A review of evidence on the environmental impact of Ireland's Rural Environment Protection Scheme (REPS)

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Abstract

Since its inception in 1994, there has been strong demand for evidence of the environmental effectiveness of the Rural Environment Protection Scheme (REPS), which paid farmers in the Republic of Ireland over €3 billion by 2010. A variety of research projects have been undertaken that investigate the environmental effects of REPS through an examination of either specific environmental measures or specific geographical areas. A review of available publications confirmed the absence of a comprehensive, national-scale study of the environmental impacts of REPS. Because of this, there is insufficient evidence with which to judge the environmental effectiveness of the national-scale implementation of the whole scheme. For some specific measures, however, sufficient evidence is available to inform an objective assessment in some cases, and to help learn how to improve environmental effectiveness in most cases. The majority of the REPS payments are now dedicated toward biodiversity objectives. Thus, biodiversity measures and options should be a priority for any national-scale environmental assessment of the scheme. Such a study would help identify the environmental benefits of REPS, the specific elements of REPS that are performing adequately, and those elements that are in need of improvement. Given the considerable overlap between REPS measures and options and those included in the 2010 Agri-Environment Options Scheme (AEOS), assessment of REPS measures could also be used to inform the likely environmental performance of the AEOS.

Introduction

Background

Agri-environment schemes in the EU are now one of the most important policy mechanisms for the protection of public goods, and offer payments to farmers in return for undertaking management practices (measures) that are intended to maintain, enhance or restore the rural environment. These public goods include clean water, biodiversity, soil quality, aesthetic landscapes, clean air, archaeological heritage, carbon storage, mitigation of extreme weather events, and provision of recreational services (Cooper *et al*. 2009). In the 2007 – 2013 programming period, almost three million farms covering almost 39 million hectares across the EU-27 Member States will be supported by agri-environment payments worth €34 billion (including national co-financing) (quoted in Cooper et al. 2009). Achieving and evaluating the environmental effectiveness of agri-environmental policy is becoming increasingly important in order to satisfy EU agri-environmental legislation, to demonstrate value-for-money to taxpayers, and to avoid accusations of trade distortion (Court of Auditors 2006; Potter and Burney 2002).

As a formal requirement of the Rural Development Regulation, Member States are obliged to monitor and evaluate the environmental, agricultural and socio-economic impacts of their agri-environment programmes (Article 16, EC Regulation No. 746/96). Summary reports on policy evaluation of agri-environment schemes have concluded that there has been insufficient measurement of their precise environmental outcomes (DG Agriculture 2004; European Commission 1998; Oréade-Brèche 2005). In practice, previous evaluation systems have concentrated on administrative issues such as: statements of the aims of the policy programme, the levels of farmer participation, budgetary considerations, administrative structures, the extent of geographical targeting, obligations of participation and the levels of provision and support from extension services (Court of Auditors 2000). However, participation in schemes *per se* does not guarantee the actual delivery of environmental protection or improvement, and only the monitoring of actual performance and environmental outcomes can demonstrate the true value and environmental impacts of agri-environment schemes (Kapos *et al*. 2009; Kleijn and Sutherland 2003; Lee and Bradshaw 1998; McEvoy *et al*. 2006).

Looking to the near future, a number of different forces are aligning that will likely result in various pressures on the design and budget for the Common Agricultural Policy (CAP), Rural Development Programme and agri-environment schemes. These include an increased number of EU Member States eligible to receive funding from the CAP and Rural Development Programme, increased pressure on EU budgets, and increased pressure on the ability of individual member States to provide co-financing. The European Court of Auditors will report in early 2011 on its audit of the environmental effectiveness of agri-environment schemes. Previous reports from the European Court of Auditors on, for example, Less Favoured Areas (COM 2009b; Court of Auditors 2003), the verifiability of agri-environment schemes (Court of Auditors 2005; 2006) and cross-compliance (European Court of Auditors 2008) have been instrumental in leading to significant changes in policy implementation. The World Trade Organisation (WTO) also requires that the environmental benefits of agri-environmental payments are clearly demonstrated, to ensure that such payments are not disguised trade subsidies. One of the best (if not only) ways to address these various pressures is to quantitatively demonstrate the environmental benefits and value-for-money of agri-environment schemes. This policy context highlights the need for quantitative demonstration of the environmental impact of agri-environment schemes, and why this will become increasingly important.

The Rural Environment Protection Scheme (REPS)

The Rural Environment Protection Scheme (REPS) is the agri-environment scheme implemented in the Republic of Ireland. The scheme was initiated in 1994, and is now in its fourth iteration. The stated objectives of REPS have been to:

- establish farming practices and production methods, which reflect the increasing concern for conservation, landscape protection and wider environmental problems;
- protect wildlife habitats and endangered species of flora and fauna, and;
- produce quality food in an extensive and environmentally friendly manner.

From 2010, the stated objectives of REPS 4 are:

- To promote:
    a) Ways of using agricultural land which are compatible with the protection and improvement of the environment, biodiversity, the landscape and its

features, climate change, natural resources, water quality, the soil and genetic diversity

b) Environmentally-favourable farming systems.

c) The conservation of high nature-value farmed environments which are under threat.

d) The upkeep of historical features on agricultural land.

e) The use of environmental planning in farming practice.

- To protect against land abandonment.
- To sustain the social fabric in rural communities.
- To contribute to positive environmental management of farmed NATURA 2000 sites.

REPS has become a widely adopted scheme (e.g. over 60,000 participants in 2009, Fahey 2010), and provides an important financial contribution to farm incomes in Ireland (e.g. McEvoy 1999 and references below). Since 1994, REPS has paid over €3.1 billion to Irish farmers, and about €368 million in 2009 (Fahey 2010). The Teagasc National Farm Survey estimated that 45% of farms received REPS payments in 2008 (Connolly *et al.* 2009), and that average family farm income on REPS farms was €18,339, about 15.5% higher than family farm income of €15,869 on non-REPS farms. About 75% of the farms that participate in REPS are in either the Cattle (Rearing and Other) or Mainly Sheep systems (specific categories in the Teagasc National Farm Survey). In 2008, average family farm incomes on cattle and sheep-dominated farms were higher on REPS farms than non-REPS farms with the REPS payment constituting a substantial proportion of the difference (Connolly *et al*. 2009).

Since the first official evaluation of REPS in 1999, the absence of both baseline data and the monitoring of biodiversity and landscape measures (DAF 1999, p. 52-53) has been regularly highlighted. Even more recently, a number of reports and documents have had a low incidence of discussion of specific and evidence-based environmental effects of the scheme (AFCon 2003; 2006; DAFF 2007). Nevertheless, since the scheme began, a number of different studies have investigated the environmental effectiveness of REPS. To date, these studies have not been collated or reviewed, which we attempt here. Further justification for this review arises from the considerable overlap and similarity between the existing REPS measures and options and those included in the new Agri-Environment Options Scheme (AEOS) that will replace REPS. Thus, a review of available evidence on the environmental impacts of REPS 3 and REPS 4 is even more relevant as it could be used to more quickly assess the environmental effectiveness of similar measures that are implemented in the AEOS. Similarly, some existing REPS measures or options not included in the AEOS may actually be very beneficial, and evidence for their effectiveness could be used as justification for their inclusion in future agri-environment schemes.

Here, our primary objective was to collate and review available literature on these studies, with an emphasis on empirical research that is directly relevant to the environmental effects of REPS. The REPS addresses multiple environmental objectives; however, the distribution of payments across those objectives is unequal, and has changed over time. Thus, a secondary objective of this paper was to compare the payment rates of the basic REPS measures and to assess the relative distribution of the payments across different environmental objectives and over time.

Expenditure on REPS measures and options

Here, we present the distribution of expenditure across different basic measures and environmental objectives, and how these have changed from REPS 1 to REPS 4.

Measures 3, 4, 5, 6 and 7 are directly associated with terrestrial and aquatic wildlife habitats, and are based on active management of farmland areas with the aim of protecting or actively enhancing farmland wildlife. The payment for Measure 7 (€8 per hectare) in REPS 4 is justified in Appendix 3 of the Irish Rural Development Plan (DAFF 2007) by the provision of a 20m buffer strip around historic features that is managed “in the interests of biodiversity and landscape”, whereas no such justification was associated with it in REPS 1. At least part of Measures 2, 10 and 11 have direct biodiversity commitments, therefore two-thirds of the payment rate for each of these three measures was estimated to contribute to biodiversity.

The basic measures of REPS 4 for grassland farmers amount to a total cost of €172 per hectare, which includes a mandatory biodiversity measure (€17/ha). About €137 (79%) is justified through measures directly aimed at farmland wildlife (M3, M4, M5, M6 and M7, and part of each of M2, M10 and M11) (see Table 2). Note that there are also indirect biodiversity objectives associated with Measures 1 and 2 that are not included here in the estimated value of €137. (For completeness, an additional payment for transaction costs brings the total payment for the basic REPS 4 measures to €234/ha.) In REPS 1, a similar approach indicates that about €80 (~57%) of the total payment of €140 was directly aimed at biodiversity objectives. In addition, Measure A pays €282/ha for Natural Heritage Areas and commonages (including Natura 2000 sites, Special Areas of Conservation and Special Protection Areas). In 2007 alone, a total of €56 million was paid for about 337,000 ha that was eligible for Measure A payments (DAFF, 2008), further increasing the total proportion of REPS expenditure that is directly attributable to biodiversity objectives.

These results show a significant increase between REPS 1 and REPS 4 in the relative proportion of expenditure on biodiversity-related objectives. This is not surprising given that most of the measures associated with the priority objective to protect water quality (largely through improved nutrient management) have since become part of the standards associated with cross-compliance levels, which are no longer paid for. In summary, although different approaches might result in different specific values, these data clearly indicate that the majority of REPS 4 payments is associated with biodiversity objectives, and there has been a considerable increase from REPS 1 to REPS 4 in the proportion of payments that are associated with biodiversity objectives.

Environmental performance of REPS: an overview of available evidence

A variety of research projects have been conducted on REPS. These are grouped under the relevant broad environmental objectives as indicated in Table 1, and each of these groups discussed in turn. This list is not intended to be exhaustive, but includes most of the published research studies as well as many of the unpublished ones. (Note that an attempted systematic review with a number of various relevant search terms in Web of Knowledge only resulted in a total of about ten relevant research articles.)

Nutrient management

Data from the Teagasc National Farm Survey were used to investigate the financial and physical impact of REPS, through a comparison of REPS (n= 261) and non-REPS farms in 1997, as well as a temporal comparison of the same REPS/non-REPS farms in 1997 with their situation in 1994 (before REPS was implemented) (McEvoy 1999). Compared to a group of extensive non-REPS farms, REPS farms had higher investment costs for machinery, buildings and higher maintenance costs for buildings and land. Investment costs associated with the need for compliance with REPS were estimated at £53.7 million, and there were also increased maintenance costs on REPS farms. McEvoy concluded that "REPS farms could be expected to have better pollution control facilities and animal housing, better farm and field boundaries and improved visual appearance of the farm as a result of REPS participation". Despite a 5% increase in stocking densities on REPS farms from 1994 to 1997 to a level equivalent to that of extensive non-REPS farms, usage of chemical nitrogen and phosphorus was lower on REPS farms by 24 kg ha^{-1} and 4kg ha^{-1} respectively (see also van Rensburg *et al*. 2009, below). Although there were system-specific effects, the overall expenditure on fertiliser per ha decreased on REPS farms from 1994 to 1997. Pesticide expenditure between 1994 and 1997 increased by 2% on REPS tillage farms and by 32% on non-REPS tillage farms. A model-based analysis of National Farm Survey data estimated that the participation of a farm in REPS contributed to average reductions of 29 kg ha^{-1} yr^{-1} of nitrogen, 8.3 kg ha^{-1} yr^{-1} of phosphorus and 14 kg ha^{-1} yr^{-1} of methane emissions (Hynes *et al*. 2008b). These data are based on a 10-year period from 1995 to 2006. Both the studies by Hynes *et al.* (2008b) and McEvoy (1999) are especially interesting because of their national-scale coverage, their use of a time-series of existing data from the Teagasc National Farm Survey and their methodology to estimate a counterfactual that clearly investigates additionality (what would have happened had REPS not been implemented on farms; Matthews 2002; Finn 2003; 2005).

A study of animal stocking rates and associated fertiliser inputs in beef suckler systems (Drennan and McGee 2009) also compared nitrate leaching under suckler beef production under management levels comparable to an intensive (~210 kg ha^{-1} of organic nitrogen) and REPS (~170 kg ha^{-1} of organic nitrogen) system. Over the three years of the study, the total load of nitrate (NO_3-N) ranged from 15 to 71 kg ha^{-1} yr^{-1}. Cumulative losses of nitrate over the 3 years (2002-2004) were >50 kg ha^{-1} yr^{-1} from the intensive treatment, and <20 kg ha^{-1} yr^{-1} from the treatment that was representative of a REPS system (Richards *et al*. 2007; Richards pers. comm.). Overall, in that study, the performance of individual animals was similar in both systems, indicating that application of fertiliser nitrogen can be substituted with additional land with no negative consequences for individual animal performance (Drennan and McGee 2009).

REPS plans were examined as part of a project that used participatory approaches to develop agri-environment measures to reduce phosphorous loading from the catchment to Lough Melvin, a candidate SAC with notable fish biodiversity (Doody *et al*. 2009). Participation rates (37%) in REPS in the catchment were substantially lower than those found in the rest of Co. Leitrim (60%), and were considered likely to limit the environmental effectiveness of REPS in the catchment. In the same project, Schulte *et al*. (2009) compared different measures to mitigate phosphorus transport; however, those measures offered by REPS did not include the two that were identified as being most cost-effective and popular in the L. Melvin catchment (feeding of concentrates with low phosphorus concentration, and non-replacement of phosphorus on Index 4 silage areas). Of the measures offered by REPS, none of 55 REPS plans included the REPS supplementary measure for riparian zones. In a participatory consultation with farmers in L. Melvin, Schulte *et al.* (2009) identified both free advisory support and nutrient management planning (NMP) as cost-effective and popular measures. Surveyed REPS participants receive NMP advice in their REPS plan, but some indicated that 'lack of on-farm support for implementation of their REPS plans' (Doody *et al*. 2009) may hinder the effectiveness of NMP in REPS.

The available evidence indicates that REPS is associated with very significant improvements in the management and storage of farm nutrients, which should not be surprising given the scheme's initial prioritisation of water quality objectives and strong emphasis on nutrient, grassland and agro-chemical management across several REPS measures. Such management on a whole-farm basis appears to have been a specific strength of REPS (which in earlier schemes was paid for but in later schemes has been a requirement of cross-compliance, see above). Note that the detection of improvements in water quality that can be attributed to one policy (especially across multiple farms) is notoriously difficult, and is further complicated by potentially long lag times between changes in management practice and both measurable changes in water quality (e.g. Fenton *et al*. 2010) and ecological recovery of aquatic systems (e.g. Kronvang et al. 2005). Overall, however, there appears to have been very significant improvements in management and storage of nutrients and agro-chemicals among REPS farmers, which would be strongly expected to translate into a significant reduction in pressures on water quality.

Gaseous emissions

Mitigation of climate change is now an explicit environmental objective of the CAP, and Life Cycle Analysis has been used to compare greenhouse gas emissions from a small sample of REPS and non-REPS farms. For four REPS and six non-REPS farms, Casey and Holden (2005) calculated that milk production on the sampled conventional (non-REPS) farms had about 18% more emissions (kg CO_2 equivalent per kg of energy corrected milk) than that on the sampled REPS farms. Emissions per hectare were 17% greater on the conventional farms, but emissions per unit milk were similar. A similar analysis of beef production compared greenhouse gas emissions (kg CO_2 equivalent per kg of liveweight) from five non-REPS, five REPS and five organic farms (Casey and Holden 2006). On average, emissions per annum or per unit area were highest on the non-REPS farms and lowest on the organic farms, and there was an overall relationship between total emissions per hectare, and intensity of production. Two important caveats arise in relation to both of these studies. First, the quite low sample sizes within each category mean that these results cannot be interpreted as being representative of the national situation. Indeed, the variability within each of these categories is likely to be quite substantial (and well worth future investigation for the identification of farm typologies that may optimise production and environmental quality). Second, assuming that the differences between REPS and non-REPS farms are representative, it is difficult to distinguish between such differences being either caused by the scheme, or reflecting the biased participation of extensive farmers in the scheme. Of course, both these alternatives are not mutually exclusive.

Archaeology (measure 7)

REPS has been associated with a beneficial impact on increasing farmer awareness, and formally identifying historical and archaeological features on their land (O'Sullivan 1998; 2001; O'Sullivan and Kennedy 1998; Sullivan 2006; Sullivan *et al*. 1999). Sullivan (2006) found that 20% of a sample of 193 features (listed on the National Record of Monuments and Places) were not recorded in the REPS plans. An additional 64 features (not listed on the Record of Monuments and Places) were identified, of which only 11% were recorded in the relevant REPS plans. In light of significant improvements in web-based mapping and REPS planning, one would expect very significant increases in detection and recording in more recent REPS plans, although this has not been verified. Nevertheless, by 1999, none of the archaeological features shown on the Sites and Monuments Record and recorded in the agri-environmental plans on 160 surveyed farms had been destroyed since

REPS commenced in 1994 (Sullivan 2006). This was against a background destruction rate of 1.3% recorded between 1996 and 1998 (O'Sullivan and Kennedy 1998). Overall, these studies suggest that this has been an effective measure in improving the protection of archaeological heritage.

Designated farmland habitats

Many farmland habitats are designated as Special Protection Areas (SPAs), Special Areas of Conservation (SACs), Natural Heritage Areas (NHAs) or commonage. If so, they are eligible for additional payment under REPS Measure A.

Commonages are typically areas of high conservation value and account for about 90% of SACs, 10% of SPAs, and 60% of Natural Heritage Areas (van Rensburg *et al*. 2009), making them highly relevant to agri-environment policy aims to halt biodiversity loss. A sample of 282 commonage farmers (193 in REPS) in Counties Galway and Mayo were surveyed by interview in 2004. Two aims of that study were to investigate whether participation in REPS has changed either farm management or farmers' environmental awareness. On average, REPS farms spent 43% less on chemical fertiliser than non-REPS farms. Stocking rates on non-REPS farms were 0.54 livestock units (LU) ha^{-1} and 0.43 LU ha^{-1} on REPS farms; 81% of non-REPS farms were obliged to reducing stocking densities in their Commonage Framework Plans, as opposed to 56% of REPS farms. The latter was attributed to a combination of the REPS management plan and the potential bias for farms with lower stocking densities to preferentially enter REPS. There was evidence of a greater level of environmental awareness among the commonage farmers in REPS, although the magnitude of this was small, and absolute levels of awareness in the sample of farmers were considered to be low (van Rensburg *et al*. 2009).

As a case study of a Measure A habitat, undergrazing and scrub encroachment were identified as severe and widespread threats in the Burren (Dunford and Feehan 2001, see also Parr *et al*. 2006, 2009). Several reports suggest that such threats have not been adequately addressed by REPS (Williams *et al*. 2009, Walsh 2009). In response to this need, since May 2010 there is a dedicated Burren Farming for Conservation Programme (BFCP) (DAFF 2010) to protect and enhance species-rich grasslands and water quality, based on lessons learned from the BurrenLIFE project (Williams *et al*. 2009; Walsh 2009).

Turloughs are a priority habitat in Ireland. In a survey of 42 farmers with turloughs on their land, thirteen were participants in REPS in 2002 (Moran *et al*. 2008). After joining REPS, six of these REPS participants changed management, and had ceased fertiliser application (n=4), ceased silage cutting (n=1) or reduced grazing periods (n=2) on the turlough land, all of which would be expected to improve the management of these turloughs for biodiversity. Moran *et al*. (2008) pointed out that the low participation rate of turlough owners currently limits the potential of REPS to improve turloughs in general. (The study did not directly compare the management practices or ecological status of the turlough areas enrolled in REPS with those not in REPS.)

One of the stated main objectives of REPS has been to "…protect … endangered species of flora and fauna". To date, there have been very few dedicated management prescriptions that are directly aimed at protecting named endangered species (as opposed to habitats). REPS does make specific mention of salmonids, crayfish (*Austropotamobius pallipes*), owls, corncrake (*Crex crex*), rare domestic animal breeds, rare apple varieties and possibly bats and the freshwater pearl mussel (*Margaritifera margaritifera*), but the effects of some of these supplementary measures and options must be low to negligible given both the very low participation rates (DAFF 2009) and the non-specific nature of some of the management prescriptions. Note, however, that these protected species may have benefited from some other REPS measures e.g. protected aquatic species may have benefited from general measures aimed at improved nutrient management and water quality.

Although there have been many projects and publications that are relevant to designated habitats, very few have specifically addressed the environmental impact of REPS on such habitats. A recent report by the National Parks and Wildlife Service (NPWS 2008) on the status of protected habitats and species in Ireland highlighted the frequent 'bad' conservation status associated with agricultural habitats. The report did not distinguish between habitats that occurred on REPS or non-REPS farms. The NPWS is responsible for management guidelines for all such designated habitats, so in the absence of contradictory evidence there is no strong reason to believe that designated habitats on REPS farms were, on average, in better condition than designated habitats on non-REPS farms. This would be very interesting to investigate, and some case studies (Moran *et al*. 2008; van Rensburg *et al*. 2009) tentatively suggest the possibility that REPS participants may implement better management of designated habitats than non-REPS participants, although this improved management may not necessarily be sufficient to attain favourable conservation status.

Non-designated farmland habitats

Measure 4 of REPS aims to protect farmland habitats that do not have a formal designation for biodiversity protection (e.g. farmland habitats that are not in a Special Protection Area, Special Area of Conservation or Natural Heritage Area), and this represents a very important policy instrument to protect farmland biodiversity. This measure aims to include a very wide range of habitats, and grasslands "with less than 25% of ryegrass, timothy, white clover either individually or in combination" (REPS planner specifications). Most studies of habitats in REPS refer to the need for more conservation and ecological advice for REPS farmers and REPS planners, with the aim of improving the identification and appropriate management of habitats (see Table 1).

In a DAF survey of REPS planners, only 25% believed that Measure 4 was effective (DAF 1999). Bohnsack and Carrucan (1999) found that habitats identified by them on a small sample of REPS farms in Co. Clare were not recorded in the REPS plans. In a report on monitoring of the environmental effectiveness of REPS, An Taisce (2002) surveyed 20 REPS farmers and 20 REPS planners and found strong support among them for more ecological expertise, and recommended "more emphasis on the integration of ecological considerations into REPS planner training". A survey in Co. Galway highlighted a lack of awareness regarding farmland habitats among REPS 1 farmers (n = 32), and inadequate information on habitat identification and management in the REPS specifications (Aughney and Gormally 2002).

A survey of 50 REPS 1 plans in Co. Roscommon found that over 70% of the farms had no habitats, which the authors commented on as 'not representative of the Roscommon countryside' (Curtin and Whelan 1998). A separate DAF (1999) analysis of 1% of REPS plans showed that no habitats were recorded on 39% of farms, but found an overall average of 1.6 habitats per farm (covering 4ha). The complete absence of habitats both in the majority of farms in the Roscommon sample and in many farms in the DAF study is very surprising given the frequency of habitats found in other studies of Irish farmland (e.g. Purvis *et al*. 2009a; Sullivan *et al*. in press; see below). This strongly suggests a non-standard methodology for the identification and/or recording of habitats in the former studies. Clarke (1998) interviewed REPS farmers in County Louth after four years of participation in REPS, and found an average of 1.55 habitats per farm. A survey of 32 farms in east Galway (outside of SAC areas) recorded an average of 2.6 semi-natural habitats per farm, with an average area of 15.2% of the farm (Sullivan 2010; Sullivan *et al*. 2011); only three farms had no semi-natural habitats and >40% of the farms had three or more semi-natural habitats. An ecological survey of 19 REPS demonstration farms found that most of the farms contained at least 5 common farmland habitats (average = 7), although the survey data were not intended for quantitative analysis (Gabbett and Finn 2005) and there was no comparison with the habitat records on the corresponding REPS plans. An accompanying attitude survey (Gabbett and Finn 2005) found that most of the surveyed REPS demonstration farmers and associated planners/advisors believed that there was a need for improved provision of information about identity and management of farmland habitats and wildlife in REPS.

The Ag-Biota project surveyed habitats on 50 farms in the south-east of Ireland (Purvis *et al*. 2009a). Thirteen of the farms were participating in REPS, and REPS status was included as a variable in a multivariate analysis of habitats. Participation in REPS was not significantly associated with a number of descriptors of farm habitats, with the exception of a significant association with the proportion of field boundary habitats on the farm. Note that an analysis of the effect of REPS was not an original hypothesis of the work, and the number of REPS farms was relatively low in the study.

In one of the few large field-based research projects on REPS, the Farmland Birds Project used birds as indicators in an ecological monitoring methodology for the REPS, to determine current impacts of REPS on biodiversity, and to offer research-based recommendations to improve REPS (Copland and O'Halloran 2010). A total of 122 farms were surveyed from 2003-2005, and consisted of 61 REPS farms and 61 non-REPS farms distributed across the north-west, midlands and south-east of Ireland. At each farm, information was collected on birds, farmland habitats, and field boundaries. Overall, there was no significant difference in either bird diversity or abundance between REPS and non-REPS farms. In addition, no significant differences occurred in the mean density of different types of field boundary or in the overall proportion of various farmland habitats. Some differences in specific habitat types were identified, and REPS farms had a greater density of hedgerows and a greater amount of some other habitats (stubbles, rough vegetation) than non-REPS farms (Copland 2009). Since the Farmland Birds Project completed its survey, REPS 4 has introduced some new options that may benefit bird biodiversity, but the effectiveness of these has not yet been assessed.

Data from both the Irish Census of Agriculture and National Farm Survey were analysed to estimate the probability of participation in REPS of broad habitat types for which data was available from the habitat data of the FIPS-IFS project (Hynes *et al*. 2008a). Farmland with wet grassland, peatland, rocky complexes, forest and shallow water habitats was more likely to be enrolled in REPS than farmland with heath, dry grassland, built land and cut fen. Note, however that the spatial resolution of the habitat data was quite coarse (based on point descriptions of habitats on a 10 km grid), and it was beyond the scope of that study to collect evidence with which to assess whether enrolment in REPS had afforded protection and proper management to habitats.

Field margins are a type of non-designated habitat that are prominent within REPS, and have been the subject of several dedicated research projects. The creation and protection of field margins in arable systems has been well documented to benefit farmland wildlife (Marshall and Moonen 2002). In contrast to arable systems, the protection of field margins in grasslands is relatively recent, and far less experimental evidence is available. Feehan *et al*. (2005) compared plant and insect diversity of watercourse and field margins in grassland (n=30) and mixed tillage (n=30) using paired samples of REPS and non-REPS farms. The comparison (in grassland and tillage systems) generally indicated no positive impact of REPS on the species richness of either carabid beetles or plants. In that study, note that although the reporting of the analysis of plant species richness in grassland margins on REPS (12.5 ± 3.3) and non-REPS (14.2 ± 3.5) farms indicated a significant difference, the size of the error estimates make this seem unlikely; in any event, the magnitude of the difference was not large. Feehan *et al*. (2005) recommended a minimum field margin width of 3m in both arable and grassland field margins; the width of 1.5m in REPS would be significantly narrower than usual (e.g. Marshall and Moonen 2002). An experimental study of field margins on a single REPS farm in Co. Longford found that plant species richness was increased (although only modestly) over a two-year period when nutrients were excluded (Sheridan *et al*. 2009). Invertebrate abundance in emergence traps was higher in field margin areas than in the main sward of the field. In the same study, there was no significant difference in either plant diversity or overall invertebrate abundance between the grazed field margin (representative of REPS situation) and the 1.5m ungrazed experimental field margin, which is likely to reflect the relatively short duration of the study. That study also documented successful efforts to control bracken in the experimental field margins. In another experimental study aimed at informing the management by REPS of grassland field margins, different establishment and management strategies of field margins had significantly different effects on plant and insect diversity over a two-year period (Sheridan *et al*. 2008). That work showed that reseeding with a diverse mixture of grass and wildflowers could successfully result in more diverse vegetation in new experimental field margins in dairy systems, and that cessation of fertiliser inputs alone was ineffective in increasing vegetation diversity. More recent research on these same plots confirmed long-term positive effects of the reseeding treatment on plant and invertebrate diversity (Fritch *et al*. 2009, 2011). A large body of international research suggests that properly managed field margin habitats can be a significant reservoir of farmland wildlife and biodiversity (e.g. Asteraki *et al*. 1995; Douglas *et al*. 2009; Marshall and Arnold 1995; Marshall and Moonen 2002; Meek *et al*. 2002; Woodcock *et al*. 2005). Unfortunately, however, the current REPS management prescriptions for grassland field margins are highly unlikely to deliver plant and invertebrate diversity, especially in more intensively managed grasslands. Cessation of nutrient inputs alone is not likely to significantly increase the conservation value of margin vegetation in such areas, and invertebrates and ground-dwelling wildlife are less able to utilise margins that are persistently grazed to a low sward height (Bakker and Berendse 1999; Bokenstrand *et al*. 2004; Marshall and Moonen 2002; Woodcock *et al*. 2005).

Measure 5 of REPS aims to protect and maintain farm and field boundaries, and hedgerow management has featured prominently in REPS. Hedgerows are one of the most abundant field boundary types in Ireland, so this measure is widely implemented. As optional measures, hedgerow rejuvenation and establishment have also been extremely popular (DAFF, 2009). Unsurprisingly Copland *et al.* (2005) found that REPS farms had a greater density of hedgerows than non-REPS farms. Despite being included in REPS since its inception, however, relatively little evidence exists on the specific environmental impact on biodiversity due to the management and/or creation of hedgerows by REPS. A doctoral study by Flynn (2002) found no significant difference in the average number of bird species or the density of birds recorded on REPS and non-REPS farms. That study found that REPS hedgerows had significantly higher botanical species richness than non-REPS hedgerows. Overall, the number of farms in the study design was too low (five REPS and five non-REPS farms) to make any general conclusions. In a relatively large study, the Farmland Birds Project found no difference in bird densities between REPS and non-REPS farms, and concluded that "field boundary management in REPS has little impact on bird populations" (Copland and O'Halloran 2010).

Generally, a variety of studies have suggested concerns with the identification and proper management of non-designated farmland habitats identified under Measure 4 (Table 1). Note that these studies were generally from the earlier REPS schemes, and the situation may have improved over time (although this is not clear). It is advisable to be cautious about over-extrapolating to the national implementation of REPS from areas and surveys that are not nationally representative, have low sample sizes and do not include random sampling in the selection of farms. Many of the studies cited here have not been published in journals, and (as often occurs in, for example, conference abstracts or short papers) lacked a formal description of both the methodology for farm selection and the definition of habitat types, which hinders comparison across studies. Even if there have been failures to properly document habitats in REPS plans, habitats may well continue to be maintained (although it would reduce confidence in the capacity of the scheme to formally protect such habitats). Overall, these studies on non-designated habitats suggest that a high priority for research is to establish the role of REPS 3 and 4 in protecting and conserving non-designated farmland habitats, and in establishing the extent to which measures exceed the requirements of cross-compliance. This could be achieved in a representative sample of REPS plans, for example, by a comparison of habitats in a farm-scale habitat survey with the habitat records in the corresponding REPS plans, as well as a comparison of habitat diversity, habitat quality and the rate of habitat modification/removal on REPS and non-REPS farms (within similar farming systems and regions). The latter would require baseline data to facilitate a comparison over time, and may still be possible *via* the use of satellite imagery or aerial photography.

Studies of multiple environmental objectives

In a wide-ranging analysis of REPS farms on the Aran Islands, Kelly (2008) emphasised the high ecological and heritage value of the area, and pointed to the lack of applicability there of many REPS measures or options. A 2007 survey of 211 REPS plans (REPS 2 and 3) identified farm characteristics, management obligations and chosen measures/options.

Questionnaire responses by 40 farmers indicated a lack of understanding of the variety and nature of wildlife habitats on their farms and, for example, they did not consider stone walls, field margins and species-rich grasslands to be habitats (*loc. cit*. p. 85). Respondents' knowledge of both archaeology and farmland habitats was considered unsatisfactory. The respondents also indicated alternative measures that would benefit the Aran Islands in the future (p. 76), with control of brambles, scrub and ferns as well as access to monuments being most frequently chosen. The study highlighted problems with scrub invasion. Overall, the respondents considered that REPS had benefited the Aran Islands. The study concluded by emphasising the need for a more targeted measure or scheme to better reflect the conservation priorities there (see also The Heritage Council 2010).

As part of the EU FP6 ITAES project (Integrated Tools to design and implement Agro Environmental Schemes), a multicriteria methodology was used to estimate the environmental effectiveness of an agri-environment scheme in each of two study areas: Ireland (REPS 2) and the Emilia-Romagna region of Italy. The environmental indicators used were based only on information from the mid-term evaluation (2003/2004) of the Rural Development Programmes (2000-2006). The results suggested that both schemes only partially achieved their objectives. This conclusion was tentative, however, due to the scarcity of quantitative data that related to effectiveness, the lack of quantitative target levels for objectives, and difficulties in determining the relative importance of different environmental objectives (Bartolini *et al*. 2005; Viaggi *et al*. in press).

Largely due to the absence of sufficient quantitative data with which to assess the environmental effectiveness of schemes in the participating countries (including REPS, see Viaggi *et al*. in press), the ITAES project also developed a methodology to estimate the environmental performance of these selected schemes. This methodology largely relied on expert panels to assess the link between environmental measures and the environmental objectives by scoring a set of specific criteria that reflect important factors for the delivery of environmental benefits (Finn *et al*. 2007; Finn *et al*. 2008a). In general, experts indicated that the objectives and targets of the REPS 2 scheme and its measures were neither sufficiently defined nor easily translated into quantifiable targets against which to monitor progress. Scores for farmer compliance were consistently high (indicating high compliance), whereas scores for targeting and participation were often low. The scores for causality and institutional implementation showed much greater variation (Finn *et al*. 2007). Measures 3, 6 and 9 of REPS 2 received the lowest effectiveness scores, largely due to the narrow width of the protective strips for these measures. The best-performing measures were considered to be Measures 1, 2 and 7 and Supplementary Measures 3 (Conservation of Animal Genetic Resources), 4 (Long-term Riparian Zones) and 6 (Organic Farming). Even the latter measures had geometric means of about 3.5 (out of 5), which implied that they either had consistent moderate deficiencies across the effectiveness criteria or severe deficiencies in some of the criteria. Despite an explicit objective of REPS to "…protect … endangered species of flora and fauna" the experts also indicated that the scheme did not sufficiently target named species (rather than habitats) in need of protection (with the sole exception of the corncrake). This did not necessarily mean that REPS 2 made no contribution to species in need of protection, but that the experts considered that the scheme design and implementation did not explicitly or sufficiently target this objective. Overall, the experts agreed that REPS has strongly contributed to an improvement in nutrient management and water quality and they specifically cited the reductions in stocking density on many commonages as a general success; however, the experts had mixed views about the role of REPS in protecting or enhancing farmland biodiversity. Further analysis of several EU case studies that included REPS in Ireland (Finn *et al*. 2009) also showed that higher priority environmental objectives (as assessed by stakeholders) were not necessarily associated with higher estimates of environmental effectiveness.

A complementary study (Carlin *et al*. 2010) also used experts' judgements to assess the options and supplementary measures associated with REPS 4, and ranked them in order of estimated effectiveness. The experts' assessment indicated that in most (but not all) cases, correct implementation of the management prescriptions is expected to achieve the environmental objective (valid cause-and-effect model), and prescriptions are expected to be implemented correctly (compliance). Several measures/options were expected to achieve little or no benefit for biodiversity. Several of those had too little participation to be effective, but some were associated with medium to very high participation levels. The experts recommended the use of a tiered approach, with the choice of options being strongly guided toward the environmental objectives that were most appropriate to the specific conditions on a farm (see also the example of riparian zones from Doody *et al*. 2009).

The EU FP6 Agri-Environmental Footprint (AE-Footprint) project developed methodology to assess the environmental effectiveness of agri-environment schemes with multiple environmental objectives (Purvis *et al.* 2009b). The AE-Footprint Index (AFI) is a weighted sum of agri-environmental indicators of environmental quality of farms on a standardised scale from 0 (low environmental performance) to 10 (high environmental performance). As a proof-of-concept application, data were collected for indicators for a small number of REPS and non-REPS farms in Sligo and Cork (Finn *et al.* 2008b). The environmental criteria used went beyond those based on REPS, to measure the wider environmental impact of the scheme. In the application of the methodology in Sligo, the mean AFI score of the REPS farms (5.74, n = 10) was significantly (p=0.05) higher than that of the non-REPS farms (5.00, n = 10). In the application of the AFI in Cork, the mean AFI scores of the REPS farms (4.72, n = 8) was about 25% greater than the mean AFI score (3.78, n = 8) of the non-REPS farms (Finn *et al.* 2008b). The interpretation of the lower scores in Cork requires considerable care due to the fact that the spatial location of the REPS farms did not overlap with that of the non-REPS farms, and the use of two slightly different forms of the AFI (weighting and indicators differed) between Cork and Sligo. Overall, great care is required in interpreting these comparisons of REPS and non-REPS farms. This study was conducted as a proof-of-concept and had very low sample sizes; coupled with the restricted geographical distribution of the study, these data are certainly not representative of the national REPS scheme.

Other topics

For selected EU agri-environment schemes (including REPS), Primdahl *et al.* (2010) distinguished among three categories of impact models (quantitative, qualitative or common sense), depending on the degree of evidence provided about the relationship between the objectives and impacts of each agri-environment scheme. The environmental indicators associated with each scheme were categorised as uptake, performance or outcome indicators. By far the most common type of indicator recorded was found to be ‘uptake’. This could be seen as a useful indicator of policy effects provided that well-developed impact models existed, but the analysis clearly indicated that this was most often not the case, as just over half of the 180 uptake indicators were linked to common sense impact models. Schemes that explicitly targeted either particular parts of individual farms or specific areas tended to be based more on quantitative impact models than whole-farm schemes or broad, horizontal schemes. They concluded that a high number of the schemes studied were not well designed to enable appropriate evaluation, which hinders efforts to learn how to improve the schemes.

The 'Others' section at the end of Table 1 presents a number of other publications that address a variety of issues, including landscape preferences, economic commentaries and general critiques.

Main outcomes

An increasing number of studies are available with which to learn about the actual or likely environmental effectiveness of REPS. A considerable proportion of these studies has not been published in international journals, and is only available as national reports, theses, conference papers and conference abstracts. Compared to the high standard of evidence associated with journal articles, care is required in the interpretation of evidence from other sources (although some of this is of a very high standard).

On the basis of these studies and publications, a number of conclusions arise that are relevant to institutional efforts to assess the environmental impacts of REPS, as follows:

- There is insufficient evidence with which to judge the environmental effectiveness of the national-scale implementation of the whole Rural Environment Protection Scheme. This makes it equally likely that the full benefits of the scheme have not been measured, as well as reducing the opportunity to learn how to improve it.
- Some individual studies provide evidence to scientifically assess the environmental effect of individual REPS measures; however, most studies lacked national-scale coverage.
- There is a distinct lack of studies that use baseline data to compare change over time (longitudinal studies).
- Of the studies undertaken to date, there has been an emphasis on biodiversity studies, but these have had little or no co-ordination in their aims, methods, temporal scales or spatial scales.
- There have been surprisingly few studies on the impact of REPS on nutrient management and water quality, but the available evidence is generally positive.

- A considerable number of studies have investigated the environmental effects of REPS, although relatively few of these have been published in journals.
- Some evidence currently exists to guide advice/recommendations about the environmental effectiveness of REPS.

A primary conclusion of this review is that there is insufficient evidence with which to judge the environmental impacts of the national-scale implementation of the whole Rural Environment Protection Scheme. It is important to note that this does not necessarily mean that REPS has not delivered environmental benefits, but that there has been insufficient collection of evidence of the environmental performance of the whole REPS programme. Thus, the full benefits of the scheme have not been measured, and there has been reduced opportunity to learn how to improve the scheme. The REPS consists of multiple measures, supplementary measures and (since REPS 3) a variety of options. For many of the newer supplementary measures and options that have been introduced since REPS 3, no empirical evidence is available with which to judge their environmental effects, which hinders an overall assessment of the whole scheme. For several other individual elements of REPS, however, sufficient evidence is available with which to either objectively assess their environmental impact or to learn how to improve their environmental effect (as reviewed above). Note, however, that the environmental impact of REPS may be more than the sum of the impacts of the measures. For example, synergistic environmental effects may arise from the ‘bundling’ of several different measures within fields or farms (but would be difficult to detect). As another example, the economic benefit of the REPS payment has almost undoubtedly been to maintain farm structures and farming in places where intensification or abandonment might otherwise have occurred.

To date, there has not been a comprehensive, national-scale study of the environmental impacts of REPS and the various studies reviewed here, either individually or in aggregate, do not (and could not be expected to) fulfil this function. Finn (2010) recently conducted a scoping study to identify the environmental aims, sampling regime and estimate of costs for a monitoring programme for REPS. To reduce the costs of a monitoring programme, a subset of measures were selected on the basis of participation levels, budget share and environmental priority. Given that the majority of the funding has been allocated to biodiversity measures, the majority of the monitoring effort should also be dedicated to biodiversity. (Note that several of the measures for water quality and mitigation of climate change are also strongly linked to biodiversity measures.) The average annual budget for environmental monitoring of the selected measures (~€0.86m) was estimated to be about 0.25% of recent annual expenditure on REPS (e.g. €368m in 2009) (Finn 2010).

Lessons learned and future prospects

The absence of a systematic, national-scale environmental monitoring programme clearly limits the *ex post* evaluation of the environmental effect of REPS (see above). The importance of the design stage of schemes (and their *ex ante* evaluation) was emphasised by Finn *et al.* (2009, p. 735), "Ideally, monitoring and evaluation should aim to confirm the good environmental performance of well-designed schemes, rather than highlight weaknesses due to poorly designed ones. Inadequate design of agri-environment schemes can lead to poor environmental performance that can take a significant duration to correct." Some specific suggestions to improve design are relevant to REPS (Finn *et al*. 2008a; 2009; Primdahl *et al*. 2010). If, as seems likely (see below), future agri-environment schemes will incorporate more specific objectives and spatial targeting, there is likely to be an increased reliance on research to inform the evidence base for policy design, *ex ante* evaluation and *ex post* evaluation. In addition to the outputs from specific projects, this review points to the research capacity that exists to conduct such research. Several of the reviewed studies are noteworthy for their methodologies. In addition to the various surveys, these include, for example, the use of participatory approaches (Doody *et al*. 2009; Purvis *et al*. 2009b), experts' judgements (Finn *et al*. 2009; Carlin *et al*. 2010), combined agronomic and economic analysis of alternative agri-environment measures (Schulte *et al*. 2009), field experiments (Richards *et al*. 2007; Fritch *et al*. 2009, 2011; Sheridan *et al*. 2009; Moran 2009), analysis and modelling of existing data (including GIS approaches and National Farm Survey data) (McEvoy 1999; Bartolini *et al*. 2005; Casey and Holden 2005; 2006; Hynes *et al*. 2008a; 2008b), use of the eREPS database (Kelly 2008), and relatively large monitoring studies directed at specific REPS objectives (Dunford and Feehan 2001; O'Sullivan 2001; Aughney and Gormally 2002; Feehan *et al*. 2005; Sullivan 2005; van Rensburg *et al*. 2009; Copland and O'Halloran 2010).

Considerable anecdotal comment highlights a success of REPS as being its role in reinforcing existing positive practices, as well as transforming farmers' attitudes and helping to incorporate environmental awareness and actions into farming practice. All

REPS participants attend a 20-hour training course on the environmental objectives of REPS, and this course would be expected to significantly increase the environmental awareness of participants. Unfortunately, there is relatively little published evidence in recent years to specifically validate this claim (but see work by Costello 2003; Hyde 2003; Kelly 2008; van Rensburg *et al*. 2009), and future studies should distinguish among awareness levels of different environmental objectives (e.g. cross-compliance, common habitats, priority habitats, fertiliser use, nutrient storage etc.). The long-term impacts of REPS on farmers' behaviour are even more unclear. Over the next few years, some participants in REPS will enter new contracts, but due to a reduction in budget and consequent restrictions on participation, many participants will conclude their contract and no longer participate in an agri-environment scheme (or will participate in a less demanding scheme). This raises several questions. Will the conditions of re-entry to a new scheme with limited budget and participation successfully target those farms that offer greatest environmental benefit? For farmers who will no longer participate in an agri-environment scheme, to what extent will they retain elements of farming practice that were learned in REPS and go beyond the requirements of cross-compliance? What will be the fate of environmental benefits that have been gained? Will management of farmland habitats change, and what will be the consequences for habitat quality and biodiversity? Answering such questions would involve its own dedicated monitoring programme, but would give insight into the long-term value of agri-environment schemes, both in protecting environmental capital but also in positively influencing farmer behaviour through improved awareness (Stobbelaar *et al*. 2009).

As is the case with many such studies that compare participating and non-participating farms in voluntary agri-environment schemes, there is a likely bias of higher participation rates of farms with higher levels of environmental quality (because they have lower costs in attaining the required environmental standards) (Matthews 2002; Quillérou and Fraser 2010). One of the best measures of the environmental effectiveness of a scheme would be a comparison of the change in environmental state before and after policy implementation, and on participating and non-participating farms (Bro *et al*. 2004; Finn 2003; Finn *et al*. 2008a). For these reasons, the collection of baseline data is an important contributor to an effective monitoring programme. Given the absence of dedicated baseline surveys in REPS, the data and sites from earlier studies provide a potential baseline of environmental status. By conducting future surveys in the same locations, changes in environmental status (due to REPS participation) may be assessed. Unfortunately, most studies cannot be repeated on the original sites because they do not contain information on the geographical location of the farm or the sampling site within the farm. Where possible, it is desirable that in future agri-environmental surveys, agreements are reached with farmers participating in a survey that allow researchers to enquire about farmers' willingness to participate in a future re-survey. In addition, data should be provided in a GIS format that is linked to the spatial location of sites.

A number of studies draw attention to, or provide examples of, the need for sufficient participation to achieve intended environmental objectives (Moran *et al*. 2008; Finn *et al*. 2007; 2008a; 2009; Doody *et al*. 2009; Finn 2010; Carlin *et al*. 2010). A key challenge for the future will be to gain a more detailed understanding of how participation (uptake) is quantitatively related to achievement of environmental objectives, and to improve our knowledge of the minimum participation rates to ensure sufficient supply of a desired environmental good. This would help ensure that limited funds do not continue to be allocated to measures for which there is already sufficient participation; nevertheless many public goods are far more likely to remain at risk of under-supply rather than over-supply. (To complicate matters, the relationship between participation and environmental supply may not be linear (Wu and Skelton-Groth 2002, Finn *et al*. 2008a)).

Biodiversity, agri-environment schemes and the post-2013 CAP

The significant role of biodiversity as a high priority objective that is associated with the majority of REPS expenditure warrants further treatment. The specific policy mechanisms and budget size for provision of public goods in the post-2013 CAP are not yet certain at either national or EU levels. Nevertheless, the provision of environmental and other public goods is very likely to be of central importance in the post-2013 CAP (see below), especially as most public goods from agriculture are threatened but remain highly valued by society (MacDonald *et al*. 2000; Cooper *et al*. 2009). The post-2013 CAP, however, is almost certain to require improved specification of policy targets, a greater level of geographical targeting, improved implementation and a stronger requirement for monitoring and evaluation (Court of Auditors 2006; Cooper *et al*. 2009). These requirements will also be expected of agri-environment schemes, and represent key challenges for policy design, targeting of financial support to where it can achieve most environmental impact, and delivery of farm-level environmental advice.

Biodiversity will continue to be a key EU-level objective for agri-environment schemes. As contracting parties to the UN Convention on Biological Diversity, the EU has been committed to halting biodiversity loss by 2010. However, recent assessments indicate that this 2010 target has not been met (CEC 2008; COM 2009a), and the EU is now preparing to strengthen its policy framework and commitment to halting the loss of biodiversity and the degradation of ecosystem services in the EU by 2020, and restoring them in so far as possible (Council of the European Union 2010). Thus, it would seem that the success of biodiversity measures in agri-environment schemes will increasingly be judged by the extent to which they halt (and/or reverse) the loss of biodiversity (and related ecosystem services). Specific biodiversity objectives in Irish agri-environment schemes might be expected to reflect national policy priorities as reflected in, for example, Ireland's National Biodiversity Plan (DAHGI 2002) and the National Strategy for Plant Conservation (National Botanic Gardens 2005). A recent assessment of the conservation status of priority habitats and species found many of those associated with farmland to be in poor or bad condition (NPWS 2008), and these are an obvious priority for strengthened biodiversity measures in REPS (or future agri-environment schemes). As with most countries, Ireland has a significant number of Red Data Book species, some of which have Species Action Plans. The targeting of biodiversity measures toward Red Data Book species (and their habitats), for example, would be expected to strongly address the objective of halting biodiversity loss.

In the new monitoring and reporting structure for the Rural Development Programme, the seven impact indicators of the Common Monitoring and Evaluation Framework (European Commission, 2006) include the Farmland Birds Indicator and the High Nature Value Indicator (Beaufoy 2008; Beaufoy and Cooper 2009). In relation to farmland birds, there are 24 bird species on the Irish Red List (Birdwatch Ireland 2010). At least eleven of the 24 species on the current Red List are considered to be farmland or commonage species, and others are on the Amber and Green Lists (Birdwatch Ireland 2010). Member States were required to identify High Nature Value farmland by 2006, and target agri-environmental payments to those areas by 2008. These farming and forestry systems can be found in designated sites, such as under Natura 2000, but are also widespread in other (non-designated) areas of countryside, especially on land where agricultural intensification has not occurred to a significant extent (Beaufoy and Cooper 2009). Significant work remains to incorporate High Nature Value farmland into agri-environment policy and practice (The Heritage Council 2010). The new Agri-Environmental Options Scheme (AEOS) aims to identify and protect selected grassland habitats, which would make some progress in the protection of High Nature Value farmland; however, this would probably only represent a small proportion of its area.

It may be useful to consider a greater differentiation of farmland biodiversity (from Finn 2010) that can help guide the prioritisation and development of agri-environment measures for the very different types of biodiversity that may relate to, for example:

- protection (including restoration) of priority habitats/species on Natura 2000 sites;
- protection of priority habitats/species that occur outside of Natura 2000 sites;
- protection of rare and threatened species (e.g. those associated with Red Data Books, Species Action Plans, Flora Protection Orders etc.);
- protection of other species and habitats of high conservation value;
- protection of species that are declining, but are not yet rare;
- protection of other common farmland habitats and species
- creation of farmland habitat to support named species;
- creation of common farmland habitats.

These different categories represent a broad spectrum of conservation value of species and habitats (which are not necessarily mutually exclusive).

More demanding environmental objectives in some areas of especially high environmental sensitivity may require measures that exceed the prescriptions of current REPS measures. Recent examples include the Burren (Williams *et al*. 2009), Lough Melvin (Schulte *et al*. 2009; Doody *et al*. 2009), commonages (van Rensburg *et al*. 2009) and the Aran Islands and Connemara (Kelly 2008; The Heritage Council 2010). If agri-environment schemes in Ireland are to achieve the objective of halting biodiversity loss, then there is likely to be an increased prioritisation of targeted and evidence-based measures aimed at named species and habitats that are of highest conservation concern. If overall budget allocations do not increase, halting biodiversity loss on farmland will probably require a greater emphasis on 'deep and narrow' rather than 'broad and shallow' measures. This process appears to be under way, but will need to be accelerated if the priority objectives of halting biodiversity loss and targeting High Nature Value farmland are to be adequately addressed.

Table 1. Description of basic measures in REPS 1 and REPS 4 and associated costs as provided in the Rural Development Plan for Ireland. Costs (€ ha^{-1} per annum) are based on those applicable to grassland farms only (some differences in costs apply to arable farms) (DAFF 2008). Also indicated for each of the scheme types are the costs of measures associated with biodiversity objectives only.

Measure	Measure name and description	REPS 1 €	REPS 1 biod. only €	REPS 4 €	REPS 4 biod. only €
M 1	Nutrient management planning	38	0	25	0
M 2	Grassland management plan	14	9.24	10.2	6.73
M 3	Protection and maintenance of watercourses, (water bodies) and wells	18	18	29.3	29.3
M 4	Retention of wildlife habitats	13	13	21.5	21.5
M 5	Maintenance of farm and field boundaries	25	25	30.2	30.2
M 6	Restricted use of pesticides and fertilisers	7.2	7.2	10	10
M 7	The protection of features of historical and archaeological interest	5	0	8	8
M 8	The maintenance and improvement of the visual appearance of farm and farmyard	8	0	0	0
M 10	Training in environmentally friendly farming practices	6	3.96	4.4	2.94
M 11	Maintenance of farm and environmental records	6	3.96	16.5	10.89
	Biodiversity options (REPS 4 only)			17	17
	Total	**140.2**	**80.36**	**172.1**	**136.53**

Table 2. Overview of research relevant to the environmental impacts of REPS.

Topic	Author	Topic/Comment
Nutrient management and gaseous emissions	McEvoy (1999)	Analysis of National Farm Survey data (NFS) showed increased investment in buildings and maintenance due to REPS, as well as reductions in application of chemical fertilisers.
	Casey and Holden (2005, 2006), Lanigan *et al*. (2008)	Life cycle analyses and discussion of effects of REPS on gaseous emissions.
	Hynes *et al*. (2007, 2008b)	NFS data showed reductions in nitrogen, phosphorus and methane on REPS farms compared to non-REPS farms within NFS categories.
	Richards *et al*. (2007)	Lower nitrate losses on REPS treatment, compared to intensive system of beef production.
	Doody (2009), Schulte (2009)	Design of agri-environmental measures to reduce phosphorous loading (L. Melvin)
Archaeology	O'Sullivan (1998, 2001), Sullivan (2005, 2006), Sullivan *et al*. (1999)	Beneficial impacts of REPS for identification and protection of national sites and monuments
Measure A farmland habitats	Dunford and Feehan (2001), Williams *et al*. (2009), Walsh (2009)	Management and quality of Burren habitats.
	Visser *et al.* (2007)	Interviews of turlough farmers, with some responses related to REPS.
	Moran *et al*. (2008)	Out of 42 farmers with turloughs, the 12 in REPS improved their management.
	NPWS (2008)	National overview of conservation status of priority habitats – most of which had ‘poor’ or ‘bad’ conservation status.
	van Rensburg *et al*. (2009)	Survey of commonages and effects of REPS participation on selected elements of farm management and farmers’ environmental awareness (but no empirical data on habitat quality).
	O’Rourke and Kramm (2009)	Socio-economics of upland farmland and commonages in the Iveragh Peninsula.
Non-designated farmland habitats	Hickie *et al*. (1999), Bohnsack and Carrucan (1999), DAF (1999), Jones *et al*. (2003)	Various references to issues associated with habitat protection and identification.
	Hyde (2003)	Survey of 43 REPS farmers in Co. Galway indicated a need for improved education and awareness of habitats.
	Aughney and Gormally (2002)	Described inadequacies in habitat identification and management.
	Gabbett and Finn (2005)	Identified a desire and need for better wildlife information for REPS planners and demonstration farms.
	Copland (2009), Copland and O’Halloran (2010)	No overall difference in mean density of different types of field boundary, proportion of various farmland habitats, bird diversity or bird density between REPS and non-REPS farms.
	Egan (2006)	Discussion of watercourse margins
	Hynes *et al*. (2008a)	Investigated match between the spatial distribution of REPS and land use types (but no specific data on habitat quality).

	Speight (2008)	Critique of expected effects of REPS 4 on habitats and hoverfly diversity.
	Purvis *et al*. (2009a, p. 17-20)	Included REPS status as a variable in multivariate analysis of habitats on 50 farms (thirteen of which were REPS participants)
Field margins	Feehan *et al*. (2005)	No overall effect of REPS on diversity of plants and beetles in field margins in grassland and tillage areas.
	Fritch *et al*. (2009, 2011), Purvis *et al*. (2009a), Sheridan *et al*. (2008, 2009)	Establishment method and management have large impacts on plant and insect diversity in experimental field margins in grassland; strong effects of intensive grazing.
Hedgerows	Flynn (2002)	Related hedgerow characteristics to birds (but low sample sizes).
	Copland *et al*. (2005), Copland (2009)	Field boundary management in REPS had little impact on bird populations.
Assessment across multiple environmental objectives	Bartolini *et al*. (2005), Viaggi *et al*. (in press)	Multi-criteria analysis used to assess the effectiveness of REPS (and Italian scheme) based on data in the mid-term evaluation only.
	Finn *et al*. (2007, 2009)	Experts' ratings of measures in REPS 2.
	Finn *et al*. (2008b)	REPS 3 farms in case study regions had higher environmental index scores than non-REPS farms (but not representative due to very low sample numbers).
	Kelly (2008)	Broad discussion of multiple measures and environmental objectives on REPS farms on Aran Islands.
	Carlin *et al*. (2010)	Experts' ratings of supplementary measures and options in REPS 4.
Financial effects	McEvoy (1999), Connolly (2005), Connolly *et al*. (2005, 2006, 2009), Kinsella *et al*. (2007ab) (and others)	National Farm Survey data includes the effect of REPS on family farm incomes.
Others	Hickie *et al*. (1999)	Analysis of REPS policy.
	Emerson and Egdell (1999)	Comparison of agri-environment schemes in Ireland and Scotland.
	Emerson and Gillmor (1999)	Detailed description of REPS participation.
	Gorman *et al*. (2001)	REPS and farm livelihoods.
	Callanan *et al*. (2001)	As part of a wider evaluation study, included survey responses about REPS.
	An Taisce (2002)	Detailed discussion of monitoring and evaluation.
	Matthews (2002)	General critique of REPS with economic emphasis.
	Costello (2003)	Survey respondents (n=97) at REPS courses (Co. Clare) indicated broad satisfaction with courses, and increased environmental awareness and ability to implement their REPS plan .
	McCarthy *et al*. (2003)	Analysis of afforestation, and effects of REPS on afforestation.
	Feehan (2003)	Discussion of monitoring and evaluation.
	Finn (2003), Harte and O'Connell (2003)	General discussion of agri-environment policy and issues, with reference to REPS.
	Finn *et al*. (2005)	Identification of environmental indicators for REPS.
	Rath *et al*. (2005)	Discussion of the achievements and future challenges for REPS.
	GFA Consulting Group (2006)	Qualitative assessment of expected impacts of REPS (no reference to published evidence).

	O'Connell and Harte (2006), Matthews (2008)	General critique of REPS 3, with economic emphasis.
	Campbell (2007), Campbell *et al*. (2006, 2008, 2009), Scarpa *et al*. (2007)	Survey of public response to landscape effects of REPS, with results on preferences, willingness-to-pay and methodological developments.
	Hynes and Hanley (2009)	Survey of REPS and non-REPS farmers on economics of corncrake conservation.
	Ducos *et al*. (2009), Hynes and Garvey (2009)	Factors affecting farmers' participation in REPS.
	Beckmann *et al*. (2009), Lenihan and Brasier (2009)	Description of institutional relationships among different stakeholders in REPS.
	Primdahl *et al*. (2010)	Use of impact models in selected schemes across Europe (including REPS).
	Finn (2010)	Design and estimate of costs of environmental monitoring of REPS.
	Whelan and Fry (2010)	Discussion of the requirement for Strategic Environmental Assessment of REPS, with emphasis on landscape protection.
	Whelan *et al*. (in press)	Discussion of the terminology of landscape categorisation used in REPS.

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