Final Report

European Monitoring of Biodiversity in Agricultural Landscapes (EMBAL)

A project for the European Commission

Directorate General ENVIRONMENT

from the

Institute for Agroecology and Biodiversity (IFAB)

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Abbreviations

AGRIT	Agro-environmental statistics, Italy
ALL-EMA	Agricultural Species and Habitats Monitoring Programme, Switzerland
BDM	Biodiversity Monitoring Switzerland
BioBio	Indicators for Biodiversity in Organic and Low-input Farming Systems
BISE	Biodiversity Information System for Europe
CAP	Common Agricultural Policy
DG	Directorate-General
EBCC	Eurpean Bird Census Council
EBONE	European Biodiversity Observation Network
EC	European Commission
EFA	Ecological Focus Area
EU	European Union
EUNIS	European Nature Information System
FADN	Farm Accountancy Data Network
FAO	Food and Agriculture Organization of the United Nations
FBI	Farmland Bird Index
GAEC	Good Agricultural and Environmental Conditions
GBCS	Great Britain Countryside Survey
GIS	Geographic Information System
HNV	High Nature Value farmland
LANUV NRW	Landesamt für Natur, Umwelt und Verbraucherschutz Nordrhein-Westfalen, Germany
LC	Land cover
LE	Landscape element
LISA	Landscape and Sustainable Infrastrcutre Analysis
LPIS	Land Parcel Information System
LUCAS	Land Use/Cover Area frame Survey
LUI	Land Use Intensity
MAES	Mapping and Assessment of Ecosystems and their Services
MS	Member State(s)
NICS	Northern Ireland Countryside Survey
NILS	National Inventory of Landscapes in Sweden
NUTS	Nomenclature of territorial units for statistics
NV	Nature Value
ÖRA	Ecological Resource Analysis, Germany
PECBMS	Pan-European Common Bird Monitoring Scheme
UAA	Utilized Agricultural Area

1 Executive summary

The objective of this service contract was to contribute towards the monitoring of biodiversity in agricultural landscapes in the EU Member States. The project developed a robust monitoring methodology that allows a rapid assessment of the structure of the agricultural landscape and the state of farmland biodiversity. For the development of the methodology, a thorough analysis of 13 existing monitoring approaches at national and European scale had been conducted. Further, experiences of two in-depth case studies revealed important aspects that informed the EMBAL methodology. With a field test in a number of Member States, the applicability of the drafted methodology could be improved.

The proposed methodology for **E**uropean **M**onitoring of **B**iodiversity in **A**gricultural **L**andscape (EMBAL) is based on field surveys of plots with a size of 25 ha (500 x 500 m). The survey follows a three-fold approach: (1) an area survey, where parameters on agricultural parcels and landscape elements are recorded, (2) a vegetation survey based on transect walks, during which parameters of the vegetation and key species are assessed and (3) a photo documentation, which is a useful tool for the visual characterization of the plot as well as tracking change over time. The detailed assessment of the parameters is described in a comprehensive and illustrated survey manual.

The United Nations Sustainable Development Goals, the EU Biodiversity Strategy to 2020 and the EU Common Agricultural Policy show that biodiversity is of major concern in national and international policies. EMBAL is a monitoring approach with which harmonized data across EU member states are recorded and fills the current data gap needed to inform policy decisions. In this way EMBAL would represent an integral process to overcome fundamental barriers in developing, monitoring and evaluating effective policy actions for biodiversity in agriculture. Where possible and feasible, we aimed at the harmonization with existing monitoring programmes such as the Land Use/Cover Area frame Survey to achieve the greatest possible synergies, increasing data availability. With a continuous annual or bi-annual monitoring cycle, changes in the agricultural landscape and farmland biodiversity are detected. Cost and effort considerations are presented to outline possible future monitoring design options, which could be based on a non-stratified regular distribution of sampling plots across EU member states or based on a stratified sampling scheme. The optimal number of required samples would need a further statistical assessment. A pilot EMBAL survey could among others help to fine-tune also this aspect of a future monitoring process.

2 Introduction

2.1 Background and objectives

The EU Biodiversity Strategy to 2020 aims to halt the loss of biodiversity and the degradation of ecosystem services in the European Union (EU). In this process, agriculture should contribute substantially to the maintenance and enhancement of biodiversity. Among the measures applied to achieve that it seeks to increase the contribution of agriculture to maintaining and enhancing biodiversity. The Common Agricultural Policy (CAP) and in interaction with other relevant agricultural and environmental policies and programmes, biodiversity protection is addressed as well. However, it is not only about the general policies which are relevant for biodiversity protection and enhancement but also the performance and implementation of these policy sectors in detail. In order to effectively maintain and enhance biodiversity in agricultural areas, the evaluation of the biodiversity strategy and evaluations of the contribution of other policies, such as the CAP, are necessary and allow effective adjustments of policy mechanisms. However, this requires good data on the state of biodiversity, both in terms of spatiotemporal coverage and quality. A sound approach and robust process for monitoring biodiversity in agricultural landscapes would ensure systematic collection of such data and would effectively address the current gaps in this regard. Besides the evaluation and enhancement of relevant policies and programmes, such a biodiversity monitoring process would also support their development and implementation, showing positive and negative outcomes.

The CAP reform in 2013 had set the stage for the CAP 2014-2020 and the “greening” had been introduced under the first pillar of the CAP in order to address environmental objectives. Components of greening include the diversification of crops, the maintenance of permanent grassland and the designation of ecological focus areas (EFAs). EFAs, including field margins, buffer strips, hedges/trees and fallow land, are a main component of greening visible in the agricultural landscape. Therefore, the implementation of greening measures from 2014 onwards reflects a point in time where changes in the agricultural landscape were likely to occur, with the aim of delivering positive results for agricultural biodiversity. However, greening is not the only factor influencing farmland biodiversity - also the rural development policy under the CAP (Pillar 2) supplements the environmental objectives through the Rural Development Programmes (RDPs) in the EU member states. With the agri-environment-climate measures (AECM) included in national or regional RDPs, biodiversity and landscape preservation are partly targeted under CAP Pillar 2. The biodiversity related measures of the CAP pillars 1 and 2 are linked to the EU Biodiversity Strategy to 2020 through Target 3a, which focuses on increasing the contribution of agriculture for biodiversity and habitat conservation.[1]

The farmer support under the CAP (with Pillar I and Pillar II) as outlined above is tied to cross-compliance measures, aiming at Good Agricultural and Environmental Conditions (GAEC). At landscape scale, especially the cross-compliance requirements of GAEC 1 (the establishment of buffer strips along watercourses) and GAEC 7 (retention of landscape features, including where appropriate, hedges, ponds, ditches, trees in line, in group or isolated, field margins and terraces) are of importance. However, up to now there is no thorough measuring of the biodiversity and environmental state of farmed landscapes in the European Union.

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[1] http://biodiversity.europa.eu/mtr/biodiversity-strategy-plan/target-3a-overview, last access November 22, 2017

Against this background, the general objective of this project is to contribute towards the monitoring of farmland biodiversity in the EU Member States. The project addresses the need for a permanent and harmonized mechanism for the monitoring of farmland biodiversity across all EU member states and increases the data available for informing the implementation of current policies like the EU Biodiversity Strategy to 2020 and the CAP. The need for a robust and coherent monitoring methodology that assesses the state of farmland biodiversity and its changes is apparent. Such monitoring would also enhance the data availability for the biodiversity indicators used for the evaluation of European policy measures, e.g. the Common Agricultural Policy including the Rural Development Programmes (European Commission, 2013) under CAP Pillar 2 .

Within this general objective, the following specific objectives are defined for the project EMBAL ("European Monitoring of Biodiversity in Agricultural Landscapes”):

1. To identify and select data for assessing the state of farmland biodiversity in the EU;
2. To contribute towards the development of the baseline of data available on the state of farmland biodiversity in the context of the current policy framework (2014-2020);
3. To develop a methodology for a survey that collects field data on farmland biodiversity at landscape scale in the future, compatible with the identified data sources and methodology from the previous objectives. The aim of the survey is to strengthen the evidence base and thus the quality of future evaluations.

Within the EMBAL approach, focus is set on the monitoring at landscape scale for several reasons: it takes into account landscape elements and agricultural parcels, which are important factors influencing biodiversity; at the landscape level, different farming systems are taken into account and data on the extent of arable land, grassland or other types of land cover can be distinguished; biodiversity-relevant changes are often manifested in the landscape structure and reflect potential effects of policy decisions. With this perspective, the EMBAL landscape approach contributes to current monitoring efforts of the member states, e.g. regarding High Nature Value (HNV) farmland.

However, one should be aware that there might be a time lag until certain land use changes manifest themselves in biodiversity – some species and habitats react very quickly while other species and habitats need longer time.

EMBAL focuses on the monitoring of areas which are under agricultural use. Therefore, the following definition of the agricultural landscape is taken as a basis:

“An agricultural landscape is characterized by the dominance of agricultural land use and management with a strong anthropological influence, introduced elements and remnants of the original natural landscape[2]. The presence of historic elements and the presence of man-made features in general, determine the character of cultural and artificial landscapes” (Jongman & Bunce, 2008 p. 11).

Besides parameters at landscape scale, concrete biodiversity data will be generated with EMBAL. For the definition of farmland or agricultural biodiversity, the broader perspective of the FAO (Food and Agricultural Organization of the United Nations) can be compared to the definition applied within the European CAP regulations in the following.

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[2] Remnants of the original natural landscape could be forest patches, old grassland or similar structures, usually distributed in a mosaic across the agricultural landscape (Hendrickx et al., 2007; Tscharntke, Klein, Kruess, Steffan-Dewenter, & Thies, 2005).

The FAO definition of agricultural biodiversity (FAO, 2004) includes harvested species as well as all species in the (wider) agricultural ecosystem (e.g. soil biodiversity, insects, earthworms):

- "Harvested crop varieties, livestock breeds, fish species and non domesticated (wild) resources within field, forest, rangeland including tree products, wild animals hunted for food and in aquatic ecosystems (e.g. wild fish);
- Non-harvested species in production ecosystems that support food provision, including soil micro-biota, pollinators and other insects such as bees, butterflies, earthworms, greenflies; and
- Non-harvested species in the wider environment that support food production ecosystems (agricultural, pastoral, forest and aquatic ecosystems)" (FAO, 2004).

The definition of agricultural biodiversity as stated by the European Commission (2017) includes:

- "all components of biological diversity of relevance for food and agriculture, and
- all components of biological diversity that constitutes the agro-ecosystem" (European Commission, 2017)[3].

Within this study, farmland biodiversity refers to the harvested species (e.g. crop varieties) as well as to the non-harvested species, particularly the plant species, following the above definition of agricultural biodiversity used in EU policy regulations.

In the following, the three main tasks within the project (illustrated in Figure 2-1) with which the project-related objectives presented above were achieved are outlined.

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[3] European Commission (2017) on agriculture and biodiversity: https://ec.europa.eu/agriculture/envir/biodiv_en, last access November 22, 2017

2.1.1 Task 1 – Data identification

Within the project, relevant existing data sources available at the local, national and EU level that allow the assessment of the state of farmland biodiversity before (2014 and earlier, see Section 2.1) and after the implementation of greening measures were identified. Further, data sources that capture the agricultural context, e.g. the landscape structure, farming practices, etc. were explored within Task 1.

2.1.2 Task 2 – Monitoring methodology

Given the results of Task 1, the most appropriate data sources were selected in Task 2 and further used for the development of a monitoring methodology. As up to now concrete biodiversity metrics have not been introduced yet in monitoring instruments on EU-level (except the bird monitoring) in this study biodiversity metrics based on concrete field data have been chosen for the development of the monitoring methodology. They have a strong indicative potential of the state of farmland biodiversity, also in a temporal comparison. Task 2 is inherently linked to the outcome of Task 1, since the development of the methodology strongly depends on the data availability and respective resolution. The methodology proposes a design for the implementation of the monitoring that ensures a representative geographical coverage across the EU MS.

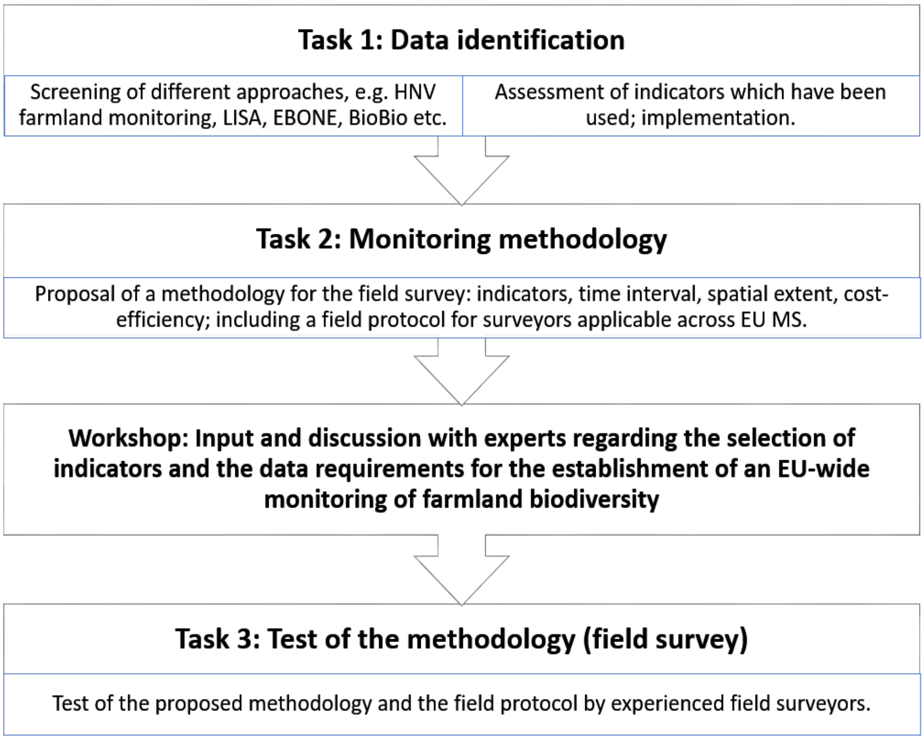

Figure 2-1 – Illustration of specific tasks for the development of a monitoring methodology for farmland biodiversity in EU Member States.

2.1.3 Task 3 – Field survey

For the methodology developed under Task 2, a field survey design is proposed that can be carried out across European countries in the subsequent years. The field survey strengthens the evidence base by providing field data on the state of farmland biodiversity, fulfilling the third objective of the project. The data generated by the survey is compatible and comparable with assessments conducted prior to the survey (in particular with the results of Task 1).

The parameters to be surveyed were identified and a corresponding field protocol. Thus a detailed survey manual and survey sheets was developed and tested in the field. The survey methodology represents a cost-effective approach for the assessment of the state of farmland biodiversity.

2.2 Project meetings

Within the project, several meetings with project partners, experts and representatives of the EU Commission took place to facilitate exchange, discussions and hence the development of a sound monitoring methodology.

Project meetings with the Commission

Inception meeting – Brussels	**February 24, 2017**
Expert workshop – Brussels	**April 25, 2017**
Mid-term meeting – Brussels	**July 4, 2017**
Final meeting – Brussels	**October 31, 2017**

Further project meetings:

Meeting with Alterra, UR Wageningen	March 14, 2017
Meeting with PAN, Munich	September 4, 2017

Frequent exchange with and feedback from the other project partners, external experts and experienced field surveyors in Spain, Hungary, Czech Republic, Germany and the Netherlands took place throughout the time of the project.

2.3 Project outputs

The project delivered the following outputs:

- A comparison of different existing monitoring approaches with respect to different farmland biodiversity parameters, related to:
  a) Ongoing monitoring systems
  b) Spatial and temporal coverage
  c) Cost-effectiveness of different approaches
  d) Ability of monitoring approaches to assign recorded change to policy measures, e.g. as result of CAP measures.
- The development of a monitoring approach with the power to generate robust data on biodiversity parameters in agricultural landscapes.
- Extensive discussions with experienced field surveyors and experts in the field of farmland biodiversity during a one-day workshop.

- The development of a field protocol for a future implementation of the monitoring scheme.
- A proposal for the design of a future monitoring scheme with according costs for the implementation.

Thus the aim of the project is to monitor biodiversity linked to the CAP and other environmental policy instruments.

The project had been carried out within eight months between February and October 2017. An overview of the project schedule is given in Annex A – Project schedule. An inception meeting took place on February 24, 2017 in Brussels.

In the following, the methods and results of the study are presented, followed by the proposal of a methodological design that allows the monitoring of biodiversity in agricultural landscapes throughout European countries.

3 Material and methods

3.1 Literature review

For the development of a sound biodiversity monitoring methodology, a thorough review of existing monitoring approaches and according literature had been carried out mainly between March and April 2017, some further newer elements could be added later on. For each of the identified approaches we compiled information regarding the spatial scale, the monitoring methodology, the monitoring effort (if available) and the possibility to track measures related to agricultural policy. Within this assessment we could draw on our experiences with different monitoring approaches, e.g. the GREENVEINS, BioBio and EBONE projects conducted by Alterra UR Wageningen, the LISA (Landscape Infrastructure and Sustainable Agriculture) approach, which had been developed by IFAB and the German HNV monitoring, managed by PAN, Munich.

3.2 Data comparison

In order to find an approach which fulfills the data requirements for a baseline, we compared the available data sets from 2014 and 2016 from the LISA approach, which already covers the major elements necessary for the monitoring of biodiversity in agricultural landscapes. With the comparison of the data, we are able to show the strengths of the already existing methodology in providing a baseline data set and analyze the suitability of the approach to track changes over time.

Besides the LISA approach, we compared cost-effectiveness, spatial and temporal coverage, and the degree of detailedness of the identified approaches to extract the most appropriate elements for the proposed EMBAL (European Monitoring of Biodiversity in Agricultural Landscapes) monitoring approach. Because of their importance at the European level, the focus was particularly put on the HNV farmland indicator and the monitoring that feeds into the Farmland Bird Index (FBI).

3.3 Workshop

Feeding into the data identification and analysis, we conducted a one-day workshop in Brussels (April 25, 2017), where experts from the European Commission, field surveyors and representatives of European organizations discussed the preliminary results with respect to a future biodiversity monitoring approach at European level. The results from the discussions were considered in the further development of the proposed monitoring methodology.

3.4 Development of a field protocol and field test

With the results from the literature review, the data comparison and the workshop discussions, parameters necessary for the monitoring of biodiversity were extracted. These parameters are the baseline for the field protocol for the proposed monitoring methodology. In May and June 2017, the monitoring methodology and the according field protocol were tested in five European countries, representing the main ecoregions of Europe, in order to ensure a sound application and reveal the needs for further refinements. The field test was carried out in Spain, Hungary, Czech Republic, the Netherlands, and Germany.

The purpose of the field test was to:

- Apply the methodology in different European ecoregions;
- Test the survey manual and its applicability in a great diversity of situations in the field for the identification of complex land cover and landscape elements;
- Test the survey manual and the record sheets for their comprehensiveness;
- Collect examples for different types of land use.

The questionnaire with the different tasks, which we handed out to the field surveyors, is shown in Annex B. The results of the field test were then used to adapt the drafted survey methodology and assure a sound, however easily applicable, field manual valid in all European MS.

4 Case studies

In the frame of this study two case studies are presented in detail. They serve as examples for monitoring approaches in agricultural landscapes with data available before the implementation of the CAP policy 2014-2020 and after the introduction of respective measures of the CAP.

In the following, the two case studies are presented: the European LISA study, which delivers data for the years 2014, 2016 and 2017 regarding structural components of the landscape (such as arable or grassland parcels, hedges, etc.) and biodiversity data of vegetation in agricultural parcels; and the German HNV farmland monitoring approach with the latest data from 2015/2016 (compared to data from 2011/2012).

The German HNV farmland indicator approach (and no other European HNV farmland indicator approach) has been chosen because it's the only one in the European Union which is based on an annual in-field-monitoring of biodiversity data (Peppiette et al. 2012).

The aim of the case study presentation is to highlight the design, interpretation potential and challenges encountered with two different monitoring approaches that are both based on field survey data but meet the requirement of a rapid approach, one condition for the EMBAL methodology. The following data compilation from LISA and HNV farmland monitoring in Germany is not exhaustive but gives a broader overview of their potential.

The findings from the case studies revealed important aspects regarding the sampling design, data obtained with the respective methodologies and the evaluation potential of the data. The experiences with these monitoring approaches at national (HNV Germany) and European (LISA) scale feed into the results and discussion derived from the other project tasks and were considered in the development of the EMBAL methodology and proposed implementation.

4.1 LISA

4.1.1 Introduction

Agricultural landscapes in Europe are characterised by a high diversity within many different natural regions and land use types. In all agricultural landscapes, there are examples of nature-friendly land use and less nature-friendly land use, and the balance between these two varies considerably between the regions. Data on plant and animal species reveal a strong decline of biodiversity in agricultural landscapes; however, until now there has been no detailed and comparable data on the extent and quality of landscape infrastructure (= landscape elements + extensively used parts of the landscape) and the sustainability of land use with respect to biodiversity and ecologically sensitive areas covering multiple European countries.

The scope of the LISA study (**L**andscape **I**nfrastructure and **S**ustainable **A**griculture) was to develop and implement a method to measure the nature value[4] and the changes in nature values of different agricultural landscapes in Europe through standardised field-level surveys.

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[4] "Nature value" is used as a summarizing expression for biodiversity and structural richness of farmland and landscape elements. This expression is used in the LISA-approach described here but also in the HNV farmland indicator case study (see chapter 4.2) as well as in the EMBAL approach.

In 2014, the LISA approach was tested in 39 regions of 500-1000 km² size in 10 European countries from Spain to Poland and from Scotland to Romania. In 2016, in 6 countries, 13 regions from the 2014 LISA survey were resurveyed.

4.1.2 Methodology

For developing the LISA methodology in 2014 a review of the literature and screening of different approaches to record the nature value of agricultural landscapes in Europe revealed the following methods and parameters to be most suitable:

- A sample plot approach with a regular grid laid across more or less homogeneous regions;
- A rapid approach for the mapping of the land use units comprising qualified estimations of the nature value – these are based on surveyor evaluation of several parameters (e.g. structural diversity of a hedgerow) on the one hand and on concrete transect records of several plots;
- The use of key species lists for recording the species richness in transect walks in arable land, in permanent cultures and on grassland;
- The recording of landscape elements and of buffer strips as well as of ecological sensitive areas may be important in respect of nature value and good farming practice and it can be easily recorded;
- In addition to the recording and mapping of the plots a comprehensive photo documentation was carried out.

Thus the LISA approach was based on plots with the size of 25 ha (500 x 500 m) in regions with a regular grid of 5 x 5 km and with 25 plots per region. Beside the mapping of these 25 plots in each plot were varied out vegetation records (transects) in arable land, grassland and fallow land. There are up to 4 vegetation transects in each plot and up to 100 vegetation transects in one survey region with 25 plots – this leading to detailed biodiversity data of the current land use. As a third method comprehensive photo documentation is carried out.

The details of the method have been worked out and described in a protocol for the field survey comprising 50 pages and illustrations.

The survey in the regions was done in spring between May and July to capture the peak of vegetation development (arable land and grassland). The regions as well as the number of completed transects in the 2016 survey are presented in Table 4-1. The 2016-survey served as monitoring experience in regions of the LISA-2014 survey (same regions 2014 + 2016).

A detailed description of the methodology is available in the report of the LISA study 2014, published at the IFAB website and accessible via the link:

http://www.ifab-mannheim.de/LISA%20report%202014-final%20July%202015.pdf.

Table 4-1 – Regions and numbers of transects recorded in the LISA 2016 survey.

Region	Plots	Altitude Ø	Biogeo-graphic region	Pre-dominant land use	Transects on arable land, permanent crops	Thereof transects in cereals	Transects on grass-land	Total number of transects
AT-01-Hollabrunn	24	310	continental	arable	48	27	5	53
CZ-01-Znojemsko	25	324	pannonian	arable	43	26	0	43
DE-02-Albstadt	25	617	continental	mixed	16	11	42	58
DE-03-Straubing	25	457	continental	arable	50	19	2	52
DE-05-Soest	25	203	continental	arable	61	46	5	66
DE-07-Magdeburg	25	100	continental	arable	41	25	3	44
DE-09-Fuerstenwalde	25	45	continental	arable	33	21	2	35
ES-02-Palencia	25	799	medi-terranean	arable	56	46	0	56
ES-03-Castilia-North	25	749	medi-terranean	arable	58	26	0	58
FR-04-Reims	25	146	continental	arable	68	40	1	69
FR-05-Rennes	25	78	atlantic	arable	60	32	4	64
PL-01-Glubczyce	13	294	continental	arable	35	30	1	36
PL-02-Chojna	25	48	continental	arable	34	31	2	36
Sum 13 regions	**312**				**603**	**380**	**67**	**670**

4.1.3 Summary of results

There is a huge extent of detailed data of the investigated regions. Out of the 13 regions there was only one region in which data interpretation was restricted due to limited extent of the survey (PL-01-Glubczyce only with 1-13 investigation plots) and the possibilities for data comparison were restricted for two regions in France because the revision of the mapping showed some serious mistakes in the 2014 data (not all data but a for a few data). Nevertheless, data from 2014 are presented in most cases to give an overview on the situation.

While the mapping delivered exact area measuring of the extent of different land uses, landscape elements etc. the vegetation transects delivered exact figures on different parameters like number of key species, of flowering species, coverage of wild plants etc.

Figure 4-1 gives an overview on the dominant land use in all regions in 2014 and 2016. The main land use of the selected regions was arable land, mainly planted with non-permanent or permanent crops (e.g. vineyards or olive groves), followed by non-agricultural lands, such as houses and roads. Grassland, including orchards, only showed substantial percentages in DE-02 Albstadt, Germany and FR-05 Rennes, France.

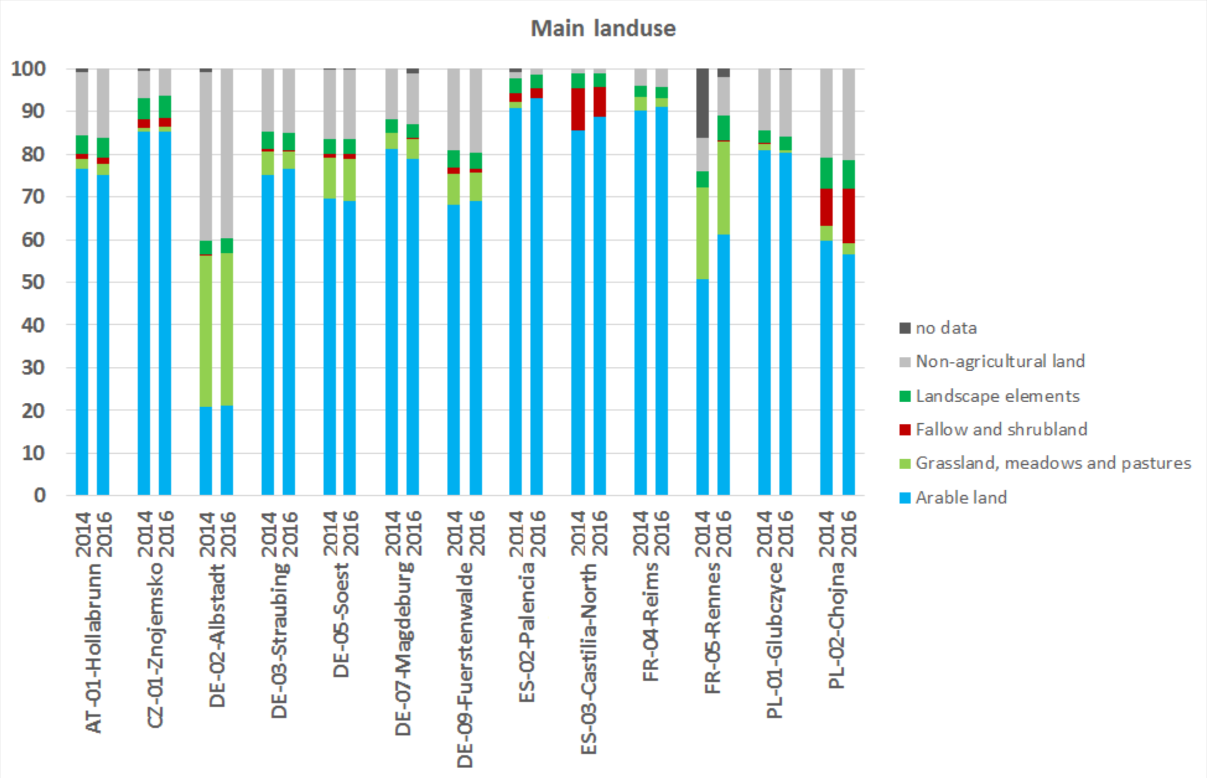

Figure 4-1 – Main land use types across the regions. The category "no data" could be chosen for invisible parts of a plot. Grassland includes fruit orchards, arable land includes permanent and non-permanent crops.

In summary, the main findings of the LISA studies from 2014 and 2016 are the following:

Methodology

- The survey methodology proved to be applicable in all European regions; a Europe-wide method for assessing the nature value of agricultural landscapes across quite different European regions was developed, refined and applied.
- Almost all surveyors were able to complete a region survey with 25 plots each of 25 ha size within 5-6 days.
- Experiences from 2014 resulted in an adjustment of the key species list for 2016, with a differentiation between essential key species, including the most common key species from 2014 on which surveyors had to focus on and a list of additional key species. This new key species list did work very well.
- The pollination potential of arable landscapes was measured with different parameters – the number of actually and potentially flowering plant species, the actual and expected flower density and the coverage of wild plants. The differentiation between the actual and the future pollination potential was a refinement of the 2016 methodology which in most regions was proofed to work well.

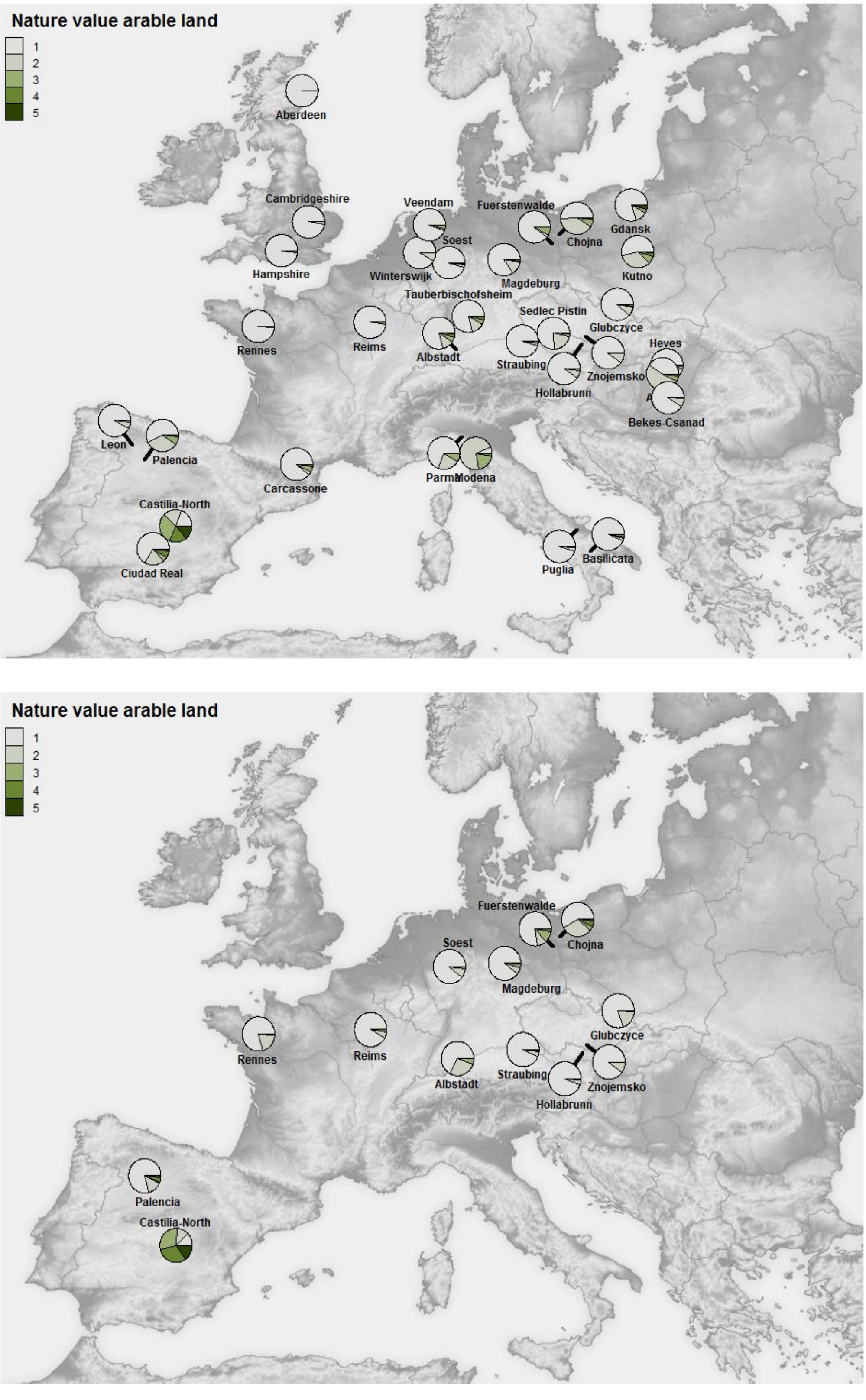

Figure 4-2 – Overview of the recorded nature value in LISA regions in 2014 (upper figure) and 2016 (lower figure). Nature value is recorded at a scale from one (low nature value) to 5 (high nature value) based on biodiversity and structural parameters.

Structural and biodiversity related results

- As in 2014, the nature value turned out to be quite low in almost all arable landscapes; the extent of species rich arable land was rather low in 2014 as well as in 2016 (cf. Figure 4-2).
- In arable land, high nature values are mainly found in some cereal fields but also in vegetables and pulses and fodder crops, but in general the biodiversity as represented through the number of key species in arable land was very low.
- Only one grassland region was surveyed in 2016 (Albstadt, Germany). In this mountainous region, more than 50 % of the grassland shows a high or very high nature value. This is consistent with the results from 2014.
- In both survey years 2014 and 2016, the number of potential key species for arable land was very low (mainly 0-1 species out of a list of about 40 species or taxa) except in very few regions where the average number was higher.
- The low numbers of potential key species are not correlated with the coverage of wild plants in arable land, as results from 2014 and 2016 show. This might be explained by the selection of key species, which do not correspond to the plants that make up the coverage of wild plants.
- A high number of key species indicates medium to high nature values.
- It turned out that the pollination potential was rather low in almost all arable landscapes with average numbers of only 0.1 to 4.5 actually flowering plant species in arable lands. Mean numbers for actually flowering plants species in grassland were between 0.0 and 10.8 and the actual flower density (on a scale from 1 to 5) in grassland was mainly low, with values between 1 and 2.
- The extent of landscape elements in 34 regions surveyed in 2014 ranges between 1.5 % and 13.1 %. For the 13 regions resurveyed in 2016, values range between 2.7 and 6.7 % of all agricultural land in 2016 (see Figure 4-3). In 6 out of 11 regions (disregarding the French study regions), the extent of landscape elements increased from 2014 to 2016, while in 5 regions the extent decreased. Highest increase was 0.45 % of all mapped land, highest decrease was -0.58 %.
- As in 2014, the nature values of these elements showed mostly a range of different values (good, medium and low values).
- Total legume cultivation increased from 2014 to 2016. In 2014 2.4 % of all arable lands were planted with Lucerne, clover or dry pulses, while in 2016 3.1% of all arable lands were planted with these crops.

The approach displayed some potential effects of policy decisions, e.g. legume increase might be a result of implemented CAP measures. However, with the LISA study no causal relations can be established between the recorded data and policies. The results of the LISA study show no increases in the assessed biodiversity parameters (number of key species, number of flowering plants) for grassland and arable land in the time period 2014 to 2016. Though this is also reflected in regional agricultural statistics, the time period might not have been sufficient for detecting change at the vegetation level. However, the LISA study showed that many biodiversity and land use parameters can be recorded at regional level with such a rapid approach and data are interpretable given a sufficiently long time series. Many methodological experiences could be gathered.

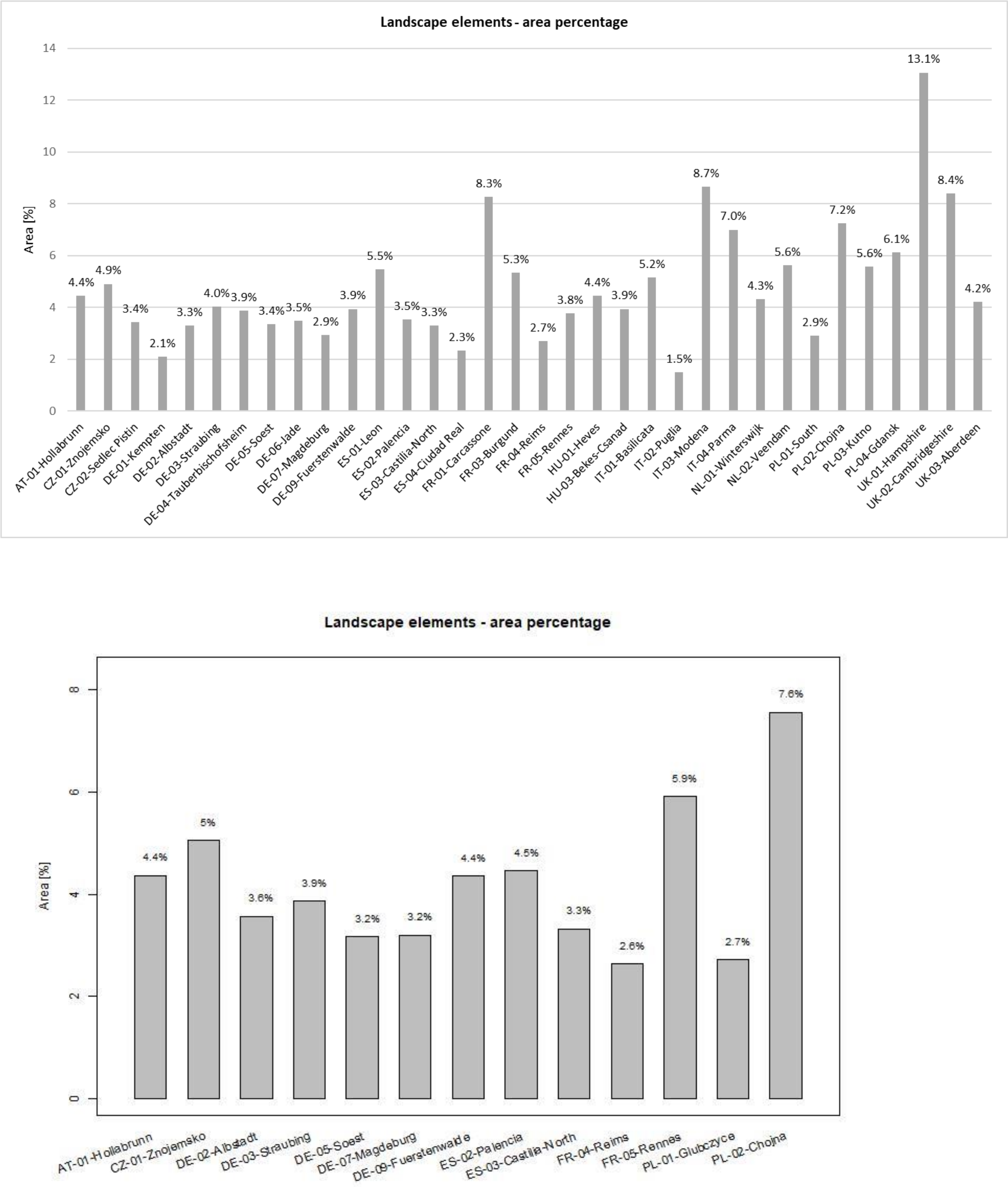

Figure 4-3 – Extent of landscape elements as % of total area in the LISA survey regions in 2014 (upper figure) and 2016 (lower figure).

Photo documentation

Due to the extensive photo collection being part of the LISA study, the advantages of this means of data recording becomes visible (Picture 1). Georeferenced pictures of landscape elements or other structures allow the visual comparison of the same sites in different years and support the surveyors' assessments.

Picture 1 – Examples of change detection via photo documentation: new construction of a field barn in Germany between 2014 (left) and 2016 (right).

In addition to the 2016-data in 2017, two German regions were resurveyed with the LISA methodology (Albstadt and Tauberbischofsheim). For Albstadt, data were available from the years 2014 and 2016, for Tauberbischofsheim data were available from the survey in 2014. The comparison of the data was very insightful regarding the significance of the data to monitor trends: similar to the comparison of legume cultivation across all study sites (see results summarized above), the results from the region of Albstadt show a similar increase. In 2014, no parcel with leguminous crops was recorded, whereas in 2017 5.3 ha were documented, which equals an increase of 4.17 % of the total agricultural area of the region. This trend could be attributed to agricultural policies which focused on the cultivation of legumes.

Resulting from the data of a three-year time line, the need for a frequent monitoring, at best at a yearly cycle becomes apparent. Only when differences due to surveyor knowledge, weather conditions or crop rotations level out, the real trends of landscape change will become visible.

4.1.4 Challenges and improvements

Given the experience with three years of field survey in a variety of European countries, the lessons learned can be summarized as follows:

- With the LISA approach, a characterization of regions is possible (e.g. differentiation of more intensive or extensive regions);
- Information related to CAP or other relevant policy measures (e.g. eligible EFAs or particular management practices of the farmer such as the type of fertilization

or crop rotation are not recorded during the field survey. This linkage has been out of the scope of the LISA study.

- The qualification of surveyors is crucial, as well as control and support during the time of the survey. Qualification should be checked before engagement of the surveyors, and additional training on the methodology is important (in the LISA study, the project team trained the surveyors before the start of the field survey)
- Data entry can produce a variety of errors, e.g. because of different wording or transposed digits. Eliminating these sources of errors would increase efficiency and data quality;
- A comparison of data is possible for different years and for different regions;
- Need for a defined time window for the survey to gain reliable and comparable biodiversity data.
- Trends of change at structural and biodiversity level can only be identified if other “data noise” such as crop rotation or individual decisions of farmers are leveled out. Therefore, consistent time series and a high number of data entries are necessary.

4.2 HNV farmland indicator monitoring in Germany

4.2.1 Introduction

High Nature Value Farmland became part of the Common Agricultural Policy’s indicator set in the programming period 2007 to 2013. The German authorities responsible for CAP related questions first hoped to be able to use existing data for the estimation of HNV farmland area and its development. Due to the federal structure of the republic where responsibility for both nature conservation and agricultural policy largely lies within the states (*Bundesländer*, NUTS level 1) this proved not to be a viable option. Only few states had ongoing monitoring programmes related to the nature value of agriculture, and these were in many aspects not comparable to each other. And whereas all states had and have programmes to monitor protected habitats, their temporal resolution (usually decades rather than years) is far too coarse to detect changes due to developments in CAP.

On this basis, a Research and Development project commissioned by the Federal Office for Nature Conservation (BfN, *Bundesamt für Naturschutz*) recommended to introduce a new monitoring programme to survey HNV farmland in the field. This programme was to be based on an existing set of sample plots already in use for the common breeding birds’ monitoring (Mitschke & Sudfeldt, 2005), using the 1,000 plots supplied for questions of federal scope (out of 2,496 for questions of both federal and states scope). A conference of the BfN with the states’ officials responsible for agri-environmental questions decided in 2008 to introduce this programme. A first complete round of surveying was to be financed jointly by the federal republic and the states. After that, field work should be commissioned and paid for solely by the states with the BfN being responsible and paying for overall coordination, quality management and reporting.

The first round of surveying took place in 2009, involving 13 of the 16 federal states with only the city states of Berlin, Bremen, and Hamburg not taking part. The state of North Rhine – Westphalia provided data from an existing environmental monitoring programme on the MhB sample plots (ÖFS, *Ökologische Flächenstichprobe*) whereas in the other 12 states field surveys were undertaken using 873 sample plots of 1 km² each. Since 2010, roughly a quarter of all sample plots are resurveyed every year. Complete repetition data sets are therefore available for 2013 and will be for 2017. A number of states meanwhile decided to increase the sample size in order to be able to calculate the development of HNV farmland on the state level with higher precision, so that in 2016 the regular sample consisted of 1,278 sample plots.

The HNV farmland baseline indicator is calculated as the proportion of HNV farmland in relation to the agricultural area. The indicator is reported biennially to the EU (in every odd year). It has meanwhile been included in a set of 24 federally coordinated sustainability indicators (LiKi, *Länderinitiative Kernindikatoren*) and in the indicator set of the German National Strategy on Biological Diversity. The German approach to reporting the EU agri-environmental indicator high nature value farmland represents one of the methods currently used across member states (Peppiette et al. 2012). Additional information about the HNV farmland indicator at European scale can be found in Section 5.2 of this report.

4.2.2 Methodology

HNV farmland indicator

In the field, all agricultural area and its components such as landscape features on the sample plots are surveyed by trained field ecologists. For all HNV farmland polygons, both the type and a nature value are recorded in the field. The HNV value of cultivated areas (meadows and pastures, arable, set aside or fallow, orchards and vineyards) is assessed using key taxa. Plant species are recorded on 30-meter transects, using regionally diversified sets of up to 35 key taxa. The minimum requirement for HNV areas is four key taxa on the transect. The nature value derives from the number of key taxa on the transects (4 or 5 key taxa: moderately high nature value / III, 6 or 7 key taxa: very high nature value / II and more than 7 key taxa: extraordinarily high nature value / I). Landscape features such as trees, hedgerows, copses, small ditches, streams, water bodies or wetlands and herbaceous strips are evaluated to qualitative criteria. All HNV farmland polygons are stored in a GIS with their attributes. Quality control has three components:

- annual surveyor training at the start of the field season,
- control surveys of 10 sample plots in each year, and
- detailed technical and optical checks of the data before inclusion in the federal data set.

In 2016 the federal sample consisted of 1,278 sample plots of 1 km² each. The sample is stratified on two levels, land use class and ecoregions (Graef, Schmidt, Schröder, & Stachow, 2005). The proportion of HNV farmland in all agricultural area is calculated using a modification of Cochrans “combined ratio estimator” (Cochran, 1977) developed at the University of Göttingen (Saborowski, 2012, 2013). For federal overviews and reports to the EU the most recent data for every sample plot are used. So to calculate the HNV farmland proportion for the year 2016, data from 2013 to 2016 are included. This increases the available sample size and guarantees proportional representation of all sampling strata but introduces a dampening time lag in the results.

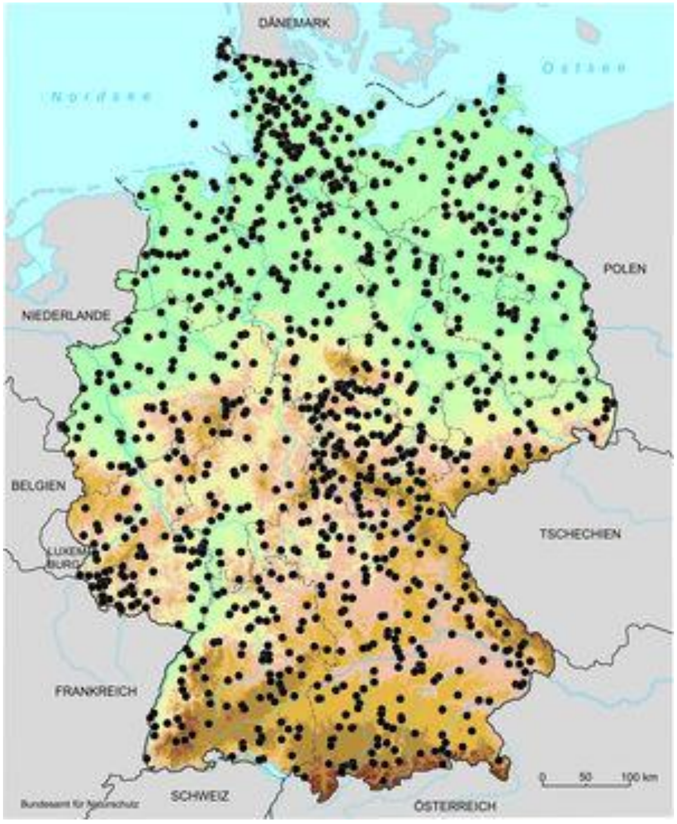

Figure 4-4 – Distribution of survey plots across Germany for the HNV farmland monitoring. Source: BfN, 2013.

This case study

Of the 1,278 plots in the programme 579 have been surveyed in 2015 or 2016. For 506 of these plots, data are available for both 2015/2016 and at least one preceding survey (i.e. from 2011 or 2012, since plots are re-surveyed every fourth year). Data from these 506 plots were used for the analysis, so a direct comparison between the situation before and after the introduction of greening regulations is possible.

4.2.3 Results

The proportion of HNV farmland in all agricultural area and for the whole of Germany fell continuously from 13.1% in 2009 to 11.4% in 2015. This represents a proportional loss of 11.9 % that is statistically significant at the 95%-level. For 2016 a very slight, but statistically not significant increase to 11.5% could be reported. Main losses occurred on arable fields (44.1% reduction) and on set-aside areas (27.3%) (see Table 4-2). Roughly 45% of all HNV farmland is species-rich grassland where losses were lower than average (7.7% for the period 2009-2016) but still significant. Landscape features which mostly fall under cross compliance regulations (cf. GAEC 7, retention of landscape elements) or are eligible as EFA (ecological focus area) such as hedgerows, copses, trees, small reedbeds, ponds and such comprise a third of all HNV farmland area and showed neither significant losses nor gains in the period 2009-2016. The proportion of HNV farmland with the lowest nature value (III) fell significantly by more than 20% from 6.3% to 4.9% whereas HNV farmland with a very or extraordinarily high nature value (II and I) shows only a small but not significant decline.

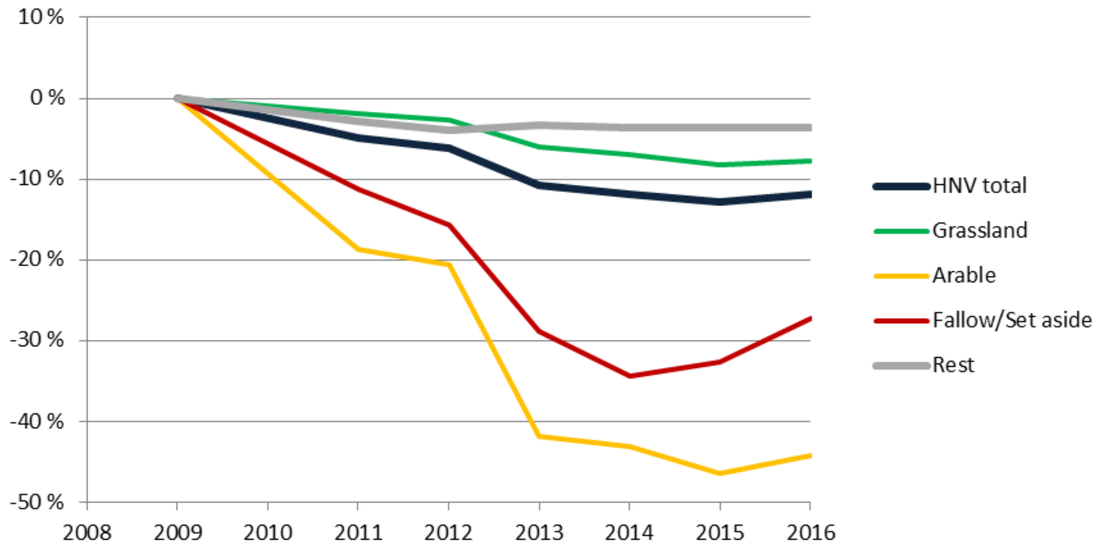

Figure 4-5 – Relative difference of the amount of HNV farmland in Germany from the baseline 2009 to 2016 for major HNV farmland types. Values for each year include data from this year and the preceding three years (gliding mean of four survey years).

For a more detailed analysis if agricultural or environmental policy regulations induce changes in the HNV farmland proportion, only data from 506 sample plots with the most recent surveying data from 2015 and 2016 were used. These data were compared with the HNV proportions on the same plots four years earlier. The results are shown in the following table.

Table 4-2 – Proportion of HNV farmland in all agricultural area for Germany in the years 2012 and 2016.

n = 506 sample plots (reduced sample size); the asterisk * denotes a difference that is statistically significant ($p < 0.05$); numbers in the fields “from” and “to” show the lower and upper bounds of the estimated HNV area ± sample error for 2016; [fa] denotes HNV farmland types which may be part of focus areas and/or GAEC 7.

Type of HNV farmland	2016	2012	difference	area [hectares] 2016	
				from	to
total	10.6%	10.5%	0.9%	1,951,352	2,188,447
extraordinarily high nature value = I	2.2%	1.9%	11.4% *	375,598	476,339
very high nature value = II	3.8%	3.9%	–3.4%	698,958	791,251
moderately high nature value = III	4.6%	4.6%	–0.5%	836,741	960,911
all agriculturally used areas	6.7%	6.7%	0.7%	1,210,944	1,430,220
all landscape features	3.8%	3.8%	1.3%	724,157	774,476
Gr – grassland	4.8%	4.8%	–0.1%	854,830	1,040,974
Ac – arable	0.6%	0.6%	–10.3%	83,611	134,781
Br – set-aside/fallow [fa]	0.5%	0.4%	26.4%	78,081	130,507
Ob – orchards	0.7%	0.8%	–5.5%	121,280	164,915
Re – vineyards	<0.1%	<0.0%	26.5%	34	290
Le – protected habitat types	0.1%	0.1%	11.0%	8,206	23,656
B – trees	0.4%	0.4%	3.5%	80,747	89,500
H – hedgerows and copses [fa]	1.1%	1.1%	5.0% *	208,612	232,521
K – complex elements [fa]	0.2%	0.3%	–36.7% *	31,103	43,308
N – dry stone walls [fa]	<0.1%	<0.1%	0.3%	598	1,668
R – herbaceous strips [fa]	0.3%	0.3%	2.6%	60,332	74,146
S – small wetlands [fa]	0.2%	0.2%	12.8%	33,471	45,461
T – ponds [fa]	0.1%	0.1%	3.3%	10,241	13,318
G – ditches [fa]	0.5%	0.5%	0.4%	89,846	109,593
W – small rivers and streams	0.2%	0.2%	–0.6%	31,720	45,572
U – lanes	0.8%	0.7%	1.5%	140,513	156,363

It should first be noted that the sub-sample used in this analysis seems to produce slightly lower estimates for the HNV farmland proportion than the full sample (compare the value for all HNV farmland for 2016 of 10.6% according to the reduced data set with the value of 11.5 % for the complete data set). This is likely due to the dampening effect mentioned above: in the full sample for 2016 data from 2013 to 2016 are included and in the sub-sample only data from the last two years. Since there seems to be a general decline in HNV farmland it is to be expected that HNV values in this sub-sample are somewhat lower.

Generally there is relatively little difference between HNV farmland proportions in 2012 and 2016, the slight overall increase of less than 1% being statistically not significant. Interestingly one of the few significant changes concerns farmland of the highest nature value, the proportion of which increased by more than 11%. Taking the 95% confidence limits into account this translates into a gain between 7,500 and 90,000 hectares for the whole of Germany, most of which was HNV farmland of a lower nature value before.

To analyse effects of CAP measures using HNV farmland data it is necessary to check how far changes due to the respective measures, such as EFAs as part of greening or cross compliance, can be reflected in HNV farmland proportions. It has to be noted that not all types of EFAs are included in German HNV farmland types – for example, agro-forestry areas or afforested areas are not included in HNV farmland surveys, and areas with nitrogen-fixing crops or catch crops would only be classified as HNV farmland if they are farmed with minimum intensity. A complete comparison of EFAs and the HNV farmland types that they represent is shown in Table 4-3. The elements covered by GAEC 1 and GAEC 7 of the cross-compliance obligations are fully represented by the HNV farmland types in Germany.

In the following, cross-compliance elements are included in the discussion about EFAs for better readability. A differentiation between cross-compliance and EFAs is not possible, because solely the landscape elements are recorded without further information on their administrative and practice management (e.g. if a hedge protected under Cross Compliance is registered as EFA or not).

Table 4-3 – Ecological focus areas (EFA) as defined in art. 46 of regulation (EU) 1307/2013 and equivalent HNV farmland types.

Ecological focus areas	**HNV farmland type**
(a) land lying fallow;	Br – set aside/fallow
(b) terraces;	– none –
(c) landscape features, including such features adjacent to the arable land of the holding which, by way of derogation from Article 43(1) of this Regulation, may include landscape features that are not included in the eligible area in accordance with point (c) of Article 76(2) of Regulation (EU) No 1306/2013;	H – hedgerows and copses G – ditches T – ponds N – stone walls R – herbaceous strips S – wetlands
(d) buffer strips, including buffer strips covered by permanent grassland, provided that these are distinct from adjacent eligible agricultural area;	R – herbaceous strips
(e) hectares of agro–forestry that receive, or have received, support under Article 44 of Regulation (EC) No 1698/2005 and/or Article 23 of Regulation (EU) No 1305/2013;	– none –
(f) strips of eligible hectares along forest edges;	– none –
(g) areas with short rotation coppice with no use of mineral fertiliser and/or plant protection products;	– none –
(h) afforested areas referred to in point (b)(ii) of Article 32(2) of this Regulation;	– none –
(i) areas with catch crops, or green cover established by the planting and germination of seeds, subject to the application of weighting factors referred to in paragraph 3 of this Article;	– none –
(j) areas with nitrogen-fixing crops.	– none –

Equally important is the fact that under German HNV farmland rules not all EFAs will be classified as HNV farmland. So for example set aside and fallow plots only are included in HNV farmland if they feature at least four relevant key plant taxa indicating species richness. On the other hand, not all HNV farmland of a given type will be eligible as an EFA, since for example many landscape elements recorded as HNV farmland will not lie on or directly next to an arable field.

The amount of EFAs reported by the German farmers in 2016 is listed in the following Table 4-4.

Table 4-4 – Amount of ecological focus areas (EFA) in Germany in 2016
Source: Bundesregierung (Bundesregierung, 2016).

Type of ecological focus area	area [hectares]
(a) land lying fallow	209,265
(b) terraces	2
(c) landscape features	30,547
(d) buffer strips	20,855
(g) short rotation coppice	2,474
(h) afforested areas	975
(i) catch crops or green cover	938,074
(j) nitrogen-fixing crops	175,646
total	1,377,837
only possible HNV farmland (a, c, d)	260,667
only landscape features (c) and buffer strips (d)	51,402

All increases and decreases shown in Table 4-2 are net developments. So an increase in, for example, set aside and fallow areas of 50,000 hectares may comprise losses of 30,000 and gains of 80,000 hectares. For further analysis only HNV farmland area in 2015/2016 was included in the calculation which had not been classified as HNV farmland in 2011/2012. The results for the relevant HNV farmland types are shown in the following table.

Table 4-5 – Area and proportion of HNV farmland first recorded in 2016

n = 506 sample plots (reduced sample size); Columns: proportion = proportion of HNV farmland in agricultural area, area = absolute area of HNV farmland with “from” and “to” denoting the limits of the mean ± sample error.

HNV farmland type	proportion	area [hectares]		
		mean	from	to
all HNV farmland	1.3%	280,998.02	249,611.17	312,384.87
set-aside/fallow	0.2%	39,269.30	24,990.27	53,548.34
hedgerows and copses	<0.1%	7,936.46	6,540.34	9,332.57
complex elements	<0.1%	1,233.24	951.23	1,515.25
dry stone walls	not calculable due to small sample size			
herbaceous strips	<0.1%	9,077.47	7,481.71	10,673.22
wetlands	<0.1%	4,799.17	3,962.90	5,635.44
ponds	<0.1%	972.69	579.54	1,365.83
ditches	<0.1%	3,175.13	2,538.92	3,811.34
all potential ecol. focus areas	0.3%	66,488.00	51,781.03	81,194.97
all potential ecol. focus areas, fallow excluded	0.1%	27,218.69	24,415.77	30,021.61

According to the general results shown in Table 4-2 all types of HNV farmland that could count as EFAs increased their proportion in the agricultural area, with the sole exception of complex elements. However, only the increase in hedgerow area was significant in this period. If all these HNV farmland types are grouped into a single category “ecological focus areas”, the proportion in 2016 is 3.0% which is an overall increase of 8% to 2012. But again, this increase is not statistically significant.

If one compares the amount of EFAs reported in 2016 in Table 4-4 with the HNV farmland area in 2016 according to Table 4-5, two important facts become clear.

Firstly, fallow and set aside forms an important proportion of EFAs as reported by farmers (15% of the total), but contribute only partly to HNV farmland. In the best case, only 62% of all set aside and fallow is HNV farmland. Taking the lower bound of the sample error into account, the proportion may even be as low as 37%. The area newly left fallow in 2015 or 2016 amounts to only 19% of all fallow as reported as focus area.

Secondly, the area of HNV landscape features vastly exceeds the area of landscape features reported as EFAs. If all potential HNV features according to Table 4-5 reported in 2016 really were HNV farmland they would amount to 12% of the corresponding types of existing HNV farmland.

4.2.4 Discussion

The question we tried to answer in this report is if the new EFA-requirement or agri-environmental measures will lead to an increase of HNV farmland in Germany. The answer must necessarily be preliminary, since only about half of all HNV sample plots have been surveyed in the field since the introduction of the CAP 2014-2020, particularly the introduction of EFAs, but the following points are noteworthy.

1. Two major components of EFA reported by German farmers in 2016 are catch crops / green covers and nitrogen fixing crops. These are not distinguished as such in the HNV farmland methodology. If EFAs of these types feature at least four of the characteristic taxa required for classification as HNV farmland in Germany, they would be recorded as HNV type “arable”. Unfortunately, the crop type is not recorded in HNV surveys, so the amount of EFAs among HNV arable cannot be determined. It is known, however, that by far the largest part of HNV arable occurs on cereal crops.
2. Fallow land is an equally important part of EFAs reported by German farmers. When HNV fallow is compared directly between 2011/12 and 2015/16 (Table 4-2) a marked increase can be detected. However, the amount of HNV fallow is considerably lower than the amount of EFAs of the type fallow as reported by German farmers in 2016. So while the increase in HNV fallow may partly be due to EFA regulation, by no means all EFA fallow contributes to an overall increase in biological diversity in the agricultural landscape as measured by the HNV farmland monitoring.
3. Landscape features and buffer strips are to date not a major component of German EFAs, comprising only 3.7% of the total. If one takes into account that the amount of existing HNV landscape features with 477,109 hectares in 2016 is distinctly larger than the 51,402 hectares reported by farmers it is very doubtful if EFA regulations can act as an incentive to create new landscape features and thus improve biological diversity with that particular means.

   The HNV farmland indicator in Germany to date works purely as a baseline indicator recording the amount of HNV farmland and its change regardless of the underlying reasons. This is mostly due to the fact that all data on agricultural funding are the prerogative of the states and fall under rather severe data protection measures. This has to be taken into account when discussing the above points. To date one can neither determine where there are EFAs of the types (a), (c), and (d) according to Table 4-3 in the HNV sample plots nor if actual HNV farmland in the plots owes its value to a recent designation as EFA or to other reasons. This is especially important in the context of fallow, with large parts of EFA fallow obviously not being classified as HNV farmland.

The methodology to record and calculate HNV farmland in Germany has been unchanged in all major points for several years now, so the comparability of data across different years is very good. It is highly recommended to repeat a study similar to the one reported here after completion of the field season 2018, when for all regularly surveyed plots data from before and after the introduction of EFA regulations are available. It will be especially interesting if the upward trend of fallow remains stable. This could be the case if land that became fallow with the introduction of EFA becomes more species-rich and therefore acquires HNV farmland status. It must be remembered in this context that the amount of HNV fallow recorded in 2016 – notwithstanding the increase in the last few years – still is considerably and significantly lower than in 2009, when the first baseline for the HNV indicator war recorded in the field.

4.2.5 Calculation of monitoring costs

The latest estimation of the German HNV monitoring programme's costs stems from 2015 and analysed the states' external running costs for the contracted field surveys from 2009 to 2013 and the BfNs external costs for coordination and quality control in the same period. Annual surveying costs differed greatly depending on the complexity of the plot and ranged (for the years 2010 to 2013) from less than €200 to over €800 per sample plot with average costs of €400 to €500 per sample plot (od 1,000 ha each). Roughly €50,000 were estimated for annual coordination, data processing and quality control. Thus, the overall costs for the surveying period from 2010 to 2013 were €170,000 per year. No data are available for the running costs for data administration at either federal or states' level.

4.2.6 Challenges and improvements

As mentioned in the discussion, to date the German HNV farmland indicator only works as a baseline indicator. If and where changes in HNV farmland are due to changes in the Common Agricultural Policy cannot be determined at the moment. This is mainly due to the fact that all funding data are personalised and therefore under strict data protection guidelines. Discussions among the states' representatives responsible for HNV farmland and with the BfN to remedy this situation are ongoing, but will probably not lead to a definite improvement in the near future. Trials in the last two years to ask the surveyors to the assess reasons for changes in the field, if only in a few coarse predefined classes, have not resulted in success. Without access to spatially explicit data on funding areas on the sample plots, calculation of an HNV impact indicator with the same precision as the baseline indicator will in all likelihood not be possible.

A major shortcoming of the current methodology is the fact that only actual HNV farmland is recorded in the field and stored digitally. No field data are available for all agricultural land that is not HNV farmland at the time of the survey. This complicates the assessment of the reasons for change because one can neither determine the origin of newly appearing HNV features nor the fate of disappearing ones. In fact, the original draft methodology envisaged recording and storing of all agricultural area during the HNV field surveys, but this provision was eliminated due to cost reasons. Partly in recognition of this shortcoming the BfN has started another project in 2016 with the aim to develop and test a methodology for a general land use and habitat survey on the HNV sample plots. Results of this project are expected for 2019.

Like all data based on a sample, the HNV farmland values and their changes reported are estimations with an error. With the actual sample size of 1,278 sample plots, major changes can be detected with adequate statistical significance for the whole of Germany. However, on a regional scale, e.g. the states' level (NUTS 1), the sample size is frequently too small to detect changes in individual HNV farmland types. Several states have therefore increased the size of their sample in the last years to reduce uncertainty, and more states are to follow. Thus they are able to receive statistically sound results for their state (as the federal sampling only allows a statistically sound result on federal level).

4.3 Summary of case study results

The case studies based on the experiences and data from the European LISA approach and the German HNV farmland monitoring revealed a number of interesting aspects regarding the availability of biodiversity-related data as well as the setting-up of a monitoring scheme. In the following, these results are summarized.

Sampling design

- The selection of sampling plots differs for the two studies: for LISA, homogeneous regions were selected within which sampling plots were distributed in a regular 5 x 5 km grid; HNV farmland monitoring in Germany is based on a stratified selection of sample plots based on an existing set of plots used for the monitoring of common breeding birds. For HNV farmland, two sample sizes are calculated: on the national scale, a total of 1000 plots are surveyed, whereas for the data collection at state level the number can be increased, depending on political and budgetary decisions. A joint data interpretation with results of the HNV farmland monitoring and the common breeding birds are not available up to now.
- Both approaches are based on an area survey and vegetation transects, for which LISA uses 500 x 500 m plots, HNV farmland monitoring uses plots with 1000 x 1000 m. A quantification of the monitoring effect of the different plot sizes is not possible due to the different monitoring approaches. The land use units (parcels and landscape elements) of these plots are mapped in the field and digitized with GIS.
- Survey cycle: for the HNV farmland monitoring, complete data sets are obtained every fourth year (1/4 of sampling plots is surveyed per year); the LISA study collected data in 2014 and 2016.

Data availability

- Complete data sets for the German HNV farmland monitoring at state-level are available for 2013 and will be for 2017. For LISA, data from 39 regions in 10 European countries are available for 2014, of these, data from 6 countries (13 regions)
  are also available from a survey in 2016.
- HNV farmland monitoring concentrates on land use units that have a high nature value (above a threshold of key taxa), therefore structural and vegetation information are only available for agricultural parcels or patches of land classified as with “high nature value”. In the LISA survey, all agricultural area was recorded within the plots and a fixed number (= 4) of transects were walked in grassland, arable land or fallow land.
- For arable land, the crop or type of culture and for grassland the type of grassland was recorded in the LISA survey but not in the HNV farmland monitoring, which only differentiates grassland, arable land, set-aside/fallow, orchards and vineyards.

Evaluation options

- Whereas the LISA survey had been conducted in several European countries, using the same methodology to obtain comparable data, the HNV monitoring described in the case study is applied in Germany only and data at national-scale as well as for the federal states is obtained. Though the HNV farmland indicator is used at the European-scale, no consistent methodology for data collection is implemented so far across EU MS.
- With the LISA approach, data is available for the same plots in a time series, so that direct detection of structural and quality change is possible. For HNV farmland in Germany, complete tracking of each parcel within a plot is not possible, because only areas qualified as HNV are recorded within the survey years.
- For both approaches, direct evaluation of policy effects such as greening of the CAP is currently not possible, since funding information at parcel level cannot be recorded in the frame of the surveys.
- Change recording is crucial for the evaluation of monitoring data: surveyors should be obliged to record the reason for changes in the structure (e.g. extent of landscape elements) and quality of the recorded parcels so that during data interpretation the real changes can be detected and can be differentiated from corrections that were made because of errors in a previous survey or due to different photo interpretation. This experience is one of the key experiences in HNV farmland monitoring in Germany.

Implementation of the monitoring system

- Proper training of field surveyors is important for a high data quality.
- Quality control of data is necessary, and control mechanisms need to be implemented either directly during data entry and/or manually by a controller at the desktop.
- During the LISA survey, errors occurred because inconsistent data entries were made (e.g. landscape elements above maximum size or key species were recorded with synonyms). Digital entry software with cross-checks and plausibility control would help to improve the data quality and reduce the effort for corrections.
- Positive experiences were made when the same surveyors are available for the survey campaigns, because they are already familiar with the methodology and at best know the plots from the previous survey cycle. With changing surveyors, a new error might be introduced, e.g. because different knowledge about key species or different interpretations of nature values.
- Continuity and extent of the monitoring system depends on the available budget. Proper funding for a minimum sample needs to be ensured in order to obtain enough data for the desired level of analysis. Therefore, a flexible system as it is implemented for the HNV monitoring in Germany (fixed sample size for the national-scale that can be enlarged for the requirements at federal state level) might be appropriate.

5 Results and discussion

5.1 Task 1 – Data identification

Since the knowledge of the decline of biodiversity in agricultural landscapes is increasingly in the focus, the need of sound monitoring systems as baseline for further policy decisions, protection measures or scientific research is acknowledged (cf. Herzog & Franklin, 2016). In their review, Herzog & Franklin (2016) identified already 11 major monitoring programmes in Europe and North America, which are operational at the regional, national or international level. The literature survey that was conducted to inform the development of the EMBAL methodology further included monitoring approaches which are not operational (yet), but refer either to the European context or one or more MS.

5.1.1 Literature review of existing monitoring approaches

The literature review revealed a total of 16 monitoring approaches or projects which are considered relevant for the EMBAL study in the first step. These are:

AGRIT/AAE – Agro-Environmental Survey Italy

In the Italian approach, quantitative and qualitative environmental information are collected in a statistical survey, covering agricultural and agro-environmental parameters.

ALL-EMA – Agricultural Species and Habitats Monitoring Programme Switzerland

The Swiss monitoring programme aims at determining the state and changes in species and habitats of the open agricultural landscape by field surveys.

BDM – Biodiversity Monitoring Switzerland

This biodiversity monitoring is based on field data collected for different taxa of plant and animal species in Switzerland’s normal landscape.

BioBio – Indicators for biodiversity in organic and low-input farming systems

This European project developed a set of indicators applicable at farm level to monitor biodiversity. Field surveys and soil samples were combined with farm questionnaires.

Biodiversity Monitoring Northrhine-Westfalia, Germany

The German approach aims at continuous observation of habitats, quantitative measures of vegetation and key animal taxa based on field surveys and also includes a monitoring of genetically modified organisms.

EBONE – European Biodiversity Observation Network

The project aimed at developing a methodology for the collection of biodiversity data at the regional to the European scale, based on field surveys and remote sensing and field sampling.

French Flower Meadows approach – France

In the French approach, a list of key species was developed to allow comparable assessments of grassland vegetation diversity across different environmental conditions.

GBCS – Great Britain Countryside Survey and **NICS** – Northern Ireland Countryside Survey

In Great Britain and Northern Ireland, a combination of satellite photo interpretation and field survey is used to record change in the landscape.

HNV farmland Germany– High Nature Value Farmland Survey Germany

To inform the reporting of the HNV baseline indicator, Germany conducts a monitoring based on field surveys, where land cover, vegetation and according value of parcels is recorded.

HNV farmland Portugal – High Nature Value Farmland Survey Portugal

In contrast to the German field survey approach for HNV assessment, the Portuguese HNV monitoring is based on the interpretation of satellite images to detect changes in the extent of HNV farmland.

LISA – Landscape Infrastructure and Sustainable Agriculture

This European-wide monitoring approach is based on areal mapping and the record of biodiversity data through vegetation transects and focusses on the agricultural landscape.

LUCAS – Land Use/Cover Area frame Survey

The LUCAS field survey is conducted at the European scale and collects information about the land cover and land use and further parameters at defined points. A grassland and soil module are added to record further data.

NILS – National Inventory of Landscapes in Sweden

The Swedish monitoring approach consists of aerial photo interpretation, field inventory regarding land cover and use as well as vegetation records.

PECBMS – Pan-European Counted Bird Monitoring Scheme

The aim of this European-wide scheme is the monitoring of common birds through field surveys at national levels. Data aggregations are then used to calculate indices and trends at the EU-level and inform policy makers and the public.

QuESSA – Quantification of Ecological Services for Sustainable Agriculture

Through 16 case studies, the projects aimed at quantifying key semi-natural habitats that deliver important ecosystem services such as the prevention of soil erosion. Data was fed into models ranging in scale from farm to EU-level.

In total, we looked at 13 out of the 16 approaches more closely. The results of the analysis are presented in Table 10-2, Annex B. Four approaches of the initial set were excluded because they did not focus on an in-situ assessment of biodiversity (QuESSA, HNV Portugal) or were considered as too specific, as in the case of the French Flower Meadows or the Biodiversity Monitoring North Rhine-Westphalia, Germany. Out of the resulting 13 approaches, 8 were considered of main relevance for the development of a European-wide biodiversity monitoring. Therefore, a summary for each approach is provided in Annex C. From the main relevant monitoring approaches, we extracted the indicators related to biodiversity and farming. In total, this revealed a set of 57 parameters, which are related to land cover, habitats and vegetation records. The full set of parameters is presented in Table 10-3, Annex B.

5.1.2 Data comparison

In a next step, we compared the spatial and temporal scale, the ability to record changes and the usability as tool to track the effect of certain measures, e.g. as result of environmental or agricultural policies of the identified approaches. An overview of the different monitoring approaches is provided in Table 10-2, Annex. The comparison revealed the following general findings:

- Out of 13 approaches, 6 are applicable at the European scale, 8 approaches cover monitoring data at the national level. Four approaches are applicable at both national and European scale.
- The scale of square plots ranges from 250 x 250 m (6.25 ha) to 1000 x 1000 m (100 ha).
- The majority of approaches is based on field surveys, recording in-situ data, or a combination of remote sensing and field sampling (7 and 5 approaches, respectively, see Table 9-2, Annex B).
- 9 out of 13 monitoring schemes are already part of a regular monitoring program, however with differing repetition cycles (ranging from yearly cycles to rolling cycles in a 5-year cycle).
- Most approaches assessed parameters of farmland/ arable land as well as habitats (10 and 12, respectively).
- For the direct assessment of biodiversity parameters, the approaches used data based on:
  - Plants (10)
  - Birds (5)
  - Insects (4)
  - Soil fauna (1)
- In general, 6 approaches have the ability to track measures potentially related to the CAP (e.g. through recording landscape elements such as hedges, buffer strips and/or legume cover). However, none of the approaches directly focused on the direct assessment of agricultural or environmental policy measures.

The identified monitoring approaches differ in their scaling and therefore also in the effort and time needed for the monitoring. Whereas in some approaches certain indicators like plants and insects need to be assessed several times per year, other approaches have a lower effort and only one visit per year, however the visit needs to be done in a certain time frame (e.g. before the first mowing cycle).

A particular focus was put on those monitoring schemes which are operational at the European level and provide data on biodiversity parameters. These are:

- PECBMS, which feeds into the Farmland Bird Index (FBI);
- HNV farmland monitoring, which together with the FBI inform biodiversity indicators used for the evaluation of the Rural Development Programme supported under CAP Pillar 2;

- LUCAS, which provides harmonized data on land cover and land use for European MS;
- The LISA approach, with which biodiversity and agricultural landscape data were collected in 2014 and 2016 in 10 European countries.

While the FBI is used as biodiversity indicator at EU level and “the best available dataset and also indicative of general environmental status” (Eurostat, 2016), the Synthesis report of the Mid-Term Evaluations of the RDPs (2007-2013) showed some weaknesses of using the FBI as biodiversity indicator on a large scale (EC, 2013). For policy evaluations based on this indicator, the limitations included that “trends in many cases cannot be measured due to insufficiently frequent data collection; where trends are measured, the causal links with the RDP cannot be demonstrated; for some RDP the FBI is stated as completely inappropriate for the kinds of measures being used, which are not anticipated to affect farmland bird populations” (EC, 2013, p. 122). In general, the analysis of effects of policy measures may need some time until they are reflected in bird data.

Besides some shortcomings in the usability of the FBI for the evaluation of the RDPs, the PECBMS as monitoring approach is a great source of data on birds and benefits from the continuous record of data for 167 species and indicator values for more than 35 years (from 1980 onwards). Most of these data are recorded by volunteers and fed into national and European platforms like www.eurobirdportal.org. With the great extent of available data at temporal and spatial scale, an important dataset regarding birds is available for EU MS.

The HNV farmland monitoring data feed into the objective-related HNV farmland indicator at European scale. The HNV farmland indicator is used as a context and impact indicator for monitoring biodiversity for the Common Agricultural Policy. This objective-related indicator is part of a set of agri-environmental indicators that inform environmental concerns of the CAP. For the HNV farmland monitoring there exist 24 different approaches in 28 Member States (Peppiette et al. 2012); partly they focus on aggregated data from different agricultural data, partly they focus on fixed area data (e.g. nature reserves) and only one approach is based on field data, thus no harmonised methodology is defined on EU-level. Data comparability and reliability across MS therefore is difficult (European Commission, 2013). However, the HNV farmland indicator has induced the development of different monitoring approaches and projects, such as e.g. CC-LandStraD (Climate Change – Land Use Strategies; cf. Klimek & Schmidt, 2010) and some of the parameters developed are used in this study to further develop a common European approach. Especially the HNV monitoring at national scales is of interest in this regard, with a particular focus on the German approach since it is up to now the only one based on field surveys, carried out in a dense time frame (Peppiette et al. 2012, see also case study Chapter 4).

The analysis of existing approaches and current literature on biodiversity monitoring shows that comparable and robust biodiversity data in agricultural landscapes are missing at the European scale. There is no common basis for measuring or monitoring biodiversity, even when necessary for informing the impact indicators of the European programmes like in the case of the Farmland Bird Index. A first attempt to establish such a common basis can be seen in the LISA approach, because it focuses on the total agricultural area and aims at covering all EU MS. Though in the first two surveys not all MS could be covered due to budgetary constraints, the methodology and existing data can be regarded as a basis for the EMBAL approach.

Additionally to the great number of national and international monitoring programmes, the analytical framework for Mapping and Assessment of Ecosystems and their Services (MAES) is an important tool to produce synergies between the different data sets already available for the evaluation of ecosystem services – also related to agricultural ecosystems.

The results of the data comparison show that it will not be possible to establish a baseline for the evaluation of European policies, especially the effects of the CAP 2014-2020, because evaluable data sets are not sufficiently available for earlier years. For this reason, we opt for a rapid implementation of a monitoring scheme in order to allow a rapid assessment of the status quo of the European agricultural landscape.

5.1.3 Effort estimations

The costs and effort that is needed for the assessment of parameters in a farmland biodiversity monitoring depend on the size of the plots, the distance to travel between plots, the required accuracy, the required expertise of field surveyors.

Within the BioBio project, a comprehensive assessment of the costs and effort for different parts of the field work has been done, of which the results confirm our focus on vascular plants as cost-efficient proxy for biodiversity.

Geijzendorffer et al. (2016) used a farm-based approach to estimate the effort and costs for the monitoring of different taxa (vascular plants, earthworms, spiders, bees). For a full vegetation record in vegetation plots of 10 x 1 m / 10 x 10 m, they estimated the time effort between 0.4 and 5.1 hours per plot. In case of the LISA study with transect walks of 30 m and the record of key species and species groups, the time effort for arable land is estimated 20 minutes, in grassland up to 40 minutes. The estimates for the recording of other taxa are provided in Table 5-1. Since the majority of identified monitoring approaches uses vegetation parameters as reliable proxy for biodiversity, we limit the assessment to vegetation records, also considering the effort and costs needed for the survey of other taxa, e.g. bees.

*Table 5-1 – Estimation of the effort needed for the survey of different taxa/biodiversity parameters, effort given per sample and per plot, assuming plots of 500 x 500 m. a – LISA approach, b – BDM Switzerland, * – BioBio, Geijzendorffer et al. (2016), c – Kühn et al. (2014).*

Taxa / parameter	**Effort per sample**	**N° of visits**	**Estimated effort per 25 ha per year (4 samples per 25 ha except butterflies + birds)[5]**
Key plant species (via transects) [a]	10-20 min per transect (30 m)	1	1 h
Birds (territorial mapping)	1.5 – 2.5 h (500 x 500 m)	3	5-7 h
Bees (via transects)*	2.8 h per 0.02 ha (100 x 2m transect)	3	30 h
Butterflies	0.5 – 2.5 km transect (5 min per 50m [c])	4-7 [b]	3-28 h
Spiders (via suction sample)*	4.5 h per sample (5 x 0.1 m)	3	54 h
Earthworms*	1.3 h per sample (30 x 30 x 20cm)	1	5 h

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[5] Effort estimation for 500 x 500 m plots (25 ha) based on the assumption that up to 4 transects/samples need to be taken for key plant species, bees, spiders and earthworms.

5.2 Potential synergies

The review of existing monitoring approaches had a twofold objective: on the one hand, it gives an overview of the methodological approaches currently established regarding the monitoring of biodiversity in agricultural landscapes. On the other hand, the review also examines opportunities for synergies between the already existing approaches and the EMBAL approach. Creating synergies has a great number of advantages:

- Facilitating the cross-comparison and analysis of data on biodiversity and thus informing the policy decisions.
- Additional information on survey plots through other monitoring programmes that help to evaluate the data received through EMBAL and vice versa.
- Joining efforts and reducing the risk of parallel assessments/monitoring as a linkage between different programmes and approaches is established.

Of special interest for the creation of synergies are the established European programmes and indicators, namely the HNV farmland monitoring, LUCAS, MAES (Mapping and Assessment of Ecosystems and their Services) and PECBMS (Pan-European Common Bird Monitoring Scheme). In the following, the identified fields for synergies are discussed. MAES, in difference to the other presented approaches, does not generate data but provides a framework in which results from a great number of programmes and indicators are compiled.

HNV farmland monitoring

- HNV farming (covering farming system as well as farmland) is established as context and impact indicator within the CAP Pillar I and II (2014-2020) (EC, 2016b);
- Heterogeneous methodology across MS, implemented at EU scale (EC, 2013) and used as agri-environmental indicator;
- Some HNV farmland monitoring approaches in EU member states are quite suitable for the assessment of semi-natural and low intensity systems; HNV indicator reporting is quite different depending on the method used for the different MS (EC, 2013);
- HNV farmland monitoring in Germany well established, delivers national data (Benzler, 2010);
- In Germany, unique field sampling approach for the assessment of HNV farmland (Benzler, 2010):
    - In-situ data recording
    - Selection of plots based on bird monitoring sampling (not a regular grid)
    - Plot size 1000 x 1000 m
    - Sampling takes place every 4 years (full data set after 4 years, 1/4 of the points per year)
    - Full data sets available for the years 2012/2013 and 2016/2017

LUCAS (Eurostat, 2017)

- Homogeneous survey carried out in all EU MS (Eurostat, 2016)
- Plots placed in a 2 x 2 km regular grid
- In-situ survey
- Point survey
- Grassland module with vegetation records from 2018 planned
  → in this study we adapted the grassland part to the LUCAS methodology

- Survey takes place every 3 years since 2006, latest data from 2015.

MAES (EC, 2014 and Biodiversity Information System for Europe, 2017)

- Overall framework for assessment of Ecosystem Services in EU and joint information platform for environmental data in EU MS
- Compilation of indicators related to the assessment of ecosystem services,
- Fed by many different programmes and indicators from national levels and EU-level, e.g. in relation to species and habitats.

Thus MAES itself does not generate data sets for the assessment but draws on existing data at regional/national or European scale; EMBAL could contribute data to a variety of indicators related to croplands and grasslands within MAES.

PECBMS (EBCC, 2017)

- Common bird monitoring as biodiversity indicator at EU scale (FBI)
- No homogeneous approach, differing methods per MS (see Annex C2 – Overview of bird counting methods for PECBMS) for an overview of the different methodologies used in the EU MS)
- Survey takes place since 2002, calculated indices are updated annually
- Extensive data set covering 167 bird species across EU member states, including 39 farmland bird species.

At EU-level, the FBI conducted from the data of the common bird monitoring programmes is up to now a commonly used indicator for environmental change and biodiversity (European Commission, 2013). Breeding bird populations as well as their assessment are subject to many factors varying between years, like for instance food availability and adverse weather conditions. It is therefore considered more meaningful to judge the indicator relative to a baseline year than to the previous adjacent year because of annual fluctuations (Eurostat webpage[6]). Within a farmland biodiversity monitoring scheme, bird indices would therefore be a useful addition for identifying long term trends due to for instance habitat quality loss or improvement, rather than for identifying the immediate, short term effects of agricultural policy measures.

Integration of farmland bird data into a farmland monitoring scheme at the regional level (e.g. NUTS classes) should basically be possible, but as the number of farmland sampling sites in Table 10-4 shows, the sampling of farmland habitat in some countries may not be sufficient at the moment. Although for consistency reasons a regional Farmland Bird Index should also sample farmland species anywhere rather than specifically count bird species within farmland, producing a reliable index will still require an adequate number of sampling sites within or near farmland habitat. Moreover, sampling the best spots for species of particular habitat types can be sufficient for establishing a national index, but may rest on very few if any sampling points in 'uninteresting' regions in any country. However, also these regions need to be reflected in reliable results in a farmland biodiversity monitoring, so that the design of the monitoring schemes need to account for this potential lack of data. It might therefore be necessary to check and extend the national schemes for those regions.

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[6] Retrieved from http://ec.europa.eu/eurostat/cache/metadata/EN/tsdnr100_esmsip.htm, last access September 29, 2017.

In Italy, data for farmland bird species were related to data about agri-environmental measures at regional scale and a study piloted in the region Emilia-Romagna between 2000 and 2012 (Calvi et al., 2013, Rossi & Calvi, 2013). The study analyzed the effect of the presence or absence of agri-environmental measures on FBI trends. For this relatively small scale (one region), bringing together information about agri-environmental measures and ornithological data showed to be a good yet time-consuming method to reveal the effects of particular policies. However, the study showed that knowledge about the agri-environmental measures as well as good biodiversity data are crucial for good results. EMBAL would contribute on the ground data about the extent of structures in the agricultural landscape; this information would be beneficial for approaches like in the Italian example.

5.3 Task 2 – Development of a methodology

With the results of the data identification and analysis as well as the experience of the contractor and the consortium in the recording of biodiversity and agricultural landscapes, a monitoring methodology has been developed, which allows a rapid assessment in the field, provides a sound methodology applicable across different regions in Europe and allows to track changes of biodiversity over time.

The drafted survey methodology had been discussed during a workshop with representatives of Directorate-General (DG) of the Environment, DG for Agriculture and Rural Development, EEA (European Environmental Agency), Eurostat, and the EMBAL project consortium. During the workshop, the issue of sensitivity in detecting change was raised as well as the choice of the monitored taxa group(s).

During the literature review as well as the workshop discussion, the need for a harmonization of the new approach with already existing monitoring schemes was stressed. Therefore, the proposed methodology aims at ensuring the synergy with the most relevant approaches at the European scale, namely the LUCAS approach, HNV farmland monitoring and MAES (Mapping and Assessment of Ecosystems and their Services). The harmonization applies particularly to the survey methodology, which is outlined in more detail in the following paragraphs.

5.3.1 Field survey approach

The draft for the field survey methodology combines the parameters from different established field survey methodologies, as indicated in Table 5-2. These are twofold: the area survey which records findings on land cover and land use as well as on features of landscape elements, and the vegetation survey which is based on transect walks. For these two methods, different survey sheets are developed that meet the challenges of each survey strategy which are illustrated in Figure 5-1) and explained below.

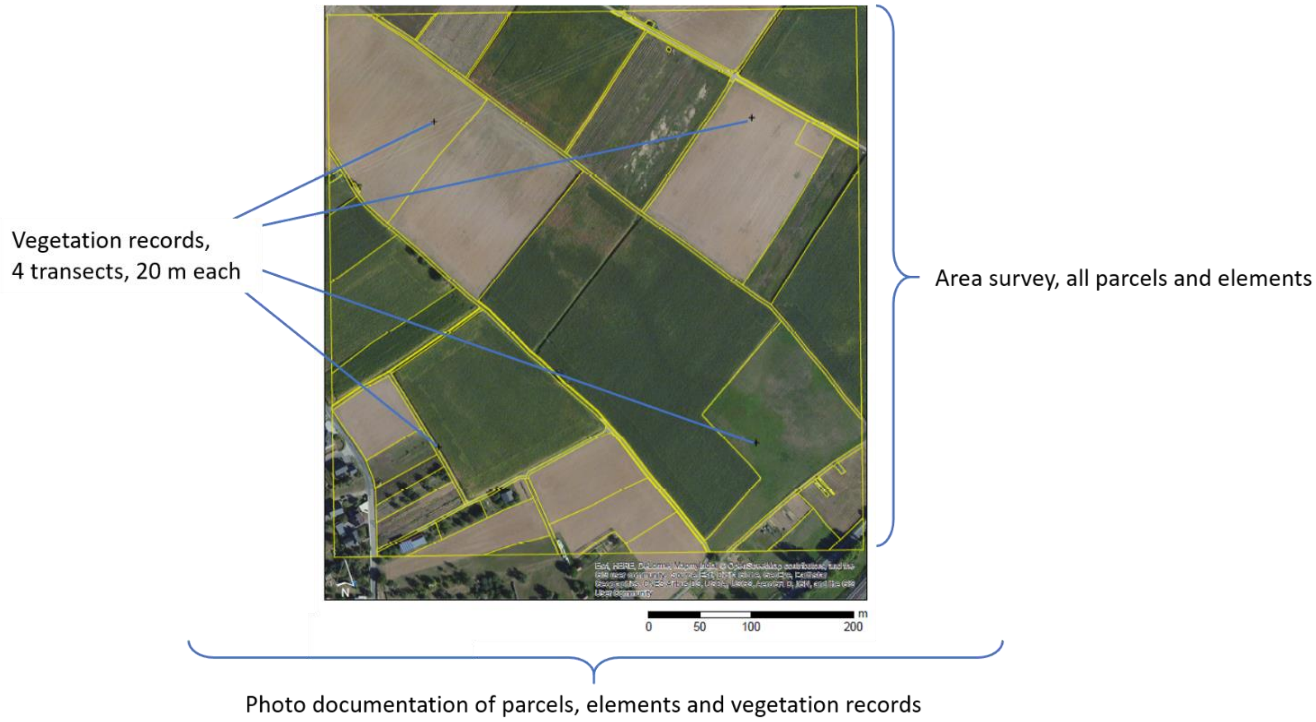

Figure 5-1 – Example plot and elements of the survey: vegetation records at 4 defined points, area survey of the whole plot, photo documentation during the area and vegetation survey.

Area survey

The parameters assessed via the area survey are represented in the main sheet. To assess the required information, the surveyor has to check the situation on the ground and record the parameters for each identified parcel in the defined plot. The results are marked on a satellite picture as well as in a table. The draft for the main sheet is given in Annex D – Field survey material.

Vegetation records

For the record of plant biodiversity data, a harmonization with major approaches at EU level is aspired. Therefore, the chosen method is the recording of key species and species groups on transect walks, as in the LUCAS grassland survey, the HNV farmland monitoring in Germany, and based on our own experiences with the LISA approach. The detailed methodology is described in the survey manual draft, which is attached Annex D – Field survey material. The use of key species has achieved a considerable distribution in Central Europe, e.g. in France, Switzerland and Germany (cf. Prairies Fleuries, 2013; LANUV NRW, 2016) and delivers reliable and comparable results with acceptable effort and costs. Therefore, the approach is suitable also for the application in other European countries.

For the EMBAL study, the key species list for grassland is harmonized with the list from the LUCAS grassland survey, which had been developed in 2016. The key species list for arable land is based on the expertise of the development of a key species list for HNV farmland monitoring Germany (personal information J. Hoffmann), the results of the European inventory conducted by Hoffmann (2012), and insights from the Biodiversity Monitoring Northrhine-Westfalia. Based on the results of the LISA investigations 2014 and 2016, the preliminary key species list for arable land had been developed further by analyzing the species and the frequency with which they were recorded in the different survey regions (e.g. Spain, Hungary, Germany etc.).

Photo documentation

In addition to the parameters recorded during the area survey and vegetation records, surveyors document the plot with photos of the whole plot (overview pictures), different elements such as landscape elements, arable fields, signs of ecological impact (e.g. erosion) and photos of the vegetation transects. The photo documentation is a useful tool to get a visual impression of the plot and the landscape, and serves as check for surveyors as well as controllers.

5.3.2 Parameter selection

For the development of the methodology, we draw on the results of the literature review and the approaches analysed above in task 1 and the hereby identified parameters/indicators (Table 10-3, Annex B). Out of the 57 identified parameters, we selected 29 parameters for further consideration. The decision about the inclusion of parameters was based on the following criteria (cf. UNEP 2003 in Dennis et al., 2009):

- Policy relevant and meaningful
- Biodiversity relevant
- Scientifically sound
- Broad acceptance
- Affordable monitoring and modelling
- Sensitive
- Representative

The criteria presented above were considered right from the beginning of the selection process, since all parameters refer to monitoring approaches implemented at national or European scale (cf. Table 5-2 and Table 10-3, Annex B). A criterion of major importance for the EMBAL study had been the affordable monitoring of the parameters, because EMBAL is designed as a rapid approach. The relevance for biodiversity and policy of course are crucial for the EMBAL parameter selection.

Besides the mapping of land cover and landscape elements in an area survey, the biodiversity parameters are related to the vegetation on grassland and arable land, since most of the existing approaches use vascular plants as proxy for farmland biodiversity (Herzog & Franklin, 2016) and vegetation surveys are most cost-efficient in terms of output and effort (Table 5-1). With the LUCAS grassland component which will be tested in a pilot study in 2018, a comprehensive and well developed approach for collecting biodiversity data in grasslands is already available. For reasons of harmonization of European approaches, we synchronized the parameters of LUCAS with the EMBAL methodology to achieve synergies through consistent data collection.

The parameters selected on the basis of the criteria above are presented in the following Table 5-2 and further outlined in the following paragraphs.

Table 5-2 – Parameters selected for the further development of the EMBAL monitoring methodology.

	Area survey	Parameter	Reference for parameter
1	**Land cover**	Type of land cover	All identified approaches
		Type of landscape element	HNV, EBONE, LISA
		Width of landscape element	HNV, LISA
		Nature value	HNV, Biodiversity Monitoring Northrine-Westfalia, LISA
		Change in the type, extent or nature value of land cover/landscape elements	HNV
		EUNIS habitat type	EUNIS
		Ecological impact	EBONE, LISA
	Vegetation survey	**Parameter**	**Reference for parameter**
2	**General**	Slope	LUCAS, LISA
		Exposition	LUCAS, LISA
		Number and list of key species	LUCAS, LISA; Biodiversity Monitoring Northrhine-Westfalia
		Site moisture	LUCAS, LISA, EBONE
		Flowering forbs	LUCAS, LISA
		Flower density	LUCAS, LISA
		Flowering colours	*Own suggestion*
		Number of key species	LUCAS, LISA
		Dominant species	LUCAS, LISA
		Species for structural characterization/problematic species	LUCAS, LISA
		Total coverage/bare soil	LUCAS, LISA
3	**Grassland**	Type of vigour	LUCAS, LISA
		Height of vegetation layers	LUCAS, LISA
		Number of vegetation layers	LUCAS, LISA
		Coverage of vegetation layers	LUCAS, LISA
		Grassland management type	LUCAS, LISA
4	**Arable land**	Height of crop	LISA
		Growth stage of crop	LISA
		Coverage of crop	LISA
		Coverage of wild plants	LISA
		Coverage of bare soil	Adapted from LUCAS
		Management type	LISA

Area survey

All biodiversity related data need to be linked to the current land cover and land use on agricultural land. Therefore, the EMBAL approach records the respective land cover for each parcel identified in the field. A comprehensive list of land cover codes is provided for the surveyors to guarantee comparable classifications. Land cover (such as permanent crops, grassland, forest or settlement area) as well as landscape elements (LE) in the agricultural area (solitary trees, hedgerows, ditches etc.) are recorded and their extent marked in a map with a satellite image as basis. For the maps, freely-available images might be used, e.g. derived from Google, Bing or a similar platform. Further, the access to the freely-available Sentinel-2 data might be an option[7]. In addition to the outlining in the map, the width of LE is recorded, since they might be too narrow to indicate their extent on a print-out only.

The nature value of is based on the degree of naturalness indicated by structure and species composition of a site; Nature value is used as proxy for the state of elements within the agricultural landscape and based on the degree of naturalness as indicated by structure and species composition of a site, e.g. a hedgerow with more than five different species and a diverse structure is assigned with a high nature value, whereas a hedgerow only consisting of *Prunus spinosa* has a lower value due to the homogeneous structure. The surveyors record the nature value for each agricultural element within the survey plot according to the characteristics and scale described in the survey manual (Annex 8.2). The data generated by the assessment of the nature value are important because:

- the nature value describes the current state of the agricultural landscapes;
- tracks changes in the state, i.e. naturalness, of the agricultural landscape;
- delivers information on the composition of the landscape at element level, plot level as well as at aggregated country level (e.g. ratio of hedgerows with high nature values compared to hedgerows with low nature values).
- In case an ecological impact is clearly observed at the parcel, e.g. gully erosion at a field without plant cover, these impacts should be noted. Examples for these kinds of impacts are provided in the field survey manual so as to guide the recording of such parameters. The data obtained by this parameter will give insights into the agricultural practice and possible changes, e.g. when an increase in fields with high erosion potential is noted in subsequent years of the study. The photo documentation of the recorded ecological impacts supports the evaluation of the data and could be fed into a database. An impact is recorded at a three-fold scale from 1 – potential impact (e.g. arable land on a steep slope) to 3 – strong impact (e.g. arable use on bog soils). Agro-environmental impacts in the following categories are noted:
- Water erosion
- Danger of water pollution on shallow soils
- Denitrification of organic/bog soils
- Direct application of plant protection products or their drift
- Drift of fertilizers
- Irrigation

Vegetation survey

For the recording of vegetation-related information, parameters are selected that need to be assessed during the transect walks described in the previous section. The parameters are adapted for transect walks in arable land and in grassland. For each vegetation record, site parameters as e.g. exposition and slope of the parcel is recorded, the site moisture is assessed at a scale from wet to dry, taking into account potential indicator species for each soil moisture class. The biodiversity information is related to the (wild) flowering species found in a transect. The parameters “number of flowering species”, “flower density” and

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[7] https://sentinels.copernicus.eu/web/sentinel/sentinel-data-access/access-to-sentinel-data;jsessionid=12381EA6DC84343F64A800FAA64E2DEE.jvm2 , last access November 27, 2017

“diversity of flower colours” serve as proxies for the species richness as well as for the pollination potential of the parcel by taking into account the key and non-key species. Additionally, they support the findings obtained from the record of key species. Cross-checks between a number of parameters is foreseen, e.g. the nature value of the parcel, the number of flowering species and the number of key species.

The selection of key species for arable land and grassland is based on species which are neither too common nor too rare and their composition mirrors certain types of grassland or arable land through characteristic species (e.g. moist/wet soils or vegetation on calcareous soils). This selection ensures that sufficient data can be recorded during transect walks (not too rare) but at the same time allows an unbiased qualitative evaluation (not too common). The presence of rare species might fluctuate considerably during the years and between habitats so that their record would not represent the general agricultural landscape.

Besides the general parameters, specific information is requested, depending on whether the transect is located in arable land or grassland. Regarding grassland, the parameter selection is harmonized with the LUCAS grassland module and mainly targets the structure of the grassland through data on the vegetation coverage, layers and heights as well as the mowing/grazing regime. The list of key species for grassland had been developed in 2016 for the LUCAS grassland survey (Eurostat, 2017). For each of the ten (biogeographical) regions defined for LUCAS, a regionalized key species list consisting of 20 key species (out of a list of 41 species) is provided, naming 13 additional species for structural characterization (such as thistles or docks). The harmonization with the LUCAS grassland module has the advantage of producing comparable results and benefits can be derived from the great amount of LUCAS points that are sampled with this methodology that might exceed the number of points sampled for EMBAL.

The vegetation transect in arable land also asks for some specific information on the particular crop of the parcel: the height and growth stage of the crop, coverage of the crop, wild plants and bare ground as well as information on the management type. Including additional crop related parameters allows conclusions regarding the intensity of use of the agricultural parcel, though the land use intensity cannot be measured in the field as such.

Land use intensity is an important parameter that can be cross-linked to a variety of biodiversity related monitoring parameters, e.g. regarding the abundance of wild species and land use intensity in arable fields. However, though the relevance of this kind of information is acknowledged by the project team, the assessment of land use intensity through an in-situ survey turned out to be rather difficult and not reliable for comparisons at the European scale. Difficulties were identified at different scales: at the local, plot level, the surveyor has no information on the level of input (e.g. fertilizers, herbicides etc.) for a particular parcel. This information is difficult to obtain, because farmers often cultivate land in different regions and already the identification of the farmer might be challenging in many European regions. But also on the country-level, the comparison of land use intensities is challenging, i.e. climate patterns and agricultural practice differ substantially. A very intensively used region in Germany looks very different from an intensively used area in Spain, where little rainfall and high temperatures might constrain growth of agricultural cultures, though input in terms of fertilizers is equally high.

The possibilities for data interpretation that arise through the selection of these parameters for the area and vegetation survey as outlined above are summarized in the following:

1. **Land cover and land use**:
    a. Area per land cover, diversity and number of different land covers
    b. Types of land cover
    c. Different land uses per land cover (e.g. extent of meadows / pastures / unmanaged grasslands etc. on permanent grassland)
    d. Area under intensive – extensive use for grasslands and arable land
        i. Grassland: intensity of use derived from type of vigour, number and kind of vegetation layers, species richness, flower richness/color diversity, use, assigned nature value
        ii. Arable land: intensity of use derived from type of vigour, species richness, flower richness/color diversity, use, assigned nature value
    e. Types and frequency of occurrence of ecological impacts (e.g. erosion, flooding, irrigation etc.), and changes of ecological impacts over time

2. **Landscape elements (LE)**
    a. Type and area of LE
    b. Types and numbers for linear LE / point LE
    c. Changes in extent of LE
    d. Width of linear LE, particularly regarding vegetation strips (flower/buffer strips for the potential evaluation of greening)

3. **Nature value of landscapes and of landscape elements**
    a. Estimation of nature values within surveyed agricultural landscape for the types of land cover and landscape elements, based on nature values (scale 1-5 with intermediary steps)
    b. Nature value of buffer strips along watercourses and hedgerows

4. **Habitat types (EUNIS)**
    a. Kinds and distribution of EUNIS habitats
    b. Area per EUNIS habitat type
    c. Nature value of EUNIS habitat types
    d. Interpretation of EUNIS habitat types related to other land use and biodiversity parameters

5. **Biodiversity parameters**
    a. Grassland (average species diversity from transect walks)
        i. (Change of) species diversity
        ii. (Change of) species composition (key species composition, extent of dominant/problematic species)
    b. Arable land (average species diversity from transect walks)
        i. (Change of) species diversity
        ii. (Change of) species composition (key species composition, extent of dominant/problematic species)
    c. Coverage of wild plants (per land cover/land use)
    d. Coverage with problematic/dominant species
    e. Coverage of wild plants in relation to
        i. total coverage
        ii. coverage of crop
        iii. open soil
        iv. degree of soil moisture

6. **Pollination potential**
    a. Number of flowering species (arable land/grassland)
    b. Coverage of wild plants (arable land/grassland)
    c. Type of crop (arable land)
    d. Nature value of LE
    e. Flower density

   f. Diversity of flower colors (arable land/grassland)

7. **Overview of plot and region nature values**
   a. Plot nature value
   b. Key parameters of the landscape

The interpretation of the pollination potential introduced above is especially relevant regarding the discussion about insects in the agricultural landscape and their importance as pollinators. Since pollinating insects depend on the nectar and pollen from the flowers of plants, the sufficient availability of flowering plants is crucial for sustaining insect populations. Recording data on the availability of flowering plant species (besides agricultural crops) therefore delivers important background information also for the evaluation of the pollination potential through pollinating insects.

Summing up the relevance of the methodology developed for the EMBAL study, the following points can be highlighted:

- EMBAL parameters are selected based on the premise of a rapid in-situ monitoring of biodiversity relevant parameters in the agricultural landscape;
- Parameters are mainly assessed through direct measurements in the field (e.g. in [cm] or [%]); nature values are assigned to all elements of the agricultural landscape, based on a defined scale and characteristics;
- All agricultural landscape is recorded within the plots (i.e. not only high nature value farmland);
- Precise information is collected on parcel level and by mapping on landscape level for arable land as well as grassland (complementing the LUCAS survey);
- Interlinkages between different parameters enhance the options for their interpretation as outlined above.

5.3.3 Plots to be surveyed

In European monitoring approaches, different plot sizes form the basis for the analysis, ranging from 250 x 250 m (6.25 ha as e.g. in the Italian AGRIT approach) to 500 x 500 m (25 ha as e.g. in NICS and LISA) and up to 1000 x 1000 m (100 ha as e.g. in EBONE, GBCS, HNV Germany). With the results from practical tests in the field as well as information from personal information and published literature, we compiled the effort that is needed for the monitoring of plots with the respective extents.

EMBAL will deliver data on the extent and state of agricultural parcels and landscape elements within the agricultural landscape. Therefore, the area to be surveyed needs be large enough to represent the mean values for landscape elements and arable land/grassland, but at the same time limits the effort for surveyors to a reasonable amount. Based on the experiences with existing monitoring schemes, Table 5-3 reflects the estimated average time needed for surveying different numbers of plots with differing structural diversity. Hereby, we draw on experiences with the LISA study: in complex landscapes like in southwestern Germany, an average of 34 land use units (parcels and landscape elements) were recorded, whereas in a large-scale landscape like in northeastern Germany only 12 land use units were recorded on average[8]. Therefore, we assume that in less structured landscapes the species diversity is lower than in highly structured landscapes and therefore calculate more time for transect walks in plots with high structural diversity (cf. Table 5-3).

We compared plot sizes of 250 x 250 m, 500 x 500 m and 1000 x 1000 m, which is illustrated in Figure 5-6. Besides the effort needed for one plot of the respective size, we also calculated the effort for aggregated plots of different numbers, e.g. arranged in a grid with a linear distance between the single plots of approx. 5 km (see layout of plots in the LISA study). For this distance we assumed a travel time of 10 to 20 minutes by car. Increasing the number of smaller plots to be surveyed in close proximity to each other allows the recording of an equal area as for fewer larger plots, but enhances the sample size for statistical analysis (cf. survey area of 100 ha: 16 plots with 250 x 250 m, 4 plots with 500 x 500 m, 1 plot with 1000 x 1000 m).

The time needed to survey an area with 100 ha depends on the number of plots, the structure of the plots and the travel time needed to reach the individual plots. For this reason, the minimum time effort would be needed for one plot with an area of 100 ha (ranging between 1.5 to 6.3 hours), whereas four plots with 25 ha each could need up to 16.7 hours in total (minimum 4.3 hours), depending of the complexity of the plots. For smaller plots of 6.25 ha each the travel time between the individual plots would already take 2.6 to 5.3 hours, decreasing the efficiency for this survey design. Given the calculations, the best trade-off between effort and data sensitivity is achieved with plots of 500 x 500 m.

Besides effort estimations which are a proxy for the costs associated with different plot sizes in different landscapes, we also compared the achieved levels of detailedness for the respective plot sizes. The level of detailedness is an important point of decision, considering that EMBAL will deliver data on landscape level (e.g. landscape elements, parcel information) as well as plant species data based on transects.

Therefore, testing for the level of detailedness of different plot sizes in different regions, we found that an optimum of detailedness and reasonable effort across European landscapes can only be reached with plot sizes of 25 ha: as shown in Figure 5-2, plots of 25 ha provide a good representation of the structural diversity of a landscape. The upper picture in Figure 5-2, showing a Spanish landscape, comprises approximately about 80 different land use units (parcels and landscape elements), whereas in the example of northeast Germany only about 7 land use units can be distinguished within a plot of 25 ha. For plots with an area of 6.25 ha, this difference in structural diversity would be less visible: for the German landscape, only one land use would be recorded, in the Spanish case approx. 25 elements. The data that would be collected in smaller plots would therefore in some European regions not sufficiently reflect the actual landscape. In contrast, plots with an area of 25 ha were found to be detailed enough to give an impression of the landscape structure while at the same time sampling effort is acceptable for both complex as well as simple-structured landscapes.

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[8] In both regions, 25 plots with 25 ha each were surveyed. The number of land use units in south-western Germany ranged from 10 to 72 (average over all 25 plots: 34 elements); in north-eastern Germany, the number of land use units ranged from 2 to 28 with an average of 12 over all 25 plots.

Table 5-3 – Overview of sampling effort required for different plot sizes and differing structural complexity of the surveyed area. Note: we assumed that in plots with a simple structure mainly species-poor parcels will be found. Time needed to travel between plots is calculated for approximately 5 km between plots, travelled by car. For the calculation, a survey with the methodology as described above is assumed.

Plot size	**250 x 250 m**				**500 x 500 m**					**1000 x 1000 m**		
Number of plots	1	4	8	16	1	4	5	6	8	1	4	5
Total survey area	6.25 ha	25 ha	50 ha	**100 ha**	25 ha	**100 ha**	125 ha	150 ha	200 ha	**100 ha**	400 ha	500 ha
Complex structure	30-90	120-360	240-720	480-1440	90-180	360-720	450-900	540-1080	720-1440	180-300	720-1200	900-1500
Simple structure	30	120	240	480	40-60	160-240	200-300	240-360	320-480	60-120	240-480	300-600
Transects (species-rich)	20-40	80-160	160-320	320-640	20-40	80-160	100-200	120-240	160-320	20-40	80-160	100-200
Transects (species-poor)	10	40	80	160	10	40	50	60	80	10	40	50
Travel distance between plots	10-20	40-80	80-160	160-320	15-30	60-120	75-150	90-180	120-240	20-40	80-160	100-200
Total effort (simple)	50-60	200-240	400-480	800-960	65-100	260-400	325-500	390-600	520-800	90-170	360-680	450-850
Total effort (complex)	60-150	240-600	480-1110	960-2400	125-250	500-1000	625-1250	750-1500	1000-2000	220-380	880-1520	1100-1900
Effort in hours, min and max values	**0.8-2.5**	**3.3-10.0**	**6.6-18.5**	**13.3-40.0**	**1.1-4.2**	**4.3-16.7**	**5.4-20.8**	**6.5-25.0**	**8.7-33.3**	**1.5-6.3**	**6.0-25.3**	**7.5-31.6**

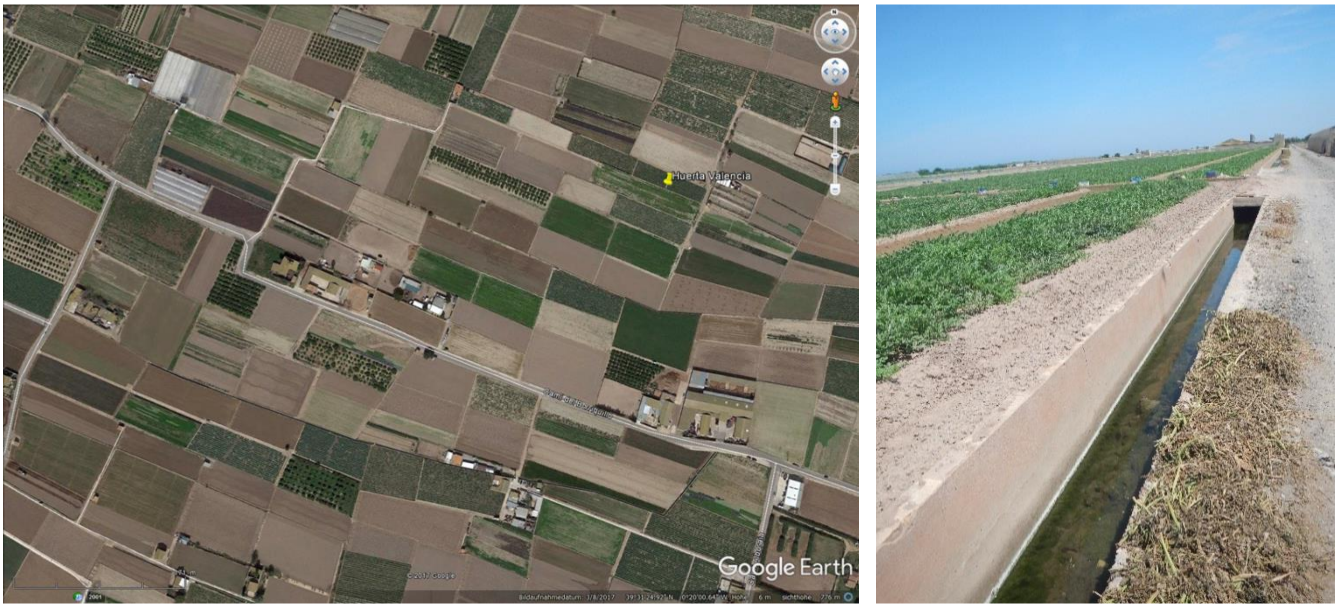
Figure 5-2 – Examples for the effect of different plot sizes in a complex landscape in southeast Spain (top) and in a rather simple landscape in northeast Germany (bottom).

5.4 Task 3 – Field test

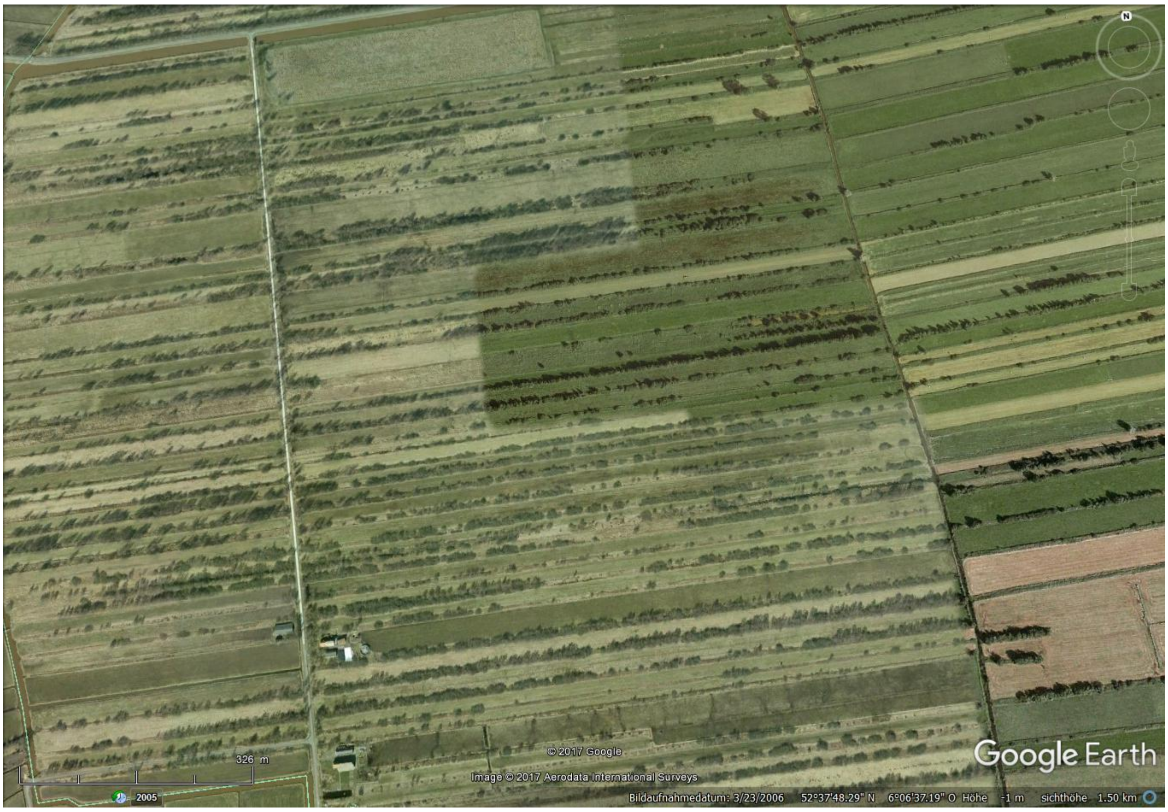
In this study field surveyors in five different European countries were asked to provide information on specific parts of the drafted survey manual and to the according survey methodology. An important aim of the field test was to get feedback if the methodology is applicable in the variety of landscapes and land cover types, test the parameters of the drafted methodology and collect examples of the landscapes in which the survey approach had been tested.

We asked the surveyors in Spain, Hungary, Czech Republic, the Netherlands and Germany to provide examples of more complex landscapes, which for example form a characteristic landscape or where the demarcation of different land cover types would be difficult. The following pictures show some examples of the feedback.

Picture 2 – Fruit orchards around Kirchheim unter Teck, Germany. Small parcels with orchards, great number of owners, transition to forest.



Picture 3 – The region of Huerta Valencia, Spain. Small-scale but intensive agriculture with frequent crop rotation, small ditches for irrigation and field tracks to access the fields.



Picture 4 – Small-scaled grassland parcels in the Netherlands, result of the partition of real estate. Hedgerows define the boundaries of the single grassland parcels.

The provided examples of the field test already show the diversity of different landscape structures and land uses. Whereas in Picture 3 the difficulty of recording the parcels lies its small scale and a crop rotation of up to three crops per year, the example from Germany (Picture 2) shows how difficult a demarcation of single parcels might be in case of a whole landscape patch. In the third example from the Netherlands (Picture 4), the landscape is very homogeneous but has a high number of hedges that demarcate the borders of intensively used grassland parcels.

In the German example, it might be useful to aggregate parcels with similar land use, e.g. fruit orchards with trees of about the same age and same quality of grassland, into a larger element and exclude the areas where the land cover/land use changes significantly, e.g. grassland without tree cover. In the following, examples are shown how surveyors proposed to aggregate landscapes in Hungary and the Czech Republic.

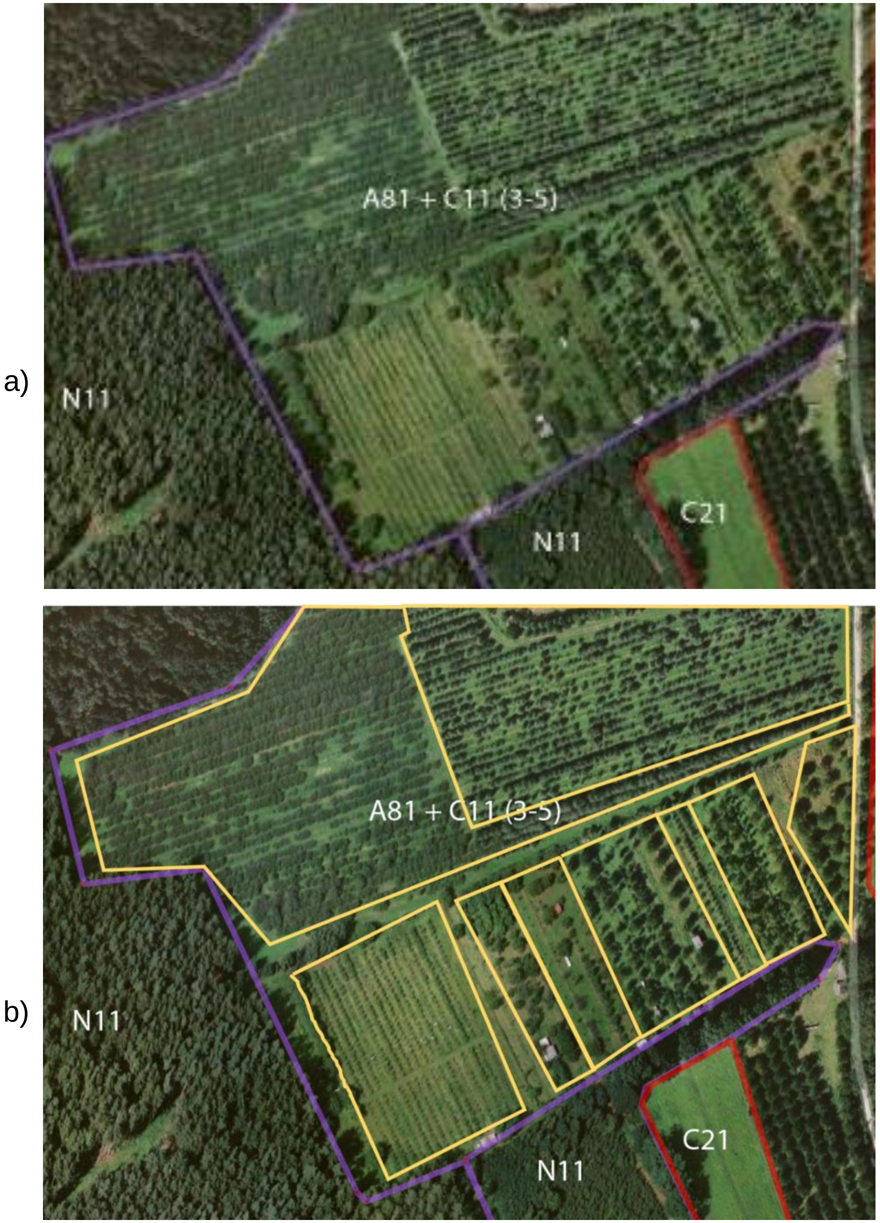


Figure 5-3 – Examples of how a surveyor would aggregate parcels with the same land cover in the Czech Republic. Land cover codes: A11 Wheat fields; A81 Apple fruit; C11(1-4) Grassland with trees (coverage from < 5% to 75%); C21 Grassland without trees; N11 Forest.

The proposed aggregations of apple trees with grassland (A81+C11(2-5) however need to be differentiated according to the age of the stands, as this influences the nature value of the parcel. The comparison of pictures a) and b) show the parcels which would – at least – need to be differentiated (marked with yellow lines in picture b).

Figure 5-3 shows an example from the Czech Republic, where the surveyor proposed to aggregate apple plantations with grassland (A81 + C11[1-4]) into larger complexes, because they are managed in a similar way. However, this example shows the difficulties of aggregation: obviously, the age of the fruit trees differs and parcels can be easily differentiated on the basis of the aerial images (see comparison of pictures a) and b) for a differentiation of apple plantations). When aggregated to a larger complex, change detection in the tree stands will be very difficult, since the data will not show if single parcels within the complex consist of dying trees, or if new trees are replanted. Therefore, an aggregation of several parcels is only feasible under the following conditions:

- The parcels have the same land cover
- The nature value of the parcels is equal for all aggregated parcels
- The aggregated area is largely homogeneous.

Besides the structural differentiation of land cover types, the quality of the understory is equally important for defining the boundaries as well as for assigning the nature value to the parcel. The pictures in Figure 5-4 show examples of how different the understory especially in permanent cultures can look like.

Figure 5-4 – Examples of vineyards (left side) and fruit orchards (right side) with differing management practices in the understory. In aggregated landscape units, the nature value of the vegetation between rows or grassland is a decisive factor. Upper left: ploughed, tall herbs beneath vines (Hungary), lower left: herbicide application, mainly grass species beneath vines (Germany); upper right: mulched grassland under apple trees, lower right: species-rich grassland under fruit trees.

The change of management practice therefore should always be reflected in the survey data to monitor change over time, e.g. if the grassland in the lower right picture will be mulched as well at the time of the future survey.

We further asked the surveyors to give feedback to the methodology for the transect walks in grassland, arable fields and fallow land. In general, the methodology had been approved and all parameters could be recorded with the survey sheets. The use of key species lists for the vegetation records were in general approved, however showed to be incomplete especially for arable fields in Spain. With the feedback of the surveyors, who proposed several plant species as potential key species, we further refined the key species list for arable land, but a thorough assessment of segetal species across Europe is necessary for the development of a sound key species list for arable land.

The pictures taken by the surveyors during the field test give valuable impressions of very different landscapes across Europe. Further, these pictures are a valuable and easily applicable tool for quality control: as they show the situation in the field, the pictures can be used to verify the data that the surveyors collected, e.g. regarding the recorded key species or the coverage of wild plants in arable fields (cf. pictures in Figure 5-5).

Figure 5-5 – Examples for biodiversity in crop fields across Europe: left – southern Spain, middle – the Czech Republic, right – Hungary. Pictures taken during transect walks give an impression of the density of the stand, growth stage of the crop and the coverage of wild plants.

In summary, the field test provided the following results:

EMBAL methodology

- The provided methodology is applicable in a great variety of European landscapes.
- In general, the comprehensiveness of the survey manual was approved. Notes were made when clarifications and more precise instructions were needed, which was used for the refinement of the manual.
- Monitoring of some landscapes might be difficult, because they are subject to frequent changes: examples from Spain show that landscape variables such as the width of field tracks change during one year as well as between different years because of frequent crop rotations. It is therefore crucial to be able to track reasons for change within the survey plots.
- A clear differentiation between buffer strips and grass-herb strips alongside roads and paths is necessary to allow more precise data interpretation. Further, a clear differentiation simplifies the work for the surveyors.
- A differentiation of complex landscape elements into two main elements is possible, e.g. for a stone wall overgrown with bushes and trees.

- In order to simplify the recording of homogeneous landscapes and reduce the time-effort, landscape units with a homogeneous land cover in terms of type and nature value can be aggregated.
- Landscape elements should always be recorded individually and can't be part of an aggregated landscape in order to be able to detect changes of their extent and quality.
- The list of key plants species in arable land was found to be incomplete for the Spanish context. A renewed review of potential key species that are appropriate in southern Europe might therefore be necessary to improve the biodiversity monitoring (see section on selection of key species in Chapter 5.3.2. A thorough consideration of the species could benefit the overall applicability in the southern European/ Mediterranean countries.

Data quality

- The field test showed that photos taken by the surveyors part of the survey (from landscape elements, vegetation transects) contribute substantially to the quality control, because they allow the verification of the surveyor's work.
- With the results of the field test it became also apparent that proper training for surveyors who are not familiar with area mapping is crucial.
- It is important to consider different legislations for the access to land in European countries.
- Quality control of the survey data is necessary. To facilitate the detection of change, surveyors should fill out an obligatory field in the survey protocol, if they record a change compared to a previous survey.

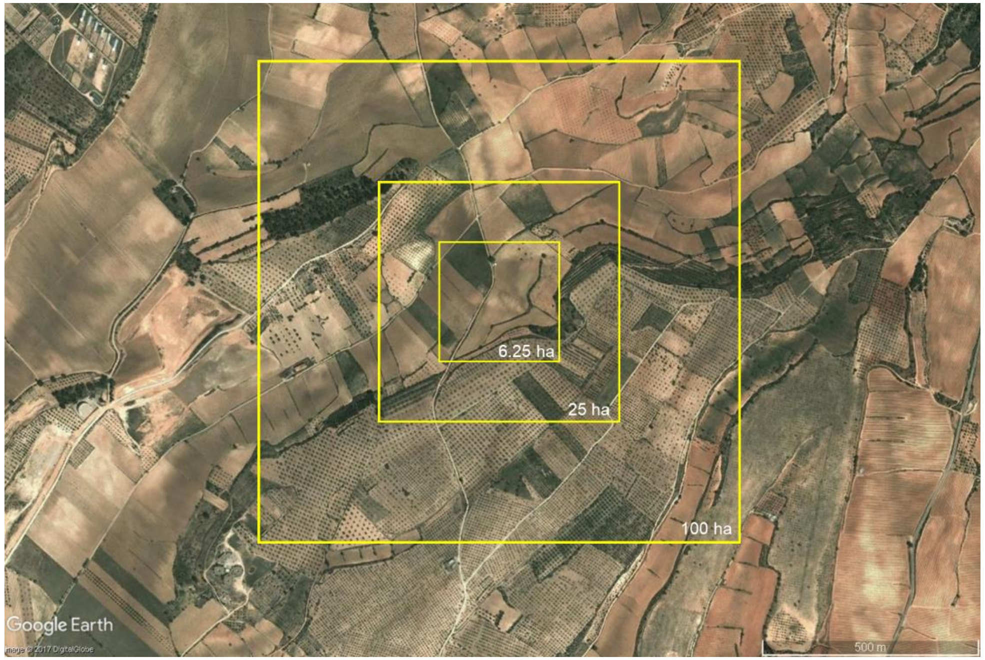


Figure 5-6 – The different plot sizes in three different landscapes in north-eastern Germany (left), southern Germany (right) and in western Spain (left below).

5.5 Overview of results of the tasks 1 – 3

The results of the data analysis and data comparison of existing monitoring approaches, the workshop held in Brussels, feedback from stakeholders and outcome of the HNV and LISA case studies guided the decision process for the development and final adaptation of the future EMBAL monitoring methodology. The parameters, their assessment and remarks considered during the refinement process of the monitoring methodology are shown in Table 5-5. The initial parameter selection followed criteria set by UNEP (2003 in Dennis et al., 2009). During the study, we followed two approaches: on the one hand, we checked the great number of available parameters from 13 existing monitoring approaches for their usability in the EMBAL approach and adapted parameters that proved feasible for the requirements of EMBAL. On the other hand, we sought for a synchronization with the LUCAS grassland approach and therefore harmonized the parameter selection as well as assessment related to grassland. The LUCAS grassland module had been developed in 2016 and will be tested in a pilot survey in 2018 across EU member states in around 3700 survey points. The pilot study, which will include a verification of the LUCAS grassland key species list, will deliver important results for the applicability of the grassland parameters and the use of the selected key species. With a harmonized approach, these findings are equally valuable for LUCAS and EMBAL and ensure extensive data collection with a sound methodology in the future. The characteristics of both EMBAL and LUCAS – their synergies as well as differences – are summarized in the following Table 5-4.

Table 5-4 – Synergies and differences between EMBAL and LUCAS.

EMBAL	LUCAS
Area survey (plot of 500 x 500 m)	Point survey on > 1 Mio points
Mapping information of a whole plot: information of land cover/use, but also on extent and share of different land uses, of landscape elements on field tracks, on hedges etc.	Point information only (one parcel): record of land cover/use on the point and other detail information
Nature value of all elements within a plot is recorded on a scale from 1 (low nature value) to 5 (high nature value)	
Up to 4 vegetation transects are conducted in each survey plot in arable land, grassland, fallow land. Grassland record is harmonised with LUCAS.	Vegetation transects only in grassland: pilot study in 2018; No transects in arable and fallow land.
Vegetation records in arable land and fallow land assess parameters related to pollination potential, wild plants and crop parameters	
No soil samples are taken.	Soil samples are taken on 10% of survey points to derive information on physical, chemical and biological (soil biodiversity) properties of the soil.
Ecological impact is recorded if visible, e.g. soil erosion	Visual assessment of soil erosion (potential) added in LUCAS survey 2018.
Continuous monitoring of all agricultural land use and landscape elements as well as of biodiversity parameters and structures	
Annual or at least 2-year monitoring cycle is proposed	Full survey every three years

For the record of changes in the area survey, we propose to apply the practiced approach of the HNV monitoring programme in Germany. There is an obligatory text field for explanations in the main sheet that needs to be filled for any change occurring in the field (in relation to the previous survey). The data controller has to be familiar with the methodology and will have to check all changes indicated by the surveyors by comparing the survey campaigns. The comparison should be done with the aerial images as well as the mapping of the surveyors from the current and previous survey. The controller has to confirm the indicated changes or has to request further explanations from the surveyors in case he/she is unsure if the changes really took place or if they arise due to different aerial photos or wrong interpretations. This procedure facilitates data control as well as subsequent data interpretation substantially.

The conclusions from the results for the EMBAL methodology are summarized in the following:

- EMBAL is a rapid approach based on an in-situ survey of plots with a size of 500 x 500 m (25 ha). This plot size yields an optimum ratio between survey effort and detailedness.
- 29 parameters have been selected and adapted to the specific requirements of EMBAL.
- The parameters are to be assessed in the field and deliver results at the area level (area and types of land cover/landscape elements, change in landscape structure, nature values for the types of land cover/landscape elements, area per EUNIS habitat type etc.) and at the transect level (coverage of wild plants in arable land, number of key species in grassland, arable land and fallow land, species composition, flower density etc. and respective changes in these parameters) (see the overview of possibilities for data interpretation on p. 42 of this report).
- Vegetation records with a list of key species/species groups are a feasible mean to compare the vegetation structure in the agricultural area across Europe. A pilot test of the LUCAS grassland module in 2018 will deliver information about the appropriateness of the grassland key species list. For arable land, such a study is needed to provide sound and comparable data.
- Other taxa of the agricultural landscape such as birds, bees, butterflies etc. provide valuable information but are by no means surveyable in a rapid and monitoring approach and they are relatively expensive (compared to vegetation monitoring).
- Data quality of the monitoring approach:
    - Training of field surveyors is of utmost importance for the data quality.
    - Monitoring of change is only possible when surveyors note the rationale behind changes that occur in the field.
    - Quality checks are necessary to guarantee consistent data that can be used for data interpretation. This includes plausibility tests, which can be automated by a digital data entry tool.

Table 5-5 – Overview of parameters included in EMBAL survey protocol, type of assessment, monitoring program, in which parameter is included and adjustments made to meet the EMBAL requirements.

Parameter **Main sheet**	Assessment	Reference for parameter	Adaptations
Type of Land Cover/LE with LC1 + LC2	Identification in the field	All identified approaches	Adaptation of definitions, introduction of new land cover codes/landscape elements when necessary
Width (+ length) of LE	Pace length	HNV, LISA	Threshold for the recording of length: only if LE > 20 m
Ecological impact	Type and intensity as observed in the field	EBONE, LISA	Review of types of impact and their identification in the field
Nature value	Scale 1 – 5 with intermediary steps	HNV LISA	Refinement of criteria set for valuation
Changes	Identification in the field	HNV	Adaptation of survey protocol, obligatory explanation introduced
EUNIS code for each LC	Automated during digital data entry	EUNIS	Translation of EUNIS habitat types to EMBAL LC/LE list
Photos			Defined set of photos to be provided by surveyors
Parameter – **Arable land**	Assessment	Reference for parameter	Adaptations
Transect information		LUCAS, LISA, HNV	Adapted from LUCAS grassland protocol
Photos		LUCAS, LISA	Adapted from LUCAS grassland protocol
Site exposition + slope	Identification in the field	LUCAS, LISA	Adapted from LUCAS grassland protocol
Site moisture	Classes from dry – moist	LUCAS, LISA, EBONE	Adapted from LUCAS grassland protocol, EBONE
Coverage of crop	%	LISA	Adapted from LISA
Coverage of wild plants	%	LISA	Adapted from LISA
Coverage bare soil/rocks	%	LUCAS, LISA	Analogous to LUCAS grassland protocol, adapted from LISA
Height of crop	cm	LISA	Adapted from LISA
Growth stage of crop	Scale 0 – 9	LISA	Adapted from LISA
Management type	Identification in the field		Introduced as new parameters; analogous to parameter from LUCAS grassland module
Number of flowering forbs	Counted	LISA	Adapted from LISA
Flower density	Scale few – many	LISA	Adapted from LISA
Flowering colours	Presence as observed		Introduced as new parameter
Key species list	Presence and abundance (in classes 1-3)	LUCAS, LISA, HNV	List adapted from LISA, information from J. Hoffmann
Sum of key species	Counted	LUCAS, LISA, HNV	Analogous to LUCAS grassland protocol
Coverage of dominant/problematic species	%	LUCAS, LISA	Analogous to LUCAS grassland protocol, list adapted from HNV Germany, LISA, information from J. Hoffmann
Parameter Vegetation sheet – **Grassland**	Assessment	Reference for parameter	Adaptations
Transect information		LUCAS, LISA, HNV	Harmonized with LUCAS grassland protocol

Photos		LUCAS, LISA	Harmonized with LUCAS grassland protocol
Site exposition + slope	Identification in the field	LUCAS, LISA	Harmonized with LUCAS grassland protocol
Site moisture	Class dry – moist	LUCAS, LISA, EBONE	Harmonized with LUCAS grassland protocol
Type of vigour	Scale 1 – 5 with intermediary steps	LUCAS, LISA	Harmonized with LUCAS grassland protocol
Total coverage	%	LUCAS, LISA	Harmonized with LUCAS grassland protocol
Coverage of different layers	%	LUCAS	Harmonized with LUCAS grassland protocol
Height of layers	cm	LUCAS	Harmonized with LUCAS grassland protocol
Number of layers	Counted	LUCAS	Harmonized with LUCAS grassland protocol
Grassland type	Type as observed	LUCAS	Harmonized with LUCAS grassland protocol
Number of flowering forbs	Counted	LUCAS, LISA	Harmonized with LUCAS grassland protocol
Flower density	Scale few – many	LUCAS, LISA	Harmonized with LUCAS grassland protocol
Flowering colours	Presence as observed		Introduced as new parameter
Key species list	Presence and abundance (in classes 1-3)	LUCAS, LISA, HNV	Harmonized with LUCAS grassland protocol, results from pilot survey in 2018 are expected
Sum of key species	Counted	LUCAS, LISA, HNV	Harmonized with LUCAS grassland protocol
Coverage of dominant species	%	LUCAS, LISA	Harmonized with LUCAS grassland protocol
Parameter – **Plot**	Assessment	Reference for parameter	Adaptations
Plot Nature Value	Scale 1 – 5 with intermediary steps	LISA	Adapted from LISA
Plot description		LISA	Adapted from LISA

6 Opportunities for policy evaluation

With a monitoring of biodiversity in agricultural landscapes, a time series concerning the development of landscapes and nature values can be drawn in the areas of the survey plots. The data recorded with the EMBAL approach allow the interpretation in a great variety of aspects related to (cf. p. 42):

- Land cover and land use
- Landscape elements
- Structure of the landscape
- Nature value of land use units and landscape elements
- Distribution and area of EUNIS habitat types
- Biodiversity-related parameters, including species distribution and coverage of wild plants
- Pollination potential of agricultural landscapes

This provides – at one hand – urgently needed reliable data at EU-level, and at the other hand the approach can display the change that is introduced through external influences, e.g. the Common Agricultural Policy. The change that is recorded in the frame of the EMBAL survey approach describes trends and is able to monitor the development of particular aspects related to the agricultural policy. The EMBAL protocol records a great number of parameters not covered as a whole set by any other monitoring programme, e.g. EMBAL differentiates between different crop types, and thus can complement existing monitoring programmes such as the German HNV monitoring, which provides data on a coarser scale. However, these positive or negative trends recorded at the regional scale might not be sufficient to be reflected at aggregated EU level. Therefore, the monitoring design needs to account for different up- or down-scaling options in order to analyse effects at regional and/ or national level.

Though decisions of farmers and other actors in the agricultural landscape are highly influenced by policy decisions, e.g. the subsidies that are drivers for agricultural production, the monitoring of the impact of CAP or other policy processes with field survey data from the proposed monitoring program is difficult. With the area approach of EMBAL, no policy-related information about the recorded features is available: we can’t know if the buffer strip along a hedgerow exists because it is protected under GAEC 1, registered as EFA or supported by and agri-environment-climate measure funded by the CAP, if the farmer registered the buffer strip at a national or regional scheme or has a purely intrinsic interest in it and doesn’t receive any financial support. Given the farm structure in many European countries, the surveyor has no possibility to record non-visible CAP and farm (management) data in the field – this would require knowledge about which parcel belongs to which farmer, contacting the farmer, interview the farmer about the particular measure and the applied financial instrument – data that most farmers probably won’t expose to an interviewer. Besides the difficulty of identifying each farmer for each parcel, time and effort for such a survey are very high and not in the scope neither in the focus of the proposed biodiversity monitoring approach. However, of course the additional information and the knowledge about the extent and state of CAP-financed measures in the field would substantially contribute to the evaluation of the CAP and other policies, and constructively underpin recommendations for the future adaptation of those policies. The intersection of data from the biodiversity monitoring and the Land Parcel Information System (LPIS), Farm Accounting Data Network (FADN) and the Integrated Administration and Control System (IACS) would be of particular interest and could be a subject of future work. In this regard, the data recorded during the LISA case study have already shown the gap to link changes to potential policy effects: in the survey region of southwestern Germany, the area on which leguminous crops (eligible as

EFA under the CAP) were cultivated shows a net increase of around 4% on all arable land in 2016, compared to 2014. However, with the available data alone it will not be possible to establish a causal link between legume increase and policy measures, but data need to be paired with other information, e.g. derived from IACS/LPIS or farmer motivation.

Besides the CAP, the EU Biodiversity Strategy to 2020 as well as the United Nations Sustainable Development Goals, especially Goal 15 to halt and reverse land degradation and halt biodiversity loss (United Nations, no date)[9], reflect the importance of biodiversity in national and international concerns. As a harmonized European monitoring approach, EMBAL would contribute to the monitoring of the EU's path towards achieving the UN Sustainable Development Goals. From the biodiversity point of view it is of utmost importance to record and to know about the de-facto-situation of biodiversity in the field, regardless of the current influence of the CAP or any other agri-environmental policy. If positive effects of those policies however should be visible and detectable in the field, they are likely to contribute to the whole biodiversity in the agricultural landscape (also to the faunistic biodiversity that is not recorded in the EMBAL approach).

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[9] United Nations – Sustainable Development Goals: http://www.un.org/sustainabledevelopment/biodiversity/

7 EMBAL future design

7.1 Layout of the proposed sampling design

In the following, we propose a future design for the EMBAL monitoring approach with the developed field survey methodology, covering the EU-28. Based on the analysis of different existing monitoring approaches (cf. Table 10-2), exchange with Prof. Dr. Saborowski (statistician, University of Göttingen) and project partners, and the comparison of costs and efficiency, we present the rationale behind the choice of the kind of sampling grid, the grid size, sampling plots and placement of sampling plots. Sampling will take place in a two-week time-frame in spring / early summer in order to catch the optimal and a comparable survey time regarding the development of vegetation and the related biodiversity patterns: the exact dates will vary between MS (and between regions within the MS) depending on the usual phenological patterns (excluding years of extreme weather events) of the region. The time framing will be comparable to the time framing of the LUCAS grassland module, which provides a detailed schedule and is appropriate for EMBAL because it takes into account the elevation and biogeographical regions of Europe to derive at the optimum period for vegetation surveys.

We propose a sampling of either an annual sampling of all plots or at least of 50 % of the survey plots every year, so that the full data set of all points is available at least every second year. Fluctuations due to weather conditions, crop rotations or other factors need to be levelled-out in the sampling cycle so that net changes would be visible and trends can be displayed accordingly. An annual monitoring would deliver better data quality and direct annual time lines of monitoring results for fluctuating parameters such as species numbers. In a bi-annual cycle, the choice of points sampled per year would be important: recording every second sampling point would for example mean great travel distances for surveyors in large countries such as France, so that more surveyors need to be employed in order to be able to survey the points in the defined period of two weeks. A different selection of points, e.g. splitting points in Eastern and Western parts of countries or even selecting single countries to be surveyed per year would have consequences for the level of confidence for the recorded data – calculating mean values for the 2-year cycle could be biased through fluctuations that occurred due to (extreme) weather conditions, e.g. in the western half of France, while in the eastern half the weather is comparable to that of other years. So, in a bi-annual cycle, probably only 50 % precision would be achieved but with more than 50 % of the effort. Finally, regarding the evaluation or informing of policies, results would be based on time series of 3 data points as compared to the annual cycle, which would deliver 6 points (in a 6-year policy cycle).

7.1.1 Grid size

The analysed monitoring approaches are based on different considerations regarding the sampling design. We can differentiate approaches with a regular or an unregular grid, stratified or non-stratified random or systematic sampling. Many of the existing monitoring approaches are based on a sampling scheme with some sort of stratification, e.g. regarding land use/land cover, habitats, biogeographical zones or combinations of those (cf. Figure 7-1 or description of monitoring approaches in Annex 10.4). Examples for the resulting grids at national scale are shown in Figure 7-2. The examples of sampling grids in Switzerland and Sweden show that based on a regular grid densification of sampling points according to the requirements of the sampling scheme are possible, as shown for northwestern and southern Switzerland.

A regular grid with a random choice of the sampling sites allows at one hand to obtain a representative number of sampling sites that can be evaluated statistically. On the other hand, this procedure ensures an independent sample. Given the findings described above, we propose a regular grid of 2 x 2 km compatible with the established LUCAS survey grid as basis for the EMBAL approach. The advantage of this harmonization is manifold:

- Data for more than 200,000 LUCAS points at the nodes of the 2 x 2 km grid are available for the years 2006, 2009, 2012 and 2015;
- Information are available for land cover, land use and associated environmental parameters, photos are available as well;
- Knowledge about the accessibility of the points is available;
- Harmonizing the EMBAL and LUCAS grid adds to a more complete data set for the survey points, especially regarding the extent of landscape elements, wild plants in arable land and additional survey points for grassland;
- Cross-checks between the LUCAS and EMBAL survey data increase accuracy.

The LUCAS grid is the only one that is consistently distributed across all member states in a single approach. Other approaches and respective grids, which could in general deliver synergies for EMBAL and vice versa, are mostly based on national schemes and differ between member states. Therefore, these grids, e.g. the national FBI sampling sites, are not considered as basis for the EMBAL grid.

Based on a regular LUCAS grid laid over the EU-28, the size, number and location of sampling points need to be defined. In the following, we will describe the options for the placement and size of sampling plots.

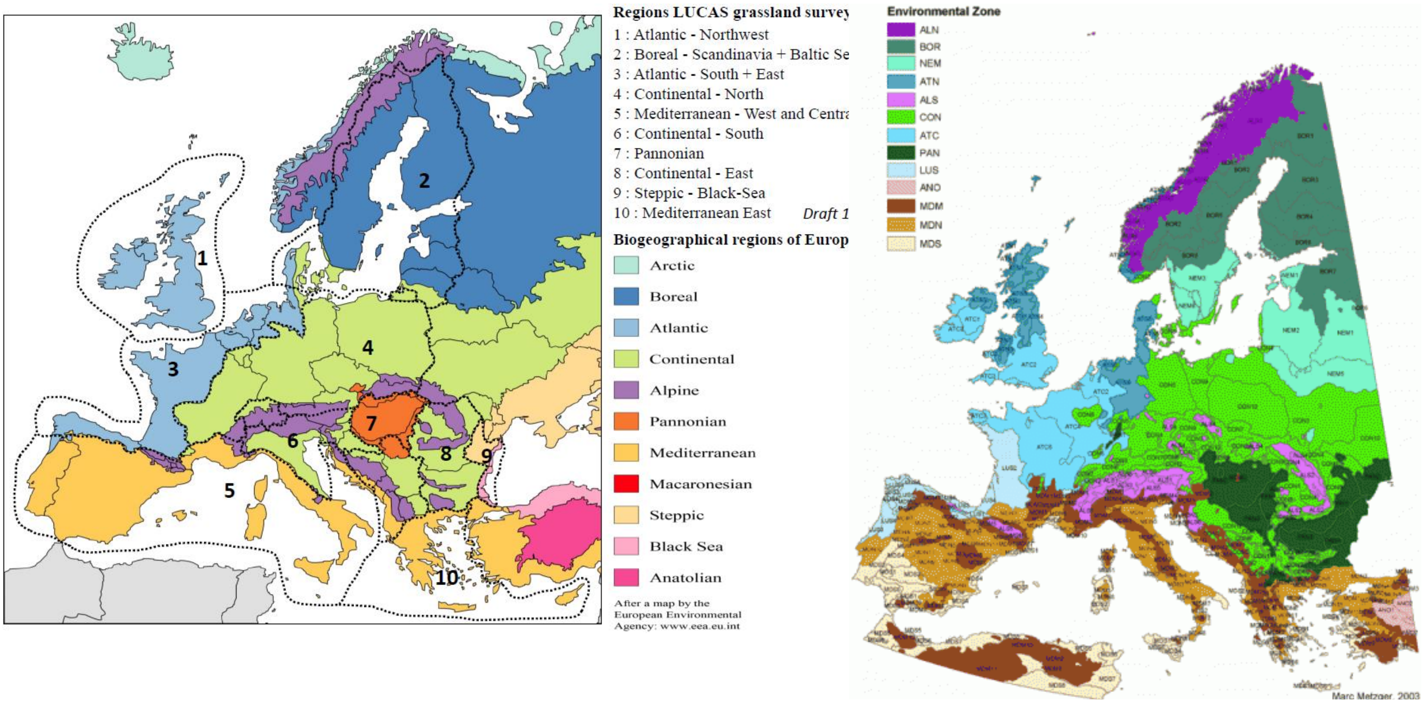

Figure 7-1 – Examples for possible stratifications, based on biogeographical regions (left, LUCAS grassland survey) and environmental zones derived from the Environmental Stratification of Europe (cf. Metzger et al. 2005, Jongman et al. 2005).

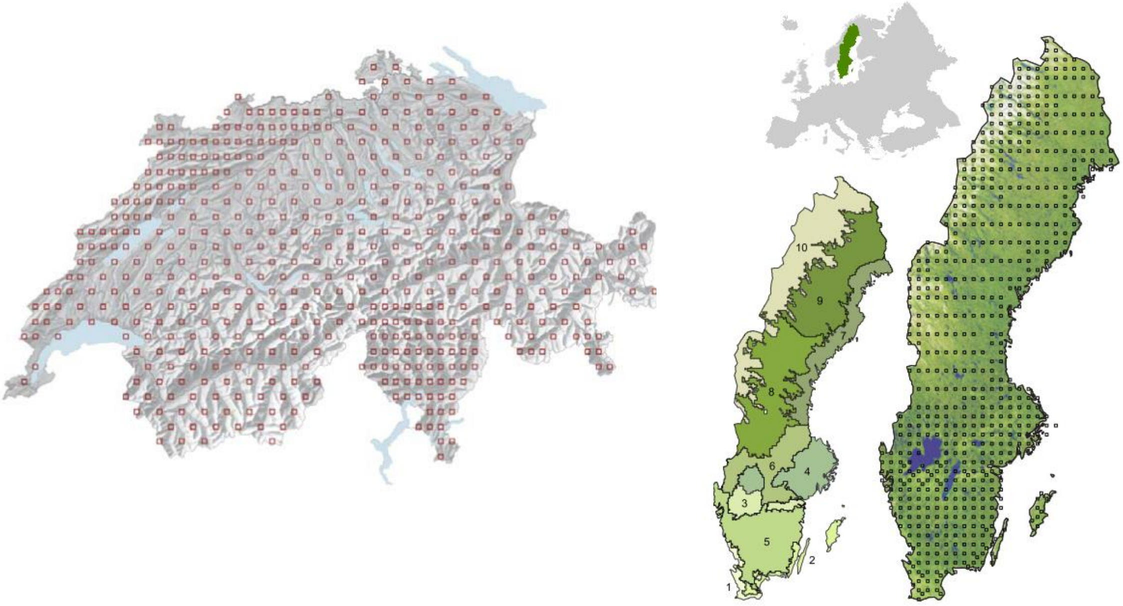

Figure 7-2 – Examples for sampling grids in Switzerland (left) with compactions of the grid in the regions Jura (northwest) and Ticino (south) (Koordinationsstelle Biodiversitäts-Monitoring Schweiz, 2011); and Sweden (right) based on a random systematic sampling with stratum-dependent densities (Ståhl et al. 2011)

7.1.2 Size of sampling plots

The placement and size of sampling plots within the regular grid of 2 x 2 km draws on the comparison of sampling efforts and the level of detailedness per sampling plots (cf. Table 5-3). Based on experience from the LISA survey (2014 and 2016) and testing of the EMBAL survey methodology in summer 2017, the average time needed to complete a 500 x 500 m plot is ca. 90 minutes (the time needed depends very much on the complexity of the plot, as indicated in the Table 5-3). Including the travelling time (assuming 5 km) between plots this would sum up to roughly 2 hours per plot. With this effort considerations, we conclude that a feasible ratio between effort and detailedness is achieved for plots with a size of 500 x 500 m. This decision is based on experience, considering the following factors:

- The plot needs to be big enough to contain more than one land use parcel even in relatively large-scale landscapes;
- A relatively large proportion of total survey time is spent for locating the plot, surveyors need to orient themselves within it and find the plot borders, before data entry can start;
- Data collection is more efficient if multiple transects within fewer, larger plots are surveyed than one transect within many, smaller plots;
- Based on experience, it is difficult to remain orientated within plots larger than 500 x 500 m, as the borders are rarely all visible at once;
- This is the size of the plots surveyed within the Northern Ireland Countryside Survey (NICS) and the LISA study, which produced data that could be statistically analysed and results that were ecologically interpretable;
- The estimated average time to survey the parameters laid out in the methodology is c. 90 minutes, which allows multiple plots to be surveyed in a day (depending on the travel distance between the plots).

Next, we propose an option for the placement of the plots at the sampling nodes of the grid, as illustrated in Figure 7-4.

Figure 7-3 – Example of the survey plot placed at intersections of the LUCAS grid.

7.1.3 Number and placement of sampling plots

Within the proposed 2 x 2 km grid, sampling plots should be located at the grid nodes in a defined distance to each other. The number of required sampling plots depends on several parameters:

- Spatial scale of the monitoring: the monitoring results shall produce data that are statistically reliable and interpretable at EU-level as well as at national state level. Therefore, a minimum number of sampling sites per member state is required.
- Level of confidence and variability: Some surveyed elements will only be surveyed in a small percentage of the sampling plots, which especially applied for landscape elements. These make up a small percentage of the surveyed landscape. Depending on the applied confidence interval, sampling sizes might need to be increased to avoid an over- or under-representation of certain elements. Further, the variability among the assessed parameters has an influence on the required number of sampling plots.
- Independent sampling: the distance between the survey plots needs to be large enough so that the data can be regarded as independent sample.
- Options for up- or down-scaling of the sampling design, according to specific requirements (e.g. densification of the survey grid could be necessary to collect data that are interpretable at regional scale).

The minimum number of survey plots necessary for a statistically reliable sample can only be calculated after an initial survey, since the number of plots depends on the variability between the targeted variables (Prof Dr Saborowski, personal communication, September 20, 2017). However, we propose to base the number of sampling nodes for a first assessment on the utilized agricultural area (UAA) of each EU member state with a minimum of 50 plots in small countries (in order to achieve a certain minimum statistical result) and a maximum of 200 plots in large countries (in order to limit the effort for the large countries). This allows to scale sampling effort to the importance of farmland in a MS. The nodes will, however, be positioned on the regular grid over the total land area, in order to ensure that even regions with relatively little-farmed area (e.g. northern Finland) are being sampled to an appropriate extent. The calculations are shown in Table 7-2.

In general, not all plots will comprise enough agricultural land to survey in order to do the effort of travel for a survey: we propose a cut-off of 10 % agricultural land (based on CORINE landcover information), with less than 10 % agricultural land the plot will not be surveyed. To achieve the required number of survey nodes per member state, either the distance between nodes should be reduced (as described below for Scandinavian countries) or alternative nodes need to be defined that replace the excluded ones. The proposed number of nodes in Table 7-2 therefore can only be an initial attempt but needs to be adjusted according to the number of plots that would be located in non-agricultural areas.

Following the rationale outlined above, we propose a minimum number of 50 sampling nodes for small countries like Luxembourg. Although difficult to predict in advance, this is presumed to provide sufficient number of data points from different agricultural land use types (arable, grassland, permanent cultures, landscape elements) even if not all land use types occur in each plot. In the smallest MS in terms of agricultural area (Luxembourg), this would mean an approximate distance between nodes of 7 km (see Table 7-1 and Figure 7-5), which should allow for statistically independent samples. To limit the sampling effort in very large countries such as France and Spain, a maximum of 200 sampling points should be used. This would mean an approximate distance between nodes of 50 km in the case of France (see Table 7-1 and Figure 7-5).

Based on the difference between the MS with the largest UAA (France) and the smallest UAA (Luxembourg), the number of nodes would increase proportionally (cf. Table 7-2). In countries with a low proportion of farmland such as Finland, this would give a minimum distance between nodes of approximately 70 km. However, as applies especially for the Scandinavian countries, many of the selected survey nodes will be placed in non-agricultural land, e.g. forest or open water, given the great extent of boreal forests in these countries. Therefore, the distribution of the number of survey nodes need to be adjusted to compensate for the non-agricultural areas. An evaluation with a geographical information system (GIS) is required to analyse the land cover for the selected nodes.

As a second option, one could follow a sampling design that is based on stratification. As shown for other monitoring approaches (e.g. HNV farmland monitoring in Germany, NICS or EBONE) stratification can be based on agri-environmental variables such as land cover types, soil types, altitude, or biogeographical regions. The procedure may look as follows: a first set of sampling points could be assigned to a grid of optimal size in order to obtain a sufficient number of sampling squares (e.g. grid size of 40 x 40 km for the European level). A screening of the first set of plots could then be done to discard locations that are not relevant (because placed in non-agricultural land or with less than 10 % of agricultural area). To compensate for those points, the grid can be shifted with a fixed distance, e.g. 20 km, to the East (or to the South) and the selection can be repeated (see Figure 7-4). This procedure should be repeated until the optimal number of sampling locations is reached for each of the strata and for the member states.

Alternatively, a denser grid of for example 10 x 10 km can be chosen; then at the first stage all points of 40 x 40 km can be selected, and if these points are not sufficient at the next stage additional points can be selected from the 20 x 20 km grid and if also these points are not sufficient at the third stage additional points can be selected from the 10 x 10 km grid.

To introduce a stratified sampling would benefit the appropriate representation of all agricultural landscape conditions and increase the possibilities for data interpretation, i.e. data cover the EU-level, MS-level, and each of the considered strata.

The proposed number of nodes to be surveyed per MS however is a first theoretical attempt to facilitate the implementation of the monitoring programme. Further statistical analysis is needed after an initial Europe-wide survey to verify the optimal number and placement of survey plots within the grid.

Table 7-1 – Examples of number of nodes and approximate minimum distance between nodes based on UAA (2013, Source: Eurostat) and total land area of four member states given as examples.

Member state	**Util. agric. area (km²)**	**Total land area (km²)**	**N nodes**	**Approx. min distance between nodes (km)**
Luxembourg	1,310	2,586	50	7
Czech Rep.	34,920	78,866	68	34
Finland	22,840	338,145	62	73
France	277,390	640,679	200	56

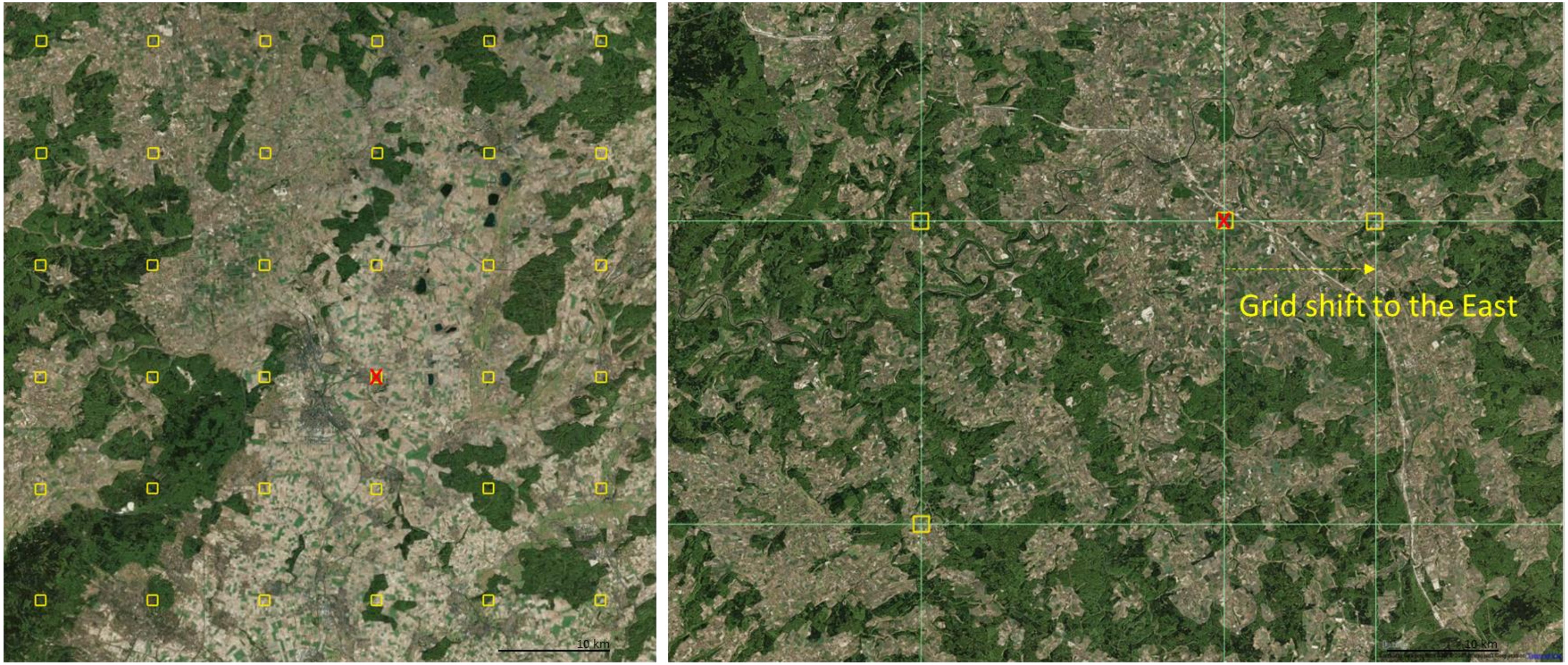

Figure 7-4 – Based on the LUCAS grid of 2 x 2 km, plots of 500 x 500 m (indicated as yellow squares) can be placed either in a regular distribution based on the number of plots per country (left). The distance between survey nodes varies with the utilized agricultural area (UAA) of the member state; or based on a stratified sampling, where grid is shifted to the east to substitute for excluded plots (right). Red x indicates excluded plots (e.g. because they are based on non-agricultural areas).

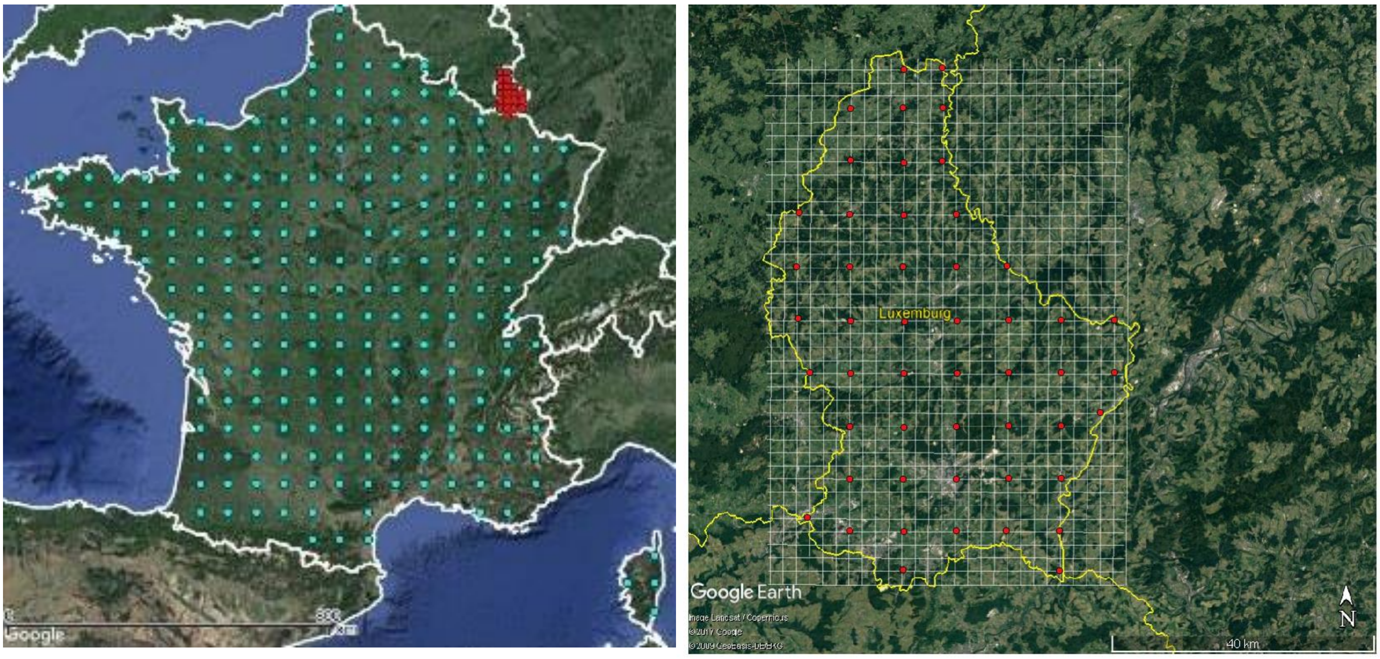

Figure 7-5 – Regular spacing of sampling nodes France (blue, with nodes missing in areas without farmland) and for Luxembourg (red) in comparison, within 2 x 2 km grid.

The final decision regarding the placement of plots depends on the priorities of DG Environment and represents a balance between data assessment at EU-level, detailedness of the data, statistical means outlined above and the available budget.

Table 7-2 – Overview of EU-28 with area, UAA, and a proposal for the number of EMBAL nodes on NUTS 0-level (adapted from Eurostat, 2013 online data code: ef_kvaareg). Calculation of the number of nodes that should be sampled according to the UAA of EU MS, ranging from minimum 50 nodes in countries with small UAA up to 200 nodes for large countries like France. In total, 2.279 nodes would be sampled. The indicated approximate distances is calculated with the number of nodes and the total area of the countries; however, this gives only a rough estimation as also the extent of forests and urban areas has to be considered (many nodes will be excluded from sampling when the fall into forest or urban areas).

EU Member States	**Area (1000 ha)**	**Agricultural Area (UAA) (1000 ha)**	**UAA as % of total area**	**EMABL nodes**	**Approx. distance between nodes (km)**
Malta	32	11	34%		
Cyprus	925	109	12%	50	13,6
Luxemburg	259	131	51%	**50**	7,2
Slovenia	2.027	486	24%	52	19,7
Estonia	4.523	941	21%	54	28,8
Belgium	3.053	1.308	43%	56	23,2
Croatia	5.659	1.571	28%	58	31,3
Netherlands	4.154	1.848	44%	59	26,4
Latvia	6.457	1.878	29%	60	32,9
Slovakia	4.904	1.902	39%	60	28,7
Finland	33.844	2.284	7%	62	74,0
Denmark	4.292	2.619	61%	64	26,0
Austria	8.388	2.727	33%	64	36,2
Lithuania	6.530	2.861	44%	65	31,7
Sweden	43.857	3.029	7%	66	81,6

Czech Republic	7.887	3.492	44%	68	34,0
Portugal	9.223	3.642	39%	69	36,5
Bulgaria	11.100	4.651	42%	75	38,6
Hungary	9.302	4.657	50%	75	35,3
Greece	13.196	4.857	37%	76	41,8
Ireland	6.980	4.959	71%	76	30,3
Italy	30.207	12.099	40%	115	51,3
Romania	23.839	13.056	55%	120	44,6
Poland	31.268	14.410	46%	127	49,6
Germany	35.734	16.717	47%	140	50,6
United Kingdom	24.853	17.327	70%	143	41,7
Spain	50.597	23.300	46%	175	53,7
France	63.283	27.739	44%	**200**	56,3
EU-28 total		**174.611**		**2.279**	

7.1.4 Extension modules for EMBAL survey

For the survey design outlined above, we propose working with sampling units based on NUTS 0 (entire MS), because NUTS 1, 2 and 3 do not provide homogenous landscapes as regards their agricultural land nor do they represent comparable administrative boundaries across MS. Therefore, it would not be an advantage to stratify the sampling design according to these administrative units.

However, MS or EU initiatives might desire more precise data at regional or local levels – either on administrative level (NUTS 1, 2 or 3) or on nature region level. These regions or landscapes could be sampled more in detail: therefore, within the given grid of 2 x 2 km more sampling points can be chosen (nodes of the grid). In this way also the Swiss biodiversity monitoring (BDM) is working (cf. Figure 7-2). Relying on the estimated distance of sampling nodes, e.g. approximately 50 km in France (cf. Table 7-1), the distance between sampling nodes could be selected according to the desired detailedness and scale (e.g. grassland data at the level of the NUTS2 region *Limousin*, France). The selection of grid level is highly flexible within the 2 x 2 km pattern:
- 2 x 2 km;
- 2 x 4 km;
- 4 x 4 km,
- 4 x 8 km,
- 8 x 8 km,
- 8 x 16 km etc. are just examples of how the grid could be set-up in order to achieve the desired number of plots located at the grid nodes can be chosen.

The selection of the number of survey points would be a political and/or budgetary decision in the responsibility of each member state. Within the German HNV monitoring, several federal states increased their monitoring effort within the programme to obtain more detailed regional data (https://www.bfn.de/0315_hnv.html, 2016). Likewise, EMBAL could provide a pan-European standard, which can be built on if desired:

- Reliable due to an annual or at least 2-year monitoring cycle (50 % of points per year) with a sampling scheme covering all EU member states;
- Adjustable to political and/or budgetary decisions;
- Able to deliver comparable and comprehensive data with a sound methodology across EU MS;

- Highly flexible regarding data collection at different scales (administrative levels, landscapes, environmental zones).

7.2 Considerations for a future EMBAL roll-out

Based on the experiences and the frequent exchange with experts concerned with the HNV monitoring in Germany, BioBio, EBONE and LUCAS, we emphasize that the following aspects need to be considered in a future monitoring approach.

Material

The surveyors need to be equipped with the relevant material that is needed for the field survey. This refers especially to up-to-date georeferenced images (orthophotos, satellite images etc.), which need to be provided in advance. For the time schedule, the acquisition and preparation of the orthophotos for each plot needs to be taken into account. In case the data are recorded with a field computer, the appropriate software has to be installed on the devices that are distributed to the surveyors. Further, the surveyors need to be equipped with a paper copy of the survey manual, and sufficient paper copies of the survey sheets (main sheet and vegetation sheets) in case the technical device is not working. Other items such as a GPS-capable camera, measuring tape, etc. should be provided for each surveyor. This way, the technological standard is the same for all surveyors.

Training

For a successful monitoring program and the reliable data collection, intensive training of the surveyors and other actors involved in the data/quality control is essential. Training for surveyors should involve the theoretical understanding of the survey manual and the monitoring methodology as well as a practical field test in order to calibrate the interpretation of actual field conditions. The training for surveyors can be organized region-specific sessions, gathering surveyors from countries with similar biogeographic regions. We estimate the needed time per training session at about 2 to 3 days.

Enable access to land

Access to land is a major prerequisite for a successful survey. Therefore, official documents should be provided so that the surveyors can explain their work, the need to access the land and prove their official concern. Further, announcements before the start of the survey campaign could be published in regional/official gazettes to inform the public about the survey.

However, there is a different laws and customs on access to the fields in different countries. In this respect it is important to stick to other official approaches for similar purposes like the LUCAS approach. The procedure for this can be adapted from the LUCAS survey which provides official documents. This way, the acceptance of land owners might be increased and access given to the surveyors. The planning of such publications and the issuing of the official documents needs to be prepared well in advance of the beginning of the survey. In case access to land is denied, the plot would not be surveyed and the surveyor would have to make a note in the main sheet of the plot. If it is foreseeable that access won't be granted in the next survey cycle, a compensation plot needs to be chosen.

Helpdesk for surveyors

During the time of the survey, surveyors (and coordinators) should have access to a helpdesk that provides support related to the record of data and data processing. A helpdesk is a helpful tool to ensure data quality, i.e. direct feedback for surveyors is possible; in difficult situations, decisions taken by surveyors can be cross-checked with helpdesk staff; constant platform/possibility for support. For the built-up of the helpdesk, trained staff is required and personnel resources that allow a constant helpdesk throughout the survey period.

Digital recording

With the experiences from a number of monitoring approaches, we propose a digital recording of survey parameters directly in the field for the following reasons:

- Time-efficiency is increased, because data entry has to be done only once
- Quality control is increased, because the software for the data entry in the field can contain error and plausibility checks during data entry.
- Simplified data delivery through online transmission of data sets. This allows a prompt feedback from the quality control team and eases the effort for surveyors.

The development of appropriate software for the record of survey data, the process of transmission and data control need to be developed and tested well before the start of the first monitoring cycle. A test of the software and the workflow within a monitoring cycle should be conducted prior to the survey to reduce difficulties.

Quality control

Quality control of the field survey data is crucial for the reliability of the data. Therefore, submitted data from the surveyors should be checked and if necessary returned to the surveyor for clarification/correction. A number of random samples of the survey plots should be chosen and cross-checked in a double-blind procedure to verify data accuracy. With the help of a digital data entry tool, plausibility checks can already contribute substantially to the quality control. The necessary procedure of reporting from the surveyors as well as quality checks and data control can be adapted from existing and established approaches such as LUCAS or HNV monitoring in Germany (Eurostat, 2015; BfN, 2017).

Data management

We propose providing surveyors with computer tablets and custom-made data entry software for direct digitisation of data in the field. This will reduce errors e.g. through typographical errors during data entry from paper field sheet, or through surveyor error in the field (e.g. forgetting to record a parameter, the software has to remind the surveyor before saving an entry in case a parameter is missing). It can also speed up the process of surveying, and allows rapid feedback to a central fieldwork coordinator. Once the tablet is connected to the internet, data can be automatically uploaded to a central database. Using a database, e.g. Microsoft Access, will allow central data management, the quality checks of the data and might ensure the linkage of the data to other monitoring approaches, such as LUCAS or adding the link to the EMBAL database to the Biodiversity Information System for Europe (BISE).

Robust tablets suitable for fieldwork are available from several different suppliers and costs range from 400-2000 € each, depending on the requirements. There are various software developers in Europe with experience in designing data collection software for ecological surveying.

The following Table 7-3 provides a summary of the considerations for a future EMBAL survey, and lists the main aspects that would need to be developed and tested during a first pilot survey.

Table 7-3 – Summary of tasks and subtasks that need to be addressed in a pilot survey.

Main tasks	**Subtasks**
Task 1 – Software	Software development for digital recording in the field.
	Field test of the software and troubleshooting.
Task 2 – Survey methodology	Test of the survey methodology in different biogeographic regions across Europe and with different surveyors; possibly adaptations to the manual might be necessary (e.g. coding harmonized with latest LUCAS codes).
	Development of key species lists for arable land in different biogeographic regions (for grassland we have 10 lists for the biogeographic regions, in total 41 species, each list comprises 20 key species).
Task 3 – Data management	Test of data management (e.g. database management) and interpretation potential with the records from the field test.
Task 4 – Survey design	Analysis of optimum number of points to be surveyed for statistical purposes, at EU-level and member state level, drawing on the data records from the field test.
	Decision on selection procedure for the points to be surveyed (grid, stratification) at EU-level and in different member states.
	Decision on survey cycle (see proposal for annual or bi-annual cycle in this report).
Task 5 – Outreach	Initiate information and participation process to involve all member states in EMBAL monitoring.

With these considerations and requirements, we provide a cost estimation for the pilot survey as well as for a full EMBAL roll-out in the following chapter.

7.3 Cost estimation

The cost estimation presented below applies for the methodology and survey design outlined above. Precise calculations however depend on the exact number of survey plots, the technological solution for the data entry, the procedure for data processing and quality control. With the compiled information from the LUCAS survey 2016 and the tender documents for the LUCAS survey in 2018 as well as with experiences from the LISA study and information from Geijzendorffer et al. (2016), we summarize the costs in Table 7-4, assuming the following average time estimates for the data record:

- Sample of 25 ha (500 x 500 m) with 4 transects: 90 – 110 minutes

- Travel time between plots, up to 60 minutes, depending on distance between plots.
- Digitization of survey data per 25 ha plot: 40 minutes
- Data control and corrections per 25 ha plot: 10 – 30 minutes

The person day costs assumed for the total cost estimation reflect an average of the LISA study results and the day rates for skilled personal assumed in Geijzendorffer et al. (2016), including average travel costs. We estimate 557 € per day for skilled surveyors on average, not taking into account different day rates for the European countries.

As outlined in Table 7-3 we suggest running a pilot study before the full roll-out could start. The aim of the pilot study is:

- Gather further experiences with the applicability of the methodology
- Digital data processing and control needs testing and it is important to check the manual in different regions during the pilot study.
- The variability between parameters and the (statistical) applicability of the sampling design need to be tested and evaluated
- Member States can be informed on the methods and the outcomes of the survey as well as on the possibilities to add additional sampling plots to the European survey.

For the pilot study we suggest working with 12 surveyors and 450 plots (approximately 1/5 of the total sampling sites based on UAA per MS). Thus, the pilot offers the possibility to conduct exemplary surveys in different regions of Europe (from Cyprus to Ireland and from Finland to Portugal) and check difficulties in the understanding and in the performance of the survey in order to further improve the methodology. One main experience will be the check of the electronic data entry based on maps. When deciding for a stratification based on agri-environmental variables, the selection procedure (see section above) would need to be tested and statistically evaluated during the selection of plots for the pilot study as well.

However, after gathering experiences with the pilot and calculating the required number of points to be surveyed to serve statistical purposes, one could start with the roll-out for the first survey. In order to be able to estimate the costs for a first survey cycle, we assume the number of plots given in Table 7-2, with a total number of 2,279 survey sites, covering all EU MS.

We assume that each surveyor could complete up to 3 plots per day (depending on travel distance between nodes), and within two weeks (2x6 days) one surveyor could complete 36 plots in the given time, thus for a total of 2,279 nodes and the time frame of two weeks per surveyor, about 65 surveyors would be needed in total for a full roll-out in an annual sampling.

Besides the field activities carried out by the surveyors, the administrative and organizational costs need to be included in the calculation. These involve the acquisition of hardware (e.g. field tablets, in case of digital recording), the recruiting of the surveyors, the creation of a database, data management and quality control, as well as reporting obligations. The respective cost positions are presented in Table 7-4. Further, we differentiate between costs for the first year of the implementation of EMBAL as well as the following years of monitoring. Following Geijzendorffer et al. (2016), a cost reduction can be assumed for the following years of implementation.

The calculation below differentiates the costs for a pilot study, a first implementation cycle and the follow-up monitoring cycle. In line with Geijzendorffer et al. (2016), we found that a considerable cost reduction for the follow-up surveys could be possible, in total potentially about 30 % of the costs for a first implementation. The costs for an annual European monitoring programme amount to roughly 1.3 Mio € for the first pilot and the first full survey.

The first full survey with 805,000 € covers the calculated 2,279 points across all EU member states. For following survey years, we calculate a cost reduction of 24 % with a full survey amounting to 615,000 € in following years. Main cost reductions can be expected in the administrative and organizational position, benefitting from a running database and mechanisms for helpdesk systems.

The costs presented in Table 7-4 apply for an annual survey. For the option of a bi-annual survey, in which 50 % of the points are surveyed every year, several aspects have to be considered:

- Though only 50 % of the points are surveyed, running costs for administration, database maintenance, surveyor helpdesk or data control are probably equally high as for the annual survey, since the same tasks need to be carried out. A considerable cost reduction of estimated 25-30 % for the surveyor costs is assumed, depending on the selection of points in the 2-year sampling cycle.
- With half the points to be surveyed, one could assume that only half the number of surveyors are needed, thus approximately half the number of trainings is needed. However, this depends on the kind of point selection in a 2-year cycle. With great travel distances between points, more than half the number of surveyors might be necessary.
- In a 2-year cycle, 50 % data accuracy is achieved, but more than half the effort is needed.

Table 7-4 – Overview of cost estimations assumed for the EMBAL pilot study, the future full roll-out, and the assumed cost reductions for following monitoring cycles in an annual sampling cycle; based on experiences with the LISA study, LUCAS tender documents and Geijzendorffer et al. (2016) and the assumed sample size of maximum 2,279 nodes.

Cost position	**Task**	**Subtasks / explanations**	**Estimated costs (in €)**
Preparation of a pilot survey	Preparation of training material	Development of training material, slide shows, concept for trainings Internal instruction of trainers	30,000 €
	5 regionalized trainings for field test surveyors	Travel costs for trainers (1 travel day per training) Average costs per training Total with five training units	6,800 € 2,500 € 19,300 €
	Software development	(Costs only rough estimation)	50,000 €
	Acquisition of survey material:	Technical devices (e.g. field tablets, GPS-compatible cameras) – 15 equipments	6,000
Subtotal			**240,000**
Pilot field survey: 430 sampling nodes / plots; 12 surveyors	Software test	Technical support for surveyors Evaluation of software solution	50,000
	Surveyor rates field test	12 surveyors à 15 days (2days training, 1 day further preparation, 12 days for field work)	100,260 €
	Evaluation of field test results	60 person days, experts	33,600 €
	Adjustments for full survey	Statistic evaluation of survey design Methodological amendments,	25,000 € 35,000 €
Subtotal			**244,000**
Total	**Pilot study incl. preparation, implementation and interpretation**		**484,000 €**
1st full survey: Surveyors in all EU MS; 2,279 sampling nodes	5 trainings for 65 surveyors	One training = 2 days + 2 travel and preparation days = 4 days + travel costs = 3,000 €	15,000 €
	Field survey, day rates + travel costs for surveyors	(65 surveyors)	390,000 €
	Technical assistance and quality control	Database development and maintenance Helpdesk for surveyors Data control and feedback to surveyors	250,000 40,000 50,000
	Data interpretation and evaluation	Final reports and proposed adaptations/refinements	60,000
Subtotal			**805,000**
Total costs for first implementation incl. pilot study			**Mio € 1.3**
Follow-up surveys: Surveyors in all EU MS; 2,279 sampling nodes	5 trainings for 65 surveyors	One training = 2 days + 2 travel and preparation days = 4 days + travel costs = 3,000 €	15,000 €
	Field survey, day rates + travel costs for surveyors	(65 surveyors)	390,000 €
	Technical assistance and quality control	Database maintenance Helpdesk for surveyors Data control and feedback to surveyors	70,000 30,000 50,000
	Data interpretation and evaluation	Final reports, minor adaptations/refinements	60,000
Total costs for follow-up monitoring cycle			**615,000 €**

7.4 Time framing for a future EMBAL roll-out

For the time framing of a future roll-out it is important to consider at the one hand that a timely implementation of the monitoring is necessary to establish a baseline for future policy evaluation, at the other hand time is needed for the preparation of the monitoring campaign, in order to ensure that surveyors are adequately trained, the technological aspects are well-functioning and there had been time for quality control and amendments prior to the European roll-out of the survey. Against this background, we propose the following schedule (Table 7-5).

Table 7-5 – Timeline of a future EMBAL pilot survey and first full roll-out.

Month	Task	Subtask
2018	Design and statistics – size of the survey sample, selection of survey plots	Workshop/meeting on statistics
	Development of software/hardware solutions for the data entry in the field	Call for tenders for software development and field test – programming and coordination of the field test Decision on contractor Information for EU MS, workshop/ meeting/ roundtable etc.
2018/2019	Field test for software, hardware and methodology as well as the establishment of a database	
Beginning of 2019	Preparation of field work for pilot survey – maps, data basis, issue permissions for access to land	
Spring/summer 2019	Pilot field survey	
End 2019	Evaluation of field test, adaptation and refinement of monitoring methodology, software/hardware, data interpretation, monitoring design	
2019/2020	Preparation for roll-out – contact surveyors to cover all EU MS, kickoff meeting	
2020/2021	First full roll-out in an annual or 2-year cycle 2020/2021	

The proposed time framing for a future roll-out of the proposed monitoring methodology is very ambitious. From our experience we know how important careful planning of the survey cycle is. We emphasize the need for a sound and robust data entry tool and see the potential in the technological advancements, e.g. in the field of digital recording. The development of a well-functioning software for this purpose would enhance data collection as well as data quality. A comprehensive tool for data management, like a database, is essential for the huge datasets generated within the survey and should take into account the opportunity to easily integrate further data sets delivered by other programmes. With reference to the considerations outlined in Table 7-3, the pilot EMBAL survey should therefore:

- Be a broad test for the application of the digital data entry in the field on a subset of the total number of plots;
- Produce results that can be statistically analysed to conclude on the variability between the assessed parameters and derive at the sample size that fits the desired confidence intervals; delivering the optimal number of plots per EU member state and – if the stratified approach is chosen – the optimal number of plots per stratum;

- Collect a first set of data at EU-level with the EMBAL methodology; these data can be used as baseline for the following monitoring cycles.

A first full assessment in 2020/2021 would be a major step towards a harmonized EU-wide baseline with the status quo of biodiversity in agricultural landscapes.

8 Outlook

The development of a robust monitoring approach is a critical step towards collecting comprehensive data on the state of biodiversity in agricultural landscapes. This will provide support to the development, implementation and evaluation of both biodiversity and agricultural policies. Despite the numerous monitoring programs already in place in many EU Member States, the present study proposes a methodology that can be applied consistently throughout all EU Member States and all biogeographic regions in Europe. It is a rapid approach that at one hand ensures easy understanding by surveyors in all countries and on the other hand delivers important data on the structure of the agricultural landscape related biodiversity parameters.

With the results of this study we propose a dense monitoring cycle based on annual or at least bi-annual assessments, in order to be able to constantly monitor change and show long-term trends in the structure and for biodiversity in agricultural landscapes. The roll-out of such a monitoring approach in all member states requires thorough preparation and testing. The technological advancements in the last years allow the record of digital data directly in the field, an approach that can reduce errors in data entry, the effort for surveyors and ensures the collection of consistent data in all countries. However, the development and especially the testing of such software for data recording is essential and must be commenced well in advance of the actual monitoring cycle.

Besides the implementation of the proposed monitoring approach, further networking and the cross-linkage of already existing initiatives and approaches is needed to supplement the information available for policy-makers, environmental organizations and other stakeholders. EMBAL has great potential to enhance the knowledge base on the European scale and provide opportunities for monitoring initiatives at national, regional and local scale. Involving the member states through consultations, during which their benefits from the EMBAL approach are communicated, and ensuring their participation in the setting-up of the EMBAL mechanism would be important for a continuing implementation of such a joint monitoring programme, and could ensure the member state’s long-term support.

9 Literature

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10 Annex

Annex A – Project schedule

Annex B – Methodological supplement

- Table 10-2 – Overview of main criteria extracted from 13 monitoring approaches.
- Table 10-3 – Overview of parameters extracted for further considerations in the development of the EMBAL methodology. Presented are the parameters, their assessment methods and sources

Annex C1 – Factsheets of monitoring approaches

Annex C2 – Overview of bird counting methods for PECBMS

- Table 10-4 – Overview of bird counting methods and number of farmland sites for the EU 28 countries. Data compiled from PECBMS website. The number of farmland sites is based on CORINE 2001 land cover map and provided by EBCC.

Annex D – Field survey material

- List of land cover codes
- Main sheet
- Vegetation sheet

10.1 Annex A – Project schedule

Table 10-1 – Overview of the project schedule.

Month	March		April				May				June				July				August				September
Week	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1-4**
Task 1	Data identification and analysis					Workshop Brussels and feedback									Mid-term report and meeting								Final report and meeting (in October)
	Comparison of approaches and costs						Comparison of approaches and costs																
				Baseline analysis			Baseline analysis		Case study data comparison							Case study data comparison							
Task 2 and 3		Draft of a monitoring methodology protocol					Refinement of protocol draft									Proposal of a monitoring methodology, including survey manual and future design							
								Field test of protocol draft															
													Feedback										
													Refinement of protocol			Refinement of protocol							

10.2 Annex B – Methodological supplement

Table 10-2 – Overview of main criteria extracted from 13 monitoring approaches.

Criteria / Approaches	**GB/CS**	**NICS**	**NILS**	**EBONE**	**BioBio**	**PECBMS**	**LUCAS**	**LISA**	**HNV Germany**	**HNV Portugal/Lower Saxony**	**BDM CH**	**ALL-EMA CH**	**AGRIT and AGRIT Agro-Environmental Survey (AAE) Italy**
Overall assessment													
Data before 2015 and from 2015 onwards?			**(x)**				**x**	**x**	**x**				**no**
Data available for years	**1978, 1984, 1990, 2007**	**first in 1998, last survey in 2007**	**since 2003, reinventory between 2008-2012**	**2010**	**project phase 2009-2012**	**since 2002**	**2008-2012, 2013-2017, grassland from 2018 onwards**	**2014, 2016**	**from 2009, 2013; partly 2016 (continued)**		**since 2000**	**first cycle 2015-2019**	**from 1988 onwards, since 2003 point frame survey**
Data basis	**Field sampling**	**Field sampling**	**remote sensing, field sampling**	**remote sensing, field sampling**	**remote sensing, field sampling, farm data**	**field sampling**	**remote sensing, field data**	**field sampling**	**field sampling**	**image interpretation**	**field data**	**field data**	**field data + remote sensing**
Assessment of greening possible?	**no / not yet**	**no / not yet**	**not yet**	**no**	**no**	**no**	**no**	**partly**	**partly**		**no**	**no**	**in general yes, baseline for Italy with 2010 pilot survey, but no regular scheme after 2015**
Spatial scale													
European level				x	x	x	x	x		x			
National level	x		x			x	x	x	x	x	x	x	
Regional level	x	x			x			x	x	x	x	x	x
Local level								x	x		x	x	x
Countries/ regions	GB	Northern Ireland	Sweden	12 countries	9 countries	15 EU countries	EU28	10 EU countries,	DE		CH	CH	IT, three regions

Criteria / Approaches	**GB/CS**	**NICS**	**NILS**	**EBONE**	**BioBio**	**PECBMS**	**LUCAS**	**LISA**	**HNV Germany**	**HNV Portugal/Lower Saxony**	**BDM CH**	**ALL-EMA CH**	**AGRIT and AGRIT Agro-Environmental Survey (AAE) Italy**
covered				within EU (+ Israel, South Africa, Australia)	within EU + Ukraine, Tunesia, Uganda			39 regions					Toscana, Marche and Sicilia (1/6 of total territory)
Focus on													
Habitats	x	x	x	x	x	partly	x	x	x	x	x	x	x
Plants	x	x	x	x	x			x	x	x	vascular plants and mosses	x	no
Birds	x		x		x	x		no		x	(indirect: synergy with bird monitoring program Vogelwarte)	(synergy with bird monitoring program)	no
Insects	x		x		x			no			butterflies	(synergy with BDM)	no
soil fauna (earthworms)					x			no			molluscs		no
In field biodiversity	x	x	x	x	x			x	x		x	x	no
Off-field biodiversity	x	x	x	x	x			x	x		x	x	no
Extent of data	1000 x 1000 m (100 ha) in stratified sample	500 x 500 m (25 ha) in stratified sample	1000 x 1000 m (100 ha) in blocks of 5x5 km squares in a stratified sample	1000 x 1000 m (100 ha) in stratified sample	Farm based plots and transects	country wide 2005-2016	point survey with 3 m diameter, and 250 m transects within grid of 2 x 2 km; selection on NUTS level	500 x 500 m (25 ha), sample based on selection of defined nature regions	1000 x 1000 m (100 ha)	parish level, yearly	1000 x 1000 m (100 ha), nested plots with 200 m2 and 10 m2 circular plots	1000 x 1000 m (100 ha), nested plots with 200 m2 and 10 m2 circular plots	250 x 250 m (6.25 ha), AGRIT yearly, AAE as rolling survey (1/3 of territory each year)
Farmland /farming recording													
Crops	x	x	x	x	x	no	x	x	x	x	x	x	
Intensity of landuse	x	x	x	x	x	no	x	indirect assessment	no	x	indirect via statistical data	no	no
Farming	indirect	indirect	indirect	indirect	x	no	x	indirect	indirect	x			no

Criteria / Approaches	**GB/CS**	**NICS**	**NILS**	**EBONE**	**BioBio**	**PECBMS**	**LUCAS**	**LISA**	**HNV Germany**	**HNV Portugal/Lower Saxony**	**BDM CH**	**ALL-EMA CH**	**AGRIT and AGRIT Agro-Environmental Survey (AAE) Italy**
practice								assessment					
Fertilisation	no	Northern Ireland	no		x	no		only when observed in the field	no	x		no	no
Application of PPP	no	no	no	no	x	no	no	only when observed in the field	no			no	no
Landscape elements (LE)	yes	yes	yes	yes	x	no	x	x	x	x	x	x	x
Extent of LE	all in the square	all in the square	selected	all in the square	all on the farm	None		all in plot	all classified as HNV	all in plot	indirect via changes in length of hedges, watercourses etc. through photointerpretation in other monitoring program	length	x
Kind of LE	all in the square	all in the square	all	all in the square	all on the farm	None		x	x			x	x
Quality of LE	indirect	indirect	indirect			None		via nature value	yes, values I-III, criteria for each quality class				no
Buffer strips	yes	yes	yes	yes	yes	no		x	indirect, together with flower strips, ruderal, grass and herbal areas				yes, recorded as polygon if larger than 5 m
Habitat consideration													
All farmed landscape	x	x	x	x	x	x	x	x	x	x	x	x	x
Focus on habitats		x											no
Possibility to track greening													

Criteria / Approaches	GB/CS	NICS	NILS	EBONE	BioBio	PECBMS	LUCAS	LISA	HNV Germany	HNV Portugal/Lower Saxony	BDM CH	ALL-EMA CH	AGRIT and AGRIT Agro-Environmental Survey (AAE) Italy
Buffer strips	yes, within the sample	yes, within the sample	yes, within the sample	yes, within the sample	yes, within the sample	no	x	indirectly	no				in general yes
Other EFAs	yes, within the sample	yes, within the sample	yes, within the sample	yes, within the sample	yes, within the sample	no	x	indirectly	partly, no clear differentiation possiblee				only partly
Time framing													
Regular monitoring	yes	yes	rolling scheme in 5 year cycle	not applicable yet	not applicable yet	x	x	not applicable yet	x	yes	x	x	not yet
Repetition cycle	about 7 years	about 7 years	5 years			1 year	3 year		rolling cycle, yearly 1/4 of federal states or half of sampling every 2 years	1 year	rolling cycle, every 5 years	1 year	foreseen rolling cycle, every 3 years (harmonized with LPIS REFRESH)
Season	height of the growth season	height of the growth season	height of the growth season	height of the growth season	spring, height of the growth season, september	spring	March-Novembe	spring	April - June, depending on site		depending on indicator	depending on altitude of sample plot	spring
Number of visits/year	1	1	1	1	1-3 visits	1	1	1	1 (except for very heterogeneous plots: maybe 2 visits necessary)	1	1-7, depending on indicator (1-2 for vegetation, 4-7 visits for butterlfies, 2-3 for birds)	2 for plants, greater altitude 1 visit (shorter vegetation period)	1
References	Maskell et al. 2008	McCann et al. 2009	Stahl et al. 2011	Bunce et al. 2010	Herzog et al. 2012	EBCC 2017	Eurostat 2016; Oppermann et al. 2016	Oppermann et al. 2015	Pan et al. 2011	Paracchini et al. 2008	Koordinationsstelle BDM 2014, Bundesamt für Umwelt Schweiz	Agroscope, Felix Herzog 2015	Tropea et al. 2012

Table 10-3 – Overview of parameters extracted for further considerations in the development of the EMBAL methodology. Presented are the parameters, their assessment methods and sources.

	Code	**Parameter**	**Methods**	**Classes / attributes of parameter**	**Measure/unit**	**Source**
A		**Sampling design**				
A	**1**	**Grid size**	Fixed grid with 5 x 5 km or 2 x 2 km			NILS, LISA or LUCAS
			Random selection, based on bird monitoring plots			HNV
A	**2**	**Sample plot size**	1000 m x 1000 m (1 km2, 100 ha)			NILS, EBONE, GBCS, HNV
			500 m x 500 m (0.25 km2, 25 ha)			LISA, NICS
A	**3**	**Stratification**	No stratification: random distribution			PECBMS
			Environmental stratification	based on climate, topography		NICS, EBONE
	4	**Regional selection**	NUTS regions	level 2, level 3		LUCAS
			Defined nature regions			LISA
			Systematic choice within targeted regions			
A	**5**	**Repitition cycle**	All sample plots in 1, 2, 3, 4 years			LUCAS, HNV, LISA, ALL-EMA
			Defined number/% of all plots every year (rolling survey)			BDM CH
			Adaptation to certain policy cycles, e.g. CAP reform every 7 years + midterm reviews			
B		**Area survey**				
B	**1**	**Land cover**	Record each patch of land cover seperately		ha/cover	LISA
			Detailed crop species	E.g. winter wheat, summer wheat, sugar beet, carrot etc.		LISA, LUCAS
B	**2**	**Landscape elements**	Record linear and point elements from predefined list	**Landscape element**	ha/element	LISA, HNV
				Wood/tree/bush elements		

	Code	Parameter	Methods	Classes / attributes of parameter	Measure/unit	Source
				Grass-herb elements and reed-sedge beds		LISA, HNV
				Water elements		LISA, HNV
				Stone, rock, raw sol and terrace elements		LISA, HNV
				Roads and tracks		LISA, HNV
				Complex elements and other elements		LISA, HNV
				Ditches		LISA, HNV
				Non-agricultural elements		
				Forest		LISA, HNV
				Wetland		LISA, HNV
				Open water		LISA, HNV
				Settlement area, asphalt roads, railways		LISA, HNV
				(Former) mining areas		LISA, HNV
				Unknown		LISA, HNV
B	**4**	**Length and width of elements (or only width)**	Exact length and width are recorded, e.g. with a threshold of > 1m		cm/m	LISA
B	**14**	**Land use/ Type of management**	Observation through field surveyor	regular grazing, annual crops, controlled burning etc.	type	EBONE
B	**15**	**Land use intensity**	Derived from land cover characteristics	for each land cover type and landscape element	scale 1-5 with intermediary steps	LISA
B	**16**	**Nature value**	Valuation through field surveyor	considering different single or aggregated parameters for different land covers (e.g. land use intensity, species richness, floral diversity	scale 1-5 with intermediary steps	LISA, HNV
B	**17**	**Ecological impact**	Intensity of potential impact is noted as observed in the field	Water erosion, water pollution on shallow soils, flooding, denitrification, application of PPP, fertilizer drift, irrigation	impact scale 1-3; presence of irrigation	LISA
B	**18**	**Habitat type**	For all identified land covers	Annex 1 Habitats Directive, EUNIS, regional habitat type, other habitat keys (e.g. ALL-EMA)	type	LISA, LUCAS, EBONE, HNV, ALL-

	Code	Parameter	Methods	Classes / attributes of parameter	Measure/unit	Source
						EMA
B	**20**	**Land use intensity along landscape elements**	For linear elements (hedges, watercourses), intensity of use of adjacent land cover is recorded within 5 m range	1: extensive grassland or unused buffer strips; 2: intensive grassland; 3: arable land or area utilized for human construction	type	ÖRA
			For peripheral areas along protected habitats (e.g. Annex 1, Habitats Directive, all point elements of certain extent + natural area not part of the agricultural landscape)	1: arable land or intensive grassland minimum 5 m distance from protected habitat area, buffer strip or extensive grassland inbetween; 2: arable land or intensive grassland in 2-5m distance, buffer strip min 2m; 3: arable land, intensive grassland or construction area directly adjacent to protected habitat		
C		**Plot survey general**				
C	**1**	**Exposition**	Record data on specific point in the landscape/survey area (e.g starting point of transect)		N, W, S, E, NE, SE, SW, NW	LISA / LUCAS grassland
C	**2**	**Inclination of slope**	Measured through field surveyor	flat (0-2°) to steep slope (> 35°)	slope classes 1-5	LISA / LUCAS grassland
	3	**Soil moisture**				
	4	**Coverage of bare soil**				
C	**5**	**Total number of flowering species**	Number is counted (for up to 15 species), estimated (for >15 species), or indicated through classes (for more than 10/15 species: > 15, > 20)		no. of species/area	LISA
	6	**Diversity of flower colors**				
	7	**Flower density**				
C	**8**	**Number of potential key species**	Exact number as recorded from vegetation survey		no. of species/area	LISA
C		**Grassland**				

	Code	Parameter	Methods	Classes / attributes of parameter	Measure/unit	Source
C	**5**	**Type of vigour**	Observation through field surveyor	very meagre/sparse, meagre growth, light growth, dense growth, very dense/mass growth	scale 1-5 with intermediary steps	LISA
C	**G2**	**Management type**	Coverage with shrubs	no shrubs, scattered shrubs in the parcel (less than 5%), shrub and bushes on 5-30% of parcel, on 30-60%, on > 60%	classes 0-4	LISA
			Management options for meadows and pastures	Meadow: 1st or 2nd growth, recently mown, x weeks ago, fallow; Pasture: time of grazing (before/after 1st grazing), type of grazing (rough, seasonal, strip), type of livestock (horses, cattle etc.)	no. of cuts/year, type	LUCAS
C	**G5**	**Height main stratum / other strata**	Measured average heights of different herb-grass vegetation layers	height for ground layer, low layer, medium layer, upper layer	cm	LISA, LUCAS
C	**G6**	**Dominance/vegetation heterogeneity**	Observation through field surveyor	homogeneous, heterogeneous, very heterogeneous	type	LUCAS
C	**G8**	**Kind and extent of vegetation layers**	Estimated through field surveyor	graminoid-herb layer, woody plants layer, bare ground layer	% / category	LUCAS
C		**Arable Land**				
C	**A1**	**Height of crop**	Measured through field surveyor		cm	LISA
C	**A2**	**Growth stage of crop**	from germaniation to senescence/beginning dormancy	from germination to senescence	stage 0-9	LISA
C	**A4**	**Coverage of crop**	Estimated through field surveyor		% / area	LISA
C	**A7**	**Coverage of wild plants**	Estimated through field surveyor		% / area	LISA
D		**Species survey**				
D	**1**	**Vegetation species**				
		Options for assessment	Plots only on vegetated areas			LISA, HNV, LUCAS

	Code	Parameter	Methods	Classes / attributes of parameter	Measure/unit	Source
			One vegetation plot in each identified land cover type and linear landscape element within survey area			EBONE, BioBio, GBCS
			Plots in representative vegetation structure of the areal element/plot (e.g. grassland)			HNV
			Defined number of plots/transects (between 1-10, see LISA with 4 transects/25 ha)			
			Predefined position of plots (e.g. along a geometric shape)			LISA
		Method for assessment	Transect walks			LISA, BDM CH, EBONE
			Area vegetation plots, either round or square (including nested plots, e.g. with sub-plots of 4m2 to 100 m2)			BDM CH, ALL-EMA, EBONE, BioBio
		Options for species recording	Key species list			LISA, LUCAS, HNV
			Regionalised key species lists			HNV, LUCAS
			Key species, when more than 2,3,4 species present in the plot			HNV
			All frequent/semi-frequent species			BDM, ALL-EMA
			Dominant species			LUCAS, LISA
			Species for structural characterization			LUCAS, LISA
			Neophytes			ALL-EMA
			Additional/quality plant species			LISA
			All plant species			EBONE, BioBio
			All plant species over threshold coverage e.g. 30 %			EBONE
D	**3**	**Bird species**	Transect walk		species/area	BDM CH, PECBMS
			Habitat mapping			PECBMS

	Code	Parameter	Methods	Classes / attributes of parameter	Measure/unit	Source
			Point survey			PECBMS

Abbreviations:

ALL-EMA	**Arten und Lebensräume Landwirtschaft Schweiz**
BDM CH	**Biodiversitätsmonitoring Schweiz**
BioBio	**Indicators for biodiversity in organic and low-input farming systems**
EBONE	**European Biodiversity Observation Network**
EUNIS	**European Nature Information System**
GBCS	**Great Britain Countryside Survey**
HNV	**High Nature Value Farmland Germany**
LISA	**Landscape Infrastructure and Sustainable Agriculture**
LUCAS	**Land Use/Cover Area frame Survey**
NICS	**Northern Ireland Countryside Survey**
NILS	**National Inventory of Landscapes in Sweden**
PECBMS	**Pan-European Counted Bird Monitoring Survey**
ÖRA	**Ökologische Ressourcenanalyse Baden-Württemberg 2016**

10.3 Annex B – Field test questionnaire

EU Biodiversity Monitoring 2017

Questionnaire for surveyors

May 10, 2017

Field test

Vegetation sheets

1. Please walk a total of around 15 transects with the following specifications:
    a. 5 transects in arable land with differing land use intensities
    b. 5 transects in grassland with different management types (meadow, pasture) and intensities
    c. 5 transects for permanent cultures (e.g. vineyards, fruit orchards, olive groves etc.) with differing combinations of ground and tree layers.

   For each transect, please give the coordinates, and take photos of the land cover. Apply the vegetation sheets for arable land and grassland. Please send us the filled out vegetation sheets, photos and coordinates and provide feedback to the assessed parameters: is the survey manual clear enough or does it need specification?
2.
    a. Do you miss any species in the list for arable land? Please name up to 3 species which you think would be important in the key species list. Please do not consider the very rare species, but the ones that are quite common, and easy to identify (since not all surveyors will be botanists, we can avoid errors by using reduced species lists, though of course we are aware that the rare species will not be fully represented through the survey)
    b. Please take photos from the key species you find in the field (if you agree we would include some pictures in the final version of the survey manual).
    c. Are there any species on the list for arable land that could be dismissed from the key species list from your experience? Please give feedback and explain.
3. Please think of situations (and take photos, if you find them in the field) where a transect in arable land would not be feasible due to the management praxis, e.g. because the field is ploughed several times and neither a crop nor wild plants are found (we found this “bare soil” frequenlty in Spain).
4. Please use the transect walks on arable land and permanent cultures to note the different management types you find in the field. Is it feasible to record the tillage regime of the ground layer? Which other management types would be important in your point of view? If possible, provide photos from the management types you find in the field.

Main sheet

1. Please find around 5 examples for complex situations in the field:
    a. Landscape elements which could be assessed as "complex", consisting of 2 or more types of elements (e.g. a stonewall with bushes and tress in between). Record the land cover codes (LC1 + LC2), the land use intensity (LUI1 + LUI2), nature value (NV1 + NV2) and EUNIS code for each of the identified elements (see survey manual). Please not in brackets the land use intensity and nature value that you would have given the element if recorded as a complex. Do the "merged" values differ from the individual values? Please take photos of the elements that you find in the field.
    b. Land cover with more than one type, e.g. agroforestry systems (consisting of tree and ground layer). Similar to the complex landscape elements, please use the main sheet and give the two land cover codes, land use intensities, nature values and EUNIS types. Are there any situations where you would need to indicate more than 2 different land covers?
2. Please use aerial images to find around 5 complex landscapes which are characteristic for a region. These complex landscapes should cover a large area and should have a largely homogeneous structure. Examples for these landscapes could be the Dehesas in the Extremadura (Spain), the fruit orchards in south-west Germany, large wetlands with pastured reed beds, juniper heaths, vineyards on terraces, etc.
    a. Please provide screenshots of the areas you would consider as complex landscapes
    b. Try to find the demarcation line: where does the complex landscape start and end? Please explain the criteria underlying your decision, e.g. at the basis of structure, size, distance between single elements (e.g. between the trees in the Dehesa).
    c. Which land cover codes would you give in your examples?
    d. In your opinion, is the characterization as "complex landscape" feasible or should each land cover and landscape element in such regions be recorded individually?
3. Please find examples for buffer strips (>1m width, could be used as arable land) and differentiate them from grass-herb strips >1m width, which could not be used as arable land because of trees/bushes, stones, slope, etc. In which situations is the distinction between buffer strips and "embankment" unclear? Please provide photos from at least 2 buffer strips, 2 "embankments" and 2 unclear elements.

Photos in a plot

Please give feedback to the following options:

1. A photo of each recorded landscape element has to be taken.
2. A photo of each key species has to be taken.
3. An exemplary picture of each kind of landscape element and each species has to be taken, but only once for the whole plot.
4. A photo of each buffer strip has to be taken.

Thank you for your feedback!

The IFAB team

10.4 Annex C1 – Factsheets of monitoring approaches

ALL-EMA

BDM Switzerland

BioBio

EBONE

HNV farmland indicator Germany

LISA

LUCAS

PECBMS

ALL-EMA

“Agricultural Species and Habitats” Monitoring Programme Switzerland

Developed in year: 2015

Developed by: Agroscope, the Swiss Federal Institute for Forest Snow and Landscape Research WSL and the Swiss Biodiversity Monitoring Programme as well as numerous other experts are partners in development and implementation.

Purpose:

Monitoring of species and habitats: To determine the state of and changes in species and habitats of the Agricultural Environmental Targets in Switzerland’s open agricultural landscape.

Evaluation of areas reserved for promoting biodiversity: To evaluate the state of and changes in species and habitats in areas reserved for promoting biodiversity that are eligible for subsidies.

Answering practice-oriented research question: To make data available at national level for the study of correlations and to answer current and future questions.

Methodology:

Threefold sampling design, harmonized with BDM Switzerland, 1 km^2 sampling squares, within which ecological quality and vegetation records are completed.

Spatial scale:

ALL-EMA is based on a systematic sampling grid, with regional densification according to biogeographical regions, high altitudes, habitats and altitudial zones, in total 170 plots

Indicators:

Main indicators covered by the following indicator groups: habitat and structural diversity, quality of habitats and structures, species diversity, quality indicator species, quality of “Biodiversitätsförderflächen”

Data available for:

First survey cycle from 2015 to 2019, to be completed.

Relevant publications:

Agroscope (2015) Agrarumweltindikatoren „Arten und Lebensräume Landwirtschaft“, ALL-EMA

Website: https://www.agroscope.admin.ch/agroscope/en/home/topics/environment-resources/monitoring-analytics/all-ema.html (last accessed June 13, 2017)

BDM

Biodiversity Monitoring Switzerland

Developed in year: 2000

Run by: Federal Office for the Environment, Switzerland

Purpose:

Complementing other environmental information, BDM data serve to underpin nature conservation policy and other political decisions with a large impact on biodiversity, such as those made regarding agriculture and forestry.

Methodology:

Survey of the long-term development of species diversity in selected animal and plant species; transect walks along 2.5 km tracks and species records in circular sampling areas.

Spatial scale:

BDM is based on a systematic sampling grid, with regional densification according to biogeographical regions, high altitudes, habitats and altitudial zones.

Indicators:

14 impact indicators (e.g. landscape elements and land use), 12 state indicators (e.g. genetic and species diversity), 6 measure indicators (e.g. protected areas, ecological focus areas).

Data available for:

Phasing survey, data available every 10 years, status reports in 2006 and 2009

Relevant publications:

Koordinationsstelle BDM (2014) Biodiversitätsmonitoring Schweiz BDM. Beschreibung der Methoden und Indikatoren. Bundesamt für Umwelt, Bern. Umwelt-Wissen Nr. 1410: 104 pages (online: www.bafu.admin.ch/uw-uw-1410-d)

Website: http://www.biodiversitymonitoring.ch/en/home.html (last accessed June 13, 2017)

BioBio

Biodiversity indicators for organic and low-input farming systems

Developed in year: 2009-2012

Developed by: Federal Department of Economic Affairs, Research Station FDEA-ART, Zurich, Switzerland; Aberystwyth University, Wales, UK; BOKU University, Vienna, Austria; Technical University of Munich, Germany; Alterra Wageningen UR, The Netherlands; Solagro, Toulouse, France; SZIE, Hungary.

Purpose:

The objective of the project was to develop a set of biodiversity indicators associated with organic and low-input farming systems. These indicators could then potentially be used to monitor the contribution of farming to the maintenance of biodiversity in areas of Europe. Indicators were selected following a major review of indicator theory and existing biodiversity indicators. The indicators are scientifically sound, generic at the European scale and relevant and useful for stakeholders.

Methodology:

Habitat mapping based on the General Habitat Category methodology across an entire farm, surveys of vegetation, spiders, wild bees and earthworms on example linear and insular habitats, interviews with farmers in 2010.

Spatial scale:

BioBio is based on farm level, study took place in 9 EU countries, Ukraine, Tunisia, and Uganda.

Indicators:

The applied indicators are part of the following main levels: genetic diversity indicators, species diversity indicators, habitat diversity indicators, farm management indicators. They are assessed via farm questionnaires, X-plots or rectangular plots of vegetation surveys, suction sampling, soil sampling, farm habitat mapping or walked transects.

Data available for:

Farm questionnaire reference year and indicator assessment in 2010.

Estimated costs/effort:

Costs per average farm (15 habitats, 8 plots, 73 ha, 1 h travel distance) € 2674 - € 8175.

Relevant publications:

Herzog et al. (2012) Biodiversity Indicators for European Farming Systems – A Guidebook, ART, Switzerland

Website: http://www.biobio-indicator.org/index.php?l=1 (last accessed June 19, 2017)

EBONE

European Biodiversity Observation Network

Developed in year: 2008-2012

Developed by: Wageningen UR, Wageningen Environmental Research (Alterra), The Netherlands.

Purpose:

The aim of EBONE is to develop a cost-effective system of biodiversity data collection at regional, national and European scale. Thereby, EBONE focused on:

1. The provision of a sound scientific basis for the production of statistical estimates of stock and change of key indicators that can then be interpreted by policy makers responding to EU Directives regarding threatened ecosystems and species;
2. The development of a system for estimating past change but also for forecasting and testing policy options and designing mitigating management strategies for threatened ecosystems and species.

Methodology:

Field data is based on records in 94 1 km^2 plots using the General Habitat Category methodology and vegetation records in each General Habitat Category plot, linear plot and in targeted habitats.

Spatial scale:

The field test of the EBONE protocol has been done in twelve European countries and three more countries (Isreal, Australia and South Africa), based on 94 plots of 1 km^2 of a stratified sample.

Indicators:

The biodiversity indicators tested within the frame of the project cover: habitats of European interest in the context of broad habitat assessment, abundance and distribution of selected species, fragmentation of natural and semi-natural areas.

Data available for:

Field test in 2010.

Estimated costs/effort:

Per 1 km^2 (preparation, field work, processing) € 1600 - € 2700.

Relevant publications:

Roche and Geijzendorffer (2013) EBONE: integrated figures of habitat and biodiversity indicators – Quantifying indicators of an integrated biodiversity observation system. Alterra Report 2392, Wageningen

Website: http://www.wur.nl/en/Expertise-Services/Research-Institutes/Environmental-Research/Projects/EBONE-2.htm (last accessed June 19, 2017)

HNV farmland

High Nature Value Farmland Indicator Germany

Developed in year: 2009

Developed by: Bundesamt für Naturschutz, Germany and the German federal states

Purpose:

Monitoring of species and habitats: To determine the state of and changes in species and habitats of the Agricultural Environmental Targets in Switzerland’s open agricultural landscape.

Evaluation of areas reserved for promoting biodiversity: To evaluate the state of and changes in species and habitats in areas reserved for promoting biodiversity that are eligible for subsidies.

Answering practice-oriented research question: To make data available at national level for the study of correlations and to answer current and future questions.

Methodology:

1 km^2 sampling squares, within which ecological quality land, landscape elements and vegetation records on transects are completed.

Spatial scale:

The HNV farmland monitoring in Germany is based on the sampling design of the German Common Breeding Bird Survey; 900 sampling sites across Germany.

Indicators:

Type of land cover, nature value of land cover, species richness

Data available for:

2009, 2013

Estimated costs/effort:

Approx. 10 minutes per HNV transect; on average 5 transects per plot. For one plot, surveyor needs half a day up to a day of field work.

Relevant publications:

Bundesanstalt für Naturschutz (2014) Erfassungsanleitung für den HNV-Farmland-Indikator.

Website: http://www.bfn.de/0315_hnv.html (last accessed June 13, 2017)

LISA

Landscape **I**nfrastructure and **S**ustainable **A**griculture

Developed in year: 2014

Developed by:

Institute for Agroecology and Biodiversity (IFAB) – Dr Rainer Oppermann, Richard Bleil, Anja Eirich, Julian Lüdemann and partners

Purpose:

The methodology was first developed for the LISA pilot study in 2014 to develop and implement a method to measure the nature value of different agricultural landscapes throughout Europe with a standardized field-level survey. In 2014 the approach was tested in 39 regions in 10 European countries, representing different intensities of use in agricultural and grassland areas. The study was repeated in 2016 in 13 regions in 6 countries. The aim of the LISA methodology is to provide a rapid approach for the assessment of nature value, based on landscape and biodiversity field data.

Methodology:

Assessment of nature value of farmland and landscape elements in a field survey; concrete biodiversity data on behalf of transect walks with identification of key species; photo documentation

Spatial scale:

LISA is based on plots with the size of 25 ha based in regions with a regular grid of 5 x 5 km;, 25 plots per region. 4 transect walks per plot (100 transect walks per region).

Indicators:

In total about 20 indicators, e.g. key plant species for grassland and arable land; extent and structure of landscape elements, etc.

Data available for:

2014 (10 EU countries, 39 regions), 2016 (6 countries, 10 regions)

Estimated costs/effort:

Time needed per plot ~ 2 h; € 80-120 per plot → € 2000-3000 per region; for transects, surveyor needs 10 – 30 minutes, depending on type of land cover.

Relevant publications:

IFAB (2015): Landscape Infrastructure and Sustainable Agriculture (LISA) – Report on the investigation in 2014; http://www.ifab-mannheim.de/LISA%20report%202014-final%20July%202015.pdf

LUCAS

Land use/cover area frame survey

Developed in year: 2001

Developed by: Eurostat

Purpose:

The survey aims to set up a European-wide area frame survey for the provision of coherent and harmonised statistics on land use and land cover in the Member States. It provides information about agriculture, the environment, landscapes and sustainable development through in-situ data collection. On a register of points, specific surveys on soil and vegetation are carried out. The LUCAS survey is based on the Decision 1445/2000/EC of the European Commission. The latest survey was carried out in 2015.

Methodology:

Field surveyors document the types of land cover and visible land use based on standardised LUCAS categories on geographically referenced points. During transect walks the land cover is recorded. At 10 % of the points, a topsoil sample is collected. In 2018 a pilot LUCAS grassland survey is carried out.

Spatial scale:

LUCAS points belong to the intersections of a 2 km regular grid that includes around 1 million points all over the EU. During the LUCAS 2015 survey, a sample of 273 401 of these points was visited on the spot by 750 field surveyors. The points are selected on the basis of stratification information.

Indicators:

Land cover and land use, land management, soil parameters, vegetation parameters on grassland.

Data available for:

Pilot survey in 2001, data sets available for 2006, 2009, 2012 and 2015, representing a portion of the total number of points throughout Europe.

Estimated costs/effort:

€ 10.5 mio. for the LUCAS survey in 2012 (http://ted.europa.eu/udl?uri=TED:NOTICE:21376-2012:TEXT:DE:HTML)

Relevant publications:

eurostat (2015) LUCAS 2015 (Land Use / Cover Area Frame Survey) – Technical reference document C1 – Instructions for Surveyors, eurostat Technical Documents

Website: http://ec.europa.eu/eurostat/web/lucas/overview (last accessed June 22, 2017)

PECBMS

Pan-European Common Bird Monitoring Scheme

Developed in year: 2002

Developed by: Joint initiative of the European Bird Census Council (EBCC) and the BirdLife International.

Purpose:

The aim of the monitoring scheme is to use common birds as indicators of the general state of nature using large-scale and long-term monitoring data on changes in breeding populations across Europe. Among others, these data can then be used to calculate European common bird indices and indicators, inform policy makers and the public, explore drivers for change in populations.

Methodology:

PECBMS collects national data from already existing large-scale monitoring monitoring schemes in European countries which are based on fieldwork of volunteers and which have standardized methodology and formal design. The countries deliver national species indices and trends with standard errors instead of raw count data.

Spatial scale:

PECBMS is based on national data, where birds are counted at sample plots. The methods with which the birds are counted differ between the Member States, and can be: line transect walks, point counts, or territory mapping.

Indicators:

Bird counts

Data available for:

Data on population trends and indices of 169 common European bird species are available for the time period between 1980 and 2014.

Estimated costs/effort:

Not available, since methods differ in each Member State.

Relevant publications:

Website: http://www.ebcc.info/index.php?ID=28 (last accessed June 22, 2017)

10.5 Annex C2 – Overview of bird counting methods for PECBMS

Table 10-4 – Overview of bird counting methods and number of farmland sites for the EU 28 countries. Data compiled from PECBMS website. The number of farmland sites is based on CORINE 2001 land cover map and provided by EBCC.

	Country	Methods	Plot selection	Remarks	Samples on farmland
1	Austria	Point counts	Free choice		206
2	Belgium	Point counts	Random stratified (Flanders, no info for Brussels and Wallonie)	Seperate schemes for Flanders, Wallonie and Brussels	136
3	Bulgaria	Line transects	Stratified random		122
4	Croatia	Point-count transects	Semi-random		?
5	Cyprus	Line transects	Stratified semi-random		82
6	Czech Republic	Point counts	Free choice		104
7	Denmark	Point counts	Free choice		899
8	Estonia	Point counts	Free choice		72
9	Finland	Line transects and point counts	Free choice and systematic selection		70
10	France	Point counts	No Information		1659
11	Germany	Line transects; Mapping and counting of territories/breeding pairs/nests	Stratified random; free choice of plots and census areas	Different schemes for common breeding birds and rare breedng birds	849
12	Greece	Point counts	Stratified random		93
13	Hungary	Point counts	Stratified semi-random		302
14	Ireland	Line transects	Stratified random		249
15	Italy	Point counts	Random		503
16	Latvia	Line transects; point counts	Systematic and random; random	Different schemes for breeding birds and birds in agricultural areas	42
17	Lithuania	Point counts	Stratified semi-		85

			random		
18	Luxemburg	Line transects and territory mapping	Stratified random		?
19	Malta	-	-		-
20	Netherlands	Point counts; territory mapping	Randomized; free choice	Farmland breeding species project and All breeding bird species project respectively; Five more schemes for specific habitats and groups are running in the Netherlands.	4785
21	Poland	Line transects	Stratified random		690
22	Portugal	Point counts	Stratified random		76
23	Romania	Point counts	Semi-random		181
24	Slovakia	Point counts	Free choice		61
25	Slovenia	Line transects with two belts (50 m and beyond)	Stratified non-random		104
26	Spain	Point counts; line transects	Stratified random	Seperate schemes for Spain and Catalunya	880
27	Sweden	Point counts (2x); line transects and point counts	Free choice; systematic (general area) and free choice (exact spot) combined; systematic	Three different schemes: summer point counts, nightroutes and fixed routes	46
28	United Kingdom	Line transects	Stratified random		3884

Box 1 – Explanation of the different bird count methods applied in EU MS, supplementing Table 10-4 above. Source: EBCC (no date) and Voříšek et al. (2008).

There is no uniformly best field method to count birds. What method is to be selected depends on, among others, the goals of a scheme, the sampling design and the availability of fieldworkers. Three main standard types of methods are available and used by national schemes within PECBMS, sometimes slightly modified for national purposes: **territory mapping**, **line transect** and **point counts**. Point counts along a transect are called point transect counts.

- Territory mapping, also known as spot mapping, this is based on the idea that it is possible, by accumulating observations of birds’ locations and activities throughout the breeding season, that one can work out the boundaries of territories and thus estimate the number of territorial birds.
- Both *line transects* and *point transects* (sometimes called point counts) are based on recording birds along a predefined route within a predefined survey unit. In line transects, birds are recorded continually along the route; in point transects, they are recorded at points at regular intervals along the route, for a given duration at each point.

Monitoring schemes contributing their data to PECBMS are based on sampling, i.e. population indices and other results are inferred from a sample of sites distributed across a country. The selection of sampling plots (sites) determines how representative the results are.

The most common methods to select sample plots in generic breeding bird monitoring schemes are free choice, systematic selection, stratified random selection and random selection. Definitions according to Sutherland et al. (2004).

- **Free choice** - there are no rules, each fieldworker is allowed to select the plot arbitrarily. This method is prone to bias. Fieldworkers can, for example, prefer to work in areas that are rich in birds. Also, observers can abandon a site that has become less attractive because birds have declined.

- **Systematic selection** - plots are uniformly distributed on a grid every kilometer or hundred kilometers (or whatever scale is appropriate). Although this method is considered much better than a free choice, it still might pose a problem for representativeness if the location of plots coincides with a systematic pattern in the landscape.

- **Random selection** - sample plots are selected by the generation of randomly distributed coordinates within the study boundary. Random sampling is the ideal method to select sample plots, although with some practical limitations, e.g. some randomly selected plots can be inaccessible. These limitations can be solved by stratified random selection.

- **Stratified random selection** - the area of interest is broken down into different sub-areas, known as strata (singular stratum), according to predefined types of habitat, altitude, land use, bird abundance, accessibility of survey sites, administrative or geopolitical boundaries, observer density, etc. Within each stratum, plots are selected at random.

Free choice was the common method in older schemes, but nowadays most of these schemes have been replaced with schemes with some element of randomization. Stratified random selection is the prevalent method of newly established monitoring schemes in Europe.

10.6 Annex D – Field survey material

10.6.1 Land cover codes

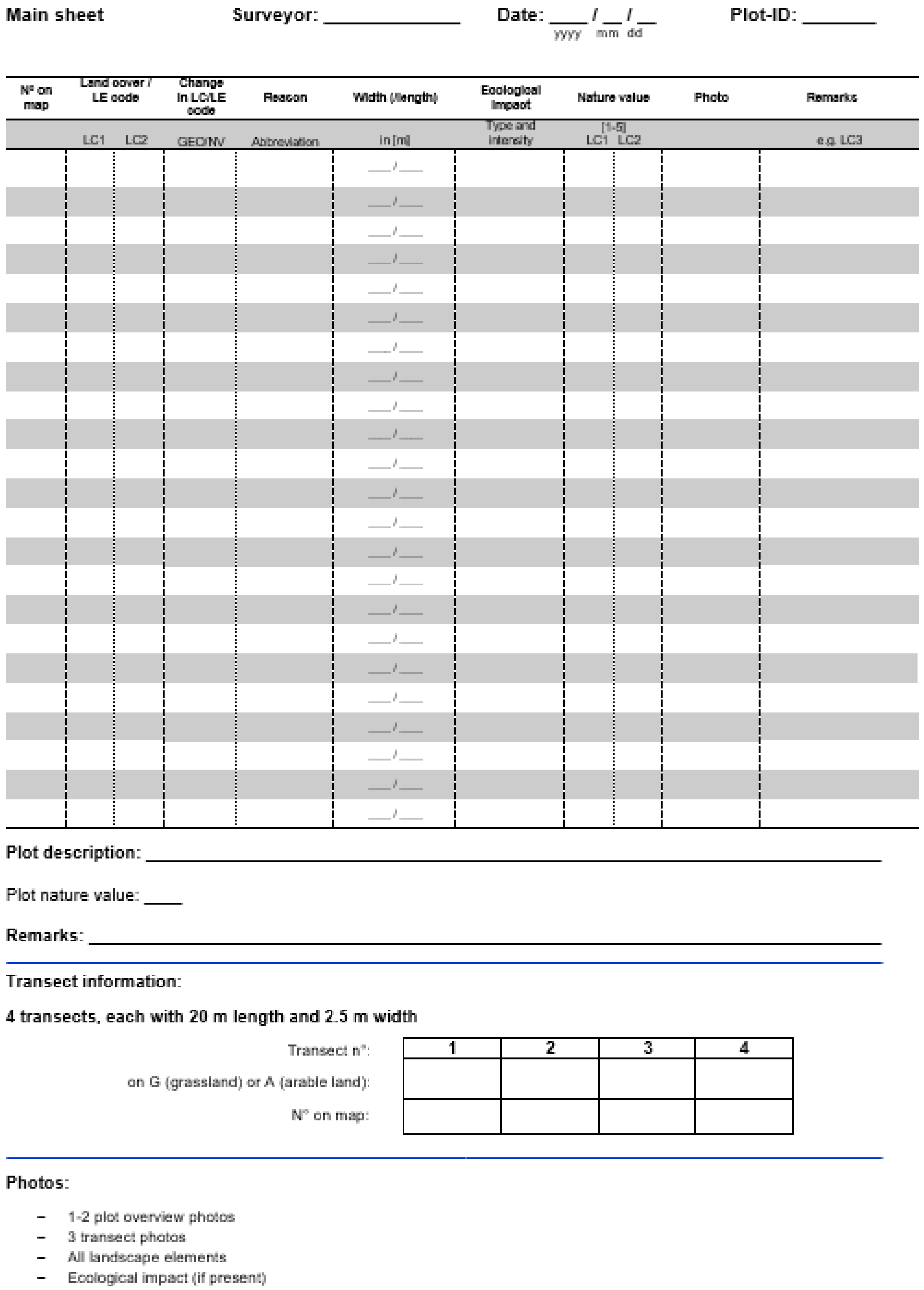
The landcover codes are based on the LISA approach and developed further within this study. Main categories are:

- A Arable land
- B Fallow land / uncultivated land
- C Grassland
- D Shrubland
- E Landscape elements
- N Non-agricultural area
- X Unknown

Some of the codes are quite similar to the LUCAS codes; however, the systematic approach of the list given below seems more logic and suitable for this EMBAL approach. For the final roll-out it has to be decided if eventually a harmonization of the land cover coded should be done. Given the ongoing changes also in the LUCAS coding, the harmonization should be done simultaneously to the preparations for the full EMBAL survey.

Landcover-code	Landcover	Category	Code	Specification				
A	Arable land	Non permanent crops	A11	Wheat	A51	Dry pulses		
			A13	Barley	A52	Tomatoes		
			A14	Rye	A53	Strawberries		
			A15	Oats	A54	Other fresh vegetables		
			A16	Maize	A55	Greenhouse culture		
			A17	Rice	A56	Foil tunnel		
			A19	Other cereals	A61	Clovers		
			A21	Potatoes	A62	Lucerne		
			A22	Sugar beet	A63	Mixed cereals for fodder		
			A23	Other root crops	A64	Sown grass on arable land		
			A31	Sunflower	A65	Grass-Clover-Mixture		
			A32	Rape and turnip seeds	A66	Other Legumes and mixtures		
			A33	Soya	A71	Floriculture and ornamental plants		
			A34	Cotton	A72	Other non permanent crops		
			A35	Other fibre and oleaginous crops	A73	Arable land without plants		
			A41	Tobacco	A74	Flower areas and strips		
			A42	Other non permanent industrial crops				
		Permanent cultures and trees	A81	Apple fruit	A91	Olive groves		
			A82	Pear fruit	A92	Vineyards		
			A83	Cherry fruit	A93	Nurseries		
			A84	Nuts trees	A94	Other permanent cultures energy crops)		
			A85	Oranges				
			A86	Lemons	A95	Fruit orchard		
			A87	Other fruit trees and berries	A96	Other trees (e.g. Dehesas)		
B	Set-aside	Fallow land or set-aside	B11	Arable fallow/set-aside				
			B12	Grassland fallow/set-aside	a	visible management		
			B13	Brownfield (industrial, settlement etc.)	b	unmanaged		
			B14	unclear fallow/set-aside	c	unclear		
					1	scattered trees/bushes (coverage < 5%)		
C	Grassland	Grassland with tree/shrub cover	C11-	Meadow / hay field	2	open stand of trees/bushes (cov. 5-25%)	a	scattered stones/rocks (coverage < 5%)
			C12-	Grazing land/pasture	3	half-open stand of trees/bushes (cov.25-50%)	b	open stand of stones/rocks (cov. 5-25%)
			C13-	Mowed and grazed grassland / unclear use	4	stand with greater gaps (cov. 50-75%)	c	half-open stand of stones/rocks (cov.25-50%)
		Grassland without tree/shrub cover	C21-	Meadow / hay field	5	closed stand of trees/bushes (cov. ≥ 75%)	d	stand with greater gaps (cov. 50-75%)
			C22-	Grazing land/pasture				
			C23-	Mowed and grazed grassland / unclear use			e	closed stand of stones/rocks (cov. ≥ 75%)
D	Shrubland	Shrubland with sparse tree cover	D11					
		Shrubland without tree cover	D12					
E	Landscape element	Wood/ Tree/ Bush elements	E11	Solitary trees and small groups of trees/bushes				
			E12	Tree lines and avenues				
			E13	Hedges and bushes (in wet, dry or other locations)				
			E14	Isolated field coppices				
			E15	Wood areas along watercourses				
		Grass-herb elements and reed-sedge beds	E19	Field margins				
			E20	Embankments				
			E21	Buffer strips				
			E22	Ruderal, grass and herbal fields of the open countryside				
			E23	Large and small reed beds				
			E24	Large and small sedge beds				
		Water elements	E31	Springs and spring swamps				
			E32	Small and medium-sized flowing waters (streams, rivers, channels)				
			E33	Ditches				
			E34	Small water bodies (natural or man-made)				
		Stone, rock, raw soil and terrace elements	E41	Dry stone and natural stone walls				
			E42	Field stone heaps and cairns				
			E43	Sand, clay and loess escarpments				
			E44	Isolated rock outcrops				
			E45	Raw soil sites (stone, sand and dirt surfaces with little or no vegetation)				
			E46	Terraces				
		Roads and Tracks	E51	Dirt/gravel track				
			E52	Grass track				
			E53	Paved farm tracks (also asphalt with grass strip)				
			E54	Sunken roads				
		Man-made structures, artefacts and other elements (do not include E21 and A74)	E62	Field barn				
			E63	(Machinery/animal) shed				
			E64	Woodpiles				
			E65	Solar elements				
			E66	Antenna/electric pylon				
			E67	Other elements				
N	Non-agricultural elements	Forest	N11	Forest				
			N12	Reforestation area				
		Wetland	N21	Inland marshes				
			N22	Peat bogs				
			N23	Salt marshes				
			N24	Salines				
			N25	Intertidal flats				
		Open water	N31	Large inland water bodies and their banks				
			N32	Large inland running waters and their banks				
			N33	Coastal water bodies and their shores				
		Settlement area and asphalt roads and railways	N41	Buildings / villages and garden areas, official roads and railways inclusive adjacent landscape elements				
		(Former) mining area	N61	Mining area or renaturated fomer mining area				
X	Unknown	Not visible	X	not visible				

10.6.2 Main sheet



Main sheet **Surveyor:** ______________ **Date:** ____ / __ / __ **Plot-ID:** ________

yyyy mm dd

N° on map	Land cover / LE code		Change in LC/LE code	Reason	Width (/length)	Ecological impact	Nature value		Photo	Remarks
	LC1	LC2	GEO/NV	Abbreviation	in [m]	Type and intensity	[1-5] LC1	LC2		e.g. LC3
					___/___					
					___/___					
					___/___					
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					___/___					
					___/___					
					___/___					

Plot description: ____

Plot nature value: ____

Remarks: ____

Transect information:

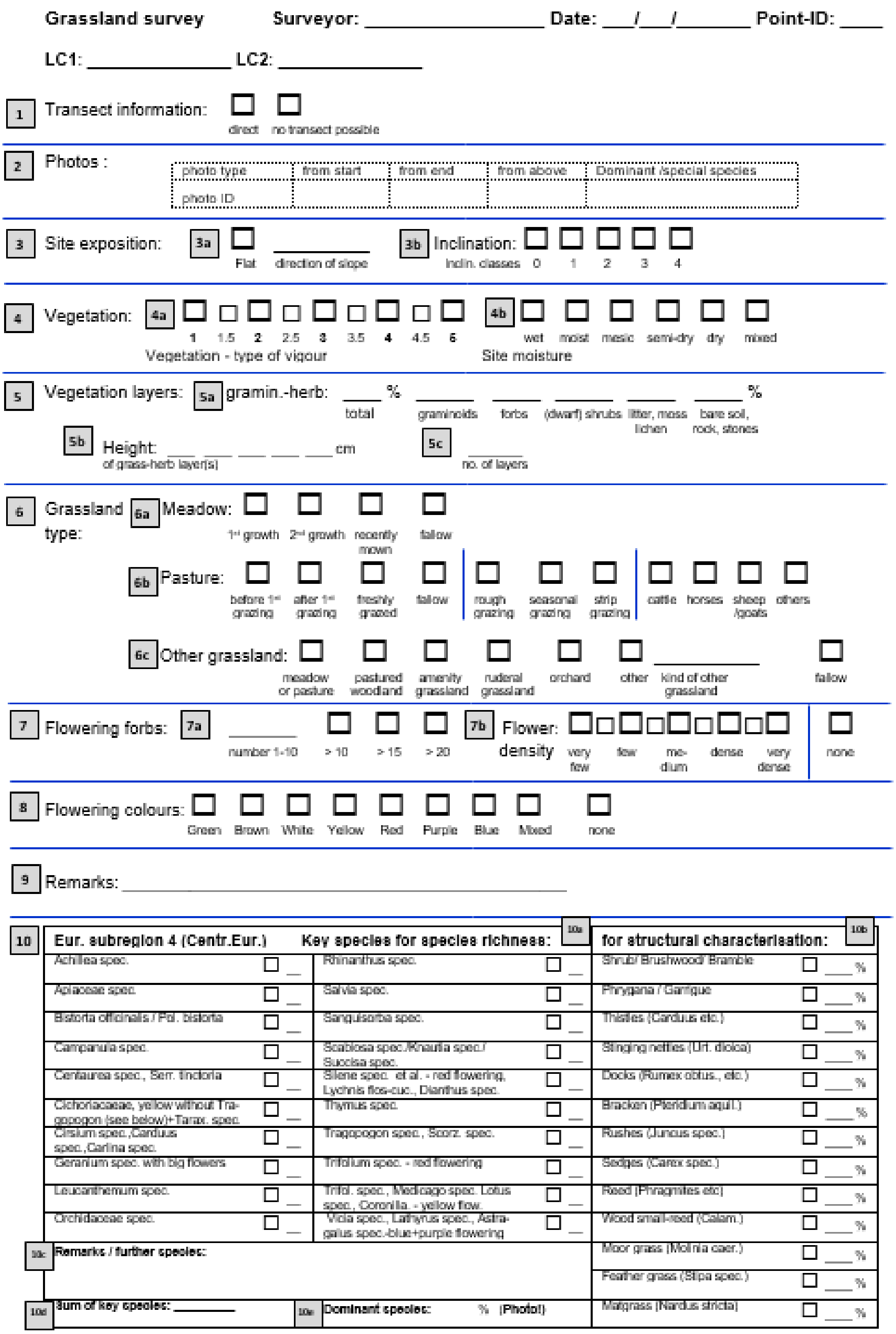
4 transects, each with 20 m length and 2.5 m width

Transect n°:	1	2	3	4
on G (grassland) or A (arable land):				
N° on map:				

Photos:

- 1-2 plot overview photos
- 3 transect photos
- All landscape elements
- Ecological impact (if present)

10.6.3 Vegetation sheets



Grassland survey **Surveyor:** ________________ **Date:** ___/___/______ **Point-ID:** ____

LC1: ______________ **LC2:** ______________

1 Transect information: ☐ direct ☐ no transect possible

2 Photos :

photo type	from start	from end	from above	Dominant /special species
photo ID				

3 Site exposition: **3a** ☐ Flat ________ direction of slope **3b** Inclination: ☐ ☐ ☐ ☐ ☐ Inclin. classes 0 1 2 3 4

4 Vegetation: **4a** ☐ 1 ☐ 1.5 ☐ 2 ☐ 2.5 ☐ 3 ☐ 3.5 ☐ 4 ☐ 4.5 ☐ 6 Vegetation - type of vigour **4b** ☐ wet ☐ moist ☐ mesic ☐ semi-dry ☐ dry ☐ mixed Site moisture

5 Vegetation layers: **5a** gramin.-herb: ____ % total ______ graminoids ______ forbs ______ (dwarf) shrubs ______ litter, moss lichen ______ % bare soil, rock, stones

5b Height: ___ ___ ___ ___ ___ cm of grass-herb layer(s) **5c** ______ no. of layers

6 Grassland type:

6a Meadow: ☐ 1st growth ☐ 2nd growth ☐ recently mown ☐ fallow

6b Pasture: ☐ before 1st grazing ☐ after 1st grazing ☐ freshly grazed ☐ fallow | ☐ rough grazing ☐ seasonal grazing ☐ strip grazing | ☐ cattle ☐ horses ☐ sheep /goats ☐ others

6c Other grassland: ☐ meadow or pasture ☐ pastured woodland ☐ amenity grassland ☐ ruderal grassland ☐ orchard ☐ other __________ kind of other grassland ☐ fallow

7 Flowering forbs: **7a** ______ number 1-10 ☐ > 10 ☐ > 15 ☐ > 20 **7b** Flower: density ☐ very few ☐ ☐ few ☐ ☐ me-dium ☐ ☐ dense ☐ ☐ very dense | ☐ none

8 Flowering colours: ☐ Green ☐ Brown ☐ White ☐ Yellow ☐ Red ☐ Purple ☐ Blue ☐ Mixed ☐ none

9 Remarks: ______________________________________

10

Eur. subregion 4 (Centr.Eur.)		**Key species for species richness:** **10a**		**for structural characterisation:** **10b**	
Achillea spec.	☐ _	Rhinanthus spec.	☐ _	Shrub/ Brushwood/ Bramble	☐ ___ %
Apiaceae spec.	☐ _	Salvia spec.	☐ _	Phrygana / Garrigue	☐ ___ %
Bistorta officinalis / Pol. bistorta	☐ _	Sanguisorba spec.	☐ _	Thistles (Carduus etc.)	☐ ___ %
Campanula spec.	☐ _	Scabiosa spec./Knautia spec./ Succisa spec.	☐ _	Stinging nettles (Urt. dioica)	☐ ___ %
Centaurea spec., Serr. tinctoria	☐ _	Silene spec. et al. - red flowering, Lychnis flos-cuc., Dianthus spec.	☐ _	Docks (Rumex obtus., etc.)	☐ ___ %
Cichoriaceae, yellow without Tragopogon (see below)+Tarax. spec.	☐ _	Thymus spec.	☐ _	Bracken (Pteridium aquil.)	☐ ___ %
Cirsium spec.,Carduus spec.,Carlina spec.	☐ _	Tragopogon spec., Scorz. spec.	☐ _	Rushes (Juncus spec.)	☐ ___ %
Geranium spec. with big flowers	☐ _	Trifolium spec. - red flowering	☐ _	Sedges (Carex spec.)	☐ ___ %
Leucanthemum spec.	☐ _	Trifol. spec., Medicago spec. Lotus spec., Coronilla. - yellow flow.	☐ _	Reed (Phragmites etc)	☐ ___ %
Orchidaceae spec.	☐ _	Vicia spec., Lathyrus spec., Astragalus spec.-blue+purple flowering	☐ _	Wood small-reed (Calam.)	☐ ___ %
10c **Remarks / further species:**				Moor grass (Molinia caer.)	☐ ___ %
				Feather grass (Stipa spec.)	☐ ___ %
10d **Sum of key species:** ______		**10e** **Dominant species:** % **(Photo!)**		Matgrass (Nardus stricta)	☐ ___ %

Arable land survey **Surveyor:** ____________________ **Date:** ___/___/_______ **Point-ID:** _____

LC1: ______________ **LC2:** ______________

1 Transect information: ☐ direct ☐ no transect possible

2 Photos :

photo type	from start	from end	from above	Dominant /special species
photo ID				

3 Site exposition: 3a ☐ Flat ___________ direction of slope 3b Inclination: Inclin. classes ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4

4 Site moisture: ☐ wet ☐ moist ☐ mesic ☐ semi-dry ☐ dry ☐ mixed

5 Coverage: 5a crop: ____ % wild plants_____ % bare soil, rock, stones _____ %

Crop: 5b Height of crop: _____ cm 5c Growth stage of crop: ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9

6 Management type: ☐ Tillage ☐ direct drilling ☐ fallow ☐ other ____________________ ☐ unclear

7 Flowering forbs: 7a _______ number 1-10 ☐ > 10 ☐ > 15 ☐ > 20 7b Flower: density ☐ very few ☐ ☐ few ☐ ☐ me-dium ☐ ☐ dense ☐ ☐ very dense ☐ none

8 Flowering colours: ☐ Green ☐ Brown ☐ White ☐ Yellow ☐ Red ☐ Purple ☐ Blue ☐ Mixed ☐ none

9 Remarks: ____

10

Key species for species richness:	10a				
Adonis spec.	☐ _	Lapsana communis	☐ _	Thlaspi arvense	☐ _
Anagallis spec.	☐ _	Lathyrus spec.	☐ _	Torilis arvensis	☐ _
Anthemis spec.	☐ _	Legousia spec.	☐ _	Trifolium spec.	☐ _
Calendula arvensis	☐ _	Linaria spec.	☐ _	Valerianella spec.	☐ _
Carduus pycnocephalus	☐ _	Lithospermum arvense	☐ _	Vicia spec.	☐ _
Centaurea spec.	☐ _	Lythrum spec.	☐ _		
Chrysanthemum spec.	☐ _	Matricaria spec.	☐ _	10b **Dominant or problematic* species:**	
Consolida spec.	☐ _	Medicago spec.	☐ _	Example:	
Epilobium spec.	☐ _	Mentha arvensis	☐ _	Cirsium arvense	☐ ___ %
Erodium cicutarium	☐ _	Myosotis spec.	☐ _		☐ ___ %
Eryngium campestre	☐ _	Ornithogalum spec.	☐ _		☐ ___ %
Euphorbia spec.	☐ _	Papaver spec.	☐ _		☐ ___ %
Filago spec.	☐ _	Ranunculus spec.	☐ _		☐ ___ %
Fumaria spec.	☐ _	Rumex spec.	☐ _		
Galeopsis spec.	☐ _	Silene spec.	☐ _		
Geranium spec.	☐ _	Spergula arvensis	☐ _		
Lamium spec.	☐ _	Stachys spec.	☐ _	*Please add, if certain weed species are dominant or problematic.	
10c **Remarks / further species:**					
10d **Sum of key species:** __________		10e **Dominant species:**	% (Photo!)		