EIP-AGRI Focus Group

Permanent Grassland

Achieving grassland production and quality that matches animal needs

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Introduction

Variation in grasslands

Permanent grasslands are exploited by grazing animals or as meadows depending on different constraints. Grazing is the most common use in large parts of Europe, especially in the northwest of Europe. However, certain areas are less suitable for grazing. In the Alps e.g. meadows are the most relevant grassland utilization option because of the steepness of the terrain and a short favourable season, so animals use stored forage during the long winter period. In the Cantabrian fringe, although climate and topography allows for a long grazing season, this is practiced in few farms due to the small size and dispersion of parcels, making it very difficult to organise a reasonable grazing scheme. In several countries in the North West of Europe zero-grazing is practised due to different reasons like large herds or use of Automated Milking Systems (AMS).

Permanent grasslands are highly variable. They differ markedly in their botanical composition and productivity, ranging from agricultural-improved grasslands with few very productive plant species, to natural and semi-natural grasslands (Peeters et al., 2014), found in a high variety of ecological conditions and thus with a high number of potentially dominant plant species, mostly of low productivity. Most ruminant livestock farmers have some agricultural-improved grassland, but depending on the livestock system, this will be the majority of their farmland (e.g. dairy farms) or the minority (e.g. goats for meat in mountain areas).

For every grassland based livestock farm, irrespective of the types of grassland used, the ideal target is that its own forage allowance matches animal needs. These two variables –forage allowance and feed requirements- are mainly dependent on the stable components of the farm (animals: type, number and annual and seasonal productivity (milk and/or meat); and grasslands: type, area, botanical composition, annual and seasonal productivity, nutritive quality), but also on the weather. Normally, the stable components of the farm are adapted to the climate, soils and other use restrictions of the area. It is the changeable inter-annual weather conditions that lead to variability in the quantity and quality of available forage, and so weather conditions are the main factor affecting the forage allowance, and so the profitability of the system in the short-medium term. The farmers have to adjust their management (fertilisation, timing of grazing / cutting, etc.) to these changeable weather conditions.

Farmers feel the need to control this short-term variability generated by changing weather conditions. Staying in control is a big issue for the farmers and they feel unsure about their livestock and grassland management if external factors like weather affect the functioning of their system. When they are not in control, it is difficult for them to see the economic profits of certain improvements, such as grazing instead of cutting in dairy or beef cattle systems (Peyraud et al, 2010).

Aim of this paper

The aim of this mini-paper is to answer the following questions:

- How can we help farmers to manage their grassland production (quantity and quality) in such a way that it approaches more the needs of animals and improves the profitability of the farm?
- How can we do this for the variety of ecological conditions, types of grasslands and livestock systems?
- How can we do this, considering key aspects such as weather variability?

Examples of European grassland systems

In extensive livestock systems, abundant in European grassland-dominated mountain areas and also in the Mediterranean region, permanent grasslands dominate, and it is common to have different pastures in terms of botanical composition and structure (i.e. gradient from totally herbaceous to plant communities dominated by woody species) in the same rangeland. Factors like variations in geology, topography, microclimate and defoliation (selectivity, intensity and frequency) influence pasture diversity just as climatic/meteorological issues. Climatic constraints are often coupled to topographic limitations and/or infrastructural deficits. In such situations, meat production with small ruminants and/or beef cattle represents an efficient alternative to dairy farming, because when the size of the livestock is reduced, the resilience of the system in hard environment conditions is increased. These systems often require tackling constraints arising from socioeconomic aspects (i.e. leisure time for shepherds, increase of predators) and specific management practices differing from those of the climatically and topographically favourable areas. The best combination of species according to their dietary overlap is often not known. In these systems, especially in communal areas, different livestock species and breeds graze at the same time with variable overlap in the use of resources depending on flock composition. These complex livestock grazing systems need a careful approach when analysing the match between animal needs and pasture production. Apart from plant availability and nutritive value, other variables –e.g. energy expenditure, defence to predators, water availability, mineral requirements and fly attacks sheltering- need to be considered. In these systems it is also important to evaluate the forage utilisation (offtake/growth) of the different pastures of the range with respect to reference values identifying sustainable use, as vegetation is dynamic, especially when extreme forage utilisation values (low or high) occur. When woody vegetation is involved a proportion of consumable vegetation versus woody vegetation in the same type of shrub should be considered if sustainable use is foreseen. When the conversion of woody vegetation to herbaceous vegetation is the key issue, adequate high stocking rates should be involved (i.e. measure 24 of rural development). Pasture offered can also be regulated by grazing and fertilization (fertiliser type, timing and dose). Pasture quality depends on the proportion of legumes, which are usually associated to K and P fertilization. Woody vegetation presence is usually a key issue when optimizing the use of nutrients. P fertilization is relevant to sustain a high proportion of legume contents in pasture allocated in Mediterranean regions.

Grassland management is adapted to the conditions. In Galicia for example, intensive grazing at the start of the growing season is essential to increase pasture use efficiency before summer drought as it increases grassland density and reduces the percentage of unused patches in the land and the percentage of flowering, which is usually related to a reduction of grassland quality. It also allows to have a higher proportion of clover at the end of the spring season. However, autumn proportion of clover in pasture is highly dependent on summer weather conditions, being higher after wet summers. In Southern regions of Spain, special care should be taken to allow grass to flower and produce seeds before grazing to allow annual species to self reseed in the next season.

In other regions of Europe, more intensive systems are found with usually a single type of agriculturally-improved grassland and few very productive plant species, and a single livestock species. They require a different approach. In countries like Ireland where grazing is the key driver for grass utilisation, the management of the grazing season is broken down into the key seasons: spring, mid-summer and autumn. There are different best practices at these different time periods due to differences in grass demand and supply, even in labour demand. For example the grazing management required in the mid-season is focused on managing peak grass supply whereas in spring the focus is on managing the farm to grow sufficient grass to feed the herd with some pasture. Therefore different levels of decision supports are required to ensure the produced grass is well utilised (Griffith et al., 2014). The amount of grass utilised per hectare and the efficiency with which that grass, together with supplementary feeds, is converted into milk or meat will determine the productivity and profitability of the farm at a per ha level. This is for example demonstrated by the Irish Grass Calculator. The Irish Grass Calculator can be used to back calculate the quantity of grass harvested or utilised on farm in terms of UFL's (Unit Feed Lactation). Data from the Irish National

Farm Survey (NFS) in 2009 was entered into the Grass Calculator to obtain an estimate of the quantity of grass utilised per hectare on the average dairy farm in Ireland (Figure 1) (Shalloo et al., 2009). On average, approximately 6.6 t DM ha^{-1} (UFL's) were utilised on the a dairy farm at a stocking rate of 1.85 cows ha^{-1}. Figure 1 shows the relationship between grass utilised per hectare and net profit for the 316 dairy farms in the NFS database. The proportion of the variation in net profit ha^{-1} accounted for by the level of grass utilized ha^{-1} was similar to that previously reported (€162 ha^{-1} for every additional one tonne of grass utilised).

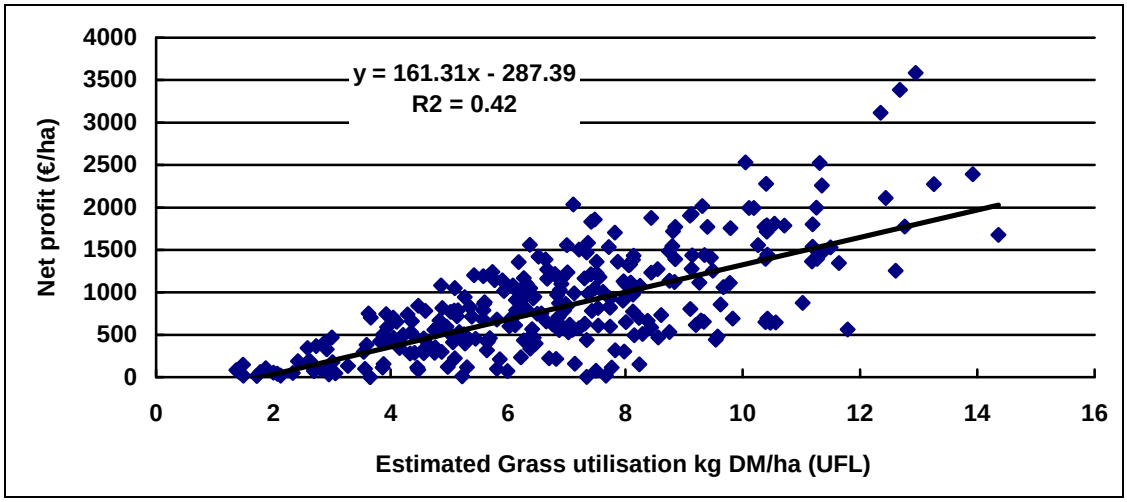

Figure 1. The relationship between estimated grass utilised per hectare (kg DM ha^{-1}) and net profit (€ ha^{-1}) in animal products in Ireland (UFL=Unit Feed Lactation) (Shalloo et al., 2009).

Farmers' needs

Permanent grasslands are exploited by grazing animals (pastures) or as meadows depending on different constraints.

Pastures

In general, grazing is considered an economically attractive practice in Europe (e.g. Peyraud et al., 2010) and therefore the needs of the farmers in this section of the paper are focused towards grazing. Several current trends in livestock farming are causing a decline in the popularity of grazing in Europe (EGF Working Group Grazing 2010; 2012; 2014 http://www.europeangrassland.org/working-groups/grazing.html). This leads to increased areas of grasslands that are only cut (zero-grazing, up to 7 cuts a year). Trends that cause a decline in the popularity of grazing include the management of larger herds and introduction of automated milking systems (AMS), land fragmentation, but also uncertain factors as weather and difficulties with grassland management (timing of grazing/cutting, fertilisation). These factors are relevant for farmers when they have to manage their grassland production (quantity and quality) in such a way that it approaches more the needs of animals and improves the profitability of their farm. An international survey (Van den Pol-van Dasselaar et al., 2012) that aimed to assess the requirements for effective grazing Decision Support Tools showed that the main concern of dairy farmers with respect to grazing is:

- "How to act on changing weather conditions which lead to less grass intake and declining milk production"

The survey further showed that the concerns of dairy farmers are related to:

- Poor predictability of the grazing system (herbage allowance, grass intake) and of the effect of management on the grazing system
- Situations of 'forced' choices, i.e. grassland management (like fertilisation, timing of grazing/cutting) has to be adapted to changing circumstances and this has to be done now

Meadows

Concerning the meadows, reacting effectively to the quantitative and qualitative fluctuations of the forage production in order to match the needs of the animals, and achieve the best possible economic efficiency, can be regarded as a priority for the farmers. With this respect, the main difficulties encountered by the farmers are:

- Making the best choice concerning the cutting time, as forage quality (in particular at first cut) decreases as the phenological development progresses
- Identifying a sustainable management intensity, ensuring acceptable yield level and forage quality in the forthcoming grazing period on one hand, and an adequate level of ecosystem services, such as biodiversity and carbon storage, on the other one.

Farmers' needs

In other words, the question is how to match animal needs and the potential of grassland to offer these needs. Farmers feel the need to have this control. Staying in control is a big issue for the farmers and they often feel unsure about their grazing management and the effect of external factors like the weather. When they are not in control, it is difficult for them to see the economic profits of using grasslands. Especially in situations of increasing herd size and/or introduction of an automatic milking system, historic knowledge and intuition may not suffice to manage the grazed grassland properly. Farmers usually lack the necessary skills to manage grazing properly since they cannot lean on a learning experience. This is not only true for farms with dairy cattle, but also for farms with beef cattle. Beef cattle are often produced in feedlots. Those beef cattle are rather fed on cereals than on grass. For producing beef, high quality of grass with enough protein should be available. Under rangeland conditions in the mountains sufficient protein content might not be guaranteed all the time, but it could be a profitable system by depending less on external inputs. For both beef and milk systems matching grassland production with animals needs while minimizing external inputs is a key issue.

Set-up of the paper

A European platform like the EIP Agri Focus Group on Permanent Grassland can help in identifying best practices and research needs. The aim of this paper is to show i) available practices and techniques, ii) research projects, iii) research needs and iv) for innovative actions to translate the scientific knowledge available on matching grassland production and animal needs into applied techniques.

Available practices and techniques

In this section concrete practices and techniques that deal with matching grassland production and animal needs are identified. Both general and local practices and techniques are mentioned. Local practices in one region can be inspiring for other regions.

Animal needs are often well-known, especially in intensive livestock systems, but grassland production is harder to determine and to forecast.

We distinguish:

- Practices and techniques with respect to grasslands
- Practices and techniques with respect to animals
- Practices and techniques with respect to management that matches grassland production and animal needs

Practices and techniques with respect to grasslands:

- Regularly measuring grass yields of pastures in a farm walk, e.g. with rising plate meters or by visual assessment whereby the observer is regularly calibrated by cutting with a quadrat and shears
- Regularly assessing farm cover based on measuring pasture cover (standing biomass) for each paddock on the farm
- Maintain grazing diaries – to calculate rotation length
- Using web based computer programs to compile grassland measurements
- Using farm collected grassland data to assist grassland farmers (many farmers in Ireland are collecting grassland data weekly which can be used to show the national picture regarding grass growth on farms) (see Appendix 1)
- Grassland Sensors. For example, soil temperature and volumetric water content sensors to indirectly monitor plant growth. This can be done in intensively managed grassland but also on natural/seminatural pastures
- Precision in fertilization, weed control, irrigation, etc. to reduce costs and environmental impact
- Undo the effect of trampling (as they do in football pitches) while maintaining biodiversity
- Sward reseeding with varieties adapted and suitable to the regions
- Using electric fencing to block grazed pastures to maximise sward utilisation and in certain areas also suitable to protect against predators

- Forage values tables as an aid to estimate forage quality depending on the phenological stage of lead species and the proportion of the functional groups grasses, legumes and forbs and to define the best cutting date

- Sensory-based systems to assess forage quality depending on appearance and smell of the conserved forage (hay, silage)

- Relatively fast methods to evaluate important aspects of profitability of grasslands, such as productivity, pattern of seasonal growth and pasture quality can be used in a range of grasslands (from intensively managed to seminatural herbaceous grasslands). These methods are based on identifying dominant plant functional types related to growth strategies, phenology, adaptation to frequency of use and feeding value.

- In acidic grasslands, especially when exchangeable aluminum in soil is high, liming is a common practice when productive forage plant species want to be introduced. It is important to evaluate its cost and its effects with respect to carbon emissions.

- In the case of shrub dominated pastures characteristic of mountain and Mediterranean regions, there are some common practices to reduce/eliminate temporarily the shrub cover:

    - Slashing: cutting woody plants at soil surface with blades or chains that spin parallel to the ground. It can be done up to a certain slope, and when ground has no rocks or stones. It is very common practice in northern Spain, especially in areas dominated by gorse (Ulex spp.).
    - Partial clearing: leaving squares of 10 x 10 uncleared surrounded by corridors of 1 or 2 m. Animals will be walking within the corridors and allowed to go from them to the inside of the squares. If animals with a preferential use of shrubs are used at high stocking rate, a natural conversion to herbaceous grasslands can happen (Rigueiro-Rodríguez et al., 2008).
    - Burning: when performed under certain weather, soil, terrain and vegetation conditions, and if performed by experienced professionals, it can be an acceptable measure to reduce woody biomass, and promote the growth of herbaceous plants and livestock grazing afterwards.
    - In Mediterranean areas dominated by Cistus spp. it is recommended to uproot the shrubs through soil mobilization (scarification + disc harrowing) followed by fertilizing (mainly phosphorous) and sowing "biodiverse legume rich permanent pastures" able to support much higher stocking rates which, through the increased grazing pressure, will prevent the reestablishment of shrubs.

Practices and techniques with respect to animals:

- Feed requirement calculators

- Sensors

    - Livestock position tracking using GPS collars and mobile phone (e.g. http://geopos.hazi.es/index.php#loginmodal)

    - Monitoring of standing time, laying time, ruminating time, grazing time

- On/off grazing techniques – giving cows access to pasture for short periods (2 * 3-4 hour periods)

- Using breeds or crossbreeds animals that are more suitable to grazing conditions, i.e. lower bodyweight animals which will place less pressure on soils, but have high intake capacity.

Practices and techniques with respect to management that matches grassland production and animal needs:

- Decision Support Tools
- Spring rotation planner
- Grass wedge
- Autumn grass budgeting
- Grass calculator – estimating grass utilisation (Shalloo et al., 2011)
- Web based decision supports
- National or regional grassland database – store and use grassland data to assist farmers in grassland decisions
- At the rangeland scale (mosaic of different NSN grasslands in a vast landscape characterised by heterogeneity), the location and regulation of access to water points or other type of attractors (salt/mineral points) is an interesting practice to influence spatial livestock distribution when man-power is scarce.
- Mixed grazing, e.g. combining cattle with small ruminants depending on sward characteristics
- Methods to assess the carrying capacity, and hence a suitable stocking rate, of extensive pastures
- Inclusion of improved pastures with diverse sward composition and higher nutritive value where grassland production cannot cover animal needs. Grazing periods can thus be extended and farms will decrease their dependence on external inputs; therefore, costs could be reduced

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Research projects

In this section research projects (focussing on results) or innovative projects that are relevant for the theme of this paper are identified and listed.

Amazing Grazing

The project Amazing Grazing (**www.amazinggrazing.eu**) in the Netherlands addresses questions like "How do we ensure that the yield of the pasture is higher with grazing compared to mowing?" The challenges are reducing the grazing losses and increasing the gross output. Innovative ways of thinking are needed concerning grazing systems, type of vegetation or grass, reducing trampling, extending the grazing season and smart combinations with type of cow and cows per ha. Or should we even grow grass vertically to enlarge pasture area? Another relevant question in this project is "How do I get a grass intake per day as high and constant as possible?" The challenge is to let cows eat much grass in limited time and to make this measurable in order to be able to adjust. Or should you better not adjust and accept fluctuations in intake and production? Do we know enough of the natural grazing behaviour of cows? Therefore, training of cow and farmer is needed. And what type of cow learns quickly? Which animals can easily match grazing and varying circumstances?

Autograssmilk

AUTOGRASSMILK (**www.autograssmilk.eu**) is a joint research project for the benefit of SME Associations, which objective is to develop and implement improved sustainable farming systems that integrate the grazing of dairy cows with automatic milking (AM) which are appropriate to the different approaches to dairy farming to be found in the different regions in Europe. Partners are from Ireland, Sweden, Denmark, the Netherlands, Belgium and France.

One of the Work Packages aims to optimise the integration of AM systems with cow grazing by using new technologies. Precision grazing management is critical for the successful integration of AM and grazing. Integrated grazing and AM systems require an even distribution of milking over a 24 hour period in order to achieve a high level of machine utilization, minimal length of cow queues at the dairy and a high ratio of cows to milking unit. In a grazing scenario, precise allocation of grass will be the main motivator for cows to move voluntarily into the AM instillation. A decision support tool will be developed allowing grassland management decisions to be made in an accurate and objective manner. A GPS farm mapping tool will be applied and demonstrated on research farms in different countries. The recording of tracking behavior of dairy cows in AM systems will be evaluated in terms of management decision making. New automated milking technologies such as the mobile AM systems for fragmented farms and carousel AM systems for larger herd sizes will also be studied in grazing environments.

Feed4Foodure - Nutritional optimization for high producing dairy cattle in grazing systems

The project is part of a public-private partnership between the Dutch Ministry of Economic Affairs and a consortium of various organizations within animal feed industry and the animal production chain (**http://www.wageningenur.nl/en/Research-Results/Projects-and-programmes/Feed4Foodure**). In the project current knowledge of high yielding dairy cattle nutrition will be used to optimize grazing systems for high producing dairy cows. New strategies will be developed to improve the synchronization of diet composition with the requirements for production level and lactation stage.

webGRAS

Web-based estimation of forage quality of permanent meadows at first cut (http://www.laimburg.it/en/mountain-agriculture/1903.asp) aims at developing a practice-oriented, GIS-based, user-friendly application for farmers and consultants for the estimation of the potential forage quality of permanent meadows at first cut in South Tyrol. Therefore, the choice of the quality parameters to be estimated and of the input data to be used takes into account the expertise of the local experts on forage and livestock production. To allow the final users a practical use of this information, the model will be integrated into a user-friendly application, freely accessible on the web. The users will provide few known information (date of pasture stage (begin of stem elongation), harvesting date, cartographic location of the meadow, agronomic management), while topographic characteristics and weather conditions will be automatically retrieved or computed by the software. The software will provide to the users a report of the estimated quality parameters.

The application, freely accessible on the web, will provide farmers and consultants of the livestock sector a tool to estimate forage quality based on several information such as the mowing date, the site characteristics, the weather conditions during forage growth and the agronomic management. Thereby, the farmers will get useful information to optimize the food ration of the animals with positive consequence on the health and productivity of the animals, and thus, in turn, to improve the economic efficiency of the farms.

Modelo PUERTO

This simulation model recreates the functioning of grazing systems in mountain areas where different herds/species utilise vast common areas of rough terrain and heterogeneous soils, microclimates and pastoral vegetation. The model simulates vegetation growth and livestock utilisation along a year considering the space explicitly. It has been used to simulate the functioning of common pastures in the north of Spain, estimating the grazing utilisation of different areas and the change in body condition of livestock. Its use is especially indicated for detecting areas with possible disequilibria (under- over-grazing and negative livestock weight balances), and to recreate the effects of possible management improvements (fertilization, shrub clearance, water availability, stocking density, etc) both for grassland productivity and nature conservation.

Virtual electric fencing

http://www.agripir.com/es/e-pasto/que-es.

Nitrogen Nutrition Index

Estimate nitrogen state of grasslands (Nitrogen Nutrition Index) through high resolution remote sensing (Mistele and Schmidhalter, 2008). If this is realised, this would allow planning rate and timing of N fertilisation precisely to any farmer and increase grass productivity.

Multisward

The MULTISWARD project "Multi-species swards and multi scale strategies for multifunctional grassland-base ruminant production systems" (www.multisward.eu) was a joint research project within FP7 (2010-2014). It aimed to increase the reliance of farmers on grasslands and on multi-species swards for competitive and sustainable ruminant production systems. Part of the work studied the sustainability and competitiveness of grassland-based systems of ruminant production in Europe using grasslands with a range of productivity levels (nutrient poor grasslands, organic systems, highly productive grasslands) through science and innovation. The investigations were focusing on evaluation and promotion of sustainable ruminant production systems based on the use of grasslands with a high level of multifunctionality in order to optimize the provision of environmental goods and biodiversity preservation, on one hand, and on the other, economic efficiency and provision of quality food.

AGFORWARD

AGFORWARD (AGroFORestry that Will Advance Rural Development) is a four-year research project funded by the European Union's Seventh Framework Programme for Research and Technological Development (FP7). It started in January 2014 and will continue until December 2017. The project builds on existing agroforestry experiments, current on-farm agroforestry trials, and previous research projects such as "Silvoarable Agroforestry For Europe (SAFE)". The European Agroforestry Federation is a partner. The start of the project coincides with the launch of EU Rural Development Regulations that can support the establishment of agroforestry systems. The overall aim of the project is to promote agroforestry practices in Europe that will advance rural development, i.e. improved competitiveness, and social and environmental enhancement. The project will achieve the above goal by addressing several objectives: to understand the context and extent of agroforestry systems in Europe; to identify, develop and field-test innovations to improve the benefits and viability of agroforestry systems in Europe; to evaluate innovative agroforestry designs and practices for locations where agroforestry is currently not-practised or is declining; to quantify the opportunities for uptake at a field-, farm- and landscape-scale; and to promote the wider adoption of appropriate agroforestry systems in Europe through policy development and dissemination. Among this objectives, solutions dealing with the use of woody vegetation as forage to overcome shortage periods are described.

Research needs

In this section research needs from practice are indicated. This section addresses those areas where more knowledge is needed. Research should focus on:

- Increasing the potential yield of grasslands through a combination of extending the grass growing season in areas where the weather allows this, plant breeding, use of mixtures of plant species (including trees), smart fertilisation and dynamic stocking systems.
- Increasing the yields of grazed pastures by reducing the grazing losses (trampling, urine and faeces) through a combination of optimising grazing systems, type of vegetation/grass and smart combinations of animals per ha and type of breed.
- Stimulating grass variety by testing under harsh conditions (e.g. trampling, ph, flooded or desert areas, etc.) in order to develop varieties better adapted to grazing.
- How to turn beef cattle back to grazing while producing healthy, tasteful and tender meat with enough fat for cooking that answers to the high quality needs of consumers with respect to fat, marble, fat cover, the balance of good acids etc.
- Reducing the acute conflicts in mountain rangelands between livestock grazing (especially small ruminants) and predators (especially wolf). This problem is felt as one of the main reasons of the grazing abandonment and shrub encroachment of many mountainous remote grasslands of some countries/regions of the EU. Research should focus on testing innovative tools that help farmers minimise animal casualties from wolf attacks.
- Developing novel grazing systems for future livestock farms (large-scale, high productive, highly automated) that i) are technically and socially feasible and ii) are economically viable and environmentally sound.
- Optimizing grazing/feeding patterns (behaviour) of ruminants to improve efficiency of grass utilization and/or to decrease emissions of pollutants.
- Establishing the fundamentals of decision supports of a resilient grazing system, i.e grass growth capacity, levels of grass utilisation, proportion of grass consumed by grazing, and designing essential decision support tools using these fundamentals that will underpin high levels of grass utilisation – these will be different across countries and at different adoptive levels.
- Increase support to farmers in less favoured areas with high risk of land abandonment where sustainable extensive livestock systems can provide a viable alternative which develops environmental benefits at the same time.
- More studies to differences in grazing behaviour, diet selection and energy needs of different breeds and mixed flocks to search for flexibility with respect to grassland allowance.
- Real-time, affordable, non-destructive monitoring of forage quality, in order to be able to quickly react to unexpected situations due to unusual weather conditions.
- Provide decision tools, taking forage production as well as a comprehensive economic evaluation in the long term into account, for integrating grazing in meadow-based production systems, as a viable method to control meadow weeds.

- To evaluate the use of woody vegetation (CRC, tree fruits, pruned branches..) to fulfil demands during the shortage periods
- To evaluate the effect of hedges and trees as a form to reduce weather fluctuation impacts (drought, frost…)

Innovative actions

In this section ideas for innovative actions (that translate the scientific knowledge available into applied techniques) are given.

Technological innovations (focussing on increasing grass utilisation through grazing animals and development of new techniques to improve grazing management) as mentioned in the previous sections are very important, but you need to simplify them and make them practical for the farmer by

- Implementing models/programs in applications accessible on the internet and/or available for a smartphone
- Measuring grass yield in a less time-consuming way, e.g. by installing suitable equipment on a quad
- Promoting learning processes in groups, e.g. operational groups where farmers learn from farmers and other stakeholders
- Convincing farmers that they may find satisfaction in succeeding the management of something that is difficult to manage
- Developing practical tools to facilitate farmers on livestock farms, e.g. computer programs, preferably farm-specific or web based programmes that allow farmers to assess farm specific data like feed wedges. Tools should:
    - Be robust, simple to use and appealing
    - Use and take advance as much as possible of the large amount of information already available in farm-related databases and territorial information systems, minimising the amount of input needed from the farmers themselves
    - Provide insight at a glance in the technical and economic consequences of management decisions (e.g. timing of grazing/cutting, fertilisation)
    - Facilitate farmers in those common situations where they have to adapt quickly to changing circumstances (nearly real-time information about the state of parameters relevant to management decisions, easy access to information related to their development over time)
- Providing technology and guidance to farmers on how to set up a farm to optimise grass production and utilisation (e.g. to optimise harvest period, liming, fertilisation (type of fertiliser, dose and timing))
- Ensuring farmers use grassland measurement in the management of pasture
- Training of young farmers. New strategies to convert grassland management into an attractive activity for younger generations
- Developing web based grassland technologies that are centred through a central grassland database
- Establishing grass growth predictive models to assist farmers in managing a fluctuating grass supply

High priority actions

- Increasing the potential yield of grasslands through a combination of extending the grass growing season in areas where the weather allows this, plant breeding, use of mixtures of plant species (including trees), smart fertilisation and dynamic stocking systems.
- Developing novel grazing systems for future livestock farms (large-scale, high productive, highly automated) that i) are technically and socially feasible and ii) are economically viable and environmentally sound.
- Establishing the fundamentals of decision supports of a resilient grazing system, i.e grass growth capacity, levels of grass utilisation, proportion of grass consumed by grazing, and designing essential decision support tools using these fundamentals that will underpin high levels of grass utilisation – these will be different across countries and at different adoptive levels.
- New strategies to convert grassland management into an attractive activity for younger generations

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Appendix 1

Example of weekly grass DM production from Irish dairy, beef and sheep farms as compiled by PastureBase Ireland (18/9/2014).