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Spatial analysis of agri-environmental policy uptake and expenditure in Scotland

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ABSTRACT

Agri-environment is one of the most widely supported rural development policy measures in Scotland in terms of number of participants and expenditure. It comprises 69 management options and sub-options that are delivered primarily through the competitive 'Rural Priorities scheme'. Understanding the spatial determinants of uptake and expenditure would assist policy-makers in guiding future policy targeting efforts for the rural environment. This study is unique in examining the spatial dependency and determinants of Scotland's agri-environmental measures and categorised options uptake and payments at the parish level. Spatial econometrics is applied to test the influence of 40 explanatory variables on farming characteristics, land capability, designated sites, accessibility and population. Results identified spatial dependency for each of the dependent variables, which supported the use of spatially-explicit models. The goodness of fit of the spatial models was better than for the aspatial regression models. There was also notable improvement in the models for participation compared with the models for expenditure. Furthermore a range of expected explanatory variables were found to be significant and varied according to the dependent variable used. The majority of models for both payment and uptake showed a significant positive relationship with SSSI (Sites of Special Scientific Interest), which are designated sites prioritised in Scottish policy. These results indicate that environmental targeting efforts by the government for AEP uptake in designated sites can be effective. However habitats outside of SSSI, termed here the 'wider countryside' may not be sufficiently competitive to receive funding in the current policy system.

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1. Introduction

1.1 The Common Agricultural Policy

The European Common Agricultural Policy (CAP) will undergo reforms post 2013 in order to adapt to evolving environmental and economic challenges (COM, 2012). Alongside the continued economic crisis there is uncertainty about how the balance of environmental and economic issues will be addressed both at the European and national level (Hodge, 2012). The Rural Development Programmes (RDP) (COM, 2012) are prominent policy mechanisms within the CAP that are designed to meet this challenge. RDPs for the programming period 2007-2013 are based on Strategic Guidelines set by the European Commission, and have three core objectives known as Axes. Whereas Axes 1 and 3 promote 'competiveness' and 'diversification' in rural areas, Axis 2 focuses on 'improving the environment and the countryside by supporting land management'. This includes a number of policy 'measures', which act as instruments for integrating environmental considerations into economic decisions.

1.2 The Scottish Rural Development Programme

Each EU Member State, [in line with the three Axes], has developed its own RDP based on national priorities, with budgets set accordingly (COM, 2005). Scotland's RDP is considered to have an "essential role in sustaining land-use systems that contribute to the survival of local communities and which are crucial to the delivery of environmental benefits, including the delivery of biodiversity targets and the maintenance of unique landscape character" (Scottish Government, 2008, p.13). Consequently, the Scottish Government has allocated over £1 billion to environmental policy measures within the RDP 2007-2013 programming period (Scottish Government, 2008). The 'environmental' budget for Scotland's RDP is spread across eight different delivery mechanisms known as schemes, illustrated in Figure 1. Between 2007 and 2010 the Rural Priorities (RP) scheme received the highest committed expenditure in comparison to the seven other schemes, at £260.7 million (Scottish Government, 2010).

The RP scheme is unique in comparison to the other delivery schemes in that it works as a competitive process where the eligibility of rural land managers to receive funding is based on a scoring system. The scoring system assesses the contribution of projects, amongst other eligibility criteria, to quantified national and qualitative regional targets both of which link to the EU strategic guidelines and objectives (Scottish Government, 2011a). The RP scheme has five environmentally centred measures, including agri-environmental expenditure (AEP) as summarised in Table 1. AEP is outlined in the Council Regulation (EC) No 1698/2005 (COM, 2005), and is a broad categorisation of numerous land management strategies known as 'options'. In Scotland there are 69 options and sub-options for the AEP measure. These options range from wetland management to bird species conservation; all options have the common aim of creating, conserving and improving habitats and biodiversity within Scotland (Scottish Government, 2008). The number and specificity of options under Scottish the AEP measures contrasts with other EU Member States, with broader options based, for example, on overall biodiversity protection rather than specific

species or habitats (Poláková et al., 2011). For Scotland, the array and the number of options are tailored to varying needs due to the diversity of Scottish landscapes (Scottish Government, 2008; Poláková et al., 2011).

1.3 Evaluating policy measures

The Scottish Government is obligated to evaluate and monitor the performance of the RDP through the Common Monitoring and Evaluation Framework (CMEF) (COM, 2006). Data on both the number of participants with contracts (uptake) and expenditure of RDP measures are required in the form of the CMEF quantitative indicators (COM, 2006). Performance can be appraised by comparing these indicators to output indicators, which are nationally pre-set Axes and measure targets (COM, 2006). Such evaluation may identify 'implementation deficits', describing the gap between policy intentions and actual outcomes (Weale, 1992; Winter 1996; Wilson and Hart, 2000). For instance, from 2008 until 2011, AEP had the highest uptake and expenditure across the RP measures from each of the Axes; receiving 39% of the total expenditure for RP (total £ 158 million) and 77% of the total contracts (total 15,322), far exceeding the AEP number of holdings output target by 135% (Scottish Government, 2008). These figures indicate that AEP adoption is meeting policy expectations. Yet the level of aggregation of these targets and whole measure analysis does little to allow a deeper understanding of what AEP management activities are being adopted and across which land and farm types.

Further assessment of option adoption, however, demonstrates a large disparity between uptake and expenditure among the 69 options under the RP scheme's AEP measure. For example from 2008 to 2011 the option 'supplementary food provision for raptors - hen harriers' had only 1 applicant and a committed spend of £5,380. In contrast the 'open grazed or wet grassland for wildlife' option had the highest uptake with 2,011 beneficiaries, and over £30 million in committed spend (Scotland's RDP Scottish Government data, 2007-2011). Yet assessing if levels of individual option uptake and expenditure are meeting policy objectives is challenging in the absence of quantifiable targets that do not go beyond the measure itself. Additionally, Potter et al. (1993) argue that "the precision with which target groups or target land are identified will be critical in their success or failure" (p.199).

It is equally challenging, therefore, to assess policy performance regionally because policy priorities are less clear at this level. The spatial distribution of AEP clearly differs across Scotland, e.g. Figure 2 shows the variation in expenditure across the eleven Regional Project Assessment Committees (RPAC) regions of Scotland for AEP. These eleven regions also have varying proportions of Scotland's total UAA (Utilised Agricultural Area). Expenditure could reasonably be assumed to be linked to the proportion of UAA within a region. However, as Figure 2 demonstrates, this is not necessarily the case. For example the Highland RPAC secured a relatively low percentage of funds relative to the proportion of its UAA while the Grampian RPAC is the opposite.

Variation in expenditure across regions, when UAA is accounted for, raises inequity issues for the targeting of expenditure and uptake for AEP. Justification of regional budgets and their targeting

performance is uncertain, since in spite of regional targets being established per RPAC, these are qualitative and fairly unanimous across the regions (Scottish Government, 2011a; RSPB 2011).

Thus, indicators of uptake and expenditure have only limited use in policy assessment. With national targets and regional priorities in the RP scheme, it is only possible to assess if broad objectives are being met (Scottish Government, 2011a). However, an understanding of the determinants of uptake and expenditures would improve policy evaluation. An analysis of the influences of spatial variability on the uptake and expenditure of RDP measures for instance, would provide insights into 'how' and 'where' these priorities are being met.

Table 1. Framework of axes, measures and options under the SRDP Rural Priorities scheme 2007-2013
Axis 1 'Competiveness'   **Axis 2 'Environment'**   Axis 3 ' 'Diversification'
Axis 2: measures (Total five)   *214 - Agri-environment payments (AEP) - - - - - - - - - - - - - - - -*   216 - Support for non-productive investments - agriculture   223 - First afforestation of Non-Agricultural land   225 - Forest-environment payments   227 - Support for non-productive investments - forestry
214 – AEP measure: options (Total 69 options and sub-options)   **Management of wetlands**   **Conversion to organic farming**   **Management of cover for corncrakes**   **Control of grey squirrel for red squirrel conservation**   **Hedgerows – 3 years biodiversity benefits   Etc ...**

1.4 Influences of spatial uptake and expenditure extent

The focus of this paper is on the spatial distribution of uptake and expenditure of the AEP RDP measure across Scotland. In line with available data, seven categories of explanatory characteristics, with expected spatial variation, were explored by modelling their influence on AEP measure uptake and expenditure. Some determinants were chosen because they were identified in previous studies as being important, including farm level variables such as; 'farm type', 'livestock' (Hynes and Garvey, 2009; Wynn et al., 2001); 'labour employment' and 'land ownership' (Defrancesco et al., 2008; Dupraz et al., 2002); as well as the regional variable 'designated areas' (Wilson, 1997). Additional regional variables such as; land capability for agriculture (LCA) and the Scottish urban-rural classifications (incorporating accessibility and size of settlements), were also included because of their importance in Scotland. Furthermore, both factors are potentially useful indicators for targeting; in identifying how and what LCA types and rural demographic levels, impact AEP participation (Potter et al., 1993).

In the absence of disaggregated quantifiable targets, it is hypothesised that the assessment of policy performance can be achieved by analysing the relationships between spatial characteristics and AEP participation and expenditure. For instance, by linking RP scheme criteria with policy outcomes, such as the criteria defined for scoring and eligibility (Scottish Government, 2011a). For example, one of the

national targets links directly with designated areas; supporting activities that will bring Scotland's nationally important nature sites (with SSSIs as nationally designated and SACs, SPAs and Ramsar sites as internationally designated sites[1]) into favourable condition (Scottish Government, 2009). Options related to designated sites attract a higher score and would therefore be prioritised (Scottish Government, 2011a). As a result it is expected, as with Wilson's (1997) findings, that the uptake and expenditure of AEP would be positively related to designated sites due to this targeting emphasis. As SSSIs are the most common of the designated sites, of which there are 1,440 in Scotland, they are assessed separately in this study unlike the merged dataset used for the other designated areas (Scottish Government, 2011g). This is used to test whether there are differences in uptake and expenditure of AEP according to the type of designated site.

Eligibility for funding is also determined by spatially-related attributes. Farm type and bio-physical characteristics can indicate how individual option criteria affect uptake. The eligibility criteria vary for each individual AEP option, depending on the options objective and management requirements. Option criteria range from being 'narrow and targeted', to the more widely applicable 'broad brush'. For example, a more targeted option includes 'grazed grassland for Corncrakes'. This option is eligible only for grazed farm land within the species distribution target areas e.g. the Western Isles, from 2008 to 2011, had 135 approved contracts (Scottish Government, 2011c). Alternatively hedgerow management' is a more 'broad brush' option and is open to all land managers who have established hedgerows (Scottish Government, 2012c). This option had the highest uptake of all RP AEP options, with 1,601 contracts from 2008 to 2011. This supports the findings of Wilson and Hart, (2001) that more generally applicable options with undemanding entry conditions are more commonly adopted.

Option management demands and labour availability are also potentially related to AEP uptake. Dupraz et al. (2002) suggested conservation intensive option requirements are more likely to be taken up by holdings with an excess of labour. Defrancesco et al. (2008) support this finding, by indicating that non-participating farmers cannot easily satisfy the extra labour required for the AEP paperwork, administration and implementation. Therefore, locations with higher labour densities and the availability of full-time staff would be expected to positively influence AEP uptake.

Agricultural land use, determined by bio-physical characteristics, will also influence the eligibility of land areas (Wynn et al., 2001; Hynes and Garvey, 2009; Buchan et al., 2010). For instance the two most prevalent land capability types in Scotland are 'rough grazing' referring to uncultivated land used for grazing livestock, and 'mixed agriculture', which refers to a combination of cropping and livestock, or mixed livestock farming approaches. Both of these farm types are prevalent in land areas with mountainous terrain, poor soils and harsh climatic conditions (Scottish Government 2008; JHI, 2013).

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[1] Site of Special Scientific Interest (**SSSI**) and Special Areas of Conservation, (SAC) are designated sites that support rare, endangered or vulnerable natural habitats and species of plants or animals (other than birds) of European importance and Special Protection Areas (SPA) support wild birds and their habitats. Ramsar sites are designated areas for wetland conservation (Scottish Government, 2011g).

These land capability types are also associated with extensive farming practices, which according to Hynes and Garvey (2009), are more likely to adopt AEP options. Such farm practices are also more likely to include mixed cattle and sheep livestock (Hynes and Garvey, 2009). Moreover, intensive farms are probably less inclined to apply, as this would result in the loss of income when converting areas for AEP practices (Hynes and Garvey, 2009). In this study, therefore, farms with both rough and mixed land capabilities with extensive farm characteristics were expected to influence positively the uptake of AEP in Scotland.

The potential explanatory determinants, however, might be important at one scale level, but not at another, known as the 'ecological fallacy', (Steel and Holt, 1996). Furthermore, as data is aggregated, information subsequently can be lost (Henderson-Sellers et al., 1985; Meentemeyer and Box, 1987). Thus, in this study, the analysis was undertaken at the smallest spatial resolution dictated by data availability i.e. at the parish[2] level; a spatial unit used in the agricultural census and for the expenditure of farming grants and subsidies.

In order to analyse the determinants of AEP uptake and expenditure, whilst taking account of measure and option distribution, a spatial modelling approach was applied. While previous work on AEP adoption has focused on specific case studies (Ruto and Garrod, 2009; Guillem et al., 2012) there are fewer studies that have attempted to model determinants at a national level (Crabtree et al., 1999, Wynn et al., 2001, Juvančič et al., 2012). This approach could have more resonance with policy makers who need to consider the broader picture. Therefore this study used a countrywide spatial modelling approach to identify determinants of AEP uptake and expenditure across Scotland.

1.5 Spatial econometric modelling

Spatial econometrics has been used widely in regional economics as well as being applied in land use models (Overmars, et al., 2003; Brady and Irwin, 2010). Yet a limited number of studies have applied spatial econometrics in order to evaluate RDP (Schmidtner et al., 2012; Bartolini et al., 2012; Juvančič et al., 2012). Furthermore, whilst there are many studies into the factors that affect AEP participation, few of these have attempted to understand the geographical dimensions of AEP and control for spatial dependence (Evans and Morris, 1997; Hynes et al., 2008; Uthes et al., 2010; Schmidtner et al., 2012). Evans and Morris (1997) argued for the necessity of using a geographical approach in order to fully understand the impacts of AEP on "land use patterns and habitat and landscape conservation" (p.202).

Spatial econometric modelling is defined here as the incorporation of spatial dependence interaction (spatial autocorrelation) and spatial structure (heterogeneity) in regression models (Paelinck and Klaassen, 1979; Anselin, 1988). Spatial heterogeneity refers to variation across space, and spatial autocorrelation,

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[2] There are a total of 891 agricultural parishes in Scotland.

considers the first law of geography that "everything is related to everything else, but near things are more related than distant things" (Tobler, 1970, p. 236), indicating that data observations are not independent.

If spatial dependency is detected, the use of spatial models is justified. There are two main types of spatial models; lag and error (Anselin et al., 2008). The spatial lag model adds a spatially lagged dependent variable to account for the dependency of another variable being jointly determined by neighbouring values, known as the 'spill-over effect' (Ward and Gleditsch, 2008; Anselin et al., 2008). Alternatively, spatial error models assume that spatial dependency occurs in the error terms, indicating that a covariate has been omitted (LeSage and Pace, 2009). It is argued that both these models provide better classification and predictive accuracy than linear regression for spatial datasets that exhibit strong spatial autocorrelation (Anselin, 1988; Kazar and Celik, 2012).

Spatial dependency effects need to be clarified to justify the use of either the spatial lag or error models (Partridge et al., 2012; Gibbons and Overman, 2012) by identifying the distinction in 'spatial dependence', i.e. whether dependent correlation is caused by spill-over effects or explanatory variables (Partridge et al., 2012). In this study, it was expected that spill-over effects would be identifiable in a holding-to-holding analysis, for example, the participation of one farmer may lead to AEP uptake by neighbouring farmers (Vehkala and Vainio, 2000; Siebert et al., 2006). However these effects are unlikely to be identifiable at a parish level. Therefore it is more likely that spatial correlation for AEP will be detected and caused by a high correlation in the explanatory variables (Hynes et al., 2006). Therefore spatial error models are expected to be more suitable for this analysis. These hypotheses can however be tested to identify the most appropriate model type (Anselin, 2005).

1.6 Summary of research aims

The novelty of this study lies in the application of spatial econometric modelling to identify spatial targeting of agri-environmental measures. To do this, the study addresses four main questions in the context of Scotland's RP scheme: 1) Are uptake and expenditure for the RP scheme AEP measure and AEP option categories spatially dependent? 2) What impact does the type of model: OLS, lag and error have on the model quality? 3) What are the determinants of participation and expenditure in Scotland? 4) What do these results tell us about the targeting effectiveness of Scotland's RDP? In order to answer these questions the following steps of analysis were applied: 1) the construction of an appropriate spatial weight matrix; 2) identification of spatial autocorrelation in the dependent variables; 3) a comparison of model performance and results between OLS and the spatial models; 4) identification of significant determinants of participation and expenditure; and, 5) assessing how these variables meet desired policy objectives. Thus this article illustrates the process and detection of spatial autocorrelation and the differing model quality. As well as describing the significant determinants of AEP participation and expenditure examining how these may relate to policy eligibility and scoring criteria.

2. Material and methods

Dependent and explanatory variable datasets were prepared for model analysis. The Scottish AEP measure, as the dependent variable, incorporates a large number and diversity of environmental management options, and consequently a breakdown into option groupings was expected to produce better fitting models. For in comparison to the whole measure analysis, the option groups would further account, at least to some extent, for the differing eligibility criteria and management requirements. The options were classified, therefore, into five groups relating to the main theme objectives: species control (total of 6 options); organic farming (total of 8 options); bird conservation (total of 12 options); water habitats (total of 10 options); and habitat management (total of 32 options)[3]. The total number of participating holdings varied across the option groups as shown in Figure 3. Due to the low uptake for the 'species control' and 'organic' options these were omitted from the analysis.

In total, 40 explanatory variables were collected as secondary datasets (summarised in Table 2). These included variables categorised as farm level variables and regional variables such as designated sites, LCA and accessibility and remoteness.

Testing for spatial autocorrelation in the dependent variables requires the development of W (the spatial weights matrix) by applying a theoretical approach that avoids misapplying spatial econometrics (Partridge et al., 2012; Corrado and Fingleton, 2012). Applying W in an ad hoc way may lead to model deficiencies (Partridge et al., 2012; Corrado and Fingleton, 2012). Therefore the weighting strategy of W should be applied in order to represent the spatial structure between features that best reflect how they interact with one other by systematically assessing the degree of connectivity between spatial units (ESRI, 2006). $W's$ were constructed using the parish spatial dataset[4].

The 'Gabriel' W was considered to be better than the two most commonly used Ws, 'queen contiguity' (based on common boundaries and vertices) and 'distance based', since it incorporates the ability to include islands and limit ranges of neighbours between parishes (see discussion in section 3.1, below). The Gabriel W uses a standardised each row weighting strategy (Gabriel and Sokal, 1969). As with Delaunay triangulation (natural neighbours) the method works as a sub-graph where neighbours are constructed by creating Voronoi triangles from point features, so that each point connected by the triangle edge are considered neighbours (ERSI, 2012).

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[3] For further details on each option group categories, see Appendix B

[4] The W and models were developed using the R 2.13.1 software (2011) [4]

Table 2. Dataset summary: dependent and explanatory variables		
Datasets	**Description**	**Data source**
Dependent variables (total 8)		
AEP measure Habitat management Bird conservation Water habitats	Two types: i) Payments per UAA ha per parish ii) Percentage of participating holdings per parish	Scottish Government: Scotland's RDP data from 2008-2011
Explanatory variables (total 40) *FARM LEVEL*		
Farm types (n=11) Rough grazing Crops and grass Grass < 5 yrs old Grass > 5 yrs old Other land Crops and fallow Other crops l Unspecified crops Vegetables Woodland Glasshouses	Proportion of total parish size (ha) e.g. percentage of crops and grass per parish Density of glasshouses is calculated from total number of glasshouses per parish divided by total UAA ha per parish	Scottish Government: agri-census data 2010
Ownership *(n= 5)* Common grazing Owned agricultural Rented agricultural seasonal rented Seasonal let	Proportion of total parish size (ha) e.g. percentage of owned agricultural area per parish	
Livestock (total four) *(n= 4)* Cattle Sheep Beef Heifers Dairy Heifers	Total number of livestock type per parish divided by total UAA ha per parish. e.g. Density of sheep per UAA ha	
Labour *(n= 5)* Full-time occupiers Part-time occupiers Full-time spouses Part-time spouse Regular & casual staff	Total labour type per parish divided by total number of holdings per parish. e.g. Density of regular and casual staff per holding	
REGIONAL		
Land Capability for Agriculture (LCA) *(n=6)* Arable Mixed a Improved Rough Built up areas Inland water area	Based on soil, climate and relief datasets land is ranked on its potential for productivity and cropping flexibility. Proportion of total parish size (ha) e.g. percentage of land capable for mixed agriculture per parish	James Hutton Institute (JHI) 2011
Designated sites *(n=3)* SSSI area Complete national designated areas RSPB reserve areas	Proportion of total parish size (ha) e.g. percentage of SSSI per parish Designated sites variable contained the merged classifications: SSSI, SAC SPAs and Ramsar sites (Scottish Government, 2011g)	Scottish Government 2012a and RSPB 2010
Accessibility and population *(n=6)* Large urban Other urban Accessible small towns Remote small towns Accessible rural Remote rural	Based on population and accessibility to settlements to classify Scotland's rural-urban areas. Calculated as a proportion of total parish size (ha) e.g. percentage of accessible rural areas per parish.	Scottish Government 2010
NB: Further detailed description on the datasets and how each variable was derived can be found in Appendix A.		

Once the **W** was constructed, spatial autocorrelation was tested using Geoda 1.0.1 (2011) to produce a Global Moran's I (Moran, 1948) for each dependent variable. The Global Moran's I, is a statistical measure that takes account of the clustering effects of a given variable between the values sampled at different points in space (Cliff and Ord, 1973). The value can range from -1.0 to +1.0, with positive values indicating spatial clustering and spatial dependency (ERSI, 2012). Furthermore, the spatial significance of clusters (spatial autocorrelation) as well as spatial outliers in the dependent datasets was identified using a Local Indicators of Spatial Association (LISA) test (Anselin, 1995). The LISA test provides a visual map indicating locations of high and low participation and expenditure for AEP.

Identification of the significant explanatory variables per dependent variable was first achieved using the aspatial OLS model forward-backward stepwise function. This function identified the most significant variables and organised them in the most effective order to achieve the 'best model fit' based on AIC (Akaike Information Criterion) (Akaike, 1973; Bozdogan, 1987). The OLS model for multivariate analysis is expressed in equation (1).

$$Y = \beta_0 + \beta_{(1)} X_1 + \beta_{(2)} X_2 + \cdots \beta_{(n)} X_{(n)} + \varepsilon \qquad (1)$$

Y represents the dependent variables (the expenditure and participation of AEP and option groups); β refers to the coefficients, which are calculated by the regression; X refers to each of the selected explanatory variables; and ε represents the random error, which refers to the unexplained part of the dependent variable. The results from this analysis were examined to check for multi-collinearity between present variables and spatial dependency of the model residuals using the OLS model definition in Geoda. Furthermore, models for each of the dependent variables were tested with the Lagrange Multiplier diagnostic, which identifies the most appropriate spatial model: lag or error (Anselin, 2005).[5] These tests produced mixed suitability for lag and error according to the dependent variable, and so subsequently both models were used. The same explanatory variables selected in the OLS models for each dependent were used in the spatial lag model and spatial error model. The spatial lag model is expressed in equation (2).

$$Y = \rho WY + \beta_{(1)} X_1 + \beta_{(2)} X_2 + \cdots \beta_{(n)} X_{(n)} + \varepsilon \qquad (2)$$

W refers to the spatial weight matrix and ρ is a 'scalar spatially autoregressive parameter, which determines the importance of spatial lag', also known as "<Rho>" (Paraguas and Kamil, 2005). "<Rho>" measures the average influence of observations from their neighbouring observations. The spatial error model is similar to the original OLS model however the ε error term is altered by adding the **W** and lambda

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[5] However the diagnostics confirmed that in the majority of cases both models types were significant. Therefore the model analysis proceeded to use both error and lag models.

as demonstrated in equation (3). Where ε is the vector of auto-correlated error terms, the lambda Λ is also a coefficient parameter, with μ as a vector of i.i.d errors[6] (Anselin, 2005):

$$\varepsilon = \Lambda\,W\,\varepsilon + \mu \tag{3}$$

All the model results were compared and analysed. A distinction between option groups and entire measures was tested to compare model quality. Note that R² in the spatial models is comparable, but not for the OLS model as the spatial results produce what is known as a 'pseudo R²' (Anselin, 2005). Thus, model comparisons were based on the AIC. In order to compare the spatial dependency between the aspatial and the spatial models, the residuals from the spatial lag and error models were tested to compare the Global Moran I results and significance compared to the original OLS model residuals. This was done in order to test whether the spatial models had accounted sufficiently for the spatial dependency.

3. Results

3.1 Spatial weight matrix

The 'Gabriel' *W* (spatial weight matrix) illustrated in Figure 4, was developed as an improved alternative to account for the limitations of both the queen contiguity and distance matrixes. The queen contiguity *W* was, limited in being unable to include all parishes in the analysis. Results returned 25 parishes with no links and [on the islands] some blocks of parishes connected only to one other. Additionally, 'Distance cut off' presented limitations due to the varying size and number of parishes. This was demonstrated in the distance matrix results that included four parishes with only 1 link, compared with the most connected parish with 147 links to 'neighbouring parishes'. However the Gabriel *W* had the added advantage, as does the Delaunay Triangulation, of not requiring a common border (i.e. islands can be retained) (Gabriel and Sokal, 1969; ERSI, 2012). Additionally, row standardization is used to create proportional weights in cases where features have an unequal number of neighbours, with a total maximum of 8. Therefore Gabriel *W* was applied to each of the following spatial tests and models.

3.2 Spatial autocorrelation detection

The spatial autocorrelation test showed that each dependent variable in the OLS models had a significant Global Moran's I, as all the values were positive indicating spatial clustering and therefore spatial dependency. Habitat expenditure had the highest spatial dependency with a Moran's I of 0.46 (Table 3). By contrast, both bird conservation models were weakly significant with a much lower Moran's I at 0.04 for expenditure, and 0.05 for participation. The spatial autocorrelation of the residuals from the OLS model compared to both the spatial models showed that in almost all the models, spatial dependency was accounted for in the spatial lag and error models.

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[6] i.i.d refers to the independent and identical distribution of random variables

Table. 3 Global Moran's I of Residuals per model			
Models	OLS Moran's I	Lag Moran's I	Error Moran's I
AEP pay	0.38 ***	0.08*	0.08*
AEP %	0.19 ***	0.01	0.02
Habitat pay	0.46 ***	0.09*	0.09*
Habitat %	0.18 ***	0.01	0.02
Bird pay	0.04 *	0.03*	0.01
Bird %	0.05 **	0.01	0.00
Water pay	0.18***	0.05*	0.04*
Water %	0.22***	0.02	0.02
*p ≤0.05, ** p≤ 0.01, *** p ≤0.001			

The LISA maps also revealed regional clusters of significantly low and high values as well as outliers (referring to low-high and high–low neighbouring values). As seen in Figure 5, it is indicated that clustering patterns are dissimilar between expenditure and participation results for the whole 'AEP' measure with the exception of clusters of both high uptake and expenditure in the North Eastern Grampian region, and low value clusters in central Scotland. This demonstrates that whilst expenditure and uptake are unequivocally related, i.e. there would be no expenditure without uptake; they are still only related to a certain degree.

3.3 Model outcomes and explanatory variables

The results from all the spatial models per dependent variable had an improved AIC in terms of relative goodness of fit compared to the aspatial OLS models (Fig. 6). For instance, for the OLS habitat management' expenditure model, the AIC was reduced by 211 by the spatial models However the 'bird conservation' models showed the least improvement with the AIC in the spatial models reduced by 5.

The AIC results between spatial lag and error models varied according to the dependents however they were either the same or only marginally different (Fig. 6). For example AIC figures were the same for AEP expenditure and bird conservation participation error and lag models. The AIC for spatial error was smaller for the rest of the participation models, with the exception of the water option group; whereas the AIC for spatial lag was smaller for the other expenditure models.

In comparing the results of the whole AEP models with the option groups, both the model quality and the corresponding explanatory variables differed (Fig. 6). For instance, each of the option group models showed an improvement in model quality with lower AICs compared to the whole measure analyses, as shown in Figure 6.

For each model, the explanatory variables differed in number, type and significance, although the same type of relationship (positive or negative) occurred across the model types (OLS, error and lag)[7]. Further reference of the model results to the spatial error model results are shown in Table 4. This is mainly because the spatial error model was considered to better represent spatial dependency. Whilst the

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[7] For all spatial model results see Appendix C

significance of explanatory variables did vary across the lag and error models, this difference was very small and in the majority of cases the same variables remained significant.

The R² in the error models were relatively low in the majority of the models e.g. < 0.28, with the exception of higher R² values for both AEP (0.37) and habitat management expenditure (0.42). The lambda, representing the coefficient of the spatially correlated errors, was found to have a positive effect and was highly significant in all the models. The variation and significance of the explanatory variables are discussed below.

3.3.1 Ownership

For ownership, only three explanatory variables were significant: 'owned', 'rented', and 'common grazing'. However, the significance of each differed according to the model dependents. Percentage of 'rented' agricultural land had a positive effect across three participation models for the whole AEP measure, habitat management options and water options. Yet percentage of 'owned land' and 'common grazing' were significant only in the bird conservation expenditure models. As expected, these two variables displayed contrasting relationships, with 'owned land' having a negative effect and 'common grazing' a positive one.

3.3.2 Farming characteristics and land capability

The six significant farming variables were mostly related to crop types, grassland, and woodland. The crop related variable, 'unspecified' crop land had a negative effect in both the water habitat management expenditure model and water management participation model. Additionally, 'vegetables' were negative, and 'crops and fallow' positive in the bird conservation participation model. 'Crops and fallow' also had positive significance in the water habitat participation model. Alternatively, the percentage of 'woodland' had significant negative association with the AEP expenditure and water habitat expenditure models.

The LCA variables differed in significance across all the models. 'Mixed' agriculture had a positive significant relationship for the majority of models, apart from the bird conservation models. Similarly 'arable' agriculture had a positive effect in both habitat management models only. 'Improved grassland' was only present in the bird participation model and was negatively significant. 'Rough grazing' also appeared as a significantly negative variable in five of the models. Additionally both 'built up areas' and 'inland water' also had negative coefficients.

The labour variables occurred only in the participation models. For example 'density of regular and casual staff' had a strong positive significance in all the dependent models apart from water habitat participation. However, for water habitats, 'density of part-time occupiers' had a positive significant relationship.

For the livestock variables, both density of 'cattle' and 'dairy' were negatively significant. For 'cattle' this determinant was present in the habitat management, water habitat, and bird conservation participation models, as well as the water habitat expenditure model. The 'dairy' livestock variable was present in the

AEP, habitat management, and water management participation models. By contrast, the density of 'sheep' was significantly positive in the water management expenditure model only.

3.3.3. Designated sites

The 'SSSI' variable was shown to have a strong positive significance in all the models, although it was absent in the habitat management expenditure model. The 'RSPB reserves' variable was a positive factor in both the bird models only. However 'designated areas' had a significant negative relationship in all the participation models.

3.3.4 Accessibility and population

The two significant variables for accessibility and population included 'accessible rural' and 'other urban' areas. 'Accessible rural' area had a significant negative effect on every model, except for the habitat management expenditure models. Meanwhile 'other urban' areas had a negative effect on the AEP and bird conservation participation models.

4. Discussion

Spatial dependency is present for participation and expenditure in the whole AEP measure and three major option group dependents, which justifies the use of spatial models. Furthermore, the determinants of either AEP participation or expenditure in Scotland vary according to the three major groupings of options. The relationship of the significant determinants with AEP was largely as hypothesised.

4.1 Spatial dependency

Spatial dependency was demonstrated for each dependent variable justifying the use of spatial models, and supporting Tobler's (1970) theory that physical and social phenomena are highly clustered in space. Yet while most of the dependent variables demonstrated reductions in the AIC and the Global Moran's I through the use of spatial models, these reductions were limited for the bird conservation dependents.

This suggests that the use of spatial models did not improve model quality for the bird conservation option group. Possible explanations for this could be the overall participation numbers for this group, or differentiation between option eligibility criteria. For instance, compared to the other dependents the bird conservation group had the lowest total number of holdings at 1,184 compared to habitat management that had almost twice as many holdings at 2,266. This suggests that a certain threshold of uptake could determine the suitability of employing a spatial analysis approach at the national scale. In addition, the twelve bird conservation options each have a large range of eligibility requirements; from the 'broad brush' aimed at wider diversity of farmland bird species to the 'targeted and narrow' aimed at single bird species. For example there are five options specifically targeting corncrake (*Crex crex*) conservation. Corncrakes have a specialised habitat distribution (Scottish Government, 2011c) and this is reflected in the option eligibility. However the most popular bird option; 'wild bird seed mix/ un-harvested crop' also included in this group, has less rigid eligibility criteria. Subsequently this option has, as with hedgerows, been adopted more widely by a large number of holding types, in both improved and arable land uses (Scottish

Government, 2011c). It is expected, therefore, that an option specific model analysis would more likely detect stronger spatial dependency.

Nevertheless, despite weaker spatial dependency for the bird conservation option group, the aspatial OLS models and the other dependents had comparatively higher AIC, and so, weaker model quality. However whilst the use of spatial error and lag models was shown to be appropriate, the spatial effects and improved suitability of the error models was not wholly as expected. It was hypothesised, for instance, that spatial dependency at the parish level would arise from an important omitted explanatory variable, which could be addressed through the application of spatial error models. The participation models, in line with expectations demonstrated this, with the spatial error results having the lowest AIC indicating stronger model quality compared to the lag and OLS models. These participation (and spatial error) models also had markedly better model quality, compared with the overall expenditure models. For example, the spatial error model for the AEP participation model was reduced by 3324 compared to the AEP expenditure error model.

It is assumed that the differences in model quality and the significance of the spatial lag models are due to data accuracy between the two variable types. For instance, in order to account for accuracy in the methods each of the variables were standardised: with expenditure to parish UAA size, and participation as proportion of the number of holdings per parish. Yet the analysis was constrained by the available datasets. An alternative for standardising expenditure would be the number of hectares of land under AEP contract since AEP options are predominantly area based e.g. expenditure per ha (Scottish Government, 2011a). This would provide a more accurate calculation of expenditure per ha compared to the expenditure per total UAA ha, as AEP options are more likely applied to a 'proportion' of a farm holding's land area, rather than to the whole UAA. Alternatively, if AEP and option area coverage datasets were available, model quality could be improved by reducing the AIC of the error model. However the associated explanatory variables would not be expected to alter significantly, as hectares under AEP contracts would still correspond (to an extent) with the analysed UAA parishes.

Table 4. Summary of spatial error model results; significant explanatory variables and coefficients per dependent variable

	AEP pay	AEP %	Habitat pay	Habitat %	Water pay	Water %	Bird pay	Bird %
FARM-LEVEL VARIABLES								
Ownership								
Common grazing							0.08 **	
Owned land							-0.04 **	
Rented agricultural		0.06 **		0.04 *		0.04 **		
Farm types								
Grass land > 5 years								0.08 *
Crops and fallow land						0.12 **		0.18 ***
Unspecified crops			-107.97 ***			-6.05 *		
Vegetables land								-3.16 ***
Other crops			82.68 ***					
Woodland	-0.50 *					-0.17 **		
Labour employment								
Density of Part-time						1.96 *		
Density regular and casual staff		3.32 ***		2.79 ***				2.93 ***
Livestock								
Density cattle				-0.92 **	- 1.13 *	-0.88 ***		-0.73 **
Density of sheep					1.18 ***			
Density of dairy heifers		-5.03**		-4.17 **				-4.02 ***
REGIONAL VARIABLES								
Land capability								
LCA Mixed	0.23 *	0.07***	0.33 ***	0.07 ***	0.08 ***	0.05 ***		
LCA rough	-0.48 ***				-0.07 **	-0.03 **	-0.10 ***	-0.06 ***
LCA arable			0.19 **	0.03**				
LCA improved								-0.03 *
Built up areas	-0.51**				-0.08 *	-0.07 ***	-0.09 **	
Inland water area						-0.25 ***		
Designated areas								
SSSI area	0.69 ***	0.25 ***		0.23 ***	0.24 ***	0.17 ***	0.16 ***	0.16***
Designated areas		-0.13 **		-0.14 ***		-0.09 **		-0.09 **
RSPB reserve							0.79 ***	0.16*
Accessibility and population								
Other urban		-0.07 *						-0.07 **
Accessible rural areas	-0.25 ***	-0.02*		-0.03 **	-0.04 **	-0.02 **	-0.03 **	-0.02 **
Lambda	0.54 ***	0.34 ***	0.58 ***	0.33 ***	0.35 ***	0.39 ***	0.10 **	0.11 **
R²	0.37	0.25	0.42	0.26	0.23	0.28	0.13	0.18

*Key: * p >0.05, ** p> 0.01, *** p >0.001*

4.2 Farming and land capability variables

The range of explanatory variables varied according to dependents, but predominately met expectations. This was indicated by the positive significance of 'rented' and 'common grazing' areas, and 'sheep' as well as LCA for 'mixed' farm type as explanatory variables appearing alternately or mutually between the expenditure and participation models. Meanwhile 'cattle' and 'dairy heifer' densities appeared as negatively significant determinants. As expected, these variables indicate characteristics of extensive farming practices, in keeping with Wynn et al. (2001) and Hynes and Garvey (2009) findings, as a positive influence on AEP uptake.

Yet in contrast to expectations 'rough grazing' was a negatively influencing factor in a number of the participation and expenditure models. However, by examining the LISA clustering map (Fig. 4) the visible clustering of patterns in the north eastern region of Scotland provides a potential explanation. These regional clusters appear in areas of predominately 'arable' and 'mixed' farm types, both of which are positive significant variables in the AEP and habitat management models (SNH, 2013). Moreover, these

regions also include a high number of applications funded for 'hedgerow development' options. As identified earlier, hedgerow management is one of the most commonly adopted AEP options in Scotland (Scottish Government 2011a).

This observation on hedgerows options also indicates the link between uptake and spending patterns with AEP option eligibility criteria. In line with expectations, more generally applicable options such as hedgerows with undemanding entry conditions are more commonly adopted (Wilson and Hart, 2001). Additionally, hedgerow option uptake will be determined by the bio-physical context, as hedgerows are less suited to areas of 'rough grazing'; habitats that are limited by difficult physical and climatic conditions (Scottish Government, 2008).

Overall average uptake and expenditure still occur in rough grazing areas, i.e. in the western and north western regions of Scotland. This is indicated by the lack of significant clusters on the AEP LISA maps. This may also explain why 'inland water' is negatively associated in all the participation models; as 'inland water' mostly in the form of lochs, are prevalent in the rough grazing regions, e.g. the Western Highlands. Additionally where large areas of inland water persist in parishes, agricultural land management will not be viable.

Likewise, the percentage of 'woodland' was negatively associated with AEP and water habitat expenditure. These results were expected as the AEP options are directed at agricultural businesses rather than forestry, with the main forestry related options present in other Axis 2 measures (Scottish Government, 2011).

Labour variables were only significant in the participation models. The density of 'regular and casual' staff showed strong positive significance, which logically indicates that the higher the density of workers in the parish, the higher the number of holding uptakes. This finding corresponds with Dupraz et al.'s (2002) research that argues that AEP participation costs are high and may be dependent on the opportunity costs of on-farm labour. Additionally, results suggest that labour intensive conservation practices are more likely to be taken up by farmers with an excess of labour in times of workload peaks (Dupraz et al., 2002; Defrancesco et al., 2008).

4.3. Regional variables

In terms of accessibility and population, 'accessible rural', and 'other urban' areas both had a negative significant relationship across the expenditure and participation models. This was largely expected since any agri-holding can apply for funding even those classified in urban areas; yet the needs of 'rural' communities are prioritised in the RDP (Scottish Government, 2008). Nevertheless, the rural urban classification variables did not provide as much insight into AEP adoption as anticipated, possibly due to the broad classifications of rural and urban areas. Further differentiation within the area classifications could provide a better understanding of the relationship between AEP, accessibility and population.

However, the explanatory variables related to designated sites did provide insights into the national targeting efforts of the Scottish Government or the Non-Governmental Organisation, RSPB. Only 'SSSI'

had a significant positive association, whilst the amalgamated 'designated areas' were significantly negative. This suggests that SSSIs are primarily connected with AEP participation and expenditure, whilst the other nationally important designated sites such as SAC, SPA's and Ramsar are not. The latter sites are aimed at bird conservation and mostly situated in wetlands, estuaries, and lochs and coastal habitats, which potentially are less suitable for AEP, which probably explains the negative relationship (Scottish Government, 2011g). This explanation is supported further by the negative significance of inland water for participation in water habitat options. Additionally, 'RSPB reserves' had a significant positive relationship in all the bird conservation models. These reserves are privately owned by the RSPB and primarily support bird conservation (RSPB, 2011). This suggests that the RSPB has been successful in gaining contracts and funding for AEP land management that promotes bird conservation.

5. Conclusions

The EU CMEF guidelines require Member States to assess individual RDP measures, as opposed to the individual options (COM, 2006). The research presented here provides insights into AEP as a whole measure, but also assists in understanding the varying pattern of uptake and expenditure between option groups. Thus for Member States that have, as with Scotland for AEP, a high number and range of options under a single measure, an analysis of option groups could provide more informative insights into policy performance. Alternatively a breakdown into singular options would likely identify more specific trends and perhaps more homogenous distributions of uptake, but as a national policy assessment this would add complexity. For regional decision-makers, however, such as the RPACs in Scotland, an individual option analysis at a regional scale would be more suitable, accounting for the regional diversity in land characteristics and the specifics of option eligibility.

The low predictive capacity of the models meant that a strong explanation of the variance in the dependent variables was not possible. This is consistent with findings from other studies on AEP in which participation in schemes could be attributed to a large number of factors such as policy design, individual behaviour and attitudes (Wilson and Hart, 2000; Siebert et al., 2006; Edwards-Jones, 2006; Ruto and Garrod, 2009). Siebert et al. (2006), assert that participation is likely to be influenced by an 'intricate interaction of contingencies' between many variables. For RP this is especially likely to be the case considering the voluntary and competitive nature of the scheme. For instance, decisions are made by applicants not only about whether to apply, but also by the government authorities who design and implement policy, and assess and score applicant proposals.

In summary the spatial approach has provided broad insights into AEP participation and expenditure determinants indicating how and where policy priorities have been met. In the absence of explicit quantified measure and option targets, spatial econometrics has provided examples of how eligibility and scoring criteria can be used to assist in policy evaluation. The importance of particular explanatory

variables such as farming characteristics, land capability, designated sites, and accessibility and population for the corresponding dependent variables of the AEP measure and option group participation and expenditure was, in most cases, as hypothesised. The study has provided, therefore, quantitative evidence about which explanatory variables concerning farm types, labour, and ownership are more likely to adopt AEP, according to option eligibility as well as how these environmentally centred AEP options meet national targets.

For instance, the RSPB and SSSI results indicate that targeting efforts by government and NGOs can be effective. From a policy perspective these are informative results in relation to how national targets are being met. The scoring process is designed to prioritise AEP applications located in SSSI sites, and as the results of this study indicate, this has been effective (Scottish Government, 2009). However the environmental benefits of AEP option uptake at these sites is not yet apparent. Furthermore, the other nationally targeted designated sites (SAC, SPA and Ramsar), were negatively associated with AEP participation, suggesting further policy efforts are required to improve agri-environmental management uptake in these areas.

Furthermore, habitats outside of SSSIs and designated zones, termed here the 'wider countryside', might be at risk of not being sufficiently competitive to receive funding under the current scoring system, despite the capacity to meet option objectives. This suggests that policy targeting for RP may need to develop further towards support for 'wider countryside' applications, in order to promote and manage biodiversity, especially to reduce the impacts of already fragmented protected habitat areas (Sutherland et al., 2006; Jackson et al., 2009).

The results presented here provide a potential policy tool for the evaluation of the extent and expenditure of the RDP measures, contributing to the understanding at a national level of the spatial patterns and determinants of policy implementation. Understanding spatial participation may reduce the risk of 'implementation deficit' by determining how policy objectives in terms of initial uptake and spending are being met. Moreover, understanding the potential determinants could guide and emphasise the importance of future targeting efforts to option level, and make these spatially explicit. Such actions are especially important with respect to the proposed reforms of the CAP, which aim at 'encouraging agri-environmental initiatives' as well as 'better targeted income support' looking towards future challenges post 2020 (COM, 2012a; 2012b; 2012c). In addition there is a "need for a more radical and geographically-defined strategy of targeting" as argued by Potter et al. (1993, p.200) especially as RDP undergoes reform and proposed CAP spending cuts become reality (Marsden, 2011; COM, 2012c).

Acknowledgments

Bibliography

Akaike, H. (1973) Information Theory as an Extension of The Maximum Likelihood Principle, 2nd International Symposium on Information Theory in B. N. Petrov and F. Csaki, (eds), Budapest, Akademiai Kaido, 267-281.

Anselin, L. (1988) Spatial Econometrics: Methods and Models, Kluwer Academic, Dordrecht.

Anselin, L, (1995) Local Indicators of Spatial Association- LISA, Geographical Analysis, 27 (2), 93-115.

Anselin, L. (2002) Under the Hood; Issues In The Specification And Interpretation Of Spatial Regression Models, Agricultural Economics, 27 (2), 247-267.

Anselin, L. (2005) Exploring Spatial Data with GeoDaTM: A Workbook, Center for Spatially Integrated Social Science, Urbana, Illinois.

Anselin, L., Gallow, J.H., Jayet, H. (2008) Spatial Panel Econometrics, In: Mátyás, L., Sevestre, P. eds. The Econometrics of Panel Data: Fundamentals and Recent Developments in Theory and Practice, Advanced Studies in Theoretical and Applied Econometrics, Springer Berlin Heidelberg, 46, 625-660.

Baker, D. J., Freeman, S. N., Grice, P.V., Siriwardena, G.M. (2012) Landscape-Scale Responses of Birds to Agri-Environment Management: a Test of the English Environmental Stewardship Scheme, Journal of Applied Ecology, 49 (4), 871–882.

Bartolini, F., Raggi, M., Viaggi, D. (2012) A spatial analysis of participation in RDP measures: a case study in Emilia Romagna Region, 1st AIEAA (Associazione Italiana Di Economia Agraria E Applicata) Conference 'Towards a Sustainable Bio-economy: Economic Issues and Policy Challenges, Italy, Trento.

Buchan, K., Matthews, K., Miller, D., Towers, W. (2010) Modelling Scenarios for CAP Pillar 1 Area Payments Using Macaulay Land Capability for Agriculture (& Less Favoured Area Designations), Final Report, The Macaulay Land Use Research Institute.

Bozdogan, H. (1987). Model Selection And Akaike's Information Criterion (AIC): The General Theory and its Analytical Extensions, Psychometrika, 52 (3), 345-370.

Brady M., Irwin E. (2010) Accounting for Spatial Effects in Economic Models of Land Use: Recent Developments and Challenges Ahead, Environmental Resources Economics, 48 (3), 487–509.

Brouwer, F. (1998) Nitrogen balances at farm level as a tool to monitor effects of agri-environmental policy, Nutrient Cycling in Agroecosystems, 52 (2/3), 303-308.

Cliff, A.D. and Ord, J.K. (1973) Spatial Autocorrelation, Pion, London.

COM (2005) Council Regulation (EC) No 1698/2005 of 20 September 2005 on support for rural development by the European Agricultural Fund for Rural Development (EAFRD), Official Journal of the European Union, Commission of The European Communities (COM).

COM (2006) Rural Development 2007-2013; Handbook on Common Monitoring and Evaluation Framework, Guidance document, Directorate General for Agriculture and Rural Development, Commission of the European Communities (COM), Brussels.

COM (2012a) Legal proposals for the CAP after 2013, Commission of the European Communities (COM), Brussels: http://ec.europa.eu/agriculture/cap-post-2013/legal-proposals/index_en.htm [Accessed 17/09/2012]

COM (2012b) Proposal for a new EU Environment Action Programme to 2020, Commission of the European Communities (COM), Brussels: http://ec.europa.eu/environment/newprg/index.htm [Accessed 03/01/2013]

COM (2012c) Concept paper: Agricultural Council; Greening, Commission of the European Communities (COM), Brussels: http://ec.europa.eu/agriculture/cap-post-2013/legal-proposals/concept-paper-on-greening_en.pdf [Accessed 03/01/2013]

Concepción, E.D., Díaz, M., Baquero, R.A. (2008) Effects of Landscape Complexity on the Ecological Effectiveness of Agri-Environment Schemes, Landscape Ecology, 23 (2), 135-148.

Cooper, T., Hart, K., Baldock, D. (2009) Provision of Public Goods through Agriculture in the European Union, Report Prepared for DG Agriculture and Rural Development, Contract No 30-CE-0233091/00-28, Institute for European Environmental Policy, London

Corrado, L., Fingleton, B. (2012) Where Is the Economics in Spatial Econometrics? Journal of Regional Science, 52 (2), 210-239.

Crabtree, J. R., Thorburn, A., Chalmers, N., Roberts, D., Wynn, G., Barron, N., Macmillan, D., Barraclough, F. (1999) Socio-Economic and Agricultural Impacts of the Environmentally Sensitive Scheme in Scotland, MLURI Economics and Policy Series 4., Macaulay Land Use Research Institute, Aberdeen.

Defrancesco, E., Gatto, P., Runge, F., Trestini, S. (2008) Factors Affecting Farmers' Participation in Agri-environmental Measures: A Northern Italian Perspective, Journal of Agricultural Economics, 59 (1), 114–131.

Dupraz, P., Vanslembrouck, I., Bonnieux, F., Huylenbroeck, G.V. (2002) Farmers' Participation in European Agri-Environmental Policies, Paper prepared for presentation at the Xth EAAE Congress 'Exploring Diversity in the European Agri -Food System', Zaragoza, Spain.

Edwards-Jones, G. (2006) Modelling Farmer Decision-Making: Concepts Progress and Challenges, Animal Science, 82 (6), 783-790.

ERSI (2012) Environmental Systems Research Institute; Modelling Spatial Relationships: http://resources.esri.com/help/9.3/ArcGISengine/java/Gp_ToolRef/spatial_statistics_toolbox/modeling_spatial_relationships.htm [Accessed 10/12/2012]

Evans, N.J., Morris, C. (1997) Towards a Geography of Agri-environmental Policies in England and Wales, Geoforum, 28 (2), 189-204.

Ferrari, S., Rambonilaza, M. (2009) Agricultural Activities, Rural Areas and Natural Environment: Drawing Up the Frontiers of the Multifunctionality Concept, In; Piorr, A., Müller, K. eds. Rural Landscapes and Agricultural Policies in Europe, Springer-Verlag, Berlin, 21-34.

Finger, R., Benni, N.E. (2013) Farmers Adoption of Extensive Wheat Production - Determinants and Implications, Land Use Policy, 20 (1), 206-213.

Gabriel, K. R. Sokal, R. R. (1969) A new statistical approach to geographic variation analysis, Systematic Zoology (Society of Systematic Biologists) 18 (3), 259–270.

Gibbons, S., Overman, H.G. (2012) Mostly Pointless Spatial Econometrics? Journal of Regional Science, 52 (2), 172–191.

Guillem, E.E., Barnes, A.P., Rounsevell, M.D., Renwick, A. (2012) Refining Perception-Based Farmer Typologies With the Analysis of Past Census Data, Journal of Environmental Management,110, 226-235.

Henderson-Sellers, A., Wilson, M.F., Thomas, G. (1985) The Effect of Spatial Resolution on Archives of Land Cover Type, Climatic Change, 7 (4), 391-402.

Hodge, I. (2012) Agri-Environment Policy In An Era of Lower Government Expenditure: CAP Reform and Conservation Payments, Journal of Environmental Planning and Management, 1, 1-17.

Hynes, S., Farrelly, N., Murphy, E., O'Donoghue, C.O. (2008) Modelling Habitat Conservation and Participation in Agri-Environment Scheme: A Spatial Microsimulation Approach, Ecological Economics, 66, 258-269.

Hynes, S., Garvey, E. (2009) Modelling Farmers' Participation in an Agri-environmental Scheme using Panel Data: An Application to the Rural Environment Protection Scheme in Ireland, Journal of Agricultural Economics, 60 (3), 546-562.

IIED (2005) 'Stakeholder Power Analysis', International institute for Environment and Development (IIED): http://policy-powertools.org/Tools/Understanding/docs/stakeholder_power_tool_english.pdf [Accessed 23/11 /2011]

Imperial, M.T. (1999) Institutional Analysis and Ecosystem Based Management: The Institutional Analysis and Development Framework, Environmental Management, 24 (4), 449-465.

Jackson, S.F., Walker, K., Gaston, K.J. (2009) Relationship between Distributions of Threatened Plants and Protected Areas in Britain, Biological Conservation, 142 (7), 1515–1522.

JHI (2013) James Hutton Institute (JHI) Land Capability: http://www.hutton.ac.uk/research/themes/delivering-sustainable-production-systems/soils/land-capability [Accessed 13/1/13]

Juvančič, L., Travnikar, T., Glavan M., Cvejić R., Pintar M. (2012) Targeting and Spatial Impacts of Agri-Environmental Support: Spatial Econometric Analysis of Agri–Environmental Measures in Slovenia, Paper prepared for presentation at the 132nd Seminar of the EAAE, Skopje.

Kazar, B.M., Celik, M. (2012) Spatial AutoRegression (SAR) Model: Parameter Estimation Techniques, Springer, New York.

Kim, C.W., Phipps, T.T., Anselin, L. (2003) Measuring The Benefits of Air Quality Improvement: A Spatial Hedonic Approach, Journal of Environmental Economics and Management, 45 (1), 24–39.

Kleijn, D., Sutherland, W. (2003) How effective are European agri-environment schemes in conserving and promoting biodiversity? Journal of Applied Ecology, 40 (6), 947–969.

Kleijn, D., Berendse, F., Smit, R., Gilissen, N., Smit, J., Brak, B., Groeneveld, R. (2004) Ecological Effectiveness of Agri-Environment Schemes in Different Agricultural Landscapes in The Netherlands, Conservation Biology, 18 (3), 775–786.

LeSage, J.P. (1997) Regression Analysis of Spatial Data, Journal of Regional Policy and Analysis, 27 (2), 83-84.

LeSage, J.P., Pace, R.K. (2009) A Matrix Exponential Spatial Specification, Journal of Econometrics, 140 (1), 190-214.

Matula, D.W., Sokal, R.R. (1980) Properties of Gabriel Graphs Relevant to Geographic Variation Research and the Clustering of Points in the Plane, University Press, Ohio.

Marsden, K (2011) CAP Reform – Legislative Approaches, SPICe Scottish Parliament Information Centre, Research Briefing, Edinburgh, Scotland

Meentemeyer, V., Box, E.O. (1987) Scale effects in landscape studies. In: Turner, M.D. ed. Landscape heterogeneity and disturbance, Springer-Verlag, New York, 15-34.

Moran, P.A.P. (1948) The Interpretation of Statistical Maps, Journal of the Royal Statistical Society. Series B (Methodological), 10 (2), 243-251.

Morton, D., Rowland, C., Wood, C., Meek, L., Marston, C., Smith G., Wadsworth R., Simpson, I. C., (2011) Final Report for LCM2007 – the new UK Land Cover Map CS Technical Report No 11/07, Centre for Ecology & Hydrology.

Overmars, K.P., de Koning, G.H.J., Veldkamp, A. (2003) Spatial Autocorrelation in Multi-Scale Land Use Models, Ecological Modelling, 164 (2/3), 257–270.

Paelinck, J., Klaassen, L. (1979) Spatial Econometrics, Saxon House, Farnborough.

Paraguas, F.J., Kamil, A.A. (2005) Spatial Econometrics Modelling of Poverty, Proceedings of the 8th WSEAS International Conference on Applied Mathematics, Spain, Tenerife, 159-164.

Partridge, M.D., Boarnet, M., Brakman, S., Ottaviano, G. (2012) Introduction: Whither spatial econometrics? Journal of Regional Science, 52 (2), 167-171.

Peco, B., Malo, J.E., Oñate, J.J., Suárez, F., Sumpsi, J.M. (1999) Agri-environmental indicators for extensive land-use systems in the Iberian Peninsula, In: Brouwer, F., Crabtree, R. eds. Agriculture and Environment in Europe: The Role of Indicators in Agricultural Policy Development, CAB International, The Hague, 137-156.

Poláková, J., Tucker, G., Hart, K., Dwyer, J., Rayment, M. (2011) Addressing biodiversity and habitat preservation through Measures applied under the Common Agricultural Policy, Report Prepared for DG Agriculture and Rural Development, Institute for European Environmental Policy: London.

Potter, C., Cook, H., Norman, C. (1993) The Targeting of Rural Environmental Policies: an Assessment of Agri Environmental Schemes in the UK, Journal of Environmental Planning and Management, 36 (2), 199-216.

Princé, K., Mouss, J.P., Jiguet, F. (2012) Mixed Effectiveness of French Agri-Environment Schemes for Nationwide Farmland Bird Conservation, Agriculture, Ecosystems & Environment, 149 (1), 74-79.

Primdahl, J., Peco, B., Schramek, J., Andersen, E., Onate, J.J. (2003) Environmental Effects of Agri-Environmental Schemes In Western Europe, Journal of Environmental Management, 67 (2), 129-138.

RSPB (2007) RSPB Reserves 2007: http://www.rspb.org.uk/Images/reserves2007_tcm9-212718.pdf [Accessed 17/04/2012]

RSPB (2011) An Assessment of the Likely Effectiveness of the Scotland Rural Development Programme 2007-2013 in Delivering for the Environment, Royal Society of Protection of Birds, RSPB Scotland External Communication.

RuDi (2010) Final Conference of the FP 7 project Assessing the Impacts of Rural Development Policies (incl. LEADER), Extended Policy Brief, RUDI (Assessing the impact of rural development policies).

Ruto, E., Garrod, G. (2009) Investigating Farmers' Preferences for the Design of Agri-Environment Schemes: A Choice Experiment Approach, Journal of Environmental Planning and Management, 52 (5), 631-647.

Schmidtner, E., Lippert, C., Engler, B., Häring, A.M., Aurbacher, J., Dabbert, S. (2012) Spatial distribution of organic farming in Germany: does neighbourhood matter? European Review of Agricultural Economics, 39 (4), 661–683.

Scottish Government (2008) Scottish Rural Development Programme 2007–2013, Rural Development Regulation (EC) No 1698/2005. Scottish Government, Edinburgh http://www.scotland.gov.uk/Publications/2010/05/05134234/0 [Accessed 12/2/2011]

Scottish Government (2010a) Mid Term Evaluation of Scotland Rural Development Programme, Report for Scottish government, P.L. Cook and partners

Scottish Government (2010b), Scottish Government Urban/Rural Classification 2009 – 2010, Scottish Government Geographic Information Science & Analysis Team

Scottish Government (2011a) SRDP: Rural Priorities - How it Works: http://www.scotland.gov.uk/Topics/farmingrural/SRDP/RuralPriorities/HowItWorks [Accessed 23/2/2011]

Scottish Government (2011b) Changes to Rural Priorities Q & A: http://www.scotland.gov.uk/Topics/farmingrural/SRDP/RuralPriorities/KeyFacts/RPchangesQandA [Accessed 17/04/2012]

Scottish Government (2011c) Corncrakes: http://www.scotland.gov.uk/Topics/farmingrural/SRDP/RuralPriorities/Packages/Corncrakes [Accessed 17/04/2012]

Scottish Government (2011d) National Statistics - Rural Scotland Key Facts 2011: http://www.scotland.gov.uk/Publications/2011/09/29133747/0 [Accessed 8/11/12]

Scottish Government (2011e) Management of species rich grassland:http://www.scotland.gov.uk/Topics/farmingrural/SRDP/RuralPriorities/Options/SpeciesRichGrassland [Accessed 24 /09 /2012]

Scottish Government (2011f) Wild Bird Seed Mix/Unharvested Crop: http://www.scotland.gov.uk/Topics/farmingrural/SRDP/RuralPriorities/Options/WildBirdSeedMix [Accessed 24 /09 /2012]

Scottish Government (2011g) Protected nature sites: http://www.scotland.gov.uk/Topics/Environment/Wildlife-Habitats/protectedareas [Accessed 14 /02 /2013]

Scottish Government (2012a) Land - Statutory Designated Areas: http://www.scotland.gov.uk/Topics/Statistics/Browse/Environment/TrendDesignatedAreas [Accessed 24 / 09 /2012]

Scottish Government (2012b) Initial Assessment of the Potential Impacts on Land Use and Environment Associated with Changes to CAP Support, Edinburgh: http://www.scotland.gov.uk/Resource/0038/00385668.pdf [Accessed 5 / 3 /2013]

Scottish Government (2012c) Management of Hedgerows: http://www.scotland.gov.uk/Topics/farmingrural/SRDP/RuralPriorities/Options/Hedgerows [Accessed 5 / 3 /2013]

Siebert, R., Toogood, M., Knierim, A. (2006) Factors Affecting European Farmers' Participation in Biodiversity Policies, Sociologia Ruralis, 46 (4), 318-340

SNH (2013) Scottish Natural Heritage (SNH):Farming and the Environment/wildlife; http://www.snh.gov.uk/land-and-sea/managing-the-land/farming-crofting/farming-wildlife/livestock-dairy/ [Accessed 12 / 07 / 2013]

Sutherland, W.J., Armstrong-Brown, S., Armsworth, P. R., Brereton, T., Brickland, J., Campbell, C. D., Chamberlain, D. E., Cooke, A. I., Dulvy, N. K., Dusic, N. R., Fitton, M., Freckleton, R. P., Godfray, H.

C., Grout, N., Harvey, H. J., Hedley, C., Hopkins, J. J., Kift, N. B., Kirby, J., Kunin, W. E., MacDonald, D. W., Markee, B., Naura, M., Neale, A.R., Oliver, T., Osborn, D., Pullin, A. S., Shardlow, M. E. A., Showler, D. A., Smith, P. L., Smithers, R. J., Solandt, J.-L., Spencer, J., Spray, C. J., Thomas, C. D., Thompson, J., Webb, S. E., Yalden, D.W. & Watkinson, A. R. (2006) The Identification Of One Hundred Ecological Questions Of High Policy Relevance In The UK, Journal of Applied Ecology, 43 (4), 617-627.

Steel, D.G., Holt, D. (1996) Analysing and Adjusting Aggregation Effects: The Ecological Fallacy Revisited, International Statistical Review, 64 (1), 39-60.

Tita, G.E., Radil, S.M., (2010) Spatial Regression Models in Criminology: Modelling Social Processes in the Spatial Weights Matrix, In: Piquero, A.R., Weisburd, D. eds. Handbook of Quantitative Criminology, Springer, New York, 101-121.

Tobler, W.R. (1970) A Computer Movie Simulating Urban Growth in the Detroit Region, Economic Geography, 46, 234-240.

Uthes, S., Matzdorf, B., Müller, K., Kaechele, H. (2010) Spatial Targeting of Agri-Environmental Measures: Cost-Effectiveness and Distributional Consequences, Environmental Management, 46, 494-509.

Ward, M.D., Gleditsch, K.S. (2008) Spatial Regression Models, Sage Publications Inc., Thousand Oaks.

Weale, A. (1992) The New Politics of Pollution, Manchester University Press, Manchester

Wilson, G.A. (1997) Selective Targeting in Environmentally Sensitive Areas: Implications for Farmers and the Environment, Journal of Environmental Planning and Management, 40 (2), 199-216.

Wilson G.A., Hart, K. (2000) Financial Imperative or Conservation Concern? EU Farmers' Motivations for Participation in Voluntary Agri-Environmental Schemes, Environment and Planning A, 32 (12), 2161-2185.

Winter, M. (1996) Rural Politics: Policies for Agriculture, Forestry, and the Environment, Routledge, London.

Wright, I.A., Birnie, R.V., Malcolm, A., Towers, W., McKeen, M (2006) The Potential Use of the Land Capability for Agriculture Classification for Determining Support to Disadvantaged Areas of Scotland, The Macaulay Institute.

Wynn, G., Crabtree, B., Potts, J. (2001) Modelling Farmer Entry into the Environmentally Sensitive Area Schemes in Scotland, Journal of Agricultural Economics, 52 (1), 65-82.

Van der Horst, D. (2007) Assessing the Efficiency Gains of Improved Spatial Targeting of Policy Interventions; The Example of an Agri-Environmental Scheme, Journal of Environmental Management, 85 (4), 1076-1087.Vandermeulen, V., Verspecht, A., Huylenbroeck, G.V., Meert, H., Boulanger, A., Hecke, E.V. (2006) The Importance of the Institutional Environment on Multifunctional Farming Systems in the Peri-Urban Area of Brussels, Land Use Policy, 23 (4), 486–501.

Vehkala, M., Vainio, A. (2000) Luonnonsuojelun yhteiskunnallinen ulottuvuus (The social dimension of nature conservation) (Vaasa: Research Institute at the University of Vaasa)