NATIONAL AND REGIONAL LEVEL FARMLAND BIODIVERSITY INDICATORS IN FINLAND

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Abstract: Four national level indicators of the state of farmland biodiversity indicate that Finnish farmland biodiversity is declining. The area of meadows has decreased to <1% of what it used to be in the beginning of the 20th century. The number of threatened farmland species has increased in all the five studied groups of organisms, and the rate of increase has been higher in farmland habitats than in any other habitat type in Finland. Dry meadows have the largest number of threatened species among farmland habitats. Some 40% of farmland butterflies have declined. The proportion of declined species is highest among meadow butterflies (71% declined). Some of the nationally useful biodiversity indicators may be too crude measures for detecting changes in biodiversity at smaller spatial scale. Therefore, and because of the needs in the monitoring of the effectiveness of the current Finnish agri-environmental support scheme to maintain farmland biodiversity, there is a need in Finland to develop farmland biodiversity indicators particularly at the landscape scale (an area of 0,5-1000 km^2). Suitable information for this purpose was collected in summer 2001 in an extensive field survey of farmland biodiversity in 58 randomly selected agricultural landscapes in southern Finland. The aim of the survey was to obtain quantitative information on 1. the amount of variation in plant, insect and bird biodiversity in ordinary Finnish farmland, 2. the key factors affecting species diversity at different spatial scales and 3. the relationship between landscape structure and biodiversity. First results on butterflies are shown. It is concluded that both national and landscape level indicators of farmland biodiversity are needed, because the same indicators are not always useful at both spatial scales.

Key words: Biodiversity survey, butterflies, threatened species, semi-natural habitats, habitat quality, landscape structure.

Introduction

Agriculture in Finland has experienced very large changes during the last 50 years. The last big change happened in the year 1995 when Finland joined the European Union (EU) and adopted the common agricultural policy of EU. Agricultural intensification and loss of open semi-natural farmland habitats has caused large-scale losses of farmland biodiversity in Finland (Pitkänen & Tiainen 2001) as well as in other parts of Europe (Krebs et al. 1999). Because of the large changes there is a substantial need for useful indicators to measure the extent of change both at the national and landscape level. A preliminary set of indicators for the sustainable use of renewable resources at the national level was approved in Finland in February 1999 (Lahti & Nikkola 1999). At a smaller spatial scale indicators are particularly needed in the monitoring and further development of the effects of the Finnish agri-environmental support scheme, which is half-funded by EU.

The aim of this paper is to summarize some recent developments and on-going work on farmland biodiversity indicators in Finland both at the national and at the landscape level. We start by showing recent results of four useful measures of the state of farmland biodiversity in Finland. After that we focus

on the landscape level indicators and describe an on-going reasearch project, which was started in the year 2000 in order to evaluate and further develop the effectiveness of the current Finnish agri-environmental support scheme to maintain farmland biodiversity. Another object of this project is to identify a set of the most useful indicators of Finnish farmland biodiversity. Finally, we compare the different needs that there are for useful farmland biodiversity indicators at the national and landscape levels.

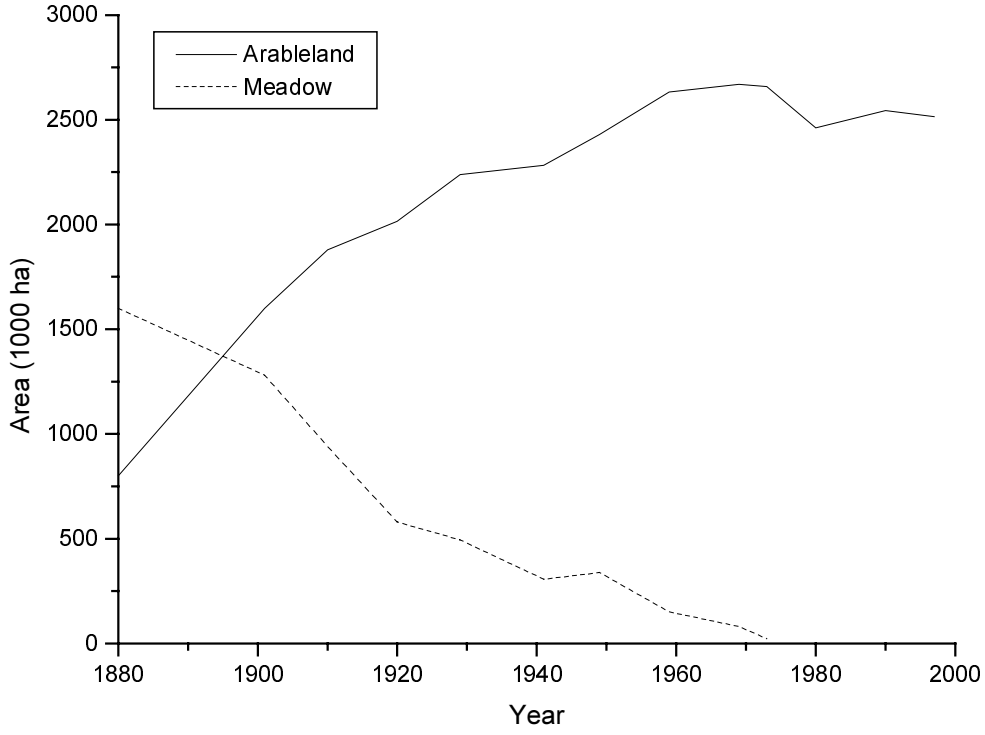
National level indicators

In this section we give a short overview of the recent trends and current state of farmland biodiversity in Finland by using four selected national level indicators: the trend in the amount of seminatural grasslands and the number of threatened species, threatened species in various farmland habitats and population trends in farmland butterflies.

1. Trend in the amount of seminatural grasslands

During the last 100 years Finnish agriculture has gone through a change from small-scale traditional agriculture to much more efficient modern agriculture with increasing farm size and increasing specialization. Traditional Finnish agriculture involved animal husbandry for which it was typical to use extensive areas of semi-natural grasslands and forests for cattle-grazing. This type of agriculture was beneficial for a large amount of grassland-specialized species, especially for many plants and insects (Pykälä 2001). Presently, the large amount of different kinds of extensively used meadowland, which existed in Finland in the beginning of 20th century, has been mostly lost and converted to intensively used cultivated fields (Fig. 1).

Figure 1. Decline of the area of semi-natural grasslands in Finland 1880-1997. *Source*: Soininen 1974, Finnish agricultural statistics.

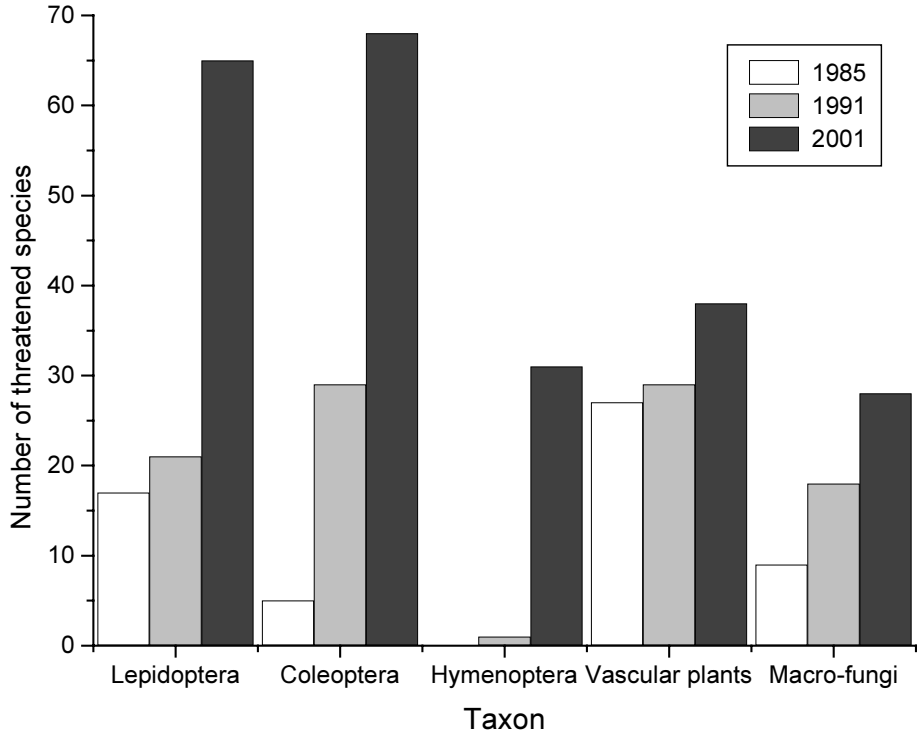


During the last 100 years the amount of medowland has decreased to less than 1% of what it used to be. Such a severe decline of suitable habitat is expected to cause a decline and regional extinctions of many meadow-associated species (Andrén 1997, Hanski 1999).

2. Trend in the number of threatened species

A comprehensive evaluation of threatened species in Finland has been made for three times, in 1985, 1990 and 2000 (Rassi et al. 2001). Based on the existing three evaluations, it is possible to analyse trends in the amount of threatened species within different habitat types. Figure 2 summarizes the trends for species which mainly occur in farmland habitats.

Figure 2. Increase of the number of threatened species in the Finnish agricultural landscapes. *Source*: Rassi et al. 2001.



In each of the five groups of organisms in Fig. 2 there is an increasing trend. This trend is logically consistent with the observed long-term declining trend of suitable open seminatural habitats (Fig. 1). However, a substantial amount of the increase in the numbers of threatened species is due to the increased knowledge of previously too poorly known groups of species. For example in Lepidoptera a substantial proportion of the currently threatened species belong to Microlepidoptera, which could not be thoroughly classified in the previous evaluations because of insufficient knowledge. Nevertheless, the increase of the amount of threatened species in the latest Finnish evaluation was higher in the species of farmland habitats than in any other habitat type (Rassi et al. 2001).

3. Threatened species in different farmland habitats

There is much variation in the numbers of threatened species among various kinds of farmland habitats. In Finland, almost half of the threatened farmland species are primarily species of dry meadows (Table 1). This is not surprising, because the area of dry meadows has decreased more than the area of any other grassland habitat type in Finnish agricultural landscapes (Heritage landscapes working group 2000). The amount of threatened farmland species is particularly high in butterflies and moths (Lepidoptera) as well as in beetles (Coleoptera; Table 1).

Table 1. Threatened species in different farmland habitats in Finland.

Habitat type	*Lepidoptera*	*Coleoptera*	*Hymenoptera*	*Vascular plants*	*Macro-fungi*	***Total***
Dry meadows	57	43	26	23	13	**162**
Fresh meadows	7	9	-	13	-	**29**
Margin habitats	58	25	11	1	-	**95**
Wooded pastures	7	16	8	10	17	**58**
Shores, river banks	11	19	1	14	2	**47**
Total	**140**	**112**	**46**	**61**	**32**	**391**

Source: Rassi et al. 2001.

4. Population trends in farmland butterflies

For the ecologically well-known groups of organisms it is possible to determine which species are primarily inhabitants of agricultural landscapes. In Finland this was recently done for butterflies. According to Pitkänen, Kuussaari & Pöyry (2001) 74 of the ca 100 permanent butterfly species live in agricultural environments. These species were further classified into three categories according to their primary habitat type: species of 1. Field margins and farmyards, 2. meadows (or seminatural grassland) and 3. forest verges and clearings (Table 2). By combining information on observed population trends of each species and the habitat classification Pitkänen et al. (2001) found that the trends are distinctly different among the species of the three habitat types. While 71% of the meadow species had declined, the corresponding figure for the species of forest verges and clearings was only 25%, and none of the species of fields and farmyards had declined (Table 2).

Table 2. Population trends in Finnish farmland butterflies.

(Number and % of species)

Habitat type	*Decreased*		*No change*		*Increased*		*Threatened* [1]	
Field margins, farmyards	0	0 %	7	88 %	1	12 %	1	12 %
Meadows	24	71 %	8	24 %	2	6 %	14	41 %
Forest verges and clearings	8	25 %	19	59 %	5	16 %	4	13 %
Total	**32**	**43 %**	**34**	**46 %**	**8**	**11 %**	**19**	**26 %**

1. IUCN classification.
Source: Pitkänen, Kuussaari & Pöyry 2001.

The trend in the national level farmland biodiversity indicators

All the above mentioned national level indicators of the state of farmland biodiversity indicate that Finnish farmland biodiversity has been declining. Eventhough the general trend has been a decline there are also exceptions, as shown for butterflies in Table 2. The situation is similar in Finnish farmland birds in which the population trends are known in detail (Tiainen and Pakkala 2001). While many farmland bird species have been severely declining, there are some others, which have become more common and increased in abundance (Tiainen and Pakkala 2001).

Landscape-level indicators

Agri-environmental support schemes aim at stopping and reversing the trend of environmental deterioration by providing economic support to farmers for applying environmentally friendly farming practices. One of the aims of such schemes is maintaining and improving farmland biodiversity. Because an effective agri-environmental support scheme is a substantial economic investment from the society, there should also be effective means to measure the environmental benefits of such a scheme.

Measurement of changes in biodiversity may be complicated by several issues. For instance, the biodiversity impacts of changing farming practices may be weak and thereby difficult to detect. In addition, populations of many species react to environmental change with a time delay. Therefore, it may take some years before the positive impacts of beneficial changes in farming practices can be seen as increasing biodiversity.

National level biodiversity indicators may be too crude measures for detecting changes in biodiversity at smaller spatial scale. For example the number of threatened species may be a very useful indicator at the national level but almost useless at the level of an ordinary farmland landscape of 10-100 km^2. The occurrence of nationally threatened species at such a small spatial scale may be a too rare event in order to have practical applicability.

In Finland insufficient knowledge on farmland biodiversity has hindered the development of the Agri-environmental support scheme towards better taking into account farmland biodiversity. Quantitative information has been lacking on the existing variation of farmland biodiversity and the primary factors affecting it in ordinary Finnish farmland. To improve the level of knowledge and in order to monitor the biodiversity impacts of the current agri-environmental scheme an extensive biodiversity survey was organized in randomly selected Finnish agricultural landscapes.

Finnish farmland biodiversity survey

A pilot survey on Finnish farmland biodiversity was conducted in 15 farmland landscapes in summer 2000. In summer 2001 the same methodology was applied to 58 randomly selected agricultural landscapes in southern Finland. The aim of the survey was to obtain quantitative information on 1. the amount of variation in plant, insect and bird biodiversity in ordinary Finnish farmland, 2. the key factors affecting species diversity at different spatial scales and 3. the relationship between landscape structure and biodiversity.

Vascular plants, butterflies, bumblebees and birds were quantitatively surveyed in a total of 58 one square kilometer study areas. In each 1 km^2 study area birds were counted from the whole farmland area, while the occurrence of plants and insects were sampled in 20 discrete 50 m long transects (altogether 1160 discrete transects), which were located in all kinds of open and semi-open uncultivated farmland habitats available within each study square. Some 30 environmental variables (e.g. habitat type and location, vegetation height, amount of nectar flowers, habitat management) were recorded from each study transect to measure local habitat quality. Additional data on the details of farming practices in the study areas will be obtained from the farmland database of the Information Centre of the Ministry of Agriculture and Forestry and by interviewing the local farmers. Measures of landscape structure and the intensity of farming will be obtained using detailed habitat maps based on low-altitude aerial photographs and GIS methods.

Multiple regression methods will be used to identify key factors affecting the diversity of various groups of organisms at different spatial scales. Additional interest is in examining the congruence of the variation of diversity among the four taxonomic groups. The results will be used in the evaluation and further development of the Finnish agro-environmental support scheme as well as in the identification of the most useful landscape level indicators of Finnish farmland biodiversity.

Results on butterflies

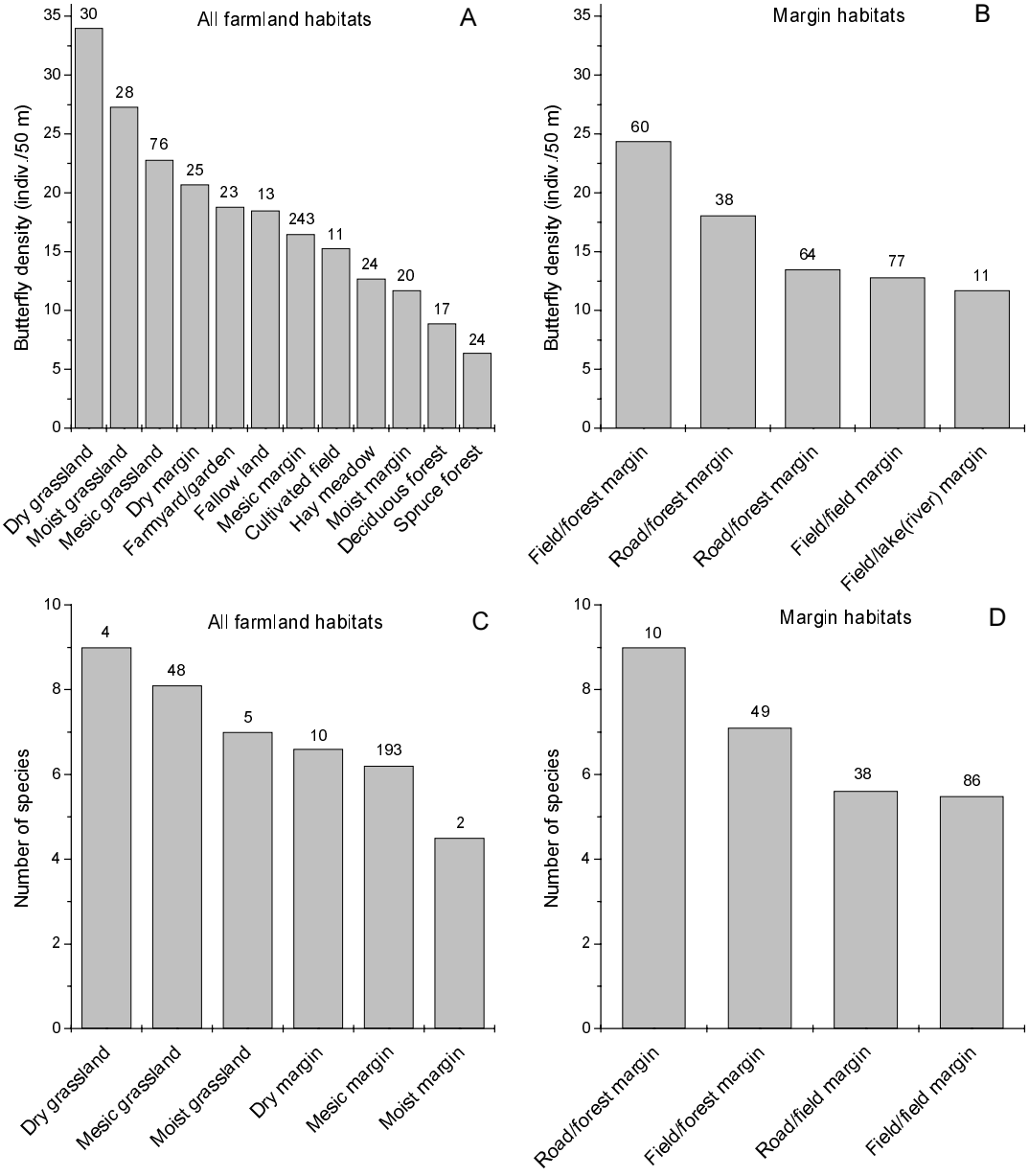
Results of the large biodiversity survey conducted in summer 2001 are not yet available, but some results from the pilot study on butterflies (Kuussaari et al. 2001) and other pollinator insects conducted in summer 2000 can be shown. Table 3 summarizes the data on the occurrence of various insect groups which was gathered from the 1 km^2 squares. These data can be analysed either at the level of the 1 km^2 square or at the level of the 50 m long sample transects.

Table 3. Summary of recorded insects in fifteen 1 km^2 study areas.

Insect group	*All study areas*		*Number of species per study area*			
	Individuals	*Species*	*Mean*	*Sd*	*Min*	*Max*
Line transects						
Butterflies	4776	51	30,5	3,2	24	35
Other day-active Macrolepidoptera	2814	69	23,7	3,2	18	30
Yellow-traps						
Bumblebees	3956	20	12,6	2,8	6	17
Other bees	332	42	6,2	3,5	2	14
Hoverflies (Syrphidae)	11441	64	16,4	5,5	6	25

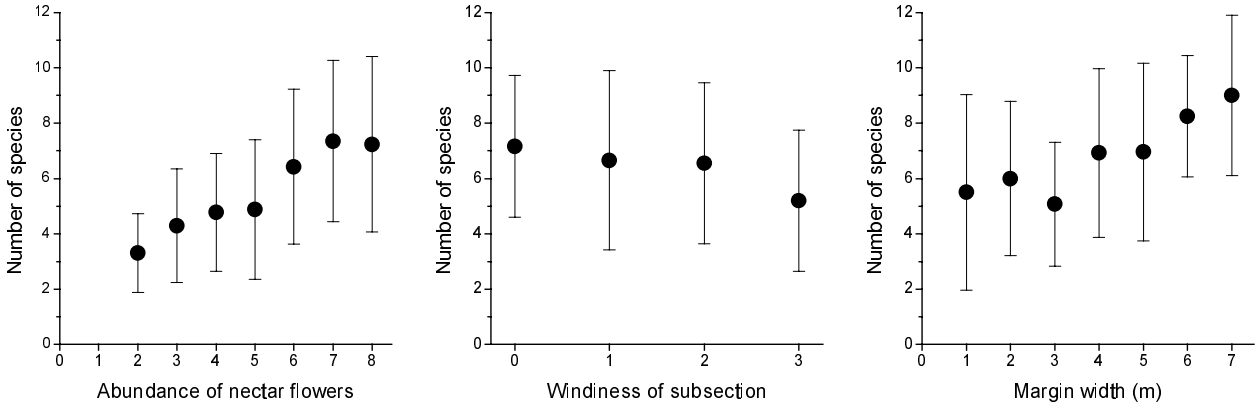
Figure 3 summarizes transect level data on the occurrence of butterflies in different seminatural habitats. Three noteworthy results emerge from the figure. First, the highest numbers of butterfly species and individuals are observed in dry meadows. Second, butterfly density and species diversity are higher in meadows than in linear field margin habitats. Third, among the different kind of linear habitats, butterfly density and species diversity are higher in the open margins between field and forest than in the margins located between cultivated fields.

Figure 3. Average butterfly densities (ind./50 m; A and B) and number of species (in 50 m transect subsections; C and D) in different agricultural habitats. Numbers above the bars indicate the number of subsections on which the mean value is based. *Source*: Kuussaari et al. 2001.



An analysis on the environmental factors affecting butterfly species richness in the linear margin habitats revealed that the most important three factors were nectar flower abundance, windiness of the site and the width of the margin. Increasing abundance of flowers and the width of the margin increased the number of butterfly species, whereas increasing windiness of the site decreased butterfly species richness (Fig. 4).

Figure 4. Factors affecting butterfly species richness in linear habitat elements (field and road margins). Means and sd bars are shown. *Source*: Kuussaari et al. 2001.



The first results of the Finnish biodiversity survey are encouraging, because they show that at least in the case of butterflies, local species richness can be explained to a substantial extent by a few easily measurable local environmental factors. However, the analysis of the extensive farmland biodiversity survey conducted in summer 2001 is just at its beginning. It will take some time before the most interesting analyses, which take into account both the local and regional environmental quality as well as the numbers of species in the different groups of study species, can be made. For example, in the forthcoming analyses an important question will be, to what extent biodiversity at the level of 0,5-1 km^2 can be explained only by measures of landscape structure (e.g. habitat diversity or the area of seminatural grassland)?

Conclusions

In this paper we have discussed the need for both national and landscape level (referring here to an area of the size of 0,5-1000 km^2) indicators of farmland biodiversity. We conclude that both kind of indicators are needed, but that the same indicators are not always useful at both spatial scales. National level indicators are needed for comparisons among countries, while in many countries there is an additional need to have landscape level indicators for example for monitoring the effectiveness of agri-environmental programs. Information on more specific landscape level indicators may help to explain and interprete observed patterns in more crude measures of national level farmland biodiversity indicators.

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