Executive summary of the research project:

“Firmen fördern Vielfalt” (companies foster biodiversity)

Practicable recording, assessment and visualisation of on-site biodiversity of agricultural suppliers of food companies

Working paper as of 20 February 2018

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gefördert durch DBU Deutsche Bundesstiftung Umwelt

www.dbu.de

This report is a working paper of the research project: “Companies foster biodiversity”.

The full text version of the project report is available in German at: https://www.dbu.de/projekt_31112/01_db_2409.html

Proposal for citation:

Bredemeier, B.; Sybertz, J.; von Haaren, C.; Matthies, S.; Reich, M.; Weller, M. & Kempa, D. (2018): Executive summary of the research project: “Firmen fördern Vielfalt” (companies foster biodiversity) – Practicable recording, assessment and visualisation of on-site biodiversity of agricultural suppliers of food companies. Working paper of the Institute of Environmental Planning, Leibniz University Hannover. www.umwelt.uni-hannover.de

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Executive summary of the research project: “Companies foster biodiversity”

How can biodiversity services of farms be recorded, evaluated and visualised in a practicable way? The modelling of species richness of vascular plants, butterflies and birds on farms sets out new ways.

For decades, a continuous loss of species diversity in the agricultural landscape has been observed. Today, not only are conservationists and governments engaged in halting the decline of farmland species diversity, but so too are actors of food production and retail. They are aware of the crucial role that farmers play in preserving and promoting species diversity. Especially, in the organic sector, the preservation and promotion of biodiversity is becoming an important ethical concern for more and more companies. In order to ensure consumer trust, companies demand greater transparency about the state of biodiversity on supplier farms. They would therefore like to record and document the contribution their supplier farmers make to the conservation of biodiversity by managing their land and to show which measures can further promote biodiversity on the farms. On the one hand, this transparency on biodiversity effects of agricultural production and its raw materials will be used by companies to further develop their environmental management. On the other hand, they are responding to increasing consumer demand for information on the background and effects of agricultural cultivation.

Existing valuation approaches and advisory systems that have been applied in practice are either very complicated and time consuming or they are adjusted to assess individual farms by advisory services. The resulting case-specific evaluation is based on the assessment and experience of the consultant and is therefore not necessarily comparable across different farms. There is, therefore, no scientifically sound evaluation system that can simply, comprehensibly and justifiably map the current value and changes in habitats and species richness on farms and thus the success of measures. On the one hand, it must meet the requirements of practice for practicability and transparency or reliability of documentation and, on the other hand, it must meet the requirements for a scientific foundation.

In order to ensure both the necessary practical relevance and the widest possible dissemination of the results, the research project “Firmen fördern Vielfalt” (companies foster biodiversity) has been implemented. The research was carried out by the Institute of Environmental Planning at the Leibniz University Hannover, in cooperation with the Association of Organic Food Processors (AöL), the Chamber of Agriculture Lower-Saxony and the Advisory Service for Bioland Farmers. The project was sponsored by the German Federal Environmental Foundation (DBU). The food companies Bionade, Hipp, Märkisches Landbrot and Neumarkter Lammsbräu supported the project. Several conventional and organic farmers tested the system, provided data and allowed mapping of biodiversity on their farmland.

In the past, the requirements for a necessary on-site recording of species and habitats for the biodiversity evaluation were considered too high by the companies and the farmers. Species richness usually needs to be recorded in several on-site surveys that can spread over an extended period of time. For food companies, such surveys are assumed to be unrealistic due to the high costs entailed. The diversity of habitat types at the farm scale could in principle be well captured with the standardized habitat classifications and valuations of the German federal states. However, existing classifications are not detailed enough to capture evidence of qualitative changes in the habitat which are caused by adaptation of the agricultural cultivation. Furthermore, the diversity of typical species is not sufficiently accounted by existing habitat evaluation systems, although it is a crucial factor to determine the individual conservation value of agricultural habitats.

Aim: Making work in practice easier

Thus, in the course of the research project “Firmen fördern Vielfalt”, a system was developed that uses easy-to-grasp key indicators to model species richness on farms. By using a modelling approach, habitat and species richness assessments could be automated and therefore repeated over time. Thus, the evaluation of habitat types is improved in such way that changes in response to modified management practices can be shown. This makes the biodiversity performance of farms measurable and comparable. Moreover, farmers are encouraged to improve the biodiversity performance of their

farm site and to direct management measures with maximum effect to the most promising locations. The required information and data for the assessment should be collected with low workloads. At best, data should be already available or easily obtainable directly from the farmer.

Methodological approach

Easily recordable key indicators and their relevance to species richness in agricultural habitat types were determined on the basis of an extensive literature review. The analysis was spatially restricted to Europe. On this basis, indicator models were developed for arable fields, hedges and field margins as well as for the species groups vascular plants, birds and butterflies. By means of these models the habitat types could be recorded and valued in a much more differentiated manner than with existing habitat classifications (e.g. of the German federal states or the European habitat classification EUNIS).

To validate the literature-based indicator models, comprehensive on-site surveys were conducted on seven farms in different regions covering coastal to mountainous landscapes (in the German federal states of Schleswig-Holstein, Lower Saxony, Brandenburg and Bavaria). Based on the previously defined indicators, 282 study sites (thereof 135 arable fields, 77 hedges and 70 field margins) have been examined on organically or conventionally managed farms. As far as possible, the species richness of the three species groups (vascular plants, birds and butterflies) was also examined on these same study sites. Typical indicators for the species richness include the soil type, the width of hedges and margins or the crop type.

The empirical field data was statistically analysed for validating the indicators. Furthermore, to meet the requirements of practicability and scientific foundation, the indicators that best predicted the species richness of the respective habitat type, were selected by statistical analyses. Less significant indicators were abandoned and, thereby, the models were simplified and indicator weightings readjusted.

The resulting simplified and adjusted models were integrated into the management software MANUELA that has been developed at the Institute of Environmental Planning. MANUELA (German acronym for “Management system for nature conservation and sustainable agriculture”) is an open source system with a specifically adapted geographic information system (GIS). The software is designed to support farmers and farm advisers with a transparent recording, assessment und visualisation of the farm’s environmental performance. Additionally, the planning of measures for the preservation and promotion of species richness in agricultural areas is assisted by the software. In the course of the project, farmers and farm advisers tested the models in MANUELA and gave precious advice on further improvement of the software’s user-friendliness.

Key determinants of on-farm biodiversity

Except for the model for birds on arable fields, the indicator models are highly significantly correlated with the numbers of typical species that were recorded in the on-site surveys[1]. Due to the statistical analyses the relevance of the combined indicators could be specified and, thus, the models could be enhanced and simplified. The indicators that affected species diversity advantageously or detrimentally are listed in table 1.

It turned out that a high diversity of butterfly and plant species on **field margins** was mainly derived from the diversity of the surrounding landscape[2] as well as the width and length of the field margins. Furthermore, the time of mowing, the proportion of grasses and herbs as well as the farming type of the adjacent field is important for butterflies on field margins. Decisive indicators for vascular plants on field margins were the length of the field margin, the amount of similar habitats in the near surrounding, the landscape heterogeneity, the presence of shrubs and trees on the field margins as well as the nutrient availability. The number of indicators that are necessary for the modelling of the butterfly species diversity on field margins could be reduced to six indicators (from the initial 13

[1] For individual species detections see: Sybertz, J., Matthies, S., Reich, M. & Haaren, C. v. (2016): Was tut der Landwirt für die Artenvielfalt? Das Projekt „Firmen fördern Vielfalt“ erforscht, wie Biodiversität in der Agrarlandschaft erfasst und bewertet werden kann. In: Alfred Töpfer Akademie für Naturschutz (Hrsg.): Mitteilungen aus der NNA 1/2016, 49-54.

[2] Proportion of semi-natural habitats within 1 km of the farm.

literature based indicators). In the case of plant species richness, six indicators were necessary for the model construction (instead of the 14 literature based indicators). For further details see Sybertz et al. (2017)[3].

In the case of the **models for hedges** the indicators for the bird species diversity could be limited from sixteen (literature based) to five. These indicators include the length and width of hedges, the number of wood species, the availability of hollow trunks and deadwood as well as the width of the adjacent field margin towards the field. The diversity of woody species in hedges could be predicted with merely three indicators (initially 17 literature based indicators). These are the hedge length, the presence of a tree layer and the width of the adjacent field margins.

The **model for arable fields** currently requires eight indicators to model the plant species diversity (in contrast to the literature based model with only 4 indicators, see Bredemeier et al. (2015)[4]). In this case a noticeable enhancement of the explanatory value could be achieved by increasing the number of indicators. Currently, the resulting indicators are the diversity of crop types within a 1 km radius around the farm, the field perimeter (length of the edges), the cultivation of legumes or agricultural grasses as the current crop type, the amount of N-fertiliser, corn or sugar beet as the preceding crop, the sum of field working operations, the cultivation of the same crop in two consecutive years as well as the presence of wet or moist patches on the field.

The literature based model for the bird species diversity of arable fields could be reduced from eight to six indicators. However, it is the least reliable model and is currently not recommended for use.
All developed models (except for the model of bird species diversity in arable fields) have a high goodness of fit, i.e. the independent variables are well suited to explain the observations (species richness). In most cases literature assumptions on the effect of certain indicators on biodiversity could be confirmed. Only in individual cases the assumptions from the literature could not be confirmed by the present study. For example, the occurrence of wet patches within field habitats indicated a negative effect on the species diversity of vascular plants. For a re-evaluation of these individual cases, a validation will be made involving farms that have not been used for the modelling.

[3] Sybertz, J.; Matthies, S.; Schaarschmidt, F.; Reich, M. & Haaren, C. v. (2017): Assessing the value of field margins for butterflies and plants: how to document and enhance biodiversity at the farm scale. Agriculture, Ecosystems and Environment 249: 165–176.

[4] Bredemeier, B.; von Haaren, C.; Rüter, S.; Reich, M. & Meise, T. (2015): Evaluating the nature conservation value of field habitats: A model approach for targeting agri-environmental measures and projecting their effects. Ecological Modelling 295: 113–122.

Table 1: Relevant indicators for the valuation of the species richness of typical plants, birds and butterflies in arable fields, field margins and hedges on seven tested farms (↑ advantageously; ↓ detrimentally; ↕ advantageously or detrimentally depending on the species of flora or fauna).
Simplified illustration, for more details please see final report.

Habitat types	Field		Field margin		Hedge	
Species group	Vascular plants	Birds	Vascular plants	Butterflies	Vascular plants	Birds
Indicators						
Features of the surrounding area						
High landscape heterogeneity		↑	↑	↑		
High proportion of similar habitats in the near surrounding			↑			
High crop type diversity within 1 km radius of examined field	↑					
Type of adjacent habitats and land use		↕ 1)		↑ 2)		↑ 3)
Habitat dimensions						
Perimeter field habitat	↑					
Length			↑	↑	↑	↑
Width				↑		↑
Management						
Mowing dates				↓ 4)		
Crop type, previous crop, crop rotation	↓ 5)	↑ 6)				
Amount of N-fertiliser	↓					
Sum of working operations	↓					
Site characteristics						
High nutrient availability			↓			
Presence of moisty patches on field	↓					
Structure						
Predominant amount of herbs (50-75%)				↑		
Presence of shrubs and trees			↑			
Presence of landscape elements on field		↑				
Presence of tree layer					↑	
Presence of hollow trunks and deadwood						↑
Low diversity of wood species						↓
Width of adjacent field margin					↑	↑
Presence of thorny shrubs						↑

Indicator that was not taken into consideration because it was not of relevance in it's present form for a particular species group.
Indicator that was taken into consideration for a particular species group, but turned out as not relevant in the cross-validation.

1) Both presence and absence of adjacent structures (e.g. shrubs, water bodies) shows effects depending on the species group
2) Farming type of adjacent fields solely organic
3) Width of herbaceous field margin
4) Complete mowing during summer months (June/July)
5) Crop type: legumes or agricultural grasses
previous crop type: corn or sugar beet
Cultivation of the same crop in two consecutive years
6) Crop type: sugar beet, potato, specials crops

Data needs

The practicability of information gathering has been strongly enhanced considering the reduced number of necessary indicators. Many of the information underlining these indicators can be provided through existing farm data. Site data can be integrated using soil maps or by the farmer him-/herself updating the information based on his/her local knowledge. However, the structure and the species composition of hedges as well as the structures on field margins should be recorded in on-site surveys (see table 2). Concerning the data input it turned out to be disadvantageous that the IACS (integrated administration and control system) data of the German federal states were differently recorded and that the corresponding geodata often show a bad quality. Currently, these data can only be used within a GIS when a high level of reworking is invested.

Table 2: Selected indicators, appropriate sources of information and alternatively usable sources

Indicator	Source of information	Alternatives (aids)
Landscape heterogeneity	GIS data of the German federal states and administrative districts, aerial photographs/orthophotos, data of the chambers of agriculture/ IACS	User's estimates on the basis of given examples
Adjacent crop types	IACS	On-site surveys, local knowledge from the farmer
Data on area sizes	IACS	Farm data, aerial photographs/orthophotos or estimates/ on-site surveys of the farmer where appropriate
Cultivation data (fertiliser, crop type, crop rotation, etc.)	Farm data	
Site information	Soil maps of the German federal states	Documented observations from the farmer (construction of an own/ corrected soil map)
Structure of hedges, field margins, number of wood species	On-site surveys	

User's opinions

The user tests of MANUELA showed that the software can be operated even by farmers inexperienced with IT. However, this does not apply for the installation of a farm in the GIS under the above-mentioned unfavourable data conditions. The heterogeneous and hardly standardised data of the German federal states hamper a consistent implementation of import functions. The cooperation with the farmers and food companies revealed that the initial set up of the farm data should preferably be performed by farm advisers who are sufficiently experienced with geodata. After data cleansing, the geodata could have high additional benefit for farms that do not yet use a GIS and are looking for modernising their operations.

Overall, the users positively commented on the basic functionality of MANUELA and its possibilities for visualisation. However, they also proposed some changes. Especially, the farmers suggested a simplification in terms of a calculation of cultivation scenarios.

Is the aim achieved?

It is possible to accomplish a sufficiently reliable and quantified valuation of biodiversity services of farms based on the above mentioned easily recordable information. Thereby, the farms' achievements and changes can be documented in a result-based way. This is not only of interest to the food industry as they gain a tool to document biodiversity services of their agricultural suppliers. Additionally, they can easily integrate the results into their business strategies or life cycle assessments. Moreover,

using the proposed models, the remuneration and control of agri-environmental measures can be arranged much more targeted and transparently.

Currently, the models are implemented in the software MANUELA. The use of MANUELA has the advantage of an automated valuation once the farms and the indicator characteristics are compiled. In reaction to the user tests with farmers and farm advisors, several input functions are presently in revision improving usability of the system. Nevertheless, due to the insufficient data quality and the heterogeneity of the geodata of the German federal states, still initial professional input of the data will be necessary. Considering these difficulties, the subsidies which the German federal states provide for farm advisory services are not sufficient to cover a farm advisor for such efforts. Therefore, increasing the subsidies for environmental advisory services for farms is strongly recommended. Moreover, the added value of fostering GIS based farm data management would be applicable to other farm operations.

Another advantage of MANUELA, biodiversity services can be put into context of other ecosystem services like climate protection services or services for landscape aesthetics. Notwithstanding the described advantages, many farms still do not use a GIS system or employ an alternative one at present and may not be interested in acquire one. In these cases, the models could also be manually applied. For this purpose, an online “biodiversity calculator” could be a useful supplement to the existing MANUELA system. Following the example of greenhouse gas calculators, this online biodiversity calculator could be an open access service available on the internet. The source code of MANUELA can be downloaded from Sourceforge[5] Within the scope of the license restrictions developers will have the possibility to carry on with the biodiversity project on their own. Interested farmers, farm advisors and companies can download the system for free. This is the best starting point for recording, analysing, visualising and valuating the biodiversity services of farms and, importantly, to carry on and plan measures to enhance species diversity and the nature conservation value of farm habitats.

There remains a need for future research regarding other habitat types of agricultural landscapes, especially grasslands. Besides, a further validation of the models in Germany and other European countries would be desirable.

[5] https://sourceforge.net/projects/manuela/?source=directory