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Interdisciplinary assessment of species- and ecosystems biodiversity in a high nature value low input farming region of Central Hungary

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Abstract

In this chapter we summarize and interpret results from the multidisciplinary analysis of a high nature value low input farming region in Central Hungary. This work was carried out as the Hungarian case study in 2010 during the international BioBio project (Indicators for biodiversity in organic and low-input farming systems, project no. EC-FP7 Contract KBBE-2B-227161 www.biobio-indicator.org) co-funded by the European Commission. Three categories of the indicator set elaborated by the BioBio project consortium were measured using three mutually complementary approaches: (a) Habitat diversity indicators were obtained via habitat mapping at farm scale; (b) Species diversity indicators were obtained by specific field-recording methods; (c) Farm management indicators were obtained through interviews with farmers. We assessed farm composition, grassland management, climatic and vegetation structure effects within low-input systems, and compared three animal taxa as indicators, representing the endogeic (earthworms, Lumbricidae), epigeic (spiders, Araneae) and flying (bees, Apoidea) macroinvertebrate fauna. We searched for proper species diversity indicators, which are relatively easy to monitor, provide relevant information on environmental conditions and its changes, and provide useful and easily understandable information for policy makers. Stakeholder consultations with farmers and conservation officials, and farm interviews complemented the field work. The study of 18 Hungarian farms showed that heterogeneous habitat composition and moderate grazing (1.75 LU/ha) intensity in grasslands have considerable importance to maintain the richness of spider and bee assemblages at the farm scale. The application of the BioBio farm-scale approach to measure the effects of farmland composition, grassland management and local vegetation characteristics revealed important effects of farm-scale habitat heterogeneity. To further explore how farmers relate to biodiversity and what kind of benefits they realize a discourse-based biodiversity assessment was carried out among organic and conventional farmers in the study area using focus group methodology. Our results suggest that biodiversity is not an independent scientific concept for farmers but is embedded in their everyday lives and linked to farming practices. Difference is found between the attitudes and perceptions of organic and conventional farmers.

Keywords: biodiversity, biodiversity indicators, low input farming systems, discourse-based non-monetary valuation, Hungary

1. Introduction

Biodiversity in the agricultural context (Kenéz et al., 2014) has gained special attention in recent years because agricultural activity can either successfully preserve or seriously threaten biodiversity (Trenyik et al., 2014). In this context, biodiversity is a joint product of human and natural processes, and its maintenance may require further human activities (Soini and Aakkula, 2007).

While agricultural activity often takes advantage of the benefits of biodiversity, intensification of agriculture is mentioned among the main threats to biodiversity worldwide (Krebs et al., 1999; Benton et al., 2003; Hole et al., 2005; Sattler and Nagel, 2010; Batáry et al., 2012). Organic agriculture, on the other hand, can contribute to biodiversity protection by applying environmentally-friendly agricultural practices such as limited use of chemicals, reduced tillage operations, crop rotations and mulching, as well as maintaining natural or semi-natural infrastructure such as shelterbelts, hedgerows, woodlots and grassy fieldmargins in the rural landscape, providing habitat for protected species and conserving a wide range of traditional breeds (Sommaggio et al, 1995, Paoletti et al 1997, Bengtsson et al., 2005; Hole et al., 2005; Paoletti et al., 2007, Norton et al., 2009, Gomiero et al., 2011). However, some studies underline that other factors beside the farming system, such as the use of annual or perennial crops, existence of non-cropped areas, the structure of the wider landscape and sensitiveness of certain taxa to disturbance can also influence biodiversity in agricultural land (Tscharntke et al., 2005; Bruggisser et al., 2010; Gomiero et al., 2011; Batáry et al., 2011, 2012). Hole et al. (2005) in their meta-analysis conclude that further research is needed to have a complex view on this issue.

The definition from the Convention on Biological Diversity (CBD) was chosen to specify the term 'biodiversity' in our research: "the variability among living organisms from all sources, including terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part" (Convention on Biological Diversity, 1992, Article 2).

Low input farming systems have been investigated widely at European scale (Hole et al., 2005; Knop et al., 2006), but their benefits are not well known yet (Kleijn et al., 2006). One of the key issues is the lack of suitable biological indicator organisms, which indicate the management effects reliably on the below- and above-ground diversity. Most studies include popular and easy-to-study taxa, such as birds or plants, and simple descriptors as species richness and/or abundance data. Moreover, studies often ignore the consideration of landscape scale effects and interactions with local scale conditions (Batáry et al., 2011; Bengtsson et al., 2005; Hole et al., 2005; Kleijn et al., 2006, 2011; Pacini et al., 2003).

Besides, there is considerable geographical unbalance between Western and Northern European countries, where most of the published studies on farmland biodiversity come from, and Central and Eastern Europe (CEE), where much less is known so far from the relationship of agricultural practices and farmland biodiversity (Báldi and Batáry, 2011; Tryjanowski et al., 2011). The remarkable difference of economic and agricultural history, and different biogeographical and climatic conditions between the old EU member states and the former socialist countries do not allow the copy paste of conservation strategies in CEE based on knowledge of farmland ecology in Western Europe, and call for need of local scale knowledge from the whole continent (Báldi and Batáry, 2011; Hartel et al., 2010).

In this chapter we summarize and interpret results from the multidisciplinary analysis of a high nature value low input farming region in Central Hungary. This work was carried out as the Hungarian case study in 2010 during the international BioBio project (Indicators for biodiversity in organic and low-input farming systems, project no. EC-FP7 Contract KBBE-2B-227161www.biobio-indicator.org) co-funded by the European Commission.

We assessed farm composition, grassland management, climatic and vegetation structure effects within low-input systems, and compared three animal taxa as indicators, representing the endogeic (earthworms, Lumbricidae), epigeic (spiders, Araneae) and flying (bees, Apoidea) macroinvertebrate fauna. We searched for proper species diversity indicators, which are relatively easy to monitor, provide relevant information on environmental conditions and its changes, and provide useful and easily understandable information for stakeholders. Furthermore, all the three groups provide important ecosystem services, i.e. their diversity and abundance might indicate also ecosystem health and proper function. Earthworms are important macro-decomposers, recycling and composting soil nutrients, enhancing soil fertility and enhancing decomposition processes (Jouquet et al., 2006). Spiders have an important role in biological control as natural enemies of invertebrate pests in agro-ecosystems (Marc et al., 1999; Riechert and Lockley, 1984; Schmidt et al., 2003). Wild bees are the most important pollinators of arable crops and wild plant species, especially in Europe (Biesmeijer et al., 2006; Klein et al., 2007).

We intended to study the effects of farmland composition, grassland management, weather conditions, vegetation structure and amount of flower resources on the species richness and abundance of all the selected indicator taxa, and testing the applicability of the selected species diversity indicators.

The environmental social science part of our research aimed at exploring the values of biodiversity assessed by farmers of the study sites. Some authors emphasize that farmers' perceptions about biodiversity are important for the conservation of biodiversity (Bengtsson et al., 2005), because it can affect their attitudes towards conservation and thus influence their farm management (Herzon and Mikk, 2007). Farmers may also appreciate the non-importable and non-marketable functions of agriculture that enhance biodiversity in the most direct manner. Therefore it is worth exploring the attitudes and values these actors attach to biodiversity, and include their approach in scientific and policy discussions. Since earlier studies (e.g. Christie et al., 2006; Soini and Aakkula, 2007) proved that biodiversity is not always well-known and easily understood by non-scientists, we put great emphasis on understanding how farmers conceptualize biodiversity, what attitudes they show towards it and what perceptions they have about the range of benefits biodiversity provides for them.

2. Case Study Area

2.1 Location, geophysical characteristics and nature values

The study was conducted in the Homokhátság ("Sand Ridge"), an alluvial plain covered with Aeolian, sand-based, low fertility plains in the Kiskunság region, Central-Hungary (Figure 1).

The region contains a mosaic of slightly undulating, semi-fixed sand hillocks and flat areas of fixed sand, and managed extensively in general. Dominant soil types include moving sand (21.6% of the area), peaty meadow soils (17.5%), humic sandy soils (10.1%) and Solonchak-Solonetz soils (9.9%).

The ecological significance of this landscape lies in its unique flora and fauna evolving through the continuous interaction between nature and people. The Homokhátság is a particular combination of sand dunes shaped by the predominant north-western and south-eastern winds, saline lowlands and desiccating lakes as a result of shortage in water, and fragile wetland areas remaining after harsh river control (Molnár, 2003). The whole process of succession on sandy soil can be followed-up here from the open grassland vegetation to the poplar-juniper forests comprising endemic plant species and an ample insect population. Wetland areas have an extremely rich birdlife based on nesting songbirds and waterfowls beside the rare fish species and mammals living in the reed and willow marshes (Tóth, 1996; Rakonczay, 2001).

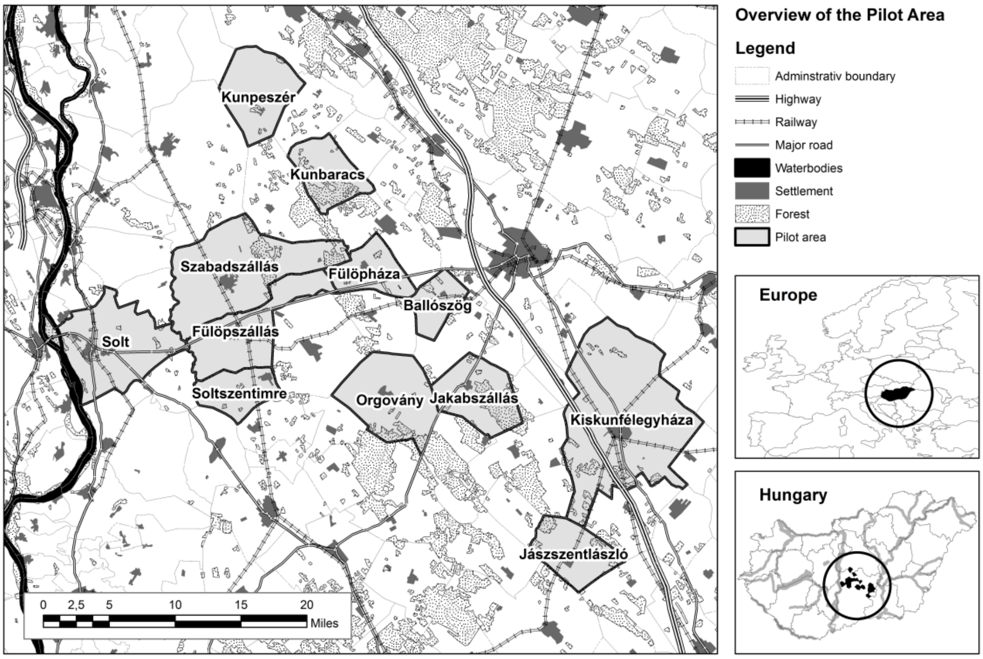

Figure 1. Location of the case study area, Homokhátság, Hungary

2.2. Land use, characteristics of agriculture, socio-economic background

The last natural vegetation of the Homokhátság was forest steppe that was modified in the course of the 16-18th century as a result of the Turkish occupation (Molnár, 2003). Depopulation caused by frequent wars issued in huge unclaimed areas around towns where extensive animal breeding expanded contributing to the evolution of bare sand dunes (Farkas, 2006). At the end of the 18th century afforestation was encouraged in order to protect the towns from shifting sand. The mixture of open access lands, private and common property that characterized the system of property rights in the first period was changed when town dwellers occupied the “nobody’s land” and the common pastures around the market-towns and established the first homestead farms in the 19th century. More intensive agricultural production started on the homesteads, although multifunctional land use practices remained dominant providing a wide variety of ecosystem services to farmers (Tóth, 1979; Farkas, 2006).

After World War II the socialist regime established state cooperatives nationwide and forced farmers to surrender their land. The area of the later designated Homokhátság High Nature Value Area (or Environmentally Sensitive Area), thanks to its unfavorable natural conditions for farming, was an exception where the cooperative membership was not accompanied by the expropriation of all private lands. Thus a mixed structure of property rights emerged where state property and intensive monoculture was dominant but private property and multifunctional farming remained characteristic in some villages (Farkas and Gaborják Vydareny, 2005). The regime change in 1989-90 and the following restitution of land as private property resulted in a fragmented farm structure dominated by private owners with a strong profit orientation, while the proportion of state property decreased and became limited to the core nature protected areas (protected by the Kiskunság National Park Directorate) and some forests.

Current farm characteristics are known from the work of Kelemen and Bela (2008). Extensive grazing system mainly for livestock production, often with old Hungarian breeds (Hungarian Simmental and Grey cattle). The average farm size is 5 ha for individual farmers and 502 ha for agricultural entrepreneurs (regional data, 2007); the average farm size in the sample is 155 ha. Cooperation among farmers is quite rare.

Due to the poor conditions and low economic power of the local land-holders; the major difference between low-input and organic farms is only certification; the management was rather similar on all farms. The major habitats of the region are unimproved semi-natural grasslands and arable fields. Agro-chemicals are not applied on the grasslands, stocking rates are very low (0.15–1.75 LU/ha grassland). Zero or low inputs of fertilizers (15–50 t/4 year solid cattle manure or 20–30 kg N/ha/year inorganic fertilizer) and one or two pesticide applications are usual on the arable fields.

A less developed region within Hungary; few working opportunities besides farming; special settlement structure with living farms (homesteads). Agri-environmental payments contribute largely to the farm income, and are often complemented with special nature protection measures issued by the national park.

3. Data Sources and Methodology

Three categories of the indicator set elaborated by the BioBio project consortium were measured using three mutually complementary approaches:

- Habitat diversity indicators were obtained via habitat mapping at farm scale;
- Species diversity indicators were obtained by specific field-recording methods;
- Farm management indicators were obtained through interviews with farmers.

The indicator campaign (Figure 2.) started with the selection of a representative sample of farms. The farmer was then contacted and an initial general interview was conducted, during which the farmer's consent, other necessary information, and maps of the farm were obtained.

The map defines the area whose habitats were mapped. The selection of plots for species sampling was based on the habitat map, with one plot per habitat type being selected at random. This means that species sampling could only begin once habitat mapping was complete.

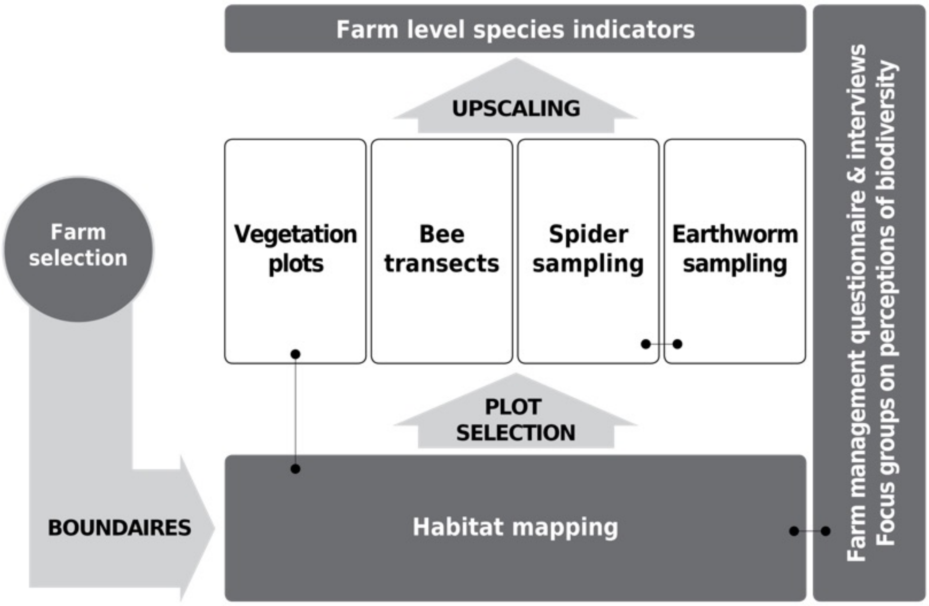

Figure 2. Overview of the BioBio indicator campaign (based on Herzog and Jeanneret, 2012)

3.1 Selection of farms

We selected 18 low-input farms; that contained a mosaic of fields under agricultural management and adjacent, non-managed landscape elements that might be affected by farming practices.

In order to choose the farmlands in the pre-selected study area and get information about how to get in touch with farmers we contacted the Kiskunság National Park Directorate, the County Agricultural Chamber and the Biokontroll Hungária Nonprofit Ltd.

Farmer contacts from earlier researches and from personal relationships were also used.

From the above mentioned data sources after discarding overlaps we got a database of 72 farms.

Engaging farmers in a research project is always a critical issue in Hungary. Therefore the main driving factor for the sampling design was farmers' willingness to participate in the project.

First, a letter was sent to all farms together with the project leaflet in Hungarian and also a questionnaire in order to explore farmers' willingness to participate in the project and to collect basic data. 25 farms gave positive answer. Further 10 farms were convinced to participate after we called them on the telephone.

Of the 35 potentially participating farms 9 farms were keeping sheep and 26 farms cattle.

The case study focused on low input grazing livestock farming systems in semi-natural grasslands with the investigations restricted to one race of livestock only. With regard to the higher number of cattle keeping farms among the potentially participating farms after the second round of approaching farmers we decided to concentrate on cattle keeping farms in the further selection process.

As a third step, the 26 cattle keeping farmers were invited to a workshop (26 March 2010) for locating their farming areas in the official IACS (Integrated Administration and Control System for administering agricultural support payments in the European Union) maps. 13 out of 26 farmers was present at the workshop and further 5 sent their maps via post as the meeting date was inappropriate for them.

3.2 Methodologies of botanical surveys

3.2.1 Habitat mapping

European scale standard habitat mapping procedure developed in the BioHab project (Bunce et al., 2008) was applied to define all habitats at each farm. This method is based on a generic system of habitat definition, the General Habitat Categories (GHC). The first level of the categorization distinguish 5 main land cover categories – as Urban, Crops, Sparsely vegetated, Vegetated/Trees and Shrubs, Vegetated/Herbaceous - and the subcategories of each are dependent from the dominant Life Form according to Raunqiaer as this feature is related to environmental factors of a habitat and a consistent feature of a plant species. Due to that an overall evaluation of habitats was possible on international scale without intercalibration. For further differentiation environmental qualifiers are specified to each habitat, which were derived from soil humidity and acidity and additional information was given by predefined list of site and management qualifiers (see details in Bunce et al., 2008 and Dennis et al., 2012). Landscape evaluation and GIS assessment point of view is important to mention that not only areal but also linear and point habitat features were characterized.

Spatial evaluation of GHC habitat data was made with ArcGIS 9.3 program V-LATE 1.1 - Vector-based Landscape Analysis Tools Extension (Lang & Tiede 2003). Basic statistics (number of patches, class area, mean patch size, patch size standard deviation was calculated. Mean shape index, edge parameters, perimeter-area ratio and mean fractal dimension was used to characterize the fragmentation.

3.2.2. Selection of sampling sites and vegetation sampling

The sampling sites were randomly selected per farm based on previously identified GHC category in 2010. In BioBio project plots were only placed in farmed habitats both in areal and linear elements, but maximum 15 sites per farm. Both the botanical and zoological survey was connected to these sampling areas (152 plots in total). During the vegetation survey areal plots were 10×10 m size and linear plots 1×10m. The plant recording procedure was the same for both types as the estimated cover (%) of each species should be listed using 5% steps (see details in Dennis et al., 2012).

3.3 Methodologies of zoological surveys

3.3.1 Sampling of earthworms, bees and spiders

Three soil samples of a 30 cm×30 cm wide and 20 cm deep area were taken in each of the sampling plots in May, 2010 (Figure 3.).

Figure 3. Earthworm sampling frame with expellant solution on the surface

We extracted earthworms first by using an expellant solution (0.1 g/l) prepared by allyl-isothiocyanate (AITC) diluted with ethanol 70% and water. After 10 min, the soil was dug up to a depth of 20 cm and hand-sorted to find all remaining earthworms.

Bees were sampled once per month in May, June and August, taking one sample per plot by walking along 100 m long and 2 meter wide transect over 15 min and catching bees by an insect net (Figure 4.).


Figure 4. Bee sampling with an insect net

Spiders were caught with a D-VAC sampler, also three times in May, June and August (Figure 5.). Five 30-second suction samples were taken in each of the selected habitat plots. Bee and spider samples were taken each month within a period of 10 days to avoid the effect of seasonal succession of species (following the approach described by Schmidt et al., 2005). Weather conditions were measured, average minimum and maximum vegetation height and flowering plant species were recorded and cover of flowering plants was estimated during each of the three sampling times.


Figure 5. Spider sampling with a D-VAC sampler

Data on farm attributes were reported by the owner in a questionnaire. Full description of the sampling methods for all taxa is described in Kovács-Hostyánszki et al. (2013).

3.3.2. Data analysis

We conducted rarefaction analyses to get species accumulation curves and measure the habitat use of bees and spiders, and the effectiveness of the sampling.

In the case of bees and spiders Rényi diversity was calculated. The Rényi diversity is a typical member of the generalized entropy functions (Ricotta, 2005), which includes as a special case the number of species, Shannon diversity, Simpson or quadratic diversity and the dominance index (Tóthmérész, 1998). When the value of the scale parameter is zero the Rényi diversity is extremely sensitive to the contribution of the rare species to the diversity of the assemblage. When the value of the scale parameter approaches one then the Rényi diversity is identical to the Shannon diversity, and it is sensitive to the rare species, although less so than at zero. When the value of the scale parameter is two, the Rényi diversity is related to the quadratic (Simpson) diversity. In this case the index starts to be more sensitive to the frequent species than to the rare ones. When the value of the scale parameter is large (approaches positive infinity) the Rényi diversity is related to the Berger-Parker dominance index that is determined only by the relative abundance of the most common species.

General linear mixed-effect models were used to study the relationship between the assumed explanatory variables and the abundance and species richness of earthworms, bees and spiders (GLMM, Bolker et al., 2009). We tested the explanatory variables in three set of models:

1. *farm model, considering the effects of farm composition and habitat type, where the sample was taken:* habitat (factor with eight levels: canal, forest, crop, grassland, linear habitat, shrubland, trees, wetland), number of habitat types per farm (numerical), total area of the farm (ha), arable area (ha), grassland area (ha), number of arable fields (within a farm), number of grassland fields (within a farm);
2. *management model, considering grassland management within the farm:* grazing type (factor with four levels: cattle, cattle-sheep, horse-cattle, horse-cattle-sheep), total number of grazing animals (per farm), LU (livestock unit/farm area), LU/grassland (livestock unit/grassland area of the farm, ha);
3. *environmental model, considering weather conditions and vegetation effects during the sampling:* cloud (cover, based on a 1-5 scale), wind (Beaufort scale), temperature (C°), minimum vegetation height (cm), maximum vegetation height (cm), flower cover (1-5 scale), number of flowering species (per field).

Full description of the applied statistical analyses is available in Kovács-Hostyánszki et al. (2013).

3.4. Methodology of stakeholder consultations and farm management surveys

3.4.1. Stakeholder consultations

Throughout the project several consultations with relevant local stakeholders (farmers, national park directorate officials) were organized to convey information on the research progress and to ask for practical views and feedback.

In the 1st workshop (March 2010) the scope and objective of the project was introduced and the farm selection process took place.

In the 2nd workshop (November 2010) we reported back on the fieldwork carried out and the preparations for surveying the farm management indicators were carried out.

A national stakeholder workshop was organized (January 2012) to ask for feedback on the relevance and performance of the BioBio indicators.

The final 3rd local workshop (July 2012) served for communicating the case study results to farmers. Each farmer received a project survey summary of the BioBio indicators respective to his farm.

3.4.1. The farm management questionnaire

Along with habitat structure of the farms, farm management largely determines the pressure on species diversity that is assessed by direct biodiversity indicators, mainly on the managed area of the farms. Farming practices are therefore key points to maintain and restore biodiversity.

The Farm Management Questionnaire developed by the BioBio project consortium enables the collection of complex information. Eight management indicators relating to energy and nutrient input (Total Energy Input, Expenditure on Inputs, Use of Mineral

Nitrogen, Total Nitrogen Input), pesticide applications (Pesticide Use), disturbance by mechanical operations (Field Operations) and pressure by livestock (Average Stocking Rate, Grazing Intensity) were calculated from the surveyed farming data as they allow to assess the intensity of farm management and can be correlated to direct habitat and species indicators.

The structure of the questionnaire was kept as simple as possible still it enables to meet the diverse data needs for the variety of farming systems (e.g. farms with and without livestock, farms with different land use types as well as semi-natural habitats (field margins, hedges etc.) and the differences in the levels of details on which the data are recorded (farm level, crop level: standard operations for each crop, field level: plots of BIOBIO survey).

The Farm Management Questionnaire includes four main Sections (A, B, C and D).

Form A General Farm Data concerns aggregated data collected on the farm level such as energy consumption, agri-environmental measures, organic matter fluxes etc.

Forms B1 and B2 survey variables that describe the plant production system of the farm. Based on standard operations such as fertilization practices, plant protection measures and mechanized field operations, data are collected for each crop or grassland type. Form B1 covers annual arable crops, orchards and vineyards, whereas form B2 focuses on grassland and perennial fodder crops. Data from forms B1 and B2 were used to calculate nitrogen input and nitrogen balances, and to assess the farming intensity based on grazing management, plant protection measures and mechanized field operations. The total of utilized agricultural area (UAA) were calculated from these data. The synthesis of data from forms B1 and B2 must reflect the management of the entire utilized agricultural area of the farm.

Forms C1, C2 and C3 concern specific management of BIOBIO plots where faunistic and floristic indicator sampling took place. Additional data were collected beyond standard operations, e.g. by estimating the timing of certain measures or by specifying grazing management and crop rotation. The forms are subdivided by categories used in the GHC method: Areal Habitats (C1 crops/vineyards and C2 grassland/perennial fodder crops) and Linear Habitats (C3). Form C3 provides short information on the management of herbaceous and woody linear habitats.

Form D Livestock Management recorded the numbers of livestock on the farm broken down by livestock categories. Livestock units were calculated from these data. Additional variables concerned meat production (indicator for productivity), use of pastures and common grazing land.

The duration of interviews were limited to a maximum of two to three hours. Due to this limitation farmers were informed about data needs before the visit and were asked to prepare certain documents (e.g., on agri-environmental measures, energy consumption, purchase and sale of organic matter).

All data collected in the farm management questionnaire were deducted from the interviews based on the farmer's operational knowledge of his or her farm and on basic farm accounting.

As a next step the filled in farm management questionnaires were digitized and the indicator values were calculated in the central database.

3.5. Methodology of collecting farmers' perceptions on biodiversity

A discourse-based qualitative valuation methodology was applied in our research to assess the values of biodiversity perceived by farmers. While previous studies showed that non-scientists sometimes have difficulties with understanding the concept of biodiversity (e.g. Christie et al., 2006; Soini and Aakkula, 2007), it seemed important to allow farmers to define the concept themselves before engaging in the valuation exercise. Therefore, instead of conducting individual methods e.g. interviews or questionnaire surveys, focus groups were chosen as the main method, allowing for discourse and interactions between participants to form their opinions and encourage a joint learning process.

The focus group method provides a good occasion for participants to listen to each others' opinion and form thoughts together on the issue under investigation, thus it is useful to understand the process of how participants conceptualize a scientific term with their own words and concepts.

The focus group design was developed by a group of researchers who applied the method in several European and one non-European country (for comparative results see Kelemen et al. 2013). Focus groups were structured into four major steps: (1) introduction; (2) a visual ice-breaking exercise (Figure 6.) to jointly interpret the different aspects of biodiversity by the help of photos taken previously in the area; (3) a concept-mapping exercise to understand farmers' perceptions of biodiversity and its values; and (4) a moderated discussion about the causal links between farming and biodiversity.

Figure 6. Visual ice-breaking exercise with farmers

Three focus groups were organized in 2010 in the case study area. One focus group was dedicated to organic farmers (7 farmers, 150 minutes) and another one to conventional farmers (3 farmers, 80 minutes). Beyond these two group discussions we had an experimental focus group to test the guideline for the discussion with 6 participating farmers, but since the guideline was modified after the test run, we skipped this test group from the analysis.

All focus group discussions were tape recorded and transcribed but only the latter two were analyzed. The qualitative content analysis method (Mayring, 2000; Elo and Kyngäs, 2008) was applied, which is a mixture of the more formalized and mathematized content analysis (Stemler, 2001) and the more intuitive and data-centered grounded theory method (Charmaz, 2006).

For the analysis of the text, an a priori coding agenda was developed by the research team consisting of the different aspects of biodiversity (diversity of genes, species and habitats), the different value types related to biodiversity (ecological, sociocultural and economic), and the main drivers of biodiversity change. We used the NVivo software to code the transcripts through an iterative process. First we read the text carefully and looked up the predefined codes, then we checked for emergent new codes (not listed in the a priori coding agenda) that complemented and explained our theory driven coding agenda. Finally we searched for linkages between the codes. Triangulation of the coding procedure was achieved by comparing preliminary results across countries.

Experiences of limitations of the applied methodology are further discussed in detail in Kelemen et al. 2013.

4. Results

4.1 Botanical indicators

The results of the habitat mapping on livestock grazing farming systems in semi-natural study area grasslands were dominated on 60.8% with high mean patch size. The proportion of arable land was 20.2% and wetlands had even relatively high share (12.9%). Although urban areas and forests had insignificant territorial share those possess the highest percentage from the number of habitat patches outlining the main features of the homestead settlement characteristics in the area.

Basic botanical indicators - Total number of species/Average number of species per plot/Area weighted number of species - were analyzed for all farms and compared. They were strong correlated to each other and no significant difference was found among them concerning other parameters. Therefore, we suggest to consider the total number of species per farm as species indicator for easy, efficient and general use. The total number of plant species was 402, and average 18 species per habitat (min. 5; max 37). Shannon and Simpson diversity of habitats per farm should be verified with Rényi diversity profiles and species number or diversity of plant species as the homogenous size of arable habitat patches could cause relative high evenness. Even the shape index and perimeter-area ratio values were correlated to high arable land proportion and low number of species in a farm. Shannon habitat diversity showed decreasing, but not significant tendency with higher grazing intensity (livestock unit per ha grassland) and increasing area of therophytes dominated habitas showed presumable overgrazing. Although the GHC habitat mapping requires not only appropriate determination skill from a botanist but also full knowledge on life forms in agricultural habitats the GHC method is more sensitive during monitoring process to represent finer changes in the spatial patterns deriving from the different management (shrub encroachment, overgrazing).

4.2. Main patterns found in zoological indicators

We found that the spiders were the most reliable indicators, especially in grasslands and woodlands (43.91 ± 0.29 species, and 46.94 ± 0.22 species, respectively), while the bees' and earthworms' species richness were unstable, thus their indicator role in this context still remained debated.

Rényi diversity profiles for spiders showed that diversity of spider assemblages was closely similar between habitat types, however the grassland was the most diverse habitat (Figure 7.). The total number of species caught was highest and identical for the grassland, trees and linear habitat types, while the diversity of dominant species was the highest and identical in the linear, croplands, and conifer habitat types.

For bees, the diversity profiles showed that the rare species dominated in the species collection and determined the outline diversity profiles in the different habitat types. The species richness was the highest in the grasslands, followed by the linear habitat types (Figure 8.), while the diversity of the dominant bee species was the highest in the canal habitat.

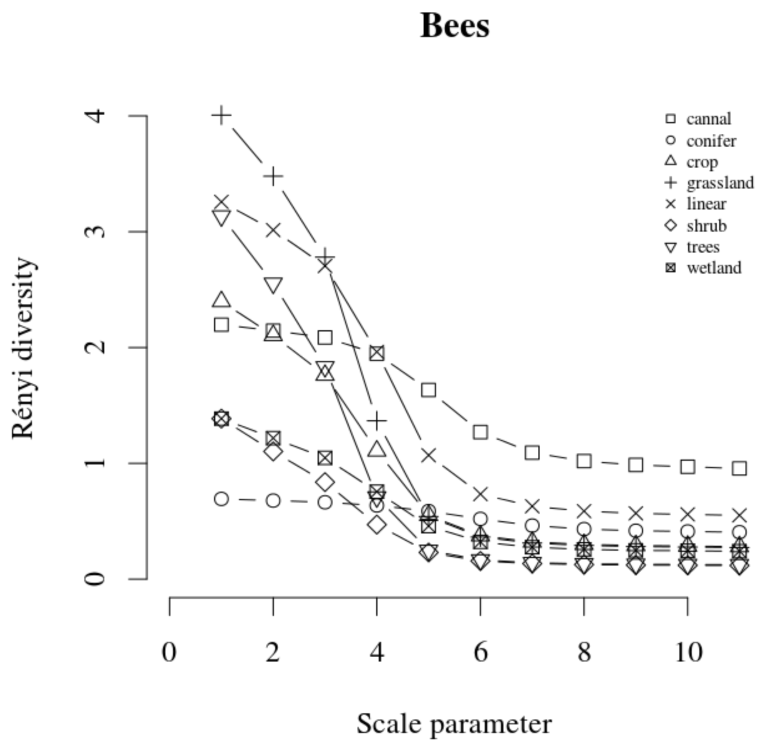

Figure 7. Rényi diversity profiles for spiders

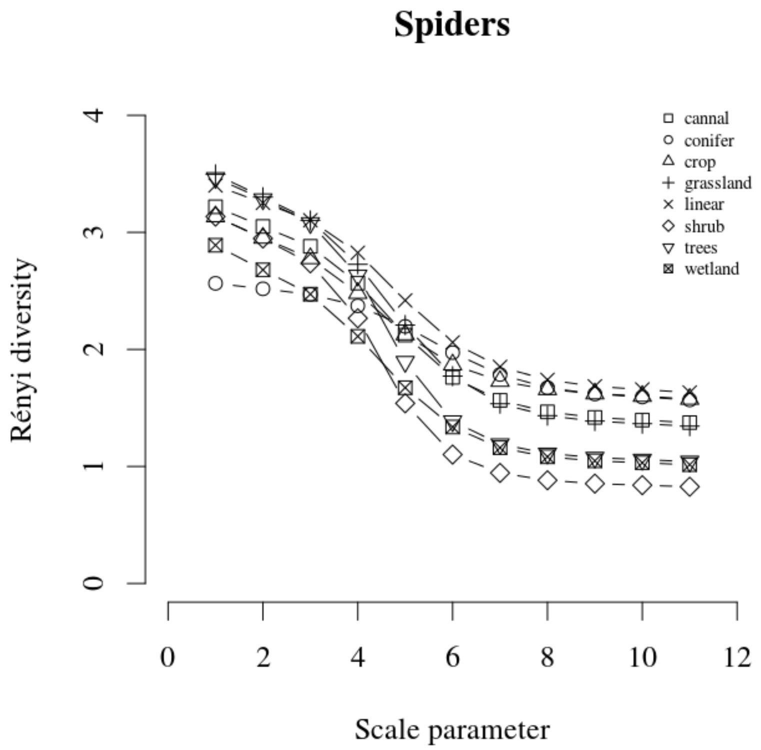

Figure 8. Rényi diversity profiles for bees

Earthworms - *no sufficient indicators*

We collected 551 individuals of seven species in total, with 93% of the individuals belonging to three *Aporrectodes* species (*A. caliginosa, A. georginii, A. rosea*). We analysed the abundance of earthworms which was not influenced by any of the studied habitat or environmental variables (Table 1).

Concerning earthworms, we have to mention that the variability of the examined soils was great. The humus rich layer varied from 5 to 100 %, compaction varied from none to extremely compacted, and soil moisture conditions from dry to wet. These conditions probably influenced earthworm diversity greatly. As some of the rea was sandy, some wind erosion accumulation area was also among the sampling sites (having two C horizons in the upper 59 cm followed by the original humus rich A horizon up to the depth of 91 cm. There was one condition that was very similar in all cases, the lime content. As the area belongs to the former River Danube watercourses and flooding (sediment) area, the majority of the soils had a high lime content. The sediment of River Danube is lime rich. Another similarity was the high water table in – again – the majority of the sampling sites as the year was extremely rainy. These soil variables explain a lot of the non-significant connection between the examined habitats.

Bees - *sensitive for weather conditions and amount of flower resources*

Although the 1135 individuals belonged to 85 bee species, most of the collected bees were honeybees (*Apis mellifera* L.). The value of livestock unit in grasslands had a significant, positive effect on bee species richness. Cloud cover had a negative effect on the abundance of bees, while the air temperature had a positive effect on species richness and abundance. Flower cover had positive effect on bee abundance and together with the number of flowering species they seemed to be the most important environmental variables influencing bee species richness (Table 1).

Spiders - *sensitive for both farm composition and local environmental conditions*

In total of 4222 individuals of 199 spider species were collected. The abundance and species richness of spiders increased by the number of habitat types per farm. The abundance of spiders was higher in farms with more grassland patches. Wind intensity negatively influenced both species richness and abundance of spiders. The minimum and maximum vegetation height had a positive impact on spiders' species richness and abundance (Table 1). Results are presented in details in Kovács-Hostyánszki et al. (2013).

Table 1. Results of general linear mixed-effect models relating farm, management and environmental variables to log-transformed abundance and species richness of earthworms (abundance only), bees and spiders.

4.3. Correlation between species diversity and farm management indicators

In the Hungarian BioBio case study significant correlation between species diversity and farm management indicators were only found in two cases (Table 2). Positive correlation was found between total nitrogen input and the number of earthworm species. Negative correlation was found between grazing intensity and the number of plant species.

Table 2. Correlation between species diversity and farm management indicators

4.4. Results of a discourse based valuation study on farmers' perceptions on biodiversity

Both focus groups reinforced that biodiversity and farming are strongly interlinked. Perceptions of biodiversity built on farmers' life experiences and everyday relationship with nature. Biodiversity was not considered an abstract, scientific term for them but an inherent part of their life, which was realized through their farming practices and their relations to local nature conservationists. Despite biodiversity was generally embedded in the lifeworld of both organic and conventional farmers, the two focus groups showed significant differences in how the term was conceptualized, and what kind of benefits were related to biodiversity by organic and conventional farmers.

In the conventional focus group farmers were unsure about what biodiversity meant; first associations ranged from heterogeneity to divergence and raised even some negative connotation. Despite the facilitator defined the term in everyday language, the concept mapping exercise remained an abstract and difficult task to conventional farmers. In the organic focus group farmers were familiar with the concept without the facilitator's definition; the concept mapping exercise energized them and fostered a lively discussion where personal opinion and experimental knowledge was shared and reflected. The richness and complexity of concept maps clearly reflects this difference, as conventional farmers built their concept map around 8 concept only, while organic farmers associated more than 30 concepts with biodiversity during the concept mapping exercise. However, the differences in the deepness of understanding between the two groups started to diminish in the second half of the focus groups when a facilitated discussion took place. As Figure 6 and Figure 7 demonstrate, the qualitative analysis of the discussion resulted in equally rich and complex conceptualizations of biodiversity and its values in both groups, although the range of benefits as well as how they were realized were specific to conventional and organic farmers.

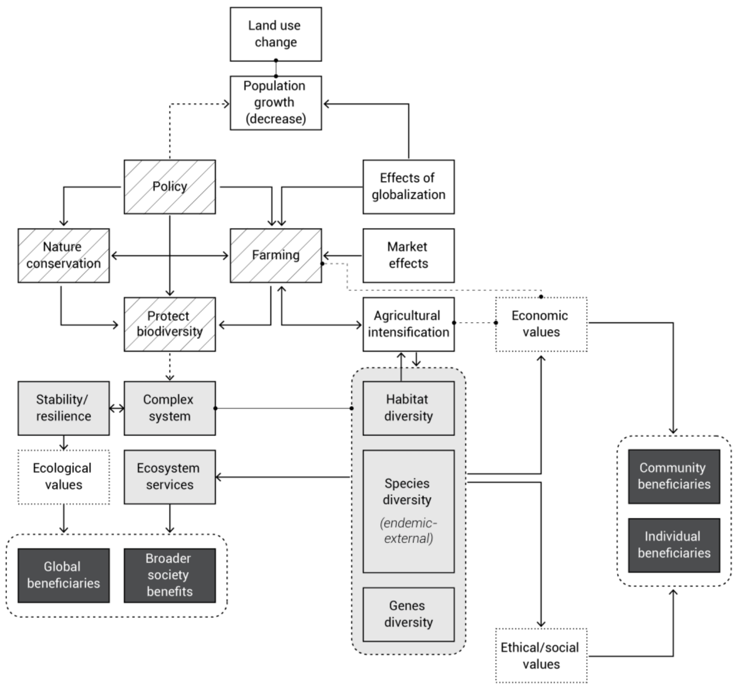

Figure 9. Perceptions of biodiversity and its values by organic farmers

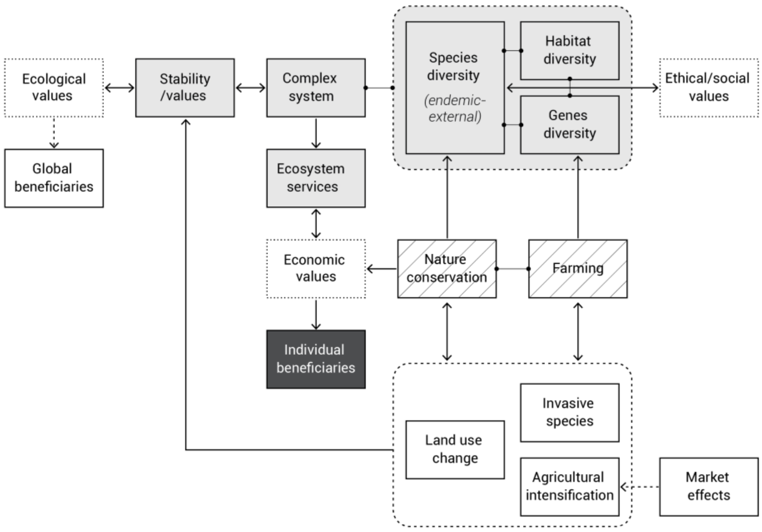

Figure 10. Perceptions of biodiversity and its values by conventional farmers

In the conventional focus group, farmers referred to genetic diversity rarely, but in all cases they interpreted it as the existence of traditional breeds. Different breeds were perceived to graze differently, to like different plants and to prefer different habitats for grazing. This indicates that both species and habitat diversity were linked to genes diversity and were experienced through farming. In addition, the interpretation of species diversity was mediated by the local presence of nature conservation; farmers frequently mentioned rare and endemic species referring back to the activities of the National Park Directorate. Participants attached sociocultural values to species diversity, e.g. the beauty of species, the various colors of the landscape, the right to exist. These sociocultural values were considered to be shared values of the whole community as the following quotation illustrates: "We were raised in this diverse landscape, we get used to it. It would be strange if this diversity didn't exist."

Genes, species and habitats were considered to constitute a complex system with mutual interactions between species and the non-living environment (e.g. they are interacting in the food web; they are part of the nutrient cycling). These interactions provided ecosystem services (e.g. pollination, healthy fodder) which represented economic value for farmers themselves. However, not only benefits were realized in economic measures, but also costs which were understood as the negative effects of biodiversity stemming from two different sources. On the one hand, certain species (e.g. weeds and invasive species) were seen by farmers as harmful ones because they had to control them which increases their costs. On the other hand, they also realized increasing costs (or profit loss) due to the environmentally friendly agricultural practices nature conservationists required from them. Although this economic effect was caused by nature conservation and not directly by biodiversity, farmers accounted these amounts as the cost of biodiversity.

The complex system constituted by species and habitats was characterized by stability/resilience which was linked to the third value dimension as the following quotation shows: "Diversity has a key role in the functioning of vegetation. The value itself is that it [the system] is working." Ecological value was considered to be rather marginal, especially comparing to sociocultural and economic values.

Conventional farmers acknowledged during the discussion that human interventions could be harmful to nature. They considered the intensification of agriculture and the changes in land use as potential drivers of the spread of invasive species and as contributing to the decrease of resilience. However, they also thought that farmers often acted as the promoters of biodiversity by fighting against invasive species or by grazing the grassland with animals etc. Market effects, although worsening the economic circumstances of small holders, were considered to foster pro-biodiversity farming instead of being a threat factor, because the growing prices of pesticides and fertilizers contributed to extensification.

In the organic focus group the three components of biodiversity – the diversity of genes, species and habitats – together with soil and humans were considered to build up a complex system, the system of natural interactions. Participants agreed that the system was resilient – i.e. well-functioning and resistant to shocks – if its elements were in harmony. The ecological value of biodiversity was strongly related to the concept of resilience, and it was argued that biodiversity had key importance for the survival of humans. Genes, species and habitats were considered to provide ecosystem services for mankind, like pollination and water purification. These ecosystem services were seen important for humanity because these make the Earth a liveable place.

Beside ecologic value, sociocultural value was also attributed to the different aspects biodiversity because they provided beauty, pleasure and refreshment to people. Participants also attached bequest value to biodiversity by indicating the importance of enabling future generations to see and enjoy biodiversity. Local people in general were considered as part of nature, which suggests that biodiversity was part of local identity, as the following quotation shows: *It is impossible to separate, that this is the vegetation, and this is me, the farmer.*

Contrary to the conventional focus group, economic values were not directly linked to biodiversity. Organic farmers argued that economic values – the benefits of biodiversity realized by them in monetary terms – were the joint outcome of the individual willingness to intensification, the chosen farming practices and the existing natural conditions. Farming practices were regarded as more important drivers of economic values than biodiversity itself.

Threats to biodiversity were mainly interpreted through farming; only agricultural intensification had direct links to biodiversity. Market processes and globalization had impacts on farming, but these negative effects were seen as possible to be balanced by the supporting policies. Policy processes were considered to directly influence farming and nature conservation, and responsibilities were allocated to the policy field in relation to biodiversity protection. However, farmers and individuals were also considered to be responsible for the loss of biodiversity. Participants of the organic focus group argued that humans had to learn from previous mistakes and had to take a better care for the environment. Attitudinal change, education and promoting new farming practices were identified as inevitable actions to halt the loss of biodiversity.

5. Discussion

5.1. Effects on botanical and zoological indicators

5.1.1. Farm composition effects

From the three selected groups only spiders showed any response to the farmland composition and habitat type. They were numerous in the grasslands, linear habitats and tree groups that highlight the importance of these marginal habitats as sources for spill-over to croplands where spiders can contribute to biological control of agricultural pests (Rand et al., 2006).

The species richness and abundance of spiders were the lowest in the crop fields, and were enhanced by the number of grassland fields in the farm. Spiders are broadly distributed in agricultural and semi-natural habitats (Schmidt and Tscharntke, 2005b) and are sensitive to arable crop (Batáry et al., 2008b; Samu, 2003) and grassland (Batáry et a., 2008a,b) management. Arable fields are preferred less by spiders than perennial grasslands (Ratschker and Roth, 2000; Schmidt and Tscharntke, 2005a), possibly due to the negative effects of management (e.g. fertilizer and pesticide use) and the less heterogeneous vegetation structure (Batáry et al., 2008a). Increasing number of grassland patches and parallel increase of habitat heterogeneity at the farm level contributes to higher spider richness and abundance (Batáry et al., 2008b; Benton et al., 2003). Therefore we suggest that the complexity of landscapes including perennial non-crop habitats is a key element to preserve or restore high levels of spider diversity (Schmidt et al., 2005).

We found only low number of species and individuals of earthworms in our study, and no difference among the different habitat types due to the frequent occurrences of sandy soils that provides inappropriate habitat for burrowing earthworms (Edwards and Bohlen, 1996; Bardgett, 2005; van Diepeningen et al., 2006). Earthworms are suggested to be suitable indicators of soil structure, tillage practice and grassland management (Chan, 2001), influenced by both physical (e.g. ploughing, trampling) and chemical (fertiliser and pesticide use) agricultural practices that affect soil conditions. However, in our study effect of sandy soil seemed to dominate over all the habitat type and management effects, and resulted in low indicator power of earthworms in our study.

Bees did not show any significant difference among the habitat types and were not influenced by the farmland composition effects either. The species richness and abundance of bees depend on the available nesting and foraging (flower) resources, which are usually provided most by the semi-natural habitats in an agricultural landscape (Sjödin et al., 2008; Steffan-Dewenter et al., 2002). However, habitat compositional change within the farm may not necessarily cause change in the total abundance or species richness as far as these resources are sufficiently available at the farm level (Carré et al., 2009).

5.1.2. Management effects

Species richness of bees at farm level was enhanced by grazing intensity in grasslands, which could have important role in the maintenance of high flower diversity, preventing the dominance of few perennial species and provide more foraging resources for bees (Sjödin et al., 2008; Batáry et al., 2010). However, it might work only at relatively low grazing pressure, whereas high grazing intensity in several Western-European countries was found to have significant negative effect on pollinators (Sárospataki et al., 2009; Batáry et al., 2010).

Grazing usually affects spiders, especially the number of vegetation-dwelling species due to the changes in the vegetation structure (Batáry et al., 2008a,b; Dennis et al., 2001; Horváth et al., 2009), however according to our results grazing type and intensity had no effects on the species richness and abundance of spiders. It could be explained on the one hand by the low grazing intensity that under 1.75 LU/ ha seems to provide valuable habitats for species rich spider assemblages. On the other hand the potential negative effects of grazing might be buffered by the semi-natural habitats and landscape heterogeneity at the farm scale in our low-input farms (Benton et al., 2003; Schmidt and Tscharntke, 2005a).

5.1.3. Vegetation structure and weather effects

Species richness and abundance of bees were mainly determined by the available flower resources: species richness of flowering plants enhanced bee species richness, while flower cover had a positive effect on both their species richness and abundance (Ebeling et al., 2008; Holzschuh et al., 2007; Sárospataki et al., 2009). The higher flower diversity provides higher variety of flowers of different morphology and phenology that makes flower resources available for higher diversity of bee species. While as higher amount of flowers occur in the habitats, as more nectar and pollen will be available for the pollinators (Potts et al., 2003).

Looking at the vegetation effects, similarly to former studies (Batáry et al., 2008a; Dennis et al., 2001; Gibson et al., 1992) we found that spiders were strongly affected by the vegetation structure. Both the species richness and abundance was enhanced by the minimum and maximum vegetation height. Complex vegetation structure supports higher species richness and abundance of spiders as lower vegetation is required by hunting species to better see and catch their prey, while web-building spiders demand higher stems at different heights to construct their nets (Dennis et al., 2001).

Weather conditions affected both bees and spiders, which warn to the importance of optimal sampling conditions to have representative samples to indicate farmland composition and management effects. The negative effects of cloud cover and positive effects of temperature in the case of bees point to the need of optimal circumstances for flying and foraging activity, varying among species, and without their detectability is much lower during sampling (Corbet et al., 1993; Stone and Willmer, 1989). Higher cloud cover and wind had negative effects on spider species richness and abundance. Wind prevents spiders from successfully foraging and destroys spider webs, which decreases their activity and forces them to hide in the lower levels of vegetation or in the litter layer, decreasing the possibility of their capture even by suction.

5.2. Farmers' perceptions of biodiversity

Our study revealed that farmers – regardless of organic or conventional – attributed a mixture of values to biodiversity, which reinforces the results of Herzon and Mikk (2007) and Soini and Aakkula (2007). The results suggest that when farmers think about biodiversity they address species and habitat diversity most frequently. Complexity is also an important component of biodiversity, and the complex nature of biodiversity is often linked to farmers' philosophical and spiritual commitment. Genetic diversity as a part of their conception of biodiversity is hardly mentioned by farmers.

One of the unique features of our research was that it could unpack differences between the perceptions of organic and conventional farmers.

Organic farmers tended to have a more complex and philosophical approach to biodiversity, while conventional farmers showed a more instrumental approach. Sociocultural values were equally important in each group, while the economic value approach was more dominant in the conventional focus group and ecological values were more frequently mentioned in the organic focus group. In organic focus groups even weeds and pests were accepted as a natural occurrence within farming, but conventional farmers usually thought pests and weeds to be the 'negative' side of biodiversity and harmful for their farm, which – at least for conventional farmers – echoes the results of Herzon and Mikk (2007) and Soini and Aakkula (2007). When the economic side of biodiversity was discussed, economic values were often in conflict with sociocultural ones, resulting in cognitive dissonance in both organic and conventional focus groups (i.e. preserving biodiversity is justified by its ethical, social and ecological values, but requires economic sacrifices on behalf of farmers). This underlies the claim that biodiversity protection needs to be a more shared, society-wide responsibility.

6. Conclusion

Low-input Eastern European farmlands are traditional, extensive management systems, characterized by rich biodiversity. The study of 18 Hungarian farms showed that heterogeneous habitat composition and moderate grazing (1.75 LU/ha) intensity in grasslands have considerable importance to maintain the richness of spider and bee assemblages at the farm scale. The application of the BioBio farm-scale approach to measure the effects of farmland composition, grassland management and local vegetation characteristics revealed important effects of farm-scale habitat heterogeneity and especially importance of semi-natural grasslands on the species diversity and abundance of spiders. Mosaic structure of crop fields and grasslands within the farms has therefore a high potential to increase spider diversity and number, and therefore the potential for efficient biological pest control by them as important natural enemies of arable crop pests. Moderate grassland grazing intensity (i.e. 1.75 LU/ha) was found to increase wild bee species richness within the farms, suggesting higher diversity of flower resources, while such grazing intensity had no effects on spiders. Low-input farming systems in the studied Hungarian farms were found to harbor rich diversity of wild bees and spiders, which conservation needs the maintenance of this traditional, extensive management.

Looking at from the indicator value point of view, the three studied taxa showed different sensitiveness to the different scale habitat properties. Earthworms were most sensitive to soil structure, and as sandy soils resulted in a low species richness and abundance of earthworms per se, they were not suitable to indicate management or habitat composition effects on the soil biota. Bees are determined most significantly by foraging and nesting resources and occur at those habitats, where flowers are available. They indicate therefore well local field characteristics and management, also the effects of grassland grazing, however, they were found less suitable to measure farm-scale composition effects, probably also due to their higher mobility. In contrast, spiders seemed to be good indicators of both local vegetation structure and farmland composition. Nevertheless we have to acknowledge the importance of optimal weather conditions during sampling, as cloud cover, wind speed and temperature considerably affect the activity and therefore the detectability of bees and spiders.

The discourse based valuation study highlighted that both organic and conventional farmers interpret biodiversity through their everyday life and farming experiences, and reinforced that their perceptions differ significantly. Although this result cannot be generalized to other socio-ecological context, a general methodological lesson was learnt, namely that discourse based methods reveal the plurality of values and allow participants to share their opinion and learn from each other. In both of our focus groups the most important learning points occurred when participants debated the responsibility of farmers in endangering (or protecting) biodiversity. Learning was achieved during the discussions from two aspects: on the one hand, participants acknowledged that different but equally legitimate viewpoints existed in the groups, which was considered as yet another aspect of diversity; on the other hand participants acknowledged that nature worked well without human intervention but humans were highly dependent on nature.

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Figure 1. Location of the case study area

Figure 2. Overview of the BioBio indicator campaign

Figure 3. Earthworm sampling frame with expellant solution on the surface

Figure 4. Bee sampling with an insect net

Figure 5. Spider sampling with a D-VAC sampler

Figure 6. Visual ice-breaking exercise with farmers (Photo: Á. Kalóczkay)

Figure 7. Rényi diversity profiles for spiders

Figure 8. Rényi diversity profiles for bees

Figure 9. Perceptions of biodiversity and its values by organic farmers

Figure 10. Perceptions of biodiversity and its values by conventional farmers

Table 1. Results of general linear mixed-effect models relating farm, management and environmental variables to log-transformed abundance and species richness of earthworms (abundance only), bees and spiders.

Table 2. Correlation between species diversity and farm management indicators