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Will agri-environment schemes deliver substantial biodiversity gain and if not why not?

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Summary

1. One of the main aims of agri-environment schemes (AESs) is to increase biodiversity on farmland. Common conservation practice is to identify areas containing valuable resources (e.g. habitats, ecosystems or species) and then to protect them – ‘protected area’ schemes. AESs differ from typical protected area schemes because they are often applied to small patches of land, such as field boundaries, and they are sometimes located in areas where the target species does not occur.

2. AESs require an enormous amount of funding and they have been applied across a large geographical area, i.e. the European Union. However, recent evidence suggests mixed results for the effects of agri-environment schemes on biodiversity.

3. It is hard to predict the consequences of AESs on biodiversity because a number of factors are seldom accounted for explicitly. For example: (1) both Optimal Foraging Theory and Metapopulation Theory predict that the distance from breeding individuals is likely to determine patch use; (2) occurrence of target species will vary between patches; (3) there will be variation in habitat preference by species in different geographical areas; (4) if resources are widely spread then the home ranges of some species may need to increase to encompass the multiple resources needed for breeding. The potential for these factors to affect the outcome of AESs on biodiversity are discussed.

4. *Synthesis and applications*. AESs are likely to increase biodiversity if a lower number of larger resource patches are provided (in contrast to current practice which promotes many small fragmented areas of environmental resource). One way of achieving this may be to run these schemes more like traditional ‘protected area’ schemes with farms or groups of farms managed using extensive farming methods. Such an approach negates some of the problems of current AESs and may help address a wider range of concerns held by different countryside stakeholders.

Key-words: wildlife and farmland, spatial ecology, integrated farming systems, farmland birds, biodiversity conservation, Common Agricultural Policy, agro-ecology.

Introduction

The role that agri-environment schemes (AESs) can play in improving biodiversity on farmland appears with increasing frequency within the scientific literature (Figure 1). AESs have other aims including the maintenance and enhancement of landscapes, the protection of the historic environment, the protection of natural resources and promoting public access to the countryside (http://www.defra.gov.uk/erdp/schemes/es/default.htm), however benefiting biodiversity gain is a major goal of these schemes. It has recently been highlighted that, overall, progress towards achieving the European Union's target to halt biodiversity loss on farmland by 2010 is not visible and the target is unlikely to be reached without additional integrated policy efforts (EEA 2006). This editorial discusses why these schemes provide particular challenges to biodiversity conservation within farmland ecosystems. It is not intended as an exhaustive ('systematic') review of the literature on AESs but as an overview, to place the papers within this Special Profile in context and to suggest directions for future research.

A common approach to conservation is to identify areas containing valuable resources (e.g. habitats, ecosystems or species) and then to protect them. Conservation schemes designed for these 'protected areas' have been categorised into five groups by the IUCN (1994) (listed in Pullin 2002): (1) 'strict' Nature Reserve – usually these contain high priority species, habitats or ecosystems; (2) Wilderness Area – unmodified or only slightly modified land designated with the aim of preserving its natural condition; (3) National Park – mainly used to protect ecosystems and land used for recreation; (4) Natural Monument – used for conservation of specific natural features; (5) Habitat or Species Management Area – management intervention to aid specific habitat/s or species/s. The rationale underpinning groups 1-4 is relatively simple: identify an important area and protect it.

The Habitat or Species Management Area classification (group 5) incorporates a range of different conservation approaches. Most are aimed at networks of sites, such as Special Protection Areas (SPAs) under the Birds Directive, or Special Areas of Conservation (SACs) under the Habitats & Species Directive, both of which are European designations aimed at minimising developments and protecting what is on the site by encouraging favourable management within the designated area. Agri-environment schemes also fall under this category. However, two properties of AESs set them apart from typical protected area schemes: (i) they are **often applied to very**

small patches of land, such as a field boundary or an individual field, and thus they create at larger scales (such as at the farm scale or larger) a complex mosaic of differing habitat quality (see Figure 2); (ii) they are sometimes **placed in areas where the target species is absent** with the intent of improving conditions necessary for the return of the target species.

Have agri-environment schemes benefited biodiversity?

Although boosting populations of wildlife is a major aim of AESs, the evidence for their effects on biodiversity are mixed. A recent review by Kleijn & Sutherland (2003) reported that the research design of most AESs was inadequate to assess the reliability of the schemes. Of nineteen bird studies providing results, four yielded positive increases in species richness or abundance, two gave negative results and eleven showed results in both directions. For the twenty arthropod studies, eleven yielded an increase in species richness or abundance and three showed mixed results, but none showed a decrease. Amongst the fourteen plant studies examined, six showed increases in species richness or abundance and two showed decreases. More recent studies have added to our knowledge of how AESs affect biodiversity, e.g. Kleijn *et al*. (2006) found that AESs in five European countries have performed poorly for a range of taxa that were considered either uncommon or were listed in Red Data Books, whereas poor to moderate effects were reported across a range of more abundant and widespread taxa including vascular plants, birds, bees, grasshoppers and crickets, and spiders.

AESs require an enormous amount of money (€24 billion was spent by the European Union between 1992 and 2003 on these schemes - Kleijn & Sutherland 2003) and they have been applied across a large geographical area: the European Union. Given the importance of this topic it is not surprising that the efficacy of these schemes is of great interest to scientists, policy-makers and the general public. For example, *What lessons can be learned from agri-environment schemes to optimise their biodiversity gain and ecological benefit?* has recently been identified by policy-makers and scientists as one of the key policy relevant ecological questions in the UK (Sutherland *et al*. 2006). Optimising the use of available measures (such as agri-environment schemes) under the reformed Common Agricultural Policy is seen by the European Commission (CEC 2006) as a major part of the European Strategy to halt biodiversity loss on farmland by 2010. Recent studies have begun to question whether the current approach is optimal and to suggest changes. In the section below I explore three areas of particular concern.

Why might AESs fail to benefit biodiversity substantially?

Clearly AESs need to provide 'good quality' habitats (e.g. by providing preferred food, improving access to food or minimising predation risk) and research is still on-going to quantify optimal environmental resources in farmland systems. Papers in this Special Profile illustrate this, for example bumblebees *Bombus* spp. make extensive use of the legume-based 'pollen and nectar flower mix' as prescribed under an English AES but this type of resource is short-lived and alternatives are needed (Carvell *et al*. 2007). Both cutting regime and fertilizer input affect beetles on grass margins, with no fertilizer input being particularly beneficial to a range of beetle species (Woodcock *et al*. 2007). Grassland restoration is a complex issue and there are a range of practical options that can be used to provide both very high quality habitat (as source populations) and other less intensive measures (Pywell *et al.* 2007). Farmland bird species that flee from predators prefer to forage in open areas, such as stubble cut short to circa 6 cm, whereas other species that rely on crypsis prefer longer vegetation, such as stubble of a length found in typical fields, circa 13 cm (Butler, Bradbury & Whittingham 2005) and so heterogeneity is a key factor (see Benton, Vickery & Wilson 2003 for a useful discussion). However, designing 'good quality' habitat does not take account of several factors which affect AESs. These factors set AESs apart from typical protected area schemes and may contribute to suboptimal performance (see below).

(i) Application to small patches of land

Prediction of the effect of environmental resource provision (e.g. management of hedges or field margins) to small patches of land by AESs is complicated by several factors. First, species require multiple environmental resources when breeding. For example, providing a section of hedge 50 m long may be important for many nesting birds but if suitable resources for foraging nearby are insufficient, then the hedgerow may be of little value for birds. Secondly, the distance between environmental resource provision and source breeding populations may be important, e.g. will an isolated hedgerow or weed rich grass margin created under an AES attract many birds, invertebrates and plants if the nearest breeding individual or population is some distance away? Metapopulation Theory predicts that the more distant the source population the less likely that the patch will be colonised (Hanski & Gilpin 1991; Sutherland 1998): for taxa with poor dispersal abilities (e.g. mainly plants and some invertebrates) even relatively small distances may affect the likelihood that a patch will be colonised. Optimal Foraging Theory (or more specifically Central Place Foraging Theory) predicts that given two patches of equal 'value' the nearest one (e.g. nearest to the nest for a bird or a bumblebee) will be preferred because it uses up less energy to visit the closer patch (Stephens & Krebs 1986; Krebs & Davies 1991). There are many empirical studies supporting these theories but two good examples from farmland systems are provided in this Special Profile. Öckinger & Smith (2007) found that grass margins further from source patches (in this case semi-natural grassland) were lower in species richness and density for both butterflies and bumblebees (*Bombus* spp.). Secondly, Clough, Kruess & Tscharntke (2007) report that insect herbivore species diversity was higher on newly created plots of their host plant (in this case creeping thistle *Cirsium arvense* L.) placed within organic wheat fields compared with those placed within conventionally managed wheat fields, probably because of the naturally higher cover of *C. arvense* in the organic fields (thus plots were on average likely to be closer to source populations in the organic fields). Thus the distance from breeding populations is likely to be critical to the use by insect communities of non-cropped areas (which are often part of AES options). In addition, the application of AESs to a variety of small patches of land may mean that collectively these do not provide sufficient additional resources to maintain viable increases in the target populations and/or offset the adverse influences of the surrounding landscape.

(ii) Placement of environmental resources by AESs where target species are absent

Clearly, AESs are likely to be most effective when applied to areas in which target species occur. A good illustration of this is provided within the farmland bird literature. The Countryside Stewardship Scheme (an English AES) has been successful in targeting management for cirl bunting *Emberiza cirlus* L. populations in a small part of SW England (the only area in which they occur in the UK) resulting in a population increase of 83% on Countryside Stewardship land. In contrast populations lying on land adjacent to agreements areas have increased by only 2% (Peach *et al*. 2001). On the other hand, studies of AESs applied over wide areas (which can thus be applied to areas in which a species is absent) have reported either limited or no effect of these schemes on bird abundance (Kleijn *et al*. 2001; Bradbury & Allen 2003; Kleijn *et al*. 2006). This is illustrated in this Special Profile in a study of waders in Holland by Verhulst, Kleijn & Berendse (2007). Dry fields, which are of little value to waders such as redshank *Tringa totanus* L. and lapwings *Vanellus vanellus* L., may still be entered into AESs in Holland; unsurprisingly, management changes to such fields as part of the AES agreement made little difference to wader numbers (Verhulst *et al*. 2007).

(iii) Generality of habitat models

An underlying assumption of AESs is that they will have similar effects on target species across the range at which the scheme is applied. This assumption is relatively under-explored in farmland systems but one recent study suggests it may not be valid. Whittingham *et al*. (in press) found that for a range of eleven farmland bird species in England and Wales, good predictors derived from sites in one geographical region tended to have little or no predictive value when applied in other areas. For example, the height of boundaries (mainly hedges) had significantly different positive effects on territory occupancy by the eleven species across south-east, northern and south-western England. This suggests that AES options targeted at a regional scale are more likely to yield beneficial results for farmland birds than options applied uniformly in national schemes. In contrast, Kleijn *et al*. (2004) found no differing effects of AESs in different landscapes (as determined by soil type: sand, peat or clay). However, neither of the biodiversity measures recorded by Kleijn *et al*. (plant species richness and meadow bird abundance) differed between control fields and fields under AESs suggesting that this may not have been the best study system to examine the interaction between AESs and landscape.

Potential changes to AESs

First, there may be benefits to adopting the traditional ‘protected area’ framework for AESs. If whole farms or groups of farms were managed using extensive farming methods and the farmers compensated appropriately then this may yield greater biodiversity gain (especially if access to this scheme was limited to those farms with existing healthy wildlife populations). This approach is also suggested by Kleijn & Sutherland (2003) who propose that the same level of reduction in agricultural intensification in extensive systems may produce greater biodiversity gains (i.e. the relationship between agricultural intensification and biodiversity is non-linear). The effects both of nearest breeding individual/s and multiple resource requirements (discussed above) may be significantly reduced if larger patches of high quality resource are provided. It could be argued that steps are already in place to this end. For example, the Higher Level Scheme (an English AES) goes some way to addressing this concern but it remains to be seen whether it will provide patches of environmental resource of sufficient quality or size.

A second issue is the current link between conservation research and policy. Currently, conservation policy is often informed by research but once a policy is formed then the process may take some time to be reviewed and updated. Perhaps AES monitoring could be viewed more as ongoing research which feeds back into policy to inform future changes to AESs? A simplistic example to illustrate this point is as follows. The process of policy development usually involves three major steps: first, conservation 'problems' (e.g. why is farmland biodiversity declining?) are often defined by a government or wildlife non-governmental organisation (NGO); secondly, research programmes are initiated to investigate the underlying causes and to trial solutions; thirdly, the results from step two are used to develop policy. However, what if the policy performs poorly or does not work? Changes are clearly needed but the time scale may be speeded up if AESs are used as the basis for trialling management options and the results are used to revise current practice.

Could an integrated countryside deliver biodiversity gains?

Farming to maximise economic performance is usually in conflict with wildlife needs. Two papers in this Special Profile address this issue. Olsen & Wäckers (2007) investigated whether field margins, which benefit the conservation of northern bobwhite quail *Colinus virginianus* L., enhance biological pest control in adjacent wheat fields. They found that AESs targeted at biodiversity did not affect pest control. Bullock, Pywell & Walker (2007), also in this Special Profile, show that the re-creation of diverse grasslands for conservation also increases yields from hay crops. These approaches help to bring farming and wildlife needs together and merit further research.

How can AESs be integrated more generally with other countryside needs? Conservation management could be aligned with other anthropogenic issues such as health, flood protection, water purification, tourism and transport policy (Sutherland 2002, 2004; Stephens, Pretty & Sutherland 2003). Steps in this direction may yield many gains and the organic farming movement (or similar movements such as low-input farming systems) is one area which could deliver, at least in part, this kind of vision particularly given the increasing consumer demand for organic food (Lohr 2001).

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Figure 1. A graph showing the increase in numbers of journal articles about Agri-Environment Schemes. These papers were those listed in 'Web of Science' using the search term 'agri-environment schemes' carried out on 18/10/06. The *Journal of Applied Ecology* published more papers than any other journal (23 out of 136 – 17%), with a total of 39 journals publishing one or more papers. *Journal of Applied Ecology* papers together accounted for 36% (434/1202) of citations. Note: the papers listed under 2006 are only those listed up until 18/10/06 and are thus only around three-quarters of those likely to be published by the year end.

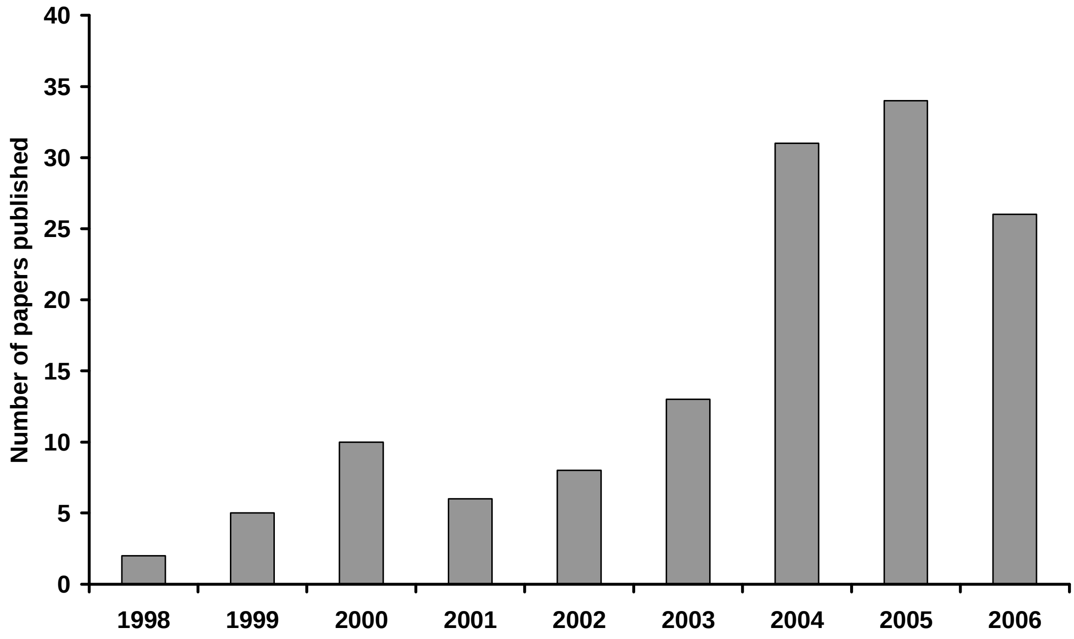

Figure 2. A fictitious example of a future 'protected' farmland area (in which the entire area shaded in grey is managed sympathetically for wildlife – i.e. a 'protected area' approach) and an AES in which small parts of a farm are managed for wildlife (the boundaries marked in black are managed for wildlife by planting grass margins, increasing hedge height and width). The 'protected area' approach outlined in the text lessens the problems associated with distance from nearest colonising source and multiple resource provision because i) the area is much larger, and ii) entry is restricted to landowners with existing 'healthy' wildlife populations.