Spatial Analysis of Rural Development Measures
Contract No. 244944

Work Package No. 5

August 2012

D5.2_UEDIN

Calibration of model and estimation - SCOTLAND -

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Document status

Public use	
Confidential use	X
Draft No.1	24/08/2012
Final	
Submitted for internal review	Date

COOPERATION

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1. Introduction

SPARD D5.2 aim is to model the participation of selected rural development programme (RDP) at case study level, in the Scottish example this is at a national level in which the RDP is designed (NUTS1). This study focuses on current Scottish rural development policy (SRDP) using data from 2008 – 2011 in terms of voluntary participation on the following selected RDP measures:

121 Modernisation of agricultural holdings (Axis one)

214 Agri environment payments (Axis two)

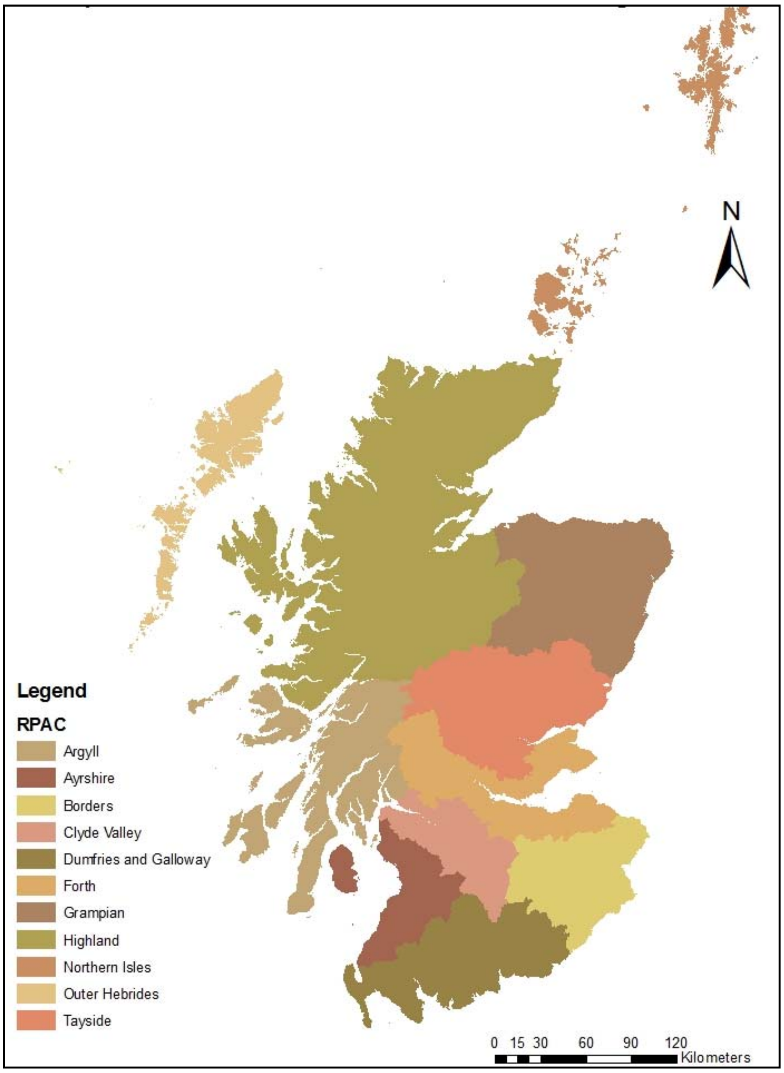
311 Diversification into non-agricultural activities (Axis three)

2. Background info and specificities of the case study region

The total SRDP is worth around € 2 billion and has incorporated both the European Union (EU) rural development objectives, and Scotland's own national objectives for delivering outcomes which benefit the Scottish people, whilst helping to make Scotland 'greener', (SEERAD, 2007). There are 'eight' delivery scheme mechanisms for the RDP in Scotland, however this study will focus on the one of the eight the scheme Rural Priorities (RP) which aims to deliver targeted environmental, social and economic benefits. RP is one of the most prominent delivery mechanisms of the SRDP as well as one of the highest funded schemes with a total committed expenditure of € 321.6 million in 2010 (Scottish Government data, 2010).

Rural priorities as one of the 'tiers' of the Rural development Contracts (RDC's), is a 'competitive process', where all types of rural land managers can compete for funding dependent on their ability to meet regional priorities of that area and other eligibility criteria. The scoring is based on regional priorities, which are derived from a menu list of general national priorities and aim to indicate which outcomes are most important considering that regions social, economic and environmental needs (Scottish Government, 2009). The Regional Priorities are determined by the Regional Proposal Assessment Committee (RPAC) from each of the 11 RPAC regions (Map.1).

This study will use spatial econometrics to model the patterns and relationships between option uptake and expenditure of RP across Scotland. The aim will be to decipher what variables whether environmental, agricultural or socio-economic could be considered determinants of option uptake and extent and whether these are spatially dependent.



MAP 1. RPAC regions of Scotland (total number of regions =11)

The main specificities of the Scottish case study background can be found in D5.1, the main points are presented below:

- Data availability and patterns of uptake maybe influenced by the regional RPAC areas, illustarated in Map 1 above. Largely as the RP scheme is adminstered at this regional level.
- Scotlands is part of the Isles of Great Britain and has 790 smaller islands.

- There was a reported 52,508 farm holdings in Scotland in 2011, combining the total land covered by common grazing and sole right land is 76 % of Scotland's total land area as utilised area for agriculture (UAA), covering 6.2 million hectares (Scottish Government data, 2010).

- Common grazings alone cover 7 % of Scotland total land area a total of 583,331 hectares (ha), mainly in the Western Highlands and Islands (Scottish Government data, 2011).

- The largest agricultural land use is rough grazing 57 %, with 24 % as grassland, and just 10 % used for crops or left fallow (Scottish Govenment, 2010a). The most prominent farm types are illustrated in Figure 2. The figure shows that the most common farm type is 'Other' with 23,732 holdings, these farms mainly consist of Specialist grass and forage farm types. Cattle and sheep (LFA) is second most common with around 13,753 holdings many of which would include crofters. As a whole Scotland has 18 % (1.80 million) of the total cattle in the UK and 21 % (6.80 million) of the UK sheep (RESAS, 2012).

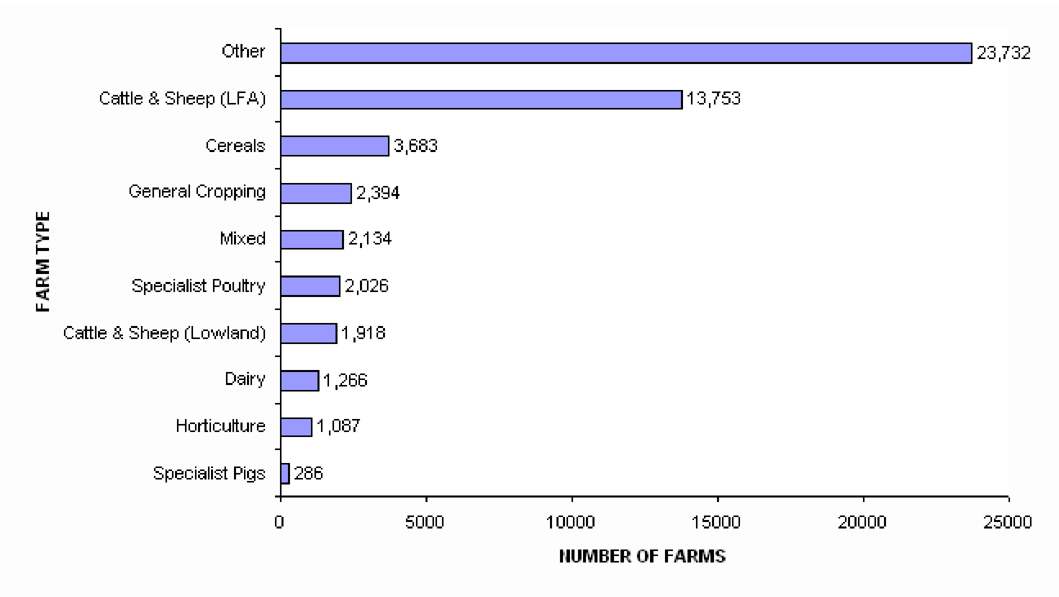


Figure 1. Total Number of farm holdings per farm type (Scottish Government, 2011)

- 85 % of Scotland is designated as LFA (less-favoured area) and typically around 13,000 farms and crofts that will apply for LFA support each year (SEERAD, 2007).

- In economic terms the actual Gross Value Added (GVA) contribution of Scotland's agriculture to the United Kingdom's (UK) total GVA in 2010 was just 0.8 % (£ 654 million) (Scottish Government, 2010a).

- The total number of holdings and total UAA hectares has fluctuated over recent years, as can be seen in Figure 2. A gradual increase in total holdings has occured, whilst the total UAA (Utilised Agricultural Area) ha, had a large decrease in 2009 and levelled out again in 2010 (Scottish Government data, 2011).

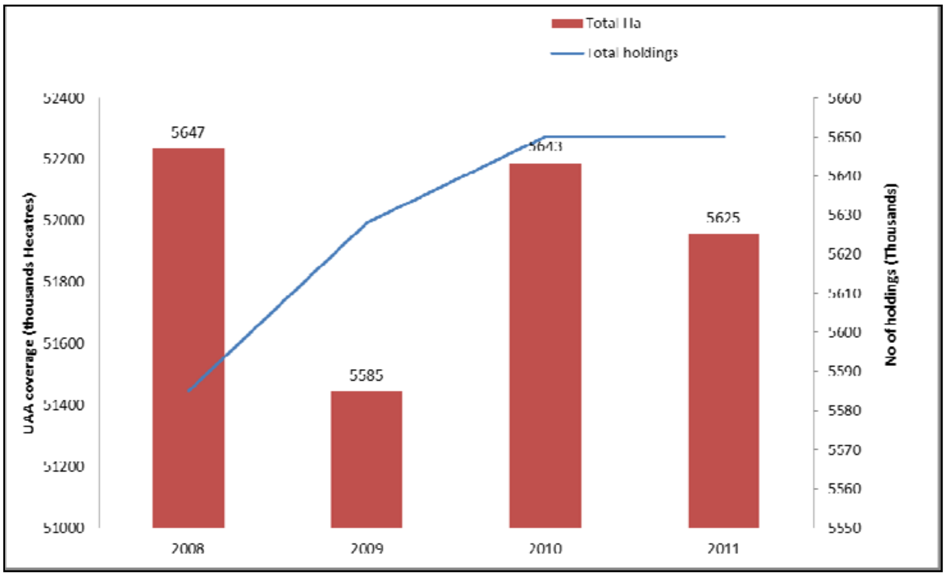


Figure 2. Total number of holdings and hectares of UAA across Scotland from 2008 – 2011 (Scottish Government data, 2011)

- As determined with D4.1 there have been many issues with data availability at NUTS 2 and 3 and also tests have revealed that lower spatial analysis might prove to show more significance due to more localised effects. The smallest territorial unit for data availability in Scotland is at Agricultural parish level (Appendix 1). A parish is defined as a'a small administrative district typically having its own church and a priest or pastor' (Oxford Dictionary, 2012). Scotland's agricultural parishes can be dated back to 1845 and were originally based on the Church of Scotland. These were abolished as an administrative unit in Scotland in 1975. However Agricultural parishes continue to be used for boundary and statistical purposes. There are now 891 agricultural parishes in Scotland and they are used in the Agricultural Census and for the payment of farming grants and subsidies and this is the level at which the data for this research project has been provided.

- There are 68 options and sub options that come under measure 214, which each have have varying eligability criteria and management actions to meet either broad or more targeted objectives. As a result it was decided for the purposes of this research that further classification of this measures options would predictably lead to varying explanatory variables and perhaps a more likely attempt to explain model variance. The five catergories include; species control (total 6 options), organic (total 8 options), bird conservation (total 12 options), water habitats (total 10 options), habitat management (total 32 options). Figure 3 illustrates the number of holdings uptake per measure 214 catergory betwen 2008 and 2011. Due to the small number of holdings uptake for catergories 'species control' and 'organic' options there will be no further analysis on these groups. For further details for the options contained within the catergories see Appendix 4.

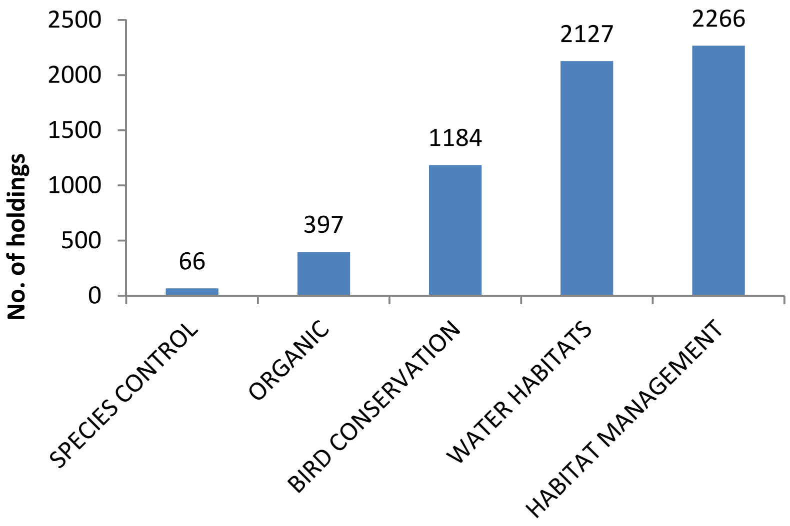


Figure 3. Total number of holdings uptake per category of measure 214, Scotland (Scottish Government data, 2008 – 2012)

3. Cross-measure issues in setting up the analysis

3.1 Dependent variables

The analysis focuses on the measures 121, 214 and 331, the dependent variables were derived using Scottish Government SRDP data and agri-census data:

3.1.1 Measure 121 Diversification of Agriculture (inc. six sub-schemes): (Total cases 1382 / 1055 holdings)

- Percentage of beneficiaries (holdings) receiving payments for measure 121 [AB]

$$\boldsymbol{Indic\_121\_benef} = \frac{\sum_{2008}^{2011} Nb\ of\ 121\ beneficiaries\ per\ parish}{Nb\ of\ farms\ per\ parish\ in\ 2011} X\ 100$$

- Payments per ha UAA for measure 121 [AA]

$$\boldsymbol{Indic\_121\_payment} = \frac{\sum_{2008}^{2011} Measure121\_subsidies\_per\ parish\ \ (£)}{UAA\ (ha) per\ parish\ in\ 2011}$$

3.1.2 Measure 214 Agri-environmental payments (69 schemes and sub-schemes): (Total cases 15,322 / 2,609 holdings)

- Percentage of all beneficiaries (holdings) receiving payments for measure 214 [BB]

$$\boldsymbol{IndicA\_214\_benef} = \frac{\sum_{2008}^{2011} Nb\ of\ 214\ beneficiaries\ per\ parish}{Nb\ of\ farms\ in\ 2011} X\ 100$$

- Payments per hectare UAA for all measure 214 [BA]

$$\boldsymbol{IndicB\_214\_payment} = \frac{\sum_{2008}^{2011} Measure214\ subsidies\ per\ parish (£)}{UAA\ (ha) per\ parish\ in\ 2011}$$

3.1.3 Categorisation of measure 214 options:

3.1.3.1 Habitat management (Total cases 7,990/ 2266 holdings)

- Percentage of beneficiaries (holdings) receiving payments for measure 214 Habitat management options [CA]

$$\boldsymbol{Indic\_214habitat\_benef} = \frac{\sum_{2008}^{\mathbf{2011}} Nb\ of\ 121\ beneficiaries\ per\ parish}{Nb\ of\ farms\ per\ parish\ in\ 2011} X\ 100$$

- Payments per ha UAA for measure 214 Habitat options [CB]

$$\boldsymbol{Indic\_214habitat\_payment} = \frac{\sum_{2008}^{\mathbf{2011}} Measure121\_subsidies\_per\ parish\ \ (£)}{UAA\ (ha) per\ parish\ in\ 2011}$$

3.1.3.2 Bird Conservation (Total cases 1,865/ 1184 holdings)

- Percentage of beneficiaries (holdings) receiving payments for measure 214 Bird Conservation options [DA]

$$\boldsymbol{Indic\_214bird\_benef} = \frac{\sum_{2008}^{\mathbf{2011}} Nb\ of\ 121\ beneficiaries\ per\ parish}{Nb\ of\ farms\ per\ parish\ in\ 2011} X\ 100$$

- Payments per ha UAA for measure 214 Bird conservation options [DB]

$$\boldsymbol{Indic\_214bird\_payment} = \frac{\sum_{2008}^{\mathbf{2011}} Measure121\_subsidies\_per\ parish\ \ (£)}{UAA\ (ha) per\ parish\ in\ 2011}$$

3.1.3.3 Water habitat management (Total cases 5221/ 2127 holdings)

- Percentage of beneficiaries (holdings) receiving payments for measure 214 Water Habitat options [EA]

$$\boldsymbol{Indic\_214water\_benef} = \frac{\sum_{2008}^{\mathbf{2011}} Nb\ of\ 121\ beneficiaries\ per\ parish}{Nb\ of\ farms\ per\ parish\ in\ 2011} X\ 100$$

- Payments per ha UAA for measure 214 Water Habitat options [EB]

$$\boldsymbol{Indic\_214water\_payment} = \frac{\sum_{2008}^{\mathbf{2011}} Measure121\_subsidies\_per\ parish\ \ (£)}{UAA\ (ha) per\ parish\ in\ 2011}$$

3.1.4 Measure 311 Diversification of non-agricultural holdings: (Total 227 holdings)

- Percentage of beneficaires (holdings) recieving payments for measure 311 [FA]

$$IndicA\_311\_benef = \frac{\sum_{2008}^{2011} Nb\ of\ 311\ beneficiaries\ per\ parish}{Nb\ of\ farms\ in\ 2011} X\ 100$$

- Payments per hectare UAA for all measure 311 [FB]

$$IndicB\_311\_payment = \frac{\sum_{2008}^{2011} Measure\ 311\ subsidies\ per\ parish(£)}{UAA\ (ha) per\ parish\ in\ 2011}$$

3.2 Explanatory variables

Table 1. Summary of independent variables at parish level

No.	Independent Variable at parish level	Data Reference variable name	Source
B1	OWNERSHIP: Percentage of common grazings	%_comm_Graz	Scottish Government: Scottish Agri-census data
B2	OWNERSHIP: Percentage of owned agricultural area	%_owned	Agri-census (2010) Scottish Government via Edina
B3	OWNERSHIP: Percentage of rented agricultural area	%_rent	Agri-census (2010) Scottish Government via Edina
B4	OWNERSHIP: Percentage of seasonal rented agricultural land	%_seasonal_rent	Agri-census (2010) Scottish Government via Edina
B5	OWNERSHIP: Percentage of seasonal let agricultural land	%_seasonal let	Agri-census (2010) Scottish Government via Edina
C6	FARMING: Percentage of Total rough grazing	%_rough	Agri-census (2010) Scottish Government via Edina
C7	FARMING: Percentage of Total crops and grass	%_totlcrps&grss	Agri-census (2010) Scottish Government via Edina
C8	FARMING: Percentage of Total grass land less than 5 years old	%_grssless	Agri-census (2010) Scottish Government via Edina
C9	FARMING: Percentage of Total grass land more than 5 years old	%_grssmore	Agri-census (2010) Scottish Government via Edina
C10	FARMING: Percentage of Total other land	%_otherland	Agri-census (2010) Scottish Government via Edina
C11	FARMING: Percentage of Total land	%_totalland	NB: not useful just another total of UAA, has been mottied from analysis
C12	FARMING: Percentage of Total crops and fallow land	%_crps&fllw	Agri-census (2010) Scottish Government via Edina
C13	FARMING: Percentage of Total other crops land	%_othrcrps	Agri-census (2010) Scottish Government via Edina
C14	FARMING: Percentage of Total unspecified crops land	%_unspec	Agri-census (2010) Scottish Government via Edina
C15	FARMING: Percentage of Total vegetables land	%_totalveg	Agri-census (2010) Scottish Government via Edina
C16	FARMING: Percentage of Total woodland	%_wood	Agri-census (2010) Scottish Government via Edina

C17	FARMING: Density of Total glass houses (glass structures)	Density_glass	Agri-census (2010) Scottish Government via Edina
E24	LIVESTOCK: Density cattle per UAA ha	Total_Cattle	Agri-census (2010) Scottish Government via Edina
E25	LIVESTOCK: Density of sheep per UAA ha	Total_sheep	Agri-census (2010) Scottish Government via Edina
E26	LIVESTOCK: Density of l beef heifers per UAA ha	Total_beef	Agri-census (2010) Scottish Government via Edina
E27	LIVESTOCK: Density of dairy heifers per UAA ha	Total-Dairy	Agri-census (2010) Scottish Government via Edina
F28	LABOUR: Density of Full-time occupiers per holdings	FT_Occup	Agri-census (2010) Scottish Government via Edina
F29	LABOUR: Density of Part-time occupiers per holdings	PT_Occup	Agri-census (2010) Scottish Government via Edina
F30	LABOUR: Density of Full-time spouses per holdings	FT_Spouse	Agri-census (2010) Scottish Government via Edina
F31	LABOUR: Density of Part-time spouse per holdings	PT_Spouse	Agri-census (2010) Scottish Government via Edina
F32	LABOUR: Density of regular & casual staff per holdings	Total_Reg_staff	Agri-census (2010) Scottish Government via Edina
D18	BIO-PHYSICAL: Percentage of land capable for supporting arable agriculture	%_arable LCA	James Hutton Institute (JHI) (national soils inventory and surveys for Scotland 1978-1987 and 2006-2011) and Scottish Government
D19	BIO-PHYSICAL: Percentage of land capable for supporting Mixed agriculture	%_mixed LCA	James Hutton Institute (JHI) (national soils inventory and surveys for Scotland 1978-1987 and 2006-2011) and Scottish Government
D20	BIO-PHYSICAL: Percentage of land capable for supporting improved agriculture	%_IMPROVED lca	James Hutton Institute (JHI) (national soils inventory and surveys for Scotland 1978-1987 and 2006-2011) and Scottish Government
D21	BIO-PHYSICAL: Percentage of land capable for supporting rough agriculture	%_ROUGHLCA	James Hutton Institute (JHI) (national soils inventory and surveys for Scotland 1978-1987 and 2006-2011) and Scottish Government
D22	BIO-PHYSICAL: Percentage of land capable for supporting built up areas	*%_BUILTLCA*	James Hutton Institute (JHI) (national soils inventory and surveys for Scotland 1978-1987 and 2006-2011) and Scottish Government
D23	BIO-PHYSICAL: Percentage of inland water area	*%_WATER*	James Hutton Institute (JHI) (national soils inventory and surveys for Scotland 1978-1987 and 2006-2011) and Scottish Government

G33	PROTECTED AREAS: Percentage of Nitrate Vulnerable Zones area	%_NVZ	Scottish Government (2012)
G34	PROTECTED AREAS: Percentage of SSSI area	%_SSSI	Scottish Government (2012) via Scottish Natural Heritage, natural spaces
G35	PROTECTED AREAS: Percentage of complete national designated areas	%_deisgn_areas	Scottish Government (2012) via Scottish Natural Heritage, natural spaces
G36	PROTECTED AREAS: Percentage of RSPB reserve areas	%_RSPB_AREA	RSPB (2012)
H37	REMOTENESS: Percentage of Scottish government rural urban classification 2009- 2010 for 'large urban' areas	%_large_urban	Scottish Government (2010)
H38	REMOTENESS: Percentage of Scottish government rural urban classification 2009- 2010 for 'Other urban' areas	%_Other_urban	Scottish Government (2010)
H39	REMOTENESS: Percentage of Scottish government rural urban classification 2009- 2010 for 'Accessible small towns' areas	%_Access_small	Scottish Government (2010)
H4-	REMOTENESS: Percentage of Scottish government rural urban classification 2009- 2010 for 'Remote small towns' areas	%_remote_small	Scottish Government (2010)
H41	REMOTENESS: Percentage of Scottish government rural urban classification 2009- 2010 for 'Accessible rural' areas	%_access_rural	Scottish Government (2010)
H42	REMOTENESS: Percentage of Scottish government rural urban classification 2009- 2010 for 'Accessible rural' areas	%_remote_rural	Scottish Government (2010)

For further details on how these explanatory variables were derived please see Appendix 2.

3.3 Data issues

Table. 2 Cross measure Issue	
Issues:	Description:
Selective data provision on selected measures	Data only provided for selected measures under RP scheme whilst funds for the selected measures are also delivered through two other SRDP schemes: Land Manager Options (LMO) Crofting Counties Agricultural Grants (Scotland) (CCAGS). Additionally Data that was requested and not yet provided includes: - Option total area Coverage (ha) per parish (measure 214) - Data on applicants who applied but didn’t get approved - Main farm holding code
Limited uptake	There was limited overall uptake for both measures 121 (total holdings 1383) and 311 (total 227), this will potentially have implications for modelling; measure 311 in particular is unlikely to be used for the models due to the prominence of zero parish values.
Excess parish codes	The total number of parishes in Scotland is officially 891 parishes, however for measure 214 there were ‘over’ the number of official parishes (i.e. uptake occurred in parish numbers up to 920). These are cross border businesses, i.e. businesses in another country that have land in Scotland. Therefore don’t have main farm codes within any of the official parishes. As a result these will not be included in the analysis.

Data confidentiality	If there are less than five holdings per parish this data should not be disclosed therefore use of maps to display data should be used with caution. Therefore holdings locations have not been provided. Certain holdings may have implemented more than one option, therefore it should be noted that each data row for measures 121 and 214 (that have multiple option choices) doesn't represent one holding but represents a single approved option– However the total number of holdings can be derived by using matching associated farm characteristic data to amalgamate holdings that have adopted multiple options *(see Appendix 2 for more details on how these variables were derived)*
One main farm location code but may have multiple minor holdings in other locations or cross-border	The main farm location code, whilst not provided in the data, the associated parish for that code is provided, however a number of holdings may be associated with different parish locations, however this information isn't provided and consequentially some results can seem unusual i.e. some parishes are over 100% UAA land cover (exceeds size of parish). Some parishes codes go between different RPACs e.g. may be that some large holdings extend between multiple parish borders. It may also be as data is assigned to main farm codes other owned holdings may be present in other locations entirely e.g. for one holding in parish 456 has associated four RPACS including: Highland, Ayrshire, Grampians and Argyll.

Data for non-agri census applicants	Data was also provided for non-agricultural applicants 121 (total =17, total expenditure = £2,570,900) 214 (total = 310, total expenditure = £4,660,623) 311, (Total= 3, total expenditure = £34, 9083). This data was described by Scottish Government “The 'SRDP records not on census' covers those records (1323 records from 545 businesses) from the SRDP system which were not included in the June Census. Most of these are *forestry holdings*, with the remainder with *no agricultural activity* (although 6 were agricultural holdings registered in the period between the census being sent out to participating holdings and the payments information being drawn). This data has been excluded from the overall analysis due to the inability to acceptably standardise such data, as the agri-census data the chosen main dependent variable will be payments per UAA hectare (Ha) per parish.
Spatial data generalisation	This is particularly evident in artificially constructed datasets such as the land capability for agriculture (LCA) and the rural urban classification or Scotland, which use a combination of data sources to develop unique classification systems that incorporates various attributes. The issues inherent with GIS are reported by Heywood (1998) including accuracy, scaling and quality problems.
Ecological fallacy	There can be a risk of ‘ecological fallacy’ (Robinson, 1950) which is when aggregated spatial data is analysed at group level and results are assumed to apply at individual level (Steel and Holt, 1996), as a result due to the non-parametric distribution of the datasets a logistic model is risky as it would insinuate that the decision made by individuals at a parish level can be generalised.
Data skewness	All the dependent variables and the majority of explanatory variables have a large number of zeros and the distributions of these data are in the majority ‘positively skewed’. Therefore not meeting the assumptions needed for linear regression.

4. Descriptive statistics

4.1 Summary of descriptive statistical analysis on measures

The most predominant uptake of all SRDP-RP measures is measure 214, as Figure 4 illustrates that with 15,322 (2609) cases/ contracts from 2008 – 2011. Measure 121 has the second highest uptake with 1383 (891 holdings) across scotland. However selected measure 311 has quite limited uptake with just 227 cases. Figure 4 also illustrates the commited expenditure for SRDP – RP measures from 2008 – 2011, thus the expediture for both 214 and 121 far surpass the other measures, whilst 311 has a much smaller overall spend of £24 million. However despite this due to the measures smaller uptake the average payment per applicant for 311 is highest at £107,472 whilst 121 is £84,326 and 214 is considerably lower in comparison at £10,323.

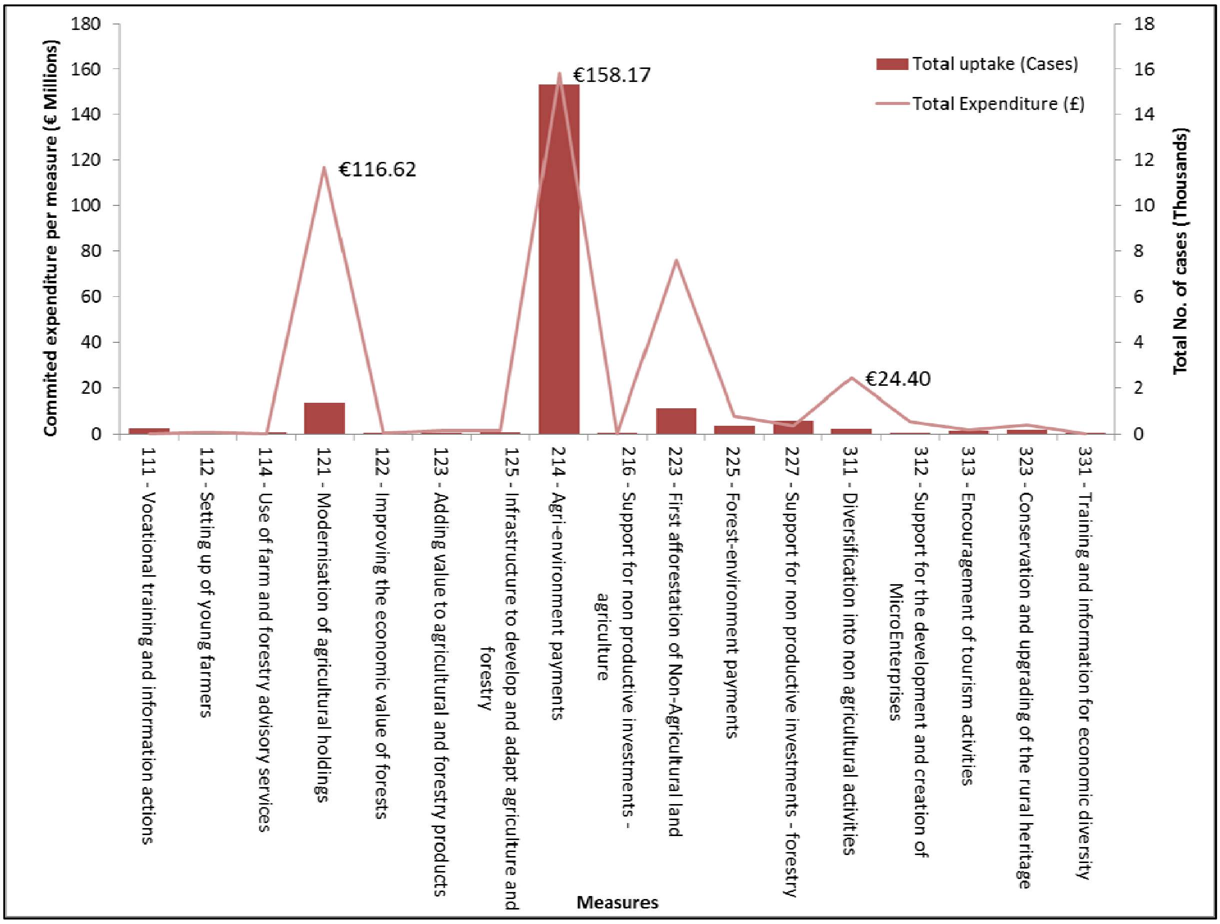


Figure 4. Total committed expenditure (£) per measure under RP and total number of cases uptake per measure 2008-2011

The total uptake over parishes of Scotland varies according to the measure. Figure 5 below shows the percentage of parishes with and without uptake for each selected measure. The Figure indicates there is a large skewness in the data distribution with data heavily bounded by zero, due to the large number of parishes without uptake. Particularly measure 311 that has lower overall uptake with just 227 holdings participating on the scheme, occurring in just 20 % (179 of the 891) parishes in Scotland. Measure 214 however, due to the larger overall uptake, occurs in up to 69% (612 of the 891) of all the Scottish parishes.

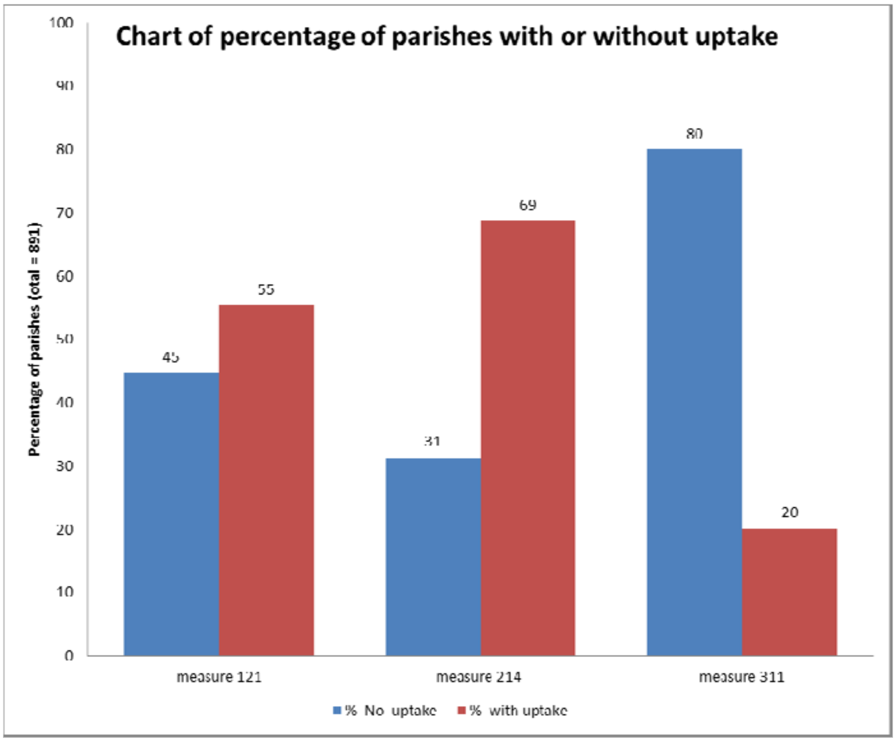


Figure 5. Percentage of parish with and without uptake for measure 121, 214 and 311

4.2 Hectares coverage per measure

Hectares coverage should only be relevant for some of the area based measures, and from the selected measures specifically this would only be measure 214 for agri-environmental payments. The total hectares covered by measure 214 is 4,104,361 ha which covers 52 % of Scotlands land area, if this is dividied against the total expenditure (£ 158,172,789) the average payment per ha is £ 38.54.

However data shows whilst this is the case for the majority of Axis two measures there are also a small number of total hectares covered by 121 (37 ha) and 311(2 ha). For measure 121 the majority of the hecatres apply to the option RP12103B - Short rotation coppice crops of willow or poplar in non LFA, which is to be expected as it relates to forest, but this option has only been taken up by one agricultural holding (See Appendix 5), However for 121 and 311 a negligible number of hectares is included but information on what this exactly applies to is not provided.

4.3 Farm type uptake per measure

The percentage of holding uptake for measures 121, 214, 311 from the total number of farms in each farm type 2008 -2011 in Scotland is shown in Figure 6, displaying the uptake for ten farm types, classified as 'robust' for each of the selected measures. For measure 311 it is not distinctly clear which farm type has a larger overall uptake due to the lower overall uptake for this measure, although general cropping at 1.42 % has a slightly larger percentage in comparison to the other farms types.

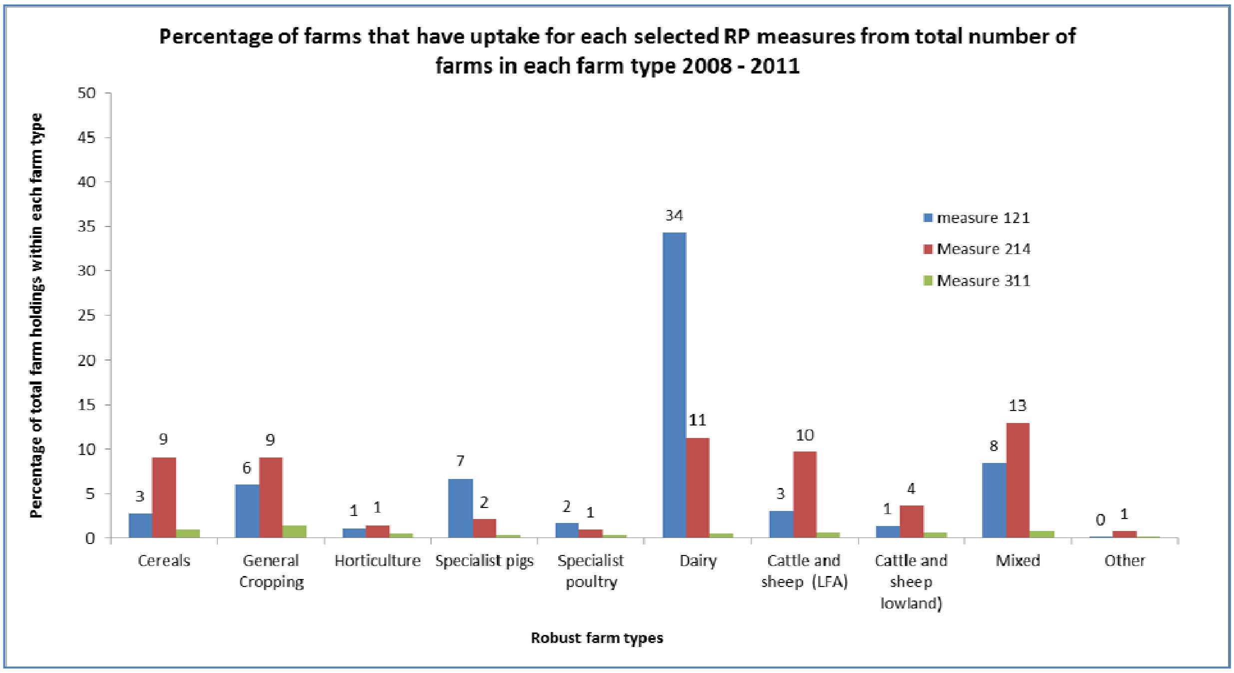


Figure 6. Percentage of holding uptake for measure 121, 214, 311 from the total number of farms in each farm type 2008 -2011 (Scottish Government data, 2011 and RESAS, 2012)

However it is apparent for measures 121 that dairy farms, with 34 % (434 of 1,266) of holdings within this farm type, have adopted this measure. This finding is to be expected as an option for 121 is dedicated to slurry and manure treatment and storage and slurry production is a major issue on most dairy farms due to the high cost of providing storage and the cost (DairyCo, 2010) and dairy farms are required under a number of regulations and legislations to comply to certain standards i.e. recent UK NVZ legislation, as well as requirements for Cross compliance requires farmers to keep land in Good Agricultural and

Environmental Condition, Control of Pollution Regulations, standards of the National Dairy Farm Assurance Scheme as well as complying with future legislations Integrated Pollution Prevention and Control (IPPC) and Water Framework Directive (WFD) (DairyCo, 2010).

For the measure 214, which is by far the most adopted measure of the three (total 2,609 holdings), there appears more of a spread of across farm types in measure 214, arguably as there is a vast range of options under 214 that are suitable therefore for vast range of applications and farm types. However mixed farms have the highest percentage of 13 % (276 of 2134) for measure 214. Mixed farms involves a combination of farm practices including cropping and dairy or cropping and mixed livestock *etc.* and perhaps diversification of practices lends itself better to adopting options under measure 214.

4.4 Summary of descriptive statistical analysis

4.4.1 Descriptive statistics for explanatory variables

The majority of independent variables are standardised as percentages of the parish hectares UAA. The descriptive statistics for each variable were produced to identify the mean, mode, median standard deviation, co-efficient of variation, kurtosis, and range. The frequency for each of the sub categories of the ownership variables are illustrated as histograms, which also illustrated the data distribution for each variable. Then each category was tested for co-correlation between the other independent variables in that category, this illustrated which variables should be selected with caution for the modelling process in conjunction with other related variables[1].

The histograms illustrated that the majority of these variables data are heavily positively skewed distribution i.e. only few variables have a ‘normal distribution e.g. percentage of ownership, total crops and grass, grass more than 5 years old and grass less than 5 years. Whilst some variables showed a high skew at the high end and low end of the X axis scale (percentage per parish) suggesting a binomial account of these values might be more preferable e.g. NVZ area and percentage of remote rural and remote small for the remoteness category.

The descriptive statistics also provide interesting hypotheses as to why certain variables interact e.g. for the livestock variables total sheep strong positive correlation with each of the

[1] For further details please contact the main author A.Yang (a.l.yang@sms.ed.ac.uk)

other livestock variables (0.32 to 0.47), therefore it could be suggested in areas where cattle whether dairy or beef there is likely to be sheep also, due to the presence of mixed livestock farm types. Finally all the independent variables where tested for correlation to test between variables category's whether correlation exists, in order to reference when selecting the independent variables for the models to check for co-correlation between the desired variables.[2]

4.4.2 Descriptive statistics for measures

The descriptive statistics for the dependent variables first included the breakdown of how many cases associated with the measure to deriving what the actual number of holdings are. This was only required for measure 121 and 214 that had a range of options that allowed holdings to take up. For each of these measures a graph showing the frequency of cases per option was produced to illustrate the type of options available and the varying levels of uptake across the options (see Appendix 5). The farm type per option uptake for measure 121 was observed to see what farms are most likely to take up each of the six options.

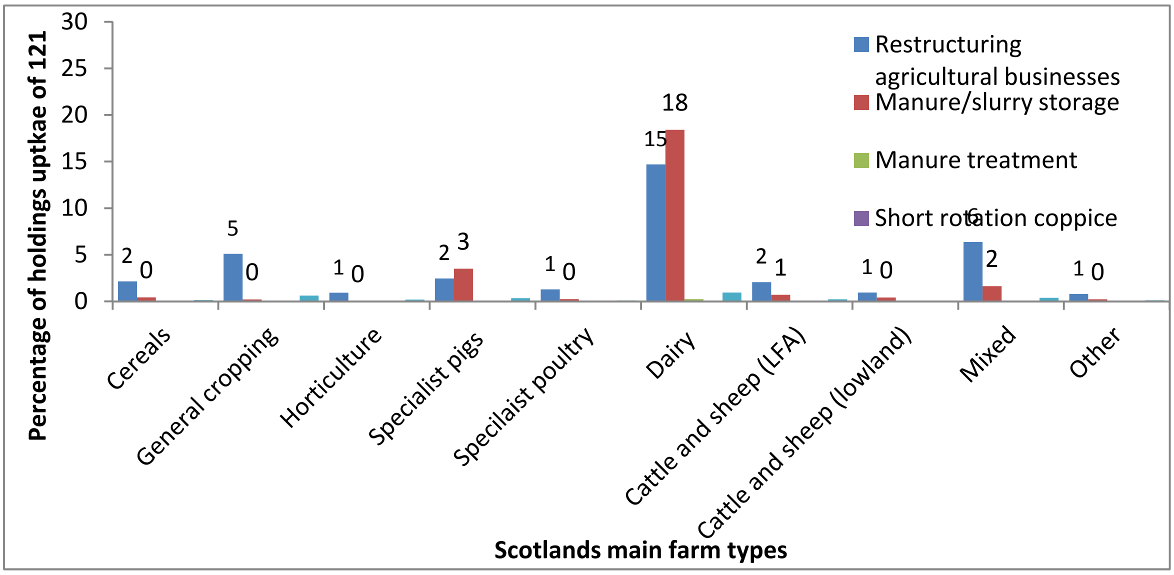


Figure 7. Percentage of holdings per farm type, per measure 121 option, Scotland (Scottish Government data, 2008- 2011)

Histogram's for each of them measures dependents where produced showing the same pattern as many of the explanatory variables a high positively skewed data distribution. The major outliers were also noted, in particular with measure 121 there are extreme outliers of high

[2] For further details please contact the main author A.Yang (a.l.yang@sms.ed.ac.uk)

payments e.g. range from > £ 400 to £ 800.72 per ha UAA. This is to be expected as payments for this measure are capital grants.

For measure 214 as an area based measure the total expenditure and percentage of UAA hectares was observed for each of the RPAC regions, see figure 8 below. It is clear that in the majority of the regions have a similar percentage of total expenditure with a reasonably similar percentage of Scotland's UAA e.g. Ayrshire, Outer Hebrides, Clyde valley etc., whilst the Grampians and the highlands show very opposite outcomes, with Grampians having the highest percentage at 31 % of expenditure and only 12 % of Scotland's UAA, whilst in contrast the Highlands has just 15 % share of the expenditure with the highest percentage of UAA hectares in Scotland (32 %).

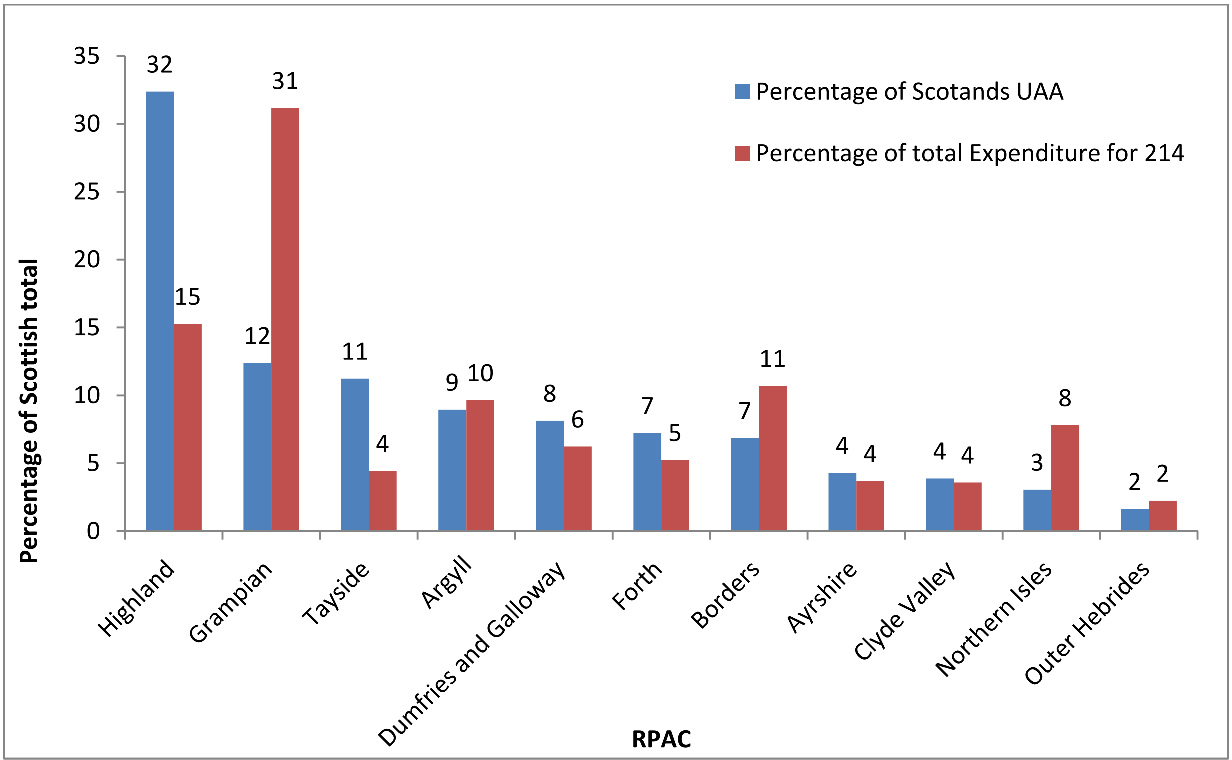


Figure 8. Percentage of Scotlands UAA hectares and total expenditure for RP measure 214 (Scottish Government data, 2011)

Finally the dependent variables where tested for correlation with each of the explanatory variables to initially observe which explanatory variables appear to have a positive and negative relationship with each of the measure dependents[3].

[3] For further details please contact the main author A.Yang (a.l.yang@sms.ed.ac.uk)

4.5 Exploratory spatial data analysis

4.5.1 Spatial weight matrix introduction

The spatial weight matrix is required to conceptualise the spatial relationship between municipality neighbours as suitably as possible, it is necessary element for spatial regression models as required for this project as well as for checking independent and dependent variables for spatial autocorrelation. The spatial relationships can be defined through a spatial weight matrix, representing the spatial structure. This is what needs to defined for the territorial units at agricultural parish scale for Scotland

4.5.2 Queen contiguity matrix

For the Scottish case study the use of the more commonly used spatial matrixes such as contiguity or distance based spatial weights were both considered, however due to unique island nature of Scotland these approaches weren't suitable.

Due to the island geographic nature of Scotland and having 790 offshore islands (See map 1 Appendix 1) the use of queen contiguity spatial matrixes (Anselin, 2002) would mean the islands would need to be cut off this would be problematic due to the high number of islands and loss of useful data,. When tested the Queen contiguity gives 25 regions with no links, and also on the islands some blocks of regions connect only to each other - this leads to trouble in estimations later (see Appendix 3, table 1).

4.5.3 Distance cut off matrix

Use of historical parishes as spatial area units also adds complexity to defining spatial relationships. This can be seen in the highlands were the parishes are much larger and less numerous compared to Eastern and central Scotland where the parishes are far smaller and far more numerous and condensed (see Appendix 1). Consequentially when a distance cut off used on the parish spatial dataset, the number of neighbours will vary as the sizes vary. Kim *et al.* (2004) argue that "a distance-band weights matrix is not feasible for rural studies since lot (farm) sizes vary greatly in rural areas. Building a weights matrix on a distance band will produce an uneven number of neighbours from rural clusters (hamlets) or a small number of neighbours for larger lots (farms)."

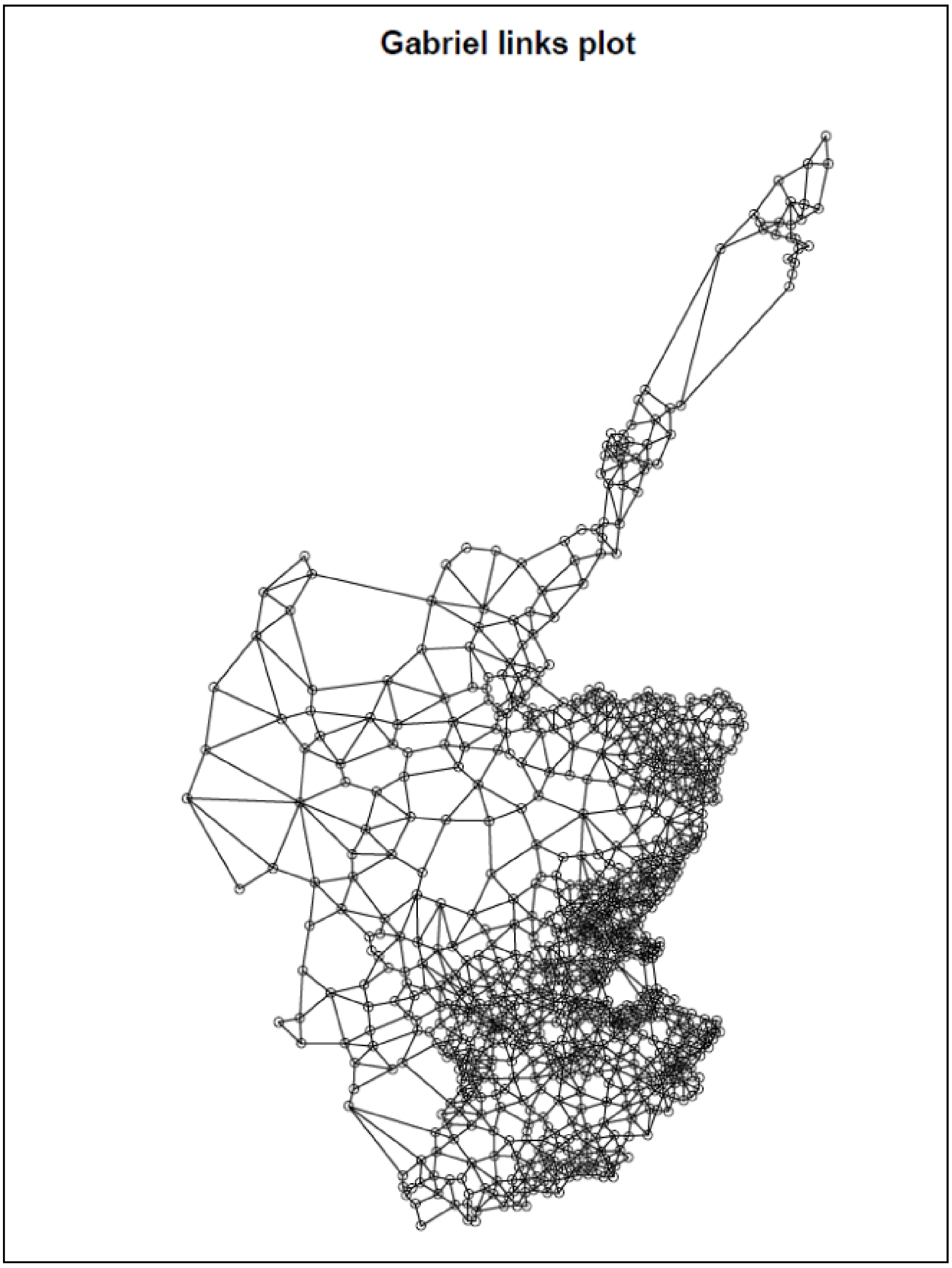
When distance cut off was tested on the Scottish parishes every parish by design has a neighbour but by taking the furthest distance to the nearest neighbour at 39km, consequentially meant some parishes have a very large amount of neighbours e.g. 147 neighbours. The results from the distance cut off show that having over 7 % non-zero items in the weight matrix (i.e. 93% of the weight matrix are just zeroes, but the other 7% of all possible links have a value) is too high and consequentially may risk over fitting of the model i.e. the results will at some point be based on what are actually measurement errors and idiosyncrasies of individual observations rather than on what was intended to measure (See Appendix 3 Table 2).

4.5.4 Gabriel weight matrix

Therefore the Gabriel matrix, which only connects neighbours that have no other neighbour in between, is the preferred option. Similar to the Delaunay triangulation (natural neighbours) option which constructs neighbours by creating voronoi triangles from point features or from centroids such that each point has a triangle node, so nodes connected by the triangle edge are considered neighbours. Ensuring each feature has at least one neighbour, particularly useful for data and spatial units such as in the Scottish case study that have islands and varying feature densities. The Gabriel matrix has the added advantage of not needing a common border (i.e., islands can stay in), but the disadvantage that it uses geographical position to construct a 1/0 matrix, so no travel times can be used. However, it can be joined with a cut off distance - the matrix then contains all observations that are neighbours in Gabriel's sense and all observations within a certain distance/travel time.

The Gabriel weight matrix was constructed using R, and the weights are row-standardized, i.e. they sum up to 1. Map 2 shows how this spatial weight matrix is represented. The islands are all included and areas that appear to within the highlands and islands (Northern western and eastern Scotland, with minimum of 2 neighbours) have the least neighbours and regions in the central and Eastern Scotland have the most neighbours (maximum total 8) summary statistics are displayed in Appendix 3 Table 3.

Map 2. Gabriel weight matrix of Scotland parishes, visual representation (2012)



4.5.5 Autocorrelation

Spatial autocorrelation was tested on each of the dependent variables for each of the selected measures. This was completed using Geoda that calculates the global Moran's I and the local Moran's using a LISA test, the output of each includes a Moran's scatter plot, LISA cluster map and significance map. If the dependent variables show no or very little spatial autocorrelation than further spatial models (error and lag) would not be necessary.

Table 4. Spatial autocorrelation test of each dependent variable		
	Morans I	**Significance**
Measure 121: Payments per UAA ha [AA]	**0.25**	**
Measure 121: Percentage of holdings [AB]	**0.20**	**
Measure 214: Payments per UAA ha [BA]	**0.46**	***
Measure 214: Percentage of holdings [BB]	**0.23**	**
Habitat management: Payments per UAA ha	**0.23**	**
Habitat management: Percentage of holdings	**0.52**	***
Bird protection :Payments per UAA ha	**0.10**	*
Bird protection: Percentage of holdings	**0.11**	*
Water habitat: Payments per UAA ha	**0.30**	**
Water habitat: Percentage of holdings	**0.30**	**
Measure 311: Payments per UAA ha	**0.00**	-
Measure 311: Percentage of holdings	**0.00**	-

The ESDA results show spatial autocorrelation exist with measure 121 and 214 and its option categories, but for measure 311 show that there is very almost no spatial autocorrelation with a Moran I of 0.0004 for payments per UAA with a marginal difference for percentage of holdings per parish 0.0075. Therefore further spatial modelling is not necessary for this measure, as this indicates no spatial relationship in the distribution or payments and uptake for this measure. Additionally it has also been concluded that further modelling of this measure would be inappropriate due to the low uptake in proportion to the number of spatial units e.g. 20% of the 891 parishes have any uptake.

The Morans I for bird protection illustrates a weak significance and Moran I values of 0.11, but further model analysis will be done with an expectation that spatial dependency for bird protection options will be not as significant as it may be for the other dependents.

5. Econometric analysis

The following methodological steps were taken to analyse the determinants of spatial uptake and expenditure of measure 121 and 214 and options categories; habitat management, bird protection, and water habitats:

Step 1. OLS regression with each dependent variables and 'all' explanatory variables

Step 2. OLS regression with each measure dependent variables and each explanatory variable's category sub sets:

- Check for multi-collinearity
- Check which of the subset have a signifcant relationship and add to the R^2 value.

Step 3 Run step wise regression model (using R commander) to find the best explanation of variables, then rerun the step wise (forward/backward) to find the best model fit with the least variables.

Step 4. Re- Run OLS with each measure dependent variables on' selected' explanatory variables on Geoda

- Check for Multi-collinearity
- Check for normaility i.e. Jarque-bera test
- Check for heteroskadiscity i.e. Breusch-pagan test and Konenker bassett test
- Check for heteroskadiscity – specification robust test i.e. White test
- Check for spatial dependency – i.e. Morans I (error residuals), LM lag, and LM error

Step 5. Run Spatial lag model with each measure dependent variables and selected explanatory variables on Geoda

- Check for spatial dependency i.e. Test Morans I on error residuals

Step 6. Run Spatial error model with each measure dependent variables and selected explanatory variables on Geoda

- Check for spatial dependency i.e. Test Morans I on error residuals

Step 7. Test and compare for spatial autocorrelation in OLS, Lag and error model residuals.

5.1 OLS results with all variables

The best model results occur with measure 214 for the overall measure percentage of holdings (adjusted R^2 18.5.) and also similarly for the option breakdown 'habitat' management (R^2 19.), (as illustrated in table 5). The payments per holding only have stronger responses for measure 121, however this had the largest standard error but this would be expected as payments in general for 121 are much more extreme than those for other measures. Whilst overall the dependent percentage of holdings works better for measure 214 and all the option breakdown categories, this may be as payments are standard rates per ha and extreme payments values as those in 121 are not common.

It should also be considered that this first model contains high leverage from multi-collinearity between variables within the same subsets. The second step will model each of the dependents against the variables within each explanatory variables subsets: ownership, farming, land capability for agriculture (LCA), livestock, labour, protected areas and remoteness.

Table 5. Results of OLS with <u>all</u> explanatory variables	**R^2**	**STANDARD ERROR**
Measure 121: Payments per UAA ha [AA]	**16. 7 *****	76.
Measure 121: Percentage of holdings [AB]	**9. *****	5.57
Measure 214: Payments per UAA ha [BA]	**15.7 *****	53.9
Measure 214: Percentage of holdings [BB]	**18.5 *****	7.69
Habitat management: Payments per UAA ha [CB]	**13.7 *****	39.7
Habitat management: Percentage of holdings [CA]	**19.*****	7.40
Bird protection :Payments per UAA ha [DB]	**10. *****	11.2
Bird protection: Percentage of holdings [DA]	**16.5 *****	6.12
Water habitat: Payments per UAA ha [EB]	**13.6 *****	11.8
Water habitat: Percentage of holdings [EA]	**18.2 *****	6.19
Significance level: '.'=0.1; '*'=0.05; '**'=0.01; '' = 0.001***		

5.2 OLS regression with explanatory variable's category subsets

Ownership (Table 6) has the most significance and highest adjusted R^2, with measure 121 for both percentage of holdings and payments per UAA ha. Ownership values have a strong significance for percentage of holdings uptake for measure 214, habitat management options and water habitat options, but not very strong significance if any for payments per UAA ha for 214 related dependents.

Table 6. Results of OLS with Ownership	R^2	STANDARD ERROR
Measure 121: Payments per UAA ha [AA]	5.5 ***	80.9
Measure 121: Percentage of holdings [AB]	6 ***	5.66
Measure 214: Payments per UAA ha [BA]	0.4	58.6
Measure 214: Percentage of holdings [BB]	2.5 ***	8.41
Habitat management: Payments per UAA ha [CB]	0.2	42.7
Habitat management: Percentage of holdings [CA]	1.9 ***	8.14
Bird protection :Payments per UAA ha [DB]	1.6 **	11.7
Bird protection: Percentage of holdings [DA]	0.7 *	6.67
Water habitat: Payments per UAA ha [EB]	1**	12.6
Water habitat: Percentage of holdings [EA]	2.5***	6.76
Significance level: '.'=0.1; ''=0.05; '**'=0.01; '***' = 0.001*		

The farming variables (table 7) have similar response as to ownership explanatory variables in that measure 121 payments per UAA ha has strong significance and highest R^2 at 5.2, however this group of variables seems to have very little significance when it comes to percentage of holding uptake per parish for the same measure. In contrast, for measure 214 and related options the most significance relationship occurs with percentage of holdings. Indicating farming variables will influence uptake more than the amount of payments made for parishes across Scotland for agri-environment

Table 7. Results of OLS with farming	R^2	STANDARD ERROR
Measure 121: Payments per UAA ha [AA]	5.2 ***	81.1
Measure 121: Percentage of holdings [AB]	1 *	5.81
Measure 214: Payments per UAA ha [BA]	2.2 *	58.0
Measure 214: Percentage of holdings [BB]	2.5 ***	8.42

Habitat management: Payments per UAA ha [CB]	**3.1 *****	42.1
Habitat management: Percentage of holdings [CA]	**2.6*****	8.11
Bird protection :Payments per UAA ha [DB]	**0**	11.9
Bird protection: Percentage of holdings [DA]	**2.7 *****	6.60
Water habitat: Payments per UAA ha [EB]	**0.3**	12.6
Water habitat: Percentage of holdings [EA]	**2.5 *****	6.76
Significance level: '.'=0.1; '*'=0.05; '**'=0.01; '' = 0.001***		

Land capability for agriculture (LCA) seems to have a stronger relationship with percentage of holdings 121, and payments per UAA ha for measure 214, habitat management, and the same water habitat (Table 8) although this dependent also has a high R^2 and significance for percentage of holdings. Notably within this subset there are high levels of multi-collinearity.

Table 8. Results of OLS with LCA	**R^2**	**STANDARD ERROR**
Measure 121: Payments per UAA ha [AA]	**3 *****	82
Measure 121: Percentage of holdings [AB]	**5.6 *****	5.67
Measure 214: Payments per UAA ha [BA]	**5.3 *****	57.1
Measure 214: Percentage of holdings [BB]	**1.8 *****	8.45
Habitat management: Payments per UAA ha [CB]	**5.7 *****	41.5
Habitat management: Percentage of holdings [CA]	**1 *****	8.18
Bird protection :Payments per UAA ha [DB]	**0.1**	11.8
Bird protection: Percentage of holdings [DA]	**0**	6.7
Water habitat: Payments per UAA ha [EB]	**6 *****	12.3
Water habitat: Percentage of holdings [EA]	**5.8 *****	6.64
Significance level: '.'=0.1; '*'=0.05; '**'=0.01; '' = 0.001***		

Livestock as an explanatory group holds highest influence on measure 121 payments per UAA ha at R^2 6.9, whilst lower R^2 value but still strong significance is shown with the same measures percentage of holdings, and both water habitat dependents (Table 9). Livestock unusually shows no significance for bird protection, habitat management options and measure 214. But to note again that the livestock variables high particularly high multi-collinearity especially between beef and dairy density's, e.g. both highly positively correlated.

Table 9. Results of OLS with livestock	R^2	STANDARD ERROR
Measure 121: Payments per UAA ha [AA]	6.9 ***	80.3
Measure 121: Percentage of holdings [AB]	2.5 ***	5.76
Measure 214: Payments per UAA ha [BA]	0.1	58.7
Measure 214: Percentage of holdings [BB]	0.6 .	8.5
Habitat management: Payments per UAA ha [CB]	0	42.8
Habitat management: Percentage of holdings [CA]	0.5	6.69
Bird protection :Payments per UAA ha [DB]	0	11.8
Bird protection: Percentage of holdings [DA]	0	6.1
Water habitat: Payments per UAA ha [EB]	1.6 ***	12.5
Water habitat: Percentage of holdings [EA]	0.2	6.84
Significance level: '.'=0.1; ''=0.05; '**'=0.01; '***' = 0.001*		

For labour habitat management and bird protection options have the highest impact on explaining variance with highly significant models and R^2 of 8.7 and 8.2 respectively. This is also the case for overall 214 measure but again showing that there is significant difference but the results for percentage of holding uptake an payments per UAA ha (Table 10).

Table 10. Results of OLS with Labour	R^2	STANDARD ERROR
Measure 121: Payments per UAA ha [AA]	2.3 ***	82.3
Measure 121: Percentage of holdings [AB]	0.2	5.83
Measure 214: Payments per UAA ha [BA]	0.9 **	58.4
Measure 214: Percentage of holdings [BB]	7.6 ***	8.19
Habitat management: Payments per UAA ha [CB]	0.5 .	42.6
Habitat management: Percentage of holdings [CA]	8.7 ***	7.85
Bird protection :Payments per UAA ha [DB]	0	11.8
Bird protection: Percentage of holdings [DA]	8.2 ***	6.69
Water habitat: Payments per UAA ha [EB]	0.6 .	12.6
Water habitat: Percentage of holdings [EA]	2.7 ***	6.75
Significance level: '.'=0.1; ''=0.05; '**'=0.01; '***' = 0.001*		

Designated sites (Table 11) show a strong significance with almost all the dependent variables but slightly less so, with a weaker R^2 for both measure 121 dependents. This result is to be expected considering some of the main targets are related to getting protected area sites into favourable conditions; the results indicate that these locations are receiving higher payments per UAA ha in particular in relation to SSSI and NVZ zones.

Table 11. Results of OLS with designated areas	R^2	STANDARD ERROR
Measure 121: Payments per UAA ha [AA]	**1.7 *****	82.5
Measure 121: Percentage of holdings [AB]	**1.4 ****	5.8
Measure 214: Payments per UAA ha [BA]	**5 *****	57.2
Measure 214: Percentage of holdings [BB]	**3.1 *****	8.39
Habitat management: Payments per UAA ha [CB]	**5.6 *****	41.5
Habitat management: Percentage of holdings [CA]	**2.8 *****	8.1
Bird protection :Payments per UAA ha [DB]	**8.5 *****	11.3
Bird protection: Percentage of holdings [DA]	**2.2 *****	6.62
Water habitat: Payments per UAA ha [EB]	**3.5 *****	12.4
Water habitat: Percentage of holdings [EA]	**2.6 *****	6.76
Significance level: '.'=0.1; '*'=0.05; '**'=0.01; '' = 0.001***		

Lastly the remoteness category subset seems to show strong significance with every dependent variable, with particular significance on water habitat percentage of holdings with an R^2 of 5.5 (Table 12). The results showed remoteness to have significance with all the dependents, with slightly stronger R^2 with payments per UAA ha.

Table 12. Results of OLS with Remoteness	R^2	STANDARD ERROR
Measure 121: Payments per UAA ha [AA]	**3.8 *****	81.7
Measure 121: Percentage of holdings [AB]	**2.8 *****	5.76
Measure 214: Payments per UAA ha [BA]	**3.2 *****	57.7
Measure 214: Percentage of holdings [BB]	**3.2 *****	8.38
Habitat management: Payments per UAA ha [CB]	**1.8 *****	42.4
Habitat management: Percentage of holdings [CA]	**3.2 *****	8.09
Bird protection :Payments per UAA ha [DB]	**1.5 *****	11.7
Bird protection: Percentage of holdings [DA]	**1.4 *****	6.65
Water habitat: Payments per UAA ha [EB]	**3.2 *****	12.5
Water habitat: Percentage of holdings [EA]	**5.5 *****	6.65
Significance level: '.'=0.1; '*'=0.05; '**'=0.01; '' = 0.001***		

These results indicate the differences between the two measure and also between the option break down categories; habitat management options, bird protection and water habitats, as each has varying significance with the subsets as do the two dependents payments and percentages with often one being strong than the other.

5.3 Run step wise regression model

5.3.1 Model results for measure 121

5.3.1.1 Step-wise Model Results for 121 payments

Table 13 Results of forward/backward STEP-WISE regression for measure 121 dependent AA (payments per UAA ha)

Parameter	estimate	s.e.	t(874)	t pr.
Constant	77.4	12.5	6.17	<.001
D21 MIXED AGRI.	-0.335	0.177	-1.89	0.059
B2 OWNED LAND	0.615	0.122	5.04	<.001
C6 ROUGH	-0.726	0.203	-3.57	<.001
G33 NVZ	-0.3254	0.0772	-4.22	<.001
B5 SEASLET	-1.321	0.419	-3.16	0.002
D22 BUILTUP	-0.832	0.249	-3.34	<.001
C16 WOODLAND	-1.460	0.490	-2.98	0.003
E24 CATTLE DENSITY	21.80	3.65	5.98	<.001
E25 SHEEP	-10.12	2.06	-4.91	<.001
C8 GRASSLESS	-3.48	1.06	-3.28	0.001
B4 SEASONAL RENT	1.242	0.731	1.70	0.090
F31 PTSPOUSE	-81.9	29.0	-2.83	0.005
F28 FTOCCUPS	81.5	38.1	2.14	0.032
D19 MIXED	-0.211	0.130	-1.62	0.106
H38 OTHERURB	-0.573	0.338	-1.69	0.091
C9 GRASS MORE	0.832	0.512	1.63	0.104
NUMBER OF OBSERVATIONS				891
ADJUSTED R^2				17.3
Standard error				75.7
MODEL Fr p.				<.001

5.3.1.2 Step-wise Model Results for 121 Percentage of holdings

Table 14. Results of forward/backward STEP-WISE regression for measure 121 dependent AB (Percentage of participating holdings)

Parameter	estimate	s.e.	t(877)	t pr.
Constant	3.605	0.732	4.92	<.001
B2 OWNED LAND	0.03021	0.00797	3.79	<.001
D21 MIXED AGRI.	-0.02812	0.00863	-3.26	0.001
D22 BUILTUP	-0.0578	0.0166	-3.48	<.001
B5 SEASLET	-0.0930	0.0296	-3.14	0.002
C8 GRASSLESS	-0.1812	0.0694	-2.61	0.009
F32 REG&CAS STAF	0.843	0.341	2.47	0.014
C13 OTHERCRPS	-3.77	1.86	-2.03	0.043
B4 SEASONAL RENT	0.0923	0.0522	1.77	0.077
B3 RENTED LAND	0.0277	0.0136	2.04	0.042
E24 CATTLE DENSITY	0.959	0.254	3.78	<.001
E25 SHEEP	-0.500	0.160	-3.12	0.002
F29 PTOCCUPS	-1.163	0.597	-1.95	0.052
D20 IMPROVED AGRI.	0.0243	0.0130	1.86	0.063
NUMBER OF OBSERVATIONS 891				
ADJUSTED R^2 10.1				
Standard error 5.54				
MODEL Fr p. <.001				

5.3.2 Model results for measure 214

5.3.2.1 Step-wise Model Results for 214 payments

Table 15. Results of forward/backward STEP-WISE regression for measure 214 dependent BA (Payment per UAA ha)

Parameter	estimate	s.e.	t(882)	t pr.
Constant	-13.55	4.87	-2.78	0.006
D19 MIXED	0.6418	0.0720	8.91	<.001
H42 REMRURAL	0.3208	0.0485	6.62	<.001
G33 NVZ	0.3726	0.0431	8.65	<.001
G36 RSPB	1.832	0.642	2.85	0.004
B1 COMM GRAZ	0.322	0.158	2.03	0.042
G34 SSSI	0.466	0.185	2.51	0.012
C16 WOODLAND	-0.769	0.328	-2.34	0.019
C17 Glass houses	-0.531	0.300	-1.77	0.077
NUMBER OF OBSERVATIONS 891				
ADJUSTED R^2 15.9				
Standard error 53.8				
MODEL Fr p. <.001				

5.3.1.2 Step-wise Model Results for 214 Percentage of holdings

Table 16. Results of forward/backward STEP-WISE regression for measure 214 dependent BB (Percentage of participating holdings)

Parameter	estimate	s.e.	t(872)	t pr.
Constant	-1.349	0.905	-1.49	0.136
F32 REG&CAS STAF	3.046	0.574	5.31	<.001
G34 SSSI	0.2391	0.0494	4.84	<.001
D19 MIXED	0.0678	0.0110	6.15	<.001
G33 NVZ	0.03558	0.00643	5.53	<.001
H42 REMRURAL	0.02693	0.00698	3.86	<.001
B3 RENTED LAND	0.0491	0.0182	2.71	0.007
E24 CATTLE DENSITY	-0.733	0.334	-2.20	0.028
G35 DESIG	-0.1171	0.0419	-2.80	0.005
E27 DAIRY	-57.4	25.7	-2.24	0.026
D23 INLAND WATER	-0.265	0.127	-2.08	0.038
C15 TOTALVEG	-1.416	0.898	-1.58	0.115
C9 GRASS MORE	-0.0865	0.0477	-1.82	0.070
B4 SEASONAL RENT	0.1677	0.0718	2.34	0.020
E25 SHEEP	0.463	0.211	2.19	0.029
B5 SEASLET	-0.0767	0.0420	-1.83	0.068
E26 BEEF	18.21	8.60	2.12	0.035
F28 FTOCCUPS	4.75	2.59	1.83	0.067
G36 RSPB	0.1393	0.0913	1.52	0.128

NUMBER OF OBSERVATIONS	891
ADJUSTED R^2	19.2
Standard error	7.66
MODEL Fr p.	<.001

5.3.3 Model results for measure 214: habitat management options

5.3.3.1 Step-wise Model Results for 214 habitat management options Percentage of holdings

Table 17. Results of forward/backward STEP-WISE regression for measure 214 habitat management options dependent CA (Percentage of holdings)

Parameter	estimate	s.e.	t(874)	t pr.
Constant	-1.969	0.946	-2.08	0.038
F32 REG&CAS STAF	3.593	0.356	10.09	<.001
G33 NVZ	0.03845	0.00633	6.08	<.001
H42 REMRURAL	0.03453	0.00711	4.86	<.001
D19 MIXED	0.0532	0.0106	5.01	<.001
G34 SSSI	0.1849	0.0475	3.89	<.001

D22 BUILTUP	-0.0168	0.0374	-0.45	0.653
B3 RENTED LAND	0.0458	0.0177	2.58	0.010
G35 DESIG	-0.0966	0.0406	-2.38	0.017
E27 DAIRY	-4.12	1.57	-2.62	0.009
C9 GRASS MORE	-0.1161	0.0441	-2.63	0.009
C15 TOTALVEG	-2.88	1.17	-2.46	0.014
B4 SEASONAL RENT	0.1246	0.0680	1.83	0.067
G36 RSPB	0.1345	0.0887	1.52	0.130
E25 SHEEP	-0.104	0.155	-0.67	0.503
C12 CROPS&FALLW	0.0894	0.0599	1.49	0.136
H37 LARGEURB	0.0395	0.0401	0.99	0.325
			NUMBER OF OBSERVATIONS	891
			ADJUSTED R^2	18.1
			Standard error	7.44
			MODEL Fr p.	<.001

5.3.1.2 Step-wise Model Results for 214 habitat management options payments

Table 18. Results of forward/backward STEP-WISE regression for measure 214 habitat management options dependent CB (Payment per UAA ha)

Parameter	estimate	s.e.	t(882)	t pr.
Constant	-9.22	3.58	-2.58	0.010
G33 NVZ	0.3039	0.0315	9.65	<.001
D19 MIXED	0.3987	0.0523	7.63	<.001
H42 REMRURAL	0.2076	0.0349	5.94	<.001
C16 WOODLAND	-0.498	0.239	-2.09	0.037
C17 Glass houses	-0.414	0.219	-1.89	0.059
G34 SSSI	0.212	0.126	1.69	0.092
C14 UNSPECFI	-111.9	28.4	-3.94	<.001
C13 OTHERCRPS	86.7	23.6	3.67	<.001
			NUMBER OF OBSERVATIONS	891
			ADJUSTED R^2	15.0
			Standard error	39.4
			MODEL Fr p.	<.001

5.3.4 Model results for measure 214: Bird protection option

5.3.4.1 Step-wise Model Results for 214 bird protection options Percentage of holdings

Table 19. Results of forward/backward STEP-WISE regression for measure 214 bird protection options dependent DA (Percentage of holdings)

Parameter	estimate	s.e.	t(872)	t pr.
Constant	-2.138	0.736	-2.91	0.004
F32 REG&CAS STAF	2.957	0.455	6.50	<.001
G33 NVZ	0.02907	0.00508	5.72	<.001
H42 REMRURAL	0.02290	0.00556	4.12	<.001
D19 MIXED	0.03819	0.00868	4.40	<.001
G36 RSPB	0.1774	0.0726	2.44	0.015
F29 PTOCCUPS	-2.426	0.737	-3.29	0.001
E27 DAIRY	-28.4	17.3	-1.64	0.102
H37 LARGEURB	0.0553	0.0192	2.88	0.004
G34 SSSI	0.1449	0.0394	3.68	<.001
G35 DESIG	-0.0806	0.0335	-2.41	0.016
F28 FTOCCUPS	4.64	2.66	1.74	0.082
E26 BEEF	8.24	5.84	1.41	0.158
D23 INLAND WATER	-0.198	0.101	-1.96	0.051
B3 RENTED LAND	0.0251	0.0143	1.75	0.080
C9 GRASS MORE	-0.0619	0.0333	-1.86	0.063
C15 TOTALVEG	-3.062	0.993	-3.08	0.002
C12 CROPS&FALLW	0.1685	0.0504	3.34	<.001
C13 OTHERCRPS	-3.10	2.19	-1.42	0.157

NUMBER OF OBSERVATIONS	891
ADJUSTED R^2	17.4
Standard error	6.08
MODEL Fr p.	<.001

5.3.4.2 Step-wise Model Results for 214 bird protection options payments

Table 20. Results of forward/backward STEP-WISE regression for measure 214 bird protection options dependent DB (Payment per UAA ha)

Parameter	estimate	s.e.	t(882)	t pr.
Constant	-9.22	3.58	-2.58	0.010
G33 NVZ	0.3039	0.0315	9.65	<.001
D19 MIXED	0.3987	0.0523	7.63	<.001
H42 REMRURAL	0.2076	0.0349	5.94	<.001

C16 WOODLAND	-0.498	0.239	-2.09	0.037
C17 Glass houses	-0.414	0.219	-1.89	0.059
G34 SSSI	0.212	0.126	1.69	0.092
C14 UNSPECFI	-111.9	28.4	-3.94	<.001
C13 OTHERCRPS	86.7	23.6	3.67	<.001
			NUMBER OF OBSERVATIONS	891
			ADJUSTED R^2	11.8
			Standard error	11.1
			MODEL Fr p.	<.001

5.3.5 Model results for measure 214: Water habitat options

5.3.5.1 Step-wise Model Results for 214 water habitat options Percentage of holdings

Table 21. Results of forward/backward STEP-WISE regression for measure 214 dependent BB (Percentage of participating holdings)

Parameter	estimate	s.e.	t(872)	t pr.
Constant	-1.349	0.905	-1.49	0.136
F32 REG&CAS STAF	3.046	0.574	5.31	<.001
G34 SSSI	0.2391	0.0494	4.84	<.001
D19 MIXED	0.0678	0.0110	6.15	<.001
G33 NVZ	0.03558	0.00643	5.53	<.001
H42 REMRURAL	0.02693	0.00698	3.86	<.001
B3 RENTED LAND	0.0491	0.0182	2.71	0.007
E24 CATTLE DENSITY	-0.733	0.334	-2.20	0.028
G35 DESIG	-0.1171	0.0419	-2.80	0.005
E27 DAIRY	-57.4	25.7	-2.24	0.026
D23 INLAND WATER	-0.265	0.127	-2.08	0.038
C15 TOTALVEG	-1.416	0.898	-1.58	0.115
C9 GRASS MORE	-0.0865	0.0477	-1.82	0.070
B4 SEASONAL RENT	0.1677	0.0718	2.34	0.020
E25 SHEEP	0.463	0.211	2.19	0.029
B5 SEASLET	-0.0767	0.0420	-1.83	0.068
E26 BEEF	18.21	8.60	2.12	0.035
F28 FTOCCUPS	4.75	2.59	1.83	0.067
G36 RSPB	0.1393	0.0913	1.52	0.128
			NUMBER OF OBSERVATIONS	891
			ADJUSTED R^2	19.2
			Standard error	7.66
			MODEL Fr p.	<.001

5.3.5.2 Step-wise Model Results for 214 water habitats options payments

Table 22. Results of forward/backward STEP-WISE regression for measure 214 water habitat options dependent EB (Payment per UAA ha)

Parameter	estimate	s.e.	t(877)	t pr.
Constant	-4.24	1.26	-3.38	<.001
D19 MIXED	0.1405	0.0162	8.67	<.001
H42 REMRURAL	0.0447	0.0109	4.10	<.001
G34 SSSI	0.2524	0.0734	3.44	<.001
C16 WOODLAND	-0.2243	0.0722	-3.11	0.002
G33 NVZ	0.03842	0.00979	3.92	<.001
D20 IMPROVED AGRI.	0.0667	0.0296	2.25	0.025
B1 COMM GRAZ	0.0790	0.0356	2.22	0.027
G36 RSPB	0.359	0.139	2.58	0.010
E25 SHEEP	0.872	0.343	2.54	0.011
E24 CATTLE DENSITY	-0.811	0.449	-1.81	0.071
C17 Glass houses	-0.1132	0.0651	-1.74	0.082
G35 DESIG	-0.1004	0.0615	-1.63	0.103
B4 SEASONAL RENT	0.1455	0.0935	1.56	0.120
NUMBER OF OBSERVATIONS 891				
ADJUSTED R^2 14.8				
Standard error 11.7				
MODEL Fr p. <.001				

The results from the models have highlighted how payments per UAA hectares for 121 had a stronger overall model output with the least variables in comparison to the percentage of holdings. Whilst for measure 214 and the option categories percentage holdings had the stronger R^2, the number of variables included in the model and therefore it was decided the most parsimonious models of the two dependents (e.g. payments) would be used for further analysis i.e. with least risk of collinearity or aliasing between parameters. Therefore the spatial models will be based on the dependents related to 'payments' only and based on the forward/backward step wise regressions.

5.4 Spatial model results

Geoda is used to test for normality, heteroskadiscity and spatial dependency. If spatial dependency is present in the models this will potentially suggest why there is a high level of heteroskadiscity in the residuals and in order to further test what type of spatial tendency is occurring a spatial lag and error model will be run using the same selected variables.

5.4.1 OLS Geoda model testing normality, heteroskadiscity, and spatial dependence

Table 23. OLS test results on selected models

OLS	121_pay	214 pay	Habitat_pay	Bird_pay	Water_pay
AIC	**10257.4**	**9640.61**	**9084.03**	**6880.63**	**6923.37**
Multi-collinearity	**16.4**	**5.99**	**6.57**	**6.57**	**8.96**
Jarque-Bera	**<.001**	**<.001**	**<.001**	**<.001**	**<.001**
Breusch-pagan	**<.001**	**<.001**	**<.001**	**<.001**	**<.001**
Koenker-Bassett test	**0.006**	**<.001**	**<.001**	**0.185**	**<.001**
White	**0.0326**	**N/A**	**<.001**	**0.54**	**N/A**
Morans I	**<.001**	**<.001**	**<.001**	**<.001**	**<.001**
Robust Lag	**<.001**	**<.001**	**<.001**	**0.005**	**<.001**
Robust Error	**0.009**	**0.122**	**0.691**	**0.0260**	**0.002**

The above results (table 23) indicate using the AIC (Akaike Information Criterion) that the options breakdown model shows an improvements in comparison to the full measure models. The model for payments 121 has the highest AIC at 10257 indicating it is the weaker of the models, whilst bird-payments has the lowest AIC at 6880 indicating a model with the best fit.

None of the models have multi-collinearity between the explanatory variables[4] following Geoda's test, whilst some correlation may exist the results a low enough to indicate this is not enough to influence the model (Anselin, 2005).

As expected all the models shows significance for the for jarque-bera test indicating that the residuals are non-normal distribution, which was already known from the initial exploratory statistics but also is to be expected if there is spatial dependency (Anselin, 2005).

Heteroskedasticity is shown to be problem for all the models; again this is an expected result due to the expected underlying spatial relationships. Both the Breusch-pagan and Koeneker tests for random coefficients, except Koeneker makes the residuals studentised e.g. they are made robust from non-normality (Anselin, 2005). The Breusch-pagan (BP) results show to be highly significant for every model, whilst Koenker-Bassett (KB) test illustrates the same with as slight lower p value for measure 121 and is insignificant for bird protection payments options. The predicted reason for having a significant BP test but negative KB is this is that KB tests is robust from non-normality and as this model has the best overall AIC this indicates that the null hypothesis can be accepted and that the model is stationary (ERSI, 2012). Howver in the majority the results showed in the model tests for heteroskedasticity indicated the residuals do not appear to be random; the error variance does not appear to be constant; and large responses are more variable than small responses. This outcome is expected when modelling dependents are being influenced by a spatial effect also due to some fo the extreme high payments per UAA ha and uptake considering some of the cross measure data issues e.g. many holdings can be assigned to one parish due to the main farm location code.

The white test is a specification for robustness, again testing for heterskadscity but not assuming a functional form, but uses a range of possibilities by all square powers. The white test is in general used more widely than the other test as it does assume any prior knowledge of heteroskedasticity (Anselin, 2005). The white test shows weak significance of 121 payments, whilst habitat payments shows a strong significance <.001 indicating rejection of null hypothesis and heteroskedasticity is present. Bird payments show a non significant value of 0.54, indicating that the null hypothesis of constant error variance is accepted. The White test returns N/A or for 214 payments and water payments this is when there is near collinearity among the terms used in the auxiliary regression (Anselin, 2005).. It is suggested

[4] Multi-collinearity is indicated by scores of less than 30, as if above 30 would be cause for concern.

that a more sophisticated approach would be to drop some of the terms in the expansion automatically, but that is not yet implemented in GeoDa (Anselin, 2005).

The spatial dependency results can be produced by adding the weight matrix; Gabriel, when the model is being created. The results show that the residuals for all the dependent models shows strong significance indicating that each have strong spatial autocorrelation. The other LM tests for a missing spatially lagged dependent variables (lagrange multiplier (lag) and the simple test for error dependence (lagrange multiplier (error). In each dependent variable the P value is <.001 indicating strong significance and spatial dependence. The robust LM (Lag) and robust LM (error) help us understand what type of spatial dependence might be occurring. In all the models both test are significant except for 214 payments, habitat management option payments, with Robust LM lag having a strong significance with p value <.001 whilst error as not significant P = 0.122. Overall in all the other model the P value for lag is stronger than that of error, therefore showing that controlling for spatial dependence, particularly in lag, will improve all the model performances.

5.4.2 Spatial lag and spatial error model results

Therefore despite the results indicating lag to be the most significant spatial dependency, both model types were ran to see what effect this had on the model quality. Results are shown the Table 24 below.

Table 24. spatial lag and spatial error test results

Spatial lag	121_pay	214_pay	Habitat_pay	Bird_pay	Water_pay
AIC	**10225.9**	**9457.93**	**8819.17**	**6871.67**	**6862.08**
Rho	**0.25**	**0.49**	**0.55**	**0.15**	**0.32**
R^2	**22.42**	**36.31**	**42.53**	**8.64**	**24.66**
Log likelihood	**-5096.94**	**-4718.96**	**-4399.59**	**3425.83**	**-3416.04**
Ratio test	**<.001**	**<.001**	**<.001**	**<.001**	**<.001**
ERROR					
AIC	**10233.2**	**9471.17**	**8825.97**	**6872.3**	**6871.27**
LAMBDA	**0.23 *****	**0.51*****	**0.57 *****	**0.14 ****	**0.33 *****
R^2	**21.43**	**35.56**	**42.37**	**8.28**	**22.80**
Likelihood	**<.001**	**<.001**	**<.001**	**0.004**	**<.001**

The results in table 24, illustrate as expected in all cases the spatial lag model shows the most model improvement, as can be seen from the lower AIC values, compared to both the OLS and error models It is also apparent that water habitat option payments has the lowest AIC and log likelihood indicating of all the models this model has the best fit. This is an interesting change as in the OLS the Bird conservation payments was the strongest model and by accounting for spatial lag this has improved the model for water habitats significantly with a reduction in the AIC of 61.29, whilst bird protection options only improved slightly with a reduction in the AIC of just 8.96.

The R^2 is shown but it is not comparable to the OLS as it is not a really R^2 but a pseudo R^2. However in comparison to the other spatial models the R^2 and more importantly the Rho is significantly improved for habitat payments.

The results confirm that there is spatial dependency for the selected rural development measures 121 and 214, and three option categories' has also shown to improve the model quality. The lag models indicates that there is a neighbouring effect, whilst the error model results also indicate that there is spatial influence that is coming through the error terms suggesting that an explanatory variables within those locations that have been omitted.

5.4.3 Test for spatial autocorrelation on residuals

The residuals of the models were tested and compared to see if the spatial models accounted for spatial dependency by reducing the spatial autocorrelation i.e. Morans I of the residuals from the OLS model.

Table 25. Morans I test results for the OLS, LAG and Error model

MORANS I residuals	121_pay	214_pay	Habitat_pay	Bird_pay	Water_pay
OLS	0.12***	0.34***	0.42***	0.07	0.17***
LAG	0.02	0.08	0.08	0.02	0.05
ERROR	0.01	0.07	0.08	0.01	0.03

The results above show that residuals of each model have all had a reduction in the Morans I score indicating that the models as expected, the inclusion of error and lag has successfully accounted for the spatial dependency within the models. Interestingly the residuals for bird protection option payments had a lower Morans I score originally within the OLS, this may also explain that bird protection in some respects has the least improvement in AIC comparing the OLS results to the Spatial models, whilst also showing contrasting results i.e. non-significance in the heteroskedasticity tests for KB test and the White test, suggesting that spatial dependency is less important for these options than it is compared to the other dependent variables.

6. Discussion

6.1 Overall model outcomes; percentage v's payments

All the models for each of the dependents were significant, the R^2 value varied according to what type of dependent value and according the measure or options included. The results indicate that from all the models 'percentage of holdings' gave the stronger model outcomes, although to note in all the models R^2 value remained relatively weak i.e. all below 20. This importantly could be expected due to the number of internal and external factors that can influence uptake and amount of funding applied for (Siebert et al. 2006).

Overall habitat and water habitat management options groups and measure 214 had the highest R^2 in the first models (including all the explanatory variables) with an R^2 from 18.2 – 19. This indicates that for measure 214 the use of spatial regional variables has a higher influence on uptake of agri-environment related measure, in comparison to uptake of measure 121. This could be expected as options for agri-environment are area based and eligibility for specific options will be in the majority of cases dependent on the regional biophysical and farming characteristics present in that location.

Whereas in contrast ‘payments per UAA ha’ for measure 121 had a much higher R^2 than that of percentage of uptake dependent, suggesting that regional selected characteristics have more of an impact of the amount of expenditure in Scottish parishes in regards to schemes related to the modernisation of agriculture. Whilst for measure 214 the R^2 was weaker for payments this is predicted to be as a result of the type of measure in terms of how payments are made e.g. for measure 121 there are capital payments that have no cap on amounts paid out, whilst measure 214 and options are ‘area based’ and in most cases have fixed payments rate per ha. Consequentially leading to much higher payments per ha with measure 121 than would be found with measure 214, and unsurprisingly leading to a higher standard error for measure 121 at 75.7, compared to 214 at 53.8.

6.2 Model subsets

For each of the dependents and different measures the different explanatory variables subsets had varying degrees of influence. For instance the ownership subset, measure 121 dependents had the largest impact on R^2 compared to the other dependents, a closer look at what variables influence percentage and payments for this measure illustrates that from all the variable’s in this subset ‘percentage of owned land’ had the biggest positive highly significant relationship with a t value of 5.75, this would fit with the expectations for the measure as before argued that those with access to financing would be more likely to be areas of owned agricultural land rather than rented or common grazing which would also be likely to support crofters, when as we already know the type of holdings taking up this measure are predominantly dairy farms. Whilst the majority of the 214 measures and options still showed ownership to be significant but alternatively with negative relationships with owned land and a positive relationship with rented land.

For measure 121 payments per UAA ha farming and livestock subsets appear to have a stronger significant relationship as before this could be related to the strong differences in the type of farming enterprises that are most likely to adopt this measure and also to their income and size relating to how much money they could be eligible for (Kamien and Schwartz, 1982). Farming variables did show to have no significant influence at all on bird protection payments per UAA ha, this could be assumed to be a consequence of options within the bird protection category also include capital payments for the most popular option ‘wild bird seed mix/ unharvested crop count' (total 953 cases/contract) which may mean that to depict farming regional trends with payments is less likely, whereas payments for habitat management showed significance at R^2 3.2 with woodland, other crops and unspecified all showing to be significant variables. However the farming variables as a subset as well as labour livestock and LCA in particular should be reviewed with caution as the variance of some parameter estimates is seriously inflated, due to near collinearity or aliasing between the following parameters.

The other subsets also showed distinct patterns according to the dependent variables, for instance for the subset labour; habitat management and bird protection options have the highest impact on explaining variance with highly significant models and R^2 of 8.7 and 8.2 respectively. Results show that the higher the percentage of holdings the higher number of total regular and casual staff, this is a reasonably expected outcome as the more farms that there are in the parish, the higher the density of labour might be, although this pattern is only predominately with measure 214 and less so for 121, arguably the more modernised farms have less requirement for labour as they have increased acess to machinery and technology (Glauben et al., 2005 in Baum et al., 2006).

Designated sites had the largest impact on payments per UAA ha of habitat management, and bird protection in particular with strong significant relationship and larger R^2. This impact remained highest for measure 214 and related options whilst for measure 121 designated sites had lower significance. This is to be expected as 214 options due to the eligibility and scoring criteria are more largely to be targeted and also get fast tracked and approved in the proposal assessment process if they are present in particular designated site locations (Scottish Government, 2009).

6.3 Explanatory variables

The results from the forward/backward step wise regression produced models that incorporated the least amount of variables to achieve the highest R^2 and limiting potential for collinearity as a result. Due to the lower numbers of variables needed for the payments per UAA ha models e.g. for measure 214 the payments model only required 8 variables, whilst 18 were present in the percentage of holdings models. The payment dependent variables were consequentially chosen for further analysis in the spatial models and the explanatory variables within these models are of interest in terms of their type and strength of relationship with each of the dependents.

There were firstly some explanatory variables that appeared in each of the models chosen for further analysis, including i.e. percentages of Mixed LCA and NVZ per parish. In measure 121 models these variables both showed to have a negative relationship with payments per UAA ha, whilst in contrast, a positive relationship with 214 and the option categories. Payments for measure 121 relationship with mixed land capability is to be expected as uptake on mixed farm land types (Figure 6, p19) shows only 8 % of holdings uptake within that farm type, whereas farms with cattle are by far the biggest number of holdings and beneficiaries for 121 payments (34 % of farms taken up these measure from total number of farms in that farm type).

Furthermore the model results for measure 121 payments also show that cattle have a very significant and positive influence on payments as a result (t value of 5.98). The negative effect with NVZ again could be related to the type of farms present in those regions i.e. by observing the map of cattle densities in Scotland these are highest in the central belt and south western borders of Scotland, whilst NVZ zones are found very strictly in the far eastern and coastal parishes of Scotland including section of the Grampians, Forth and the borders RPACs (see Appendix 7). Additionally the bigger dairy farms or others that would be more likely to take up the modernisation measure that as capital payments require larger investments from the holdings themselves in the first place.

In contrast the 214 had quite and even spread across many of the farm types but included 13 % of mixed farm types as the most common farm, which fits well with the results of the model. These positive significant trends remained the same for the 214 option groups also, indicating that mixed farm lands are important determinant for all agri-environmental related options. However the results with NVZ are a little more unexpected, whilst it was predicted this would be a somewhat important determinant the strength and impact indicated by the high t values is unexpected. It is assumed that due to the originally identified almost binomial frequency distribution of this explanatory variable, it will have a consequentially higher leverage on the dependents. Arguably whilst NVZ area is a designated sites, observing the map of uptake and percentages for 214 dependents the spread is much more widespread i.e. outside of the NVZ then these model results would indicate. Therefore this outcome is observed with less confidence.

Additionally it is believed the same consequence has occurred with the variable ’remote rural’ which also appears to have a strong significant positive relationship with the 214 measure and options dependents and also had the same type of histogram distribution as NVZ. Having remote rural areas as a influencing factor for remote rural areas would be an encouraging result, in terms of seeing higher payments per ha being made to areas who could arguably be deemed more in need i.e. lower income farms, but the Figure 8 on P.22 disputes that this is the regional pattern that is occurring i.e. in terms of highlands not getting the equivalent proportion of expenditure according to the its area of UAA, with higher spending occurring in the Grampians. However in support of the model results the spread of remote rural areas in Scotland is nationwide and so are payments per UAA ha for measure 214. Interestingly though this variable was absent from measure 121 models, indicating that for modernisation remote rural is not of importance in determining payments for his measure

Another variable that weren't present in the 121 models, but appeared in all other models (those related to measure 214), was SSSI (protected areas). This is to be expected as mentioned with measure 214 influence with the designated sites model subsets, this variable in especially as SSSI zones in particular receive more points in the competitive application process and to bring SSSI sites to favourable conditions is one of the SRDP national targets. Therefore applicants in these sites are more likely to be successfully beneficiaries (Scotland Government, 2009). Interestingly the amalgamated designated sites variables (including Ramsar, SSSI etc.) failed to appear as significant, although did appear in the dependent for percentage of holdings and also payments per UAA ha for after habitat options, but interestingly the t values were negative. This is a surprising results, but perhaps as SSSI still appears as a significant positive impact this outcome indicates that from all the various types of designated areas it is really only SSSI that evidently has a clear positive uptake and impact on payments for the agri-environment options.

Those variables that indicated a negative relationship for the measure 214 models included glass houses density, and percentage of woodland (farming). This result is also to be expected as glass houses for agriculture could be assumed to be related to more intensive practices of agriculture that aren't as cohesive with agri-environmental options, whilst woodlands although eligible or rural payments are not targeted as such with the measure 214, but primarily through other Axis 2 measures. Generally due to the nature of agri-environmental options many of the same explanatory variables appeared in the 214 whole measure model, as well as the option breakdowns.

Overall the explanatory variables from the step wise models were as expected, with some unusual results that could be attributed to the frequency distribution of those variables and parishes. Measure 121 showed to have the highest R^2 of all the payment per UAA ha models, with 17.3, however consequentially had the highest number of variables required for the model including the highest standard error (SE 75.7). While measure 214 as a whole had a higher R^2 at 15.9 then the option breakdowns but again had a higher standard error of 53.8 thus of all the models bird payments had the best model fit with the lowest AIC, which may also be largely be due to the smaller number of variables contained in the model. Thus by breaking the measure 214 down it did consequentially improve the model overall and also expresses more specific trends related to the options within those categories.

6.4 Spatial dependency

The results show as expected that the uptake of these measures and payments per UAA ha is spatially dependent. However all the models tested spatial lag to have the biggest improvement on the strength of the model showing there is indeed a neighbourhood effect occurring between parishes in the Scotland case study situation.

The spatial error models also were significant indicating an underlying missing spatial explanatory variable, this may be a missing regional characteristic but could equally be a less tangible influential variable related to that area such as social networks, access to advice etc.

The final spatial autocorrelation test on the residuals from the OLS, spatial lag and error models showed that there is certainly a spatial dependency at play although the results of bird protection were marginal indicating that spatial dependency is not as strong in connection to these options, although it is predicted that if these options if further broken down to single options would likely predictably correlate with bird distributions that those options target.

and whilst this is indicated further research into what regions in particular experienced what type of trends would be encouraged to see whether particular variables have certain impacts at a more isolated level, that can be depicted at a national scale analysis.

7. Conclusion

Overall the results showed improvement by suing the spatial models to compensate for spatial dependency in the OLS models. The varying importance of particular variables with the corresponding dependent variables was in most cases as expected and gives some helpful insights into part of the story as to the uptake and level of expenditure for rural development measures implemented under the rural priorities scheme in Scotland. However the low R^2 values have meant that a strong explanation of the variance in the dependents was not found however, due to the nature of 'voluntary' RDP option uptake and the competitive process of the scheme it is understood that a large number of other factors are responsible for the uptake of these rural measures. For example the economic consideration of taking up a particular measure and option is argued to be an important factor (Wilson and Hart, 2000), this may be related to economic incentives, access to finance, etc. However, Farmer's co-operation in such schemes, as argued by Siebert et al. (2006) cannot be attributed to solely economic factors, but is an 'intricate interaction of contingencies' of many variables. Moreover, people are not rational in the pure economic sense, as defined by a cost-benefits analysis, but are just as likely to be influenced by personal factors (DEFRA, 2008).

Accordingly, there are a number of variables which may influence the uptake of measures by farmers, as outlined by Edwards-Jones (2006) including; socio-demographics and psychological make up of farmers, farm household characteristics, structure of farm business, other social factors and finally the characteristics of the schemes themselves (Ruto and Garrod, 2009). These variables can be categorised as: external, internal and social external referring to outside influences, and internal being related to the farmer directly, and finally social influences related to social networks. Therefore with all these considerations the regional spatial determinants for uptake and expenditure, will predictably have some influence but this is, as the results also show, unable to explain the full story of how decisions are made not only by the applicants but also the government authorities who design and implement the policy, and importantly assess and score the applicants proposals.

8. Implications for further work

The data was run as linear regression models in order to be to be comparable to the other case studies, and also to be able to use the spatial model capabilities within Geoda. Considering the skewed distribution of many of the dependent and explanatory variables in this study, further investigations using non-parametric models to analyse the data would be useful to see if better results can be provided. However it may mean that the variables may still provide similarly weak explanations of the variance due to the likelihood of other external variables. The type of models that could be used include: logistic model, Tobit and Heckman selection.

Further investigation into individual options would also be predicted to bring out stronger trends than that found in the analysis of measures as one, The types of options available are very wide and therefore have various specific eligibility criteria, it would be useful if time is available to investigate deeper into what variables might influence specific option uptake for

214. However this would only be possible with options with high uptake levels, therefore for measure 214 this could include options for example on hedgerows or management of species rich grassland.

Lastly as suggest earlier a break down of the regions and further modelling analysis into the regional explanatory variables that influence the dependent variables could be conducted to explore further where these patterns occur and understand more about the type of spatial dependency relationships at play.

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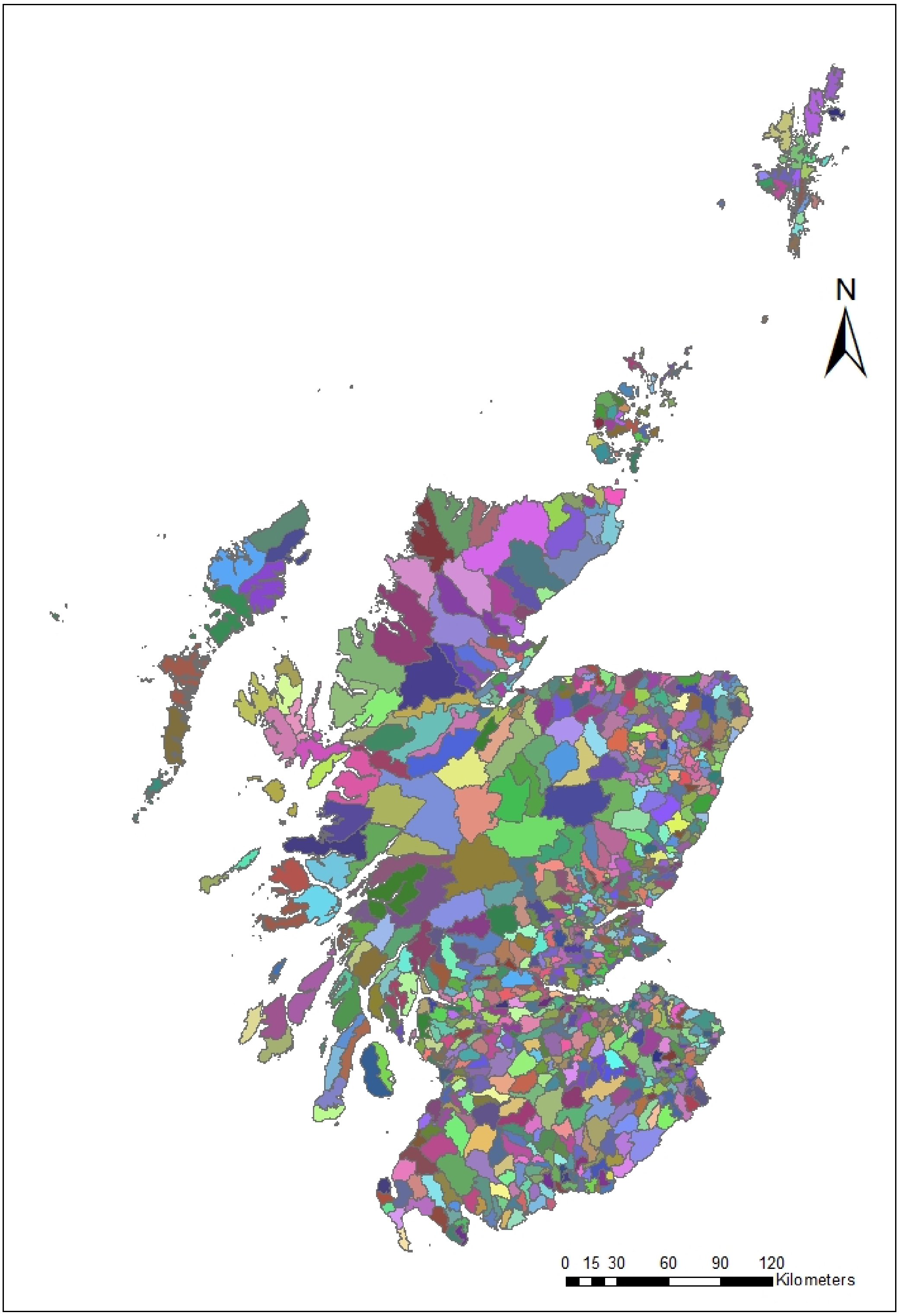
Appendix 1. Scottish agricultural parish map (n = 891)



Appendix 2. Data details

Table 1. Spatial Data Units

No.	Spatial data identifier	Data Reference variable name	Other information	Source
1a	Parish code	PARCODE	Total number = 891	Scottish Government
2a	Parish name	PARNAME	-	Scottish Government
3a	Parish size (Ha)	Parish_area_ha	Derived independently using GIS and spatial Scottish parish dataset	Scottish Government
4a	RPAC name	RPAC	Total number of Scotland RPAC regions = 11	Scottish Government

Table 2. Dependent variables

No.	Dependent Variable	Data Reference variable name	Other information	Source
1b	Percentage of Holdings uptake per parish	%__uptake	This data is derived independently from separate measures 121, 214 and 311 parish number of holdings uptake per parish 2008 – 2011 and total number of all agri-holdings per parish, 2011 The main farm location code whilst not provided in the data, the associated parish for that code is provided, however a number of holdings may be associated with different parish locations, however this information	Scottish Government: SRDP and agri-census data (2008 – 2011)

			isn't provided and consequentially some results can seem unusual i.e. some parishes are over 100% UAA land cover (exceeds size of parish). Some parishes codes go between different RPACs e.g. may be that some large holdings extend between multiple parish borders. It may also be as data is assigned to main farm codes other owned holdings may be present in other locations entirely e.g. for one holding in parish 456 has associated four RPACS including: Highland, Ayrshire, Grampians and Argyll. To illustrate how this would lead to misleading results if the percentage of holdings taking up measure 214 (15,322 from 2008 - June 2011) is compared to the total number of holdings across Scotland (52,279, 2010) (Scottish Government, 2011) it would mean that 29% of all farm holdings. have taken up 214. However as this refers to option uptake, rather than the number of holdings itself, it was important to determine what the true numbers of holdings are. Therefore in this case for 214 the actual derived number of holdings comes to 2,163 this would be a much smaller proportion of total holdings of 4.14%.	
2b	Total expenditure per parish	Expend_perUAA	This data is derived independently separate	Scottish Government: SRDP

	per UAA hectare		measures 121, 214 and 311 expenditure per parish for agri-holdings (£) 'divided' by total UAA hectares per parish (ha)	and agri-census data (2008 – 2011)

Table 3. Farm characteristic data explanatory variables				
No.	Independent Variable at holding level	Data Reference variable name	Other information	Source
1c	Standard Gross Margin	SGM_2000	SGM is the Scottish average for the years 1998 to 2002. It represents the farmgate worth generated by a holding's crops and livestock and is calculated by applying multipliers (in £s) to all crop areas and livestock units. These multipliers are calculated at a Scotland level and take into account average output values, variable costs and subsidy levels.	Scottish Government: SRDP and agri-census data (2008 – 2011)
2c	Standard Labour requirements	SLR	SLR represent the amount of labour required by a holding to carry out all of its agricultural activity and is also used as a measure of farm size. Standard Labour Requirements are derived at an aggregate level for each agricultural activity. The total SLR for each farm is calculated by multiplying its crop areas and livestock numbers by the appropriate SLR	Scottish Government: SRDP and agri-census data (2008 – 2011)

			coefficients and then summing the results for all agricultural activity on that farm. One SLR equates to 1900 working hours per year.	
3c	Economic size Unit	ESU	European Size Units (ESU) equate to the European Commission's measure. To convert from SGMs to ESU the SGM total is divided by €1,200.	Scottish Government: SRDP and agri-census data (2008 – 2011)
4c	Farm type	Robust / Mains	The farm type variables included in the dataset are 'main' and 'robust'. These are typologies organised on a hierarchical basis which describe the dominant activity on the holding (e.g. a 'Cereals' holding may also have some livestock). Main farm types includes 27 classes whilst robust provides a summary of these classes as 10 classes. See appendix for further information on how these classes are divided (See Appendix 6)	Scottish Government: SRDP and agri-census data (2008 – 2011)

Table 4. Explanatory variables

No.	Independent Variable at parish level	Data Reference variable name	Other information	Source
1d	OWNERSHIP: Percentage of owned agricultural area	%_owned	This data is derived independently from the spatial agri-census hectares of owned land data which by using GIS is converted to parish scale, which is then calculated as a proportion of total parish size (ha)	Agri-census (2010) Scottish Government via Edina

2d	OWNERSHIP: Percentage of rented agricultural area	%_rent	Same as above (using agri-census hectares of rented land data)	Agri-census (2010) Scottish Government via Edina
3d	OWNERSHIP: Percentage of seasonal rented agricultural land	%_seasonal_rent	Same as above (using agri-census hectares of seasonal rented land data)	Agri-census (2010) Scottish Government via Edina
4d	OWNERSHIP: Percentage of seasonal let agricultural land	%_seasonal let	Same as above (using agri-census hectares of seasonal let land data)	Agri-census (2010) Scottish Government via Edina
5d	OWNERSHIP: Percentage of common grazings	%_comm_Graz	This data is independently derived from the total hectares of common grazing's 2011 per parish, which is then calculated as a proportion of total parish size (ha)	Scottish Government: Scottish Agri-census data
6d	LIVESTOCK: Total cattle	Total_Cattle	This data is derived independently from the spatial agri-census total cattle data which by using GIS is converted to parish scale.	Agri-census (2010) Scottish Government via Edina
7d	LIVESTOCK: Total sheep	Total_sheep	Same as above (using agri-census total sheep data)	Agri-census (2010) Scottish Government via Edina
8d	LIVESTOCK: Total beef heifers	Total_beef	Same as above (using agri-census total beef heifers data)	Agri-census (2010) Scottish Government via Edina
9d	LIVESTOCK: Total dairy heifers	Total-Dairy	Same as above (using agri-census total dairy heifers data)	Agri-census (2010) Scottish Government via Edina
10d	LABOUR: Full-time occupiers	FT_Occup	Same as above (using agri-census total full-time occupiers data)	Agri-census (2010) Scottish Government via Edina

11d	LABOUR: Part-time occupiers	PT_Occup	Same as above (using agri-census total part-time occupiers data)	Agri-census (2010) Scottish Government via Edina
12d	LABOUR: Full-time spouses	FT_Spouse	Same as above (using agri-census total full-time spouses data)	Agri-census (2010) Scottish Government via Edina
13d	LABOUR: Part-time spouse	PT_Spouse	Same as above (using agri-census total part-time spouses data)	Agri-census (2010) Scottish Government via Edina
14d	LABOUR: Total regular & casual staff	Total_Reg_staff	Same as above (using agri-census total regular and part time staff data)	Agri-census (2010) Scottish Government via Edina
15d	BIO-PHYSICAL: Percentage of land capable for supporting arable agriculture	%_arable LCA	The land capability for agriculture (LCA) 1:25000 scale vector dataset is used to "rank land on the basis of its potential for productivity and cropping flexibility. This is determined by the extent to which physical characteristics of the land (soil, climate, and relief) impose on long terms restrictions on its use" (JHI, 2001). This data is derived independently from the spatial LCA dataset using GIS to reclassify (class 1 to 3.1) and extract 'arable' class only then converted to parish scale which is then calculated as a proportion of total parish size (ha). JHI (2011) states land in this class is	James Hutton Institute (JHI) (national soils inventory and surveys for Scotland 1978-1987 and 2006-2011) and Scottish Government

			considered "prime agricultural land, capable of supporting a wide range of crops".	
16d	BIO-PHYSICAL: Percentage of land capable for supporting Mixed agriculture	%_mixed LCA	Same as above (extracting mixed class only (class 3.2 to 4.2). JHI (2011) states land in this class is considered "capable of being used to grow a moderate range of crops including cereals, forage crops and grass".	James Hutton Institute (JHI) (national soils inventory and surveys for Scotland 1978-1987 and 2006-2011) and Scottish Government
17d	BIO-PHYSICAL: Percentage of land capable for supporting improved agriculture	%_IMPROVED lca	Same as above (extracting improved class only (class 5.1 to 5.3). JHI (2011) states land in this "has the potential for use as improved grassland… limitations on this land include climate, slope, wetness and other heterogeneous patterns that render even occasional cultivation unsuitable".	James Hutton Institute (JHI) (national soils inventory and surveys for Scotland 1978-1987 and 2006-2011) and Scottish Government
18d	BIO-PHYSICAL: Percentage of land capable for supporting rough agriculture	%_ROUGHLCA	Same as above (extracting Rough class only (class 6.1 to 7). JHI (2011) states land "has very severe limitations that prevent sward improvement my mechanical means. The land is either too steep, very poorly drained, has very acidic or shallow oils and occurs in wet, cool climate zones."	James Hutton Institute (JHI) (national soils inventory and surveys for Scotland 1978-1987 and 2006-2011) and Scottish Government
19d	BIO-PHYSICAL: Percentage of land capable for supporting built up areas	*%_BUILTLCA*	Same as above (extracting built up class only (class 888).	James Hutton Institute (JHI) (national soils

			Land in this class represent built up/ urban areas.	inventory and surveys for Scotland 1978-1987 and 2006-2011) and Scottish Government
20d	BIO-PHYSICAL: Percentage of inland water area	*%_WATER*	Same as above (extracting inland water class only (class 999). Land in this class represents inland water e.g. lochs, rivers etc.	James Hutton Institute (JHI) (national soils inventory and surveys for Scotland 1978-1987 and 2006-2011) and Scottish Government
21d	BIOPHYSICAL: Percentage of rough grazing area	*%_ROUGH*	This data is derived independently from the spatial agri-census hectares of rough grazing data which by using GIS is converted to parish scale, which is then calculated as a proportion of total parish size (ha).	Agri-census (2010) Scottish Government via Edina
22d	BIOPHYSICAL: Percentage of woodland area	*%_woodland*	Same as above (using agri-census woodland hectare area data).	Agri-census (2010) Scottish Government via Edina
23d	BIOPHYSICAL: Percentage of crops and grass area	*%_Total_crops&grass*	Same as above (using agri-census hectares of crops and grass area data)	Agri-census (2010) Scottish Government via Edina
24d	BIOPHYSICAL: Percentage of grass less than five years old area	%_grass<5yrsold	Same as above (using agri-census hectares of grass less than five years old area data)	Agri-census (2010) Scottish Government via Edina
25d	BIOPHYSICAL: Percentage of grass more than five years old area	%_grass more 5yrs older	Same as above (using agri-census hectares of grass more than five years old area data)	Agri-census (2010) Scottish Government via Edina
26d	BIOPHYSICAL: Percentage of other land area	%_other land	Same as above (using agri-census hectares of other land area data)	Agri-census (2010) Scottish Government via

				Edina
27d	BIOPHYSICAL: Percentage of total crops and fallow area	%_totalcrops_Fallow	Same as above (using agri-census hectares of total crops and fallow area data)	Agri-census (2010) Scottish Government via Edina
28d	BIOPHYSICAL: Percentage of other crops area	%_other crops	Same as above (using agri-census hectares of other crops area data)	Agri-census (2010) Scottish Government via Edina
29d	BIOPHYSICAL: Percentage of total vegetables area	%_total vegetables	Same as above (using agri-census hectares of total vegetables area data)	Agri-census (2010) Scottish Government via Edina
30d	BIOPHYSICAL: Percentage of other land area	%_Other land	Same as above (using agri-census hectares of total vegetables area data)	Agri-census (2010) Scottish Government via Edina
31d	BIOPHYSICAL: Percentage of unspecified area	%_unspecified	Same as above (using agri-census hectares of total vegetables area data)	Agri-census (2010) Scottish Government via Edina
32d	BIOPHYSICAL: Percentage of total crops and grass area	%_totalcropsand_grass	Same as above (using agri-census hectares of total vegetables area data)	Agri-census (2010) Scottish Government via Edina
33d	PROTECTED AREAS: Percentage of Nitrate Vulnerable Zones area	%_NVZ	Same as above (using NVZ area data)	Scottish Government (2012)
34d	PROTECTED AREAS: Percentage of SSSI area	%_SSSI	The SSSI (Sites of Special Scientific Interest) are those areas of land and water that Scottish Natural Heritage (SNH) considers to best represent it's natural heritage, many of which are designated as Natura sites (SNH, 2012).	Scottish Government (2012) via Scottish Natural Heritage, natural spaces

			This data is derived independently from the spatial SSSI vector dataset using GIS to reclassify to simplify data class then data was joined with the parish layer and then SSSI coverage worked out as a proportion of total parish size (ha).	
35d	PROTECTED AREAS: Percentage of complete national designated areas	%_deisgn_areas	This data is derived independently from SSSIs, SACs (Special areas of conservation), SPAs (Special protected areas) and Ramsar sites spatial datasets. This selection of designated sites were chosen to form an individual layer as it is these sites that are noted in the rural priorities as key national targets to bring these sites to 'favourable condition' and contribute to scoring higher points in the project assessment process. The four datasets where merged and reclassified, was joined with the parish layer and then designated site coverage calculated out as a proportion of total parish size (ha).	Scottish Government (2012) via Scottish Natural Heritage, natural spaces
36d	PROTECTED AREAS: Percentage of RSPB reserve areas	%_RSPB_AREA	The RSPB (Royal Society for the protections of birds) reserve data is derived independently from the spatial RSPB Scotland vector dataset using GIS to reclassify to simplify data class then data was joined with the parish layer and then RSPB reserve coverage worked out as a proportion of total parish size (ha).	RSPB (2012)
37d	REMOTENESS: Percentage of 'large	%_large_urban	The Scottish Government (SG) Urban/Rural	Scottish Government

	urban' areas		Classification the 6 fold classification system provides a consistent way of defining urban and rural areas across Scotland. The classification is based upon two main criteria: (i) population as defined by the General Register Office for Scotland (GROS), and (ii) accessibility based on drive time analysis to differentiate between accessible and remote areas in Scotland (Scottish Government 2010). The large urban areas data is derived independently from the spatial rural urban classification Scotland vector dataset using GIS to define agricultural boundaries, were areas (ha) per class type were calculated then extract the dbf file of the attribute data, which is then joined with the parish layer and proportion of that class is calculated as a proportion of total parish size (ha).	(2010)
38d	REMOTENESS: Percentage of 'Other urban' areas	%_Other_urban	Same as above (for other urban areas data)	Scottish Government (2010)
39d	REMOTENESS: Percentage of 'Accessible small towns' areas	%_Access_small	Same as above (for other accessible smaller town areas data)	Scottish Government (2010)
40d	REMOTENESS: Percentage of 'Remote small towns' areas	%_remote_small	Same as above (for other remote smaller town areas data)	Scottish Government (2010)
41d	REMOTENESS: Percentage of 'Accessible rural' areas	%_access_rural	Same as above (for other Accessible rural areas data)	Scottish Government (2010)
42d	REMOTENESS: Percentage of 'Accessible rural' areas	%_remote_rural	Same as above (for other remote rural areas data)	Scottish Government (2010)

Appendix 3. Spatial weight matrix results

Table 1 Summary: Queen contiguity for Scotland's parishes	
Number of regions:	891
Number of nonzero links:	4472
Percentage nonzero weights:	0.56
Average number of links:	5.019
25 regions with no links:	147 148 153 164 168 279 443 456 457 465 610 613 627 630 631 632 633 634 869 874 879 886 889 890 891
Link number distribution:	0 1 2 3 4 5 6 7 8 9 10 11 25 22 54 87 154 168 171 117 65 22 4 2
22 least connected regions:	150 151 157 165 166 172 274 275 341 460 462 583 611 612 623 628 629 861 862 871 876 880 with 1 link
2 most connected regions:	521 807 with 11 links

Table 2 Summary: Distance cut off for Scotland's parishes	
Number of regions:	891
Number of nonzero links:	58832
Percentage nonzero weights:	7.41
Average number of links:	66.03
Link number distribution	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 3 4 4 10 7 7 8 6 7 6 4 8 8 6 9 6 9 12 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 5 6 6 12 3 4 3 3 5 3 3 5 7 5 7 5 6 6 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 8 7 6 5 11 5 6 10 6 5 7 4 7 5 9 11 12 6 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 5 9 9 7 9 8 13 16 9 5 9 10 7 7 9 13 6 5 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 10 6 7 15 7 9 7 7 11 9 8 7 4 8 10 10 6 6 91 92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108

	5 6 8 8 3 5 8 5 5 3 6 3 5 4 11 5 10 6 109 110 111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 5 3 4 6 3 6 8 6 6 6 4 1 4 3 2 4 4 5 127 128 129 130 131 132 133 134 135 136 138 139 140 141 142 143 146 147 6 5 1 3 3 2 5 3 9 3 2 3 1 1 3 2 1 1
3 least connected regions	168 443 457 with 1 link
1 most connected region:	403 with 147 links

Table 7. Summary Gabriel matrix for Scotland's parishes	
Number of regions:	891
Minimum links:	2
Maximum links:	8
Average number of links:	4.47
Standard deviation	1.092
32 least connected regions (total 2 links):	26 27 150 158 168 225 227 248 251 289 313 337 350 369 397 426 471 473 515 601 623 745 753 792 831 858 862 869 871 873 876 886
3 most connected regions (8 links):	880 456 843

Appendix 4 measure 214 option categorisation

Bird protection	Total contracts
RP21402 - Wild Bird Seed Mix/Unharvested Crop Count	953
RP21408 - Management of Cover for Corncrakes Count	215
RP21405C - Mown Grassland for Corncrakes - 1 Sept Count	164
RP21406 - Grazed Grassland for Corncrakes	135
RP21405A - Mown Grassland for Corncrakes - 1 Aug	119
RP21410C - Mammal and Bird Control - for Black Grouse/Capercaillie	86
RP21405B - Mown Grassland for Corncrakes - 15 Aug	62
RP21404 - Mown Grassland for Corn Buntings	57
RP21407 - Creation and Management of Cover for Corncrakes	47
RP21411B - Supplementary Food Provision for Raptors - Golden Eagles	6
RP21412A - Wardening for Golden Eagles - Farm unit	2
RP21411A - Supplementary Food Provision for Raptors - Hen Harriers	1

Non- native species control	
RP21413E - Control of grey squirrel for red squirrel conservation	100
RP21413A - Control of invasive non-native species - Rhododendron	27
RP21410A - Mammal and Bird Control - Predator control	16
RP21413C - Control of invasive non-native species - Giant Hogweed	6
RP21413B - Control of invasive non-native species - Japanese Knotweed	5
RP21413F - Control of grey squirrel for broadleaf woodland protection	2
RP21410B - Mammal and Bird Control - crow control	18

Habitat management	
RP21433A - Hedgerows - 3 years for biodiversity benefits	1601
RP21414 - Management of Species Rich Grassland	1131
RP21403 - Mown Grassland for Wildlife	947
RP21417 - Management of Habitat Mosaics	635
RP21435A - Grass Margins and Beetlebanks - mixed arable	488
RP21427 - Management of Moorland Grazing	343
RP21434 - Extended hedges	338
RP21416 - Creation and Management of Species Rich Grassland	278
RP21439 - Scrub and Tall Herb Communities	274
RP21415 - Bracken Management Programme for Habitat Enhancement	269
RP21441A - Conservation Management for Small Units - Individual	239
RP21429 - Moorland - Stock Disposal	222
RP21432 - Muirburn and Heather Swiping	213
RP21433B - Hedgerows - 2 years for landscape benefits	161
RP21430 - Away-Wintering of Sheep	138

RP21442B - Grazing Management of Cattle - Introduction	130
RP21436A - Biodiversity Cropping on In-Bye - basic management	107
RP21442A - Grazing Management of Cattle - Retention	93
RP21431 - Off-Wintering of Sheep	92
RP21428 - Moorland Grazings on Uplands and Peatlands	67
RP21437A - Cropped Machair - with FYM/seaweed	43
RP21441B - Conservation Management for Small Units - Collective	38
RP21425 - Lowland Heath	27
RP21426 - Wildlife Management on Upland and Peatland Sites	26
RP21440 - Arable reversion to grassland	24
RP21437B - Cropped Machair - with FYM/seaweed and binder/stooks	18
RP21438A - Ancient Wood Pasture - In-bye Land	14
RP21437D - Cropped Machair - without FYM/seaweed, with binder/stooks	11
RP21438B - Ancient Wood Pasture - Rough Grazing	11
RP21435B - Grass Margins and Beetlebanks - organic	11
RP21436B - Biodiversity Cropping on In-Bye - with binders/stooks	2
RP21437C - Cropped Machair - without FYM/seaweed	7

Organic farming	
RP21401F - Maintenance of organic farming - improved grassland	100
RP21401E - Maintenance of organic farming - arable	78
RP21401H - Maintenance of organic farming - rough grazing	78
RP21401B - Conversion to organic farming - improved grassland	51
RP21401A - Conversion to organic farming - arable	44
RP21401D - Conversion to organic farming - rough grazing	37
RP21401C - Conversion to organic farming - fruit and veg	10
RP21401G - Maintenance of organic farming - fruit and veg	5

Water habitat	
RP21421A - Water Margins - Enhance biodiversity	1691
RP21409 - Open Grazed or Wet Grassland for Wildlife	1680
RP21418 - Management of Wetland	1189
RP21421B - Water Margins - reduce diffuse pollution	248
RP21424 - Coastal or Serpentine Heath	131
RP21422 - Management of Flood Plains	120
RP21419 - Create, Restore and Manage Wetland	80
RP21420B - Lowland Raised Bogs - Basic plus Grazing Management	25
RP21423 - Buffer Areas for Fens and Lowland Raised Bogs	24
RP21420A - Lowland Raised Bogs - Basic management	22

Appendix 5 Descriptive statistics

5.1 Option uptake for measure 121

There are 6 options under 121 (as shown in the figure 1 below) and from the process of obtaining the true number of total holdings descriptive statistics indicated that the majority of holdings only took up 1 option (Table 2) therefore it justifies keeping the data in its original form, however it should be recognised that both approaches have a level of error.

The figure below also shows that only two of the six options have the most significant uptake including restructuring agricultural business (total participants 896) and manure/slurry storage (Total participants 416). Whilst the option renewable energy has 79 participants this is clearly a weak uptake from the total ~52,508 holdings in Scotland. While the last two options; manure/ slurry storage treatment and short rotation coppice have very limited uptake.

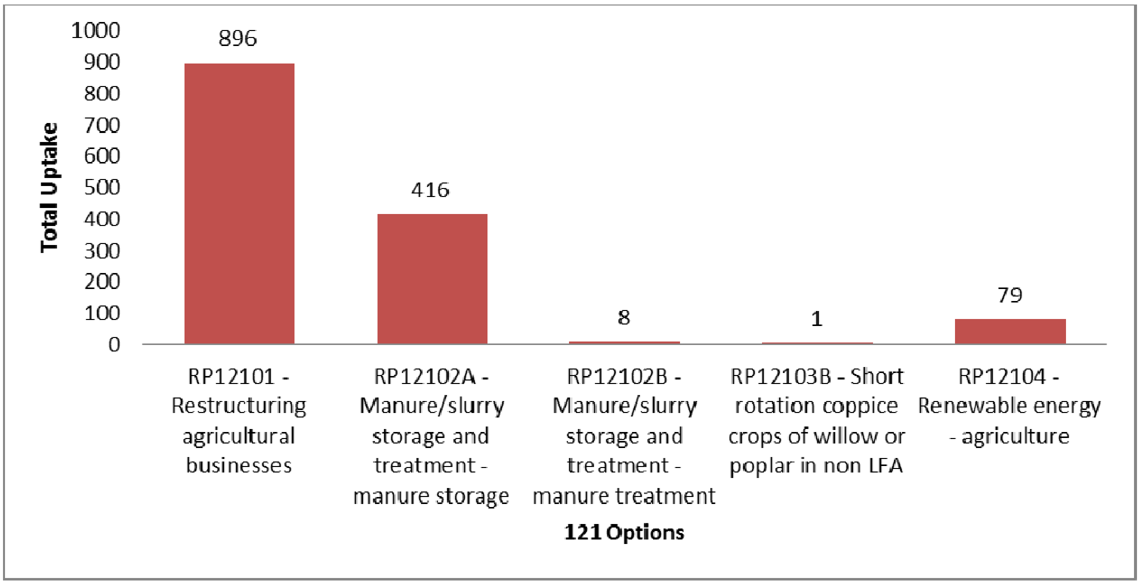


Figure 1. Frequency of cases per option fro measure 121, Scotland (Scottish Government data, 2008 – 2011)

5.2 Option uptake for measure 214

There are a total of around 69 options and sub-options for the measure 214, these are centred on biodiversity and habitat management, organic farming, bird protection and control of non-native species.

The types of options available are very wide and therefore have various specific eligibility criteria, it would be useful if time is available to investigate deeper into what variables might influence specific option uptake for 214.

However due to the extremely high number of options available these would not be possible or particularly useful due to the very specific nature of some of the options but also due the relatively limited uptake the majority of options have. As can be seen in the bar chart below there is long skewed distribution with most uptake occurring within ten options. Due to the high number these options they were organised into groups for further analysis (see appendix 4)

The percentage of farm's per robust farm type category shows that from the five option categories that habitat options have the highest percentage with most the farm types, but this is to be expected as these types of options have the highest uptake (Figure 2).

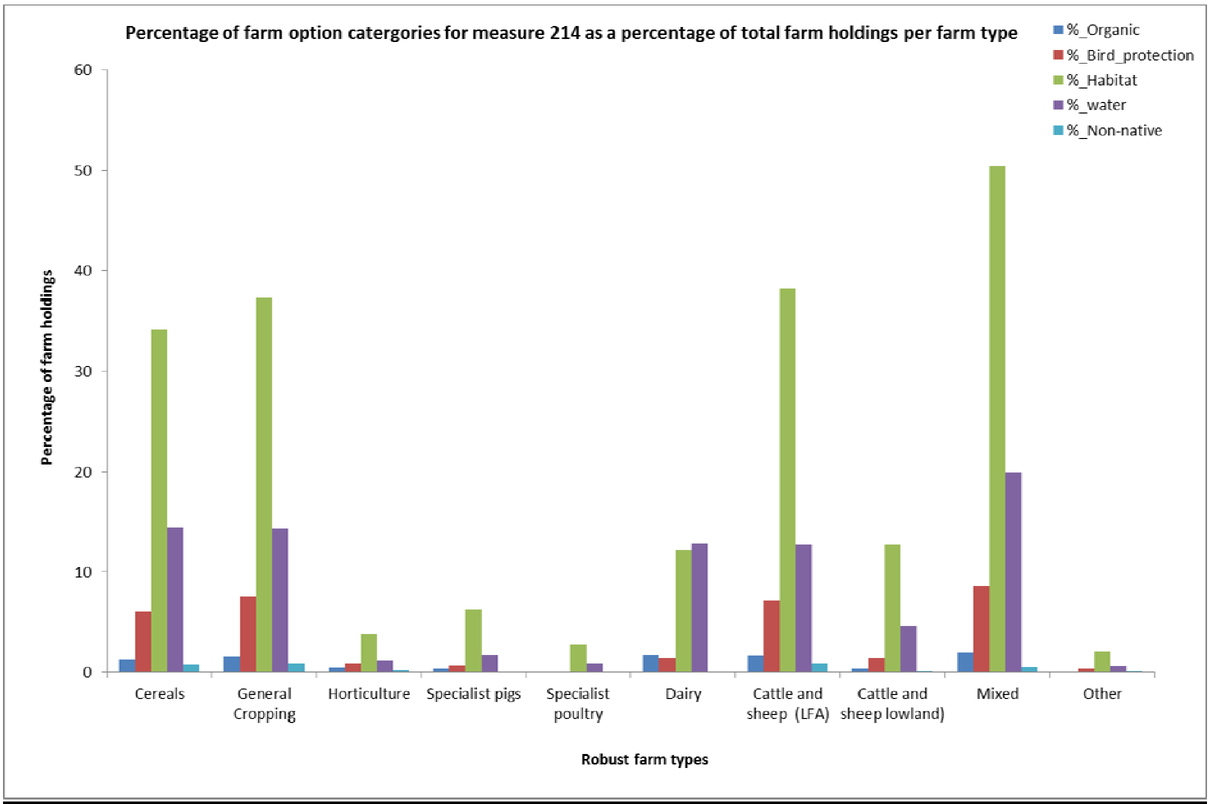
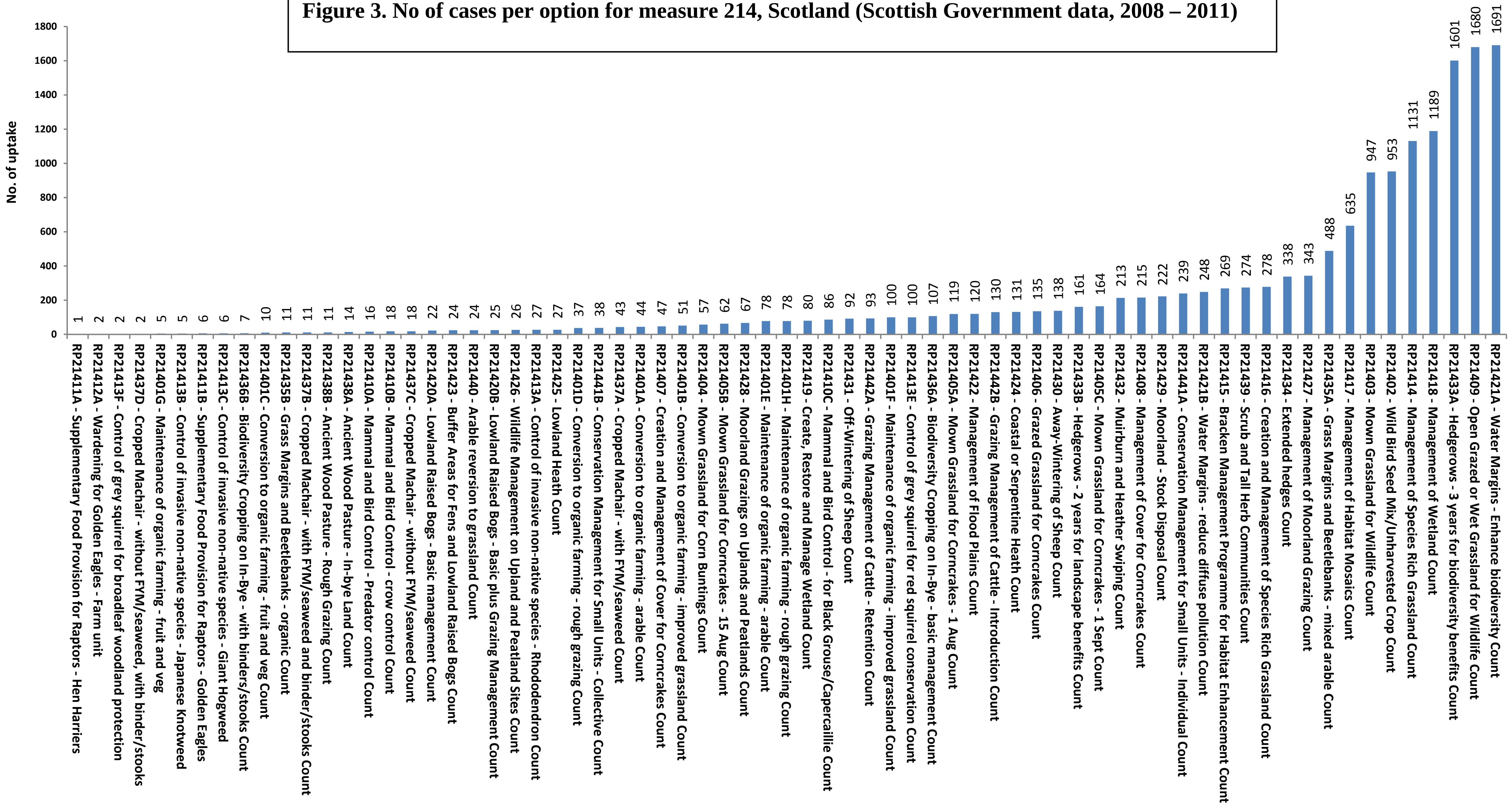


Figure 2. Percentage of farm option categories for measure 214 as a percentage of farm holdings per farm type.

The total number fo cases per measure 214 options is illustrated in figure 3 below. There are a total of around 69 options and sub-options for the measure 214, these are centred on biodiversity and habitat management, organic farming, bird protection and control of non-native species. The types of options available are very wide and therefore have various specific eligibility criteria. As can be seen in the bar chart below there is long skewed distribution with most uptake occurring within around ten options.

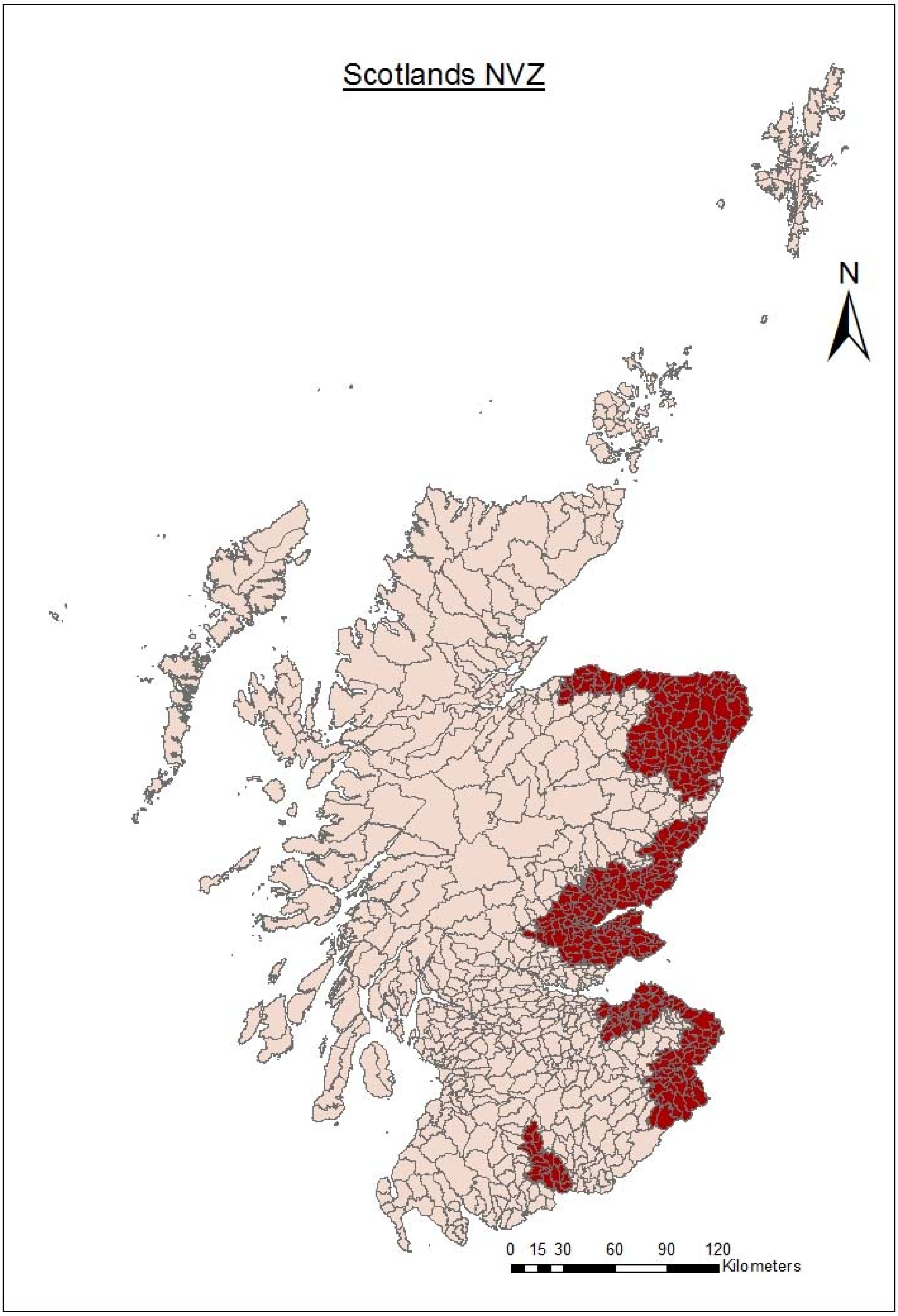
Figure 3. No of cases per option for measure 214, Scotland (Scottish Government data, 2008 – 2011)



Appendix 6 Farm type

Robust		Main	
1	Cereals	1	Cereals
2	General Cropping	2	General Cropping
		3	Specialist Fruit
		4	Specialist Glass
		5	Other Horticulture
3	Horticulture	21	Specialist Mushrooms
4	Specialist Pigs	6	Specialist Pigs
5	Specialist Poultry	7	Specialist Poultry
		9	Dairy (LFA)
6	Dairy	10	Dairy (Lowland)
		11	Specialist Sheep (SDA)
		12	Specialist Beef (SDA)
		13	Mixed Cattle and Sheep (SDA)
7	Cattle and Sheep (LFA)	14	Cattle and Sheep (DA)
8	Cattle and Sheep (Lowland)	15	Cattle and Sheep (Lowland)
		16	Cropping and Dairy
		17	Cropping, cattle and sheep
		18	Cropping, pigs and poultry
		19	Cropping and Mixed Livestock
9	Mixed	20	Mixed Livestock
		22	Specialist set-aside
		23	Specialist grass and forage
		25	Specialist horses
		26	Non-classifiable - fallow
10	Other	27	Non-classifiable - other

Appendix 7 NVZ map (Scottish Government 2010)



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