Agriculture, Ecosystems and Environment 249 (2017) 165–176

Contents lists available at ScienceDirect

Agriculture, Ecosystems and Environment

journal homepage: www.elsevier.com/locate/agee

Assessing the value of field margins for butterflies and plants: how to document and enhance biodiversity at the farm scale

Janine Sybertz[a,*], Sarah Matthies[a], Frank Schaarschmidt[b], Michael Reich[a], Christina von Haaren[a]

[a] Leibniz Universität Hannover, Institute of Environmental Planning, Herrenhäuser Str. 2, D 30419 Hannover, Germany
[b] Leibniz Universität Hannover, Institute of Biostatistics, Herrenhäuser Str. 2, D 30419 Hannover, Germany

ARTICLE INFO

Keywords:
Lepidoptera
Vascular plants
Field boundaries
Organic farming
Indicators
Germany

ABSTRACT

With ongoing biodiversity loss in agricultural landscapes, there is an increasing demand to document how farmers preserve and enhance biodiversity on their farmland. This subject is not only of interest for conservation authorities and NGOs, food companies also look for ways to integrate biodiversity issues into their corporate activities. They want to know how their farm product suppliers contribute to biodiversity on their land. However, species counting and mapping on contracted farms seems unrealistic to these companies. Therefore, we aimed to devise simple and easy-to-use but scientifically sound parameters to assess the biodiversity value of farmlands. For this we focused on estimating the value of field margins for butterflies and typical vascular grassland plants. We identified 13 parameters that are of likely importance for the species numbers of butterflies and 14 parameters likely to be important for the species numbers of plants on field margins. These parameters were tested on a total of 70 field margins on seven farms located throughout Germany. Automatic linear modelling procedures selected six parameters as the most important variables in predicting butterfly numbers: the landscape heterogeneity of the surroundings, the time of mowing, the width and length of the margin, the grass-herb-ratio and the management of the adjacent field. For predicting plant species numbers, the automatic linear modelling procedures again selected six parameters as best predictors: the length of the margin, the presence of trees and/or shrubs, the amount of source habitats in the surroundings, the width of the margin, the nutrient availability and the landscape heterogeneity of the surroundings. The adapted final model for butterfly species numbers explained 63% of the variation. The adapted final model for typical vascular grassland plant species numbers, which excluded the margin width variable as it did not prove stable in cross-validation procedures, explained 67% of the variation in plant species numbers. Both models can be used by farmers and food companies alike to rapidly assess the present value of field margins for butterflies and plants on their (contracted) farms and to identity potential and appropriate measures to enhance biodiversity.

1. Introduction

With ongoing intensification of agricultural production since the second half of the twentieth century, an increasing loss of biodiversity in agricultural landscapes has been observed (Benton et al., 2002; Stoate et al., 2001). Decreasing populations and local extinctions are documented e.g. for plants (Albrecht, 1995), birds (Donald et al., 2006; Donald et al., 2001) and butterflies (Van Dyck et al., 2009; Van Swaay et al., 2006; Van Swaay et al., 2015). As the political and public awareness of these trends increases, food companies have begun to discover the importance of biodiversity issues for their policies (Kempa, 2013). Most especially, companies with organic products want to integrate aspects of biodiversity management into their corporate activities and document what their contracted farmers do to protect biodiversity on their farms (Business and Biodiversity initiative 'Biodiversity in Good Company', 2010; Gottwald and Stein-Bachinger, 2015). This information can be used for public relations on the one hand and on the other hand, it encourages farmers to implement measures for enhancing biodiversity.

Despite these ambitions, direct biodiversity assessments by means of species counting and mapping, on contracted farms, seem unrealistic for this purpose as they are expensive and time consuming. Therefore, the aim of our study was to identify simple but scientifically sound indicators that reflect the biodiversity value of agricultural habitats. We used species richness as a measure of biodiversity as it is, besides the occurrence and abundance of endangered and specialized species, used as a core criterion for the conservation value of agrarian landscape habitats (Bredemeier et al., 2015). Furthermore, there is evidence that

* Corresponding author. Present address: Bosch & Partner GmbH, Lortzingstr. 1, D 30177, Hannover, Germany.
E-mail address: sybertz@umwelt.uni-hannover.de (J. Sybertz).

http://dx.doi.org/10.1016/j.agee.2017.08.018
Received 31 March 2017; Received in revised form 11 August 2017; Accepted 15 August 2017
0167-8809/

the occurrence of endangered species is more likely in species-rich farmland habitats (Bredemeier et al., 2015; Kolářová et al., 2013). Models, which project species numbers, should help farmers and company consultants to easily assess the biodiversity value of their farmland and identify any potential to enhance the biodiversity. We developed such assessment models for butterflies and plants on field margins. During this process, workshops and discussions with food companies and their contracted farmers helped to assure the usability of the models and to gather information about implementation conditions.

The habitat preferences of butterflies are well studied. Parameters found to influence their richness and abundance in field margins include the width of the margin (e.g. Kuussaari et al., 2007; Sparks and Parish, 1995), its management (e.g. Feber et al., 1996), the floral richness or nectar availability on the margin (e.g. Clausen et al., 2001; Pywell et al., 2004) and its structural complexity (e.g. Dover et al., 2000; Haaland and Gyllin, 2010). Furthermore, shelter from wind is also likely to be important (Dover et al., 1997). Butterflies have also been found to be influenced by pesticide drift and consequently by the agricultural management of adjacent fields (e.g. Rands and Sotherton, 1986; De Snoo et al., 1998) and other land uses and structures bordering the margin (e.g. Kuussaari et al., 2004). Other authors have found connections between butterflies and the surrounding landscape, either concerning landscape heterogeneity, forest cover or the agricultural management (e.g. Rundlöf and Smith, 2006; Toivonen et al., 2017; Weibull et al., 2000).

For the species richness of vascular plants, environmental conditions, followed by landscape parameters, adjacent habitats, management and margin structures, have been found to be the most important parameters to influence this variable (Le Coeur et al., 1997). Parameters describing environmental conditions include the availability of nutrients (e.g. Hovd and Skogen, 2005; Tarmi et al., 2009), the soil type (e.g. Manhoudt et al., 2007) and the lime content of soils (Jantunen et al., 2006). Landscape parameters refer to the overall habitat heterogeneity (e.g. Ma et al., 2013) and the amount of source habitat available in the surroundings (Jantunen et al., 2006). Parameters summarized under the term adjacent habitats include the adjacent land cover (e.g. Hovd and Skogen, 2005), the farm type of adjacent fields (e.g. Manhoudt et al., 2007) and the existence of margin strips (e.g. Marshall, 2009). The mowing intensity (e.g. Aavik et al., 2008) and the removal of the mowing cuttings (e.g. Hovd and Skogen, 2005) are relevant to management parameters. Additionally, the margin width (e.g. Hovd and Skogen, 2005; Tarmi et al., 2009), the margin length (Le Coeur et al., 1997) and the presence of trees and/or shrubs (Wuczyński et al., 2014) influence species richness of vascular plants in field margins.

In this study, these parameters are tested for their suitability as simple and reliable indicators to predict and assess butterfly and plant species richness on a range of different field margins in several ecoregions in Germany. Additionally, we assess how much of the variance in butterfly and plant species richness can be explained by models based on these parameters and how high the prediction error of these models is. Based on statistical analyses and literature research we develop an easy-to-use model to predict butterfly and plant species richness on field margins. Leading on from this, we discuss how the models can be applied as a tool for biodiversity assessments on the farm scale and how the results of these assessments can be used to identify appropriate measures to enhance biodiversity.

2. Materials and Methods

2.1. Study sites

The study was carried out on seven farms situated in different landscapes in Germany, each with varying environmental and agricultural conditions (Fig. 1; for details see Table S1, Supplementary material). The size of these farms ranged from 58 ha to 700 ha. Two of the farms were managed conventionally and five were organically managed. At each farm ten arable field margins, which were at least 50 m long and 1 m wide, were randomly chosen for the sampling of butterflies and plants. Altogether 70 field margins were studied. The field margins were permanent, not sprayed and entirely uncropped but in the immediate vicinity of tilled soil (see Table S1, Supplementary material, for impressions of the sampled field margins). All were bordered by an arable field on one side. The majority were bordered by a farm track or road on the other side; a few were bordered by other arable fields, gardens or semi-natural habitats. Temporary margin strips with only annual vegetation were not sampled.

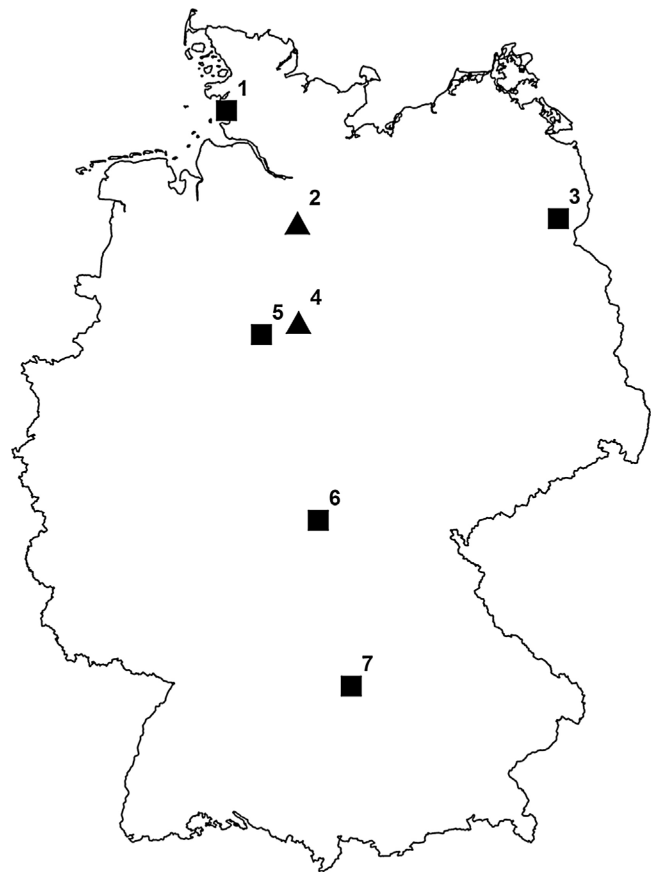

Fig. 1. Study sites in Germany (■ organically managed farms; ▲ conventionally managed farms; 1: Friedrichsgabekoog (FRI), 2: Bispingen (BIS), 3: Angermünde (ANG), 4: Algermissen (ALG), 5: Hameln (HAM), 6: Ostheim vor der Rhön (OST), 7: Megesheim (MEG)).

2.2. Identification of variables important for butterflies and plants

Through an extensive literature research, variables were identified that are likely to have an influence on butterfly richness, and/or abundance, or on vascular plant species richness on field margins (Table 1, Table 2). If similar, these variables were combined into variable groups. Only field studies in Europe were included.

2.3. Survey of butterflies and plants

Butterfly recordings were conducted between June and August of 2015. The recording was based on the line transect method of Pollard and Yates (1993) and the specifications of the German butterfly monitoring scheme (Kühn et al., 2014). Each field margin was sampled up to a length of 250 m (transect). Each of these transects was sampled six times during favorable weather conditions (air temperature of a min. 13 °C under sunny conditions or a min. 17 °C if cloudy and wind speed