Agricultural Grasslands in the Landscape: an Issue of Structural and Spatial Uniformity

Jerry Tallowin\textsuperscript{1}, Chris Clegg\textsuperscript{2}, Phil Hobbs\textsuperscript{3} & Alan Hopkins\textsuperscript{1}

\textsuperscript{1} Behavioural and Community Ecology
\textsuperscript{2} Cross Institute Programme for Sustainable Soil Function
\textsuperscript{3} Manures and Farm Resources

Grassland structure, habitat quality and biodiversity

Understanding systems for habitat improvement

Sustainable systems for biodiversity maintenance

Integrating biodiversity into multifunctional farmed landscapes

Integrating socio-economics and ecology to deliver biodiversity
GER’s wide-ranging expertise in investigating processes above and below ground and their interactions at a range of scales gives the Institute a key role in addressing major agro-ecological issues that will be crucial to understanding the interactions between management at the field scale and habitat quality at the landscape scale.

**Grassland structure, habitat quality and biodiversity**

Lowland grassland is a key habitat for a wide variety of wildlife associated with farmland in the UK. However, there is now considerable evidence that the quality of this habitat for wildlife has declined over recent decades. Among the most noticed and publicised declines, and in some cases regional extinction, has been that of farmland bird species. These losses have been associated with agricultural intensification and dominance of landscapes by agricultural grassland. Getting biodiversity back into intensively farmed landscapes is a key environmental policy and sustainability issue.

Recent IGER collaborative research with the British Trust for Ornithology (BTO) and CABI Bioscience examined relationships between livestock farming intensity, grassland composition and structure and associated fauna. This Defra-funded project revealed, in two lowland sample regions in the UK, the ubiquity of grass-dominated, species-poor and structurally uniform grasslands, irrespective of apparent broad differences in farming intensity. Figure 8.1 shows that where grasslands received more than 50 kg N/ha per year there were generally fewer than three forb (broadleaved flowering plants) species per m² and, where present, forbs generally contributed less than 5% of the ground cover. Low diversity and abundance of forb species and thus low flower numbers severely limit the value of such grasslands for nectar and pollen feeding invertebrates such as butterflies and bumblebees.

This project also indicated that the relationships between birds and their plant and invertebrate food supplies in grassland are extremely complex and species-specific and, not surprisingly, affected by management practices. The accessibility of prey is a key issue for birds in grassland systems. Our research indicated a need to create habitat diversity at the scale of individual fields and
whole farms not only to increase invertebrate abundance but also, and crucially, to improve the accessibility of prey to foraging birds.

A current Defra-funded IGER research project with the Centre for Agri-Environmental Research (CAER) at Reading University and the BTO has already demonstrated biodiversity benefits arising from simply manipulating canopy structure of the grassland. Not cutting or grazing during the growing season doubled the structural diversity of the existing grassland and provided the highest levels of invertebrate abundance and diversity compared with treatments such as simply not applying fertiliser and raising mowing height or only cutting in July. We have also provided the first experimental test of the use of sown, seed-rich margins in the pastoral landscape on bird populations (Figure 8.2). Benefits of the sown treatments for birds have been clearly shown.

**Understanding systems for habitat improvement**

Understanding the mechanisms constraining the restoration of biodiversity to agriculturally improved grassland is the focus of ongoing research. Studies taking place on upland acid-neutral grassland at ADAS Pwllpeiran and lowland grassland at IGER Trawsgoed have demonstrated that hay cutting and aftermath grazing is significantly more effective in enabling increases in botanical diversity by natural recolonisation than hay cutting alone or extensive grazing (Figure 8.3). During the first decade of this experiment the development of a relatively high cover of *Holcus lanatus* (Yorkshire fog) appeared to impede increase in botanical diversity. A recent dramatic decline in the cover of *H.*
lanatus was associated with an increase in the cover of Cynosurus cristatus (crested dog’s tail), particularly in limed plots, and the first appearance of a number of naturally colonising desirable species, such as Rhinanthus minor (yellow rattle) and Dactylorhiza maculata (heath spotted orchid). We have also found that the soil microbial biomass and the soil fungi to bacteria ratio (FBR) have become significantly different under hay plus grazing management compared with other extensive managements, which suggests that plant-soil biota feedbacks are now occurring. However, to date we have not seen recruitment of plant species such as Succisa pratensis (devil’s-bit scabious) or Campanula rotundifolia (harebell), which are indicators of high biodiversity value grassland. This project emphasises the value of long-term ecological study sites that provide platforms for detailed mechanistic research into complex processes.

In order to gain greater mechanistic understanding of plant - soil associations for enhancing botanical diversity in grassland, IGER, in collaboration with the Universities of Lancaster, Newcastle and Reading, has embarked on a major Defra project that brings together expertise in plant ecology, soil microbiology and soil chemistry (Figure 8.4). The project has four aims: (1) to confirm the reported association of high FBR with species-rich grasslands relative to agriculturally improved and semi-improved grasslands; (2) to quantify the impact of key plant species in the development of fungal dominated...
soils and resultant impacts on vegetation community development; (3) to identify the mechanisms underlying the influence of plant species on FBR in the soil and soil biota influences on vegetation development; and (4) to evaluate other potential indicators that could be used in agri-environment schemes to target sites for re-creation or enhancement of grassland biodiversity.

Changes to the composition of microbial assemblages in soils are brought about by such practices as inorganic-N additions, soil drainage and animal grazing, and the effects of each of these factors can be different with respect to different microbial groups. For example, the application of inorganic N fertiliser can bring about an increase in the abundance of nitrifiers, whilst at the same time lead to an apparently unrelated decrease in the abundance of actinomycetes in soils. Soil microbial communities appear to be dynamic and are invariably linked to both the present and, probably more significantly, the legacy of previous botanical communities. Linking shifts in microbial community composition to shifts in the fluxes of soil process is the challenge ahead for understanding the functional attributes of different grassland soils.

IGER is at the forefront of research on identifying the phospholipid fatty acid (PLFA) signatures of different microbial communities in soils and the wider environment. PLFA analysis enables estimates of the relative proportions of gram positive, gram negative, actinomycetes and fungal groups within microbial communities. We are also developing a range of new tests to diagnose the composition of the microbial community by analysis of the metabolic products or remains of the larger natural polymeric compounds such as proteins and lipids. PLFA analysis can only monitor microbes present in the oxic environment. We will soon be monitoring phospholipid ether linked compounds that are present in viable cell walls of more primitive organisms (i.e. the arachaea) that live in anoxic conditions.

**Sustainable systems for biodiversity maintenance**

Identification of what constitute sustainable management practices for the maintenance of existing grassland biodiversity has been a theme of IGER’s research for the past 20 years and continues to be. The Tadham project on the Somerset Levels, which was initiated in 1986 in collaboration with the Institute of Terrestrial Ecology (now Centre for Ecology and Hydrology, CEH), demonstrated that botanical diversity was sensitive to additions of as little as 25 kg fertiliser N/ha per year. This project also provided some predictions of timescales, and uncertainty, for restoration of botanical diversity following cessation of fertiliser inputs. The importance of phosphorus (P) as a major factor influencing plant
diversity was also demonstrated (Figure 8.5). Our subsequent research with CEH on one of the UK’s priority Biodiversity Action Plan habitats, the purple moor grass and rush pasture, showed that retention of very low (index 0) soil P availability was a key factor in the maintenance of such habitats. As part of an EU-funded project, IGER, with collaborators in Belgium, the Netherlands and Spain, established the generality of the association between low soil P availability and high plant diversity for temperate grasslands.

The sustainability of grazing as the sole management to maintain the biodiversity interests of species-rich neutral grassland has to be questioned in light of findings from some of our research. In a Defra and English Nature-funded project, we applied different grazing pressures over five years to unfertilised, agriculturally unimproved neutral grassland. Plant species diversity declined and the cover of competitive plant species increased under all grazing pressures. The increase in cover of more
competitive species indicated a general increase in nutrient availability, which was corroborated by soil analysis of total N amount in the surface horizon. Prior to the initiation of this experiment the site had been under hay cutting management for several years. In isolation this result could, therefore, have been largely a response to management change from former hay cutting to grazing, with the latter stimulating nutrient cycling. However, similar comparative ecological changes were also found at another site after applying similar grazing pressures to agriculturally semi-improved neutral grassland. Our research indicated that grazing-induced nutrient cycling, particularly early in the growing season, was a key factor leading to the loss of botanical diversity.

Integrating biodiversity into multifunctional farmed landscapes
IGER is at the forefront of cross-cutting research to examine the role of agriculturally improved and unimproved communities as both sinks and sources of nutrients, carbon and greenhouse gases. In reacting to change in grassland and farmed landscapes, we need to think beyond the simple notion of applying the principles of traditional farming practices that are perceived as being environmentally benign. Our landscapes have experienced dramatic changes over past centuries from both cultural effects and environmental changes, and future needs are likely to include increased requirements for a range of services including recreation, water catchments, carbon storage, the production of crops for energy and industrial uses, as well as food production and nature conservation. Future climate change is also emerging as an important issue, and there are already indications that the flora and fauna are responding to recent warming trends and changes in precipitation. While we have started to gain an insight into how some relatively simple agricultural systems (such as arable crops or ryegrass-legume grassland) respond under climate change scenarios, the resilience of agriculturally unimproved communities is much less certain. Many contain species assemblages that have survived since the last Ice Age: how will these survive rapid warming? How will wet grasslands and mires respond to increased frequency of summer droughts? How can the species diversity that remains be incorporated into new land-use options such as biofuel cropping? Future agriculturally unimproved communities may have quite different structures to those we see today. These may result from environmental changes and what may be quite different functional requirements.

Integrating socio-economics and ecology to deliver biodiversity
A joint research council funded “Rural Economy and Land Use” project with IGER, CEH, Exeter University and CAER has just started to examine socio-economic and ecological constraints to biodiversity enhancement in farmed landscapes. Specifically, we will be examining the impact of training on farmers’ delivery of agri-environmental objectives and assessing the permeability of farmed landscapes to dispersal of biodiversity elements.