



EU-wide maps of grassland management using 2022 LUCAS grassland and extended grassland data

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Abstract. Grassland is a major European ecosystem that provides a variety of services, including food production, greenhouse gas mitigation, biodiversity conservation or cultural services. As such, it occupies a central position in environmental and food production considerations. Grasslands across Europe come with a diversity of management, from extensive semi-natural and species rich pastures to very intensive single species meadows. As management determines the services provided by grasslands, it ultimately influences the resilience of European agricultural systems. Consequently, there is a pressing need for a monitoring system to inform evidence-based decision-making for a sustainable management of grasslands across Europe. The 2022 LUCAS grassland and extended grassland surveys collected over 29 900 samples across the entire EU27, providing harmonized in-situ observations for various grassland-related information, including their use (meadows, pastures, pastures or meadows) and intensity (intensive, moderately intensive or extensive) of management. We present the regionally aggregated (NUTS2 level) outputs from these surveys, delivering the first EU27 level map based on harmonized, in-situ collected data of grasslands intensity and use management, their forb-to-grass ratio and age category (i.e. temporary vs permanent). A strong zonation of intensity and use has been reported, with high intensity grasslands located in central and northern Europe and extensive ones located in southern Europe. Meadows prevail in central and eastern Europe, while pastures are predominant in western Europe. Highest forb ratio are generally observed in central and northern Europe. Furthermore, weak but statistically significant correlations were observed between forb ratio and management intensity. Permanent grasslands represented the dominant age category. This dataset can underpin Earth Observation-based monitoring systems as well as large scale modelling studies, further strengthening the evidence base for decisions on grassland management and use, and the multiple productive and ecological services they provide. Data described in this manuscript can be accessed at the JRC Data Catalogue repository under <https://doi.org/10.2905/JRC.CVXWHE8> (Morel et al., 2026).



20 1 Introduction

Grasslands, defined as open habitats dominated by herbaceous vegetation, particularly grasses and other graminoids, with limited woody cover, are among the major ecosystems of the world and account for close to one-third of the agricultural land use in Europe (Eurostat, 2025). They encompass a wide range of forms, species compositions and diversity levels, from natural and semi-natural grasslands typically found in the Alpine arc or around the Mediterranean basin to highly managed grasslands common in northern Europe (Bengtsson et al., 2019).

Grasslands, and permanent grasslands in particular, provide a wide range of ecosystem services, as summarised by Schils et al. (2022). They remain the cheapest source of protein and energy for cattle feeding and are therefore central to the meat and dairy sectors (Peeters, 2009). Their dense and diverse root systems contribute to water purification by reducing the leaching of potentially harmful substances into groundwater (Viglizzo et al., 2016), while also limiting run-off and soil erosion (Milazzo et al., 2023). These well-developed and relatively undisturbed root systems further support the accumulation of soil organic matter and contribute to carbon sequestration (Bai and Cotrufo, 2022; Hungate et al., 2017; Conant et al., 2017), helping to mitigate the effects of climate change. Natural and semi-natural grasslands are also important biodiversity hotspots (Shipley et al., 2024), and in some cases, they can host vascular plant diversity exceeding that of tropical rainforests (Wilson et al., 2012).

Given the ecosystem services they provide and the large share of land they occupy across Europe, grasslands are central to several objectives of the European Green Deal (Morel and Rossi, 2025). In particular, they contribute to key priorities related to (i) *Climate adaptation*, (ii) *Preserving and restoring ecosystems and biodiversity* and (iii) the *Farm to fork* strategy. Grassland management choices strongly influence the trade-offs and synergies among these objectives, as summarised in Fig. 1. Productive grasslands are typically intensively managed permanent or temporary grasslands, characterized by regular fertilization, re-sowing of monospecies swards, frequent mowing, or grazing at high livestock densities. These practices can increase biomass production (Smit et al., 2008) and thereby support the objectives of the *Farm to Fork* strategy. However, they can also disturb root systems and reduce biodiversity (Socher et al., 2012). By contrast, semi-natural grasslands are low-input systems characterized by reduced fertilization, moderate grazing, more developed root systems, and higher biodiversity (Schils et al., 2022). These systems therefore contribute to the *Climate adaptation* and *Preserving and restoring ecosystems and biodiversity* key priorities.

Several studies have addressed grassland extent, dynamics or management across Europe, but, to our knowledge, none have relied on harmonized, in-situ data on grassland management collected across the European Union (EU). For example, Smit et al. (2008) mapped the productivity and extent of permanent grasslands across Europe using non-harmonized sources, including national statistics, Eurostat and FAO datasets. Pazúr et al. (2024) assessed grassland cover dynamics across the EU28 using CORINE land cover, but they did not account for grassland management. Estel et al. (2018) mapped management intensity across Europe using MODIS-derived mowing frequency, although their approach relied on remote sensing proxies with



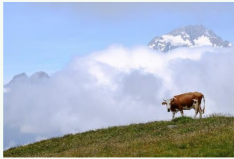
EGD	Key factors and traits	Low benefits	High benefits
Climate adaptation	• High water retention • Water run-off regulation • Greenhouse gas sink • Prevent soil erosion • High climate resilience	 Temporary grasslands	 Permanent grasslands
Greening and Farm to Fork	• High productivity • High protein content • N and P fixation • High social and economic resilience	 Extensive or mixed	 Temporary or intensive
Ecosystem and Biodiversity	• Species richness • Different and rare species composition • Limited use of pesticides • Abundant pollinators • High ecological resilience	 Temporary or intensive	 Permanent extensive or mixed

Figure 1. Ecosystem services and European Green Deal objectives - adapted from Morel and Rossi (2025)

acknowledged limitations. Similarly, Dou et al. (2021) developed a 1 km² European land-system classification incorporating land use intensity and landscape characteristics relevant for biodiversity assessment, including grassland intensity indicators; however, the grassland component was still based on proxy variables such as livestock density, nitrogen input and mowing frequency rather than harmonised in-situ observations of grassland management. Together, these studies highlight a clear gap for a harmonised, in-situ grassland use and management-intensity product across Europe, which the LUCAS 2022 grassland modules can help address.

The Land Use/Cover Area frame Survey (LUCAS) is a harmonised in-situ land cover and land use data collection exercise, conducted by Eurostat, the statistical office of the EU. It covers the territory of the EU Member States and provides detailed information on land cover and land use, including agricultural areas, forests, artificial surfaces, wetlands, and water bodies. LUCAS data are widely used for environmental monitoring, policy support, and scientific research. The survey is typically carried out every three to five years.

The 2022 LUCAS survey included two grassland focused modules: a main grassland module, hereafter referred to as LGM, and an extended grassland module, hereafter referred to as LGEM, which formed part of the LUCAS Core. The LGM includes



several variables describing the status and management of grassland fields, including estimated age, signs of fertilization, presence or signs of cattle, presence of shrubs, forb-to-grass ratio, etc.; see Eurostat (2022) for a comprehensive list of variables included in the module. The LGEM extends the LUCAS Core module and includes a subset of the LGM variables. LGM and LGEM differed slightly in their field methodology, with LGM including transect-based assessments around the survey point, whereas LGEM relied solely on extended point-based observations (see Eurostat (2022) for more details on the methodologies). Combining both modules yielded 29 954 samples across the EU27. Among the variables included in both modules, grassland type describes both use, for example meadow, defined as grassland mown to produce livestock feed, or pasture, defined as grassland used for animal grazing, and management intensity, ranging from very extensive to very intensive. The forb-to-grass ratio (hereafter referred to as forb ratio) and the approximate grassland age are also reported and provide relevant indicators of management intensity.

The original LGM and LGEM data were collected as geolocated points. However, because the point-level data cannot be publicly shared due to privacy and confidentiality requirements, they were aggregated to level 2 of the Nomenclature of Territorial Units for Statistics (NUTS2). In this paper, we present a harmonised regional dataset derived from the LUCAS 2022 grassland modules, providing NUTS2-level information on grassland management intensity, grassland use type, forb ratio and age category (permanent vs temporary) across the EU27. The aim is to present and evaluate aggregated grassland management indicators, with the objective of showing their strengths, limitations and readiness of use in environmental monitoring, policy evaluation and spatial modelling of grassland ecosystem services, biodiversity and management trade-offs.

2 Data and methods

2.1 LUCAS Grassland sampling and aggregation procedures

The LGM and LGEM were originally planned to include 20 000 and 40 000 samples, respectively, in the 2022 survey. However, practical constraints during the sampling campaign reduced the actual sample sizes to 12 040 for the LGM and 17 914 distinct observations for the LGEM, resulting in a total of 29 954 samples available for analysis. Indeed, some observations were included in both the LGM and LGEM. To avoid double-counting, these overlapping observations were attributed to the LGM, since all variables used from the LGEM are also available in the LGM, whereas the converse is not the case. The realised number of grassland and extended grassland samples was lower than planned because only preselected points that were accessible and meet the in-field criteria were surveyed. Specifically, points had to be located in grassland or have sufficient grass or herbaceous cover; inaccessible points or points found to be misclassified in the field were excluded. In addition, the module had a shorter temporal sampling window than other LUCAS surveys, covering only a few days around the expected peak flowering period. Among these observations, only those reported in locations classified as agricultural land (class U111, 9 308 samples) or fallow land (class U112, 14 793 samples) were used. This resulted in 24 101 samples available for analysis. Table A1 provides a simplified overview of the combinations of land use and land cover reported in the LGM and LGEM data.



The LGM and LGEM surveys were implemented as stratified samples within the LUCAS Core survey, which itself follows a multiphase sampling design. The sampling procedure is briefly summarized as follows:

1. A stratified LUCAS Core sample was defined based on NUTS2 region, Corine land cover, photo-interpreted land cover from the 2018 LUCAS survey, and the predictability of land cover.
2. The LUCAS Core sample was divided into two parts: one that was only photo-interpreted, and one that was both photo-interpreted and surveyed in the field.
3. Points in the LUCAS Core field sample that were eligible for the grassland and external grassland module were identified. For the Grassland Module, eligible points were those with at least 30 % grass coverage and land cover classes D (shrubland) or E (grassland). For the Extended Grassland Module, eligible points were those with land cover class E.
4. Eligible points in the grassland sample were then subsampled using a two step approach for the Grassland Module. First, a stratified subsample was selected, with stratification variables including grassland regions in selected large countries, namely Germany, Spain, France, and Italy, and whether the point was located inside or outside Natura 2000 sites. Additional points were added to ensure sufficient representation across elevation classes and in agro-sylvopastoral systems in the Iberian peninsula (i.e. *dehesas* in Spain and *montados* in Portugal). The final sample therefore combines random sampling and systematic sampling components. The Extended Grassland Module did not include any further subsampling.

The pre-calculated LUCAS weights are not directly applicable to the two grassland modules because only a subset of the original sample locations was surveyed. Recalculating weights is not straightforward, because it is unclear whether the realized sample can be treated as random. One difficulty is that the original stratification was highly complex and included non-random sample allocation. Although many of the original LUCAS strata (more than 20 000 in total) do not contain grassland, the grassland modules still cover a large number of strata: more than 3 000 strata for each of the submodules and almost 5 000 strata when the two modules are combined. Many of these strata would also need to be further divided into substrata, as described above.

For this reason, the grassland-specific sub-stratification was not used when recalculating the weights. Instead, weights were recalculated based only on the LUCAS Core strata. Alternative approaches would have been to recompute weights for the grassland-specific stratification using the sampling rate within each final stratum, or to use only NUTS2 regions as strata. The former approach was considered unlikely to produce robust results, given the complexity of the original weighting procedure and the different allocation methods used. The latter approach was considered to be too simplified. As there is no unequivocally correct weighting strategy, the weights were calculated separately for the two modules, together with a joint weight for the variables that were present in both modules. This approach assumes that sampled locations were randomly distributed within their respective strata. Equation 1 shows how to estimate the weights W_s for a stratum s



$$W_s = \frac{N_s M_s}{N'_s M'_s} \quad (1)$$

135 where N_s is the number of points in the LUCAS master grid, N'_s is the number of points in the LUCAS Core sample, M_s is the number of eligible points in the LUCAS Core sample, and M'_s is the number of grassland samples in the stratum. The first part of the equation is the weight for the LUCAS Core sample.

140 A further limitation is that surveyors only sampled locations that were eligible in the field, introducing a preferential sampling effect. As a result, the samples cannot be used to estimate grassland areas directly, but only proportional shares.

In addition to NUTS2 regions, shares of management intensity and use, as well as the forb ratio, were computed for the different biogeographical regions of Europe, as substantial differences in grassland management can be expected among biogeographical regions. For this purpose, we used the biogeographical regions defined by Metzger (2018). Weights were recalculated using the stratification described above and the biogeographical regions.

2.2 LUCAS Grassland variables

150 Surveyed grasslands were classified according to use type and management intensity, and the forb ratio and age category were also recorded. Table 1 provides a summary of the original use and intensity classes, shown in the first and third columns, respectively, and the simplified classes used in the analysis.

Use classes included "Amenity grassland", referring to grasslands in and around cities, villages and human settlements, such as parks, roadsides, football pitches, gardens; "Meadow", referring to grasslands that are cut one or more times per year for hay, silage or biomass; "Meadow or pasture", referring to grassland that cannot be clearly categorised as either meadow or pasture, or that serves both purposes; "Pasture", distinguished from meadows by indicators such as fences, animals, animal tracks, dung, water supplies or animal shelters; "Only occasionally grazed", referring to very extensive pasture, often with shrubs; "Pastured woodland", referring to parcels where animals regularly graze under tree cover; "Ruderal/fallow grassland", referring to mainly self-seeded grassland with grasses and forbs that may resemble extensively used pastures or meadows; and "Unclear/other kinds of grassland". All definitions are taken from the technical surveyor instructions (Eurostat, 2022).

160 For the analysis, use classes were grouped into four simplified classes, as reported in the second column of Table 1: (i) "Meadow", including grasslands labelled as meadows; (ii) "Pasture", including grasslands labelled as pastures; (iii) "Meadow or pasture", including grasslands labelled as meadow or pasture, and (iv) "Unclear", including all other grassland types. Although amenity grasslands are not expected in agricultural or fallow land use classes, their presence likely reflects occasional misclassification by field surveyors or transitional land use situations. They were retained in the analysis because they represent



Table 1. Summary of grasslands use and management intensity classes reported in the LGM and LGEM tables.

Use	Simplified use	Intensity	Simplified intensity	Samples (LGM LGEM)
Amenity grassland	Unclear	Not specified	Unclear	223 723
Meadow	Meadow	Extensive	Extensive	1430 1403
Meadow	Meadow	Intensive	Intensive	1077 2036
Meadow	Meadow	Medium intensive	Moderately intensive	2146 3991
Meadow	Meadow	Very extensive	Extensive	328 406
Meadow	Meadow	Very intensive	Intensive	161 352
Meadow or pasture	Meadow or pasture	Not specified	Unclear	862 1565
Only occasionally grazed	Unclear	Not specified	Extensive	478 246
Pasture	Pasture	Extensive	Extensive	1283 1092
Pasture	Pasture	Intensive	Intensive	296 856
Pasture	Pasture	Medium intensive	Moderately intensive	1143 2524
Pastured woodland	Unclear	Not specified	Unclear	78 9
Ruderal/fallow grassland	Unclear	Not specified	Extensive	1696 1809
Unclear/other kinds of grassland	Unclear	Not specified	Unclear	839 902

only a minor share of the dataset and their exclusion would not significantly alter the results.

Management intensity classes included "Very intensive", "Medium intensive", "Intensive", "Very extensive" and "Extensive". These classes are derived from other variables assessed during the survey, including vegetation vigour, vegetation height, signs of fertilization, signs of irrigation, and vegetation structure, such as grass dominance and absence of flowers, as specified by Oppermann and Mettler (2018) and Eurostat (2022). For the analysis, intensity classes were grouped into four simplified classes, as reported in the fourth column of Table 1: (i) "Intensive", including grasslands labelled as "Very intensive" and "Intensive"; (ii) "Moderately intensive", including grasslands labelled as "Medium intensive", (iii) "Extensive", including grasslands labelled as "Very extensive" or "Extensive", as well as "Ruderal/fallow grassland" and "Only occasionally grazed"; and (iv) "Unclear" for all other grassland categories.

In addition to management information, the forb ratio and grassland age were recorded. Forbs are defined as non-woody plants other than grasses, sedges, rushes or reeds, and also include fern species (Eurostat, 2022). The forb ratio is a useful indicator of management intensity because intensively managed grasslands swards tend to be dominated by one or a few grass species, such as the English raygrass in temperate regions (*Lolium perenne*), whereas extensively managed grasslands are typically more species-rich and include a wider range of herbaceous species, including both grass and forbs, as well as annual plants and shrubs (Smit et al., 2008; Hoekstra et al., 2023; Jezequel et al., 2024). The forb ratio is reported as a numerical variable expressed as a percentage, ranging from 0, indicating no forbs, to 100, indicating no grasses. Grassland age



is defined as the length of time for which the current vegetation has been growing without disturbance of the sward through ploughing or other cultivation. It consists of two classes: grasslands five years old or younger, corresponding to temporary grasslands, and grasslands older than five years, corresponding to permanent grasslands. This indicator is also relevant for management intensity, as temporary grasslands are generally located in more productive areas and are regularly resown to maximise productivity.

2.3 Integrated Farm Statistics data

Eurostat collects Integrated Farm Statistics (IFS), previously known as the Farm Structure Survey (FSS), from EU Member States following a harmonized protocol covering a wide range of agricultural statistics. The agricultural census is conducted every 10 years, and the 2020 census also included the EFTA countries Iceland, Norway and Switzerland, covering more than 9 million farm holdings (Eurostat, 2024). Countries are encouraged to use a variety of data sources, including registers and administrative data, to reduce the reporting burden, provided that statistical quality requirements are met (Eurostat, 2024). The resulting statistics are freely available through the Eurostat data browser.

Most IFS variables are area-based, with each farm reporting the total area used for different types of agricultural production. Grassland area is included in the questionnaire, including total grassland area, whether the production is organic and temporary grassland, defined as grassland five years old or younger.

3 Results and discussion

The following subsections report the shares of management intensity and use of grasslands as well as their forb ratio, both at NUTS0 and NUTS2 level, across EU Member States (EU27). NUTS2 regions with less than 10 samples collected were deemed non-representative and hence were discarded from the analysis. As a result, Malta was discarded, as only 3 samples were reported (Table B1).

3.1 Intensity of management

At the EU level, extensive and moderately intensive grasslands represented the largest shares of grassland management intensity, accounting for 35.7 % and 34.1 %, respectively (Fig. 2). Intensively managed grasslands accounted for 18.9 % of grasslands, while grasslands with unclear management intensity represented 11.4 %. These EU-level averages conceal marked spatial differences among Member States and NUTS2 regions.

A clear north–south gradient was observed in grassland management intensity. Intensively managed grasslands were concentrated mainly in northern and central Europe (Fig. 3a). The highest national shares occurred in the Netherlands and Denmark, followed by Czechia, Germany and Austria, while the highest NUTS2-level share was reported in the Austrian region of *Vorarlberg*. These regions correspond broadly to productive livestock and dairy systems where frequent mowing, reseeding,



215 fertilization or high grazing pressure are more common.

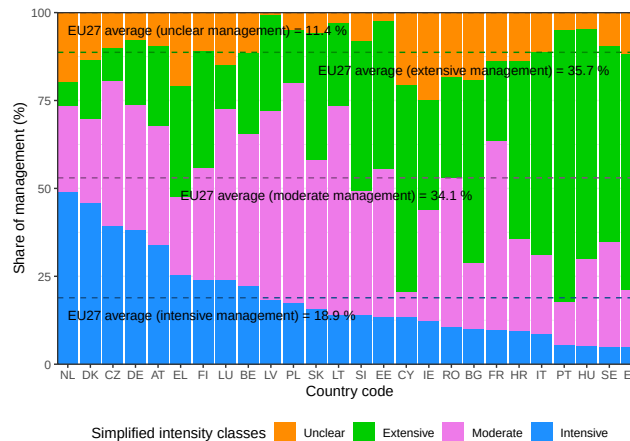


Figure 2. Share of different intensities of grasslands management per Member State. Malta returned only three samples (see Table B1) and was hence discarded from the analysis.

Moderately intensive grasslands formed the dominant or co-dominant class in several central and eastern European countries (Fig. 3b). The highest national shares were reported in Poland, Lithuania, France and Latvia, with the highest NUTS2 level share observed in *Nord-Pas de Calais*, France. This class therefore occupies an intermediate position between the highly productive grassland systems of north-western and central Europe and the more extensive systems found in southern Europe.

Extensively managed grasslands showed the opposite spatial pattern to intensively managed grasslands. They were most prominent in southern Europe, particularly Portugal, Spain, Hungary, Cyprus and Italy, although Sweden also showed a relatively high share (Fig. 3c). At NUTS2 level, the highest shares were found in the Spanish regions of *Illes Balears* and *Región de Murcia*, where all sampled grasslands were classified as extensive. The spatial concentration of extensive management in southern Europe is consistent with the prevalence of low-input grazing systems, semi-natural grasslands and agro-silvo-pastoral landscapes in these regions.

Grasslands with unclear management intensity accounted for a smaller share overall, but they were not evenly distributed across Europe (Fig. 3d). The highest national shares were reported in Ireland, Greece, Cyprus, the Netherlands and Bulgaria, while the highest NUTS2-level share occurred in *Notio Aigaio*, Greece. This category may reflect transitional land uses, ambiguous field conditions, mixed management signals, or limitations in assigning management intensity from field-observed indicators. It is therefore useful not only as a residual class, but also as an indication of where grassland management may be more difficult to characterise consistently.

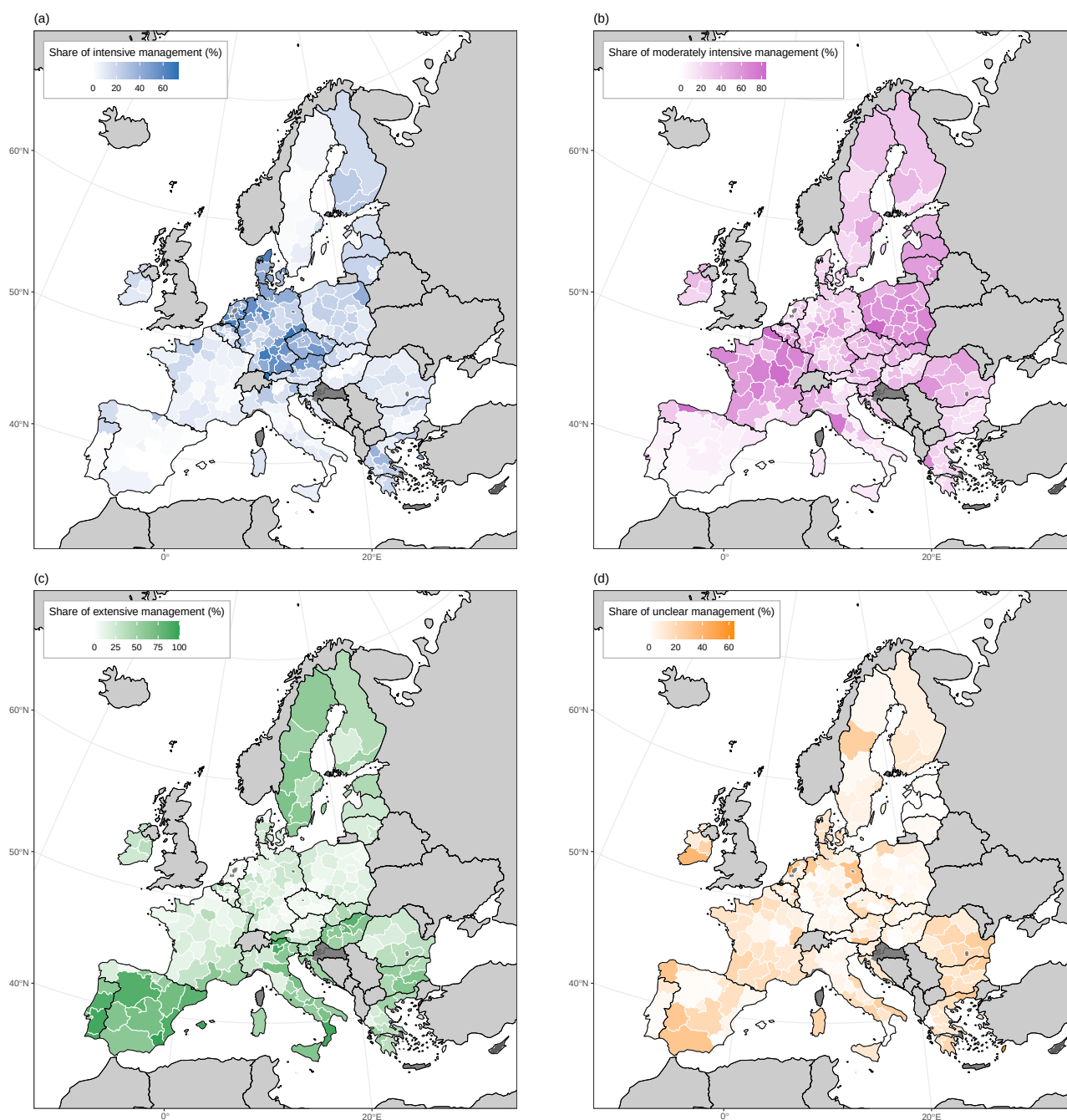


Figure 3. The distribution of grassland intensity at NUTS2 level, based on the LGM and LGEM datasets for the share of grasslands (a) managed intensively, (b) with moderate intensity, (c) extensively managed, and (d) unclearly managed. Grey areas indicate countries outside of EU27. Dark grey areas indicate missing data. Map data from EuroGeographics.



Overall, the results reveal a strong regional structuring of grassland management intensity across the EU27. Intensive management is concentrated in northern and central Europe, extensive management is dominant in southern Europe, and moderate management forms an important intermediate class across parts of central and eastern Europe. Full country-level values for intensive (Table C1), moderately intensive (Table C2), extensive (Table C3) and unclear (Table C4) grassland management are provided in the appendix.

3.2 Type of use

At the EU27 level, meadows represented the dominant grassland use type, accounting for 52.5 % of grasslands (Fig. 4). Pastures accounted for 25.2 %, while grasslands classified as either meadow or pasture represented 7.6 %. Grasslands with unclear use accounted for 14.7 %. As with management intensity, these EU-level averages mask strong spatial differences among Member States and NUTS2 regions.

A clear east–west gradient was observed in grassland use. Meadows were most prevalent in northern, central and eastern Europe (Fig. 5a), with particularly high national shares in Estonia, Poland, Latvia, Czechia and Lithuania. At NUTS2 level, the highest share was reported in *Warszawski stołeczny*, Poland. These patterns indicate that mown grasslands used for hay, silage or biomass production are especially important in the grassland systems of central, eastern and parts of northern Europe.



Figure 4. Share of different grasslands use per Member State. Malta returned only three samples (see Table B1) and was hence discarded from the barplot.

In contrast, pastures were concentrated mainly in western and southern Europe (Fig. 5c). The highest national shares were reported in Belgium, France, Ireland and Greece, with high values also observed in Sweden, Spain and Portugal. At NUTS2 level, the largest share was found in *Principado de Asturias*, Spain. This spatial pattern is consistent with the greater importance



255 of grazing-based grassland systems in Atlantic and Mediterranean farming contexts.

The mixed category “meadow or pasture” accounted for a comparatively small share of grasslands at EU27 level, but it was locally important in some regions (Fig. 5b). The highest national shares were observed in Ireland, the Netherlands and Romania, and the highest NUTS2-level share was reported in *Noord-Holland*, the Netherlands. This class likely captures grasslands
 260 with flexible or mixed management, where mowing and grazing may both occur or where field evidence does not allow a clear distinction between the two uses.

Grasslands with unclear use were more unevenly distributed and were most prominent in southern Europe (Fig. 5d). The highest national share was reported in Cyprus, followed by Spain, Portugal and Greece, while the highest NUTS2-level share
 265 occurred in *Región de Murcia*, Spain. This pattern suggests that grassland use is more difficult to classify in some Mediterranean contexts, potentially because of mixed land-use systems, fallow or semi-natural vegetation, agro-silvo-pastoral landscapes, or ambiguous field indicators at the time of the survey.

Overall, the results show that grassland use across the EU27 is structured by a strong spatial gradient. Meadows dominate in
 270 northern, central and eastern Europe, while pastures are more characteristic of western and southern Europe. Mixed and unclear categories are smaller at EU27 level but provide important information on regions where grassland use is flexible, transitional or more difficult to classify consistently. It is worth stressing that each observer visits a sampling location only once, hence making it difficult to determine which use type prevails, especially if grazing occurs early or late in the season. The appendix contains the complete set of country-level values meadows (Table D1), pastures (Table D2), meadow or pasture (Table D3) and
 275 unclear (Table D4) grassland classes.

3.3 Grassland management across biogeographical regions

Figure 6 shows intensity and use-type shares across five contrasting biogeographical regions: Alpine South, Atlantic Central, Atlantic North, Continental and Mediterranean South. Grassland management differed clearly among these regions. The Mediterranean South was characterised by a predominance of extensive pastures, with negligible shares of mown or intensively
 280 managed grasslands and a relatively high share of unclear use. In contrast, the Atlantic North and Continental regions showed the opposite pattern, with intensive and moderately intensive meadows accounting for the largest shares. The Alpine South showed a more balanced distribution, with similar shares of pastures and meadows as well as extensive to moderately intensive grasslands. In the Atlantic Central region, grassland use is dominated by moderately intensive pastures.

285 The spatial patterns of management identified in our study are consistent with previous European-scale assessments. For example, Smit et al. (2008) mapped grassland productivity across Europe and found that the most productive areas were located mainly in northern Europe, while less productive regions were concentrated in the south. Because management intensity is closely linked to productivity, this north–south gradient is consistent with our results. Similarly, Estel et al. (2018), who

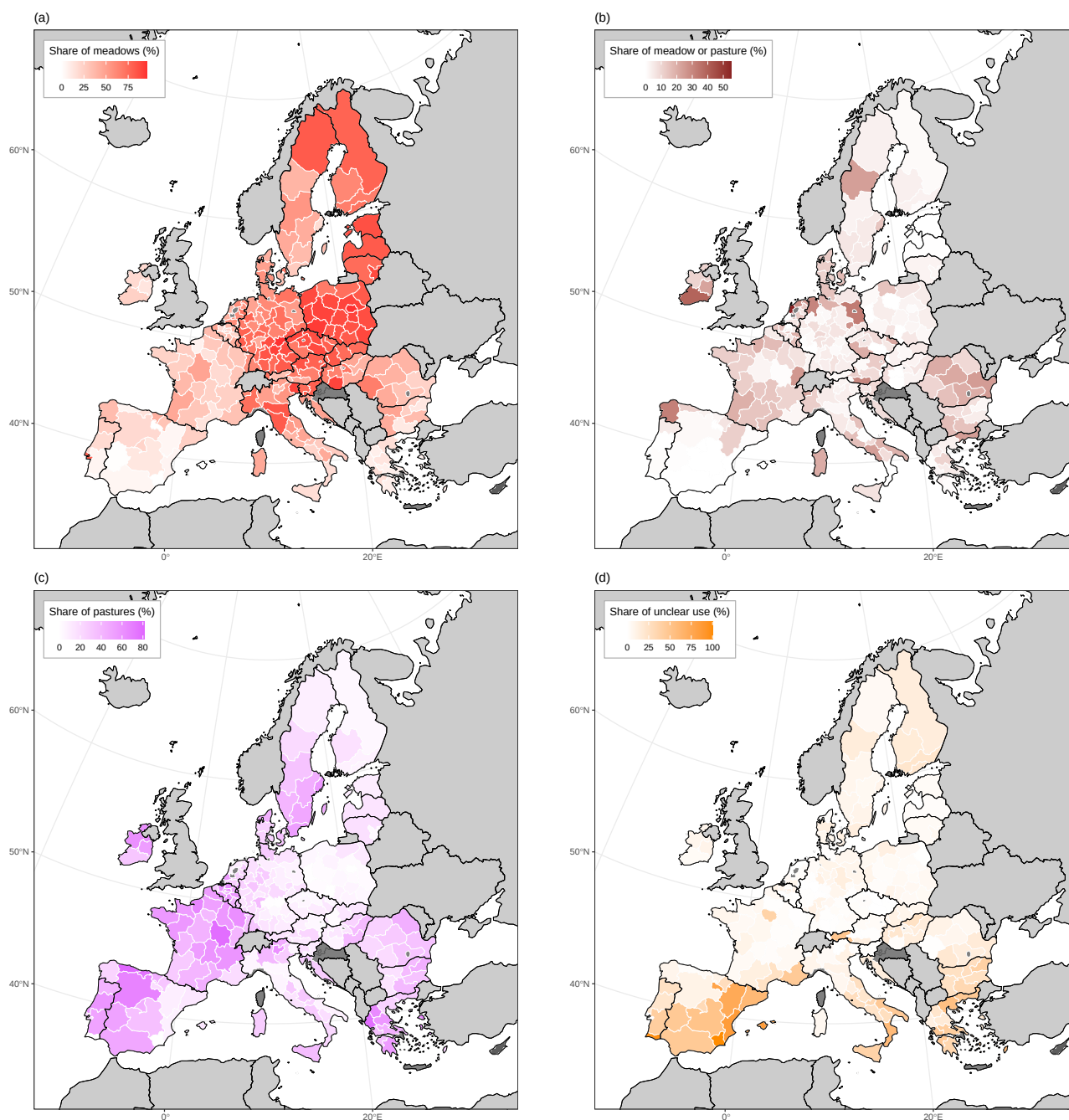


Figure 5. The distribution of the type of grassland use at NUTS2 level, based on the LGM and LGEM datasets for the share of (a) meadows, (b) meadows or pasture, (c) pastures, and (d) and unclear type of grassland. Grey areas indicate countries outside of EU27. Dark grey areas indicate missing data. Map data from EuroGeographics.

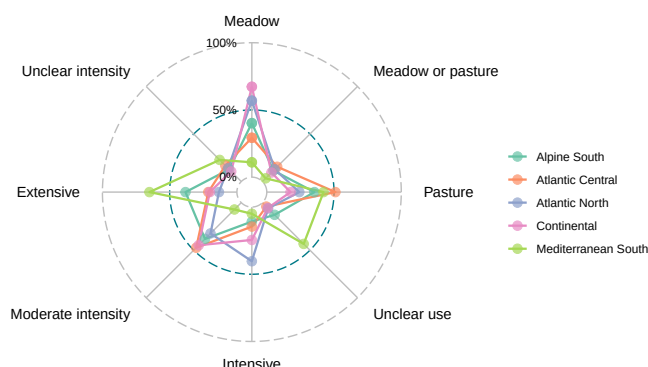


Figure 6. Radar plot for use and intensity of management of grasslands across five contrasting biogeographical regions.

mapped mowing frequency using satellite image time series, identified intensive clusters in the Benelux countries, Germany
 290 and Denmark, and low intensity clusters in southern Europe. These patterns are consistent with our findings, as mowing
 frequency is a direct indicator of grassland management intensity: intensively managed grasslands are generally mown several
 times during the growing season, whereas extensive grasslands are usually cut once per season or not mown at all. Malek
 et al. (2024) used statistical and in-situ data together with machine learning to map livestock density in the EU and the United
 Kingdom. Their results similarly indicate that high-density livestock systems are concentrated mainly in northern Europe,
 295 while lower-density systems are more common in southern Europe. The consistency between these studies and the patterns
 observed here supports the usefulness of the LGM and LGEM as a resource for EO- and model-based monitoring of grassland
 management at the EU scale.

3.4 Forb ratio

The average forb ratio across the EU27 was 28.9 % (Fig. 7a). The ratio varied regionally across Europe, with the highest
 300 values generally observed in central and northern Europe, followed by southern Europe (Fig. 7b). However, the forb ratio can
 be difficult to estimate consistently in the field. For example, forbs such as legumes may be partly hidden beneath the grass
 canopy, particularly close to flowering, creating a non-negligible risk of misestimation, as noted in the preliminary analysis
 based on the 2018 LUCAS Grasslands data (Oppermann and Mettler, 2018). In addition, the timing of the survey is likely to
 affect the estimation of the forb ratio, as the grasses and forbs composing the sward differ in phenology and are not necessarily
 305 equally detectable throughout the season.

At the country level, the highest forb ratio was observed in Austria, at 45 %, with the Austrian region of *Tirol* reporting the
 highest NUTS2 level value across the EU27, at approximately 61 %. High forb ratios were also observed in Czechia, at 40 %, the Baltic countries, at 34–39 %, and Greece, at 36 %, although substantial regional variability was evident. Intermediate val-

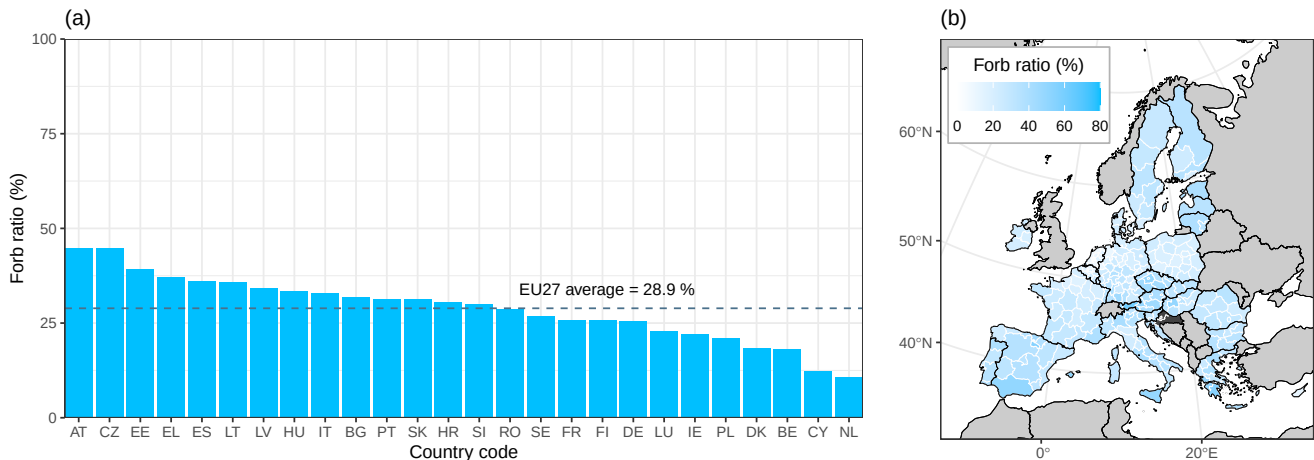


Figure 7. a) Average forb ratio per Member State. Malta returned only three samples (see Table B1), and was hence discarded from the analysis. b) Forb ratio (%) across European NUTS2 regions based on LGM and LGEM datasets. Dark grey areas indicate missing data. Map data from EuroGeographics.

ues, approximately 26–34 %, characterised much of central, southern and northern Europe, including Italy, Hungary, Bulgaria, Portugal, Slovakia, Croatia, Slovenia, Romania, Finland, Sweden and Germany. Lower forb ratios were observed in France, Luxembourg, Ireland and Poland, at 20–25 %, while the lowest values were reported for Denmark, Belgium, Cyprus and the Netherlands. The Netherlands had the lowest national forb ratio at 10 %.

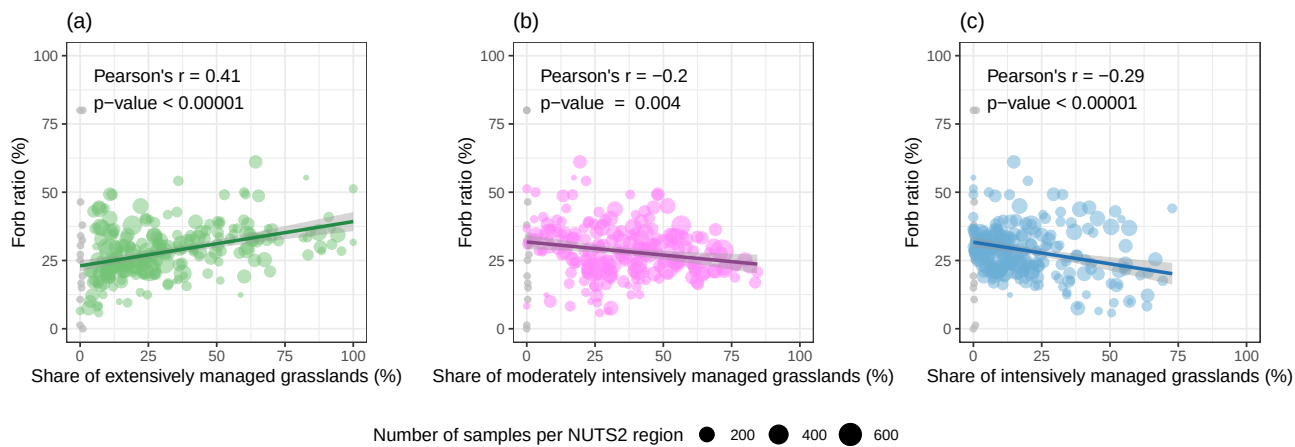


Figure 8. Correlation scatter plots between NUTS2-aggregated forb ratio (Y-axis) and share of extensively (a) , moderately intensively (b) and intensively (c) managed grasslands (X-axis). The grey shaded area indicates the 95 % confidence interval. Grey symbols indicate NUTS2 regions that were discarded from analysis because of an insufficient number of samples (i.e. less than 10 samples per NUTS2 region).



Weak but statistically significant correlations were observed between forb ratio and management intensity, with Pearson's r values of -0.29, -0.20 and 0.41, for intensively, moderately and extensively managed grasslands, respectively (Fig. 8). These patterns are consistent with established ecological knowledge: higher management intensity, particularly through fertilisation and frequent mowing or grazing, tends to favour a small number of productive graminoid species at the expense of more diverse forb communities (Socher et al., 2012; Kleijn et al., 2009). Conversely, extensive management can help maintain lower-nutrient conditions and limit the dominance of competitive grasses, thereby creating conditions more favourable to forb-rich plant communities (Bonavent et al., 2023), particularly under low-density year-round grazing regimes (Søndergaard et al., 2025). From an ecological perspective, this suggests that the forb ratio provides information on grassland functioning and management intensity, as higher forb dominance may reflect management conditions that maintain open, low-competition swards and allow subordinate plant species to persist (Reich et al., 2012). This interpretation should be tempered by the fact that very high forb ratios may also occur under intensive management, for example when productive legumes such as *Medicago* or *Trifolium spp.* are sown for forage quality and nitrogen fixation. However, because the positive relationship between management intensity and forb ratio was observed only within extensively managed grasslands, it is more likely to reflect ecological responses to low-intensity management than the agronomic enrichment of swards with sown legumes.

Recent evidence further suggests that grazing seasonality may be important. Low-density year-round grazing, and particularly dormant-season grazing, can increase species richness and forb cover by reducing grass dominance and weakening competitive exclusion (Søndergaard et al., 2025). This is consistent with the idea that seasonal agri-environmental grazing concentrated during the growing season may be insufficient, or in some contexts counterproductive, for promoting forb-rich communities. Policies aiming to reconcile grassland production and biodiversity targets should therefore not focus only on reducing management intensity, but also consider grazing regimes that better reproduce the ecological role of large herbivores in maintaining species-rich, forb-dominated grasslands (Ejrnæs et al., 2024).

3.5 Temporary and permanent grasslands

In addition to the permanent and temporary grassland categories described below, a small share of samples could not be reliably assigned an age category, for example when field indicators of vegetation age were ambiguous or missing. At the EU27 level, this unclear category represented less than 1 % of grasslands overall, although it was locally higher as in e.g. Belgium (2.0 %), Luxembourg (3.7 %) and Netherlands (5.1 %). Given its limited share at EU27 level, this category is not mapped or tabulated separately; the permanent and temporary shares reported below should accordingly be read as shares of the classified (i.e. non-unclear) samples.

345

At the EU27 level, permanent grasslands represented the dominant age category, accounting for 83.5 % of grasslands (Fig. 9). Temporary grasslands accounted for 16.5 % and were mainly present in some areas of northern and southern Europe (e.g.



Centro in Portugal or *Sjælland* in Denmark, see Fig. 10).

350 Temporary grasslands, typically sown as part of arable rotations, tend to be located in the most productive agricultural regions, where periodic reseeding maximises forage yield, whereas permanent grasslands dominate in areas less suited to annual cropping or managed under long-term, low-input systems.

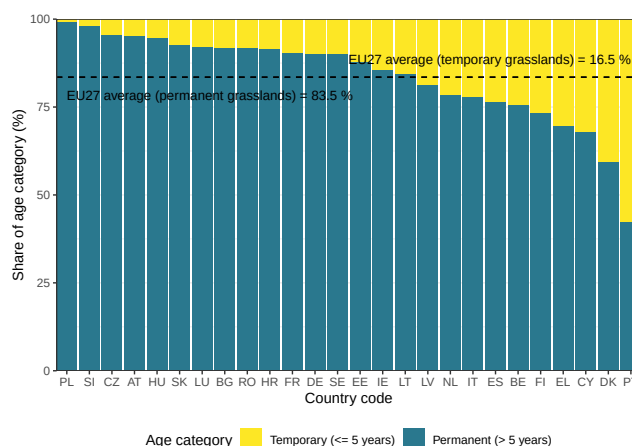


Figure 9. Share of different grasslands age categories per Member State. Malta returned only three samples (see Table B1) and was hence discarded from the barplot.

At the national level, the highest shares of temporary grassland were reported in Portugal (57.7 % on average across NUTS2 regions), Finland (41.5 %) and Denmark (40.7 %), while the lowest shares occurred in Poland, Slovenia and Austria, where grasslands were almost exclusively permanent (Table F2). At NUTS2 level, several regions in the Iberian peninsula, Finland and Denmark as well as Belgium reported shares of temporary grasslands ranging between 85 and 100 %, indicating strongly rotational systems at the local scale (Table F2, Fig. 10a).

360 These patterns are further examined in Section 3.5.1, which compares the LUCAS-derived shares of temporary grassland with those reported in the EU's Integrated Farm Statistics (IFS).

3.5.1 Comparison with IFS

The LUCAS-derived share of temporary grassland can be compared with the share reported in the IFS, as shown in Fig. 11. The IFS-derived share of temporary grassland is shown on the x-axis, while the LUCAS-derived estimate is shown on the y-axis. 365 The error bars for the LUCAS estimates represent two standard deviations, approximately corresponding to a 95 % confidence interval, and the 1:1 line indicates perfect agreement between the two datasets. For many countries, the IFS estimates fall

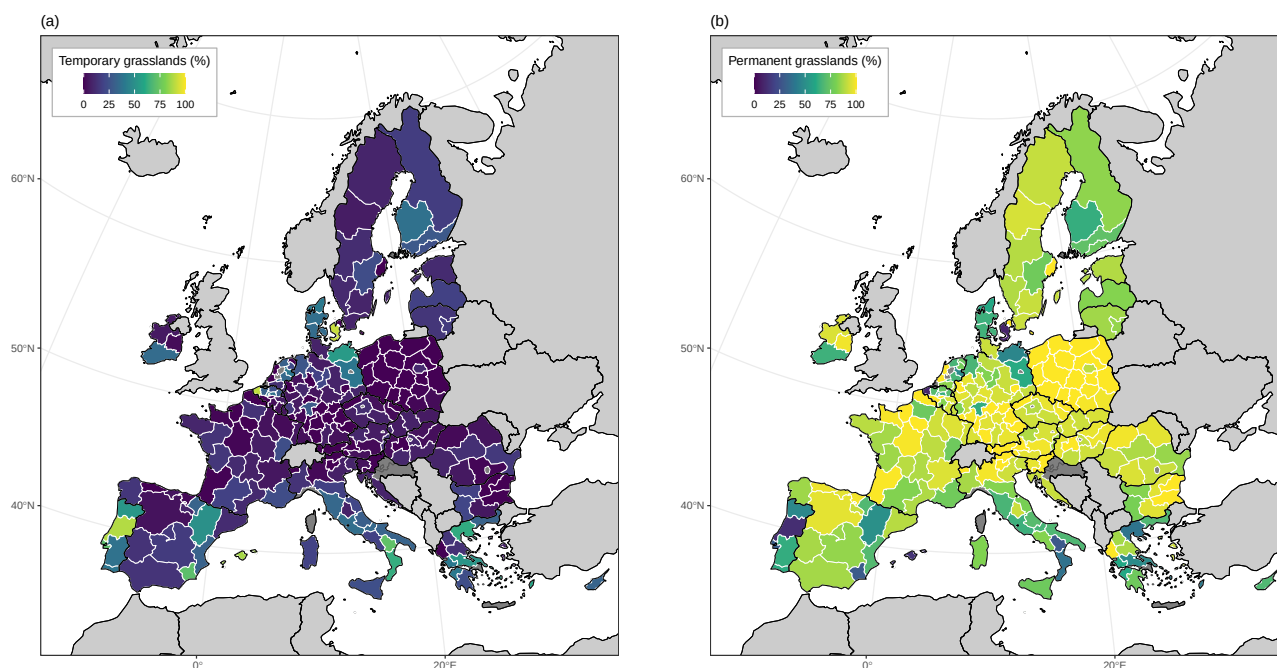


Figure 10. Share of temporary (a) and permanent (b) grasslands (%) across European NUTS2 regions based on LGM and LGEM datasets. Dark grey areas indicate missing data. Map data from EuroGeographics.

outside the uncertainty intervals of the LUCAS estimates.

Overall, LUCAS-derived estimates indicate lower shares of temporary grassland than IFS statistics in most countries, with particularly pronounced differences in Finland and Sweden. In contrast, higher LUCAS-derived shares relative to the IFS are observed in Portugal.

These discrepancies likely reflect structural differences between an observation-based land monitoring system, such as LUCAS, and an administrative, farm-reported statistical system, such as the IFS. They may also arise from differences in the operational definitions of temporary grassland and from country-specific grassland management systems as summarized below:

- **Data collection methodology:** LUCAS classifications are based on harmonized in-situ field observations at sampled points, while IFS data are derived from farm-reported land-use categories collected within the framework of agricultural statistics. The two systems therefore capture land use from different perspectives: observed land cover and land use at a specific point in time versus administratively reported land-use categories.

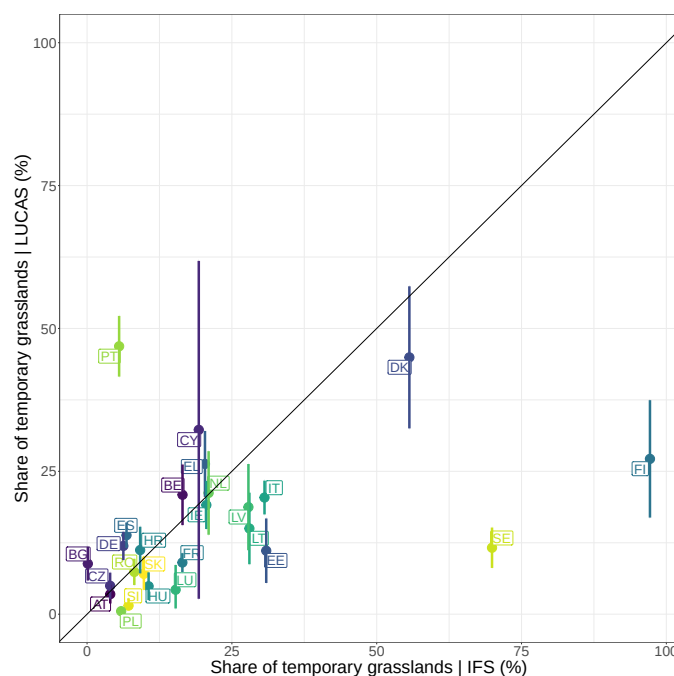


Figure 11. Relationship between the estimated share of temporary grassland from LUCAS and from the IFS. Error bars represent two standard deviations from the estimate.

– **Definition and operationalization:** In LUCAS, temporary grassland (TG) is derived from combinations of land cover, land use and field observations. In the IFS, temporary grassland is an administrative land-use category reported according to agricultural statistical regulations. Differences in how temporary grassland is operationalized in the two systems may therefore lead to divergent estimates.

385 – **Structural characteristics of national grassland systems:** In Finland and Sweden, temporary grassland often remains in place for several years as part of crop rotations. These multi-annual leys may exhibit structural characteristics similar to permanent grassland towards the end of the rotation cycle, particularly in the absence of recent soil disturbance. A point-based visual assessment may therefore classify such areas as permanent grassland, contributing to lower LUCAS-derived temporary grassland shares relative to the IFS. In contrast, Mediterranean farming systems such as those in

390 Portugal often include short-term sown pastures, fallow land with spontaneous herbaceous vegetation, and agro-silvo-pastoral systems with grass-dominated understory. Such land may visually resemble temporary grassland at the time of the survey, even if it is administratively reported under other categories, such as fallow, permanent pasture, or mixed systems. This may contribute to comparatively higher LUCAS-derived shares of temporary grassland in Portugal relative to the IFS. A closer inspection of the LUCAS data confirms this interpretation as almost 40 % of observations classified

395 as temporary grassland were recorded under land-use categories other than agriculture, most commonly fallow arable land, forestry or seminatural landscapes.



The observed differences therefore likely arise from a combination of definitional, methodological, and structural factors, interacting with country-specific agricultural practices. These inconsistencies have potential implications for cross-country comparisons of grassland management, monitoring of crop rotation practices, and policy-relevant assessments related to grass-
 400 land permanence, carbon storage, and biodiversity. This comparison should therefore be interpreted not as a direct validation exercise, but as an assessment of consistency between two systems that measure related, but not identical, representations of temporary grassland. Full country-level values for permanent (Table F1) and temporary (Table F2) grasslands are provided in the appendix.

4 Conclusion and outlooks

405 The 2022 LUCAS grassland modules provide a new harmonized, in-situ basis for characterizing grassland management across the EU27. By aggregating 29 954 geolocated observations to NUTS2 level, we have produced, to our knowledge, the first EU-wide regional dataset describing grassland management intensity, use type, forb ratio, and temporary versus permanent grasslands from harmonized field observations. The dataset reveals clear spatial differentiation in grassland management across Europe. Intensively managed grasslands are concentrated mainly in central and northern Europe, moderately intensive grass-
 410 lands are particularly prominent in Poland and France, and extensively managed grasslands occur mostly in southern Europe. Grassland also shows a marked east–west gradient, with meadows more common in northern, central and eastern Europe and pastures more prevalent in western and southern Europe. These patterns are broadly consistent with previous studies, supporting the usefulness of the LGM and LGEM data for large-scale assessment of European grasslands. The relationship between management intensity and the forb-to-grass ratio further suggests that the LUCAS grassland variables capture ecologically
 415 meaningful differences in grassland condition. The forb ratio was negatively correlated with the share of intensively and moderately intensively managed grasslands, and positively correlated with the share of extensively managed grasslands. Although the forb ratio should not be interpreted as a direct measure of plant diversity, it provides a useful indicator of functional traits and of the degree to which management conditions allow non-grass herbaceous species to persist. Permanent grasslands largely dominate across Europe, with localised exceptions northern and southern Europe, suggesting strong rotational systems in these
 420 areas. Comparisons with temporary grassland shares reported in the IFS showed both alignments and discrepancies at the country level. These differences highlight the need for further harmonization between statistical reporting systems and field-based observations, particularly where grassland definitions, reporting units or classification rules differ. They also underline the added value of harmonized in-situ observations for interpreting grassland management patterns across countries.

425 The next LUCAS survey is planned for 2027. In the current proposal, 20 000 grassland points will be sampled as part of LUCAS Core using a panel approach. This will enable temporal comparisons with the 2022 survey. Most grassland variables are expected to be retained, although the key species component related to biodiversity will not be continued. Instead, a new image-based protocol is planned, whereby top-down photographs will be taken from a height of 1 m at three representative locations within the extended grassland observation window. These images will then be analysed using computer vision meth-



430 ods to quantify the number and colours of individual flowers, following the approach proposed by Elvekjær et al. (2024). Continued alignment is also foreseen with the European Monitoring of Biodiversity in Agricultural Landscapes (EMBAL), should this monitoring activity be repeated in the future. The LGM and LGEM surveys provide a unique harmonized snapshot of grassland management across all EU Member States. As such, they could support the development of EO-based monitoring systems for grassland condition and management. An initial study has already explored the use of the LGM dataset to estimate the sward height as a proxy for biomass production using Sentinel data (Gruschwitz et al., 2026). Building on this work, 435 further studies could examine how management intensity and type of use can be harmonized across reporting systems and observational datasets, and how LUCAS grassland information can be integrated with EO and biodiversity-monitoring data. Such developments would support year-to-year monitoring of grassland management and provide more consistent evidence for policy evaluation and decision-making. This dataset could also support the grassland modelling community by providing 440 spatially explicit information on management intensity and use. These variables can inform assumptions about management practices such as fertilization, mowing frequency and grazing pressure, although such practices should be inferred with caution and, where possible, be validated against independent data. Process-based grassland models such as ModVege (Jouven et al., 2006), Most GG (Ruelle et al., 2018) and Gras-Sim (Kokah et al., 2023), which rely on plant functional types and management assumptions, could benefit from the regional information presented here.

445 5 Data availability

The datasets generated and analysed during the current study are available in the JRC Data Catalogue, <https://doi.org/10.2905/JRC.CVXWHE8> (Morel et al., 2026).

6 Code availability

The R code used to process the confidential point-level LUCAS data and generate the aggregated NUTS2-level dataset is not 450 publicly available, as it references restricted-access source data.



Appendix A: Land use and land cover of the LUCAS Grassland and Extended Grassland data

U11 includes agricultural land (U111), fallow land (U112) and kitchen gardens (U113). The table is simplified in the sense that nine samples, including six kitchen gardens (U113) and three bare soils (F40), were excluded from the analysis but remain present in the simplified table. The land uses and land covers in the table are summarised as:

- 455 – A: Artificial land
- B: Cropland
- C: Woodland
- D: Shrubland
- E: Grassland
- 460 – F: Bare land and lichens/moss
- G: Water areas
- H: Wetlands
- U11: Agriculture
- U12-U15: Other primary sectors: forestry, aquaculture, mining, other primary production
- 465 – U2x Secondary sector, energy production, industry and manufacturing
- U3x Tertiary sector, transport, utilities and residential
- U41 Abandoned areas
- U42 Semi-natural and natural areas not in use



Table A1. Table of combinations of land use and land cover for LUCAS grassland samples. The red colour identifies samples included as part of the agricultural grassland selection, whereas the green colour identifies semi-natural grassland samples.

	A	B	C	D	E	F	G	H	Sum
U11	3	219	61	206	23618	3	0	0	24110
U12	0	1	179	22	191	0	0	0	393
U14	0	0	0	2	15	0	0	0	17
U15	0	0	1	1	3	0	0	0	5
U21	0	0	0	1	7	0	0	0	8
U22	0	0	0	0	8	0	0	0	8
U31	12	0	5	9	401	0	0	0	427
U32	0	0	0	1	20	0	0	0	21
U33	0	0	0	0	31	0	0	0	31
U34	0	0	0	0	30	0	0	0	30
U35	0	0	0	2	47	0	0	0	49
U36	0	0	8	3	252	0	1	0	264
U37	1	1	7	1	883	0	0	0	893
U41	0	2	13	35	493	0	0	3	546
U42	0	0	142	453	2516	2	4	35	3152
Sum	16	223	416	736	28515	5	5	38	29954



Appendix B: Summary tables - Samples per country, intensity and use

Table B1. Number of samples collected for land use classes U111 (Agriculture) and U112 (Fallow land) at country (NUTS0) level for each simplified management intensity class.

Country code	Extensive	Intensive	Moderately intensive	Unclear
AT	133	412	454	84
BE	126	110	281	84
BG	302	39	121	100
CY	6	2	1	1
CZ	77	308	334	91
DE	487	1323	1184	237
DK	61	123	69	43
EE	69	25	67	6
EL	191	125	114	87
ES	862	127	384	225
FI	100	75	84	24
FR	981	423	2547	704
HR	124	37	127	31
HU	296	28	107	34
IE	334	173	399	429
IT	705	138	299	143
LT	129	67	271	17
LU	12	22	41	12
LV	65	29	115	4
MT	3	0	0	0
NL	41	318	173	116
PL	265	380	1243	101
PT	401	24	37	17
RO	331	134	465	173
SE	569	55	312	84
SI	169	55	126	32
SK	166	72	211	27



Table B2. Number of samples collected for land use U111 (Agriculture) and U112 (Fallow land) at country (NUTS0) level for each simplified use class.

Country code	Meadow	Meadow or pasture	Pasture	Unclear
AT	857	74	120	32
BE	200	80	301	20
BG	175	54	168	165
CY	3	0	1	6
CZ	651	86	64	9
DE	2427	202	485	117
DK	144	35	92	25
EE	138	0	18	11
EL	62	30	234	191
ES	346	153	708	391
FI	208	9	26	40
FR	1404	604	2366	281
HR	224	18	43	34
HU	263	20	110	72
IE	291	420	552	72
IT	702	105	249	229
LT	364	14	80	26
LU	47	12	28	0
LV	169	2	33	9
MT	0	0	0	3
NL	377	101	152	18
PL	1704	74	120	91
PT	87	8	218	166
RO	484	164	323	132
SE	454	69	407	90
SI	301	28	47	6
SK	369	17	57	33



470 Appendix C: Summary tables - Main statistics for NUTS2 level intensity of management, aggregated at NUTS0

Table C1. Main statistical indicators for land use U111 (Agriculture) and U112 (Fallow land) grasslands intensively managed, aggregated at national level. n indicates the number of NUTS2 regions available for computations.

Country code	Mean	Mean (filtered)	Median	Standard deviation	Minimum	Maximum	n (unfiltered)	n (filtered)
NL	48.3	49.2	48.2	14.3	28.6	74.1	12	9
DK	45.9	45.9	43.1	12.6	34.2	64.0	5	5
CZ	46.8	39.3	40.5	22.6	28.4	100.0	8	7
DE	35.9	38.2	34.3	18.4	0.0	69.3	38	35
AT	33.9	33.9	27.4	20.7	14.8	72.8	8	8
EL	23.8	25.4	19.9	12.7	9.1	54.2	13	10
FI	19.3	24.1	22.8	11.7	0.0	30.1	5	4
LU	24.0	24.0	24.0	NA	24.0	24.0	1	1
BE	22.2	22.2	20.9	10.8	6.2	41.4	10	10
LV	18.4	18.4	18.4	NA	18.4	18.4	1	1
PL	17.4	17.4	18.3	8.1	7.4	40.6	17	17
SK	15.9	15.9	15.8	5.2	11.0	21.2	4	4
LT	14.1	14.1	14.1	10.1	6.9	21.2	2	2
SI	14.0	14.0	14.0	0.2	13.8	14.1	2	2
EE	13.5	13.5	13.5	NA	13.5	13.5	1	1
CY	13.4	13.4	13.4	NA	13.4	13.4	1	1
IE	12.3	12.3	10.9	5.1	8.0	17.8	3	3
RO	9.4	10.8	9.4	4.4	0.0	14.6	8	7
BG	10.1	10.1	9.8	6.1	2.8	17.0	6	6
FR	9.2	9.7	7.1	7.8	0.0	34.9	22	21
HR	9.5	9.5	9.5	NA	9.5	9.5	1	1
IT	8.4	8.8	6.1	8.4	0.0	31.9	21	20
PT	5.5	5.5	1.2	8.1	0.0	19.2	5	5
HU	5.3	5.3	5.5	4.5	0.0	11.3	7	7
SE	5.1	5.1	3.8	4.6	0.8	14.6	8	8
ES	5.0	5.0	2.2	8.3	0.0	31.9	16	16
MT	0.0	NA	0.0	NA	0.0	0.0	1	0



Table C2. Main statistical indicators for land use U111 (Agriculture) and U112 (Fallow land) grasslands managed with moderate intensity, aggregated at national level. n indicates the number of NUTS2 regions available for computations.

Country code	Mean	Mean (filtered)	Median	Standard deviation	Minimum	Maximum	n (unfiltered)	n (filtered)
PL	62.7	62.7	61.7	9.7	43.2	83.6	17	17
LT	59.5	59.5	59.5	4.2	56.5	62.5	2	2
FR	53.5	53.9	54.2	18.5	11.4	84.4	22	21
LV	53.7	53.7	53.7	NA	53.7	53.7	1	1
LU	48.5	48.5	48.5	NA	48.5	48.5	1	1
BE	43.4	43.4	40.6	15.2	24.7	76.7	10	10
SK	42.4	42.4	41.5	7.8	33.8	52.7	4	4
RO	47.1	42.3	42.4	17.9	24.4	80.8	8	7
EE	41.9	41.9	41.9	NA	41.9	41.9	1	1
CZ	36.3	41.5	41.4	15.5	0.0	47.9	8	7
DE	35.9	35.8	30.3	17.1	0.0	80.0	38	35
SI	35.5	35.5	35.5	0.6	35.1	35.9	2	2
AT	34.0	34.0	34.8	13.1	14.5	51.6	8	8
FI	35.5	31.9	39.7	13.4	14.0	50.0	5	4
IE	31.7	31.7	30.3	8.2	24.3	40.4	3	3
SE	29.7	29.7	27.5	9.5	20.9	50.1	8	8
HR	26.2	26.2	26.2	NA	26.2	26.2	1	1
HU	24.6	24.6	21.7	12.9	11.1	39.7	7	7
NL	23.3	24.2	25.8	12.5	0.0	40.2	12	9
DK	23.9	23.9	22.2	7.8	16.2	37.2	5	5
EL	20.6	22.3	21.7	17.3	0.0	66.7	13	10
IT	21.9	22.3	13.3	19.2	0.4	76.5	21	20
BG	18.7	18.7	17.0	4.0	15.0	25.6	6	6
ES	16.2	16.2	8.3	20.0	0.0	79.9	16	16
PT	12.2	12.2	7.5	16.9	0.0	41.8	5	5
CY	7.2	7.2	7.2	NA	7.2	7.2	1	1
MT	0.0	NA	0.0	NA	0.0	0.0	1	0



Table C3. Main statistical indicators for land use U111 (Agriculture) and U112 (Fallow land) extensively managed grasslands, aggregated at national level. n indicates the number of NUTS2 regions available for computations.

Country code	Mean	Mean (filtered)	Median	Standard deviation	Minimum	Maximum	n (unfiltered)	n (filtered)
PT	77.4	77.4	88.0	19.7	51.3	94.4	5	5
ES	67.1	67.1	71.5	26.9	6.5	100.0	16	16
HU	65.4	65.4	63.8	14.0	47.9	84.3	7	7
CY	58.8	58.8	58.8	NA	58.8	58.8	1	1
IT	59.0	57.6	59.9	22.3	15.3	95.7	21	20
SE	55.9	55.9	59.2	9.4	39.1	67.5	8	8
BG	52.1	52.1	49.6	10.6	41.3	65.6	6	6
HR	50.4	50.4	50.4	NA	50.4	50.4	1	1
SI	42.4	42.4	42.4	2.0	41.0	43.9	2	2
EE	42.3	42.3	42.3	NA	42.3	42.3	1	1
SK	35.9	35.9	35.5	7.5	29.4	43.2	4	4
FI	36.4	33.0	40.5	15.0	20.4	50.4	5	4
EL	37.9	31.4	36.0	24.1	5.9	83.3	13	10
IE	31.2	31.2	30.9	6.1	25.3	37.5	3	3
RO	26.3	28.6	27.9	10.4	9.6	36.7	8	7
LV	27.3	27.3	27.3	NA	27.3	27.3	1	1
LT	23.5	23.5	23.5	6.2	19.2	27.9	2	2
BE	22.9	22.9	22.9	12.0	8.4	39.0	10	10
AT	22.6	22.6	16.5	18.9	7.4	64.3	8	8
FR	22.3	22.6	17.3	15.2	4.0	61.2	22	21
DE	20.9	18.2	17.4	17.0	3.7	100.0	38	35
DK	16.6	16.6	20.2	9.5	6.4	27.7	5	5
PL	14.8	14.8	15.0	5.5	4.7	23.1	17	17
LU	12.8	12.8	12.8	NA	12.8	12.8	1	1
CZ	8.1	9.2	9.0	4.4	0.0	12.4	8	7
NL	5.4	6.8	5.4	4.6	0.0	14.3	12	9
MT	100.0	NA	100.0	NA	100.0	100.0	1	0



Table C4. Main statistical indicators for land use U111 (Agriculture) and U112 (Fallow land) grasslands with unclear intensity, aggregated at national level. n indicates the number of NUTS2 regions available for computations.

Country code	Mean	Mean (filtered)	Median	Standard deviation	Minimum	Maximum	n (unfiltered)	n (filtered)
IE	24.8	24.8	24.2	14.3	10.9	39.5	3	3
EL	17.7	20.9	17.2	16.6	0.0	63.9	13	10
CY	20.6	20.6	20.6	NA	20.6	20.6	1	1
NL	22.9	19.8	20.1	14.3	4.9	54.9	12	9
BG	19.1	19.1	19.3	5.6	12.8	26.7	6	6
RO	17.2	18.3	18.5	6.7	9.6	27.3	8	7
LU	14.7	14.7	14.7	NA	14.7	14.7	1	1
HR	13.9	13.9	13.9	NA	13.9	13.9	1	1
FR	14.9	13.7	14.6	8.4	1.1	40.0	22	21
DK	13.5	13.5	14.6	6.8	3.2	22.2	5	5
ES	11.7	11.7	7.4	11.5	0.0	32.2	16	16
BE	11.4	11.4	11.4	5.1	3.0	19.9	10	10
IT	10.8	11.3	8.8	8.6	0.0	26.1	21	20
FI	8.8	11.0	9.8	5.3	0.0	13.1	5	4
CZ	8.8	10.0	7.0	8.5	0.0	21.6	8	7
AT	9.6	9.6	6.5	9.9	1.5	31.4	8	8
SE	9.4	9.4	6.9	7.8	3.2	26.6	8	8
SI	8.1	8.1	8.1	2.4	6.4	9.8	2	2
DE	7.2	7.8	5.1	8.3	0.0	33.5	38	35
SK	5.8	5.8	6.0	2.5	2.7	8.4	4	4
PL	5.0	5.0	4.3	5.0	0.0	22.4	17	17
PT	4.8	4.8	3.2	5.0	0.0	11.9	5	5
HU	4.7	4.7	4.6	3.6	0.0	9.6	7	7
LT	2.9	2.9	2.9	0.2	2.8	3.1	2	2
EE	2.3	2.3	2.3	NA	2.3	2.3	1	1
LV	0.7	0.7	0.7	NA	0.7	0.7	1	1
MT	0.0	NA	0.0	NA	0.0	0.0	1	0



Appendix D: Summary tables - Main statistics for NUTS2 level use, aggregated at NUTS0

Table D1. Main statistical indicators for land use U111 (Agriculture) and U112 (Fallow land) meadow grasslands, aggregated at national level. n indicates the number of NUTS2 regions available for computations.

Country code	Mean	Mean (filtered)	Median	Standard deviation	Minimum	Maximum	n (unfiltered)	n (filtered)
EE	86.3	86.3	86.3	NA	86.3	86.3	1	1
PL	86.2	86.2	87.9	6.8	68.4	96.3	17	17
LV	82.4	82.4	82.4	NA	82.4	82.4	1	1
CZ	84.4	82.2	87.0	9.9	68.7	100.0	8	7
LT	81.7	81.7	81.7	9.2	75.2	88.1	2	2
SI	77.4	77.4	77.4	3.3	75.1	79.7	2	2
SK	77.4	77.4	75.9	3.9	74.6	83.1	4	4
DE	70.8	71.7	73.4	15.7	20.0	100.0	38	35
FI	71.0	70.0	71.7	6.4	62.6	78.7	5	4
AT	67.5	67.5	70.5	19.2	33.8	88.6	8	8
HU	60.6	60.6	65.5	17.8	40.1	90.5	7	7
LU	53.7	53.7	53.7	NA	53.7	53.7	1	1
NL	47.1	52.0	57.1	19.1	13.4	70.7	12	9
DK	50.8	50.8	49.9	13.4	35.5	69.6	5	5
IT	51.1	49.3	50.2	22.1	17.8	91.2	21	20
HR	48.7	48.7	48.7	NA	48.7	48.7	1	1
SE	43.5	43.5	41.6	19.2	18.5	82.4	8	8
RO	41.4	41.9	40.5	12.3	24.1	66.9	8	7
BE	32.5	32.5	34.9	9.3	18.0	47.3	10	10
BG	29.7	29.7	30.9	15.5	11.9	48.0	6	6
FR	30.4	29.7	30.1	11.8	7.4	58.4	22	21
PT	26.8	26.8	19.3	31.0	3.1	79.4	5	5
CY	19.6	19.6	19.6	NA	19.6	19.6	1	1
IE	19.5	19.5	19.9	5.5	13.9	24.8	3	3
ES	14.3	14.3	9.5	13.9	0.0	42.0	16	16
EL	9.1	10.1	8.7	6.1	0.0	17.2	13	10
MT	0.0	NA	0.0	NA	0.0	0.0	1	0



Table D2. Main statistical indicators for land use U111 (Agriculture) and U112 (Fallow land) pasture grasslands, aggregated at national level. n indicates the number of NUTS2 regions available for computations.

Country code	Mean	Mean (filtered)	Median	Standard deviation	Minimum	Maximum	n (unfiltered)	n (filtered)
BE	52.4	52.4	56.5	10.2	29.2	62.3	10	10
FR	48.5	50.1	53.7	14.9	15.0	78.0	22	21
IE	49.5	49.5	54.5	15.4	32.2	61.9	3	3
EL	45.0	48.2	44.3	21.8	4.8	77.7	13	10
SE	39.1	39.1	43.8	16.9	9.3	58.2	8	8
ES	35.9	35.9	34.0	25.1	0.0	81.6	16	16
PT	34.7	34.7	42.5	24.2	0.0	59.0	5	5
BG	31.6	31.6	36.1	12.5	14.8	45.4	6	6
LU	31.6	31.6	31.6	NA	31.6	31.6	1	1
DK	30.7	30.7	25.4	8.7	24.0	43.9	5	5
RO	31.6	30.0	31.5	9.1	20.3	44.6	8	7
HR	28.2	28.2	28.2	NA	28.2	28.2	1	1
NL	29.7	27.8	26.2	20.0	0.0	57.3	12	9
IT	22.2	23.3	22.0	16.0	0.0	61.4	21	20
HU	21.1	21.1	16.4	13.1	6.8	38.5	7	7
DE	18.8	17.0	16.2	14.1	0.0	80.0	38	35
LV	15.1	15.1	15.1	NA	15.1	15.1	1	1
SI	13.6	13.6	13.6	4.4	10.5	16.8	2	2
AT	13.5	13.5	13.6	8.8	0.0	24.1	8	8
LT	10.8	10.8	10.8	9.9	3.8	17.8	2	2
SK	10.8	10.8	13.2	5.6	2.4	14.4	4	4
EE	10.1	10.1	10.1	NA	10.1	10.1	1	1
FI	7.2	9.1	7.0	6.2	0.0	16.9	5	4
CZ	6.6	7.5	4.9	4.4	0.0	13.5	8	7
CY	7.2	7.2	7.2	NA	7.2	7.2	1	1
PL	4.9	4.9	4.3	4.0	0.0	14.7	17	17
MT	0.0	NA	0.0	NA	0.0	0.0	1	0



Table D3. Main statistical indicators for land use U111 (Agriculture) and U112 (Fallow land) meadow or pasture grasslands, aggregated at national level. n indicates the number of NUTS2 regions available for computations.

Country code	Mean	Mean (filtered)	Median	Standard deviation	Minimum	Maximum	n (unfiltered)	n (filtered)
IE	24.1	24.1	22.6	14.3	10.6	39.2	3	3
NL	15.6	17.9	13.0	16.0	0.0	54.9	12	9
RO	16.4	17.4	17.8	6.0	9.4	24.5	8	7
LU	14.7	14.7	14.7	NA	14.7	14.7	1	1
FR	12.5	11.2	12.0	8.9	0.7	40.0	22	21
DK	11.1	11.1	11.9	5.1	3.2	17.1	5	5
BE	10.1	10.1	11.4	6.6	0.0	19.9	10	10
CZ	8.3	9.5	6.0	8.3	0.0	21.5	8	7
BG	8.9	8.9	7.9	5.7	1.9	16.2	6	6
IT	8.5	8.9	5.3	7.7	0.0	23.9	21	20
AT	8.7	8.7	6.2	9.9	0.0	30.0	8	8
HR	8.4	8.4	8.4	NA	8.4	8.4	1	1
SE	8.1	8.1	5.3	7.3	3.2	23.8	8	8
SI	7.4	7.4	7.4	1.9	6.0	8.7	2	2
DE	6.4	7.0	4.3	8.1	0.0	33.0	38	35
EL	5.3	5.4	2.4	7.2	0.0	24.2	13	10
ES	4.4	4.4	0.6	8.3	0.0	31.7	16	16
PL	3.6	3.6	2.4	3.6	0.0	14.8	17	17
HU	3.2	3.2	2.9	2.8	0.0	7.5	7	7
LT	2.5	2.5	2.5	0.5	2.1	2.8	2	2
SK	2.5	2.5	2.5	2.2	0.0	5.2	4	4
FI	1.9	2.4	1.3	1.7	0.0	3.8	5	4
PT	1.1	1.1	0.0	2.1	0.0	4.9	5	5
LV	0.3	0.3	0.3	NA	0.3	0.3	1	1
CY	0.0	0.0	0.0	NA	0.0	0.0	1	1
EE	0.0	0.0	0.0	NA	0.0	0.0	1	1
MT	0.0	NA	0.0	NA	0.0	0.0	1	0



Table D4. Main statistical indicators for land use U111 (Agriculture) and U112 (Fallow land) grasslands with unclear use, aggregated at national level. n indicates the number of NUTS2 regions available for computations.

Country code	Mean	Mean (filtered)	Median	Standard deviation	Minimum	Maximum	n (unfiltered)	n (filtered)
CY	73.2	73.2	73.2	NA	73.2	73.2	1	1
ES	45.4	45.4	46.3	33.0	1.7	100.0	16	16
PT	37.3	37.3	25.7	36.6	0.0	96.9	5	5
EL	40.6	36.2	42.4	21.1	12.6	78.6	13	10
BG	29.8	29.8	27.1	5.9	25.0	40.0	6	6
FI	19.8	18.5	20.4	3.9	15.3	25.0	5	4
IT	18.2	18.4	13.3	16.5	0.0	59.7	21	20
HU	15.2	15.2	15.2	7.1	2.7	25.0	7	7
HR	14.8	14.8	14.8	NA	14.8	14.8	1	1
RO	10.6	10.7	9.9	6.1	0.8	19.4	8	7
AT	10.3	10.3	3.6	16.5	0.0	49.1	8	8
SK	9.3	9.3	9.5	2.0	6.8	11.2	4	4
SE	9.2	9.2	8.4	3.9	4.8	15.6	8	8
FR	8.6	9.0	4.7	12.1	0.0	45.4	22	21
DK	7.4	7.4	7.1	5.0	1.8	12.8	5	5
IE	6.8	6.8	7.6	2.7	3.8	9.0	3	3
PL	5.2	5.2	4.9	2.9	0.4	12.6	17	17
BE	5.1	5.1	5.3	4.5	0.0	11.7	10	10
LT	5.1	5.1	5.1	1.3	4.2	6.0	2	2
DE	4.0	4.3	1.9	4.0	0.0	13.8	38	35
EE	3.6	3.6	3.6	NA	3.6	3.6	1	1
LV	2.2	2.2	2.2	NA	2.2	2.2	1	1
NL	7.6	2.2	1.8	13.4	0.0	35.8	12	9
SI	1.6	1.6	1.6	0.7	1.1	2.1	2	2
CZ	0.7	0.8	0.2	0.9	0.0	2.2	8	7
LU	0.0	0.0	0.0	NA	0.0	0.0	1	1
MT	100.0	NA	100.0	NA	100.0	100.0	1	0



Appendix E: Summary tables - Main statistics for NUTS2 level forb ratio, aggregated at NUTS0

Table E1. Main statistical indicators for land use U111 (Agriculture) and U112 (Fallow land) forb ratio, aggregated at national level. n indicates the number of NUTS2 regions available for computations.

Country code	Mean	Mean (filtered)	Median	Standard deviation	Minimum	Maximum	n (unfiltered)	n (filtered)
AT	44.8	44.8	42.9	7.5	37.3	61.1	8	8
CZ	44.7	39.6	39.8	15.2	34.3	80.0	8	7
EE	39.2	39.2	39.2	NA	39.2	39.2	1	1
EL	37.0	36.4	38.0	8.9	26.7	54.2	13	10
ES	36.1	36.1	34.2	9.4	23.6	55.3	16	16
LT	35.8	35.8	35.8	3.0	33.6	37.9	2	2
LV	34.1	34.1	34.1	NA	34.1	34.1	1	1
IT	32.9	33.6	34.4	7.3	19.3	48.7	21	20
HU	33.5	33.5	33.3	8.0	25.0	49.1	7	7
BG	31.7	31.7	32.9	3.1	26.5	35.4	6	6
PT	31.4	31.4	34.4	8.3	17.7	38.4	5	5
SK	31.2	31.2	31.5	2.2	28.4	33.4	4	4
HR	30.6	30.6	30.6	NA	30.6	30.6	1	1
SI	29.9	29.9	29.9	2.6	28.1	31.8	2	2
RO	28.8	29.0	28.7	3.1	23.3	33.9	8	7
FI	25.6	28.3	24.3	8.9	15.0	35.3	5	4
SE	26.8	26.8	28.1	4.9	19.1	32.3	8	8
DE	25.5	26.3	25.3	8.8	0.0	44.4	38	35
FR	25.7	25.4	26.2	5.4	16.2	38.4	22	21
LU	22.9	22.9	22.9	NA	22.9	22.9	1	1
IE	21.9	21.9	21.7	1.9	20.2	23.9	3	3
PL	21.1	21.1	21.1	2.3	16.9	24.7	17	17
DK	18.4	18.4	20.3	3.6	13.3	21.9	5	5
BE	18.2	18.2	17.7	4.5	12.4	24.8	10	10
CY	12.4	12.4	12.4	NA	12.4	12.4	1	1
NL	10.6	10.0	9.1	6.1	1.3	25.1	12	9
MT	80.0	NA	80.0	NA	80.0	80.0	1	0



Appendix F: Summary tables - Main statistics for NUTS2 level age category, aggregated at NUTS0

Table F1. Main statistical indicators for land use U111 (Agriculture) and U112 (Fallow land) permanent grasslands, aggregated at national level. n indicates the number of NUTS2 regions available for computations.

Country code	Mean	Mean (filtered)	Median	Standard deviation	Minimum	Maximum	n (unfiltered)	n (filtered)
PL	99.2	99.2	100.0	2.5	89.7	100.0	17	17
SI	98.1	98.1	98.1	2.4	96.4	99.7	2	2
CZ	95.3	95.3	96.6	4.5	88.4	100.0	8	7
AT	95.1	95.1	96.7	5.6	86.3	100.0	8	8
HU	94.7	94.7	96.1	3.7	90.1	100.0	7	7
SK	92.5	92.5	92.8	1.6	90.5	94.0	4	4
LU	92.0	92.0	92.0	NA	92.0	92.0	1	1
BG	91.8	91.8	95.2	9.2	79.1	100.0	6	6
RO	92.7	91.6	92.7	5.4	84.0	100.0	8	7
HR	91.4	91.4	91.4	NA	91.4	91.4	1	1
FR	90.6	90.2	90.9	8.2	75.5	100.0	22	21
DE	90.6	90.1	95.1	12.8	45.9	100.0	38	35
SE	89.9	89.9	91.0	6.6	76.6	100.0	8	8
EE	87.8	87.8	87.8	NA	87.8	87.8	1	1
IE	85.3	85.3	94.1	18.6	64.0	97.9	3	3
LT	84.3	84.3	84.3	1.2	83.5	85.2	2	2
LV	81.3	81.3	81.3	NA	81.3	81.3	1	1
NL	78.2	78.2	77.5	17.1	47.7	100.0	12	9
IT	78.9	77.8	81.2	19.8	27.9	100.0	21	20
ES	76.3	76.3	85.3	25.0	14.1	98.4	16	16
BE	75.4	75.4	78.0	26.7	9.8	100.0	10	10
FI	58.5	73.2	72.1	33.5	0.0	82.7	5	4
EL	71.8	69.6	76.2	24.6	37.0	100.0	13	10
CY	67.7	67.7	67.7	NA	67.7	67.7	1	1
DK	59.3	59.3	63.7	32.6	8.8	100.0	5	5
PT	42.3	42.3	46.8	21.6	12.0	62.2	5	5
MT	33.3	NA	33.3	NA	33.3	33.3	1	0



Table F2. Main statistical indicators for land use U111 (Agriculture) and U112 (Fallow land) temporary grasslands, aggregated at national level. n indicates the number of NUTS2 regions available for computations.

Country code	Mean	Mean (filtered)	Median	Standard deviation	Minimum	Maximum	n (unfiltered)	n (filtered)
PT	57.7	57.7	53.2	21.6	37.7	88.0	5	5
DK	40.7	40.7	36.3	32.6	0.0	91.2	5	5
CY	32.3	32.3	32.3	NA	32.3	32.3	1	1
EL	28.2	30.4	23.8	24.6	0.0	63.0	13	10
FI	41.5	26.8	27.9	33.5	17.3	100.0	5	4
ES	23.5	23.5	14.6	25.1	0.0	85.9	16	16
BE	22.6	22.6	16.0	27.8	0.0	90.2	10	10
IT	21.1	22.2	18.8	19.8	0.0	72.1	21	20
LV	18.7	18.7	18.7	NA	18.7	18.7	1	1
NL	16.7	16.7	12.6	15.6	0.0	39.7	12	9
LT	15.7	15.7	15.7	1.2	14.8	16.5	2	2
IE	14.3	14.3	5.5	18.3	2.1	35.4	3	3
EE	11.1	11.1	11.1	NA	11.1	11.1	1	1
SE	9.9	9.9	9.0	6.5	0.0	23.4	8	8
HR	8.6	8.6	8.6	NA	8.6	8.6	1	1
DE	8.0	8.4	3.5	12.2	0.0	54.1	38	35
FR	7.9	8.2	5.8	7.7	0.0	23.8	22	21
SK	7.5	7.5	7.2	1.6	6.0	9.5	4	4
BG	7.4	7.4	2.5	9.7	0.0	20.9	6	6
RO	6.3	7.2	4.7	5.8	0.0	16.0	8	7
HU	5.1	5.1	3.6	3.9	0.0	9.9	7	7
CZ	4.7	4.7	3.4	4.5	0.0	11.6	8	7
AT	4.4	4.4	2.6	5.2	0.0	13.7	8	8
LU	4.3	4.3	4.3	NA	4.3	4.3	1	1
SI	1.9	1.9	1.9	2.4	0.3	3.6	2	2
PL	0.8	0.8	0.0	2.5	0.0	10.3	17	17
MT	66.7	NA	66.7	NA	66.7	66.7	1	0



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