Overview of selected SHOWCASE biodiversity indicators

Deliverable D3 (D1.3)

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Robin Séchaud[1], Felix Herzog[1], Matthias Albrecht[1], Philippe Jeanneret[1], Vincent Bretagnolle[2], Kati Häfner[3] Annette Piorr[3], Simon G. Potts[4], Jochen Kantelhardt[5], Lena Schaller[5] & David Kleijn[6]

[1]Eidgenoessisches Departement für Wirtschaft, Bildung und Forschung (WBF), [2]Centre National de la Recherche Scientifique (CNRS), [3]Leibniz-Zentrum für Agrarlandschaftsforschung (ZALF) e. V., [4]University of Reading (UREAD), [5]Universität für Bodenkultur, Wien (BOKU), [6]Wageningen University (WU).

SHOWCASE

SHOWCASing synergies between agriculture, biodiversity and Ecosystem services to help farmers capitalising on native biodiversity

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Note:
On 3 September 2022, the Project Officer of the SHOWCASE project requested the revision of the deliverable stating: “It is advised to revise the deliverable in order to add information regarding how: (1) indicators for EBAs could relate to national or European scale indicators; (2) the indicators can be integrated in the farmland bird, grassland butterfly or draft pollinator index; (3) the result of the review of output of previous projects can improve assessment of progress to date and screening of existing and most suitable indicators for further development and inclusion in SHOWCASE.” In this revised version:

(1) The selected SHOWCASE indicators are set in context with the European scale indicators (Section 2.7). We refrain from a detailed listing of national biodiversity indicator programs as this information is available to the European Union via the EEA. Also, the purpose of the indicators selected for SHOWCASE is the evaluation of the biodiversity intervention and – if possible – the detection of causal relationships between the interventions and observed effects by means of explanatory variables. This is usually beyond the scope of national and international monitoring and indicator systems because the effort for doing so can only be afforded by research programs such as SHOWCASE.

(2) See Section 2.7. Farmland birds and grassland butterflies are highly mobile and therefore they are used above all for monitoring and evaluation purposes at landscape scale. In SHOWCASE, the selected indicators had to be relevant to the scale of the field (section “2.1 Scale of indicators”), which only partially corresponds to these two groups as they also respond to broader scale processes (i.e., landscape). However, birds and butterflies are included as optional indicators and can therefore be monitored according to the specific needs of each EBA. Biodiversity species indicators such as wild bees, butterflies and syrphids are in line with the future “Pollinators” European monitoring.

(3) A literature survey (systematic review) on farmland biodiversity indicators is in progress. The review protocol has been published (Séchaud et al, 2022) and the screening of the 23,000 articles is now ongoing. The results are expected for spring 2023. Yet, a first pilot EBA field season had been planned already for 2021, such that operational indicators had to be ready already in winter 2020 (see Section 2). The timing of the literature review was therefore no longer critical and more time was available. This is why we opted for a systematic review, which is more thorough but requires more time.

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Summary

The decline of biodiversity raises concerns about the loss of farmland species in general and of ecosystem services crucial for agriculture productivity, such as pest control, soil fertility and pollination. The sustainability of farming systems is dependent of these services and thus the effect of agricultural practices on farmland biodiversity has to be evaluated with relevant indicators. They should reflect the status of farmland biodiversity and inform on its trends, acting as guides for a transition to a more sustainable agriculture.

The European project SHOWCASE aims to deliver tools to facilitate the transition towards more biodiversity-friendly farming practices. Its first work package aims to develop a multi-disciplinary approach - including for example farm production, biodiversity protection and social impacts - that will be tested and evaluated in a network of Experimental Biodiversity Areas (EBAs). In this context, the present report aims at identifying a set of relevant biodiversity and ecosystem service indicators to be measured in the different EBAs.

Based on previous projects and on an iterative process of bilateral discussions and workshops between the EBAs project partners, we propose here a minimum set of core biodiversity indicators, which will be measured in all EBA sites based on a standardized measurement protocol. We also proposed additional indicators, which may be appropriate for some of the EBAs, depending on their farm type and type of intervention. In general, these indicators are grouped in four main categories: (i) habitat and species, (ii) ecosystem services, (iii) management and (iv) socio-economic indicators. The indicators selected are relevant and adapted to the SHOWCASE project's aims and will be used in subsequent steps, particularly in WP3.

List of abbreviations

EU	European Union
EBA	Experimental Biodiversity Area

1 Introduction

This first section provides a brief introduction on the interconnection between farmland ecosystems, agricultural practices and biodiversity in Europe. It stresses the need for relevant bioindicators to evaluate the impact of the different farming practices and guide the transition to more sustainable agriculture. In this context, this report specifically aims at identifying a set of relevant biodiversity and ecosystem service indicators to be measured in the framework of the European SHOWCASE project.

1.1 European farmland biodiversity

Farmland is the most abundant land use in Europe, covering approximately 45% of the total land area of the EU-27 (Eurostat, 2020). Over the last decades, the intensification of agricultural practices has profoundly modified the functioning of agro-ecosystems. As a result of this intensification, 76% of farmland habitats and 70% of their inhabiting species have been reported with an unfavourable conservation status (European Environment Agency, 2015). The three key biodiversity indicators measuring progress towards Sustainable Development Goals 15 (Life on land) for EU-28 are: Surface of terrestrial sites designated under Natura 2000, Common bird index, and Grassland butterfly index; all of which show “Insufficient progress towards the EU target” (Eurostat, 2019).The causes of this steep decline in biodiversity are diverse, but the main ones are the simplification and homogenization of the landscape, the loss of semi-natural habitats and the increased application of fertilizers and pesticides on fields (Geiger et al., 2010; Green et al., 2005; Kleijn et al., 2009; Tscharntke et al., 2005).

The decline of biodiversity raises considerable concerns about the loss of ecosystem services essential for agricultural productivity (Cardinale et al., 2012; Hooper et al., 2005). Pollination, habitat maintenance, formation of soils, and pest regulation are all reported to be decreasing in western and eastern Europe (IPBES, 2018). To ensure the continuity of these services, and thus the sustainability of farming systems, a set of relevant indicators of the state of biodiversity should be used to measure the effect of the agricultural practices on farmland biodiversity, and thus guide the transition to a more sustainable agriculture.

1.2 Biodiversity indicators

There are numerous types of farmland biodiversity indicators, and their use depends on the scale considered, the specific context and the expected application (Herzog & Franklin, 2016). In general, a good indicator should reflect the status of a system and be sensitive enough to vary with changes in its exploitation or condition. To be effective in this respect, an indicator must commonly satisfy a number of criteria, such as being scientifically supported, easily collected on the field, repeatable in time and space, cost effective, ecologically meaningful and relevant for stakeholders (Dennis et al., 2012; Herzog et al., 2012). At present, only birds and butterflies are monitored at the European scale, both showing significant declines over the past decades in farmland (Brlík et al., 2021; Pellissier et al., 2020). However, other taxa impacted by farming practices – such as wild bees, spiders and plants – are monitored in national or local programmes, which makes comparisons at larger scales difficult.

1.3 SHOWCASE project and deliverable 1.3

The steep decline in European farmland biodiversity observed in the last decades is accompanied by a growing concern about the associated loss of public goods and ecosystem services (Cardinale et al., 2012; Hooper et al., 2005). To help developing and promoting more sustainable agricultural ecosystems, the European project SHOWCASE aims to deliver tools to facilitate the transition towards more biodiversity-friendly farming practices. The first work package of SHOWCASE aims to develop a multi-disciplinary approach (e.g., farm production, biodiversity protection, social impacts) that will be tested and evaluated in a network of Experimental Biodiversity Areas (EBAs). The EBAs are located in 10 different countries (CH, EE, ES, FR, HU, NL, RO, PT, SE, UK) and have been selected based on their representativeness of the diversity of European farming systems, as well as on already existing local or regional multi-stakeholder structures (see deliverable 1.1 – Network of EBAs established across Europe).

In this context, the present report (deliverable 1.3) aims at identifying a set of relevant biodiversity and ecosystem service indicators to be measured in the different EBAs.

2 Selection of a set of biodiversity indicators

This second section reports the results of the biodiversity indicator selection, which consisted of an iterative process of bilateral discussions and workshops between the EBAs project partners. We present below the different steps of the selection process and provide a list of a core set of bioindicators to be collected in all EBA following standardized measurement protocols.
A literature survey (systematic review) on farmland biodiversity indicators is in progress. The review protocol has been published (Séchaud et al, 2022) and the screening of the 23,000 articles is now ongoing. The results are expected for spring 2023. Yet, the SHOWCASE consortium had decided to run a first pilot EBA field season already in 2021, therefore the selection of the indicators was done with the participatory approach described in this deliverable, strongly based on experience from recent EU framework projects, notably on the project "Indicators for Biodiversity in Organic and Low Input Farming Systems", which selected farmland biodiversity indicators for Europe, developed methods for their measurement and actually evaluated the effectiveness and feasibility of the indicators across a series of European case study regions (www.biobio-indicator.org). This allowed to have an indicator set ready in time for a first application in 2021.

2.1 Scale of indicators

As a first step, the scale at which the indicators should be valid had to be defined. This depends on the scale at which the interventions will be conducted in the different EBA. Interventions could be made at the field, the farm scale or the landscape scales, and indicators then need to be able to grasp the effects of the intervention at the relevant scale. During the first workshops conducted in WP1 with the different EBA managers it became clear that in all EBAs, most interventions will be implemented at the field scale. This clarified and actually facilitated the selection of indicators. The farm scale will then become relevant in particular for the socio-economic context of the farms that are involved. The landscape scale will be addressed partly by investigating the importance of the landscape context on the effectiveness of the field-scale interventions. Landscape scale aspects are also addressed in other tasks of the SHOWCASE project, which are not directly related to the EBA interventions.

2.2 Selection process

A first list of potential biodiversity indicators was obtained by screening the rich body of literature and evidence from previous projects and monitoring initiatives on indicators selection (e.g. Dennis et al., 2012; Herzog et al., 2012). This literature screening highlighted the need for a global synthesis, which led to a literature review project (Séchaud et al., 2022). The potential biodiversity indicators list integrates the indicators already monitored in the European farmland bird and butterfly schemes, as well as the core indicators under development in the European pollinator monitoring scheme (wild bees, butterflies, and syrphids, except for the moths). The links between SHOWCASE biodiversity indicators and these existing European ones are further discussed in the section 2.7 “Connections with national and European scale indicators”.

These potential indicators were grouped into four main categories:

- Habitat and species indicators
- Ecosystem service indicators
- Management indicators
- Socio-economic indicators

The different bioindicators listed were then evaluated and rated by all EBA project partners based on their 1) scientific support, 2) relevance at the European scale, 3) ease of data collection, 4) price sensitivity, 5) ecological meaning and 6) ease of communication with relevant stakeholder groups. See Annex I for details on the evaluation process. This resulted in the identification of a set of core indicators, which will be measured in all EBAs following common protocols. In complement, a group of optional indicators was also proposed to account for the EBA site specificities (i.e., farm type or intervention), and that will be implemented by the EBA managers. The sections 2.2 to 2.5 below report and describe the selected core and optional indicators.

During the biodiversity indicator listing and selection steps, and in addition to the six criteria aforementioned, we paid particular attention to three additional parameters. First, we discussed the potential associations with citizen science approaches and expert evaluations. We decided that for the purpose of collecting biodiversity data that is fit for statistical analysis that allows to evaluate the effectiveness of the biodiversity interventions, it would be too risky to rely on citizen science and expert evaluations as standardization and replicability of the methods is much more difficult to achieve. Second, we explored the the opportunities offered by remote sensing technologies, especially the use satellite images and of unmanned aerial vehicles (UAVs), for example drones. Such technologies have recently emerged as new methods to collect information mostly on habitat structure and composition, and less frequently on species (mostly in marine environments and/or on large species). While they offer new opportunities to acquire fine spatial and temporal resolution data, their use is relatively recent and therefore still under development. While the use of UAVs would allow for the acquisition of data with high spatial and thematic resolution, again, standardization across EBAs would be a major challenge. Therefore we opted for the use of satellite data for the recording of landscape characteristics around the EBA fields and control fields. Third, we evaluated the relevance of the SHOWCASE indicators for indicators that are currently used national and European projects, as well as existing policy reporting frameworks. These synergies are presented in the section 2.7 “Connections with national and European scale indicators”.

FI Sadly, we could not directly involve farmers and other stakeholders in the identification and selection of biodiversity indicators because the interactions were complicated by the health restrictions due to the covid-19 pandemic. We therefore limited the consultation to the EBA project partners, who selected the indicators according to their specific local conditions and the needs of their respective stakeholders (see selection criteria number 6 “relevance for stakeholders”). In addition, the proposed list of indicators was also based on previous projects that had already developed their indicators in collaboration with stakeholders (see for example Herzog et al., 2012). These links between the SHOWCASE indicators and the farmers/stakeholders ensure a strong understanding and applicability on the field.

2.3 Habitat and species indicators

A core set of four habitat and species indicators was selected to be measured in all EBAs and is described below. Six optional indicators have been added to the list and will be measured according to each EBA site location, farm type and scale of interest. Table 1 summarizes the four core and five optional habitat and species indicators.

Habitat type: Habitat is itself an important component of biodiversity (e.g., Bailey et al., 2007) and a good indicator of biodiversity at the species level. Habitat mapping is the first step to monitor habitat type and diversity. The QuESSA standardized approach will be used to map the habitat (Holland et al., 2014), in combination with the use of new monitoring methods based on remote sensing (i.e. satellite-based images).

Vascular plants: They are the primary producers in farmland and are at the basis of the food chain, being thus essential to the maintenance and stability of higher trophic levels (Ebeling et al., 2018; Nicholls & Altieri, 2013). Vascular plant diversity or richness is particularly sensitive to specific field management, but also to the presence of pollinators or seed dispersers. Therefore, they are good bioindicators of agricultural management and practices, and they are widely studied and well documented (Billeter et al., 2008; Duelli & Obrist, 1998; Herzog et al., 2012; Liira et al., 2008).

Wild bees: This indicator groups essential pollinators of farmland ecosystems. It includes many threatened nationally red-listed species and functionally important species and is therefore relevant for conservation as well as ecosystem service provision (Klein et al., 2018; Rasmont et al., 2017). Their recent decline has attracted public attention and raised awareness to the link between biodiversity and ecosystem services (e.g., Sutter et al., 2018). The factors behind their decline seem to be multiple and complex (González-Varo et al., 2013; Goulson et al., 2015; Potts et al., 2010), but the spread of chemical compounds and the loss of plant diversity (and year-long availability) have been shown to be important. Wild bees have also been selected because they generally demonstrate consistent relationships with environmental drivers (Hendrickx et al., 2007; O. Schweiger et al., 2005), unlike Syrphids for example (i.e., some species increase with increasing proportion of arable land; Schweiger et al., 2007). Compared to butterflies, wild bees have the advantage of not comprising pest species, and also that a sufficient number of species are present in intensively managed landscapes to collect robust and reliable data. Therefore, wild bees were preferred over the other pollinator groups for their relationship with environmental conditions, their ease of identification and collection, as well as their appeal to the public and farmers.

Spiders: They are a large group of predator species, with several of them preying on agricultural pest insects and thus reducing crop damages. Sensitive to farming practices, vegetation composition and structure (Diehl et al., 2013; Schmidt et al., 2005; O. Schweiger et al., 2005), they are good indicators of management at the plot level. They have been preferred over carabid beetles as the latter, despite being easy to catch and identify, are not very indicative of land use change (Cole et al., 2005; Hendrickx et al., 2007). Among the orders that include significant numbers of species preying on agricultural pests (Hymenoptera, Coleoptera, Arachnida and Neuroptera), the spiders are the most numerous in the fields (unpublished data collected in a master project). Compared to the Hymenoptera, they present the advantage of being easily monitored and identified. In addition, thrips (Neuroptera) have the disadvantage of including species that are serious pests, and some of the species are difficult to determine, which is not the case for spiders. Therefore, spiders were preferred over the other predator groups as they better fit the aim to find indicators that correlate with biodiversity interventions that are good for biodiversity and the farmer.

Finally, the three selected species biodiversity indicators (vascular plants, wild bees and spiders) represent three different trophic levels, corresponding to the main ecosystem services provided by biodiversity in farmland (pollination and pest control). As they are sensitive to land-use and management changes, they are suitable indicators to monitor the effects of the the interventions that will be tested in the different EBAs. In addition, the data collected will be reliable as all three groups are quite common in all farming systems (arable, grasslands, orchards), except for extremely intensive ones, and can be found in fair numbers in all countries hosting EBAs. Their identification is also manageable as EBA countries have access to identification guides or experts available to assist with species identification. The combination of these different factors led to the selection of this set of core indicators.

2.4 Ecosystem service and ecosystem service provider indicators

The agronomic yield was the only ecosystem service indicator selected to be measured in all EBAs. The main objective of farmers is to maintain, or even increase, yield and it is thus relevant to measure the services provided by biodiversity (e.g., pollination, pest control, decomposition) on farm production. The services which underpin production vary widely between systems (e.g., arable and grassland) and so no other single ecosystem service was relevant to all EBAs. Agronomic yield comprises both, the quantity that is harvested, as well as the quality of the product as quality is relevant for the financial return that can be obtained. Once the financial return is available, it can be related to other socio-economic indicators of the performance of the farm business at the field and farm scale.

The agronomic yield indicator is accompanied by five optional indicators that will be collected depending on the EBA site and farm type. They are summarized in table 2.

2.5 Management indicators

Farm management affects biodiversity and the three core management indicators selected reflect the intensity of farming practices, with variations in indicator measurement depending on the EBA site (e.g., farm type, type of intervention). Additionally, a set of three optional management indicators has been defined, their collection depending on the EBA site. The different management indicators will then be compared to species indicators and will be converted into management costs for economic analysis. Table 3 synthesizes the core and optional management indicators, and the three indicators composing the core set are briefly described below.

Field operations: It characterizes the disturbance caused by farming operations on farmland. Variations in indicator types and monitoring methods are planned in relation to the type of farming and intervention of the different EBA sites (i.e., mowing frequency in grassland, or plowing depth in crops).

Nitrogen input: Nitrogen is one of the key elements favoring biomass production and farmers try to raise the level of nutrients in the soil to increase yields. In contrast, plant species diversity is higher in low nitrogen environments. The runoff and leaching processes generalize the effect on biodiversity of nitrogen application on a parcel to adjacent habitats and ecosystems.

Pesticide use: Pesticide application is commonly associated with a loss of biodiversity in agricultural landscapes. By being relatively non-specific, the application of herbicides, insecticides and fungicides has negative effects on numerous species and disrupts the ecosystem trophic web at different scales and levels.

Management indicators, as well as biodiversity indicators, will be measured both, on the field that contains an intervention, and on the control field without intervention.

2.6 Socio-economic indicators

The socio-economic conditions have a strong impact on the farmers' motivation and feasibility to implement agri-environmental measures. The purpose of the selected socio-economic indicators is to understand the context of the farms within the individual EBAs, mostly in relation to the motivation of the farmers, to their economic situation and to the larger policy context.

The selection of core socio-economic indicators has focused on identifying and gathering the most important information which is central for the preparation and conduction of the socio-economic analyses in WP2, and which is moreover realistically and feasibly collectable in all EBAs. The common indicators to be collected in all EBAs and presented here will be supplemented by specific socio-economic indicators in WP2. This procedure has been decided by the task leaders, as specific indicators, which will support specific socio-economic analyses in specific WP2 tasks, will need to be specifically integrable for the farms/EBAs involved, as well as specifically fit for the research questions of the respective WP2 tasks.

For the list of selected core indicators the following group of variables has been considered:

- Indicators related to the farmer (age of the farmer, gender, training/education),
- Indicators related to the farms (farming type, farm size, type of management, farm income, ownership)
- Indicators related to biodiversity management (biodiversity related practices, subsidies/AES, conservation advice received)

Table 4 synthesizes the core socio-economic indicators.

2.7 Connections with national and European scale indicators

The core and optional indicators proposed here meet SHOWCASE objectives while offering connections with biodiversity indicators used at national, European and international scales.

The biodiversity indicators measured in the different European countries are diverse, both in terms of types and collection methods, and it is therefore up to the EBAs to adapt to local conditions according to their needs. The development of optional indicators also intends to offer local adaptation opportunities, and thus to promote synergies between SHOWCASE and national programs. Here we refrain from a detailed listing of national biodiversity indicator programs as this information is available to the European Union via the EEA. Also, the purpose of the indicators selected for SHOWCASE is the evaluation of the biodiversity intervention and – if possible – the detection of causal relationships between the interventions and observed effects by means of explanatory variables. This is usually beyond the scope of national and international monitoring and indicator systems because the effort for doing so can only be afforded by research programs such as SHOWCASE.

At the European scale, only common birds and grassland butterflies are currently surveyed in a common program. Those two indicator groups are highly mobile and therefore they are used above all for monitoring and evaluation purposes at landscape scale. In SHOWCASE, the selected indicators had to be relevant to the scale of the field (section “2.1 Scale of indicators”), which only partially corresponds to these two groups as they also respond to broader scale processes (i.e., landscape). However, birds and butterflies are included here as optional indicators and can therefore be monitored according to the specific needs of each EBA. Biodiversity species indicators such as wild bees, butterflies and syrphids are in line with the future “Pollinators” European monitoring. In addition to species indicators, various habitat and management indicators are used in Europe by the European Environment Agency (EEA - “Biodiversity and Ecosystem indicators”) or the Organization for Economic Co-operation and Development (OECD - “Environmental Indicators for Agriculture”). Table 5 summarizes the connections between these European and international biodiversity indicators and the ones selected for the SHOWCASE EBAs.

3 Conclusions

Here, we identified a minimum set of core biodiversity indicators, which will be measured in all EBA sites based on a standardized measurement protocol. We also proposed additional indicators, which may be appropriate for parts of the EBAs, depending on their farm type and their type of intervention. These indicators are grouped in four main categories: (i) habitat and species, (ii) ecosystem services, (iii) management and (iv) socio-economic indicators.

The approach used to propose and select these indicators, which consisted in using the knowledge developed in previous projects and in using a collaborative approach between the different actors and managers of EBAs, provided a set of indicators that are relevant and adapted to the SHOWCASE project's aims. The set of indicators proposed herein will be used in next steps T1.2 and T1.4.

Table 1: Habitat and species indicators. The core indicators (in green) will be measured in all EBAs following common protocols, and the optional indicators (in yellow) will be collected depending on the EBA site specificities (i.e., farm type or intervention).

Indicator Type		Potential indicator metrics	Method	Comments	Responsible person
Core	Habitat type	Habitat diversity, target habitat, semi-natural habitat.	QUESSA protocol and remote sensing (satellite)	Standardized protocols to record the habitat type of the focal field and of the surrounding landscape. Relevant explanatory variables for the intervention will be computed from habitat map.	F. Herzog D. Rocchini
	Vascular plants	Diversity, abundance, richness, target species, flagship species.	Ten times 1x1m squares	Important as they support higher trophic levels. Plant species diversity and abundance (1) of the focal field as a whole and (2) as related to the intervention depending on where in the focal plot the intervention takes place.	D. Kleijn
	Wild bees	Same as plants.	Transect walks	Wild bees are important ecosystem service providers (pollination). Good biodiversity indicators.	D. Kleijn M. Albrecht
	Spiders	Same as plants.	Suction samples	Spiders are important ecosystem service providers. As biodiversity indicators, they respond to the structure of the habitat.	F. Herzog P. Jeanneret
Optional	Butterflies	Same as plants.	To be decided by each EBA	Iconic species group of socio-cultural value, taxonomy well established, potential for involving citizen scientists.	EBA site managers
	Syrphids	Same as plants.	To be decided by each EBA	High species diversity, providing both pollination and predation ecosystem services.	EBA site managers
	Carabid beetles	Same as plants.	To be decided by each EBA	Well known species group, important ecosystem service provider. Good indicator in arable systems.	EBA site managers

	Nesting birds	Same as plants.	To be decided by each EBA	Landscape scale indicator. If a specific EBA intervention aims at promoting birds, it may also be necessary to monitor them at field scale (e.g., number of nests of soil breeding birds). Also, in some EBA it may be interesting to evaluate their role as predators of insects. High potential for involvement of citizen scientists.	EBA site managers
	Bats	Same as plants.	To be decided by each EBA	Predators of common nocturnal insects, sensitive to changes in land-use practices.	EBA site managers
	Earthworms	Biomass and same as plants.	To be decided by each EBA	The total biomass is of interest as it is a proxy for the potential service provided. Earthworms should only be sampled if the EBA intervention is expected to affect soil properties. High interest from farmers.	EBA site managers

Table 2: Ecosystem service and ecosystem service provider indicators. The core indicators (in green) will be measured in all EBAs following common protocols, and the optional indicators (in yellow) will be collected depending on the EBA site specificities (i.e., farm type or intervention).

Indicator Type		Potential indicator metrics	Method	Comments	Responsible person
Core	Agronomic yield	Yield and quality. Crops: Output quantities (e.g., kg/ha: min/max) and commercially relevant qualities (e.g., % of protein in wheat) Grass: Yield and fodder quality	• farmer interviews. • 4x1m2 in cereals but adapt to crop type (wheat, OSR, sunflower, legumes, lupin, alfalfa). • Grassland: mostly pastures, no meadows yet. Fodder quality. • Orchards	Yield is the main ecosystem service obtained from agriculture and the main objective of farmers is to maintain / increase yield. In crops, measure also the yield quality if it may be affected by the intervention.	V. Bretagnolle
Optional	Pollination	Pollination success	No bagging	Only makes sense in insect pollinated crops	M. Albrecht D. Kleijn
	Pest control, (including dis-service and dis-service provider)	Pest pressure, damage, crop health. Measure predation in control and treatment sites. Possibly also weed pressure.	Depends on crop type: wheat, OSR, sunflower, legumes, lupin, alfalfa.	Key ecosystem service for EBA that aim at promoting natural pest control.	EBA managers propose a protocol and send it to V. Bretagnolle
	Decomposi-tion	percentage of decomposition	Tea-bag experiment or standardised leaf material in cellulose bags	Soil activity, measurement makes sense in EBA where agronomic management changes are likely to affect soil properties.	V. Bretagnolle
	Shrub encroach-ment	Shrub cover, poisonous plants (if applicable)	To be decided by each EBA	In 4 EBA the goal is to reduce shrub encroachment on grasslands.	EBA site managers
	Other		To be decided by each EBA	Depending on the EBA goal and on the intervention, other indicators may be needed	EBA site managers

Table 3: Management indicators. The core indicators (in green) will be measured in all EBAs following common protocols, and the optional indicators (in yellow) will be collected depending on the EBA site specificities (i.e., farm type or intervention).

Indicator Type		Potential indicator metrics	Method	Comments
Core	Field operations	Number and type of field operations (including crop rotation, not only a single year). Information on EBA crop or grassland type (e.g., cut date, cutting machinery or ploughing depth). To record in intervention and control fields.	See Annex II. Additional specific indicators per EBA type and intervention.	Field operations are disturbances.
	Nitrogen input	Total amount of nitrogen. Fertilizer type (mineral / organic)	See Annex III.	Nitrogen is a key driver of biodiversity.
	Pesticide use	Total number of pesticide applications Use of specific insecticides/ herbicides relevant for the EBA under investigation.	See Annex IV.	Pesticides affect biodiversity directly. Mostly for arable / horticultural EBA, potentially herbicide applications also on grassland (weed control)
Optional (obligatory in grassland EBAs)	Grazing density	Type of livestock and livestock unit per hectare per season.	Farmer interviews and/or farm plans	Evaluate the grazing pressure on the focal field as compared to the control field

	Mowing frequency	Type of grassland use (only cut, cut/grazing, timing and no. of usages per year (1-6, normally, while beyond 3 is rather intensive) Type of mechanisation, e.g., bar mowers or rotating mowers	Farmer interviews and/or farm plans and/or direct measurement of sward height and composition	The intensity of grassland use needs to be assessed as it is to be expected that biodiversity in intensively managed grasslands is low. Number and frequency of usage in combination with fertilisation are good indicators for intensity. Type of mechanisation might have an impact on killing of insects while mowing.
	Other			Depending on type of EBA and on intervention

Table 4: Socio-economic indicators. The core indicators (in green) will be measured in all EBAs following common protocols, and the optional indicators (in yellow) will be collected depending on the EBA site specificities (i.e., farm type or intervention).

Indicator Type		Potential indicator metrics	Method	Comments
Core	Farmer	age gender education/training	• Interview withEBA farms • Application of the Protocol: “Obtaining general information on the farmers” of Workpackage 2 // Task 2.2: Interview Guideline / Questionnaire Part V	Farm level
	Farm	Farm type	• Interview with EBA farms • Application of the Protocol: “Obtaining general information on the farmers” of Workpackage 2 // Task 2.2: Interview Guideline / Questionnaire Part I, Question 1	Farm level
		Farm size Ownership	• Interview with EBA farms • Application of the Protocol: “Obtaining general information on the farmers” of Workpackage 2 // Task 2.2: Interview Guideline / Questionnaire Part I, Question 2	Farm level
		Type of management	• Interview with EBA farms • Application of the Protocol: “Obtaining general information on the farmers” of Workpackage 2 // Task 2.2: Interview Guideline / Questionnaire Part I, Question 3	Farm level
		Farm income Non-farm income	• To be decided by the EBAs • Absolute numbers or categories	Farm level
	Biodiversity implementation	Biodiversity related practices applied	• Interview with EBA farms • Application of the Protocol: “Obtaining general information on the farmers” of Workpackage 2 // Task 2.2: Interview Guideline / Questionnaire Part IIIa, Question A (incl. table)	Farm level

		Subsidies received / AES implemented	• Interview with EBA farms • Application of the Protocol: “Obtaining general information on the farmers” of Workpackage 2 // Task 2.2: Interview Guideline / Questionnaire Part IIIa, Question B	Farm level
		Conservation advice received	• Interview with EBA farms • Open question on conservation advice received in the last year	Farm level
Optional	Other			Depending on EBA specificities.

Table 5: Connections between SHOWCASE, European and international biodiversity indicators. We listed the “Biodiversity and Ecosystem indicators” from the European Environment Agency (EEA) and the “Environmental Indicators for Agriculture” from the Organization for Economic Co-operation and Development (OECD) and related them to the set of SHOWCASE biodiversity indicators.

Source	Indicator description	SHOWCASE connections
EEA	Abundance and distribution of selected species in Europe: common birds and grassland butterflies	Related to "Nesting birds" and "Butterflies" optional indicators (Table 1 - Habitat and species indicators).
EEA	Pollinator Initiative (not yet monitored)	Related to "Wild bees", "Butterflies" and "Syrphids" indicators (Table 1 - Habitat and species indicators).
EEA	Conservation status of species under the EU Habitats Directive	Subcategory of the selected species indicators (Table 1 - Habitat and species indicators).
EEA	Ecosystem coverage in Europe	No connections.
EEA	Conservation status of habitats under the EU Habitats Directive	Subcategory of the selected habitat indicator (Table 1 - Habitat and species indicators).
OECD	Agricultural land area	Related to the "Habitat type" core indicator (Table 1 - Habitat and species indicators).
OECD	Farm bird index	Related to "Nesting birds" optional indicator (Table 1 - Habitat and species indicators).
OECD	Pesticide sales	Related to the "Pesticide use" core indicator (Table 3 - Management indicators)
OECD	Nitrogen balance	Related to the "Nitrogen input" core indicator (Table 3 - Management indicators)
OECD	Phosphorous balance	No connections.
OECD	Ammonia emissions	Related to "Field operations" core indicator (Table 2 - Management indicators) and to "Farm" core indicator (Table 4 - Socio-economic indicators)
OECD	Greenhouse gas emissions	Related to "Field operations" core indicator (Table 2 - Management indicators) and to "Farm" core indicator (Table 4 - Socio-economic indicators)
OECD	Energy use and biofuel production	Related to "Field operations" core indicator (Table 2 - Management indicators) and to "Farm" core indicator (Table 4 - Socio-economic indicators)
OECD	Soil erosion	No connections.
OECD	Water quality	No connections.
OECD	Water resources	No connections.

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5 Annex I: Online consultation and species group indicator selection table

We set up an online consultation among the EBA partners to prioritize the biodiversity indicators and develop the sets of core and additional species indicators. All EBA managers were asked to indicate their favourite species groups (from 1 to 3 in the Table S1 below), beside the vascular plants and earthworms, which were both obligatory indicators at this stage of the selection. After this indicator ranking process, earthworms were moved to the optional category because they could not be measured in all EBAs (sandy soil in HU, only possible for intervention 2 in NL, expert need in RO).

Table S1: Species indicator selection table. Based on the online consultation of the different EBA partners, the core species indicators selected are indicated in green and the optional ones in yellow. The table reports the preference scores attributed by the EBA partners to the different species indicators (O = obligatory; 1 to 3 = favourite groups; X = not favourite but of interest).

	EE	FR	HU1	HU2	NL	PT	ROdce	ROstm	ES	SE	CH1	CH2	UK
Vascular plants	O	O	O	O	O	O	O	O	O	O	O	O	O
Butterflies	3	X	X				1	X	2	2			
Wild bees		2	X	X	1			NA	1	3	2	1	2
Syrphids		X	X	X	3			NA	3		3	2	
Spiders	2	3	X		2		3	X			1	3	3
Carabid beetles	2	1	X			X	2	X					1
Earthworms	X	X	No	No	No/X	X	No	X	X	X	X	X	X
Nesting birds	1	X				X				1			

6 Annex II: BioBio indicator factsheet - Field Operations (FieldOp)

This factsheet is part of the Guidelines Biodiversity indicators for European Farming Systems, developed in the EU FP7 research project BioBio (Herzog et al., 2012).

ART Schriftenreihe 17 | September 2012

BIOBIO indicator factsheet

Field Operations (FieldOp)

Refers to Chapter 8 'Management related indicators' of the Guidebook 'Biodiversity Indicators for European Farming Systems'

Agroscope

Bio Bio

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Federal Department
of Economic Affairs FDEA
Agroscope Reckenholz-Tänikon
Research Station ART

Field Operations (FieldOp)

Description

Quantifies the number of mechanised field operations in crop fields and grassland. The **unit** of measurement is the total number of field operations. On farm-level the area-weighted average is calculated.

Sub-indicators:

The indicators 'Mowing frequency', 'Mowing timing' and 'Soil Cultivation: ploughing' are no genuine sub-indicators because they use different input variables. However, they are treated in this fact sheet because they are thematically related.

It is a **pressure indicator**. Generally, trends in the intensification of production are strongly connected to processes that will increase the use of machinery on the parcels and the number of passages that is required in the cultivation of agricultural land. In grasslands, productivity increases with the number of cuts that are possible (1 to 2 cuts in extensive grassland, 4 to 6 cuts in intensively managed grassland). Equally in arable land or horticulture the number of operations from weeding, fertilisation or pesticide treatments increases with intensification.

Surveyor skills

Data collection can be implemented by technical staff (farm interviews, retrieval from databases). For data validation, skills in the interpretation of farm balances and background knowledge in agriculture are necessary to examine the plausibility of both the input and output variables.

Data collection method

In farm-level surveys, farmers must be interviewed using a structured questionnaire. Regional surveys can retrieve available data from official farm accounting databases.

Calculation method

Total number of field operations (FieldOp)

Input variables:

Number of mechanised field operations from

- Soil cultivation and seeding (S_i)
- Fertilisation (F_i)
- Mechanical weeding (W_i)
- Pesticide treatments (P_i)
- Mowing / harvesting (M_i)
- Other operations (O_i)
- Area for each crop or grassland type (Ai)

The number of operations must be added up for each crop or grassland. Subsequently, an **average weighted by the area** that each crop/grassland covers on the farm is calculated.

$FieldOp = \Sigma(S_i + F_i + W_i + P_i + M_i + O_i) * A_i / A_{UAA}$

Mowing Frequency of Grassland or Perennial Fodder Crops (MowFreq)

Input variables:

- Number of cuts per year (differentiated by grassland type) (C_i)
- Area of each grassland type (A_i)

An **average weighted by the area** that each grassland type covers on the farm is calculated.

$MowFreq = \Sigma\, C_i * A_i / A_{UAA}$

Mowing Timing (for grassland or perennial fodder crops) (**MowTime)**

Input variables:

- First cutting (calendar week) – differentiated by grassland type (Wk_i)
- Area for each grassland type (A_i)

An **average weighted by the area** that each grassland type covers on the farm is calculated.

$MowFreq = \Sigma Wk_i * A_i / A_{UAA}$

Soil Cultivation: Ploughing (% arable land) (**Plough)**

Input variables:

- Arable land ploughed in periodical intervals (A_p)
- Total arable land (A_a)

$Plough = A_p / A_a$

Results from BioBio case studies

With regard to the number of field operations (FieldOp) the most intensive systems were Italian vineyards (frequency of pesticide operations), as well as Swiss grassland farms (mowing operations) and German mixed farms (operations in arable fields and grassland). In Bulgarian and Welsh grasslands as well as in the Dehesas, mechanized field operations were at a minimum, close to zero, indicating that the farm area is mainly used by grazing.

Grassland management was most intensive in Swiss and German farms, indicated by the number of cuts (average between 3 and 4 cuts per year) and the early date of the first cut (calendar week 20; mid-May). Most other farms with grassland had fewer cuts: 1 to 2 cuts or below 1. The indicator 'Mowing frequency' in stockless arable systems is connected with the management of rotational grassland which is managed in an extensive way (only 1 or 2 cuts per year, often for green manure).

Synergies with other indicators

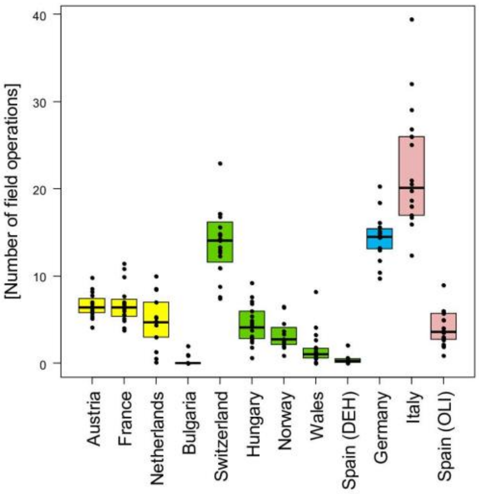
In interviews, data collection can be implemented in a joint questionnaire form along with the appraisal of indicator 'Pesticide Use'.

Estimated effort and costs (labour effort required, analysis)

An average of 8 hours per farm must be calculated for the collection of the BioBio farm management indicators. This includes the interview, data processing and data check. However, there is considerable variation in time effort depending on the complexity of farms and the implementation (telephone interviews or farm visits).

Correlation with other indicators

In four case studies negative relationships between field operations and species indicators were established: Austrian arable systems (plant diversity), German mixed farms (earthworm diversity), Norwegian grassland systems (plant diversity) and Spanish olive farms (diversity of plants, bees and earthworms).



Average number of field operations in BIOBIO case study farms

Legend: the colour of the bars signify the type of land management. Yellow: arable including horticulture; green: grassland; blue: mixed arable and grassland; pink: tree-based systems

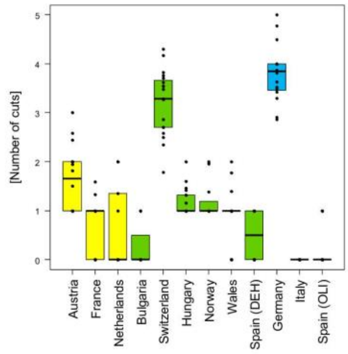
The date of the first cut (Mowing timing) was positively correlated with 'Vascular Plants' in German mixed farms and Swiss grassland systems, i.e. delayed timing of the first cut promoted species diversity. Furthermore, 'Wild Bees and Bumblebees' was positively related with late cuts in German farms and French arable farms.

Quite unexpectedly, certain species indicators were related positively to mowing frequency in the arable farms of Austria and France ('Wild Bees and Bumblebees'), the Dehesas ('Vascular Plants', 'Earthworms', 'Spiders') and the Hungarian grassland farms ('Vascular Plants', 'Wild Bees and Bumblebees'). Generally, the mowing frequency in all these case studies was low (< 2 cuts). Mowing operations were rare and restricted to species-rich land-use types (meadows, lucerne).

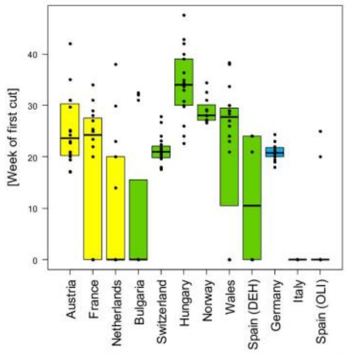
The type of soil cultivation showed hardly had relationships with species indicators. Only in the Austrian arable farming system, plant, bee and spider diversity increased with increasing percentage of ploughing. As the main increase related to semi-natural habitats, a causal relationship is unlikely. Presumably, this correlation is an artifact. In the French arable farms, 'Earthworms' decreased with increasing ploughing.

Field operations change as an indicator

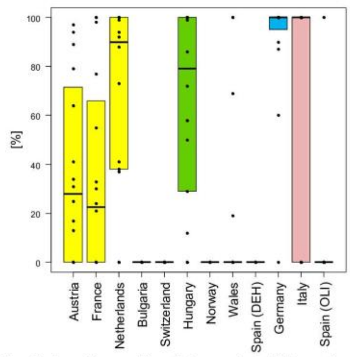
An increase in the indicators summarized under 'Field Operations' would be related to an intensification of field passages in the course of crop cultivation or grassland management. Most likely this will lead to disruptions and disturbances of plant and animal populations on the plot that should also be reflected in animal counts.



Average number of cuts in BIOBIO case study farms



Average date of the first cut (calendar week) in BIOBIO case study farms



Proportion of ploughed area (% arable area) in BIOBIO case study farms

'Mowing timing' (date of the first cut) must be interpreted differently, as diversity tends to increase with late cuts, i.e. increasing indicator values.

Strengths and weaknesses

The headline indicator 'Field Operations' is applicable across all types of production systems.

Sometimes progressive mechanisation brings a reduction in field operations (eg. equipment for direct sowing).

Soil cultivation intensity hardly differed with varying percentages of ploughing because the frequency of field cultivator use increased with decreased ploughing in most of the case studies. The only exception was the arable farms in France, where reduced ploughing was associated with an increased percentage of minimum tilliage.

This factsheet is part of the Guidelines **Biodiversity Indicators for European Farming Systems**.
More detailed information on the set of indicators developed in the EU FP7 research project BIOBIO (Biodiversity indicators for organic and low input farming systems, KBBE-227161) is given in a printed report, published as ART Publication Series Nr. 17. The report can be downloaded from the BIOBIO website.
Printed versions can be ordered at www.agroscope.admin.ch or at Agroscope, Reckenholzstrasse 191, 8046 Zurich, Switzerland

BIOBIO Indicator Factsheets

Genetic diversity

Breeds:	Number and amount of different breeds
CultDiv:	Number and amount of different varieties
CropOrig:	Origin of crops

Species diversity

Plants:	Vascular plants
Bees:	Wild bees and bumblebees
Spiders:	Spiders
Earthworms:	Earthworms

Habitat diversity

HabRich:	Habitat richness
HabDiv:	Habitat diversity
PatchS:	Average size of habitat patches
LinHab:	Length of linear habitats
CropR:	Crop richness
ShrubHab:	Percentage of farmland with shrubs
TreeHab:	Tree habitats
SemiNat:	Percentage of semi-natural habitats

Indirect management indicators / parameters

EnerIn:	Total direct and indirect energy input
IntExt:	Intensification/Extensification - Expenditure on inputs
MinFert:	Area with use of mineral nitrogen fertiliser
NitroIn:	Total nitrogen input
FieldOp:	Field operations
PestUse:	Pesticide use
AvStock:	Average stocking rate
Graze:	Grazing intensity

7 Annex III: BioBio indicator factsheet – Nitrogen Input (NitroIn)

This factsheet is part of the Guidelines Biodiversity indicators for European Farming Systems, developed in the EU FP7 research project BioBio (Herzog et al., 2012).

ART Schriftenreihe 17 | September 2012

BioBio indicator factsheet

Nitrogen Input (NitroIn)

Refers to Chapter 8 'Management related indicators' of the Guidebook 'Biodiversity Indicators for European Farming Systems'

Agroscope

Bio Bio

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Federal Department
of Economic Affairs FDEA
Agroscope Reckenholz-Tänikon Research Station ART

Nitrogen Input (NitroIn)

Description

The **unit** of measurement is average input of nitrogen at the farm-level (kg N per ha UAA)
Subindicators are Organic nitrogen fertilizer input measured as kg N per ha UAA and Nitrogen Balance measured as N-saldo per ha UAA.
Nitrogen input is a **pressure indicator** that has proven useful for the assessment of land-use intensity in a series of studies in Europe and beyond. It largely determines the production intensity, e.g. the number of possible cuts for grasslands or the plant density in arable crops like cereals[1]. It affects the growth conditions for grassland species and arable weeds and, thus, the vegetation composition and density of flowering plants on managed farm fields. This trait, in turn, affects the occurrence of pollinators and other insects.
When recording 'Nitrogen Input', several fractions must be taken into account:

- organic nitrogen from housed or grazing livestock,
- organic nitrogen from plant compost or commercial organic fertilisers
- symbiotic nitrogen from biological fixation (leguminous crops)
- mineral nitrogen from synthetic fertilisers

Surveyor skills

Data collection can be implemented by technical staff (farm interviews, retrieval from databases). For data validation, skills in the interpretation of farm balances and background knowledge in agriculture are necessary to examine the plausibility of both the input and output variables.

Data collection method

In farm-level surveys, farmers must be interviewed using a structured questionnaire. Regional surveys can retrieve available data from official farm accounting databases.

Calculation method

BioBio used the tool DIALECTE for the agri-environmental assessment of farms to calculate the average nitrogen input on farm level. DIALECTE applies a soil surface balance looking at the nutrient flows in the parcels.
Input variables:

- Quantities of mineral nitrogen applied per crop (kg N/ha) (Nmin)
- Number and type of livestock to calculate the total organic nitrogen production (Norg)
- Import and export of organic fertilisers (Norg)
- N_2 fixation by legumes (crops, grassland) (Nfix)
- Yields of crops and grassland to calculate the exports of nitrogen of the parcels. Leguminous cover crops are taken into account.
- Total Utilized Agricultural Area (UAA)

Farmyard manure (top) and leguminous crops (bottom) are important sources of nitrogen in organic farms. Photos: M. Heinzinger, BOKU

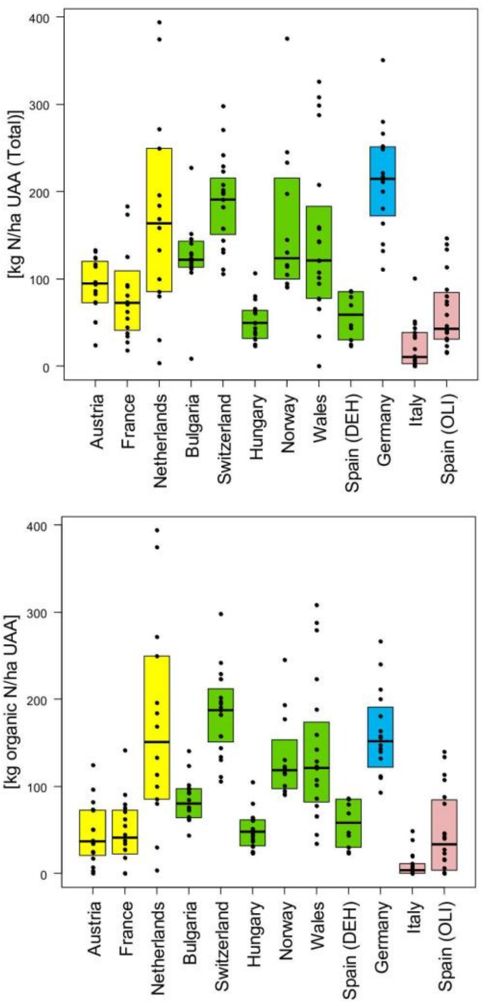
Some of the variables cannot be assessed directly from interview data. For N_2 fixation and organic nitrogen approximations are made, as described below.
N_2 fixation is estimated as the equivalent of the nitrogen content of the harvest (grain or forage). The input data used are the yield of leguminous crops and the average nitrogen content of the plant material. For example, 1 ton of peas will fix 32.5 kg N and 1 ton of alfalfa 39 kg N. The nitrogen available in the soil is not assessed and there is, therefore, potential for under- or overestimation of the actual nitrogen input using this method.
Organic nitrogen production by farm livestock (manure) is calculated from standard reference values differentiated by livestock type. Example: The production of organic nitrogen for a milk cow producing 6000 kg of milk is 97 kg N/LU/year.

[1] Kleijn D. et al., 2009. On the relationship between farmland biodiversity and land-use intensity in Europe. *Proc. R. Soc. B* 276, 903–909

Production of organic nitrogen per livestock type. Exemplary data as applied by the DIALECTE model.		
Type of animal	Livestock unit (LU)	kg Norg produced per animal (excluding volatilisation)
Milk cow – 5000 kg of milk	0.9	93
Milk cow – 6000 kg of milk	1	97
Suckler cow	0.8	77
Heifer 1-2 years	0.6	54
Meat sheep	0.15	11

Nitrogen Input (NitroIn)
NitroIn = Nmin + Norg + Nfix
The N deposition is not taken into account.
Organic Nitrogen Fertilizer Input (Norg)
Norg = Norg from farm livestock + imported Norg – exported Norg
Nitrogen Balance (Nbal)
N balance = N input – N export by the crops – N exports by the forage (harvested or grazed).

A nitrogen balance has been calculated for all farms in the tool DIALECTE. Despite the fact that it is of less relevance for the interpretation of biodiversity data, DIALECTE proved to be very useful for controlling the plausibility of input variables. Balances with a striking bias to either the negative or positive side were re-examined with regard to input data. A main difficulty concerns the estimation of grass production which can be harvested or grazed. To estimate the grass production, DIALECTE calculates a fodder balance taking into account the total livestock units, the need of fodder per livestock unit and the grassland production to verify that the grassland can feed all the animals.



Range of total nitrogen input (top) and organic nitrogen input (bottom) in BioBio case study farms (kg N per ha UAA)

Legend: the colour of the bars signify the type of land management. Yellow: arable including horticulture; green: grassland; blue: mixed arable and grassland; pink: tree-based systems.

Results from BioBio case studies

The boxplots for nitrogen input show the highest average nitrogen input in German mixed farms, Dutch horticulture farms and Swiss grassland systems, suggesting a high farming intensity on these farms. The lowest median was measured in Italian vineyards.

A large range in indicator values for 'Organic Nitrogen' was observed for the farms in the Netherlands and this is reflected by a highly variable 'Nitrogen Input' and 'Nitrogen Balance' (graph). This suggests that there are large differences in fertilisation intensity among the farms in this case study.

Synergies with other indicators

In interviews, data collection for a nitrogen soil surface balance can be combined with the recording of other management practices required for 'Pesticide Use' and 'Field Operations'. It is also possible to calculate the data for 'Area with Use of Mineral N Fertiliser' from the Nitrogen input data. Reducing the input variables to 'Mineral N fertiliser' only, is sufficient. Therefore, no full soil surface balance is required for this purpose.

Estimated effort and costs (labour effort required, analysis)

An average of 8 hours per farm must be calculated for the collection of the BioBio farm management indicators. This includes the farm interview, data processing and data check. However, there is considerable variation in time effort depending on the complexity of farms and the implementation (telephone interviews or farm visits).
As the indicator “Average Stocking Rate” uses the same input data for the estimation of livestock on the farm, it can be derived in a separate calculation.

Correlation with other indicators

Correlations were negative with ‘Vascular Plants’ in the Austrian (arable farming), German (mixed farming), and Swiss (grassland) case studies. For the other case studies, no significant correlations were observed. Negative correlations were also established between this indicator and ‘Wild Bees and Bumblebees’ in France (arable farming), Germany and the olive farming systems in Spain and with ‘Spiders’ in the Swiss case study. The indicator ‘N-input’ was positively correlated with ‘Earthworms’ in grazing systems of Wales and Hungary.
Habitat indicators had no consistent relationship with ‘Nitrogen Input’ among the case studies. In Bulgarian grassland, higher N-inputs are positively correlated with an increase in indicators for ‘Habitat Diversity’, ‘Tree Habitats’ and ‘Percentage of Semi-natural Habitats’. For ‘Habitat Richness’, there was a negative correlation in France and a positive correlation in the Dehesas. Thus, the relationship of ‘Nitrogen Input’ with habitat indicators need careful case by case interpretation.

Nitrogen Input change as an indicator

Increased levels of nitrogen fertilisation boost productivity on farms and are often accompanied by other changes in the management of livestock or field crops. Rising values for nitrogen input indicate that intensification on the farm is in progress. Potential causes for intensification (e.g. raised stocking rates, changes in land-use) and the threat to biodiversity can be examined using a combination of other farm management indicators or habitat indicators.
Driving forces for a decrease in nitrogen input to farmland may be a change in the management system (e.g. conversion to organic farming) or extensification measures within the framework of agri-environment schemes.

Strengths and weaknesses

‘Nitrogen Input’ is an indicator that can be applied and compared across all farm types..
In the EU, farm-level nitrogen data become increasingly available due to the documentation requirements in the implementation of cross-compliance rules.
Compared to other BioBio farm management indicators, the data needs are quite demanding. In addition, quality control and data checks are essential and require a good understanding of the farming systems and their management.
A main difficulty in the use of the soil surface balance is the need to estimate the yield of grassland (fodder, silage and grazing). However, alternative approaches, such as the farm gate balance, have the disadvantage that the nitrogen content of all purchased feedstuff must be quantified.

This factsheet is part of the Guidelines **Biodiversity Indicators for European Farming Systems**.
More detailed information on the set of indicators developed in the EU FP7 research project BIOBIO (Biodiversity indicators for organic and low input farming systems, KBBE-227161) is given in a printed report, published as ART Publication Series Nr. 17. The report can be downloaded from the BIOBIO website.
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BIOBIO Indicator Factsheets

Genetic diversity

Breeds:	Number and amount of different breeds
CultDiv:	Number and amount of different varieties
CropOrig:	Origin of crops

Species diversity

Plants:	Vascular plants
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Indirect management indicators / parameters

EnerIn:	Total direct and indirect energy input
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PestUse:	Pesticide use
AvStock:	Average stocking rate
Graze:	Grazing intensity

8 Annex IV: BioBio indicator factsheet – Pesticide Use (PestUse)

This factsheet is part of the Guidelines Biodiversity indicators for European Farming Systems, developed in the EU FP7 research project BioBio (Herzog et al., 2012).

ART Schriftenreihe 17 | September 2012

BioBio indicator factsheet

Pesticide Use (PestUse)

Refers to Chapter 8 'Management related indicators' of the Guidebook 'Biodiversity Indicators for European Farming Systems'

Agroscope

Bío Bío

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Federal Department
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Research Station ART

Pesticide Use (PestUse)

Description

This indicator measures the frequency of pesticide use on the farm. The **unit** of measurement is the area-weighted average of numbers of pesticide applications on a farm.

Sub-indicators differentiate specific classes of pesticides: 'Herbicide Use', 'Insecticide Use' and 'Fungicide Use'.

It is a **pressure indicator**. The use of chemical pesticides is significantly restricted in organic farming according to the organic regulations EC 834/2007 and EC 889/2008. This restriction results in a reduced input of pesticides in organic systems compared to conventional systems, e.g. a 97 % reduction was found by Mäder et al. (2002)[1]. Organic systems rely on a variety of practices (e.g. crop rotation, biological control, mechanical weed control) to manage weeds and invertebrate pests instead[2]. This avoids direct and indirect pesticide effects, as follows.

Direct effects: Herbicides are a significant factor in the declines of many common arable flowers in Europe[3]. Insecticides have a major negative influence on invertebrates[4].

Indirect effects: Weed communities were found to have a higher diversity on organic farms than on conventional ones[5]. Chemical pesticides lead to a reduction in plant food resources and invertebrate abundance[6]. This is a factor in the declines of a range of farmland bird species[4].

Surveyor skills

Data collection can be implemented by technical staff (farm interviews, retrieval from databases). No specific expert knowledge is required for indicator calculation.

Data collection method

In farm-level surveys, farmers must be interviewed using a structured questionnaire (farm visits or telephone).

[1] Mäder P. et al., 2002. Soil fertility and biodiversity in organic farming. Science, 296, 1694-1697

[2] Lampkin N., 2002, Organic Farming. Ipswich, Old Pond.

[3] Andreasen C., et al., 1996. Decline of the flora in Danish arable fields. Journal of Applied Ecology, 33(3), 619-626.

[4] Hole D.G. et al., 2005. Does organic farming benefit biodiversity? Biological Conservation, 122(1), 113-130.

[5] Tyser G.W. et al., 2008. Community structure and metabolism through reconstruction of microbial genomes from the environment. Nature, 428(6978), 37-43.

[6] Dubois D. et al., 2003. Influence of organic farming and different cultures on the earthworm fauna. In: Freyer, B. (Ed.) Contributions to the 7th Scientific Conference on Organic Farming: Organic farming in the future. Vienna, University of Agricultural Sciences, 24 to 26 February 2003, pp. 445-446.

Calculation method

Categories of pesticides (P_i):

- Herbicide – Number of Treatments
- Fungicide – Number of Treatments
- Insecticide – Number of Treatments
- Retardant – Number of Treatments
- Molluscicide– Number of Treatments
- Nematicide– Number of Treatments
- Other Measures (to be specified) – Number of treatments
- Area for each crop or grassland type (A_i)

In practice, farmers may apply different types of pesticides as mixtures. In the interviews, such operations are recorded as separate treatments.

e.g. 1 application with a combination of a fungicide and an insecticide = 2 pesticide treatments

but: 1 application with 2 different fungicidal substances = 1 fungicide treatment

The pesticide treatments are recorded for each crop or grassland type. They are summed up for each crop/grassland. Eventually, an **average weighted by the area** that each crop/grassland covers on the farm is calculated.

$$PestUse = \Sigma N_i A_i / A_{UAA},$$

where N_i is the number of treatments with a certain pesticide type (P_i) and A_i is the area on which this type of treatment is applied. A_{UAA} is the total Utilized Agricultural Area.

Results from BioBio case studies

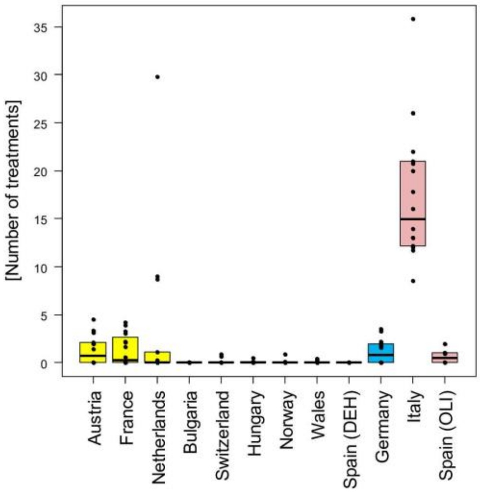
The graph depicts average pesticide treatments applied on BioBio case study farms. The indicator is of relevance for arable and mixed farms as well as for some permanent crops systems (vineyards, orchards). In grassland case studies, pesticides were only applied occasionally as spot treatments. Certain specialist permanent crop systems are demanding with regard to pest and disease management. In this group, olives are an exception, requiring few interventions with pesticides. Most striking is the treatment frequency in Italian vineyards (15 applications per year on average) and in certain horticultural systems (production of fruits and field vegetables).

Synergies with other indicators

In interviews, data collection can be implemented in a joint questionnaire form along with the appraisal of BioBio Indicator 'Field Operations'.

Estimated effort and costs (labour effort required, analysis)

An average of 8 hours per farm must be calculated for the collection of the BioBio farm management indicators This includes the interview, data processing and data check. However, there is considerable variation in time effort depending on the complexity of farms and the implementation (telephone interviews or farm visits).



Average number of pesticide applications per farm
Legend: the colour of the bars signify the type of land management. Yellow: arable including horticulture; green: grassland; blue: mixed arable and grassland; pink: tree-based systems.

Correlation with other indicators

In BioBio cases studies, PestUse was negatively correlated with 'Vascular Plants' in arable and mixed case studies as well as in Spanish olive plantations and Dutch horticulture farms. Relationships with other species indicators were negative as well but these were not consistent across case studies: correlations with 'Wild Bees and Bumblebees' in French arable and German mixed farms, with 'Spiders' in German mixed farms and 'Earthworms' in olive farms.

Italian vineyards were the only case studies that intensively applied pesticides, however the indicator did not show a relationship with any of the species diversity indicators.

Pesticide Use change as an indicator

Major shifts in pesticide use on the farm-level may indicate if pressure on organisms is changing for better or worse. Such changes would mainly originate from shifts in the crop rotation and land-use on the farm: a change to more or less intensive forms of agriculture with regard to pesticide treatments.

Interpretation

Certain specialist permanent crops require high inputs of pesticides (fruit production, vineyards). Even organic farmers frequently apply substances that constrain organisms e.g. fungi in grapes. These systems are often characterised by high application frequencies.

In annual crops pesticides are applied less frequently. However, crops vary from very demanding ones such as potatoes to crops that are easier to handle, particularly if farmers can rely on well-adapted, resistant cultivars (e.g. many cereals).

The indicator is not useful in grassland systems where pesticides are seldom used. Herbicides spot-treatments are only applied to problematic herbs (e.g. Rumex sp.).

Strengths and weaknesses

This indicator is easy to calculate. At farm level, the indicator measures the intensity of land-use, rather than the actual application rate of biologically active compounds. Unlike the treatment frequency index, it does not require knowledge about specific substances (ration of applied and recommended standard dose).

It is an aggregated indicator summarising substances with different target organisms. Thus, the actual effect on species groups will depend on the pesticide type applied.

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