LUCAS grassland module 2018
- Description and validation –

A project for the EUROPEAN COMMISSION – EUROSTAT

Grassland test module report for the LUCAS-website

Project carried out by

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Content

1 Introduction

LUCAS is the abbreviation for the Land Use / Cover Area frame Survey (http://ec.europa.eu/eurostat/web/lucas). EUROSTAT realised this survey every 3 years since 2006 to identify changes in land use and cover in the European Union with a common approach. LUCAS surveys are carried out in situ; this means that observations are made and registered in the field all over the EU. Surveyors examine land cover and land use, irrigation management and structural elements in the landscape. For the statistical sample of the LUCAS survey, a regular 2 km grid with over 1,100,000 points is overlaid on the EU territory: of these points, a sample of 337,855 points was assessed in the LUCAS 2018 survey either in-situ or through photointerpretation.

In 2018, a grassland test module was added to the LUCAS survey. Up to 2015 there was no recording of qualitative information on the grassland – in contrast to the arable land in which already were specific information such as the kind of crops is recorded. The aim of this grassland survey is to provide qualitative information on the grassland, especially regarding its biodiversity value. Surveyors assessed a subset (n=3734) of LUCAS points on grassland via various structural and plant taxa indicators. As this module was new, the quality of data has been verified on a subset of the grassland module points (n=747 over the whole EU). This verification was executed by experienced botanists performing full species inventories (relevé, 50 m²) in addition to a repeat of the grassland module survey.

Summary	**Number of points to be surveyed 2018**
Main LUCAS survey	337,855
Subset with additional grassland module	3734 (ca. 1% of total and about 5 % of the grassland points)
Subset with expert vegetation survey	747 (c. 20% of grassland module points)

2 Aim of the grassland module

In the LUCAS surveys prior to 2018, grassland as a landcover was simply classified as being with or without trees or being spontaneously re-vegetated surface, and not further differentiated. However, grassland covers around one fifth of the EU territory, and includes a very wide variety of different vegetation types. It plays an important role economically for farming, ecologically for water- and climate protection and for biodiversity, and culturally for the identification of cultural landscapes and for recreation and tourism. Especially the ecological and biodiversity-related factors are becoming increasingly important for land management and policy decisions. There is therefore a need for more detailed information on the status of grassland: how it is used (e.g. high or low intensity, grazing or mowing), if it is old or young grasslands (≥ 5 years, < 5 years), if it is fertilised or not, the species richness and biodiversity status, and its provision of pollination services. Systematically collected data on these parameters can e.g. help inform about the effects of agricultural and environmental policy on European grassland. Such a large, geographically widespread and long-running dataset is also potentially of great use to scientists. Gathering these data from a statistically representative sample would allow conclusions to be drawn at the level of the EU, biogeographic region, or member state.

Thus, starting in 2016 a more detailed grassland monitoring method was developed. This method was tested in a pilot in spring / early summer during the LUCAS 2018 survey on a subset of the available LUCAS grassland points, spread across 26 EU member states (Figure 1). This was the first time a standardized methodology has been used to collect ecological data on grasslands in a coordinated manner over so wide a geographical range in Europe. The aim of this pilot was to validate the methodology, not to collect statistically significant information.

This report describes the methodology, the results of the pilot and the analysis of the reliability of the data collected by LUCAS surveyors and botanists. While the limited number of points included in the pilot to not allow to extract statistically valid results, this report is intended to showcase the potential of the data collected with the grassland module within the LUCAS survey in case a statistically significant sample was allocated.

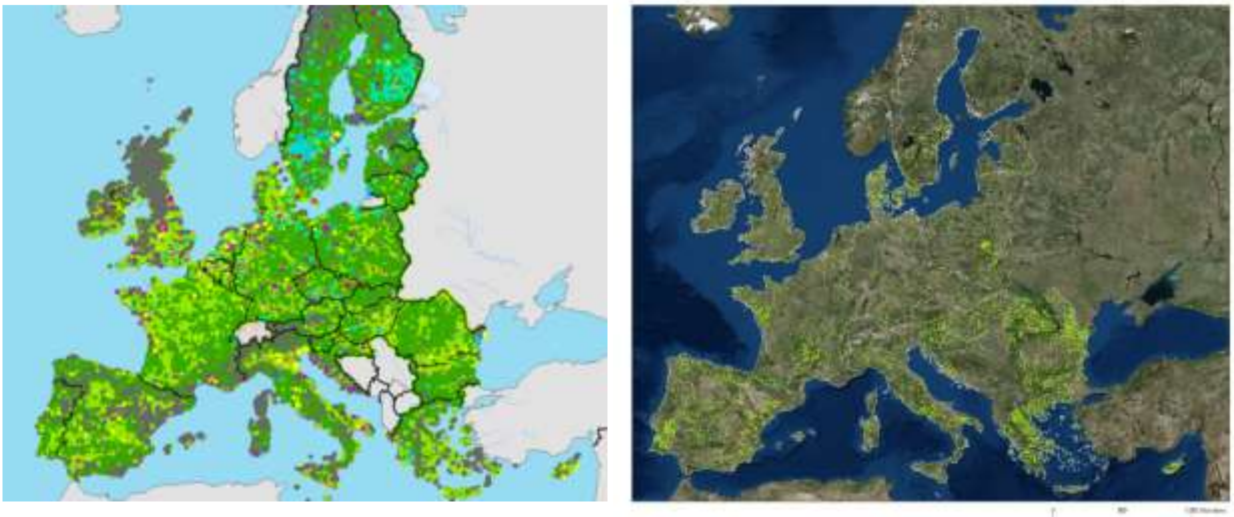


*Figure 1: Left: Distribution of the surveyed LUCAS points in 2018: the survey is a subset of the 2 * 2 km grid (Administrative boundaries: © EuroGeographics © UN-FAO © Turkstat; Cartography: © Eurostat - GISCO).*

Right: Distribution of the surveyed LUCAS grassland module 2018 (Photo: © Terra Metrics, © Google; Administrative boundaries: © EuroGeographics; Cartography: © IFAB).

3 Method

3.1 Selection of grassland points for the 2018 pilot

The subsample of points to be surveyed in the grassland module was selected as follows:

- With respect to the logistical effort, it was decided that approximately 20 % of the potential grassland points in the 2018 sample (c. 3700 points) could be surveyed for an effective pilot.
- All points that were recorded as grassland in LUCAS 2015 were preselected, i.e. LUCAS land cover categories “grassland with sparse tree/shrub cover”, “grassland without trees”, “spontaneously revegetated surfaces”, “shrubland with trees”, “shrubland without trees”. To qualify for the grassland survey a point had to have at least 50% of grass cover in the INSPIRE Pure Land Cover Component assessment in 2015 and the point was reached in 2015.
- In order to distribute the points to cover as wide a range of grassland types as possible, the 10 biogeographic regions were taken, based on the biogeographical regions of the EEA (European Environment Agency) with some minor modifications.

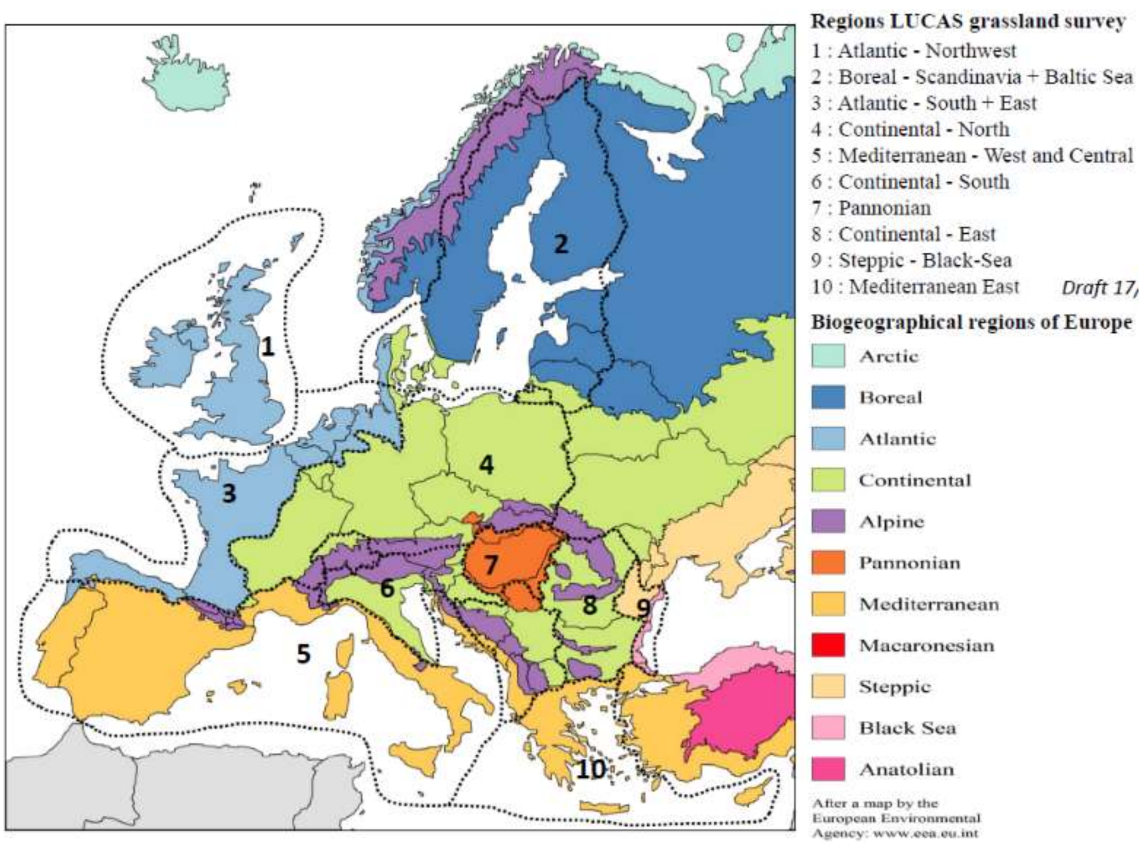


Figure 2: The 10 grassland regions 1-10 for the LUCAS grassland survey; the grassland regions are geared to the biogeographical regions (without alpine regions) and sub-regions were introduced.

Used data basis: © EuroGeographics for the administrative boundaries (2016); © Council of Europe (CoE) & © Directorate-General *for Environment (DG ENV) for Biogeographical boundaries (2016) modified 2016 by Institute for Agroecology and Biodiversity (IFAB) to create the Regions LUCAS grassland survey*

- At least 90 points were selected from LC type E20 (= "permanent grassland without tree cover") for each of the ten biogeographic regions, and for each elevation class present in the region (<200, 200-500, 500-1000, >1000).
- In addition to this random stratified sample, eight clusters were selected to assess specific natural environments in the bio- geographical regions where they can be found: broad- leaved forests with significant grass cover in Boreal and Mediterranean zones, temporary grasslands in Boreal, Atlantic and Mediterranean zones and fruit trees and berries with relevant grass cover in Continental and Mediterranean zones.
- Points where soil samples were also taken were preferentially selected (N=203).
- Points are distributed geographically as widely as possible whilst travel time between points is reduced as much as possible. For example, very remote grassland points and those on small islands were substituted with better reachable points.

This resulted in 3734 points for the grassland module. This sample was not designed to be statistically representative, but to test the methodology on as wide a range of grassland points as possible.

From this subsample, approximately 20 % (747 points) was selected for quality control by experts with a full vegetation survey. For each of the 747 selected points, between 1-3 alternative points were identified from the main grassland point sample: should a survey not be possible (e.g. very recently mown, dangerous to access etc.), then the botanist will proceed directly to the nearest alternative point of the same land cover class.

Approximately similar proportions of points were allocated in the different land cover classes and biogeographic regions (see Table 1).

Table 1: Planned theoretical distribution of grassland pilot points according to land cover and biogeographical region (expert/grassland pilot). The numbers (e.g. 21/90) indicate the number of the full vegetation survey points (expert sample – first figure) and the total sample of the grassland pilot sample (second figure) for the main land cover classes covered by this survey.

		LAND COVER							
	REGION	B55	B7x	C10	D10	D20	E10	E20	E30
1	Atlantic - Northwest							21/90	
2	Boreal - Scandinavian + Baltic Sea	21/90		21/90				21/90	
3	Atlantic - South + East	21/90						42/180	
4	Continental -North		21/90					80/360	
5	Mediterranean - West + Central	21/90	21/90	21/90	21/90	21/90		79/360	
6	Continental - South							42/180	
7	Pannonian							21/90	
8	Continental - East		21/90				42/180	42/180	
9	Steppic + Baltic Sea							21/90	21/90
10	Mediterranean - East						42/180	21/90	42/180

For each biogeographic region and elevation zone, an optimum time frame of 15 days was defined during which the survey must be carried out (s. annex II). This is important to ensure that the parameters can be recorded accurately, as most of them depended on a vegetation that is well developed but not yet cut or heavily grazed. An earlier start or later finish for the survey of 5–10 days is possible if weather conditions mean that the phenology is earlier or later than usual. The earliest surveys started in Cyprus in mid-April, and the latest ended in mid-July in northern Scandinavia.

3.2 LUCAS grassland methodology

Over 50 individual parameters were developed for the 2018 pilot survey, addressing the aspects of grassland ecology and management shown below. At every grassland point, the parameters are recorded on a transect of 20 m in length and 2.5 m in width[1], giving a total surveyed area of 50 m² (Figure 3). Certain parameters regarding the wider habitat, such as presence of fertilization or cover of trees, are observed on a larger transect of 10 m width or at parcel level[2]. One photo of the transect was taken in walking direction, one against walking direction and one from above.

The transect is always laid to the east of the LUCAS point, to avoid subjective selection of the vegetation surveyed. The starting point and the transect should be at least 5 m inside the grassland field, as the information collected on the transect should be representative for the grassland type of the parcel and not

[1] The grassland point identified by coordinates is the starting point of the transect.

[2] For further information, see the survey manual.

influenced by neighbouring land use at the edge. The point must be shifted if this condition is not satisfied.

Figure 3: Grassland transect methodology with normal transect of 20 x 2.5 m and enlarged transect of 20 x 10 m (left: own figure) and a photo of the normal transect in the field (right, source: D. Gómez).

The parameters were chosen to provide information on the ecological and environmental conditions of the grassland for example:

- **Environmental conditions**: e.g. slope in degrees, orientation, heterogeneity of soil surface
- **Use type:** e.g. type of grazing animal, evidence of abandonment, presence of agroforestry
- **Intensity of grassland use** deriving from type of vigour, height of vegetation, indicated fertilization, indicated irrigation, monostructured vegetation (e.g. grass dominance, absence of flowers)
- **Biodiversity / Species richness of grasslands:** Distribution and abundance of key species, structural characteristics of grasslands
- **Flower richness of grasslands and importance for pollinators**: Flower species richness, flower abundance
- **Distribution and abundance of EUNIS habitat types**
- **Ecological value** deriving from EUNIS type, Extensive land use (see above), structural characteristics, species richness, flower richness.
- **Grassland age**: Grasslands > 5 years versus ≤ 5 years age, seeded / revegetated / other grasslands, fallow grassland.

The complete instructions for the grassland module can be found in the technical reference document "C1 - Instructions for Surveyors" and the document C2 "Field Form and Ground Document" (https://ec.europa.eu/eurostat/documents/205002/8072634/LUCAS2018-C1-Instructions.pdf), it contains the complete field form in a printable format. In the 2018 field survey, most data was entered digitally in the field using a specially designed app.

A brief description of a selection of parameters recorded in the 2018 grassland survey is given below.

(1) Grassland type

First the grassland type (meadow, pasture, other grassland) must be selected. Further parameters provide information on the time the grassland is used, such as 1st or 2nd growth if meadow (before or after first cut), or before or after first grazing if pasture. Other grassland could be meadow or pasture (not clear or both), pastured woodland, amenity grassland, ruderal grassland or fallow other grassland.

Figure 4: Examples of different grassland types (© IFAB).

(2) EUNIS habitat types

European Nature Information System is a Classification system for ecology and conservation (https://eunis.eea.europa.eu/habitats.jsp). It is also used for Natura 2000 and coordinated with the related EMERALD Network of the Bern Convention, relevant for environmental reporting. The full official EUNIS classification system can be found on the website of the EEA. The grassland points should only be identified to level 2 (there are up to 8 levels of increasing detail about the habitat type).

Figure 5 shows some examples of these. The most common EUNIS grassland habitats are:

E1 – Dry Grasslands

E2 – Mesic grasslands

E3 - Seasonally wet and wet grasslands

E4 - Alpine and subalpine grasslands

E5 - Woodland fringes and clearings and tall forb stands

E6 - Inland salt steppes

E7 - Sparsely wooded grasslands

Figure 5: Example of some EUNIS grassland habitat types (© IFAB).

(3) Fertilization

Surveyors should assess whether the grassland was fertilized, probably fertilised or not based on visible cues, such as presence of slurry or the lushness of the vegetation (Figure 6). The specification unclear was also possible. In those cases where there were clear signs of fertilization the kind of fertilization (mineral, slurry, solid manure, or pasture dung) had to be ticked. This parameter provides an indication of the use intensity.

Figure 6: Examples for the parameters fertilization and type of fertilization (© IFAB).

(4) Layer components

The coverage on the transect is divided in the herb layer (non-woody plants), the woody layer and the bare soil / rock / litter layer – the coverages should be estimated by the surveyor.

The herb layer consists of the graminoids (grass-like plants), forbs (broad-leaved plants), mosses and lichens.

The bare layer can consist of bare soil, rock or litter on the ground.

The woody layer is divided into orchard, old trees, shrub, dwarf shrub, other wooded and dead wood.

(5) Grassland flowers

This section deals only with the insect-pollinated plant species. The flower density was estimated on a scale from 1 to 10 and the number of different flowering plant species was counted (Figure 7).

Figure 7: The flower density in these three pictures reaches from none (right) over very few (almost no), over few-medium ("between-category") to (very) dense (left, source: LUCAS grassland module C1 instructions, based on photos taken by R. Oppermann). Picking one of each of the flowering species makes it easier to count the total number (right, source: R. Oppermann).

(6) Grassland key species (groups)

One of the most important ecological parameters is the list of key, or indicator, species. This was also the most complex parameter to design and it is based on the experience of the experts surveying different types of grasslands in their home countries. An overview on all key species /key species groups and their application as key species in different regions is given in annex II.

The aim of the indicator species is to reflect the vegetation diversity and (to some extent) use history, in a way that is relatively easy for non-experts to record. Document C6 (Grassland Survey - Identification Guide) gives an overview of all key species, including photos. In total there were 41 indiator species or species groups covering the whole EU.

In each of the 10 biographical zones (Figure 2), 20 indicator species out of the set of 41 species had to be recorded. Ten of these species' groups were "core species" which were recorded in all biogeographical zones. Thus, a comparable approach and at the same time a region-specific approach should be achieved. In addition to a core list of 10 indicator species or species groups (e.g. *Geranium* sp. with flowers > 1 cm) that are recorded in every zone, each zone has a further 10 species that are specifically selected for that zone.

(7) Grassland age

The section grassland age consists of the parameters Grassland age and Grassland installation. Normally, grassland that is older than 5 years is rich in species and no seeding rows from a seeding drill are visible. If the grassland is no more than 5 years old, the rows are visible and / or there are only a few grass and forb species. At the parameter grassland installation, it should be indicated if the young grassland (≤ 5 years) was seeded or if it has spontaneously revegetated, e.g. by regularly mowing former set aside areas.

Figure 8: Example of a newly seeded grassland (© IFAB).

3.3 Expert survey

With the aim to check the quality of the data from the non-expert surveyors, 20% (747) of the grassland module points were additionally visited by expert botanists. The experts recorded the grassland module parameters as well as a full vegetation survey (i.e. a full inventory of all plant species growing on the transect). For the quality of the results, it was important that both surveyors (normal LUCAS grassland surveyors and the botanists) record the point within the set optimum time frame.

To standardise the approach, the expert surveyors were provided a set of additional equipment, especially to mark the transect. The equipment included measuring tape 2 m and 20 m, sticks to mark the transect, pens and clipboard for the specialised data records, a compass with inclination measure. Besides this equipment, each surveyor received printed ground documents for each original and alternative point.

3.4 Survey training

In March-May 2018, 24 LUCAS grassland training sessions were implemented in 20 countries for grassland surveyors from all 28 EU member states. Training was mandatory for the surveyors involved in the grassland module, and the grassland module training was linked to the general LUCAS surveyor training. In total, 164 surveyors participated in the grassland training as well as most regional coordinators and quality controllers. The botanical experts participated in 11 out of the 24 training sessions.

Where the experts could not attend the training, they discussed the parameters with the trainers via an online video conference. Each training had a theoretical introduction to the grassland module and to each of the grassland parameters and their background. The theoretical part was followed by a practical field exercise, during which on average two different grassland parcels were visited and recorded by the surveyors. Depending on the time available for the grassland training, two or more transects were recorded during the practical training. Many contractors provided tablets with a special app for the recording of the LUCAS parameters to the surveyors. During some training sessions, the data entry on the tablet could already be practiced: this was also found to be useful to identify any remaining bugs and difficulties with the software or hardware.

There were five experts as trainers for the LUCAS grassland trainings. It was important that the same information was given at all training sessions ensuring that the results of the field surveys are comparable. This was ensured by involving all five experts in the detailed development of the training materials. In this way they could acquire an in-depth knowledge of the material and had the opportunity to harmonize their approach to communicating the material. Furthermore, each expert collected questions and answers during the training session and added these to the catalogue for the Helpdesk, which were then shared with the other experts. If the question was more complicated, the expert asked for advice from the other experts before given an answer to the surveyor.

Figure 9: Photo of a grassland training meeting (© IFAB 2018)

3.5 Data analysis

Chapter 4.3 provides an overview of the type of analysis that would be possible if a statistically representative grassland sample had been assessed.
As the test run in 2018 aimed to assess the feasibility of the approach and is not statistically representative on the member state or biogeographic region level, the results in the next section are therefore presented without statistical interpretation.

4 Results

4.1 Experience with the grassland training

The presence of the botanical experts during the surveyor training was regarded as beneficial, as the botanists could explain difficult aspects of the methodology in the native language and had the necessary background and knowledge about the region for very specific country-related questions.

The most important aspects affecting the quality of the training were found to be:

- Language: almost all trainings were held in English (apart from France, held in French). To ensure clear understanding, translation of all or part of the theoretical and practical parts was provided by regional coordinators, trainers or botanists experts.

- Knowledge of plant identification: many surveyors were experienced LUCAS surveyors but not trained in plant identification. Therefore, a great concern was their capacity to recognize and identify the indicator species and legumes. Grassland training sessions had to take place before the peak of flowering, as this period was reserved for the surveys. As only few key species were flowering at the time of the training, help with identifying key species was limited to only a few species and to the more theoretical introduction to species/species groups during the presentation.

- Some parameters were found to be more difficult for the surveyors to understand. These were: the estimation of coverage of different layers (herbaceous layer, bare layer, woody layer) and their components; the herb layer heterogeneity; the type of grassland (meadow, pasture etc.). Especially the last parameter was difficult to assess in Mediterranean countries, as types of land use are often mixed and no clear differentiation is possible.

4.2 Implementation of the grassland survey

Not all points visited were possible to survey (e.g. land cover was no longer grassland, dangerous animals were present, or access to the land was not possible through blocked roads or difficult terrain). The results of the following sup-chapters are based on the revised data set with 2663 valid surveyor points, and 729 valid expert points. Table 2 shows the distribution of points per LUCAS land cover type, biogeographic region and altitude. Figure 10 shows the distribution of points per country, showing that larger numbers of points were surveyed in southern and eastern European countries.

Table 2: Number of points originally planned to be surveyed (ptbs), points actually recorded by surveyors (su) and points actually surveyed by experts (ex) per biogeographic region (an explanation of the abbreviations is given in Annex I) and land cover code/altitude

Biogeographic regions	Atlantic North			Boreal			Atlantic South			Continental North			Mediterranean West/Ce			Continental South			Pannonian			Continental East			Steppic and Black Sea			Mediterranean East					
Biogeographic regions	**1**			**2**			**3**			**4**			**5**			**6**			**7**			**8**			**9**			**10**			**total**		
land cover code / altitudes	**ptbs**	**su**	**ex**	**ptbs**	**su**	**ex**	**ptbs**	**su**	**ex**	**ptbs**	**su**	**ex**	**ptbs**	**su**	**ex**	**ptbs**	**su**	**ex**	**ptbs**	**su**	**ex**	**ptbs**	**su**	**ex**	**ptbs**	**su**	**ex**	**ptbs**	**su**	**ex**	**ptbs**	**su**	**ex**
B55	15	8		93	13	1	92	30	11	10	2	1	93	4	6	11	2	1	1			1	1		2			1			**319**	**60**	**20**
B71	0			0			0			71	61	12	1			0			0			20	16	4	0			0			**92**	**77**	**16**
B72	0			0			0			1	2		5	2		0			0			2	2	1	0			0			**8**	**6**	**1**
B73	0			0			0			17	15	5	5	2		0			0	1		9	5	1	0			0			**31**	**23**	**6**
B74	0			0			0			2			84	20	14	0			0			11	14	1	0			0			**97**	**34**	**15**
B75	0			0			0			6	5	2	25	15	4	0			0			45	29	12	0			0			**76**	**49**	**18**
C10	0			90	55	24	0	6		0	3	1	109	101	18	0	1		0	1		0	4	2	0	2	2	0	5		**199**	**178**	**47**
D10	0			0	4		0			0	2		89	36	15	0	1		0			0	8	3	0	2		0	1		**89**	**54**	**18**
D20	0	1	1	0	1		0	7	1	0	2		89	76	21	0	1		0	5		0	12	4	0	2		0	1	1	**89**	**108**	**28**
E10	**22**	**14**	**0**	**29**	**14**	**0**	**33**	**18**	**1**	**21**	**18**	**1**	**23**	**44**	**6**	**17**	**14**	**3**	**16**	**9**	**0**	**188**	**126**	**27**	**48**	**43**	**1**	**178**	**135**	**43**	**575**	**435**	**82**
alt. 0-200 m	20	12		26	14		19	8		12	10	1	7	8	1	4	6	2	11	8		31	29	5	37	32		47	27	9	**214**	**154**	**18**
>200-500 m	2	2		3			8	3		6	5		5	16	1	7	4		5	1		69	43	9	11	11	1	42	28	13	**158**	**113**	**24**
>500-1000 m	0			0			1	2	1	3	2		7	10	2	4	1		0			78	50	12	0			73	66	17	**166**	**131**	**32**
>1000 m	0			0			5	5		0	1		4	10	2	2	3	1	0			10	4	1	0			16	14	4	**37**	**37**	**8**
E20	**89**	**71**	**20**	**88**	**69**	**29**	**174**	**160**	**43**	**356**	**321**	**80**	**357**	**238**	**68**	**177**	**136**	**35**	**89**	**81**	**19**	**180**	**180**	**53**	**88**	**92**	**22**	**89**	**53**	**17**	**1687**	**1401**	**386**
alt. 0-200 m	68	56	14	82	65	29	74	74	38	90	73	11	89	50	17	38	22	8	77	68	15	27	25	6	74	80	20	57	25	6	**676**	**538**	**164**
>200-500 m	21	15	6	6	4		17	15		91	81	25	89	57	21	51	43	9	12	13	4	66	74	24	14	12	2	32	23	10	**399**	**337**	**101**
>500-1000 m	0			0			67	57	4	86	84	26	90	68	16	64	52	15	0			77	71	21	0			0	5	1	**384**	**337**	**83**
>1000 m	0			0			16	14	1	89	83	18	89	63	14	24	19	3	0			10	10	2	0			0			**228**	**189**	**38**
E30	**12**	**2**	**0**	**22**	**9**	**0**	**21**	**10**	**2**	**20**	**4**	**0**	**27**	**23**	**4**	**22**	**5**	**1**	**33**	**6**	**0**	**49**	**13**	**2**	**88**	**28**	**10**	**178**	**98**	**34**	**472**	**198**	**53**
alt. 0-200 m	12	2		22	9		18	9	2	9			7	8	1	10	4	1	26	5		26	4		84	26	10	65	41	10	**279**	**108**	**24**
>200-500 m	0			0			3	1		7	3		6	5	1	9			7	1		18	7	2	4	2		24	17	12	**78**	**36**	**15**
>500-1000 m	0			0			0			4	1		12	8	2	3	1		0			4	1		0			83	36	12	**106**	**47**	**14**
>1000 m	0			0			0			0			2	2		0			0			1	1		0			6	4		**9**	**7**	**0**
other landcover categories					6	3		4	1		2	1		11	18		1	2		3	1		7				2		6	11	**0**	**40**	**39**
total	**138**	**96**	**21**	**322**	**171**	**57**	**320**	**235**	**59**	**504**	**437**	**103**	**907**	**572**	**174**	**227**	**161**	**42**	**139**	**106**	**20**	**505**	**417**	**110**	**226**	**169**	**37**	**446**	**299**	**106**	**3734**	**2663**	**729**

In some figures we show surveyor data (which contains more points, but for some parameters is less reliable), and for others we show expert data (if reliability thought to be an issue). For some parameters we show all available data (providing a larger sample size points), but if the parameter is of particular interest for “typical” agricultural grassland we restrict the points to those recorded under the LUCAS codes E10 (grassland with sparse shrub/tree cover), E20 (permanent grassland without tree cover) and E30 (spontaneously vegetated surfaces). We display the results per country or per biogeographic region, depending on which shows the most meaningful trend. The sample is not representative; therefore we can only interpret trends of the data.

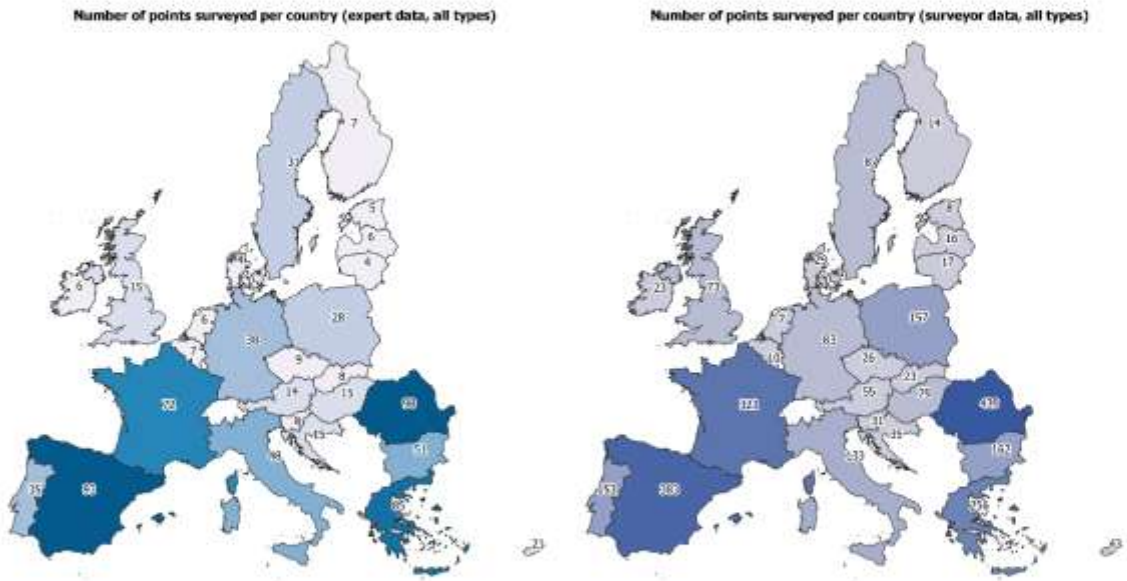


Figure 10: Distribution of the valid points surveyed per country by experts (left) and surveyors (right) (all grassland types – the number of points is given, and the darker the colour, the larger the number).
Used data basis: © EuroGeographics for the administrative boundaries.

Timing of the survey

As the biotic parameters are linked to the vegetation, it was important that the survey took place during peak flowering and vegetation development in early summer. The experts carried out most of the surveys within either the optimal or suboptimal timeframe[3]. Concretely, this were 55 % in the optimal timeframe and mostly over 70 % of the points in the optimal or sub-optimal timeframe. In contrast the performance of the surveyors was very variable depending on country, with Ireland, Romania and UK not surveying any points within the given time frame (Figure 11).

[3] The time framing is indicated in Annex II: the green marked periods indicate the optimal time frame, the yellow marked periods indicate the suboptimal time frame.

Figure 11: Number (given as digits within the bars) and percentage of points surveyed by experts (l.) and surveyors (r.) within the optimal and suboptimal time frames, and outside of these ("other").

Figure 12 shows that just over half the meadow points were visited by surveyors within the optimal time frame (272 out of 532 points). The aim of the time frame was to increase the chance of a surveyor visiting the grassland before the first cut, as only then all parameters can be reliably recorded: more plants are in flower and the vegetation structure is well developed. In both optimal and suboptimal time frames, between 65-70% of points were surveyed before the first cut. Of the points surveyed before or after the predefined time frame ("other"), only around 45% were surveyed before the first cut. This suggests that the time frame was overall appropriate.

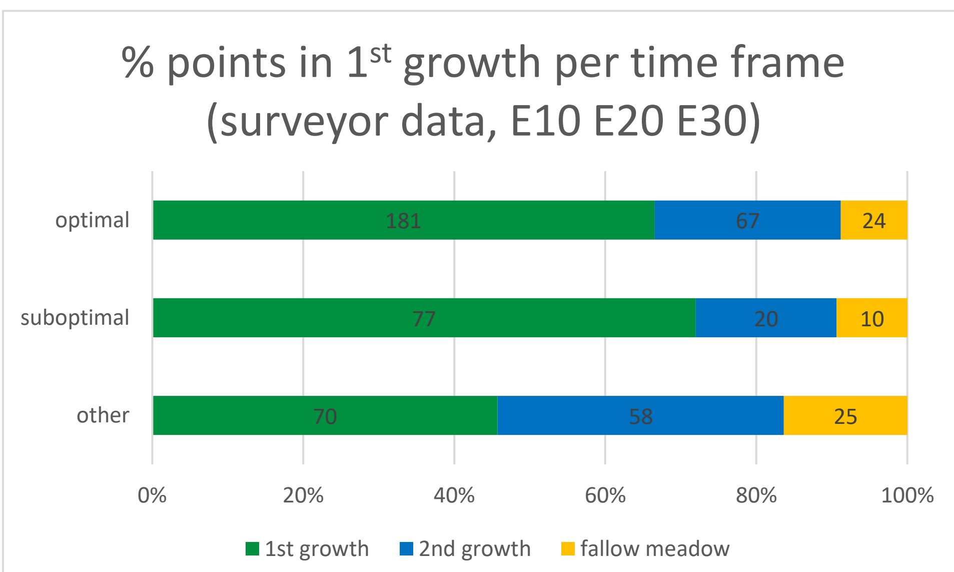


Figure 12: Percentage of the 532 points visited by surveyors and categorized as meadows and as LUCAS habitat types E10, E20 and E30 that were in 1st growth (i.e. before the first cut = green)), in 2nd growth (after the 1st cut = blue) or fallow (assumed by the surveyor not to be mown = orange), and split into the different time frames..

4.3 Results of the parameters

Here we have selected some of the results from the 2018 data to give an insight in the multitude of different aspects of the survey. Once again, we should state that **the results are not statistically representative at the region or country level,** as this requires a much larger sample size. The data are presented at country or biogeographical region level to demonstrate potential uses of future results and the distribution of the parameters.

(1) Grassland types and grassland use

Figure 14Figure 13 shows the distribution of different grassland types per country, whilst this information is displayed in map form only for meadows and pastures in Figure 14. Grassland use as meadow tends to be concentrated in the most intensively farmed areas of Europe (e.g. Germany, Austria, Netherlands), whilst pasture use is more common in southern and eastern Europe.

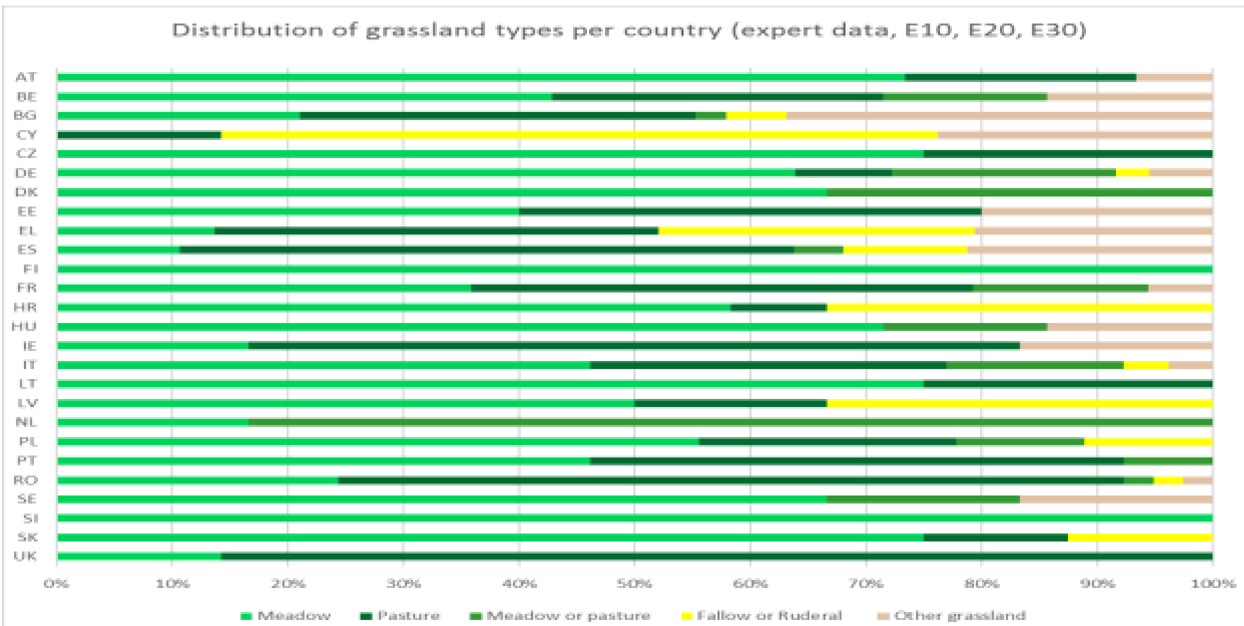


Figure 13: Proportions of different grassland types per country (expert data, E10, E20, E30)

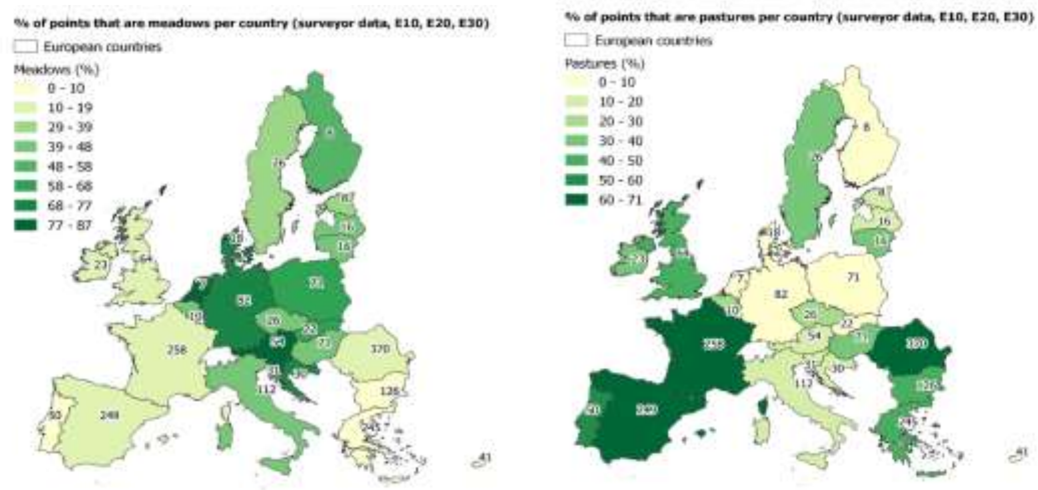


*Figure 14: Percentage of points that were recorded by surveyors as **meadows** (left) and as **pastures** (right) per country (surveyor data, E10, E20, E30)*
Used data basis: © EuroGeographics for the administrative boundaries.

(2) EUNIS – Habitat types

Figure 15 and Figure 16 show the distribution of EUNIS categories E1-E7 per biogeographic region, which are the "typical" EUNIS grassland types. There are large proportions of dry grassland (E1) as well as wooded grassland (E7) in the Mediterranean regions, the latter probably being due to dehesa farming systems. Salt steppes are found in the Pannonian and Black Sea regions, as would be expected. Wet grasslands are more prevalent in the Atlantic region.

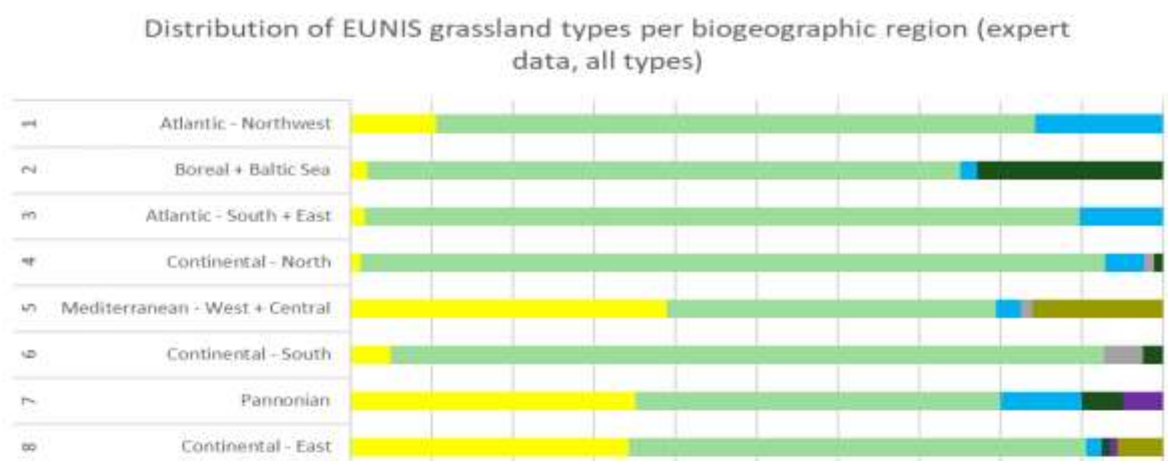
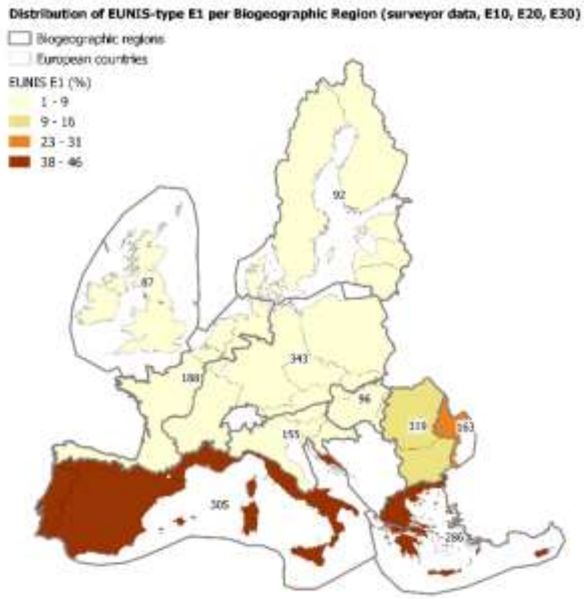
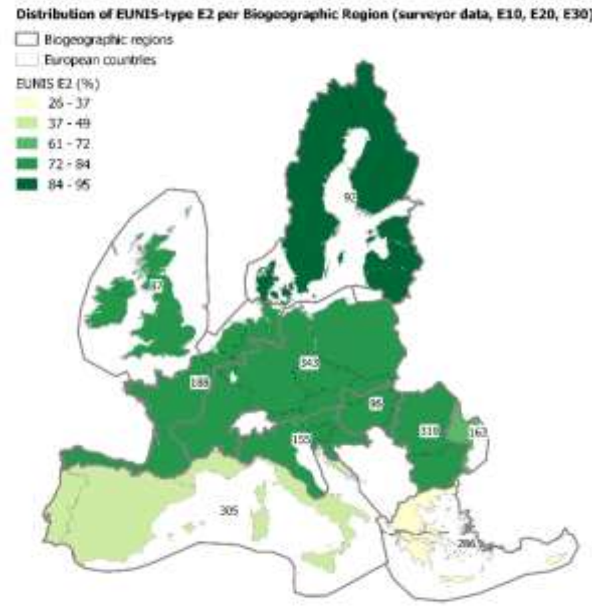
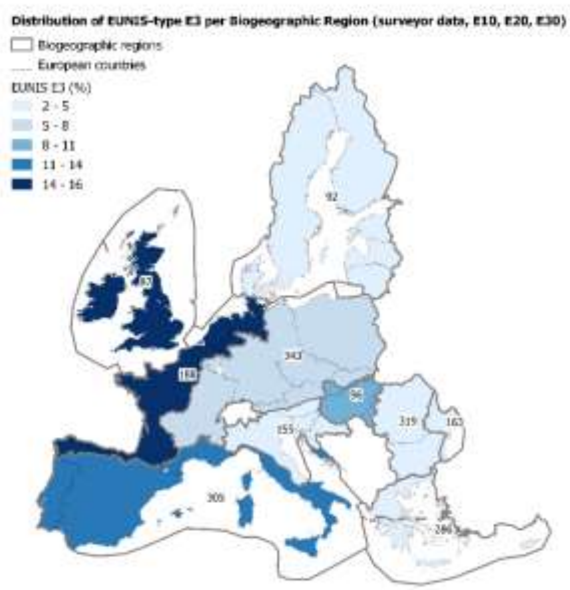


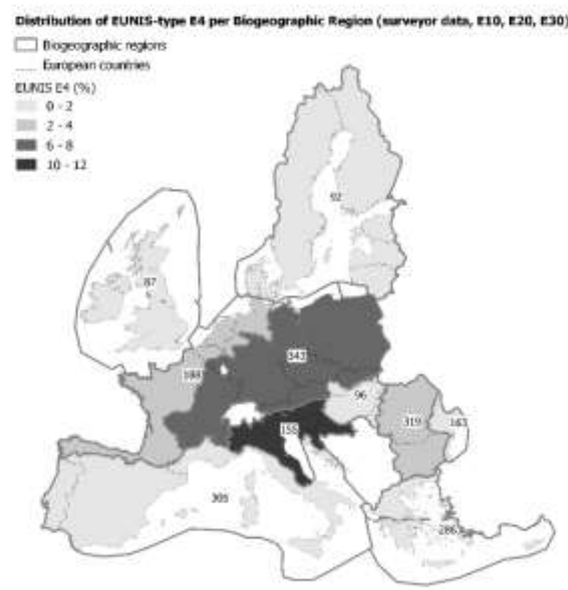
Figure 15: % points in the categories E1-E7 per biogeographic region (expert data, all grassland types).

Yellow: E1 = dry grasslands
Green: E2 = mesic grasslands
Blue: E3 = Seasonally wet and wet grasslands
Grey: E4 = Alpine and subalpine grasslands
Dark green: E5 = Woodland fringes and clearings and tall forb stands
Violet: E6 = Inland salt steppes
Olive: E7 = Sparsely wooded grasslands


Distribution of EUNIS-type E1 per Biogeographic Region (surveyor data, E10, E20, E30)
Biogeographic regions
European countries
EUNIS E1 (%)
1 - 9
9 - 16
23 - 31
38 - 46


Distribution of EUNIS-type E2 per Biogeographic Region (surveyor data, E10, E20, E30)
Biogeographic regions
European countries
EUNIS E2 (%)
26 - 37
37 - 49
61 - 72
72 - 84
84 - 95


Distribution of EUNIS-type E3 per Biogeographic Region (surveyor data, E10, E20, E30)
Biogeographic regions
European countries
EUNIS E3 (%)
2 - 5
5 - 8
8 - 11
11 - 14
14 - 16


Distribution of EUNIS-type E4 per Biogeographic Region (surveyor data, E10, E20, E30)
Biogeographic regions
European countries
EUNIS E4 (%)
0 - 2
2 - 4
6 - 8
10 - 12

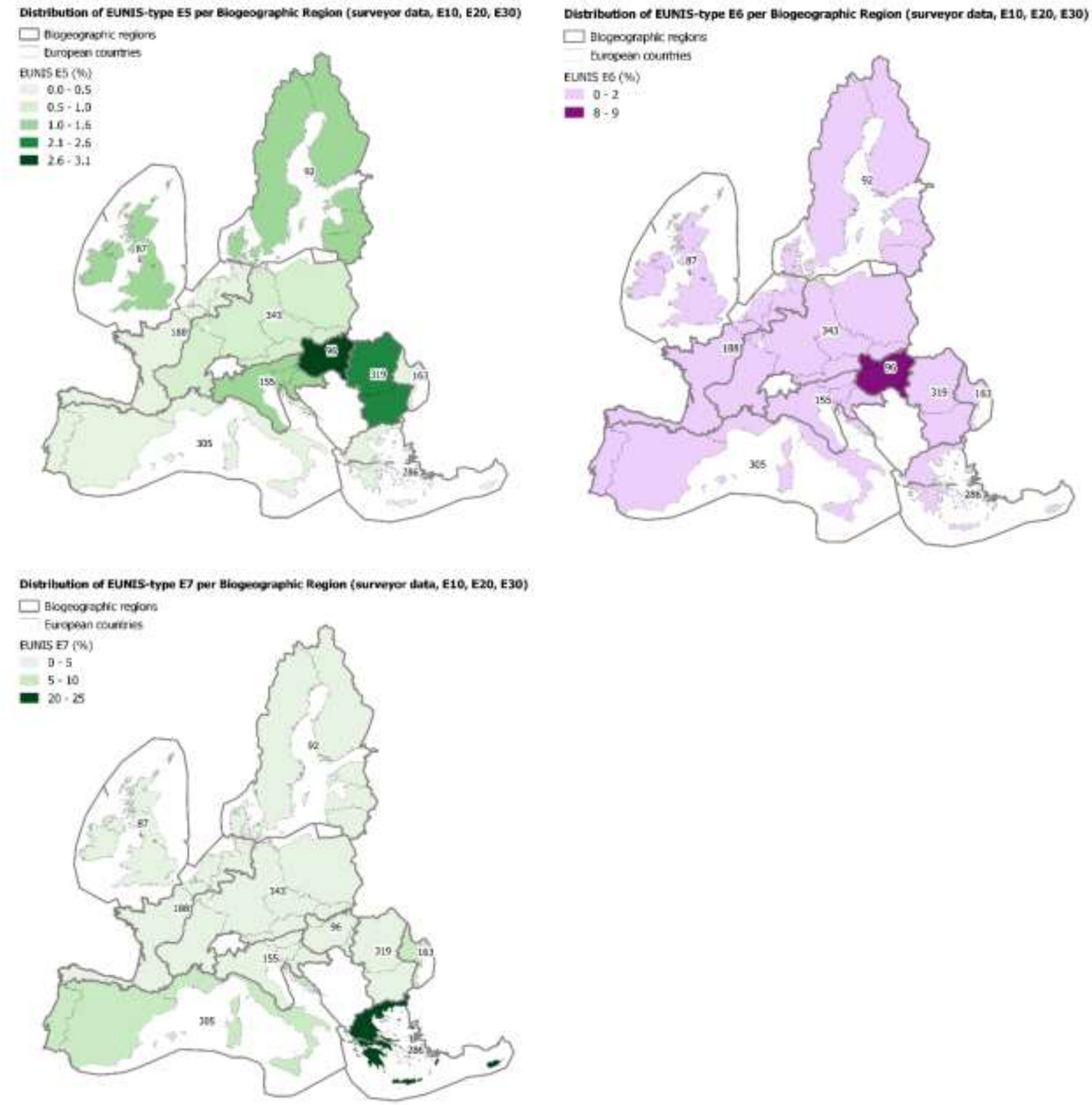


Figure 16: Distribution of the EUNIS types E1-E7 per biogeographic region (surveyor data, only grassland types E10, E20 and E30). The numbers in the map refer to the absolute number of points used for this analysis.

Used data basis: © EuroGeographics for the administrative boundaries (2016); © Council of Europe (CoE) & © Directorate-General for Environment (DG ENV) for Biogeographical boundaries (2016) modified 2016 by Institute for Agroecology and Biodiversity (IFAB).

(3) Fertilisation

Figure 17 shows only the expert data, as the presence of fertiliser was difficult for the surveyors to record. Austria, Netherlands, UK and Ireland all have >70 % points considered to be fertilised “for sure”: this reflects patterns of intensification, but it should be noted that extensively grazed pastures with signs of animal dung are also recorded as fertilised “for sure”.

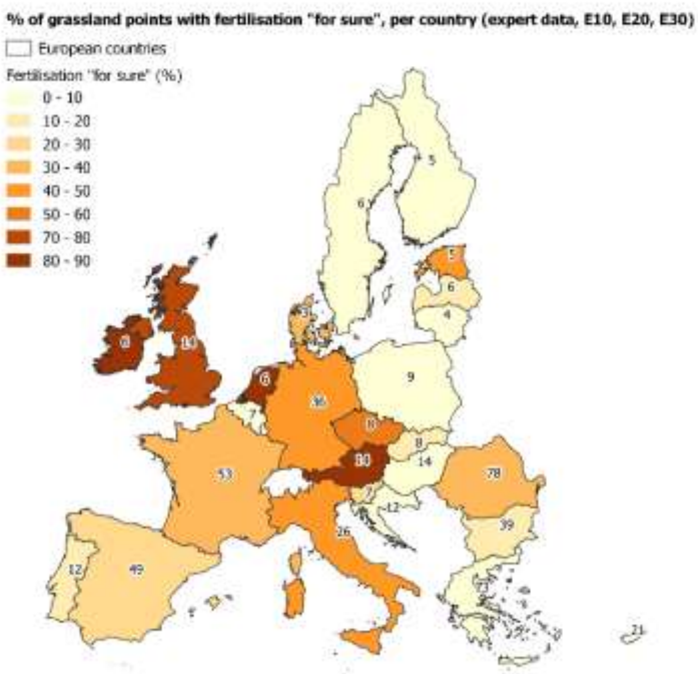


Figure 17: % of points recorded as having been fertilised “for sure” per country (expert data, only LUCAS grassland types E10, E20 and E30). The numbers in the map refer to the absolute number of points used for this analysis.

Used data basis: © EuroGeographics for the administrative boundaries.

(4) Herb layer components (graminoid to forb ratio)

Figure 18 shows that the southern European biogeographic regions have a greater dominance of forbs (i.e. broad leaved plants, as opposed to grasses), whilst the grasslands in northern and central Europe are dominated by graminoids (i.e. grass and grass-like plants such as sedges). This is presumably due to climatic factors favouring graminoids in wetter and colder regions, as well as intensification in central Europe promoting graminoids.

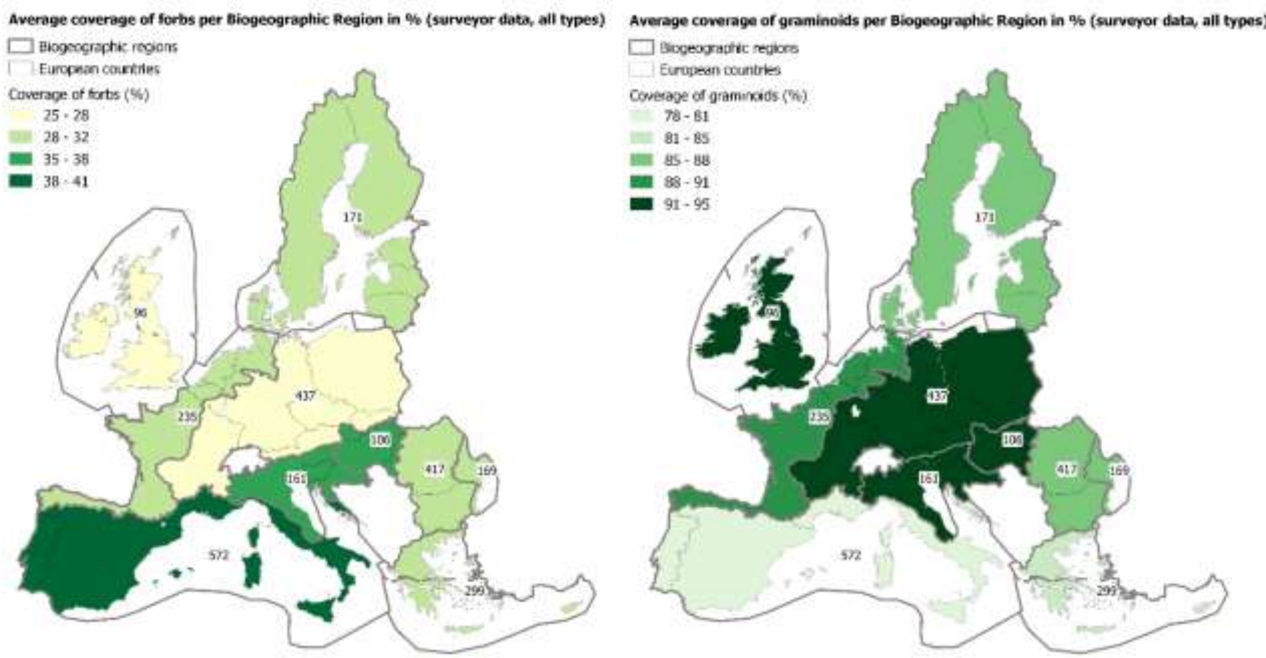


Figure 18: Average % coverage of forbs (left) and graminoids (right) in the herbaceous layer per biogeographic region (surveyor data, all grassland types). The numbers in the map refer to the absolute number of points used for this analysis. Used data basis: © EuroGeographics for the administrative boundaries (2016); © Council of Europe (CoE) & © Directorate-General for Environment (DG ENV) for Biogeographical boundaries (2016) modified 2016 by Institute for Agroecology and Biodiversity (IFAB).

(5) Coverage of woody layer

Figure 19 shows again that the woody layer components are high in some southern countries such as Cyprus, Greece, Portugal and Spain, probably due to their olive grove and dehesa/montado farming systems with cork oaks or other trees.

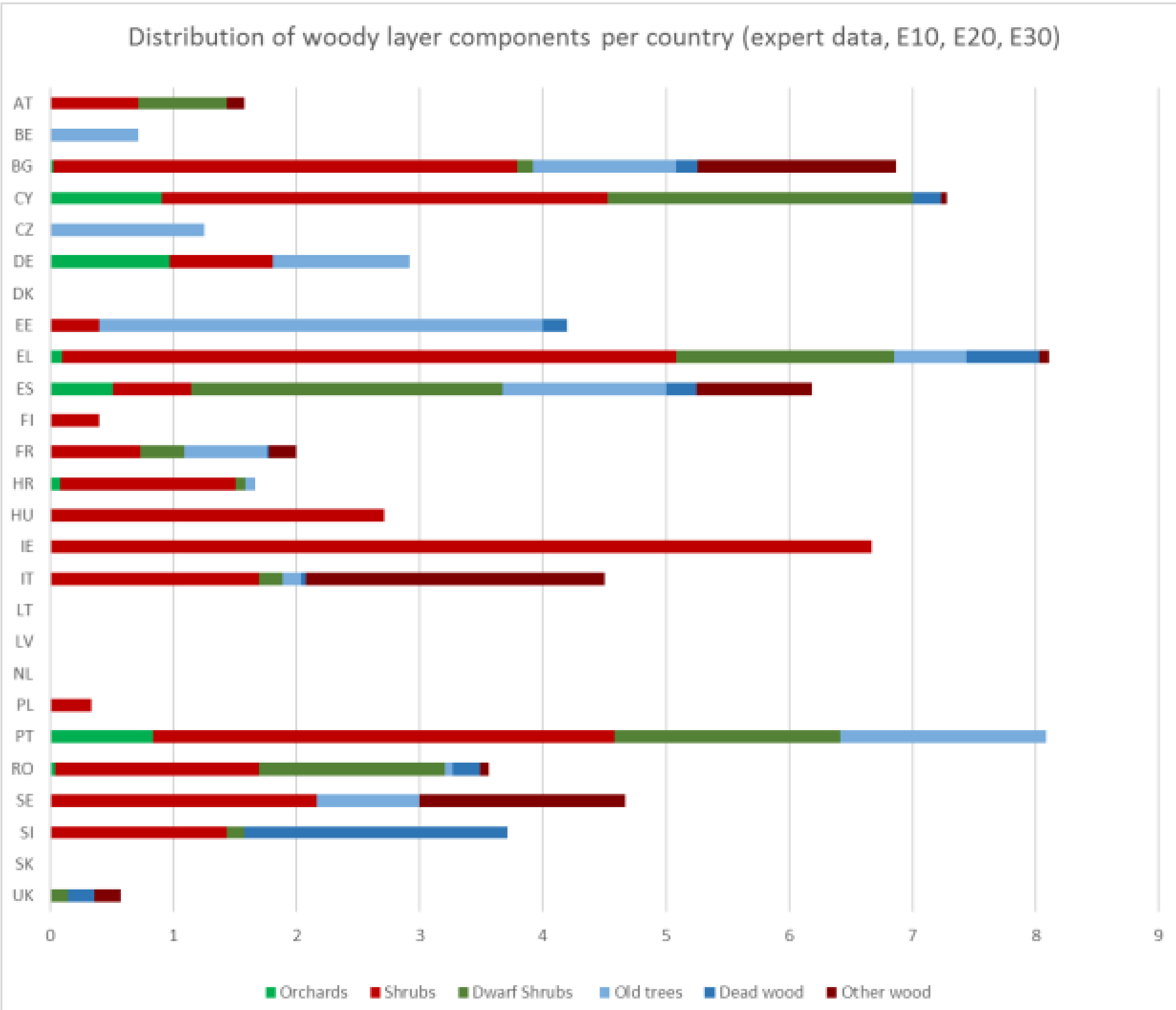


Figure 19: Average % coverage of woody layer components per country (expert data, E10, E20 and E30).

(6) Grassland flowers

Figure 20 shows that the southern and eastern member states had a generally higher number of flowering forbs and flower density on their grassland points than the northern MS.

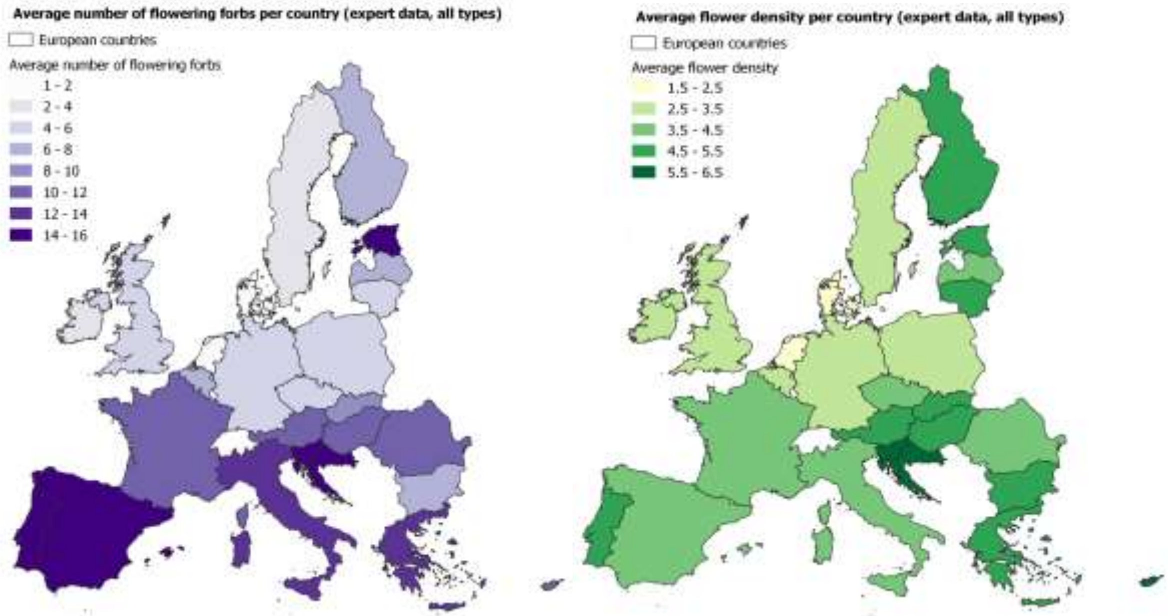


Figure 20: Average number of flowering forbs and flower density per country.

Used data basis: © EuroGeographics for the administrative boundaries.

(7) Number of key species

Figure 21 shows that the Continental S and Continental E regions have the largest proportions of points with high numbers of key species. The continental and Mediterranean regions are naturally more species rich than the Atlantic regions.

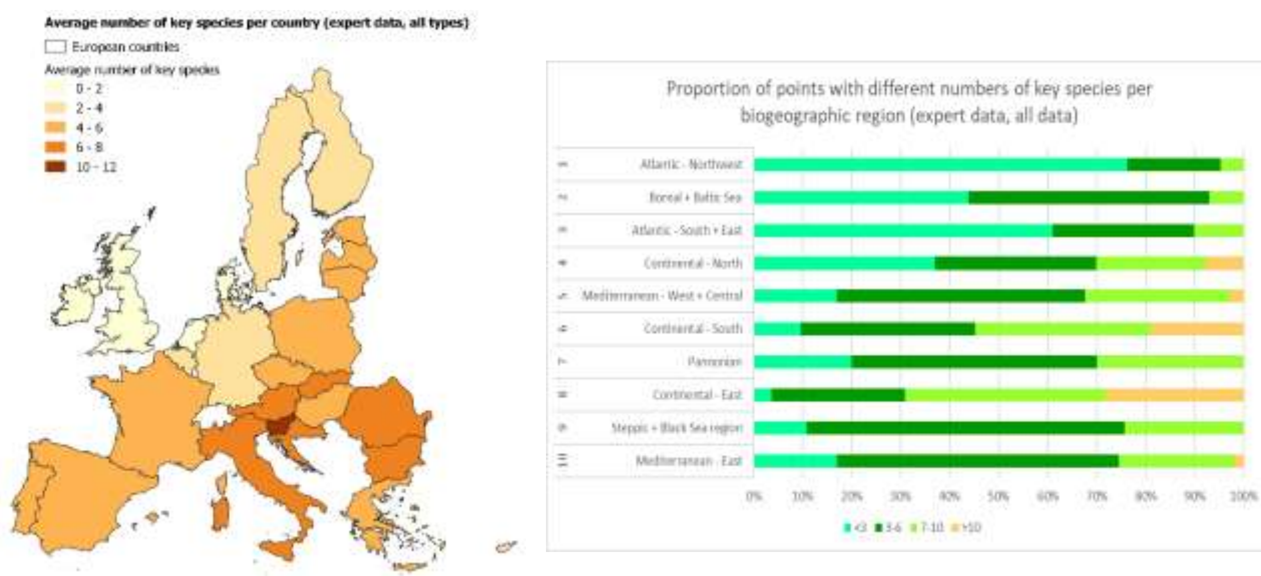


Figure 21: Average numbers of key species per member state (left) and proportion of points with different numbers of key species (right), displayed as categories >3 key species, 3-10 key species and >10 key species per biogeographic region. Using

expert data and all grassland types.
Used data basis: © EuroGeographics for the administrative boundaries.

Figure 22 shows the proportion of points at which each key species was found by experts. Some species were found at a large proportion of points (over 50% in all regions, in the case of yellow flowering (legume species Spec12), whilst others were only found on one or two occasions (e.g. *Clematis integrifolia*, *Limonium* spp.). The frequency of the species varied between the regions, as shown with the example of the Boreal region (relatively species poor due to the cold and wet climate) and the Pannonian region (relatively species rich) in Figure 23.

Number	Species number	Name
215	SPEC12	Trifolium spp., Medicago spp., Lotus spp., Coronilla (yellow flowering)
186	SPEC9	Cichorioideae without Tragopogon spp. and without Taraxacum spp.
179	SPEC8	Apiaceae
217	SPEC7	Vicia spp., Lathyrus spp., Astragalus spp. (blue or purple flowering)
214	SPEC31	Trifolium spp. (red flowering)
187	SPEC15	Cirsium spp., Carduus spp., Carlina spp.
177	SPEC27	Achillea spp.
185	SPEC28	Centaurea spp., Serratula tinctoria
194	SPEC38	Galium spp. (white flowering)
205	SPEC3	Potentilla spp. without Potentilla anserina
210	SPEC11	Silene spp., Lychnis flos-cuculi, Dianthus spp. (red flowering)
190	SPEC36	Eryngium planum and other, Echinops spp.
191	SPEC17	Euphorbia spp.
195	SPEC19	Galium verum
208	SPEC24	Sanguisorba spp.
213	SPEC6	Tragopogon spp., Scorzonera spp.
212	SPEC25	Thymus spp.
209	SPEC30	Scabiosa spp., Knautia spp., Succisa spp.
201	SPEC21	Myosotis spp.
199	SPEC29	Leucanthemum spp.
184	SPEC34	Campanula spp.
182	SPEC33	Astragalus spp., Coronilla spp., Onobrychis spp., Hedysarium coronaria (
202	SPEC10	Orchidaceae spp.
207	SPEC4	Salvia spp.
198	SPEC40	Juncus spp.
206	SPEC23	Rhinanthus spp.
196	SPEC39	Genista spp., Spartium spp., Calicotome spp., others
180	SPEC13	Artemisia spp.
193	SPEC18	Filipendula spp.
181	SPEC41	Asphodelus spec., Narthecium spec., Paradisea liliastrum
188	SPEC35	Cistus spp.
197	SPEC20	Geranium spec. with big flowers (flower diameter ≥ 1cm)
192	SPEC37	Euphrasia spp.
183	SPEC14	Bistorta officinalis (= Polygonum bistorta)
178	SPEC32	Adonis spp.
216	SPEC26	Valeriana spp.
203	SPEC2	Pedicularis spp.
204	SPEC22	Phlomis fruticosa
200	SPEC1	Limonium spp.
211	SPEC5	Thalictrum spp.
189	SPEC16	Clematis integrifolia

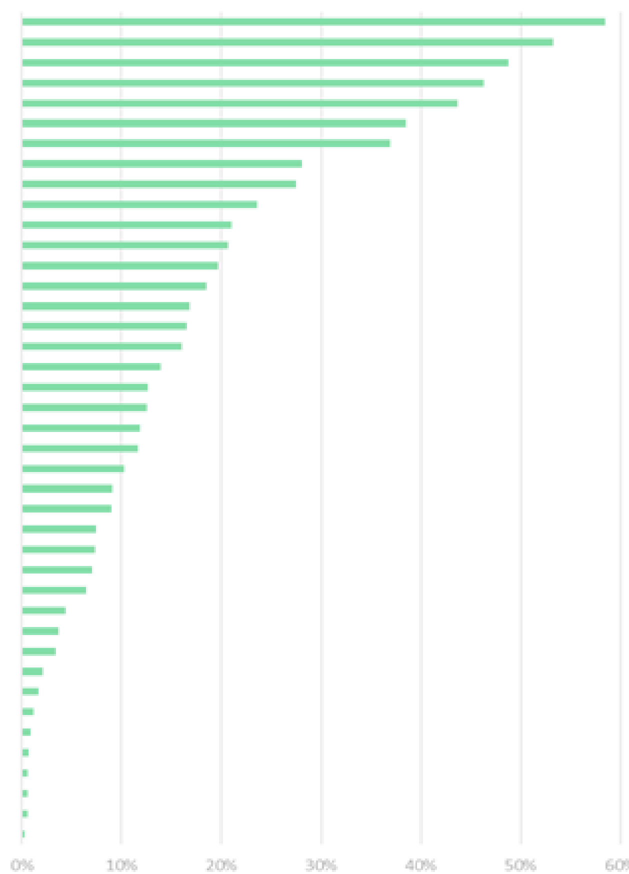


Figure 22: Names and numbers of key species as well as Proportion of points (green bar) at which each key species was found (expert data, all grassland points).

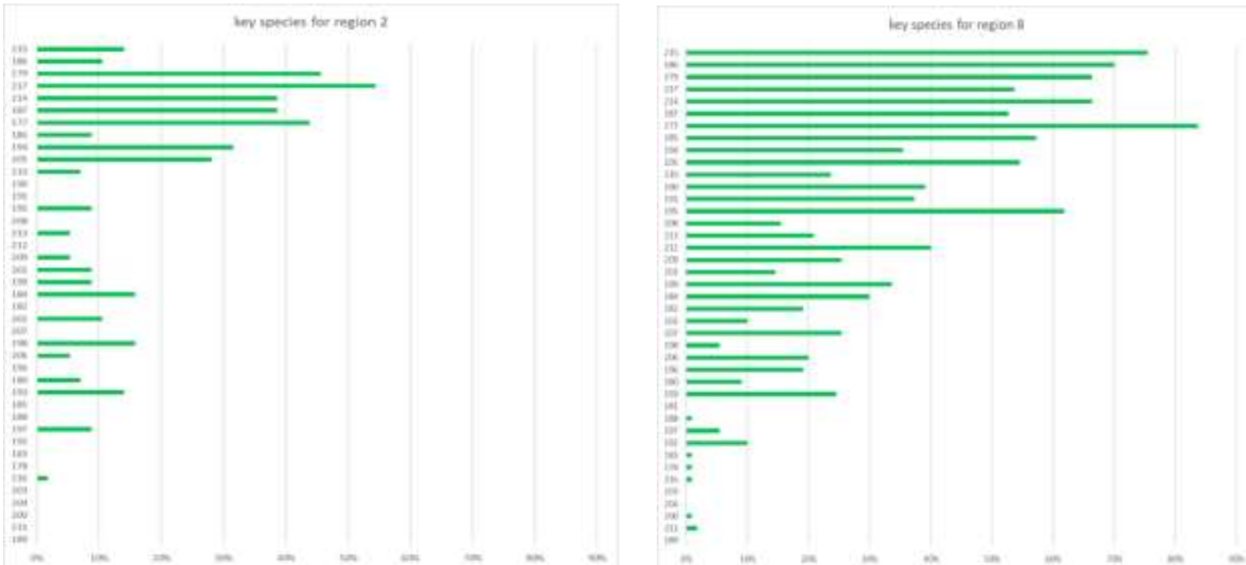


Figure 23: Proportion of points at which each key species was found (expert data, region 2 - Boreal and 8 - Pannonian).

(8) Grassland age, using the example of Natura 2000

The data set could also be used to describe differences between grassland parameters in and outside Natura2000 areas, such as the grassland age (Figure 24) or the average number of key species (Figure 25).

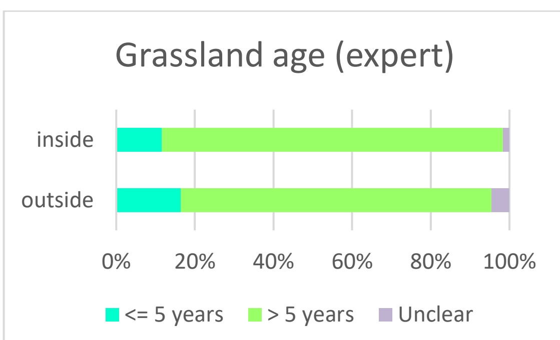


Figure 24: Grassland age as estimated by experts on points within and outside of Natura 2000 protected areas.

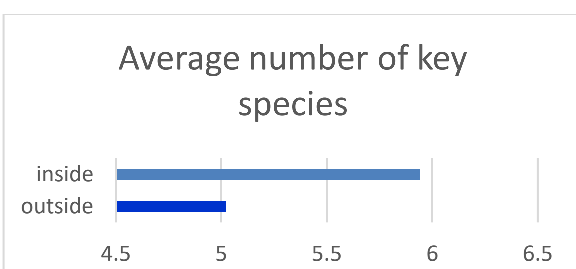


Figure 25: Average number of key species detected on points within and outside of Natura 2000 protected areas.

5 Validation and improvement of the methodology

5.1 Validation

The expert and surveyor data sets were compared to determine the deviation rate of each parameter (Figure 26 – see methods for the explanation of the different time lag classes A-D). Less than 20% error rate is considered here as reliable.

To validate the data, the expert and normal LUCAS surveyor results were compared. In total there were 611 points for which data of both surveyors and experts are present. However, a series of the points had unexpectedly large time lags between surveys (or a few were not recorded at exactly the same coordinates). We therefore further divided this dataset into subsets for the comparison of reliability, namely:

- A: data of surveyors and experts have been recorded within 10 days of each other, all data have been recorded on the point and the transect was orientated in the same direction, or both shifted in the same direction.
- B: data of surveyors and experts have been recorded with a difference of 11-25 days, all data have been recorded on the point and the transect was orientated in the same direction or both shifted in the same direction.
- C: data of surveyors and experts have been recorded with a difference of more than 25 days, all data have been recorded on the point and the transect was orientated in the same direction or both shifted in the same direction.
- D: rest of the data – there may have been shifts of the surveyor or the expert or the transect may have been carried out in different directions. This data set has not been analysed further in this preliminary analysis (e.g. the coordinates and transect directions are the same but the indicated slope inclinations vary largely - with the photos it can be checked if there is a mistake in the indicated slope or if the transects have been carried out in a different way).

Subset	N points	Accuracy	error_SURVEY_GRASS_SLOPE	error_SURVEY_GRASS_EUNIS_HABITAT	error_SURVEY_GRASS_ORIENTATION	error_SURVEY_GRASS_SITE_MOISTURE	error_SURVEY_GRASS_SURFACE	error_SURVEY_GRASS_ANIMAL_PATHS	error_SURVEY_GRASS_FERTILIZ	error_SURVEY_GRASS_FERTILIZ_TYPE	error_SURVEY_GRASS_GRASSLAND_TYPE	error_SURVEY_GRASS_MEADOW_GROWTH	error_SURVEY_GRASS_PASTURE_CATTLE	error_SURVEY_GRASS_OTHER_TYPE	error_SURVEY_GRASS_FALLOW_AGE	error_SURVEY_GRASS_AGE	error_SURVEY_GRASS_VIGOUR_VEG	error_SURVEY_GRASS_GRMHRB_PERC	error_SURVEY_GRASS_BARE_PERC	error_SURVEY_GRASS_WOODY_PERC	error_SURVEY_GRASS_GRMHRB_GRAM_PERC	error_SURVEY_GRASS_GRMHRB_FORBS_PERC	error_SURVEY_GRASS_HERB_LAYER1_H_CM	error_SURVEY_GRASS_HERB_LAY_HETEROG	error_SURVEY_GRASS_HERB_LAY_HET_REAS	error_SURVEY_GRASS_FLOWERING_FORBS_N	error_SURVEY_GRASS_FLOWER_DENSITY	error_NUMBER_KEY_SPECIES	error_SURVEY_GRASS_LEGUME_TOTAL_PERC
A	133	within 10 days	5%	26%	16%	12%	5%	32%	30%	20%	8%	12%	13%	6%	26%	18%	28%	17%	34%	19%	35%	37%	11%	7%	2%	55%	33%	32%	44%
B	93	within 11-25 days	5%	33%	27%	10%	5%	34%	29%	18%	8%	11%	22%	13%	35%	16%	24%	18%	34%	14%	51%	45%	48%	5%	5%	74%	41%	37%	45%
C	78	more than 25 days	26%	18%	22%	12%	3%	40%	24%	17%	9%	28%	24%	12%	18%	10%	32%	18%	31%	14%	47%	45%	53%	1%	0%	72%	42%	68%	38%
D	311	other critical data	37%	25%	24%	10%	7%	28%	33%	21%	5%	21%	18%	14%	24%	18%	29%	19%	39%	23%	50%	49%	42%	7%	2%	68%	39%	47%	41%
All data	611	whole dataset	30%	26%	26%	11%	6%	32%	31%	20%	6%	22%	18%	13%	25%	17%	29%	18%	36%	19%	46%	46%	55%	6%	3%	67%	38%	45%	42%

Figure 26: Results of the data analysis regarding the reliability of different parameters: the table shows in the different lines the different subsets of samples in which the surveys were carried out (subset A expert and non-expert survey time within 10 days, subset C the difference in the date between the expert survey and non-expert survey was more than 25 days; subset D comprises data in which there were other critical components of the data such as shifted points / shifted transects, different directions of the transect, differences of records regarding 1st and 2nd growth); in the different columns the different survey parameters are listed (the abbreviations are explained in Annex I); the percent values indicate the proportion of points that exceed the pre-defined tolerance ranges; up to 20 % of exceeding values is seen as normal range of fluctuation

Legend for marked values	
(green)	within expected range of fluctuations
(yellow)	small exceedance of expected range
(orange)	high exceedance of expected range
(red)	critical exceedance of expected range

The % value describes the proportion of points within the different subgroups where the records of the surveyors and experts disagree (being outside the given tolerance ranges). For % values ≤ 20, these are coloured green, because they are within our (subjective) expected range of fluctuation (there will always be some points where, due to chance or a degree of subjectivity, surveyors and experts will perceive different things). For values 21-30%, these are coloured yellow to indicate that they slightly exceed our expected range of fluctuation. For values 31-40%, these are coloured orange to indicate that they highly exceed our expected range of fluctuation. At values over 41% (coloured red) there is a critical exceedance of expected range. Source: Bionum GmbH - Büro für Biostatistik und Ökologische Statistik and IFAB 2019 for the Evaluation of the LUCAS survey on behalf project for Eurostat.

Summarising these results, 15 of the analysed parameters were recorded reliably (≤ 20% error/deviation rate) provided the transects were repeated within 10 days of each other and on the same area of ground (i.e. not more than a few meters away from each other). 10 parameters were recorded with moderate reliability (20-40% error/deviation rate) and 2 parameters were less reliable (40-60% error/deviation rate).

It is interesting to note that the mean averages calculated often do not differ so much between surveyor and expert, even if the error rate is high. For example, there is the error rate of the forb content (error_SURVEY_GRASS_GRMHRB_FORBS_PERC) in relation to the entire data set at 46% (s. Figure 26). The average value from the experts (e) with 35.95% herb coverage differs only slightly from average value from the surveyors (s) with 31.86% herb coverage (s. Figure 27). This is due to the often equal likelihood of over or underestimating a value, so that in larger sample sizes the “noise” of individual small errors is cancelled out. Thus, even if there are differences in the records the average results often show similar results such as the estimation of the coverage of forbs or the flower density.

In contrast, there are also parameters that were consistently recorded differently by surveyors and experts, such as the percentage of the bare ground layer (SURVEY_GRASS_BARE_PERC) and the number of flowering forbs (SURVEY_GRASS_FLOWERING_FORBS_N).

Average values	n =		e_SURVEY_GRASS_SLOPE	s_SURVEY_GRASS_SLOPE	e_SURVEY_GRASS_GRMHRB_PERC	s_SURVEY_GRASS_GRMHRB_PERC	e_SURVEY_GRASS_BARE_PERC	s_SURVEY_GRASS_BARE_PERC	e_SURVEY_GRASS_WOODY_PERC	s_SURVEY_GRASS_WOODY_PERC
Average A	133	within 10 days	2,97	3,21	85,84	89,74	[illegible]	[illegible]	[illegible]	[illegible]
Average B	93	within 11-25 days	3,58	3,60	85,51	82,73	[illegible]	[illegible]	6,92	7,28
Average C	78	more than 25 days	5,44	8,19	89,35	89,09	10,81	7,27	4,23	3,62
Average D	311	other critical data	7,39	8,73	84,15	86,37	[illegible]	[illegible]	8,77	8,59

Average values	e_SURVEY_GRASS_GRMHRB_GRAM_PERC	s_SURVEY_GRASS_GRMHRB_GRAM_PERC	e_SURVEY_GRASS_GRMHRB_FORBS_PERC	s_SURVEY_GRASS_GRMHRB_FORBS_PERC	e_SURVEY_GRASS_HERB_LAYER1_H_CM	s_SURVEY_GRASS_HERB_LAYER1_H_CM	e_SURVEY_GRASS_FLOWERING_FORBS_N	s_SURVEY_GRASS_FLOWERING_FORBS_N	e_SURVEY_GRASS_FLOWER_DENSITY	s_SURVEY_GRASS_FLOWER_DENSITY	e_SURVEY_GRASS_LEGUME_TOTAL_PERC	s_SURVEY_GRASS_LEGUME_TOTAL_PERC
Average A	59,86	68,15	[illegible]	31,53	70,17	66,11	[illegible]	[illegible]	4,50	3,81	12,77	14,29
Average B	55,51	64,51	[illegible]	34,34	62,25	59,33	[illegible]	[illegible]	4,62	4,08	15,65	13,08
Average C	66,00	63,15	[illegible]	30,72	[illegible]	[illegible]	[illegible]	[illegible]	3,76	3,27	[illegible]	[illegible]
Average D	58,65	64,50	[illegible]	[illegible]	63,84	54,98	[illegible]	[illegible]	4,28	3,75	13,49	12,27

Figure 27: Comparison of average data between surveyor data (s_SURVEY_…) and expert data (e_SURVEY_…).

Source: Bionum GmbH - Büro für Biostatistik und Ökologische Statistik and IFAB 2019 for the Evaluation of the LUCAS survey on behalf project for Eurostat.

In the following, we highlight a few observations on the performance of the individual parameters and implications for the further development of the methodology.

- Grass slope: the parameter concerning the slope of the grassland point is highly reliable. It is notable that the surveyors who were rather late (>25 days) had a much higher rate of error (26 % versus 5 %), which may suggest that they were working less carefully.
- EUNIS-Habitat type: this is a very specific parameter, which requires some understanding of the vegetation types. There are roughly 30 % of the points where the surveyor and expert data did not agree.
- Grass orientation: the parameter concerning the orientation of the grassland site is reliable. Similarly, to the parameter grass slope, it is surprising that a larger time gap between surveys affected the error rate.
- Site moisture: highly reliable.
- Grass surface (heterogeneity): highly reliable.
- Animal paths: this parameter is a difficult one because in many extensive pastures, you can see only small signs of animal paths or one is not sure if these animal paths derive from wild animals or from domestic animals. Thus, the high rate of error is not surprising (one shouldn't call it "error" – better it would be to call it "deviation" but for the reason of homogeneity in the wording we decided to keep the expression "error")

- Fertilisation: this parameter is also difficult to determine in the field. Experts may use the presence of certain plants that indicate fertilisation to make their decision, which is not an option available to surveyors, potentially explaining the error rate here.
- Kind of fertilization: if there were any fresh signs of fertilization in the grassland such as slurry or pasture dung they were easy to recognize; therefore, for this parameter there is a high accordance.
- Grassland type: highly reliable.
- Meadow growth: logically, with increasing time between the two surveys the agreement on whether the grassland is in first or second growth decreases.
- Kind of pasturing animals (cattle): if animals are on the pastures they are recognized by surveyors and experts; also here with increasing time between the surveys it becomes more probable that the cattle is moved and thus the accordance decreases.
- Grassland fallow age: The judgement of the age of fallow grassland is not easy, especially in the beginning of the main vegetation season. Therefore, the results of the surveyors can differ considerably from the judgement of experienced experts who are familiar with the signs of fallow ages. It is interesting that points surveyed with a long time-lag (i.e. the surveyor visits much later than the expert) show better results– probably because then it becomes clear which grasslands are used and which are fallow for longer time.
- Grassland age: the grassland age was reliably recorded. However, it must be considered that there is a proportion of the grasslands for which either the surveyors or the botanists have indicated that the age of the grasslands is unclear.
- Grassland type of vigour: The type of vigour is one of the parameters that caused difficulties in the judgement for either, the surveyors or the botanists or for both. There is a moderate error rate in the results.
- Percentage of grass-herb-layer, bare layer and woody layer: The cover of the grass herb layer was reliably estimated whereas the bare layer was not. This could have happened because the share of the bare layer is small (compared to the grass herb layer) and thus deviations in the judgement may have happened more often. The woody layer can be distinguished more clearly as it is clearly visible above the grass-herb layer and therefore it was recorded reliably.

  The results are confirmed by the average values (table 2) – the mean grass herb layer coverage is 86 – 90 % in all data subsets. For the bare layer, the relative difference is much larger (subset A 18% vs. 9%) and for the woody layer (subset A 7% vs. 9%).
- Percentage of graminoids and forbs: Going more into the details of the composition of the grass herb layer – thus estimating the percentage of the graminoids and of the forbs – it turned out that this caused more difficulties. For botanists it is usual to record the graminoid and the forb layer whereas for the normal surveyors this was more difficult. This resulted in only a low reliability. However, building the mean values the differences of surveyors and experts are partly levelled out.

- Height of upper vegetation layer (cm): This parameter was recorded reliably when the two surveys were close (within 10 days). Quite logically, the agreement decreased with increasing time lag between the surveys. .

- Heterogeneity of grass-herb layer and reasons for heterogeneity of grass-herb-layer: these two parameters were recorded reliably.

- Number of flowering forbs and flower density: there were big differences in records of these parameters. Probably the surveyors didn't recognize the small flowering species (e.g. the species with flowers of 1-5 mm diameter) and thus didn't count the correct numbers.
  Looking at the average values, the surveyors only recorded about half the number of flowering forbs compared to the experts (mean averages subset A 9.7 versus 5.6 species).
  Estimating the flower density also seemed to be a difficult task. Interestingly the average results for the flower density are closer (subset A: flower density 4.5 compared to 3.8) and thus the individual differences in the data records levelled out to a large extent).

- Number of key species: the number of key species also differed, in that the surveyors recorded fewer species than the experts did. However, recording the key species went much better than the pure number of flowering forbs – obviously due to the fact that the surveyors had an illustrated instruction booklet with the species they had to look for and also due to the fact that almost all key species are plants with bigger flowers (easier to recognize).

- Percentage of legumes: the estimation of the coverage of the legumes is a difficult task as one has to summarise all the legumes in the transect (thus the different clover and other legume species) and then estimate the total coverage. We assume that this went much better for the botanists because they do not have to check a list of legumes but they know them all and only have to concentrate on the estimation of the coverage.
  The average values for the legume cover are relatively close together (sum A: 12.8 % versus 14.3 % of legumes).

5.2 Improvement of the LUCAS instructions based on the results

The data collected by surveyors and experts were used to evaluate the reliability and meaningfulness of the parameters. Based on this, the parameters and the instructions to surveyors were reviewed together with three external grassland specialists and people with experience of coordinating the LUCAS survey in 2018.

The pilot LUCAS grassland survey and the data analysis showed that the grassland module has proven to be practical overall. The expert survey has shown that many of the parameters can be recorded reliably across a range of grassland types and regions, but that some improvements are required. The LUCAS grassland module instructions have thus been revised as follow:

- Approx. half of the parameters were dropped
- A few parameters need further discussion during the detailed planning of the next LUCAS grassland survey (e.g. type of fertilisation, dead wood layer coverage…)
- We improved the classification of some parameters (e.g. categories of slope instead of a continuous scale or new list of 12 key-species for all biogeographical regions instead of 20 key species of each European subregion)
- We merged some fields to be more intuitive (e.g. grassland types)
- We proposed new parameters (e.g. posy of flowers as a quality control option for the key species/number of flowering forbs)

The example of the key species parameter shows how and on what basis such an adjustment was worked out.

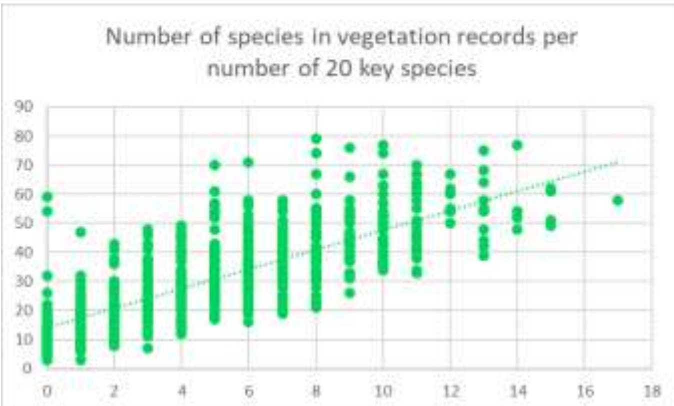
The error rate of 43% between surveyor data and expert data (s. Figure 26) is probably because the surveyors have little or no knowledge of plant identification. The aim of the adjustment was therefore to simplify handling, but to retain the meaningfulness of this parameter.

Table 3 shows that 9 of the 41 key species were recorded in a maximum of only 4 regions, whilst 15 occur in all regions (expert data). The question is therefore whether less than 20 key species have the same meaning for all regions as the respective 20 key species for the respective biogeographic region.

Table 3: Occurrence of the key species in the 10 biogeographic regions (expert data). The numbers in the column 1 – 10 indicate percentages of presence in the transect records. The ten core species have a grey background.

Code Number	Biogeographic region / Key species / key species groups / number of vegetation rec	1	2	3	4	5	6	7	8	9	10	Sum	Number of regions
		21	57	59	89	177	42	17	110	37	104	713	
SPEC12	Trifolium spp., Medicago spp., Lotus spp., Coronilla (yellow flowering)	5	8	17	31	124	29	9	83	29	82	417	10
SPEC9	Cichorioideae without Tragopogon spp. and without Taraxacum spp.	5	6	19	41	123	31	5	77	12	61	380	10
SPEC8	Apiaceae	2	26	14	40	82	28	9	73	18	56	348	10
SPEC31	Trifolium spp. (red flowering)	3	22	16	52	71	30	8	73	5	31	311	10
SPEC27	Achillea spp.	2	25	9	49	7	23	12	92	24	20	263	10
SPEC28	Centaurea spp., Serratula tinctoria	1	5	7	15	41	23	7	63	14	24	200	10
SPEC30	Scabiosa spp., Knautia spp., Succisa spp.	1	3	3	11	27	12	2	28	2	10	99	10
SPEC10	Orchidaceae spp.	2	6	1	7	28	3	1	11	1	13	73	10
SPEC11	Silene spp., Lychnis flos-cuculi, Dianthus spp. (red flowering)	0	4	4	16	66	11	2	26	2	19	150	9
SPEC29	Leucanthemum spp.	0	5	7	19	5	14	2	37	0	0	89	7
SPEC7	Vicia spp., Lathyrus spp., Astragalus spp. (blue or purple flowering)	1	31	10	37	81	27	12	59	16	56	330	10
SPEC15	Cirsium spp., Carduus spp., Carlina spp.	6	22	15	17	58	13	14	58	21	50	274	10
SPEC38	Galium spp. (white flowering)	3	18	10	28	46	26	5	39	6	15	196	10
SPEC3	Potentilla spp. without Potentilla anserina	3	16	4	17	17	19	6	60	5	21	168	10
SPEC21	Myosotis spp.	2	5	5	15	17	11	2	16	2	15	90	10
SPEC34	Campanula spp.	1	9	1	9	15	6	2	33	1	7	84	10
SPEC40	Juncus spp.	9	9	4	8	18	1	3	6	2	4	64	10
SPEC19	Galium verum	0	5	1	5	7	9	11	68	17	9	132	9
SPEC6	Tragopogon spp., Scorzonera spp.	0	3	1	11	31	6	8	23	6	29	118	9
SPEC17	Euphorbia spp.	0	0	2	6	46	6	3	41	8	28	140	8
SPEC24	Sanguisorba spp.	0	0	3	8	36	7	1	17	2	46	120	8
SPEC25	Thymus spp.	0	0	1	6	28	6	1	44	5	23	114	8
SPEC33	Astragalus spp., Coronilla spp., Onobrychis spp., Hedysarium corona	0	0	1	2	25	3	5	21	2	24	83	8
SPEC13	Artemisia spp.	0	4	0	2	8	3	1	10	19	3	50	8
SPEC18	Filipendula spp.	1	8	2	1	3	2	2	27	0	0	46	8
SPEC4	Salvia spp.	0	0	0	1	10	13	2	28	1	10	65	7
SPEC36	Eryngium planum and other, Echinops spp.	0	0	1	0	50	0	4	43	10	39	147	6
SPEC23	Rhinanthus spp.	0	3	0	9	6	12	1	22	0	0	53	6
SPEC39	Genista spp., Spartium spp., Calicotome spp., others	0	0	0	4	25	1	0	21	0	1	52	5
SPEC20	Geranium spec. with big flowers (flower diameter ≥ 1cm)	0	5	0	5	0	3	0	6	5	0	24	5
SPEC37	Euphrasia spp.	1	0	0	0	1	0	0	11	1	1	15	5
SPEC26	Valeriana spp.	0	1	0	0	1	0	1	1	2	0	6	5
SPEC41	Asphodelus spec., Narthecium spec., Paradisea liliastrum	0	0	1	0	20	1	0	0	0	9	31	4
SPEC35	Cistus spp.	0	0	0	0	17	0	0	1	0	8	26	3
SPEC32	Adonis spp.	0	0	0	0	6	0	0	1	0	1	8	3
SPEC2	Pedicularis spp.	2	0	0	2	1	0	0	0	0	0	5	3
SPEC1	Limonium spp.	0	0	0	0	0	0	1	1	0	2	4	3
SPEC14	Bistorta officinalis (= Polygonum bistorta)	0	0	0	11	0	0	0	1	0	0	12	2
SPEC22	Phlomis fruticosa	0	0	0	0	0	0	0	0	1	3	4	2
SPEC5	Thalictrum spp.	0	0	0	0	0	2	0	2	0	0	4	2
SPEC16	Clematis integrifolia	0	0	0	0	1	0	0	0	1	0	2	2
	Sum of occuring key species per region	18	24	26	31	36	31	30	37	30	32	41	10

Therefore, the correlation between total number of plant species in the vegetation records were checked related to differed number of key species. Figure 28 show the relationship between the number of key species (left all 20 key species per region and right the 10 core key species) and the total number of higher plant species recorded in the vegetation records. There is a strong correlation for both indicators.



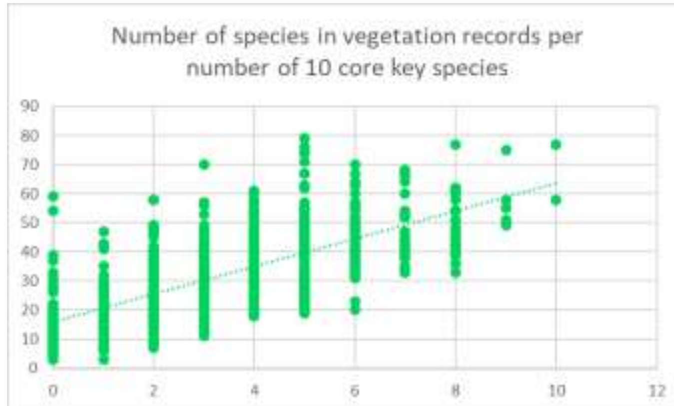


Figure 28: Total number of plant species in the vegetation records (Y-axis) related to the number of 20 key species (left) and related to the number of 10 core key species (right, X-axis).

Therefore, the detailed correlation coefficients for all regions and for different sets of key species and with the total number of vascular plant species from the vegetation records (experts) were checked (s. Table 4).

Table 4: Correlation table for the correlation of the sets of key species with the total number of vascular plant species from the vegetation records (experts) in the different biogeographic regions.

Biogeographic region	**all 41 key spec.**	**20 key spec.**	**10 core key spec**	**new - 12 key spec**
Region 1	0.924	0.906	0.909	0.913
Region 2	0.755	0.679	0.513	0.667
Region 3	0.866	0.849	0.702	0.795
Region 4	0.782	0.733	0.663	0.732
Region 5	0.684	0.648	0.577	0.642
Region 6	0.743	0.745	0.653	0.679
Region 7	0.834	0.671	0.678	0.809
Region 8	0.830	0.767	0.763	0.752
Region 9	0.579	0.511	0.622	0.661
Region 10	0.774	0.784	0.616	0.749
All regions	**0.782**	**0.754**	**0.694**	**0.757**

A new set of key species was tested also in regard of the correlation coefficients.

Whether 20 or 12 key species, the correlation coefficient for all regions together remains similarly high. With the new 12 key species, region 1, 7 und 9 have a higher correlation coefficient, while region 3, 6 and 10 have a lower correlation coefficient. For the remaining 4 regions (2, 4, 5 & 8) the correlation coefficient remains roughly the same.

This optimum result is reflected by the following correlation coefficients with total number of species in vegetation records:

2018 set of 10 core key species r = 0.694

2018 region specific set of 20 key species r = 0.754

2018 (theoretical) consideration[4] of all 41 key species r = 0.782

New selection of 12 EU-wide key species group r = 0.757

This new set with a catalogue of 12 key species groups (Table 5) was identified which reflects an optimum regarding the reduction of key species to a unique EU-list and the adequate consideration of the presence of the species in all biogeographic regions.

The region-specific set of 20 key species is not better correlated with the total number of plant species than the new set of 12 species. However, the 12 species are much easier to handle than the 20 key species and the results with a EU-wide list of 12 key species are better to compare than the results of 10 different lists (for 10 biogeographic regions). In future surveys, the 12 key species given in Table 5 should be worked with.

Table 5: Proposal for a new EU-wide set of 12 key species

SPEC8	Apiaceae
SPEC34	Campanula spp.
SPEC28	Centaurea spp., Serratula tinctoria
SPEC15+36	Cirsium spp., Carduus spp., Carlina spp. together with Eryngium planum, Echinops spp.
SPEC40	Juncus spp.
SPEC 21	Myosotis spp.
SPEC10	Orchidaceae spp.
SPEC30	Scabiosa spp., Knautia spp., Succisa spp.
SPEC11	Silene spp., Lychnis flos-cuculi, Dianthus spp. (red flowering)
SPEC31	Trifolium spp. (red flowering)
SPEC12	Trifolium spp., Medicago spp., Lotus spp., Coronilla (yellow flowering)
SPEC7	Vicia spp., Lathyrus spp., Astragalus spp. (blue or purple flowering)

[4] All 41 key species / key species groups were only recorded by the botanists (this would not be applicable in an extended EU-wide survey by “normal” LUCAS surveyors

6 Summary and outlook

The Land Use/Cover Area-Frame Survey (LUCAS) is a European inventory carried out every three years and coordinated by Eurostat. It aims to provide information for policy and science on land use, land cover and environmental parameters by surveying a statistically representative sample of points spread across the EU countries. In 2018, a new grassland module was piloted within the survey. This pilot aims to collect detailed information on the environmental and ecological quality of the grassland, as well as its type and intensity of use. Between April and July 2018, 3734 grassland points in 26 countries were surveyed using this standardized methodology. Of these points, 747 underwent an additional quality control to check the accuracy of the survey method. This is the first time a standardized methodology has been used to collect ecological data on grasslands in a coordinated manner over so wide a geographical range in Europe.

In this report, the methodology of the LUCAS grassland module is described, and results and validation analysis are presented. Some examples of graphics and maps were worked out and show the interpretation potential of the LUCAS 2018 grassland module However, as the sample was not representative, the results presented are only illustrative to show how the data can be presented.

The results of the LUCAS 2018 grassland survey were very encouraging, and the analysis and interpretation of the data allow to give a clear recommendation for the continuation of the LUCAS grassland survey. More detailed information on the LUCAS grassland methodology is given in the original document of the survey, and photos of the LUCAS points are available under https://ec.europa.eu/eurostat/web/lucas/.

ANNEXES

Annex I – List of abbreviations used

EUROSTAT	Eurostat is the statistical office of the European Union.
LUCAS	Land Use and Coverage Area frame Survey; Eurostat has carried out this survey every 3 years since 2006 to identify changes in the European Union
EU	European Union
IFAB	Institute for Agroecology and Biodiversity

EU member states

AT: Austria	BE: Belgium	BG: Bulgaria	CY: Cypris
CZ: Czech Republic	DK: Denmark	EE: Eastland	EL: Greece
ES: Spain	FI: Finland	FR: France	HR: Hungary
HU: Croatia	IE: Ireland	IT: Italy	LT: Lithuania
LV: Latvia	NL: Netherlands	PL: Poland	PT: Portugal
RO: Romania	SE: Sweden	SI: Slovenia	SK: Slovakia
UK: United Kingdom			

Biographic regions LUCAS grassland survey

1: Atlantic – Northwest
2: Boreal – Scandinavia + Baltic Sea
3: Atlantic – South + East
4: Continental – North
5: Mediterranean – West and Central
6: Continental – South
7: Pannonian
8: Continental – East
9: Steppic Black-Sea
10: Mediterranean East

LUCAS habitat types

A30 Other artificial areas
B50 Fodder crops (mainly leguminous)
B55 Temporary grasslands
B70 Permanent crops: Fruit trees
B80 Other permanent crops
C10 Broadleaved woodland
C20 Coniferous woodland
C30 Mixed woodland

D10 Shrubland with sparse tree cover
D20 Shrubland without sparse tree cover
E10 Grassland with sparse tree/shrub cover
E20 Grassland without tree/shrub cover
E30 Spontaneously re-vegetated surfaces
H10 Inland wetlands
H20 Coastal wetlands

EUNIS (EUropean Nature Information System) descriptions of the most frequent habitat types in the LUCAS grassland survey to Level 2

A Marine habitats

A2 Littoral sediment

B Coastal habitats

B1 Coastal dunes and sandy shores

C Inland surface waters

C3 Littoral zone of inland surface waterbodies

D Mires, bogs and fens

D1 Raised and blanket bogs

D2 Valley mires, poor fens and transition mires

D3 Aapa, palsa and polygon mires

D4 Base-rich fens and calcareous spring mires

D5 Sedge and reedbeds, normally without free-standing water

D6 Inland saline and brackish marshes and reedbeds

E Grasslands and lands dominated by forbs, mosses or lichens

E1 Dry grasslands

E2 Mesic grasslands

E3 Seasonally wet and wet grasslands

E4 Alpine and subalpine grasslands

E5 Woodland fringes and clearings and tall forb stands

E6 Inland salt steppes

E7 Sparsely wooded grasslands

F Heathland, scrub and tundra

[F1 Tundra] [not relevant for LUCAS survey as Tundra occurs only north/east of EU-28]
F2 Arctic, alpine and subalpine scrub

F4 Temperate shrub heathland

F5 Maquis, arborescent matorral and thermo-Mediterranean brushes

F6 Garrigue

F7 Spiny Mediterranean heaths (phrygana, hedgehog-heaths and related coastal cliff vegetation)

F8 Thermo-Atlantic xerophytic scrub

F9 Riverine and fen scrubs

FA Hedgerows

FB Shrub plantations F3 Temperate and Mediterranean-montane scrub FB Shrub plantations

G Woodland, forest and other wooded land

G1 Broadleaved deciduous woodland
G2 Broadleaved evergreen woodland
G3 Coniferous woodland
G4 Mixed deciduous and coniferous woodland
G5 Lines of trees, small anthropogenic woodlands, recently felled woodland, early-stage woodland and coppice

I Regularly or recently cultivated agricultural, horticultural and domestic habitats

I1 Arable land and market gardens
I2 Cultivated areas of gardens and parks

For more detailed information please consult the original EUNIS habitat description:
Davies, C.E., Moss, D., Hills, M.O. (2004): EUNIS Habitat classification, revised 2004. R Report to the European Environment Agency / European Topic Centre on Nature Protection and Biodiversity. 310 pages.

Number of parameters, species number and name of key species

Number	Species number	Name
215	SPEC12	Trifolium spp., Medicago spp., Lotus spp., Coronilla (yellow flowering)
186	SPEC9	Cichorioideae without Tragopogon spp. and without Taraxacum spp.
179	SPEC8	Apiaceae
217	SPEC7	Vicia spp., Lathyrus spp., Astragalus spp. (blue or purple flowering)
214	SPEC31	Trifolium spp. (red flowering)
187	SPEC15	Cirsium spp., Carduus spp., Carlina spp.
177	SPEC27	Achillea spp.
185	SPEC28	Centaurea spp., Serratula tinctoria
194	SPEC38	Galium spp. (white flowering)
205	SPEC3	Potentilla spp. without Potentilla anserina
210	SPEC11	Silene spp., Lychnis flos-cuculi, Dianthus spp. (red flowering)
190	SPEC36	Eryngium planum and other, Echinops spp.
191	SPEC17	Euphorbia spp.
195	SPEC19	Galium verum
208	SPEC24	Sanguisorba spp.
213	SPEC6	Tragopogon spp., Scorzonera spp.
212	SPEC25	Thymus spp.
209	SPEC30	Scabiosa spp., Knautia spp., Succisa spp.
201	SPEC21	Myosotis spp.
199	SPEC29	Leucanthemum spp.
184	SPEC34	Campanula spp.
182	SPEC33	Astragalus spp., Coronilla spp., Onobrychis spp., Hedysarium coronaria (with red or red-white flowers)
202	SPEC10	Orchidaceae spp.
207	SPEC4	Salvia spp.
198	SPEC40	Juncus spp.
206	SPEC23	Rhinanthus spp.
196	SPEC39	Genista spp., Spartium spp., Calicotome spp., others
180	SPEC13	Artemisia spp.
193	SPEC18	Filipendula spp.
181	SPEC41	Asphodelus spec., Narthecium spec., Paradisea liliastrum
188	SPEC35	Cistus spp.
197	SPEC20	Geranium spec. with big flowers (flower diameter ≥ 1cm)
192	SPEC37	Euphrasia spp.
183	SPEC14	Bistorta officinalis (= Polygonum bistorta)
178	SPEC32	Adonis spp.
216	SPEC26	Valeriana spp.
203	SPEC2	Pedicularis spp.
204	SPEC22	Phlomis fruticosa
200	SPEC1	Limonium spp.
211	SPEC5	Thalictrum spp.
189	SPEC16	Clematis integrifolia

Abbreviations used in the figures in the results:
The word "error" in front of the parameter name (e.g., error_SURVEY_GRASS_SLOPE) means the error rate of this parameter when surveyor data and expert date is compared.
The letter "s" in front of the parameter name (e.g., s_SURVEY_GRASS_SLOPE) means the average value of this parameter as determined by surveyors.
The letter "e" in front of the parameter name (e.g., e_SURVEY_GRASS_SLOPE) means the average value of this parameter as determined by experts.

DMT-name	No. of parameter	Parameter
SURVEY_GRASS_SLOPE	101	Site slope (in degrees)
SURVEY_GRASS_EUNIS_HABITAT	98	EUNIS Grass habitat type
SURVEY_GRASS_ORIENTATION	100	Site orientation
SURVEY_GRASS_SITE_MOISTURE	102	Site moisture
SURVEY_GRASS_SURFACE	103	Soil surface
SURVEY_GRASS_ANIMAL_PATHS	104	Presence of animal paths
SURVEY_GRASS_FERTILIZ	106	Fertilisation
SURVEY_GRASS_FERTILIZ_TYPE	107	Type of fertilisation (if, probably or for sure)
SURVEY_GRASS_GRASSLAND_TYPE	109	Grassland type
SURVEY_GRASS_MEADOW_GROWTH	110	Growth if meadow
SURVEY_GRASS_PASTURE_OTHER	123	Animals if grazed pasture (multiple choice) - Other
SURVEY_GRASS_FALLOW_AGE	125	Age, if fallow (meadow, pasture or other fallow)
SURVEY_GRASS_AGE	127	Grassland age
SURVEY_GRASS_VIGOUR_VEG	142	Vigour of vegetation
SURVEY_GRASS_GRMHRB_PERC	143	Herbaceous layer on grass transect (%)
SURVEY_GRASS_BARE_PERC	144	Bare layer on grass transect (%)
SURVEY_GRASS_WOODY_PERC	145	Woody layer on enlarged grass transect (%)
SURVEY_GRASS_GRMHRB_GRAM_PERC	147	Herb layer components (on grass transect) - Graminoids (grass-like plants)
SURVEY_GRASS_GRMHRB_FORBS_PERC	148	Herb layer components (on grass transect) - Forbs (broad-leaved plants)
SURVEY_GRASS_HERB_LAYER1_H_CM	165	Height of highest layer
SURVEY_GRASS_HERB_LAY_HETEROG	170	Herb layer heterogeneity
SURVEY_GRASS_HERB_LAY_HET_REAS	171	Herb layer heterogeneity reason
SURVEY_GRASS_FLOWERING_FORBS_N	173	Number of species of flowering forbs:
SURVEY_GRASS_FLOWER_DENSITY	174	Flower density (all flowers)
NUMBER_KEY_SPECIES	177-217	Number of key species
SURVEY_GRASS_LEGUME_TOTAL_PERC	236	Total cover of legumes (%)

Annex II – Timing of the LUCAS grassland survey

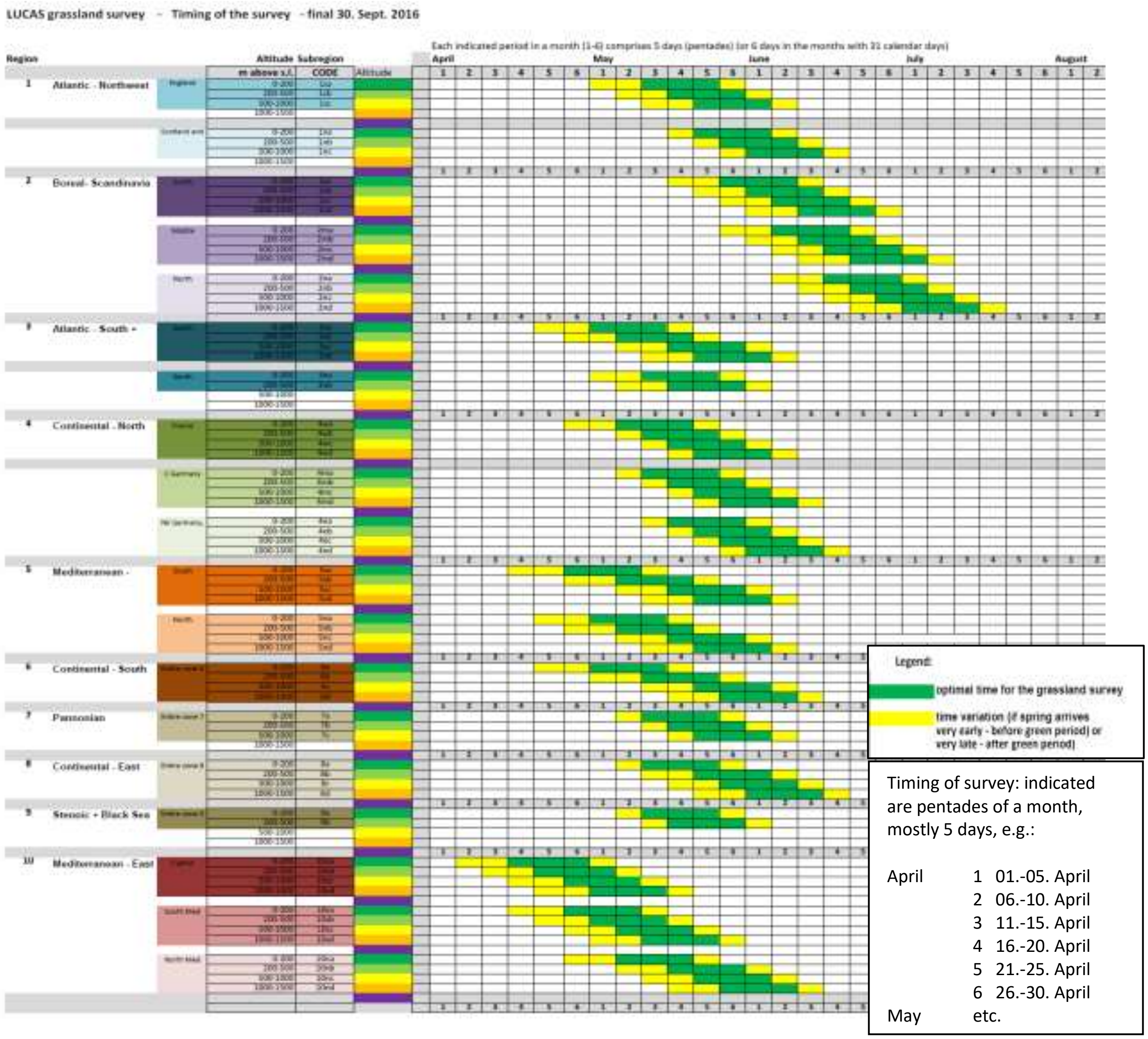


Figure 29: The time framing for the LUCAS grassland survey for all 10 regions and 19 regions+ subregions. The more northern and the higher in altitude, the later the survey should take place according to the development and phenology of the grassland vegetation. IFAB 2016 for the preparation for the LUCAS grassland module on behalf project for Eurostat.

Annex III – List of the key species (groups) and their application in different regions

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5 Overview on the key species / key species groups and their application as key species in different regions, the colour of their flowers and the plant families.

Selected species / species groups	European Regions / English names	1 Atlantic - Northwest	2 Borea + Baltic Sea	3 Atlantic - South+East	4 Continental - North	5 Mediterranean - West+Central	6 Continental - South	7 Pannonian	8 Continental - East	9 Steppic + Black Sea region	10 Mediterranean - East	Σ Sum of Regions	Colours of the flowers	Plant family (botanical name)	Plant family (English name)
Achillea spec.	Yarrow	x	x	x	x	x	x	x	x	x	x	10	white, yellow	Asteraceae	Daisy family
Apiaceae	Carrot family	x	x	x	x	x	x	x	x	x	x	10	white, yellow	Apiaceae	Carrot family
Centaurea spec., Serratula tinctoria	Knapweed	x	x	x	x	x	x	x	x	x	x	10	red, pink	Asteraceae	Daisy family
Cichoriaceae, yellow without Tragopogon (see below) and without Taraxacum off.	Daisy family	x	x	x	x	x	x	x	x	x	x	10	yellow	Asteraceae	Daisy family
Leucanthemum spec.	Daisy	x	x	x	x	x	x	x	x	x	x	10	white	Asteraceae	Daisy family
Orchidaceae spec.	Orchid family	x	x	x	x	x	x	x	x	x	x	10	all colours	Orchidaceae	Orchid family
Scabiosa spec., Knautia spec., Succisa spec.	Scabious	x	x	x	x	x	x	x	x	x	x	10	blue, white	Dipsacaceae	Teasel family
Silene spec. - red flowering, Lychnis flos-cuculi, Dianthus spec.	Campion	x	x	x	x	x	x	x	x	x	x	10	red, pink	Caryophyllaceae	Pink family
Trifolium spec. - red flowering	Clover	x	x	x	x	x	x	x	x	x	x	10	red	Fabaceae	Legume family
Trifolium spec., Medicago spec., Lotus spec., et al. Coronilla - yellow flowering	Trefoil, Vetch	x	x	x	x	x	x	x	x	x	x	10	yellow	Fabaceae	Legume family
Adonis vernalis spec.	Pheasant's eye									x		1	yellow	Ranunculaceae	Buttercup family
Artemisia spec.	Wormwood							x		x		2	yellow -grey	Asteraceae	Daisy family
Asphodelus spec., Narthecium spec., Paradisea liliastrum	Asphodel, Paradise lily					x					x	2	white, yellow	Liliaceae, Asparagaceae	Lily family, Asparagaceae family
Astragalus spec., Coronilla spec., Onobrychis spec., Hedysarum coron. , -red+white flowers	Vetch, Sainfoin,					x	x	x	x	x	x	6	red, rose, red-white	Fabaceae	Legume family
Bistorta officinalis / Polygonum bistorta	European bistort		x	x	x							3	rose	Polygonaceae	Knotweed family
Campanula spec.	Bellflower		x		x		x		x			4	blue, white	Campanulaceae	Bellflower family
Cirsium spec., Carduus spec., Carlina spec.	Thistle		x	x	x	x	x					5	red, yellowish	Asteraceae	Daisy family
Cistus spec.	Rockrose										x	1	pink, white	Cistaceae	Rock rose family
Clematis integrifolia	Solitary clematis							x				1	blue	Ranunculaceae	Buttercup family
Eryngium planum et al., Echinops spec.	Eryngo, Globe thistles					x			x	x	x	4	blue	Apiaceae, Asteraceae	Carrot family, Daisy family
Euphorbia spec.	Spurge								x	x	x	3	yellow , green-yellowish	Euphorbiaceae	Euphorbias
Euphrasia spec.	Eyebright	x	x									2	white-purple-yellow	Scrophulariaceae	Figwort family
Filipendula spec.	Meadowsweet	x							x			2	white-yellowish	Rosaceae	Rose family
Galium spec. (white flowering)	Bedstraw	x	x	x								3	white	Rubiaceae	Bedstraw family
Galium verum (yellow flowering)	Yellow bedstraw	x					x		x	x		4	yellow , green-yellowish	Rubiaceae	Bedstraw family
Genista spec. , Spartium spec., Calicotome spec., et al.	Broom			x							x	2	yellow	Fabaceae	Legume family
Geranium spec. with big flowers	Cranebills				x							1	rede, blue, purple, brown	Geraniaceae	Cranesbill family
Juncus spec.	Rush			x		x						3	gree, brown	Juncaceae	Rush family
Limonium spec.	Sea-lavender							x				1	blue	Plumbaginaceae	Thrift family
Myosotis spec.	Forget-me-not	x		x								2	blue	Boraginaceae	Borage family
Pedicularis spec.	Lousewort		x									1	yellow , red	Scrophulariaceae	Figwort family
Phlomis fruticosa	Jerusalem sage										x	1	yellow	Lamiaceae	Labiate family
Potentilla spec. (without Pot. anserina)	Cinquefoil	x	x	x						x		4	yellow	Rosaceae	Rose family
Ranunculus spec. (yellow flowering)	Buttercup											1	yellow	Ranunculaceae	Buttercup family
Rhinanthus spec.	Rattle	x	x		x		x	x				5	yellow	Scrophulariaceae	Figwort family
Salvia spec.	Clary				x	x	x	x	x	x	x	7	blue, white	Lamiaceae	Labiate family
Sanguisorba spec.	Burnet			x	x	x	x	x	x			6	red	Rosaceae	Rose family
Thalictrum spec.	Meadow-rue							x				1	yellow , rose	Ranunculaceae	Buttercup family
Thymus spec.	Thyme	x	x	x	x	x	x	x	x		x	9	red, purple	Lamiaceae	Labiate family
Tragopogon spec., Scorzonera spec.	Salsify		x		x	x	x	x	x	x		7	yellow , purple	Asteraceae	Daisy family
Valeriana spec.	Valerian	x										1	white, rose	Valerianaceae	Valerian family
Vicia spec.+ Lathyrus spec. + Astragalus spec. - blue+purple flowers	Vetch	x		x	x	x	x			x	x	7	blue, purple	Fabaceae	Legume family
		20	20	20	20	20	20	20	20	20	20	42			

Source: LUCAS 2018 Technical reference document C6 - Grassland Survey - Identification Guide, p. 7. IFAB 2016 for the preparation for the LUCAS grassland module on behalf project for Eurostat.