Grassland in the Twentieth Century

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This article provides a summary of the major changes in grassland area and use during the 20th Century and then outlines developments in practice and science in key topics, with consideration of ley farming, fertilisers and manures, grass utilisation and grassland biodiversity.

Some changes during the Century
It is well recognised that the 20th Century was one of tremendous change for British agriculture. The number of farm holdings in England and Wales fell from 440,000 to 170,000 and the number of farm workers fell from around 1 million to 180,000, with most of these changes occurring in the last 50 years. The present importance of larger farms is highlighted by the fact that 50% of the land is farmed by just 11,000 holdings (each with 200 ha or more). Grassland has been the predominant form of land use throughout the century, occupying 58 - 76% of the agricultural area in England and Wales and it has continued to provide the major source of nutrients to the nation’s cattle and sheep. There have, however, been radical changes in the requirements from grassland in relation to management and intensity of production. Figures 3.1 and 3.2 illustrate changes in grassland area and the populations of livestock principally supported from grassland. At the beginning of the century, agriculture was beginning to emerge from the depression of the 1880’s and 90’s with development of dairying being an important feature. The First World War stimulated national food production and, with this, the ploughing of substantial areas of permanent grassland. This

Figure 3.1 Area of temporary and permanent grassland in England and Wales (M ha) (From 1975 temporary grassland was classified as grass established for five years or less and permanent grassland as grass over five years. The additional area of grassland classified as rough grazing has varied between 1.5 and 2.5 M ha)

Figure 3.2 Numbers of cattle, sheep and agricultural horses in England and Wales (M)
released land for crop production and also the nutrients released following ploughing contributed to higher crop yields. A return to free-trade policies following the war reduced prices and the profitability and extent of crop production in Britain. The area of permanent grassland remained above 6 M ha. The productivity of the grassland was low, but the nutrients accumulated in soil organic matter were a national resource which was capitalised upon during the Second World War. The area of permanent grassland fell by 2.3 M ha, with the released nutrients again contributing to national food production, as did livestock production, which was sustained from the more intensively managed remaining grassland area (Figure 3.3).

Following the war, the 1947 Agriculture Act provided the framework for a sustained period with policy strongly directed to achieving a high level of national food self-sufficiency. Farming prosperity was further enhanced with accession of UK to the European Community. Thus, in contrast to the situation following the First World War, the area under arable crops was largely sustained and price support encouraged intensification and increase in production from grassland, reflected in the increases in cattle and sheep numbers shown in Figure 3.2. Higher inputs and adoption of new technology increased production rapidly. The utilised metabolisable energy output per hectare was estimated to have increased by 1.8% per year from 1950 to 1970. There was increased specialisation, with reduction in mixed farming and progressive concentration of grassland in the wetter areas of the west and north of the country.

Uncoupling of supply from demand, however, resulted in accumulation of surplus products and

*Figure 3.3 The early days of grass-cutting machinery*
very high cost of the Common Agricultural Policy (CAP) to the taxpayer. A series of measures was introduced to restrict output, with the introduction of milk quotas in 1984 being followed by compulsory set-aside and restrictions on the number of cattle and sheep. Whilst different producers have reacted in different ways to these pressures, in aggregate, there has been some reduction in external inputs (for instance N fertiliser use fell by 15% from 1985 to 1995) and a stabilisation of output from grassland. Further driving forces over the last decade have been (a) increased evidence of pollution of water and the atmosphere from intensive farming and requirements to constrain agriculture to reduce pollution, (b) increased concern to maintain biodiversity both at global and local scales and the demand for wildlife conservation and (c) increased concerns for food quality and animal welfare. Agri-environmental measures have been introduced to improve the environmental impact of agricultural land use and substantial areas of grassland are now being managed for this objective.

There have been significant responses by grassland farming to the various economic and policy signals during the century. These signals have determined the relative importance of exploiting grassland as a feed for livestock, a source of plant nutrients and a resource for environmental protection and enhancement. There has, however, at any time been much variation in the methods followed and in the intensity of grassland use and this has contributed to the ability of British grassland to respond to requirements for change.

Developments in key topics

Ley farming
This system, involving rotation between grass and arable crops, was much advocated by scientists from the Welsh Plant Breeding Station in the 1930’s, and its adoption made a major contribution to farming in the middle of the century. The principle of ley farming is that the period under grass is one of fertility accumulation during which soil organic matter from roots and returned excreta increase at over 1t/ha per year with accumulation of N at about 100kg/ha per year, with accompanying improvements in soil structure. When the ley is ploughed for arable cropping, mineralisation of soil organic matter occurs to provide nutrients for the subsequent crop. The rotation also restricts the development of weeds, pests and diseases in both arable crops and grassland. Thus ley farming gives a sustainable system without need for large areas of land to be left fallow or for high fertiliser inputs.

In England and Wales ley farming was at its zenith during the 50’s and early 60’s, with the area of temporary grass reaching a peak in 1960 of 1.8 M ha, compared with about 0.9 M ha in the 30’s. Classic rotation experiments at GRI, Hurley in the early 70’s demonstrated that some 80% of the variation in yield of cereals could be accounted for by the level of mineralisable N in the soil, with this being a function of the duration, composition and management of the preceding grass ley. Further, responses to N fertiliser were lower in soils with high contents of mineralisable N. Improvements in soil structure during the grass phase were not of critical importance at Hurley, but may be of greater consequence with soils with greater problems of structure and stability.

However, the ready availability of N fertilisers and development of herbicides and pesticides made intensive cereal production possible without the use of grass leys. Progressive specialisation in British agriculture ensued, with large reductions in grassland in the east of the country and complete elimination of ruminant livestock in some areas. The area of temporary grassland has now again fallen to 0.9 M ha. A grassland survey indicated that even by
1970 less than one seventh of the sum of temporary and permanent grassland was being grown in rotation with arable crops. Ley farming has continued to be important in some areas of the UK (e.g. North East Scotland) and continues to be the key to efficient production in many areas of the world where technical chemicals have limited availability or use.

With a change in requirements over the last decade, there has been a re-awakening of interest in Britain in ley farming because of concerns for the environmental impacts of agrochemicals. In organic systems, most such inputs are prohibited and systems commonly involve rotation between grassland and arable crops, with the grass phase contributing to nutrient supply, weed, pest and disease control and being crucial for the maintenance of production. Other low-input systems seek to exploit the complementary nature of grassland and arable crops. The rate of change to such systems will, however, be restricted by the absence of structure and management skills for livestock in specialised arable areas and the large capital requirements for change. Furthermore, steps need to be taken to ensure that large losses of nutrients to the environment do not occur following the transition from grassland to arable cropping.

Fertilisers and manures

The return of manure to crop land was a key feature in farming systems for many centuries. Although production of mineral fertilisers commenced in the 19th Century, their use remained very low until the 1940's (Figure 3.4) and was initially dominated by phosphatic fertilisers with N representing only 15% of the total nutrients applied in the first quarter of the century.

In the 1940's the average input of N fertiliser to grassland provided less than 5kg N/ha per year. However, it was increasingly recognised that N was the most important nutrient limiting grass production, and experiments demonstrated that with pure grass swards under cutting management, the response to N fertiliser was more or less linear up to application levels of at least 300kg/ha. With guaranteed product prices and subsidised fertilisers, intensive systems with high N inputs were widely advocated by fertiliser companies (and their well-developed advisory services), by government advisory services and by researchers. With realisation of the need to increase stocking rates to utilise the extra herbage grown and progress in grass conservation methods, such systems were highly successful, combining predictability with profitability.

In the 60's some farmers applied rates above 600kg N/ha. Average N application rates, however, peaked at some 135kg N/ha in the mid-80's, well below the level required for maximum response. Average rates were higher in dairying than with beef or sheep and also higher for temporary rather than permanent grassland. It is notable that, despite many years of advocacy of high N rates, even in 1986 over 30% of grassland received less than 50 kg N/ha whilst 12% received more than 300 kg/ha (Figure 3.5). It appears that farmers with low N usage were not consciously
seeking to exploit clover as an alternative source of N, but rather they had decided to remain at existing levels of production, because of high capital costs associated with increasing livestock numbers.

In the later part of the century two factors led to some reduction in total N use on grassland. Firstly, the imposition in 1984 of quotas on milk production, followed by constraints on other classes of livestock, reduced the demand for extra herbage. Secondly, evidence increased of inefficiency of N use, particularly in grazing systems. Herbage responses to N fertiliser were shown to be lower in permanent grassland, where substantial quantities of N are supplied from soil organic matter, than for short-term grassland growing in arable soils. Also, extension of experiments to grazing, where N is returned in excreta, demonstrated lower optimal N application rates than with cutting. Probably of greater long term significance was the realisation that the recovery in animal products of the N consumed rarely exceeds 20%. The remainder is at risk of loss to the environment, particularly with long-term grassland, which has reduced capacity to store additional N in soil organic matter. Intensive grassland makes major contributions to N loss through leaching to aquifers and watercourses, through ammonia volatilisation and through denitrification. N fertiliser inputs are restricted in Nitrate Vulnerable Zones and, in some European countries, high N usage is restricted by the need to satisfy N budget targets.

There is now much more concern to improve utilisation of N from livestock manures, soil organic matter and biological N fixation, particularly at the research level. Research in IGER has provided a much improved understanding of the processes controlling N transformations in grassland systems. This has been incorporated into models which consider parameters such as crop requirements, N supply from sources other than fertilisers and soil and climatic factors, giving the prospect of precision fertiliser systems. The use of such models will be aided by techniques for the rapid determination of soil mineral N and the availability of N in livestock manures.

These developments are leading to a reappraisal of the approach to slurry and manure management. During the period of grassland intensification since the 50’s, the attitude to livestock manures changed from consideration as a key resource for sustaining production to being a waste product presenting a major disposal problem. In this latter period, little cognisance was placed on the nutrient value of these materials, point source pollution of watercourses was common and manures made major contributions to environmental losses of N, particularly as ammonia. A combination of legislation, advice given (for example, in Codes of Good Agricultural Practice), improved understanding of the processes involved and the development of aids and models for appraising the nutrient value of slurries and manures, is now providing the basis for improved manure management. Manures are being regarded again as a resource requiring appropriate collection, storage and use in ways to maximise nutrient recovery and to facilitate reduction in fertiliser inputs.
Grass utilisation
Throughout this century, grass has been utilised by ruminants almost entirely by grazing or after conservation as hay or silage. With farms generally being unfragmented and having enclosed fields, the structure suited grazing, rather than stall feeding with cut-and-carry of fresh grass, a system which prevails through much of the world.

Much impetus to improve grazing was provided by major research programmes carried out from the 1950’s in Britain, New Zealand, Australia and America and also by innovative farmers. The research provided understanding of the factors determining the reaction of grasses and white clover to grazing and identified major factors determining intake and production by the grazing animal. A major output was the identification, development and promotion of simple guidelines for the control of grazing based on sward height.

During the early stages of intensification there was major focus on maximising grazing, because of (a) lower costs for grazed rather than conserved grass, (b) higher feeding value and higher animal production with grazing and (c) difficulty in conserving the large quantities of forage required for the increased stock numbers. A major thrust of research in the 50’s and early 60’s was to provide grasses and forages for grazing throughout the year. This did not, however, come about and there was a major increase in grass conservation as silage up to the late 80’s (Figure 3.6) with reduction in reliance on grazing.

The major stimulus for this change was technical progress in silage making: (a) the development of high-capacity forage harvesters; (b) the availability of polythene sheeting to achieve and maintain anaerobic conditions and restrict losses; (c) research information on factors determining the course of the silage fermentation; and (d) the development of effective additives and application systems, and techniques to prevent adverse clostridial fermentation and to improve wilting. Whilst this technology still had limitations, with silages generally being rather lower in feeding value than fresh grass, the silage produced was of much higher feeding value than most hay, and large quantities of herbage could be conserved in a short period of time (Figure 3.7).

The quantity of silage produced in the UK increased from 1.5 M t DM in 1968 to 10 M t in 1986 to reach a peak of 11 M t in 1993. This increase led to an increase in the total production of conserved forage and to reductions in both haymaking and in grazing. The proportion of grass utilised by grazing fell from 72% in 1970 to 53% in 1990, with a corresponding increase in grass conservation. Dates of turnout in spring became later and time of housing, particularly for dairy cows, became earlier. These responses reflected greater ease of management and control of feeding with housed than grazing animals during periods of unreliable grass growth and high risks of sward damage through poaching. Silage use also increased with “buffer” feeding of silage during the summer to guard against...
deficiencies in the quantity and quality of grass for grazing.

Whilst the change to increased silage and reduced grazing produced easily managed systems, this was at the expense of increased feed costs, because of the greater resource requirement for silage than for grazing. With reduced real prices for animal products in the 90’s, a re-evaluation was required and many farmers, particularly in the west of the country, are increasingly reliant on grazing, with the grazing season being extended using feed budgeting and grazing methods to reduce the risk of sward damage. The production of grass silage has fallen by 20% over the last six years. There is prospect for further improvement in the efficiency of grazing as current research has identified grass cultivars capable of giving increased intake and production with grazing. Nevertheless, silage is still likely to play a pivotal role in feed provision during the winter months, when the potential for herbage production is low. Silage making complements efficient grazing, as cutting excess growth for silage is an important management tool for the maintenance of sward quality for grazing.

Grassland biodiversity

In the early part of the century extensively managed grassland was characterised by a high level of botanical diversity with meadows used for haymaking often having a particularly large number of broad-leaved species and supporting large populations of insects and birds (Figure 3.8). The ploughing out of much old grassland and increased intensity of management of the remaining grassland led to the loss of much of this biodiverse resource. A report in 1984, for example, concluded that 95% of the neutral grasslands lacked significant wildlife interest and only 3% had not been damaged by intensification.

The loss coincided with increased concerns by society for wildlife, environmental protection and enhancement, and concerns about agricultural overproduction and the cost of the CAP. Several actions to encourage grassland management and, specifically, to maintain or enhance biodiversity were taken in the last part of the century, including: EC regulation on ‘Improving the Efficiency of Agricultural Structures’ in 1985, the UK Agricultural Act of 1986, and a number of Agri-Environmental Schemes, including Environmentally Sensitive Areas, Countryside Stewardship, Tir Cymen/Gofal and Habitat Schemes. The Biodiversity Action Plans, produced by Government as a response to the Rio Convention, set targets for increasing the area of particular grassland types with high levels of biodiversity. A total of about 1 M ha of grassland in the UK is now being managed within Agri-Environmental Schemes.

Management agreements for grassland generally involve restricting the quantities of fertilisers and manures that can be applied, prohibit the use of pesticides and restrict the timing of cutting and grazing. In many cases the permitted time for cutting is late in the summer to facilitate seed-shed by plants and rearing of young by ground-nesting birds.
Whilst such regulations may maintain biodiversity in situations which are already species rich, research and experience indicate that there may be little response in relatively simple swards that have been farmed intensively. It is now clear that, for a rapid recovery to take place, there must be low soil nutrient status, particularly in relation to phosphorus, and also a source of propagules of new species in the seed bank or from adjacent vegetation.

There is a need for effective targeting of efforts to increase biodiversity in grassland, otherwise the returns from public support for schemes to enhance biodiversity may be poor. It may be more appropriate to target a proportion of grassland for specific management of biodiversity, whilst managing the remainder for efficient agricultural production, rather than reducing somewhat the intensity of inputs on all hectares. The latter approach has the risk of lowering agricultural efficiency, whilst giving no biodiversity benefits. With the targeted approach, the use of land with contrasting managements, producing feeds of contrasting quality, could form part of an integrated production system.

It is probable that financial support for management of the environment and for biodiversity will be an important feature of grassland for at least the next decade. If it is targeted correctly there will be an increase in the areas of grassland with high numbers of plant and insect species. It is, however, inconceivable that the area of such swards will approach that in the first half of the 20th Century.

**Concluding remarks**

Grassland farmers in Britain have shown considerable ability to respond to different requirements during the century. With the present accents on sustainability, environmental protection and enhancement, some of the practices from the early and mid part of the century are being increasingly featured - the use of the ley, organic manures and the creation of biodiverse grassland. The challenge is to harness scientific understanding and technology to develop methods for optimising grassland management and land use to effectively satisfy the new and more complex demands that are being put on the countryside.

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