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Policy Brief

The use of biodiversity data in rural development programming

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Abstract

This study focuses on rural development policy implementers and evaluators as users of European biodiversity data. It critically analyses the use of biodiversity data for measuring the impact of agri-environment programmes and related rural development funding, and highlights good practices from a range of countries. The examples show the possibilities for better targeting and evaluation of agricultural funding to biodiversity conservation if sufficient biodiversity data are available and are used in policy. However, many biodiversity datasets exist at the national or regional level but are still not integrated in the RDP monitoring system and thus not accessible to evaluators, and many RDPs still feature only the obligatory EU-level indicators. It is important to differentiate between the need for standardised EU-level datasets that can be used for an overall assessment of the impact of the CAP, where there is still a huge data gap, and the national or regional programming level, where there are often existing data that are not being used for various reasons. The study is part of the EU BON project, which aimed to build an integrated biodiversity information system for Europe.

Keywords

biodiversity data, high nature value farming, high nature value farmland, HNV, agri-environment, monitoring, evaluation of impact, European Union, Rural Development

Programmes (RDPs), common farmland Bird Index, species of EU conservation concern, habitats of EU conservation concern, agricultural practices, nature conservation, land cover data, species occurrence, habitat distribution, EU BON

Key questions and premises

Agricultural land is of great importance for biodiversity in Europe as it occupies approximately 40% of the total land area and includes biodiversity-rich habitats and landscapes that have developed in close relationship with low intensity agriculture. The High Nature Value (HNV) farming systems include traditionally managed hay meadows and semi-natural pastures, and mixed farming landscapes with high densities of habitats such as hedges, ponds, ditches, copses and woodland patches, and other field edge habitats (Oppermann et al. 2012). Rural development programmes (RDPs) under the Common Agricultural Policy (CAP) are one of the main EU funding sources for biodiversity conservation in agricultural and forest landscapes. Member States must allocate at least 30% of their RDP funding to environmental issues (including biodiversity) and climate change action in the current funding period (2014-2020), and must allocate funding to the Natura 2000 network[*1]. Since 2000, the policy includes an obligation to monitor and assess impacts on biodiversity. Rural development policy therefore requires the use of biodiversity data for targeting, monitoring and evaluating policy impacts on biodiversity.

This study focuses on rural development policy implementers (and associated sectoral stakeholders) as users of European biodiversity data and potential users of the EU BON biodiversity portal and related tools. Public policy-makers rarely use data sources directly, but are informed by reports and briefings in which the data are interpreted and synthesised. In the case of RDPs, the key primary data users are public institutes and private consultancies that are providing *ex ante* baseline assessments, implementation reports, and *ex post* evaluations for policy implementers. Key secondary data users are farmers and agricultural organisations and the public authorities who are responsible for the implementation.

The study focuses on the identification of criteria that have enabled successful use of biodiversity data in rural development planning and targeting, the barriers to use of existing data sources, and the key data gaps that hinder effective implementation. It contributes to the EU BON project objective to identify and pilot new approaches to overcome gaps in biodiversity data in conservation policy at European and national levels.

This project firstly reviewed the current legislative framework and guidance on rural development programming to identify policy relevant uses of biodiversity data, secondly reviewed the available biodiversity indicators and data sources used to target and evaluate agricultural policy, and thirdly carried out a series of case studies to identify the key aspects of the use of biodiversity data in rural development programming using literature and interviews.

Biodiversity information and data requirements for Rural Development Programming

This section describes the requirements for biodiversity information and data that arise from EU rural development programming. Biodiversity data play a role in three key processes within the rural development programming cycle, namely policy targeting, monitoring and evaluation. In particular;

1. Biodiversity data sources are needed for the indicators that Member States use to describe the state of biodiversity in their agricultural areas, their resulting programming needs and corresponding measures, and the impact of those measures, as defined by the Common Monitoring and Evaluation Framework (CMEF)[*2]. RDP evaluation must be carried out by independent evaluators, and the rural development programming authority has the responsibility to ensure that the evaluators have sufficient data on general trends, outputs and results to carry out their evaluation. Member States have developed various monitoring and biodiversity data utilisation frameworks to attempt to evaluate the impact of their programme on biodiversity, as described in their programme evaluation reports.
2. Biodiversity data are required in order to better target certain rural development measures and payments to particular areas or types of farmland where they will have most benefit for biodiversity.

Biodiversity data needs for monitoring impacts and evaluating success of RDP measures

The Common Monitoring and Evaluation Framework requires the use of a set of indicators including context and baseline indicators, result indicators, target indicators, and impact indicators, as illustrated in Fig. 1. The indicators directly relevant to biodiversity, their uses and their underlying datasets are described in the next section.

The Commission has responsibility for producing guidance on the assessment of values for the result indicators, on how to assess impacts, and on answering the common evaluation questions, proposing additional data, judgement criteria and a range of possible approaches to answer the evaluation questions[*3]. The European Evaluation Help Desk for Rural Development[*4] produces guidance and runs workshops to assist Member States to use the Common Monitoring and Evaluation System (European Commission 2015). In this respect, a set of agri-environment indicators was developed in 2006 at the EU level to assist Member States in assessing the impacts of their rural development programmes on biodiversity and the environment[*5]. Some of the indicators have been further developed by the European Environment Agency in the SEBI (Streamlining European Biodiversity Indicators) initiative (EEA 2012). These indicators rely on datasets that are available at the EU level, primarily through EuroStat.

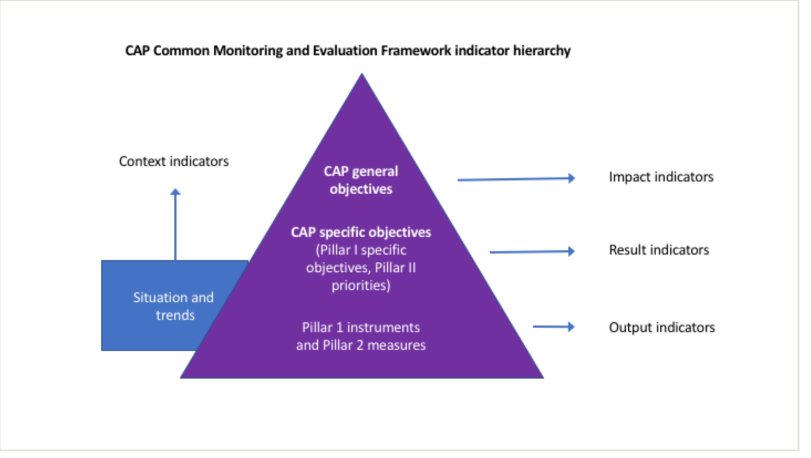

Figure 1. doi

Use of CMEF indicators in CAP monitoring and evaluation (reproduced from European Commission 2015)

Biodiversity data needs for targeting RDP measures at biodiversity conservation

Member States have the option of targeting rural development payments to particular areas or farm types, such as areas of high biodiversity value. This requires a method for mapping the relevant areas where measures to benefit particular types of biodiversity are expected be most effective, either because the target species or habitat is already there and the measure will secure or increase its distribution and population, or because the target species can be attracted back into the area through the measure or the habitat can be recreated under particular conditions and linked to existing habitat. Targeting requires distribution maps of the target species and habitats at a scale that is fine enough to be relevant to individual farms; and the integration of the target maps into the IT system in which selection, prioritisation and allocation of rural development payments is managed, and also ideally into the Land Parcel Identification System that registers individual farm parcels and associated rural development contracts.

Relevant biodiversity indicators and data sources

This section examines the use of biodiversity data sources in the most frequently used indicators in more detail:

- Common farmland bird index
- Conservation status of agricultural habitats - grassland
- High Nature Value (HNV) farming indicator and mapping
- Other indicators - bats and butterflies

Common Farmland Bird Index

The common farmland bird index (CFBI) is calculated by each EU Member State from the results of national breeding bird surveys using a common methodology (Gregory et al. 2003, Gregory et al. 2005). Member States use the national farmland bird index as a biodiversity and agri-environment context and impact indicator in their rural development programmes. Birds are considered a suitable proxy for biodiversity because they are sensitive to environmental change and can reflect wider ecosystem responses (Gregory and Strien 2010). The national common farmland bird index is based on aggregating data from the abundance of a nationally selected set of farmland species, using only the species which have sufficient abundance at the national level to generate a sufficiently large dataset. The imputed national totals are then expressed as percentages relative to the starting year and these numbers are the national yearly indices. The Common Farmland Bird Index therefore generates comparable values between 1 and 100 in all EU countries.

National breeding bird surveys are large-scale monitoring projects carried out by ornithologist volunteers using comparable methods that estimate the abundance of the more common bird species. Surveys are carried out in all EU Member States; the UK has the longest-running scheme, starting in 1966, while the Lithuanian scheme is the most recent, starting in 2011[*6]. An example from Ireland is described in Suppl. material 1. The count estimates used to generate the Common Farmland Bird Index have various limitations, for example the presence of unusually high counts resulting from mobile wintering flocks of certain species or from game bird releases (Crowe et al. 2014,Phillips et al. 2010). For spatial analyses, it is therefore often more reliable to use bird presence data only. However, the advantages of the bird monitoring scheme include its considerable geographic coverage and low running costs. Although breeding bird monitoring schemes are primarily designed to measure change over time rather than abundance, distance sampling modelling procedures can be used to derive additional population density estimates from such monitoring data (eg Newson et al. 2005).

Bird counting approaches may include territory mapping, line transects and point counts. Site selection is most commonly done using stratified random selection of sampling sites. National coordinators collect the yearly all-site totals for each species by summing the counts from sample sites. In those counting schemes based on free choice of sample sites, weighting is used to counteract the effect of oversampling particular strata and reduce the bias in the index. Data are subject to quality control at multiple levels. At the national level, this is performed by the monitoring scheme, which ensures that volunteer surveyors are adequately trained. Automatic tools apply appropriate restrictions to data as it is entered. The TRIM (Trends and Indices for Monitoring data) programme is used to control for the effect of missing values, which are common in count data (see Suppl. material 1 for further details).

The national data are used to compute European-level trends through the Pan-European Common Bird Monitoring Scheme (PECBMS) (see Fig. 2 and Suppl. material 1 for more information). Although the index has a relatively narrow focus, the underlying dataset covers a relatively long time-series, with records from the 1960s onwards for some countries; and has an EU-wide geographic scope (Gregory and Strien 2010).

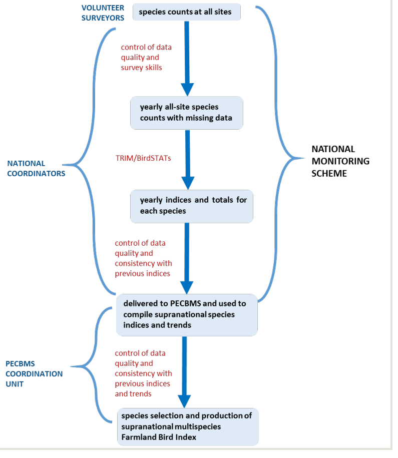

Figure 2. doi

Workflow of the production of the EU Farmland Bird Index. Adapted from source: http://www.ebcc.info/wpimages/schema2016_big.jpg

Conservation status of agricultural habitats - grassland

In Europe, semi-natural grasslands are of considerable importance for biodiversity and are widely used for agriculture, primarily for grazing (i.e. as pastures) and/or for hay production (ie. as meadows). Indeed, as semi-natural grasslands, they are partly or completely dependent on continued grazing and/or mowing to continue existing, as they would otherwise be succeeded by scrub and trees. Semi-natural grasslands are also unmodified by agricultural improvements, such as drainage or fertilisation, and therefore often species-rich and/or support rare species and communities. In recognition of their potential biodiversity value, the conservation status of grassland agricultural habitats is an obligatory context indicator for rural development programming. This CMEF indicator is actually the conservation status and distribution of the natural and semi-natural grassland habitat types listed in Annex I of the EU Habitats Directive as reported by Member States for the 2007-2012 period (ETC/BD 2015).

Many Member States have carried out field surveys of grassland habitats to inform their reporting under the Habitats Directive. For example, the Irish semi-natural grasslands survey carried out between May 2007 and September 2012 mapped a total of 23,188 ha of semi-natural grassland habitats (O'Neill et al. 2013). The data were consolidated into one ArcMap polygon shapefile database, and an Access database and a Turboveg database containing all site and sample (relevé) data. However, very few Member States have complete and up-to-date inventories covering semi-natural farmland habitats, and most of the datasets on habitats within Natura 2000 areas need further improvement and/or updating.

Other data sources relevant to semi-natural grassland mapping are being developed, alhtough methods and classification systems differ (EEA 2014). The European Vegetation Archive contains a data repository of vegetation-plot observations (i.e. records of plant taxon co-occurrence at particular sites, also called phytosociological relevés) from Europe and adjacent areas, classified according to the EuroVegChecklist, a hierarchical floristic classification system of vascular plant, bryophyte, lichen, and algal communities (EVS 2017). This dataset is currently being matched to the EUNIS habitat classes so that it can be used to validate land-cover derived grassland mapping[*7]. One challenge is that although the plot data (relevés) are identified by date, their exact location is often uncertain.

Some examples of national level spatial grassland datasets are given in Suppl. material 1 and case studies of good practices in grassland data use are described in the following section.

High Nature Value (HNV) farming indicator and mapping

High Nature Value farmland (HNVF) comprises areas where agriculture is a major (usually dominant) land use and where that agriculture supports or is associated with either a high species and habitat diversity, or the presence of species of European and/or national and/or regional conservation concern (Beaufoy and Cooper 2008). HNVF is under threat from agricultural intensification, land abandonment and urbanisation. HNVF can be classified into three types (although they are not mutually exclusive), and the indicator covers all of these. Type 1 contains a high proportion of semi-natural habitats; Type 2 is a mosaic of low-intensity farming with natural or structural elements and Type 3 is farmland that provide habitat used by a large proportion of the total European or global population for one or more rare species (or species of conservation concern). HNV farmland hosts some of the most important habitats for biodiversity in Europe, with some species only found in such landscapes (Oppermann et al. 2012). 63 habitats and 257 species of EU conservation concern (i.e. listed in Annex I or II Habitats Directive) depend on or are associated with farming (European Commission 2014, Halada et al. 2011).

The Common Monitoring and Evaluation Framework requires that EU Member States assess the extent, condition and dynamics of HNV farmland, and HNV farmland is used as a context, result and impact indicator. There are common guidelines but there is no standardised procedure for assessing the HNV indicator across the EU, due to the variations in data availability and land types. Data sources may include CORINE Land Cover, Land use/cover area frame survey (LUCAS) and other land cover data, Integrated Administration and Control System (IACS) data on crop diversity, livestock types and density, fertiliser application, etc, Land Parcel Information System (LPIS) cadastral data, Farm Structure Survey (FSS) data, species and habitat distribution databases, specific sampling surveys, Rural Development Programme monitoring data, and maps of designated protected areas (Natura 2000 protected habitats, national nature reserves, etc.).

Identifying and mapping HNVF can be approached using three different types of data:

- Land cover data to map a) presence of semi-natural habitats in farmland and b) density of landscape features and/or small parcel size to delineate mosaic farmland;
- Farm system information to characterise and map farms with low intensity management (e.g. fertiliser use, soil productivity);
- Distribution and occurrence of semi-natural habitats and protected species using a) maps of protected areas, b) habitat surveys, and/or c) species distribution data.

Member States are still carrying out their baseline calculations of HNV farmland (European Commission DG AGRI 2016b), and adjusting their methods of defining HNVF and calculating baseline levels. The European Commission has emphasised that successful assessment of the impacts of the CAP on HNV farmland requires a robust 2013-2014 baseline data to set the context and basis for future updates and assessment from periodic updates (European Commission DG AGRI 2016b). Member States in the 2007-2013 programming period have used more than 20 different approaches with widely differing effectiveness in identifying HNVF (European Commission DG AGRI 2016b,Peppiette 2011). 24 regional and national programming authorities, covering 22 Member States, defined values for the HNV indicators. Of these, 22 identified Type 1, 14 identified Type 3, and only four identified Type 2 (Oppermann et al. 2012). The land cover and designated area approaches are the most widely adopted (in 13 and 12 cases).

The HNV land cover approach is most effective at identifying HNVF when used in combination with species distribution data and other farming data. However, there are a number of challenges to using habitat and species data: there are far more data for certain taxa, especially birds, than for others, with the result that some farmland habitats are poorly represented; geographical coverage of datasets is highly variable and rarely complete; the spatial resolution generally is poor (e.g. presence/absence of species in a 10x10 km square); data are often not recent; and time series data are available for only a few species so temporal resolution is low (Keenleyside et al. 2014). Tests that have compared HNV maps produced from land cover data with species and habitat occurrence on the ground have found that accuracy is low, partly because of the land cover spatial resolution and scale but also partly because of uncertainty about which species are the best HNV indicators and lack of data on these indicator species. In the UK, the HNVF map produced for the 2007-2013 RDP using land cover data was compared to local data from three case study regions, which found that the species and habitat mapping was very unreliable at the local level (Beaufoy and Jones 2012). A study in Italy (Morelli et al. 2014) compared the HNV distribution mapped from land cover data with species distribution models for breeding farmland birds in a region from point counts. The study found that HNVF was predicted by the combination of the presence of just four common bird species and the absence of Skylark (*Alauda arvensis*) and Greenfinch (*Chloris chloris*)[*8]. The HNV mapping was therefore not capturing all species of conservation interest and excluding the habitats of some key species which may be dependent on HNV farming in that region.

Efforts have focused on HNV identification methods that can be used to improve the interpretation of land cover data using farming systems data. The European Commission's Joint Research Centre has developed a simple methodology for HNV measurement that uses EU level data sources to estimate the density of 'biodiversity friendly farming practices' at the regional (NUTS2) level in order to improve land cover interpretation (see Suppl. material 1 for description). The indicator combines measures of crop diversity, nitrogen input, livestock density and land use produced by Eurostat at the NUTS2 level (Paracchini and Britz 2010), and does not use any biodiversity data. Recently, high resolution maps of grazing intensity and nitrogen balance have been produced, which will be used in combination with land cover data to more accurately exclude farmland under high intensity management from HNV maps[*9]. However, the lack of sufficiently robust biodiversity data on semi-natural habitats and species associated with HNV farmland means that it is still not possible to ground-truth this mapping with HNV biodiversity in many places.

Other approaches combine agricultural statistics on extensive farming practices (livestock density and irrigated area) and crop diversity (Shannon's evenness index and crop richness) with spatially explicit data on landscape elements (natural constraints, arable area vs forest, Shannon's landscape diversity and evenness indices, edge density and others) at the local administrative unit (LAU) level (Lomba et al. 2015,Lomba et al. 2014). An example is the map of likely occurrence and distribution of HNV farmland in the Republic of Ireland at the electoral division level, which uses semi-natural habitat cover, stocking density, hedgerow density, river and stream density and soil diversity data (Matin et al. 2016) (see Suppl. material 1 for more details).

This HNV mapping approach was tested in France and the Netherlands using farm structure survey (FSS) data collected at the local administrative level (LAU) on crop diversity at farm level (weighted by UAA), share of permanent grassland in UAA, and share of afforested farm areas in UAA (Desjeux et al. 2015). The HNV indicator in France was strongly associated with those LAUs with a higher density of rural development measures but the relationship was weak in the Netherlands, where the data were much less comprehensive and fine-scale (Desjeux et al. 2015). The French HNV map identifies HNV from a combination of crop diversity and share of permanent grassland, extensive farming practices (estimated with FSS data) and presence of specific landscape elements (Pointereau et al. 2007). The HNV indicator is the sum of the scores of the three components for the agricultural area of each municipality (LAU) (Pointereau et al. 2010). A comparison of French Breeding Bird Survey data from HNV and non-HNV survey sites (Doxa et al. 2010), found that farmland bird species richness was not higher in HNV sites, but bird communities tended to have more specialist species than in non-HNV areas, and these specialist species are more abundant than on non-HNV sites and do not have declining trends.

This HNV approach was trialled using data from IACS and LPIS in Lower Saxony, Germany, to identify and assess values for HNVf extent at municipality (LAU-2) level (Lomba et al. 2017). However, a weakness of LPIS datasets is that they do not include grazed habitats that are not registered for CAP direct payments, either because of eligibility reasons or because some common land is not registered, and the LPIS therefore underestimates HNV farmland.

Sample site field surveys can fully identify HNVF type 1 with no additional identification method needed, and this produces statistically rigorous information on trends in indicator species and habitats that is sensitive to change. Germany has developed the most systematic HNV monitoring methodology (see Suppl. material 1 for more details). The advantages of the German sampling approach are that it delivers statistically sound results from all the federal states, including confidence levels for estimates and trends, and detects changes in HNV farmland conditions quickly due to the annual updates (European Commission DG AGRI 2016a). The HNV monitoring utilizes the plots of Germany's national biodiversity monitoring programme, ensuring that data sets are complimentary. The site sampling approach cannot, however, be used to identify HNV farmland and target agricultural payments, because it measures only a sample of farms, and the sampling grid was not designed to optimise sampling of HNV farmland as it was originally designed for biodiversity monitoring.

A study tested how closely the German HNV farmland indicator was associated with bird species abundance, richness and community composition, particularly of specialist species, using German Common Bird Census data provided by the Federation of German Avifaunists gathered from the same sample plots as the HNV indicator data (Aue et al. 2014). The aggregated HNV indicator score for the 1 km2 plot showed a weak but positive relationship with generalist bird species only, while specialist species were associated with the wet grasslands and open farmland features recorded in the HNV survey but were not correlated with the aggregate score. The authors conclude that although the German HNV monitoring scheme provides a precise picture of HNV farmland components within the 1 km2 sampling square, it fails to take account of the wider landscape context, which has a strong influence on bird species richness and abundance.

Denmark has created a 10 m x 10 m resolution map of HNV farmland, which is integrated into the LPIS and used to target RDP funding at HNV farmland (see section below for more details). The mapping approach uses data on landscape structure, land use, plant habitat indicators and occurrence of endangered species. Each parameter is registered in each 10 m x 10 m grid square as present (1) or absent (0). The decision was made not to use farming system indicators such as crop diversity or livestock density, as these variables are less permanent in time and less closely correlated with high biodiversity than the available fine-grained data on plant species richness, soil fertility, natural hydrology and presence of vulnerable species (Brunbjerg et al. 2016). This approach enables the targeting of agricultural payments to farms but does not allow the monitoring of change in the extent of HNV farmland because the data are being continually updated and therefore are not comparable over time.

Other species indicators - grassland butterflies and bats

In addition to the obligatory CMEF indicator requirements, Member States are expected to use other indicators and data to monitor and assess the impacts of their agricultural policy on biodiversity. Butterflies are currently the only terrestrial insects with long-term population monitoring that allows trend calculations. Butterflies, like birds, are sensitive to environmental change. They are particularly vulnerable to habitat fragmentation and loss because some species occur in a meta-population structure, in which distinct populations exist and disperse through colonisation and extinction processes. Butterfly data complement bird data in that they use the landscape at a much finer spatial scale. The European grassland butterfly indicator is the only EU biodiversity indicator based on species abundance for an invertebrate group (EEA 2013) (see Suppl. material 1 for futher information).

Butterfly monitoring has been carried out using comparable survey methods in 15 EU countries since 2013 (10 since 2007), and monitoring schemes are being set in up in more countries every year (Van Swaay et al. 2016). All schemes currently employ the basic counting method developed for the original British Butterfly Monitoring Scheme (Pollard and Yates 1997). However, there is considerable national variation between other relevant parameters including method of site choice, transect length, visits per year, counts per transect and whether surveyors are volunteers or professionals. In 2016, Butterfly Conservation Europe and the Centre for Ecology and Hydrology in the UK developed the European Butterfly Monitoring Scheme (eBMS)[*10]. Together with a central database and online portal, it is hoped that this will encourage wider adoption of the scheme; in particular, data from Eastern and Southern Europe are currently lacking.

Bats are the only terrestrial group other than birds and butterflies with widespread monitoring programmes in Europe, forming a data set suitable for calculating an indicator (Haysom et al. 2013) (see Suppl. material 1 for more information). Bats are proposed as suitable indicators of land management because they are sensitive to habitat disturbance, pollutants and temperature, generally occupy higher trophic levels, have relatively stable taxonomy, and reproduce slowly so that their responses to change are less affected by small-scale changes (eg Jones et al. 2009). A 2015 review of the potential of bats as bio-indicators of the impacts of agriculture (Park 2015) concluded that the few existing studies suggest that bat populations respond positively to lower-intensity farming approaches, but that more research is needed to assess bat responses to change in a wider range of environments.

Uses of biodiversity data to better target agricultural support measures: case studies

A series of case studies were carried out to identify the key aspects of the use of biodiversity data in rural development programming using literature and interviews. The interviews followed a semi-structured format, with the questions varying depending on whether the focus was on the use of biodiversity data sources for policy monitoring and evaluation, or policy targeting.

Denmark - HNV targeting framework

Denmark has recently developed its HNV indicator using an approach combining land cover, habitat distribution maps, farming system characterisation and species occurrence, as described in the previous section (Brunbjerg et al. 2016). The Danish HNV map for all agricultural and protected areas has a very fine resolution of 10 m x 10 m and contains 14 layers which map landscape structure, land use, and habitat-based indicators and locations of endangered species. Six species habitat maps for vascular plants and species of conservation concern were compiled by experts at Aarhus University between 2012 and 2014 using all available data in national and local (municipal) databases and data sources, using expert knowledge to combine both precisely geo-referenced data (<100m uncertainty) with imprecise observations (up to 10 km uncertainty), in order to include data on rare and endangered species. Three of the data layers use vegetation survey data collected by government surveys. The other species data layers use various sources of data on species of high conservation priority or on the Danish red list, for example beetles and rare plants. The experts were given detailed maps and aerial photographs and asked to delineate areas of distribution, and the associated certainty. Only species information with a high level of spatial accuracy and high certainty were used for the HNV data layers [*11]. Each parameter is registered in each 10 m x 10 m grid square as present (1) or absent (0), assigning each square a score from 0 to 13 based on its value for biodiversity. Areas with a score of 5 or over are classed as high nature value. The HNV farming map is available online[*12] (see Fig. 3), and a simpler version has been integrated into the Danish LPIS. The data layers are updated annually with new data and removal of old data, which has meant that there has been fluctuation in HNV scores as new data improve the map (Brink and Bladt 2016).

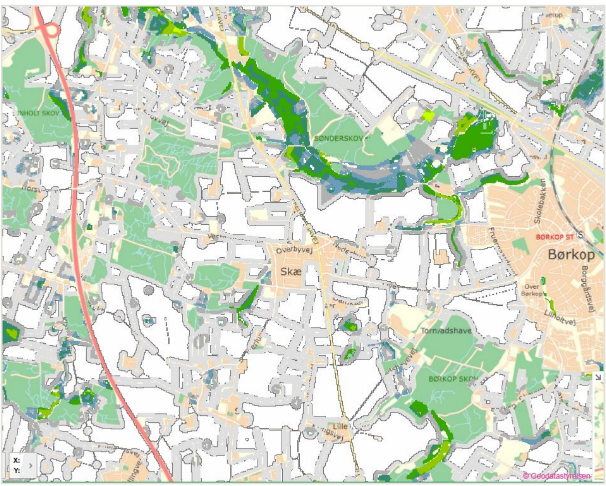

Figure 3. doi

Extract of the Danish HNV map. Available at http://arealinformation.miljoeportal.dk/distribution/

All farmland within Natura 2000 is eligible for funding, but outside Natura 2000, areas of farmland are prioritized for RDP funding based on the HNV farming map by allocating funding to those applications with the highest HNV score on any square on the farm. The policy challenge faced in Denmark was that the country has 340,000 ha of habitats (wet meadows, salt meadows and marshes, dry grasslands, and heaths) that need grazing or mowing, but sufficient RDP budget to support the management of only 90,000-100,000 ha, more than half of which lies outside the Natura 2000 network of protected areas. It is therefore necessary to have a method by which management payments can be targeted to those areas of habitat that have the highest biodiversity value worth conserving. It was not possible to use satellite or aerial imaging data to map HNV in Denmark because the remaining semi-natural grasslands with high biodiversity value are in small fragmented patches on many farms, and because of the difficulty of distinguishing grasslands with high biodiversity value from remote sensing data (Brink and Bladt 2016). Therefore, the approach described above was developed to use the best available biodiversity data sources. The targeting has triggered farmers to ask their local authorities to survey their land or update their survey, so that the land can be registered as of higher nature value and therefore qualify for payments[*11]. As the data layers are updated every year at the start of September, farmers know that if their land is surveyed they will be able to apply for funding without much delay.

UK - England - agri-environment targeting framework

In England, agri-environment-climate agreements under the new environmental land management programme 2014-2020 are awarded on a competitive basis using a national targeting framework which defines different objectives in specific areas, and scoring priorities which are ranked and defined differently in each area. England has been divided into 159 National Character Areas, which are natural subdivisions of land based on the clustering of landscape, biodiversity, geodiversity and economic activity. Maps identify priority targets for each area. Under the biodiversity objective, agriculture or forestry-related management actions are identified for a total of 19 UK priority habitats and more than 650 UK priority species[*13] (Natural England 2013a, Natural England 2013b). Each National Character Area has a defined set of priority species and habitats which farmers should aim to promote through packages of management measures. Farmers are funded to manage priority species either through the mosaic approach, bespoke approaches adapted to particular species, or through the Wild Pollinator and Farm Wildlife Package.

The national targeting core technical group carried out a vast data gathering exercise in order to develop the targeting framework and select the priority species (Somerset Local Nature Partnership 2014b). Research and data were pooled together to assess and select the key themes, species and habitats that need to be addressed by land management. More details on the methods and data sources used are provided in Suppl. material 1. An expert group developed the list of species targeted under the Wild Pollinator and Farm Wildlife Package. The selected bumblebee and solitary bee species are found on farmland, have well-known ecology and distribution, are either declining according to new Red List analyses or have declined prior to the Red List focal period, and are known to benefit from agri-environment measures (Dicks et al. 2015). The Bird Conservation Targeting Project[*14] collated all the available national, regional and local bird survey data for the breeding distribution of farmland and woodland birds including 14 priority species (Phillips et al. 2010). The validated data were fed into the National Biodiversity Network and mapped using GIS. The National Biodiversity Network gateway was then used to extract all the required data in a uniform format in one step.

Some key challenges were faced in developing the targeting framework[*15]. The selection and definition of priority species and habitats required the involvement of many people who have the knowledge and data, both civil society organisations and individuals. Local knowledge was validated through a series of regional consultations. The definition of the National Character Areas had to ensure uniformity across the country in the scale and detail of available data. Biodiversity datasets had to be assessed to determine the extent of missing data. Stakeholders at the regional validation meetings raised concerns about data quality, quantity and validity (Somerset Local Nature Partnership 2014a). Missing sites on the priority habitat maps were supplemented with local data but this also raised data quality issues, coverage issues and data consent and licencing issues, as well as going beyond the scope and timescale of the scheme set up.

The data gathering exercise resulted in a biodiversity data matrix which is linked to the Land Parcel Identification System (known as the Rural Land Register) at the parcel level. Around 400 datasets were pooled into 40 data layers. The data layers were simplified and transferred into a back-end system to the Rural Land Register that assigns priorities and scores to each of the land parcels. As a result, the system is static and not directly updated from the original data layers. The integration of the data proved a challenge as the compatibility of all data layers needed to be considered. For example, some layers map areas that are suitable for actions such as afforestation to prevent flooding, but because of their lower degree of mapping precision, when these were overlain with land cover maps there were areas of anomalies indicating for example that trees should be planted in bodies of water.

The system is designed to allow applicants to see for their land parcel how well they score for particular agri-environment priorities prior to submitting their funding application. Stakeholders wanted all the data presented in a visual map format, but due to the large volume of information provided this proved to be extremely hard to interpret and read. Instead the data have been summarized within each of the areas in text form supplemented by selected spatial information. However, there is still a feeling that this format is not the optimal solution for data presentation.

The integration of the 40 data layers into the Rural Land Register has significantly expanded the capacity of the system to target environmental priorities regionally[*16]. The national targeting framework is designed to be flexible and able to accommodate changes. However, changes which affect publically available information such as target statements and maps are resource demanding. There is also a need to provide consistency in communications to the land management community on scheme objectives in their local area, which implies that very visible changes should be limited. The evidence base for the national targeting framework, including biodiversity data, will be revised during the mid-term review of the rural development programming period.

Czech Republic - agri-environment targeting framework and habitat and species databases

The Czech Republic Nature Conservation Agency (AOPK ČR) has assembled a biotope mapping database covering the entire territory of the state (EEA, 2014), based on a detailed habitat mapping survey (2001-2005) and an ongoing update cycle (2007-2018)[*17]. The biotope mapping layer maps all semi-natural and natural habitats using a detailed classification that is based on EUNIS and the Habitats Directive Annex I habitats but also includes a comprehensive classification of other habitat types, with an average polygon size of 1.5 ha[*18]. The AOPK species occurrence database centralizes all available recent and historic species records, particularly the results of AOPK species surveillance (species monitoring, bird monitoring)[*19]. The database also integrates regular inventory data from the Czech Society for Ornithology, the butterfly records database of the Entomological Institute of Czech Academy of Sciences, monitoring carried out by experts and researchers, and citizen science data[*20]. Field experts use the mobile phone application BioLog[*21] to create species records and log data directly into the database. The species database contains a complete Czech species list, including species protected under the Birds and Habitats Directives and also Czech species of high conservation priority. The databases are being made available for public access (see Fig. 4).

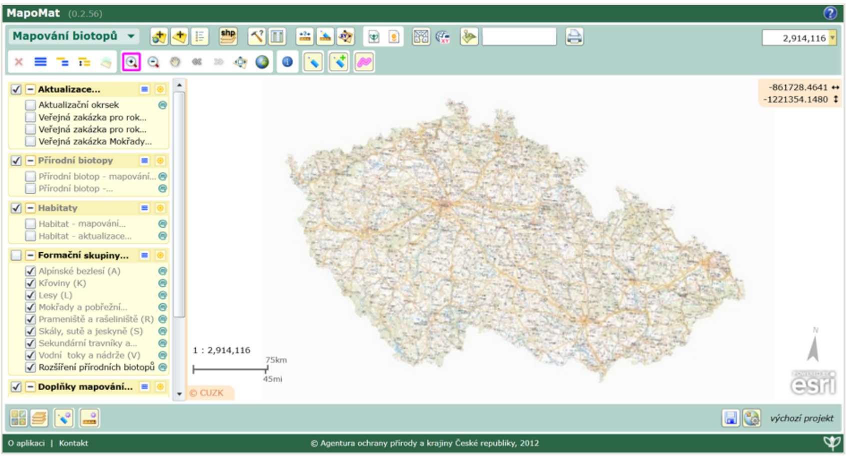

Figure 4. doi

User interface of the Czech Republic biotope map. Available at http://webgis.nature.cz/

The habitats and species data were used to inform the design and targeting of agri-environment measures in the current Czech RDP 2014-2020, for example for *Maculinea* butterfly species and farmland bird species of high conservation priority (Lapwing *Vanellus vanellus*, Corncrake *Crex crex*)[*43]. The biotope mapping and species occurrence data were revised by AOPK and the Czech National Park authorities and then used to produce a GIS data layer integrated into the Czech LPIS that defines target areas for different habitat and species management options[*22]. The Czech RDP 2014-2020 design and implementation process is therefore making good use of the available biodiversity data and expertise in the country, with an intensive collaboration between the agriculture and environment ministries including shared implementation of the agri-environment targeting framework and map[*22].

Estonia - semi-natural habitat targeting in collaboration between RDP paying agency and Environmental Board

In Estonia regular semi-natural habitat surveying and monitoring is carried out and the semi-natural habitat data are maintained in the Nature Information System-Environmental Registry[*23]. Maintenance of semi-natural habitats in protected areas (mainly Natura 2000 areas) has been supported by agricultural policy measures (within the RDP) since 2007. Farmers applying for rural development support for semi-natural habitats must check that their semi-natural habitat is recorded in the Environmental Registry and get approval from the Environmental Board before submitting their funding application. The Environmental Board will only give approval for habitat areas which are in a suitable condition for agricultural maintenance, i.e. that do not require restoration, and must approve all changes in management, as well as providing tailored management requirements to farmers. The Environmental Board also offers tailored management advice for land managers on how to achieve the best habitat improvement. The RDP paying agency (Agricultural Registers and Information Board) publishes information on the registered semi-natural habitats to the registered users, who then can send it to the Environmental Board for approval and after receiving approval, add the approved map layer to the support application. The habitat data in the Environmental Registry cannot however be used directly for determining or targeting rural development payments, as the registry does not distinguish between habitats that require restoration before they can be managed for agriculture, and the data also contain inaccuracies, for example with regard to wooded meadows and floodplain meadows[*24]. The targeting of RDP measures to biodiversity therefore relies on the good cooperation between the RDP paying agency and the Environmental Board responsible for practical application of environmental protection policy, whose specialists have the detailed knowledge of what should be done, what is required and what is happening in their regions.

The habitat data from the national monitoring programme are used as background information to evaluate the impact of the Estonian rural development programme, in particular the agri-environment-climate support scheme for semi-natural habitats, but the usefulness of the dataset is limited because currently it is not possible to easily differentiate areas that have received RDP support and those that are not supported[*24]. The main focus of both environmental and agricultural policy is to reach policy targets on scheme uptake and maintenance of semi-natural habitats listed in the Habitats Directive Annex I within Natura 2000 areas, and the data on semi-natural habitats outside Natura 2000 are insufficient. There is also very little available information on the status and management of semi-natural habitats outside of the areas that receive CAP support.

Slovakia - certification of grassland in LPIS using a grassland inventory

Slovakia carried out a comprehensive grassland inventory between 1998 and 2006, which mapped and processed into GIS more than 16,000 polygons[*25] with nearly 1 million vascular plant species records. The inventory covers around 96% of the country. The grassland inventory is used to certify grasslands that are eligible for the agri-environment programme scheme for the conservation of semi-natural and natural grasslands, which has been available to farmers since 2003. Each application is checked against the grassland inventory, and the eligible areas are then certified by the State Nature Conservancy of the Slovak Republic[*26]. The LPIS parcels (blocks) with certified grassland are mapped into a GIS layer which is integrated into the LPIS and updated annually. Although the agriculture payment agency would like to have the complete grassland data integrated into the LPIS, this was found to be technically challenging[*27]. The LPIS therefore currently records only those areas of semi-natural grasslands where certification has been requested and given. However, it is estimated that currently around 80 to 90% of the area of inventoried eligible grasslands has been certified[*27], and 121,000 ha in more than 660 farms were already certified for agri-environment support by 2006 (Galvanek 2012).

This data system has enabled the integration of a large proportion of semi-natural grasslands into agri-environment schemes that support continued management. However, it has a number of weaknesses. The Slovak LPIS contains blocks (parcels) of very varying sizes, from the legal minimum of 0.3 ha to over 700 ha, as a legacy of the soviet system of collective farms. Even though many of these blocks are now managed in diverse ways, for example through the conversion of part of a block into arable land, the tendency of the Slovak LPIS is to further increase the block size by merging blocks[*27]. If semi-natural grassland is only present on part of a block, it may not receive certification, as although it has been possible to certify parts of large blocks, the agricultural payment agency is concerned about problems with control and auditing (for example of fertilisation rates).

The main challenge faced by the system is that there are currently few prospects that the grassland inventory will be updated. Although local updates are being integrated, for example as the result of the preparation of a Natura 2000 site management plan, there is no systematic updating process. Prospects for a systematic update, both in terms of funding and expert capacity, are limited, and the original inventory was already constrained by the availability of expert capacity in Slovakia, which resulted in some areas of lower quality mapping by surveyors who lacked sufficient botanical expertise[*27]. It is likely that there are now areas of grassland that would qualify for support but are not mapped, as they were managed intensively during the 1980s but are now reverting to more species-rich communities under low intensity management. It is also difficult to remove certified grassland blocks from the system if they have lost their biodiversity value. The dataset on habitats and species of EU Community interest from the 2013-2015 monitoring programme is compatible as it uses the same polygon layer, but this monitoring was only carried out within a representative sample of polygons.

Another challenge to maintaining a policy-relevant data system is that biological monitoring of a sample of the certified blocks in 2012 and 2016 found that many grasslands had deteriorated in quality despite the agri-environment support[*27]. In addition, around one third of the grassland area in the inventory was mapped as not eligible for CAP payments because of abandonment and succession of the vegetation[*28]. The restoration of these grasslands is not funded under the RDP. They are therefore to a certain extent 'invisible' to agricultural policy, even though Slovakia reported that 15 out of 22 grassland habitats of European interest under Annex I of the Habitats Directive were in unfavourable condition in the 2007-2012 period and these may require active restoration (Šefferová Stanová et al. 2015).

Romania - semi-natural grassland targeting

In Romania, the grassland agri-environment payments are available for all permanent grasslands identified in their Land Parcel Identification System, in order to maintain mowing or grazing within limits that prevent high levels of fertiliser application and stocking density. The payments are targeted at HNV grassland, but in fact they can be claimed for any permanent grassland, as the grassland mapping in the LPIS does not distinguish between semi-natural grassland and improved grassland. This is because the LPIS grassland layer was created under time pressure and in the absence of grassland habitat distribution data before the 2007-2013 RDP programming period[*29], with some adjustments in the surface areas for the 2013-2020 period. The LPIS grassland layer identifies land parcels in the communes[*30] that have more than 50% grassland cover, identified using the 2006 CORINE land cover dataset, which does not allow the distinction between different types of permanent grassland. This is therefore a subset of the total HNV grassland area in Romania because it does not include grassland in the other communes, but it also includes grasslands that are more intensively managed and therefore less valuable for biodiversity conservation. However, according to an expert opinion, the errors are not significant, and the grassland mapping captures almost all of the HNV grassland in Romania[*29].

The LPIS maps a total of 1.6 million ha of grassland and there are 240,000 beneficiaries of the payment, which shows the scale of the challenge faced by Romania in mapping and targeting its rural development support for farmland biodiversity conservation[*29]. Romania has one of the largest areas of semi-natural grassland in the EU, and 23% of the Romanian terrestrial area is designated as Natura 2000 sites. Grassland habitat surveying efforts have therefore been concentrated on the Natura 2000 network, and Natura 2000 site management plans (which include habitat distribution maps) have now been prepared and accepted by the Ministry of Environment. There are currently no resources available to map semi-natural grassland outside Natura 2000 sites.

Romania also targets agri-environment payments at particular bird species (Corncrake *Crex crex*, Lesser Grey Shrike *Lanius minor* and Red-footed Falcon *Falco vespertinus*) and butterflies (*Maculinea* sp.) associated with semi-natural grassland. These agri-environment packages are targeted to regions that have been identified as eligible in the LPIS using species distribution data received from the Romania Lepidopteran Society and the Romanian Bird Society.

Ireland - targeting measures to farmland biodiversity despite data gaps

The first national-scale biodiversity monitoring of agri-environment scheme performance in Ireland was introduced in 2015, but at a relatively low level due to insufficient funding, and current biodiversity data are not adequate to assess the impact of agri-environment schemes[*31]. However, recent years have seen improvements in monitoring and evaluation, in particular for mapping species distributions, which is now being used to improve scheme targeting.

The current Irish agri-environment programme 2014-2020 (known as the Green Low Carbon Agri-Environment Scheme GLAS) contains some measures targeted at those species and habitats for which maps are available. The GLAS includes measures targeted to a small set of bird species of conservation concern in Ireland, as defined by their threat status according to the national Red List, and which typically have restricted geographic ranges (Ó hUallacháin et al. 2015). Seven red-listed species on Birdwatch Ireland's "Birds of Conservation Concern" list are targeted by specific measures; however, species without mapping efforts, such as Barn Owl (*Tyto alba*), have not received such measures. Common Bird Survey data were used to inform the design of additional relatively "broad and shallow/ horizontal" GLAS measures targeted at more widespread farmland birds such as Skylark (*Alauda arvensis*) (Copland et al. 2010). However, some researchers suggest that these measures will not significantly benefit the majority of farmland species of greatest conservation concern (Ó hUallacháin et al. 2015).

Conservation efforts would be improved by developing national-scale distribution maps for more habitats and species. The National Biodiversity Data Centre[*32] hosts species and habitat distribution maps which could be used to inform the next Irish RDP. A working group of scientists and senior policy representatives recommended the urgent collation and integration of biodiversity data and the establishment of a user friendly portal and policy tools that use the data to improve policy for biodiversity (NBPR 2012). An improvement of the recent RDP has been the inclusion of locally-led agri-environment-climate schemes, which have the potential to provide highly targeted measures tailored to species of European conservation concern[*31]. Locally-led schemes allow stakeholders to contribute to the design and implementation, using local data sources.

Uses of biodiversity data for assessing the impact of agri-environment schemes

Data on the abundance of common farmland birds have been used to assess the success of agri-environmental schemes in protecting biodiversity. Evaluation methods often involve statistical modelling approaches using agri-environment attributes to predict farmland bird abundances. Some examples of the use of farmland bird survey data to evaluate the impact of agricultural policies are detailed below;

- A study of the effects of implementing agri-environment schemes on French farmland bird diversity found that some grassland agri-environment measures were correlated with higher bird species richness (Princé and Jiguet 2013). However, the authors make the point that it is hard to rule out the influence of selection effects, as agri-environment uptake is highest in low-intensity, high-biodiversity areas.

- A study using the UK Breeding Bird Survey data for England and additional survey sites found limited evidence of positive impacts of simple agri-environment schemes (entry-level stewardship) in England (Davey et al. 2010). Another study (Baker et al. 2012) of the impacts of individual agri-environment options on Breeding Bird Survey data found that providing winter food through the sowing of winter bird seed mixes improved the population trends of certain species, but was not sufficient to reverse national-level declines. However, other researchers suggest that breeding bird survey data may not accurately capture the effects of basic agri-environment schemes (Sage et al. 2015).
- The effect of the Polish agri-environment programme 2007-2013 was examined by counting grassland birds on agri-environment and control parcels, within and outside SPAs, during 2013 and 2014 (Żmihorski et al. 2016). General additive mixed models were used to investigate the effects of agri-environment schemes (specific to bird protection) and SPAs[*33]. They found no impact of agri-environment on the species richness of birds targeted by the schemes. While the species richness of SPA-target species was not higher on SPAs, beta diversity was. The authors recommend greater targeting of agri-environment schemes to meet the needs of individual species, such as Lapwing (*Vanellus vanellus*) and Corncrake (*Crex crex*).

The butterfly data are less widely used to evaluate the impact of agri-environment schemes, but there has been an analysis using UK butterfly monitoring data. A recent study (Oliver 2014) used data from the UK Butterfly Monitoring Scheme (UKBMS) and the Wider Countryside Butterfly Monitoring Scheme (WCBMS) to investigate the effects of agri-environment schemes on butterfly populations in the UK. The use of UK butterfly monitoring data to test effects of agri-environment was motivated by the availability of relatively extensive spatiotemporal data from the two monitoring schemes, in comparison to the lack of data on other invertebrate groups. The spatial and temporal effects of agri-environment schemes in England on butterflies were assessed separately using a variety of statistical modelling approaches. The temporal effects were evaluated using the UKBMS data, which has been running since 1976. Scale was considered, with the effects at 1km and 3km radii assessed separately.

The results suggested that the UK agri-environment measures are associated with higher butterfly density, and the agri-environment options that specifically favour butterflies (such as tall grass field margins) were the best predictors of butterfly density (Oliver 2014). The positive effect was only visible for the agri-environment programme 2001-2006 (ESA), which was restricted to particular environmentally sensitive areas, and the targeted higher-level agri-environment agreements (Countryside Stewardship) around the sites monitored under the WCBMS, with no evidence of effects on UKBMS monitored sites and no evidence of effects from the more widely applied entry-level agri-environment scheme 2007-2013 (Environmental Stewardship). The authors conclude that the UK Butterfly

Monitoring Scheme failed to show effects of agri-environment agreements because the bulk of the data (1976-2004) from this scheme is based on a non-random sample of sites known to host suitable butterfly habitat, ie semi-natural or protected areas, whereas the Wider Countryside Butterfly Monitoring Scheme is based on sampling two parallel transects in each randomly chosen 1 km x 11 km square. The results of this report and other studies (Mountford and Smart 2014, Norton and Henrys 2014) were used to help design some of the agri-environment measures in the current RDP for England.

Monitoring the impact of agri-environment schemes on biodiversity

Estonia - agri-environment monitoring programme

Estonia has monitored the impact of its RDP on biodiversity since 2004[*34]. The monitoring programme includes a bumblebee transect and a breeding birds survey on a sample of monitored farms that have environmentally friendly management (EFM) support (one of the agri-environment agreements) or organic farming support, and a control set of farms (Viik 2015). It also includes a survey of vascular plants on field edges on a sample of the farms under the environmentally friendly management scheme. More details of the method and data are available in Suppl. material 1. The Agricultural Research Centre[*35] is the ongoing evaluator of the RDP measures related to the environment and thus responsible for the design and execution of the monitoring and evaluation programme and delivers annual reports to the government. The last 6-year monitoring data set indicates that farmland breeding birds are significantly more abundant in organic farms than on farms under the environmentally friendly management scheme or non-participant farms, whilst bumblebees are more abundant on both the EFM farms and the organic farms compared to non-participant farms. Strengths of the monitoring are the inclusion of three taxa groups that react differently to RDP measures, the inclusion of a control, and the unbroken data series. Weaknesses are the possibility that the sample farms may convert monitored arable land into permanent grassland thus breaking the continuity of monitoring, combined with the high variability between farms, and the difficulty of differentiating the effect of the RDP measure from other confounding factors, including farmer attitudes and awareness change and the landscape context (Viik 2015).

The biodiversity data from the arable farmland monitoring are curated by the Centre, and are shared with researchers, which has already resulted in some publications (Marja et al. 2014, Muljar et al. 2010). The Estonian Environment Agency is developing an environmental data access platform which will probably also include the Centre's biodiversity database[*36]. The Agricultural Research Centre also provide annual feedback to each of the monitored farmers with both the average results and the farm-specific results so that farmers can benchmark their farm biodiversity, as well as running awareness raising and training days for farmers.

UK - Wales - agri-environment monitoring programme

The Welsh agri-environment scheme 2012-2020 is known as Glastir. Its environmental effects were monitored through the Glastir Monitoring and Evaluation Programme (GMEP), led by the Centre for Ecology and Hydrology, from 2012 to 2016. GMEP was a comprehensive monitoring scheme to assess the effects of Glastir against its intended outcomes, one of which is a halt of the decline of biodiversity (Emmett et al. 2017), in particular the UK priority species and habitats associated with farmland in Wales. GMEP is the largest and most in-depth ecosystem monitoring and evaluation programme of any Member State and Managing Authority within the European Union to date. GMEP was established before the start of Glastir, an improvement on previous monitoring programmes which reported only after the end of the rural development programming period. GMEP used a structured annual field survey of 1km x 1km sample squares across Wales, in which a series of surveys and sampling protocols were carried out. To evaluate impacts on biodiversity, the survey results are combined with biodiversity data from ongoing voluntary species monitoring schemes in Wales. More details of the GMEP method and data are available in Suppl. material 1.

GMEP resulted in a large dataset of monitoring observations available on a data portal[*42]. The programme has already provided evidence that land which has been under agri-environment schemes for a number of years has a higher biodiversity value than land which is only now entering the agri-environment programme (Emmett et al. 2017). Data from GMEP was used to produce a unified map of peatland, which was used to target Glastir payments; and the modelling results from the first year were used to predict potential biodiversity benefits of the scheme. The consortium also provided data to inform the Welsh government's biodiversity targets.

It is anticipated that the successor to GMEP will form part of an integrated natural resources monitoring framework, to be phased in over the next five years. The biodiversity monitoring component will have a similar structure including a field survey informed by earth observations and model simulations[*37]. A priority will be to adopt a clear approach to efficient and effective sharing of data to enable the conversion of data into robust evidence products with stakeholders across the monitoring community, including groups managing protected areas, such as the National Park authorities and National Trust Wales, and the local biodiversity record centres.

New monitoring schemes for farmland biodiversity and monitoring proposals

Pollinator monitoring in the UK

There is currently no systematic monitoring of pollinators anywhere in the EU. Nonetheless, there is growing evidence that pollinators (bees, hoverflies, and butterflies) are declining in the EU from studies that have analysed records of species occurrence in various EU countries (Casey et al. 2015, Dupont et al. 2011, Ollerton et al. 2014). Agricultural changes are responsible for a significant part of this trend (Kosior et al. 2007).

In the UK, a proposal for a systematic national wild pollinator monitoring scheme has been developed (Carvell et al. 2016) and a 3-year monitoring programme for Great Britain (i.e. England, Scotland, Wales) is now being funded by the UK government. The monitoring scheme will show how the status of insect pollinator populations and communities change over time in both agricultural landscapes and the wider environment, and also how pollination services to agriculture and horticultural crops are changing over time. The information will be useful for assessing changes in pollinator communities in relation to land use change at the regional level, for example change in the availability of flower-rich grassland or field margins. The systematic monitoring scheme relies on the context and baseline supplied by existing occurrence data coming from schemes and records being collected and submitted by societies such as the Bees Wasps and Ants Recording Society. More details of the proposed method are given in Suppl. material 1.

Proposals for EU-wide farmland biodiversity monitoring

The European Commission is providing some funding for the establishment of an EU-wide monitoring programme of farmland biodiversity[*38]. The plan is to fund the development of a methodology for a survey to collect field data on farmland biodiversity from 2017, as well as to develop a baseline of farmland biodiversity from selected data sources before the implementation of the CAP 2014-2020 and a methodology for a robust comparison after the implementation of the new CAP (2016 and beyond). As described below, two projects have previously made proposals for EU-wide farm monitoring.

The BioBio project (Targetti et al. 2014) proposed an EU-wide farm-scale monitoring scheme to measure six biodiversity parameters including vascular plants, wild bees, spiders and earthworms. The authors suggest that an EU-wide scheme would need to monitor at least 6.3% of farms across the EU[*39] in order to have a sufficient sample size to detect a 10% change in species richness of all the indicators with high robustness, or 1.3% of farms with medium robustness and excluding bees, or 0.2% with low robustness and with a reduced indicator set, with cost ranging between €2,700 and €8,200 per farm depending on the degree to which the monitoring relies on volunteer involvement (Geijzendorffer et al. 2015).

A survey in 2014 gathered baseline data on biodiversity and landscape features in arable farmland across the EU. The survey sampled data from about 800 plots each of 25 ha in size in 39 regions of 10 European countries. It was repeated in summer 2016. The survey team proposes the methodology as a suitable model for ongoing EU-wide monitoring of arable farmland (IFAB 2015). More details are available in the supplementary material.

Improving biodiversity data use for implementing and assessing agricultural policy

Biodiversity data are essential for two key processes within the rural development planning cycle, firstly policy targeting and secondly evaluation. This study has identified a number of examples of good practice in the use of biodiversity data for each of these policy processes, and also highlighted some current weaknesses and barriers.

Improving policy targeting with biodiversity data

Targeting agri-environment measures and other rural development payments at farmland that already contains some species and habitats of conservation value is important, because it has been shown that measures that are designed to protect particular species and habitats can be much more effective and efficient for conservation than untargeted measures (Batáry et al. 2015). This study has described some examples of thorough uses of available biodiversity data to improve the targeting of agricultural policy, particularly for agri-environment payments. For example, the England targeting framework incorporates a large collection of data sets into 40 data layers in the LPIS, mapping both priority species and habitats and more common but declining farmland species, and allowing the assignment of priorities and scores to each land parcel. The framework is the result of the involvement of many experts and civil society organisations, as well as consultations with regional groups to define local priorities. The Danish HNV targeting framework combines land cover and habitat mapping data with species data on characteristic plants and species of high conservation priority onto a 10 m x 10 m grid that is superimposed on the LPIS parcels to score each land parcel.

It is important to distinguish between data and tools that are intended for the purposes of monitoring biodiversity under the CMEF requirement, and data and tools that are intended for targeting policy instruments at biodiversity. Although the data and tools used for these two purposes may sometimes overlap, it is important to be clear from the start of any data collection work that the technical requirements are different. For example, monitoring can be achieved through sample surveys whereas effective targeting of support measures cannot. Conversely, a map designed for targeting support at certain species or habitats may be unsuitable for monitoring changes in species or habitat distribution or conservation status.

Improving policy monitoring and evaluation with biodiversity data

Policy monitoring and evaluation requires the use of data and indicators that measure impact. The Common Monitoring and Evaluation Framework of the CAP requires the use of indicators of biodiversity based on the common farmland bird index, the conservation status of grasslands, and HNV farmland. The CMEF bird and grassland indicators use biodiversity datasets and methodologies that follow a common EU-wide approach, and that have sufficient data to measure progress in biodiversity conservation over time at the national level. However, neither indicator as presented in RDPs gives sufficient information to allow an assessment of actual impacts on biodiversity in the absence of supporting information and analysis, as the indicators are simply a number, sometimes with a trend graph.

The grassland CMEF indicator, for example, is only defined as measuring the conservation status of the grassland habitats, and presents the data only as the percentage of assessments of habitats in 2013 which are in favourable, unfavourable – inadequate, unfavourable – bad, and unknown status. This information gives no indication of the total area of habitat in question, as the assessments are undertaken at the biogeographical region level within Member States, with habitat areas ranging from a few square kilometres to tens of thousands of square kilometres. The data on the actual area in each conservation status category could be used to show how much land needs to be targeted by RDP measures and what proportion of total grassland area is species rich. Unless the RDPs include a more in-depth discussion of the habitat survey data available at the national level and what policy needs to deliver to make a change, the indicator is of limited usefulness. Analysts of the Irish RDP concluded that the indicator has not been taken seriously by the agricultural ministry in Ireland and is of little practical use in measuring impacts on species-rich grassland (Gallagher et al. 2015).

The Common Farmland Bird Index does not necessarily reflect the trends in all farmland species, as an increase in the index could indicate an increase in some species but a decline in others. For example, generalist species outcompeting specialists has been shown to be a likely outcome of habitat fragmentation (Devictor et al. 2008). Accurate policy targeting therefore requires an analysis of the available information on individual species trends combined with research findings on which measures would benefit which species. For example, the Malta Rural Development Programme mentions the decline in the Malta Farmland Bird Index in the context of an afforestation measure which is proposed to reverse the trend[*40]. However, afforestation is expected to benefit migratory species rather than farmland species[*41], although it could have a positive effect on a few farmland species such as the Serin (*Serinus serinus*). A more meaningful use of farmland bird monitoring data is to analyse the effects on individual species and then to aggregate the outputs.

The HNV indicator is potentially a valuable tool for integrated monitoring of the nature value of farmland, or for the targeting of RDP support to farmland with high potential to support biodiversity. The indicator is intended to combine measures of semi-natural habitat on farmland, farmland species of conservation concern, and diverse landscape structures that support high levels of biodiversity. However, few countries have assembled the required data to accurately map HNV at the farm parcel level in a consistent, comprehensive and up-to-date form, although many have partial data that could be completed (Keenleyside et al. 2014). Species datasets are often not consistent or complete enough to reliably identify HNV farmland. For example, the link between bird abundances and mapped HNV farmland is not simple, as it differs according to the dominant characteristics of HNVF at the local level and the different habitat preferences of farmland birds.

HNV mapping approaches do not currently allow the assessment of pressures that may be driving the changes, but if farm data on management practices (such as fertiliser use and stocking densities) from the IACS database of all farms receiving CAP payments could be included it would be possible to evaluate the impacts of CAP funding on HNV quality of the agricultural landscape (European Commission DG AGRI 2016b). For example, Austria is recording in IACS the intensity of meadow management (the number of cuts per year) at the parcel level, which will allow for detailed analyses of impacts of management changes on HNV (Bartel et al. 2011).

Assessing impacts on biodiversity requires strong links between monitoring, ongoing evaluation and impact evaluation over the whole programme implementation period. With respect to biodiversity, this should ideally be based on a coherent biodiversity data management system and monitoring framework, together with process steering and appropriate methodologies and instruments. The lack of such a data collection and management system is one of the key barriers to the effective use of biodiversity data to inform agricultural policy (see Fig. 5) (ENRD 2012). Common problems are lack of biodiversity data at regional level and lack of time series data (ENRD 2013). A review of RDP 2007-2013 mid-term evaluations in 16 Member States found that only 13 RDPs identified a causal relationship between impact on biodiversity or wildlife, indicator and RDP measure, although most of the RDP measures were described as benefiting biodiversity and wildlife (Smyrniotopoulou and Vlahos 2013). Most of the 172 uses of biodiversity indicators failed to establish a causal link between measure, indicator and biodiversity impact, and did not provide a quantified value. A review of the 2007-2013 agri-environment programmes in five EU countries concluded that the quality of supporting data on biodiversity is very low (Wissman et al. 2013). A recent review in Germany (Dauber et al. 2016) highlighted the urgent need to collate available biodiversity data in order to inform better designed and more efficient agricultural policy measures.

Assessing the impact of individual measures, for example an agri-environment scheme, requires population monitoring surveys of target species and habitats, in order to monitor and evaluate impact in the target areas with comparable data from non-target areas as a control (i.e. to assess the counterfactual). This requires a planned and targeted monitoring programme designed specifically for monitoring the impact of the identified measures. This study has described the nationally structured systematic monitoring programmes to measure the impact on biodiversity of agri-environment measures in Wales and Estonia, and showed how these are being used to improve the effectiveness of rural development funding for biodiversity conservation.

A recent report carried out an EU-wide analysis of the relationship between agricultural land use and biodiversity, for which the authors compiled a database of biodiversity data sources and identified the obstacles encountered in the use of biodiversity data (Siriwardena and Tucker 2017). These obstacles included issues of data availability, such as a lack of accessible abundance data in some Member States especially for butterflies, the restricted range of taxa monitored, the large scale of most agricultural datasets (e.g. NUTS3), and the lack of accessible data on some key agricultural factors such as pesticide usage. Of particular concern is the spatial scale of data, which is too large to reflect the scale of biodiversity-relevant responses, and the unwieldiness of large datasets. Extending atlas projects to encompass more Member States and implementing fine-grained agricultural monitoring data, including information such as field boundaries, would increase the scope and quality of assessments of agricultural measures for biodiversity. Problems can also arise from restricted access to existing biodiversity data, as some data holders require payments for data to cover their costs, and others wish to withhold data for academic purposes, or due to concerns over their possible mis-use.

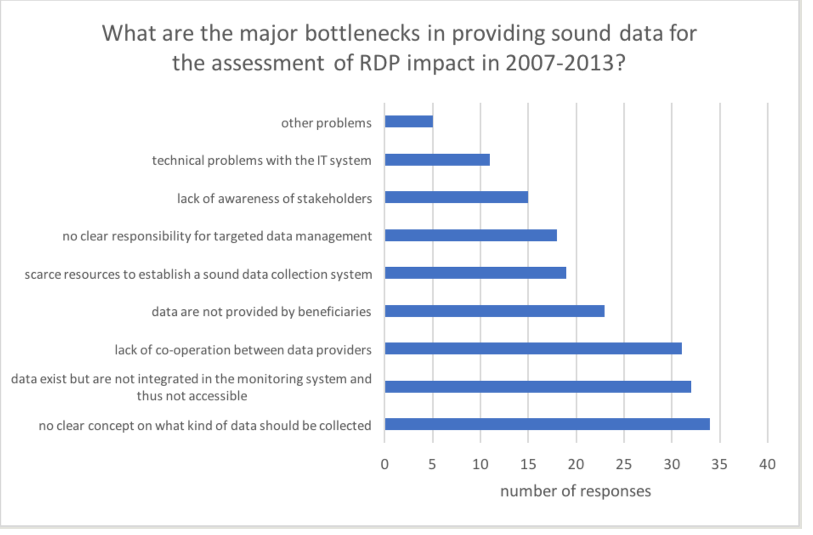

Figure 5. doi

Opinions of RDP policy evaluators on data availability and bottlenecks. Results reproduced from ENRD 2012.

A group of 58 RDP policy evaluators were asked about data availability and bottlenecks to data use for agricultural policy impact evaluation in 2007-2013. In response to the question: “To what extent are sound data available to carry out RDP impact evaluations?” 2% (1) replied ‘fully available’, 24% (14) replied ‘largely available’, 72% (42) replied ‘partly available’, 2% (1) replied ‘not available’. The answers to the question “What are the major bottlenecks in providing sound data for the assessment of RDP impact in 2007-2013?” are shown in the graph.

Studies exploring the effects of agri-environment schemes on biodiversity may choose to perform their own surveys rather than utilising the farmland bird indicator dataset, due to barriers to use of monitoring datasets. The national monitoring schemes may not contain sufficient samples from sites with a particular agri-environment scheme to allow for an evaluation using the data, as the method of stratified random site selection employed in most national schemes may result in insufficient samples of protected area or agri-environment scheme sites. In addition, the 1 km^2 scale employed by the PECBMS and ECBMS may not be appropriate for assessing the impact of small agri-environment features. It should also be borne in mind that the national breeding bird surveys do not effectively monitor rare or threatened birds (and are not designed to do so). A proposed rare bird index would provide information on the endangered species which are often targets of agri-environment schemes (Gregory and Strien 2010).

Prospects for biodiversity monitoring and data use to inform agricultural policy

The examples in this study show the possibilities for better targeting and evaluation of agricultural funding to biodiversity conservation if sufficient biodiversity data are available and are used in policy. For example, the Danish HNV targeting framework uses available fine-grained data on plant species richness, soil fertility, natural hydrology and presence of vulnerable species rather than farming system indicators such as crop diversity or livestock density, as these variables are less permanent in time and less closely correlated with high biodiversity (Brunbjerg et al. 2016). However, as noted by many RDP evaluators, many biodiversity datasets exist at the national or regional but are still not integrated in the RDP monitoring system and thus not accessible to evaluators. Many RDPs still tend to feature only the obligatory EU-level indicators. There is however a clear difference between the need for standardised EU-level datasets that can be used for an overall assessment of the impact of the CAP, and the much more detailed and specific datasets that can be used at the national or regional programming level. At the EU-level, there is still a huge gap in useable biodiversity data, whilst at the national and regional levels, there are often datasets that are not being used for other reasons.

The examples described in this study are producing large datasets on agricultural biodiversity that could be used in further analyses to inform policy. For example, German HNV farmland monitoring is producing a valuable database of farmland habitat distributions with a high potential for informing research to deliver a better understanding of the changes in farmland biodiversity (European Commission DG AGRI 2016b). The HNV farmland indicator has been integrated into the German national biodiversity strategy, and is one of the German Federal States' core environmental indicators. Initial results indicate that over only two years the amount of HNV farmland has reduced significantly, mainly as a result of losses of poorer quality HNV arable and grassland areas (see Fig. 6) (Benzler et al. 2015).

The movement towards the digitisation and aggregation of biodiversity records is increasing the accessibility of high quality biodiversity data for analysis held by specialist organisations, individual experts or local recording centres which has not always been freely accessible for policy monitoring. For example, in the UK the National Biodiversity Network partnership provides access to rapidly increasing collections of data on biodiversity, although the number of publicly accessible records available at fine spatial scales is still low (Fig. 7).

One key development in the improvement of biodiversity data provision and integration is the European Biodiversity Observation Network (EU BON), which has produced a suite of tools including the European Biodiversity Portal (http://biodiversity.eubon.eu/). This is a gateway to biodiversity datasets and allows population trend visualisation, drawing on data from sources such as the Global Biodiversity Information Facility. As such, it could be used as a decision support tool for informing rural development policies. EU data sources on farmland species and relevant agricultural data have been identified and summarised in a meta-database for the European Commission as part of a recent study (Siriwardena and Tucker 2017).

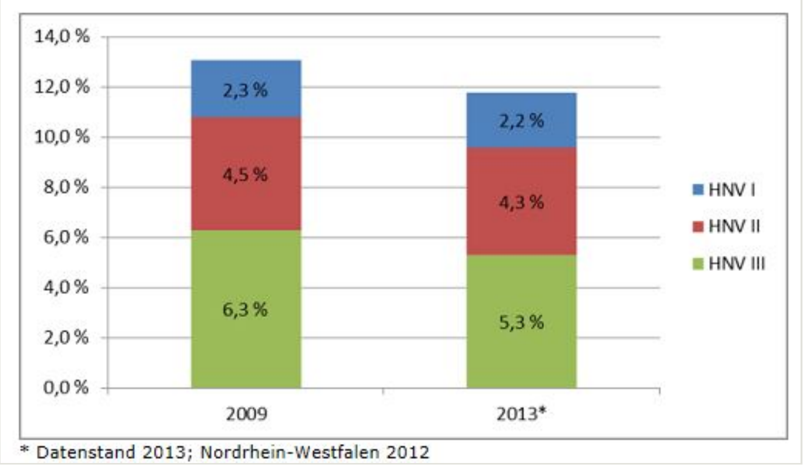

Figure 6. doi

The German HNV monitoring methodology and results - HNV value decline

In Germany, the HNV monitoring methodology has enabled an initial assessment of the trend in HNV value of farmland. Between 2009 and 2013, there was a significant decline of HNV value, in particular in the HNV class III, which represents the lowest value (in terms of species richness and structure). Graph reproduced from (Benzler et al. 2015).

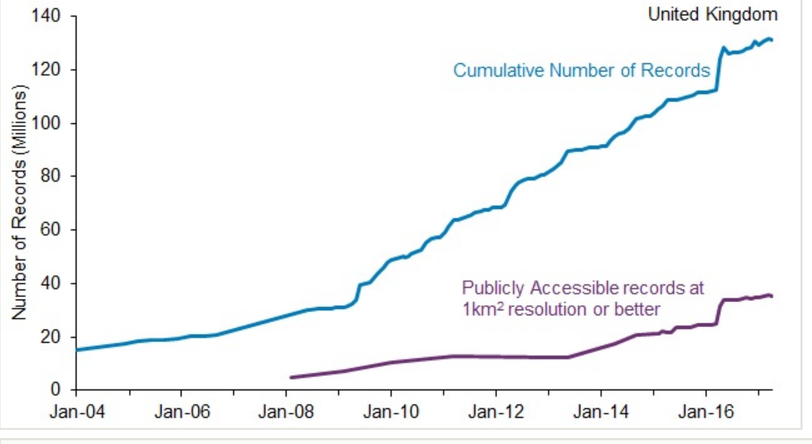

Figure 7. doi

Records added to the National Biodiversity Network Gateway, 2004 to 2015. From UK Biodiversity Indicators 2015, http://jncc.defra.gov.uk/page-4229 Source: NBN Gateway and NBN Atlas.

Systematic EU wide monitoring programmes are being developed for butterflies and pollinators. Monitoring pollinators is more challenging than birds, because there are many more species, most of these cannot be identified to species in the field so capture of specimens becomes necessary, there are comparatively few volunteer recorders or citizen science initiatives focussed on pollinating insects, and identification of collected specimens is time-consuming and requires specialist skills (Carvell et al. 2016). Therefore, the sampling design, taxonomic resolution and range of species or groups to be monitored, levels of volunteer and professional involvement, data handling and support tools are all critical to the success of long-term monitoring.

In future, species-rich grassland monitoring at the EU level will be improved by the planned new LUCAS grassland survey methodology, which will be available from the 2021 LUCAS survey onwards[*9]. LUCAS will survey vegetation on standard grassland transects at more than 270 000 sample data points across the EU. However, as the LUCAS sampling provides only one point per $16km^2$, i.e. around 0.06 survey points per square km, the resolution is too coarse to allow for any use to target agri-environment contracts or other RDP payments to individual farmers, or to monitor the impacts of farm-level schemes. Remote sensing may be a viable solution for habitat mapping in the future (Stenzel et al. 2017). For example, airborne laser scanning data (LIDAR) were capable of mapping ten grassland habitat types in a Natura 2000 site with 68% accuracy (Zlinszky et al. 2014). However, applications and methods are still being developed and are not yet sufficiently reliable and economical for large-scale use (Rocchini et al. 2015).

In summary, there is an urgent need for increased and better use of biodiversity data in supporting CAP measures, especially rural development programmes, that aim to conserve semi-natural habitats and species associated with farming. Recommendations for the improved use of biodiversity data for agricultural policy include the improvement of datasets of semi-natural grasslands; the establishment of sample surveys of semi-natural grassland condition; the systematic transect monitoring of butterflies, alongside continued monitoring of farmland birds. This needs to be supported by more comprehensive and finer grained (ideally field scale) data on agricultural systems and practice.

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Supplementary material

Suppl. material 1: The use of biodiversity data in rural development programming doi

Authors: Underwood, Evelyn & Grace, Miriam
Data type: descriptive text
Brief description: The supplementary material provides additional detail on methods and data sources used in the case studies and examples that are describe in the main article.
Filename: UnderwoodGrace2017_supplmaterial.docx - Download file (414.18 kb)

Endnotes

*1 Regulation (EU) No 1305/2013 Preamble paragraph (24) and Commission Implementing Regulation (EU) No 808/2014 Annex I 4(b) (http://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX:32014R0808)
*2 Regulation (EU) No 1306/2013 available at http://eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX%3A32013R1306
*3 Annex VI in Commission Implementing Regulation (EU) No 808/2014 of 17 July 2014 laying down rules for the application of Regulation (EU) No 1305/2013 of the European Parliament and of the Council on support for rural development by the European Agricultural Fund for Rural Development (EAFRD) (http://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX:32014R0808)
*4 http://enrd.ec.europa.eu/evaluation_en
*5 Proposed by the Commission in COM(2006) 508 and then approved by the Agriculture Council. The IRENA project has been stopped, and the IRENA indicator set is no longer being updated by the EEA. EuroStat is continuing to update some of the indicators in an adapted form, see http://ec.europa.eu/eurostat/web/agri-environmental-indicators/indicators
*6 European Bird Census Council. http://www.ebcc.info/index.php?ID=616
*7 Ongoing project of European Environment Agency and Alterra
*8 Skylark is negatively correlated with hedgerow presence and Greenfinch prefers forest patches, which are present only marginally in the HNV farmland and more present in urban areas.
*9 Personal communication, Maria-Luisa Paracchini, Joint Research Centre, 12 June 2017
*10 http:/www.butterfly-monitoring.net
*11 Personal communication, Jesper Bladt, Aarhus University, 20 January 2017
*12 http://arealinformation.miljoeportal.dk/distribution

[*13]The England lists of 56 priority habitats and 943 priority species are published according to Section 41 (S41) and detailed in Section 42 of the Natural Environment and Rural Communities (NERC) Act 2006 (available at http://www.legislation.gov.uk/ukpga/2006/16/contents). In Wales, Section 7 of the 2016 Environment Act (Wales) replaces Section 42 of the 2006 NERC Act (available at http://gov.wales/topics/environmentcountryside/consmanagement/natural-resources-management/environment-act/?lang=en).

[*14]The Bird Conservation Targeting Project is a joint Natural England, RSPB, BTO and Forest Commission initiative which works closely together with BirdTrack (www.birdtrack.net), a partnership between the BTO, the RSPB and BirdWatch Ireland, with the aim of automating the process of collating bird records. Local bird clubs and individuals are encouraged to share their bird data in BirdTrack and/or the National Biodiversity Network, and efforts are ongoing to integrate BirdTrack with the NBN web services.

[*15]Issues DEFRA encountered as per personal communication with Clive Porro (December, 2015)

[*16]A few weaknesses still create obstacles to smooth administration of contracts; for example, agri-environment applications need to be processed before land use changes are registered in the system, as this is only done once a year, so a landowner could apply for an arable agri-environment option on a land parcel that is still registered as temporary grassland in the system. Personal communication with Clive Porro December 2015.

[*17]www.nature.cz; http://www.ochranaprirody.cz

[*18]http://www.casopis.ochranaprirody.cz/vyzkum-a-dokumentace/jemne-predivo-ceske-krajiny-v-gis/

[*19]http://portal.nature.cz/publik_syst/ctihtmlpage.php?what=3&nabidka=hlavni

[*20]Personal communication, Karel Chobot & Iva Hönigová, Nature Conservation Agency (AOPK), 11 January 2017

[*21]http://biolog.nature.cz/en

[*22]Personal communication, Klara Čamska, Nature Conservation Agency (AOPK), 11 January 2017

[*23]Regular semi-natural habitat surveying and monitoring is carried out in the Estonian national environmental monitoring program. The Estonian Nature Information System-Environmental Registry contains the most up to date habitat information, however it is mostly restricted to semi-natural areas located in the Natura 2000 network. Available at http://register.keskkonnainfo.ee/envreg/main#HTTPim5RXclcpOHb7wTQbTgFhPK8rr6tcZ

[*24]Personal communication, Eneli Viik, Agricultural Research Centre Estonia, 21 December 2016

[*25]Derived from vector maps at a 1:25 000 scale

[*26]Called Banská Bystrica. Until 2007 the verification and certification process was carried out by Daphne. The GIS is updated by the Institute of Soil Science.

[*27]Personal communication, Dobromil Galvanek, independent consultant, 12 January 2017

[*28]In Slovakia, the eligibility criteria for direct payments under Pillar 1 and Pillar 2 payments are the same, so all farmers who receive agri-environment payments are also eligible for direct payments. Restoration takes place only when farmers invest their own resources to clear vegetation or when other funding sources are accessed by protected area authorities, NGOs, etc.

[*29] Personal communication, Razvan Popa, Director of Fundatia Adept, 14 December 2016

[*30] This is the lowest level of administration (ie LAU level) in Romania, typically representing an area with a few villages and up to 10,000 inhabitants.

[*31] Personal communication, Daire Ó hUallacháin, Teagasc, 5 January 2017

[*32] http://www.biodiversityireland.ie

[*33] The Polish RDP has restricted the implementation of agri-environment schemes targeted at birds to parcels within SPAs. See Poland RDP 2014-2020 http://www.minrol.gov.pl/Wsparcie-rolnictwa/Program-Rozwoju-Obszarow-Wiejskich-2014-2020

[*34] As the agri-environment scheme for environmentally friendly management and the organic farming support for 2014-2020 are similar to the previous period, the biodiversity monitoring scheme is continuing in a similar format to the monitoring up to 2015, with a slightly changed sample of farms.

[*35] See http://pmk.agri.ee and http://pmk.agri.ee/mak/avaleht

[*36] The Centre had planned to provide data access via a web platform but this was abandoned due to lack of funding. Personal communication, Eneli Viik, Agricultural Research Centre Estonia, 21 December 2016.

[*37] Personal communication, Bronwen Williams, CEH Bangor, 10 January 2017.

[*38] Tender ENV.D.2/SER/2016/0058MV available at http://ec.europa.eu/environment/funding/calls_en.htm

[*39] There are currently approximately 10.8 million agricultural holdings in the EU. Eurostat statistics http://ec.europa.eu/eurostat/statistics-explained/index.php/Farm_structure_statistics.

[*40] On p36 in Malta RDP 2014-2020 available at https://eufunds.gov.mt/en/EU%20Funds%20Programmes/European%20Agricultural%20Fund/Documents/RDP%202014-2020/Malta%27s%20Rural%20Development%20Programme%202014-2020.pdf

[*41] Personal communication, Nicholas Barbara, BirdLife Malta, 16 December 2016

[*42] https://gmep.wales

[*43] Certain AECM options (e.g. management of mesic and slightly wet meadows, dry and mountain meadows) are available only inside protected areas (Landscape Protected Areas, National Parks and their buffer zones, and Natura 2000 sites).