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Extensification - benefits and disadvantages to grassland biodiversity

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Abstract

It is implicit in policies that encourage extensification within agriculture that previous intensification of farming practices has harmed the environment and is no longer desirable. However, the argument that biodiversity is related to the intensity of farming within agriculturally dependant ecosystems and that extensification will lead to improvements in biodiversity is simplistic. The effects of extensification policies within grassland ecosystems depend on the starting point in terms of grassland species and the little understood interactions between soil, plant and animal processes. Therefore, extensification may lead to both benefits and disadvantages in terms of biodiversity and the challenge for the future is to be able to predict these in order to target extensification policies more effectively to achieve environmental objectives.

Keywords: biodiversity, extensification, grassland, hill, lowland, management.

Introduction

Agricultural policy makers are under increasing pressure to encourage farming systems that are more sympathetic to the requirements for protection and re-creation of wildlife habitats. As a result, many governments have put in place legislation that employs extensification as a means of achieving environmental objectives in farming. One example is the European Union regulation No. 2078 (EC, 1992) that beholds member states to institute agri-environmental schemes in which farmers are paid to protect and/or re-create farming dependant wildlife habitats. This regulation arose as part of the MacSharry reforms of the CAP and as such, agri-environmental schemes (for example, SOAEFD, 1994 and 1995) provide support for 'extensification' in farming systems.

In the context of grassland, extensification can be defined as reduction of inputs into systems in terms of stocking rate, fertilisers, cutting and grazing management, animal feeding and fixed costs (including labour). The ultimate of extensification is abandonment of farming practices, which is an important consideration throughout Europe.

An implicit assumption in extensification policies is that 'extensification' will benefit the 'environment'. However, in terms of biodiversity (which for the purposes of this paper will include all the flora and fauna that can exist in farmed grassland habitats) this is a largely untested and unproven assumption.

The objective of this paper is to provide a broad overview of current knowledge on how extensification impacts on biodiversity in grassland. Grassland will be divided into 'lowland' and 'hill'. 'Benefits' have been taken as increases in the number of flora and fauna species, or re-creation/preservation of particular habitats for specifically highly valued wildlife species. 'Disadvantages' has been taken to mean the opposite of this; that is, loss of species number or important habitats.

It should be appreciated that there are relatively few reports in the literature on the effects of extensification in grassland. Most work is in the German literature, but even here the amount is small compared to the potential impacts of the policies that encourage extensification.

Lowland grasslands

Grassland production systems in lowland areas have been the most amenable to intensification in the last 50 years and have thus experienced a profound increase in agricultural output per unit area and subsequent loss of biodiversity. This is because they are based on the most productive soils and provide for easy application of new technologies. Traditionally, extensive (low input/low output) lowland grassland systems have supported a wide diversity of fauna and flora (Crofts & Jefferson, 1994).

Table 1. Yield, number of species and net energy content of the hay of different permanent pasture association (Jeangros & Schmid, 1991).

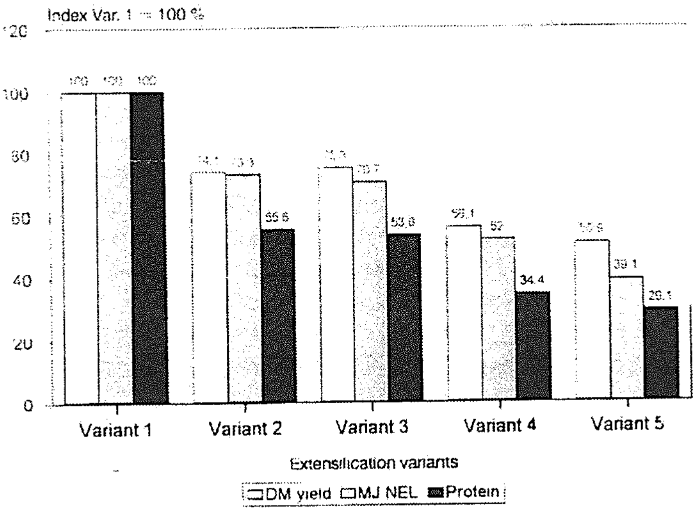
	Ryegrass[1]	Arrhenatherion[2]	Arrhenatherion[2]	Mesobromion[3]
Intensity of menagement	very high	intermediate	low	very low
Number of species	≈20	≈30	≈40	≈60
DM yield (t ha^{-1})	10-13	9-11	5-8	13.5
Net energy for location (MJ kg^{-1} DM)	6.0	5.2	4.9	4.6

[1]Main species: Lolium perenne, Poa trivialis, Taraxacum officinale, Trifolium repens; hay cut at beginning of inflorescence of the grass.

[2]Mainly used for hay production; cutting at full inflorescence emergence (intermediate intensity) or just after the end of inflorescence emergence (low intensity).

[3]On dry and infertile soils; no or very moderate fertilisation; late hay cut.

Figure 1. Experiment of extensification of lowland pasture in 'Relliehausen' (Germany). Relative yields of DM, energy and protein in the years 1986, 1987 and 1988 (average).



The results are the averages of the years 1985 to 1988
DM yield: 100 % = 11.26 t DM ha^{-1}, Net Energy for Lactation (NEL): 100 % = 56.675 MJ NEL ha^{-1}; Crude Protein: 1.54 t CP ha^{-1}
Variant 1: three cuts, 200 kg N ha^{-1}; **Variant 2:** two cuts, first after 1 July, 50 kg N ha^{-1}; **Variant 3:** two cuts, first after 15 July, 50 kg N ha^{-1}; **Variant 4:** two cuts, first after 1 July, no fertiliser; **Variant 5:** one cut at 15 August, no fertilizer

These biodiverse ecosystems are almost exclusively semi-natural, with farming providing habitats (fields, hedges, wetlands, field margins and woodland) for plant species, on which invertebrate and vertebrate food chains are dependant.

Potentially, biodiversity on lowland grasslands has much to benefit from extensification measures. This potential was described by Nösberger et al. (1994) and can be quantified in terms of management intensity, plant species number and herbage DM yield (Table 1). It is clear that extensification can lead to radical changes in productive parameters such as herbage dry matter, energy and protein yields (Figure 1). The question in each case where extensification is applied is do these changes benefit or harm biodiversity?

Benefits to biodiversity in lowland grasslands

Attempts to re-create biodiverse ecosystems have been made. For example (Frame et al., 1994) by sowing a diverse flora and instituting extensive management (zero fertilisation, one hay cut, extensive grazing) on swards that were previously sown monocultures and intensively managed (200 kg N ha-1, two cuts of silage, intensive grazing). Seven years after the re-creation of this 'artificial' habitat the invertebrate fauna on the grassland had become more diverse and the body size of carabid species had increased to the potential benefit of insect foraging mammals and birds (Blake et al., 1996). However, this positive movement in invertebrate diversity had not resulted in a developed fauna that was similar in character to the traditional semi-natural grassland of the area; the achievement of this would take many years. Further, in situations where management had been only marginally extensified (from very intensive management to moderate levels) no benefits in invertebrate diversity, and thus potential for a diverse ecosystem, were detected. Thus, this work (Blake, 1996) indicates that extensification of intensively managed lowland grassland only benefits biodiversity if the reduction in management inputs are large and radical and approach the systems on which the original biodiverse ecosystems existed.

A less artificial approach to extensification is to greatly reduce management inputs to a species-poor grassland and allow species to regenerate naturally. Wind et al. (1994) demonstrated a significant improvement in plant species number in a 'dry sandy soil' sward that had previously been intensively managed. These workers also suggested that the greatest increases in botanical diversity were achieved after the greatest reductions in management intensity and noted that even after 23 years of extensification, the sward had not reached a stable botanical composition.

The removal of fertilisation has also been shown by Bakker (1994) to benefit the diversity of plant species. Improvements were demonstrated on many different swards (Table 2), but the common finding among all soil types was that management of hydrological processes was crucial to success. Again this work shows that after a long period of extensification, swards remain in dynamic change and have not reached a stable phase where improvements in diversity can be characterised as sustainable.

Table 2. Dynamics of species replacement on a moist peaty soil with calcium-poor seepage cut for hay in July and receiving no fertiliser application after 1972. Percentage cover of characteristic species. (Bakker, 1994).

	1972	1974	1976	1978	1980	1982	1984	1986	1988	1990	1992
Alopecurus geniculatus	10	4	1	10	1	1	1	-	-	-	-
Festuca pratensis	40	4	4	2	2	1	1	1	2	2	2
Anthoxanthum odoratum	-	2	1	1	8	2	8	10	1	12	4
Festuca rubra	-	-	-	1	1	1	1	1	8	12	1
Juncus effusus	-	-	-	1	1	-	1	1	4	8	10
Rhinanthus angustifolius	-	-	1	-	20	20	2	1	1	-	1
Juncus acutiflorus	-	-	-	-	-	-	1	1	1	1	1
Leontodon autumnalis	-	-	-	-	-	-	1	1	1	1	2
Caltha palustris	-	-	-	-	-	-	-	1	1	1	2
Lotus uliginosus	-	-	-	-	-	-	-	1	-	1	1

Disadvantages to biodiversity in lowland grasslands

Although extensification has been shown to lead to increases in botanical diversity in some cases, in others no improvements have been demonstrated (Neuteboom et al., 1994). It can be argued that on dense intensively managed swards under wet conditions, extensification does not result in the ingression of favoured species, but rather densely growing species such as perennial ryegrass remain dominant for very long periods. There is also ample evidence that minor moves towards extensification do not result in increases in biodiversity. For example, reducing nitrogen fertilisation of a perennial ryegrass sward to almost zero and encouraging white clover may be viewed as a major extensification of intensive grassland systems. However, this approach which is sanctioned by many agricultural policy makers (Bax & Browne, 1994) does not improve biodiversity, even where it is accompanied by large reductions in stocking rate (Marriott et al., 1996).

This lack of positive effect may not represent actual disadvantages to biodiversity. Indeed, the lowering of stocking rates and nitrogen fertiliser applications that these reductions in management bring may be of major importance in reducing the risk of pollution, particularly to ground waters in wet regions. However, they do not represent any benefits to biodiversity. Thus, if biodiversity is to be achieved as a result of extensification, it must be an explicit and integrated objective in the extensification process. Only in this way will managements be applied that will enhance biodiversity. To this end, it is unclear which managements, in which situations, will provide for increases in biodiversity. This is because there is a lack of scientific understanding of the plant and animal processes that change as a result of management change. Therefore, the benefits of extensification of specific management practices and the time scale over which benefits will arise can not be accurately predicted. The resolution of these issues requires a mechanistic approach to studying the effects of extensification, of the kind conducted by Kading et al. (1993). However, this type of work is rare.

At the other extreme of extensification, abandonment of all agricultural practices can lead to the dominance of certain, usually tussock growing, species (Rychnovská et al., 1994). These workers describe successional phases of change in grasslands following abandonment, which usually reduce biodiversity. They also advocate management strategies to halt degeneration, all of which involve some form of agricultural intervention.

A further problem with extensification policies is their sustainability in terms of time. The work reviewed suggests that benefits to biodiversity following extensification happen in the long-term. Even after 20 years, botanical change is still unstable and the end point of extensification can not be predicted. If extensification is considered at the field, farm and landscape scales (Balent et al., 1994), a complex picture of changing flora and fauna can be built. It is unlikely that the benefits of extensification policies can be sustained in the long-term, unless the policies address biodiversity at all relevant scales. At present, most policies encourage extensification at a field scale, or at most on larger parts of single farms. The disadvantage here is that much effort may be made in extensification with little or no benefit to biodiversity and the benefits accrued may be lost because policies do not advocate an integrated approach at the landscape scale.

Hill grasslands

Botanical change in hill grasslands is intrinsically slower than in lowland grasslands. Therefore, the benefits or disadvantages of extensification policies in terms of biodiversity will take many years to become apparent. In European terms, such policies have not been in place long enough for grassland researchers to characterise the changes in biodiversity that may result. However, there is work in progress (for example, Davies et al., 1994; Fisher & Waterhouse, 1994 and Rahmann, 1996) that is monitoring the effects of extensification in hill regions.

Most knowledge regarding the impacts of extensification on biodiversity in hill grasslands relates to abandonment. In this context, abandonment may be defined as the cessation of agricultural practices on a grassland area. Although this is an extreme form of extensification, it is an important feature resulting from political and agricultural policy change within Europe and, therefore, must be considered.

Benefits to biodiversity in hill grasslands

In the past 25 years the hill regions of north western Europe have experienced an increase in the numbers of grazing animals and changes in grazing species, with sheep replacing cattle. In many areas these changes have resulted in the degradation of some species-rich semi-natural hill grasslands with loss of important species and dominance of less desirable tussock growing grass species. The need to reverse this process of so called 'over-grazing' is explicit in many extensification policies.

In the context of biodiversity, the effects of extensification through reducing grazing pressure and/or changing grazing species and the calendar of grazing activities are dependant on complex and little understood processes. In many areas, the assumption that reducing grazing intensity will encourage the reversion of an over-grazed pasture to a previous species-rich state seems simplistic. However, there is potential for extensification to encourage biodiversity in this situation; the requirement at this point is for scientific understanding of how extensification management can lead to benefits, without proliferation of the undesired grass species which tend to become dominant during the process of 'over-grazing'.

Disadvantages to biodiversity in hill grasslands

As in lowland regions, agriculturally dependant ecosystems in hill areas require farming inputs and managements if they are to be sustained. Extensification resulting in abandonment has lead to the removal of agricultural practices in certain hill regions, with resultant collapse of the ecosystem and loss of biodiversity.

Assuming that abandoned 'wilderness' areas are not desired, even if they may contribute to biodiversity in a global sense, work in Germany (Nitsche & Nitsche, 1994 and Spatz, 1994) has shown that the key change in loss of biodiversity lies with the plant species. The diversity of plants dependant on the maintenance of short vegetation is lost following abandonment. This is due to competition for light, nutrient and water resources from taller growing grass, shrub and tree species which successfully ingress and become dominant. For example, after the abandonment of sheep grazing on the Kalk-Magerrasen in Germany, the number of plant species initially increased from 35 to 95. However, after 10 years without grazing plant species numbers again declined to 35, but with radically different species being present compared to the swards that existed when grazing was practised. Grasses became dominant and species such as orchids (Orchidaceae) disappeared so that no rare plants existed on the abandoned ex-pasture. Even with the re-introduction of grazing, it might not be possible to reverse this important loss of biodiversity. The issue here is not necessarily the reduction of biodiversity through the loss of species numbers per se, rather the major problem caused by abandonment is the loss of rare, and therefore important anf valued, species. Throughout Germany, over 800 plant species are present in hill lime grass meadows. Over 500 of these species are now endangered because of the abandonment and grazing and cutting practices (Rahmann, 1997).

Conclusions

Extensification of grassland systems can lead to useful increases in biodiversity. However, improvements may only be achieved in the long-term and at present most extensification policies that support farmers for changing management practices are too short. Policies also lack directions and specific objectives. The best results are achieved where extensification results in the re-adoption of managements that simulate those that created biodiverse ecosystems, prior to agricultural intensification. There is also a lack of scientific knowledge on which to base successful extensification strategies. Therefore, future work should address a) the mechanisms of species change following extensification, b) the integration of extensification with farming policy at field, farm and landscape scales, so that improvements are sustainable biologically and economically, and c) take a multi-disciplinary approach so that the impact of extensification on biodiversity is studied in terms of whole ecosystems, including flora and fauna.

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