Grassland areas, production and use

Lot 2. Methodological studies in the field of Agro-Environmental Indicators

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and
the *Working group on 'Grassland term definitions' of European Grassland Federation (EGF) and the FP7 Multisward research project'*: Paragraph 3.5 and Annex 1. "Grassland term definition and classification"

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Executive summary

Need for grassland data

Grasslands are an important land use in Europe covering more than a third of the European agricultural area. Grasslands have a basic role in feeding herbivores and ruminants and provide important ecosystem services, including erosion control, water management and water purification. Grasslands also support biodiversity and cultural services and are an important stock of carbon. Grasslands are very diverse in terms of management, yield and biodiversity value. They range from semi-natural grasslands with low yields and high biodiversity values to fertilized mono-cultural grasslands.

There is a need for data about grassland in several European policies, i.e. Nitrates Directive, Common Agricultural Policy, EU Climate policies, Biodiversity policies, and the Renewable Energy Directive (Table 1). The required data include area and yield of grassland, biodiversity value, area grazed non-herbaceous grasslands, actual use (such as livestock density(management options (permanency, grazing, fertilization, tillage and cutting. The Economy-wide Material Flow Accounts need data domestic extraction of biomass, including fodder crops and grazed biomass. Moreover, data about grassland area, yields and nutrient contents are needed to calculate the gross nutrient balance, which is one of the Agri-environmental indicators.

If nutrient balances are used to identify hotspots in EU with high nitrogen pressure, the nutrient balance should relate to the area of agricultural land which is potentially fertilised to avoid a bias in the balance for countries with large extensive and not utilised areas. Grassland with no or low inputs of mineral and organic nitrogen, low grazing density and low yields should not be included in the Gross Nutrient Balance calculation.

Clearly, there is a need for well-defined characterization of the grassland types, management of these grasslands and data about the productivity (both in terms of biomass and nutrients). The definitions and characterization should be used in an uniform and harmonized way in the EU-27 so that the same information is gathered in the member states. Eurostat needs recommendations to collect data about areas and production of different types of grasslands, which should take existing methods of collecting data and existing surveys into account.

Table 1. Data needs on grassland for the respective EU policies (X: required; (x): useful)

Data needs	Nitrates Directive	Common Agricultural Policy	EU Climate policies	Biodiversity policies	Renewable Energy Directive
Grassland area	X	X	X		X
Grassland yield	X	(X)			
Biodiversity value		X		X	X
Permanency	(X)	X	X	X	(X)
Status of grazing		X		X	
Status of fertilization	X		X	X	
Status of tillage		X	X		
Status of cutting	(X)	(X)		(X)	
Amount of manure from grazing on non-grasslands	X				

Objectives of the study

The general objective of this study is to bring clarity into the issue of defining, classifying, collecting and disseminating data on European grassland areas, use and production. The more specific objectives are:

- To make a literature review of existing definitions and classifications of grasslands that are used in diverse domains, both statistical, administrative, scientific and other.
- To make a literature review on existing methodologies to estimate grassland production and to estimate biological fixation in grasslands, including a review on the methodologies currently applied by countries.
- To make recommendations for (i) potential definitions of grasslands, (ii) classification schemes on grassland, and iii) methods to quantify grassland production.
- To collect and analyse data about grassland production in the EU Member States, Norway and Switzerland.
- To create a set of recommendations on how to collect data on grasslands, in ways allowing the creation of coherent European datasets.

Existing definitions and classifications

A literature review has been carried out of existing definitions and classifications of grasslands that are used in diverse domains, both statistical, administrative, scientific and other. Most of the statistical sources of grassland data deal with land use, whereas the remote sensing based sources refer to land cover. Land use is a description of how people utilize the land and socio-economic activity. Land use is often recorded via questionnaires and statistics. Definitions of grassland can be found in the scientific literature, Common Agricultural Policy, Farm Structure Survey, FADN, FAOSTAT, IPCC guidelines, LUCAS, remote sensing based sources (CORINE, FAO-Land Cover Classification System, EAGLE) and, for habitat classification, in the EU Habitats Directive and the EUNIS habitat classification.

The statistical sources do have clear definitions for different grassland types. Although remote sensing sources have clear classification schemes, the usefulness is limited as the classification is focussed on land cover and not on land use. The spatial coverage for most grassland sources is sufficient and cover the EU-27. Many EU policies require data on grasslands. None of the current grassland definitions and classification does fulfil the data needs of the different EU policies (Table 2).

Table 2. Assessment of usefulness of current grassland classifications and definitions for different EU policies (white is high, grey medium and black low potential for use policy data needs).

Classification / definition	Nitrates Directive	Common Agricultural Policy	EU Climate policies	Biodiversity policies	Renewable Energy Directive
International terminology for grazing lands and grazing animals					
Common Agricultural Policy					
Farm Structure Survey					
FAOSTAT					
UNFCCC					
LUCAS					
CLC classification					
FAO-LCCS					
Habitats Directive					

Methods to estimate grassland production and biological fixation

A literature review was carried out of existing methodologies to estimate grassland production and to estimate biological fixation in grasslands, including a review on the methodologies currently applied by countries. The estimates of grassland production have a large effect on the nutrient balance of grassland based livestock systems. Furthermore, estimates of biological nitrogen fixation of mixed legume-grass swards are not included in current nutrient balances. Most grassland used for agricultural purposes is stocked by animals for at least part of the time and in many cases year-long. Grazing affects grassland production because of defoliation, treading and fouling. Harvesting and grazing take place frequently or at least several times in a year. For these reasons measuring yield of forage is more difficult than that of other crops.

The methods for determining grassland production can be classified in destructive (cutting) and non-destructive (visual estimates, grass height measurements and remote sensing) measurements, and modelling (Table 3). Destructive measurement is commonly applied on grassland experiments throughout Europe. Although non-destructive methods are less accurate on a per sample basis than cutting methods, they take less time per observation and involve less physical effort by the operators. The larger number of observations offers more opportunity for examining spatial and temporal heterogeneity. Remote sensing offers a potential alternative for monitoring vegetation condition and estimating productivity over large areas of grasslands. However, such methods have proven difficult to be applied in crop yield forecasting applications operating at regional to continental scales. The main reason for this slow adoption is the disparity in scales between the process and the type of observing system. When comparing methods it is important to consider that the different methods measure either gross production, net production or net feed intake.

There is a wide variety in modelling approaches of grassland production. Process based models and empirical models are distinguished. Empirical models include the feed balance approach in which grassland yields are estimated using statistical data on feed availability for ruminants and their feed requirements.

Measurement of nutrient contents in grassland is also categorised in destructive (sampling and analysing) and non-destructive (chlorophyll, near infrared reflectance spectrometry).

The amount of N fixed by clover is difficult to estimate, because both the estimate of the average share of clover in grassland in a region or field and the amount of N fixed per unit clover are uncertain. If clover is grown on soils that contain mineral N (e.g. because of N fertilizer or manure application), clover can use this N at the cost of atmospheric N fixation. There are many techniques available for the direct quantitative measurement of legume biological nitrogen fixation in the field. However, these are time-consuming and therefore expensive, and generate data relevant only to the time and place of measurement. Alternatively, biological N fixation can be estimated by either empirical models or dynamic mechanistic simulation models.

Table 3. Overview of grass production assessment methods

Method	**Scale**	**Gross production**	**Net production**	**Net feed intake**
Cutting and weighing	plot, field, farm	x	x	
Height and density measurement	plot, field	x		
Visual estimate	plot, field, farm	x	x	
Modeling	plot, field, farm, region	x	x	x
Remote sensing	region	x		
Feed balance	farm, region			x

Results of a questionnaire

A questionnaire with questions about collection of grassland data, nutrient balances, and extensively grazed areas has been sent to 280 grassland experts in the EU Member States, Norway and Switzerland. In total 81 responses were obtained, of which 67 responses were completed. By far, most of the data sets categorised the grassland according to Farm Structure Survey. The methods used to estimate grassland production by countries are very heterogeneous. Most members states use expert estimates, while destructive measurements are also mentioned frequently. Less frequently mentioned methods involve default values from literature, non-destructive measurements, calculations with a crop growth model and estimates using feed balance calculation. With respect to nutrient contents, members states mainly use derived values from literature or direct measurements in samples of harvested grass. Data on biological nitrogen fixation are usually not collected. Those countries that do, mostly rely on values retrieved from literature in combination with expert estimates. Measurements and models are not mentioned frequently. Spain, Portugal, Switzerland, and Latvia indicated that some of the grazed areas are not included in utilized agricultural area. Data availability on these grasslands is diverse. Many

respondents gave positive response to the main idea to estimate national nutrient balances both including and excluding extensive grassland and grazing areas.

Case study on classification of grazed non-herbaceous grasslands in Spain

A case study on classification of grazed non-herbaceous grasslands in Spain showed there are no reliable data for calculating the total extent of all grassland categories. Grassland classifications in Spain are quite clear, and many of the broad concepts are common across different data sources. However, there are considerable variations in interpretation and in specific criteria resulting in different data sources showing very different totals of permanent grassland. The great majority of grazing land in Spain is not purely herbaceous grassland. By far the largest grassland extent is shown by Land Parcel Identification System (LPIS; 18.6 Mha of which >85% has a proportion of trees and/or shrubs). A considerable problem is that there is no way of knowing from existing data whether a pasture is in current use. In Spain, the EU requirement for farmers claiming CAP payments to declare all the land they use has not been strictly applied. Many farmers declare only the number of hectares they need to claim their Single Farm payment rights, which is less than the area shown as eligible on LPIS.

Agricultural data bases provide very detailed information on the agricultural grassland categories (forage crops and cultivated meadows), including the extent of different types, their productivity and the methods of use. However, far less information is available on the wide range of uncultivated grasslands, including forest pastures. There is no reliable source of data on the actual use of these grasslands, i.e. if they are in use or not, and if in use then what is the livestock density or grazing days per year. This is a major problem from the point of view of a range of Agro-Environmental Indicators, including the gross nutrient balances. The situation could be greatly improved by standardisation and harmonisation of data sets, and accurate recording of what pastures each farmer is really using and the number of grazing livestock units per holding.

Recommendations of definitions and classification of grasslands

Based on the needs in policies, a grassland classification scheme is proposed (see Figure *1* and, presented in a different way, Table 4). The definitions of the grassland types in this scheme are presented below.

Grassland: Land predominantly covered by grass, grass like plants, forbs and shrubs and that in some circumstances may also have a tree canopy, including

i) agricultural used permanent and temporary grassland and legumes and
ii) non-agricultural grassland including fallow and abandoned land, clear cuts within previously existing forests, grasslands associated to residential, transport, business, and community service areas, grassland for recreation, natural grassland not used for grazing and grassland outside agricultural areas not utilized.

Agricultural grasslands: All land which is in agricultural use and is not permanent crops or arable, except temporary grassland and legumes, and thus:

- Excludes grasslands in which there is no evidence of human intervention (e.g. through grazing, mowing) and cannot therefore be categorized as agricultural land.
- Includes all uncultivated land with vegetation that is grazed and/or cut for fodder, including herbaceous and non-herbaceous species.

Permanent grassland: Permanent grassland and permanent pasture means land used to grow grasses or other herbaceous forage naturally (self-seeded) or through cultivation (sown) and that has not been included in the crop rotation of the holding for ten years or more; it may include other species such as shrubs and/or trees which can be grazed provided that the grasses and other herbaceous forage remain predominant; as well as, subject to a decision by Countries to include land which can be grazed and which forms part of established local practices where grasses and other herbaceous forage are traditionally not predominant in grazing areas.

Agriculturally improved permanent grassland: Permanent grasslands on good or medium quality soils, used with more frequent defoliations, higher fertilization rates, higher stocking rates and producing higher yields than semi-natural grasslands. Three N inputs by fertilizer, manure, grazing and biological N fixation are considered:

- **< 50 kg N per ha per year**
- **50 - 150 kg N per ha per year**
- **> 150 kg N per ha per year**

Unimproved grassland (semi-natural grassland): A category of grasslands (including those with non-herbaceous species) that are notable, within the overall context of agricultural grasslands, for their ecological value. Unimproved grasslands have a spectrum of values depending on management but focus on biodiversity value and there is often a strong relation between high biodiversity value and other services. Unimproved grasslands are semi-natural and natural grasslands that are not substantially agriculturally-improved (e.g. through cultivation, reseeding, fertilisation, irrigation and drainage) of long standing and species–rich (taking account of all taxa not only higher plants).

Permanent grasslands out of production but well maintained: Areas of permanent grasslands, regardless of the grassland type and the previous use, of which the produced biomass is no longer used for agricultural production purposes, but which are maintained in good agricultural and environmental condition by appropriate measures.

Temporary grasslands: Grasslands sown with forage species that can be annual, biennial or perennial. They are sown on arable land and can be integrated in crop rotations or sown after another grassland vegetation. They are kept for a short period of time (from a couple of months to usually a few years). They can be established with pure sowings of legumes, pure sowings of grasses or grass/legume mixtures.

Temporary grasslands with pure sowings of grasses Temporary grassland sown with only grass species.

Temporary grasslands with pure sowings of legumes: Temporary grassland sown with forage legume only.

Temporary grasslands with grass/legume mixtures: Temporary grassland sown with a mixture of grass and forage legumes.

Non-agricultural grassland: Natural, recreation and ornamental grasslands, not used for agriculture and not part of the utilized agricultural area.

Natural grassland: Non-agricultural low productivity grasslands, including climax grasslands, with minimum human interference (not mowed, fertilized or stimulated by chemicals which might influence production of biomass), often situated in areas of rough, uneven ground.

Recreation and ornamental grasslands: Non-agricultural grasslands associated to residential, transport, business, and community service areas, and grasslands for recreation.

Biodiversity classification is not further developed in this study. See Elbersen et al. (2014) for a more in depth discussion about biodiversity in grasslands.

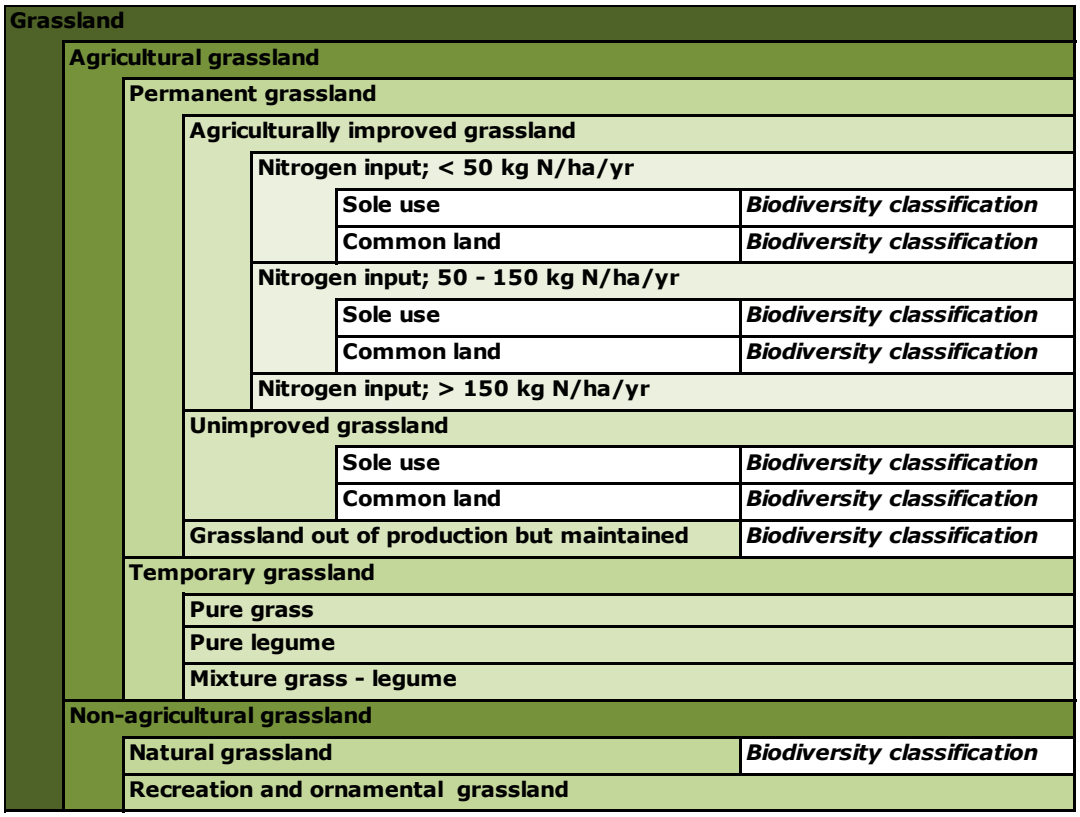


Figure 1. Proposed grassland classification scheme.

Table 4.Classification scheme for grasslands.

1. Agricultural grassland	
1.1 Permanent grassland	
1.1.1. Agriculturally improved grassland	
1.1.1.1 Nitrogen input; < 50 kg N/ha/yr	
1.1.1.1s Sole use	Biodiversity classification
1.1.1.1c Common land	Biodiversity classification
1.1.1.2 Nitrogen input; 50 - 150 kg N/ha/yr	
1.1.1.2s Sole use	Biodiversity classification
1.1.1.2c Common land	Biodiversity classification
1.1.1.3 Nitrogen input; > 150 kg N/ha/yr	
1.1.2. Unimproved grassland	
1.1.2s Sole use	Biodiversity classification
1.1.2c Common land	Biodiversity classification
1.1.3. Grassland out of production but maintained	Biodiversity classification
1.2 Temporary grassland	
1.2.1 Pure grassland	
1.2.2 Pure legumes	
1.2.3. Mixture grass - legume	
2. Non-agricultural grassland	
2.1 Natural grassland	Biodiversity classification
2.2 Recreation and ornamental grassland	

Parallel to the work of Alterra on grassland in this project, the Working group on 'Grassland term definitions' of European Grassland Federation (EGF) and members of the FP7 Multisward research project made a proposal of definition and classification of grassland. This proposal is included as an Annex to this report. The grassland classification scheme proposed by the EGF/Multisward working group and that proposed in this report are largely the same, but some differences occur (see paragraph 7.6.2).

The need for grassland data differ for different policies and data users, and mostly information is only needed for part of the grasslands in the proposed classification scheme. Several agricultural categories of both permanent and temporal grasslands are relevant for Common Agricultural Policy. In the new CAP 2014-2020 stricter requirements are set to permanent grasslands. In the proposed classification scheme, the CAP definition of permanent grassland has been adapted, except that the age of grassland is more than 10 years instead of the 5 years in the definition of CAP. The EGF gives a good explanation for the requirement of 10 years and this confirms that they specifically link ecosystem service capacity of a grassland to the definition of the permanent grassland category (Annex 1).

Grasslands that have ecological value and which have to be considered in the Birds Directive and the Habitats Directive and the EU biodiversity strategy are indicated in the proposed scheme by "biodiversity classification". The same holds for the grassland to be considered in the Renewable Energy Directive (2009/28/EC). Development of a classification scheme for biodiversity is out of the scope of this project. For the Nitrates Directive, grasslands with high N inputs (> 50 kg N per ha) are relevant because there is a risk of nitrate leaching and part of these grasslands may be considered for higher manure application rates than the standard of 170 kg N per ha. For Economy-wide material flow accounts, all agricultural grasslands are relevant. For the gross nutrient balance, the agriculturally improved grasslands and temporary grasslands should be considered because these are the grasslands with N inputs by mineral fertilizer, manure, biological N fixation and grazing and which are used for agricultural production. The other grassland categories have no or low inputs and should not be included in the gross nutrient balance calculation.

In FAOSTAT under the land statistics (part of the Resource statistics), grassland categories are distinguished. The main distinction is between temporal and permanent grassland, irrigated versus non-irrigated and organic versus conventional agriculture. Both irrigation and organic farming systems are not part of the proposed grassland classification scheme. However, data about irrigation and organic farming is collected by Eurostat because both are Agri-environmental indicators. Information about irrigation is collected in Survey on Agricultural Production Methods (SAPM) of FSS and the Organic farming statistics of Eurostat, respectively. The IPCC guidelines give a broad definition for grasslands for reporting of greenhouse gas emission to the UNFCCC, but many countries use their own definition, depending on their national circumstances and data availability. This indicates that the proposed classification scheme can be used for reporting of greenhouse gas emissions (including those related to Land Use Land Use Change and Forestry) to the UNFCCC. The required grassland category for the OECD Environmental data fall in the category Permanent grassland of the proposed scheme. The LUCAS definition of Grassland covers all grasslands (agriculture and non-agriculture) of the proposed classification scheme. Most of the LUCAS categories fit in the proposed scheme. The LUCAS category B55 Temporary grassland does not include pure legumes and mixture of grass – legume.

Recommendations for data collection

LPIS provides the most detailed information about agricultural permanent grasslands, but data are not (yet) widely available in the EU. Remote sensing information of the HR layer permanent grassland will be available next year and provides information at a high resolution (20*20m) about the area of permanent grassland, including information of permanent grassland with agricultural use and grassland with other use (artificial grasslands). The LUCAS in-situ survey provides information about land cover and land use.

LPIS information in combination with HR layer permanent grassland and support layer (or Corine Land Cover map) enriched with land use information based on the in-situ observations from LUCAS will be the

best available source for mapping of the total grassland extent (agricultural + non-agricultural) in the near future. LUCAS also provides information to distinguish between category natural and artificial grasslands. It recommended to use statistical sources for area of agricultural grasslands. Crop statistics and FSS can be used to obtain data about permanent grassland, including those out of production but maintained.

The Land Parcel Identification System (LPIS) may be used to validate the results of crop statistics for permanent grassland area and, if needed, to improve collection of grassland data in crop statistics. Moreover, LPIS can be used to link the data on land management, grazing practices, to the land uses/land cover categories. Data about N inputs as fertilizer and manure should be collected in FSS and the Survey on Agricultural Production Methods (SAPM). The presence of legumes in permanent grassland, and area of temporary grasslands (pure temporary grassland, pure legumes, and mixture grass-legume) are collected in Crop Statistics.

The proposed sources of data needed for the area of the grassland categories in the grassland classification scheme are summarized in Table 5). Recommendations about data for biodiversity classification are out of the scope of this project.

A tiered approach is recommended for collecting data about grassland production, including fixed, modelled or measured values for each of the three parameters (Table 6).

- Fixed estimates are those values that are derived from literature research in combination with expert opinions. Sources are preferably peer reviewed papers, but data from other sources may be used as well. Often data availability is limited with white spots for certain areas or periods. Regional and national grassland experts are a valuable resource for completing these missing data. Data availability will decrease in the order yield > nutrient content > fixation, but in all cases the framework of the approach is similar.

- Modelled estimates comprise a wide range of empirical or mechanistic approaches of estimating yields, nutrient content or biological fixation, with varying complexity. Models are preferably published and peer reviewed and calibrated and validated on local conditions. Again in this category, models for yield estimates are developed abundantly, compared to models for nitrogen fixation. With respect to yield estimates, the use of feed balances has been applied in several countries and may serve as a template for other countries. Less experience is available for nitrogen fixation. Whichever modelled approach is chosen, the most important underlying factors, proportion of legumes in the sward and applied nitrogen, should be considered.

- Measured estimates are those values derived from *in situ* measurements of yields, nutrient contents of nitrogen fixation. Although the direct measurement is in theory the best proxy, the methods has similar pitfalls as the lower tier methods with respect to upscaling from a local site at a specific time to higher spatial and temporal scales. Furthermore it has to be clear that on experimental sites potential yields are measured. Potential yields are significantly higher than those obtained under commercial farming conditions. Therefore, measurement networks should preferably be located at commercial farms, on plots used for grazing as well.

In the Tier 1 method, estimates of grassland yields, nutrient contents and nitrogen fixation should be made on a preferably NUTS II level (or for smaller countries at national level) and annual basis. This has to be done for the grasslands that are relevant for nutrient balances, i.e. the agricultural improved grasslands and temporary grasslands.

N and P contents in dry matter are needed to calculate the total N and P removal by the harvest crops and should be estimated for all grassland types in the categories agriculturally improved grasslands and temporary grasslands. If data are available, the nutrient contents on a national of regional level can be

used. It is recommended that the required Tier 1 estimates of dry matter yield, nutrient content, and nitrogen fixation are derived by one group of experts, using a combination of literature, expert estimates, remote sensing data, and models. The advantage of deriving yields estimates by one expert group instead of estimates by country experts is that a uniform approach is used that guarantees that the yields in the EU are estimated with the same approach. If the proposed estimates of grasslands, nutrient contents, and nitrogen fixation for the Tier 1 methodology are available, the calculation of gross nutrient balances on NUTS II level will be significantly improved and harmonized over the European Union, compared to the current estimates. The data required for the Tier 2 (modelling including feed balances) and Tier 3 (measurements) methods strongly depend on the approach that will be used. No general recommendations can be made for data collection using Tier 2 and 3.

Table 5. Proposed sources of data needed for the area of the grassland categories in the grassland classification scheme.

Type of information	**Source**
Total area grassland (land cover)	Remote sensing: CORINE + HR layer grassland + LUCAS
Area of agricultural and non-agricultural grasslands	LPIS + LUCAS + CORINE + HR layer grassland
Area of natural and artificial grassland	LUCAS + CORINE + HR layer grassland
Area permanent and temporary agricultural grasslands	Crop statistics
	LPIS
Nitrogen input to grassland as fertilizer, grazing and manure	Farm Structural Survey/Survey on Agricultural Production Methods
Percentage of legumes in permanent grassland area	Crop statistics (*Note: not for classification but for N input*)
Area of grassland out of production but maintained	Farm Structural Survey
Area of sole use grassland and common land	Farm Structural Survey
Area temporary grassland: pure grassland	Crop statistics
Area of temporary grassland: legumes	Crop statistics
Area of temporary grassland: mixture grass - legume	Crop statistisc
Biodiversity classification	Out of scope of this project

Table 6 Framework for three tiered approach for quantification of grassland production.

	Fixed estimate (Tier 1)	**Models (Tier 2)**	**Measurements (Tier 3)**
Sources	Literature Experts	Calibrated and validated model Meteorological data Farm management data Statistical farm data Feed requirements Data on imported feed Data on legume contents in swards	Network of experimental plots Network of commercial (pilot) farms
Temporal scale	Annual	Seasonal Annual	Seasonal Annual
Spatial scale	Regional National	Regional National	Regional National
Uncertainties and risks	Expert bias Incomplete spatial coverage of data	Availability of data for calibration and validation Feed balances require many additional data on livestock and external feed inputs and quality	Overestimation of actual yields Availability of representative monitoring network
Relative costs	Low	Medium	High

1 Introduction

1.1 Grasslands

Grasslands are an important land use in Europe covering more than a third of the European agricultural area (Figure 2). Grasslands have a basic role in feeding herbivores and ruminants and provide important ecosystem services, including erosion control, water management and water purification. Grasslands provide important fire-breaks in Mediterranean forest landscapes. Grasslands also support biodiversity and cultural services. Grasslands are an important stock of carbon (Guo and Gifford, 2002; Vertès et al., 2007). Cultivation of grasslands, and other modifications of grasslands through desertification and livestock grazing can be a significant source of carbon emissions.

The EU livestock sectors annually use around 500 million tonnes of animal feed. About 40% of this quantity is in grass (expressed in dry matter), 28% in cereals, and the rest consists of a range of products (Lesschen et al., 2011). A grassland area of around 65 to 70 million hectares is needed to produce feed for the EU livestock sector. Grasslands are very diverse in terms of management, yield and biodiversity value. They range from semi-natural grasslands with low yields and high biodiversity values to fertilized mono-cultural grasslands.

Most of the grass in the EU originates from intensively managed grasslands, stimulated by fertilizer application. Extensive, high nature value grasslands have low yields. Moreover, some of the grasslands are temporary grasslands on land that could also be used for crop production (Reheul et al., 2007).

Accurate data on grassland area, grassland production and nutrient contents and grassland use (grazing LU/ha, cutting) are very important for calculation of gross nutrient balances in the EU and other agri-environmental indicators (e.g. greenhouse gas emissions) and policies (e.g. CAP reform). This requires well-defined characterization of the grassland types, management of these grasslands and the productivity (both in terms of biomass and nutrients).

The definitions and characterization should be used in a uniform and harmonized way in the EU-27 so that the same information is gathered in the countries. Such a uniform approach is needed to derive gross nutrient balances (and other Agri-environmental indicators) based on the same methodology and type of data. Only then, the gross nutrient balances can be used to compare countries in benchmarking studies, such as done by Eurostat, DG Environment (e.g. Nitrates Directive) and European Environmental Agency (EEA, e.g. the state of the Environment).

Eurostat needs recommendations to collect data about areas and production of different types of grasslands, which should take existing methods of collecting data and existing surveys into account. It is well known that setting up new systems of collecting data or new surveys is costly and increases the burden of statistical offices in the different countries. Therefore, collection information about grasslands should (as much as possible) be built in existing surveys. On the other hand, there is currently considerable duplication and overlap between data sets, so there is scope for rationalisation and improvement.

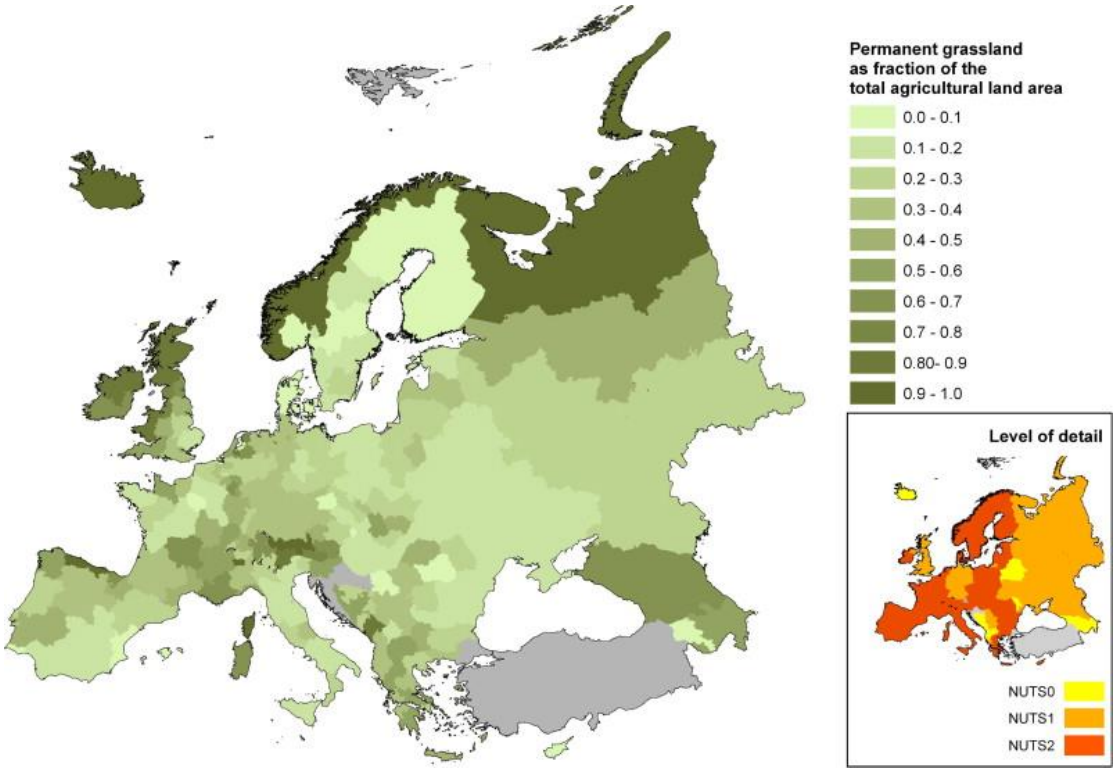


Figure 2. Spatial distribution of permanent grassland as a percentage of utilized agricultural land (average of 1995–2004) in Europe (Smit et al., 2008).

1.2 Objectives of the study

The general objective of this study is to bring clarity into the issue of defining, classifying, collecting and disseminating data on European grassland areas, use and production. The more specific objectives are:

- To make a literature review of existing definitions and classifications of grasslands that are used in diverse domains, both statistical, administrative, scientific and other.
- To make a literature review on existing methodologies to estimate grassland production and to estimate biological fixation in grasslands, including a review on the methodologies currently applied by countries.
- To make recommendations for (i) potential definitions of grasslands, (ii) classification schemes on grassland, and iii) methods to quantify grassland production.
- To collect and analyse data about grassland production in the EU Member States, Norway and Switzerland.
- To create a set of recommendations on how to collect data on grasslands, in ways allowing the creation of coherent European datasets.

1.3 Research framework

The research framework of the study comprised of the following tasks:

- A literature review of existing definitions and classifications of grasslands that are used in diverse domains, both statistical, administrative, scientific and other.
- A literature review on existing methodologies to estimate grassland production and to estimate biological fixation in grasslands, including a review on the methodologies currently applied by countries.
- A questionnaire to collect and analyse information about grassland classification, definitions, use and production in the EU Member States, Norway and Switzerland.

- A case study on classification of grazed non-herbaceous grasslands in Spain (this study was carried out by Guy Beaufoy)
- Recommendations for potential definitions and classification of grasslands, and to propose possible strategies to collect data.

Parallel to the work of Alterra on grassland in this project, the Working group on 'Grassland term definitions' of European Grassland Federation (EGF) and members of the FP7 Multisward research project made a proposal of definition and classification of grassland. This working group was led by Alain Peeters of RHEA in Belgium. Their proposal is integral included in Annex 1 of this report and summarized in. paragraph 3.5

In the project *Aspects of data on diverse relationships between agriculture and the environment (DG ENV contract no.: 07-0307/2012/633993/ETU/B1)* a consortium led by Alterra made a proposal for definitions of Ecological Valuable Grasslands. The focus of that project was biodiversity in relation to Common Agricultural Policy (Elbsersen et al., 2014). Relevant results obtained in the DG ENV contract is included in this report for Eurostat.

This reports includes a synthesis and summary of different studies carried out in this project, presented in the following documents:

- Jan Peter Lesschen, Berien Elbersen, Gerard Hazeu, Anne van Doorn, Sander Mucher, and Gerard Velthof. Defining and classifying grasslands in Europe. Alterra.
- René Schils, Gerard Velthof, Sander Mucher, Gerard Hazeu, Oene Oenema, Allard de Wit, Annemieke Smit. Current methods to estimate grassland production and biological fixation. Alterra.
- Annemieke Smit. Results of the grassland questionnaire, an excel documents with the detail results of the questionnaire. Alterra.
- Guy Beaufoy. Grazing in non-herbaceous areas in Spain; their use and extent is included in this report.

Based on these documents and reports, recommendations are made for potential definitions and classification of grasslands, for estimation of yields and to propose possible strategies to collect data.

2 Need for grassland data

This Chapter summarizes the need of grassland data in several EU policies, for Agri-Environmental indicators and for Economy-wide material flow accounts. A more detailed assessment is presented by Lesschen et al. (2014)[1].

2.1 Common Agricultural Policy

The Common Agricultural Policy (CAP) is the European Union legislation regulating agriculture and rural development. The 2003 reform of CAP introduced a major change in European agricultural policy and 'decoupled,' the direct link between farm payments and agricultural production. For the post-2013 CAP the EC proposed "greening measures" to further support innovation in and sustainability of farming by linking them to the system of direct payments (pillar one). Three measures have been proposed i.e. crop diversification, permanent grassland protection and ecological focus areas. The strength in these measures lies in the fact that they create a level playing field in the EU, because they are compulsory for almost all farmers. The greening measures go beyond cross-compliance obligations and raise the baseline, thereby increasing the environmental ambitions of the EU as a whole.

The 2003 CAP reform obliges Member States to ensure that their area of permanent pasture (the ratio compared to total agricultural land) does not reduce as a result of the reform. The monitoring is based on a ratio of permanent pasture compared to total agricultural land. If there is a significant decrease in the ratio, national authorities may impose measures to stop the decline (e.g. prior authorisation for ploughing; obligation to return arable land to pasture). Good information on the grassland and especially the status of permanency is obviously very important for correct payment of the CAP subsidies. In addition, there are some aspects under cross compliance related to grasslands, including the Nitrates Directive and Habitat Directive and some of the measures under the good agricultural and environmental condition (GAEC).

2.2 Biodiversity policies

The EU is committed to the protection of biodiversity, and to halting biodiversity loss within the EU by 2020. The EU has built up a network of 26000 protected areas in all the Member States and an area of more than 750.000 km^2, which is known as Natura 2000. The legal basis for Natura 2000 comes from the Birds Directive and the Habitats Directive, which form the backbone of the EU's internal biodiversity policy. The Habitats Directive (92/43/EEC) has focused on the requirement of Member States to establish a network of special areas of conservation (SACs) that, together with the special protection areas (SPAs) designated under the Birds Directive (79/409/EEC), make up the Natura 2000 network. Annexes I and II to the Habitats Directive list the habitats and species whose conservation requires the designation of SACs. Some of them are defined as 'priority' habitats or species (in danger of disappearing). Annex 1 of the Habitats Directive included several types of grassland. The Habitats Directive requires continuous monitoring of the condition of species and of the full extent of habitats within each member state (within Natura 2000 sites and also outwith these sites), with results being updated every six years. The Birds

[1] Jan Peter Lesschen, Berien Elbersen, Gerard Hazeu, Anne van Doorn, Sander Mucher, and Gerard Velthof. Defining and classifying grasslands in Europe. Alterra.

Directive (2009/147/EC) is aimed at the conservation of wild birds, which creates a comprehensive scheme of protection for all wild bird species naturally occurring in the European Union.

The EU biodiversity strategy to 2020 (COM(2011) 244) has defined six targets, of which target 3 is to increase the contribution of agriculture and forestry to maintaining and enhancing biodiversity. It aims to maximise by 2020 the areas under agriculture across grasslands, arable land and permanent crops that are covered by biodiversity-related measures under the CAP so as to ensure the conservation of biodiversity. The strategy should bring a measurable improvement in the conservation status of species and habitats that depend on or are affected by agriculture and in the provision of ecosystem services as compared to the EU 2010 Baseline. The improvement is to be measured against the quantified enhancement targets for the conservation status of species and habitats of EU interest and the restoration of degraded ecosystems.

2.3 Nitrates Directive

The main objective of the EU Nitrates Directive (91/676/EEC) is to reduce water pollution caused or induced by nitrates from agriculture, and to prevent further such pollution. Member states have to take actions in so-called nitrate vulnerable zones (NVZ), which have to be presented in an Action Programme. The area and production of grasslands is required for several aspects in the Nitrates Directive. For all crops, member states have to present nitrogen application standards (and in some member states also phosphorus application standards), which follow the principle of balanced nitrogen (or phosphorus) application. The yield and nitrogen uptake of the crops are important factors affecting the application standards.

Every four years, member states have to report to the Commission their progress in implementing the Nitrates Directive. This report should also include the nitrogen and phosphorus balances of agriculture. This balance is calculated using the inputs by fertilizer and manures and the outputs by harvested crop products. To calculate the nitrogen and phosphorus balances, estimates of yields are needed, including those for grasslands.

Countries can apply for a derogation for application of manure above the standard of 170 kg N per year following the Nitrates Directive. One of the criteria of using more manure than this standard is the nitrogen uptake capacity and the length of growing season. Grasslands have a long growing-season and high nitrogen uptake capacity. There is a need by the Nitrates Directive for data on grassland area and production (for different grassland types and management).

2.4 EU climate policy

Grasslands are an important stock of carbon and a source of nitrous oxide. Countries have to report the emissions to the United Nations Framework Convention on Climate Change (UNFCCC). Different methodologies are used to quantify greenhouse gas emissions. Emissions of N_2O are different for grasslands than for cropland, and some countries like the Netherlands use different emission factors for grassland than for arable land (Velthof and Mosquera, 2011). For such an approach, the area and management of grassland is needed. As IPCC encourage countries to use country specific Tier 2 or 3 methodologies it may be expected that the need for data on area and use of grasslands will increase.

In addition the EU parliament recently approved a law to establish common rules for accounting for GHG emissions and removals of carbon from the atmosphere resulting from activities related to land use, land-use change and forestry (LULUCF). This decision represents a first step towards incorporating the forestry and agriculture sectors, the last major sectors without common EU-wide rules on GHG, into EU climate policy. One of the aspects is the mandatory accounting of grazing land management by the

member states, for which more grassland related data would be needed. This includes data on soil type (especially grassland on peat soil), changes in land use, and information of grassland management (e.g. grazing and grassland renovation).

2.5 Renewable Energy Directive

In 2009 the Renewable Energy Directive (2009/28/EC) on the promotion of the use of energy from renewable sources was adopted. The Directive sets ambitious targets for all Member States, such that the EU will reach a 20 % share of energy from renewable sources by 2020 and a 10 % share of renewable energy specifically in the transport sector. It also establishes a sustainability scheme for biofuels and bioliquids: in order to be accounted in the national binding targets biofuels and bioliquids have to meet specified sustainability criteria set in article 17 of the Directive. One of the criteria is that no raw material should be obtained from land with high biodiversity value, which includes highly biodiverse grassland.

Highly biodiverse grassland is defined as i) natural, namely grassland that would remain grassland in the absence of human intervention and which maintains the natural species composition and ecological characteristics and processes; or ii) non-natural, namely grassland that would cease to be grassland in the absence of human intervention and which is species-rich and not degraded, unless evidence is provided that the harvesting of the raw material is necessary to preserve its grassland status. This definition has been the source of debate among experts, policy makers and environmental NGOs with uncertainty over its coverage and how the definitions could be operationalised. The European Commission is tasked with establishing criteria and geographic ranges to determine which grassland shall be covered. Although the Renewable Energy Directive refers to the global level, also data on European grasslands is required to identify these areas of highly biodiverse grasslands.

2.6 Economy-wide material flow accounts

The European Strategy for Environmental Accounting (ESEA) identifies Economy-wide Material Flow Accounts (EW-MFA) as one core module of Environmental Accounts to be produced regularly and in a timely fashion in order to support policy making. EW-MFA has been included as one of three modules in Regulation (EU) No 691/2011 on European Environmental Economic Accounts which will enter into force with the 2013 data collection.

Economy-wide material flow accounts provide information in tonnes about the physical flows of materials through economies. The accounts provide an aggregate overview of the annual extraction of raw materials as well as of the physical amounts of imports and exports. These accounts include data on domestic extraction of biomass. Biomass comprises organic non-fossil material of biological origin. Biomass consists of primary crops (A. 1.1), of used crop residues, fodder crops and grazed biomass (A.1.2), wood (A.1.3) and of the biomass extracted through fish capture (A.1.4) and hunting and gathering (A.1.5). The category A.1.2.2. "Fodder crops and grazed biomass" includes different types of roughage including fodder crops, biomass harvested from grassland and biomass directly grazed by livestock. Biomass grazed by livestock is accounted for in material flow accounts. This type of biomass extraction is not reported in standard agricultural statistics.

2.7 Agri-environmental indicators

Member States have to report on the progress of the implementation of the agri-environmental policies on a regular basis (once in 4 to 6 years). For these reports detailed information is needed about the (changes) in resource use, emissions and production methods in agriculture. Agri-environmental

indicators (AEIs) are important in the assessment of trends over time of (i) the effects of agriculture on the environment, and (ii) the effectiveness and efficiency of agricultural and environmental policy measures such as CAP, Nitrates Directive, and climate policies.

The AEIs are increasingly seen as means to report on the agri-environmental interaction and on the implementation of agri-environmental policies. Eurostat coordinates the work within the European Commission on the 28 Agri-environmental indicators (AEIs) that were identified in the Commission (Communication COM(2006) 508) and subsequently approved by the Agricultural Council (Table 7).

In 2009 – 2011, the DireDate (Direct and indirect farm data needs for agro-environmental indicators) project was carried out for Eurostat [2]. The general objective of DireDate was "*to create a framework for setting up a sustainable system for collecting a set of data from farmers and other sources that will serve primarily European and national statisticians for creating the agreed 28 agri-environmental indicators and thus serve policy makers, but as well agricultural and environmental researchers, observers of climate change and other environmental issues linked to agriculture*". In the DireDate project recommendations were made for priority data collection for AEIs. In the DireDate project a prime focus was on AEIs related to nitrogen and phosphorus balances and greenhouse and ammonia emissions, as several EU policies demand these data. The AEIs related to manure and fertilizer have the most in common with policy data requirements.

In DireDate project it was concluded that accurate yields of grasslands are lacking, but are needed to obtain data for the nitrogen and phosphorus balances. It was recommended to develop a methodology to estimate the grassland yields in different countries/regions in EU-27, taking the different management types into consideration (rough grazing, extensively managed, and intensively managed). It was also recommended to develop a method to estimate the biological nitrogen fixation by clover. A harmonised approach is needed to define and classify grassland which can be used for different purposes, and to develop uniform methods to estimate yields and biological nitrogen fixation in the EU members states.

The Gross nutrient balance require data on the nutrient content of the grassland production (harvested and grazed) at NUTS2 level in tonnes of nitrogen and phosphorus, and data on grassland areas included and excluded from the reference area. According to the Eurostat/OECD Gross Nitrogen Balances Handbook, "ideally the balance result should be related to the area of agricultural land which is potentially fertilised, to avoid a bias in the result for countries with large extensive and not utilised areas". The reference area should thus refer to the potentially fertilised utilised agricultural area, where "potentially fertilised" means fertilised with mineral and organic fertilisers. Areas used for extensive grazing that are normally not actively fertilised with mineral or organic fertilisers could therefore be excluded, but any decision should be properly built under with reliable information and proper analyses on consequences.

The following criteria for exclusion from the reference area are currently proposed by Eurostat:

- No mineral or organic fertilisers are applied (organic farming and temporary fallow or unfertilised areas are excluded from this criteria);
- Very low livestock densities (higher livestock densities means that significant amounts of manure are dropped on the area);
- Low yields.

Examples of such areas are mountain summer grazing areas, semi-natural grasslands and other areas used for extensive grazing. Following these criteria, Eurostat proposed to exclude the following areas of the utilized agricultural area to be excluded from the reference area for gross nutrient

[2] http://epp.eurostat.ec.europa.eu/portal/page/portal/product_details/publication?p_product_code=KS-RA-11-005

balances i) kitchen gardens, ii) rough grazings, and iii) permanent grassland not used for production. There might also be other areas with similar features that should be taken into account, either in inclusion or exclusion from the reference areas. One possible solution would be to include only areas where agriculture is the primary usage. An analysis of whether the present definitions and classifications of grasslands meet the needs of following the nutrient flows is therefore needed.

There is a need for improved information on areas of temporary grasslands, permanent pastures, rough grazings, permanent grassland not used for production, and other kind of grassland, not presently properly available in statistics, such as the Spanish dehesas, wooded pasture, low intensity grassland (limestone grassland, grassland with rocks spread, pastures without grassland, grasslands mixed with heathers etc.

Table 7. The 28 Agri-environmental indicators (AEIs).

No	Indicator title (AEI)	No	Indicator title (AEI)
1	Agri-environmental commitments	14	Risk of land abandonment
2	Agricultural areas under Natura 2000	15	Gross nitrogen balance
3	Farmers' training levels	16	Risk of pollution by phosphorus
4	Area under organic farming	17	Pesticide risk
5	Mineral fertiliser consumption	18	Ammonia emissions
6	Consumption of pesticides	19	Greenhouse gas emissions
7	Irrigation	20	Water abstraction
8	Energy use	21	Soil erosion
9	Land use change	22	Genetic diversity
10.1	Cropping patterns	23	High nature value farmland
10.2	Livestock patterns	24	Production of renewable energy
11.1	Soil cover	25	Population trends of farmland birds
11.2	Tillage practices	26	Soil quality
11.3	Manure storage	27.1	Water quality - Nitrate pollution
12	Intensification/ extensification	27.2	Water quality - Pesticide pollution
13	Specialisation	28	Landscape - State and diversity

2.8 Summary

There is a need for data about grassland in several European policies, i.e. Nitrates Directive, Common Agricultural Policy, EU Climate policies, Biodiversity policies, and the Renewable Energy Directive (Table 8). The data considered are area and yield of grassland, biodiversity value, area of grazed grassland including non-herbaceous grasslands, management options (permanency, grazing, fertilization, tillage and cutting.

The Economy-wide Material Flow Accounts need data domestic extraction of biomass, including fodder crops and grazed biomass. Moreover, data about grassland area, yields and nutrient contents are needed to calculated the gross nutrient balance, which is one of the Agri-environmental indicators. If nutrient balances are used to identify hotspot in EU with high N pressure, the nutrient balance should relate to the area of agricultural land which is potentially fertilised to avoid a bias in the balance for countries with large extensive and not utilised areas. Thus, the reference area for the gross nutrient balance should thus refer to the potentially fertilised utilised agricultural area. Grassland with no or low inputs of mineral and organic N, low grazing density and low yields should not be included in the Gross Nutrient Balance calculation.

Table 8. Data needs on grassland for the respective EU policies (X: required; (x): useful).

Data needs	Nitrates Directive	Common Agricultural Policy	EU Climate policies	Biodiversity policies	Renewable Energy Directive
Grassland area	X	X	X		X
Grassland yield	X	(X)			
Biodiversity value		X		X	X
Permanency	(X)	X	X	X	(X)
Status of grazing		X		X	
Status of fertilization	X		X	X	
Status of tillage		X	X		
Status of cutting	(X)	(X)		(X)	
Amount of manure from grazing on non-grasslands	X				

3 Grassland classification and definition

This Chapter provides a summary of the main findings of a literature review of existing definitions and classifications of grasslands that are used in diverse domains, both statistical, administrative, scientific and other. The literature study is presented by Lesschen et al. (2014)[3].

3.1 Grasslands types

Grasslands are very diverse in terms of management, yield and biodiversity value. They range from semi-natural grasslands with low yields and high biodiversity values to fertilized mono-cultural grasslands. There is no general overview and typology of grasslands in Europe. A distinction can be made between production grassland, which have mainly a fodder production function, and semi-natural grasslands that provide a large range of ecosystem services including biodiversity.

For production grasslands the main differentiation is between permanent and temporary grassland and in their level of intensification. The difference in permanent grassland and temporary grassland is relevant for soil carbon storage and also for biodiversity aspects. The level of intensification, i.e. the inputs of manure and fertilizer, grazing pressure, mowing frequency and grassland renewal, determines the grassland productivity, but can also be seen as a proxy for its biodiversity value.

Semi-natural grasslands include self-seeded herbaceous and shrub vegetation that are used for livestock grazing and/or mowing. Semi-natural pastures and meadows are typified by extensive farming using traditional breeds of livestock, and have a relatively low productivity compared with intensively managed grasslands. Semi-natural pastures are of exceptional environmental value compared with cultivated grasslands. They are central to the concept of High Nature Value farming and are profoundly valuable for the large range of ecosystem services they provide. Common land is land owned collectively or by one person, but over which other people have certain traditional rights, such as to allow their livestock to graze upon it or to collect firewood. In some countries common land grazing is still very important. Dehesa (In Portugal montado) is a sparse wood pasture made up principally of holm and evergreen cork oak, grazed by livestock, and without scrub undergrowth.

3.2 Sources of grassland information

In this section, an overview of statistical, study based and remote sensing sources of grassland information is presented. Most of the statistical sources deal with land use, whereas the remote sensing based sources refer to land cover. Land use is a description of how people utilize the land and socio-economic activity. Land use is often recorded via questionnaires and statistics. The definitions and classification of grassland used in the different sources are presented in paragraph 3.3.

[3] Jan Peter Lesschen, Berien Elbersen, Gerard Hazeu, Anne van Doorn, Sander Mucher, and Gerard Velthof. Defining and classifying grasslands in Europe. Alterra.

3.2.1 Statistical sources

Farm Structural Survey (FSS)

The main EU wide statistical source of information on agricultural land use is the Farm Structural Survey (FSS)[4]. It provides EU wide harmonised data on agricultural holdings in the EU. The classification of permanent grassland in FSS is built up hierarchically (see paragraph 3.3.3). At the highest level there is one land use class 'Permanent grassland and meadow', which is sub-divided into three classes i) Pasture and meadow, excluding rough grazing, ii) Rough grazing, iii) Permanent grassland no longer used for production purposes and eligible for the payment of subsidies. In addition to the FSS there is also Survey on Agricultural Production Methods (SAPM) which was carried out for the first time in 2010 to collect data at farm level on agri-environmental measures such as tillage methods, soil conservation, landscape features, animal grazing, animal housing, manure application, manure storage and treatment facilities and irrigation.

Farm Accountancy Data Network (FADN)

The Farm Accountancy Data Network (FADN)[5] is an annual survey carried out by all EU Member States. FADN data are collected every year from a sample of the agricultural holdings in the European Union. The definitions used in FADN are identical to those used in FSS.

Eurostat Crop Statistics

Eurostat compiles a range of crop and land use statistics at both national and regional level[6].Member States provide the Commission annually with the data on 1) crops from arable land 2) vegetables, melons and strawberries, 3) permanent crops and 4) agricultural land use. Under Crops from arable land "Temporary grasses and grazing" is included. Under Agricultural land use "Permanent Grassland" is included, for which the area should be reported at regional level.

Land Parcel Identification System (LPIS)

The land parcel information system (LPIS)[7] is the spatial register within the Integrated Administration and Control System (IACS). The IACS ensures that payments of the EU Common Agricultural Policy (CAP) are made correctly. LPIS identifies and quantifies agriculture land for the purpose of targeting CAP payments. The CAP payments can only be targeted to agricultural land which is 'eligible' (see paragraph 3.3.2). LPIS distinguishes different types of permanent pasture in some member states:

- Permanent pasture (sown), defined as permanently cropped area with graminoid crop(s)
- Permanent pasture (selfseed), defined as closed medium to tall grassland
- Permanent pasture (selfseed with shrubs), defined as medium to tall grassland with medium high shrubs
- Permanent pasture (selfseed with sparse trees), defined as medium to tall grassland with low trees

LUCAS

LUCAS stands for Land Use and Cover Area frame Survey[8]. The aim of the LUCAS survey is to gather harmonised data on land use/cover and their changes over time. In addition, the survey provides territorial information facilitating the analysis of the interactions between agriculture, environment and countryside. LUCAS is an in-situ survey area frame survey, which means that the data is gathered through direct observations by the surveyors on the ground. The land cover and the visible land use are classified according to the harmonized LUCAS land cover and land use nomenclatures (see paragraph 3.3.6).

[4] http://epp.eurostat.ec.europa.eu/portal/page/portal/farm_structure_survey/introduction
[5] http://ec.europa.eu/agriculture/rica/index.cfm
[6] http://epp.eurostat.ec.europa.eu/portal/page/portal/agriculture/data/database
[7] http://ies.jrc.ec.europa.eu/our-activities/support-for-member-states/lpis-iacs.html
[8] http://www.lucas-europa.info/

Economy-wide material flow accounts (EW-MFA)

The Economy-wide material flow accounts are compiled by Eurostat[9]. EW-MFA include data on domestic extraction of biomass. Biomass comprises organic non-fossil material of biological origin and include "Fodder crops and grazed biomass". This category includes different types of roughage including fodder crops, biomass harvested from grassland and biomass directly grazed by livestock. Coverage of these large flows in statistics is usually poor. In case no reliable data for both fodder crops and grazed biomass exist, guidance is provide to estimate the total amount of biomass.

FAOSTAT

In FAOSTAT grassland categories are distinguished under the land statistics (part of the Resource statistics[10]). The main distinction is between temporal and permanent grassland and between irrigated and non-irrigated (See paragraph 3.3.4). For many countries these detailed classes are not available. In the crop production statistics of FAOSTAT no data is available for grass, neither for other forage crops.

UNFCCC

Annex 1 countries have to reported their greenhouse gas emissions annually to the UNFCCC for both the convention as for the Kyoto Protocol. In the Sector Land Use Land Use Change and Forestry (LULUCF[11]) emissions from land use, land use change and forestry are reported. Here countries also have to report the areas of the main land use categories, including grassland. The IPCC guidelines give a definition for grasslands, but many countries use their own definition, depending on their national circumstances and data availability (paragraph 3.3.5). The reports include data on area of grassland remaining grassland, land converted to grassland, and grassland converted to forest land, cropland, settlements, wetlands and other land are reported.

OECD

The data in the OECD Environmental data compendium are mainly derived from FAO, and have been supplemented by data from other international and national sources. OECD states that for permanent grassland the comparability of data among countries is unsatisfactory. Permanent grassland refer to land use for five years or more for herbaceous forage, either cultivated or growing wild.

3.2.2 Study based sources

Pasture Knowledge Base (PASK)

The Pasture Knowledge Base (PASK)[12] is developed for the MARS (Monitoring Agriculture with Remote Sensing) at DG-JRC EC. It contains a monograph on pasture systems in use in Europe, descriptions at national level and of the main varieties in use, mainly basing on a collection of existing information. The PASK study used the grassland categories as defined by EUROSTAT, as officially published in "Methods and nomenclature. Crop Production, Glossary 2001" and in the "Manual for current statistics on crop products".

FAO country pasture profiles

[9] http://epp.eurostat.ec.europa.eu/portal/page/portal/environmental_accounts/publications/economy_wide_material_flow_accounts

[10] http://faostat3.fao.org/faostat-gateway/go/to/home/E

[11] http://unfccc.int/methods/lulucf/items/3060.php

[12] http://www.marsop.info/marsopdoc/pask/00000000.HTM

Similar to the PASK database of JRC there is also a website by FAO[13] with country pasture profiles worldwide. This is an initiative of the Grassland and Pasture Crops Group to make basic information about the pasture and forage resources of countries available on the internet. Each profile provides a broad overview of relevant general, topographical, climatic and agro-ecological information with focus on livestock production systems and the pasture/forage resource. However, for the EU the coverage is not complete with information being available for only 12 member states (Belgium, Bulgaria, Czech Republic, Estonia, France, Hungary, Ireland, Latvia, Lithuania, Poland, Slovakia and United Kingdom). Most information is descriptive and often tables with some statistics for specific years are included. However, the level of detail and information varies per country and no standard definitions for grasslands are used.

Biodiversity data centre

The Biodiversity data centre (BDC)[14] managed by the European Environmental Agency (EEA) provides data and information on species and habitat types of European importance, red listed species in Europe, Natura 2000 sites and nationally designated areas in European countries. At the website of the BDC several data sources and maps can be found, including the Natura 2000 ecological network of protected areas. In addition databases are available on the Annex 1 habitat and EUNIS habitat types, which classify amongst other habitat types the natural and semi-natural grasslands.

High Nature Value farmland

JRC/EEA updated the High Nature Value (HNV) farmland indicator and in 2012 a further update of the indicator was produced by the ETC-SIA for the EEA[15]. This assessment is based as much as possible on existing European wide datasets (CLC 2006, Natura 2000 sites, Important Bird Areas (IBAs), Prime Butterfly Areas (PBAs)) , enriched with national data for some countries. The selection of the classes per database allocated to HNV farmland are specific per environmental zone. There are three HNV types distinguished: 1) farmland with a high proportion of semi-natural vegetation, 2). farmland with a mosaic of low intensity agriculture and natural and structural elements, such as field margins, hedgerows, stone walls, patches of woodland or scrub, small rivers etc., and 3). farmland supporting rare species or a high proportion of European or World populations.

3.2.3 Remote sensing based sources

GlobCover

The GlobCover Land Cover Map was created by the ESA's GlobCover . The map displays land classification information for most of the Earth's surface at a resolution of 300 meter (9 ha per pixel) and contains 22 different land cover types. The data was collected from the MERIS sensor on the ENVISAT satellite during 2009. There is also an older map, the Global Land Cover Product from the period 2005-2006. The global Globcover legend is compatible with the GLC2000 global land cover and the Land Cover Classification System (LCCS) developed by FAO.

Grassland is mapped in the following mosaic/composite land cover classes:

- 20 Mosaic cropland (50-70%) /vegetation (grassland/shrubland/forest) (20-50%)
- 30 Mosaic vegetation (grassland/shrubland/forest) (50-70%) / cropland (20-50%)
- 110 Mosaic forest or shrubland (50-70%) and grassland (20-50%)
- 120 Mosaic grassland (50-70%) and forest or shrubland (20-50%)
- 140 Closed to open (>15%) grassland

[13] http://www.fao.org/ag/AGP/AGPC/doc/pasture/forage.htm
[14] http://biodiversity.europa.eu/data
[15] The detailed description of the methodology and the data sources will be published by EEA in 2012: 'Updated High Nature Value Farmland in Europe - An estimate of the distribution patterns on the basis of CORINE Land Cover 2006 and biodiversity data'.

GLC2000

The global land cover data for the year 2000 (GLC2000) project[16] coordinated by JRC, provides consistent global land cover information for the year 2000. The GLC2000 database has 22 classes, including herbaceous Cover, closed open and regularly flooded shrub and/or herbaceous Cover.

CORINE land cover

The CORINE (CO-oRdination of INformation on the Environment) programme was initiated by the EU in 1985[17]. Up to now three maps have been produced (1990, 2000 and 2006) and the fourth (2012) is under development. The final CLC database consists of a geographical database describing land cover/use in 44 classes grouped into a three level hierarchical structure. The CORINE land cover nomenclature has 5 major categories at the first level, 15 land cover categories at the second level and 44 categories at the third level. In Annex 1 of the Lesschen et al. (2013) examples for the different pasture types are provided.

GIO HR grassland

GIO HR stands for GMES (Global Monitoring for Environment and Security) Initial Operations High Resolution[18]. A high resolution data set of permanent grassland will be produced. The analysis will use the three reference years (2006, 2009, 2012) to detect the permanent presence of grassland. Grassland is defined as ground covered by vegetation dominated by grasses and other herbaceous plants with dominantly agriculture use. Grassland includes the following landscape types:

- Pastures, grassland used for grazing or hay production
- Cultivated or semi-natural grassland within forests, and grass covered surfaces with-in transitional woodland
- Natural grassland in any surrounding
- Grassy areas with low (10%) fraction of scattered trees and shrubs.
- Alpine meadows with low fraction of bare rock or gravel.

Land covers not to be considered as grassland are:

- Grassland in urban areas: parks, urban green in residential and industrial areas.
- Grass surfaces in sport and recreation areas, incl. golf courses.
- Clearcut areas, new forests.
- Areas of shrubs: areas dominated by moors and heathland (Atlantic) or sclerophyllous vegetation (Mediterranean).
- Surfaces covered exclusively by mosses and lichen (*Subarctic).*
- Peatland

Geoland2 HR Grassland

Within the GMES initiative (Global Monitoring for Environment and Security) the Land Services provide cross-border harmonised geo-information at global to local scales in a time- and cost-effective manner. Geoland2 aims to organise a qualified production network to build, validate and demonstrate operational processing lines and to set-up a user driven product quality assurance process. One of the core mapping services is EUROLAND which provides land cover, land use and land cover change data. The Geoland2 HR grassland layer has so far only been produced for three case study areas in Germany, Austria and Greece[19]. The developed overall concept will serve the following layers i) a grass surface indicator (primary probability layer), ii) a grass surface mask (secondary layer), and iii) an arable land mask (annual crops). The following intensity layers (secondary layers) are specified: shrub and trees indicator, grass density indicator, and cutting indicator.

[16] http://bioval.jrc.ec.europa.eu/products/glc2000/glc2000.php
[17] http://www.eea.europa.eu/publications/COR0-landcover
[18] http://www.eea.europa.eu/themes/landuse/gio-land
[19] http://www.geoland2.eu/portal/service/ListService.do?serviceCategoryId=CA80C481

3.2.4 Analysis of possible sources of grassland data

Table 9 provides an overview of an assessment of the grassland data sources for several criteria which determine the usefulness for data collection on grasslands to create a coherent European dataset that serves European policy needs. White indicates that the data source has a high potential when evaluated against the criterion, grey a moderate potential and black a low potential.

This assessment shows that there is no data source that scores well on all criteria. In general the remote sensing based sources have a low score on criteria as clear and harmonized definitions, the temporal coverage and resolution and the lack of data on grassland productivity.+

The statistical sources perform lower on the spatial resolution and most also lack data on grassland productivity. FSS and FADN statistics score both well, only FSS is lacking the grassland productivity data and has not an annual frequency.

LPIS data only score bad at the clear harmonized definitions and on the public availability aspect. However, both could be improved with Eurostat support, which would make this a very valuable data source.

When detailed grassland locations are needed the Corine Land Cover map and related products are most useful, while LUCAS is more valuable for general and regional trends in grassland areas and use, as this is the grassland data source that is most harmonized among EU member states.

Table 9. Assessment of grassland data sources (white is good, grey medium and black bad performance on criteria).

Name of data source	Clear harmonized definitions	Spatial coverage	Spatial resolution	Temporal coverage	Temporal resolution	Grassland productivity data	Availability
FSS							
FADN							
Eurostat crop statistics							
LPIS							
LUCAS							
EW-MFA							
FAOSTAT							
UNFCCC							
OECD							
PASK study							
GlobCover							
GLC2000							
Corine Land Cover							
GIO HR grassland							
Geoland2 HR Grassland							

Table 10 shows an overview of sources of grassland data in relation to the needs for data in policies. This assessment does not consider the temporal and spatial dimension and resolution, see previous tables, at which the data is available. It is clear that almost all data sources have information on grassland areas, but for the other data needs the potential data sources are limited or not available at all. Many of the data sources also provide only the indirect information from which a specific data need can be derived.

For example, grassland yields are often only indirect available (e.g. FADN provides it in financial terms) or from scattered or descriptive sources (e.g. Eurostat crop statistics and the PASK study).

Table 10. Overview of grassland data sources in relation to data needs from a policy perspective

Data needs	FSS	FADN	Eurostat crop	LPIS	LUCAS	EW-MFA	FAOSTAT	UNFCCC	OECD	PASK study	GlobCover	GLC2000	Corine Land	GIO HR	Geoland2 HR
Grassland area	x	x	x	x	x		x	x	x	(x)	x	x	x	x	(x)
Grassland yield		(x)	(x)	(x)		(x)			x	(x)					
Biodiversity value					(x)					(x)			(x)		
Permanency	(x)	(x)	(x)	x	(x)		(x)	(x)					(x)	x	(x)
Status of grazing	(x)	(x)			(x)										x
Status of fertilization		(x)													
Status of tillage	(x)				(x)										
Status of cutting		(x)													x
Area non-grasslands which are grazed	(x)				(x)										
Amount of manure from grazing on non-grasslands															

3.3 Overview different definitions and classifications

3.3.1 International terminology for grazing lands and grazing animals

Allen et al. (2011) published the most relevant terms related to grassland. It is intended that these terms enhance communication in education, science, industry and production and that they become the standard for use in publications. A selection of definitions of Allen et al. (2011) is presented below.

- **Grazing land**. Any vegetated land that is grazed or has the potential to be grazed by animals (domestic and wild). This term is all-inclusive and covers all kinds and types of land that can be grazed.
- **Pastureland.** Land (and the vegetation growing on it) devoted to the production of introduced or indigenous forage for harvest by grazing, cutting, or both. Usually managed to arrest successional processes
- **Grassland.** The term 'grassland' is synonymous with pastureland when referring to an imposed grazing-land ecosystem. The vegetation of grassland in this context is broadly interpreted to include grasses, legumes and other forbs, and at times woody species may be present.
- **Annual pastureland / grassland.** Forage is established annually, usually with annual plants, and generally involves soil disturbance, removal of existing vegetation, and other cultivation practices.
- **Cultivated pastureland / grassland.** Forage is established with domesticated introduced or indigenous species that may receive periodic cultural treatment such as renovation, fertilization or weed control.
- **Permanent pastureland / grassland.** Land on which vegetation is composed of perennial or self-seeding annual forage species which may persist indefinitely. It may include either naturalized or cultivated forages.

- **Temporary pastureland / grassland.** Land on which vegetation is composed of annual, biennial, or perennial forage species kept for a short period of time (usually only a few years). Note: Temporary pastureland / grassland can be regularly resown or can be integrated in a crop rotation (ley). It is usually composed of simple mixtures of grasses, grass / legume or legume species.
- **Ley.** Temporary pastureland / grassland that is integrated in a crop rotation.
- **Naturalized pastureland / grassland.** Forage species present are primarily introduced from other geographical regions that have become established and have persisted under the existing conditions of environment and management over a long time.
- **Semi-natural pastureland / grassland.** Managed ecosystem dominated by indigenous or naturally occurring grasses and other herbaceous species (cf. Native grassland).
- **Meadow.** A natural or semi-natural grassland often associated with the conservation of hay or silage. Note: A meadow may exist as a result of discontinuous features of hydrology, landscape position, or soil characteristics that differ from the surrounding landscape and vegetation. Descriptive terms include 'mountain meadow,' 'alpine meadow,' 'wet meadow,' and 'hay meadow.' 'Flower meadows' are kept for aesthetic interest and can also provide feeding or bedding.
- **Rangeland.** Land on which the indigenous vegetation (climax or sub-climax) is predominantly grasses, grass-like plants, forbs or shrubs that are grazed or have the potential to be grazed, and which is used as a natural ecosystem for the production of grazing livestock and wildlife. Note: Rangelands may include natural grasslands, savannas, shrublands, many deserts, steppes, tundras, alpine communities and marshes.
- **Native or natural grassland.** Natural ecosystem dominated by indigenous or naturally occurring grasses and other herbaceous species used mainly for grazing by livestock and wildlife. Note: There are many types of natural grasslands, with vegetation characteristics determined by climate and soil conditions, by grazing animals and by fire. Examples of local / regional variations follow. Geographical regions where examples may be found are provided in parentheses following the definition. This is not an all-inclusive list of grassland types or of locations in which they are found but provides some examples.
- **Marshland.** Flat, wet, treeless wetland usually covered by shallow water and dominated by marsh grasses, rushes, sedges, other grass-like plants and forbs.
- **Shrubland.** Land on which the vegetation is dominated by low-growing woody plants.
- **Tundra.** Land areas in arctic and alpine regions devoid of large trees, varying from bare ground to various types of vegetation consisting of grasses, sedges, forbs, dwarf shrubs and trees, mosses and lichens.

3.3.2 Common Agricultural Policy

The EU needed a clear and simple definition of permanent grassland in the framework of their subsidization policy. In 2004 the EU defined permanent grassland as: land used to grow grasses or other herbaceous forage naturally (self-seeded) or through cultivation (sown) and that is not included in the crop rotation of the holding for five years or longer. The definition of permanent pasture has been very much debated during the process of the CAP-reform. The definition for permanent grassland is not officially published in October 2013, but the following definition is currently proposed:

"Permanent grassland and permanent pasture means land used to grow grasses or other herbaceous forage naturally (self-seeded) or through cultivation (sown) and that has not been included in the crop rotation of the holding for five years or more; it may include other species such as shrubs and/or trees which can be grazed provided that the grasses and other herbaceous forage remain predominant; as well as, subject to a decision by Member States to include land which can be grazed and which forms part of established local practices where grasses and other herbaceous forage are traditionally not predominant in grazing areas".

3.3.3 Farm Structure Survey

The classification of permanent grassland in FSS is build up hierarchically. At the highest level there is one land use class F defined as:

F. **PERMANENT GRASSLANDS** (2.03) which is described as:

I. Land used permanently (for five years or more) to grow herbaceous forage crops, through cultivation (sown) or naturally (self-seeded) and that is not included in the crop rotation on the holding.

II. The land can be used for grazing or mowed for silage or hay.

This main Permanent grassland and meadow class is further sub-divided into 3 classes:

- F/1 **Pasture and meadow, excluding rough grazings** (2.03.01)
  I. Permanent pasture on good or medium quality soils. These areas can normally be used for intensive grazing.
  II. The following are excluded:
  — rough grazing, whether used intermittently or permanently (F/2),
  — pasture and meadow not in use (H/1).
- F/2 **Rough grazings** (2.03.02)
  I. Low yielding permanent pasture, usually on low quality soil, for example on hilly land and in high altitudes, usually unimproved by fertiliser, cultivation, reseeding or drainage. These areas can normally be used only for extensive grazing and cannot support a large density of animals and are normally not mowed.
  II. This can include stony ground, heath, moorland and 'deer forests' in Scotland.
  Rough grazing not in use is excluded (H/1)
- F/3 **Permanent grassland no longer used for production purposes and eligible for the payment of subsidies** (2.03.03)
  Areas of permanent grassland and meadows no longer used for production purposes, which, in line with Regulation (EC) No 1782/2003 (or, where applicable, the most recent legislation), are maintained in good agricultural and environmental condition and are eligible for the single payment.

In addition there are also land uses in the forage plant category which are relevant to provide a definition for and which include the temporary grassland category:

D/18 **Plants harvested green** (2.01.09):

I. All 'green' arable crops intended for animal feed, grown in rotation with other crops and occupying the same land for less than five years (annual or multiannual feed crops).

II. These 'green' (as opposite to those 'for dry grain') crops are normally used for allowing animals to graze or are harvested green, but can be also harvested dried, like dry hay. Generally the whole plant, except the roots, is harvested and used for fodder. Crops not used on the holdings but sold, either for direct use on other holdings or to industry, are included. Cereals, industrial plants and other arable land crops harvested and/or consumed green for fodder are included. Fodder roots and brassicas (D/12) are excluded.

D/18a **Temporary grass** (2.01.09.01)**:**

I. Grass plants for grazing, hay or silage included as a part of a normal crop rotation, lasting at least one crop year and less than five years, sown with grass or grass mixtures. The areas are broken up by ploughing or other tilling or the plants are destroyed by other means such as by herbicides before they are sown again.

II. Mixtures of predominantly grass plants and other forage crops (usually leguminous), grazed, harvested green or as dried hay are included here. Annual grass crops (lasting less than one crop year) are not included here.

3.3.4 FAOSTAT

In FAOSTAT under the land statistics (part of the Resource statistics), grassland categories are distinguished. The main distinction is between temporal and permanent grassland and also irrigated versus non-irrigated is distinguished. The following definitions are used

- Permanent meadows and pastures is the land used permanently (five years or more) to grow herbaceous forage crops, either cultivated or growing wild (wild prairie or grazing land).
- Permanent meadows and pastures - Naturally grown is the land not being controlled under permanent meadows and pastures such as wild prairie or grazing land.
- Permanent meadows and pastures - Cultivated and irrigated, area of the "Cultivated Permanent meadows and pastures" which is actually irrigated in a given year.
- Permanent meadows and pastures - Cultivated and non- irrigated, area of the "Cultivated Permanent meadows and pastures" which development relies on rainfed irrigation in a given year.
- Permanent meadows and pastures is the land used permanently (five years or more) to grow herbaceous forage crops, either cultivated or growing wild (wild prairie or grazing land).
- Part of the area of the "Permanent meadows and pastures" exclusively dedicated to organic agriculture and managed by applying organic agriculture methods. It is the portion of land area managed (cultivated) or wild harvested in accordance with specific organic standards or technical regulations and that has been inspected and approved by a certification body.
- Part of the area of the "Permanent meadows and pastures" which is going through the organic conversion process, usually two years period of conversion to organic land.
- Sum of areas under "Permanent meadows and pastures area certified organic" and "Permanent meadows and pastures area in conversion to organic".
- Temporary meadows and pastures irrigated, area of the "Temporary meadows and pastures" which is actually irrigated in a given year.
- Temporary meadows and pastures non- irrigated, area of the "Temporary meadows and pastures" which development relies on rainfed irrigation in a given year.
- Temporary meadows and pastures is the land temporarily cultivated with herbaceous forage crops for mowing or pasture. A period of less than five years is used to differentiate between temporary and permanent meadows.

3.3.5 UNFCCC

According to the IPCC Good Practice Guidance for LULUCF (2003) the definition of grassland is: *"Grassland includes rangelands and pasture land that is not considered as cropland. It also includes systems with vegetation that fall below the threshold used in the forest land category and are not expected to exceed, without human intervention, the threshold used in the forest land category. The category also includes all grassland from wild lands to recreational areas as well as agricultural and silvi-pastural systems, subdivided into managed and unmanaged consistent with national definitions".*

A very similar definition is used in the IPCC 2006 guidelines: *"Grassland includes rangelands and pasture land that are not considered Cropland. It also includes systems with woody vegetation and other non-grass vegetation such as herbs and brushes that fall below the threshold values used in the Forest Land category. The category also includes all grassland from wild lands to recreational areas as well as agricultural and silvi-pastural systems, consistent with national definitions".*

However, countries are allowed to use their own definition for the different land use categories to account for the local circumstances or to fit to available land use data sources.

3.3.6 LUCAS

The relevant classes for grassland of the LUCAS nomenclature are in stated below. The full nomenclature can be found on the Eurostat website[20].

Grassland (E00)
Land predominantly covered by communities of grassland, grass like plants and shrubs. The density of tree-crown is less than 10% and the density of tree+shrub-crown is less than 20%. The following three subclasses are discerned: E10 Grassland with sparse trees, E20 Grassland without trees, E30 Spontaneous vegetation.

E10 Grassland with sparse trees: Land predominantly covered by communities of grassland, grass-like plants and forbs including sparsely occurring trees (the density of the tree crown is between 5 and 10% and the total density of the tree+shrub crown is between 5 and 20% of the area). Fruit trees in small groups or along an avenue on grassland are classified here as well.

E20 Grassland without trees: Land predominantly covered by communities of grassland, grass like plants and forbs without trees and shrubland (density of tree+shrub crown is less than 5%).

E30 Spontaneous vegetation: Mostly agricultural land which has not been cultivated this year or the years before. It has not been prepared for sowing any crop this year. This class can also be found on unused land, storage land etc. This class includes set aside land within agricultural areas and unused artificial land.

B55 Temporary grassland: Land occupied by temporary and artificial pastures, occupying the ground for at least one crop year and less than five years, the seeds being either pure or mixed grass, on cropland areas. This can also be the case on fallow fields, when i.e. after some years graminaceous plants settle over spontaneously. If the soil is ploughed and /if the grass is sown the same year, the grassland is very likely a temporary one and not a permanent one. This class includes temporary pastures (Italian ryegrass, other ryegrasses, cock's foot, fescues, timothy) on agricultural areas/cropland. This class excludes permanent grassland (E), mix of legumes with gramineous plants for fodder (B53), and mix of cereals for fodder (B54).

3.3.7 CORINE Land Cover (CLC) classification

The final CLC database consists of a geographical database describing land cover/use in 44 classes grouped into a three level hierarchical structure. The CORINE land cover nomenclature has 5 major categories at the first level, 15 land cover categories at the second level and 44 categories at the third level. The CORINE Land Cover nomenclature includes the grassland categories 2.3.1 Pastures and 3.21. Natural grassland.

The level 3 category Pastures (category 2.3.1) belongs to level 2 category Pasture (2.3) and level 1 category Agricultural areas. The level 3 category Natural grassland (3.2.1) belongs to level 2 category Scrub and/or herbaceous associations (3.2) and level 1 category 3 Forest and semi-natural areas.

Pastures are defined as lands, which are permanently used (at least 5 years) for fodder production. Pastures include natural or sown herbaceous species, unimproved or lightly improved meadows and grazed or mechanically harvested meadows. Convential agriculture impact influences the natural development of natural herbaceous species composition. Pastures are extensively used grasslands with presence of farm structure such as: fences, shelters, enclosures, watering places, drinking trough, or regular agricultural works: mowing, drainage, hay making, agricultural practices, and manuring.

Natural grasslands are low productivity grasslands, often situated in areas of rough, uneven ground. Natural grasslands frequently includes rocky areas, briars and heathland. Natural grasslands are areas

[20] http://epp.eurostat.ec.europa.eu/portal/page/portal/lucas/documents/Nomenclature_LUCAS2009_C_3.pdf

with herbaceous vegetation (maximum height is 150 cm and gramineous species are prevailing) which cover at least 50 % of the surface covered by vegetation which developed under a minimum human interference (not mowed, fertilized or stimulated by chemicals which might influence production of biomass); here belong for instance grass formations of protected areas, karstic areas, military training fields, etc. (even though the human interference cannot be altogether discarded in quoted areas, it does not suppress the natural development or species composition of the meadows), areas of shrub formations of scattered trees.

In Annex 1 of Lesschen et al. (2013) more detailed information is presented of grassland definition in the CORINE Land Cover (CLC) classification.

3.3.8 FAO-Land Cover Classification System

The Land Cover Classification System (LCCS) is a comprehensive, standardized a priori classification system. The classification has two main phases i) an initial Dichotomous Phase, where eight major land cover types are distinguished, and ii) a subsequent Modular-Hierarchical Phase, where the set of classifiers and their hierarchical arrangement are tailored to the major land cover type. Further definition of the Land Cover Class can be achieved by adding environmental attributes (e.g. climate, landform, altitude, soil, lithology and erosion) and specific Technical Attributes are associated with specific technical disciplines (e.g. floristic aspects, crop type or soil type).
Grasslands occur under "Cultivated and managed Terrestrial Areas" and "Natural and Semi-Natural Terrestrial vegetation". In the second modular-hierarchical phase a set of classifiers are tailored to the major land cover types. Classifiers describing grassland are Life forms (Herbaceous – Forbs or Graminoids), Cover and Height. Relevant definitions with regards to grasslands in the classification system are:

- **Herbaceous**: Plants without persistent stem or shoots above ground and lacking definite firm structure are defined as herbaceous. There are two categories, depending on the physiognomy, namely Graminoids and Forbs.
- **Graminoids**: Includes all herbaceous grasses and other narrow-leaved grass-like plants that are not grasses according to the taxonomic definition. Guidelines: Graminoid vegetation is defined by the presence of more than 75% of Graminoids in the herbaceous coverage. There is no upper limit of height: the only condition is the physiognomy of the plant.
- **Cover**: The cover can be considered as the proportion of a particular area of the ground, substrate or water surface covered by a layer of plants, considered at the greatest horizontal perimeter level of each plant in the layer. A distinction is made between closed (more than 60–70%), open (70–60% to 20–10%), closed to open (between 100 and 15%) and sparse (20–10% to 1%). As herbaceous plants are seasonal in character, it has to be noted that the cover of herbaceous vegetation is always considered at the time of its fullest development.
- **Height**: The height of a certain layer is measured from the ground to the average top of the life form being assessed. Height sub-divisions are: >30 down to 3 m for Trees; 5 m to 0.3 m for Shrubs; and 3 m to 0.03 m for Herbaceous. Each class is further sub-divided.

3.3.9 EAGLE

The EAGLE group (EIONET Action Group on Land monitoring in Europe) was set up as a working group with members of EIONET NRCs on land cover. The objective of the working group is to elaborate a future-oriented conceptual solution that will allow the "feeding" of a European land monitoring database from existing national sources, and to integrate the upcoming approach of object oriented data modelling in the field of land monitoring. Although the work of the EAGLE group is still on-going, an example of the classification for grasslands is provided below:

- **Herbaceous Plants** (Grasses and Forbs). Annual, biennial or perennial plants that do not have a persistent woody stem above the ground (in botanical term: herb). In contrary to woody plants, which have stems above ground that remain alive during the dormant season and grow shoots the next year from the above-ground parts, shoots of herbaceous plant die down at the end of growing

season, so they regenerate themselves from tissues left above or under the ground (e.g. bulbs, rhizomes, tubers, seeds).

- **Graminaceous** (grass-like). Grasses, or more technically graminoids, are monocotyledonous, usually herbaceous plants with narrow leaves growing from the base. They include the "true grasses", of the Poaceae (or Gramineae) family, as well as the sedges (Cyperaceae) and the rushes (Juncaceae). The true grasses include cereals, bamboo and the grasses of lawns (turf) and grassland. Sedges include many wild marsh and grassland plants, and some cultivated ones. Belonging here regardless of being wild-growing - forming natural grasslands or being component of other biomes (e.g. wetlands, forest, tundra) or cultivated – forming cropland (arable, meadow, pasture) or grass surfaces/lawn for sports/recreation.
- **Regular Graminaceous** (grasses, cereals). Annual or perennial graminaceous plants, naturally growing or cultivated, with potential height not exceeding 2 meter. This includes most grass species and cereals (e.g. wheat, barley, maize, rice), except reeds and bamboo.

3.3.10 DG Environment project Ecologically Valuable Grasslands

In a related project for DG Environment (Contract No. 07-0307/2012/633993/ETU/B1), a consortium led by Alterra, defined ecologically valuable grasslands. This study proposes several relevant definitions for grasslands.

Grassland is defined as all land which is in agricultural use and is not permanent crops or arable and thus:

1) Excludes grasslands in which there is no evidence of human intervention (e.g. through grazing, mowing) and cannot therefore be categorized as agricultural land.
2) Includes all uncultivated land with vegetation that is grazed and/or cut for fodder, including herbaceous and non-herbaceous species.

Ecologically Valuable Grassland (EVG) are a category of grasslands (including those with non-herbaceous species) that are notable, within the overall context of agricultural grasslands, for their ecological value. EVG have a spectrum of values depending on management but focus on biodiversity value and there is often a strong relation between high biodiversity value and other services. The EVG are semi-natural and natural grasslands that are not agriculturally-improved (e.g. through cultivation, reseeding, fertilisation, irrigation and drainage) of long standing and species–rich (taking account of all taxa not only higher plants).

3.3.11 Habitat classifications

There are several European habitat classifications, including Annex I habitats of the EU Habitats Directive, the EUNIS habitat classification and the phytosociological alliances as well as the nomenclatures of the following databases: CORINE Biotopes, CORINE land cover and the PNV map.

Habitats Directive

The European Commission has published an Interpretation Manual of EU habitats in 1999 for the delineation of Natura 2000 sites (European Commission, 2007). Annex I lists today 231 European natural habitat types, including 71 priority. Annex I is based on the hierarchical classification of European habitats developed by the CORINE Biotopes project 2 since that was the only existing classification at European level. For both natural and semi-natural grassland formations habitat types have been distinguished (see Lesschen et al., 2013).

EUNIS Habitat classification

The EUNIS habitat classification is based on general vegetation science with additions of abiotic features. The EUNIS habitat classification gives a more comprehensive overview of European habitats (more than 2600 terrestrial classes have been identified already) than the 231 Annex I habitats of the Habitats Directive and has a more scientific approach. For the purposes of EUNIS, a 'habitat' is defined as: 'a place where plants or animals normally live, characterized primarily by its physical features (topography, plant or animal physiognomy, soil characteristics, climate, water quality etc.) and secondarily by the

species of plants and animals that live there'. On the first level the EUNIS habitat classification has ten major habitats. On the second level there are 54 habitats, on the third level there are 162 habitats and on the lowest level there are already more than 2400 habitats for the terrestrial environment.

The first level habitat categories include **E Grassland and tall forb habitats**. This is defined as: Non-coastal land which is dry or only seasonally wet (with the water table at or above ground level for less than half of the year) with greater than 30% vegetation cover. The vegetation is dominated by grasses and other non-woody plants, including mosses, macrolichens, ferns, sedges and herbs. Includes semiarid steppes with scattered [Artemisia] scrub. Includes successional weedy vegetation and managed grasslands such as recreation fields and lawns. Excludes regularly tilled habitats (I1) dominated by cultivated herbaceous vegetation such as arable fields. At the second level, the following categories are distinguished 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, and E7 Sparsely wooded grasslands.

Phytosociological plant communities in Europe

Phytosociology is the science which attempts to describe the diversity of plant communities. On the first level there are 15 formations on the second level there are 80 classes, on the third level there are 233 orders and on the fourth level there are 928 alliances. However, most alliances have several EUNIS classes (and vice versa) indicating that the links are not straightforward in many cases. A link needs to be established also with Annex I habitat types. In Annex 2 of Lesschen et al. (2013) the phytosociological alliances for grasslands are presented.

3.4 Assessment of grassland definitions and classifications

3.4.1 Existing grassland definitions and classifications

In the section the existing grassland definitions and classifications are discussed. The work of the EAGLE working group is still on-going and no final definition or classification has yet been established. Therefore these three sources of grassland definitions and classifications have not been included in the assessment. Also the EUNIS Habitat classification and the phytosociological plant communities in Europe are not further discussed here, since the focus of this project is mainly on grassland for agricultural uses and their production potential, while the very detailed habitat classifications have a very strong focus on biodiversity aspects.

International terminology for grazing lands and grazing animals

The benefit of the international terminology for grazing lands and grazing animals is that it is accepted by the global grassland research community. However, in several cases the definitions are not sufficiently elaborated to be used directly for policy purposes. For example in the definition of permanent and temporary grassland no time horizon is included in the definition for a clear distinction between these two categories. Furthermore, there is no data source behind these definitions, which would only make them useful for new grassland data inventories.

Common Agricultural Policy

The current definition of permanent grassland under the CAP is more clear compared to the one from the international terminology, since the temporal dimension is specified. However, the definition still leaves space for discussion, which is also shown by different interpretations of the definition by the EU member states. The definition for the post 2013 CAP is still under discussion, and is probably broader compared to the current definition.

Farm Structure Survey

The grassland definitions from the farm structure survey are useful for agricultural purposes. It has a clear distinction between permanent and temporary grassland and also the rough grazing grasslands are distinguished. However, it does not address the biodiversity aspects of grassland, and also the intensity of grassland use is not very well expressed in these definitions. However, the benefit of this classification is that it is widely used in the data collection on grasslands for Eurostat (e.g. FSS, FADN and partly for the crop statistics).

FAOSTAT

The FAOSTAT classification for grasslands is rather extensive and distinguishes between permanent and temporary grassland. It also provides information regarding the intensity of use, i.e. whether it is cultivated or naturally grown and whether it is irrigated or under organic agriculture. However, the availability of data for the sub-categories is very limited in FAOSTAT.

UNFCCC

The general definition of grassland as stated in the IPCC good practice guidance for LULUCF (2003) is very broad and is a kind of remaining category, in which other land uses that are not cropland, forestland, wetland or settlement. In addition, many countries use their own definition of grassland for UNFCCC reporting. This definition is too broad and not consistent among member states for most EU policy purposes.

LUCAS

The LUCAS land use classification is well elaborated and includes a good split between temporary and permanent grassland. However, the subclasses of grassland (Grassland with sparse trees, Grassland without trees, and Spontaneous vegetation) are linked to land cover than land use and do not provide further detail about management, which is relevant for EU policies. The tree/shrub canopy thresholds have the effect that large areas of actively grazed wood pasture (such as Iberian dehesas/montados) and wooded meadows (e.g. in Estonia) are not counted as grasslands. The benefit of the LUCAS land use data is that these are collected in a harmonized way throughout the EU and it is actually observed data in the field.

CLC classification

The CLC classification has been developed for land cover data. The classification is well elaborated and frequently used in remote sensing studies. However, the classification does not provide much information about the grassland management. Pastures refer to permanent grassland (> 5 years not in rotation), but the temporary grasslands are not included as separate category. On the other hand natural grasslands are better distinguished compared to many agricultural related classifications.

FAO-LCCS

The Land Cover Classification System (LCCS) is mainly aimed at land cover related classifications, which means that land management is not included as criteria in the classification. Grasslands can be described in terms of life form, cover and height, which can be relevant for biodiversity purposes, but not directly for agricultural and environmental policies. The classification is often used in a global context, due to the involvement of FAO, but it is not frequently used in Europe.

Habitats Directive

The habitat classification of the Habitats Directive provides a good classification for the natural and semi-natural grasslands in Europe. It distinguishes about 30 grassland habitats, which are reasonably well described. However, it is only focussed on the semi-natural and natural grasslands and does not include the more intensively used agricultural grasslands.

3.4.2 Assessment of grassland definitions and classifications

In Table 11 an assessment is presented of the usefulness of the current grassland definitions and classifications for the different policy needs of the Nitrates Directive, EU Climate policies, Common Agricultural Policy, Habitat Directive and the Renewable Energy Directive. The table shows that there is indeed the need for better data on the issue of defining, classifying, collecting and disseminating data on European grassland areas, use and production. For the Nitrates Directive none of the current grassland classifications and definitions really fits the policy needs, as there is no clear distinction in the intensity and management level of the grasslands. The same holds for the climate policies, for which also data on grassland management would be needed. For the CAP the definition of permanent grassland and the FSS statistics are currently sufficient, but with the renewal of the CAP probably new data needs on grassland will be added (e.g. grasslands within Natura 2000 areas). For biodiversity policies the corresponding classification is useful, however, the mapping of the habitats at EU level still requires harmonisation, and there is not yet an overall EU map with all habitats according to this classification. Finally for the Renewable Energy Directive a definition and corresponding mapping of highly biodiverse grassland is needed, but none of the current definitions would fit, or all grassland classified under the habitat Directive should be included. A specific issue is how to determine the boundary between grasslands and forests: many data bases explicitly include all grazing land as grassland, but some data bases apply thresholds on tree/shrub canopy that have the effect of excluding significant grazing lands and putting these into forest categories.

Table 11. Assessment of usefulness of current grassland classifications and definitions for different EU policies (white is high, grey medium and black low potential for use policy data needs).

Classification / definition	Nitrates Directive	Common Agricultural Policy	EU Climate policies	Biodiversity policies	Renewable Energy Directive
International terminology for grazing lands and grazing animals					
Common Agricultural Policy					
Farm Structure Survey					
FAOSTAT					
UNFCCC					
LUCAS					
CLC classification					
FAO-LCCS					
Habitats Directive					

It is concluded that few sources have clear and harmonized grassland definitions. The statistical sources of FADN, FSS and FAOSTAT do have clear definitions for different grassland types, although it remain unclear whether member states provide all information according to these definitions. Although remote sensing sources have clear classification schemes, the usefulness is limited as the classification is focussed on land cover and not on land use (e.g. no distinction between permanent and temporary grassland). The spatial coverage for most grassland sources is sufficient and cover the EU-27.
Spatial resolution differs largely, many statistical sources only provide data at national level, whereas the remote sensing sources can provide data at 100 meter grid cell resolution. Most statistical sources have already established a long time series and provide data at annual time steps. The remote sensing sources are often products produced for a certain year, although for the Corine Land Cover maps several time steps are available and updates are on-going. The current remote sensing sources for data on grassland areas, do not provide data on productivity, other remote sensing sources might be used to derive productivity data. Many EU policies require data on grasslands. Harmonization of grassland definitions and classifications would reduce the amount of data that has to be collected and would improve the data quality. None of the current grassland definitions and classification does fulfil the data needs of the different EU policies.

3.5 Grassland term definition and classification; proposal by EGF and Multisward

The Working group on 'Grassland term definitions' of European Grassland Federation (EGF) and members of the FP7 Multisward research project made a proposal of definition and classification of grassland. This proposal is included in Annex 1 in this report. The classification scheme proposed by this working group is shown in Table 12.

Table 12 Grassland classification scheme proposed by the working group on 'Grassland term definitions' of European Grassland Federation (EGF) and members of the FP7 Multisward research project (see Annex 1 for the definitions proposed for this classification scheme).

3.2. Classification based on grassland types only

Grasslands

1. **Permanent grasslands**
   - **1.1. Agriculturally-improved permanent grasslands**[4]
   - **1.2. Semi-natural grasslands**
     - 1.2.1. Pastures, including rangelands, rough grazing, wood pastures etc.
       - 1.2.1.1. Sole use
       - 1.2.1.2. Common land
     - 1.2.2. Traditional hay meadows
   - **1.3. Permanent grasslands no longer used for production.**

2. **Temporary grasslands**
   - **2.1. Pure legume sowing**
   - **2.2. Grass/legume mixtures**
   - **2.3. Pure grass sowing**

3.3. Classification based on all fodder types

Fodder area

1. **Arable fodder crops**
   - **1.1. Temporary grasslands**
     - 1.1.1. Pure legume sowing
     - 1.1.2. Grass/legume mixtures
     - 1.1.3. Pure grass sowing
   - **1.2. Green cereals**
     - 1.2.1. Green oats, spelt, triticale, rye and other C3 cereals
     - 1.2.2. Green maize and sorghum
   - **1.3. Fodder roots (including fodder beet)**
   - **1.4. Fodder brassicas**
   - **1.5. Fodder *Compositeae*: sunflower**

2. **Grazed fallow lands**

3. **Permanent grasslands**
   - **3.1. Agriculturally-improved permanent grasslands**[5]
   - **3.2. Semi-natural grasslands**
     - 3.2.1. Pastures, including rangelands, rough grazing, wood pastures, etc.
       - 3.2.1.1. Sole use
       - 3.2.1.2. Common land
     - 3.2.2. Traditional hay meadows
   - **3.3. Permanent grasslands no longer used for production**

[4] Almost always in sole use but occasionally common land
[5] Almost always in sole use but occasionally common land

3.6 Summary

Grasslands are very diverse in terms of management, yield and biodiversity value. A distinction can be made between production grassland, which have mainly a fodder production function, and semi-natural grasslands that provide a large range of ecosystem services including biodiversity. For production grasslands the main differentiation is between permanent and temporary grassland and in their level of intensification. Most of the statistical sources of grassland data deal with land use, whereas the remote sensing based sources refer to land cover. Land use is a description of how people utilize the land and socio-economic activity. Land use is often recorded via questionnaires and statistics.

Definitions of grassland can be found in the scientific literature, Common Agricultural Policy, Farm Structure Survey, FADN, FAOSTAT, IPCC guidelines, LUCAS, remote sensing based sources (CORINE, FAO-Land Cover Classification System, EAGLE) and, for habitat classification, in the EU Habitats Directive, and the EUNIS habitat classification. The statistical sources do have clear definitions for different grassland types. Although remote sensing sources have clear classification schemes, the usefulness is limited as the classification is focussed on land cover and not on land use (e.g. no distinction between permanent and temporary grassland). The spatial coverage for most grassland sources is sufficient and cover the EU-27. Many EU policies require data on grasslands. Harmonization of grassland definitions and classifications would reduce the amount of data that has to be collected and would improve the data quality. None of the current grassland definitions and classification does fulfil the data needs of the different EU policies.

4 Methods to estimate grassland production and biological fixation

This Chapter provides a summary of the main findings of a literature review of current methods to estimate grassland production and biological fixation. The literature study is presented by Schils et al. (2014)[21].

Most grassland used for agricultural purposes is stocked by animals for at least part of the time and in many cases year-long. Grazing affects grassland production because of defoliation, treading and fouling. Harvesting takes place frequently or at least several times in a year. For these reasons measuring yield of forage is more difficult than that of other crops.

4.1 Measurement of grass production

4.1.1 Unit of yield

Biomass of grassland vegetation refers to above-ground herbaceous material, commonly referred to as dry matter (DM) yield. Instead of DM yield, vegetation mass can also be expressed as organic matter (OM). Organic matter yield has the advantage that it is true herbage yield without soil contamination, which often occurs in herbage samples as a result of mechanical cutting, raking up of grass or rain splash. In intensive animal production systems, grassland yield, although initially sampled as dry matter or organic matter, is often expressed in terms of feeding units based on net energy value. Several systems are in use, such as VEM ('fodder units milk') or VEVI ('fodder units intensive beef production') in The Netherlands, ME ('metabolizable energy') in the UK, and UF ('unité fourragère') in France. In the USA and many Latin American countries the TDN ('total digestible nutrient') system is used, which is based on digestible energy. In some countries the original SE ('starch equivalent') is still in use.

4.1.2 Destructive measurement

Destructive measurement is commonly applied on grassland experiments throughout Europe. The simplest devices are hand-operated tools, such as scissors, shears, secateurs, sickles, knives and scythes. Small hand-held tools are useful for small plots when the material is to be divided into species or groups of species. Engine-driven reciprocating cutter bar mowers and lawn mowers with a catcher can be used in short to medium tall swards. A commonly used Danish harvester (Haldrup) has a cutting width of 1.5 m, with adjustable stubble height. The total fresh weight is automatically recorded for each plot. A sample of the cut material is taken by hand, or automatically in new models.

It is essential with any type of cutting implement that cutting height above ground level can be controlled. Hand-held shears or secateurs can cut to near ground level. However, this may affect regrowth and sampling areas cut to ground level should be omitted from sampling again in the near future. Cutting heights will vary depending on the type of grassland, ranging from 1 cm in closely grazed pastures to 10–20 cm in tall swards. In many experiments, grasslands are cut at 4 to 5 cm. Low cutting

[21] René Schils, Gerard Velthof, Sander Mucher, Gerard Hazeu, Oene Oenema, Allard de Wit, and Annemieke Smit (2014). Current methods to estimate grassland production and biological fixation. Alterra.

heights and mechanized equipment can suck in extraneous material such as detached litter, twigs, gravel and dry faeces.

4.1.3 Non-destructive measurement

Destructive sampling requires high inputs of labour and/or equipment. This can be costly and may lead to insufficient sample numbers, resulting in low precision. Destructive sampling also prevents measuring changes of the sward in the sampling area. In small grazed plots the material removed by cutting may be a significant proportion of the feed available. For these reasons, non-destructive sampling techniques have been developed, which can be grouped into visual estimation, height and density measurements, and measurement of non-vegetative attributes that can be related to DM yield.

Visual assessment may be carried out by experienced operators who are very familiar with the type of pasture under consideration. They may be able to estimate the dry matter yield within circa one ton per ha. However, this procedure is of limited value research without any calibration. The comparative yield method has been widely used in grassland research. With this method, regression equations derived from standards covering a range of dry matter yields are used to calculate the dry matter yields based on estimates from operators.

The standing biomass of an area of grassland is related to the density and height of its individual components. Height and density measurements of a sward can be integrated using a 'weighted disc', 'rising plate', 'drop-disc', or 'pasture disc', of which there are many types in use. They consist of a round or square disc of light metal or of plastic foam of a given weight that can slide along a central rod, which is lowered or dropped from a fixed height on to the sward.

Capacitance meters can be used to estimate yield. This method is based on a signal produced by an oscillator in an electrical circuit, which changes as the capacitance under the measuring head changes. Herbage mass has a high capacitance whereas that of air and wood is very low. The difference in capacitance between a quadrat on bare ground and on a grass sward is an indirect method to measure dry matter yield. Capacitance meters have been used since 1956 and although improved versions have been developed, their performance still leaves much to be desired, except under the special circumstances.

The non-destructive methods in use are often double sampling techniques, i.e. two overlapping methods are used. One is an accurate determination of DM yield in a few samples (standards) and the other is a visual estimate, height or capacitance reading of herbage in many samples, including the standards. Regression equations between the estimated non-yield parameter and DM yield of the standards provide the calibration of the technique. Therefore, non-destructive techniques still require some sample cutting, but the amount to be cut is small and, if necessary, cutting can be restricted to an area of the same sward that is outside the measurement or treatment area.

4.1.4 Remote sensing

Remote sensing has proven to be an important tool for monitoring land cover classes, including grasslands. The relevance of remote sensing as a source of information for grasslands is conditioned by the sensor characteristics spatial resolution, spectral resolution, and temporal resolution. The distinction of grassland types can only be improved by better understanding and description of habitat types in terms of their spectral signatures and their spatial and temporal variation, next to the description of textural features (tone, texture, structure and patterns) of the different types of satellite imagery (e.g. Landsat TM, IKONOS) depicting the grasslands.

Remote sensing can contribute to identify spatially the land cover class grassland and in some cases specific types of grasslands. There are many different local and regional grassland classification schemes

(floristic, habitat, climatic, management, use etc.). In most cases floristic composition plays an important role and is not that easy to distinguish from satellite imagery. Remote sensing can contribute to identify grassland parameters, including Leaf Area Index, fraction of cover, the canopy shade, gap in the fraction of soil (e.g. bare land), biomass content, and canopy coverage.
Remote measurements of canopy spectral reflectance can provide a rapid and non-destructive method for assessing plant canopy biophysical parameters (i.e., green leaf area and biomass). Red and near infrared reflectance have been found to best correlate with amount and duration of green leaves, but the empirical relationships between canopy biophysical parameters and spectral reflectance are also dependent of site and data-set effects.

Research on improving the simulation of crop canopy development has mostly focused on the use of sequences of high spatial resolution satellite imagery (20-30 m) to either recalibrate crop model parameters such as the emergence date, or to integrate the observations in a model using a forcing or updating approach. Although results demonstrated that many crop model states (e.g. simulated biomass, leaf area index, yield) could be improved using satellite observations, such methods have proven difficult to be applied in crop yield forecasting applications operating at regional to continental scales. The main reason for this slow adoption is the disparity in scales between the process (crop growth on fields often as small as 1 hectare) and the type of observing system that can be used operationally and economically over large areas with high temporal frequency (satellite sensor observations with a spatial resolution ranging from 250 m to 1 km). Given the relatively coarse spatial resolution of such satellite sensors, in many parts of the world the instantaneous field of view covers a mixture of various land cover types, making it difficult to estimate the value of crop states (LAI or biomass) for specific crops. The launch of the European SENTINEL satellites with a maximum spatial resolution of a 10 meter for SENTINEL-2 and a revisit time of a few days in combination with radar satellite SENTINEL-1 can provide a new boost for the integration of satellite imagery with crop yield models to assess actual yields.

For the implementation of the Common Agricultural Policy, the European Commission needs timely information on the agricultural production to be expected in the current season. This is a main concern of the MARS-project (Monitoring Agriculture by Remote Sensing) of JRC. Despite the initial focus on the use of remote sensing techniques for crop yield forecasting within the MARS project, it was gradually recognized that remote sensing derived indicators played a minor role in forecasting of crop yield in Europe. The approach for quantitative crop yield prediction within the MARS project gradually shifted towards an agrometeorologic approach, while remote sensing derived indicators were merely used as qualitative descriptors of the growing season.

4.1.5 Modelling

There is a wide variety in modelling approaches of grassland production, both mechanistic and empirical models. For purposes of farming systems research and collection of statistical data on regional levels, feed balances are often used to estimate grassland production.

Mechanistic models for predicting grassland production are often based on growth, senescence, litter and standing biomass, using data on incoming radiation, temperature, soil moisture, day length and altitude. Empirical models are derived or calibrated with data from field experiments, e.g. experiments in which effects of nitrogen application have been tested, Regression analysis is used to derive equations, e.g. growth curves for the potential dry matter yield without water limitation.

Grassland yields can be estimated using data on milk production, energy requirements, feed composition, and maize yields in a farm, region or country. The grassland yield is the output of the balance calculation. The advantages of using a feed balance model are that the method is fairly simple, the method is based on statistics, and that the method takes account of farm management practices, fertiliser use, livestock density, feed and forage availability and varying soil production. Grass consumption is part of the feed consumed and therefore part of the minerals which end up in manure.

On the other hand it is an output of the soil surface balance. This implies that inaccuracies in the calculation of grass consumption do not affect the surplus of the soil surface balance.

4.2 Measuring nutrient contents in grasses

4.2.1 Destructive measurement

It is important to take a representative sample of grass for analysis of nitrogen and phosphorus contents, because spatial variability of contents may be high in a field. The spatial variability will be highest in natural or extensively managed grassland with a large diversity of grass species, grazed grassland, and fields on farms. The spatial variability will be much smaller in well-managed plots in controlled field experiments.

In cut grassland, samples can be taken from the cut grass. In grazed grassland, samples should be taken at different intervals and different sites in the field during the grazing period to obtain an average value of the nitrogen and phosphorus of the grass consumed by the livestock. In natural or extensively managed grasslands, samples should be taken that are representative for the species found in the specific field. Besides harvesting parts of the grassland area by mowing, also individual plants can be sampled. An alternative way of sampling, is that not the grass in the field is sampled, but grass in the silage pit or stored hay. It must be noted that some nitrogen will be lost during silage and storage of hay. Samples should be taken in different places in the silage pit and stored hay to representative samples for the whole harvest.

Plant samples should always dried as soon as possible or stored at cool conditions in order to minimize respiration and decomposition. Drying is best carried out at 60–80 ^{o}C. The dry matter content of a plant sample is determined by the gravimetric loss of water at drying at 105 ^{o}C for 2 hours. The dry-matter content is used to correct the concentration in a sample dried at 70-80 ^{o}C to an absolute dry-matter basis. Drying at 105 ^{o}C can change the chemical composition of plant material, so that samples dried at 105 ^{o}C should not be used for chemical analysis.

Plant tissue samples previously dried, ground, and weighed are prepared for elemental analysis through decomposition/destruction of organic matter. The two commonly used methods of organic matter destruction are dry ashing (high-temperature combustion) and wet ashing (acid digestion). Wet digestion samples can be used for analyses of N and P (and other elements) and dry ashing and microwave digestion for P (and other elements). The choice for the analytical method depends on the available equipment and the elements that have to be analysed.

4.2.2 Non-destructive measurement

The strong positive relationship between leaf chlorophyll content and leaf N concentration can be used for predicting crop N status. Hand-held chlorophyll meters (SPAD) permit an in situ rapid and non-destructive determination of leaf chlorophyll content by measuring leaf transmittance. However, chlorophyll meter readings are affected by crop cultivar (and grass species), stage of growth, soil moisture status, and nutrients other than N. Chlorophyll meters can used for detecting the need for N fertilizer application. Chlorophyll meters can be used to determine N concentration in grassland for specific conditions, but site-specific and grass-land specific calibration procedures are needed. 2001).

With near infrared reflectance spectrometry (NIRS) monochromatic light is directed at the plant tissue sample. Diffuse light is deflected from the sample and detected by detectors. In order to calibrate the NIR instrument, it is necessary to determine the same parameters via wet chemistry on a large

population of samples. The major advantage of NIR is that the analysis is non-destructive, simple and very rapid.

Strong correlations exist between data from satellite imagery and the concentration of many biochemicals within vegetation canopies. The concentration of chlorophyll within a vegetation canopy is positively related to the point of maximum slope at wavelengths between 690 nm and 740 nm in reflectance spectra. This point is known as the "red edge" of plant reflectance, and characterizes the effective boundary between the strong absorption of red radiation by chlorophyll and the increased multiple scattering of radiation in near-infrared wavelengths. As indicated in paragraph 4.1.4, the European SENTINEL satellites can be used to integrate satellite imagery with crop yield models to assess actual yields.

4.3 Biological nitrogen fixation

There are several sources of biological N fixation, i.e. the fixation by free living soil bacteria, clover in grasslands, and other leguminous crops. The N fixed by free living soil bacteria is generally small, i.e. < 5 kg N per ha per year; Paul and Clark, 1996).

4.3.1 Measurement

The amount of nitrogen fixed by clover is difficult to estimate, because both the estimate of the average share of clover in grassland in a region and the amount of N fixed by clover are uncertain. If clover is grown on soils that contain mineral N (e.g. because of N fertilizer or manure application), clover can use this N and may not or slightly fix atmospheric N. In that case, not all N of the clover should be included in the gross N balance calculations. Only the biologically fixed N has to be included in gross N balance, because this N is "new" N in the N balance.

Basic methodologies that are available to quantify biological N fixation (Herridge et al., 2008) include the acetylene reduction method, N balance calculations, N difference method, and the use of ^{15}N label nitrogen. The N balance and N difference methods provide estimates of N fixation on an area basis, i.e. kg N/ha. The ^{15}N method, on the other hand, provides estimates of the percentage of plant N derived from N fixation. An amount of N fixed per unit area or unit of production can only be calculated when this percentage is combined with an estimate of organism biomass and total N content. The overall average for N fixation by forage legumes is about 50 kg N fixed/Mg shoot biomass, but variation is large 29 – 69 kg N/Mg (Schils et al., 2013).

4.3.2 Modelling

In the scientific literature, several models are described including empirical models for quantification of symbiotic nitrogen fixation in grass-clover mixtures (Høgh-Jensen et al., 2004), simple and empirical models based on experiments where ^{15}N was used for determination of N2-fixation (Boller, 1988; Carlsson and Huss-Danell, 2003), and a model based on a linear relation between N_2-fixation and dry matter yield excess in grass-clover swards compared with pure grass swards (Watson and Goss, 1997). Most simulation models estimate the N fixation rate from a pre-defined potential N fixation rate, adjusted by the response functions of soil temperature, soil/plant water status, soil/plant N concentration, plant carbon supply and crop growth stage (Liu et al., 2010).

4.4 Current methods in countries

An analysis has been made of the response of members states to questions in the questionnaire described in Chapter 6.

4.4.1 Grassland yields

Countries collect a wide variety of relevant data about production (Table 13), either directly as yield, or indirectly through volume of grazed grass, volume of cut grass, number of cuts/harvests per year, management intensity, grazing status, grazing intensity, nitrogen input levels as fertiliser or manure, and proportion of clover or other N fixing plants. A few countries also collected data on legumes (biological nitrogen fixation).

The methods used to estimate grassland production are very heterogeneous (Table 14). Most members states use expert estimates, while destructive measurements are also mentioned frequently. Less frequently mentioned methods involve default values from literature, non-destructive measurements, calculations of a crop growth model and estimates using feed balance calculation. The specified options mentioned as 'other' methods are generally based on one of the standard categories.

The temporal scale of grassland production estimates is mostly on an annual basis, but sometimes on smaller time windows: four-monthly, monthly or even weekly. It is remarkable that some countries mention a standard value for each year. The spatial scale varies from National (NUTS0) to regional scale (NUTS 2/3), and further to farm or even field scale. Regional scales are mentioned most frequently.

Table 13. Collected data in grassland surveys per member state (results from questionnaire; see Chapter 6).

country	Yield (ton /ha)	Volume of grazed grass	Volume of cut grass	Number of cuts/harvests (times per year)	Management intensity (cleared, leveled, ploughed)	Grazing status (grazed, not grazed)	Grazing intensity (stocking density, daily duration)	Nitrogen input levels as fertiliser (kg N)	Manure input levels	% of clover or other N fixing Plants	Biological N fixation(in kg N / ha)
CH				v	v	v	v			v	
CZ	v										
DE	v		v								
DK	v										
EE		v	v					v	v		
EL											
ES											
FI	v			v		v		v		v	
FR	v			v		v	v	v	v		
HR	v	v	v								
HU	v	v	v			v		v	v		
IE	v			v		v		v	v		
IT											
LT	v	v	v			v					
LU	v										
LV	v	v			v						
ME											
NL			v	v							
NO	v		v	v	v						
PL											
PT	v	v	v	v		v					
RO	v										
RS	v		v								
SE						v		v			
SI	v			v			v				
TR											
UK						v				v	
Proportion (%)	56	22	33	26	7	30	7	22	15	7	0

Table 14. Methods used to estimate grassland yields in countries (results from questionnaire; see Chapter 6).

Member State	no	Yes, expert estimates	Yes, default values from literature	Yes, destructive measurements (harvests)	Yes, non-destructive measurements	Yes, use of remote sensing	Yes, calculations of a crop growth model	Yes, estimates using feed balance calculation	Yes, other (please specify)	specification
BE		1	1	1	1			1		
BE				1						
BE									1	NSI
CH									1	A mix between standard values from literature and expert estimates for each separate fodder year. We use all information over the fodder year (weather reports, news articles, information about crop situation, etc.) in order to adjust default values. Control values are given by fodder requirement from livestock taking also into account that stocks of forage are changing in a plausible way.
CH		1		1	1			1		
CH		1	1							
CH		1	1	1				1		
CZ		1		1						
CZ									1	statistical survey
DE		1							1	Ernte- und Betriebsberichterstattung (EBE) über Feldfrüchte und Grünland
DE		1		1	1		1	1		
ES		1	1	1					1	se utiliza el índice de Rosenzweig para extrapolar territorialmente los datos medidos
FI		1							1	Variety testing results and results from other experiments.
FR							1	1	1	agricultural annual statistics
FR							1			
HR		1								
HU									1	sample survey
IE		1		1	1					
IE									1	Grassland utilisation is estimated form National Farm Survey Data. Some Research plot data also available
IT		1								
LT									1	Data available from annual survey on on the area and the harvest on agricultural crops
LU		1							1	essais comparatifs variétés de graminées fourragères et légumineuses fourragères; essais sur les pratiques culturales en prairies et pâturages permanents: experimental fields for comparison of grass and leguminous fodder varieties; experimental fields on production methods in permanent grassland
LV									1	We have had a service called "Mowing service" having measured average data from each region of the country. But this service is not available any longer. Grass yield is measured individually now.
LV			1						1	As proportion of organic carbon stock in soil

NL								1		
NO				1						
PL		1							1	sample survey
PL		1								
PL		1	1	1			1			
PL		1	1	1			1			
PT		1								
PT		1	1							
SE									1	Standard value based on a calculation of a ratio compared to yield on temporary grasses. (1200 kg/hectare)
SI		1							1	reports of agricultural holdings which are enterprises and expert estimates for farmers (big share of all grassland area)
SI		1							1	reports of agricultural holding which are enterprises and expert estimates for farmers (big share of all grassland area)
SI		1								
SK				1						
SK				1						
UK	1								1	www.defra.gov.uk Fertiliser Manual (RB209) provides information for estimating crop requirements and using expected yield based on rainfall and soil type.

4.4.2 Nutrient content in grasses

Most members states use derived values from literature or direct measurements in samples of harvested grass (Table 15). The specified options mentioned as 'other' methods are generally based on one of the standard categories.

Table 15. Methods used to estimate nutrient contents in grass in countries (results from questionnaire; see Chapter 6).

	No	Yes, expert estimates	Yes, default values from literature	Yes, measurements	Yes, derived from measured protein contents of grass	Yes, other (please specify)	specification
BE		1	1	1	1		
BE			1				
BE							
CH			1				
CH				1			
CH							
CH				1	1		

CZ		1		1			
CZ			1				
DE				1	1		
DE				1			
ES		1	1		1		
FI				1	1	1	In research studies values are available for those particular materials included in the study.
FR		1					
FR							
HR							
HU			1				
IE				1	1		
IE						1	Some data is available from research experiments at some locations
IT						1	estimation based on ELBA model (Environmental Levelness Blant Agriculture) managed by University of Bologna
LT	1						
LU			1				
LV			1		1		
LV			1				
NL					1	1	Yes, derived from measured phosphorus contents of grass
NO			1	1			
PL	1						
PL	1						
PL		1	1	1			
PL			1	1			
PT		1					
PT		1	1				
SE						1	Source: STANK in mind
SI							
SI						1	Data on N and P content are available for farms which analyse their forages on voluntary basis in Slovenian labs.
SI						1	Data on N and P content are available for farms, which analyse their forages on voluntary basis in Slovenian labs.
SK			1	1			
SK							
UK			1				

4.4.3 Biological nitrogen fixation

A significant proportion of countries do not collect data on biological nitrogen fixation in mixed swards (Table 16). Those that do, mostly rely on values retrieved from literature in combination with expert estimates. Measurements and models are not mentioned frequently.

4.5 Summary

The estimates of grassland production have a large effect on the nutrient balance of pasture based livestock systems. Furthermore, estimates of biological nitrogen fixation of mixed legume-grass swards are not included in current nutrient balances.

Most grassland used for agricultural purposes is stocked by animals for at least part of the time and in many cases year-long. Grazing affects grassland production because of defoliation, treading and fouling. Harvesting and grazing take place frequently or at least several times in a year. For these reasons measuring yield of forage is more difficult than that of other crops.

The methods for determining grassland production can be classified in destructive (cutting) and non-destructive (visual estimates, grass height measurements and remote sensing), and modelling. Destructive measurement is commonly applied on grassland experiments throughout Europe. Although non-destructive methods are less accurate on a per sample basis than cutting methods, they take less time per observation and involve less physical effort by the operators. The larger number of observations offers more opportunity for examining spatial and temporal heterogeneity. Remote sensing offers a potential alternative for monitoring vegetation condition and estimating productivity over large areas of grasslands. Research has mostly focused on the use of high spatial resolution satellite imagery on behalf of crop modelling. Although results demonstrated that many crop model states could be improved using satellite observations, such methods have proven difficult to be applied in crop yield forecasting applications operating at regional to continental scales. The main reason for this slow adoption is the disparity in scales between the process and the type of observing system. There is a wide variety in modelling approaches of grassland production. Process based models and empirical models can be distinguished. Empirical models include the feed balance approach in which grassland yields are estimated using statistical data on feed availability for ruminants and their feed requirements. Measurement of nutrient contents in grassland is also categorised in destructive (sampling and analysing) and non-destructive (chlorophyll, near infrared reflectance spectrometry).

The amount of N fixed by clover is difficult to estimate, because both the estimate of the average share of clover in grassland in a region and the amount of N fixed by clover are uncertain. If clover is grown on soils that contain mineral N (e.g. because of N fertilizer or manure application), clover can use this N and may not or slightly fix atmospheric N. In that case, not all N of the clover should be included in the gross N balance calculations. There are many techniques available for the direct quantitative measurement of legume biological nitrogen fixation in the field. However, these are time-consuming and therefore expensive, and generate data relevant only to the time and place of measurement. Alternatively, legume biological N fixation can be estimated by either empirical models or dynamic mechanistic simulation models.

The methods used to estimate grassland production by countries are very heterogeneous. Most countries use expert estimates, while destructive measurements are also mentioned frequently. Less frequently mentioned methods involve default values from literature, non-destructive measurements, calculations of a crop growth model and estimates using feed balance calculation.

With respect to nutrient contents, members states mainly use derived values from literature or direct measurements in samples of harvested grass. Data on biological nitrogen fixation are usually not collected. Those countries that do, mostly rely on values retrieved from literature in combination with expert estimates. Measurements and models are not mentioned frequently.

Table 16. Methods used to estimate biological fixation in grasslands in countries (results from questionnaire).

	No	Yes, expert estimates	Yes, default values from literature	Yes, measurent	Yes, model calculations	Yes, other (please specify)	specification
BE		1	1	1			
BE			1				
BE						1	research report and papers
CH		1	1		1		
CH		1		1	1		
CH							
CH		1		1			
CZ	1						
CZ	1						
DE		1	1			1	Default values from literature for estimation of BNF of legumes and free-living organisms. Expert estimations of BNF by legumes in permanent pasture.
DE		1			1		
ES		1					
FI		1	1				
FR		1					
FR							
HR							
HU	1						
IE						1	calculated by difference
IE		1					
IT						1	Until 2002 OECD estimations
LT	1						
LU			1				
LV						1	We use a data from Swedish advisory tool- the program called Stank. Fixation intensity depends on a crop and its yield.
LV			1				
NL			1				
NO		1	1	1	1		
PL	1						
PL	1						
PL			1				
PL			1		1		
PT			1				
PT		1					
SE	1						
SI							
SI			1				
SI			1				

SK	1						
SK							
UK	1						

5 Existing grassland surveys; results of a questionnaire

This Chapter provides a summary of the main findings of questionnaire sent to all countries of the European Union, Switzerland, and Norway. The detailed results are presented in an Excel document, supplied to Eurostat as separate document.

5.1 Design of the questionnaire

The questionnaire was designed in close cooperation with Eurostat, to make sure that the content (questions) and the structure of the questionnaire were suitable for the inventory of available knowledge about grassland datasets and data collection methods. The questionnaire consisted of three parts. For each part respondents could indicate whether they were expert on that part. If not, they were redirected to the next part.

Part A dealt with grassland data. Respondents were asked to provide information about grassland data sets, data collection, classification criteria and reporting purposes. Questions were:

- What is the name of the data set you want to provide information about? Please include references or web links.
- Could you specify the grassland categories (classification/typology) in the data set and give a short definition?
- What data collection methods are used for the data set ?
- Could you specify what information on grassland is collected for this data set and what information is used as classification criteria for the different grassland categories?
- Please give the thresholds for the relevant criteria (see previous question)
- At what frequency are data on different types of grassland collected?
- What is the coverage of the data on area of different types of grasslands?
- What is the spatial scale of the data on area of different types of grasslands?
- Can you please specify the geographical scale or administrative level?
- For what reporting purposes are data of this data set used?

Part B was about nutrient balances. This part asked for information about data collection methods on grassland yields and nutrient contents used for the estimation of nutrient balances. The questions were:

- Are data on grassland yields available in your country?
- On what temporal scale is the grassland yield estimated?
- On what spatial scale is the grassland yield estimated?
- Could you provide information on methodologies applied to estimate the yields?

- Are data on nitrogen and phosphorus contents in grass available in your country?
- Could you provide information on methodologies applied to estimate the nitrogen and phosphorus contents?

- Are data available on the biological fixation in grasslands?
- Could you provide information on methodologies applied to estimate biological N fixation?

Part C dealt with possibilities for accounting nutrient balances at national level and a proposal to include extensively grazed areas. In this part we suggested a combination of estimations of grassland yields and asked the respondents opinion about that.

- Are data available in your country to distinguish different grassland and grazing areas? If yes, what type of data?
- Are there areas used for grazing which are not counted in European statistics on UAA, but which are published at national level as agricultural land?
- Do you have data available on the following for these grazed areas? If yes, what type of data?
- Which thresholds would you propose to be used to determine whether these areas should be included in the UAA (provide number)

"A problem in nutrient balances at national level is that including large extensive areas, which are only used for a short period of the year, suppress the estimated surplus and may mask intensive practices. An idea to improve the indicator would be to estimate it both including and excluding extensive grassland and grazing areas. Extensive grazing areas could be differentiated further into areas used approximately the whole year round, areas used only for a short period. These data could also be useful for other indicators such as cropping patterns, livestock patterns, intensification/ extensification."

- What is your opinion on this idea?
- Which thresholds would you propose to be used to classify grassland and grazing areas as extensive areas: *grazed year round* (please provide number for livestock densities, yield or other parameter) ?
- Which thresholds would you propose to be used to classify grassland and grazing areas as extensive areas: *grazed part-time use* (please provide number for livestock densities, duration of grazing, yield or other parameter)?
- Which thresholds would you propose to be used to classify grassland and grazing areas as extensive areas: *mowed* (please provide number for mowing frequency, yield or other)?

In the questionnaire a broad definition of grasslands was chosen: 'Grasslands' include all land dominantly covered by grasses and other herbaceous plants (except cropland) regardless of the land use (which can be e.g. agricultural, recreational, urban, or have no visible use (natural grasslands).

5.2 Response to the questionnaire

The invitation to fill the on-line questionnaire was sent to grassland 280 experts in Europe. Experts were members of the Eurostat working groups Agri-Environmental Indicators and Crop Statistics, experts mentioned in a preliminary short questionnaire carried out in February 2013, or experts found in a literature research. Addressees were encouraged to coordinate the replies at a national level, to make sure that for each country all important data sets were mentioned and for all parts of the questionnaire at least one expert could provide information.

We received 81 responses, of which 67 responses were completed (Figure 3). Incomplete responses only contained a few (and sometimes random) answers and were not used in further analyses.

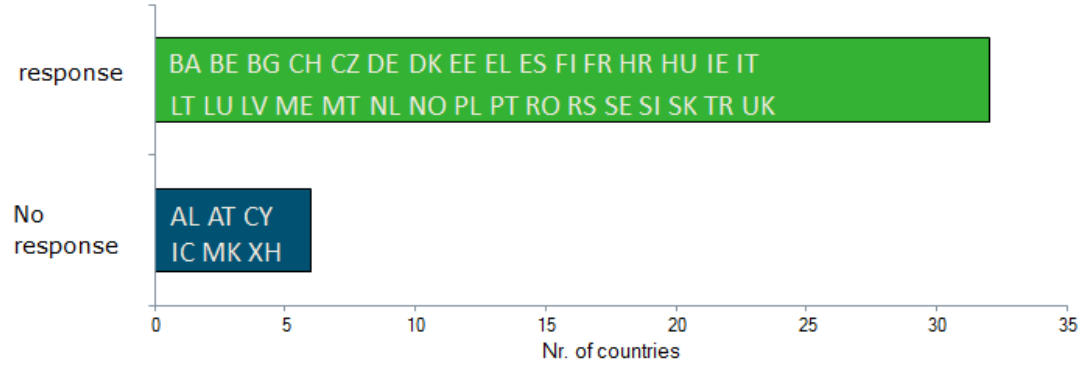


Figure 3. Number of countries with one or more responses.

To get an overview of the expertise and background of respondents, a question about field of expertise and organisation was included (Figure 4). Most of the respondents work at a national statistical institute or a research organisation. Some respondents with expertise in agriculture, grassland yields or land use work at a ministry.

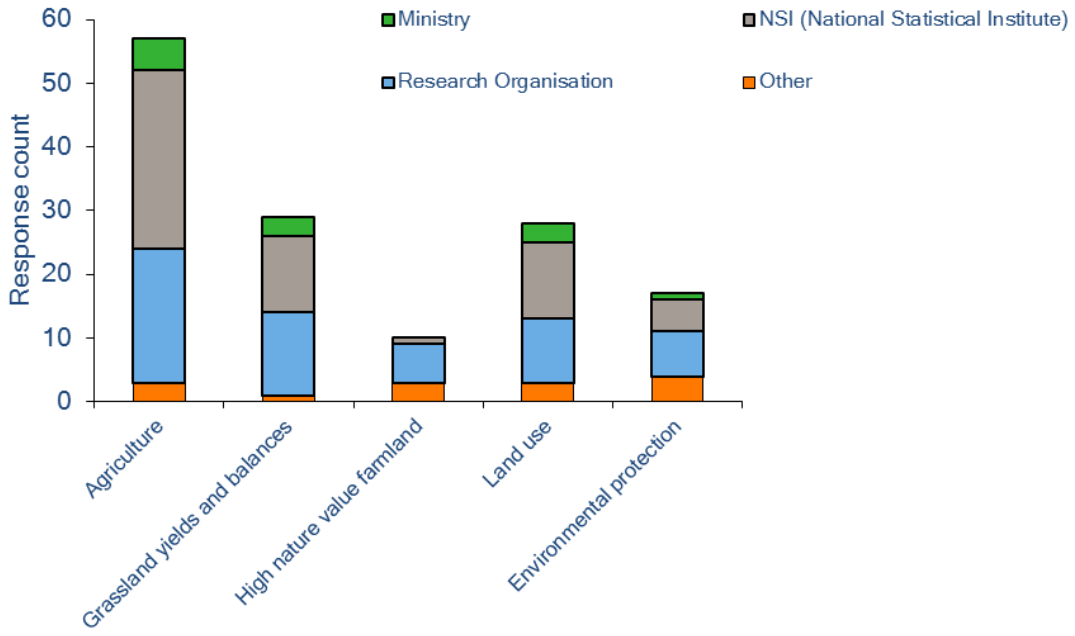


Figure 4. Field of expertise and organisation of the respondents

5.3 Results of Part A: data sets and data collection

In part A 43 respondents provided information about 1 or more data sets. In total information about 62 data sets from 27 countries was given.

The grassland categories seemed very diverse at first sight. Some data sets contained 8 or more categories for grassland. However, most of the data sets categorised the grassland according to FSS.

Data collection methods are shown in Figure 5. Farmers'/ landowners reports are the most important method, the different methods to collect geographical information (Remote sensing and other) were least important. The 'other' –option was specified as : FADN methodology + accountancy offices; Administrative level ; Governmental grants; Cadastral records; Aerial pictures, visual photo-interpretation and cyclorama pictures; Experiments and measurement of harvested yield; IACS annual declaration in case of some schemes specific category. In 30 data sets one method was used, in 21 data sets two methods were used and 11 data set were based on three data collection methods.

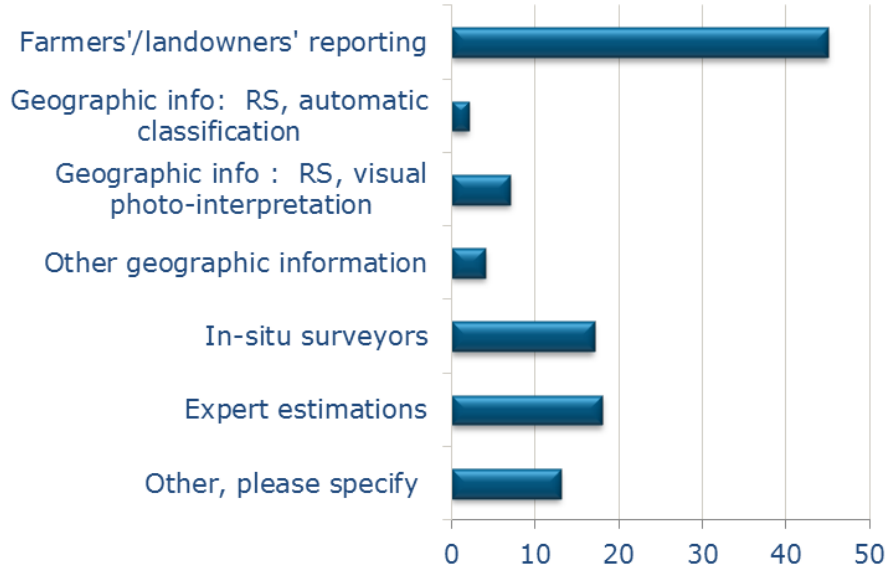


Figure 5. Data collection methods for the data sets.

For most data sets, more data are collected than specifically needed for grassland classification. E.g. data on the distinction between permanent and temporal grassland are collected in about 45 data sets, while in just 15 data sets these data are used for classification. The collected data focussed on land use/land cover (including permanent or temporary grassland) and yield (including number of cuts, volume of cuts of volume of grazed grass (Figure 6). Data on species and on soil and hydrology were less often collected and used for classification.

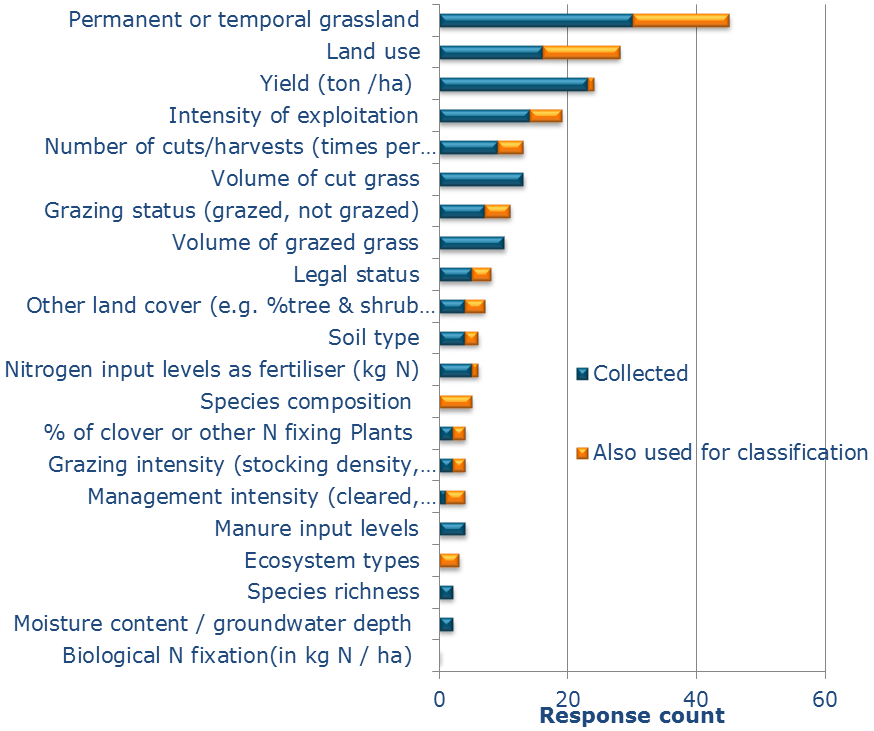


Figure 6. Collected data and data that are not only collected but also used for classification of grassland types.

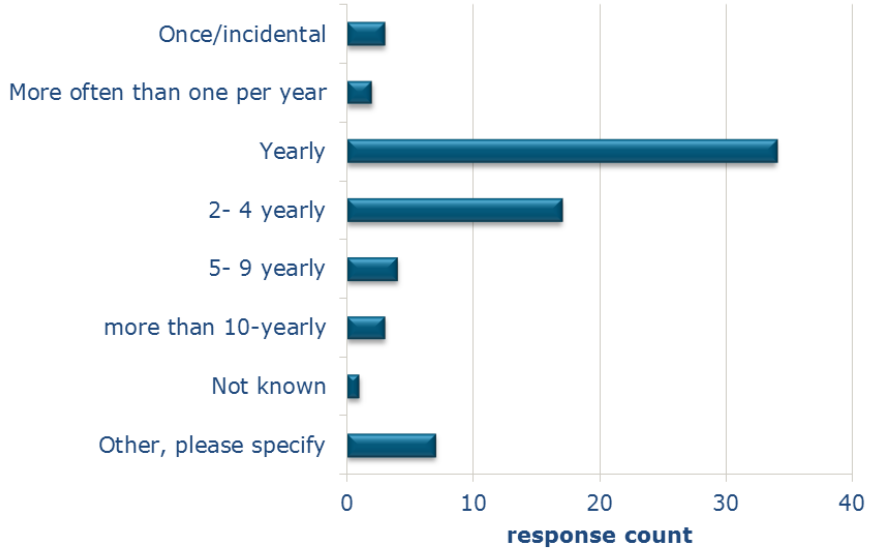


Figure 7. Frequency of data collection.

For most data sets data are collected yearly or less frequent (Figure 7). The frequencies noted as 'other' mostly were detailed notes about frequencies and could be placed in the categories 2-4 yearly and more than 10-yearly. In some data sets only part of the data are collected yearly, other data less often.

Most data sets (84%) have a full country coverage (Figure 8). The other 10 data sets mentioned partial coverage, e.g. research sites, large farms, conservation areas, FADN sample site selection. Data on area of different types of grassland are collected at administrative level in most data sets (73%). For those data sets, the administrative level was specified (Figure 8). Data were collected at a geographical scale in 16% of the data sets.

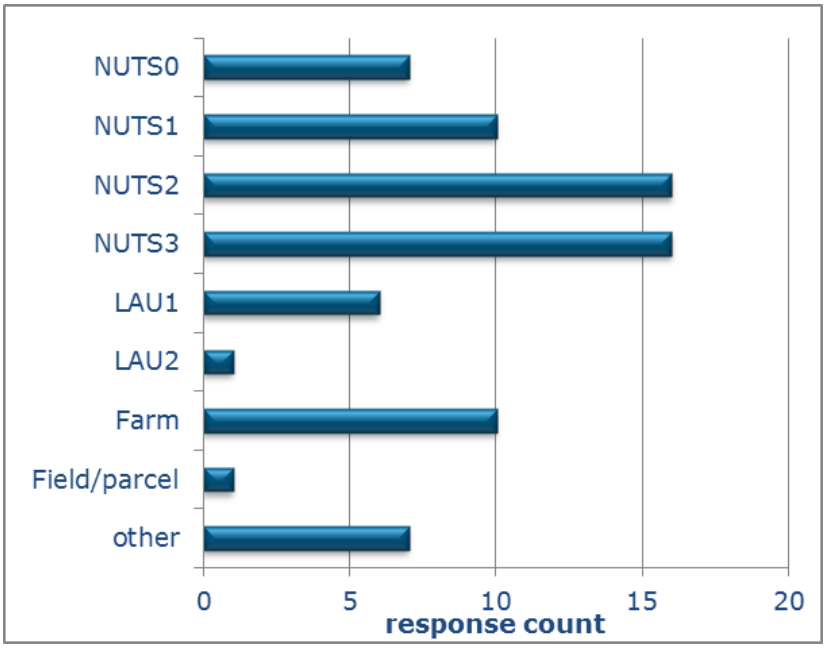


Figure 8. Administrative level of data collection on area of different grassland categories. (response count refers to the number of data sets).

5.4 Results of Part B: Nutrient balances

In part B information about data collection methods on grassland yields and nutrient contents used for the estimation of nutrient balances was asked. There were 39 responses from 22 countries. Dry matter yields are generally derived from expert estimates (Figure 9). Table 14 in Paragraph 4.4 presents detailed results of the methods used by countries to estimate grassland yields. The temporal scale of grassland yield measurements was on annual basis in most countries (Figure 10 upper graph). The spatial scale of the data varied from field scale to national scale (NUTS 0) (see Figure 10 lower graph).

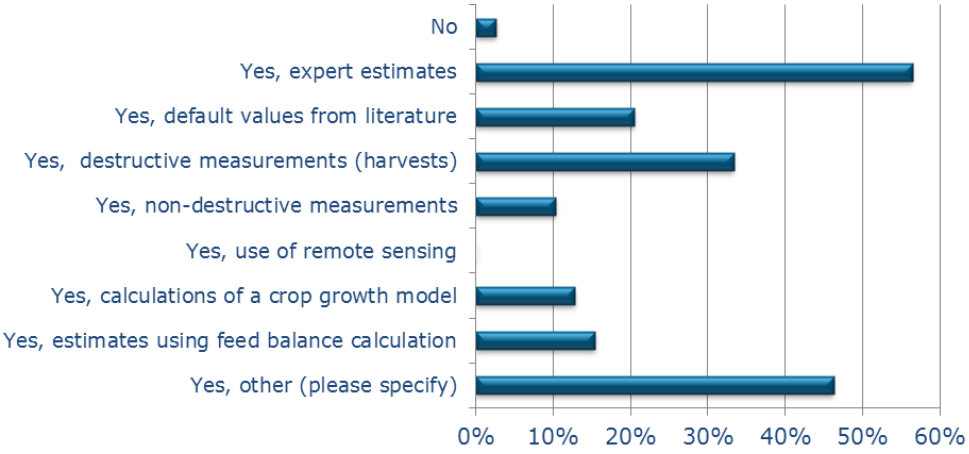


Figure 9. Answers to the question: Are data on grassland yields available in your country?

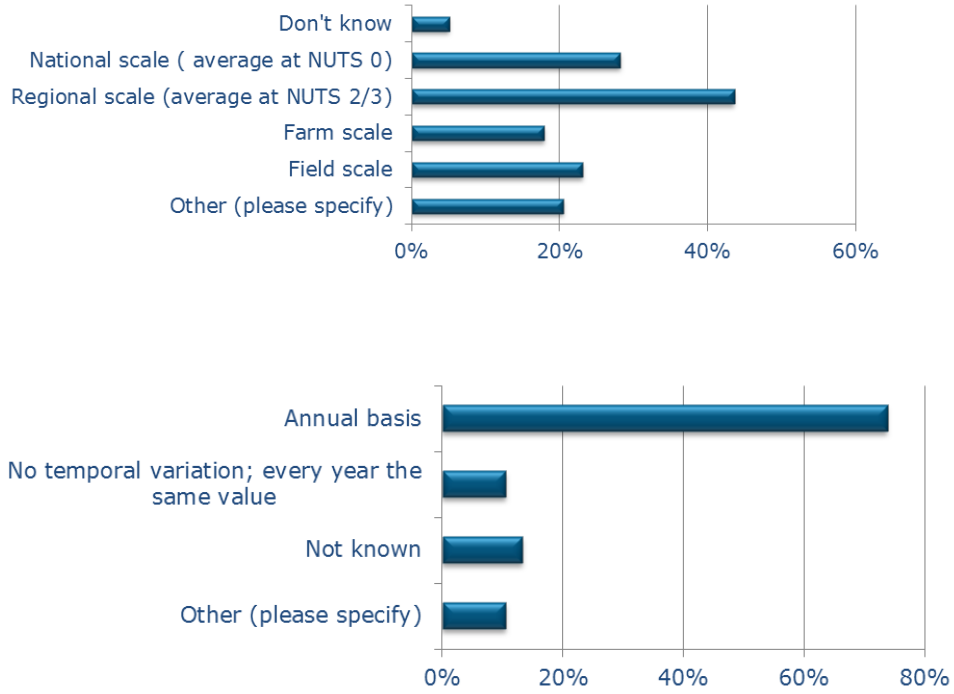


Figure 10. Spatial (upper graph) and temporal (lower graph) scale of grassland yield measurements.

The answers to the questions ' Are data on nitrogen and phosphorus contents in grass available in your country?' and 'Are data available on the biological fixation in grasslands?' are presented in Figure 11 and Figure 12, respectively. Table 15 and Table 16 in Paragraph 4.4 present detailed results of the methods used by countries to estimate grassland yields. The methods used to estimate grassland production by countries are very heterogeneous. Most members states use expert estimates, while destructive measurements are also mentioned frequently. Less frequently mentioned methods involve default values from literature, non-destructive measurements, calculations of a crop growth model and estimates using feed balance calculation. With respect to nutrient contents, members states mainly use derived values from literature or direct measurements in samples of harvested grass. Data on biological nitrogen fixation are usually not collected. Those countries that do, mostly rely on values retrieved from literature in combination with expert estimates. Measurements and models are not mentioned frequently.

Data collection methods showed no difference between the large and small scales (both spatial and temporal). This lack of differentiation may be induced by the multiple answers almost all respondents gave on both questions and it may be no indication for the very poor relation between scale and method.

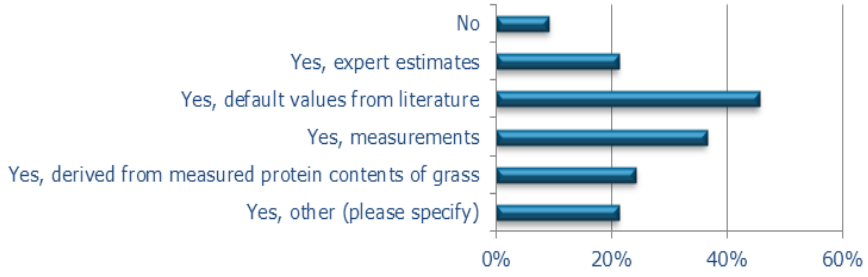


Figure 11. Answers to the questions ' Are data on nitrogen and phosphorus contents in grass available in your country?'

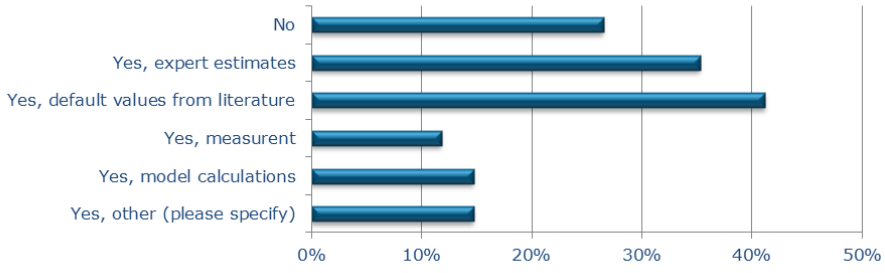


Figure 12. Answers to the questions ' Are data available on the biological fixation in grasslands?'

5.5 Results of Part C: Nutrient balances at national level

Part C dealt with the possibilities for accounting nutrient balances at national level. It also contained a proposal to include extensively grazed areas to which respondents were asked to add ideas or make comments. This part had 23 responses.

In answer to the question Are data available to distinguish different grassland and grazing areas?, 10 respondents gave alternative answers (see Figure 13). Some of those answers were specifications of duration of grazing (e.q. grazing seasons) of livestock densities (e.g. type of livestock), some answers indicated that the only distinction made is temporary vs. permanently grazed. Some respondents answered that species composition is a distinguishing factor.

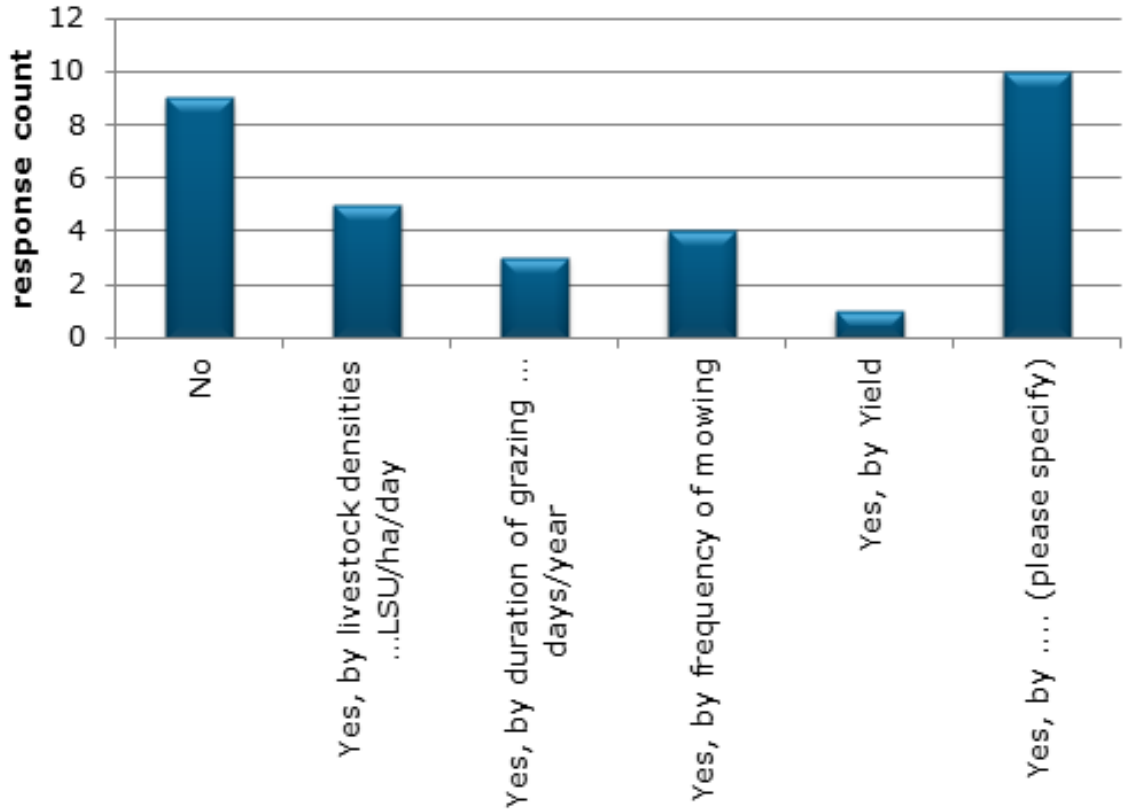


Figure 13.Answers to the question: Are data available to distinguish different grassland and grazing areas?

The question "Are there areas used for grazing which are not counted in European statistics on UAA, but which are published at national level as agricultural land?" was answered with a 'no' by most respondents. Although the expectation was that all Mediterranean countries would answer with a 'yes', only respondents from Spain and Portugal indicated that those areas exists. In addition respondents non-Mediterranean countries, such as Switzerland, Poland, and Latvia also answered with a 'yes'.

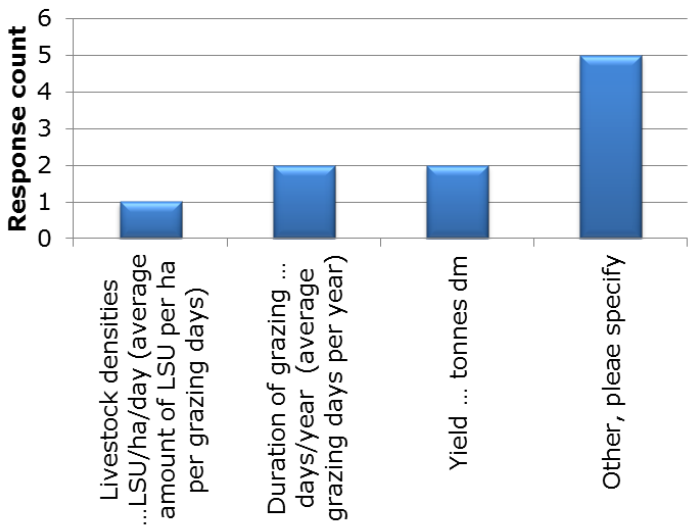


Figure 14. Answers to the question "Do you have data available on the following for these grazed areas?".

The answers to the question "Do you have data available on the following for these grazed areas?". were diverse (Figure 14). Only answered by the 5 respondents that answered 'yes' and the one respondent that answered 'yes, however negligible' in the previous question. The 'Other-option' was specified as follows:

- no data
- Data should be estimated by survey on farm level in specific categories
- Carbon stock in soil in grassland
- "Area in ha. The mountain summer pastures are not included in the Swiss UAA. By mixing data of the agricultural census with data of the landuse statistics (see above), the area of summer pastures can be roughly deduced".
- The number of animals and the number of days (or LSU for bovine) on summer pastures are available, but not where animals are located, so it is not possible to calculate intensity by field (only possible for the total area of summer pastures)."
- surfaces are known by categories of pasture and dry matter production

The next question (Which thresholds would you propose to be used to determine whether these areas should be included in the UAA (provide number)?) provided the following answers:

- 5 LSU/ha/day
- 30 days of grazing/ year
- No need for threshold due to high uncertainty and fluctuations and management practices
- All surfaces used by agricultural holdings following NACE01
- Year-round operation of a farm
- based on the livestock and practices of each zone

All respondents were asked to give to an opinion on an idea to improve the calculation of national nutrient balances. The idea was: *A problem in nutrient balances at national level is that including large extensive areas, which are only used for a short period of the year, suppress the estimated surplus and may mask intensive practices. An idea to improve the indicator would be to estimate it both including and excluding extensive grassland and grazing areas. Extensive grazing areas could be differentiated further into areas used approximately the whole year round, areas used only for a short period. These data could also be useful for other indicators such as cropping patterns, livestock patterns, intensification/ extensification.*

The extensive (and non-edited) replies can be found in the excel-sheets with rough data. The answers can be categorized in the following 'groups':

- Problem is not relevant (e.g. since there are no large areas with extensive grasslands)
- Agree with solution
- Problems with data collection will occur, e.g.:
    - "the realization of such data collection is critical – data on permanent grassland are in Slovenia collected every 3 years in Farm Structure Survey and estimated for the intermediary years. Additional questions on duration of grazing have no legal bases and would endanger the FSS survey which is already a time demanding survey A solution might be the inclusion of this additional information in the yearly IACS system.
    - "Total UAA (all extensive and intensive areas) should be included in nutrient balance calculation as it was agreed on Eurostat AEI WG meetings. The reason for calculating these balances is to indicate the risk that agriculture may have on the environment. Therefore the total agricultural area must be counted. Problematic areas can be identified when calculating balances at lower level (NUTS2)."
- It is already difficult to collect data on grasslands, it will only be more difficult when extensively grazed areas have to be differentiated
- Diversity in use within the extensively used grasslands is a problem, which again comes to dealing with averages.

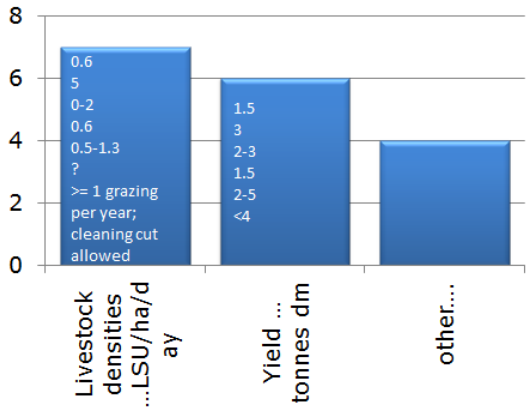


Figure 15. Answers to the question: Which thresholds would you propose to be used to classify grassland and grazing areas as extensive areas grazed year round (please provide number)?

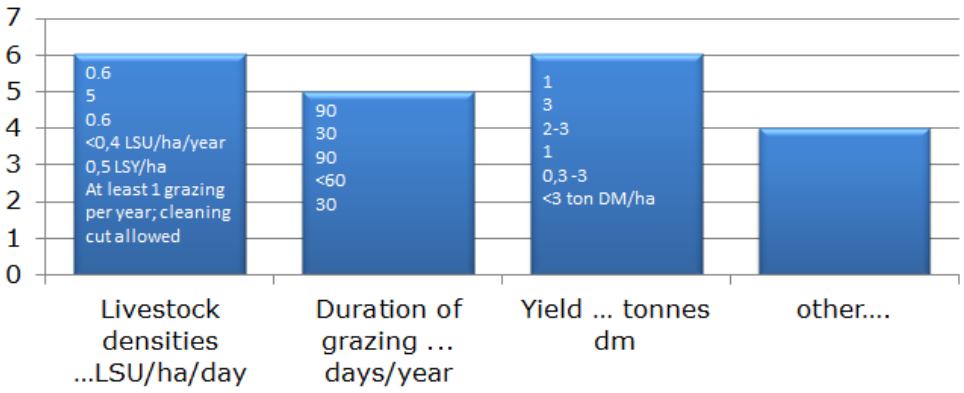


Figure 16. Answers to the question Which thresholds would you propose to be used to classify grassland and grazing areas as extensive areas grazed part-time use (please provide number).

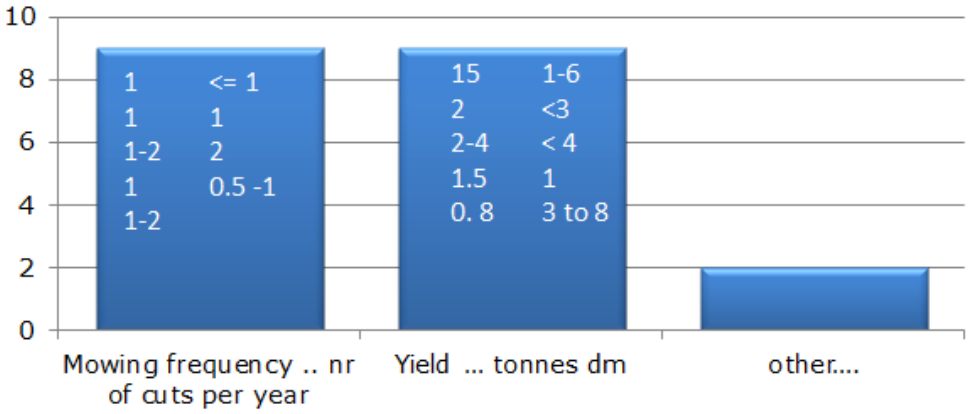


Figure 17. Answers to the question Which thresholds would you propose to be used to classify grassland and grazing areas as extensive areas mowed.

The respondents were asked to provide thresholds to be used to classify grassland and grazing areas that are grazed year round (Figure 15), grazed in part-time use (Figure 16) and areas mowed (Figure 17The thresholds given for yields differed most both within grassland types and between grassland types. The thresholds given for both mowing frequency and livestock densities did not show much differences.

5.6 Summary

A questionnaire with questions about collection of grassland data, nutrient balances, and extensively grazed areas has been sent to 280 grassland experts in Europe. In total 81 responses were obtained, of which 67 responses were completed. By far, most of the data sets categorised the grassland according to FSS. The methods used to estimate grassland production by countries are very heterogeneous. Most countries use expert estimates, while destructive measurements are also mentioned frequently. Less frequently mentioned methods involve default values from literature, non-destructive measurements, calculations of a crop growth model and estimates using feed balance calculation. With respect to nutrient contents, countries mainly use derived values from literature or direct measurements in samples of harvested grass. Data on biological nitrogen fixation are usually not collected. Those countries that do, mostly rely on values retrieved from literature in combination with expert estimates. Measurements and models are not mentioned frequently. Spain, Portugal, Switzerland, and Latvia indicated that some of the grazed areas are not included in utilized agricultural area. Data availability on these grasslands is diverse. The proposed method to improve the calculation of national nutrient balances led to extensive answers, that explained what new problems this method might induce, although many respondents gave positive response to the main idea to estimate national nutrient balances both including and excluding extensive grassland and grazing areas.

6 Review of grazing in non-herbaceous areas in Spain; their use and extent

At request of Eurostat, a case study was carried out about grazing in non-herbaceous areas in Spain. This review study was carried out by Guy Beaufoy and included in this Chapter.

The case study aims to answer the following questions:

- Which other land cover types than pure grasslands are grazed?
- In which geographical areas grazing is mainly taking place?
- Under which circumstances grazing takes place (lack of alternative feeding sources, climatic conditions, with which type of animals etc.)?
- What is the extent of grazing outside grasslands (number of ha affected, rough number of animals, type of animals, proportion of total animals, proportion of animal feed, period of time etc.)?
- What other land uses are present in these areas?
- What kinds of environmental impacts grazing has on non-herbaceous habitats?
- How should these areas be treated vis-à-vis UAA and Gross Nitrogen Balance (GNB)? Should they be included in the GNB? If yes, to which extent?

6.1 Review, interpret and describe the Spanish pasture categories distinguished in different statistical and spatial data sources

The purpose of this section is to distinguish pasture categories that meet the CAP definition of herbaceous permanent pasture and those that are not mainly herbaceous and elaborate a classification for these types.

6.1.1 Current CAP definitions

The current CAP definition of permanent pasture describes it as "grasses and other herbaceous forage", thus apparently excluding ligneous plants. However, the rules and guidance on CAP eligibility make allowance for the presence of trees and shrubs. In other words, one thing is the *definition* and another thing is the application of this definition in policy practice in accordance with the detailed rules and guidance. There is a contradiction inherent in the policy.

Thus Regulation 1122/2009 Art 34 states that *an agricultural parcel that contains trees shall be considered as eligible area for the purposes of the area-related aid schemes provided that agricultural activities or, where applicable, the production envisaged can be carried out in a similar way as on parcels without trees in the same area.*

The MARS website marswiki.jrc.ec.europa.eu guidance clarifies further:

- With regards to **shrubs, rocks** etc., the conditions under which these elements can be considered as part of the agricultural parcel should be defined on the basis of the customary standards of the Member State or region concerned (e.g. land cover type, maximum area percentage).
- To assess the eligibility of / eligible area within an agricultural parcel of (permanent) pasture, Countries can use a **reduction coefficient**, which can take the following forms:

- a *pro rata* system whereby the eligible area taken into account is determined according to different thresholds applied at the level of each parcel. For instance, if the crown cover determined on the ortho-imagery and recorded as such in the LPIS-GIS ranges between 25% and 75%, the parcel is considered as 50% eligible.

This is precisely the approach applied in Spain until now. Thus given the flexibility built in to the CAP rules and guidance, it can be argued that all Spanish pasture types meet the 2009 CAP definition of permanent pasture, even though the great majority of pasture in Spain is not predominantly herbaceous.

Under the new wording for Permanent Grasslands and Pastures agreed under the June 2013 CAP reform texts, there is a clear option to include non-herbaceous pastures if Countries choose.

6.1.2 Overview of Spanish pasture types

Spain has an extremely long and varied pastoral tradition. Pastures cover approximately 20 million hectares (40% of the country's land area) and exist in a great variety of types, ranging from irrigated forage crops and sown silage fields to alpine grasslands and grazed forests.

Before looking in more detail at data bases, it is useful to introduce Spanish pasture types and common terminology. The Spanish Society for the Study of Pastures (SOCIEDAD ESPAÑOLA PARA EL ESTUDIO DE LOS PASTOS - SEEP) agreed a terminology/typology of pastures in 2001. The original proposals and justifications are explained in the publication Pastos (1997).

The following presentation of pasture terminology and types is based on the SEEP structure and interpretations, translated by the present author and with additional comments especially in relation to currently applied CAP definitions (the latter with underlined red font).

PASTO: *Pasture* – any vegetative resource that is used to feed domestic livestock, either through grazing or as fodder. *Pastos* are divided into two broad groups:

Pastos de origen agrícola: all pastures on agricultural land, including sown grasslands, arable stubbles and abandoned arable land

Pastos naturales* or *forestales: all unsown/uncultivated pastures and meadows

These two groups break down as follows:

PASTOS DE ORIGEN AGRÍCOLA:

Cultivos monofitos (o de mezcla sencilla): *forage crops (single species or simple mixes)* – winter or spring cereals, legumes, root crops, sown fallows etc. Mainly mown for fodder as hay or silage, but in some cases may be grazed. May be annual or pluri-annual. In CAP terms, this generally corresponds to arable land or temporary grassland, not permanent pasture.

Pradera: *Sown grass for mowing* – generally refers to more productive grasslands that have been sown with grasses and legumes and agronomically improved. Generally they are pluriannual. In some cases they are in rotation and would be considered Temporary Grasslands (<5years on same parcel), but in some cases they remain on the same parcel and are re-seeded after a number of years, in which they correspond with herbaceous CAP Permanent Pasture. Note: after several years without cultivation a pradera will revert to a more natural prado (or pastizal in drier areas).

Rastrojos: *arable stubbles* – crop residues used for grazing, especially by shepherded flocks of sheep (sometimes goats). Not CAP Permanent Pasture.

Barbecho: *arable fallows* – arable land that is left to rest for one or more years as part of a long rotation (a common practice in much of Spain, fallow land covers several million hectares annually), spontaneous vegetation used for grazing especially by shepherded flocks of sheep (sometimes goats). Some fallows are tilled and thus bare soil with no grazing. Not CAP Permanent Pasture unless >4 years, in which case they become either *erial a pastos* or *pastizal* (see below).

Erial a pastos (baldío): spontaneous vegetation on low-productivity land that is no longer cultivated and used for grazing especially by shepherded flocks of sheep (sometimes goats). Depending on the land in question and how many years since abandonment, the vegetation may be herbaceous or evolving to shrubs and trees. Considerable overlap can be expected on the ground and in data bases with *pastizal* (see below), in fact there is no clear line between the two concepts. If this land has been uncultivated for >5years then it can correspond with CAP Permanent Pasture. The critical question with this category is whether it is actually in use as forage, or whether it is in a state of total abandonment. On LPIS this category does not exist and would appear either as pasture (one of three types explained below) or as non-productive. See following section.

PASTOS NATURALES/FORESTALES:

Pastos herbáceos: *herbaceous pastures* These all meet the CAP definition of herbaceous Permanent Pasture, although they may have a high proportion of trees and shrubs. High mountain pastures could face eligibility issues post-2014 if land is required to be available for use throughout the year.

- PRADO: grasslands in more humid areas (e.g. Atlantic Spain) that are productive enough to be mown at least once per year (although they may be not mown in practice). *Prados* can have some trees and shrubs. They are unsown (and hence sometimes called *prados naturales*) but may have been improved through manuring and artificial fertilisation, and may be irrigated.
- PASTIZAL: permanent grasslands in dry areas (i.e. most of Spain) that generally are not productive enough to be mown and that dry out in the summer months. In principle they have not been sown and climate/soil conditions do not allow for significant agronomic improvement. They may be ploughed occasionally especially to clear shrubs. They frequently have scattered woody species. The LPIS category *pastizal* is defined as having less than 40% shrubs/trees.
- PASTO DE PUERTO (also called DE ALTA MONTAÑA): summer pastures at alpine and sub-alpine altitudes, relatively humid and dense and used for extensive seasonal grazing.

Pasto arbustivo: *shrub pasture* – pasture of woody species (trees or shrubs) of less than 5 metres in height. Used mainly by goats, sometimes by sheep. This type of pasture may include a significant herbaceous element but shrubs may be predominant or even 100%. Technically this does not meet the current herbaceous Permanent Pasture *definition*, but nevertheless is CAP-eligible under the flexible rules and guidance referred to above. On LPIS these pastures are defined as having >40% shrub coverage.

A new system is being introduced for 2013, with regional variations – the national framework applies automatically through LPIS a co-efficient based in a combination of slope and non-productive elements (e.g. tracks, rocks). Some regions have also applied a co-efficient based on presence of impenetrable vegetation. In regions that have not done this, the claimant should declare any patches of impenetrable shrubs that are then deducted from the eligible area.

Pasto con arbolado ralo/disperso: *Pasture with sparse tree cover* – Forest with open, gappy tree cover (natural or thinned) used for extensive grazing but not the main production. [the present author questions this last phrase from the SEEP typology – such land had other uses historically e.g. charcoal making, firewood, but at present there may be no economic use other than grazing and perhaps shooting]. See below for comments on these last 3 categories.

Dehesa: *dehesa* – a distinctive landuse of the west and south-west with more or less dispersed tree cover and a well-developed herbaceous layer, with the shrub layer is largely eliminated. Origins [and current use] are a mix of extensive cropping on very long rotations and extensive grazing. Livestock use

the herbaceous pasture as well as the tree foliage and acorns (*pasto de montanera* = pannage). Note: overlap with the previous category. In forestry data bases, some pasture dehesas appear as *pasto con arbolado ralo/disperso.* However, note also that dehesa is a landuse and landscape typical of the west and south-west of the country, with evergreen oaks pruned for wood and acorn production and often with an arable component; whereas grazed, open woodland is a more nationally widespread type of rough grazing land, usually with no tree pruning and no arable cropping. See below for comments on these last 3 categories.

Pasto con arbolado denso: *Pasture with dense tree cover* – Woodland or forest plantation of high density that allow extensive grazing of the herbaceous understorey and browsing of shrubs and trees. Grazing is more or less limited and is not the main production. However there are many situations where grazing is the main use. In the north-west of Extremadura, goat grazing is the main use of *Quercus pyrenaica* forest, and this forest provides the main forage resource for this farming system (see Annex 2 photo 2). Also see Box 1 examples for mixed use forests including grazing. See below for comments on these last 3 categories.

As indicated above, three different categories of pasture with tree cover are described, covering a wide range of situations. Dehesas may have very few trees per hectare, or a large number. The upper limit generally is considered to be 60% tree cover. However in practice there are dehesas and also large areas of grazed forest with a tree cover considerably more than 60%. Even with 100% tree cover there can be significant forage and active grazing, especially by goats. Recently the authorities have reviewed LPIS and reclassified as Forest all parcels with a tree cover >75%. This has caused many complaints and allegations from claimants. See example from Navarra below. Pastures with trees technically do not meet the current herbaceous Permanent Pasture definition, but nevertheless they comply with the CAP eligibility rules and guidance referred to above.

The SEEP categorisation makes clear that, compared with some regions of the EU where pasture is generally synonymous with grassland, in Spain there is a very wide range of vegetation types used and categorised as pasture. This includes many types of land with woody vegetation, even quite dense forest; and also arable stubbles, arable fallow and abandoned arable land.

It is very significant in the above classification that all non-cultivated pastures are referred to as "forest pastures" (also "natural pastures"), including the pure grass *prados* (meadows) of Atlantic regions. This reflects the fact that in the Spanish language "agricultural land" refers to cultivated land only. All grazing land that is unsown/uncultivated (semi-natural and natural pastures) is regarded as "forest", even if it is purely herbaceous. In the Censo Agrario (farm census) these forest pastures are all included in the UAA, while in some other data bases they are excluded from the UAA. In other words, there is a very large overlap in Spain between pastures categorised as agricultural land in agricultural data bases, and pastures categorised as forest in forest data bases, as explained below.

Livestock grazing is a major use of forest land in Spain, whether such land has tree cover or not. Pastures and grazing systems are studied as part of forestry degrees at university and are (partly) the responsibility of the forestry administration, regardless of the presence of trees. The national forest strategy has more pages devoted to pastures than to timber production (MIMAM, 1999)) reflecting the economic importance of grazing livestock as part of forest production, and this document estimates the total extent of pasture in Spain as approaching 20 m ha.

In practice, from the perspective of GNB and CAP eligibility, the most difficult issue to address is not whether a particular vegetation type meets CAP definitions and rules as Permanent Pasture, but whether a particular parcel is actually *in use as livestock forage*. This is especially problematic in the case of pastures with a high proportion of shrubs/trees, and even more so on common grazings that are not the responsibility of a single claimant. Common land in Spain covers some 7.5 million hectares, a large part of which is grazing land while some is "pure" forest.

BOX 1: forage resources in forests and dehesas with a high percentage of crown cover
In Navarra (and in other regions) there have been cases of farmers objecting to recent reclassification of wooded pastures (eligible for CAP) as forest (not eligible) on the basis of aerial photography showing a tree crown cover of >75%. More details on individual cases can be supplied.
While it is true that at high tree densities the availability of herbaceous pasture diminishes, this is not to say that >75% crown cover the pasture availability is negligible. Other factors play a critical role, e.g. tree species, soil, slope. In wood pastures of *Quercus faginea* and *Quercus humilis* in Navarra with crown cover >75%, the production of herbaceous pasture has been measured at between 250 kg DM/ha/year and 1,467 kg DM/ha/year. By comparison in herbaceous pastures of Sierra de Andía the production ranges from 900 kg DM/ha/year and 1,850 kg DM/ha/tear.

In total the forage value of *Quercus faginea* woodland taking into account grass and shrubs is estimated at 350 Forage Units per ha/year, similar to shrub pastures in the same area that are eligible for CAP support. In addition, there is a forage value in the fruits and foliage of the trees, estimated at 150 Forage Units per ha/year.

The LPIS criteria in Spain consider forest with >75% crown cover to be primarily for forest production (in the case of the ESYRCE data base, the threshold is >20% - see below), but the reality is "forest" production in many cases is limited to firewood and environmental goods. Livestock grazing cannot realistically be considered a lesser production than these two, they are all complementary.

6.2 Review and interpret pasture categories of other classifications at State level in terms of main characteristics scanning different national and regional statistical and spatial data sources

The purpose of this section is to clarify which other land cover types than pure grasslands are grazed? In which geographical areas is it mainly taking place? Under which circumstances does it take place (lack of alternative feeding sources, climatic conditions, which types of animals etc.)?

6.2.1 Types and importance of pasture other than pure grasslands

Of the total Spanish pasture area, only a very small proportion is predominantly herbaceous. This is illustrated very clearly by the LPIS data from 2013, shown in Table 17 below. Approximately 86% of the total area of pastures on LPIS are in the categories of pastures with trees (PA) and pastures with shrubs (PR). These LPIS categories have 40-100% shrub cover and 40-75% tree cover. They amount to 16 m ha in total. By contrast "herbaceous" pastures (PS) cover only 2.5 m ha, but note that this category of pasture can include up to 40% tree/shrub cover, so even this type is far from being purely herbaceous.

As Table 17 shows, pastures with >40% trees/shrubs are the predominant types in all regions of Spain, not only in certain regions. However, there are variations to the pattern. Regions where herbaceous pastures make up a more significant proportion of all pastures (though still only 30% at most) include Atlantic regions such as Asturias, Basque Country, Cantabria and Galicia, as well as Andalucía. At the other extreme are regions such as Castilla la Mancha where less than 4% of pastures are in the predominantly herbaceous category and there are 2.5 m ha of pastures with >40% trees/shrubs.

It is therefore apparent that pastures that are not predominantly herbaceous constitute the great majority of Spanish pastures (86%), that they cover a very large area of territory (>16 m ha), and that they are the predominant pastures in all regions, but especially in the drier regions.

Table 17 LPIS categories PA (pasto arbolado), PR (pasto arbustivo) and PS (pastizal) – all are CAP eligible, see Excel for criteria. FO is forest, shown on LPIS but not CAP eligible.

	2013					
	PA	**PR**	**PS**	**Total pasture**	**FO**	**TOTAL**
	(ha)	(ha)	(ha)		(ha)	(ha)
ANDALUCIA	1,006,509.87	881,027.19	965,678.66		1,153,160.06	4,006,375.77
ARAGÓN	373,460.78	1,379,050.30	43,029.85		889,389.99	2,684,930.92
ASTURIAS	11,819.92	308,187.55	109,519.05		385,660.39	815,186.90
BALEARES	40,092.49	81,008.05	3,144.78		101,403.43	225,648.75
CANARIAS	1,670.20	376,507.06	4,421.53		102,827.51	485,426.29
CANTABRIA	24,929.75	179,899.73	119,722.12		141,813.41	466,365.01
CASTILLA-LA MANCHA	816,848.95	1,669,865.52	92,891.96		983,492.80	3,563,099.23
CASTILLA Y LEÓN	772,475.24	2,277,397.58	371,840.50		1,312,796.58	4,734,509.90
CATALUÑA	397,729.72	672,859.10	40,284.47		895,323.73	2,006,197.03
EXTREMADURA	1,059,218.30	789,970.03	223,955.64		297,642.98	2,370,786.95
GALICIA	63,234.99	825,041.40	344,193.24		1,051,577.56	2,284,047.19
MADRID	94,360.39	186,774.95	37,668.71		70,524.45	389,328.50
MURCIA	93,630.50	295,201.63	6,828.34		121,418.28	517,078.75
NAVARRA	28,302.12	145,820.62	77,046.62		362,426.44	613,595.80
PAIS VASCO	22,789.40	77,123.21	73,389.13		359,448.01	532,749.75
LA RIOJA	34,082.99	182,668.91	5,454.95		84,382.79	306,589.63
VALENCIA	153,895.86	767,102.17	13,356.79		357,500.19	1,291,855.00
TOTAL	**4,995,051.47**	**11,095,504.98**	**2,532,426.33**	**18,622,982.78**	**8,670,788.59**	**27,293,771.38**

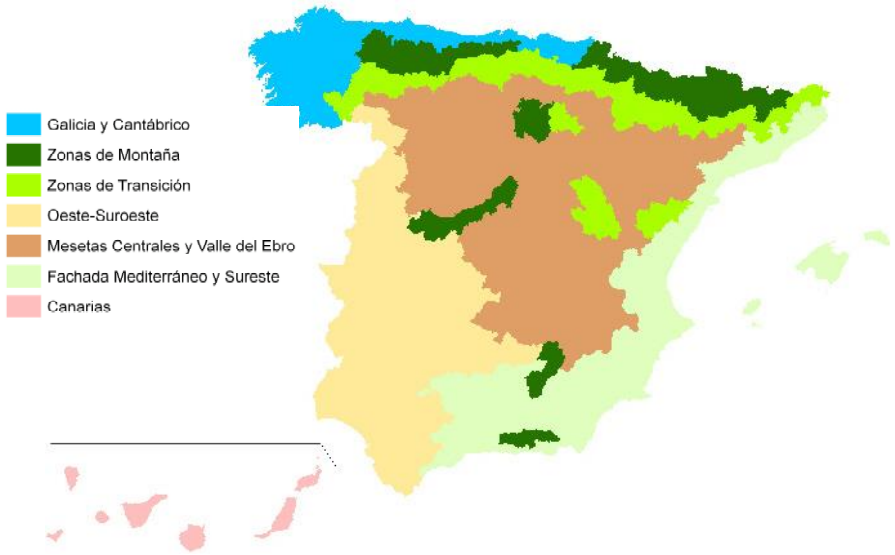
Source; SIGPAC (LPIS) 2013

6.2.2 Geographical patterns of pasture use

The TAPAS project (TAPAS, 2002) for MAGRAMA produced a zonification of Spain, based on livestock farming systems, grazing systems, climate, relief, bioclimatology and vegetation. The new GNB methodology being developed by MAGRAMA is based partly on this zonification, which is summarised below:

Table 18 Pastoral Regions of Spain

I	West-South-west
II	Galicia and Cantábrico
III	Mountain Zones
IV	Transition Zones
V	Mesetas and Ebro Valley
VI	Mediterranean and South-east
VII	Canary Islands



Regions I and II have a notable suitability and vocation for pasture-based livestock raising and account for about 65% of Livestock Units (LU) in extensive systems in Spain (50% in I and 15% in II), according to work in previous years on *Balances de Nitrógeno y Fósforo en la Agricultura Española* (B.N.P.A.E.), or Nitrogen and Phosphorous Balances of Spanish Agriculture (MAGRAMA, unpublished).

The main pastoral characteristics of the seven regions as reported in the MAGRAMA paper on GNB methodologies (MAGRAMA, unpublished) are as follows (additions by present author in underlined red font):

I. West-South-West: Mainly herbaceous xero-mesophytic and xerophytic grasslands, without or with tree cover (mainly the broadleaved dehesas), with more or less abundant *matorral* (shrub) patches. Soils are generally poor and acidic. Precipitation is typically 500-800 mm per year. Average altitude is around 500 m above sea level. Main extensive systems are of sheep and beef cattle, followed by Iberian pigs. Goats are also important, although in decline. Predominantly latifundia. This is the region where the 4 m ha of dehesa wood pastures are concentrated, mainly used by beef cattle, sheep and pigs. Treeless pastures are typical grass steppelands of this region, mainly under sheep grazing. In the uplands there are landless graziers using common lands of tree/shrub pastures, especially for goats.

II. Galicia and Cantábrico: Notable presence of unsown mesophytic grasslands suitable for mowing (*prados naturales*), using for mowing and/or grazing. Also shrubby rough pastures on acid soils, except in eastern areas where pH is near to 7. Grazing of shrubs is not common. Average precipitation is above 1,200 mm. Average altitude is 500 m, reaching 800 m in the interior. Livestock is mainly bovine, milk and beef, with some significant sheep numbers especially in the east. Predominantly minifundia.

III. Mountain Zones: In several parts of the country, and thus with a diversity of soils. Mainly seasonal mountain pastures used for grazing in spring and summer, by bovine cattle, sheep and to a lesser extent goats (depending on the area). Pastures include grasslands, shrub pastures and *eriales* (abandoned arable land), all with and without tree cover. A very high proportion are common lands.

IV. Transition Zones: Similar pastures to mountain zones, but with more grasslands suitable for mowing. In some areas cattle are more significant than sheep, and on other areas the roles are reversed.

V. Mesetas and Ebro Valley: Areas with an arable vocation. Stubbles and fallows provide an important grazing resource. Permanent pastures are mainly xeric or xero-mesophytic with a high presence of shrubs in mosaic. Precipitation averages 300 to 600 mm. Altitude is between 500 m and 800 m. Sheep are the main livestock type, followed by goats and beef cattle according to the area.

VI. Mediterranean and South-East: Region with soils suitable for cropping, especially permanent crops such as olives and citrus fruits. Pastures are of low productivity with high presence of woody species that are of better pasture quality than the herbaceous species. Precipitation averages 200 m to 400 mm. In the South-east, dairy goats and sheep are of equal importance. In the Mediterranean coastal area sheep are more important than goats.

VII. Canary Islands: Mainly extensive shrub pastures used by goats and to a lesser extent sheep. No grasslands for mowing or high mountain grasslands.

6.3 Access and report on pastures data at State level in LPIS and other data sets

The purpose of this section is to obtain quantified data on extent of each pasture category. Which is the extent of grazing outside grasslands (number of ha affected, rough number of animals, type of animals, proportion of total animals?).

The sources of quantified data on pastures are described below, including the most recent figures for the extent of permanent pastures from each data base. The attached Excel file shows the main Spanish pasture types described in Section 1 and how each of these pasture types is addressed by the most relevant data bases.

For each pasture type, the Excel shows the specific criteria that are used for each data base. These are translated from the official Spanish texts that accompany each data base. These sources are cited below for each data base and attached as pdf documents.

It can be seen that the data bases follow the same broad concepts but with significant variations in some specific categories and terminologies, and in some cases also in criteria, such as the number of trees per hectare that determine whether land is counted as pasture or as forest. In fact a large grey area exists, on the ground in and data bases, between agricultural land and forest land.

Even predominantly herbaceous pastures in less productive conditions (*pastizales*) come under the heading of "forests" on some data bases (e.g. Mapa de Cultivos y Aprovechamientos) but the same pastures are included as part of the UAA on other data bases (e.g. Censo Agrario).

Pastures with trees are classed as forests and excluded from the pasture categories in ESYRCE (tree cover >20%) and in Estadísticas Agrarias even in the case of forest land with zero tree cover, although the official text states that such land may be used as pasture under Spanish law. However on SIGPAC (LPIS) and Censo Agrario this same land is included within the pasture categories and UAA.

6.3.1 ESYRCE

http://www.magrama.gob.es/es/estadistica/temas/estadisticas-agrarias/agricultura/esyrce/

ESYRCE is a sample survey similar to the LUCAS model. It is used by the new MAGRAMA proposals for calculating nutrient balance, as they see it as the most reliable data base for the purpose (explained below).
Permanent pastures according to ESYRCE covered 8,360,026 ha in 2012. This figure includes pastures with trees up to 20% cover and pastures with shrubs that may reach 100% cover if still used for grazing. It does not include land with >20% tree cover.

6.3.2 Estadísticas Agrarias

http://www.magrama.gob.es/es/estadistica/temas/publicaciones/anuario-de-estadistica/2011/default.aspx?parte=3&capitulo=13

Agricultural Statistics (Anuarios de Estadística Agroalimentaria) are the agricultural statistics published annually by the Ministry of Agriculture MAGRAMA. These are the statistics communicated to Eurostat. They are also used as part of the nutrient balance calculations (explained below). The publication describes the statistics as being informed by various sources, including ESYRCE (above).

These statistics give a total extent of pastures (*prados* and *pastizales*) in 2011 of 6,494,036 ha. However, the extent of permanent pasture is given as 8,377,400 ha which seems to coincide with the figure from the Census (see below) and is the figure reported to Eurostat for permanent pastures in Spain. However the tables show a column for "land principally used as pasture" that includes *eriales* (abandoned cropland used for grazing), giving a total for 2011 of 10,021,637 ha. This figure does not include grazing land with trees, that is counted in the Agricultural Statistics under "forests", although the section of the statistics introducing forests explains that this includes land where scattered trees share the space with other uses, that may include grazing under Spanish law. Note that *dehesas* alone cover around 4 million ha but apparently are not counted in the permanent pasture area under these statistics.

6.3.3 Censo Agrario

http://www.ine.es/jaxi/menu.do?type=pcaxis&path=%2Ft01%2Fp042/E01&file=inebase&L=0
The Agricultural Census (Censo Agrario) is collated by the National Statistics Institute (INE). The census gives the total extent of permanent pasture in 2009 as 8,377,389 ha. In this case permanent pasture includes all types of pasture of >5 years, including pastures with trees and shrub (quantitative criteria on % coverage are not given) and *eriales*, when these are under some form of farming use.

6.3.4 SIGPAC (LPIS)

http://sigpac.magrama.es/fega/visor/ SIGPAC
is the Spanish LPIS and is the responsibility of the Paying Agency FEGA, and of the regional governments. According to LPIS there was a total area of permanent pasture of 18,622,983 ha in 2013. This figure is the sum of the categories PA (*pasto arbolado* or pasture with trees >40% cover), PR (*pasto arbustivo* or pasture with shrubs >40% cover) and PS (*pastizal* or pasture with <40% tree/shrub cover).

6.3.5 Other relevant data bases

Other relevant data bases from which data has not been extracted for this report include:
Map of crops and landuses (Mapa de Cultivos y Aprovechamientos)
http://www.magrama.gob.es/es/cartografia-y-sig/publicaciones/agricultura/mac_2000_2009.aspx
Also used as part of the nutrient balance calculations. See below.

Spanish Forest Map (Mapa Forestal de España (MFE50))

http://www.magrama.gob.es/es/biodiversidad/temas/ecosistemas-y-conectividad/mapa-forestal-de-espana/mfe_50.aspx
Developed by the Environment and forestry departments of MAGRAMA.

Sistema de Información sobre la Ocupación del Suelo en España (SIOSE)
http://www.siose.es/siose/
An integrated landuse data base developed by the Dirección General del Instituto Geográfico Nacional.

6.3.6 Number of animals using different pasture types

Data is not available on the number of animals using different pasture types. However, there is some broad data that gives an indication of tendencies in pasture use. Sheep are the livestock type most commonly farmed on an extensive basis, and data on livestock numbers since 1990 shows a very strong decline in sheep numbers. This decline is partly explained by the fact that sheep have traditionally been the main livestock on unfenced pastures (common land and arable stubbles/fallows) and this system has a high labour requirement (shepherding). It is also the case that the CAP has historically provided a much lower level of economic subsidy for sheep (and goats) compared with suckler cattle. The decline in sheep numbers has accelerated considerably since the decoupling of CAP support.

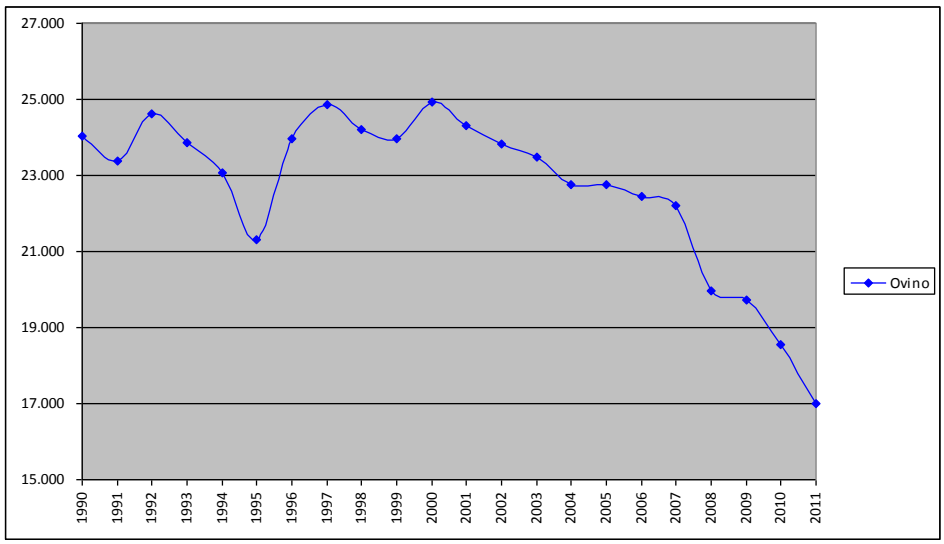


Figure 18.Trends in sheep numbers (1000 heads) since 1990. Source: MAGRAMA, unpublished.*

In contrast to sheep, the more highly subsidised bovine sector has seen a significant increase in numbers. Suckler cattle require less labour than sheep, as animals can be left unattended on extensive pastures.

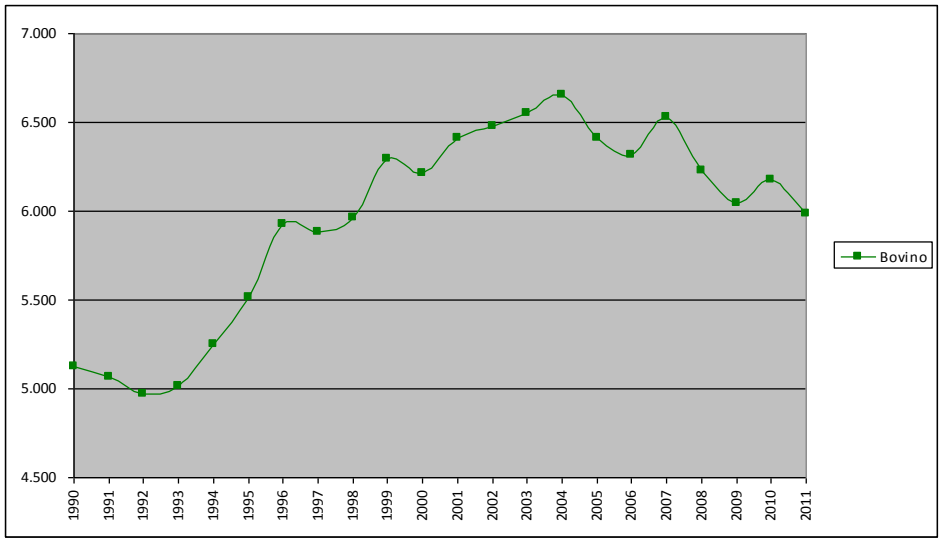


Figure 19. Trends in suckler cow numbers (1000 heads) since 1990. Source: MAGRAMA, unpublished.*

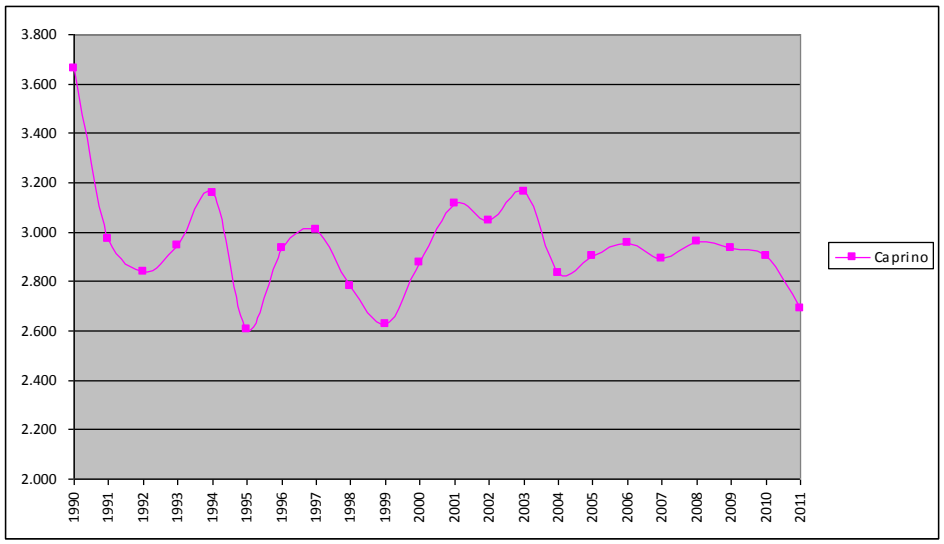


Figure 20. Trends in goat numbers (1000 heads) since 1990. Source: MAGRAMA, unpublished*

Goat numbers have also declined although less consistently than sheep numbers. Goats are also traditionally a highly extensive system using the poorest shrub and tree pastures. However, the fact that numbers have been maintained to some extent is partly because a large part of goat production is milk-orientated and more economically viable than meat production.

However both the goat and sheep sectors have seen considerable intensification, especially for dairy production, with a corresponding decline in the use of extensive pastures in many areas. This tendency is more extreme in some areas than in others.

Sheep and goats for meat production generally are extensive grazing systems, whereas dairy production is more likely to be intensive. The MAGRAMA study *Bases zootécnicas para el cálculo del balance de nitrógeno y de las emisiones de gases producidas por la actividad ganadera en España* (Madrid, 2010) found that sheep for dairy production are almost entirely in intensive production systems with little or no use of pastures. In the case of goats for dairy production, the following analysis was made of the proportion of dairy goat production in extensive and intensive regimes:

Table 19. Proportion of dairy goats in extensive/intensive regimes, by province. Source: MAGRAMA (unpublished).

			Extensive	Intensive
1	15	La Coruña	0.9	0.1
2	27	Lugo	0.9	0.1
3	32	Orense	0.65	0.35
4	36	Pontevedra	0.7	0.3
5	33	Asturias	0.8	0.2
6	39	Cantabria	0.8	0.2
7	1	Álava	0.7	0.3
8	20	Guipúzcoa	0.8	0.2
9	48	Vizcaya	0.8	0.2
10	31	Navarra	0.55	0.45
11	26	La Rioja	0.7	0.3
12	22	Huesca	0.65	0.35
13	44	Teruel	0.65	0.35
14	50	Zaragoza	0.6	0.4
15	8	Barcelona	0.55	0.45
16	17	Girona	0.55	0.45
17	25	Lleida	0.55	0.45
18	43	Tarragona	0.55	0.45
19	7	Baleares	0.3	0.7
20	5	Ávila	0.55	0.45
21	9	Burgos	0.3	0.7
22	24	León	0.3	0.7
23	34	Palencia	0	1
24	37	Salamanca	0.35	0.65
25	40	Segovia	0.65	0.35
26	42	Soria	0.7	0.3
27	47	Valladolid	0.3	0.7
28	49	Zamora	0.25	0.75
29	28	Madrid	0.2	0.8
30	2	Albacete	0.5	0.5
31	13	Ciudad Real	0.65	0.35
32	16	Cuenca	0.65	0.35
33	19	Guadalajara	0.5	0.5
34	45	Toledo	0.7	0.3
35	3	Alicante	0.5	0.5
36	12	Castellón de la Plana	0.5	0.5
37	46	Valencia	0.5	0.5
38	30	Murcia	0.3	0.7
39	6	Badajoz	0.7	0.3
40	10	Cáceres	0.6	0.4
41	4	Almería	0.4	0.6
42	11	Cádiz	0.65	0.35
43	14	Córdoba	0.65	0.35
44	18	Granada	0.65	0.45
45	21	Huelva	0.7	0.3
46	23	Jaén	0.65	0.35
47	29	Málaga	0.55	0.45
48	41	Sevilla	0.6	0.4

			Extensive	Intensive
49	35	Las Palmas	0.05	0.95
50	38	Sta. Cruz de Tenerife	0.6	0.4

Sheep and goat numbers that are in grazing regimes were calculated for the nutrient balance calculations of MAGRAMA – these are shown in section 4.

Overall, despite the decline in animal numbers it would be wrong to assume that extensive grazing systems are disappearing in Spain. There have been significant declines and changes in livestock types (e.g. fewer sheep, more cattle) in many areas, but overall the activity is still a major feature of the livestock sector and of land use on a very large scale. In the current economic crisis and with high feed costs, a trend back towards extensive grazing is reported in some areas, as farmers seek to reduce costs and make use of available forage.

6.3.7 Conclusions on data sources

Table 20 shows an overview of the extent of permanent pastures according to the main data sources, and summarises the types of pasture included/excluded in each case.

Table 20: Extent of permanent pastures in Spain according to different data sources, using most recent years available in each case

Source / year	Included / excluded	Hectares
ESYRCE 2012	Includes pastures with trees up to 20% cover and shrubs up to 100%	8,360,026
Estadísticas Agrarias 2011	Prados and pastizales, not including grazing land with trees	6,494,036
	Land principally used for grazing – as above plus *eriales*	10,021,637
Censo Agrario 2009	Includes pastures with trees and shrubs when in farming use, abandoned arable land, and pastures kept in GAEC for CAP purposes	8,377,389
SIGPAC (LPIS) 2013	Includes pastures with trees up to 75% cover and pastures with shrubs up to 100%	18,622,983

By far the largest extent is shown by LPIS (18.6 m ha). The figure is approximately 10 m ha greater than typically shown by other sources. The other data bases show broadly similar figures. In the case of Estadísticas Agrarias there are two figures, the second including *eriales* (abandoned arable land used for grazing). There are some doubts about how much of this category is in grazing use.

At first sight, it seems one explanation of the extra 10 m ha shown by LPIS may be that the category "pasture with trees" can have up to 80% tree cover. By contrast the ESYRCE data base only counts land as pasture when tree cover is <20%. The Estadísticas Agrarias exclude land with trees from the permanent pastures figure.

However, the Censo Agrario apparently includes as pasture *all* land that is used for livestock raising, with no limit applied to the tree or shrub cover. Yet the total extent of permanent pasture shown by this data base is not significantly higher than shown by ESYRCE and is considerably less than the extent of land principally used for grazing (excluding land with trees) according to the Estadísticas Agrarias; and 10 m hectares less than shown by LPIS.

The reasons for the differences between the figures shown by the different data bases therefore are not fully clear. In principle the LPIS figure should be a reasonable reflection of the reality on the ground, especially as there have been recent revisions to reclassify wood pastures with >75% crown cover as Forest (FO). The data base is constructed from interpretation of aerial photography, in some cases

corrected by farmers' allegations. If land is shown as pasture on LPIS it is almost certainly land that *could* be used as pasture, and either *is* in use or *has* been used as pasture at some time in the recent past.

However, a considerable problem is that there is no way of knowing from existing data whether a pasture is in current use. In Spain the EU requirement for farmers claiming CAP payments to declare all the land they use is reported by some commentators not to have been strictly applied. Many farmers seems to declare only the number of hectares they need to claim their SPS (Single Farm payment) rights. For historic reasons, SPS rights in Spain are available on 13 m ha less land than is shown as eligible on LPIS.

Overall, it is reasonable to assume that the permanent pasture extent shown by data bases such as Estadísticas Agrarias and ESYRCE under-estimate the extent of permanent pasture in actual grazing use, because of their exclusion of pastures with more than a certain tree cover. The Censo Agrario may be an under-estimate due to farmers declaring less than the amount of grazing land they use for their CAP claims, and then declaring the same amount on the census (this is conjecture on the part of the present author). On the other hand, the LPIS figure may be an accurate reflection of the situation when the data base was first established, but now may be over-estimate due to the decline in livestock numbers in recent years.

Thus it is reasonable to conclude that the true extent of permanent pasture in grazing use lies somewhere between 8.5 m ha and 18.5 m ha.

Linking animal numbers to particular types of pasture is generally not possible at present. In theory it would be possible if farmers declared all of their land and all of their livestock with their CAP claims.

6.4 Review which part of the pasture land is included in the Nutrient balance calculation and which data sources are used

The purpose of this section is to determine reference situation for pasture land included in the Nitrogen balance reporting of the Spanish Ministry MAGRAMA.
The present draft is based on draft papers supplied by the Ministry and subsequent queries and responses (MAGRAMA, unpublished). The overall challenges faced by MAGRAMA can be broken down into two aspects:

- Calculating as accurately as possible to true extent of pastures in use as forage
- Calculate the nutrient balance on this land, necessitating a breakdown into pasture types according to their dry-matter production and protein content

6.4.1 Estimating the extent of pastures in current use

For the calculation of the extent of pastures, the ESYRCE data was chosen as the most reliable. However, it has the disadvantage of being available in a complete form only from 2005. The MAGRAMA proposal is to use the ESYRCE categories and proportions of the total taken from 2005, but to apply these proportions to the equivalent total from the Agricultural Statistics data base (as this has a much longer time series). For the purposes of illustration, the exercise is carried out using national-level data for 2000, although the final work should be done using data at Provincial level from 2005.
As explained above, a key problem is that for some types of pasture there is no data on the extent that is actually *in use*. The permanent pasture figure derived from the ESYRCE pasture categories (see above) is assumed to be an under-estimate of the true extent of land in grazing use, because it excludes land with >20% tree cover. The approach taken therefore was to go to the opposite extreme and to start by

combining all categories of land from ESYRCE that are *potentially* in grazing use, including *eriales* (abandoned arable land) and broadleaved forest land with varying proportions of tree cover.

Table 21. Illustration of how land use percentages from ESYRCE are used to estimate extent of different pasture types from Agricultural Statistics.

ESYRCE 2005	Ha	%
Prados Naturales Secano	869.929	3,0%
Prados Naturales Regadío	70.980	0,2%
Pastizal Alta Montaña	323.696	1,1%
Pastizal Sin Arbolado	2.582.737	8,9%
Pastizal Con Arbolado	2.074.675	7,2%
Pastizal-Matorral Sin Arbolado	826.466	2,9%
Pastizal-Matorral Con Arbolado	580.853	2,0%
Matorral Sin Arbolado	5.230.862	18,1%
Matorral Con Arbolado	2.532.891	8,8%
Frondosas de crecimiento lento CA>20	2.909.186	10,1%
Erial y Baldío	2.508.783	8,7%
Otras superficies forestales arboladas	8.378.515	29,0%
TOTAL	28.889.572	

Agric Stats 2000	Ha
Prados Naturales Secano	1.213.351
Prados Naturales Regadío	326.885
Pastizal	5.492.832
Eriales	3.892.650
Monte abierto	5.055.187
Monte leñoso	4.299.892
Otras superficies forestales arboladas	9.213.714
TOTAL	29.494.511

The total figure that emerges of almost 29 million hectares (see Table 21) is clearly an overestimate of the extent of pasture in current use. In order to reduce this over-estimate to a more realistic area, a series of "corrections" were introduced step by step, as explained below.

For example the ESYRCE forest category *Forestal arbolado - Frondosas de crecimiento lento CA>20%* (slow-growing broadleaved forest with >20% tree cover) is included, but only up to a crown cover of 60% as a pragmatic cut-off point in order to capture the broadleaved forest most likely to be in grazing use, even though the text recognises that grazing can occur above this threshold. To apply this threshold, which is not available in ESYRCE or Agricultural Statistics, they use the *Mapa de Cultivos y Aprovechamientos (MCA) 1:50.000* of 2009.

For other aspects, different criteria were applied according to the region, using the regionalisation from the Ministry's TAPAS project referred to above (see map and description of zones above). For the region *Galicia and Cantábrico*, shrub pastures are not commonly used nowadays, so the hectares of these pastures were excluded for these regions, producing the corrected estimates shown in Table 22.

This produces a figure very similar to that shown by LPIS for 2013 (see above). However, further adjustments are made. The selection of the category *Forestal arbolado >20%* is excluded for all regions except for West-South-west (the dehesa region). This may be an excessive step as broadleaved forests with >20% crown cover are grazed on a considerable scale in other regions (see Box 1), but the extent is not known. This is therefore a pragmatic attempt to include only the forests that are *most likely* to be *all* grazed, which is the case in the West-South-West region.

Finally, the statistics show that there has been a severe decline in extensive livestock numbers in the past 20 years in Spain, especially of sheep and goats that are the main users of shrub pastures. The total number of these grazing animals in 1999 was 78% of the number in 1990. If it is assumed that all shrub pastures were in use in 1990, then the estimate is made that 78% were in use in 1999.
For the final calculations at provincial level the intention presumably is to factor in the continued decline of grazing livestock numbers to 2010. The statistics show a total decline from 1990 to 2010 of 47%, see Table 23.

Table 22. Adjusted pastures total estimate 2000

GNB estimate for 2000	Area (ha)
Prados Naturales Secano	888.145
Prados Naturales Regadío	72.466
Pastizal Alta Montaña	330.474
Pastizal Sin Arbolado	2.636.819
Pastizal Con Arbolado	2.118.118
Pastizal-Matorral Sin Arbolado	843.772
Pastizal-Matorral Con Arbolado	593.015
Matorral Sin Arbolado	4.627.430
Matorral Con Arbolado	2.376.163
Frondosas de crecimiento lento CA entre 20 y 60	1.664.812
Erial y Baldío	2.561.316
TOTAL	18.712.531

Table 23. Trends in grazing sheep/goat numbers since 1990 by broad livestock region.

	I: Oeste-Suroeste	II: Galicia y Cantábrico	III: Zonas de Montaña IV: Zonas de Transición	V: Mesetas y Valle del Ebro	VI: Fachada Mediterránea y Sureste	VII: Canarias
1990	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
1991	84.5%	112.0%	96.4%	108.7%	83.7%	91.6%
1992	86.4%	123.6%	93.6%	103.3%	80.1%	108.8%
1993	86.7%	124.2%	86.1%	95.7%	74.7%	118.1%
1994	87.8%	128.7%	82.7%	86.5%	78.5%	109.1%
1995	77.7%	123.4%	74.1%	79.0%	67.5%	87.5%
1996	80.4%	121.0%	81.4%	83.3%	82.7%	120.8%
1997	77.5%	125.8%	83.1%	94.1%	72.2%	112.0%
1998	79.3%	131.9%	77.3%	78.3%	73.1%	109.8%
1999	77.6%	130.0%	76.0%	83.3%	70.4%	100.8%
2000	74.4%	126.0%	76.7%	84.7%	77.3%	139.9%
2001	71.1%	121.6%	72.5%	78.0%	66.1%	145.2%
2002	76.0%	107.2%	68.5%	76.2%	63.5%	130.5%
2003	72.0%	142.5%	69.3%	68.0%	70.5%	126.8%
2004	69.1%	138.7%	61.1%	63.2%	61.1%	125.0%
2005	68.6%	135.4%	60.1%	63.3%	59.9%	152.6%
2006	66.8%	124.3%	54.0%	58.4%	55.7%	151.6%
2007	65.6%	117.3%	54.8%	58.2%	58.3%	155.9%
2008	60.8%	119.4%	49.6%	51.2%	51.5%	123.9%
2009	55.2%	106.8%	43.7%	44.2%	49.2%	108.1%
2010	52.5%	97.2%	41.8%	41.3%	47.1%	120.4%

After applying all the correction factors, the initial estimate of total uncultivated pastures for 2010 is 14 million hectares, as shown below. Note that this is almost 5 million hectares less than shown by LPIS for the same year.

Table 24. Adjusted pastures total estimate 2010.

GNB estimate for 2010	Ha
Prados Naturales Secano	901.822
Prados Naturales Regadío	36.128
Pastizal Alta Montaña	332.633
Pastizal Sin Arbolado	2.703.466
Pastizal Con Arbolado	1.807.575
Pastizal-Matorral Sin Arbolado	1.700.360
Pastizal-Matorral Con Arbolado	585.879
Matorral Sin Arbolado	2.053.246
Matorral Con Arbolado	776.530
Frondosas de crecimiento lento CA entre 20 y 60	797.059
Erial y Baldío	2.354.399
TOTAL	14.049.097

In the 2012 GNB calculations a total permanent pasture extent of 20,323,310 ha was used. To this were added arable fallows of 3,733,421 ha. The new MAGRAMA proposal is to include fallows only in regions V, VI y VII (3,280,660 ha), thus giving a total pasture extent (permanent pasture + arable fallows) of 17,329,757 ha, compared with 24,056,731 ha used in the 2012 calculations (28% less). Grazing of forage crops and stubbles is also incorporated although the exact approach is not yet determined.

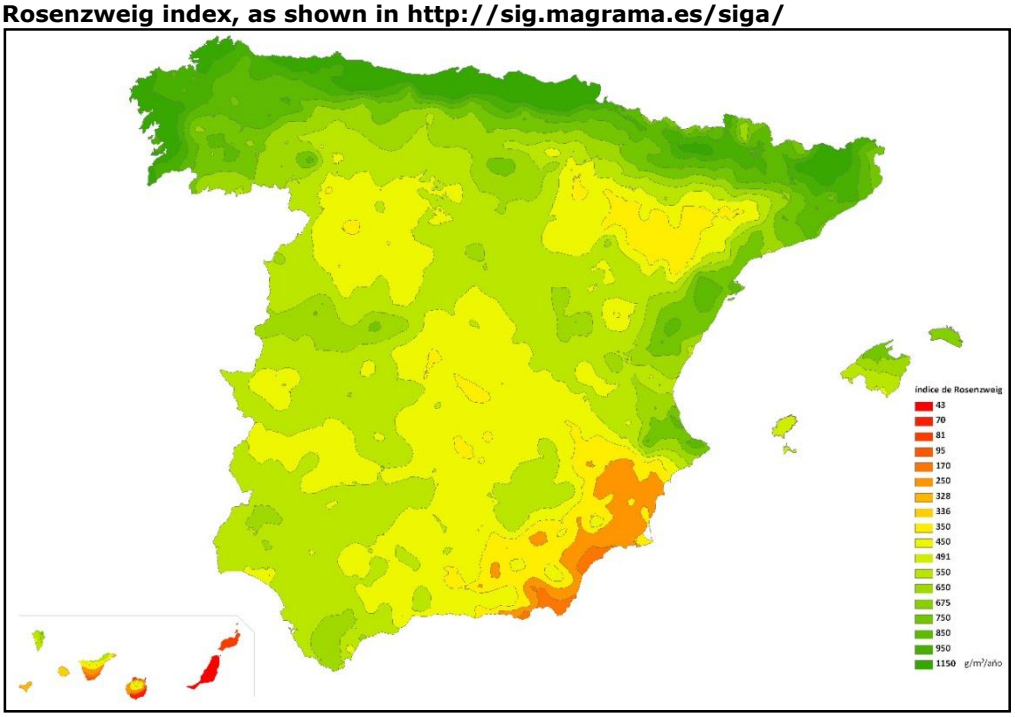
6.5 Nutrient balance method

The method used until now to calculate the Dry-Matter (D.M.) production in each pasture zone has been the *Modelo para estimar la variación anual de la producción de pastos*, using climatic variables (average monthly temperatures and rainfall), developed by the *Instituto Nacional de Investigaciones Agrarias* (I.N.I.A.). This gives an average Provincial production of DM for *prados naturales en regadío, prados naturales en secano, pastizales, monte abierto, monte leñoso* and *erial a pastos* (see Excel file for interpretations of these types).

However, this model presents a series of problems. The programme used has a number of errors for some pasture types and Provinces, with illogical results in some cases. As it is not published or documented, it is not possible to make corrections. It is programmed in dbase and current computers cannot use it. The original designer is retired from professional work.

For these reasons, a new method is required, based either on the Provincial Turc index or a similar index such as Rosenzweig that estimates net primary production on the basis of real evapotranspiration. The proposal is to use the Provincial Rosenzweig index calculated from the GIS *Sistema de Información Geográfica Agraria* (S.I.G.A.) of MAGRAMA, which covers the period 1961 to 2007.

Rosenzweig index, as shown in http://sig.magrama.es/siga/



The index is used to adjust real production values of herbaceous pastures studied in *dehesas* of Sevilla, Badajoz, Cáceres, Cádiz, Toledo and Ciudad Real over 5 years (Olea et al, 1986) to the conditions of different zones across Spain. The base values are shown below.

Table 25: Results of Olea et al.

Pasture type	Production (kg d.m./ha)	% legumes			% protein		
		Max	Min	Average	Max	Min	Average
6.5.1.1.1.1 Natural	1,440	24	4	8,5	14,9	8,5	10,3
Fertilised	2,238	48	12	18	17,8	9,7	11,6

The researchers emphasised the enormous differences in production between parcels and also from year to year e.g. parcels with annual minimum of 187 kg d.m./ha and parcels with annual maximum of 7,320 kg d.m./ha (C. Hernández Díaz-Ambrona *et al.*, 2008). And in dry years in Extremadura average productions of 640 kg d.m./ha and in normal years 3,010 kg d.m./ha (Murillo *et al.*, 2007).

Nevertheless the average figure of 1,440 kg d.m./ha for a dryland *dehesa* in Badajoz is considered a reasonable average and is used as the baseline figure to which the Rosenzweig index is applied.

6.6 Investigate pasture types and grazing systems at regional level not included in N-balance calculation

Get more detail on the specific pasture types in different regions and how they are used for livestock raising and which should become part of N-balance. What other land uses are present in these areas? What kinds of environmental impacts this grazing has? Finally clarify how these areas should be treated vis-à-vis UAA and GNB? Should they be included? If yes, to which extent?

6.6.1 Specific pasture types and how they are included in GNB

As explained in 4.1, the revised methodology being developed by MAGRAMA takes as its starting point the inclusion of all types of pasture and of all land that is potentially in grazing use. It then applies a series of "corrections" that aim to exclude land where grazing is likely to be of limited significance. The MAGRAMA draft paper explains that these corrections are crude and approximate. They are likely to exclude some land in actual grazing use in some regions, and to include some land that is out of use in other regions. However, without more informative data bases it is not possible to make precise calculations of the extent pastures actually in use, especially for the types with shrub and tree cover (the majority of pastures in Spain).

For arable fallows, a figure is used for Regions V, VI y VII (a total of 3,280,660 ha; see Table 23 for region names), taking the general category "fallows" from the Estadísticas Agrarias. However, there is a specific category for "grazed fallows" (2,736,362 ha nationally in 2011) that possibly could be used instead; the methodology is not yet fully defined on how to treat these pastures.

Also not fully determined is the methodology for including arable stubbles. The Estadísticas Agrarias include a figure specifically for grazed stubbles (5,124,814 ha in 2011) that possibly could be used. The same applies to grazed forage crops; these are discussed in the draft methodology but a definitive approach is not presented.

Overall then, there seems to be no broad type of pasture that is excluded from the proposed GNB methodology.

The methodology also attempts to include dry-matter calculations for forage sources that are not herbaceous, for example browse (tree foliage) and acorns. Thus an average figure of 400 kg of acorns/ha (fresh) is taken as a reasonable average for dehesa conditions, drawing on several data sources. This converts to 160 kg d.m./ha/year. For tree foliage, the figure selected is 400 kg d.m./ha/year.

6.6.2 Other land uses and environmental effects

Pastures in Spain are highly multifunctional, especially the pasture categories labelled as "natural" or "forest" pastures.

Typical landuses that overlap with livestock grazing include hunting and forestry (timber, firewood and non-wood products such as wild plants and fungi). See Box 1 for an example of forest pastures that are also used for timber/firewood harvesting.

Many of the larger dehesa estates are managed in part or primarily for hunting of large game such as deer and wild boar. Upland shrub and tree pastures are also used for hunting in most regions. Arable fallows and stubbles are part of the matrix of farmland where small-game shooting is widespread (e.g. hares, rabbits, partridge).

Environmental effects of pastures and associated farming systems are complex and variable according to the local situation. In simple terms the effects can be summarised as follows:

Positive impacts – keeping habitats open and maintaining biodiversity, reducing accumulation of dry matter and thus reducing fire risk and consequent carbon release land degradation, enabling public access by controlling scrub development. Grazing plays an important role in preventing wild fires especially on shrub and tree pastures. It is estimated that in the period 1990 to 2000 wild fires produced 1% of all GHG emissions in Spain.

Negative impacts – in some cases there is localised over-grazing, especially caused by bovines that are left unattended and concentrate on their preferred areas of vegetation; where there are too many animals, prevention of tree regeneration can be caused in dehesas, especially by bovines.

All of the uncultivated pasture categories ("natural" and "forest" pastures, i.e. the great majority of Spanish pastures) can be considered High Nature Value (HNV) farmland according to broad European definitions. These are described in Oppermann et al. (2011), as follows.

Mountain livestock systems
Low-intensity livestock systems occupy very large areas of land in the many mountain ranges. The farming systems are diverse and include suckler cattle, sheep (meat and dairy), goats (meat and dairy) and in some localities horses (meat, recreation). Dairy cattle were widespread in the past, especially in the northern mountain ranges, but with a few exceptions have become concentrated in coastal areas and valleys under intensified systems.

A common characteristic is the use of vast areas of semi-natural land for grazing and browsing. Practically all land used as pasture in mountain areas can be considered HNV farmland, even though current management may not always be optimum for nature conservation (over-grazing and under-grazing do occur). A large proportion of this pasture is common land, much of which is unfenced, making some use of herders necessary, especially for sheep and goats. Cattle may be left unattended for periods. Pastures range from largely herbaceous grasslands to pure shrublands and forest with quite dense tree cover.

Mountain livestock systems are responsible for maintaining a large number of habitat types of European importance (NATURA 2000 habitats). Particularly widespread are European dry heaths (habitat 4030), Alpine and Boreal heaths (4060) and Semi-natural dry grasslands and scrubland facies on calcareous substrates (6210). Other quite widely distributed types are Siliceous Pyrenean *Festuca eskia* grasslands (6140), Oro-Iberian *Festuca indigesta* grasslands (6160), Alpine and subalpine calcareous grasslands (6170), Lowland hay meadows (6510), Mountain hay meadows (6520), *Molinia* meadows (6410) and Mediterranean tall humid grasslands (6420).

Particularly in southern mountains, widespread pastoral habitats are Endemic oro-Mediterranean heaths with gorse (habitat 4090) and Pseudo-steppe with grasses and annuals of the *Thero-Brachypodietea* (priority habitat 6220).
The more productive herbaceous grasslands (*prados*) in mountains and uplands have been losing natural value in recent decades and years. Semi-natural hay meadows traditionally were widespread, particularly on the north side of the Cantabrian mountains and wetter parts of the Pyrenees and Central mountains. In the main valleys, these have undergone a process of intensification (fertilisation, reseeding) or substitution by arable crops, leading to very extensive losses of this type of HNV farmland since the 1980s. At higher altitudes, meadows have tended to revert to grazing use only, or have been abandoned. The transformation from mown to grazed-only grasslands leads to encroachment by bracken, and the deterioration of an important cultural heritage in the form of stone walls and stone and wooden buildings for animal shelter and hay storage.

The loss of traditional hay meadows has been relentless over the past 20 years. However, considerable areas still exist. In the Basque Country alone, some 50,000 ha of hay meadows are mapped on the Habitats Directive inventory, although only 3% of the inventoried area is included in designated Natura 2000 sites. Butterfly monitoring in the Parque Natural de Aiguamolls de l'Empordà (Catalunya) found that of all habitat types the traditional hay meadows were of exceptional value for the abundance of butterflies, and the variety and rarity of the species present.

Plains and hills livestock systems
The plains and rolling hills of the Spanish interior include two main pastoral systems of high nature value: the dehesas and the pseudo-steppes.

Dehesas cover approximately 4 million ha in the west and south-west. This low-intensity pastoral system consists of semi-natural pasture with an open tree canopy, usually of evergreen oaks, ranging from thinly scattered trees up to about 60 trees per ha. There is some arable cultivation on better soils, usually for the production of animal fodder. A proportion of the pasture is typically cultivated every 10-15 years to prevent gradual deterioration through scrub invasion. Traditional farms have a mix of livestock, including sheep and goats, suckler cattle and pigs, usually of native breeds. However, the tendency is towards specialisation on one or two livestock types. In recent decades, a considerable increase in livestock densities has led to a general lack of tree regeneration (Díaz *et al.*, 1997).
Silviculture is an integral part of traditional dehesa management, providing an essential part of the seasonal forage (acorns, foliage), firewood and charcoal. The pastures and acorns are especially valuable for foraging Iberian pigs and the production of quality hams, an important economic sector linked with the dehesa.

Where intact, the system maintains a diverse mosaic of habitats, including species-rich dry grassland, open woodland, scrub and low-intensity cropping. Typical Natura 2000 pastoral habitats associated with these systems are dehesas of evergreen *Quercus* spp. (6310), cork-oaks *Q. suber* (9330) and oak forests of *Q. ilex* subsp. *ballota* (9340).

Pseudo-steppes occupy vast landscapes with almost treeless scant vegetation and flat or gently undulating topography, characteristics that resemble the true steppes of Russia and Asia. Semi-natural pastures, shrub vegetation and extensive cereal crops are the main habitat components of these systems, occurring in varying proportions and with varying degrees of farming intensity. Although there are considerable cross-overs between them in terms of landuse and farming systems, three broad types of pseudo-steppe can be described, based on the dominant land cover: extensive grasslands, cereal pseudo-steppes and shrub pseudo-steppes.

In some areas the landscape is predominantly extensive permanent grassland, with arable cropping a minor element limited by physical conditions. These areas, which include also pockets of shrub vegetation, are grazed by flocks of sheep and to a lesser extent goats. Suckler cattle are common in some areas.

This landscape is widespread in the west (Extremadura, parts of Castilla y León and Andalucía), where the grazing resource is mainly private, fenced grassland, although with some cereal stubbles and fallows. Sheep farming systems have become more intensive and animals have become more concentrated in these plains areas as the uplands have suffered from abandonment. This system merges with *dehesas* (see above). Shepherded flocks exist, but these are mostly marginal producers using scattered grazing resources (e.g. village commons).

Typical Natura 2000 pastoral habitats associated with these systems are Semi-natural dry grasslands and scrubland facies on calcareous substrates (*Festuco-Brometalia*) (6210) and Pseudo-steppe with grasses and annuals of the *Thero-Brachypodietea* (priority habitat 6220). Occasional localised arable cropping adds habitat diversity to the pastoral landscape.

Cereal pseudo-steppes are found in areas with more productive potential, where extensive arable cropping is the dominant landuse. In fact arable land with high nature values generally consists of a mosaic of dryland cereal crops, fallow land, legume crops and dry grasslands. Mosaics vary in character, for example, small-scale arable mosaics are typical in parts of northern Spain (Galicia, parts of Asturias, north of Léon), while larger-scale mosaics are characteristic of the central and southern plains, often

including olives and vines amongst the mix of arable land and pastures, all of which may be grazed or browsed by livestock at certain times of the year.

These cereal pseudo-steppes cover at least 7 million ha (Oñate, 2003) and fallowing is still commonly used to enable cropping under limiting climatic and edaphic conditions. Arable fallows covered more than 3 million ha in 2009. The fallow proportion typically constitutes a third of the arable area, rising to as much as 80% on the most marginal soils. The traditional 3 year rotation is cereals (wheat, barley and oat) - fallow - legumes (vetch). Variations include a longer fallow period (up to 7 years) on less fertile soils, and a shorter cycle of alternating cereal-fallow-cereal in intensified systems. In all cases, the presence of cereal stubble during summer and autumn is typical. Agricultural productivity is low, with average cereal production of 2.5 t/ha, compared to 6.0 t/ha EU average.

Extensive livestock has important functions in this agro-ecosystem. During the fallow period, the soil is improved by incorporated stubbles along with livestock dung from grazing sheep flocks. Grazing livestock also prevent succession to scrub on areas of semi-natural vegetation, thus maintaining habitat suitable for steppeland birds, and disperse weed species that are consumed by birds.

In the vast inland plains of Castilla and Aragón, livestock producers generally own little or no land and rely on the shepherded grazing of flocks on land rented annually, usually a combination of arable stubbles/fallow on the better land and rough grazing on the poorest land and hills. The latter is often owned by local authorities. The administration of grazing rights on cereal stubbles is based on old laws and depends on Local Grazing Commissions (Juntas de Pastos) involving cereal farmers (landowners) and graziers (largely landless). Sheep for milk make more use of arable land, whereas meat sheep depend more on rough grazing. Milk sheep spend more time indoors than meat sheep, but shepherding is still practised for a large part of the year. In both milk and meat systems, the stocking densities are extremely low (0.15-0.3 LU/ha).

Depending on fallow duration, the density and composition of vegetation colonising fallow parcels varies considerably (assuming succession is not prevented by tillage). The variability in the length of fallows creates spatial and temporal habitat heterogeneity, which is positively linked to diversity and abundance of steppeland birds. The fallow land itself is particularly selected during the breeding season, and also benefits wider biodiversity (flora, invertebrates, and reptiles). The presence of landscape features such as field boundaries of spontaneous vegetation and seasonal streams and ponds (e.g. priority habitat 3170) further increases the nature value of such farmland.

Shrub pseudo-steppes are located on high altitude plains of the north and southeast. They share harsh climatic conditions and edaphic limitations, and a distinctive vegetation of coarse grasses and shrubs. The *páramos* in the Iberian highlands are characterised by scattered *Juniperus* woods (priority habitat 9560). These areas were traditionally used as summer grazing, but have suffered severe rural exodus and the traditional grazing system has declined sharply, with a move to semi-indoor systems. Many juniper wood pastures are in a state of abandonment with rampant scrub invasion. Dupont's lark (*Chersophilus duponti*), the most threatened passerine bird in Europe, is an emblematic species of such areas. This bird's habitat depends on continued grazing for its existence, and abandonment of this activity is among the main threats to the species.
In the southern shrub pseudo-steppes, pockets of arable crops are located in valley bottoms and better soils, but the landscape is dominated by coarse grasses and shrub in a highly diverse mosaic. Important priority habitats include Mediterranean saline steppes (1510) and gypsum vegetation (1520). Meat sheep and goat rearing is nowadays the dominant use, the harvesting of esparto grass (*Stipa tenacissima*) and aromatic plants being almost abandoned.

Long-distance transhumance between plains and mountains was a major feature of livestock farming in Spain until the recent past. Some 125,000 km of drovers' roads are still in existence and protected by law, forming valuable ecological corridors and recreational routes. Although much reduced from historic

levels, long-distance transhumance is still practised by some farmers, often by lorry. More local livestock movements on foot between lowlands and neighbouring uplands and mountains (*trasterminancia*) is still common in many areas and is essential to the continued maintenance of high mountain pastures, and of the network of drovers' roads. It is estimated that around 100,000 head of livestock still undertake seasonal movements on foot every year (J. Garzón, pers. com.).

6.7 Conclusions

The great majority of grazing land in Spain is not purely herbaceous grassland. On the one hand are vast areas of grazed arable stubbles and fallow. On the other hand, the majority of permanent pastures include a considerable proportion of shrubs and/or trees. Grassland with <40% tree/shrub cover represent only 14% of the total permanent pasture.

Pasture classifications in Spain are quite clear, and many of the broad concepts are common across different data sources. However, there are considerable variations in interpretation and in specific criteria (such as tree density thresholds) resulting in different data sources showing very different totals of permanent pasture. Currently there is no reliable data for calculating the total extent of all categories.

The main differences between data bases relate to the dividing line between farmland and forests. Some data bases put large areas of less productive pastures into forest categorises, even when predominantly herbaceous (e.g. Mapa de Cultivos y Aprovechamientos, Mapa Forestal de España). Some data bases can include pastures with a very high percentage of shrubs/trees as farmland (e.g. LPIS). The percentages of tree/shrub cover applied to different categories also varies from one data base to another. See Annex 2.

Another important dividing line in some data bases is between permanent pasture and abandoned farmland used for grazing (eriales). The latter category covers very large areas of land but an unknown proportion is in actual grazing use. The inclusion or not of this category makes a very significant difference to estimates of total pasture area. For example, the extent of "permanent pasture" in the Estadísticas Agrarias is considerably less than the extent of "land used principally for grazing" (including eriales but excluding arable stubbles, fallows etc.) shown by the same data base.

Agricultural data bases provide very detailed information on the "agricultural" pasture categories (forage crops and cultivated meadows), including the extent of different types, their productivity and the methods of use. However, far less information is available on the wide range of uncultivated pastures, including forest pastures. There is no reliable source of data on the actual use of these pastures, i.e. if there are in use or not, and if in use then what is the livestock density or grazing days per year.

This is a major problem from the point of view of a range of Agro-Environmental Indicators, not only GNB but also in relation to biodiversity, High Nature Value farming and other environmental services. It is also a problem for reporting under Article 17 of the Habitats Directive, given that a large proportion of uncultivated pastures are Annex 1 habitats. These habitats depend on appropriate grazing for their maintenance, and many species of conservation concern also depend on continued grazing of uncultivated pastures, including forest pastures, for example many butterfly species. Monitoring the actual use of this land, and whether it is grazed and with approximately what livestock density, is therefore of considerable interest. Without such data it is impossible to assess the trends affecting vast areas of Annex 1 habitats.

The situation could be greatly improved by standardisation and harmonisation of data sets, and accurate recording of what pastures each farmer is really using, and of the total LU using pastures on the holding and off the holding. This could be tightened up considerably through CAP declarations, LPIS, Farm Census and ESYRCE. Effective indicators cannot be devised without data on different land cover and vegetation types, and on LU and where they are.

7 Proposal for definitions and classification of grasslands

7.1 Introduction

A proposal has been made for possible definitions and classification of grassland based on the needs for grassland data in different policies (Chapter 1), the existing data sources, classification and definitions (Chapters 3). The classification scheme should include all types of grasslands, and be used for collection of data related to land cover, land use, and management. The EGF/Multisward working group has proposed classifications for agricultural statistical systems based on grassland types only, on all fodder types, and all agricultural land use types (Annex 1). Deviations between the grassland classification proposed in the current project and that of EGF working group will be elucidated in this Chapter. The proposed classification scheme is shown in Figure 21. This is the whole classification scheme, but for most of the policies only a selection of the categories included in the scheme are relevant (paragraph 7.7).

The focus of the study presented in this report was on agricultural grasslands, because of the large impact of grassland area and yield on nutrient balances. In the project *Aspects of data on diverse relationships between agriculture and the environment (DG ENV contract no.: 07-307/2012/633993/ETU/B1)* a consortium led by Alterra made a proposal for definitions of Ecological Valuable Grasslands. The focus of that project was biodiversity in relation to Common Agricultural Policy (Elbsersen et al., 2014). The study of Elbersen et al. (2014) shows that countries set different thresholds and rules for inclusion of land in the permanent grassland category and, therefore, show large differences in what they include in the eligible area, e.g. in some Mediterranean countries wood-pastures or grazed agro-forestry areas are included (see also the case study of Spain in Chapter 6). In countries in North and Western Europe the types of grasslands separately registered in different statistical sources is generally limited to the categories in FSS.

A specific issue is how to determine the boundary between grasslands and forests. Some data bases (e.g. LUCAS) apply tresholds on three and shrub canopy and by that exclude large areas of grazed lands, such as the Iberian Dehesas/montados and wooded meadows. However, these grasslands should be accounted for in the grassland classifications, although they may be excluded in the nutrient balance calculations as the external inputs of nutrients by fertilizers is generally limited. The nitrogen and phosphorus excreted during grazing of these types of grassland areas is mainly derived from an internal cycle (i.e. the grazed grass or other plants) and the nutrient balance of these systems do not provide an indicator of nitrogen pressure on the environment. Eurostat launched the project described in the current report because of the need of reliable data for nutrient balances. According to the Eurostat/OECD Gross Nitrogen Balances Handbook, "ideally the balance result should be related to the area of agricultural land which is potentially fertilised, to avoid a bias in the result for countries with large extensive and not utilised areas". The reference area should thus refer to the potentially fertilised utilised agricultural area, where "potentially fertilised" means fertilised with mineral and organic fertilisers. Areas used for extensive grazing that are normally not actively fertilised with mineral or organic fertilisers can therefore be excluded in the calculation of nutrient balances.

In the following paragraphs a grassland classification based on a differentiation in nitrogen inputs is proposed to be used for biodiversity classification and nutrient balances. At relatively low nitrogen inputs,

grasslands may still have ecological value. Part of the agriculturally improved grassland with low nitrogen inputs can be considered High Nature Value (HNV) grassland (e.g. HNV farmland type 2 and 3).

Elbersen et al. (2014) concluded that it is important to consider an appropriate EU-level definition of uncultivated grasslands, including grasslands in which herbaceous forage coverage is not predominant for defining the management parameters of ecologically valuable grasslands at the EU level.

Grassland				
	Agricultural grassland			
		Permanent grassland		
			Agriculturally improved grassland	
				Nitrogen input; < 50 kg N/ha/yr
				Sole use — ***Biodiversity classification***
				Common land — ***Biodiversity classification***
				Nitrogen input; 50 - 150 kg N/ha/yr
				Sole use — ***Biodiversity classification***
				Common land — ***Biodiversity classification***
				Nitrogen input; > 150 kg N/ha/yr
			Unimproved grassland	
				Sole use — ***Biodiversity classification***
				Common land — ***Biodiversity classification***
			Grassland out of production but maintained — ***Biodiversity classification***	
		Temporary grassland		
			Pure grass	
			Pure legume	
			Mixture grass - legume	
	Non-agricultural grassland			
		Natural grassland — ***Biodiversity classification***		
		Recreation and ornamental grassland		

Figure 21. Proposed grassland classification scheme.

7.2 Grassland

The classification starts with a broad definition of "grassland", i.e. a land cover type including all agricultural and non-agricultural grasslands.

Most definitions of grassland only include grassland with dominantly agricultural use (paragraph 3.3). LUCAS also include non-agricultural grassland. Through remote sensing data on both agricultural and non-agricultural grasslands is available.

LUCAS defines grassland as *Land predominantly covered by communities of grassland, grass like plants and shrubs. The density of tree-crown is less than 10% and the density of tree+shrub-crown is less than 20%.* LUCAS uses direct ground observations including land use, and is complementary with other statistical sources, such as FSS. In LUCAS the following links with land use are made for grasslands:

- E10 - U111 Agriculture: Permanent pastures, rough grazings, alpages, meadows
- E10 - U112 Fallow and abandoned land
- E10 - U120 Clear cuts within previously existing forests
- E10 - U210 Energy production
- E10 - U31x Associated areas of transport areas

- E10 - U340 Grassland attached to commerce, finance or business areas
- E10 - U350 Grassland attached to community service areas
- E10 - U36x Grassland for recreation: public gardens, golf courses and nature reserves
- E10 - U370 Grassland attached to residential areas
- E10 - U400 Natural grassland or grassland outside agricultural areas not utilized

The following definition of grassland is proposed: *Land predominantly covered by grass, grass like plants, forbs and shrubs and that in some circumstances may also have a tree canopy, including*

iii) agricultural used permanent and temporary grassland and legumes and

iv) non-agricultural grassland including fallow and abandoned land, clear cuts within previously existing forests, grasslands associated to residential, transport, business, and community service areas, grassland for recreation, natural grassland not used for grazing and grassland outside agricultural areas not utilized.

7.3 Agricultural grassland

In the project *Aspects of data on diverse relationships between agriculture and the environment* (DG ENV contract no.: 07-0307/2012/633993/ETU/B1; Elbersen et al., 2014) the definition of grassland is A*ll land which is in agricultural use and is not permanent crops or arable and thus:*

- *Excludes grasslands in which there is no evidence of human intervention (e.g. through grazing, mowing) and cannot therefore be categorized as agricultural land.*
- *Includes all uncultivated land with vegetation that is grazed and/or cut for fodder, including herbaceous and non-herbaceous species.*

This definition holds for permanent grasslands and does not include temporary grassland.

The EGF working defines grassland (paragraph 3.5 and Annex 1) as: *Land devoted to the production of forage for harvest by grazing/browsing, cutting, or both, or used for other agricultural purposes such as renewable energy production. The vegetation can include grasses, grass-like plants, legumes and other forbs. Woody species may also be present. Grasslands can be temporary or permanent.*

Both proposals deal with agricultural grassland. The following definition of grassland will be used for grassland: *All land which is in agricultural use and is not permanent crops or arable, except temporary grassland and legumes, and thus:*

- *Excludes grasslands in which there is no evidence of human intervention (e.g. through grazing, mowing) and cannot therefore be categorized as agricultural land.*
- *Includes all uncultivated land with vegetation that is grazed and/or cut for fodder or other biomass use, including herbaceous and non-herbaceous species.*

When proposing this definition we follow the recommendation on this issue already made by the EFNCP in a study by Beaufoy et al. (2010) who state that 'that minimum activity should be the basic criterion for determining if a pasture is eligible to receive direct payments, not whether it is grass, shrub or wood pasture, or whether the proportion of herbaceous vegetation is dominant'. Therefore all pasture lands that are grazed or cut and thus show evidence of minimum activity should be covered in the permanent grassland definition in all EU countries. Following this logic also ensures we do no longer create 'grey areas' that have a too high tree or shrub coverage and for that reason fall outside any registration system. From the case study in Spain (see Chapter 6) such an approach is legitimate given the observation that there are *dehesas* and also large areas of grazed forest with a tree cover considerably more than 60%. Even with 100% tree cover there can be significant forage and active grazing, especially by goats. While it is true that at high tree densities the availability of herbaceous pasture diminishes, this is not to say that >75% crown cover the pasture availability is negligible. Other factors play a critical role, e.g. tree species, soil, slope. In wood pastures of *Quercus faginea* and *Quercus humilis* in Navarra

with crown cover >75%, the production of herbaceous pasture has been measured at between 250 kg dry matter/ha/year and 1,467 kg dry matter/ha/year. By comparison in herbaceous pastures of Sierra de Andía the production ranges from 900 kg dry matter/ha/year and 1,850 kg dry matter/ha/year.

7.3.1 Permanent grassland

The definition of permanent grassland is important for the eligibility criteria in CAP. The following definition has been proposed for permanent grassland in the most recent CAP reform proposal[22] : *Permanent grassland and permanent pasture means land used to grow grasses or other herbaceous forage naturally (self-seeded) or through cultivation (sown) and that has not been included in the crop rotation of the holding for five years or more; it may include other species such as shrubs and/or trees which can be grazed provided that the grasses and other herbaceous forage remain predominant; as well as, subject to a decision by Member States to include land which can be grazed and which forms part of established local practices where grasses and other herbaceous forage are traditionally not predominant in grazing areas.*

The EGF working group proposes the following definition of permanent grassland (paragraph 3.5 and Annex 1): *Grasslands used to grow grasses or other forage (self-seeded or sown and/or reseeded) and that have not been completely renewed after destruction by ploughing or spraying (herbicide) for ten years or longer. They can be agriculturally improved, semi-natural or no longer used for production.*

The EGF working group state about the age of grassland: "Long-term grasslands provide more ecosystem goods and services than short-term grasslands (ex.: carbon storage, biodiversity levels). A minimum duration of 10 years is necessary in most situations for reaching, in a previously cultivated soil, a level of soil organic carbon that is representative of long-term permanent grasslands. A period of 10 years is also considered as a minimum for reaching soil biodiversity and especially higher plant diversity that is noted in long term permanent grasslands for a given intensification level. The effects of cultivating and reseeding can though vary according to the region and type of grassland, and the acceptable frequency of cultivation also varies. For example, in Mediterranean areas, self-seeded permanent grasslands consisting mainly of annuals can be tilled (light harrowing, not deep ploughing) e.g. every few years without destroying floral biodiversity."

It is clearly acknowledged that the CAP and the EGF definition are fundamentally different. The CAP definition still leaves room for a complete renewal of the grass through ploughing and reseeding while in the EGF definition a complete renewal of the grass is not possible. The other difference is the length of the period a grassland needs to be excluded from the rotation. The EGF gives a good explanation for the requirement of 10 years and this confirms that they specifically link ecosystem service capacity of a grassland to the definition of the permanent grassland category.

It is recommended to use the definition for permanent grassland as proposed in the CAP, because then there is a direct link with eligibility criteria in CAP, but to change the age to ten years or more as proposed by EGF. The proposed definition of permanent grassland is:

*Permanent grassland and permanent pasture means land used to grow grasses or other herbaceous forage naturally (self-seeded) or through cultivation (sown) and that has not been included in the crop rotation of the holding for **ten** years or more; it may include other species such as shrubs and/or trees which can be grazed provided that the grasses and other herbaceous forage remain predominant; as well*

[22] Proposal for a Regulation of the European Parliament and of the Council establishing rules for direct payments to farmers under support schemes within the framework of the common agricultural policy *(CAP Reform)- Consolidated draft Regulation. September 2013.*

as, land which can be grazed and which forms part of established local practices where grasses and other herbaceous forage are traditionally not predominant in grazing areas.

This definition is consistent with the overall agricultural permanent grassland definition above. It should include all land used for grazing and/or cutting, including herbaceous and non-herbaceous species, whatever their relative area coverage is.

Three groups of permanent grassland should be considered: agriculturally-improved grassland, unimproved grassland and grasslands out of production but maintained. This differentiation is needed for biodiversity classification, CAP payments, and calculation of nutrient balances.

Agriculturally-improved grassland

The working group of the EGF gives the following definition for agriculturally-improved permanent grasslands: *Permanent grasslands on good or medium quality soils, used with more frequent defoliations, higher fertilization rates, higher stocking rates and producing higher yields than semi-natural grasslands.*

A differentiation in nitrogen inputs is proposed to be used for biodiversity classification and nutrient balances. At relatively low nitrogen inputs, grasslands still may have biodiversity value. Part of the agriculturally improved grassland with low nitrogen inputs can be considered as High Nature Value (HNV) grassland. HNV farmland are defined as[23] : *Those areas in Europe where agriculture is a major (usually the dominant) land use and where that agriculture supports, or is associated with, either a high species and habitat diversity or the presence of species of European conservation concern, or both."*

Grassland with high nitrogen inputs have largest risk of nitrogen losses to the environment. These grasslands are important for environmental policies such as the Nitrates Directive. These grasslands are also important for calculations of nutrient balances, because of the high nitrogen inputs and, generally, high yields.

A classification based on nitrogen inputs has been chosen because it can also be used for classification of agriculturally improved grassland with ecological value. Another option is the a classification on basis of yields. Grassland yields are not only affected by the nitrogen input, but also by pedo-climatic factors, such as temperature, rainfall and soil type. Accurate data about grassland yields should be collected to calculate nutrient balances. It is proposed to collect yield data for all types of grassland are collected using the proposed methodologies to estimate grassland yields (Chapter 4) instead of a classification based on yields (e.g. using potential yields based on maps of pedo-climatic zones[24]).

The following nitrogen input classes are defined:

- Agriculturally-improved permanent grasslands with N inputs by fertilizer, manure, grazing and biological N fixation < 50 kg N per ha per year
- Agriculturally-improved permanent grasslands with N inputs by fertilizer, manure, grazing and biological N fixation 50 - 150 kg N per ha per year

[23] See (Elbersen et al., 2014) for the report of the project *Aspects of data on diverse relationships between agriculture and the environment (DG ENV contract no.: 07-0307/2012/633993/ETU/B1)* for a more detailed description of semi-natural grasslands and High Nature Value farmland

[24] See report of the project Recommendations for establishing Action Programmes under Directive 91/676/EEC concerning the protection of waters against pollution caused by nitrates from agricultural sources http://ec.europa.eu/environment/water/water-nitrates/studies.html

- Agriculturally-improved permanent grasslands with N inputs by fertilizer, manure, grazing and biological N fixation > 150 kg N per ha per year

Unimproved agricultural grassland (semi-natural grassland)
Unimproved agricultural grasslands are grasslands that are not agriculturally-improved through cultivation, reseeding, fertilization, irrigation and drainage. These grasslands are grazed or used for making hay, and additional inputs of nutrients by fertilizers or manure are low (< 50 kg N per ha per year). The nutrient inputs are low, the yields are low, and the livestock density is low, so that these grassland should not be accounted for in the calculation of nutrient balances.

In the project *Aspects of data on diverse relationships between agriculture and the environment* (Elbersen et al., 2014) Ecological Valuable Grasslands (EVG) have been defined as *A category of grasslands (including those with non-herbaceous species) that are notable, within the overall context of agricultural grasslands, for their ecological value. EVG have a spectrum of values depending on management but focus on biodiversity value and there is often a strong relation between high biodiversity value and other services. The EVG are semi-natural and natural grasslands that are not agriculturally-improved (e.g. through cultivation, reseeding, fertilisation, irrigation and drainage) of long standing and species–rich (taking account of all taxa not only higher plants).*

The EGF working group defines semi-natural grassland as *Low-yielding permanent grasslands, dominated by indigenous, naturally occurring grass communities, other herbaceous species and, in some cases, shrubs and/or trees. These mown and/or grazed ecosystems are not substantially modified by fertilisation, liming, drainage, soil cultivation, herbicide use, introduction of exotic species and (over-)sowing.*

In the EGF definition of semi-natural grasslands there is still room for some limited improvement of the grasslands as long as it does not lead to a substantial modification. These semi-natural grasslands fall in the "Unimproved permanent grassland".

The unimproved grassland category includes rough grazing, which is defined in FSS as *Low yielding permanent pasture, usually on low quality soil, for example on hilly land and in high altitudes, usually unimproved by fertiliser, cultivation, reseeding or drainage. These areas can normally be used only for extensive grazing and cannot support a large density of animals and are normally not mowed.*

The definition of Elbersen et al. (2014) will be adopted in the classification scheme (Figure 21) with a small modification, i.e. that there is still room for some limited improvement of the grasslands as long as it does not lead to a substantial modification. By that, the semi-natural grasslands defined by EGF fall in the "Unimproved permanent grassland".

The final definition for unimproved permanent grasslands is therefore as follows:
A category of grasslands (including those with non-herbaceous species) that are notable, within the overall context of agricultural grasslands, for their ecological value. Unimproved grasslands have a spectrum of values depending on management but focus on biodiversity value and there is often a strong relation between high biodiversity value and other services. Unimproved grasslands are semi-natural and natural grasslands that are not substantially agriculturally-improved (e.g. through cultivation, reseeding, fertilisation, irrigation and drainage) of long standing and species–rich (taking account of all taxa not only higher plants).

In order to define the 'long-standing' attribute of these grasslands it is suggested to link to the threshold proposed by EGF for permanent grasslands specifying that these have not been renewed through ploughing and reseeding for 10 years or more. The 10 year threshold can also be combined with the status of 'unimproved' implying that grasslands have to be unimproved for 10 years or longer.

One final note should be made and that is that some originally natural grasslands can also be part of this unimproved permanent grassland class. These refer to natural grasslands which have some extensive level of grazing with livestock that have taken over the grazing function of wild species (e.g. deer, rabbits etc.).

Grasslands out of production but maintained

A special group of permanent grasslands are the grasslands that are no longer used for production. These grasslands eligible for the single payment as long as they fulfil the Cross Compliance requirements of minimal level of maintenance and, therefore, should be included in the classification scheme as separate class.

In FSS these grasslands are defined *as areas of permanent grassland and meadows no longer used for production purposes, which, in line with Regulation (EC) No 1782/2003 (or, where applicable, the most recent legislation), are maintained in good agricultural and environmental condition and are eligible for the single payment.*

The EGF provides the following definition for permanent grasslands no longer used for production: *Areas of permanent grasslands, regardless of the grassland type and the previous use, of which the produced biomass is no longer used for agricultural production purposes, but which are maintained in good agricultural and environmental condition by appropriate measures.*

These grassland should not be accounted for in the calculation of nutrient balances.

Common land

Eurostat defines *common* land *as the land not belonging directly to any agricultural holding but it is land on which common rights apply; the area used by each holding is not individualised*.

In general terms, common land is utilised agricultural area owned by a public authority or entity (state, parish, farmers' association, individual land owner etc.) over which another person is entitled to exercise rights of common, and these rights are generally exercisable in common with others. Most common lands fall in the permanent grassland category as defined in the most recent CAP reform definition. The majority of common land is used for grazing animals.

Most common land is found in Mediterranean Countries (Portugal, Spain, Cyprus, Italy, Greece and France), in mountainous countries (Switzerland, Austria, Norway), in some Central and East European countries (Slovenia, Bulgaria, Hungary, Romania, Montenegro and Croatia), in countries which have extensive grassland areas (Ireland, Iceland and the United Kingdom) and in Germany. In Regulation 1166/2008 it was decided that data on the UAA collected in the FSS should cover common land in all countries. Common land is also covered by crop statistics.

The EGF working group defines common land as *Permanent grasslands where two or more persons have the right to graze concurrently; in some cases these rights are not permanently vested in the same individuals but are allocated from time to time by a body with legal authority to do so.*

To avoid double counting of areas of grassland in farm statistics, data about common land and grassland of a sole owner should be collected separately. Therefore common land is included in the classification as an additional classification variable (see Figure 21). Common land can be found in the category of agriculturally improved grassland with low nitrogen inputs and that of unimproved grasslands. The EGF definition of common land is adopted in the classification scheme.

7.3.2 Temporary grassland

CAP gives a definition of permanent grasslands. The remaining agricultural grasslands can be considered as temporary grasslands. In FSS, temporary grassland consists of two types of crops, i.e. forage plants and temporary grass.

D/18 Plants harvested green (2.01.09):
I. All 'green' arable crops intended for animal feed, grown in rotation with other crops and occupying the same land for less than five years (annual or multiannual feed crops).
II. These 'green' (as opposite to those 'for dry grain') crops are normally used for allowing animals to graze or are harvested green, but can be also harvested dried, like dry hay. Generally the whole plant, except the roots, is harvested and used for fodder. Crops not used on the holdings but sold, either for direct use on other holdings or to industry, are included. Cereals, industrial plants and other arable land crops harvested and/or consumed green for fodder are included. Fodder roots and brassicas (D/12) are excluded.

D/18a Temporary grass (2.01.09.01):
I. Grass plants for grazing, hay or silage included as a part of a normal crop rotation, lasting at least one crop year and less than five years, sown with grass or grass mixtures. The areas are broken up by ploughing or other tilling or the plants are destroyed by other means such as by herbicides before they are sown again.
II. Mixtures of predominantly grass plants and other forage crops (usually leguminous), grazed, harvested green or as dried hay are included here. Annual grass crops (lasting less than one crop year) are not included here.

The EGF working group defines temporary grasslands as: *Grasslands sown with forage species that can be annual, biennial or perennial. They are sown on arable land and can be integrated in crop rotations or sown after another grassland vegetation. They are kept for a short period of time (from a couple of months to usually a few years). They can be established with pure sowings of legumes, pure sowings of grasses or grass/legume mixtures.*

The EGF defines three subcategories of temporary grasslands, i.e. 'Leguminous plants' that are pure stands of leguminous plants or mixtures of predominantly leguminous plants mixed with grasses.

For calculation of nitrogen balance, the EGF proposal has the advantage that the N input by biological N fixation can be better estimated when three classes of temporary grasslands are distinguished, i.e. pure sowings of legumes, pure sowings of grasses or grass/legume mixtures. Also for CAP it is important to distinguish between different forage crops (paragraph 7.7.1). Chapter 0 presents a methodology to estimate biological N fixation. The classification for temporal grassland proposed by EGF is adopted.

Temporary grassland are generally use in intensive cropping systems and therefore no nitrogen input classes are distinguished.

7.4 Non-agricultural grassland

Non-agricultural grassland *is defined as natural, recreation and ornamental grasslands, not used for agriculture and not part of the utilized agricultural area.*

Non-agricultural grasslands include the following LUCAS land use classes
- U112 Fallow and abandoned land
- U120 Clear cuts within previously existing forests
- U31x Associated areas of transport areas
- U340 Grassland attached to commerce, finance or business areas
- U350 Grassland attached to community service areas

- U36x Grassland for recreation: public gardens, golf courses and nature reserves
- U370 Grassland attached to residential areas
- U400 Natural grassland or grassland outside agricultural areas not utilized

7.4.1 Natural grassland

In the proposed classification scheme (Figure 21), natural grasslands are not part of the utilised agricultural area, and there is no human interference to stimulate production of biomass, such as application of fertilizer, and manure, livestock grazing or mowing.

Corine land cover classification defines natural grasslands as: *Natural grasslands are low productivity grasslands, often situated in areas of rough, uneven ground. Natural grasslands frequently includes rocky areas, briars and heathland. Natural grasslands are areas with herbaceous vegetation (maximum height is 150 cm and gramineous species are prevailing) which cover at least 50 % of the surface covered by vegetation which developed under a minimum human interference (not mowed, fertilized or stimulated by chemicals which might influence production of biomass); here belong for instance grass formations of protected areas, karstic areas, military training fields, etc. (even though the human interference cannot be altogether discarded in quoted areas, it does not suppress the natural development or species composition of the meadows), areas of shrub formations of scattered trees.*

It is however clear that the status of 'non-agricultural use' is difficult to establish based on the Corine land cover classification. Several of the grasslands identified in Corine as 'natural grasslands' will in fact be unimproved agricultural grasslands, especially those where livestock has taken over the natural grazing function of wild animals.

The EGF working group wrote that natural vegetation types are communities where the vegetative cover is in dynamic balance with the abiotic and biotic (human species excluded) forces of its ecosystem. Semi-natural vegetation is not planted/sown by humans but is influenced by human actions. These may result from grazing, cutting or burning. Previously cultivated areas that have been abandoned and where vegetation is regenerating may also evolve to semi-natural vegetation. In contrast with natural vegetation, semi-natural communities need thus regular anthropogenic disturbances to be maintained.' If the latter is the case these grasslands will fall in the agricultural unimproved grasslands category.

In the proposed classification the Natural grasslands are therefore defined as *Non-agricultural low productivity grasslands, including climax grasslands, with minimum human interference (not mowed, fertilized or stimulated by chemicals which might influence production of biomass), often situated in areas of rough, uneven ground.*

7.4.2 Recreation and ornamental grasslands

Recreation and ornamental grasslands include *all grasslands associated to residential, transport, business, and community service areas, and grasslands for recreation (public gardens, golf courses).*

7.5 Biodiversity classification

Following the classification scheme in Figure 21, there are several grassland categories which have ecological value (agriculturally improved grasslands with low input, unimproved grasslands, grasslands out of production but maintained, and natural grasslands. For these categories, the classification can be extended on basis of plant species (as biodiversity indicator). This biodiversity classification is needed for Habitat Directive (92/43/EEC), the EU biodiversity strategy 2020 (COM(2011) 244), and Renewable Energy Directive (RED) (Directive 2009/28/EC). There are several European habitat classifications, including Annex I habitats of the EU Habitats Directive, the EUNIS habitat classification and the

phytosociological alliances as well as the nomenclatures of the following databases: CORINE Biotopes, CORINE land cover and the PNV map (paragraph 3.3.11).

The development of biodiversity classification of grasslands fall out of the scope of this study. The project *Aspects of data on diverse relationships between agriculture and the environment (DG ENV contract no.: 07-0307/2012/633993/ETU/B1)* deals with aspects related to ecological value of grasslands in relation to CAP and other policies.

7.6 Proposed scheme and definitions

7.6.1 Proposed scheme and definitions

The proposed classification scheme is presented in Figure 21. The definitions of the grassland types in this scheme are presented below. The scheme of Figure 21 is also presented as a Table (Table 26).

Grassland: Land predominantly covered by grass, grass like plants, forbs and shrubs and that in some circumstances may also have a tree canopy, including

i) agricultural used permanent and temporary grassland and legumes and
ii) non-agricultural grassland including fallow and abandoned land, clear cuts within previously existing forests, grasslands associated to residential, transport, business, and community service areas, grassland for recreation, natural grassland not used for grazing and grassland outside agricultural areas not utilized.

Agricultural grasslands: All land which is in agricultural use and is not permanent crops or arable, except temporary grassland and legumes, and thus:

- Excludes grasslands in which there is no evidence of human intervention (e.g. through grazing, mowing) and cannot therefore be categorized as agricultural land.
- Includes all uncultivated land with vegetation that is grazed and/or cut for fodder, including herbaceous and non-herbaceous species.

Permanent grassland: Permanent grassland and permanent pasture means land used to grow grasses or other herbaceous forage naturally (self-seeded) or through cultivation (sown) and that has not been included in the crop rotation of the holding for ten years or more; it may include other species such as shrubs and/or trees which can be grazed provided that the grasses and other herbaceous forage remain predominant; as well as, subject to a decision by Countries to include land which can be grazed and which forms part of established local practices where grasses and other herbaceous forage are traditionally not predominant in grazing areas.

Agriculturally improved permanent grassland: Permanent grasslands on good or medium quality soils, used with more frequent defoliations, higher fertilization rates, higher stocking rates and producing higher yields than semi-natural grasslands. Three N inputs by fertilizer, manure, grazing and biological N fixation are considered:

- **< 50 kg N per ha per year**
- **50 - 150 kg N per ha per year**
- **> 150 kg N per ha per year**

Unimproved grassland (semi-natural grassland): A category of grasslands (including those with non-herbaceous species) that are notable, within the overall context of agricultural grasslands, for their ecological value. Unimproved grasslands have a spectrum of values depending on management but focus on biodiversity value and there is often a strong relation between high biodiversity value and other services. Unimproved grasslands are semi-natural and natural grasslands that are not substantially

agriculturally-improved (e.g. through cultivation, reseeding, fertilisation, irrigation and drainage) of long standing and species–rich (taking account of all taxa not only higher plants).

Permanent grasslands out of production but well maintained: Areas of permanent grasslands, regardless of the grassland type and the previous use, of which the produced biomass is no longer used for agricultural production purposes, but which are maintained in good agricultural and environmental condition by appropriate measures.

Temporary grasslands: Grasslands sown with forage species that can be annual, biennial or perennial. They are sown on arable land and can be integrated in crop rotations or sown after another grassland vegetation. They are kept for a short period of time (from a couple of months to usually a few years). They can be established with pure sowings of legumes, pure sowings of grasses or grass/legume mixtures.

Temporary grasslands with pure sowings of grasses Temporary grassland sown with only grass species.

Temporary grasslands with pure sowings of legumes: Temporary grassland sown with forage legume only.

Temporary grasslands with grass/legume mixtures: Temporary grassland sown with a mixture of grass and forage legumes.

Non-agricultural grassland: Natural, recreation and ornamental grasslands, not used for agriculture and not part of the utilized agricultural area.

Natural grassland: Non-agricultural low productivity grasslands, including climax grasslands, with minimum human interference (not mowed, fertilized or stimulated by chemicals which might influence production of biomass), often situated in areas of rough, uneven ground.

Recreation and ornamental grasslands: Non-agricultural grasslands associated to residential, transport, business, and community service areas, and grasslands for recreation.

Biodiversity classification is not further developed in this study. See Elbersen et al. (2014) for a more in depth discussion about biodiversity in grasslands.

Table 26.Classification scheme for grasslands; whole scheme.

1. Agricultural grassland	
1.1 Permanent grassland	
1.1.1. Agriculturally improved grassland	
1.1.1.1 Nitrogen input; < 50 kg N/ha/yr	
1.1.1.1s Sole use	Biodiversity classification
1.1.1.1c Common land	Biodiversity classification
1.1.1.2 Nitrogen input; 50 - 150 kg N/ha/yr	
1.1.1.2s Sole use	Biodiversity classification
1.1.1.2c Common land	Biodiversity classification
1.1.1.3 Nitrogen input; > 150 kg N/ha/yr	
1.1.2. Unimproved grassland	
1.1.2s Sole use	Biodiversity classification
1.1.2c Common land	Biodiversity classification
1.1.3. Grassland out of production but maintained	Biodiversity classification
1.2 Temporary grassland	
1.2.1 Pure grass	
1.2.2 Pure legume	
1.2.3. Mixture grass - legume	
2. Non-agricultural grassland	
2.1 Natural grassland	Biodiversity classification
2.2 Recreation and ornamental grasslands	

7.6.2 Comparison with classification proposed by EGF/Multisward working group

The grassland classification scheme proposed by the EGF/Multisward working group (paragraph 3.5) and that proposed in this report are largely the same. Differences between the two classification schemes are:

- The EFG classification deals with agricultural grasslands and grazed ecosystems, whereas the classification proposed in this project also includes non-agricultural grasslands. Therefore, the definition of "Grasslands" is broader in this study than in the EGF proposal.
- The age of permanent grassland differs; minimum 10 years in the EGF proposal and 5 years in CAP definition of permanent grassland, which has been adopted in this study. Instead it is proposed to add the 10 year threshold to the status of unimprovement.
- The classification proposed in this report includes categories based on nitrogen inputs, both for permanent and temporary grasslands. A differentiation in nitrogen inputs is proposed to be used for biodiversity classification and nutrient balances. At relatively low nitrogen inputs, grasslands may still have ecological value. The grassland with high nitrogen inputs have largest risk of nitrogen emissions to the environment and are relevant for nutrient balances and environmental policies.
- In the EGF proposal common land is one subcategory of semi-natural grasslands, with a remark that agriculturally-improved grasslands are occasionally common land. In the proposal in this report, both the improved and unproved grasslands include a common land subcategory.
- The EGF proposal includes a category of traditional hay meadows. This category will be part of the unimproved grasslands. For the elaboration of nitrogen balances it is however not relevant whether the grassland is mowed or extensively grazed. The nitrogen inputs on this type of land will be low in both cases. Knowledge on whether a permanent grassland is a traditional hay-meadow is relevant from a biodiversity perspective though and it is therefore logical to let this category fall in the

"Biodiversity classification" in the classification scheme of this project. The elaboration of the biodiversity classification is however not further developed in this project.

7.7 Use of the proposed scheme for policies and other data users

The need for grassland data differ for different policies and data users, and mostly information is only needed for part of the grasslands in the proposed classification scheme. This section presents the classification schemes which should be followed to collect data for different policies and for Agri-environmental indicators sources.

7.7.1 Common Agricultural Policy

Several agricultural categories of grasslands are relevant for Common Agricultural Policy (*Table 27*). In the new CAP 2014-2020 stricter requirements are set to permanent grasslands. The permanent grassland (category 1.1) in the proposed classification scheme follows the CAP definition of permanent grassland, except that the age of grassland is more than 10 years instead of the 5 years in the definition of CAP. The EGF gives a good explanation for the requirement of 10 years and this confirms that they specifically link ecosystem service capacity of a grassland to the definition of the permanent grassland category (Annex 1).

The new CAP 2014-2020 proposal includes several mechanisms to protect environmental values of permanent pastures, i.e. the ecologically valuable grasslands. In the new Directive of the CAP ((EC, 2013, Article 31 on permanent grassland it is formulated as follows:
'The Member States may, in order to ensure protection of environmentally valuable permanent grasslands, decide to designate further sensitive areas situated outside areas covered by Directives 92/43/EEC or 2009/147/EC, including permanent grasslands on carbon rich soils. Farmers shall not convert and not plough permanent grassland situated in areas designated by Member States under the first sub-paragraph and, where applicable, the second sub-paragraph.'.

The category in our classification that should at least be covered by this obligation is the category 1.1.2. Unimproved grassland. In addition to this it should be investigated whether the permanent grasslands in the low input category (category 1.1.1.1) should also be included as these are known to be overlapping with where the HNV farmland areas are.

Another relevant category of permanent grassland with CAP focus is covered by the category 'Areas of permanent grassland that are no longer used for production purposes but are maintained in in good agricultural and environmental condition and are eligible for the single payment. This is why this category is kept separate in the proposed classification, i.e. the category 1.1.3. Grassland out of production but maintained.

Crop diversification in arable farming systems is one of the greening instruments in CAP. A "crop" can include temporary grass and fallow land. Crop diversification will not be applicable to holdings where more than 75% of the total agricultural area is permanent or temporary grass or left fallow, as long as the remaining arable area does not exceed 30 ha. Therefore, the exact registration of permanent and temporary grassland area is required to determine whether a farmer has to comply or not with the greening obligations to allocate 5% of the UAA to an Ecological Focus Area (EFA).

There is discussion about a proposal to include legume production as an option for ecological focus areas as one of the measures under 'greening' in the CAP 2014-2010. Legumes are included in categories 1.2.2 and 1.2.3.

Table 27. Classification scheme for grasslands; Common Agricultural Policy.

1. Agricultural grassland	
1.1 Permanent grassland	
1.1.1. Agriculturally improved grassland	
1.1.1.1 Nitrogen input; < 50 kg N/ha/yr	
1.1.1.1s Sole use	Biodiversity classification
1.1.1.1c Common land	Biodiversity classification
1.1.1.2 Nitrogen input; 50 - 150 kg N/ha/yr	
1.1.1.2s Sole use	Biodiversity classification
1.1.1.2c Common land	Biodiversity classification
1.1.1.3 Nitrogen input; > 150 kg N/ha/yr	
1.1.2. Unimproved grassland	
1.1.2s Sole use	Biodiversity classification
1.1.2c Common land	Biodiversity classification
1.1.3. Grassland out of production but maintained	Biodiversity classification
1.2 Temporary grassland	
1.2.1 Pure grass	
1.2.2 Pure legume	
1.2.3. Mixture grass - legume	

7.7.2 Biodiversity policies

Table 28 shows the grasslands that have ecological value and which have to be considered in the Birds Directive and the Habitats Directive and the EU biodiversity strategy. Development of a classification scheme for biodiversity is out of the scope of this project (see Elbersen et al., 2014 for classification for biodiversity).

Table 28.Classification scheme for grasslands; Biodiversity policies.

1. Agricultural grassland	
1.1 Permanent grassland	
1.1.1. Agriculturally improved grassland	
1.1.1.1 Nitrogen input; < 50 kg N/ha/yr	
1.1.1.1s Sole use	Biodiversity classification
1.1.1.1c Common land	Biodiversity classification
1.1.1.2 Nitrogen input; 50 - 150 kg N/ha/yr	
1.1.1.2s Sole use	Biodiversity classification
1.1.1.2c Common land	Biodiversity classification
1.1.2. Unimproved grassland	
1.1.2s Sole use	Biodiversity classification
1.1.2c Common land	Biodiversity classification
1.1.3. Grassland out of production but maintained	Biodiversity classification
2. Non-agricultural grassland	
2.1 Natural grassland	Biodiversity classification

7.7.3 Nitrates Directive

The Nitrates Directive aims at reducing nitrate leaching from agricultural soils to groundwater and surface water. Member states should take measures in areas with elevated risk of leaching (i.e. the Nitrates Vulnerable zones). Information is needed of land use and management types with high N inputs. Table 29 includes the intensively managed grasslands that have a risk of leaching.

The Nitrates Directive also includes a standard for maximum use of animal manure, i.e. 170 kg N per ha. Countries may use a higher standard (i.e. derogation) if they can show that higher rates do not increase nitrate leaching. Criteria used for derogations are a long growing season and high N uptake capacity of the crop. Grasslands have a long growing season and high uptake capacity. Most of the existing derogation for the Nitrates Directive[25] are based on grassland. Grassland categories 1.1.1.3 and 1.2 include the grasslands for which a derogation is granted and may be granted in future.

Table 29.Classification scheme for grasslands; Nitrates Directive.

1. Agricultural grassland

1.1 Permanent grassland

1.1.1. Agriculturally improved grassland

1.1.1.2 Nitrogen input; 50 - 150 kg N/ha/yr

1.1.1.2s Sole use

1.1.1.2c Common land

1.1.1.3 Nitrogen input; > 150 kg N/ha/yr

1.2 Temporary grassland

1.2.1 Pure grass

1.2.2 Pure legume

1.2.3. Mixture grass - legume

7.7.4 Renewable Energy Directive

One of the criteria in the Renewable Energy Directive (2009/28/EC) is that no raw material should be obtained from land with high biodiversity value, which includes highly biodiverse grassland. Highly biodiverse grassland is defined as i) natural, namely grassland that would remain grassland in the absence of human intervention and which maintains the natural species composition and ecological characteristics and processes; or ii) non-natural, namely grassland that would cease to be grassland in the absence of human intervention and which is species-rich and not degraded, unless evidence is provided that the harvesting of the raw material is necessary to preserve its grassland status.

Table 30 shows the grasslands that have ecological value. It is recommended that these grasslands are considered for the Renewable Energy Directive.

[25] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2013:0683:FIN:EN:PDF

Table 30.Classification scheme for grasslands; Renewable Energy Directive.

1. Agricultural grassland	
1.1 Permanent grassland	
1.1.1. Agriculturally improved grassland	
1.1.1.1 Nitrogen input; < 50 kg N/ha/yr	
1.1.1.1s Sole use	Biodiversity classification
1.1.1.1c Common land	Biodiversity classification
1.1.1.2 Nitrogen input; 50 - 150 kg N/ha/yr	
1.1.1.2s Sole use	Biodiversity classification
1.1.1.2c Common land	Biodiversity classification
1.1.2. Unimproved grassland	
1.1.2s Sole use	Biodiversity classification
1.1.2c Common land	Biodiversity classification
1.1.3. Grassland out of production but maintained	Biodiversity classification
2. Non-agricultural grassland	
2.1 Natural grassland	Biodiversity classification

7.7.5 Economy-wide material flow accounts

Economy-wide material flow accounts (EW-MFA) provide information in tonnes about the physical flows of materials through economies. These accounts include data on domestic extraction of biomass, including fodder crops and grazed biomass. The category "Fodder crops and grazed biomass" in EW-MFA includes different types of roughage including fodder crops, biomass harvested from grassland and biomass directly grazed by livestock. *Table 31 shows the grasslands categories which are grazed or used as fodder crops. It is recommended that these grasslands are considered forEconomy-wide material flow accounts.*

Table 31.Classification scheme for grasslands; Economy-wide material flow accounts.

1. Agricultural grassland
1.1 Permanent grassland
1.1.1. Agriculturally improved grassland
1.1.1.1 Nitrogen input; < 50 kg N/ha/yr
1.1.1.1s Sole use
1.1.1.1c Common land
1.1.1.2 Nitrogen input; 50 - 150 kg N/ha/yr
1.1.1.2s Sole use
1.1.1.2c Common land
1.1.1.3 Nitrogen input; > 150 kg N/ha/yr
1.1.2. Unimproved grassland
1.1.2s Sole use
1.1.2c Common land
1.2 Temporary grassland
1.2.1 Pure grass
1.2.2 Pure legume
1.2.3. Mixture grass - legume

7.7.6 Agri-environmental indicators: gross nutrient balance

The Gross nutrient balance is one of the Agri-environmental indicators. According to the Eurostat/OECD Gross Nitrogen Balances Handbook, "ideally the balance result should be related to the area of agricultural land which is potentially fertilised, to avoid a bias in the result for countries with large extensive and not utilised areas". The reference area should thus refer to the potentially fertilised utilised agricultural area, where "potentially fertilised" means fertilised with mineral and organic fertilisers. Areas used for extensive grazing that are normally not actively fertilised with mineral or organic fertilisers could therefore be excluded, but any decision should be properly built under with reliable information and proper analyses on consequences.

The following criteria for exclusion from the reference area are currently proposed by Eurostat:

- No mineral or organic fertilisers are applied (organic farming and temporary fallow or unfertilised areas are excluded from this criteria);
- Very low livestock densities (higher livestock densities means that significant amounts of manure are dropped on the area);
- Low yields.

The agriculturally improved grasslands and temporary grasslands are the grassland with N inputs by mineral fertilizer, manure, biological N fixation and grazing and which are used for agricultural production. The other grassland categories have no or low inputs and should not be included in the gross nutrient balance calculation. Table 32 shows a proposal of the grasslands that should be included in the calculation of the gross nutrient balance.

Table 32. Classification scheme for grasslands; gross nutrient balances as Agri-environmental indicator.

1. Agricultural grassland
1.1 Permanent grassland
1.1.1. Agriculturally improved grassland
1.1.1.1 Nitrogen input; < 50 kg N/ha/yr
1.1.1.1s Sole use
1.1.1.1c Common land
1.1.1.2 Nitrogen input; 50 - 150 kg N/ha/yr
1.1.1.2s Sole use
1.1.1.2c Common land
1.1.1.3 Nitrogen input; > 150 kg N/ha/yr
1.2 Temporary grassland
1.2.1 Pure grass
1.2.2 Pure legume
1.2.3. Mixture grass - legume

7.7.7 FAOSTAT

In FAOSTAT under the land statistics (part of the Resource statistics), grassland categories are distinguished. The main distinction is between temporal and permanent grassland, irrigated versus non-irrigated and organic versus regular agriculture.

Table 33 shows the link between FAO definitions and the definitions in the proposed classification (

Table 26). Both irrigation and organic farming systems are not part of the proposed grassland classification scheme. However, data about irrigation and organic farming is collected by Eurostat because both are Agri-environmental indicators (Table 7). Information about irrigation is collected in Survey on Agricultural Production Methods of FSS and the Organic farming statistics of Eurostat26, respectively. Thus, coupling of the data in Survey on Agricultural Production Methods of FSS and the Organic farming statistics with the proposed grassland classification scheme, can deliver the information required for FAOSTAT.

Table 33. Link between FAO definitions and proposed definitions in the proposed classification scheme.

FAO Definition	**Definition in proposed scheme and comments**
Permanent meadows and pastures is the land used permanently (five years or more) to grow herbaceous forage crops, either cultivated or growing wild (wild prairie or grazing land).	1.1 Permanent grassland
Permanent meadows and pastures - Naturally grown is the land not being controlled under permanent meadows and pastures such as wild prairie or grazing land.	2.1 Natural grassland
Permanent meadows and pastures - Cultivated and irrigated, area of the "Cultivated Permanent meadows and pastures" which is actually irrigated in a given year.	Part of 1.1.1. Agriculturally improved grassland. Data of irrigation should be collected in surveys, such as Survey on Agricultural Production Methods of FSS
Permanent meadows and pastures - Cultivated and non-irrigated, area of the "Cultivated Permanent meadows and pastures" which development relies on rainfed irrigation in a given year.	Part of 1.1.1. Agriculturally improved grassland. All agriculturally improved grassland except the irrigated grasslands.
Part of the area of the "Permanent meadows and pastures" exclusively dedicated to organic agriculture and managed by applying organic agriculture methods. It is the portion of land area managed (cultivated) or wild harvested in accordance with specific organic standards or technical regulations and that has been inspected and approved by a certification body.	Part of 1.1.1. Agriculturally improved grassland. Organic farming systems is not part of the classification, but this information can be collected separately from the Organic farming statistics of Eurostat[27].
Part of the area of the "Permanent meadows and pastures" which is going through the organic conversion process, usually two years period of conversion to organic land.	Part of 1.1.1 Agriculturally improved grassland. No data available about conversion process.
Temporary meadows and pastures irrigated, area of the "Temporary meadows and pastures" which is actually irrigated in a given year.	Part of 1.2 Temporary grassland. Data of irrigation should be collected in surveys, such as Survey on Agricultural Production Methods of FSS
Temporary meadows and pastures non- irrigated, area of the "Temporary meadows and pastures" which development relies on rainfed irrigation in a given year.	Part of 1.2 Temporary grassland. Data of irrigation should be collected in surveys, such as Survey on Agricultural Production Methods of FSS
Temporary meadows and pastures is the land temporarily cultivated with herbaceous forage crops for mowing or pasture. A period of less than five years is used to differentiate between temporary and permanent meadows.	1.2 Temporary grassland

26 http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Organic_farming_statistics#Percentage_of_utilised_agricultural_area_.28UAA.29

27 http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Organic_farming_statistics#Percentage_of_utilised_agricultural_area_.28UAA.29

7.7.8 UNFCCC

The IPCC guidelines gives a definition for grasslands for reporting of greenhouse gas emission to the UNFCCC (see 3.4.1), but many countries use their own definition, depending on their national circumstances and data availability.

According to the IPCC Good Practice Guidance for LULUCF (2003) the definition of grassland is: *"Grassland includes rangelands and pasture land that is not considered as cropland. It also includes systems with vegetation that fall below the threshold used in the forest land category and are not expected to exceed, without human intervention, the threshold used in the forest land category. The category also includes all grassland from wild lands to recreational areas as well as agricultural and silvi-pastural systems, subdivided into managed and unmanaged consistent with national definitions".*

A very similar definition is used in the IPCC 2006 guidelines: *"Grassland includes rangelands and pasture land that are not considered Cropland. It also includes systems with woody vegetation and other non-grass vegetation such as herbs and brushes that fall below the threshold values used in the Forest Land category. The category also includes all grassland from wild lands to recreational areas as well as agricultural and silvi-pastural systems, consistent with national definitions".*

These grassland definitions are broad definitions of grasslands and include all the agricultural and non-agricultural grasslands of the proposed scheme. Countries can use their own definitions in the reports of greenhouse gas emission to UNFCCC. This indicates that the proposed classification scheme can be used for reporting of greenhouse gas emissions (including those related to Land Use Land Use Change and Forestry) to the UNFCCC. Notice that for quantification of land use changes, also information is needed about changes in other land use types, i.e. areas of forest, crop land and other natural land.

7.7.9 OECD

The data in the OECD Environmental data compendium are mainly derived from FAO. Permanent grassland refer to land use for five years or more for herbaceous forage, either cultivated or growing wild. These type of grassland fall in the category 1.1 Permanent grassland of OECD and Eurostat have developed a handbook for calculation of gross nutrient balances. The classification scheme in Table 32 can be used for calculation of gross nutrient balances.

7.7.10 LUCAS

The LUCAS definition of Grassland (E00; see paragraph 3.3.6) covers all grasslands (agriculture and non-agriculture) of the proposed classification scheme .

The LUCAS categories E10 Grassland with sparse trees and E20 Grassland without trees are not included in the proposed classification scheme.

The LUCAS category E30 Spontaneous vegetation is defined as *Mostly agricultural land which has not been cultivated this year or the years before. It has not been prepared for sowing any crop this year. This class can also be found on unused land, storage land etc. This class includes set aside land within agricultural areas and unused artificial land.*

This category includes the categories 1.1.2. Unimproved grassland, 1.1.3. Grassland out of production but maintained, and part of 2.2 Artificial grassland (i.e. the unused artificial land).

The LUCAS B55 Temporary grassland is defined as: *Land occupied by temporary and artificial pastures, occupying the ground for at least one crop year and less than five years, the seeds being either pure or mixed grass, on cropland areas. This can also be the case on fallow fields, when i.e. after some years graminaceous plants settle over spontaneously. If the soil is ploughed and /if the grass is sown the same year, the grassland is very likely a temporary one and not a permanent one. This class includes temporary pastures (Italian ryegrass, other ryegrasses, cock's foot, fescues, timothy) on agricultural*

areas/cropland. This class excludes permanent grassland (E), mix of legumes with gramineous plants for fodder (B53), and mix of cereals for fodder (B54).

This category includes 1.2.1 Pure temporary grass, but not the temporary grasslands categories 1.2.2 Pure legumes and 1.2.3. Mixture grass – legume.

LUCAS land use types U111 (Agriculture: Permanent pastures, rough grazings, alpages, meadows) and U210 (Energy production) are related to the category 1. Agricultural grassland of the proposed classification scheme.

All the other grassland uses are related to category 2. Non-agricultural grassland. The land use types U112 Fallow and abandoned land, U120 Clear cuts within previously existing forests, and U400 Natural grassland or grassland outside agricultural areas not utilized are related to category 2.1 Natural land.

Land use types U31x Associated areas of transport areas, U340 Grassland attached to commerce, finance or business areas, U350 Grassland attached to community service areas, U36x Grassland for recreation: public gardens, golf courses and nature reserves, and U370 Grassland attached to residential areas are related to category 2.2 Artificial land.

7.8 Summary

The proposed classification scheme is presented in Figure 21 and the definitions of the grassland types are presented in paragraph 7.6. The scheme of Figure 21 is also presented as a Table (Table 26). The grassland classification scheme proposed by the EGF/Multisward working group and that proposed in this report are largely the same, but some differences occur (paragraph 7.6.2).

The need for grassland data differ for different policies and data users, and mostly information is only needed for part of the grasslands in the classification scheme. Several agricultural categories of both permanent and temporal grasslands are relevant for Common Agricultural Policy. In the new CAP 2014-2020 stricter requirements are set to permanent grasslands. The permanent grassland in the proposed classification scheme follows the CAP definition of permanent grassland, except that an age of more than 10 years is proposed instead of the 5 years in the CAP definition.

The grasslands that have ecological value and which have to be considered in the Birds Directive and the Habitats Directive and the EU biodiversity strategy are indicated in the proposed scheme by "biodiversity classification". The same holds for the grassland to be considered in the Renewable Energy Directive (2009/28/EC). Development of a classification scheme for biodiversity is out of the scope of this project. For the Nitrates Directive, grasslands with high N inputs (> 50 kg N per ha) are relevant because there is a risk of nitrate leaching and part of these grasslands may be considered for higher manure application rates than the standard of 170 kg N per ha. For Economy-wide material flow accounts, all agricultural grasslands are relevant.

For the gross nutrient balance, the agriculturally improved grasslands and temporary grasslands should be considered because these are the grasslands with N inputs by mineral fertilizer, manure, biological N fixation and grazing and which are used for agricultural production. The other grassland categories have no or low inputs and should not be included in the gross nutrient balance calculation.

In FAOSTAT under the land statistics (part of the Resource statistics), grassland categories are distinguished. The main distinction is between temporal and permanent grassland, irrigated versus non-irrigated and organic versus conventional agriculture. Both irrigation and organic farming systems are not part of the proposed grassland classification scheme. However, data about irrigation and organic farming is collected by Eurostat because both are Agri-environmental indicators. Information about irrigation has been collected in Survey on Agricultural Production Methods of FSS and the Organic

farming statistics of Eurostat, respectively. The IPCC guidelines gives a broad definition for grasslands for reporting of greenhouse gas emission to the UNFCCC, but many countries use their own definition, depending on their national circumstances and data availability. This indicates that the proposed classification scheme can be used for reporting of greenhouse gas emissions (including those related to Land Use Land Use Change and Forestry) to the UNFCCC. The required grassland category for the OECD Environmental data fall in the category Permanent grassland of the proposed scheme. The LUCAS definition of Grassland covers all grasslands (agriculture and non-agriculture) of the proposed classification scheme. Most of the LUCAS categories fit in the proposed scheme. The LUCAS category B55 Temporary grassland does not include pure legumes and mixture of grass – legume.

8 Proposal for a methodology to estimate grassland production

8.1 Methods to estimate grassland production, nutrient contents and biological N fixation

In this Chapter recommendations are presented about methods to estimate grassland production and biological fixation in grasslands based on the report of Schils et al. (2014)[28]. Grassland production and the associated nitrogen off take are an important part of nutrient balances. Therefore, knowledge of the underlying methods will help to better assess the uncertainty of nutrient balances. Furthermore, guidelines on appropriate methods will contribute to a more uniform and harmonized approach across EU member states.

8.1.1 Production

Grasslands convert solar energy into plant biomass, which is utilized through grazing or cutting. Only a small fraction of light energy is finally ingested by livestock, or another end-user such as a digester. It seems obvious that from an agronomic point of view, only above ground biomass is considered as this is removed fraction. However, in between above ground biomass and net feed intake, there is still considerable room for different interpretations. The following definitions of grassland production may apply:

1. *Gross production*
   ...excluding harvest and grazing losses gives:
2. *Net production*
   ...excluding conservation and feeding losses gives:
3. *Net feed intake*

Thus, when assessing grassland production it is important to know whether gross grass production, net grass production or net feed intake was measured. Losses during harvest, grazing, conservation and feeding are variable, depending on the management system.

In the review about method to estimate grassland yields (Chapter 4) six main categories for production estimates were presented (Table 34):

1. Cutting and weighing is the most direct assessment method. It is carried out on experimental plots to determine gross production. It may also be carried out on farm fields to determine the harvested net yield of a complete field or farm.
2. Height and density measurements are carried out on experimental plots and complete fields. They are estimates of the standing crop (gross production).
3. Visual estimates may are usually carried out on a standing crop and thus give an estimate of gross production of plots and fields. However, visual estimates may also be performed on hay stacks or silage heaps in which case they are an estimate of net production at farm level.

[28] René Schils, Gerard Velthof, Sander Mucher, Gerard Hazeu, Oene Oenema, Allard de Wit, and Annemieke Smit (2014). Current methods to estimate grassland production and biological fixation. Alterra.

4. Crop modelling is a powerful tool to estimate gross and net production over all possible scales. In combination with farm and livestock modelling it is also possible to estimate net feed intake.
5. Remote sensing in combination with crop modelling supplies estimates of gross production at larger scales.
6. The feed balance is in fact a simple model that estimates net feed intake, based on the feed requirements of livestock. It may be applied at farm or regional level.

Table 34 Overview of grass production assessment methods

Method	Scale	Gross production	Net production	Net feed intake
Cutting and weighing	plot, field, farm	x	x	
Height and density measurement	plot, field	x		
Visual estimate	plot, field, farm	x	x	
Modeling	plot, field, farm, region	x	x	x
Remote sensing	region	x		
Feed balance	farm, region			x

8.1.2 Nitrogen content

In order to calculate nitrogen removals through grazed and harvested grass, the nitrogen content needs to be assessed. Methods used for measurement of nutrient contents in grassland comprise three main categories:

1. Sampling of herbage and subsequent laboratory analysis, mostly available from harvested hay or silage, but in specific cases also from fresh herbage.
2. Rapid non-destructive direct determination of nutrient content with near infrared reflectance spectrometry, or indirect determination through chlorophyll meters, which is an estimate for nitrogen content.
3. Remote sensing of reflectance spectra indicating chlorophyll content, which is an estimate for nitrogen content.

8.1.3 Biological nitrogen fixation

Nitrogen-fixing legumes are significant components of many agricultural systems. The amount of N fixed by clover is difficult to estimate, because both the estimate of the average share of clover in grassland in a region and the amount of N fixed by clover are uncertain. The major methods used to determine BNF are:

1. Direct measurement of legume BNF in the field, usually only executed at experimental plot level.
2. Modelling of legume BNF is applicable from plot to regional scale.

8.1.4 Methods currently used

Currently, countries collect a wide variety of yield data, either directly as yield, or indirectly through volume of grazed grass, volume of cut grass, number of cuts/harvests per year, management intensity, grazing status, grazing intensity, nitrogen input levels as fertiliser or manure, and proportion of clover or other N fixing plants.

The methods used to estimate grassland production are very heterogeneous. Most members states use expert estimates, while destructive measurements are also mentioned frequently. Less frequently mentioned methods involve default values from literature, non-destructive measurements, calculations of a crop growth model and estimates using feed balance calculation.

With respect to nutrient contents, members states mainly use derived values from literature or direct measurements in samples of harvested grass.

Data on biological nitrogen fixation are usually not collected. Those countries that do, mostly rely on values retrieved from literature in combination with expert estimates. Measurements and models are not mentioned frequently.

8.2 Recommendation for a tiered approach to estimate grassland production

8.2.1 Framework for three tiered approach

Taking into account the large variation in available methods and the large variation in currently applied methods, the challenge is to develop a harmonized framework for grassland production, nutrient content and biological nitrogen fixation. The variety in methods described for the three different parameters, decreased in the order yield, nutrient content and biological nitrogen fixation. Despite these large differences in underlying methods we suggest a tiered approach for each of the three parameters.

The three proposed levels are:

- Tier 1. Fixed estimate
- Tier 2. Modelled, including feed balances
- Tier 3. Direct measurements

These levels do not represent one single method per tier, but a cluster of methods. This allows freedom of methodology as long as the methodology is clearly described. In fact, nearly all methods described in this report may be considered. Only remote sensing currently seems a step to far. Although the ability to model production with remote sensing based data has increased significantly in recent years, a valid method across all regions has not yet evolved.

In theory, each of the three methods can be applied at different spatial and temporal scales, but it makes sense that the spatial and temporal resolution increase from tier one to tiers two and three. For each of the three approaches, it is evident that there has to be a clear description available which contains definitions, assumptions, calculation methods, used models and measurement techniques, as well as upscaling methods from plot, field, farm, region to national estimates and from individual harvests to annual yields. Table 35 shows, for each tier, an overview of the sources, temporal and spatial scales, risks and uncertainties, and relative costs.

8.2.2 Fixed estimates

Fixed estimates are those values that are derived from literature research in combination with expert opinions. Sources are preferably peer reviewed papers, but data from other sources may be used as well. Often data availability is limited with white spots for certain areas or periods. Regional and national grassland experts are a valuable resource for completing these missing data. Data availability will decrease in the order yield > nutrient content > fixation, but in all cases the framework of the approach is similar.

8.2.3 Modelled estimates

Modelled estimates comprise a wide range of empirical or mechanistic approaches of estimating yields, nutrient content or biological fixation, with varying complexity. Models are preferably published and peer

reviewed and calibrated and validated on local conditions. Models need good quality data on weather, farm management, nutrient inputs, botanical composition. Again in this category, models for yield estimates are developed abundantly, compared to models for nitrogen fixation.

With respect to yield estimates, the use of feed balances has been applied in several countries and may serve as a template for other countries. Feed balances require additional data on livestock feed requirements and amounts and quality of imported feed. Less experience is available for nitrogen fixation. Whichever modelled approach is chosen, the most important underlying factors, proportion of legumes in the sward and applied nitrogen, should be considered.

8.2.4 Measured estimates

Measured estimates are those values derived from *in situ* measurements of yields, nutrient contents of nitrogen fixation. Although the direct measurement is in theory the best proxy, the methods has similar pitfalls as the lower tier methods with respect to upscaling from a local site at a specific time to higher spatial and temporal scales. Furthermore it has to be clear that on experimental sites potential yields are measured such as in the grassland network used in the 1980's (Corrall, 1988; Peeters and Kopec, 1996). Potential yields are significantly higher than those obtained under commercial farming conditions. Therefore, measurement networks should preferably be located at commercial farms, on plots used for grazing as well.

Table 35 Framework for three tiered approach for estimating grassland yield. The sources, the temporal and spatial scales, risks and uncertainties, and relative costs are presented for methods based on fixed estimates, models, or measurements.

	Fixed estimate (Tier 1)	**Models (Tier 2)**	**Measurements (Tier 3)**
Sources	• Literature • Experts	• Calibrated and validated model • Meteorological data • Farm management data • Statistical farm data • Feed requirements • Data on imported feed • Data on legume contents in swards	• Network of experimental plots • Network of commercial (pilot) farms
Temporal scale	• Annual	• Seasonal • Annual	• Seasonal • Annual
Spatial scale	• Regional • National	• Regional • National	• Regional • National
Uncertainties and risks	• Expert bias • Incomplete spatial coverage of data	• Availability of data for calibration and validation • Feed balances require many additional data on livestock and external feed inputs and quality	• Overestimation of actual yields • Availability of representative monitoring network
Relative costs	• Low	• Medium	• High

8.3 Summary

A tiered approach is suggested, including fixed, modelled or measured values for each of the three parameters.

Fixed estimates are those values that are derived from literature research in combination with expert opinions. Data availability will decrease in the order yield > nutrient content > fixation, but in all cases the framework of the approach is similar.

Modelled estimates comprise a wide range of empirical or mechanistic approaches of estimating yields, nutrient content or biological fixation, with varying complexity. Models are preferably published and peer reviewed and calibrated and validated on local conditions. With respect to yield estimates, the use of feed balances has been applied in several countries and may serve as a template for other countries. Less experience is available for nitrogen fixation.

Measured estimates are those values derived from in situ measurements of yields, nutrient contents of nitrogen fixation. Although the direct measurement is in theory the best proxy, the methods has similar pitfalls as the lower tier methods with respect to upscaling from a local site at a specific time to higher spatial and temporal scales. Measurement networks should preferably be located at commercial farms, on plots used for grazing as well.

9 Data collection

9.1 Collection of grassland characteristics

The proposed classification scheme in paragraph 7.6 includes all grasslands as land cover (both agricultural and non-agricultural). LPIS provides the most detailed information about agricultural permanent grasslands, but data are not (yet) widely available in the EU. Remote sensing information of the HR layer permanent grassland will be available from EEA next year and provides information at a high resolution (20*20 m) about the area of permanent grassland, including information of permanent grassland with agricultural use and grassland with other use (artificial grasslands). The LUCAS in-situ survey provides information about land cover and land use (Paragraph 3.3.6). The land use information can be used to distinguish between agricultural used grasslands (category 1 of the proposed classification scheme) and non-agricultural used grasslands (category 2). LUCAS also provides information to distinguish between category 2.1 Natural grasslands (includes LUCAS land use types U400, U112 and U120) and category 2.2. Artificial grassland (includes LUCAS land use types U31x, U340, U350, U36x, and U370). Note that the LUCAS grassland definition excludes areas of grassland with tree and shrub cover.

LPIS information in combination with HR layer permanent grassland and support layer (or Corine Land Cover map) enriched with land use information based on the in-situ observations from LUCAS will be the best available source for mapping of the total grassland extent (agricultural + non-agricultural) in the near future (Table 36). LUCAS only contains a limited number of observation which need to be extrapolated. Information about land use can be obtained from the additional support layers of HR layer permanent grassland.

Statistical sources can be used for area of agricultural grasslands. FSS collects data on areas of temporary and permanent grasslands every 3 years for a sample and every 10 years for full census. Crop statistics data are collected every year. It is recommended that crop statistics collect data of agricultural grasslands, using the proposed definitions.

In FSS and crop statistics, Permanent grasslands are currently subdivided into "pasture and meadows", "rough grazings" and "permanent grassland no longer used for production purposes and eligible for the payment of subsidies". If the proposed classification scheme is adopted in FSS and crop statistics, the category "pasture and meadows" should be replaced by category 1.1.1 Agriculturally improved grassland, and "rough grazing" by category 1.1.2 Unimproved grassland. The main difference between "rough grazing" of FSS and category 1.1.2 Unimproved grassland, is that rough grazing may include extensively managed grassland with low inputs of organic nitrogen, whereas the category unimproved grassland excludes additional nitrogen inputs except those by grazing. The category 1.1.3 Grassland out of production but maintained includes the existing FSS category "grassland out of production".

Another source of area of permanent grassland is LPIS, which is used for CAP payment. LPIS contains parcel information and it is recommended to collect more information collected at this level. LPIS data may be used to validate the results of FSS for permanent grassland area and, if needed, to improve FSS collection of grassland data. The case of Spain indicates that a very large part of the grazed habitats in Spain falls in the category 'Unimproved grasslands' and 'Agriculturally improved grassland with low N input'. For the gross nutrient balance calculations it is a challenge to separate these two categories. The only way to do this is by integration of data sources at parcel level to LPIS. It is recommended to integrate FSS and LPIS, so that all crop information and inputs are collected at parcel level (ideally).

The current question in FSS about 'common land' is not yet harmonized between member states. Some countries have not covered common lands as required by the FSS regulation and the methodology used to cover common land is also different among the countries. There is a need of accurate estimates of common land, because there might be overlap (doubling counting) between the grassland use by sole owners and those of common land.

Three categories of N inputs are distinguished. This demands for data on N application rate as fertilizer and manure and the presence of legumes in grassland at least farm level, but ideally on field level. Farms may have different grasslands from which the intensively managed grassland (high inputs and high grazing density) are generally found near the farm and livestock housing and the extensively managed grassland are at larger distance from the farm. This means that farms may have both fields that can be considered 'out of production, but maintained', 'unimproved grassland', and 'agriculturally improved grassland with different nitrogen application rates'.

FSS and the Survey on Agricultural Production Methods (SAPM) should include questions about the use of fertilizers, manure, and legumes as sources of nitrogen, which can be used to differentiate between unimproved (no additional nitrogen inputs) and improved grasslands and between the different groups of N input. The biological N fixation can be estimated using one of the proposed Tier methods (Chapter 4), and needs data on the type of legume, the portion of legumes in the grassland, and the N input as fertilizer and manure to legumes as legumes can use soil mineral N instead of biologically fixed N. This information can be obtained from Crop Statistics. IACS declarations may be an important data base for livestock numbers.

For temporary grasslands, data should be collected in Crop Statistics on pure temporary grassland, pure legumes, and mixture grass-legume. Recommendations about data for biodiversity classification are out of the scope of this project, but can be found in Elbersen et al. (2011). The proposed sources of data needed for the area of the grassland categories in the grassland classification scheme are summarized in Table 36.

Table 36 Proposed sources of data needed for the area of the grassland categories in the grassland classification scheme.

Type of information	**Source**
Total area grassland (land cover)	Remote sensing: CORINE + HR layer grassland + LUCAS
Area of agricultural and non-agricultural grasslands	LIPIS + LUCAS + CORINE + HR layer grassland
Area of natural and artificial grassland	LUCAS + CORINE + HR layer grassland
Area permanent and temporary agricultural grasslands	Crop statistics
	LPIS
Nitrogen input to grassland as fertilizer and manure	Farm Structural Survey/Survey on Agricultural Production Methods
Percentage of legumes in permanent grassland area	Crop statistics (*Note: not for classification but for N input*)
Area of grassland out of production but maintained	Farm Structural Survey
Area of sole use grassland and common land	Farm Structural Survey
Area temporary grassland: pure grassland	Crop statistics
Area of temporary grassland: legumes	Crop statistics
Area of temporary grassland: mixture grass - legume	Crop statistisc
Biodiversity classification	Out of scope of this project

9.2 Collection of data of grassland production

The removal of nitrogen and phosphorus with harvested and grazed grasslands is required to calculate the gross nitrogen and phosphorus balances. A tiered approach to estimate grassland production is recommended, expressed in dry matter yield, nitrogen yield, and phosphorus yield (Paragraph 8.2).

In the Tier 1 method, estimates of grassland yields and nutrient contents should be made on a preferably NUTS II level (or for smaller countries at national level) and annual basis. This has to be done for the grasslands that are relevant for nutrient balances (Table 32). Table 37 show the proposed table that have to be filled for a Tier 1 method. The yields of sole use and common land within the same category will be similar, so that these classes will not be further distinguished for the yield estimates. Although the yields of grassland that are only cut are generally higher than grazed grassland, it is proposed that the yields in this Tier 1 approach are estimated for grassland with both cutting and grazing or for the dominant grassland management type in the specific region, if this information is available for that region.

Table 37. Proposal for table to be used in a Tier 1 approach for estimates of dry matter yields of grassland in kg per ha per year, for different grassland classes (paragraph 7.6) and regions in EU.

	Region/member state					
	1	2	3	4	5	etc.
1.1 Permanent grassland						
1.1.1. Agriculturally improved grassland						
1.1.1.1 Nitrogen input; < 50 kg N/ha/yr						
1.1.1.2 Nitrogen input; 50 - 150 kg N/ha/yr						
1.1.1.3 Nitrogen input; > 150 kg N/ha/yr						
1.2 Temporary grassland						
1.2.1 Pure grass						
1.2.2 Pure legume						
1.2.3. Mixture grass - legume						

The N and P contents in dry matter, which are needed to calculate the total N and P removal by the harvest crops, should be estimated for all grassland types (Table 38). If data are available, estimates nutrient contents on a national of regional level can be used.

It is recommended that the required estimates of dry matter yield and nutrient content are derived by one group of experts, using a combination of literature (e.g. Peeters and Kopec, 1996, Smit et al., 2008; Velthof et al., 2009), expert estimates, remote sensing data (MARS project at JRC), and models such as LINGRA (Schapendonk et al., 1998). The advantage of deriving yields estimates by one expert group instead of estimates by country experts is that a uniform approach is used that guarantees that the yields are estimated with the same approach.

If the proposed estimates of grasslands and nutrient contents are available, the calculation of gross nutrient balances on NUTS II level will be significantly improved and harmonized over the European Union, compared to the current estimates. The data required for the Tier 2 (modelling including feed balances) and Tier 3 (measurements) methods strongly depend on the approach that will be used. No general recommendations can be made for data collection using Tier 2 and 3[29]. Part of the data required for Tier 2 models can be collected using FSS, but detailed data and coefficients (e.g. losses during silage) should be obtained from literature or expert estimates.

[29] Example of calculation of a feed balances in the Netherlands are presented by Aarts et al. (In Dutch) and CBS (2012)

Table 38. Proposal for table to be used for estimates of N and P content of dry matter of grassland in g per kg dry matter, for different grassland classes.

	N content	P content
1.1 Permanent grassland		
1.1.1. Agriculturally improved grassland		
1.1.1.1 Nitrogen input; < 50 kg N/ha/yr		
1.1.1.2 Nitrogen input; 50 - 150 kg N/ha/yr		
1.1.1.3 Nitrogen input; > 150 kg N/ha/yr		
1.2 Temporary grassland		
1.2.1 Pure grass		
1.2.2 Pure legume		
1.2.3. Mixture grass - legume		

9.3 Summary

LPIS provides the most detailed information about agricultural permanent grasslands, but data are not (yet) widely available in the EU. Information of the HR layer permanent grassland will be available next year and provides information at a high resolution (20*20m) about the area of permanent grassland, including information of permanent grassland with agricultural use and grassland with other use (artificial grasslands). The LUCAS in-situ survey provides information about land cover and land use, but exclude grasslands with trees and shrubs above a low threshold that excludes much of the pasture area in countries such as Spain

LPIS information in combination with HR layer permanent grassland and support layer (or Corine Land Cover map) enriched with land use information based on the in-situ observations from LUCAS will be the best available source for mapping of the total grassland extent (agricultural + non-agricultural) in the near future. LUCAS also provides information to distinguish between category natural and artificial grasslands. It recommended to use statistical sources for area of agricultural grasslands. Crop statistics and FSS can be used to obtain data about permanent grassland, including those out of production but maintained.

The Land Parcel Identification System (LPIS) may be used to validate the results of crop statistics for permanent grassland area and, if needed, to improve collection of grassland data in crop statistics. Moreover, LPIS can be used to link the data on land management, grazing practices, to the land uses/land cover categories. Data about N inputs as fertilizer and manure should be collected in FSS and the Survey on Agricultural Production Methods (SAPM). The presence of legumes in permanent grassland, and area of temporary grasslands (pure temporary grassland, pure legumes, and mixture grass-legume) should be collected in Crop Statistics. Recommendations about data for biodiversity classification are out of the scope of this project. The proposed sources of data needed for the area of the grassland categories in the grassland classification scheme are summarized in Table 36.

IACS declarations may provide a useful source of data on livestock numbers at the holding level

A tiered approach to estimate grassland production is recommended. In the Tier 1 method, estimates of grassland yields and nutrient contents should be made on a preferably NUTS II level (or for smaller countries at national level) and annual basis. This has to be done for the grasslands that are relevant for nutrient balances. For N and P contents in dry matter, needed to calculate the total N and P removal by

the harvest crops, should be estimated for all grassland types. If data are available, the nutrient contents on a national of regional level can be used.

It is recommended that the required estimates of dry matter yield and nutrient content are derived by one group of experts, using a combination of literature, expert estimates, remote sensing data, and models. The advantage of deriving yields estimates of one expert group instead of estimates by country experts is that a uniform approach is used that guarantees that the yields are estimated with the same approach. If the proposed estimates of grasslands and nutrient contents for the Tier 1 methodology are available, the calculation of gross nutrient balances on NUTS II level will be significantly improved and harmonized over the European Union, compared to the current estimates. The data required for the Tier 2 (modelling including feed balances) and Tier 3 (measurements) methods strongly depend on the approach that will be used. No general recommendations can be made for data collection using Tier 2 and 3.

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Annex 1. Grassland term definition and classification; proposal by EGF and Multisward

The Working group on 'Grassland term definitions' of European Grassland Federation (EGF) has made a proposal of definition and classification of grassland. This work was not part of the Alterra project. However, it has been agreed with EGF and Eurostat that the EGF proposal will be included in this report, as the EGF view on grassland definitions and classification is relevant for the discussion about grassland classification. This working group was led by Alain Peeters of RHEA in Belgium. The EGF proposal is presented in this Chapter.

European Grassland Federation

MultiSward Research project

Grassland term definitions and classifications adapted to the diversity of European grassland-based systems

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1. Introduction

A Working Group on 'Grassland Term Definition' has been set up during the 24th General meeting of the European Grassland Federation (EGF) that took place on 3-7 June 2012 in Lublin (Poland). It gathered together 22 experts from 13 countries (Belgium, Bulgaria, France, Germany, Italy, Poland, Rumania, Slovakia, Spain, Sweden, Switzerland, The Netherlands, United Kingdom). The group is thus representative of the diversity of thinking of European grassland researchers.

The purpose of the creation of the Working Group was to support the European Union (EU) institutions to better take into account grasslands into the Common Agricultural Policy (CAP). The EGF adopted a resolution on the reform of the CAP during its General Assembly. This resolution was sent to a wide group of decision makers of the EU. The participants to the EGF conference estimated that a glossary could also be useful in addition to their ideas on the future CAP. It was thus decided to draft a vocabulary of grassland terms.

After contacts with Eurostat, it appeared that this European Commission organization would also be interested in a better definition and classification of grassland terms. This classification could improve the present system of data collection and could lead to a better consideration of the importance and the diversity of grasslands in European agricultural statistics. The system should be simple but at the same time be able to collect some new agri-environmental indicators on grasslands and grassland-based systems.

The present text is largely inspired by the work of Allen *et al.* (2011)[1] who defined many grassland terms at global level. In this work, the Working Group tried to adapt the results of this previous publication to European specificities.

This work would not have been possible without the support of the FP7 research project MULTISWARD 'Multi-species swards and multi-scale strategies for multifunctional grassland-based ruminant production systems' (Grant agreement N[r]: FP7-244983). It is a joined document of the EGF and MULTISWARD.

[1] Allen V.G., Batello C., Berretta E.J., Hodgson J., Kothmann M., Li X., McIvor J., Milne J., Morris C., Peeters A., Sanderson M. (2011) An International Terminology for Grazing Lands and Grazing Animals. Grass and Forage Science 66: 2-28.

2. Grassland term definitions

1. **Fodder areas**: Part of the agricultural area that includes permanent grasslands, arable fodder crops and grazed fallow lands.

2. **Arable fodder crops**: Annual, biennial or perennial species sown on arable land for the production of forage and harvested green. They include temporary grasslands, green cereals (C3 species such as oats, spelt, triticale, rye and C4 species such as maize and sorghum), fodder roots, some *Brassiceae* and *Compositeae* (ex.: sunflower) species.

   Additional remarks:
   Crops that are harvested as grain (cereal grain and pulses) and used for animal feeding are not classified in fodder crops.
   Cereals represent a traditional and strategic resource in Mediterranean areas especially for mixed farming systems (livestock, grasslands and grain cereal productions). Even when sown for grain production, their management can be flexible according to weather conditions prevailing along the growing season. For instance, cereal crops for grain production can be grazed in winter and then harvested for grain production, or only grazed when estimated grain productions do not compensate the costs of mechanical harvesting.
   If cereals are harvested green (by grazing or harvested for silage as immature cereals), they should be defined as fodder crops.

3. **Grasslands**: Land devoted to the production of forage for harvest by grazing/browsing, cutting, or both, or used for other agricultural purposes such as renewable energy production. The vegetation can include grasses, grass-like plants, legumes and other forbs. Woody species may also be present. Grasslands can be temporary or permanent.

   Regarding management types of grasslands, two categories can be identified:
   - **Meadows**: grasslands that have been harvested predominantly by mowing over the last 5 years[2] or since the establishment of the sward if it is less than 5 year-old.
   - **Pastures**: grasslands that have been harvested predominantly by grazing over the last 5 years[2] or since the establishment of the sward if it is less than 5 year-old.

4. **Permanent grasslands:** Grasslands used to grow grasses or other forage (self-seeded or sown and/or reseeded) and that have not been completely renewed after destruction by ploughing or spraying (herbicide) for ten years or longer. They can be agriculturally-improved, semi-natural or no longer used for production.

   Additional remarks:
   Long-term grasslands provide more ecosystem goods and services than short-term grasslands (ex.: carbon storage, biodiversity levels). A minimum duration of 10 years is necessary in most situations for reaching, in a previously cultivated soil, a level of soil organic carbon that is representative of long-term permanent grasslands. A period of 10 years is also considered as a minimum for reaching soil biodiversity and especially higher plant diversity that is noted in long-term permanent grasslands for a given intensification level.
   The effects of cultivating and reseeding can though vary according to the region and type of grassland, and the acceptable frequency of cultivation also varies. For example, in Mediterranean areas, self-seeded permanent grasslands consisting mainly of annuals can be tilled (light harrowing, not deep ploughing) e.g. every few years without destroying floral biodiversity.

[2] In case of recent change in the management strategy (more recently than 5 years), the new management type has to be taken into account.

Harrowing is a quite common practice to control scrub invasion e.g. in Dehesas/Montados. In these conditions, permanent grasslands can be tilled more frequently than once every 10 years.
European permanent grasslands can be dominated notably by:

- one or several grass species;
- one or several grass species and one or several legume species;
- grasses, several forb species and possibly legume species;
- grass-like species and possibly forb species;
- shrubby zones (see 'semi-natural grassland's for more information);
- grazed wooded areas (see 'semi-natural grasslands' for more information).

5. **Agriculturally-improved permanent grasslands**: Permanent grasslands on good or medium quality soils, used with more frequent defoliations, higher fertilization rates, higher stocking rates and producing higher yields than semi-natural grasslands.

Additional remarks:
Agriculturally-improved permanent grasslands can be dominated notably by:

- one or several grass species;
- one or several grass species and one or several legume species;
- grasses, one or several forb species and possibly legume species.

Agriculturally-improved permanent grasslands are often classified, in terms of production, on the basis of the proportions of high-, medium- and low-productivity/quality grasses as well as on the proportion of legumes.

6. **Semi-natural grasslands**: Low-yielding permanent grasslands, dominated by indigenous, naturally occurring grass communities, other herbaceous species and, in some cases, shrubs and/or trees. These mown and/or grazed ecosystems are not substantially modified by fertilisation, liming, drainage, soil cultivation, herbicide use, introduction of exotic species and (over-)sowing.

Additional remarks:
Occasional liming on acidic grasslands, or the application of very low amounts of organic fertilizers, if not combined with other 'improvement' techniques, are not considered to substantially modify habitats. Drainage can transform wet semi-natural grassland into mesophilous semi-natural grassland but if it is not associated with higher fertilization or stocking rate, it is not considered to substantially modify habitats too. In contrast with most semi-natural communities, some of them, like purple moor grass (*Molinia caerulea*) or tall sedge (*Carex* spp.) communities can be quite productive.

Natural vegetation types are communities where the vegetative cover is in dynamic balance with the abiotic and biotic (human species excluded) forces of its ecosystem. Semi-natural vegetation is not planted/sown by humans but is influenced by human actions. These may result from grazing, cutting or burning. Previously cultivated areas that have been abandoned and where vegetation is regenerating may also evolve to semi-natural vegetation. In contrast with natural vegetation, semi-natural communities need thus regular anthropogenic disturbances to be maintained.

Semi-natural grasslands are usually biodiverse. They include:

- grazed (pastures) or mown (meadows) grasslands in the plain or low mountain areas including in wet areas (riparian vegetation, valleys, flooding areas) where grazing and mowing are usually combined in time and/or space;
- mountain and sub-Alpine meadows and pastures;
- grazed steppes and dry pastures;
- land crossed during transhumance where the animals spend a part of the year (approximately 100 days) without returning to the holding in the evening;
- grazed wooded areas (agroforestry areas, Dehesa and Montado type for example). Forestland that produces, at least periodically, spontaneous native understorey vegetation

that is grazed and where shrubs and trees are browsed is also considered as grazed semi-natural vegetation, including fire-break lines;
- grazed/browsed shrubby zones (ex.: heath, maquis, matorral, garrigue).

'Agroforestry' is the integration of woody perennials, crops and/or grasslands on an area of land. Trees may be single or in groups, inside parcels (silvoarable agroforestry, silvopastoralism, grazed or intercropped orchards) or on the boundaries (hedges, tree lines). Silvoarable systems are extensively used in Mediterranean areas; they include forage crop rotation under the trees for feeding animals during the shortage periods. Agroforestry systems are obtained by planting trees on agricultural land or by introducing agriculture in existing woodland (e.g. silvopasture).

A silvopastoral system, like the Dehesa/Montado, has the chief aim to provide food for livestock while taking advantage of the presence of trees (ex.: shade, shelter, milder microclimate, nutrients pump, strategic browsing and acorn grazing), and obtaining a secondary profit of trees in the mid/long term (ex.: cork, wood, firewood).
Silvopastoral systems also include those areas where the understorey of a forest is grazed. It combines grazing with tree production (wood, fruits, fodder) and the maintenance of the forest ecosystem. This system reduces fire risk by controlling inflammable understorey and preserves biodiversity through animal disturbances. In some high forest, the main productive use is wood, but many grazed forests have minimal value for timber or firewood, and grazing is really the most important productive use (e.g. in Mediterranean areas). There are different situations and the official classifications and statistics should recognise this.

7. **Permanent grasslands no longer used for production**: Areas of permanent grasslands, regardless of the grassland type and the previous use, of which the produced biomass is no longer used for agricultural production purposes, but which are maintained in good agricultural and environmental condition by appropriate measures.

8. **Temporary grasslands**: Grasslands sown with forage species that can be annual, biennial or perennial. They are sown on arable land and can be integrated in crop rotations or sown after another grassland vegetation. They are kept for a short period of time (from a couple of months to usually a few years). They can be established with pure sowings of legumes, pure sowings of grasses or grass/legume mixtures.

   Additional remarks:
   This category includes 'Leguminous plants' that are pure stands of leguminous plants or mixtures of predominantly leguminous plants mixed with grasses.
   Temporary grasslands can be grazed or harvested green, as hay or silage.

9. **Rangelands**: Extensive, large-scale grazed grasslands. Rangelands can be fenced or not but they are usually not fenced, so a shepherd is often needed.

   Additional remark:
   Rangelands are dominated by grazed semi-natural vegetation. They may include natural and semi-natural grasslands, shrublands, steppes, tundras, alpine communities, marshes and understorey of forestland.

10. **Grazed fallow lands**: Extensively grazed uncultivated land after a cropping episode. The duration of the fallow is typically between one and four years. The land is then cropped again.

    Additional remark:
    Fallow lands are very commonly grazed in Mediterranean areas for livestock feeding. They are also important for wildlife (*i.e.* bird breeding) and soil conservation.

11. **Grazed common lands**: Permanent grasslands where two or more persons have the right to graze concurrently; in some cases these rights are not permanently vested in the same individuals but are allocated from time to time by a body with legal authority to do so.

Additional remarks:
Common lands are part of the utilized agricultural area. They can be private or public (state, parish, etc.). They are generally semi-natural, but not always; some common lands have been 'improved' by reseeding and fertilisation.
Rangeland is mostly common land, but not always, it can be in sole use[3]. Most common land is rangeland, but not always; it can consist of grassland, forest, horticultural or other land.

[3] The term 'sole use' is used for land that is not common.

3. Classification of grassland types into an agricultural statistics system

3.1. Preamble

In the classification system described below, three main ideas are introduced:

- Permanent grasslands are described in three main categories:
  - Agriculturally-improved permanent grasslands
  - **Semi-natural grasslands**
  - Permanent grasslands no longer used for production
- The existing Eurostat category 'Forage crops/Leguminous plants' has been clustered with the category 'Forage crops/Temporary grass' for creating a new category 'Forage crops/**Temporary grasslands**'
- A new category is introduced for '**Grazed fallow land**'.

Almost no surface data were collected in the past in Europe on '**Semi-natural grasslands**'. They differ from 'Agriculturally-improved permanent grasslands' since they are usually richer in biodiversity because of a lower intensification rate and a smaller modification of their habitats. Statistical data on these semi-natural grassland types could thus be an important biodiversity indicator.
Two main types can be defined: 'Pastures' (including rangelands, rough grazing, wood pastures etc.) and 'Traditional hay meadows'. Pastures can be managed in 'Sole use' or have the status of 'Common land'.

The two following arguments justify defining a category '**Temporary grasslands**':

- Grassland areas are often underestimated when they correspond to the category 'Permanent grassland and meadow' or even to the sum of the category 'Permanent grassland and meadow' and the category 'Forage plants/Temporary grass'. 'Forage plants/Leguminous plants' are usually not included in grasslands since they are supposed to not include grass!
- The category 'Forage plants/Leguminous plants' is unclear. According to the understanding of farmers and national statistical services, they can include pure forage legumes or legume/grass mixtures. There is indeed no clear difference between the following covers: 100% lucerne, 90% lucerne/10% grass, 80% lucerne/20% grass, etc. Moreover, a pure sowing of lucerne can include after some time a variable proportion of spontaneous grasses.
  Regarding (red) clover/grass mixtures, the situation is even less clear since red clover is almost never sown in pure stand; it is almost always mixed with grass. Do they have to be classified in the category 'Forage plants/Leguminous plants' or in 'Forage plants/Temporary grass'? For farmers, pure lucerne, lucerne/grass mixtures and red clover/grass mixtures are just similar crops. They use one or the other according to soil characteristics, their experience and other factors. If red clover/grass mixtures are classified in 'Forage plants/Leguminous plants' the problem is that after 2-3 years, they can include much more grass than clover!
  According to countries, legume/grass mixtures can thus be included in the category 'Forage plants/Leguminous plants' or in the category 'Forage plants/Temporary grass'.

All these problems do not exist if the categories 'Forage plants/Leguminous plants' and 'Forage plants/Temporary grass' are replaced by 'Forage plants/ Temporary grasslands'.
In order to take into account the variable proportion of legumes in temporary grassland swards, a simple 3-level system is proposed: pure legume sowing; legume/grass mixtures; pure grass sowing. This system could be replaced in the future by a new one where a more

precise proportion of legumes in the sward will be assessed. That could be done in a later document for temporary and permanent grasslands.

3.2. Classification based on grassland types only

Grasslands

1. **Permanent grasslands**
   - **1.1. Agriculturally-improved permanent grasslands**[4]
   - **1.2. Semi-natural grasslands**
     - 1.2.1. Pastures, including rangelands, rough grazing, wood pastures etc.
       - 1.2.1.1. Sole use
       - 1.2.1.2. Common land
     - 1.2.2. Traditional hay meadows
   - **1.3. Permanent grasslands no longer used for production.**

2. **Temporary grasslands**
   - **2.1. Pure legume sowing**
   - **2.2. Grass/legume mixtures**
   - **2.3. Pure grass sowing**

3.3. Classification based on all fodder types

Fodder area

1. **Arable fodder crops**
   - **1.1. Temporary grasslands**
     - 1.1.1. Pure legume sowing
     - 1.1.2. Grass/legume mixtures
     - 1.1.3. Pure grass sowing
   - **1.2. Green cereals**
     - 1.2.1. Green oats, spelt, triticale, rye and other C3 cereals
     - 1.2.2. Green maize and sorghum
   - **1.3. Fodder roots (including fodder beet)**
   - **1.4. Fodder brassicas**
   - **1.5. Fodder *Compositeae*: sunflower**

2. **Grazed fallow lands**

3. **Permanent grasslands**
   - **3.1. Agriculturally-improved permanent grasslands**[5]
   - **3.2. Semi-natural grasslands**
     - 3.2.1. Pastures, including rangelands, rough grazing, wood pastures, etc.
       - 3.2.1.1. Sole use
       - 3.2.1.2. Common land
     - 3.2.2. Traditional hay meadows
   - **3.3. Permanent grasslands no longer used for production**

[4] Almost always in sole use but occasionally common land
[5] Almost always in sole use but occasionally common land

3.4. Classification based on all agricultural land use types

Utilized Agricultural Area

1. Arable land

- **1.1. Fodder crops**
  - **1.1.1. Temporary grasslands**
    - 1.1.1.1. Pure legume sowing
    - 1.1.1.2. Grass/legume mixtures
    - 1.1.1.3. Pure grass sowing
  - **1.1.2. Green cereals**
    - 1.1.2.1. Green oats, spelt, triticale, rye and other C3 cereals
    - 1.1.2.2. Green maize and sorghum
  - **1.1.3. Fodder roots (including fodder beet)**
  - **1.1.4. Fodder brassicas**
  - **1.1.5. Fodder *Compositeae*: sunflower**
- **1.2. Fallow lands**
  - **1.2.1. Grazed fallow lands**
  - **1.2.2. Non-grazed fallow lands**
- **1.3. Other crop types**

2. Permanent grasslands

- **2.1. Agriculturally-improved permanent grasslands**[6]
- **2.2. Semi-natural grasslands**
  - **2.2.1. Pastures, including rangelands, rough grazing, wood pastures, etc.**
    - 2.2.1.1. Sole use
    - 2.2.1.2. Common land
  - **2.2.2. Traditional hay meadows**
- **2.3. Permanent grasslands no longer used for production**

3. Permanent crops

[6] Almost always in sole use but occasionally common land

4. Multilingual vocabulary of grassland terms

Fodder areas: Futterflächen (DE); Superficies forrajeras (ES); Surfaces fourragères (FR); Superfici foraggere (IT); Voederareaal (NL); Plochy krmovín (SK); Foderarealer (SE)

Fodder crops: Futterpflanzen (DE); Cultivos forrajeros (ES); Cultures fourragères (FR); Colture foraggere (IT); Voedergewassen (NL); Krmoviny (SK); Fodergrödor (SE)

Grasslands: Grünland (DE); Pastos (ES); Prairies (FR); Prati e pascoli (IT); Grasland (NL); Trávne porasty (SK); Gräsmarker (SE)

Meadows: Wiesen (DE); Pastos de siega (ES); Prairies de fauche (FR); Prati da sfalcio (IT); Maailand (NL); Lúky (SK); Slåtterängar (SE)

Pastures: Weiden (DE); Pastos de pastoreo (ES); Pâtures, prairies pâturées (FR); Pascoli (IT); Weilanden (NL); Pasienky (SK); Betesmarker (SE)

Permanent grasslands: Dauergrünland (DE); Pastos permanentes (ES); Prairies permanents, Surfaces toujours en herbe (FR); Prati e pascoli permanenti (IT); Blijvend grasland (NL); Trvalé trávne porasty (SK); Permanenta gräsmarker (SE)

Agriculturally improved permanent grasslands: Landwirtschaftlich entwickeltes Dauergrünland (DE); Pastos mejorados (ES); Prairies permanentes améliorées (FR); Prati e pascoli permanenti migliorati (IT); Landbouwkundig verbeterd blijvend grasland (NL); Intenzifikované trvalé trávne porasty (SK); Förbättrade permanenta gräsmarker (SE)

Semi-natural grasslands: Naturnahes Dauergrünland (DE); Pastos seminaturales (ES); Prairies semi-naturelles (FR); Prati e pascoli semi-naturali (IT); Half natuurlijk grasland (NL); Poloprírodné trávne porasty (SK); Hagmarksbeten; naturbetesmarker (SE)

Permanent grasslands no longer used for production: Aus der Produktion genommenes Dauergrünland (DE); Pastos permanentes no utilizados para la producción (ES); Prairies permanentes plus utilisées pour la production (FR); Prati e pascoli permanenti non più utilizzati per la produzione (IT); Blijvend grasland dat uit productie is genomen (NL); Neprodukčné trvalé trávne porasty (SK); Permanenta gräsmarker tagna ur produktion (SE)

Rangelands: Rangelands, Hutungen (DE); Rangelands, Pastos de uso extensivo (ES); Parcours (FR); Rangelands, Spazi vasti a pascolo (IT); Rangelands, woeste gronden (NL); Rangelands, Extenzívne pasienky (SK); Rangelands, Extensiva betesmarker (SE)

Temporary grasslands: Wechselgrünland (DE); Pastos sembrados temporales (ES); Prairies temporaires (FR); Prati e pascoli temporanei (IT); Tijdelijk grasland (NL); Dočasné trávne porasty (SK); Vall på åker (SE)

Grazed fallow lands: Beweidete Brachen (DE); Barbechos y posíos (ES); Jachères pâturées (FR); Riposo pascolativo (IT); Braakliggende gronden die beweid worden (NL); Spásaný úhor (SK); Betad träda (SE)

Grazed common lands: Gemeinschaftsweiden (DE); Pastos comunales (ES); Terrains communaux pâturés (FR); Terreni a pascolamento collettivo (IT); Gemeenschappelijke weidegronden (NL); Obecné pasienky (SK); Betad allmänning (SE)

Annex 2. Photographs of pasture types as classified by Sociedad Española para el Estudio de los Pastos (SEEP).

Source: APMM and EFNCP, 2013 except where indicated

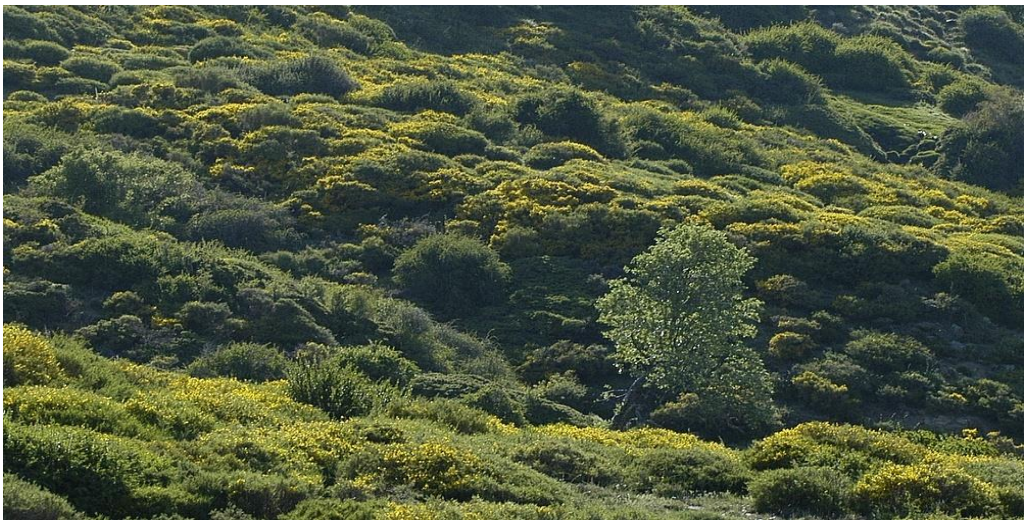
Pastos con arbolado denso. Pasture with dense tree cover. Grazed pine woodland of *Pinus pinea*.

Pastos con arbolado denso. Pasture with dense tree cover. Grazed oak woodland of *Quercus pirenaica.* The main forage resource of extensive goat graziers in north-west Extremadura. Source: G Beaufoy

***Pastos con arbolado ralo**.* Pasture with dispersed tree cover. *Pinus nigra* with shrub understorey of *Erynacea anthyllis* and herbaceous plants.

***Dehesas**.* Distinctive landscape of pruned evergreen oaks over predominantly herbaceous pastures and occasional cultivation, here with relatively sparse cover of *Quercus rotundifolia.*

Pastos de alta montaña. Mountain pastures. SHrub pastures in Sierra Nevada, dominated by *Cytisus galianoi* and *Genista versicolor* and with abundance of *Juniperus communis* and *Berberis hispanica*.



Pastos arbustivos de zonas subdesérticas. Shrub pastures. Sub-desertic zone with precipitation of <300 mm/year. Species include *Chamaerops humillis*, *Lycium intrincatum*, *Rhamnus lycioides*

Pastos arbustivos. Shrub pastures. Communities on substrates with special characteristics such as these salt pastures

Pastos arbustivos. Shrub pastures. Here with a high proportion of herbaceous pastures and presence of leguminous and other shrubs.

Pastos arbustivos / eriales. Shrub pastures on abandoned arable land. Here dominated by light-demanding colonisers and woody species on abandoned arable.

Pastos herbáceos de puerto. Herbaceous mountain pastures.

Pastos herbáceos. Herbaceous pastures. Here xero-mesophytic pastures of *Festuca* spp and *Stipa tenacissima*. Generally of low productivity.

Pastos herbáceos. Herbaceous pastures. Here dominated by annual species with few legumes, here in a dry area.

Pastos de origen agrícola. Pastures on arable land.

Annex 3. Overview pasture categories in Spain

SEEP PASTURE TYPES	ESYRCE	Criteria summary	CENSO AGRARIO	Criteria summary	SIGPAC (LPIS)	Criteria summary	Mapa Cultivos y Aprovechamientos	Criteria summary	Estadísticas Agrarias	Criteria summary
Rastrojos - Arable stubbles	*Rastrojos*	Crop remains have not been ploughed in. After 1 year becomes *barbecho*	Not specified	Included within *cultivos herbáceos* (herbaceous crops)	Not specified	Included within arable land; fallow land is indicated on an annual basis in IACS declarations but not on LPIS	Not specified	Included within herbaceous crops and arable	*Rastrojeras pastadas*	Statistics show a figure specifically for grazed stubbles.
Barbechos- Arable fallows	*Barbechos*	Maximum 4 years out of use, then becomes *baldío* (non-UAA, see below)	*Barbechos*	Arable land that is "resting", may be ploughed, sown to green manure, or spontaneous vegetation.			Not specified		*Barbechos pastados*	Arable land not in use for the year for whatever reason, may be used for grazing. Statistics show a figure specifically for grazed fallow.
Cultivos forrajeros - Forage crops	*Cultivos forrajeros*	Included in *tierras de cultivo* (cultivated land)	*Cultivos forrajeros*	Forage crops, includes as subcategory grasslands that remain on same parcel <5yrs			*Cultivos forrajeros*	Included with herbaceous crops (irrigated) and arable (non-irrigated)	*Cultivos forrajeros*	Data is by individual crop, including production/ha. Total is divided into % dehydrated, silage, hay, green. And into those that are harvested (and maybe also grazed), and those that are grazed only. And irrigated/non-irrigated.
Praderas - Sown grasslands for mowing or intensive grazing	*Praderas*				*Pastizal*	Permanent grassland with <40% coverage of trees and shrubs. Praderas included here if on same parcel over >5years, otherwise in			*Praderas*	

Prados naturales - Grasslands in more humid areas (e.g. Atlantic Spain) that are productive enough to be mown at least once per year (although they may be not mown in practice). Prados can have some trees and shrubs. They are unsown (and hence sometimes called prados naturales) but may have been improved through manuring and artificial fertilisation, and may be irrigated.	*Prados naturales regadío*	Unsown grasslands capable of mowing at least once per year. May have occasional trees. Irrigated.	*Prados o praderas permanentes*	Grasslands sown or natural >5yrs on same parcel, may be resown, productive enough for mowing or intensive grazing		arable land. Original SPS co-efficient = 100%. New co-efficient based on % of non-productive elements, slope, and vegetation structure.	*Prados o praderas naturales - regadío y secano*	Natural grasslands characteristic of humid or sub-humid climates with homogeneous seasonal production and from year to year, suitable for mowing. Categories for irrigated and non-irrigated. Several subcategories for presence of shrubs and/or trees upto 60% and 20% respectively.	*Prados naturales*	Unsown herbaceous vegetation of perennial species in humid and sub-humid climates and in drier climates where there is sufficient soil humidity suitable for mowing at least once per year. Relatively stable production year to year and to a lesser extent within the year.
	Prados naturales secano	As above. Non-irrigated.					**FOLLOWING ARE ALL CLASSED AS FOREST IN M.C y A.**			
Pastizal de puerto / alta montaña - High mountain seasonal grasslands	*Pastizal alta montaña*	High mountain seasonal grasslands	*Otras superficies utilizadas para pastos*	All other land used as pasture, including poorer uncultivated			*Prados de alta montaña*	Herbaceous communities in mountain, sub-alpine and alpine areas, exclusively used for grazing.		

Pastizal - Unsown dry grasslands with limited shrub/tree cover. Highly variable production (spatial and temporal). May be ploughed occasionally.	*Pastizal sin arbolado*	Unsown dry grasslands with <20% shrubs and <5% trees. May be ploughed occasionally.		grasslands, dehesas, shrublands, abandoned arable land, or kept in GAEC for CAP purposes. All included in UAA			*Pastizal*	<5% tree cover and <20% shrub cover.	*Pastizal*	Unsown pastures typical of dry-subhumid, semi-arid and arid zones, dominated by annual grasses. Suitable for grazing and not ploughed except occasionally. great variability in production year to year and within the year. Not suitable for mowing.
Pasto con arbolado ralo/disperso - Unsown dry grasslands with scattered trees	*Pastizal con arbolado*	Unsown dry grasslands with 5-20% trees			*Pasto con arbolado*	Permanent grassland with >40% coverage of trees. Original SPS co-efficient 25%. If tree cover >80% generally classified as *forestal* - see below	*Pastizal con arbolado*	5-20% tree cover, but upper limit only if no significant grazing use. <20% shrub.		
Pasto con arbolado denso - Woodland or forest plantation of high density that allow extensive grazing of the herbaceous understorey and browsing of shrubs and trees.	If >20% tree cover considered as "pure" forest, see below under non-pasture categories.									
Dehesas - Pasture with oak tree cover typically upto 60%, sometimes more. Some extensive arable cropping.	Included within the various *pastizal con arbolado* categories and *forestal arbolado*									

Pasto arbustivo - Pasture of woody species (trees or shrubs) of less than 5 metres in height. Used mainly by goats, sometimes by sheep. This type of pasture may include a significant herbaceous element but shrubs may be predominant or even 100%	*Pastizal-matorral sin arbolado*	Unsown dry grasslands with >20% shrub cover that may reach 100% if still used for grazing. Trees <5%			*Pasto arbustivo*	Permanent grassland with >40% coverage of shrubs. Original SPS co-efficient 50%.	*Pastizal-matorral*	<5% tree cover and 20-60% shrub cover		
Pasto arbustivo con arbolado - as above with tree cover	*Pastizal-matorral con arbolado*	As above, with tree cover of 5-20%					*Pastizal-matorral con arbolado*	5-20% tree cover and 20-60% shrub cover		
Erial a pasto - Sparse spontaneous vegetation on abandoned poor arable land. Evolves to shrubs. Overlap with pastizal	Either included in pastizal categories or as not pasture - see below				*Erial* is either in *Pastizal* or *improductivo* (not in production)		*Erial* is Included within the *pastizal* categories above		*Erial*	If in areas with grazing, included in pastizal. But if classed as erial then it is in areas with no livestock so no grazing. May only be enough for 10kg live weight/ha/year
	FOLLOWING NOT PASTURE IN ESYRCE		**FOLLOWING NOT UAA IN CENSO**		**FOLLOWING NOT ELIGIBLE FOR CAP**				**FOLLOWING CLASSED AS FOREST, NOT COUNTED IN THE PASTURE AREA BUT THE TEXT SAYS THAT IT MAY BE USED AS PASTURE**	
	Otras tierras - baldío	Abandoned agricultural land not used for crops or grazing	*Otras superficies*	Includes arable land and shrubland that is out of use whether for crops or grazing. Not in UAA	*Improductivo*					

	Otras tierras - erial	Abandoned agricultural land with poor and scarce vegetation (often degraded land). Grazing use is almost non-existent due to lack of livestock								
	Matorral sin arbolado	100% shrub with no grazing, <5% trees					*Matorral*	<5% tree cover, >60% shrub cover	*Monte desarbolado*	Treeless forest with little human intervention, tree cover <5%
	Matorral con arbolado	100% shrub with no grazing, 5-20% trees					*Matorral con arbolado*	5-20% tree cover, >60% shrub cover	*Monte arbolado disperso*	Forest with disperded tree cover of 5-10% and shrub or pasture vegetation
	Forestal arbolado - subcategories include Frondosas crecimiento lento (slow-growing broadleaves)	Forest with tree cover >20% not principally used for grazing, or with <20% where only use is timber production, environmental protection, etc. (no grazing).			*Forestal*		*Superficie arbolada con especies forestales*	Includes an indication of tree species and crown cover	*Monte arbolado ralo*	Forest with 10-20% tree cover and shrub or pasture vegetation
									Monte arbolado	Forest with >20% tree cover