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Relevance and functionality of semi-natural grassland in Europe – status quo and future prospective

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Abstract

An overview is presented of the role and functions of semi-natural grassland (SNG) in Europe. SNG has declined in recent decades and, despite policy support through agri-environment schemes, threats from further intensification and abandonment remain. Evidence of their agricultural value in terms of productivity, forage quality and product value is reviewed. Production from SNG is typically less than 50% that of improved grasslands but comparable to unfertilized sown grassland; feed value is also variable with lower digestibility in SNG but differences in chemical composition may enhance the nutritional, health or gastronomic value of meat and dairy products compared with conventional feeding systems. SNG has an important role in biodiversity protection and in delivering ecosystem services which can contribute further to socio-economic values for rural communities. Many uncertainties surround the future for SNG as land management adapts in response to global changes including issues of security of food, water, energy and other agricultural inputs. Climate change poses threats to SNG in some areas, notably through water stress, but some types of SNG may be more resilient and contribute to mitigating the causes and effects of climate change. The role of SNG within the concept of multifunctionality is discussed.

Introduction

European grasslands vary greatly in terms of their management, agricultural productivity, sustainability, wider socio-economic values and their nature conservation status. Grasslands have existed in the temperate areas of Europe over millions of years. Their history of expansion and contraction, their co-evolution with large mammalian herbivores, and the exchange of species between other biomes such as steppe, forest, alpine and Mediterranean communities, and the effects of physical disturbance associated with grazing (by wild or domesticated herbivores), fire and farming (including mowing) have shaped their biota and diversity that remains today (Vera, 2000; Pärtel et al., 2005). The pivotal role of human intervention over thousands of years, mainly through farming, has led to the adoption of the rather imprecise term 'semi-natural grassland' (Van Dijk, 1991). Semi-natural grassland (SNG) is essentially that which has developed as a consequence of pastoral agriculture being imposed on cleared woodland or drained marshland, or to natural climax grasslands modified by human activity but which still retain a predominance of native species and remain relatively 'unimproved' in agricultural terms. It is a broader term than 'High Nature Value' (HNV) grassland (the subject of other presentations in this workshop) but is more specific than 'permanent grassland' which is a more general category that includes long-term but often agriculturally improved land lacking in environmental value. However, for SNG generally, and HNV grassland in particular, there are important linkages between the grassland habitat and the farming systems which maintain them.

Until the mid-20th century (and more recently in some areas) European grassland agriculture was generally of low intensity, enabling habitat diversity to co-exist with food production. Semi-natural grassland could be considered as both an input to, and a product of, pastoral farming. In the decades since the 1940s there has been a drastic decline in the extent and connectivity of SNG as a consequence of the intensification of agriculture. International recognition of the negative impacts of habitat loss and other environmental damage has led to the adoption of successive measures to incorporate nature and landscape conservation within EU farm policy, with similar arrangements in some non-EU states. In many countries, protection of biodiversity within agricultural habitats also became a commitment under the terms of the Convention on Biological Diversity in 1992.

The CAP is now increasingly aimed at delivering benefits to wider society, including environmental protection and the conservation of nature and landscapes. This is not just seen as meeting environmental preferences, but as essential for developing the long-term socio-economic potential of rural areas, encapsulated in the Killarney Declaration and the Malahide Commitments of 2004, and the 2010 targets of the European Biodiversity Strategy. There is also increasing recognition of the wider contribution of grasslands, and SNG in particular, to ecosystem services, including the protection of soils, regulation of water and its quality, and carbon storage. The present structures imply a long-term commitment to maintaining biodiversity objectives within the farmed environment and carry an increased urgency in an era of global climate change, population growth and concerns about security of resources. In the context of maintaining SNG this poses a number of challenges in terms of how these objectives can be met within the context of profitable and sustainable farming that delivers quality food production and wider ecosystem and socio-economic benefits. Nevertheless, the remaining areas of SNG in Europe face many threats and are vulnerable to the effects of land-use change from both intensification and reduced management or abandonment.

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The objective of this paper is to present an overview of the relevance and functions of semi-natural grasslands in Europe at the present time, and to consider, in the context of policy changes and other drivers of change, the prospective for these grasslands in the future.

The status quo

Extent of semi-natural grassland in Europe

How extensive are SNG in Europe today? Statistics on the areas occupied by SNG are limited by the lack of precise definitions and different approaches followed in different countries which reflect differences in interest and concern for SNG as a habitat. The EEA (1994) report estimated that 15-25% of the European countryside supported farmland of high nature value, (mostly grassland) based on the EU15 countries. A more recent review (Emanuelsson, 2008) has considered regional differences and noted the serious losses of SNG in north-western Europe (Norway, Benelux, Denmark) and problems elsewhere due to the lack of grazing systems for maintaining SNG (notably in parts of Germany, UK and Sweden). The situation in eastern and central Europe is somewhat mixed: Romania is identified as the country that probably has the greatest well-managed SNG in Europe, but elsewhere contractions in the agricultural sector and uncertainties about land ownership have resulted in large areas of SNG now becoming unmanaged. In southern Europe the situation is also mixed, and there are many areas of remaining SNG and considerable interest in transhumance systems such as the Iberian dehesa and montado areas (Olea and San Miguel-Ayanz, 2006). In alpine regions SNG is often associated with tourism, and in many places it has a traditional link to niche food products (e.g. speciality cheeses) characterized by livestock feeding of forage (hay and grazing) of SNG mountain pastures and meadows (Lombardi et al., 2008). This concept of valorization of SNG through high-value products has gained attention in recent years and is being seen as an opportunity to improve the socio-economic value of farmland that has high conservation value (considered further in this paper).

The productivity and forage value of semi-natural grasslands

Herbage production potential, as well as its seasonal distribution, feeding value and the suitability of swards either for grazing or mowing are of paramount importance for farmers utilizing SNG. Factors affecting herbage production are primarily environmental: soil water, nutrient status, temperature and length of growing season. But these also affect sward botanical composition with the more productive grass species dominating under favourable conditions. Today, SNG is mainly to be found in areas of low growth potential such as mountain pastures, drought-prone shallow soils, coastal salt-marsh, heathlands etc., though there are some exceptions. Examples include lowland peaty areas and also situations where, for reasons of policy or land ownership, potentially productive grassland sites have survived with SNG under traditional low-input management. The evidence from both empiral studies and field surveys suggests that herbage production from SNG is generally low, especially when botanical diversity is high, and is typically less than half that which may be obtained from agriculturally improved grassland in the same localities (Peeters and Janssens, 1998). Most of the evidence is from cutting experiments and there are few comparisons under grazing due to the difficulties with determining herbage production under grazing. In a review of lowland experiments, Tallowin and Jefferson (1999) reported found that dry matter production (as hay) of unfertilized species-rich SNG was 0.2-0.8 of the production that might be expected from agriculturally improved and intensively managed grassland. However, it is important to recognize that comparisons need to be on a like-for-like basis and in most studies reported in the literature agriculturally 'improved' grassland is managed with at least moderate inputs of fertilizers. Studies comparing low-input SNG with similarly managed grassland based on sown species have usually shown much smaller differences, and in some cases their production may even exceed that of sown swards (Hopkins et al., 1990), for instance if the SNG contains species such as N-fixing legumes, or grasses and forbs that have seasonal advantages, e.g. deep-rooting species during dry periods.

These effects will often be greater in grazed grassland than in meadows because of the need of grazers to maintain adequate herbage over a longer growing season. There is also evidence from experiments with sown multi-species swards under nil or low nutrient inputs that herbage production can exceed that from swards composed of single species (Hector et al., 1999; Tilman et al., 2001). Based on multi-site European experiments, Hector et al. (1999) found that 29 of 71 common species had significant effects on productivity, with one species, *Trifolium pratense*, having the greatest effect. Thus, increased productivity with species richness as noted in this case is not a simple one of species numbers - since productivity can saturate at a relatively low number - but of functional groups, of which the presence of legumes, long recognized by grassland agronomists as essential components for production, is a key feature.

Herbage production is only a partial measure of forage value. How does the feeding value of herbage from SNG compare with other grassland herbage? There has been relatively little scientific investigation of the chemical composition of the herbage from SNG, and for individual plant species, especially non-legume forbs, compared with the main species of sown grassland. A review of factors affecting forage digestibility from SNG (Bruinenberg et al., 2002) concluded that digestibility is usually lower than in forages from grasslands used in intensive production.

Greater variation in forage digestibility in SNG swards is attributed to there being greater variation in heading dates and growth stages, and the presence of more forbs whose effects can be either positive or negative, depending on leaf : stem ratio. Bruinenberg et al. (2002) also urge caution on methodical approaches, noting that in-vivo predictions based on those for *Lolium perenne* can be inaccurate when applied to other species.

The most meaningful information on the feeding value of SNG forage is that based on animal performance. Findings reviewed in Bruinenberg et al. (2008) and Huyghe et al. (2008) indicate there is potential for feeding SNG forage in beef and sheep systems, where such forage will require a longer period to reach target weights, as well as for dairy heifers and even for lactating dairy cows. A number of studies have indicated that animal performance on SNG is better than might be expected from forage analysis and many research challenges remain to address this. In swards of diverse botanical composition livestock may be presented with an array of choices of species and plants at different growth stages, reflecting differences in content of carbohydrate, N, fibre, and possibly also minerals, condensed tannins and other secondary metabolites. The implications for grazing preferences and intake rates are considerable, especially for intake and feeding preference of non-legume forbs. Studies have shown that intake of fodder-based rations increases as the proportion of grasses declines relative to that of legumes and fine herbs (Jans, 1982; Lehmann and Schneeberger, 1988). The consequences of this effect show up in milk yield of dairy cows, with a reported 40% greater milk production potential from a green fodder diet with a grass : herbs+legume ratio of 40:60 compared with a ratio of 90:10. Plant morphological characteristics and sward responses to environmental stress can limit intake on some types of biodiverse pastures. On a cattle-grazed Cirsio-Molinietum fen meadow, low animal growth rates, low herbage energy value, and mineral imbalances and deficiencies were identified and these increased from summer to autumn (Tallowin et al., 2002). Thus, we can identify situations where SNG pastures provide resources for high intake of nutritionally adequate forage and others where this is not the case.

Intake of SNG forage will depend on the characteristics of the plants species present and their growth stage. Many grassland species have evolved adaptations as potential defence strategies against herbivory, including secondary metabolites, spines, toughened leaves etc. and adaptive growth forms such as basal rosettes and lignified stems (Herms and Mattson, 1992). In some cases there is an inference that herbivory, and thus intake of some forb species, will be lower than for grasses and forage legumes, especially under continuous grazing (but in other cases intake of forbs may be higher). The issue is further complicated by the consideration that some plant secondary metabolites may have evolved for other plant survival strategies (e.g. to attract pollinators) and thus not necessarily deter herbivory. Other metabolites are frequently found in the forb species of SNG (Rychnovska et al., 1994) and contribute to the grazing animals' nutrient requirements, including supplying fibre needed for rumen function.

Although measures of digestibility, and to a lesser extent protein concentration, are usually the main farm-scale indicators of feed value, other components of chemical composition of forage influence the quality of ruminant products and thus the potential output value of the grassland. A number of recent studies have highlighted positive benefits for feed derived from SNG for meat quality in terms of nutritionally beneficial fatty acids, vitamin E, skatol, carotenes and terpenes. There is also evidence that the milk from cows fed on forb-rich permanent grassland has higher contents of omega-3 and conjugated linoleic acids compared with milk from temporary grassland (Wyss and Collomb, 2008). These finding may also provide a scientific basis for the concept of 'terroir' which links locally produced foods to particular locations (Whittington, 2006; Wood et al., 2007). Cheese sensory characteristics are also affected by the production system, of which botanical composition of forages is one part of the 'terroir' effect (Martin et al. 2005; Moloney et al., 2008).

Semi-natural grasslands and biodiversity

Biodiversity protection has emerged as a key driver in environmental policy particularly since the1992 Rio de Janeiro Convention on Biological Conservation. Biodiversity protection is an issue of regional and global security. Grasslands are particularly important sources of biodiversity as hosts not only to a vast number of plant species but also to vertebrate and invertebrate fauna (Hopkins and Holz, 2006). Recent EU regulations promote the protection of key habitats and species and individual countries have targets which in some cases aim to increase the area of different types of SNG. The year 2010 was set for halting the loss in biodiversity loss and a point for reviewing progress in meeting targets (http://www.countdown2010.net/?id=35). The term biodiversity, however, extends beyond species, and issues of provenance have focused attention on the role of existing SNG as donor sites of seed for habitat creation or diversity enhancement based on native seed that respects the genetic diversity of SNG as well as diversity at the species and habitat levels. This is a potential new economic benefit for land managers of donor sites where the value of agricultural production might otherwise be low. In many areas adequate supplies of seed of native ecotypes are seldom available.

Other ecosystem services associated with semi-natural grassland

The concept of 'ecosystem services' emerged in the late 1990s and was incorporated into the Millennium Ecosystem Assessment (2005) which classifies ecosystem services into four main groups summarized below. The examples listed within each group indicate some of the existing and future functions that can be associated with SNG in Europe:

1) **Provisioning services:** products of ecosystems such as food (e.g. meat, dairy products, herbs, honey), genetic material (e.g. for new forage accessions and seed for habitat restoration projects), fresh water.

2) **Supporting services:** those that underpin other services, e.g. soil formation, carbon fixation through photosynthesis, nutrient cycling, water cycling.

3) **Regulating services:** stability to the natural environment, e.g. through regulating air quality (mitigating Greenhouse Gas emissions - CO_2 sequestration and CH4 capture), water quality, soil erosion (stabilization

on slopes), water run-off (water retention and stem flow regulation).

4) **Cultural services:** non-material benefits that can affect health and well-being, e.g through recreational opportunities (including agro-tourism) and aesthetic experiences (including the aspects of 'terroir' food products that add a cultural experience beyond food as a provision).

Future prospective

The preceding sections have emphasized the important role of SNG in contributing to agriculture, rural livelihoods and the wider rural environment. Losses of SNG have occurred, and continue to occur, as a result of agricultural intensification, abandonment and other land-use changes. What is the future for SNG in Europe and can its functions be developed further? Although outcomes cannot be predicted it is relevant to examine the drivers of change that are impacting on land use and determining rural land-use policy and to consider these in terms of the relevance of SNG.

Global population growth, declining resources and food security

The role of technology combined with public policy has enabled European farming to raise food production that matches or even exceeds present demand, and the development of agri-environmental policies since the 1980s can be seen as an 'environmental dividend' of that success. If global population growth continues to the 15 billion projected to occur this century will it be possible to reconcile environmental and food production objectives? Opportunities for agricultural intensification are, however, likely to be limited by declining stocks of resources that are part of the food production chain, notably oil, water (EEA, 2009) and phosphorus for fertilizer (EcoSanRes, 2008), and this strengthens the argument for retaining a sustainable management of low-input SNG as part of a multiple role rural land use. There are clearly many policy and research challenges for determining how SNG can contribute to these multiple goals.

Climate change

Projected changes in global climate change, attributed, at least in part, to increased atmospheric emissions of Greenhouse Gases (GHG : CO_2, CH_4 and N_2O) are widely considered to pose threats and uncertainties for land use management in the decades ahead. Key features of climate change scenarios for Europe indicate higher temperatures in summer and winter, increased winter rainfall in most regions and more frequent extremes of weather (Hopkins and Del Prado, 2007). Impacts are considered likely to be greatest for grasslands in southern Europe (droughts and increased fires leading to desertification), northern Europe (drying of tundra), coastal areas affected by rising sea levels (inundation of salt marsh etc) and alpine areas (reduced water from snow melt). Seasonal drying of wet grasslands is a particular threat. Enhanced CO_2 also has implications for photosynthesis and in leading to shifts in species composition of diverse swards.

Although livestock farming is often seen as a contributor to GHG emissions, extensive grassland including SNG probably has the greatest potential to contribute to mitigating this, through net CO_2 sequestration into herbage and soil and possibly also through CH_4 capture (reviewed in Hopkins and Lobley, 2009). (However, against this there is the issue that the longer periods required for grazing livestock to reach maturity on extensive grassland means CH_4 emissions are greater per unit of product, though not per hectare.) There is also a potential for SNG to be managed to help in regulating the overall impacts of climate change, e.g. through water retention and reduced surface run off from slopes following intense rainfall, as well as through the functions of soil structure relative to soil on cropland, and the benefits of having species that can be adapted to seasonal changes, such as deep-rooting plants in dry periods.

Land use changes and bio-energy

One consequence of both declining energy supplies and of measures to reduce GHG emissions is the emergence of biofuel cropping as an alternative land use. High prices for food commodities are likely to deter the conversion of arable and improved grassland to biofuels, and this leaves the option of SNG and other low output grasslands to be used for biomass. There may be potential on some sites suited to machinery access for the harvesting of SNG as a fuel for combustion or as a feedstock for biodigestors, but there is also a threat to SNG habitats that this might adversely affect their other environmental values (Stein and Krug, 2008). There is clearly a need to identify managements that can satisfy both nature and bio-energy requirements.

Socio-economic benefits of semi-natural grassland

The previous paragraphs have highlighted the roles of SNG in contributing to agricultural production and the potential for high-value products linked to the SNG environment or production system. This assumes greater importance as the links between livestock diets and the balance of fatty acids, and their human health implications, suggest that by some measures SNG forage can be regarded as of superior economic value. But SNG also provides other benefits to society beyond the immediate rural locale, including potential benefits for future use, as well as existence values of nature and landscapes (Lehman and Hediger, 2004). One further example is the future potential for carbon trading which offers the prospect to support the funding of surplus or abandoned land to be restored to appropriate management.

Multifunctionality: a unifying concept for policy makers to maximize the relevance of semi-natural grassland?

The concept of multifunctionality has been developed by academics and policy makers over the past decade as a concept for linking economic, social and environmental aspects of land use against a background of post-productivist agriculture (Wilson, 2007). There is scope to develop this

concept around the future roles of SNG, identifying the particular strengths where there are good overlaps. For instance, situations where SNG enables the production of foodstuffs of high nutritional or gastronomic value which are able to raise living standards and well being of farmers an associated rural businesses, while at the same time maintaining rural communities and halting land abandonment and also delivering strong environmental goods such as biodiversity protection and regulating ecosystem services. This concept also enables the identification of situations where there inherent weaknesses in functions that SNG delivers: how can we maintain SNG entirely on the basis of its biodiversity or other environmental values, or when its economic or social values are low how these can be raised, for instance through training and rural development programmes. However, in a world with increased market liberalization there is a threat that environmental support payments linked to multifunctional land use may also be challenged as an opportunity for subsidizing agriculture within the framework of European rural policy (Potter and Tilzey, 2007).

Conclusions

Semi-natural grassland has many important roles in contributing to a multifunctional rural land use. Although its agricultural value in terms of forage production and feed value is low compared with more intensive grasslands, there is a clear potential for SNG to contribute to livestock production, particularly for niche products, linked to environmental and social values. Many uncertainties remain concerning the future for SNG and for future rural land-use policy in general. Security is now emerging as a new leitmotiv in rural policy development amid concerns about global food supplies, water, energy and other inputs, as well as the impacts of climate change, and this focuses on the need to identify resilience and weaknesses in land-use systems. The future prospective for SNG lies in strengthening the overlapping values of economic production, environmental deliverables and social benefits to rural communities and beyond.

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