Landscape Infrastructure and Sustainable Agriculture (LISA)

Report on the investigation in 2014

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Project management:

Institute for Agroecology and Biodiversity (IFAB)

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Special support:

The survey design was partially funded by the Joint Research Centre (JRC), Institute for Environment and Sustainability, Ispra, Italy, - Service Contract No.CCR.IES.C390304.X0 – Development of a method for a European field survey of nature value in agricultural landscapes.

The difficult work in Italian case study regions was supported by INEA (Istituto Nazionale di Economia Agraria), Roma, Italy.

The development of a potential key species list was supported by Dr. Dr. Jörg Hoffmann, Julius-Kühn-Institut (Federal Research Centre for Cultivated Plants), Kleinmachnow, Germany.

An extensive case study in Germany was supported by the Gregor Louisoder Umweltstiftung, Munich, Germany.

The fieldwork in several countries was supported by the European Environmental Bureau (EEB), Brussels, Belgium.

Thanks also to all other numerous partners and surveyors!

Cooperation partners and surveyors:

Country	Supporting institutions and organisations	Field surveyors*
Czech Republic	Czech Society for Ornithology and University of South Bohemia	Martin Šálek, Martin Strelec
European Commission - JRC	Joint Research Centre (JRC) of the European Commission, Ispra, Italy	
France	Solagro / Philippe Pointereau	Lou Morin
Germany	Institut für Agrarökologie und Biodiversität (IFAB), Julius-Kühn-Institut (JKI – Dr.Dr. Jörg Hoffmann) and Gregor Louisoder Umweltstiftung	Anja Eirich, Julian Lüdemann, Philipp Bauer
Hungary	Institute of Environmental and Landscape Management, Szent Istvan University, Gödöllö, Hungary	Péter Tóth, Péter Palatitz, András Schmotzer, Gábor Balogh
Italy	Istituto Nazionale di Economia Agraria (INEA) / Antonella Trisorio	Michele Adorni , Enrico Perrino
Poland	Pracownia Przyrodnicza	Marek Jobda, Diana Fajka, Arek Gorczewski, Richard Bleil, Eva Lutz
Romania	Fundatia ADEPT	Sabin Baderau
Spain	Fundación Global Nature	Jordi Domingo, Ernesto Aguirre, Jenja Kronenbitter
The Netherlands	Rob Schröder Consult	Sylvain Wamelink
United Kingdom	Royal Society for the Protection of Birds (RSPB)	Catherine Tregaskes, Jenja Kronenbitter

* The field surveyors partly are independent from the supporting institutions or organisations and partly have been charged directly by IFAB.

Supporting instructors for the field survey:
Richard Bleil, Jenja Kronenbitter, Dr. Rainer Oppermann (all from IFAB)

Acknowledgement

Partners, co-operators and surveyors from ten countries across Europe have participated in the project. They have supported the study design and organisation, and have done tremendous work in the field, collecting data on many different features of the agricultural landscape in the study regions. Only with their great and immense contribution this study has become possible.

Thanks a lot to all persons and institutions who have contributed and/or supported this work.

Content

List of tables

List of figures

Executive summary

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

The scope of the LISA pilot study (**L**andscape **I**nfrastructure and **S**ustainable **A**griculture) was to develop and implement a method to measure the nature value of different agricultural landscapes in Europe through standardised field-level surveys. The following report describes the development of the field method and parameters to be surveyed, the selection of plots for the testing phase, and the testing of the survey methods in 2014.

A review of the literature and screening of different approaches to record the nature value of agricultural landscapes in Europe revealed the following methods and parameters to be most suitable:

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

The details of the method have been worked out and described in a protocol for the field survey comprising 50 pages and illustrations. The approach is based on elements of existing approaches, but it also comprises new elements like a European indicator species list for recording of ecologically valuable arable land and grassland.

In 2014, the LISA approach was tested in 39 regions of 500-1000 km² size in 10 European countries from Spain to Poland and from Scotland to Romania. In total 22 surveyors investigated about 800 plots each of 25 ha in size from May to July 2014.

The results were the following:

- The survey methodology proved to be applicable in all European regions; a Europe-wide method for assessing the nature value of agricultural landscapes across quite different European regions was developed and applied.
- Almost all surveyors were able to complete a region survey with 25 plots each of 25 ha size within 5-6 days; however, a few refinements can be made in order to improve the data records and the data interpretation.

- The estimation of the nature value based on a field guide turned out to work quite well: the results of detailed vegetation transects support the results of judging the nature value.
- The nature value turned out to be quite low in almost all arable landscapes as the extent of species rich arable land was rather low – even in regions where it was expected to be high.
- The number of potential key species for arable land was very low (mainly 0-1 species out of a list of about 100 species or taxa) except in very few regions where the average number was higher.
- The low numbers of potential key species are not correlated with the coverage of wild plants in arable land – the highest number of key species and the highest nature values were found in arable fields with a medium landuse intensity and on fields with a low to moderate coverage of wild plants.
- The list of potential key species proved to work well; however, the list of about 100 species and taxa can be reduced to about 50) species each in arable land and in grassland.
- The pollination potential of arable landscapes was measures with different parameters – the number of flowering plant species, the flower density and the coverage of wild plants. It turned out that the pollination potential was rather low in almost all arable landscapes with values of only 1 flowering plant species and an average flower density of only 1.3 on a scale of 1 – 5.
- In comparison to arable land, the situation of nature value and biodiversity in grasslands was higher: at least in mountain regions a range of different nature values could be observed.
- The extent of landscape elements varied between 1.5 % and 8.7 % in the investigated areas. The nature values of these elements showed mostly a range of different values (good, medium and low values).
- Buffer strips were recorded over 0.1 % - 1.1 % of the arable land area with a medium width of 1.1-5.5 m.
- Photographs were taken in order to document the landuse and nature situation in 2014. There is an archive of over 16,000 photos of all plots (n = 857 plots).
- Good and bad landuse practices were also documented with photos.

The LISA approach could be applied to far more regions in Europe and thus deliver a complete and representative view on the ecological situation of agricultural landscape. The field effort is only about one week per region and the interpretation of data also needs one week per region. Thus, the method is a rapid approach method which delivers detailed results with a relatively limited effort.

1. Background and context of the project

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

With the greening in the CAP a new mechanism is being introduced to achieve ecological improvements. It is important to carry out an assessment of the effects and the achieved improvements of the greening. Not only the direct effects of greening but also the overall state of biodiversity, landscape structures and the potential for the delivery of ecosystem services such as pollination are interesting and important topics for a common EU-wide recording. Moreover, it is important to collect best practice examples of farming in Europe in order to develop further greening approaches in agriculture. Given this background, this European project was designed also to explore some of the issues of a future monitoring and cover several purposes; thus it shall contribute to the development of an ecologically compatible agriculture in Europe.

This LISA-study (LISA = Landscape Infrastructure and Sustainable Agriculture) was not only dedicated to develop and to test a new method for a common European survey of ecological data; it may serve also as a baseline survey in order to compare the situation in 2014 before introduction of the greening in the CAP with the situation in 2016 and later after the implementation of the greening in the investigated regions.

Besides working on scientific development, practical experiences and agri-environmental evaluation the study also served for a European cooperation with different institutions and scientists, and an intensive exchange during and after the field survey.

2. Project approach and aims of the project

There is currently no standardised method for comparing the nature value / ecological value of different landscapes in Europe. The focus of this study was therefore to develop and test an integrative approach for recording the nature value / ecological value across Europe. For this purpose, a methodology was worked out, building on elements of existing approaches. The methodology was then implemented in 39 regions (each about 500-1000 km² in size) in 10 European countries (Figure 2). Data was collected in a sample plot approach in 25 plots per region (each 25 ha in size), focusing on type of landcover (arable crops, different types of grassland, fallow, landscape elements and non-agricultural elements), nature value of agricultural plots and landscape elements, and floral species richness on agricultural plots.

With this approach, several aims of the project were pursued:

1. The current extent, quality and state of landscape infrastructure, landuse and ecological value of farmland across European regions was measured with a common approach in order to achieve comparable information.
2. By covering 39 regions in Europe in 10 countries, it was intended to be able to illustrate the situation in several parts of Europe from North to South and from East to West. At the same time, the methodology was tested across different parts of Europe with different characteristics regarding climate, flora, and landuse practices. Thereby, information was collected for refinement of the methodology, particularly in terms of providing comparable data across Europe.
3. The study started in 2014 in order to record a status quo prior to the implementation of the CAP greening with Ecological Focus Areas (EFAs). With a first record in 2014 with this approach one will be able to record changes in landuse, extent and quality of landscape infrastructure from 2016 onwards after the introduction of greening in 2015.
4. Good and bad practice examples of landuse and greening were collected and documented photographically (positive e.g. implementation of buffer strips alongside of ditches and hedges, extensive management of ecologically valuable sites, negative problems of soil erosion, impact of plant protection products in water courses).
5. We intend to repeat this survey in 2016 using a refined methodology.

Based on the results, further scientific and evaluation work can and should be done in order to use the collected experiences.

3. Material and Methods

First of all it was important to identify the parameters to be surveyed and to describe them. For this we reviewed various relevant existing methods (see section 3.1) as well as the relevant literature (e.g. Benzler 2009, 2010, 2012; BfN 2012; Herzog et al. 2012; Bundesamt für Naturschutz (BfN), 2012); European Commission 2013; Mestelan et al. 2010; Oppermann et al. 2012 ; PAN et al. 2011, Paracchini 2013; Tropea et al. 2012), and selected suitable parameters based on this.

For the set-up of a protocol for the field survey the details of the method have been worked out and described. The approach is based on elements of existing approaches but also comprises new elements. Much emphasis was laid on taking into account methods to estimate and to measure the nature value, as we found no existing EU-wide approaches in this sector.

In detailed field guidance for the surveyors the methods were described and record sheets were provided and explained. Also illustrated examples have been worked out.

In different regions randomly selected plots were chosen. The survey in the regions was done in spring between May and July in order to capture the peak of vegetation development (arable land and grassland). This test of the protocol took place on pilot plots under different conditions (arable land, grassland).

Within this project, 39 different regions with 25 plots each (in a few regions only 12 plots) were surveyed. This provided experiences under different conditions (e.g. large-scale monocultures and structurally-rich landscapes, species poor landscapes and species rich landscapes). The protocol was implemented out by different persons (to test the accurate interpretation of the protocol) and was documented with photos.

The application of the protocol and the experiences are described in this report. There is also an illustration with some photos out of a huge photo documentation. Thereby the applicability and effectiveness of the protocol is of special interest regarding the wider implementation of these methods and this approach in general. Recommendations are given for the refinement and further development of this approach in section 6.

3.1. Development of the methods / Identification of parameters to be surveyed

Beside the bird indicator the only indicator of nature value across Europe is the HNV-indicator – the High Nature Value farmland indicator. This indicator is recorded in a very different way across Europe (more than 20 approaches, compare Pepiette 2012) most of them reflecting only the area identified as HNV farmland and not the current situation of biodiversity and nature value in the field. Thus a method has to be developed to measure the nature value of different agricultural landscapes in Europe through harmonised ground surveys.

For the survey of biodiversity there are some crucial points which have to be considered in the development of the protocol for the field survey. These points base on widely acknowledged experience and own experiences in the development of the High Nature Value (HNV-) Indicator in Germany (Benzler 2009, 2010, 2012, Oppermann et al. 2008, PAN et al. 2011).

The crucial points are the following:

- Time window: There is a short time window of about 6 - 10 weeks within which the survey has to be carried out. This time window extends from end of April to begin of June (Southern European Countries) and from end of May to mid of July (Northern European Countries) or to the climatic situation and altitude, respectively.
  In this time most of the plants are well developed and can be observed and the fields have not yet been harvested or mown. For parts of the meadows the time window is shorter in spring but there is a second chance in a later stage, for the pastures the situation is more complicated.
- Size and number of plots: It's obvious that larger plots require more time for the survey than smaller plots and that numerous plots deliver better results for a region than only a few plots Thus there are several parameters which should be optimized for the survey in order to be representative.

The optimal compromise between the required number of plots and this size of the plots is different for different landscapes as there are structurally heterogeneous landscapes (e.g. Southwest Germany) and homogenous landscapes (e.g. Northeast Germany). However, a single size was required for comparability across Europe. After counting the number of parcels and landscape elements on different sample plots in differently structured landscapes we decided to fix the size of the plots to a size of 500m x 500m = 25 ha.

For the 2014 survey the total number of plots per regions was fixed to 25. However, for a long term survey this should be revaluated depending on what degree of accuracy should be achieved and how many plots will be necessary for this.

- Rapid approach: As described before, the time window is small but a large number of relatively large plots must be surveyed in order to be representative. In relation to this, another crucial point is that each surveyor must do at least about 25 plots within the short time window in order to gather experiences with the method and to see different regions in order to be able to judge different situations. Thus the approach has to be a rapid approach which cannot focus on singular vegetation units for a long time.

Given these restrictions, we reviewed the literature in order to find key indicators for the development of the protocol for the survey. Mainly we screened literature to find parameters and indicators under the described pre-conditions. The following short review on literature gives only short overview on some important work in this field and does not aim to be a comprehensive literature review.

I) HNV indicator in Germany

This HNV indicator is the only approach within the multitude of HNV indicator approaches across Europe which is based on concrete field data (Pepiette 2012).

The German HNV farmland indicator is a sample approach which is carried out on about 800 sample plots of 1 km^2 each every second, partly every fourth year. It comprises the following elements (Benzler 2010, Benzler 2012, PAN et al. 2011):

HNV farmland comprises:

- species rich grassland
- fallow land
- species rich arable land
- species rich vineyards
- orchards
- habitat types according to habitats directive within the agricultural landscape
- protected biotopes within the agricultural landscape
- landscape features (e.g. ditches, hedges, unpaved field roads, ponds, small watercourses, dry-stone walls)

Species richness in arable land, fallow land, vineyards and on grassland is measured with indicator species lists, the habitat and biotope types are recorded with specific descriptions of the habitats (based on plant species) and the nature value of orchards and landscape elements is based on described structural and diversity parameters and classified on a 5-class-scale.

This indicator approach is implemented since 2009 and works quite well (see comprehensive report from PAN et al. 2011). In respect of applicability in Europe there would be a demand to adapt the key species lists to other environmental regions (e.g. Southern and Northern Europe) and the effort regarding the singular plots of 100 ha size should be reduced.

II) AGRIT-approach in Italy

In Italy also a sample approach was tested in order to achieve information on the extent and quality of landscape elements (Tropea et al. 2012). This approach was carried out in three exemplary regions in Italy and comprised a field survey on plots of 250 m * 250 m (6.25 ha). It was supported by spatial information from integrated administration and control systems (IACS). There were some very interesting results regarding landscape structure (extent, age and partly general state of vegetation quality or naturalness) but biodiversity and nature value in the closer sense (based on species diversity) has not been recorded, as the list of parameters shows (out of Tropea et al. 2012, page 10):

More in detail, the following estimates are make available:

I . For arable land, permanent crops and permanent grassland:

- irrigated extent;
- erosion extent;
- water stagnation extent;
- extent of areas with the presence of landslides;
- extent of areas with the presence of terraces;
- extent of areas with the presence of ditches

II . For permanent crops:

- extent by tillage method;
- extent by status of the crop (abandoned or not);
- extent by type of inter-row soil cover (bare soil, mulched or grassed)

III . For grasslands:

- natural pasture extent;

IV . For watercourses, ponds, reservoirs and small ponds:

- extent by type (natural or artificial);
- extent by type (permanent or temporary);
- extent by type of banks (e.g grassed or artificial)

V . For hedges and rows:

- the total length for the whole region and for plain, hill and mountain areas
- extent by Phylum (broadleaved or coniferous);
- extent by age;
- extent by vegetative condition (good-poor)

VI . For stone walls:

- the total length for the whole region and for plain, hill and mountain areas
- extent by condition (good-poor)

VII . For isolated tree in agricultural context:

- abundance by age;
- abundance by vegetative condition (good-poor)

There was a huge number of parcels investigated in this approach and it delivered exact and reliable information on the parameters shown above. However, this approach was interesting in respect of the application of a sample plot approach and in practising of a rapid approach. Biodiversity parameters were not recorded in this approach.

III) European Bio-Bio-study

An interesting European project was a study on biodiversity Indicators for European farming systems (Herzog et al. 2012). In this study many parameters and indicators regarding farming and farmland were investigated. There were parameters which have been recommended to be applied and others which were discarded after checking the applicability. In respect of biodiversity there were recommended several species groups such as vascular plants, earthworms, spiders, bees and birds. Considering these indicators for this approach all the faunistic parameters would require a lot of time for recording and achieving a reliable data base.

The indicators of this approach were recorded on farm level and not on landscape level. Therefore it was difficult to use the information for this sample plot approach.

Species indicators of the Bio-Bio-study (box below, out of Herzog et al. 2012):

Table 6.4: BioBio species indicator set: Recommended indicators, research indicators, and indicators discarded for not meeting the selection criteria, *: low, **: medium, *: high, n.a.: not applicable / not tested in BioBio.**

	Name	Unit	Data Source	Cost	Scientifically Sound	Practicable	Attractive
Recommended indicators							
Plants	Vascular plants	N° of species per farm	Field survey	***	***	***	***
Earthworms	Earthworms	N° of species per farm	Field survey	***	***	***	***
Spiders	Spiders	N° of species per farm	Field survey	***	***	***	***
Bees	Wild bees and bumblebees	N° of species per farm	Field survey	***	***	***	***
Birds*	Birds of farmland habitats	N° of species per farm – Specialist species	Field survey	n.a.	n.a.	n.a.	n.a.

Sub-indicators for all four indicator species groups:
1) Gamma diversity – species of cultivated forage, food crops and semi-natural habitats
2) Alpha diversity – species of cultivated forage, food crops and semi-natural habitats
3) Area weighted diversity – species of cultivated forage, food crops and semi-natural habitats
4) Rarefied richness – species of cultivated forage, food crops and semi-natural habitats
5) Chao estimated richness – species of cultivated forage, food crops and semi-natural habitats

1.1) Gamma diversity – species of cultivated forage and food crops
1.2) Gamma diversity – species of semi-natural habitats
2.2) Alpha diversity – species of semi-natural habitats
2.1) Alpha diversity – species of cultivated forage and food crops
3.1) Area weighted diversity – species of cultivated forage and food crops
3.2) Area weighted diversity – species of semi-natural habitats

Comments:
Gamma diversity: Total number of species aggregated over the habitats
Alpha diversity: Average number of species over the habitats
Area weighted diversity: Number of species over the habitats weighted by the area of the habitats
Rarefied richness: Average number of species over the smallest number of plots found in a farm
Chao estimated richness: Extrapolated number of species based on the accumulated number of species found in plots

Discarded indicators	Name	Unit	Data source	Comments
Butterflies	Rhopalocera of farmland habitats	N° of species per farm	Field survey	Much data available. Observations are weather dependent (as for bees). Indicators of grassland conditions.
Hymenoptera-Ants	Ants of farmland habitats	N° of species per farm	Field survey	Lack of information. Require much laboratory work. Require further consideration due to functions (ecosystem engineering, biological properties of soils, pest control).
Small mammals	Small mammals of farmland habitats	N° of species per farm	Field survey	Lack of data. Difficult to survey. Include pests.
Carabid beetles	Carabids of farmland habitats	N° of species per farm	Field survey	Biocontrol agent. Well investigated in agro-ecosystems. Require much laboratory work.
Diptera, Syrphidae, Hoverflies	Hoverflies of farmland habitats	N° of species per farm	Field survey	Biocontrol agent. Require much laboratory work.
Bats	Bats of farmland habitats	N° of species per farm	Field survey	Lack of information. Difficult to survey.

[a] Birds were not tested in BioBio, but should be part of a species indicator set for monitoring

IV) European Quessa-approach

The Quessa Project is funded by the European Commission through the Seventh Framework Programme and aims "to quantify the key semi-natural habitats (SNH) providing these essential ecological services (ES) across economically important cropping systems, farming intensities and four European agro-climatic zones." (www.quessa.eu). It started recently in 2013 and is carried out in 16 case studies in 8 countries. The focus lies on the control of crop pests by natural enemies, crop pollination, soil erosion, soil fertility and weed control, - thus the focus is much more specific on concrete effects of farming on biodiversity. The indicators are not developed for a landscape survey. However, there can be interesting comparisons between a European survey of nature value and concrete studies of Ecosystem Services as they are expected in the Quessa-study.

V) French flower meadows approach

An interesting approach regarding the identification of indicator or key species for agricultural habitats over a wide range of different environmental conditions has been developed in France by Mestelan et al. (2010). For the purpose of creating a comparable base for a national competition on flower meadows a list of key species has been identified which covers the whole diversity of grasslands from the North Sea to the Mediterranean Sea and from the Alps in the East to the Atlantic Ocean in the West. The list has now become a part of the national program for agri-environmental measures 2015-2020 (Figure 1 and Table 1).

Figure 1: Excerpt from the French information brochure for the agri-environmental measures 2015-2020: Out of national list of 35 plant species (see Table 1 on the next page) on a regional level 20 plant species have to be selected). Source: information brochure of the French Ministry for Agriculture, download on May, 25th, 2015:

http://www.laregion.fr/cms_viewFile.php?idtf=3772&path=dc%2F3772_047_20140704_reu_inter-reg_maec.pdf.

This list has been used together with the German list of grassland indicator species for the HNV indicator (PAN et al. 2011) in order to extend the list of indicator species for a European approach. For the LISA study experts from other European countries have been asked to name important species which should be integrated in a standard list of key species.

Table 1: Information on the French national list of indicator species for species rich grassland within the agri-environmental measures ("Mesures Agro Environnementales et Climatiques (MAEC)" – latest download from May, 25th, 2015 under: http://www.gard.gouv.fr/content/download/13681/89469/file/20140731_maec_shp_liste_plantes_indicatrices.pdf

N°	Nom usuel des plantes de la catégorie	Nom scientifique des plantes de la catégorie	Fréquence	Facilité de reconnaissance	
				Période floraison	Critère
1	Liondents, Épervières ou Crépis	*Leontodon sp. ; Hieracium sp. ;Crepis sp.*	Forte	fp	fleurs/feuilles
2	Petites Oseilles	*Rumex acetosa, acetosella*	Forte	dp	fleurs/feuilles
3	Trèfles	*Trifolium sp.*	Forte	fp	fleurs/feuilles
4	Achillées, Fenouils	*Achillea sp. ; Meum sp. ; Foeniculum sp.*	Forte	été	fleurs/feuilles
5	Gaillets vivaces	*Galium sp. parmi les espèces vivaces*	Forte	dp	fleurs/feuilles
6	Géraniums	*Geranium sp.*	Forte	dp	fleurs/feuilles
7	Grande Marguerite	*Leucanthemum vulgare*	Moyenne	fp	fleurs
8	Centaurées ou Sératules	*Centaurea sp. ; Serratula tinctoria*	Moyenne	fp	fleurs/feuilles
9	Lotiers	*Lotus sp.*	Moyenne	dp	fleurs/feuilles
10	Gesses, Vesces ou Luzernes sauvages	*Lathyrus sp. ; Vicia sp. ; Medicago lupulina, falcate, minima*	Moyenne	fp	fleurs/feuilles
11	Laîches, Luzules, Joncs ou Scirpes	*Carex sp. ; Luzula sp. ; Juncus sp. ; Scirpus sp*	Moyenne		fleurs/feuilles
12	Myosotis	*Myosotis sp.*	Moyenne	dp	fleurs
13	Saxifrage granulé ou Cardamine des prés	*Saxifraga granulata ; Cardamina pratensis*	Moyenne	dp	fleurs
14	Silènes	*Lychnis flos-cuculi ; Silene sp.*	Faible	fp	fleurs
15	Narcisses, Jonquilles	*Narcissus sp.*	Faible	dp	fleurs
16	Renouée Bistorte	*Polygonum bistorta*	Faible	été	fleurs/feuilles
17	Menthes ou Reine des prés	*Mentha sp. ; Filipendula ulmaria*	Faible	été	fleurs/feuilles
18	Raiponces	*Phyteuma orbiculare, spicatum*	Faible	été	fleurs
19	Pimprenelle ou Sanguisorbe	*Sanguisorba minor, officinalis*	Faible	fp	fleurs/feuilles
20	Campanules	*Campanula sp.*	Faible	été	fleurs
21	Knauties, Scabieuses ou Succises	*Knautia sp. ; Succisa pretense ; Scabiosa sp.*	Faible	fp	fleurs
22	Salsifis ou Scorsonères	*Tragopogon sp. ; Scorzonera humilis*	Faible	fp	fleurs
23	Rhinanthes	*Rhinanthus sp.*	Faible	dp	fleurs/feuilles
24	Sauges	*Salvia sp.*	Faible	fp	fleurs/feuilles
25	Thyms et origans	*Thymus sp. ; Origanum vulgare*	Faible	été	fleurs/feuilles
26	Arnica	*Arnica montana*	Faible	fp	fleurs
27	Orchidées ou Œillets	*Orchidaceaea sp. ; Dianthus sp.*	Faible	dp	fleurs
28	Polygales	*Polygala vulgaris*	Faible	fp	fleurs
29	Genêts gazonnants	*Genista sp.*	Faible	été	feuilles
30	Lins	*Linum sp.*	Faible	fp	fleurs
31	Astragales, Hippocrépis ou Coronilles	*Astragalus sp. ; Hippocrepis comosa ; Coronilla sp.*	Faible	fp	feuilles
32	Anthyllides ou Vulnéraires	*Anthyllis sp.*	Faible	dp	feuilles
33	Hélianthèmes ou Fumanas	*Helianthemum sp. ; Fumana sp.*	Faible	été	fleurs
34	Pédiculaires ou Parnassies	*Pedicularis sp. ; Parnassia sp.*	A préciser par les CBN		
35	Narthecies ou Scutellaires	*Narthecium sp. ; Scutellaria sp.*	A préciser par les CBN		

Tableau n°1 : liste nationale des plantes indicatrices de l'équilibre agro-écologique des prairies permanentes à flore diversifiée

VI) Study on diversity of arable land across Europe

In order to create a key species list for arable habitats across Europe a first list could be drafted with the help of Jörg Hoffmann who carried out vegetation comparisons of arable fields in different regions from South Italy north to Norway (Hoffmann 2012b). A first list was drafted with recommendations from his side, further some other experts from other European countries have been asked to name important species which should be integrated in a standard list of key species. In this way a list of about 100 species or genera of species was developed which should be tested in the field.

VII) LUCAS approach

Last but not least, a very important approach on the European level is the LUCAS approach (Europ. Commission 2013). While the nature value is not in the focus of the LUCAS approach the sample approach itself and the landuse units and the numerous parameters were an important help to develop a handbook and guideline for the identification and recording of landuse units. It's also interesting to see which kind of data interpretation can be made only from structural parameters in the LUCAS survey (Paracchini 2013).

In this respect a more in-depth-analysis of the concrete biodiversity in the field in relation to landuse practice would be helpful either as part of the further development of the LUCAS approach or as a stand-alone-monitoring, for example to further develop the HNV farmland approach (Beaufoy et al. 2012), the approaches to show an adequate picture of nature value of agricultural land in Europe (Paracchini & Capitani 2012) and to promote attempts to integrate more nature sensitive landuse practices in Europe.

Conclusions from literature review and screening different approaches

Most suitable from literature review and screening different approaches in respect of developing an approach to record the nature value of agricultural landscapes in Europe seemed to be the following approaches and parameters:

- A sample plot approach with a regular grid laid across more or less homogeneous regions, the singular plots being not too large (regarding the time required for recording) and not too small (regarding the covered area in total and the relation between minimum effort for visiting the plots and the recording time);
- A rapid approach for the mapping of the landuse units comprising qualified estimations of the nature value – these based on a detailed guidance on the one hand and on concrete and detailed transect records of several parcels in each plot;
- The use of key species lists for recording the species richness in transect walks in arable land, permanent cultures and on grassland – with a main list as initial list and space for additional species which may turn out as important species during the testing phase.
- The recording of small structures larger than one meter in width and the recording of buffer strips as well as of ecological sensitive areas as this information may be important in respect of nature value and good farming practice and it can be easily recorded.
- In addition to all recording and mapping a photo documentation should be carried out in order to develop an archive on the different types of landuse and landscape elements and in order to further illustrate a guidance in the follow-up of this project.

The details of the method have been worked out and described. Thus the approach is based on elements of existing approaches, but it also comprises new elements like a European indicator species list for recording of ecologically valuable arable land and grassland. Most important in this respect are methods and parameters which deliver comparable information on landuse, landscape infrastructure, species richness, ecologically sensitive areas etc.

3.2. Methods

In this chapter the methods applied in the LISA field study are described giving a more or less detailed view on the different of the field survey methods.

The development of the field survey is based on a random sample method approach. On the sample plot spatial information was recorded, additionally detail information on biodiversity and photo documentation was collected.

The protocol for the field survey comprises three elements:

a) Mapping / recording of all types of landuse landscape elements and ecological valuable sites in extent and quality; for the field survey of satellite photos have been used;

b) Detailed records in several points / transects: in these detailed records the biodiversity was recorded with the help of plant key species lists (this serves as qualification for the nature value), further other parameters were recorded;

c) Photo documentation of the plot and its elements (e.g. types of landscape elements and landuse) → also here an instruction was prepared in order to achieve standardised photos.

The detailed and illustrated guidance comprises about 50 pages and is an extra document.

Information to be collected

There are two types of record sheets to be filled out by the surveyors, a "main sheet" and a "vegetation sheet". The former is to be filled out while mapping the plots, the latter on the transect walks. In addition a photo documentation had to be done according to a specific guidance for this photo documentation.

In the main sheet the surveyors had to collect information on the share of landuse and landscape features and the type and quality of ecological sensitive areas of the investigation plots. This was done by mapping different units on a satellite photo and filling in the main sheet. A time of ½ - 1 hour in the field was estimated in average for the mapping of one plot.

In the vegetation sheets the surveyors had to record detailed information on biodiversity on 1 up to 4 defined transects starting from a point defined by given coordinate points. The length of the transects was 30 m. The observation frame was 1 m to the left and 1 m to the right side walking along the transect. During the transect walks, the surveyors had to record the presence of potential key plant species given in a list as well as information on the structure of the fields. This information reserved a) as qualification of the landuse intensity which is estimated in a different way and b) as biodiversity record which enables further data interpretation. The transect walks needed 5 – 15 minutes each and all 1-4 transect records took in average ½ - ¾ of an hour per plot.

Altogether the total time per plot was estimated to need 1,5 – 2 hours including the time needed to walk from the car to the plot. However, there were considerable differences in practice: some plots especially in mountainous and small structured regions needed much more time (up to 3-4 hours) while a few others in homogeneous landscapes could be done within one hour. In most regions up to 5 plots could be completed in one day.

In the annex an overview on the record sheets and the information collected in the plots is given.

3.3. Selection of the study sites and overview on the investigation areas and data

There were several aims for the selection of study sites:

- There should be covered several geographical and natural regions within the participating countries (e.g. not all 4 study sites in France should be done only in one part of the large country);
- The focus was laid on arable landscapes as they are the most important landscapes in respect of greening within the Common Agricultural Policy (e.g. implementation of EFAs - Ecological Focus Areas); however, some grassland areas were chosen as well in order to test the method in respect of functioning in grassland areas as well;
- It was tried to find intensive as well as extensive areas both in arable and in grassland regions from existing preinformation in order to test the methods in both kind of landscape types; as preinformation there were used data on average yields in cereals (arable landscapes) and milk (grassland landscapes) as well as personal judgements of the partners in the participating countries;
- The study regions themselves should be as homogeneous as possible regarding the altitudes, the coverage of agricultural land and forests and the distribution of settlements; this was decided with interpretation of satellite photos (google earth);
- Within the study regions a random approach was chosen by using a 5 km x 5 km grid in order to determine the centre of the investigation areas;
- Last not least some preferences for considering the one or the other region by the regional partners was taken into account as many of the partners participated voluntary and put in own resources;

Altogether we achieved a widely spread net of investigation areas covering several geographical and natural regions as well as intensive and extensive areas in arable and in grassland regions. Thus it is not representative for the average situation in Europe or within the countries but it represents a wide range of different agricultural regions within Europe.

Data was collected in 39 regions across Europe (see Figure 2a). The figure also shows the distribution of the plots in a 5 km x 5 km grid across homogeneous regions (see Figure 2 b and c).

Table 2 gives an overview on the regions, the extent of data collection and some characteristics.

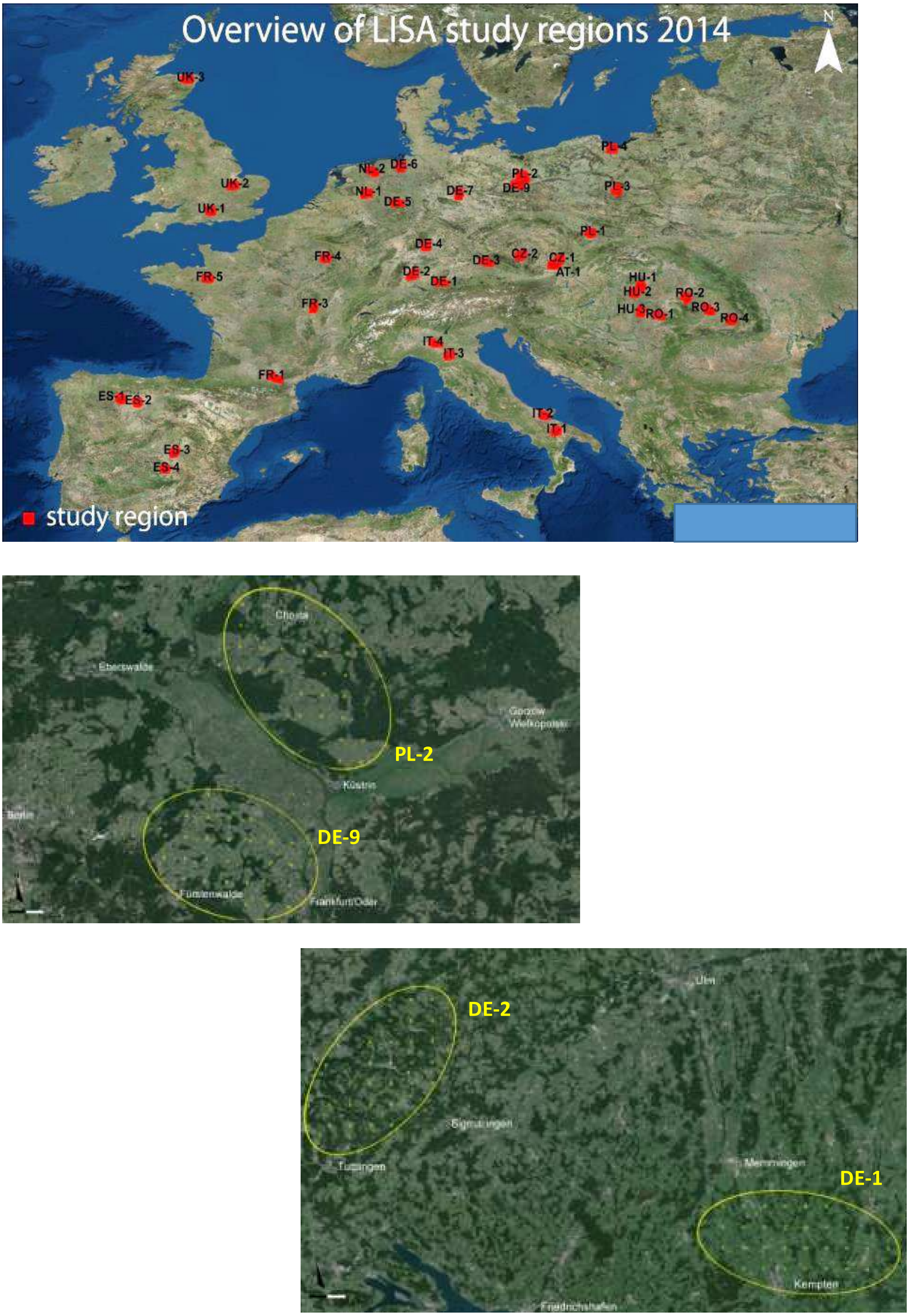


Figure 2: Map of the 39 study regions in 2014 (a – top) and examples of the sample grid (b and c): the yellow dots indicate plots of each 25 ha size in the Polish PL-2 Chojna region and the bordering German DE-9 Fürstenwalde region (b – middle), and in DE-2 Albstadt region and DE-1 Kempten region (c - bottom). Images: Google

Table 2: Overview of LISA study regions 2014.

Region	Plots	Altitude Ø	Biogeographic region	Predominant landuse	Transects on arable land and permanent crops	thereof transects in cereals	Transects on grassland	Total number of transects
AT-01-Hollabrunn	25	310	continental	arable	65	41	5	70
CZ-01-Znojemsko	25	324	pannonian	arable	46	21	3	49
CZ-02-Sedlec Pistin	25	566	continental	mixed	32	18	18	50
DE-01-Kempten	25	677	continental	grassland	2	2	51	53
DE-02-Albstadt	25	617	continental	mixed	18	15	37	55
DE-03-Straubing	25	457	continental	arable	71	35	2	73
DE-04-Tauberbischofsheim	25	348	continental	arable	45	38	7	52
DE-05-Soest	25	203	continental	arable	52	37	5	57
DE-06-Jade	25	9	atlantic	grassland	5	1	13	18
DE-07-Magdeburg	25	100	continental	arable	47	35	2	49
DE-09-Fuerstenwalde	25	45	continental	arable	38	22	5	43
ES-01-Leon	25	864	mediterranean	arable	43	13	0	43
ES-02-Palencia	25	799	mediterranean	arable	61	33	0	61
ES-03-Castilia-North	25	749	mediterranean	arable	67	29	0	67
ES-04-Ciudad Real	25	700	mediterranean	arable	57	30	0	57
FR-01-Carcassone	25	317	mediterranean	arable	50	25	10	60
FR-03-Bourgogne	24	328	continental	grassland	0	0	0	0
FR-04-Reims	25	146	continental	arable	68	38	2	70
FR-05-Rennes	25	78	atlantic	mixed	41	21	8	49
HU-01-Heves	25	113	pannonian	arable	47	20	10	57
HU-02-Abony	25	101	pannonian	arable	28	13	3	31
HU-03-Bekes-Csanad	25	85	pannonian	arable	61	29	12	73
IT-01-Basilicata	19	468	mediterranean	arable	56	43	3	59
IT-02-Puglia	19	205	mediterranean	arable	59	35	1	60
IT-03-Modena	25	507	continental	mixed	33	7	52	85
IT-04-Parma	24	143	continental	arable	76	19	8	84
NL-01-Winterswijk	21	37	atlantic	mixed	19	3	34	53
NL-02-Veendam	21	6	atlantic	mixed	46	13	15	61
PL-01-Glubczyce	14	294	continental	arable	27	22	0	27
PL-02-Chojna	25	48	continental	arable	36	28	5	41
PL-03-Kutno	12	108	continental	arable	41	21	0	41
PL-04-Gdansk	13	29	continental	arable	37	31	1	38

Region	**Plots**	**Alti-tude Ø**	**Biogeographic region**	**Predomi-nant landuse**	**Transects on arable land and perma-nent crops**	**thereof transects in cereals**	**Transects on grass-land**	**Total number of tran-sects**
RO-01-Arad	25	145	pannonian/ continental	arable	81			81
RO-02-Sag (Tusa)	21	419	continental/ alpine	mixed				
RO-03-Campia Turzii	27	426	continental/ alpine	arable	73		30	73
RO-04-Viscri	25	562	continental	grassland				
UK-01-Hampshire	25	102	atlantic	mixed	0	0	0	0
UK-02-Cambridgeshire	26	31	atlantic	arable	0	0	0	0
UK-03-Aberdeen	12	111	atlantic	mixed	0	0	0	0
Sum 39 regions	**857**				**1528***	**738**	**342**	**1870**

* Note: In some countries additional transects have been made in plots which couldn't be used for other data interpretation; thus the total number of transects was 1549 – this data basis has been used in the specific data interpretation on the key species while in the most interpretations the number of 1528 transects was used;
In some countries no transects could be carried out or interpreted due to different reasons (e.g. due to no land access in the UK, due to pasturing and pasture fences in Bourgogne, incoherent data in Romania etc.).

4. Results

There is a huge extent of detailed data of the investigated regions. Out of the 39 regions there are only a few regions in which data interpretation was restricted due to limited land access (UK-regions), due to limited accuracy of mapping (RO-regions) or due to limited extent of the survey (3 regions in PL and 1 region in UK only with 1-13 investigation plots instead of 25 in all other regions).

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

Figure 3 gives an overview on the dominant landuse in all regions.

The 39 regions comprise

- 26 regions with predominance of arable land,
- 9 regions with a mix of arable land and grassland and
- 4 regions with predominant grassland use.

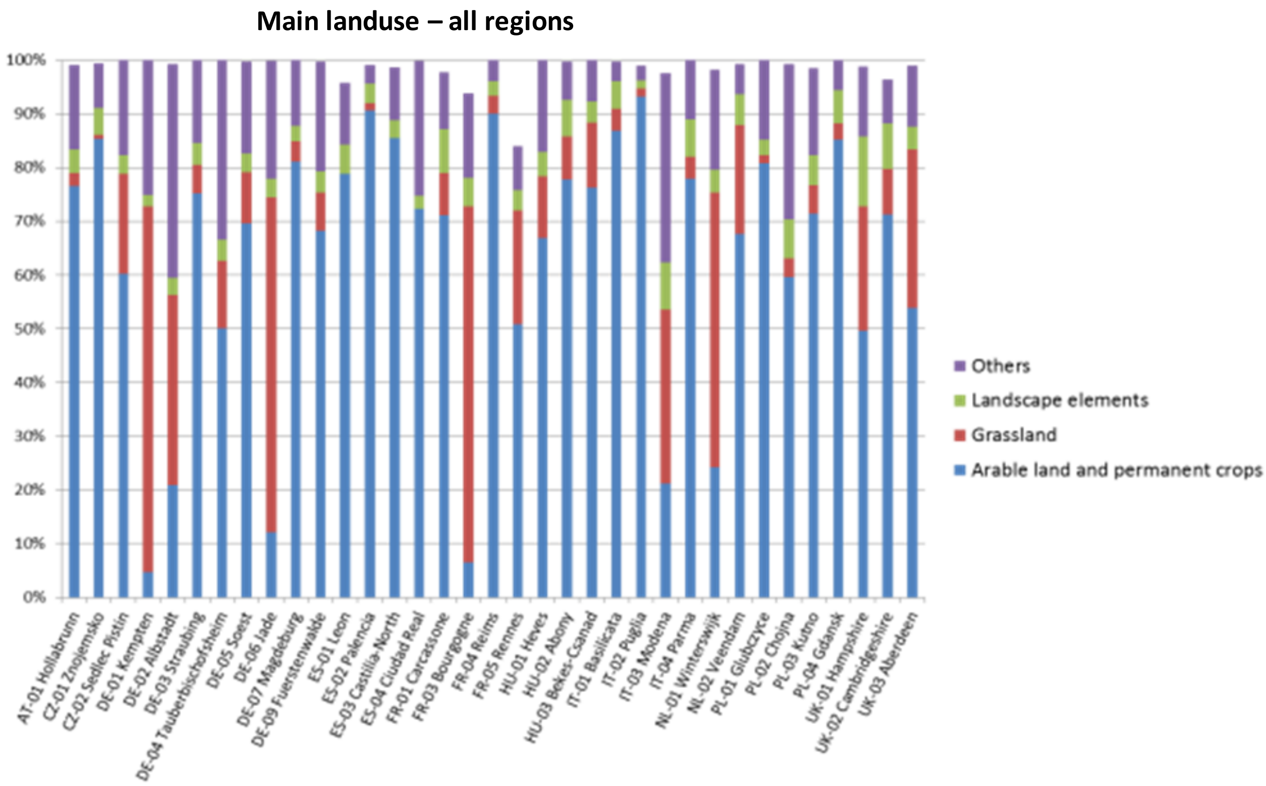


Figure 3: Main landuse types across the regions (except Romania).

4.1. Overview on available data

In total in the investigated 39 regions, 21,157 ha of land were mapped and interpreted with GIS.

In Figure 4 the main crops in arable land are displayed.

Most of the arable land is cultivated with cereals, followed by maize and rape. Among the cereals wheat is the most common one, followed by barley and rye. The distribution of landuse doesn't correspond to the average distribution in the countries, it's just the distribution of the landuse types in the investigation areas.

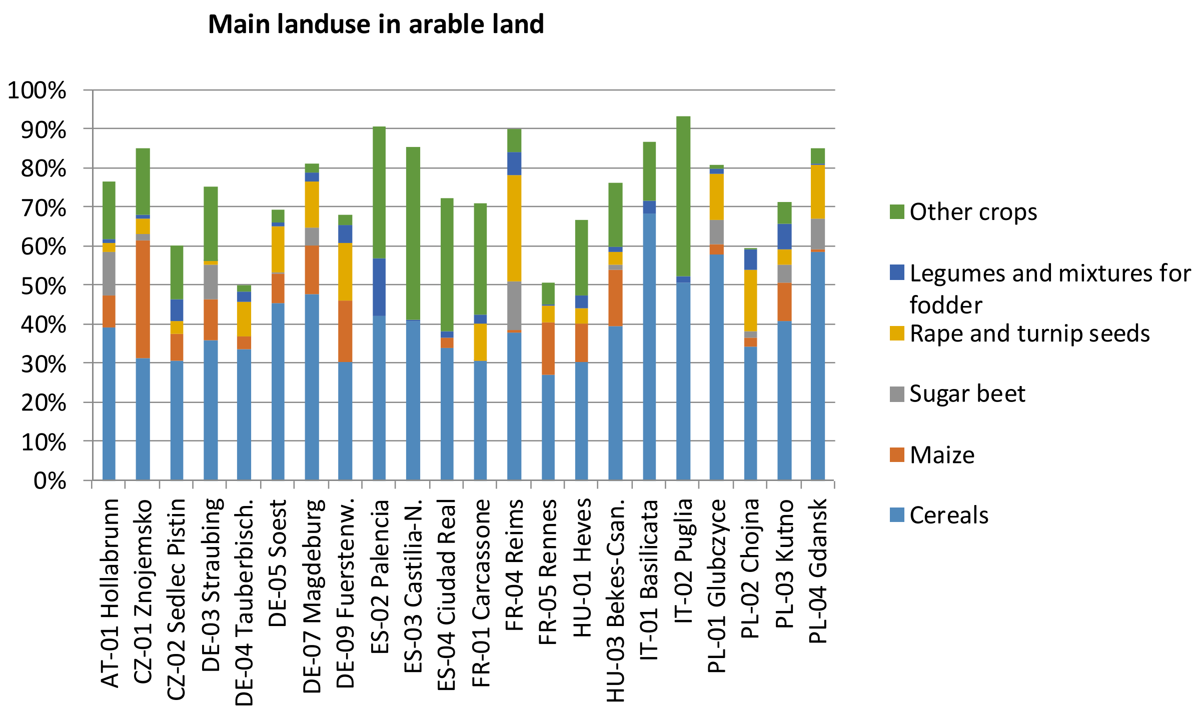


Figure 4: Main landuse in arable land in the arable regions.

Regarding the vegetation transects the distribution is as follows:

- Total number of transects 1870
  - thereof transects in arable land 1528
  - thereof transects in grassland 342

▪ within the arable land	cereals	738
▪	maize	183
▪	sugar beets + root crops	69
▪	potatoes	41
▪	sunflowers	38
▪	lucerne	65

• within the cereals	wheat	420
•	barley	185
•	rye	64

The list is not complete; it just gives an impression of the most dominant landuse types and crops.

4.2. Landuse intensity and nature value of arable land and cereals

Expectedly the landuse intensity is high or very high in almost all arable regions (categories 4 and 5 on a scale from 1 to 5). This is the case for arable land in general as well as for cereals more in detail (Figure 5 and Figure 6). However, not expected from our side was the fact, that the landuse intensity was also high or very high in the selected extensive regions[1] or in poorer countries (e.g. Romania, Poland). It turned out that also in these regions/countries on arable land artificial fertilization and spraying PPPs and is very common and leads to the observed high landuse intensity[2]. Nevertheless there are slight and remarkable differences in landuse intensity and nature value. In contrast to the landuse intensity the nature value of the most investigated arable regions is low to very low (categories 1 and 2 on the scale 1 to 5). Both categories (1 and 2) often comprise more than 80-90 % of all arable fields and the categories 4 and 5 (high and very high) nature value are absent or are nearly absent. Only 4 out of 32 regions with arable land show an extent of more than 5 % of arable land with a nature value 4 and 5. In this context the region Castilia North has to be highlighted which shows about 20 % of arable in the nature value categories 4 and 5 (compare also chapter 4.6 biodiversity parameters).

While it seems that landuse intensity and nature value are always in contrast to each other (high landuse intensity ≙ low nature value and inverse) this is not (always) the case and also the situation may be different for arable land and grassland in the same region. One example is the region “Albstadt” in Southwest Germany: while arable land shows a high landuse intensity there is a moderate nature value in arable land while in grassland almost one third of the area shows “very high nature value” (5), and another third shows “high nature value” (4) while landuse intensity predominantly is on a moderate level (about 40 % category 3).

In the following figures we show the values for arable land in general and for cereals; in most of the examples also in the further results the parameters are clearer in cereal fields as the different cereals are more similar to each other than other arable crops.

[1] The preselection was made either by statistical means (e.g. in Germany regions with the lowest cereal yields or by personal estimation of the partners).

[2] The landuse intensity is estimated with visible parameters such as density of crops (not with input parameters, compare guidance document).

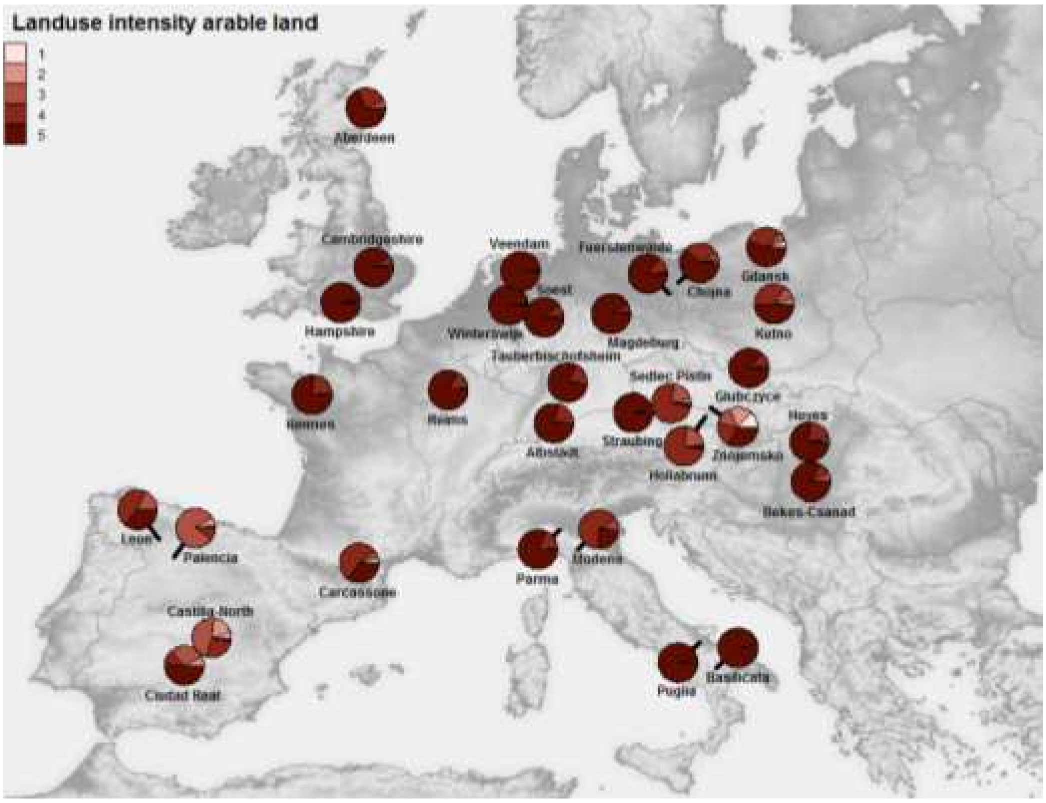


Figure 5: Landuse intensity in arable land in the investigated areas.
Dark red color indicates a very high landuse intensity (category 5 on the scale 1-5), very light color indicates low landuse intensity (category 1 – nearly missing in this figure).

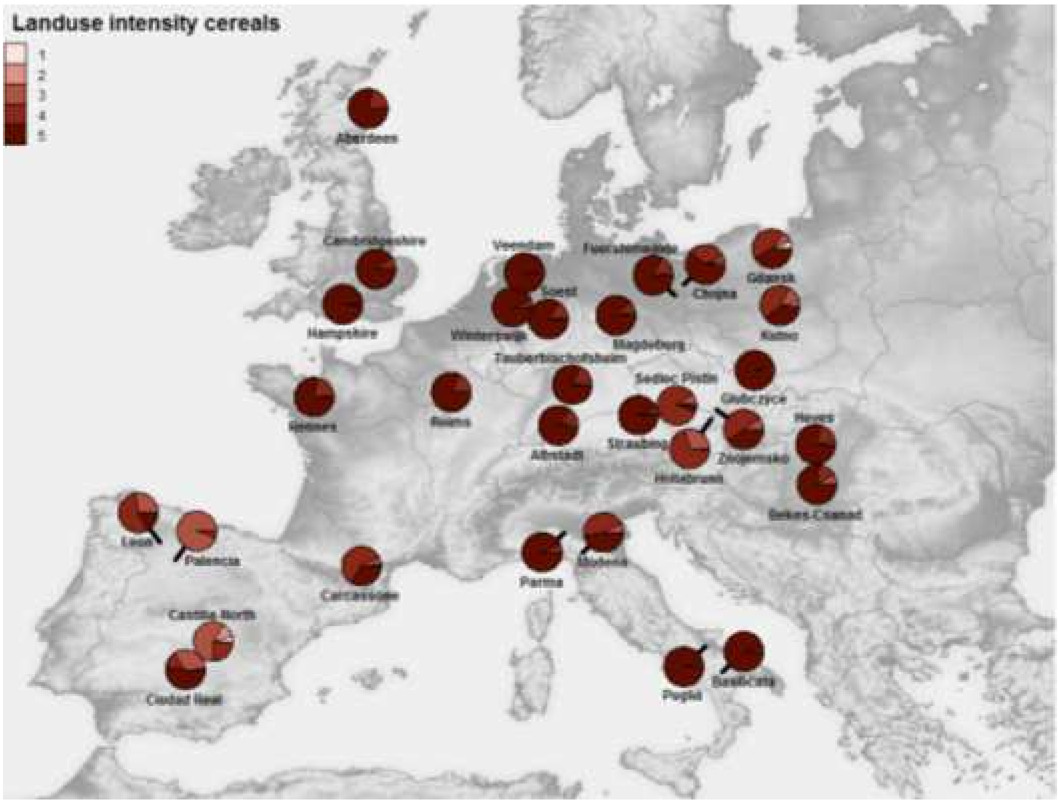


Figure 6: Landuse intensity in cereal fields in the investigated areas.
The intensity is even higher compared to Figure 5.

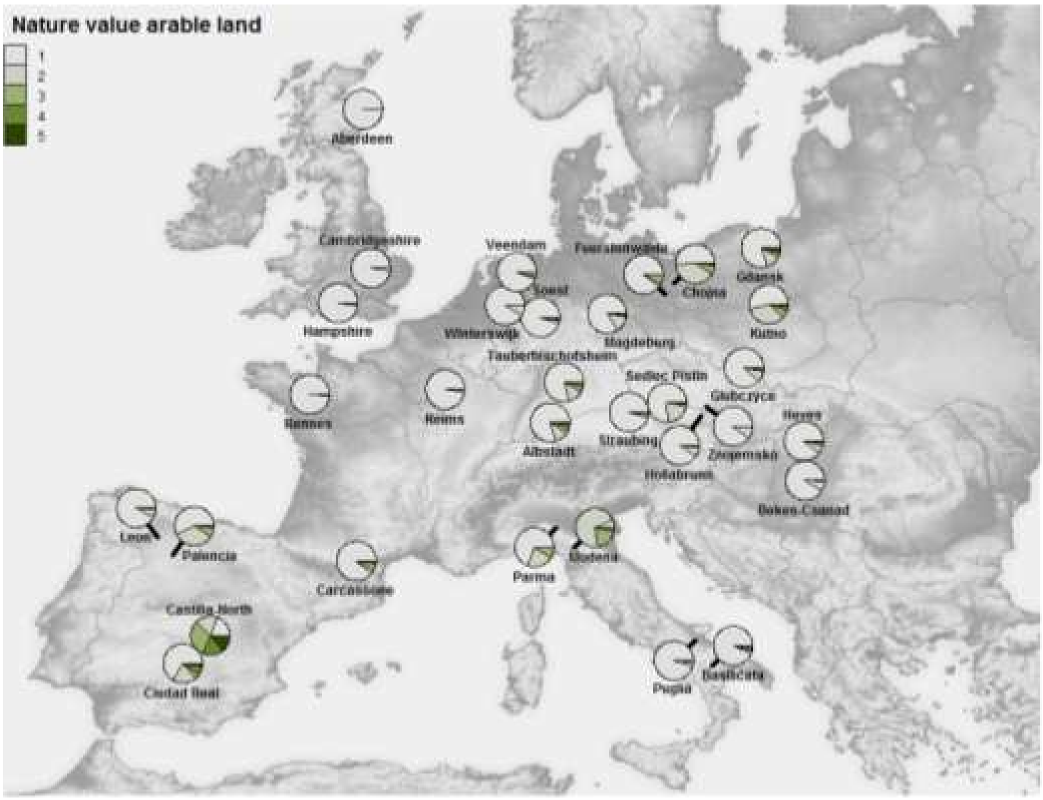


Figure 7: Nature value of arable land.
Dark green colour indicates a very high nature value (category 5 on the scale 1-5), very light colour (almost white) indicates low nature value. There are only a few regions with a considerable extent of arable land with high nature value.

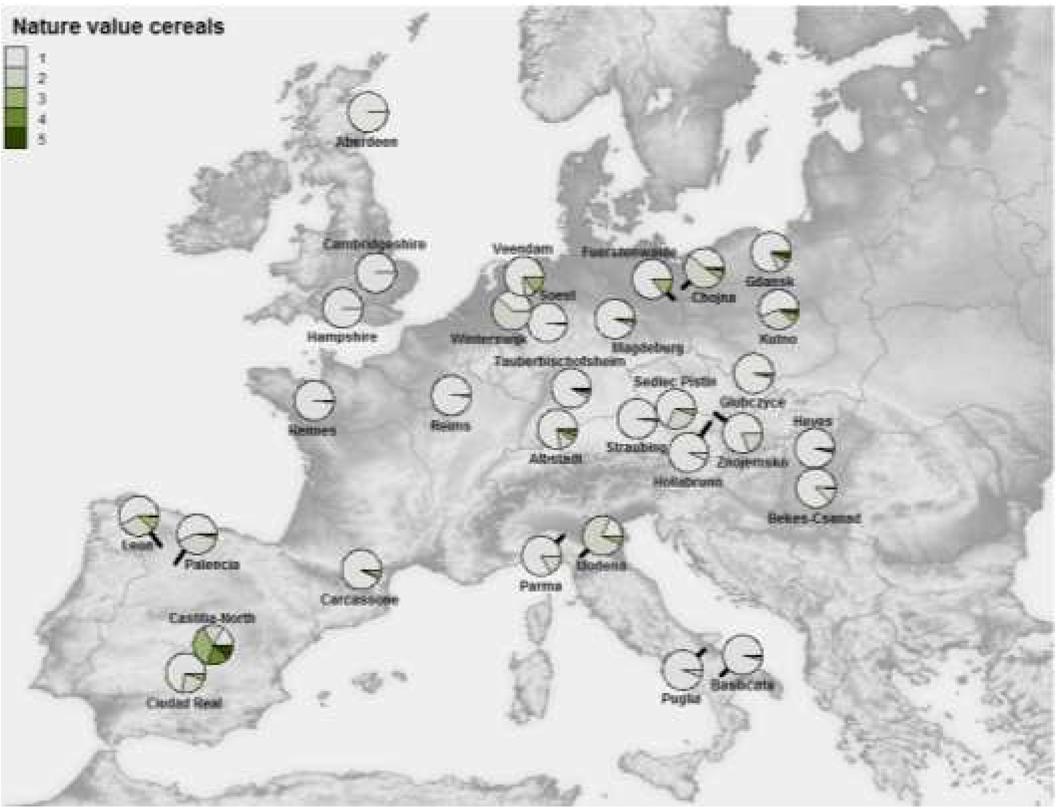


Figure 8: Nature value in cereal fields.
Very low and low nature value (categories 1 and 2 on the scale 1-5) are dominating in almost all regions.

4.3. Landuse intensity and nature value in grassland

In the selection of study sites we only considered 9 sites with a medium or high share of grassland, - just as examples for the application of the LISA-methodology and as examples for regions in quite different nature regions (from Scotland to Italy and from Western France to Romania). The investigated study regions show a high landuse intensity (we didn't consider explicit mountain regions) also in grassland except two regions: the region Albstadt in Germany laying in the Jura mountains (altitude between 350 and 850 m a.s.l.) and the region Modena in Italy laying in the Apennine mountains (altitude between 40 and 2040 m a.s.l.). Both regions show more than 50 % of the grassland with a high or very high nature value (categories 4 and 5). For some of the Romanian regions this may also be the case, however, there were shortcomings in the mapping of the different types – thus no exact figures can be given.

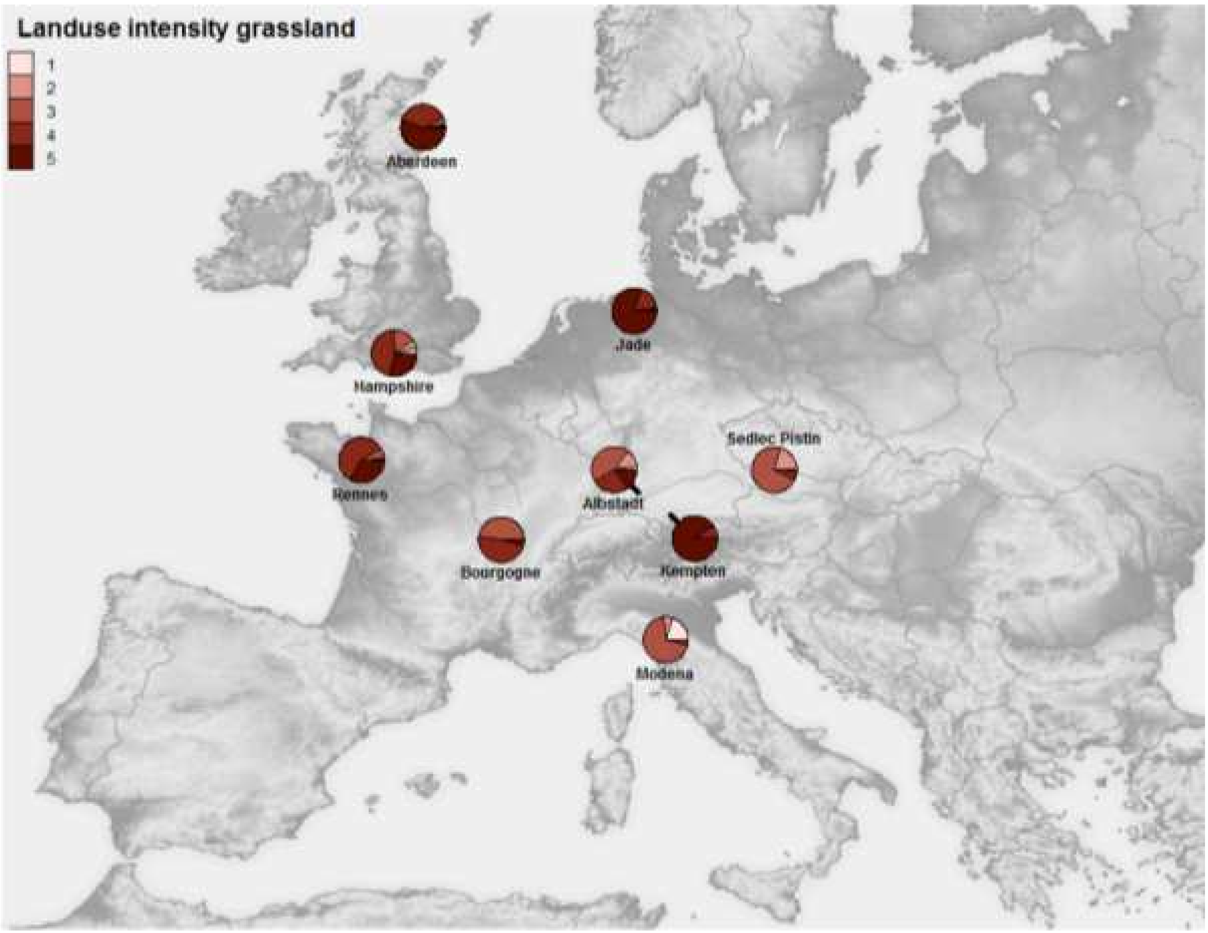


Figure 9: Landuse intensity of grassland in regions with a considerable share of grassland. Dark red colour indicates very high landuse intensity (category 5 on the scale 1-5), very light colour indicates low landuse intensity.

Figure 10: Nature value of grassland regions with a considerable share of grassland. Dark green colour indicates a very high nature value (category 5 on the scale 1-5), very light colour (almost white) indicates low nature value.

The selected regions show quite different values reaching from dominating low values in some regions in the Northwest and more differentiated intensities in mountain regions such as Albstadt and Modena.

4.4. Landscape elements

The extent of landscape elements in the 39 regions comprises values between 1.5 % (Ciudad Real, Spain) and over 13 % (Hampshire, UK). In most regions there is an extent of 3-6 % landscape elements. The most common landscape elements are complex elements (e.g. hedges with a grass-herb buffer strip and a ditch) and water elements (e.g. ditches).

Within the category landscape elements the complex elements dominate, but also water elements, field tracks and tree-bush elements play an important role. However, the extent of the different types of landscape elements vary considerably between the regions (see Figure 11).

Table 3: Overview on the landscape elements mapped within the investigated plots.

Complex elements	32 %
Water elements	21 %
Field tracks	19 %
Wood/Tree/Bush elements	15 %
Grass-herb elements	10 %
Man-made structures	3 %
Total	100 %

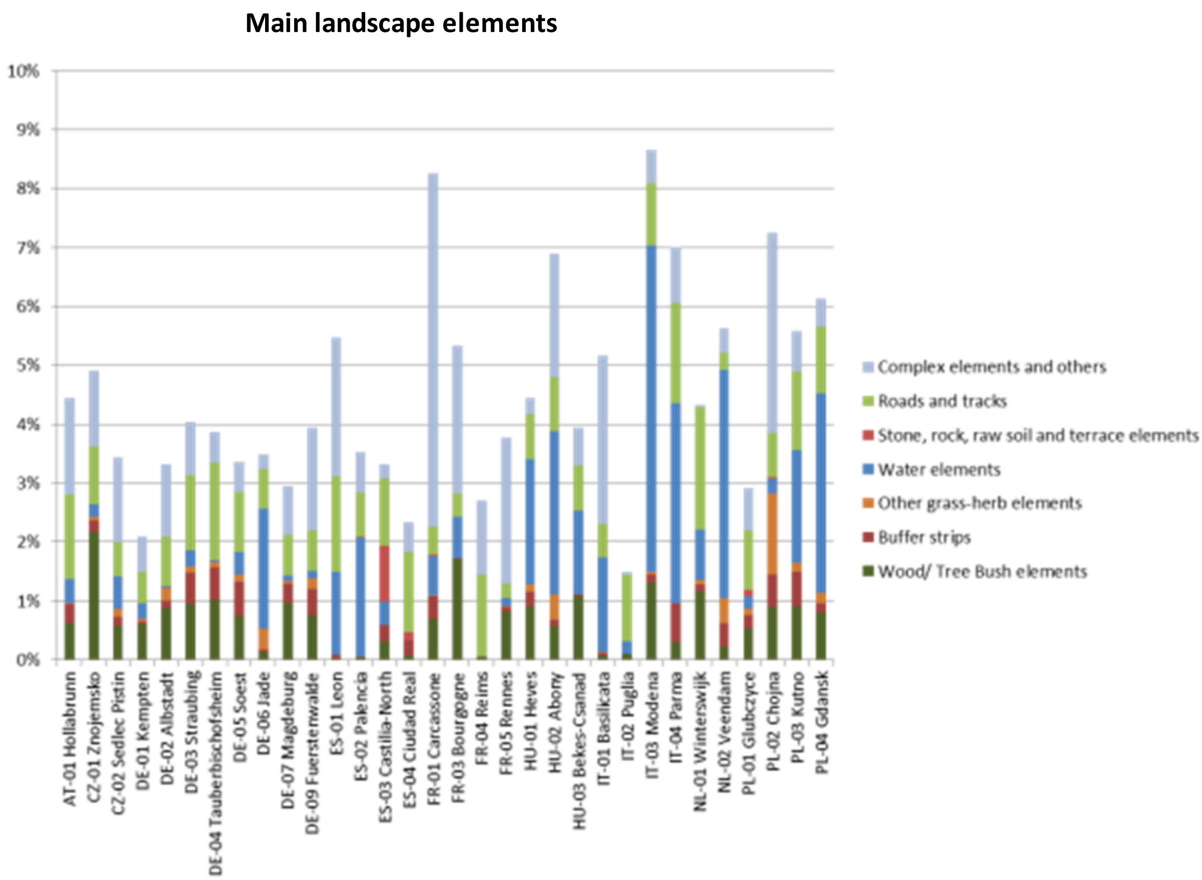


Figure 11: Types and extent of the mapped landscape elements. In total they cover 1.5 % to 8.5 %. Three types are present in all regions (Water elements, Roads/ tracks and Complex elements).

Regarding the nature value of the landscape elements there are considerable differences: while and wood / tree / bush elements as well as complex elements show a high / very high extent of high nature value for the most other elements the predominant category is a moderate nature value.

For man-made structures and artefacts the result is remarkable: the share of elements with very high nature value (5) is much higher than of any other category (1-4) – mainly due to wooden fences and wooden or stone huts etc. which provide very valuable habitats and thus form important landscape elements in the cultural landscape.

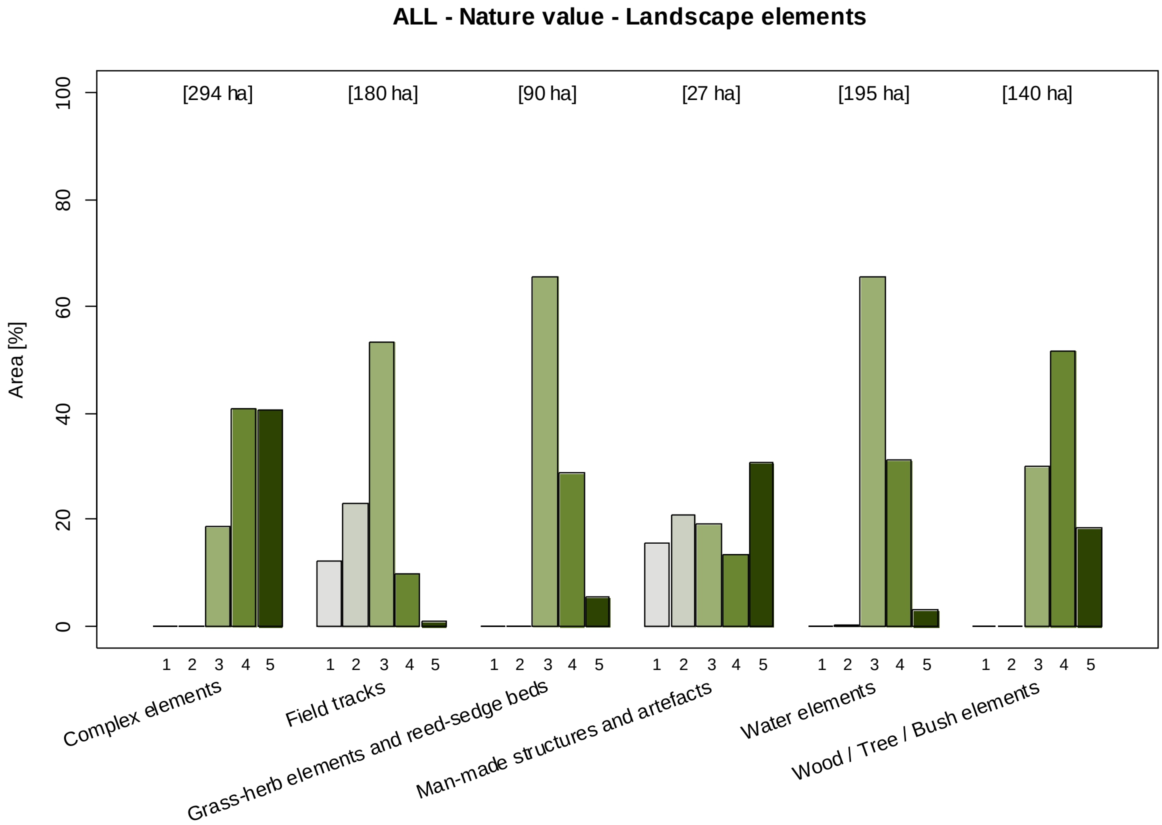


Figure 12: Nature value of the landscape elements.

4.5. Buffer strips

Special consideration within the LISA project was given to the extent and quality of buffer strips. The extent of buffer strips reaches from 0 % (or near to 0 % in Czech Republic, Hungary, Poland, Spain) to values of more than 2 % (in two UK regions). In the most regions values of 0.4 – 0.9 % occur. The width of the buffer strips mostly stretches from 2 to 4 m and to maximum mean values of about 5 m (in Hampshire in the UK up to nearly 7 m). The quality of the buffer strips mostly shows nature values of 3 or 4. Buffer strips mainly occur alongside of water courses, hedges and forest edges.

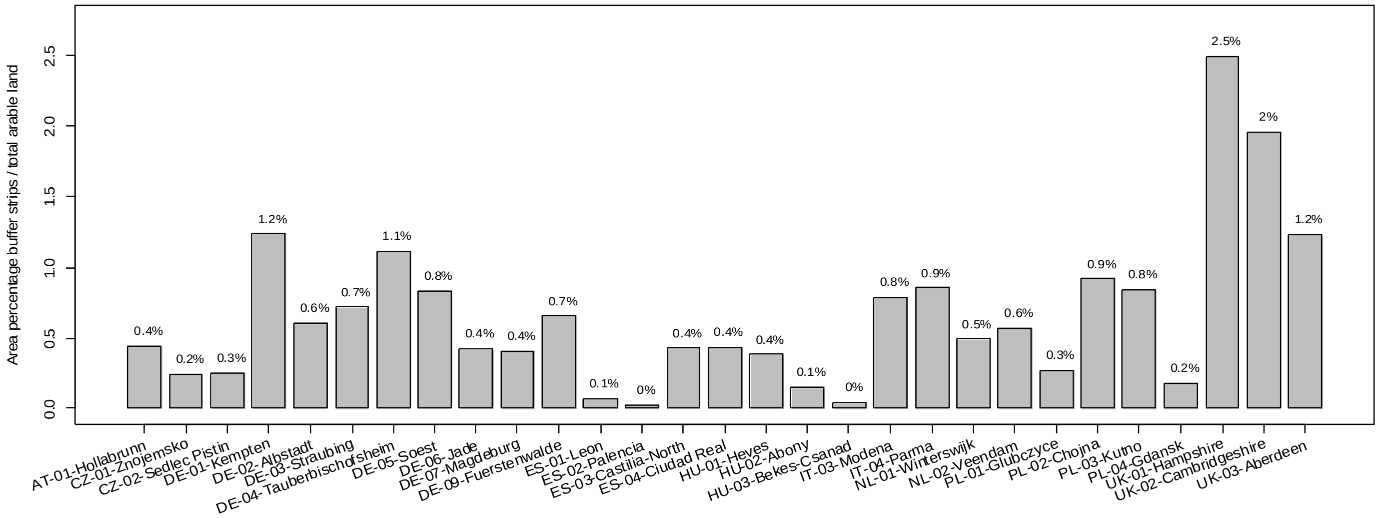


Figure 13: Extent of buffer strips in % of all arable land. The values vary widely between near to 0 % and 2.5 %.

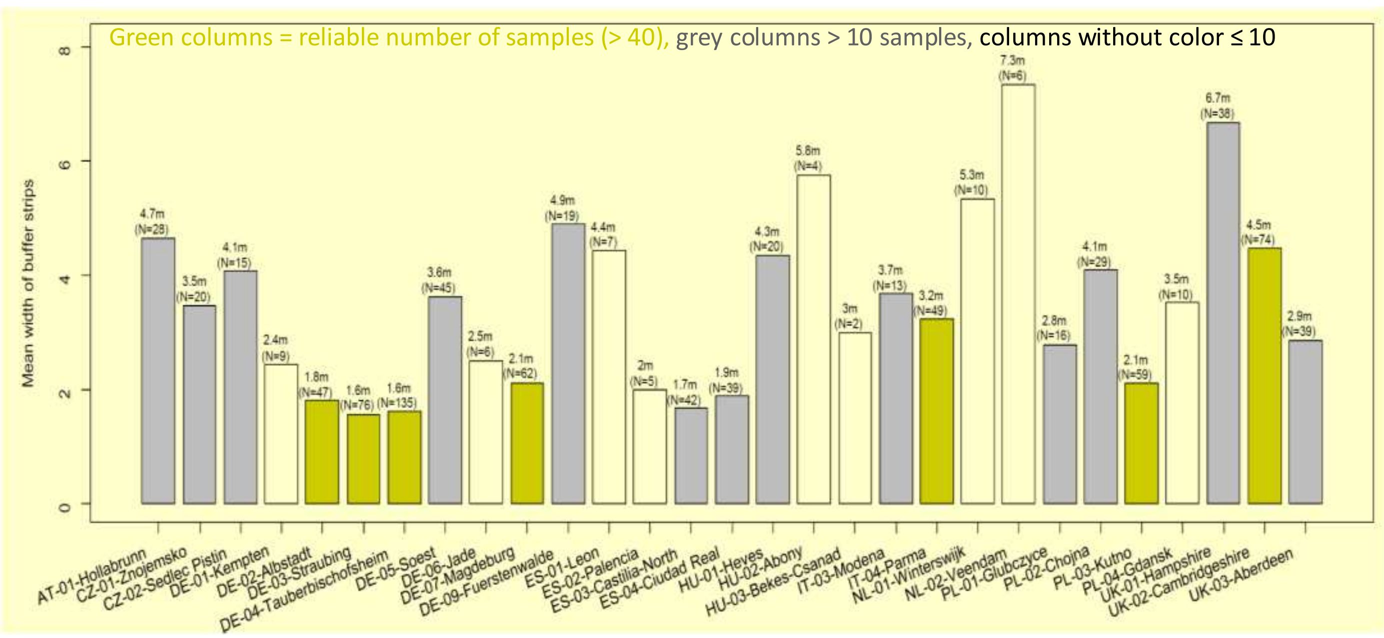


Figure 14: Mean width of buffer strips.

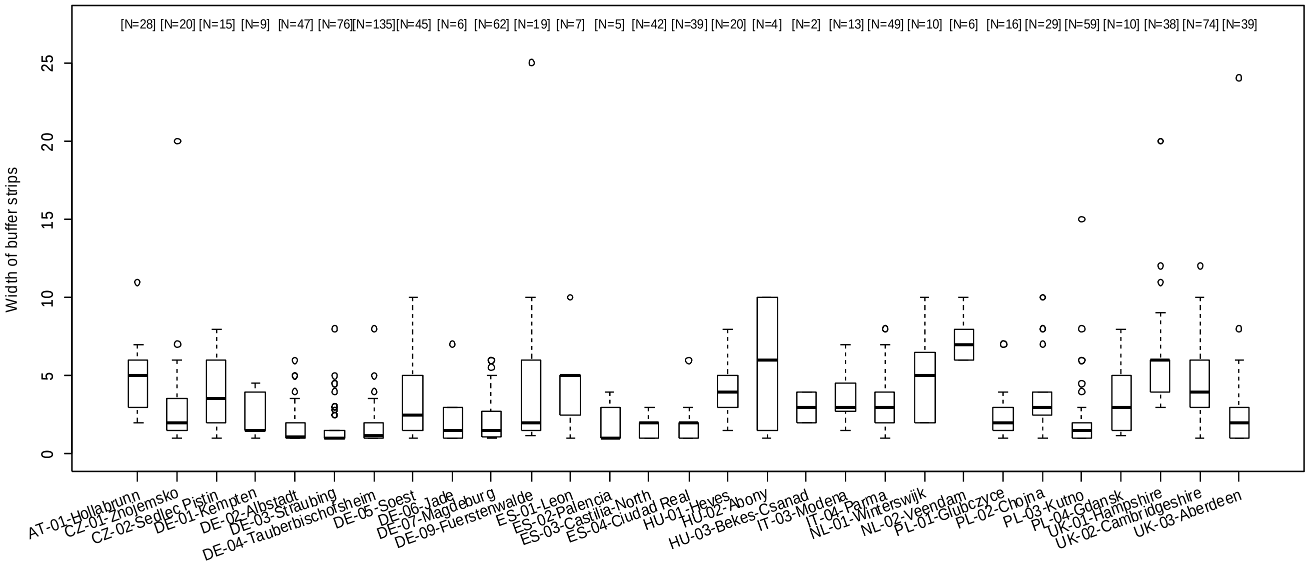


Figure 15: Variation in the width of the buffer strips. In most regions there is only a small variation in the width, whereas in a few regions there are considerable differences within the region.

4.6. Biodiversity parameters

One main focus of the LISA-study was to develop comparable and reliable biodiversity parameters. Therefore detailed biodiversity parameters were recorded in up to four transects in each investigation plot. This also served for a detailed description of the nature value.

The recorded biodiversity parameters were the following:

- Coverage of wild plants (in arable land)
- Number of flowering species
- Flowering density
- Potential key species
- Number of potential key species

Figure 16: Diversity and extent of wild plants in arable land and other indicators are important parameters for the biodiversity and nature value of arable land.

Coverage of wild plants (in arable land)

The coverage of wild plants indicates to which extent there are other plants on the fields beside the crop. If the coverage is 0 % there aren't any other plants on the field - thus the living conditions also for animals depending on wild plants are bad (e.g. for insects, birds and other animals). If the coverage is high (depending on species composition > 10-50 %) it's likely that farmers will have problems with their crops regarding dominating weeds. A certain low coverage of wild plants (5 - 20 %) indicates a certain habitat quality for wildlife and may have no or only minor effects on the yields for farmers (depending on the kind of wild plants there also may occur effects on the yield or quality of yield – thus the effects of coverage of wild plants cannot be generalized).

The results of our study show the distribution of this parameter with mainly low to very low values of coverage of wild plants.

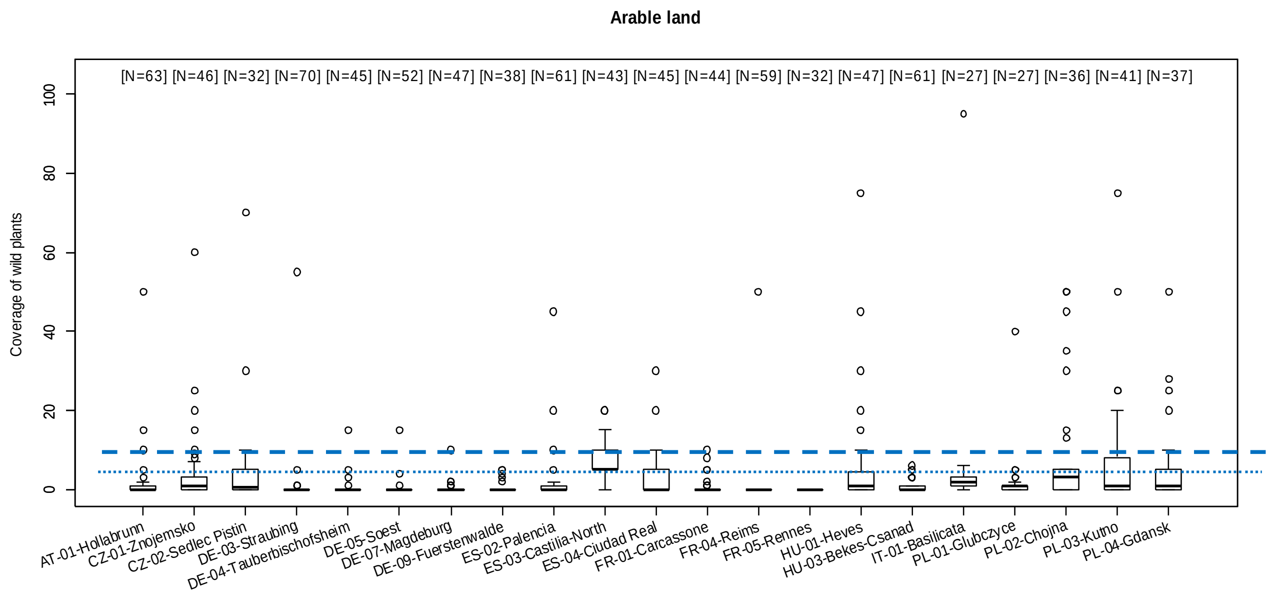


Figure 17: The mean coverage of wild plants is near to 0 % on arable land in almost all regions. The blue lines indicate the 10 % -coverage and the 5 % -coverage.

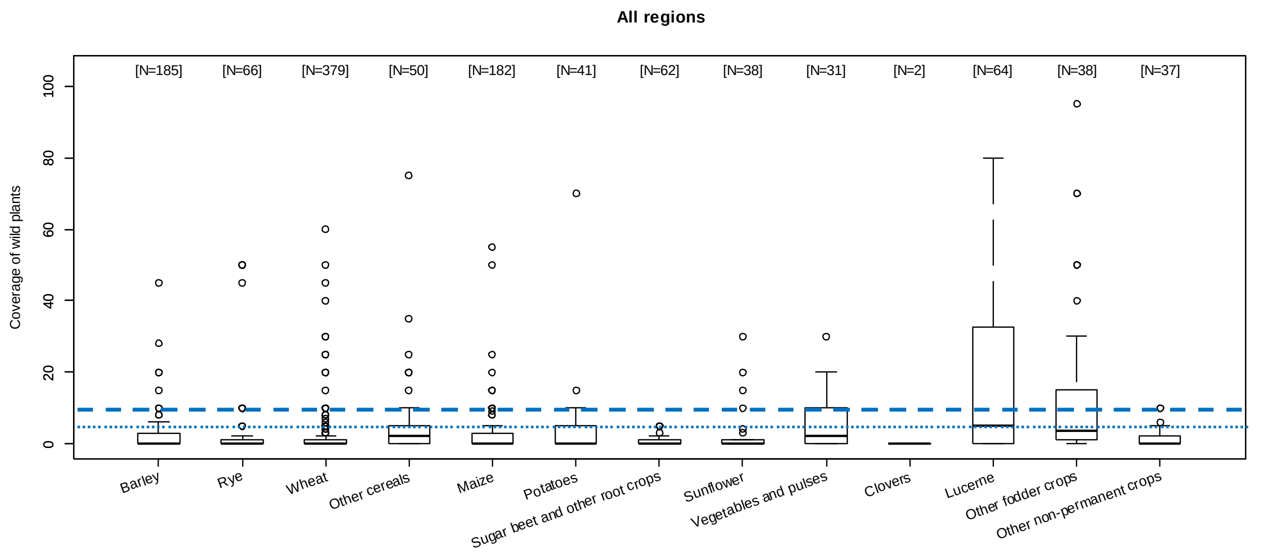


Figure 18: Except in Lucerne and other fodder crops the coverages of wild plants is near to 0 % also in all crop types. The blue lines indicate the 10 % -coverage and the 5 % -coverage.

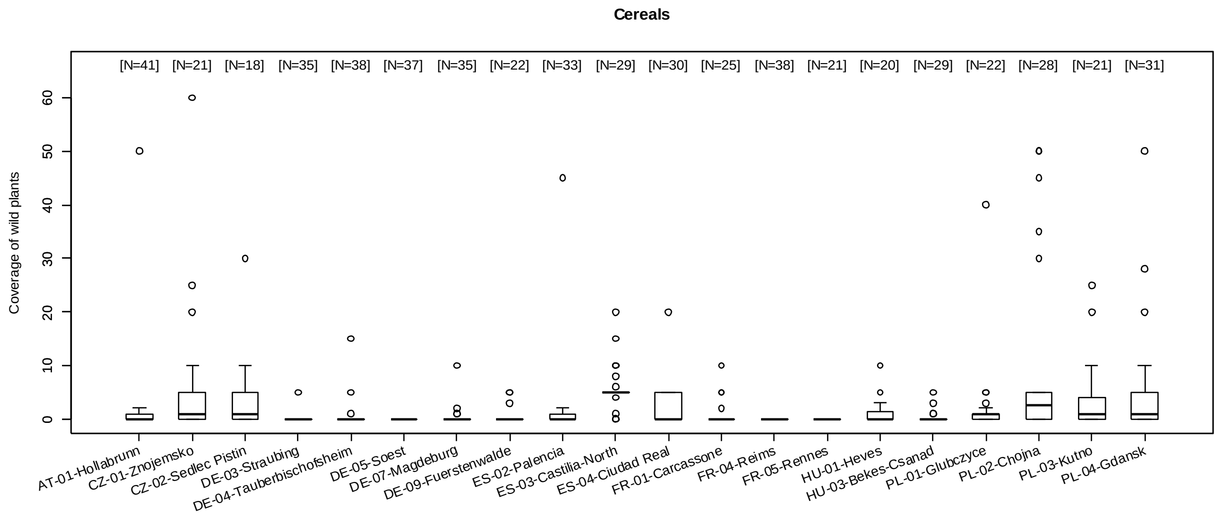


Figure 19: The coverage of wild plants in cereal crops is extremely low in almost all regions.

The lowest values can be seen in all kinds of cereals (with slight differences), in maize, sugar beets and sunflowers – the mean values are all near to 0 % and only very few investigated transects show values of more than 5 %. The only crop with higher coverage is lucerne with a medium coverage of wild plants of about 5 % and with 50 % of all values laying between 2-35 % coverage. On semi-permanent grassland, lucerne is resown only after three to five years. This might – in part - lead to lucerne plots showing the highest coverage of wild plants among all crops. However, other fodder crops also showed a certain level of coverage of wild plants. Potatoes, maize, sunflowers and cereals had on average between 1% and 5% coverage of wild plants. Sugar beets and other root crops (without potatoes) were almost free of any segetal vegetation with segetal plants showing a mean value of less than 1% coverage.

These results occur in all regions in more or less the same way except two regions: in the Spanish region Castilia North there is a mean value of 5 % coverage of wild plant in both arable land in general (n=43) and in cereals (n=29); in the Polish region Chojna the values are only a bit higher than in all other regions with about 2 % coverage of wild plants in arable land (n=38) and in cereals (n=28).

Number of flowering species

As one indicator for pollination potential we counted the numbers of flowering plant species both in arable land and in grassland. These reached values of up to 15 species in arable land and up to 28 species in grassland (only herbs, without grass-species). An expected result was that the species numbers were higher in grassland than in arable land. However, not expected was the result that even in cereals there were found up to 15 flowering herb species; in a small but considerable minority of the transects were found 5-10 flowering species.

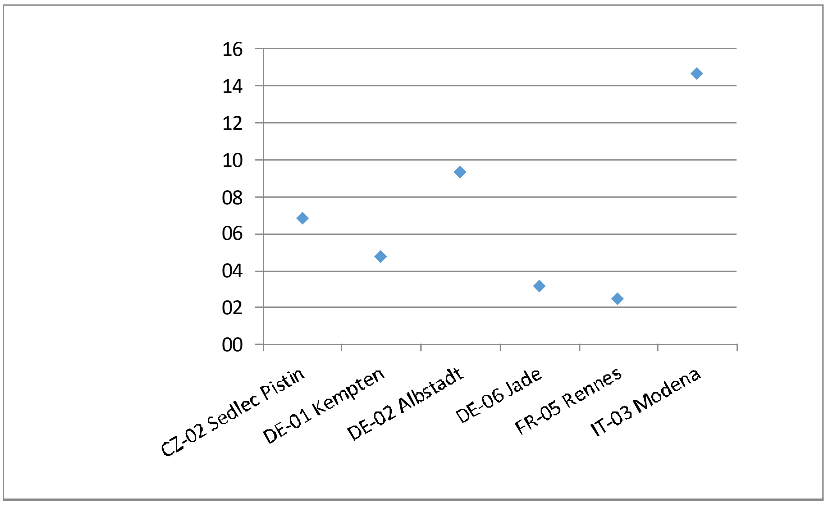


Figure 20: Mean number of flowering species in grassland.

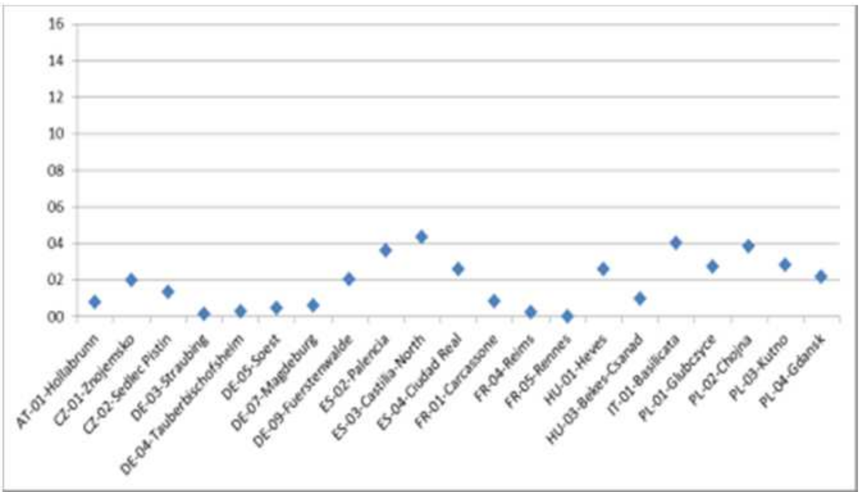


Figure 21: Mean number of flowering species in arable land.

Flowering density

A further parameter related to pollination was the flowering density of flowering herbs measured on a scale from 1 to 5 (1 indicating the lowest and 5 the highest flower density).

The flower density in arable land was fairly low with about 90 % of all transects (n=1528) showing values of only 1, and 7 % of the parcels showing values of 2[3].and only 3 % showing values of 3 or 4[4].

Regarding the situation in grassland a wide range of flowering density values occur. However, the results also show that grassland doesn't perform predominantly flowering meadow and pasture habitats but often only is "grassland" (without flowering species or these occurring only to a very small extent). Here the differences between the investigated regions very large: in extensive grassland regions such as Albstadt (Germany) we found a median flower density of 4 while in Jade (Germany) there was found a mean flower density of 1 (no flowers). Even if the flower density could be high with just one species (e.g. flowering *Taraxacum officinale* in spring) a high flower density occurs more likely in grassland with many flowering species.

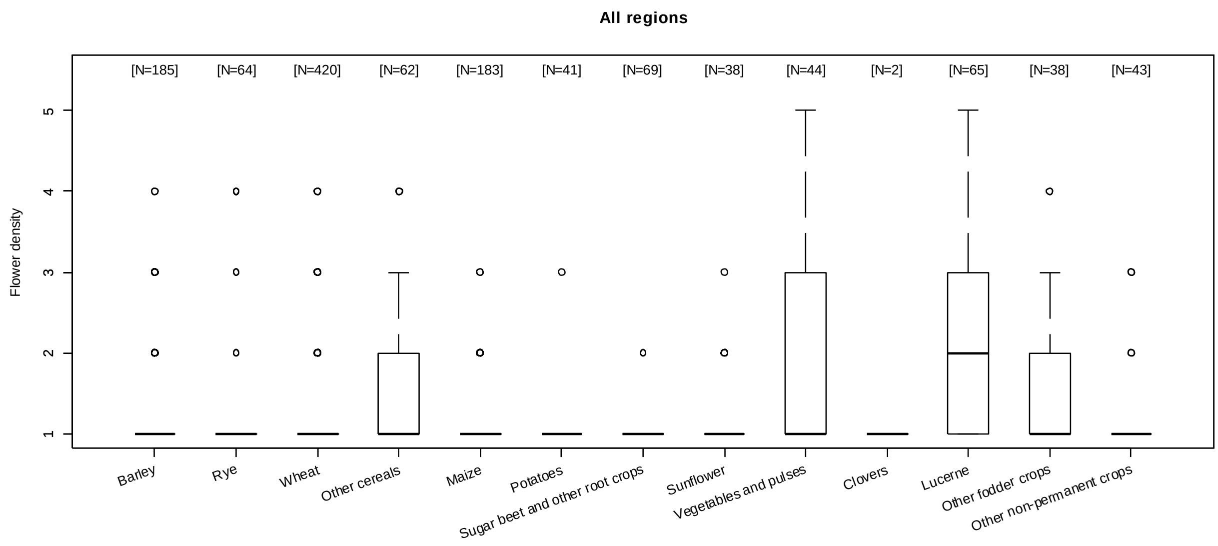


Figure 22: Flower density in different crops in all regions.

[3] flower density 1 = very low flower density: no or only very few flowers in the crop or in the undergrowth of the crop; flower density 2 = low flower density: some flowers occur in the whole parcel or in the undergrowth but there is no flower layer throughout the whole parcel;

[4] flower density 3 = medium flower density: the crop is not dominated by flowers, but there is a certain density of flowers in the crop throughout the whole parcel; flower density 4 = high flower density: flowers partly tend to dominate in the crop;

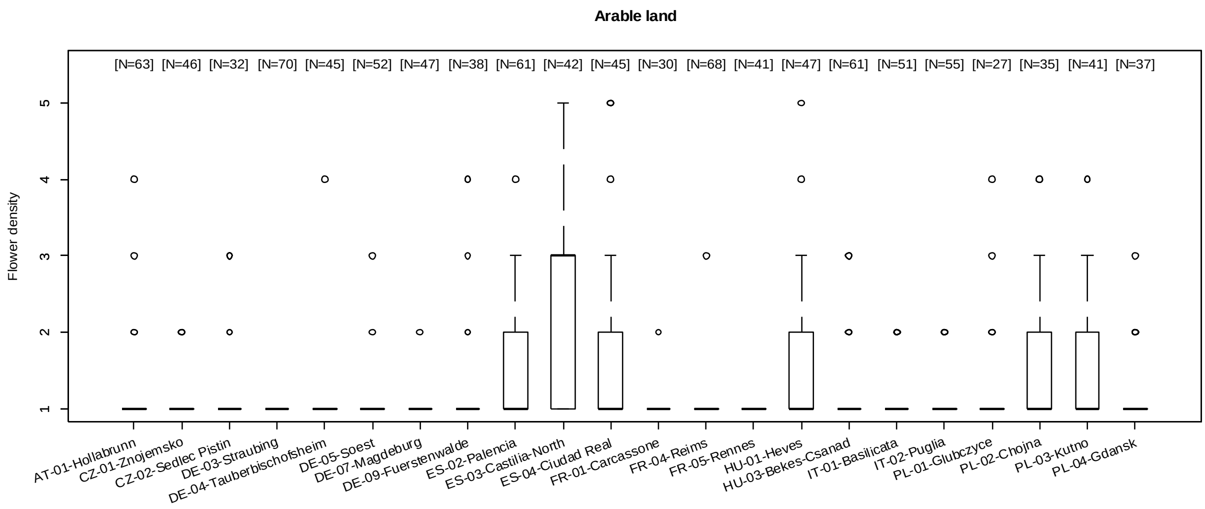


Figure 23: Flower density in arable land.

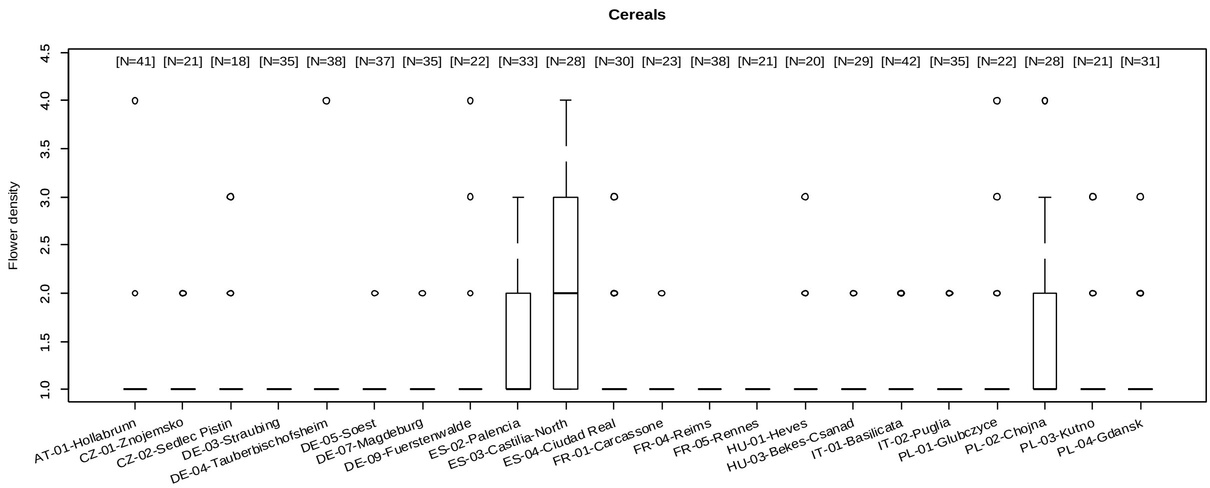


Figure 24: Flower density in cereal fields.

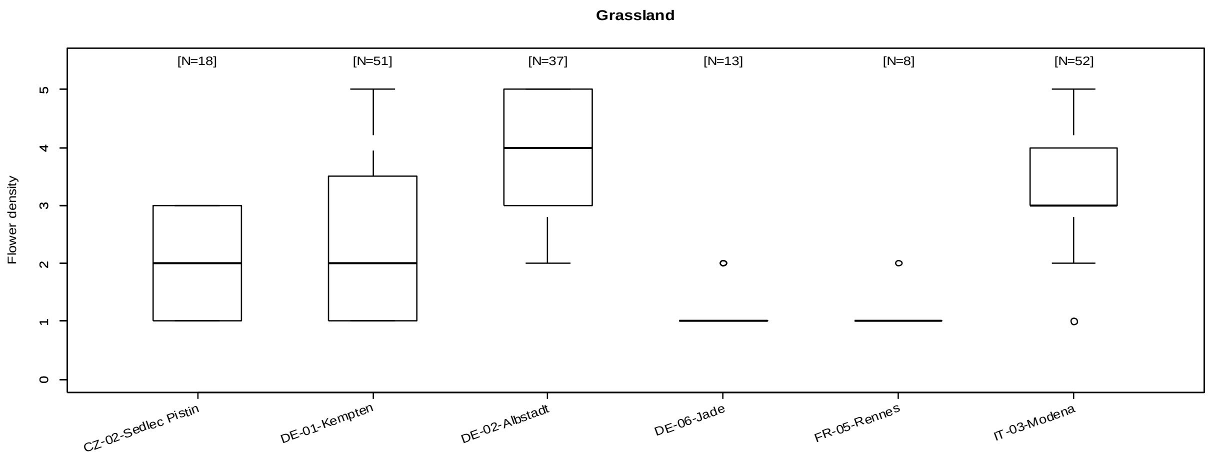


Figure 25: Flower density in grassland regions.

Potential key species

Key species lists are used in several European countries for the identification of species rich grassland within agri-environmental schemes (in France, Germany, and Switzerland). With developing and applying a European list of potential key species for arable land and for grassland we wanted to make sure that the surveyors had a look on all indicated species and that they were recorded in the same way in all countries and regions. An evaluation which species are really suitable in which region as "real key species" and how many key species are necessary as threshold for defining species rich habitats has to be worked out separately and has not been part of this study. However, we present some results on the occurrence of species and genera in different countries. Annex 4 and 6 show the lists with the potential key species / species groups.

Table 4: Occurrence of potential key species in the investigated transects in arable land. Presences in more than 1% are highlighted in orange, and with more than 5% are highlighted in red.

Key species	Occurrence of potential key species in %										
	total	AT	CZ	DE	ES	FR	HU	IT	NL	PL	RO
Number of transects	1549	65	81	278	229	160	137	225	64	156	154
Papaver_spec	12,57	0,00	0,00	2,52	29,69	2,50	10,19	29,78	0,00	12,82	9,09
Matricaria_spec	8,97	1,54	0,00	8,99	17,47	0,00	11,68	3,11	29,69	12,82	7,14
Geranium_spec	4,34	0,00	0,00	3,96	0,44	1,88	7,41	9,33	0,00	12,82	1,30
Centaurea_spec	3,88	0,00	0,00	3,24	4,80	0,00	0,00	0,00	1,56	12,82	11,69
Rumex_spec	3,81	0,00	0,00	3,96	1,31	0,63	2,19	12,00	1,56	1,28	7,14
Euphorbia_spec	3,75	0,00	2,47	2,16	10,04	0,00	5,56	3,56	0,00	2,56	5,19
Lamium_spec	3,68	4,62	9,88	3,24	0,87	0,00	0,93	0,44	6,25	12,18	5,84
Anagallis_spec	3,62	0,00	1,23	1,80	1,75	0,00	1,85	12,44	0,00	2,56	7,14
Vicia_spec	2,89	0,00	0,00	2,88	1,31	0,00	0,93	4,00	0,00	8,33	6,49
Anthemis_spec	2,63	0,00	2,47	0,36	0,00	0,00	11,11	2,67	0,00	0,00	12,34
Fumaria_spec	2,50	0,00	2,47	1,08	7,86	0,00	0,00	2,22	0,00	1,92	4,55
Consolida_spec	2,13	0,00	0,00	0,36	0,44	0,00	12,41	1,78	0,00	0,64	5,84
Trifolium_spec	2,04	0,00	0,00	3,60	0,44	0,63	0,93	5,33	3,13	0,64	1,95
Lithospermum_arvense	1,97	0,00	0,00	0,00	0,87	0,00	0,00	0,00	0,00	0,00	18,18
Myosotis_spec	1,91	0,00	2,47	2,16	0,00	0,00	0,00	0,89	7,81	8,33	0,65
Adonis_spec	1,78	0,00	0,00	0,00	1,31	0,00	2,78	2,22	0,00	0,00	10,39
Thlaspi_arvense	1,61	0,00	1,23	3,24	0,00	0,00	3,65	0,44	0,00	3,85	1,95
Legousia_spec	1,51	0,00	0,00	0,00	0,00	0,00	0,00	10,22	0,00	0,00	0,00

The most dominant species in arable land were poppy species (*Papaver spec*.) occurring in 13 % of n=1549 transects followed by *Matricaria spec*. (9 %) and *Geranium spec*. (4 %). The results are shown in Table 4. Some caution is necessary regarding the interpretation of these results as obviously not all species were recorded by all surveyors with the same accuracy; only the species easy to be identified (e.g. *Papaver spec., Geranium spec.* and *Rumex spec*.) were recorded well. If the species are not resistant against herbicide application they may also serve as indicators for suitability of the arable fields as habitats for wild plants and insects.

Figure 26 shows the distribution of the most commonly found potential key species / key genera Papaver sp. in some countries. The occurrences of Papaver sp. were mostly determined as Papaver rhoeas; Papaver dubium was only found on 0.45% of the transects.

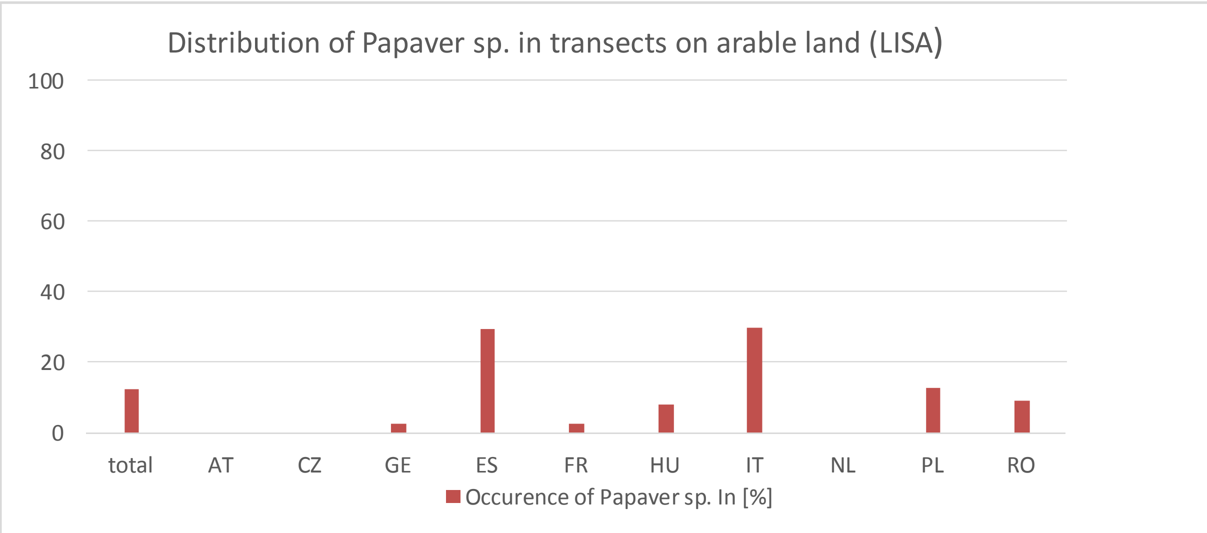


Figure 26: Distribution of Papaver sp. in transects on arable land

Figure 27: Papaver rhoeas (left) and Matricaria spec. (right) in wheat fields.

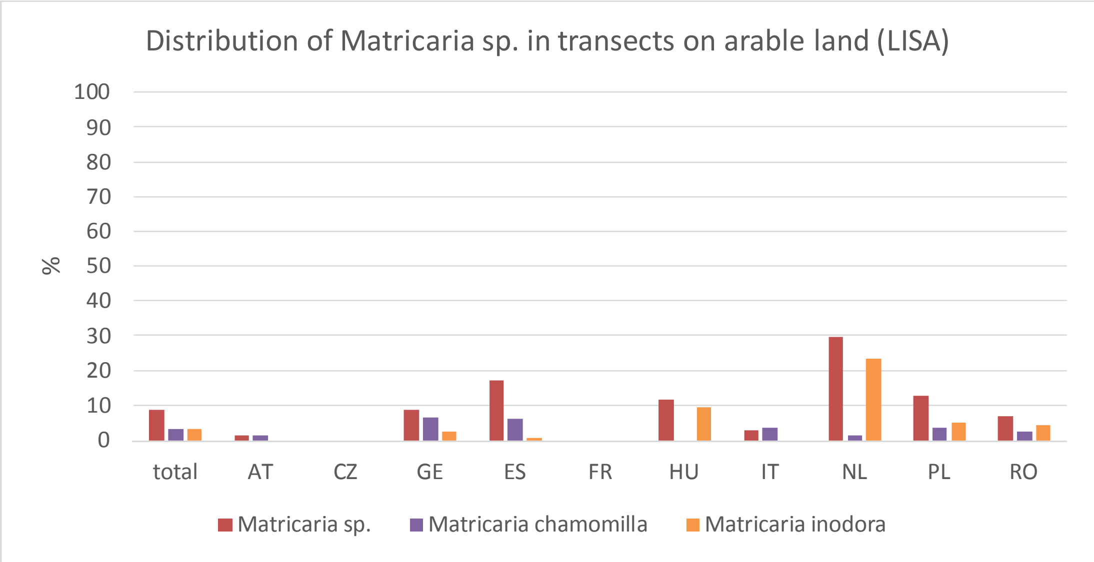


Figure 28: Occurrence of Papaver sp. (top) and of Matricaria sp. including Tripleurospermum perforatum syn. Matricaria inodora (bottom) in % of transects across countries.

In total, 72 different potential key species (169 species including the individual species of those pooled at genus-level)[5] were found on arable land. The species density on arable fields was found to be extremely low in general throughout all study regions.

For cereals – the crop type with the largest coverage and transect sample size in all regions – on a half or more of the examined fields in the majority of the regions, no potential key species at all could be found except in a very few regions, see also Figure 29. In most regions, the flower density of nearly 100% of the cereal fields was assessed to be "hardly any flowers in the whole parcel/transect" and again in the majority of the regions, the coverage of wild plants was estimated to be 0% on half or more of the examined cereal fields. In the eight intensive arable regions of Austria, France, and Germany that were surveyed, about 100% of transects in cereal fields were performed without finding any key species. Flower density and coverage of wild plants was extremely low in these regions, showing that the low species richness found was not due to an unsuitable composition of key species on the key species list, but rather due to intensive farming practices.
Only in the regions ES-03-Castilia-North, IT-01-Basilicata and PL-02-Chojna, an average number of about two key species was found in cereal fields. Only in Northern Castilia the median of flower density estimations was "quite a few scattered flowers" (in all other regions, it was "hardly any flowers in the whole parcel/transect"). A mean coverage of wild plants of over 5% was only found on the cereal fields of Northern Castilia and Chojna.

[5] In some cases the list of potential key species contains genera rather than species, e.g. *Papaver* sp. I.e. if more than one species of for example Papaver spec. (e.g. Papaver rhoeas and Papaver dubium) was found in the same field, they together contributed with "1" to the number of potential key species of that field.

Figure 29: Extensive cereal field in ES-03-Castilia North with wild plants and a relatively high flower density (top) and an intensive cereal field in FR-04-Reims without any segetal plants (bottom).

Number of potential key species

As we applied the same list of potential key species in all regions we can also compare the number of observed potential key species. In arable land there were recorded up to 9 key species in all transects (n = 1549), however, the average of all transects in arable land was only 0.9 potential key species. Only in about 2 % of the transects (24 of 1549) 5 and more key species were found.

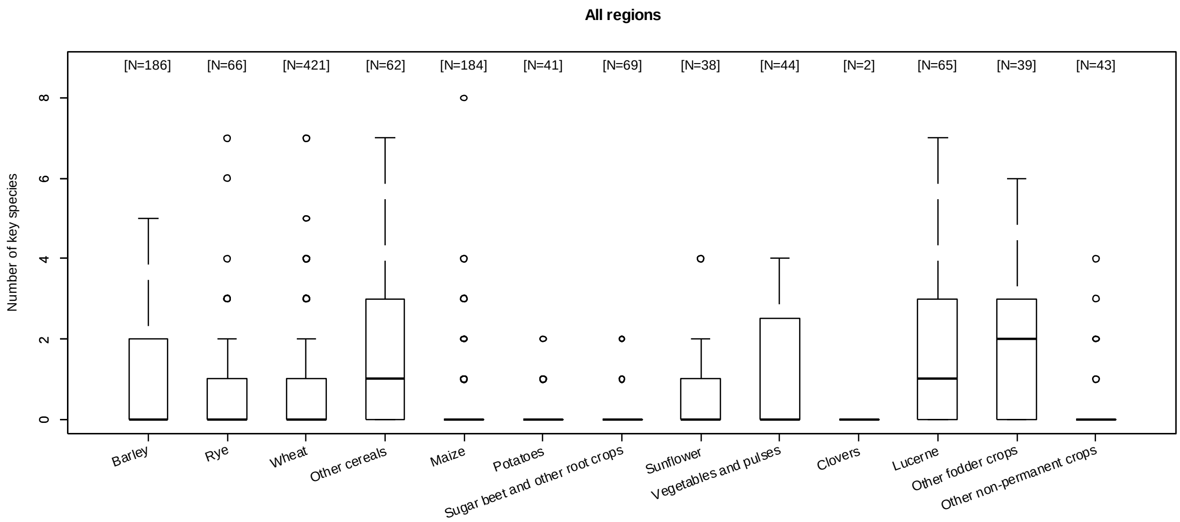


Figure 30: Mean number of potential key species in the different arable crops.

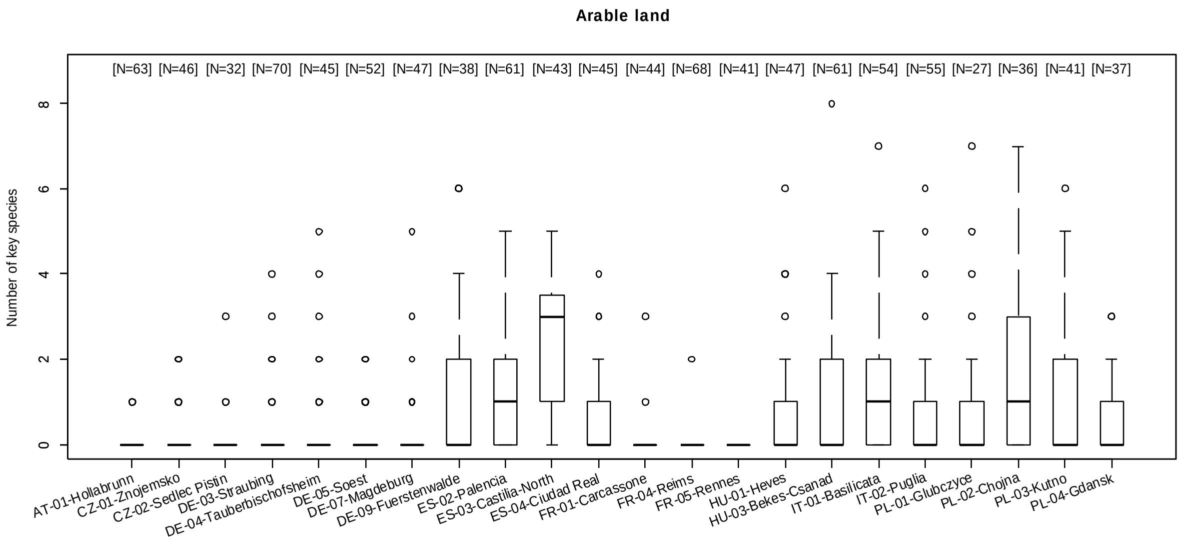


Figure 31: Mean number of potential key species in all arable regions.

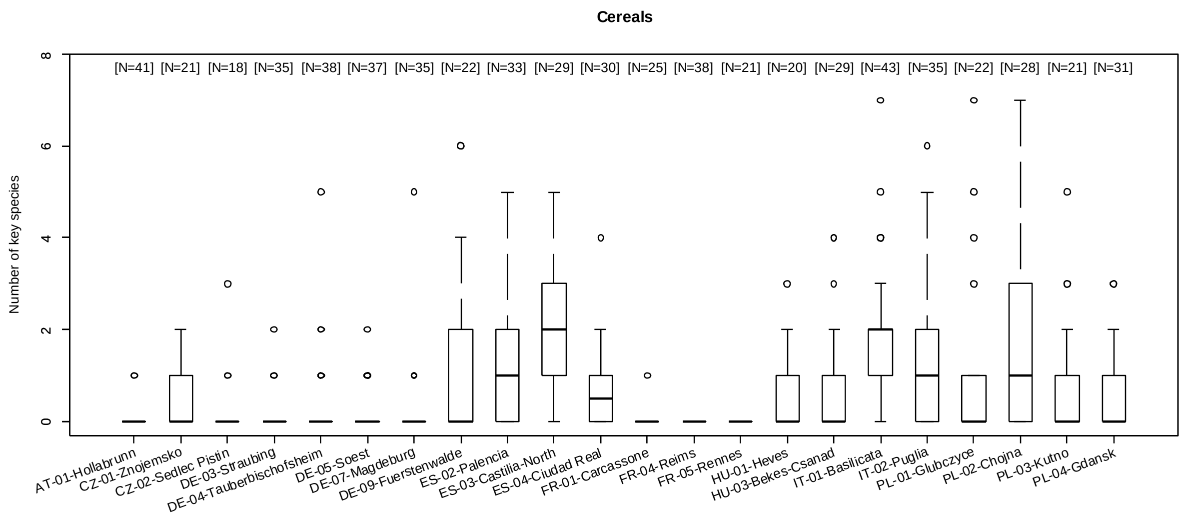


Figure 32: Mean number of potential key species in all cereal transects.

In grassland there were recorded up to 25 potential key species the main distribution of potential key species laying between 0 and 17 with an average of about 6 potential key species. It must be stressed on the fact that the species recorded are just “potential” key species, not real key species. There are some species or genera in the list like e.g. *Ranunculus spec. / Ranunculus acris* or *Asteraceae spec*. which may be real key species only in some regions whereas in other regions they occur quite frequently. So the number of potential key species is just a mean to compare a selected species spectrum. The differences between the regions are considerable: whereas in Modena (Appenin mountains in Italy) in average 9 (between 1 and 20) potential key species were recorded and in Albstadt (Jura mountains in Germany) in average 13 (between 6 and 25) potential key species were recorded, in other regions like Kempten (Allgäu) there were recorded in average only 6 (between 3 and 19) potential key species (however, most of the intensively managed meadows had already been mown and are not considered in the average numbers).

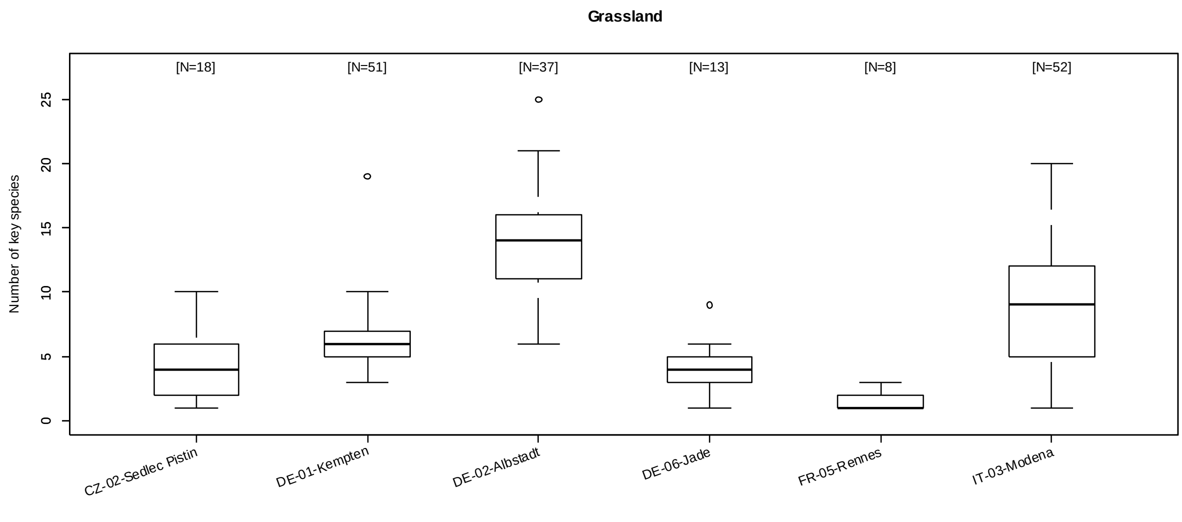


Figure 33: Mean number of potential key species in the grassland regions.

4.7. Relationships between landuse intensity, nature value and biodiversity parameters

As already mentioned there are multifold relationships between the recorded different parameters. By relating different parameters to each other in series of graphs we want to give an impression of the relationships. We didn't do any statistical analysis in detail nor did we proof the normal distribution of the data nor did we investigate exact correlation figures and statistical differ – we just show the data in graphs as they are. We present a selection of the huge data set regarding the following questions:

(1) Is the number of potential key species related to the number of flowering plant species?
(2) Are the numbers of potential key species and of flowering plants related to the coverage of wild plants?
(3) How is the relationship between the coverage of wild plants and nature value and landuse-intensity?
(4) How is the relationship between the species numbers and the nature value on the one hand and the landuse intensity on the other hand?
(5) To which extent landuse intensity and nature value are in contrast to each other?
(6) How is the parameter flower density related to the other parameters?
(7) What are the main findings regarding relationships between different biodiversity parameters in arable land and in grassland?

(1) <u>Is the number of potential key species related to the number of flowering plant species?</u>

There is a relationship between both parameters in arable land, in cereal crops as well as in grassland. As in arable land and especially in cereal crops many transects showed only very few potential key species (mostly 0-1 or 0-2, respectively) and very low numbers of flowering plant species, the relationship is very wide (Figure 34 and Figure 35). In contrast in grassland (Figure 36) the relationship is clearer and is based on a broad range of sample values.

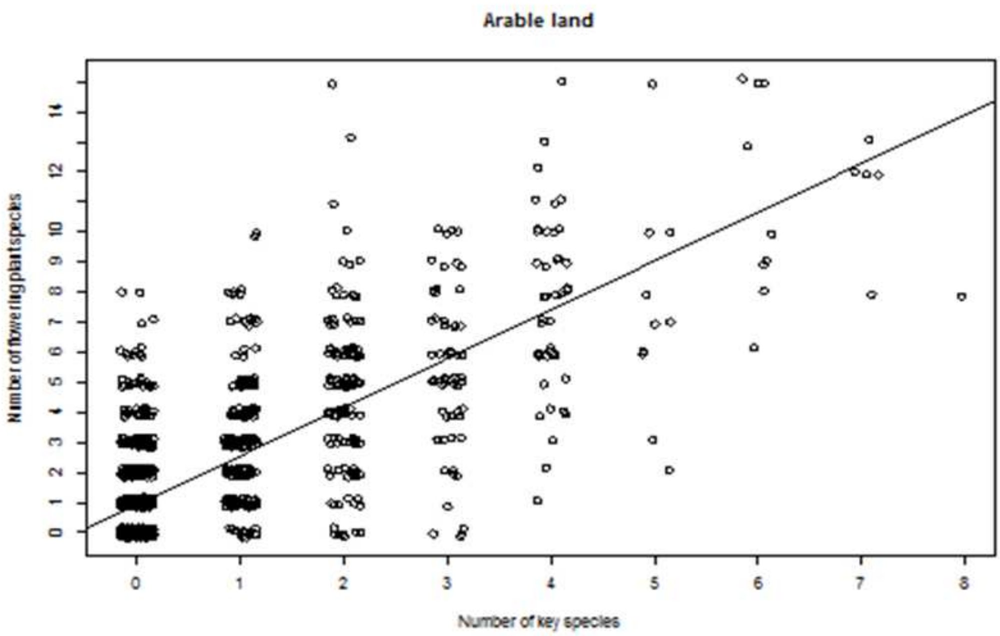


Figure 34: Relationship between number of potential key species and number of flowering plant species.

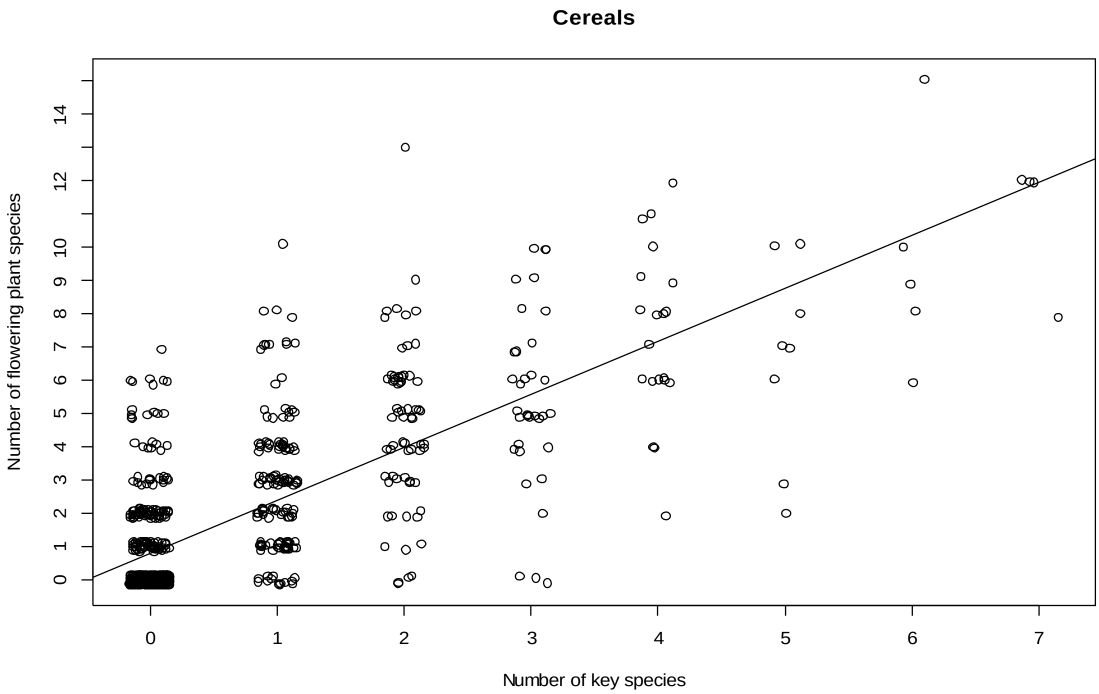


Figure 35: In cereal fields the relationship between the number of potential key species and the number of flowering plant species is clearer than in arable fields in general.

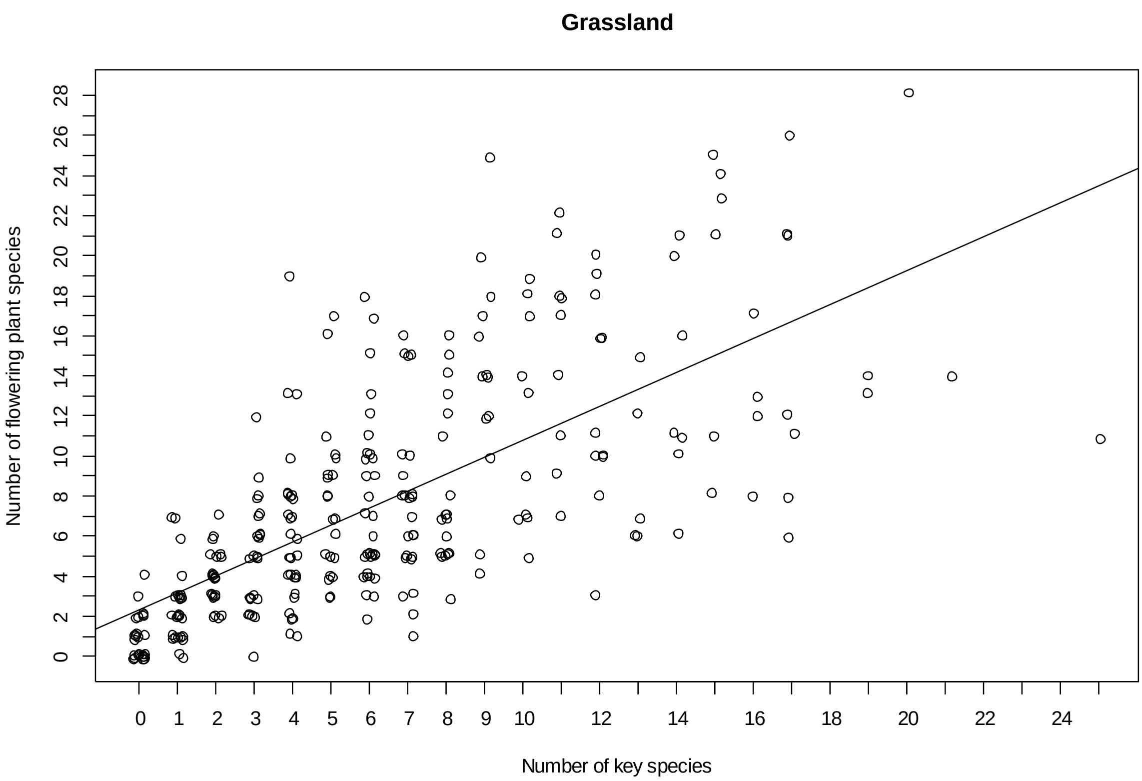


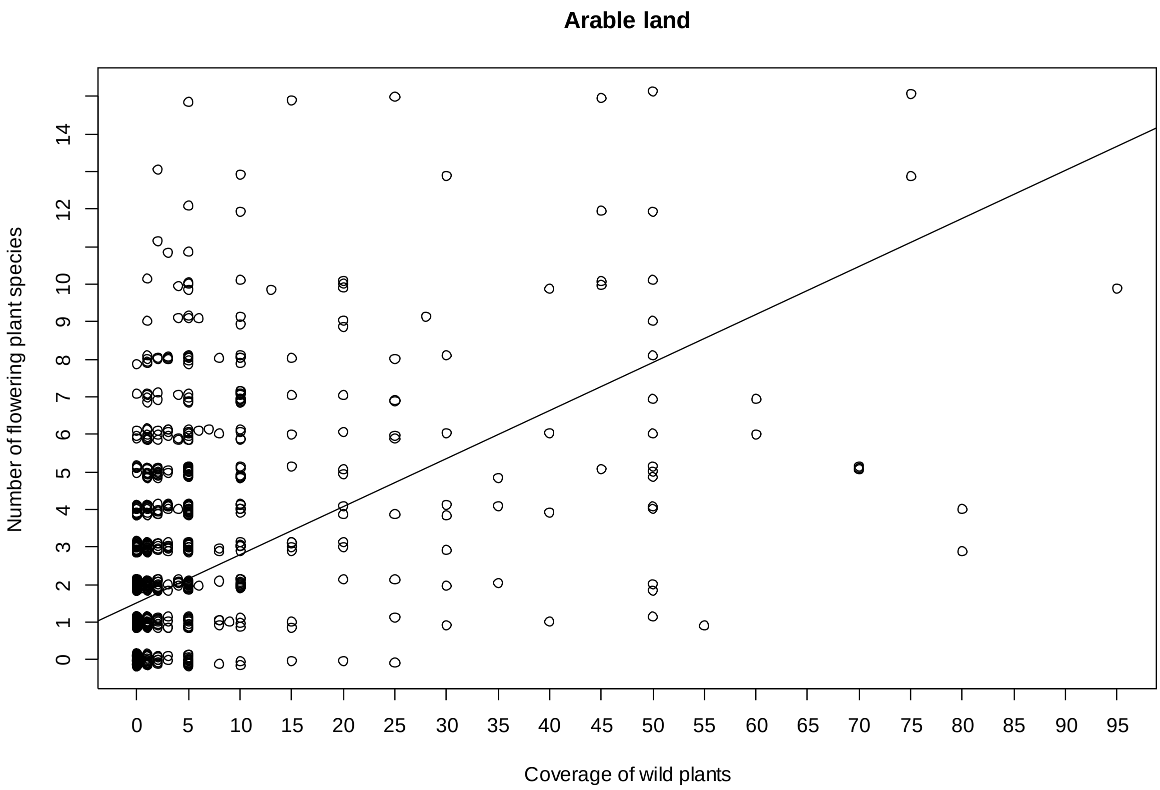
Figure 36: The strongest relationship between number of potential key species and number of flowering species occurs in grassland.

(2) Are the numbers of potential key species and of flowering plants related to the coverage of wild plants?

Intuitively one could think that the higher the coverage of wild plants in an arable field is the higher will be the number of plant species. Looking to the graph in Figure 37 the two things become clear:

- ⇨ Most value of coverage of wild plants are between 0 % and 10 % and within this small range of values there is a big variance of species number values (both from flowering species and potential key species).
- ⇨ Beyond this 10 % value of coverage there are only few data points and these data points don't show a clear relationship.

The results indicate that a high coverage of wild plants can be built either by only one or few species or by many species. Inversely a high number of species doesn't mean that there will be a high coverage of wild plants (the latter potentially being able to cause a decline of crop yields).



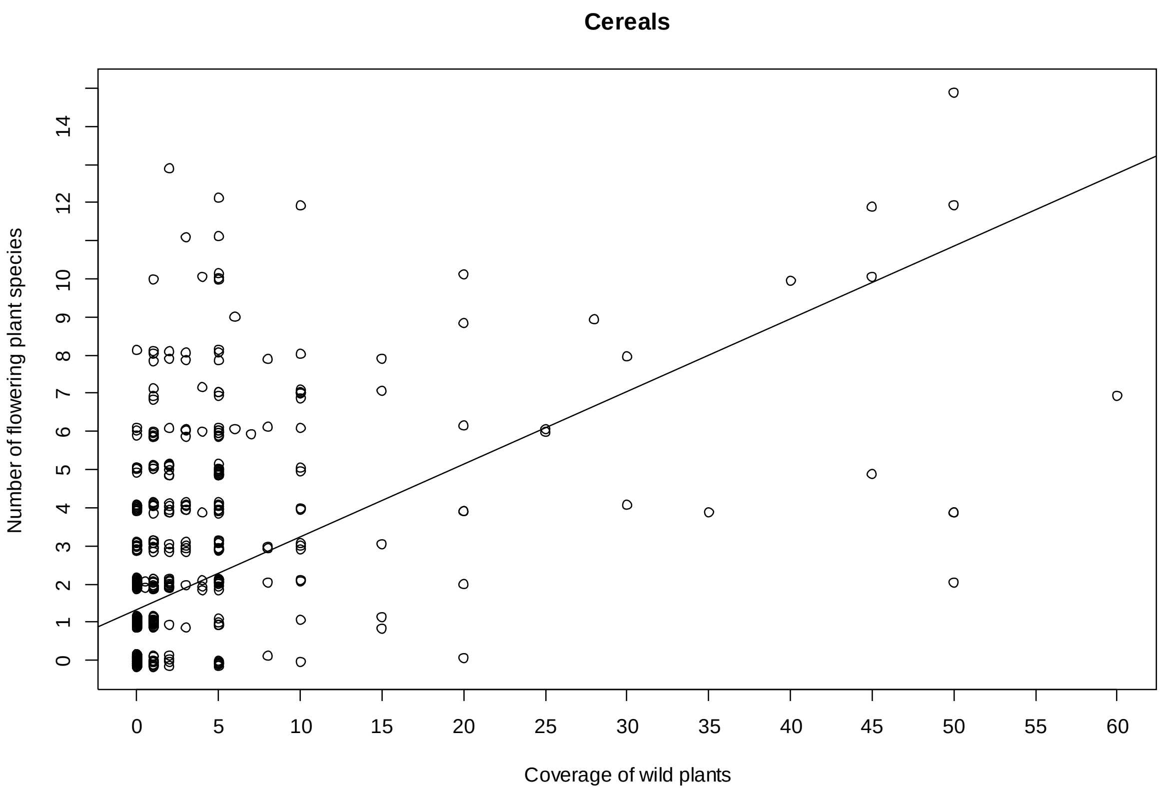
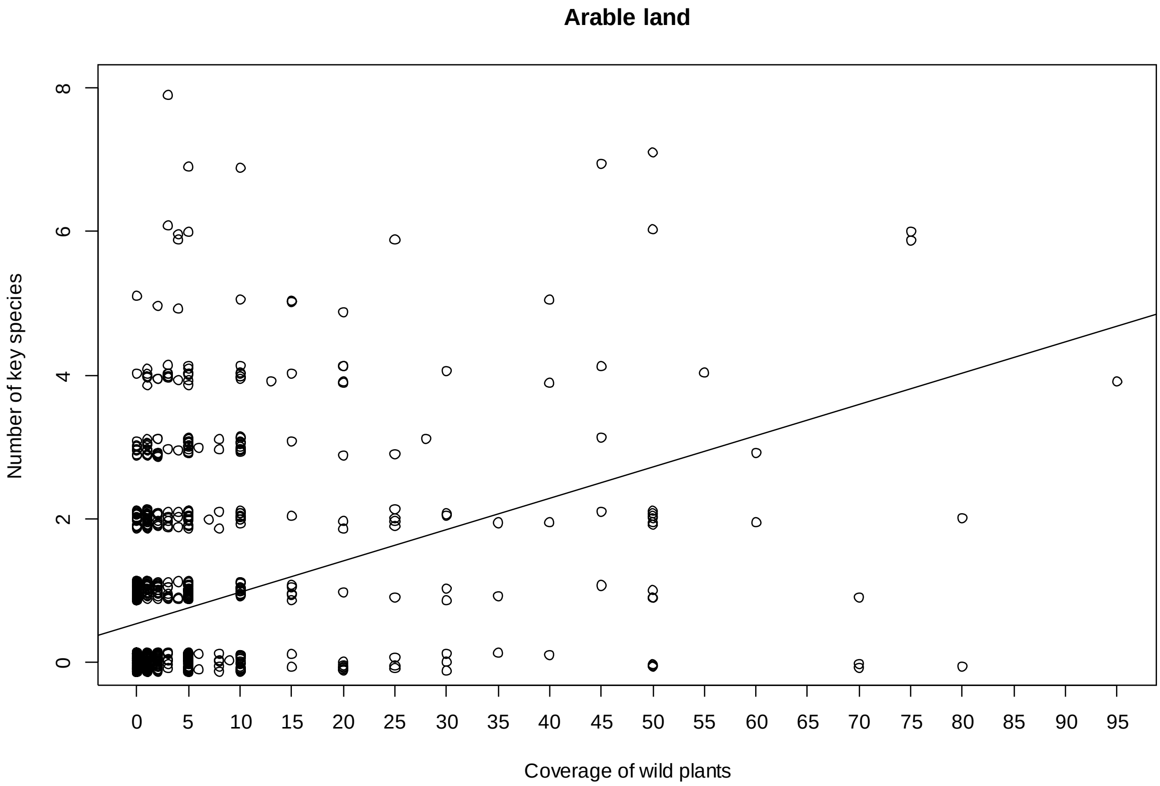


Figure 37: There is no obvious relationship between the coverage of wild plants and the number of flowering plant species neither in arable land in general nor in cereal fields.



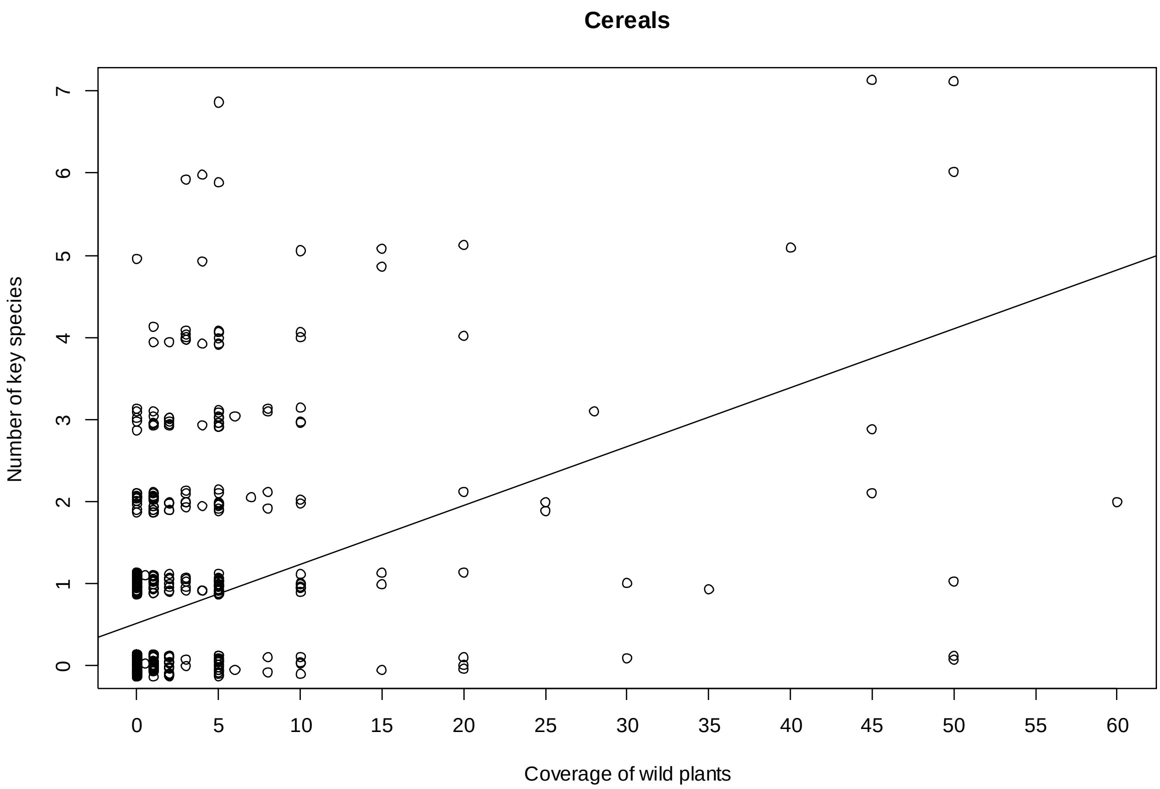
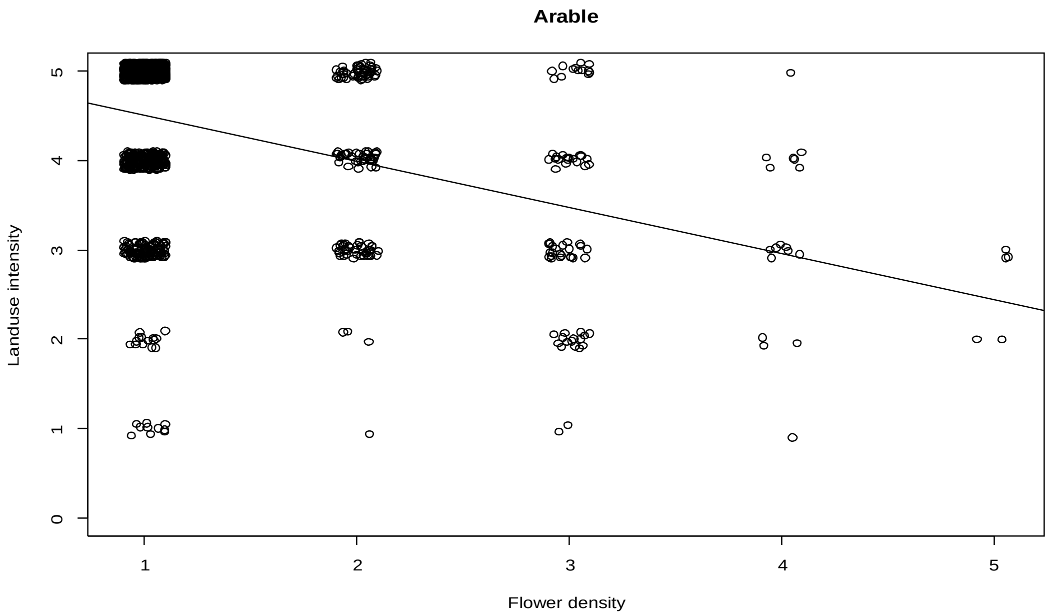


Figure 38: Also regarding the relationship between coverage of wild plants and potential key species there is no obvious relationship neither in arable land nor in cereal fields.

(3) <u>How is the parameter flower density related to the other parameters?</u>

The parameter flower density shows highest values (4 and 5) in parcels of medium landuse intensity both in arable land and in grassland – and as always – with a wide range of values.

In contrast the nature value is clearly and positively related to the flower density with the highest nature values occurring in parcels with higher flower density.



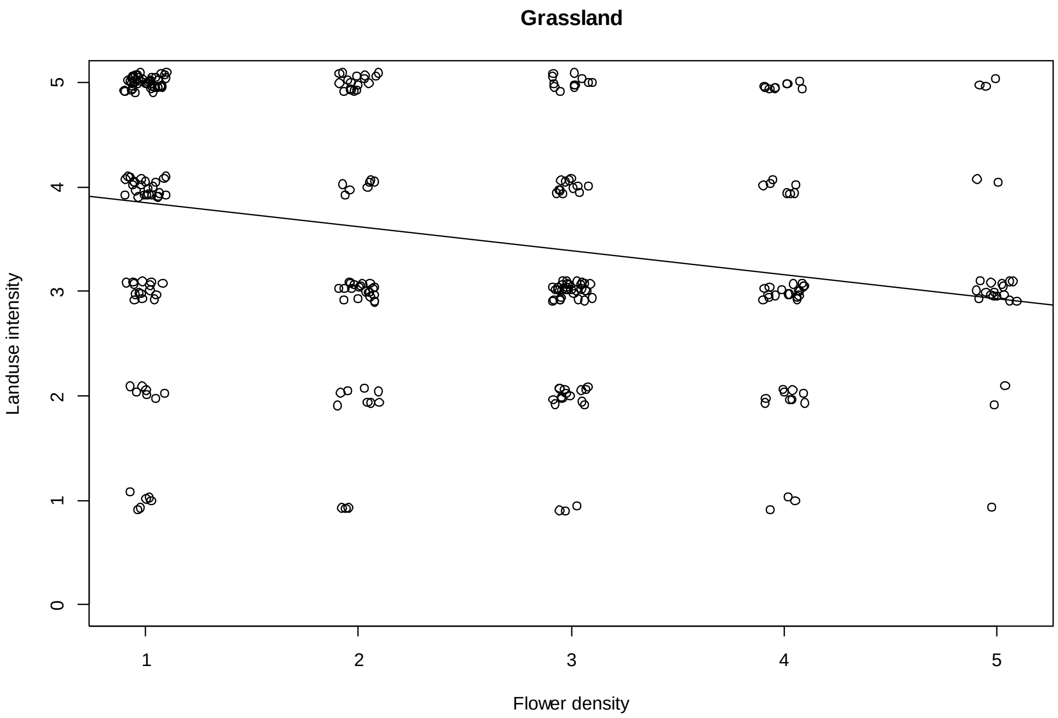


Figure 39: Relationship between flower density and landuse intensity. The most samples with a high flower density occur in parcels with a medium landuse intensity.

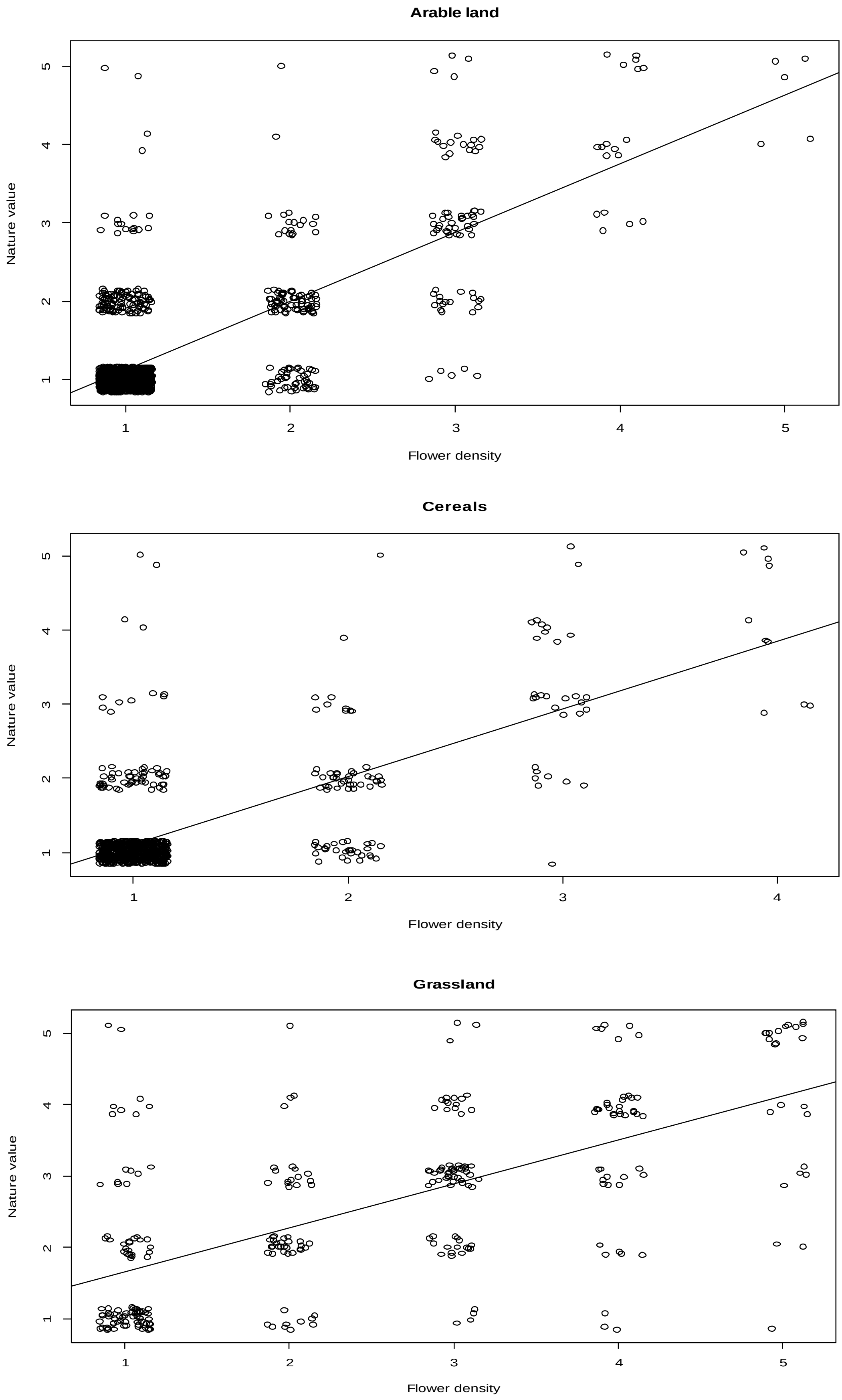
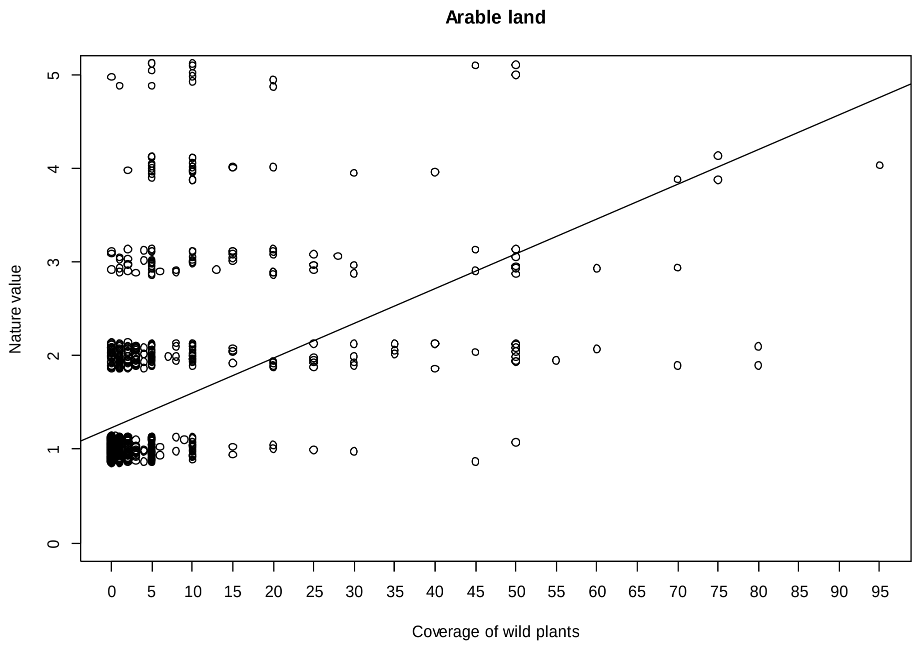


Figure 40: Relationship between flower density and nature value. High nature values clearly occur mostly in parcels with a high flower density.

(4) <u>How is the relationship between the coverage of wild plants and nature value and landuse-intensity?</u>

As one can already assume from the previous results there is no clear relationship between coverage of wild plants and the parameters nature value. Figure 41 and 44 show the relationships. This is due to the fact that most values of coverage are between 0 % and 10 % and larger values show a wide range of related values. However, interestingly the high or very high nature values (4 and 5) occur in transects with a coverage of wild plants up to 10 %. Inversely coverages of wild plants of more than 10 % do not mean that there are high nature values – mostly they lay about in the medium category (3 or 2).



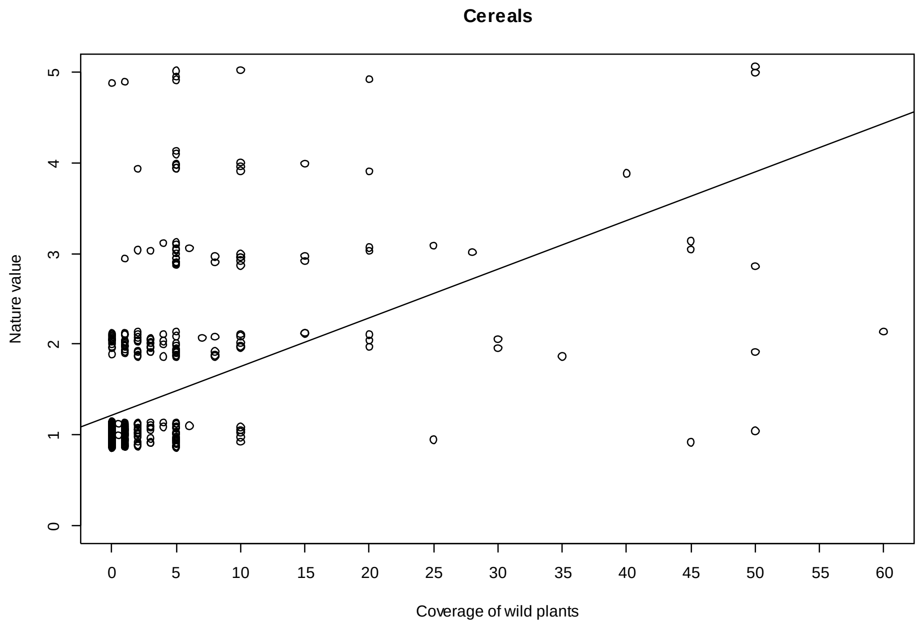
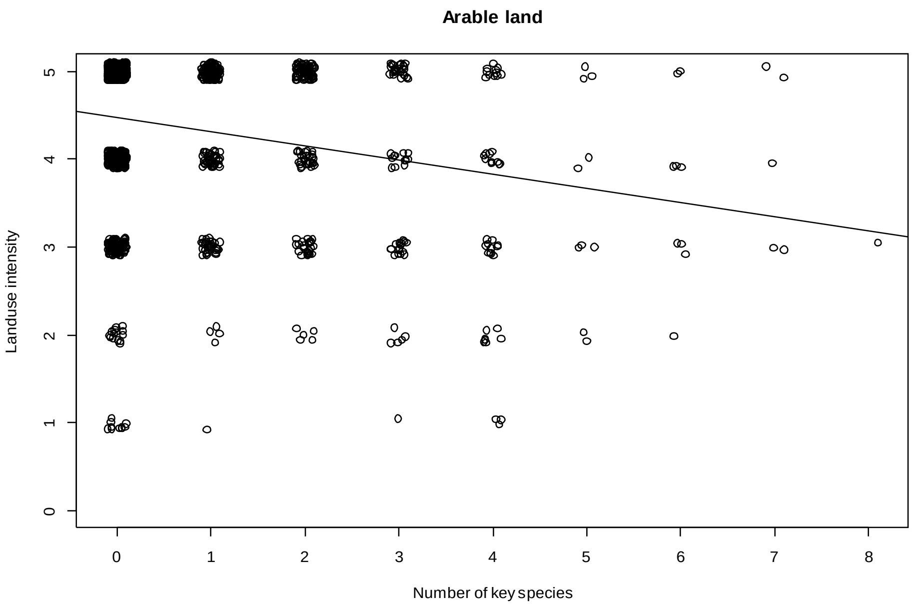


Figure 41: Relationship between coverage of wild plants and nature value. There is no obvious relationship. However, it's remarkable that the most samples with high nature values (categories 4 and 5) occur in fields with a coverage of wild plants of up to 10 %.

(5) How is the relationship between the species numbers and the nature value on the one hand and the landuse intensity on the other hand?

The clearest relationships in this respect occur in grassland: the higher the number of either flowering plant species or of potential key species, the higher the nature value. However, regarding the landuse intensity, the highest species numbers occur in parcels with a medium landuse intensity (not in the plots with the lowest landuse intensity!).

In arable land it's obvious that the lowest species numbers occur in parcels with a high or very high landuse intensity while higher species numbers are present more or less in all categories of landuse intensity.



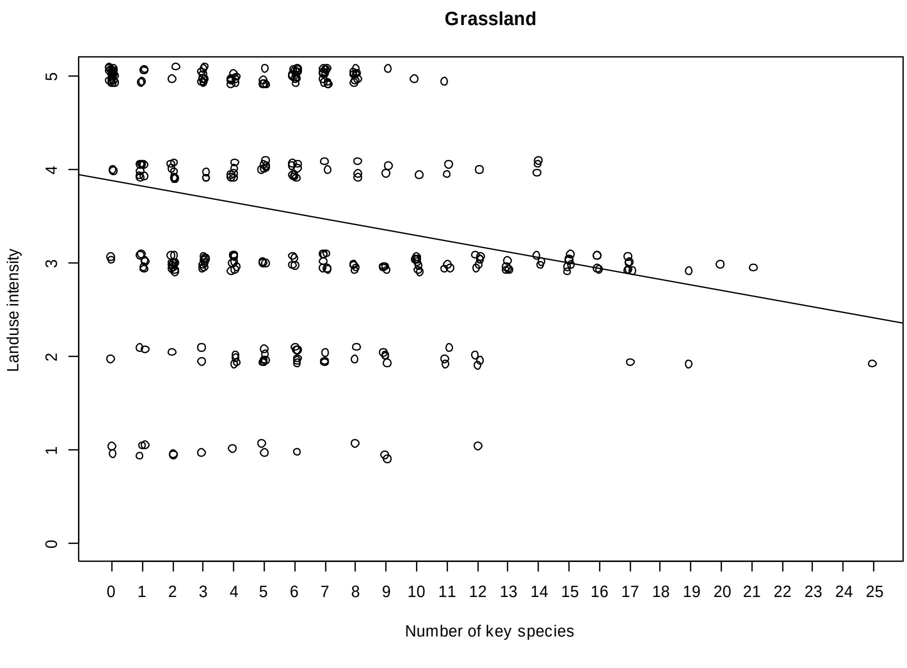


Figure 42: Relationship between number of key species and landuse intensity in arable land and in grassland. There is a tendency that the highest number of potential key species occur in samples with a medium landuse intensity.

Interestingly the highest nature values (4 and 5) in arable land occur in parcels with medium species numbers (5-10 flowering plant species, 2-5 key species) and not in parcels with high numbers of key species.

In contrast in grassland there is a clear relationship between number of potential key species and the nature value – high nature values occurring in parcels with high species numbers.

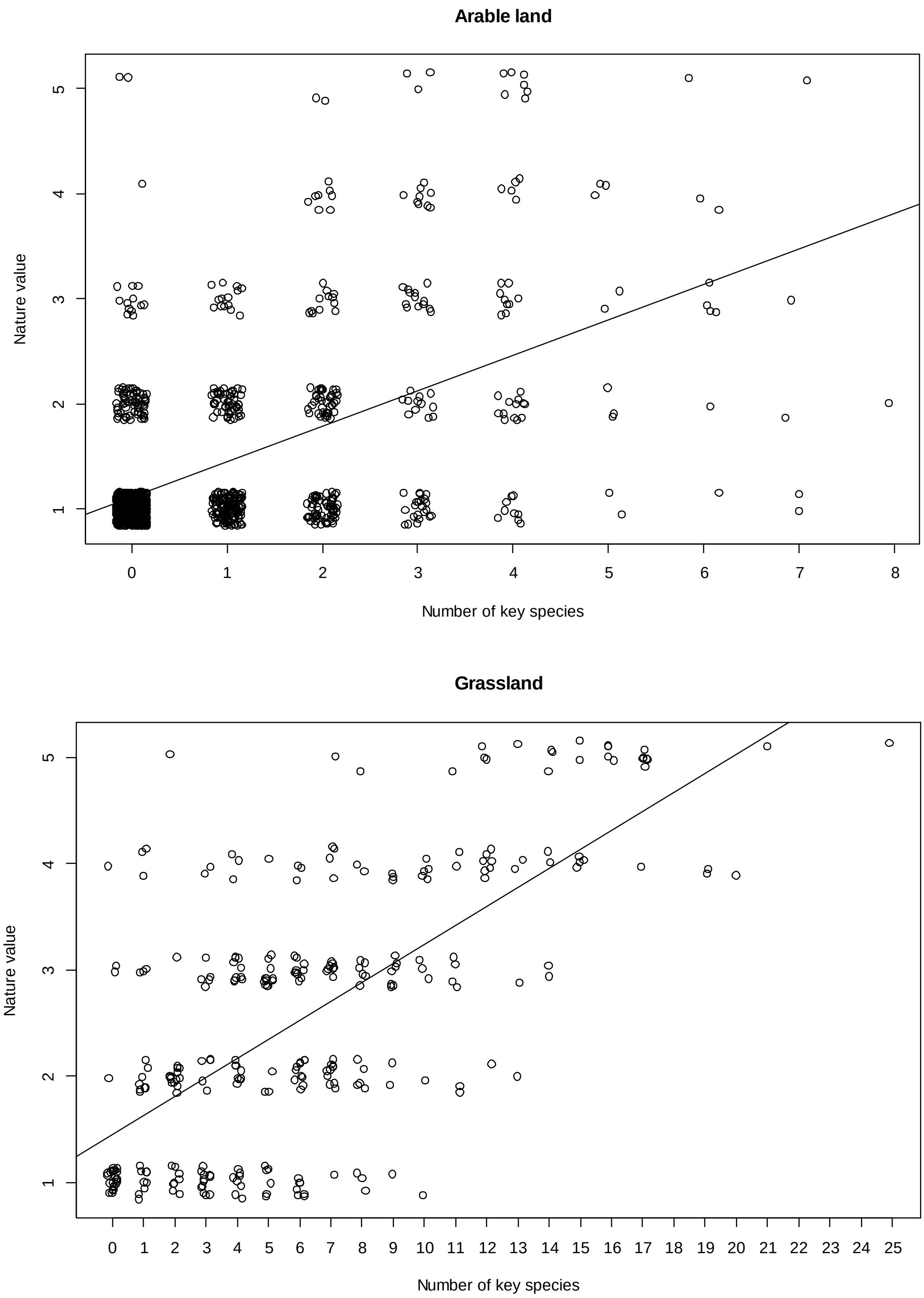
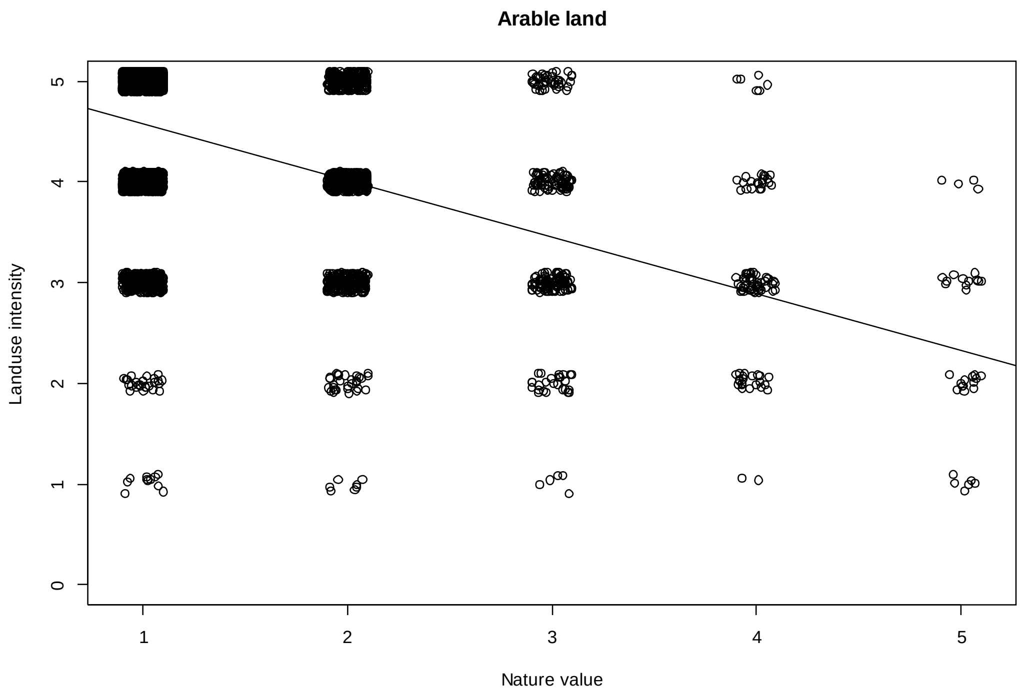
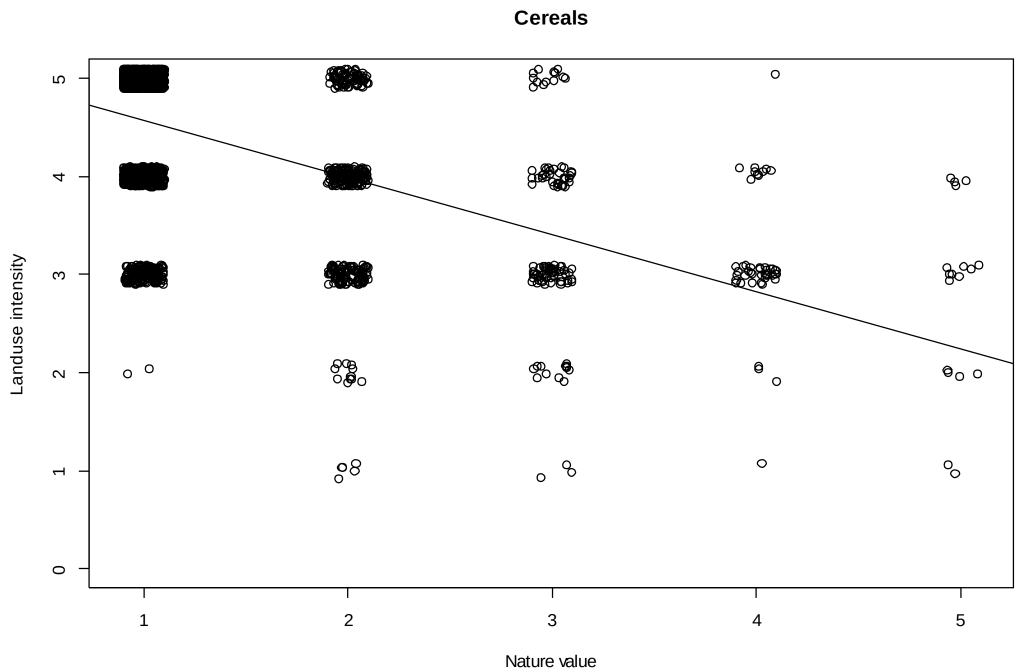


Figure 43: Relationship between number of key species and nature value.

(6) <u>To which extent landuse intensity and nature value are in contrast to each other?</u>

Normally one would assume that high landuse intensity is related to low nature value and inversely. This is true only in a general way but regarding the graphs more in detail it becomes clear that there is a wide range of values both for arable land and grassland. Interestingly the most parcels with high or very high nature value (4 and 5) occur in medium landuse intensity parcels.





Figures 44: Relationship between the parameters nature value and landuse intensity for arable land and cereal fields. In arable land the most samples with high nature values (4+5) occur in fields with a medium landuse intensity

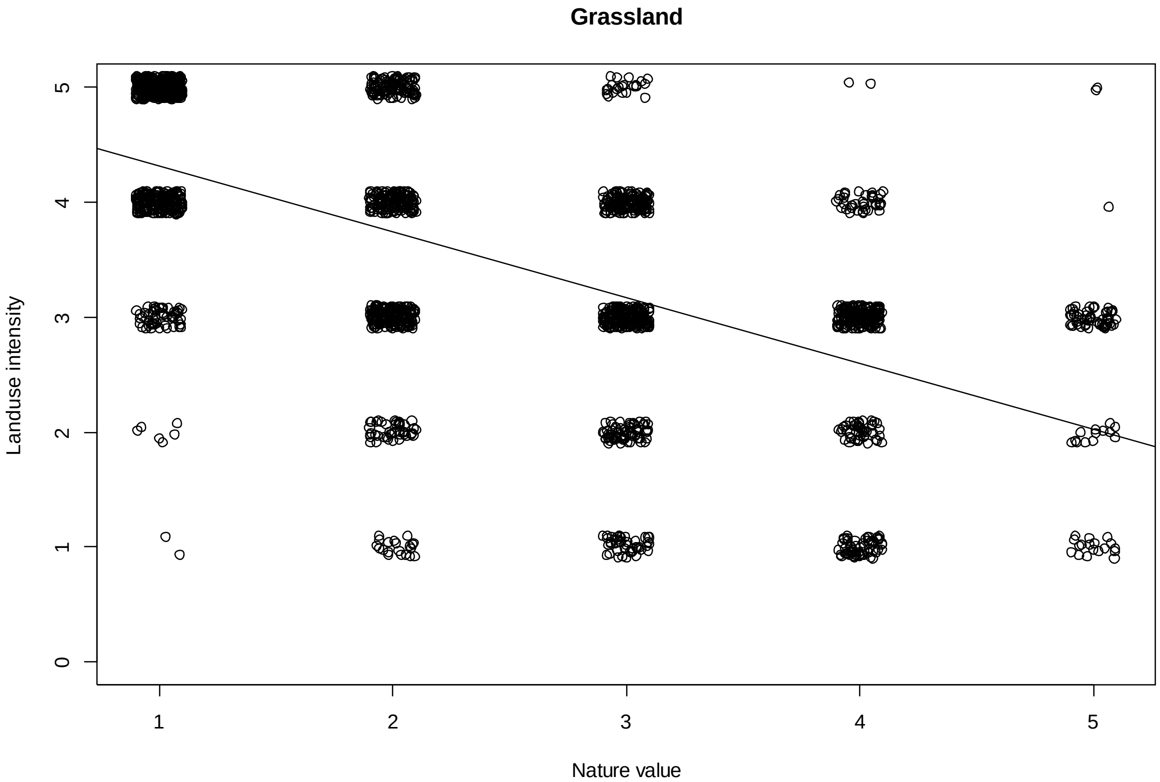


Figure 45: Relationship between the parameters nature value and landuse intensity for grassland. In grassland the relationship is stronger in general as in in arable land, however, with a wide range of values in each category.

(7) <u>What are the main findings resulting from the consideration of relationships between different biodiversity parameters in arable land and in grassland?</u>

There are many interesting findings, some of them having been expected and some of them being unexpected. We summarize the main findings as follows:

- ⇨ Species numbers (flowering plant species and potential key species) indicate parcels with a high nature value, but they don't indicate parcels with low landuse intensity or with a high coverage of wild plants.
- ⇨ Species numbers in average are highest in parcels with medium landuse intensity, however, with a broad range of values.
- ⇨ The coverage of wild plants doesn't relate clearly to any of the other parameters.
- ⇨ High values of flower density are clearly related to high species numbers (flowering plant species, potential key species), to high nature value and to medium landuse intensity.
- ⇨ The number of key species shows clear relationships to the number of flowering species, to flower density, to nature value, but not to landuse intensity.
- ⇨ Medium landuse intensity in general seems to perform best values of general values of biodiversity (not considering seldom species and special habitats!); however, in general there are only relatively few parcels with low or medium landuse intensity.

Biodiversity and nature value in agricultural landscapes depend on a medium landuse intensity and could be enhanced by farming practices allowing higher number of plants and flowering plants to grow within the fields.

4.8. Examples of good and bad landuse practice regarding nature value and biodiversity

In the study a very wide range of landuses, landscape elements and different nature values / biodiversity performance was observed. Within this wide range examples of different quality could be found – in our context quality regarding nature value and biodiversity. Two main aspects have to be differentiated: the area quality – that means the nature value and biodiversity performance of the arable land and the grassland, and the structural quality – that means the landscape elements and their borders / buffer strips to the bordering fields.

<u>Area quality:</u>

An interesting and encouraging result of the LISA study 2014 was the fact that we found quite a few parcels and plots in which biodiversity parameters showed good and remarkable results while the same parcels and plots landuse intensity was considered on a medium or sometimes even high level. Without having looked closer to the yield and the examples show that it is possible to manage arable fields in a way that delivers at the same time reasonable crop yields (and quality) and biodiversity. If such parcels do have sufficient extent in a landscape (and are scattered across the landscape) they may deliver yields and biodiversity at the same time and form a sustainable landuse in a way that populations of wild plants and animals survive in sufficient populations. Figure 46 shows a few examples of arable crops with visible biodiversity and crop yields.

Figure 46: Some of the few examples of relatively high biodiversity within fields with a good productivity and cereal yield are shown here; - from UK (top left), from Spain (top right) and from Poland (bottom left and right).

Regarding grassland in a few regions (mainly in mountain areas) biodiversity is still common whereas in other regions the biodiversity situation in grassland is as severe as in arable regions. In thode regions the main point will be to care for a sufficient extent of low intensity grassland use on landscape level in order to maintain or enhance populations of wild plants, animals and habitats. Figure 47 shows examples of species rich grassland.

Figure 47: In grassland regions like here in the Jura Mountains in Southwest Germany (region Albstadt) there can be found species-rich meadow which do not only a very good hay but also a high biodiversity and habitats for wildlife.

Structural quality:

Landscapes are characterized visually by structures and landscape elements such as hedges, trees, ditches etc. These structures do not only form the visual character and determine the identity and tourism value of landscape – they also form ecosystem structures and habitats. Depending on the structure of these landscape elements themselves and the adjacent landuse the ecological performance of the landscape elements can be low, medium or high. For example a hedge consisting of only one species doesn't have the value of a same-sized hedge constituted by many species. However, while the species composition of the landscape elements themselves is more or less fix (unless one creates be new landscape elements) there is a huge difference in the management of the borders of the landscape elements and the adjacent fields.

Figure 48). These buffer strips prevent fertilizers and plant protection products (PPPs) from entering into the landscape elements and they also build additional foraging habitat e.g. for birds nesting in the adjacent hedges. These examples may also serve as good illustrations for a good use of buffer strips within the current greening obligation (Figure 49), whereas small buffer strips don't fulfil the mentioned functions (Figure 50).

Figure 48: Examples for a broad bufferstrip from Germany (top) and Hungary (bottom).

Figure 49: Two further examples show broad buffer strips from the UK (left) and France (right), while the figures below show very shallow strips.

Figure 50: In such small strips the functionality of the ecosystem services is very limited – two examples out of a huge collection of similar examples, - here from Poland (left) and France (right).

We also found very bad landuse practices, - e.g. with spraying of plant protection products (PPPs) till the edge or even into the landscape elements (hedges, ditches, see Figure 51) or with heavy fertilisation or/and mineralisation and influence on the aquatic ecosystems (Figure 52). Also soil erosion occurred (e.g.
Figure 53) and in these situations buffer strips would have helped to prevent the soil being washed in the water courses.

Figure 51: Spraying in ditches occurred several times during the field visits – here an example from Italy.

Figure 52: Heavy fertilization on the adjacent fields leads to hypertrophic situation in the ditches – the ecosystem functions are very limited. Here one example from the Netherlands is shown.

The following composition of some photos (Figures 53 and 54) show some aspects of good and bad practice regarding nature value and biodiversity.

Figure 53: Bad practice examples: entire parcels (top left) and diches (top right) cleared with broad-spectrum herbicides. Undergrowth completely removed with herbicides (bottom left). Large-scale monotonous cultivation and soil erosion (bottom right).

Figure 54: Good practice examples: flower-rich cereal fields (top). Dense undergrowth of segetal plants (bottom left) field with trees and Papaver flowers (bottom right).

4.9. Photo documentation

In the previous subchapters we showed a few examples of the huge photo documentation. The pictures were not only taken for these illustration purposes but also for the documentation of the current survey. Thus the situation of buffer strips or an extensive landuse from 2014 can be compared to any other repetition of the survey in the following years. All the photo sites were captured with GPS data in order to be able to find the exact point of the photos.

With the photo documentation a comparison beyond pure numbers and figures and mappings is possible (Figure 55). A later judgement can rely on photo impressions as well.

Figure 55: Intensive grassland with high inputs of fertilizer, low floral diversity and low structural diversity of the landscape in DE-01-Kempten (top) versus extensive mosaic of grassland, orchards and landscape elements in DE-02-Albstadt (bottom).

4.10. Case study Germany: Landuse intensity and nature value of agricultural land

As there was the opportunity to survey eight regions in Germany (more than in other countries) we use this as possibility to have a closer look to the performance of different values – just as an example what a study within one country can deliver. However, it would be even more interesting to have more and representative study regions. But as we chose regions of different landuse intensity it might be interesting anyway to see the performance and the range of values.

Among the eight German regions, DE-02-Albstadt and DE-04-Tauberbischofsheim were chosen because they represent relatively extensive regions with the predominant landuse types grassland and arable land, respectively. DE-01-Kempten and DE-06-Jade represent intensive grassland regions in mountainous and lowland area, respectively. DE-03-Straubing, DE-05-Soest, and DE-07-Magdeburg represent intensive arable regions, and DE-09-Fuerstenwalde was chosen for a cross-border comparison with the Polish region "PL-02-Chojna". It can be considered as a medium intensive area with predominant arable use.

In all German regions taken together, a total of 5,347 ha were surveyed. Table 5 shows the distribution of different landcover types in all eight regions. A total of 3,948 ha of agricultural land were evaluated regarding landuse intensity and nature value. Landuse intensity was judged as very high on about 90% of arable land without very pronounced variations between regions that were chosen as relatively extensive on poorer soils and intensive regions (Figure 56, top left and shown for cereals, top right). Regarding cereals – by far the most common crop type– the proportion of area rated as very high intensity varied from region to region between 80% and 100%. The remaining percentages were distributed among rather high intensity and – to a much lesser degree – medium intensity. Only about 0.3 ha of cereals in one region (DE-04-Tauberbischofsheim) were judged as rather low intensity. Cereal fields judged as low intensity did not occur.

In contrast for grassland differences in landuse intensity and nature value were obvious. For example a pronounced difference was found with the two intensive regions having about 80% of their grasslands judged as very intensive, as opposed to the relatively extensive region with less than 20% of its grassland rated as very intensive, and the largest fraction rated as medium intensive (Figure 56, bottom).

Table 5: Landcover of the German regions as percentage of the total area surveyed.

Region	Arable land	Grassland	Landscape elements	Non-agricultural land	No data/Other
DE-01-Kempten	4.70%	67.89%	2.09%	25.15%	0.18%
DE-02-Albstadt	21.40%	32.17%	3.30%	39.49%	3.63%
DE-03-Straubing	74.37%	5.16%	4.04%	14.72%	1.71%
DE-04-Tauberbischofsheim	49.49%	9.08%	3.87%	30.95%	6.60%
DE-05-Soest	69.55%	9.36%	3.35%	16.33%	1.41%
DE-06-Jade	12.04%	62.43%	3.48%	21.56%	0.49%
DE-07-Magdeburg	81.09%	2.49%	2.94%	11.99%	1.48%
DE-09-Fuerstenwalde	68.12%	7.19%	3.94%	19.09%	1.66%

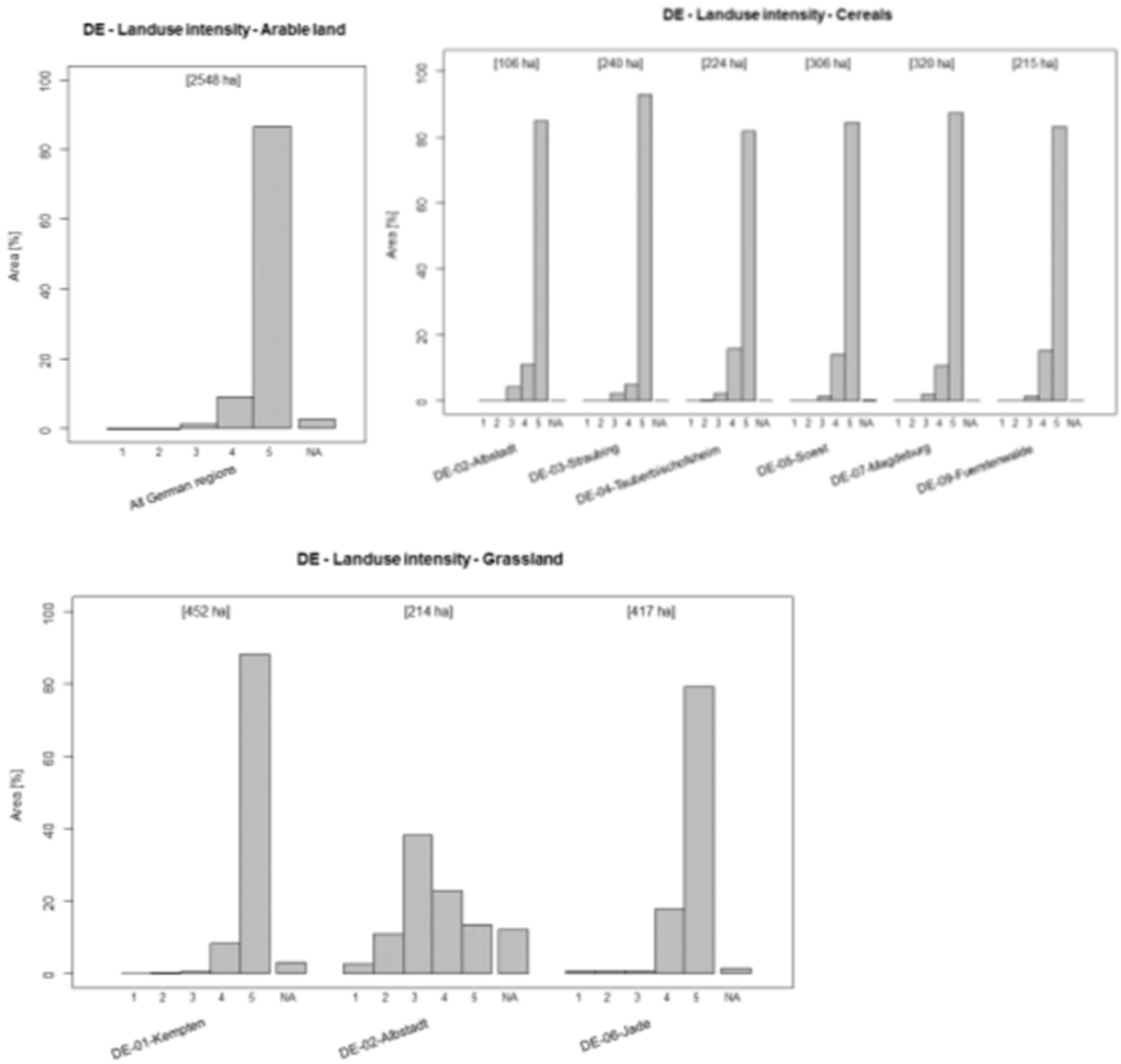


Figure 56: Landuse intensity for arable land in eight German regions (top left); for cereals in the six regions with at least 100 ha of cereal fields evaluated (top right); for grassland in three regions with at least 100 ha of grassland evaluated (bottom). The bars show the area of each landuse intensity level (levels 1 "very low intensity" – 5 "very high intensity") as percentage of the total area of each landcover type in each region.

Consistent with landuse intensity results, nature value was judged as very low on about 90% of arable land (Figure 57, top left). Interestingly, in grassland, nature value data do not correspond to landuse intensity data as closely. Particularly in the regions DE-02-Albstadt, the distribution of data is more skewed towards the low intensity side than it is towards the low nature value side (cf. Figure 56, bottom and Figure 57, bottom). This means, that more often e.g. grassland plots judged as very intensive were not judged as being of very low nature value, but higher. A large proportion of the grassland could not be evaluated for nature value, because it had already been mown at the time of the survey, the cut down vegetation making it impossible to assess species richness and composition.

The proportion of cereal cropping area judged as very low nature value varied between about 80% in the extensive region of DE-02-Albstadt and almost 100% in DE-03-Straubing and DE-05-Soest. Compared to landuse intensity, the remaining percentages of cereal fields were more evenly distributed among the other nature value categories (Figure 57, top right).

In general, it can be said that arable land with high nature value is very scarce in German landscapes, comprising only very little more extent in relatively extensive regions as compared to intensive regions. With regard to grassland, high nature value areas are as scarce as for arable land in the intensive regions, however about 50% of grassland with rather high or very high nature value were found in the one relatively extensive region DE-02-Albstadt (Table 6).

The amount of landscape elements with high nature value depends very much on the predominant type of landscape elements in a region. In DE-06-Jade, the most common type of landscape elements are ditches which are quite poor in structure and plant species, leading to only about 6% of high nature value landscape elements. In contrast, in DE-07-Magdeburg mostly hedges, field coppices, and complex elements occur which attain more often higher nature values. Consequently, in Magdeburg about 64% of its landscape element area judged as “rather high nature value” or “very high nature value” (Table 6).

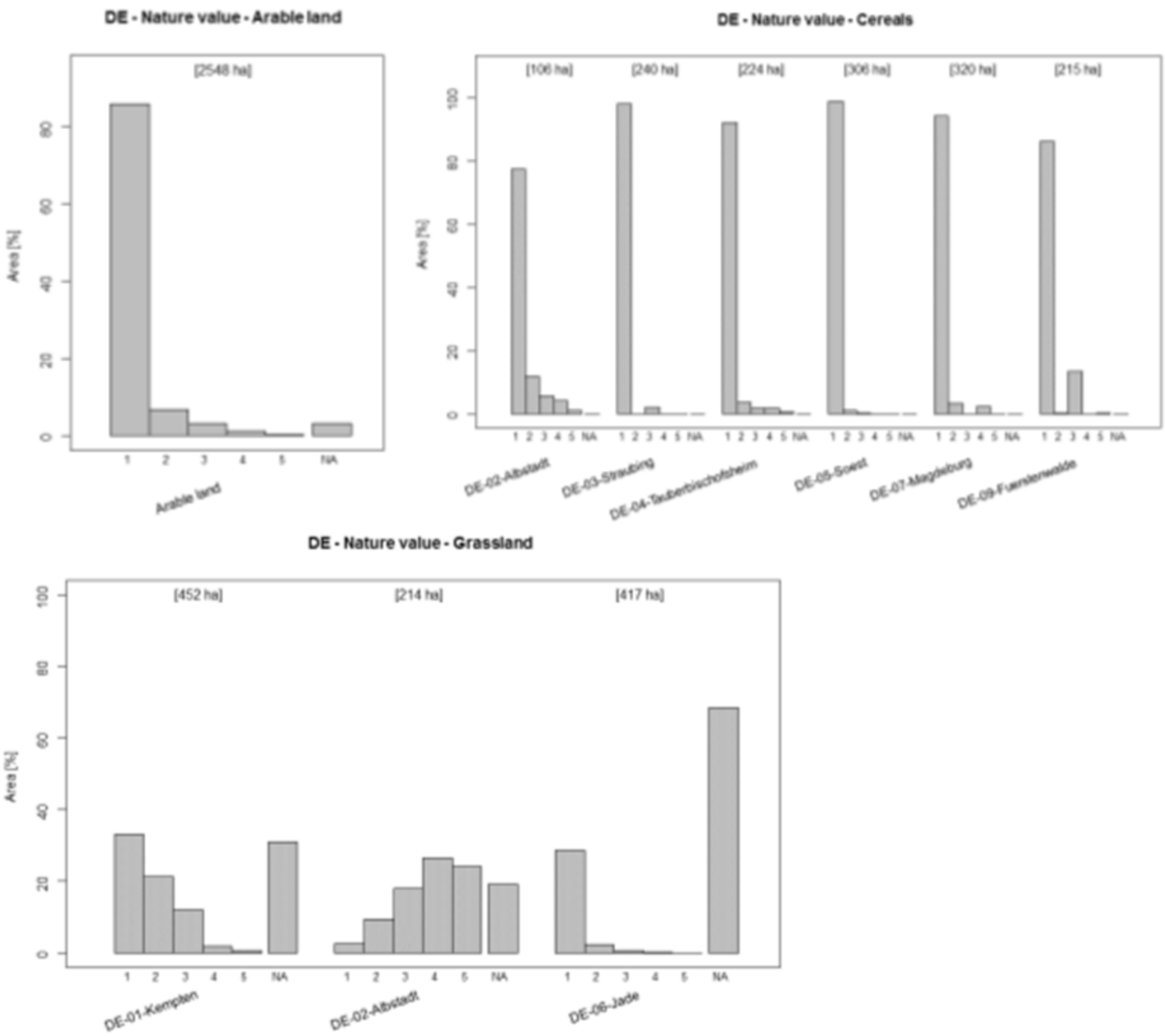


Figure 57: Nature value for arable land in eight German regions (top left); for cereals in the six regions with at least 100 ha of cereal fields evaluated (top right); for grassland in three regions with at least 100 ha of grassland evaluated (bottom). The bars show the area of each nature value level (levels 1 “very low nature value” – 5 “very high nature value”) as percentage of the total area of each landcover type in each region.

Table 6: Proportions of areas with high nature value (nature value 4 "rather high nature value" and 5 "very high nature value"), compared to low and medium nature value (1 "very low nature value", 2 "rather low nature value" and 3 "medium nature value").
Data from regions with less than 100 ha of arable land or grassland evaluated are greyed out.

	Arable land				Grassland				Landscape elements			
Region	NV≤3	NV>3	no data	total [ha]	NV≤3	NV>3	no data	total [ha]	NV≤3	NV>3	no data	total [ha]
DE-01-Kempten	(24.51%)	(0.00%)	(75.49%)	(31.25)	66.44%	2.60%	30.96%	451.76	38.95%	56.96%	4.08%	13.90
DE-02-Albstadt	82.46%	3.76%	13.77%	142.38	30.04%	50.73%	19.23%	214.01	51.71%	47.10%	1.20%	21.98
DE-03-Straubing	99.27%	0.02%	0.70%	497.89	(62.11%)	(20.25%)	(17.65%)	(34.55)	49.08%	48.95%	1.98%	27.02
DE-04-Tauberbischofsheim	95.45%	3.31%	1.24%	331.34	(15.02%)	(45.54%)	(39.44%)	(60.81)	54.26%	44.26%	1.48%	25.90
DE-05-Soest	98.32%	1.22%	0.45%	465.76	(51.67%)	(4.36%)	(43.98%)	(62.69)	69.21%	28.05%	2.75%	22.45
DE-06-Jade	(72.79%)	(0.00%)	(27.21%)	(80.50)	31.50%	0.10%	68.40%	417.38	93.03%	6.07%	0.90%	23.24
DE-07-Magdeburg	98.44%	1.40%	0.17%	543.23	(29.72%)	(54.63%)	(15.65%)	(16.71)	33.50%	64.22%	2.27%	19.70
DE-09-Fuerstenwalde	99.73%	0.13%	0.13%	455.89	(86.53%)	(3.18%)	(10.29%)	(48.12)	52.40%	42.95%	4.65%	26.39

In total the results of the case study Germany show that such an approach can be pursued on country level as well. The LISA study was designed to be implemented on European level. However, also on country level it's interesting when there are enough study regions which can be compared to each other.

5. Discussion

The LISA study 2014 is one of the first European field surveys working with concrete biodiversity and landuse parameters in a sample plot approach across many European regions. As the methodology was specially developed for this study, we will now discuss methodological aspects and also the significance for further greening. We don't use literature here because this report is dedicated to give a feedback to all involved partners and institutions and not for specific scientific discussion – however, we just want to reflect the findings in the indicated thematic fields with our thoughts.

Figure 58: Biodiversity is excellent in this rye field, - however, the yield will not be high in this example from Poland. Other examples show a more balanced situation between biodiversity and crop production (Figure 46).

5.1. Methodological aspects

Developing a new method has to be accompanied by reflection if the elements of the methodology are chosen well and if there are any better alternatives in elements of the methodology. We will give a few thoughts and experiences to the issues that arose during the survey 2014.

Selection of study regions: For the purpose of developing the methodology the regions selected proved to be ideal – just a mixture of intensive and extensive regions, of arable and grassland regions, of northern, southern, western and eastern European countries.

For a broader application, one could think about either a continuous sample approach across Europe or a random selection of study sites across Europe or of the application in all NUTS 3 or NUTS 4 regions (administrative regions). However, there are different advantages and disadvantages of each approach.

Distribution and size of the plots: The distribution of the plots with one plot every 25 km² (5 km x 5 km grid) proved to work quite well. A grid could be smaller (e.g. 2 km x 2 km) but it shouldn't be bigger than 10 km x 10 km as the time for driving from one to the next plot becomes much longer and also the heterogeneity of the landscapes covered increases with such a large grid. The plot size of 500 x 500 m proved to work well. It was a compromise between large-scale and small-scale landscapes.

Number of the plots: The number of plots for a thorough statistical interpretation would have to be worked out with statistics experts. The necessary number of plots depends largely on the desired quality, exactness and fidelity of the results that should be achieved. We had the impression that with the 25 plots per region we did in this pilot approach for developing the methodology we achieved a good overview of the values and typical composition of the regions (of the "average landscape"). Rare habitats and species of course cannot be identified with such a sample approach.

Selection of parameters: In general, the parameters chosen were fine – the time for filling the data sheets was in a good relationship to the time walking around in the plots and to the results we could use and work out. However, there are a few improvements which could and/or should be made (see chapter 6).

Key species lists for whole Europe: When drafting the methodology we were aware that just one species list for whole Europe will be a) difficult to work with, b) will cause criticism and c) will be difficult in application regarding the knowledge of the surveyors. However, as such species lists are already applied in big countries with quite different nature regions such as France we wanted to start this trial. We also wanted to avoid to work with several different key species lists and we wanted to find out what is worth to be developed further and what should be skipped.

The results were encouraging, - in spite of the fact that not all surveyors were familiar with the species lists. However, we found that there are a few species with a wide distribution that can and should be used in such a list. From our perspective, the list can be reduced to the most common species in order to have species for real comparison. On country level and/or regional level additional species could be added.

More weight can and should be given to the flowering species for the following reasons: a) they are easier to be identified (and to be seen) in the transects (compared to non-flowering key species) and b) there is an obvious relation to pollination aspects and c) the relationships of different indicators are similar regarding potential key species and flowering plant species.

Qualification of the surveyors: Almost all surveyors worked very well and there was no doubt about their qualification – in spite of the short time between starting the project and the field work. As a very important point it turned out that the surveyors had a good in-field-introduction with colleagues of the core study team of IFAB (Figure 59). Thus difficult issues in the field could be decided in field and through the direct and personal contacts further contact was facilitated and a quasi-hotline was available.

In total the survey and the applied methodology worked quite well - in spite of the short preparation time and the new approach. It was impressive how a huge amount of interesting and comparable data could be collected within a short time frame across Europe.

Figure 59: The survey comprised both intensive field work with recording the data as well as mapping and filling the data sheets (examples with colleagues from Spain (top) and from Poland (bottom)).

5.2. Results and their further significance for the greening policy in agricultural landscapes

The LISA approach was developed in order to contribute to better data approaches on nature value in Europe but it was also developed to contribute to reflect the nature and biodiversity situation in respect to landuse practice and greening[6] policy.

The results showed a wide range of very interesting results – positive results and negative results, expected and unexpected results, good and also bad examples of landuse etc.

Most striking from the positive side were:

- We could find quite a few positive examples of good landuse practice, e.g. with large buffer strips protecting hedges or water courses from pesticide and fertilizer input from adjacent fields.
- We could also find a few examples of fields with at the same time high crop yields and high biodiversity;
- The highest nature value and species numbers were associated with a medium landuse intensity; - this shows that considering biodiversity aspects in farming doesn't mean the necessity to go back to very low yields;
- We could find interesting figures regarding the extent and width of buffer strips before implementation of the CAP greening as well as data on the extent, quality and nature value of landscape elements;
- As a very interesting point it turned out to achieve data on the pollination potential by recording flowering species in fields, in grassland as well as the amount and kind of landscape elements in different agriculture landscapes.

In contrast to these main positive results there were also negative results, some of them unexpected and alarming:

- In nearly all arable landscapes including the landscapes expected to be managed in a more extensive way we found a really very low biodiversity in the arable fields. Obviously in nearly all arable fields spraying and partly fertilizing is such intensive that hardly any other than the crop species occur.
  Related to these figures also the pollination potential of the arable fields turned out to be extremely low.
- Also in grassland – in the intensive grassland regions – the number of potential key species, of flowering species and of parcels with high flowering density was low or very low. These regions are managed at least as intensive as arable landscapes and beside biodiversity consideration, also pollination and other ecosystem services are not delivered to a considerable extent.
- Last but not least we also found a number of bad landuse practices and examples which should not occur any more (e.g. spraying in ditches and hedges, soil erosion, etc.).

Regarding the significance of the multitude of results on biodiversity and landuse practice it will be interesting if with the greening element "buffer strip" in the current CAP implemented in practice in 2015 the extent and the width of buffer strips will increase and if negative examples of landuse like spraying in ditches and hedges are likely to disappear. Moreover it may be possible that farmers use the opportunity of implementing random strips and fallow areas on difficult sites such as the borders of hedges or ditches or on moist sites – this would occur as positive element of the greening policy

[6] Greening not in the sense of the current CAP-regulation but in a wider sense (in order to achieve a "greener" and more nature sound agriculture).

and could be proved with the data of LISA 2014 compared to data which can be recorded in 2016 on the same plots.

Bearing the first results in mind it should be considered a strategy how to enhance medium landuse intensities to a certain extent in area (to a certain minimum extent) in order to support pollination, biodiversity and other ecosystem services throughout the European landscapes. More weight should be given to this aspect of agrobiodiversity and landscape ecology.

A third aspect is a methodological one regarding monitoring and evaluation for the greening policy in agricultural landscapes: on the European level methods with an annual or biannual recording of biodiversity indicators in the field can help to detect the development of biodiversity, pollination potential and related ecosystem services accurately in time alongside with policy development in order to have actual data and in order to be able to react quickly on the results of such a kind of monitoring.

6. Experiences on the applicability and effectiveness of the field survey and outlook for the further work

The field survey was carried out by several persons in many plots. Thus a broad base for applicability of the protocol is available.

First of all – all the results achieved and interpreted show that the field surveyors were mostly successful in applying the protocol. There was a hotline during the field survey in respect of occurring questions. Most of them could be answered, for a few issues the experiences were collected and have to be decided later for the further development of the protocol (e.g. the question of scale: initially we worked with 5 categories of landuse intensity from 1 – low to 5- high, but during the field survey it turned out that sometimes a category in between e.g. 2 and 3 – thus 2.5 – would be suitable in order to make differences between the differently managed fields).

The effectiveness of the protocol was given and underlined by the fact that most surveyors were able to complete their survey within 5-6 days (25 plots – the calculation was 5 days for 25 plots – thus 5 plots per day in average). However, this requires a good training of the surveyors. In some cases of small scaled agriculture e.g. in mountainous regions this target could not fully be met (some surveyors needed 10 days for the 25 plots).

In total the project team was satisfied with the protocol and the work in the field – thus in our view the protocol has proved its applicability and effectiveness even if there are several issues which can be improved.

6.1. General experiences with the protocol

In this following subchapter a rough list of notes and recommendations for improving the protocol is given, also some experiences from other plots and other countries than the described ones here in this report. These points derive from reports of the surveyors working in the field, - they need to be checked in detail before implementation.

- The plot size was generally seen as appropriate, even though the time needed for one plot differed greatly from region to region, depending on infrastructure/ accessibility and heterogeneity of the plot.
- Except for the UK, the accessibility of plots was mostly unproblematic. In the UK farmers generally didn’t allow to enter their fields.
- GPS-navigation systems were essential for surveyors working alone. For finding remote plots, a smartphone with Google maps showing the surveyor’s position on satellite pictures proved very helpful. A smartphone was also helpful for car navigation. Important in this context is the battery content and the possibility to charge / recharge the batteries.
- Overview prints/maps showing the surrounding of a plot are helpful to find the plot.

Some detailed proposals for improvements of the field protocol were noted and given by the surveyors. They are listed in Annex 7.

All the notes and proposals given show that the surveyors have worked intensively with the protocol and as usual for the development of such a protocol all kind of thinkable and “unthinkable” cases of landuse and specific situations occur. The protocol has to give instruction for all these cases.

6.2. Recommendations for the application of a next LISA survey

The LISA survey is intended to be continued and extended in the following years. As the method has proved to be applicable and quite interesting results could be worked out with the 2014 approach we propose to do a next LISA survey in 2016 in order to achieve the following:

- In 2015 and 2016 the greening elements of the current CAP will be put in practice – thus it is possible to compare the 2014 results with 2016 results and detect the progress made in reality on behalf the regions selected – using the 2014-survey as baseline and the 2016-survey as comparison in order to identify and document the effects. Such a comparison could form a part of the evaluation of the CAP greening. For example results regarding the introduction of buffer strips and fallow land can be expected.
- Also regarding the greening good practice examples can be documented (photo documentation across all participating countries or regions).
- The repetition of the survey will deliver methodological results, e.g. to which extent there is a reliability of data and to which extent where will be changes in landuse and landscape structures.
- The improvement of the methods shall be tested (especially regarding data input in data sheets and maps – using a new data form). Some further details can be extended (e.g. explicit consideration of pollination issues, some aspects of the description in the guidance) and the application and of the approach can be improved by an early start in autumn 2015.
- The application in different regions can be extended to further countries and regions in Europe (e.g. Greek and Scandinavian partners have asked to participate) and to administrative units (e.g. to NUTS 3 or NUTS 4 level in order to compare other agricultural data with LISA data).
- Thus there is a wide range of different issues that shall be investigated with a LISA-2016-survey.

All these aspects and the results of a 2016 survey as well as the comparison of 2014 to 2016 results can be fed in the review of the current CAP taking place in 2017. The results will also be useful in a future monitoring (e.g. either by integration in the European LUCAS approach, or in another monitoring approach in cooperation with the Member States). Finally, some aspects of the LISA approach are interesting from a scientific point of view, for example regarding statistical aspects and application of medium landuse intensity technology to assure ecosystem services.

However, a LISA-2016-survey needs a sufficient financing. In 2014 the survey was done on own initiative, with the help of some supporting institutions and funding organisations and with a lot of volunteer work. For planning a LISA-2016-survey we would like to start in early autumn 2015 with the following issues:

- Developing an electronic entry form for the field data.
- Recruiting the field surveyors for 2016.
- Fine tuning of the field guidance with the help of the surveyors 2014 (organising a work meeting).
- Decision on the regions to be involved – repetition of the suitable 2014 regions and adding a few new regions in the survey (e.g. in Greece and Sweden).

Regarding the overall approach the LISA survey can and shall remain mainly the same as in 2014.

6.3. Outlook and perspectives for further work

The pilot study in 2014 already shows many interesting results regarding species richness, pollination potential, landscape elements and buffer strips etc. in arable fields and in some grassland regions, - all based on a common European method. The data interpretation demonstrates the suitability of the chosen approach. Exact data on the situation in landscapes before greening implementation across the EU have been collected as well (baseline data 2014). Beside the direct results a lot of experience has been collected in cooperation with many different partners across Europe.

The next steps will be the compilation of publications on these results of the project, the fine tuning of the methodology for the following surveys and the acquisition of a project budget for 2015/2016. It is intended to start the follow-up project in autumn 2015 and a field survey in 2016 which will deliver comparison results showing for example the changes in agricultural use – especially related to greening. These results could be used for the further development of the CAP /Common Agricultural Policy. In respect of agricultural practice the photos collected during the LISA-approach in 2014 will help to demonstrate good and bad landuse practice and show ways how agriculture can develop further.

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8. Annexes

Annex 1 Main sheet – Overview on the main sheet information to be collected

The explanations below follow the structure of the main sheet (field form; see annex 2) and provide a basic definition and description of each element.

Items	Description
(1) Surveyor name	Initials of the surveyor
(2) Plot-ID	Unique code of the plot including information on country and region. (will be provided)
(3) Date	Date of observation in the format YYYY/MM/DD.
(4) Number on map	Every observed element is given a consecutive number with two digits by the surveyor starting from 01. The number is also noted on the aerial photo of the plot in a way that it can be attributed to the element.
(5) Landcover	Coding of land cover according to the classification in the "Code-list Landcover", Annex 2. e.g. A11 (arable field with common wheat) E51 (Landscape element: unpaved farm track) If an element is assigned one of the following categories, the exact plant species / species assemblage has to be noted: A 19 Other cereals A 23 Other root crops A 35 Other fibre and oleaginous crops A 42 Other permanent industrial crops A 54 Other fresh vegetables A 66 Other legumes and mixtures for fodder A 72 Other non-permanent crops A 87 Other fruit trees and berries A 94 Other permanent crops If an element is assigned one of the following categories, a description / specification has to be made (in English): E 63 Other landscape elements (please describe) If an element has more than one landcover type (e.g. mixed crops), all types are noted in this field and a remark is made in the remarks section explaining why there is more than one entry (e.g. "mixed cropping of rye and lentils"). Special case: orchards on grassland/arable land get an appendix according to the density of the stand of trees (see "Code-list Landcover"). E.g. a meadow orchard with an open stand of trees (coverage 5-25%) is coded C31-2.

(6) Landuse intensity	Coding of the landuse intensity of an element (only land cover categories A [arable land], C [grassland], and E21 [buffer strips]). Land use intensity is estimated in 5 categories mainly based on structure and density of the stand (see detailed description on page 9).
(7) Nature value	Coding of the nature value of an element (only land cover categories A [arable land] – E [landscape element]). The nature value is estimated in 5 categories based on biodiversity and structural parameters (see detailed description on page 10).
(8) Size of the element	The size of parcels will be calculated by GIS (done by IFAB), whereas the size of linear and punctual elements has to be recorded via width and length (length only for small or new elements).
(8.1) Width	The width of linear and punctual elements with a width of ≥ 1 m and < 10 m is estimated in the field. For elements with heterogeneous widths, the average width is estimated. If necessary, the width is measured at different points by step length. Also a heterogeneous element can be subdivided into two or more homogeneous elements for ease of estimating the width (see example on page 8). Elements with a width < 1 m are added to the neighbouring element. Landscape elements are added to other landscape elements with priority. They are added to agricultural parcels only if there are no directly adjacent landscape elements. Elements with a width > 10 m are treated as areal elements. Their size is calculated in GIS.
(8.2) Length	The length of linear elements shall be recorded only for elements shorter than 10 m. For longer elements it will be calculated by GIS (IFAB) but please make sure that the contouring line you draw on the photo is correct.
(9) Ecological sensitivity	Coding of ecological sensitivity of an element, if applicable, according to the description below (page 17).
(10) Habitat type	Coding of the habitat type in case an element can be attributed to a habitat type according to the Habitats Directive (see description on page 19).
(11) Photo No.	Photos are taken following a standardised method (description on page 35). Use this field to note the numbers given to the photos automatically by the camera.
(12) Remarks	Any relevant remarks, e.g. if a field is harvested and therefore no identification of crop is possible, etc. are filled in here. In case there is more space needed for a remark, it can be written on the backside of the sheet. Reference is made by a number in a circle ① which is written in the reference field as well as at the beginning of the remark on the backside. Remarks have to be noted in English.
(13) Plot nature value	This item is a subjective estimation of the surveyor concerning the nature value of the study plot (see description on page 19).
(14) General judgement	A personal judgement of the surveyor on the overall landuse intensity, biodiversity and biodiversity potential of the investigation plot is given with verbal comments and / or a rough general estimation in categories (see description on page 20).
(15) Further remarks	This item is for remarks concerning anything related to further issues and to the study methodology. Please note what could be interesting in your mind. For example: Were there any special nature observations or landuse practices? Which parameters are missing in the record and should be added to the next survey? Which parameters should be deleted or changed, which ones should be considered stronger in order to record the characteristics of the whole plot? Are there points in the manual which are unclear / need revision? → Please make suggestions.

Annex 2 - Field form of the main sheet

Main sheet Plot-ID: (2) ....

Surveyor: ..(1)............................... Date: 2014/ .... / .... (Year/mm/dd) (3)

Number on map	Landcover	Landuse intensity	Nature value	Size of element		Ecolog. sens.	Habitat type	Photo number	Remarks
				Width	Length				
(4)	(5)	(6)	(7)	(8.1)	(8.2)	(9)	(10)	(11)	(12)

Number on map	Landcover	Landuse intensity	Nature value	Size of element		Ecolog. sens.	Habitat type	Photo number	Remarks
				Width	Length				

General judgement of the plot **Plot nature value:** (13)

- Landuse intensity: ....
- Biodiversity: (14) ....
- Bidiversity potential: ....

Further remarks: (15) ....

....

Annex 3 - Information to be collected on the vegetation sheet – arable land

The vegetation sheet has to be filled out on the transect walks. The information collected on the vegetation sheet will be used to assess the nature value of the arable fields.

Recording of potential key species on transect walks

The method of recording key species on transect walks has proved to be effective in several grassland schemes in France, Germany and in small plots in Switzerland. Also for arable land, key species lists are applied for several purposes.

However on the European level such an approach has not been applied yet. The record of potential key species is a pilot study. Therefore the species which are in the list are only "potential" key species. It will have to be proved if they qualify as "real key species". However, we want to make sure that at least all species or taxa on the list are recorded (for reasons of comparability). Therefore, of course many species are on the list which may not occur at all in your region or your country because the list comprises species of all European regions. In many cases it will be necessary or at least desirable to note more in detail which species of a taxon occurs (e.g. *Ranunculus acris* or *Ranunculus bulbosus*).

There will be for sure some other species which you might consider as valuable potential key species. Please feel free to note these species. This will help us to develop the approach further.

Transect walks

Transects are 30 m in length and the observation frame is 1 m to each side of the surveyor.

It is advisable to walk the 30 m transect first with a step length of 1 m to determine the end point and then walk the transect back to the starting point doing the observations.

The items of the vegetation sheet are described in the following table.

Items	**Description**
(1) Surveyor name	Initials of the surveyor.
(2) Point-ID	Unique code of the point including information on country – region – plot (1-25) – transect(1-4). E.g. De – 1 – 05 – 02 (Germany - Kempten – plot number 5 – transect 2).
(3) Date	Date of observation in the format YYYY/MM/DD.
(4) Coordinates	Coordinates of the starting point of the transect.
(5) Photo No.	Photos of the vegetation are taken following a standardised method (page 35). Use this field to note the number(s) of the photo(s) automatically given by the camera.
(6) Exposition / Inclination of slope	The exposition is the horizontal direction to which the slope of the parcel faces. E.g.: East for a slope facing to the eastern direction. For the inclination see page 33.
(7) Information from main sheet	Transfer the information from the main sheet to the vegetation sheet.
(8) Crop	E.g. rye, maize, etc. see code list. (fill in the code number according to annex 6).

(9) Height and stage of crop	The height is measured in [cm] and the stage is noted (see defined code list for crop stages in the annex). Please consider the height of the main mass of the crop not of single high stalks of e.g. wheat.
(10) Total coverage	The total coverage of vegetation is estimated in % (value between 0 % and 100 %). (The total coverage is not the sum of crop and wild plant coverage (see below) as both can overlap. The sum of coverage of crop and of wild plants may exceed 100% whereas total coverage may not exceed 100%).
(11) Coverage of crop / type of vigour	The coverage of the crop plants is estimated in %. The type of vigour is noted according to the description / sketch on page 33.
(12) Coverage of wild plants	The coverage of non-crop plants is estimated in % (excluding second growth plants of a previous crop).
(13) Total number of flowering plant species / Flower density	The number of insect-pollinated non-crop plant species (including plants which are not flowering at the time of observation) is counted (species with +/- coloured flowers, not grasses and sedges, also excluding second growth plants of a previous crop). The density of insect-pollinated plants (again including plants which are not flowering at the time of observation) is recorded according to the scale further down.
(14) Number of potential key species	Count the number of potential key species (every species, eg. *Papaver rhoeas* and *Papaver dubium* are counted as two species), which you have observed on the transect walk.
(15) Remarks	Any remarks, e.g. if a field is harvested, therefore no identification of the crop, etc.
(16) Potential key species	The presence of a species / genus from the list along the transect is marked with ×. For more than one species of a genus write e.g. × × or × 2.
(17) Species determination	The species of a genus has to be specified here. **If the box is framed you have to specify the species** (e.g. for the genus *Adonis* spec.). If the box is not framed, specification of the species is not obligatory. Nevertheless, a specification would be very useful. For a genus with a framed box, the "Photo illustration of potential key species" may help.
(18) Other potential key species	You may find other species which you consider to be suitable as key species* or as extraordinary / characteristical species that are not yet included in the key species list to date. Please note these species. This item is for further development of the key species list.
(19) Dominant species	Any dominant non-crop species shall be noted (not necessarily a species from the key species list). A species is considered dominant if it covers more than half of the area covered by wild plants as in (12). This is only applicable if coverage of wild plants exceeds 10 %.

* Suitable potential key species are species

- that are easily to be seen / identified (e.g. *Adonis aestivalis*, *Centaurea cyanus*)
- that indicate species rich arable land (those species which occur occasionally on extensively used parcels).
- that are neither too seldom nor too common

Annex 4: Field form vegetation sheet arable land

Vegetation - Arable Land

Surveyor: (1) ....

Point-ID: (2) ....

Date: 2014 / .... / .... (Year/mm/dd) (3)

Coordinates: (4) ....

Photo No.: (5) ....

Exposition / Inclination of slope: .... (6) ....

Information from	No. on map	Landcover	Landuse intensity	Nature value	Ecological sensitivity	Habitat type
main sheet:	(7)					

Crop: (8) ....

Height / Stage of crop: (9) ....

Total coverage: (10) ....

Coverage of crop / Type of vigour: (11) ....

Coverage of wild plants: (12) ....

Total number of flowering plant species / Flower density: (13) ....

No. of potential key species (list below): (14) ....

Remarks: (15) ....

Potential key species	Observ.	Species determination
Adonis spec. (16)		(17)
Agrostemma githago		
Ajuga chamaepitys		
Allium spec.		
Ammi majus		
Anagallis spec.		
Anchusa azurea		
Andryala integrifolia		
Anthemis spec.		
Aphanes spec.		
Aristolochia clematitis		
Arnoseris minima		
Asperugo procumbens		
Asperula spec.		
Bellardia trixargo		
Bidens tripartita		
Blackstonia perfoliata		
Bupleurum rotundifolium		
Calendula arvensis		
Camelina microcarpa		
Carduus pycnocephalus		
Caucalis platycarpos		
Centaurea spec.		
Cerinthe minor		
Chrysanthemum spec.		
Consolida spec.		
Delphinium halteratum		
Epilobium spec.		
Erodium cicutarium		
Eryngium campestre		
Erysimum spec.		
Euphorbia spec.		
Filago spec.		
Filipendula ulmaria		
Fumaria spec.		
Gagea arvensis		
Galactides tomentosa		
Galeopsis speciosa		
Geranium spec.		
Gladiolus segetum		
Gypsophila muralis		
Heliotropium annuum		
Hypochaeris spec.		
Kickxia spec.		
Knautia integrifolia		
Lamium spec.		
Lappula squarrosa		
Lapsana communis		
Lathyrus spec.		
Legousia spec.		
Lepidium perfoliatum		
Limosella aquatica		
Linaria spec.		

Potential key species	Observ.	Species determination
Lithospermum arvense		
Lotus ornithopodioides		
Lycopsis arvensis		
Lythrum spec.		
Matricaria spec.		
Medicago spec.		
Melampyrum arvense		
Mentha arvensis		
Misopates orontium		
Muscari spec.		
Myagrum perfoliatum		
Myosotis spec.		
Myosurus minimus		
Neslia paniculata		
Nigella spec.		
Odontites vernus		
Orlaya spec.		
Ornithogalum spec.		
Ornithopus perpusillus		
Orobanche spec.		
Pallenis spinosa		
Papaver spec.		
Potentilla supina		
Ranunculus spec.		
Rapistrum rugosum		
Rhagadiolus stellatus		
Rumex spec.		
Scandix pecten-veneris		
Sherardia arvensis		
Sideritis romana		
Silene spec.		
Spergula arvensis		
Spergularia rubra		
Stachys spec.		
Teesdalia nudicaulis		
Thlaspi arvense		
Thymelaea passerina		
Torilis arvensis		
Tragopogon spec.		
Trifolium spec.		
Trigonella corniculata		
Tulipa sylvestris		
Valerianella spec.		
Vicia spec.		

Other potential key species: (18)

Dominant species: (19)

Annex 5: Information to be collected on the vegetation sheet – grassland

The vegetation sheet has to be filled out on the transect walks. The information collected on the vegetation sheet will be used to assess the nature value of the grassland. The items of the vegetation sheet are described in the following table.

Items	**Description**
(1) Surveyor name	Initials of the surveyor
(2) Point ID	Unique code of the point including information on country – region – plot (1-25) – transect (1-4). E.g. De – 1 – 05 – 02 (Germany - Lower Saxony – plot number 5 – transect 2)
(3) Date	Date of observation in the format YYYY/MM/DD.
(4) Coordinates	Coordinates of the starting point of the transect.
(5) Photo Number	Photos of the vegetation are taken following a standardised method (page 35). Use this field to note the number(s) of the photo(s) automatically given by the camera.
(6) Exposition / Inclination of slope	The exposition is the horizontal direction to which the slope of the parcel faces. E.g.: East for a slope facing to the eastern direction. For the inclination see page 33.
(7) Information from main sheet	Transfer the information from the main sheet to the vegetation sheet.
(8) Characterisation of vegetation type	Define the degree of moisture, as described below (page 33). If it is easily possible note the plant association.
(9) Management type	Note if the parcel is used as a pasture, a meadow, a mowed pasture or not at all. Note the code for the type of shrub coverage which you can find further down.
(10) Type of vigour	The type of vigour is measured in 5 categories described below (page 33).
(11) Height main stratum / other strata [cm]	The height is measured in [cm]. The height of the main stratum (most biomass) is noted first. If there are other strata, note the height of the lowest and highest in parenthesis. For example 70 (50-140) cm. This means that the main biomass is in the vegetation stratum up to 70 cm but there are further layers of the vegetation between 50 cm and 140 cm height.
(12) Total number of flowering plant species / Flower density	The number of insect-pollinated non-crop plant species (including plants which are not flowering at the time of observation) is counted (species with +/- coloured flowers, no grasses/sedges). The density of insect-pollinated plants (again including plants which are not flowering at the time of observation) is recorded according to the scale on p.34.
(13) Number of potential key species	Count the number of potential key species (every species, eg. *Campanula patula* and *C. persicifolia* are counted as two species), which you have observed on the transect walk.
(14) Remarks	Any remarks, e.g. if a grassland is mown and the identification of species is not possible.
(15) Potential Key species	The presence of a species / genus from the list along the transect is marked with ×. For more than one species of a genus write e.g. × × or × 2.
(16) Species determination	The species of a genus has to be specified here. **If the box is framed you have to specify the species** (e.g. for the genus Ranunculus). If the box is not framed, specification of the species is not obligatory. Nevertheless a specification would be very useful. For a genus with a framed box the "Photo illustration of potential

	key species" may help.
(17) Other potential key species	You may find other species which you consider to be suitable as key species* or as extraordinary / characteristical species that are not yet included in the key species list to date. Please note these species. This item is for further development of the key species list.
(18) Dominant species	Any dominant species shall be noted. A species is considered dominant if it covers at least 25%.

* Suitable potential key species are species

– that are easily to be seen / identified (e.g. *Chrysanthemum leucanthemum, Trifolium pratense*)
– that indicate species rich grassland (those species which occur occasionally on extensively used parcels).
– that are neither too seldom nor too common

Annex 6: Field form vegetation sheet grassland

Vegetation - Grassland

Surveyor: (1) ....

Point-ID: (2) ....

Date: 2014 / .... / .... (Year/mm/dd) (3)

Coordinates: (4) ....

Photo No.: (5) ....

Exposition / Inclination of slope: .... (6) ....

Information from	No. on map	Landcover	Landuse intensity	Nature value	Ecological sensitivity	Habitat type
main sheet: (7)						

Characterisation of vegetation type: (8) ....

Management type/ shrubtype: .... (9) .... / ....

Type of vigour: (10) ....

Height main stratum / other strata [cm] .... (11) ....

Total number of flowering plant species / Flower density .... (12) ....

No. of potential key species (list below) .... (13) ....

Remarks: (14) ....

Potential key species	Observ.	Species determination
Achillea spec. (15)		(16)
Agrimonia eupatoria		
Ajuga reptans		
Alchemilla spec.		
Althaea officinalis		
Anthericum liliago		
Anthyllis vulneraria		
Apiaceae spec.		
Armeria spec.		
Artemisia spec.		
Aster spp.		
Asteraceae yellow flowers		
Astragalus spec.		
Betonica officinalis		
Caltha palustris		
Campanula spec.		
Cardamine pratensis		
Carlina spec.		
Centaurea spec.		
Centaurium spec.		
Cerastium arvense		
Chamaespartium sagittale		
Cirsium spec.		
Clematis integrifolia		
Clinopodium vulgare		
Coronilla spec.		
Cyperacea spec.		
Dianthus spec.		
Euphorbia spec.		
Euphrasia spec.		
Filipendula spec.		
Fumana procumbens		
Galium white flowers		
Galium verum		
Genista spec.		
Gentiana spec		
Geranium spec.		
Geum rivale		
Helianthemum spec.		
Hippocrepis comosa		
Hypericum spec.		
Iris spec.		
Juncus spec.		
Knautia spec.		
Lathyrus spec.		
Lavandula angustifolia		
Leucanthemum spec.		
Limonium spec.		
Linum spec.		
Lotus spec.		
Luzula spec.		
Lychnis spec.		
Lysimachia vulgaris		
Lythrum salicaria		

Potential key species	Observ.	Species determination
Medicago blue flowers		
Medicago yellow flowers		
Mentha spec.		
Myosotis spec.		
Narcissus spec.		
Onobrychis spec.		
Orchidaceae spec.		
Origanum vulgare		
Ornithogalum spec.		
Paradisea liliastrum		
Parnassia palustris		
Phyteuma spec.		
Polygala spec.		
Polygonum bistorta		
Potentilla spec.		
Primula spec.		
Prunella spec.		
Ranunculus spec.		
Rhinanthus spec.		
Rumex spec.		
Salvia spec.		
Sanguisorba spec.		
Saxifraga granulata		
Scabiosa spec.		
Scutellaria spec.		
Securigera varia		
Serratula tinctoria		
Silene spec.		
Stachys spec.		
Stellaria spec.		
Succisa pratensis		
Symphytum spec.		
Thalictrum spec.		
Thymus spec.		
Trifolium red flowers		
Trifolium yellow flowers		
Trifolium white flowers		
Trollius europaeus		
Valeriana spec.		
Verbascum spec.		
Vicia spec.		
Viola spec.		

Other potential key species: (17)

Dominant species: (18)

Annex 7: Detail proposals for improving the field protocol (methodology) – not decided yet (just a collection of proposed points – needs to be reviewed for the follow-up-survey).

In this annex some detailed proposals for improvements of the field protocol are given.

Landcover categories

- Include a field for the number of the overview picture in the headline of the main sheet.
- Indicate the degree of scrub encroachment also for meadows/pastures (not only degree of tree cover on meadow orchards).
- Triticale and Durum wheat do not necessarily have to be distinguished from common wheat (they can be distinguished if known or otherwise recorded as “wheat”)
- Categorise the density of meadow orchards according to the distance of tree stems instead of the crown cover. In that way, newly established meadow orchards already receive a high nature value rating and not only after x years.
- Extend category “E53 - paved farm tracks” to “paved and cobbled farm tracks”. Cobbled farm tracks with grass strips in the middle receive nature value “2” (or “3”) and thus correspond to a pure gravel or dirt track (or dirt/gravel track with grass strip, respectively).
- The category “E61 – complex elements” includes partly “E21 – buffer strips” which will bias data analyses, because the area proportion of E21 will be underestimated.
- Join categories “N41 – Buildings/villages and private garden areas” and “N51 – Roads and railways inclusive adjacent landscape elements” to “N41 – Settlement area and transport”.
- It needs to be specified more clearly what is “shrubland”, how it is distinguished from grassland with trees/bushes, how its nature value is assessed, and whether it receives a landuse intensity rating (e.g. in case it is used by shepherds from time to time) or not.
- The division of roads and tracks in landscape elements (farm tracks: E51-E54) and non-agricultural elements (official roads: N51) has turned out to be very much dependant on the different countries. E.g. a 4 m gravel track can in some countries be a common official road linking two villages, whilst in other countries this will almost never be the case.

New categories to be included

- Afforestation areas;
- Meadows which are both mown and pastured, or whose type of use is unclear; Litter meadows (occurs e.g. in alpine and pre-alpine regions);
- Fallow grassland (or if not then fallow grassland has to be characterised / identified by landuse intensity);
- Flowering strips (and determine how to rate their nature value);
- short rotation coppice
- Wooden energy plants (e.g. poplars, willows) which are not managed as short rotation coppice;

- Fallow vineyards;
- Small groups of trees (3 trees), which do not have the character of a coppice but can neither be recorded as solitary trees, because they stand together (or extend the category “solitary trees” to small tree groups);
- Ditches and streams with trees/bushes (perhaps e.g. “E33-1” to “E33-5” according to the degree of coverage);
- Other non-agricultural areas, such as e.g. forestry fallows or mining areas;
- Dikes, embankments (grown with herby or woody vegetation) – also take account of special management form: “flower dikes”;
- Recreational track or road (with bridges, styles, marks, plates, etc.) – important elements for accessibility of countryside and multi-functional agriculture;
- Field gardens;
- Debris tips.

<u>Landuse intensity</u>

- Determine which land use intensity is assigned to mown grassland if mown before a date x. Later in the year, it is virtually impossible to assess if the meadow was mown for the first or second time;
- Clarify in which case a landuse intensity may be predicted for fields with young plants (where the density of the crop stand cannot be assessed but only predicted);
- It was seen as very difficult to evaluate the mowing/mulching frequency of buffer strips. Include examples in the protocol.

<u>Nature value</u>

- Include intermediate values for nature value assessment (1-2, 2-3, etc.). Rating has sometimes turned out to be difficult with only five categories, particularly in the middle range.
- Determine how to rate flowering crops like sunflower or lupine (there are often very few segetal plants on the field but still these fields have a certain nature value by providing resources for pollinators);
- The lowest possible nature value for most landscape elements is “3”. Some field surveyors have found it inappropriate to rate certain landscape elements as high (e.g. ditches in northern Germany are mostly very species-poor regarding both, the margin vegetation and the water vegetation, and their presence is responsible for changes in species communities of wet meadows and facilitates arable farming).

<u>Habitat type</u>

- The manual should include a description of the most common/important N2000 habitat types (e.g. how to determine whether a meadow is 6510/6520 or not).

<u>Vegetation sheet</u>

- The stage of crop is hard to assess for some cultures like sugar beet, cabbage, onions, Lucerne. The question was raised if a precise classification of crop stage is necessary at all, or if a rough estimation would be sufficient.
- To keep order, vegetation sheets should be filled in also if a transect cannot be done, stating the reasons why the transect was not done.
- Change the protocol to include the following case: if there are no walkable structures like farm tracks on the plot, the starting point of any transect is determined as usual, starting from the point where the surveyor enters the respective field, choosing the easiest way of access.
- Indicate that "type of vigour" for permanent crops is the type of vigour of the undergrowth.
- Indicate that no transect needs to be done on flowering strips.
- Particularly in cereal fields, it is easiest to do the transect walks in the tractor traces; however sometimes, there are more segetal plants in the traces than in the field. It needs to be indicated that if the transect is walked in a trace, plants growing in the trace have to be excluded.
- Split the list of potential key species into a southern and a northern list, for ease of use.
- Some surveyors have noted that they would prefer if the list of potential key species was ordered by family rather than alphabetically.
- For arable fields with very young growth, it was sometimes difficult to determine potential key species, as well as flower density (unclear which seedlings are insect pollinated plants).

All the notes and proposals given show that the surveyors have worked intensively with the protocol and as usual for the development of such a protocol all kind of thinkable and "unthinkable" cases of landuse and specific situations occur. The protocol has to give instruction for all these cases.

With the help of all these notes and recommendations the further development of this protocol and field survey is possible.