a practical approach. Chichester. Pp. 340.

Korneck D., Schnittler M., Klingenstein F., Ludwig G., Takla M., Bohn U., May R. 1998. Warum verarmt unsere Flora? Auswertung der Roten Liste der Farn und Blütenpflanzen Deutschlands. Schriftenreihe für Vegetationskunde. 29, 299–444.

Matson P. A., Parton W. J., Power A. G., Swift M. J. 1997. Agricultural Intensification and Ecosystem Properties. Science. 277(5325): 504–509.

Sutcliffe O. L., Kay Q. O. N. 2000. Changes in the arable flora of central southern England since the 1960s. Biological Conservation. 93(1): 1–8.

Piorr H. P., Eppler G., Eiden, Scott A. 2003. Proposal on Agri-Environmental Indicators–Interim Report. LANDSIS g. e. i. e. Luxembourg, Germany, United Kingdom. Pp. 34-48.

Piorr H. P. 2003. Environmental policy, agri-environmental indicators and landscape indicators. Agriculture, Ecosystems and Environment. 98: 17–33.

Tait J. 2001. Science, governance and multifunctionality of European agriculture. Outlook Agric. **30:** 91–95.

Waldhardt R., Simmering D., Albrecht H. 2003. Floristic diversity at the habitat scale in agricultural landscapes of Central Europe–summary, conclusions and perspectives. Agriculture, Ecosystems & Environment. 98(1-3): 79–85.

Whittaker R. H. 1975. Communities and Ecosystems. (2nd ed.). New York. Pp. 385.

Received: 01.12.2008.
Accepted: 20.09.2009.