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The XX International Grassland Congress took place in Ireland and the UK in June-July 2005. The main congress took place in Dublin from 26 June to 1 July and was followed by post congress satellite workshops in Aberystwyth, Belfast, Cork, Glasgow and Oxford. The meeting was hosted by the Irish Grassland Association and the British Grassland Society.

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Grassland in Ireland and the UK

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Key points

1. Grassland is the dominant land use option in Ireland and the UK, and is characterised by a long growing season.
2. Dynamic, interactive systems of grassland management have been developed which combine high grass dry matter intakes with good sward quality. In the better grassland areas milk yields in excess of 7000 kg/cow are attainable with low levels of concentrate supplementation.
3. In the times to come, measures to protect the environment will constrain stocking rates, and fertiliser and manure use on intensive grassland enterprises.
4. A high proportion of beef and sheep farms participate in voluntary, EU-funded agri-environmental schemes that promote less intensive production systems and high standards of environmental protection.
5. Access for the public to, and conservation by farmers of, the countryside have become increasingly important in the last 20 years. In the future, grasslands will have to meet a variety of demands and be truly multifunctional.

Keywords: intensive, dairy, pollution, biodiversity, multifunctional

Introduction: background and context

Irish agriculture is overwhelmingly grass based, and concerned with the conversion of grass to milk, beef or sheep-meat. Agriculture in the UK is similar except that cereal production also assumes importance. Details on land use, livestock numbers and farm structure and type are given in Tables 1 and 2. Permanent grassland is by far the largest land use option for agricultural land in Ireland, accounting for almost 80% of the land area. This is almost twice the proportion in the EU-15 as a whole. Grassland also dominates in the UK, though cereal production accounts for 18% of the land area. This compares to 7% and 26% for Ireland and the EU-15 respectively. While grassland and rough grazing are the major land use options, it is worth noting that many dairy farms in the UK (and Ireland to a lesser extent) also use maize silage or whole-crop cereal silage in addition to grass silage.

The vast majority of farms in Ireland are owned and operated by farmers. Historically most farmland in the UK was tenanted, but today 66% of farms are owned by the occupying farmer. A large proportion of farm households in both countries also have a source of off-farm income. Dairy herds, usually concentrated on the more productive land, account for 19% and 11% of farms in Ireland and the UK respectively. However the most common farm type in Ireland is the beef cattle farm, while in the UK it is the sheep farm. Many of the beef cattle and sheep farms in both countries are in areas classified under EU regulations as Less Favoured Areas (LFA). There are relatively high numbers of beef cows in both countries. Sheep production is also an important enterprise in both Ireland and the UK.

Table 1 Land use and livestock numbers

	Ireland	UK
Total agricultural area (000 ha)	4,370	18,449
Grassland	3,466	6,884
Rough grazing	468	5,565
Forage maize	16	119
Arable silage (mainly wholecrop cereals)[1]	29	38
Other forages (roots, green crops)	5	55
Breeding livestock (000)		
Dairy cows	1,156	2,192
Beef cows	1,187	1,700
Ewes	3,615	14,926

Data for 2003 from: Ireland - Central Statistics Office; UK - Defra.
[1](Wilkinson & Toivonen, 2003)

Table 2 Structure of agricultural holdings in Ireland and the UK (Charlier, 2003)

	Ireland	UK
Size of farm (ha)	31	68
Proportion of farms by type (%)		
Specialist dairy	19	11
Specialist cattle – rearing and fattening	51	14
Sheep and other grazing livestock	20	38
Specialist cereals, general cropping or horticulture	4	22
Proportion of organic farms	1	1

The role of grassland in Ireland and the UK is greatly influenced by the Common Agricultural Policy (CAP) of the European Union. Following entry in 1973 the rapid expansion of both milk and meat production continued, and sheep numbers rose dramatically, encouraged by CAP headage payments. However, the growth of intervention stocks of many agricultural products created difficulties, and measures to limit production began in 1984 with milk quotas, which are still in place today. Milk quotas reversed the growth in dairy cow numbers. Under the McSharry reforms in 1992 there was a shift from support for market prices, to headage payments for both sheep and beef. The growth in animal numbers contributed to overgrazing of grassland and resulted in damage to some environmentally sensitive areas. In 2003 a radical reform of the CAP was agreed, resulting in complete decoupling of income support from production in both Ireland and the UK. The many headage payments for livestock (and area payments for crops) have been discontinued. Income support for farmers, now known as the 'Single Farm Payment', is not dependent on the production of any specific crop or livestock. The introduction of decoupling may lead to profound changes in grassland usage within the EU in the years ahead.

Through the 1970s and 1980s, evidence began accumulating of the impact of the intensification and specialisation of agriculture on both surface water and groundwater. Agriculture was also found to be impacting on soil and air quality, and on the landscape and biodiversity. A number of statutory and voluntary schemes have been introduced to promote less intensive and more environmentally friendly systems of animal production. The most recent EU reform of the CAP includes a clause that makes all direct payments conditional on cross-compliance by farmers with a range of food safety, animal welfare and environmental measures. In Ireland farmers must follow the Code of Good Farming Practice and in the UK the land must be kept in Good Agricultural and Environmental Condition.

Two other major EU Directives, the Water Framework Directive and the Nitrate Directive, also have major implications for livestock production and for grassland management. It is likely that on intensive grassland farms, mainly in the dairy sector, farmers may have to reduce stocking rates, or export animal manures to neighbouring farms. In addition to requiring farmers to avoid air and water pollution the public, especially in the UK, are also seeking access to a countryside that exhibits attractive landscapes, ecological balance and biodiversity. These pressures will all impinge on the use of grassland in the future, and the mix of animal enterprises and management practices may therefore change significantly in years ahead.

Effects of location and climate on grass production

Ireland and the UK are located on the northwest edge of Europe. Dublin, at 53°N latitude, is further north than Calgary (Canada) or Irkutsk (Siberia). The most southern point of the UK lies further north than the 49°N parallel, which forms much of the border between Canada and the United States. Ireland and the UK benefit greatly from the moderating influence of the Atlantic, and particularly with the warming effects of the Gulf Stream. The maritime climate is mild and moist which is good for growing grass and is especially important in giving a long growing season. Likewise the length of the grazing season in the most favourable areas in Ireland and the UK is a major advantage relative to many parts of Europe. However, one commonly overlooked disadvantage arising from the location and climate in both countries is that the intensity of radiation during the summer may be sub-optimal for grass growth and, more particularly, for some other high output forage crops. A comparison of the Irish climate with some selected regions is given in Table 3 (Keane & Sheridan, 2004).

Taking into account the altitude and distance from the sea, the January temperatures illustrate the mildness of the winters in Ireland and in many areas of England and Wales. However, the July temperatures show why Ireland is disadvantaged in relation to forage maize production compared to the other sites. The July rainfall values are also noteworthy – rainfall in Ireland and the UK is similar to the other sites, but tends to fall in prolonged, relatively light showers rather than in heavy ‘downpours’ which are more common on continental Europe. The favourable climatic conditions of Christchurch are also apparent. (Christchurch is located on the South Island in New Zealand which has much less favourable growing conditions than the North Island where most of the dairy cows in New Zealand are located.)

Regional and annual variation within Ireland and the UK

While the climate in Ireland and the UK is, in general, very suitable for grass production, it is also suitable for growing a range of other crops including cereals and potatoes. This is particularly so in the eastern half of Britain and in more limited areas in the eastern and southern parts of Ireland. Such crops compete with grassland as land use options for some of the best land, and tend to dominate in the low rainfall areas, especially in eastern England (Hopkins, 2000). Grassland is the predominant land use option in all other areas, especially in the hills and in areas where wetter soils make the growing and harvesting of arable crops more difficult. In these areas the less intensive use of grassland is the norm, with sheep production and suckler cows more common than milk production.

Table 3 Temperature, precipitation and sunshine at selected met stations, 1961-90 (Keane & Sheridan, 2004)

Country		Ireland	England	France	Netherlands	N. Zealand	Poland
Station		Birr	Lyneham	Nantes	De Bilt	Christchurch	Poznan
Altitude (m)		73	147	27	3	37	84
Mean	Jan	4.8	3.4	5.2	2.2	17.2	-2.0
Temperature	April	7.9	7.7	10.3	8.0	12.2	7.6
(ºC)	July	15.0	16.0	19.0	16.8	5.8	18.0
	Oct	10.2	10.4	12.7	10.5	11.8	8.8
Precipitation	Jan	76	64	87	69	46	30
(mm)	April	53	45	50	53	53	36
	July	59	55	46	76	68	69
	Oct	84	64	79	75	44	39
Sunshine	Jan	50	53	72	47	215	40
(hr)	April	139	153	187	153	143	152
	July	131	205	267	187	126	218
	Oct	83	101	141	103	187	102

Hopkins (2000), outlined the variation in grass growing days in the UK based on temperature, adjusted for drought and altitude. The variation was from less than 200 days to in excess of 300 days. In Ireland a large area of the country has a growing season of between 270 and 300 days (Burke *et al*., 2004). This is an area devoted to intensive grassland enterprises, mainly dairying. Peel & Matkin (1982) described 7 climatic zones in relation to grass productivity in England and Wales. They used a calculated 'drought factor' and noted that even in areas with high concentrations of dairy cows, that summer rainfall was significantly less than the potential evapotranspiration, so that soil moisture deficits were not uncommon.

Collins *et al*. (2004), reviewed climate and soil management in Ireland, whilst the relationship between soil type and grassland productivity have been summarised by Ryan (1972). Soils described as either dry and light, or dry and loamy, predominate in the main agricultural areas. With the exception of some restrictions on summer growth due to low rainfall these soils have few limitations for grass production. Soils described as wet and heavy, or wet and peaty have serious restrictions on both the production, and utilisation of grass for periods of the year. Intensive dairying is mainly based on dry loamy land, with some also on wet heavy land in the southern part of the country. Two thirds of the dairy cows in Ireland are located in Munster (1 of 4 provinces). Beef production in Ireland is distributed across all areas, with some based on intensive grassland located on good land across the country.

Shalloo *et al*. (2004a) compared the profitability of a typical dairy enterprise on free draining, or on badly drained soil in southern Ireland using the most suitable technology on both sites. Very large differences in annual profitability (*circa* €28,000) were observed, such that, even with relatively high milk prices, milk production was hardly viable on the badly drained site. The difference in profitability was due to a variety of factors arising mainly from the longer overwintering period, but also from interruption to grazing due to soil conditions following rainfall. Additional concentrate feeding and silage making costs accounted for almost half the difference in profitability. Capital charges arising from higher infrastructure costs plus land charges accounted for most of the rest (L. Shalloo, *pers. comm.*). If the expected drop in EU milk price occurs, milk production in the less favoured areas (even in Ireland) can only be viewed as a transition phase, probably to non-intensive part-time farming, combined with off-farm employment. This is a situation that is likely to be repeated in many areas across Europe.

Variation from year to year is of great significance for the management of intensive, grass-based animal production enterprises. In spring-calving dairy herds, poor grass growth in the critical early lactation period due to a 'slow' spring can have serious consequences for the rest of the lactation. Likewise an unexpected period of high growth can lead to a rapid deterioration in sward quality. This unpredictable variation in grass growth has provided the impetus in recent years for the development of dynamic interactive systems of grassland management to replace more static, date-based guidelines. Burke *et al*. (2004) presented Irish data on the variation in expected growth between regions, and between years for a 10-year period. In the January to April (winter-spring) period and also in the May to August (summer) period, the difference between the best and the worst years was in excess of 1000 kg DM/ha. In the September to December (autumn-winter) period the variation was little more than half the variation in the other two periods. Since the overall growth in winter-spring was much less than in summer, the relative variation in growth rates in the spring is much higher.

Again, as in the UK, soil moisture deficits are a continuing feature affecting grass growth in parts of Ireland. Burke *et al*. (2004) present data for a 20-year period from 1956 to 1975. The average losses in growth were relatively low, but in the eastern regions the average losses were in excess of 10% of annual growth. In the 5 driest years, a loss of at least 20% of annual output occurred in most areas, while the losses in the low rainfall areas were in excess of 30% of annual dry matter output.

The evidence that the climate is changing seems to be quite strong - four of the five warmest years recorded in central England since records began in 1772 have occurred since 1990. Rainfall in the last 30 years has been higher in winter but lower in summer compared to the 150-year historical data (Defra, 2004). It is expected that weather will also become more variable with more extremes occurring. In future, therefore, it is likely that soil moisture deficits during the summer months will become more serious in the main agricultural areas in Ireland and the UK, and grass growth during the summer months will be adversely affected. Temperature and rainfall are expected to increase in winter. Grass growth over the winter months will increase but the wetter soils will make grazing difficult. If these changes transpire, it is likely that forage maize for silage will become more important and that grass may be devoted almost entirely to grazing, with a small amount of surplus grass made into silage in the early part of the grazing season. It is also possible that there will be greater interest in *Medicago sativa* (lucerne) and other drought-resistant forages.

Forage species, fertilizers and conservation: the basic framework

Forage species

The forage area in Ireland and the UK is overwhelmingly devoted to permanent grassland, along with a substantial area that can be described as rough grazing. A relatively small proportion of the total grassland area forms part of a regular rotation with arable crops – amounting to about 10% in England and Wales, with substantially less in Ireland. However, at least half of all enclosed grassland has been sown since the mid 20th century – often reseeded directly from grass to grass. Hopkins (2000) estimated that 70% of swards over 20 years old in the UK could be classified as first or second grade *Lolium perenne* L. (perennial ryegrass) pastures. By far the most widely sown grass species is *L. perenne*, accounting for some 80% of agricultural grass seed sold in the UK (Defra, 2003a). Most of the remainder is either *Lolium multiflorum* Lam. (Italian ryegrass) or *Lolium hybridum* (hybrid ryegrass) for use in 2 - 4 year grass leys. The only other significant sown species is *Phleum pratense* L. (Timothy), which is often included in long-term mixtures as a minor component. The position in Ireland is similar but with *L. perenne* in an even more dominant position.

Of the legumes, *Trifolium repens* (white clover) is the only widely used species, and is a component of most long-term mixtures. In recent times, there has been increased research interest in *Trifolium pratense* (red clover), but this has only made a major impact on organic farms. *Lotus* spp. (Trefoils) have been shown to be suitable legumes on more difficult soils, but uptake has been very small. *M. sativa* is scarcely used.

The context for the choice of forage species is that Ireland and the UK are very suitable for ryegrass species, and ryegrass is suitable for both grazing and silage. Fertiliser nitrogen has been relatively inexpensive, and was heavily promoted from the 1960's to the 1980's. Robust and productive legume varieties have been bred, and legume-based systems have been extensively researched, but they have only been widely adopted on organic farms.

Fertilisers

Average fertiliser applications on grassland in Ireland, and particularly in the UK, are high by European standards, though they are much lower than the recommended economically optimum rates for intensive grassland enterprises. Data for enclosed grassland in Britain (Defra & SEERAD, 2004) shows that the proportion of grassland receiving the different elements is 73% for nitrogen, 60% for phosphate, 59% for potash and 6% for sulphate with average rates of application of 89, 20, 25 and 44 kg/ha respectively (Figure 1). Areas cut for silage receive much higher rates (133 kg/ha of N) than areas for grazing. Also much higher rates are applied on dairy farms than on beef and sheep farms.

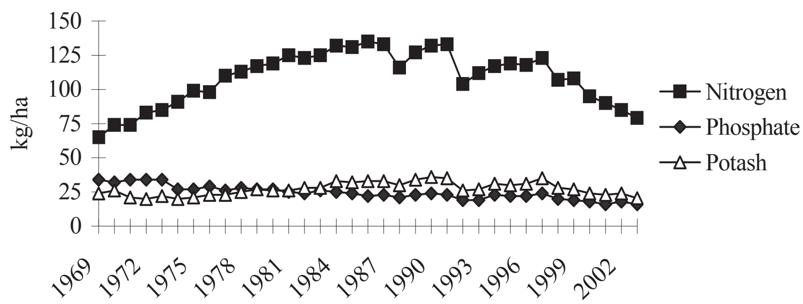

Figure 1 Overall fertiliser use on grassland in England and Wales

In recent years application rates in the UK are falling. The annual dataset for England and Wales (Figure 1) goes back to 1969, when overall rates were 65 kg/ha N, 34 kg/ha phosphate and 22 kg/ha potash. Nitrogen use peaked in the mid 1980's at 130 kg/ha. The recent trend reflects a number of factors including lower farming profits, recommendations for lower levels of N application, a reduction in the amount of grass ensiled and an increased participation by farmers in agri-environmental schemes.

Forage conservation

Silage is the dominant means of grass conservation. Wilkinson & Toivonen (2003) summarised the silage making practices in the UK and Ireland. Grass silage accounts for 83% and 70% of the forage conserved in Ireland and the UK respectively, with only 16% and 18% as hay. Most of the grass silage in Ireland, and in the western part of the UK is low dry matter silage, either direct cut or subjected to only a brief wilt. Additives are widely used - bacterial inoculants and enzyme products now more popular than acids and salts. A large silage cut taken in late May or early June is the norm on dairy and cattle farms. A smaller second cut is also common. Machinery contractors with high capacity systems carry out a high proportion of silage making - 60% in the UK, a higher proportion in Ireland. Big-bale silage has been widely adopted on smaller farms, and also on larger farms for supplementary cuts, and as an aid to the management of sward quality - 35% of grass silage in the UK is made as big bale silage.

The area of forage conserved in the UK is falling - from 2.7 million ha in 1994 to 2.2 million ha in 2000. This may reflect the fall in cattle numbers, and perhaps also recognition that grass silage is expensive compared with grazing. As yield of dry matter for individual cuts of grass silage are low relative to the yield of forage maize or whole crop cereal, costs of ensiling are high. When dry matter yields of grass silage are low, the total cost per ton of dry matter for grass silage are similar to the cost of cereals purchased at harvest and stored on farm.

There has been a substantial increase in the use of whole crop cereals for silage in the UK and in the use of *Zea mays* (maize) for silage in both Ireland and the UK. The major limitations of grass silage, especially low dry matter silage, arise from its low intake characteristics. The higher intakes achieved with *Z. mays* silage make it a valuable alternative in the feeding of high yielding dairy cows, and in the intensive fattening of beef cattle. Keady (2003) reviewed the use of *Z. mays* silage in Northern Ireland. He concluded that *Z. mays* silage had a role to play even under the rather unfavourable climatic conditions in Northern Ireland using the complete cover plastic mulch system, which improved both dry matter yields and feeding value.

Intensive grassland production systems

Targets for milk output

The development of efficient grassland-based systems of milk production, which rely heavily on grazed grass, has been the subject of much research in Ireland over the last decade. This work has mainly focused on assessing the suitability of such feeding systems for Holstein-Friesian dairy cows with high genetic potential for milk production. The suitability of different strains of Holstein-Friesian, of alternative dairy breeds and, more recently, of crossbred animals has also been assessed. The emphasis in Ireland has been on spring calving dairy cows (Buckley *et al*., 2000; Kennedy *et al*., 2002; Horan *et al*., 2005) while work in Northern Ireland has focused on autumn-calving herds (Ferris *et al*., 2002).

The challenge of achieving high milk yields per cow from grazing systems has been reviewed by Mayne *et al*. (2000), and by Peyraud *et al*. (2004), who stated that the gap between the potential (or expected) milk yield and the actual milk yield achieved on grass increases progressively as the potential milk yield increases. The gap is substantial at potential milk yields of 40 kg/day, which is well within the capability of modern dairy cows. The limitation of grass as a feed is probably the major reason why the average milk yield per cow in both Ireland and New Zealand is low by international standards. In addition, seasonal-calving dairy herds must maintain a 365-day calving interval, combined with low levels of involuntary culling, which may be a much more challenging target than achieving high milk yields *per se.*

The milk output achieved by Kennedy *et al*. (2002) in southern Ireland is a benchmark in Western Europe for high genetic merit Holstein-Friesian dairy cows in spring-calving systems, under favourable grassland conditions. Average annual milk yields per cow were 7389 and 8461 kg for low concentrate (377 kg) and high concentrate (1540 kg) groups respectively (with some groups producing in excess of 9000 kg per annum). These yields correspond to levels of *milk from forage*[1] of approximately 6500 and 5000 kg. (*Milk from forage* will normally be reduced as a result of additional concentrate feeding, due to the phenomenon of substitution of the additional concentrates for the basal forage intake). Likewise, Ferris *et al*. (2002) achieved benchmark levels of milk output from autumn-calving dairy cows under slightly less favourable conditions for grass production and utilisation in Northern Ireland. Animals received 928 kg concentrate dry matter (DM) in a system based on top quality grass silage combined with generous allowances of high quality grass for grazing. Cows consumed 1895 kg grass silage DM, and 3119 kg grass DM, and achieved an annual milk yield of 7868 kg per cow corresponding to a *milk from forage* value of almost 5500 kg. Results from commercial dairy farms in the UK show lower levels of *milk from forage – circa* 2700 kg on average, but with important regional variations (Simpson, 2004). Selected groups of dairy farmers were achieving a very efficient combination of milk yields of 7700 kg along with *milk from forage* values of more than 4000 kg per cow.

Feeding systems which achieve high milk yields per cow from animals receiving low levels of concentrates, require high grass DM intakes by the grazing animal and very high levels of technical and biological efficiency in the utilisation of grass (Kennedy *et al*., 2003). However, such high levels of technical and biological efficiency are not necessarily synonymous with optimum economic efficiency. Analysis of the data from Kennedy *et al*. (2002) by Shalloo *et al*. (2004b), found that high levels of concentrate feeding were economically justified in certain circumstances with very high genetic merit animals, even though *milk from forage* and grass utilisation were reduced somewhat. Also, when rigid quantitative limits on milk output were imposed, as in the operation of the EU milk quota regime in Ireland, dairy cow genotypes which produced somewhat lower levels of milk output from low levels of concentrate input were economically very efficient. The data of Ferris *et al*. (2002) also showed that maximising milk output from forage was not necessarily the most economic in all circumstances. Nevertheless, achieving high levels of *milk from forage*, especially from grazed grass, on a per cow basis as well as on a per unit area basis, will probably remain a key objective in the profitable production of milk in temperate grassland regions for the foreseeable future.

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[1] *Milk from forage* is calculated by first estimating the milk yield equivalent of the concentrates fed per cow using nutrient requirement tables. This is then deducted from the total yield per cow to obtain *milk from forage.*

While very high milk yields have been achieved with Holstein-Friesian cows, there have been problems with reproductive performance and with maintaining body condition. Limitations on grass DM intake may contribute to these problems, but it is important to note that feeding high levels of concentrate did not overcome poor reproductive performance. However, there have been promising results with some strains of Holstein-Friesian cows, which have slightly lower milk yields, and also with alternative breeds and crossbred dairy cows (B. Horan, *pers. comm*.). In the future the focus may be on animal genotypes and feeding systems that combine slightly lower milk yields with good reproductive performance. However, even in such systems, a target for milk from forage in excess of 5000 kg per cow should be realistic, arising from a total milk yield per cow of between 6000 and 7000 kg combined with a moderate levels of supplementary concentrate feeding.

Evolution of grassland management to optimise milk production

Until the establishment of milk quotas within the EU in 1984, the emphasis was on increasing output per unit area, mainly through increasing stocking rate. This focus will become important again if milk quotas are removed. However, since 1984 the emphasis has switched to reducing the costs of production - large differences in costs per unit dry matter has led to attempts to replace concentrates by forages, and especially by grazed grass. The cost of ground, pelleted concentrates is relatively high, and in Ireland and parts of the UK total mixed ration systems are not common, due to small herd size. Grass silage is also a relatively expensive feed source. Optimising the use of grazed grass has therefore been a high priority.

Post-grazing residual sward surface height and herbage allowance

Mayne *et al*. (1987, 1988) and Stakelum (1993), emphasised the importance of post-grazing residual sward surface height (PGRSSH) and its relationship to dry matter intake and milk yield, and to sward morphology and digestibility in subsequent grazings. Previously grassland management systems tended to be inflexible, with fixed proportions devoted to grazing and to conservation at various times during the year. This resulted in a serious deterioration in sward quality when grass growth was higher than normal during the first half of the grazing season. Guidelines for PGRSSH, and the need to adjust grazing plans for changing sward conditions are important components of current recommendations for optimum grassland management.

The effects of daily herbage allowance (DHA) on milk yield and milk composition have been addressed by Maher *et al*. (1999). O'Donovan *et al*. (1998, 2000) established that the inclusion of DHA along with PGRSSH considerably improved the management of grass DM intake at farm level. Selection of the appropriate level of DHA is important in the development of grassland management plans for high yielding dairy cows. Guidelines for DHA, in addition to PGSSH guidelines, are now considered to be critical components of current recommendations for the optimum management of grazing animals.

Feed budgeting and average pasture cover

Clark and Jans (1995) refer to the concepts of feed profiling, feed budgeting and grazing plans, and to the development of decision support models for pasture management in New Zealand. Stakelum, (1996) refers to annual, intermediate and short term feed budgeting, and to the concept of average pasture cover. This refers to the amount of grass dry matter per hectare, averaged across all paddocks within the grazing area. This was further developed by O'Donovan *et al*. (1997, 1998), who also addressed the problem of estimating herbage mass at farm level. Targets were developed for average pasture cover, expressed on either a per hectare or a per cow basis. The latter is probably more functional across a range of grassland situations. Likewise it may be easier to communicate the concept to farmers, if pasture covers were expressed as the number of cow grazing days ahead of the herd rather, than as kg DM/ha.

Average pasture cover is important because it allows short term feed budgets to be constructed based on the feed requirements of the animals when it is combined with expected grass growth for the period ahead. Any deviation from the target cover signals that the overall strategic plan for the grassland area requires tactical adjustments to the short term and/or intermediate term feed budgets. This is important because grass growth is variable during spring, mainly due to variations in temperature, while soil moisture deficits lead to variation in growth in summer in regions with low rainfall.

Feed budgeting is one of the most important concepts to have been introduced into grassland management for dairying in Ireland and the UK in the last decade. It has been critically important in enabling farmers to exploit the benefits of early turnout to pasture in spring (Dillon & Crosse, 1994; Sayers & Mayne, 2001), and of extended grazing in the late autumn – early winter period. Progressive dairy farmers have, in general, adopted dynamic interactive systems of grassland management that involve the setting of targets for various milk output and pasture parameters. Continuous monitoring of these parameters, and adjustment of the grassland and feeding programme is required. Comprehensive guidelines for dynamic interactive systems of grassland management are now available (O'Donovan *et al*., 1998; Mayne, 2000; MDC, 2003; Teagasc, 2004b).

Other issues

The suitability of various cultivars of perennial ryegrass has been investigated (Gilliland *et al*., 2002; Gowen *et al*., 2002; Wilkins & Humphreys, 2003). The impact of sward factors on dry matter intake and milk output, and the impact of the quantity and the composition of supplementary feeding for the grazing animal are under consideration (McGilloway & O'Riordan, 1999; Mayne & Laidlaw, 1999; Mayne *et al*., 2000b; Peyraud *et al*., 2004). The preceeding discussion of developments in intensive grassland management has focused almost entirely on dairying, but similar concepts have been developed or are being developed in relation to beef and sheep production (Mayne *et al.,* 2000a; Steen, 1998; Teagasc 2004a).

Environmental aspects of intensive grass and forage systems

Statutory measures to reduce nitrate pollution of surface waters and groundwater began to be introduced in the 1990s. Nitrate Vulnerable Zones (NVZs) were designated in all areas where the existing or predicted concentration of nitrate N was greater than 50 mg/l. Nitrate Vulnerable Zones currently cover about 55% of England and a small proportion of the rest of the UK. The position in Ireland is under review at the time of writing, but it is likely that the entire country will be designated as a NVZ. In these zones farmers are required to keep records of fertiliser and manure applications. Fertiliser N must not be applied in excess of crop or grassland requirements, and a limit is set on the maximum loading of organic N in animal excreta. For grassland this was initially set at 250 kg/ha, but is now expected to be reduced to 170 kg/ha. This means that on intensive grassland farms (mainly the dairy sector), farmers may have to reduce stocking rates, or export animal manures to neighbouring farms.
Other environmental problems addressed by the EU Water Framework Directive include pollution of surface waters by phosphorus and soil runoff, and atmospheric pollution by ammonia, nitrous oxide and other gaseous emissions including methane. In Ireland, where

the Kyoto targets will be very difficult to meet, the national greenhouse gas abatement strategy requires a significant contribution from agriculture, which may increase the pressure to reduce the total number of ruminant animals in the country.

Extensive grassland: a multifunctional resource

Farmers have traditionally grazed sheep and beef (including suckler cows), on non-intensive grassland and rough grazing. However, increasing public interest in access to the countryside, may in time impact on such grassland farmers. As well as an intensive network of public footpaths, there is now a ‘right to roam’ on most open grazing land in Britain, and it is recognised that in many rural parts of Ireland and the UK, that tourism now has a higher economic value than agriculture. Whilst it can be difficult to reconcile public access with farming, it does present farmers with commercial opportunities – with farmers paid from public funds to care for and maintain extensive grassland as part of a multifunctional resource.

Landscape, environmental features and farm types

In most of Scotland and Wales and in parts of Ireland and northern England, the landscape is dominated by hills and rugged terrain that is typically between 300m and 1000m altitude. It has a combination of difficulties including steep slopes, rocky outcrops, and acid soils, some of which are permanently waterlogged. Most of it is unenclosed moorland characterised by heather and other dwarf shrubs, and has traditionally served the dual function of rough grazing for sheep or beef cattle, and hunting of wild deer and birds, particularly the red grouse. In nature conservation terms it is valued highly. The UK contains a substantial proportion of the world’s resource of this habitat. Heather and other shrubs can only tolerate limited grazing – about 40% of each year’s growth. Increased sheep numbers have contributed to a major decline in heather cover, particularly in England and Wales, and have led to its replacement by grasses such as *Nardus stricta*.

In the lowlands, particularly in the UK, the landscape has a characteristic ‘patchwork quilt’ appearance of fields enclosed by walls or hedgerows. Some of these are of great antiquity, and many more were constructed in the 18th and 19th centuries following government land reforms. Until the widespread use of inorganic fertilisers in the 1960s, the hay meadows, pastures and grazing marshes within this landscape were highly biodiverse. Since then such habitats have become rare.

The best of the historic environment and the richest examples of wildlife habitats, through the hills, uplands and lowlands, are now protected by European and national legislation. This includes the widespread network of ‘Natura 2000’ sites in the UK designated in response to the EU Birds and Habitats Directives. In addition to these high profile sites, many environmental features such as hedgerows and semi-natural grassland are also now protected through the use of cross-compliance. This was further extended on 1 January 2005 - from this date the Single Farm Payment can be partially or wholly withheld if such features are damaged.

The differentiation of the hill and upland sectors from the lowland sector is more distinct in the UK than in Ireland, and the descriptions that follow are more typical of the UK situation than the Irish situation.

Hill farms
Most of the land area is moorland rough grazing. Breeding sheep are the main or only enterprise, where hardy breeds such as the Scottish Blackface or Welsh Mountain produce on average only one lamb per ewe per year. They graze the moorland for most of the year and are brought down to lower ground to mate in the autumn and to lamb in the spring. The ewes may be mated with a ram of a larger and more prolific breed to produce female lambs, which can be sold to upland or lowland farmers. These females will then be mated with a ram such as a Suffolk or Texel to produce prime lamb for meat. This tradition of sheep moving from hills to uplands to lowlands is known as the 'stratification' of the sheep industry.

Hill farms often have very little 'in-bye' land from which to cut grass for hay or silage. They are unable to support large numbers of cattle since these usually have a much higher requirement for winter-feed. Farms that have more 'in-bye'` may have suckler cows, usually of a hardy breed such as Galloway or Welsh Black. Although cattle have been less profitable than sheep for several decades, cattle may in future be required for maintaining diverse moorland and grassland. In both hill sheep and cattle production there is a need for low-cost, 'easy-care' systems, which nevertheless have good animal welfare and are compatible with protection of the environment.

Upland farms
The convention in the UK is that those farms in hilly areas where the majority or all of the land area is enclosed grassland are known as upland farms. Some of these were created from moorland from the 1940s to 1980s. Its productivity was improved by the use of lime, fertilisers, cultivation and/or reseeding. The native grasses, typically *Festuca rubra* (Red fescue), *F. ovina* (Sheep's fescue) and *Agrostis capillaries* (Bent grass), were replaced with *L. perenne* and *T. repens.* More recently many of these swards have partially or wholly reverted to the native grass species as inputs have been reduced. These farms often have both sheep and cattle enterprises, and farmers may have invested heavily in silage pits and winter housing or hard-standing areas. This enabled the farmer to achieve higher stocking rates, have greater flexibility to breed animals out of season and fatten livestock.

Lowland farms
Grassland farms in the lowlands are often intensively managed for dairying or other enterprises. However, there are also extensive grassland-based enterprises that may occur for two main reasons. They may be farms with an area of existing permanent grassland that is difficult to manage intensively because of steepness, wetness, obstructions or accessibility. In many cases the farmer is eligible for agri-environment payments to maintain or restore this grassland. A second group may have income from another business or off-farm employment. Extensive grassland on lowland farms is often integrated with more intensive grassland, and/or arable crops. It can complement the other land such as providing summer grazing. The extensive livestock 'enterprises' found on lowland farms are hugely varied. In Ireland extensive systems of beef and sheep production are widely practiced on high quality soils in lowland areas. The main reason is probably historical in that the creameries that processed manufacturing milk were not distributed around the whole country but were concentrated in the southern region.

Support for extensive grassland farming

All hill land, most uplands and some lowlands with heavy wet soils, are classified within the EU as Less Favoured Areas (LFA). Forty four per cent of agricultural land in the UK, and

53% in Ireland, is classified as LFA. Until 2004 all beef and sheep, managed extensively or intensively, received support payable per head, with the payment being higher within the LFA. In future all headage for beef and sheep payments are consolidated into the Single Farm Payment, which is decoupled from production. This decoupling may lead to a substantial reduction in beef and sheep numbers, especially in the LFA. A recent survey of farmers in Ireland anticipates a reduction in sheep numbers, with an increase in the area devoted to forestry.

Since the mid 1980s a small but increasing proportion of government support for agriculture has been through voluntary Agri-Environment (AE) schemes. The first of a number of schemes in the UK was the 'Environmentally Sensitive Areas Scheme', which was introduced in 1986. These schemes offer annual and capital payments to farmers for restoring or recreating plant, bird or other wildlife habitats by reducing or ceasing fertiliser inputs to grassland. They were superseded in England in 2005 by the more ambitious 'Environmental Stewardship Scheme', which also includes soil and water protection as an objective. The aim is for the majority of all land in England to be in at least the lower tier of this scheme within the next few years.

In Ireland, the 'Rural Environment Protection Scheme' (REPS) was introduced in 1994 and initially covered 33% of farmland. The emphasis was on limiting the input of both organic and inorganic nitrogen on grassland, the development of nutrient management plans and the avoidance of pollution. In the third version of REPS (recently introduced) there is greater emphasis on broader environmental objectives with farmers expected to be managers of the natural heritage. These schemes are popular with farmers, and also have the support of the public.

Conclusions

Conditions in the more favourable areas in Ireland and the UK are very suitable for grass production over a long growing season. Intensive systems of milk production, and to a lesser extent beef and sheep production, using high inputs of fertiliser nitrogen, have been developed and are widely used by farmers. Guidelines for dynamic interactive systems of grassland management that rely heavily on grazed grass have been developed. Very high levels of biological and economic efficiency in both seasonal and non-seasonal systems of milk production can be achieved.

Changes in the EU income support system for beef and sheep farmers agreed in 2003, may lead to significant reductions in the numbers of beef and sheep in Ireland and the UK. Intensive grass-based systems of animal production create risks of pollution to surface- and ground- water. A high proportion of beef and sheep farms participate in voluntary, EU-funded agri-environmental schemes. All EU direct income support payments are dependant on cross compliance with a range of food safety, animal welfare and environmental measures. Grassland farmers in particular, are regarded as custodians of the countryside. However the public, especially in the UK increasingly require access to the countryside which must not be polluted and which demonstrates ecological balance and attractive landscapes.

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