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Do farmers in Agri-Environmental Schemes make appropriate ecological choices for the habitats on their farms? Modelling the biodiversity undertakings chosen within the Irish Rural Environment Protection Scheme

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Abstract

Farmers participating in agri-environmental schemes (AESs) that are aimed at protecting biodiversity should ideally make decisions relating to the ecological management of their farms based on the habitat types found on their farms. In reality, a variety of economic, demographic, farm and farmer characteristics influence all the management decisions made by farmers, including those relating to AESs. In Ireland, the Rural Environment Protection Scheme (REPS) requires that farmers choose at least 2 biodiversity undertakings (BUs) from a menu as part of their AES contract. Using a multinomial logit model, the likelihood of farmers choosing different BUs was estimated using data from the 2007 National Farm Survey as a function of georeferenced habitat data. A comparison is then made between the probable selection of BUs with what would be considered the optimal selection from an ecological perspective. The results indicate that farmers' most likely choices of BUs only sometimes equates with the optimal ecological choices. This highlights deficiencies in the design of REPS, knowledge of which is very timely, given the imminent replacement of REPS by a new AES.

Keywords: Habitat conservation; Rural Environment Protection Scheme (REPS); Farmer behaviour; Georeferenced habitat data

JEL Classification: Q18, Q57.

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1. Introduction

Agri-environmental schemes (AESs) represent a political response to the environmental problems caused by modern farming practices, where enhanced productivity usually requires intensive farming practices. The environmental damage resulting from output oriented agriculture includes, inter-alia, water pollution and a loss of biodiversity of fauna and flora due to the destruction of habitats located on farm land (Feehan and O'Connor, 2009). Agri-environmental schemes generally operate by financially incentivising farmers to farm in a manner that protects and enhances the fragile environment over which they are custodians. These invariably require a halting or removal of intensive farming practices.

The European Union (EU) adopted an incentive approach to agri-environmental protection when it introduced regulation (EEC) 2078, which requires all EU Member States to introduce such schemes. The EU also provided the majority of the funding for such schemes. Habitat conservation and enhancement is one of the objectives of the regulation. However when it came to the design of agri-environment schemes the principle of subsidiarity applied, meaning that Member States had considerable autonomy in how they gave expression to the spirit of the regulation. The justification for applying the subsidiarity principle to environmental legislation is that many environmental problems are local or regional in nature and there is a presumption that lower levels of government are best equipped in terms of information to effectively deal with such issues. However, such an approach has meant that across Member States of the EU, there is considerable diversity in the design of AESs, with some countries operating more spatially targeted schemes while in other countries the scheme applies throughout the country. Such institutional diversity underlines the importance of research that evaluates how effective these schemes have been in delivering on the objectives of regulation (EEC) 2078. In this way, we can learn what schemes have been most effective and why and what needs to be done to improve the less effective schemes (Hanley et al., 1999, Hynes et al. 2008a).

This paper aims to add to our collective knowledge on the effectiveness of AESs by evaluating the effectiveness of the Rural Environment Protection Scheme (the Irish institutional response to regulation EEC 2078). This is not the first study to look at the Rural Environment Protection Scheme (REPS) - see Emerson and Gilmore (1999), Hynes et al. (2008b) and Hynes and Garvey (2009). Similar to these studies, the focus of this paper is on the behaviour of farmers as opposed to scientific studies that attempt to evaluate in a more direct way the impact of AESs on the ecology of farm habitats (In this, we are operating within the data constraints of the Irish situation). However, unlike the aforementioned studies, which have focused on participation in REPS and attempted to explain the likelihood of participation in terms of farm type, farmer characteristics and land features, our study looks at the behaviour of farmers already in REPS, where their choices have no direct financial consequence.

It has long been argued that REPS has been more about income support to farm families than on delivering environmental goods (Matthews, 2003). According to Hynes et al (2008b), the fact that REPS uptake has been greatest among extensive farmers points to the likelihood that the Irish scheme may be compensating farmers in areas not in need of environmental improvement, hence appearing to corroborate Matthew's assertion. However, Kleijn and Sutherland (2003) adopt a contrary view arguing that the environmental payback to the adoption of agri-environmental schemes on extensively farmed land is greater than on intensively farmed land. This is because schemes that aim to protect existing biodiversity by preventing intensification or abandonment are capable (if effective) of delivering more than schemes aimed at redressing damage already done on intensively used farmland. However, the authors point to the lack of evaluation studies of the effectiveness of AESs in extensive areas. Given that REPS adoption has been highest among extensive Irish farms, it would be revealing to have other data on the behaviour of participant farmers to ascertain if farmer choices are adding to environmental protection. In this study, we have additional data on the behaviour of REPS farmers that may help shed light on this central issue.

All Irish farmers who participate in REPS have to adopt some additional measures known as biodiversity undertakings (BUs), aimed at protecting and enhancing species diversity. The farmer has a choice among various BUs and receives no additional payment for the measures taken. This study uses the new data on BU choices of REPS farmers and attempts to evaluate such choices in terms of their ecological suitability, given the type of habitats that REPS farms contain. If it is the case that REPS farmers are making appropriate choices given the habitats found on their farms, then it points to the effectiveness of REPS in terms of the design of the scheme. If it turns out that, in some instances, farmers are choosing inappropriate BUs given the habitats on their land, then not only does this point to a failure of the design of REPS, it prompts us to ask why farmers are making such ecologically inappropriate choices. The answer to this question will be important in terms of improving the design of the system. It could be a clear conflict between ecological benefits and economic costs (in terms of resources such as time and effort) or farmers not being aware of the ecological impact of different measures. Kleijn and Sutherland (2003), in their review of the literature on the effectiveness of AESs, concluded that they were most effective when they enabled farmers to carry out measures that they felt positive about. Inappropriate behaviour because of lack of environmental awareness is possibly the easiest system flaw to redress, in that it points to the need for more resources to be devoted to the educational aspects of the scheme. However, if farmers' lack of positivity about certain measures is for economic reasons, then it points to the need for a less flexible system, such as a more spatially targeted system or one that permits farmers less choice when it comes to adopting BUs as well as greater monitoring to ensure farmer compliance. With this in mind, we first evaluate the ecological soundness of the choices that REPS farmers have made and then, in the event of inappropriate choices, attempt to disentangle the reasons for such behaviour.

The next section will explain the main features of REPS, the Irish AES that was established to comply with regulation (EEC) 2078. This is then followed by a discussion of evaluation studies of EU AESs in section 3. Section 4 introduces the data used in this study and elaborates on how we have categorised and aggregated the data in order to make it tractable for estimation. Section 5 explains the estimation method used in this study and the theory that underpins it, while section 6 presents the results of the estimation exercise. Finally section 7 concludes with a discussion of the implication of the results, including how the latest Irish agri-environmental scheme could be improved.

2. The Rural Environmental Protection Scheme

Regulation (EEC) 2078 required that AESs reduce the negative environmental effects of conventional agriculture, enhance the visual and amenity aspect of the rural environment and provide for the education and training of farmers in those practices that protect the environment. Given that regulation (EEC) 2078 was created with the aim of Member States generating subsidiary AESs that best fit individual national farming systems as well as habitats, this section contains a detailed description of REPS and how it has been administered in the Republic of Ireland. REPS was introduced in 1994, was mitigated by the Department of Agriculture, Fisheries and Food (DAFF) and was made universally available to every farmer in the country on a voluntary basis. As participants were obliged to farm in an environmentally benevolent manner, they received annual stipends to compensate for production losses. REPS contracts required that farmers adhered to individual farm-specific environmental plans on their entire holdings for the duration of five years. These plans were created by advisors who either worked for the main semi-state agricultural agency, Teagasc, or for DAFF-approved private companies. In conjunction with other relevant state agencies, DAFF organised training courses for REPS planners and farmers. Farmers were obliged to attend approved education courses for at least 20 hours as part of their contracts.[1]

The main objectives of REPS, which were to be incorporated into each farm plan, were to establish farming practices and production methods that reflect the concern for conservation and landscape protection, to protect wildlife habitats and endangered

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[1] These courses are tailored to large groups of farmers but one on one farm walks between the farmer and their REPS advisors are supposed to provide further guidance to farmers, designed to help them decide the BU choices that are appropriate to the land cover on their specific farm.

species of flora and fauna and to produce quality food in an environmentally friendly manner. The scheme closed to new entrants in 2009, although many of the 52,000 farmers who were participating in REPS at the beginning of 2010 still had the majority of their five year contracts to complete, meaning the absolute year of completion for the scheme is 2014 (DAFF, 2010a).

There have been four phases of REPS since 1994. At the time of data collection for this study, 2007, REPS farmers may have been participating in either the third or forth phase – REPS III or REPS IV respectively. All four phases had a general programme that consisted of a set of 11 compulsory basic measures for the entire farm holding. Unlike the previous two phases, REPS III and IV required that, in addition to the 11 eleven basic measures, farmers incorporated at least two biodiversity undertaking options (BUs) on their farms. Farmers who were in the general REPS programme were entitled to carry out up to 2 supplementary measures for additional payment if they so desired (DAFF, 2004; 2007).

This paper is concerned with the BU options that farmers were required to take – the primary objective of which was to improve biodiversity levels on participating farms. The majority of the BUs in REPS strove to meet this objective by enhancing pre-existing habitats on extensive farms. Of course some farms do not have habitats with high biodiversity levels to enhance, perhaps because the land has been intensively managed for agricultural production over a long period of time (Bignal, 1998). For these REPS farms there were BUs that were specifically designed to generate biodiversity rich areas on the farm. The amount of land on a farm holding that was required to be covered under the BUs varied according to the specifications of each BU. In REPS III farmers had 16 BUs to choose between, whereas in REPS IV, the number of options had increased to 24 (see Appendix A). Farmers could not choose the same BU twice.

In both REPS III and REPS IV specific measures were provided for land that was protected under the Birds, Habitats or Water Framework Directives (79/409/EEC, 92/43/EEC and 2000/60/EC) or under the Wildlife Amendment Act (2000) – henceforth referred to as target land. The details of the management goals for target land were contained in Measure A and Measure 4 of the REPS III and REPS IV contracts, respectively. Specific management goals for target land were included in the environmental farm plans and were given precedence over BU choices whenever the target land and BU objectives were at odds. As a consequence of the independent treatment of target land under REPS contracts, this study assumes that BU choice did not impact upon how target land was managed.

3. Previous studies evaluating EU agri-environmental schemes (AESs)

To understand the effectiveness of REPS at protecting the Irish environment, it helps to review the findings of studies carried out on the various subsidiary European AESs that were created in response to (EEC) 2078, as well as those carried out on REPS. These studies have taken the form of ecological investigations (Hanley et al., 1999; Kleijn et al., 2006; Sutherland, 2006; Whittingham, 2007), subjective evaluations of the value of farm habitats (Alvarez-Farizo et al., 1998; Campbell, 2007) and behavioural studies (Wilson, 1996; Wynn et al., 2001; Morris, 2004; Defrancesco et al., 2008). The results from ecological studies tend to be varied. Certain species groups can fare better than others. In a review by Kleijn and Sutherland (2003) of different European AESs and their effectiveness at conserving biodiversity, findings showed that arthropod diversity was easier to enhance using AESs than plant or bird diversities. Kleijn et al. (2006) showed that generalist species were benefitting from the presence of AESs on farms yet Whittingham (2007) expressed concern for the future of specialist species on farm land under AES contracts. The impact that REPS had on general species richness and abundance levels of both field margin flora and Carabidae (ground beetles) was previously found to be negligible (Feehan et al., 2005). Unfortunately the worth of these ecological studies is somewhat reduced by the fact that there are rarely any baseline ecological data, taken before the introduction of AESs in Member States, with which comparisons of current ecological standards can be made.

A contingent valuation study by Alvarez-Farizo et al. (1998) found that users' and non-users' were willing to pay £1,046 million per year for the environmental benefits provided by farmers through an AES in Breadalbane, Scotland. In Ireland, Campbell (2007) found that members of the public were willing to pay the highest amounts of money for the protection of stonewalls and mountain land and the lowest amounts for preserving cultural heritage.

Behavioural studies focus on the idea that participation in AESs is, in itself, a gauge of the success of a scheme. A variety of methods have been utilised to look at factors that may impact upon farmers' decisions to participate in an AES such as behavioural models (Morris and Potter, 1995; Wilson, 1996; 1997; Burton, 2004), actor network theory (Morris, 2004) and various econometric techniques (Dupraz et al., 2003; Wossink and vanWenum, 2003; Defrancesco et al., 2008; Hynes and Garvey, 2009). Rather than focusing on the issue of why farmers choose to participate in an AES, this paper is concerned with the decisions farmers made in regard to the agri-environmental management of their farms after they joined. A fundamental difference between these two decision making processes is that a farmer who evaluated whether to participate in REPS or not would have considered the extra utility from REPS payments as part of his/her decision, whereas choosing one BU over another did not result in extra payments for the same farmer. Aside from this difference, we believe that it is reasonable to assume that other farm and farmer characteristics that have been found to impact upon farmers' participation decisions in AESs also impacted upon their decision to choose specific BUs.

Demographic and socio-economic factors, such as age, presence of a successor, education and knowledge levels, have been identified as variables that impress upon farmers' participation decisions for AESs. Younger farmers are generally more likely to participate than older farmers. The reason for this is assumed to be that they are more environmentally aware or more inclined to try new management systems than older farmers (Wynn et al., 2001; Hynes et al., 2008b). If the second assumption is true, then we would expect to find that younger farmers are more likely to choose innovative BUs than older farmers. There is some debate over whether the presence of a successor on a farm encourages or discourages farmers to participate in AESs. The issue was originally raised by Potter and Lobley (1992), who argued that elderly farmers with no successors tend to simplify and reduce their agricultural enterprises as they near retirement. Consequently they are liable to find the prospect of receiving payments for keeping extensive farming systems in place attractive. Elsewhere Lynch and Lovell (2003) and Wilson (1996) both found that having a successor was positively correlated with farmers' decisions to participate in AESs, while Wossink and vanWenum (2003) found the variable was insignificant in their study.

Dupraz et al. (2003) found that farmers with augmented levels of environmental awareness were, *ceteris paribus*, more likely join a Dutch AES than those who were less aware. This conclusion was reached by employing a variable comprising of a multiple factor correspondence analysis of farm households' answers to a range of general environmental issues. In a review of 31 international analyses of farmer participation behaviour in conservation tillage programmes, Knowler and Bradshaw (2007) alleged that, despite the fact that the education levels of farmers are often assumed to influence adoption decisions, it had a mixed effect. Elsewhere, the impact of receiving specific agricultural education has been found to improve farm efficiency levels, which may indicate that these farmers are more likely to prioritise production over the environment (Jamison and Lau, 1982). However, seeing as productivity levels are improved as a result of being more informed, farmers with an agricultural education may include long term goals in their plans, meaning they would be more susceptible to considering sustainable agricultural solutions.

Farmers in REPS do not receive extra payments for choosing one BU over another, so the direct income effect of their decisions can not be evaluated. However, Van Wenum et al. (2004) found that increasing opportunity costs can negatively influence a farmer's decisions not to participate in an AES. In fact, low farm productivity levels and poor soil types have been found to, *ceteris paribus*, increase the chances of farmers' choosing to participate in an AES (Dupraz et al., 2003; Hynes and Garvey, 2009). Wynn et al. (2001) found that the more a scheme "fit" with farmers' current agricultural activities, the more likely a farmer was to choose to participate in the scheme. So one would expect that farmers were more likely to choose BUs that required lower levels of effort, opportunity costs or management changes to their current agricultural activities.

In contrast to Van Wenum et al. (2004) there have been some findings which indicate that the security of an agri-environment payment might be preferable to commodity market risk for small scale farm operators regardless of opportunity costs. In this regard Matthews (2010) points out that the increase in the variability of agricultural prices in recent years, in itself, does not necessarily imply riskier prospects for European farmers since the presence of a fixed income component in the form of the direct and agri-environmental payments provides a measure of protection against the fluctuations in prices.

In a study of farmer participation behaviour in the Cambrian Mountain Environmental Sensitive Areas (ESA) scheme, UK, Wilson (1996) found that the primary incentive for farmers with semi-natural grasslands to join was payments offered by the AES, whereas the primary incentive for farmers with broadleaved woodlands was environmental considerations. Herzon and Mikk (2007) found that both Finnish and Estonian farmers displayed a similar desire to those in the UK for conserving tree groups, but that the desire to conserve habitats extended to semi natural grasslands for Estonian farmers. In terms of Irish farmers, Aughney and Gormally (2002) found that REPS farmers thought only non-productive areas of their farms, such as scrub, had any conservation value, while historically areas of peatland have been viewed as wastelands with little ecological value (IPCC, 2010). These results reflect the fact that farmers may perceive agricultural landscapes in many ways according to historical and cultural opinions of farm habitats, both of which may vary geographically (Burgess et al., 2009).

Hynes et al. (2008b) advanced earlier econometric behavioural studies of AES participation by including habitat data in a logit model of REPS participation behaviour. In doing so they took a step in the direction of an increased multidisciplinary approach towards the question of why farmers would choose to participate in an AES as the role of habitat type in this decision making process has implications for both the farmer and the farm environment. The authors found that farmers are more likely to participate in REPS if they have wet grassland, shallow water, forest and scrubland, fen, blanket bogs or rocky complexes on their farms. Farmers were less likely to participate in REPS if they had dry grassland, heath, built land or cutover fen habitat types on their farms. This paper adds to the research of Hynes et al. (2008b) by further investigating how farmers maximise their utility in relation to land use once they have decided to participate in REPS. While Hynes et al. (2008b) were interested in the relationship between REPS participation and habitat type we are interested in the relationship between the BUs undertaken within the scheme and given the habitat type on the farm. Also unlike Hynes et al. (2008b) we have data for the habitats associated with actual farms rather than those associated with spatially simulated, representative farm types. Furthermore, this paper combines specialist ecological knowledge with a discrete choice model of farmer utility maximising behaviour to compare the decisions farmers should have made with the decisions they actually made. As such it presents findings on the policy performances of AESs in relation to biodiversity on the farm that to date has not been adequately dealt with in the literature.

In 2009 a new agri-environmental scheme was introduced in Ireland called the Agri-Environment Option Scheme (AEOS). One of the primary aims of the AEOS is to protect the biodiversity levels of farm habitats. The duration of an AEOS contract is at least five years and the entire farm is not required to be covered by the scheme – just identified areas. Farmers with target land or commonage sites (category 1 applicants) are given precedence for participation in the scheme, whilst all other farmers (category 2 applicants) must submit an application based on one of three possible environmental objectives for their farm. Then, under their chosen objective, they select at least two undertaking options from a list of 18. Category 2 applicants are not required to prepare a sustainable management plan as part of their application. Funding is limited for the new scheme and contracts are offered to farmers based on a strict ranking system (DAFF, 2010b; Mooney, 2010; Teagasc, 2010). The AEOS is being offered to the same cohort of Irish farmers as REPS, and the majority of the undertakings in the new scheme are no different to the BU options in REPS. Clearly any information gleaned about farmers' reasons for choosing different BUs, and the effect that farm habitats have on the decisions, will benefit policy makers in the identification of these participants.

4. Data

For the analysis undertaken in this paper, we use the National Farm Survey (NFS) dataset collected by the main Irish agricultural research organisation, Teagasc, as part of its data collection commitments to the Farm Accountancy Data Network (FADN) of the European Union. The aim of FADN is to analyse the incomes and economic performance of agricultural holdings in all member states**.** This paper uses the 2007 NFS dataset, which consisted of a random sample of 1,151 farms representing 111,913 farms nationally (Connolly *et al.*, 2008). Table 1 shows the variables relating to farm and farmer characteristics that were used for this study.

(Table 1)

In 2007, REPS farmers who participated in the NFS were asked to fill out supplementary questions asking, amongst other things, which BUs they had chosen for their farms. Farmers were not required to complete BUs as part of the second phase of the scheme, REPS II, so participants in REPS II were excluded from this study. All of the remaining observations came from REPS III and REPS IV farmers (424 participants in total). Each farmer was obliged to choose at least 2 BUs as part of their contract, meaning there were at least two observations for each REPS farmer in the NFS.

Two of the BUs that were only offered to REPS IV farmers, low input spring cereals and minimum tillage, were not chosen by anyone in the supplementary survey. Also, 12 of the 24 BUs were only chosen by farmers on ten or less occasions. Therefore, we categorised each of the BUs into one of five BU groupings according to the type of management changes that they required of the farmers, to improve terrestrial biodiversity on their farm. The five groupings were categorised as *enhance field margins*, *maintain/enhance grazing areas*, *setaside*, *create habitats* and *maintain water quality* and are defined in Table 2. The disparity between the number of BUs made available to REPS

III and REPS IV farmers was accounted for by using this grouping system because a number of BU choices from REPS III and REPS IV are included in each grouping. As each farmer selects more than one BU, the multiple (and exclusive) choices are affected by the same farm habitats and farmer characteristics and therefore the individual's choices cannot be considered independent. To control for this dependence,,we include a dummy variable in our model that indicates whether a farmer chooses BUs from the same grouping or not as the other choice made. In this manner, dependence across BU choices is incorporated into our model via the dummy term for the other choice[2]. Our final dataset contained 870 observations for 424 REPS farmers.

(Table 2)

As mentioned earlier, the objectives of the BUs are to, firstly, enhance non-target habitats where they exist and to, secondly, promote the creation of new habitats where they do not exist. Two of the BU groupings are entirely devoted to the enhancement and maintenance of pre-existing farm habitats – *enhance field margins* and *maintain/enhance grazing areas*. In particular, they guard against the effects of land abandonment or intensification, because the removal of traditional farm practices on extensively farmed areas can result in habitat deterioration. *Enhance field margins* contains three BUs that call for the maintenance of traditional style hedgerows and stone walls and four BUs that enhance the development of habitats on farm margins by stipulating that traditional grazing and strict chemical management routines are adhered to. *Maintain/enhance grazing areas* contains BUs that forbid intensification of the grazing areas on a farm yet they ensure grazing levels and nutrient cycles are maintained as they always have been.

Setaside and *create habitats* are both intended to generate new habitats on farmland where biodiversity levels are low. These are often intensively farmed or modified areas.

[2] Another approach to controlling for the dependence across a farmer's BU choices would be the introduction of an individual fixed effect into the model (i.e. assuming a panel sample). However, this was not possible because the explanatory variables do not vary across the choices made by the farmer, thus resulting in a model that drops (or has only insignificant) coefficients.

The difference between the two BUs is that *setaside* involves fencing off a section of the farm and ceasing agricultural activity in the area, whereas *create habitats* stipulates that farmers must plant some new form of vegetation to improve the habitat biodiversity on the farm. BUs in the *maintain water quality* category are not primarily intended to help terrestrial biodiversity, but are aimed instead at reducing sediment and nutrient run-off into water bodies. Nonetheless, if farmers do choose these options, they will impact on farmland habitats and therefore these BUs need to be considered in this paper.

(Table 3)

Habitat data for this paper came from a map that was produced to indicate the likely distribution of habitats in Ireland. The map was derived from a spatial model implemented in a geographical information system (GIS) using real data on peatlands (Hammond, 1978) and elevation, landcover and subsoils (Fealy et al., 2004). The spatial model incorporated an expert rule base, which was used to perform a pixel-by-pixel analysis on these data sources and created a final map with a minimum mapping unit of 1 ha (1 ha = 16 pixels) and which identified a total of 29 habitats (Table 3). This GIS land cover dataset was then linked to the farms in our sample to examine the relationship between habitat type on the farm and the BU options chosen.

The georeferenced location of the farm boundaries of each observation in the 2007 NFS was not available but the geo-co-ordinates of the farmhouse for each of the sample farms was known by the NFS department. Due to reasons of confidentiality we were not given access to the actual farmhouse co-ordinates but were granted access to GIS data relating to the land cover within a specified radius of each farm. Therefore, an assumption was made that each farm in the sample is located in a circle with a 0.5 km radius surrounding the farmhouse, making each farm a circle of 78.5 ha. Although the average size of a REPS farm in the sample is 39.287 ha (Table 1), we believe that this is a reasonable assumption to make because in reality Irish farm holdings tend not to be in a single block but can be broken up around the general area of the farm house (Aughney and Gormally, 2002). The habitat data were then overlaid on our GIS farm data to match up land cover types to farm holdings. Dummy variables were created indicating whether each of 29 possible habitat types were present in the 78.5 ha circles representing every REPS farm in the NFS dataset (1 if the habitat is present on the farm, 0 otherwise). The 29 habitats are listed in Table 3. However, not all 29 were used as explanatory variables in the model. Five of the habitat types only cover 0.01 percent (or less) of the country and were not found on any of the farms in the NFS sample, so they have been excluded from the study. Dry grassland was present on all of the farms in the sample, so it had to be excluded from the analysis because it would not have been possible to measure the marginal effect of this variable on farmers' decision making.

Built land was also removed because it is irrelevant as a landcover type under an AES (it mainly refers to residential and commercial units). Finally, habitats that are listed as priority habitats and that are allocated their own management plans under REPS III Measure A and REPS IV Measure 4 were removed from this analysis because contractually they should not be affected by farmers' BU choices. These include intact raised bogs, intact blanket bogs, fens and mature forests. Consequently, this analysis looks at how a total of 424 farmers assigned BUs to 15 habitat types on their farms.

(Table 4)

For inclusion in our multinomial logit model, the 15 habitat types in Table 3 have been re-classified, using ecological expert advice, according to the type of agricultural management that best suits their ecological needs. "A guide to habitats in Ireland" (Fossitt, 2000) is a hierarchical habitat classification system for Ireland with 11 broad habitat groups, 30 habitat subgroups at level 2 and 117 subgroups at level 3. Clearly we did not have information relating to all the habitats contained in level 3 subgroups under Fossitt's classification system, so we did not utilise its habitat subgroup nomenclature for our habitat groupings as it would have been misleading. Instead, we created original headings that relate back to Fossitt's. Consequently our results are comparable with other literature relating to Irish habitats.

As well as presenting our habitat groupings, subsequent paragraphs also discuss each possible BU-habitat grouping combination in terms of whether a BU is the optimal ecological choice, a good ecological choice or a damaging ecological choice for a habitat grouping (i.e. Table 5 contains an outline of how, in an ideal world, the BUs in REPS should be assigned to different farmland habitats in Ireland). All the groupings and categorical assignments in Table 2, Table 4 and Table 5 have been compiled based on a variety of literary sources and with the aide of both ecological and REPS experts[3].

(Table 5)

Habitat Categorisation and Appropriate Biodiversity Undertakings (BUs)
All the habitat types in the grouped habitat variable peatlands are Fossitt's subgroup level 3 habitats except heath, which is a subgroup level 2 category because it can be further defined as siliceous, calcareous, wet or montane heath. These habitats have been grouped together because agriculture is an essential actor in both their formation and maintenance. Peatlands are not agriculturally productive habitats, so the main threats to them are the consequences that occur if they are either under or overgrazed (Foss et al., 2001). So, as they are dependent on traditional grazing, *maintain/enhance grazing areas* is the optional choice for these habitats. *Setaside* excludes animals from the area and would be a poor choice because peatlands revert to scrub if left ungrazed. *Creating habitats* would also be detrimental to these habitats because this BU would fundamentally alter the structure of what are ecologically important habitats.

In marginal grasslands, exposed calcareous rock and wet grasslands are both subgroup level 3 variables but coastal complex can be further identified according to Fossitt (2000) as embryonic, marram or fixed dunes. These habitats have been grouped together because, like peatlands, they are reliant on continued extensive agricultural management.

[3] The authors recognise the input of a number of individuals in assisting in the formation of these biodiversity groupings and on deciding the optimal BU choices across farm habitats. These individuals include REPS planners from Teagasc, Mr Damian Costello and Mr. Mark Gibson and ecologist Dr. Catherine Keena.

However, being more productive land than peatlands, marginal grasslands may be improved by farmers in a way that would disrupt the biodiversity in the habitats e.g. farmers may add lime to reduce the acidity of the land for agricultural reasons. So, marginal grasslands have been assigned to the BUs in the same way as peatlands because they have similar requirements in terms of farm management, but they are more threatened by intensification than peatlands.

The georeferenced data for immature forest only identifies that the habitat is scrub/traditional woodland, which is a subgroup level 2 in Fossitt's classification system. Some types of immature woodland and scrub have high ecological value and are viewed as being precursors to important woodland habitats, but others are just seen as unmanaged grasslands – the species composition of the immature forest is the decisive factor in which type it is and our data do not provide this information. Nonetheless, important woodland sites are likely to be recorded as target land on REPS farms, so we assume in this study that immature forest is mostly unmanaged grasslands that mainly exist because of land abandonment. In this scenario, it needs to be managed sensitively, because, as mentioned above, in the absence of grazing or mowing, immature forest has the potential to expand and replace marginal grasslands or peatlands. Therefore *maintain/enhance grazing areas* is the best option for immature forest and allowing it to grow uncontrollably as *setaside* would be problematic. Controlling immature forest by including it in *enhance field margins* is also a beneficial option and planting over it by choosing *creating habitats* would not be an issue under the assumption that it is an encroaching and uncontrolled habitat.

Wetlands contain any type of still water body, swamp or marsh and are only at the first group level in Fossit's classifications. We feel this low categorisation level is justified because these habitat types are found at the boundary of what can be defined as utilisable farmland (note that running water is not included in wetlands). Any part of this habitat type that is farmed would require continued grazing, so *setaside* is a damaging option and *maintain/enhance grazing areas* is a good ecological option. *Enhance field margins* could increase biodiversity in these habitats, but *maintain water quality* is the best ecological option for wetlands because nutrient run-off is a major threat to these ecosystems.

Reclaimed peatlands are defined in greater detail than Fossitt's subgroup level 3 because the expert base rule was used to identify peatland subsoils so that the habitats could be identified as reclaimed peatlands and not grasslands, which is what they appear to be to the naked eye. This distinction is important because it will impact upon both the productive and biodiversity levels found in the grasslands. In general, the biodiversity levels of reclaimed peatlands would be low because the peatland biodiversity will be removed and they will not have had time to build up biodiversity levels that exist in naturally created grasslands. Therefore none of the BUs would damage them and the optimal choices that farmers could make would be *creating habitats* or *setaside*, as these encourage the growth of new habitats on this particular type of farmland.

5. Theoretical framework and estimation model

The theoretical framework used to interpret the results of the estimation exercise is a standard neoclassical one. In other words, the underlying behavioural assumption is that all farmers behave in a utility maximising way. This can be expressed as follows:

$$U(Y(BU_i), E(BU_i), BU_i) \qquad (1)$$

where, Y is the income impact of implementing the biodiversity undertaking, E is the effort associated with adopting the particular biodiversity undertaking and BU_i is the biodiversity undertaking adopted. It is reasonable to assume that all BUs will require some resources and therefore lower farm income, just as all BUs will require farmer effort as an input. Neoclassical theory assumes that lower income and higher effort reduce utility, while it is assumed that the environmental good that is a product of the particular BU will contribute directly to utility. Since all BUs will have different incomes, effort and direct utility effects (depending on the preferences of the farmer) whatever the farmer chooses must be optimal for him/her. The manner in which a BU impacts on the farmer's income, effort and utility will be determined by farmer and farm characteristics, including the habitats found on the farm.

In the estimation in this paper, the farmer chooses from 5 biodiversity undertakings. The probability that a farmer will choose a particular biodiversity undertaking *m* from the mutually exclusive choices $j = 1, \ldots, M$ is expressed as:

$$\Pr(Y_i = m) = \frac{\exp(\beta_{im}^{'} x_{im})}{\sum_{j=1}^{M} \exp(\beta_{ij}^{'} x_{ij})} \quad j = 1 \ldots M \tag{2}$$

where β_j is the vector of coefficients associated with the vector of farm, farmer and habitat explanatory variables, *x*, when the farmer chooses biodiversity undertaking *j*. Because the probabilities $\Pr(Y_i = j)$ sum to 1 over all BU choices, only M – 1 of the probabilities can be determined independently. To deal with this problem, β_{i1} is normalised to equal zero, which results in a base case, $\Pr(Y_i = 1)$, being generated. In this paper, the base case is the BU *create habitats* and the probability of it being chosen is given as:

$$\Pr(Y_i = 1) = \frac{1}{1 + \sum_{j=2}^{M} \exp(\beta_{ij}^{'} x_{ij})} \tag{3}$$

The remaining M – 1 unknown probabilities are estimated as a ratio in terms of the base case in the following way:

$$\Pr(Y_i = m) = \frac{\exp\left(\beta_{im}^{'} x_{im}\right)}{1 + \sum_{j=2}^{M} \exp(\beta_{ij}^{'} x_{ij})} \tag{4}$$

However, if one wishes to calculate the ratio of the probability of selecting BU_j relative to BU_1 the log of this expression reduces to a simple linear function of the explanatory variables.

$$\log\left(\frac{p_j}{p_1}\right) = \beta_j^{'}x \tag{5}$$

So $\exp(\beta_j^{'})$ represents the change in the probability of being in BU_j relative to the probability of being in BU_1 associated with a unit change in the independent variable. In this scenario $\beta_j^{'}$, is called a relative risk ratio. The coefficients in the next section are expressed in this way. An estimated coefficient greater (less) than 1, indicates that that particular BU is more (less) likely to be chosen than *create habitats* when there is a positive change in the explanatory variable. So, for example, if a coefficient associated with a BU is equal to 2, that means that it is twice as likely as the base case but if it is equal to 0.33, then it is only a third as likely.

Of particular interest in this paper are the habitat variables and the effect that their presence on farms has on the likelihood of a farmer choosing a particular BU relative to *create habitats.* However, as habitats are not the only determining factors of a farmer's choice, we also control for the impact of other farm characteristics (such as farm size, system and profitability) and farmer profile (such as age, family status, educational attainment and off farm employment, if any). Finally, as only the BU decisions of farmers already participating in REPS are being analysed in this paper, the estimated relative risk ratios are conditional on farmers adopting the scheme;

$$\left(\frac{p_j}{P_1}\Big|\text{REPS participant}\right) \tag{6}$$

This conditional probability is appropriate for the model because the purpose of the paper is to look at the likelihood of farmers choosing different BUs based on the choices REPS farmers actually made in 2007 and to evaluate them in terms of what would be considered the ecologically optimal choices. Therefore, concern over potential sample selection bias due to the exclusion of non-REPS farmers is not an issue because we are only interested in the actions of the sub-sample of Irish farmers who are actually participating in the REPS programme.

6. Results

The parametric regression results of the multinomial logit of BU choices made by REPS farmers (weighted using the individual farm population weights provided in the NFS) are presented in Table 6. The likelihood ratio $\chi 2$ statistic shows that, taken jointly, the coefficients across all categories are significant at the 1% level.

(Table 6)

The results show that larger farm size increases the likelihood that farmers will choose *maintain and enhance grazing* and *set aside* over the other BUs. *Set aside* is also the most attractive option for farmers with lower farm income and part time farmers. By contrast, if farmers are married *set aside* is considerably less likely than all other BUs, with married farmers showing a preference for *create habitats* and *enhance field margins*. The latter BUs are also more likely to be chosen if farmers have finished secondary school. Intriguingly, having an agricultural education results in farmers displaying different preferences, with *create habitats* and *enhance field margins* going from being the most likely BUs to be chosen to being the least likely, while the reverse happens for *maintain and enhance grazing*, which now becomes the most probable choice. In accordance with the literature cited earlier, one possible explanation for such divergent preferences may be that while a general education fosters more environmental awareness, an agricultural education may prioritise production and economic sustainability. Our systems information is compelling, revealing that farmers with livestock systems of cattle and dairying are much more likely than the base case of sheep farming to choose *maintain water quality* above all other BUs. Tillage farmers display a preference for *set aside*, while the most probable choice for sheep farming (base case) is *maintain and enhance grazing*.

The ‘Same Option’ variable (which helps account for dependence across BU choices) indicates that farmers are more likely to choose BUs from different groupings rather than from the same grouping. This variable is significant in all but the *maintain/enhance grazing areas* grouping. Only in the base case of *create habitats* are farmers more likely to choose a second options from within than BU grouping. In order to highlight the impact of habitats on BU choice, it is useful to profile the types of farmers and farms associated with each BU, independent of whether they have habitats or not on their land. Our regression results indicate the following: (i) *maintain and enhance grazing* is most attractive to sheep farmers and those with an agricultural education and bigger farms; (ii) *set aside* is more probable if one is a tillage farmer, single, with a low income, off farm job and a bigger farm; (iii) *maintain water quality* is most likely to be chosen by cattle, dairy and older farmers; (iv) *enhance field margins* appeals to full time farmers with smaller farms while; (v) *create habitats* finds favour with married farmers who have completed secondary schooling.

The habitat results in table 6 show that farmers with peatland on their farms are more likely to choose *enhance field margins* than any other BU. This choice is 1.5 times more likely than the next preferred option of *maintain water quality* and over 4.5 times more likely than the least favoured option of *maintain and enhance grazing areas.* The marginal grasslands habitat favours the *set aside* option, with it being 1.6 times more likely than the second most favoured choice of *enhancing field margins* and 2.5 times more likely than the least favoured option of *maintain and enhance grazing areas.* Immature forest is most associated with *create habitats,* followed closely by *maintain/enhance grazing areas and set aside,* although it should be noted that the coefficients in the latter two instances are insignificant. Those with wetlands habitats are most likely to choose the optimal ecological choice, *maintaining water quality* followed closely by *enhancing field margins* (odds of 1.06), with the least favoured option *maintain and enhance grazing area* being highly unlikely (odds of 7.2 between most and least likely). Finally, for farmers with reclaimed peatlands, *maintain and enhance grazing area* is the most likely choice with odds of 1.2 over the second most likely choice (*setaside*) and odds of 1.7 over the least likely choice (*maintain water quality*).

Table 7 combines information on the choices that farmers, whose farms contain habitats, should make (if guided by ecological considerations only) with the choices that they are likely to make. Normative considerations are represented by colour coding (as per Table 5), while the likely choices as revealed in Table 6 are shown as a ranking, with 1 being the most likely and 5 the least likely. Of those farmers that had one of the five grouped habitats on their farm, 33.6% made an optimal ecological choice, 47.2% made good ecological choices and 19.2% made damaging ecological choices. In an ideal world with a perfectly designed AES, the optimal choices would also be the most likely (get a high ranking) and the damaging ecological choices would be the least likely (get a low ranking).

(Table 7)

The results for peatland are not ideal. On the one hand, the most likely BU *enhance field margins* is an ecologically acceptable choice and much more likely than the damaging choices of *set aside* and *create habitats* (2.1 and 3.5 being the respective odds of the former with respect to the latter two BUs). However, the ecologically optimal choice would be *maintain and enhance grazing areas,* which is ranked the least likely of all BU choices for this habitat. The situation is even more serious in the case of the marginal grasslands habitat. In this instance, farmers have shown themselves to be most likely to choose the damaging option of *set aside* with it being 2.5 times more likely than the optimal choice *maintain and enhance grazing areas.* The situation with regard to immature forest is better from an ecological suitability perspective, as the two ecologically optimal choices (*create habitats* and *maintain/enhance grazing areas*) for this habitat type have been ranked 1 and 2 in table 7. These results must be interpreted with caution, however, as there is little difference in the probability between the top three most likely BUs and the coefficients in two instances are insignificant.

Farmers' choices with regard to wetlands appear to indicate that this habitat is well protected by the choices that farmers make. The BUs ranked 1 and 2 for wetlands are the ecologically optimal *maintain water quality* and the good *enhance field margins*, respectively. There is little scope for farmers with reclaimed peatlands to make poor choices, since none of the BUs are deemed to be ecologically damaging for this type of habitat. This is because, as fundamentally altered habitats, it is assumed that many of the ecosystem processes that would have been found on the peatlands to begin with have already been irreversibly damaged. However, farmers are still not making the best choices so there is room for improvement even where this habitat is concerned.

Our results indicate that the marginal grasslands habitat is not well protected by the current choices of farmers and that there is considerable room for improvement where the peatlands habitat is concerned. Even where there is limited scope for further ecological damage (reclaimed peatlands), the situation could be enhanced. What needs to be examined is why farmers with marginal grassland are choosing *set aside* and why *maintain and enhance grazing areas*, which is the optimal choice for those farms with both marginal grasslands and peatlands, is such an unlikely outcome in both instances. As mentioned earlier, *set aside* appeals most to those with an off farm job, are single, have lower farm income, with bigger farm area and tillage systems. Farmers whose farms contain marginal grasslands have a mean income of €14,200, an average farm size of 50 hectares, 47% have off farm jobs and their average age is 52. In other words the only appreciable way in which they differ from the total sample of REPS farmers in this study is that they have a lower farm income, larger farms and a greater percentage have off farm jobs (see Table 1 for the summary statistics for the total sample). These three factors would predispose farmers to choose set aside as the BU. Possibly, the much lower attractiveness of *maintain and enhance grazing* compared to *set aside* for farmers with grassland habitats has to do with the additional effort of putting a proper grazing management plan in place for this land cover, compared to the ease of implementation of *set aside*, especially if they have off farm jobs. Alternatively, a lack of ecological knowledge may explain the appeal of *set aside.*

The case of farms with peatlands is even harder to explain since farms with peatland habitats have a higher mean area (68.75ha) and a bigger percentage of sheep systems (39.7%) than our total sample of REPS farms (see Table 1). According to our regression results the aforementioned characteristics should predispose farmers towards the BU choice of *maintain and enhance grazing areas* but that is not the case, which means that the low odds of this choice must be uniquely associated with the peatland habitat in some way. One potential reason for the low priority attached to *maintain and enhance grazing areas* by farmers with peatlands may be that they view this habitat as wastelands with no grazing potential (IPCC, 2010). On the other hand, the appeal of *enhance field margins* may be related to its association with stonewalls. It has been observed that Irish people attach a high value to the preservation of stonewalls, which are commonplace in peatland areas (Campbell, 2007 and Hynes et al., 2011). As stone walls come under the BU *enhance field margins,* this stated preference of the public may have predisposed farmers with peatland to prioritise this visible BU over others.

7. Conclusion

All participants in the Rural Environment Protection Scheme (the Irish institutional response to regulation (EEC) 2078) had to adopt 2 additional BUs from a potential menu of 24, designed to protect and enhance biodiversity of species of fauna and flora found on farms. Their choices as to BUs were relatively unconstrained, although farmers did get advice from REPS planners as to the BU choices that were appropriate to the land cover found on their farms. How effective or otherwise this institutional modus operandi has been in protecting ecologically important habitats is what this paper attempted to evaluate.

The novel feature of this paper was that it combined new information on farmer choices as to biodiversity undertakings with data on actual habitats located on farms, and estimated the likelihood of each BU for a given habitat. This is a distinct advance on Hynes et al (2008b) who examined the probability of REPS participation as a function of simulated habitats found on farms. Furthermore, in this paper the choices that farmers were likely to make, given the habitats found on their farms, were evaluated in terms of ecological desirability (where ecological desirability was determined on the basis of discussion with experts in the field). While such an approach does not address directly the environmental impact that the scheme has had on the natural environment, it does serve to highlight whether farmer behaviour is consistent or otherwise with some of the environmental objectives of the scheme.

Our results reveal that certain habitats, namely wetlands and reclaimed peatlands, are relatively well protected by the scheme as currently constituted, in that the likelihood of farmers adopting a damaging BU for these habitats is low. By contrast, the habitats of peatlands and marginal grasslands are not being sufficiently protected by the choices that farmers are making. In both instances, the ecologically optimal choice, which is *maintain and enhance grazing* has the lowest probability of being chosen and, in the case of marginal grasslands, the most likely choice *set aside* is actually ecologically unsuitable. So clearly, REPS as currently constituted is coming up short when it comes to protecting all ecologically valuable habitats found on Irish farms. Trying to determine why farmers sometimes made ecologically correct choices as to BUs and other times were much less likely to do so is, in the absence of direct attitudinal studies, inevitably speculative. For farms with marginal grasslands, the reasons may be partly economic, especially if a lot of those farmers have off farm jobs. However, it would be incorrect to exclude genuine lack of awareness of the ecological value of maintaining grazing on farms with such habitats. Similarly, the same may be said in the case of peatlands. All the socio-economic data indicated that the optimal BU (*maintain and enhance grazing areas)* should have been the most likely to be chosen, so it is not too unreasonable to assume that farmers failure to do so may have been as a result of misinformation as to what BUs are most ecologically suitable for their type of land cover. However, all this points to the need for further study to ascertain farmer motivation. Attitudinal studies could reveal not just the extent of farmer environmental awareness but also their willingness to act as genuine custodians of the environment.

The results also raise some important issues in regard to the scheme that will be fully replacing REPS in 2014, the Agri-Environment Option Scheme (AEOS). Many of the individuals who apply to participate in the AEOS may be category 2 participants that do not have target land (that gets special protection) on their farms. So they will be similar in profile to those REPS farmers who get to choose from a range of BUs. Category 2 applicants are not required to prepare a sustainable management plan for their farms and the Land Parcel Identification System data that they are obliged to send the DAFF, provides information on land use, not farm habitats. Therefore, the decisions being made for farm habitats under the application process for the new scheme will, similarly to REPS, be a matter of farmer preference. Given that the Department of Agriculture will apply a ranking system to determine who will be accepted into the new scheme, it makes sense if this ranking system can identify and prioritise those farmers who are predisposed to making the best possible environmental decisions for their farms. By appealing to and recognising this type of "active participant" (Morris and Potter, 1995), the AEOS will achieve the maximum possible returns for the cost of the AEOS payments. Finally, this paper has helped with the identification of key areas that need to be improved in relation to farmers' decision making processes, particularly in connection with peatlands and marginal grasslands. To avoid repeating the misallocation mistakes that occurred in REPS, policy makers in the AEOS should consider including ecological assessments and habitat specific educational courses in future phases of the scheme.

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Table 1. Description and summary statistics of farm and farmer explanatory variables taken from the 2007 NFS

Variable	Description	Mean/ Proportion
Farm income	Income from the farm (excluding REPS payments) in €1,000s	25.236
Farm size	Size of farm (ha)	39.287
Off farm job	0: farmer has no off farm employment 1: farmer has off farm employment	0.338
Farmers' age	Age of farmer (years)	52.525
Married	0: farmer has never been married 1: farmer is or has been married	0.820
Children	0: no children living on the farm 1: children living on the farm	0.509
Finished school	0: farmer did not finish secondary school 1: farmer finished secondary school	0.603
Agricultural education	0: farmer has no agricultural training beyond REPS courses 1: farmer has agricultural training	0.493
Sheep	0: not a specialist sheep farm enterprise 1: specialist sheep farm enterprise	0.149
Cattle	0: not a specialist cattle rearing enterprise 1: specialist cattle rearing enterprise	0.220
Cattle other	0: not a specialist cattle rearing and fattening enterprise 1: specialist cattle rearing and fattening enterprise	0.228
Dairy other	0: not a specialist dairy with other enterprise 1: specialist dairy with other enterprise	0.077
Dairy	0: not a specialist milk production enterprise 1: specialist milk production enterprise	0.232
Tillage	0: not a tillage enterprise 1: tillage enterprise	0.094
Same option	0: both BU options are from different groups 1: both BU options are from the same group	0.149

N=424. NFS: National Farm Survey 2007.

Table 2. BU Groupings

Enhance field margins	**Maintain/ enhance grazing areas**	**Setaside**	**Create habitats**	**Maintain water quality**
Arable margins	Traditional hay meadows	Creation of a new habitat	Broadleaved tree planting	Exclude bovines from water courses
Hedgerow laying	Species rich grassland	Environmental management of setaside	Farm woodland establishment	Use of clover in swards
Hedgerow coppicing	Control of invasive species	Planted buffer zones	Traditional Irish orchards	Use of trailing shoe technology
Stone wall maintenance	Nature corridors		Landscaping around farms	Green cover establishment
Increase water course margins			Bird/bat boxes	
Maintaining access to archaeological sites			New hedgerow establishment	
Buffer zones around archaeological sites				
n = 238	n = 59	n = 126	n = 303	n = 144

Sources: (Fossitt, 2000; Foss et al., 2001; Gwyn et al., 2003; NPWS, 2005; Finn et al., 2009; IPCC, 2010) as well as expert advice.

Table 3. Percentage coverage in Ireland of the 29 habitat types identified using the spatial model

Habitat	**Coverage (%)**
Cutover fen	<0.01
Bog and heath	<0.01
Cutover upland blanket bog	0.01
Sand	0.01
Salt marsh	0.01
Fen	0.03
Coastal complex	0.12
Bare rock	0.14
Reclaimed fen	0.16
Karst bare rock	0.18
Bare peat and soil	0.20
Cutover/eroding lowland blanket bog	0.47
Wetland	0.54
Cutover/eroding upland blanket bog	0.57
Reclaimed upland blanket bog	0.69
Reclaimed lowland blanket bog	1.03
Cutover raised bog/fen	1.12
Built land	1.21
Intact raised bog/fen	1.71
Water	1.94
Immature woodland and scrub	3.04
Rocky complex	3.19
Intact lowland blanket bog	3.22
Intact upland blanket bog	3.37
Mature forest	3.65
Heath	4.13
Reclaimed raised bog/fen	4.76
Wet grassland	5.74
Dry grassland	58.76

Source: Fitzpatrick and Green (2007).

Table 4. Habitat Groupings

Peatlands	Marginal Grasslands	Immature forest	Wetlands	Reclaimed peatlands
Cutover/eroding lowland blanket bog	Wet grassland	Scrub/transitional woodland	Water	Reclaimed fen
Cutover/eroding upland blanket bog	Exposed calcareous rock		Wetland (Springs or Swamps)	Bare peat and soil
Cutover raised bog/fen	Coastal Complex			Reclaimed upland blanket bog
Heath				Reclaimed lowland blanket bog
				Reclaimed raised bog/fen

Sources: (Fossitt, 2000; Foss et al., 2001; Gwyn et al., 2003; NPWS, 2005; Finn et al., 2009; IPCC, 2010) as well as expert advice.

Table 5. Optimal BU choices for farm habitats according to Expert Opinion

	Biodiversity Undertakings (BU)				
Habitat Group	Enhance field margins	Maintain/enhance grazing areas	Setaside	Create habitats	Maintain water quality
Peatlands	Good choice	Optimal ecological choice	Damaging choice	Damaging choice	Good choice
Marginal Grasslands	Good choice	Optimal ecological choice	Damaging choice	Damaging choice	Good choice
Immature forest	Good choice	Optimal ecological choice	Damaging choice	Optimal ecological choice	Good choice
Wetlands	Good choice	Good choice	Damaging choice	Damaging choice	Optimal ecological choice
Reclaimed peatlands	Good choice	Good choice	Optimal ecological choice	Optimal ecological choice	Good choice

Key

Optimal ecological choice	(light yellow)
Good choice	(orange)
Damaging choice	(red)

Sources: (Fossitt, 2000; Foss et al., 2001; Gwyn et al., 2003; NPWS, 2005; Finn et al., 2009; IPCC, 2010) as well as expert advice.

Table 6. Results of a multinomial logit on REPS farmers' choices of BUs using all relevant NFS variables combined with habitat data

	Enhancing field margins	Maintain/enhance grazing areas	Setaside	Maintaining water quality
Farm income (€)	1.003(4.08)***	1.001(0.81)	0.992(-10.17)***	1.004(5.03)***
Farm size (ha)	0.992(-17.53)***	1.005(7.84)***	1.003(6.89)***	0.998(-3.19)***
Off farm job	0.777(-10.95)***	0.880(-3.21)***	1.292(9.05)***	1.146(4.83)***
Farmers' age	0.999(-0.58)	0.985(-8.37)***	1.008(5.66)***	1.025(17.35)***
Married	1.033(1.11)	0.825(-3.97)**	0.517(-18.30)***	0.812(-5.82)***
Children	0.814(-8.11)***	0.897(-2.50)**	1.192(5.35)***	1.105(3.14)***
Finished school	0.902(-4.65)***	0.539(-16.17)***	0.746(-10.27)***	0.548(-22.46)***
Agricultural education	0.955(-2.10)**	1.346(7.97)***	1.163(5.49)***	1.213(7.03)***
Cattle	0.986(-0.48)	0.683(-8.04)***	1.387(9.04)***	2.837(25.38)***
Cattle other	0.934(-2.50)**	0.590(-12.12)***	0.628(-12.45)***	1.754(14.26)***
Dairy other	0.768(-6.51)***	0.521(-10.09)***	0.938(-1.27)	1.940(12.72)***
Dairy	0.672(-10.04)***	0.086(-24.27)***	1.087(1.65)	2.904(21.62)***
Tillage	0.953(-1.23)	0.478(-10.39)***	2.022(14.82)***	1.466(6.60)***
Peatlands	3.526(31.51)***	0.775(-3.06)***	1.649(9.83)***	2.362(16.38)***
Marginal grasslands	1.269(10.51)***	0.800(-5.54)***	1.984(25.44)***	1.236(7.62)***
Immature forest	0.608(-10.98)***	0.988(-0.18)	0.985(-0.30)	0.563(-10.27)***
Wetlands	2.725(14.25)***	0.398(-4.11)***	1.521(4.71)***	2.875(12.96)***
Reclaimed peatlands	1.372(13.54)***	1.623(12.79)***	1.403(11.90)***	0.952(-1.63)
Same option	0.596(-20.75)***	0.001(0.01)	0.101(-40.01)***	0.117(-41.86)***

All values are provided in comparison with the base category *create habitats* as the odds ratios (the likelihood of a farmer choosing the given BU divided by the likelihood of him choosing the base category). Z values in parentheses. N = 870 (77,104 with weights), log likelihood = - 104293.16: Mean VIF: 1.60. ***: significant at 1%, **: significant at 5%, *: significant at 10%

Table 7. The most to least likely BUs that farmers will choose for farm habitat types

	Biodiversity Undertakings (BU)				
Habitat Group	Enhance field margins	Maintain/enhance grazing areas	Setaside	Create habitats	Maintain water quality
Peatlands	**1**	**5**	**3**	**4**	**2**
Marginal Grasslands	**2**	**5**	**1**	**4**	**3**
Immature forest	**4**	**2**	**3**	**1**	**5**
Wetlands	**2**	**5**	**3**	**4**	**1**
Reclaimed peatlands	**3**	**1**	**2**	**4**	**5**

Results based on habitat grouping coefficients in multinomial logit. Numbers indicate the likelihood of farmers with the given habitat type on their farm choosing each BU where 1: most likely option to be chosen, 2: second most likely option to be chosen, 3: third most likely option to be chosen, 4: second least likely option to be chosen and 5: least likely option to be chosen. Colour Key the same as table 5.

Key

Optimal ecological choice	
Good choice	
Damaging choice	

Appendix A

Table A1. Requirements for REPS III and REPS IV contracts

11 obligatory measures	REPS III BU options	REPS IV BU options
1. Nutrient management		
2. Grassland and soil management	Traditional hay meadows	Traditional hay meadows
	Species rich grassland	Species rich grassland
		Use of clover in grassland swards
		Use of trailing shoe technology
		Control of invasive species
3. Protect and maintain watercourses and wells	Increase watercourse margin	Increase watercourse margin
	Exclude all bovine access to watercourses	Exclude all bovine access to watercourses
		Use of planted buffer zones
4. Retain wildlife habitats	Creation of a new habitat	Creation of a new habitat
	Broadleaved tree planting	Broadleaved tree planting
	Nature corridors	Nature corridors
		Farm woodland establishment
5. Maintain farm and field boundaries	Hedgerow coppicing and laying	Hedgerow coppicing
		Hedgerow laying
	New hedgerow establishment	New hedgerow establishment
	Additional stonewall maintenance	Additional stonewall maintenance
6. Restricted use of pesticides and fertilisers		
7. Biodiversity buffer strips around archaeological sites	Increase in archaeological and historical buffer margins	Increase in archaeological and historical buffer margins
	Management of publically accessible archaeological sites	
8. Maintain and improve visual appearance of farm and farmyard	Provide landscaping around the farm	Traditional Irish orchards
		Install bird and/or bat boxes
9. Produce tillage crops respecting environmental principals	Green cover establishment	Green cover establishment
	Environmental management of setaside	Environmental management of setaside
	Increased arable margins	Increased arable margins
		Low input spring cereals
		Minimum-tillage
10. Training in environmentally friendly farming practices		
11. Maintenance of farm and environmental records		