RESAS RD 3.4.1 Demographic change in remote areas

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Outline Conceptual Framework and Definition of the Scottish Sparsely Populated Area (SPA)

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Introduction

This working paper is the first output of a project funded by the Scottish Government's Rural and Environment Science and Analytical Services (RESAS) division's 2016-2020 Strategic Research Programme[1]. More precisely this work has been carried out under Research Deliverable 3.4.1.

The research question addressed by this project is "How do changes in the population of remote rural areas of Scotland affect the social, economic and ecological resilience of these areas?". It thus explores the land use, economic and environmental implications of demographic change in the sparsely populated areas (SPA) of Scotland.

The first step in such an exercise is to define more precisely the territory which is commonly referred to as "remote" or "sparsely populated". This is the purpose of this working paper.

Remoteness and sparsity are, strictly speaking, distinct characteristics, although in the real world they are very often associated in location and process. The term "remote" is often seen as equivalent to "peripheral" – and as the opposite of "accessible". There is a large European literature on "peripherality" and "peripheralization", as a socio-economic process. It is defined by levels of economic and social interaction, with "hubs" of economic activity which are outside the territory. Sparsity, on the other hand is a more local, endogenous, characteristic, and relates to the advantages and disadvantages of a thinly scattered population. Whilst the term "remote" is used in the title of the project it is clear from the terms of reference that the chief concern was with the effects of sparsity upon land use, the environment and economic activity, especially if these areas continue to lose population over the coming decades.

Why is this Important for Policy?

This project reconsiders (in the context of twenty-first century technological, economic and social environment) the rationale for supporting small scale farming and other land-based activities in remote rural areas as a means of preventing "desertification", and ensuring the delivery of ecosystem services, in remote and sparsely populated areas of Scotland. The research also addresses fundamental questions about the changing technological context of living and conducting business in the Scottish SPA, and the role of local territorial capital. Most popular theories require at least part of the impetus for rural development to originate in the local population, pointing to a range of (local) human and social capital characteristics as preconditions for positive local economic and social dynamics. The logical implication is that declining population may (once a certain threshold has been passed), trigger a downward spiral. However, more recently, the advocates of "organised proximity" and networked models of development have argued that increasing opportunities for external interaction may compensate for sparse and dwindling local capacity.

Demographic Change in the Scottish SPA and its implications

For more than a century the dominant demographic process in remote rural Scotland has been "desertification" through the selective out-migration of the younger and more highly educated segment of the workforce towards cities and towns. This has exacerbated the demographic ageing common to most of rural Western Europe. A second process involves a gradual drift of population

[1] http://www.gov.scot/Topics/Research/About/EBAR/StrategicResearch/strategicresearch2016-21/srp2016-21 [accessed 31st January 2017]

from the most remote and sparsely populated areas into nearby villages and towns. Both of these have substantial implications for the demand for and cost of delivering “services of general interest ” (SGI) and hence the equality agenda. They may also have more subtle effects on the “critical mass” of communities and their capacity for endogenous development.

These demographic changes have accompanied gradual but longstanding changes in crofting/farming land use and intensity, with associated implications for natural assets and provision of Ecosystem Services (ES).

Adding complexity to the picture, remote and sparsely populated areas, and their local economies, have to varying degrees participated in diversification and restructuring. Within the farming/crofting sector this has manifest itself in increasing links between farm businesses and the wider local economy, either through the incorporation of activities such as tourism/recreation, or through the participation of farm household members in off-farm work. Established rural activities, such as forestry, fishing, aquaculture and tourism have adjusted, and new activities, such as renewable energy, have emerged.

These three key components of change in remote and sparsely populated areas have taken place against a changing backdrop of economic and social “framework conditions”. These include subtle, incremental and selective changes in the meaning of peripherality, accessibility, and proximity, driven by information and communications technology (ICT), improvements in infrastructure, and changing working practices and lifestyles. They also interact with a more immediate macro-economic context (crisis and recovery) and consequences in terms of local authority budgets.

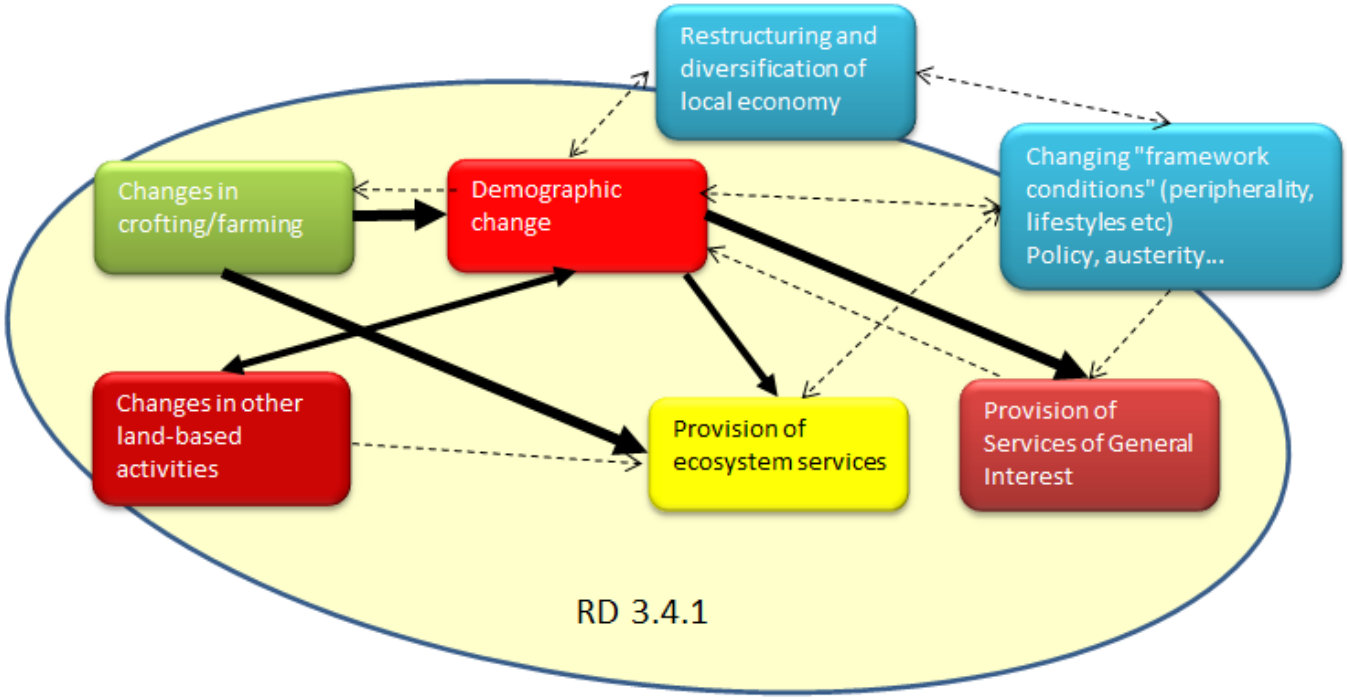
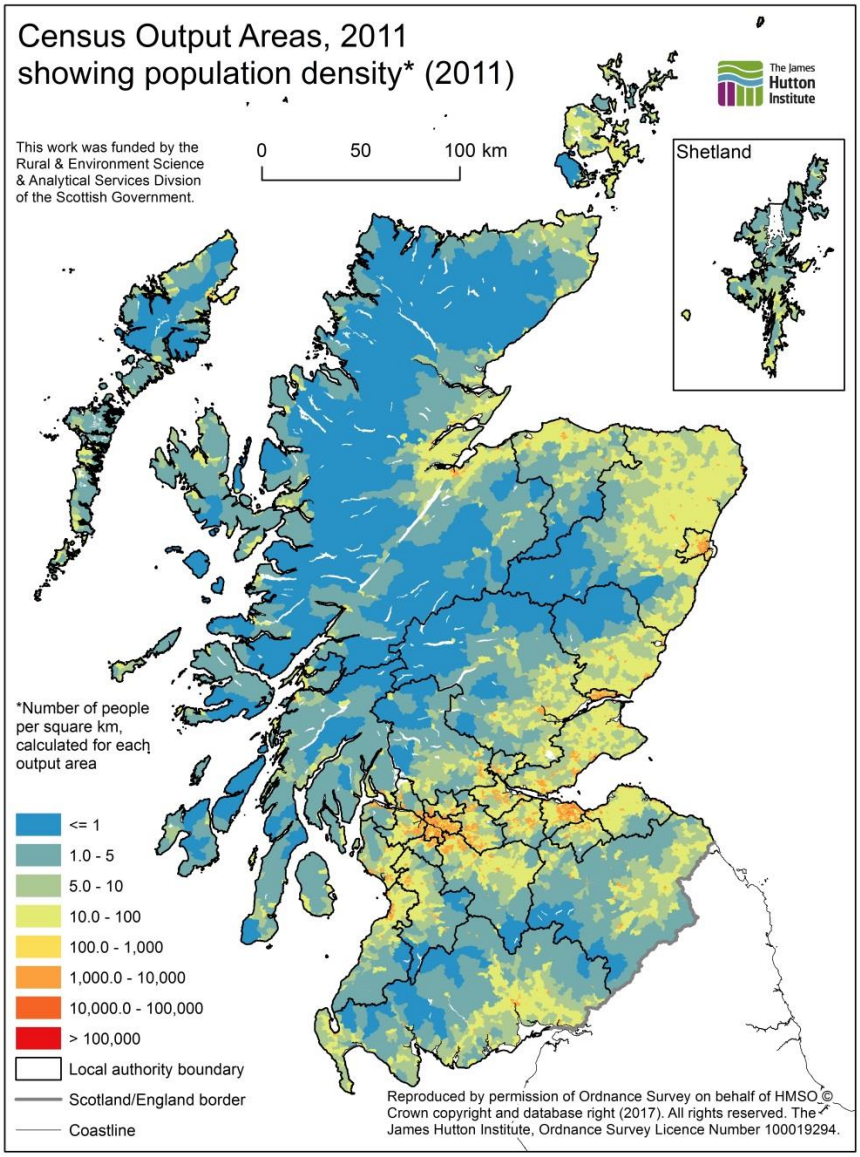


Figure 1: The wider Implications of Demographic Change in the SPA

The causal links between the drivers and outcomes described above are illustrated in Figure 1. Clearly the demographic changes are part of a very complex, recursive system, reflecting a range of

social and economic processes. However in this project the starting point will be the redistribution of population as a consequence of changes in small scale farming, other key rural industries, and broader economic diversification.

It is assumed that changes in natural assets and provision of ES are partly a direct result of changes in farming and other key industries, and partly a "second round" effect of associated demographic changes, diversification of the economy, and broader social changes. Changes in provision of services of general interest are assumed to be driven in the medium term by changes in the distribution of population, but also strongly affected in the short term by policy expenditure priorities.



Spatial information shown: 2011 Output Area Boundaries: Clipped to the coastline (MHW) © Crown copyright. Data supplied by National Records of Scotland. Scotland/England border from Ordnance Survey Strategi® data, coastline and local authority boundaries from Ordnance Survey Boundary-Line™ data. Population density calculated from output area areas and 2011 Census data © Crown copyright. Data supplied by National Records of Scotland. Downloaded from http://www.scotlandscensus.gov.uk/documents/censusresults/release1c/rel1c2tableA2.csv.

Map 1: Population Density by Output Area

The Population Potential Concept

The simplest and most direct way to define the Scottish SPA would be to set a population density threshold, and to designate all areas with less than a certain density as SPA. This immediately raises issues of scale of analysis. Larger territorial units (such as council areas, or travel-to-work-areas) tend to be heterogeneous. Highland Council, for example has the second lowest population density of the 32 Council Areas in Scotland, but contains within its boundaries relatively densely populated areas in and around Inverness. The obvious solution is to define the SPA in terms of the smallest spatial units for which data is available – in this case the Output Areas of the 2011 Census of Population (Map 1).

However a simple density criteria for the SPA at output area level has a number of shortcomings:

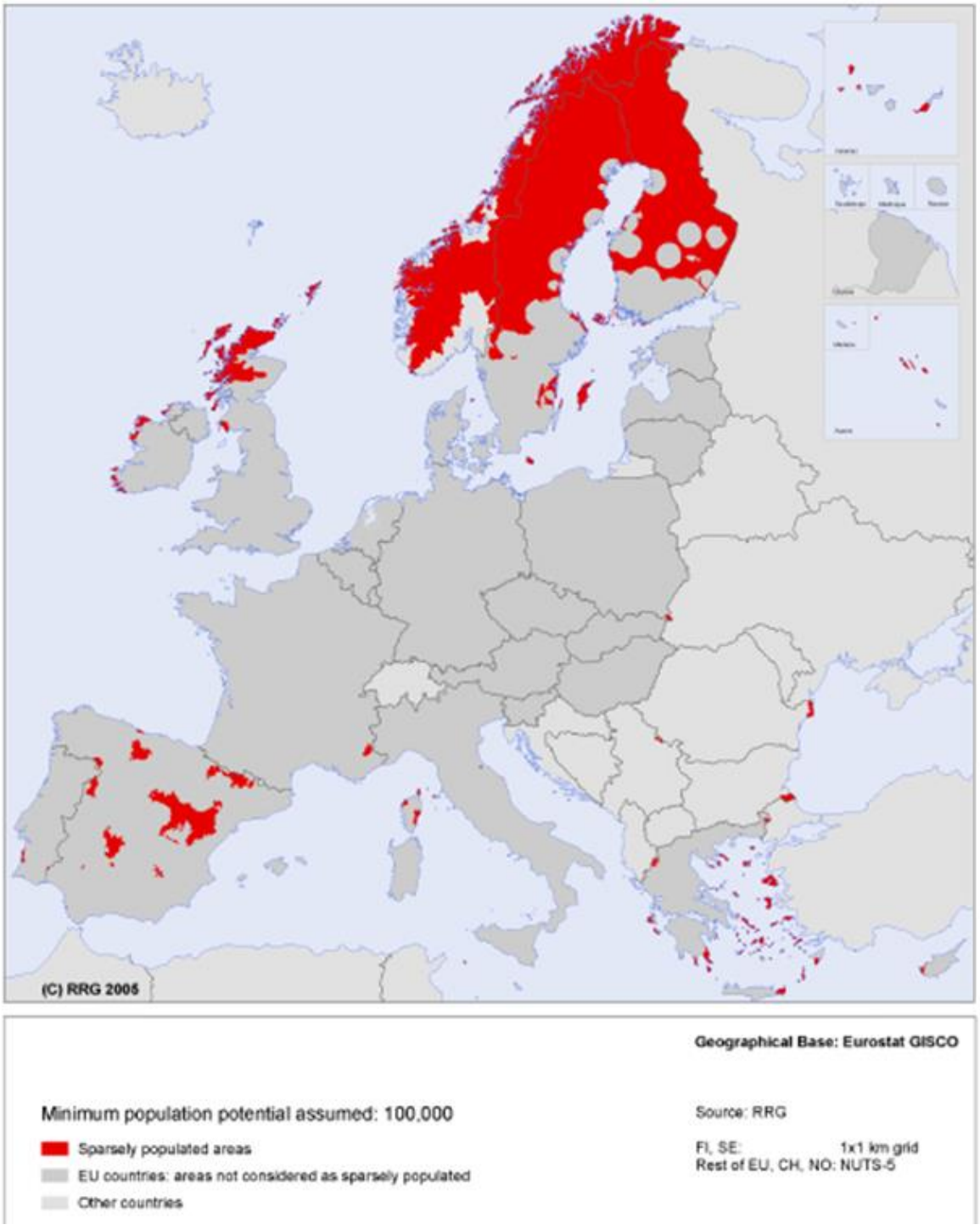
(i) A rather fragmented distribution, a complex boundary.

(ii) No account is taken of the remoteness ingredient of the thinking of the terms of reference.

(iii) A point location on a map of density does not capture the realities of living or conducting a business from that location, which also reflects the wider environment. In other words it is important to take account not only the local sparsity, but also the range of opportunities for interaction which are accessible. A sparsely populated output area which is adjacent to a small town is a very different living/business environment to one which is surrounded, for many miles, by equally sparse areas. The challenges in terms of service provision are also very different.

This issue of defining SPAs in a way which both avoided fragmentation and reflected the realities of sparsity constraints was recognised in an EU policy context in the late 1990s after the accession of Sweden, Finland and Austria, regions with an average population density of less than 8 persons per square kilometre became eligible for Structural Fund assistance under Objective 6. This sparked interest in the concept of sparsity and its role on rural economic development. One of the outcomes was a research project (Gloersen et al 2006) which developed a definition of SPAs which could be mapped for the whole of Europe. This involved the use of GIS analysis to generate an indicator known as “population potential”, which combines information on sparsity and remoteness. In essence it classifies areas in terms of the number of persons who reside within a certain distance. This approach takes account of both low density within the immediate area, and access to adjacent populations. Arguably this better represents the real economic and social implications of sparsity than a simple choropleth map of population density. It has the added advantage of smoothing out abrupt changes in density, and generating a “population potential” surface or gradient.

The resulting map (Map 2) is dominated by Scandinavia, where sparsity is very pronounced and extensive across northern Norway, Sweden and Finland. However one of the largest SPA outside the Nordic countries occupies the Highlands and Islands of Scotland. The interior of Spain is the only other part of Europe to have such an extensive SPA, while there are much smaller areas in France (Corsica and the Alps) in Greece, Cyprus and Romania.



Map 2: European SPAs as defined by population potential
Source: Gloersen et al 2006

Implementing the Population Potential Definition in Scotland

Objectives

Our main objective was to use the population potential concept (Gløersen et al., 2006) to define a Sparsely Populated Area (SPA) within Scotland, to be used as a basis for studying demographic and economic changes. This approach required a geographic information system (GIS) analysis of fine-grained population data (available for Census Output Areas in Scotland). We aimed to define a relatively homogenous area, which could be linked to other geographical units (via lookup tables to Data Zones and Agricultural Parishes) in order to extract and analyse data relevant to the SPA. As described below, the initial population potential approach was developed further through the course of our work.

Data used

The table below shows all data used within the population potential analysis shown in this report. Other geographic data and features are shown on maps, and are acknowledged on them. Relevant downloads were made in 2016. All data used were publicly available. The methods used are described in the section "Population potential methodology and assumptions", below.

Table 1: Data used within the population potential analysis

Description	Data source and copyright acknowledgement
Scotland Output Areas – population data, 2011	2011 Census data, available at Scotland's Census (http://www.scotlandscensus.gov.uk/). Bulletin Figures and Tables. Statistical Bulletin - Release 1C (part two), Table A2: Census day usually resident population and households by census output area, 2011. Download: http://www.scotlandscensus.gov.uk/documents/censusresults/release1c/rel1c2tableA2.csv © Crown copyright. Data supplied by National Records of Scotland.
England and Wales Output Areas – population data, 2011	2011 Census data, available at Nomis. 2011 Census Bulk Data Download (Release 2). KS101EW – Usual Resident Population. Download: https://www.nomisweb.co.uk/output/census/2011/ks101ew_2011_oa.zip © Crown copyright. Source: Office for National Statistics. Contains public sector information licensed under the Open Government Licence v3.0.
Scottish Government Urban Rural Classification 2013-2014 – lookup table for 2011 Output Areas	Scottish Government Urban Rural Classification 2013-2014 Lookup Files. Download: http://www.gov.scot/Resource/0046/00464793.zip © Crown copyright. Contains public sector information licensed under the Open Government Licence v3.0.
Scotland Output Areas – point locations*	National Records of Scotland. 2011 Output Area – Population Weighted Centroids. Download: http://www.nrscotland.gov.uk/files/geography/output-area-2011-pwc.zip © Crown copyright. Data supplied by National Records of Scotland.
England and Wales Output Areas – point locations*	Office for National Statistics. 2011 OA population weighted centroids. Download: http://www.ons.gov.uk/ons/external-links/social-media/g-m/2011-

	oa-population-weighted-centroids.html © Crown copyright. Source: Office for National Statistics licensed under the Open Government Licence v.3.0.
UK road network*	Ordnance Survey Open Roads. Contains OS data © Crown copyright and database right (2016)
UK ferries and journey times*	Ordnance Survey Strategi®. Contains OS data © Crown copyright and database right (2016)
Ferry terminals (links between ferries and roads)*	Edits to the above data, derived from terminal locations shown on the OS OpenData Viewer (https://www.ordnancesurvey.co.uk/opendata/viewer/index.html), mapping type OS Street View® (1:10 000 scale) Resampled and other data shown
Settlement locations*	Ordnance Survey Strategi®. Contains OS data © Crown copyright and database right (2016)
Road travel speeds	Derived from information on average speeds on page 11 of Scottish Government Geographic Information Science & Analysis Team (GI-SAT) Rural and Environment Science and Analytical Services Division (2014) Scottish Government Urban/Rural Classification: 2013 – 2014. The Scottish Government, Edinburgh. Available at http://www.gov.scot/Resource/0046/00464780.pdf.

*: spatial data. Note that some other datasets (for instance, population data for 'Small Areas' in Northern Ireland, and some data for the Isle of Man) were included within earlier versions of the analysis, but were not included in the final analyses.

Population potential methodology and assumptions

'Population potential' and its use to measure 'sparsely populated areas' was described in a report produced at Nordregio (Stockholm) in 2006. The authors acknowledge that "…low regional population densities are not sufficient to characterise a region as "sparse". Sparsity occurs insofar as the combination of low population densities and dispersed settlement patterns lead to specific challenges for economic activity" (Gløersen et al., 2006: 3). Therefore, population potential relates to the "…number of persons that can be reached", with the authors using a 50 km radius as a proxy for "…a generally accepted maximum commuting distance" (ibid: 3). This study used a threshold of 100,000 people within this radius to define sparsely populated areas within Europe. The authors related this threshold to 12.5 people per square kilometre – one of the "…population densities often referred to in the European context" (ibid: 36). Arguably, describing the population potential as a population density is unhelpful, as the sea and other water bodies may be included within the 50 km radius, and this type of description will not be used within the text below.

In the UK context, Census Output Areas are the most useful geographical unit for a detailed assessment of the location of people. There are 46,351 Output Areas in Scotland, each with a population of 50 or more[2], and 181,408 within England and Wales (average population: 309)[3]. In addition to this fine-grained coverage, the location of the 'population-weighted centroid' for each Output Area has been defined for the Output Areas in Scotland, England and Wales, and Census data on the household population of each Output Area was also available for these areas (Table 1). GIS

[2] see https://data.gov.uk/dataset/2011-census-output-areas (Accessed 4th January 2017)

[3] see https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates/bulletins/2011censuspopulationandhouseholdestimatesforsmallareasinenglandandwales/2012-11-23 (Accessed 4th January 2017)

software[4] was used to produce a 'feature class'[5] which combined the locations of Output Areas in Scotland, England and Wales with their populations. Population potential was calculated based on information from this feature class. In addition to the GIS software noted above, other calculations and data handling were carried out using R[6].

Two sets of population potential data calculations are presented within this report. Firstly, the number of people living within 50 km of each non-urban Output Area in Scotland was calculated. This replicates the 'straight line distance' approach of Gløersen et al. (2006) and uses the same distance threshold. Using ArcGIS, the buffer tool was used to identify the area within 50 km of the population-weighted centroids of all Output Areas classified as rural areas or small towns (n = 13,814)[7]. Next, the spatial join tool was used to calculate the sum of the population living within each buffer polygon, representing the population potential of each Output Area.

The results of the straight line distance model are described below. While this analysis was useful, it was felt that the use of a straight line distance did not measure meaningful access to people, particularly in some islands and coastal areas. Therefore, a more advanced method was used, incorporating a transport network constructed for the UK (containing the road network and ferries in Scotland) and estimated travel times. This analysis used the same population data for Output Areas, but instead defines population potential as the number of people who live within 30 minutes' travel. This travel time is based on that used within the Scottish Government's Urban Rural Classification, where rural areas and small towns within 30 minutes' drive of a settlement with over 10,000 people are defined as accessible[8]. It also reflects a reasonable commuting time, linking to the justification for the 50 km straight line distance which the first population potential analysis was based on.

This method used tools within the ArcGIS Network Analyst extension[9]. In order to calculate population potential based on travel time, it was necessary to calculate the area which could be reached in 30 minutes' travel from each Output Area in small towns and rural areas of Scotland. This was done using a multimodal network dataset[10] which used road and junction data from the Ordnance Survey's Open Roads product and data on ferry links from the Ordnance Survey Strategi® dataset (Table 1). Average travel speeds for different types of roads, within urban and rural locations, have been used by the Scottish Government to develop the Urban Rural Classification (Table 1). The 'Open Roads' data contained information on road classification (Motorway, A road, etc.). Roads were split into 'urban' or 'rural' sections using the location of urban areas, sourced from

[4] ESRI (2013) ArcGIS 10.2.1 for Desktop. ESRI, Redlands.

[5] A spatial dataset of geographic features and associated data. See http://support.esri.com/other-resources/gis-dictionary/term/feature%20class (Accessed 4th January 2017)

[6] R Core Team (2016) R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. https://www.R-project.org/. Work also used the 'foreign' package, citation: R Core Team (2015) foreign: Read Data Stored by Minitab, S, SAS, SPSS, Stata, Systat, Weka, dBase, ... https://CRAN.R-project.org/package=foreign

[7] Since in this exercise we are only interested in rural and small town Scotland, urban output areas (as defined by the Scottish Government's 8-fold Urban-Rural classification) were excluded.

[8] See http://www.gov.scot/Topics/Statistics/About/Methodology/UrbanRuralClassification (Accessed 9th January 2017)

[9] Network Analyst 10.2.1, Copyright ©1999-2013 Esri Inc. All Rights Reserved.

[10] see https://desktop.arcgis.com/en/arcmap/10.3/manage-data/network-datasets/what-is-a-network-dataset.htm#ESRI_SECTION1_A1E26CFCBAE54A469689CEE06FD3EC43 (Accessed 5th January 2017)

the Strategi® dataset. After creating new 'junctions' as appropriate, the time taken to travel along each section of road was calculated, based on the length of the road section and the assumed average speed. Next, ferry links were created using the ferry routes and journey times[11] shown within the Strategi® data. These links were drawn manually, taking into account the road network position and the locations of ferry terminals shown on maps (Table 1). Finally, a network dataset was created from the roads, ferries, road junctions and points to link the road network to ferries, and an attribute of travel time (in minutes) was created. Service area analysis[12] was used to identify the geographical area which could be accessed in 30 minutes from each Output Area centroid within rural areas and small towns in Scotland, and then the population within each service area was calculated using spatial joins between these areas and population data for Output Areas in Scotland and England. Therefore, population potential calculated using the transport network takes into account the distribution and concentration of the population, but also the location, density and quality of the transport network. While this forms a more advanced method than using distance alone, this approach required some assumptions: immediate transfers from roads to ferries, no traffic delays, and travel using car and ferry methods only.

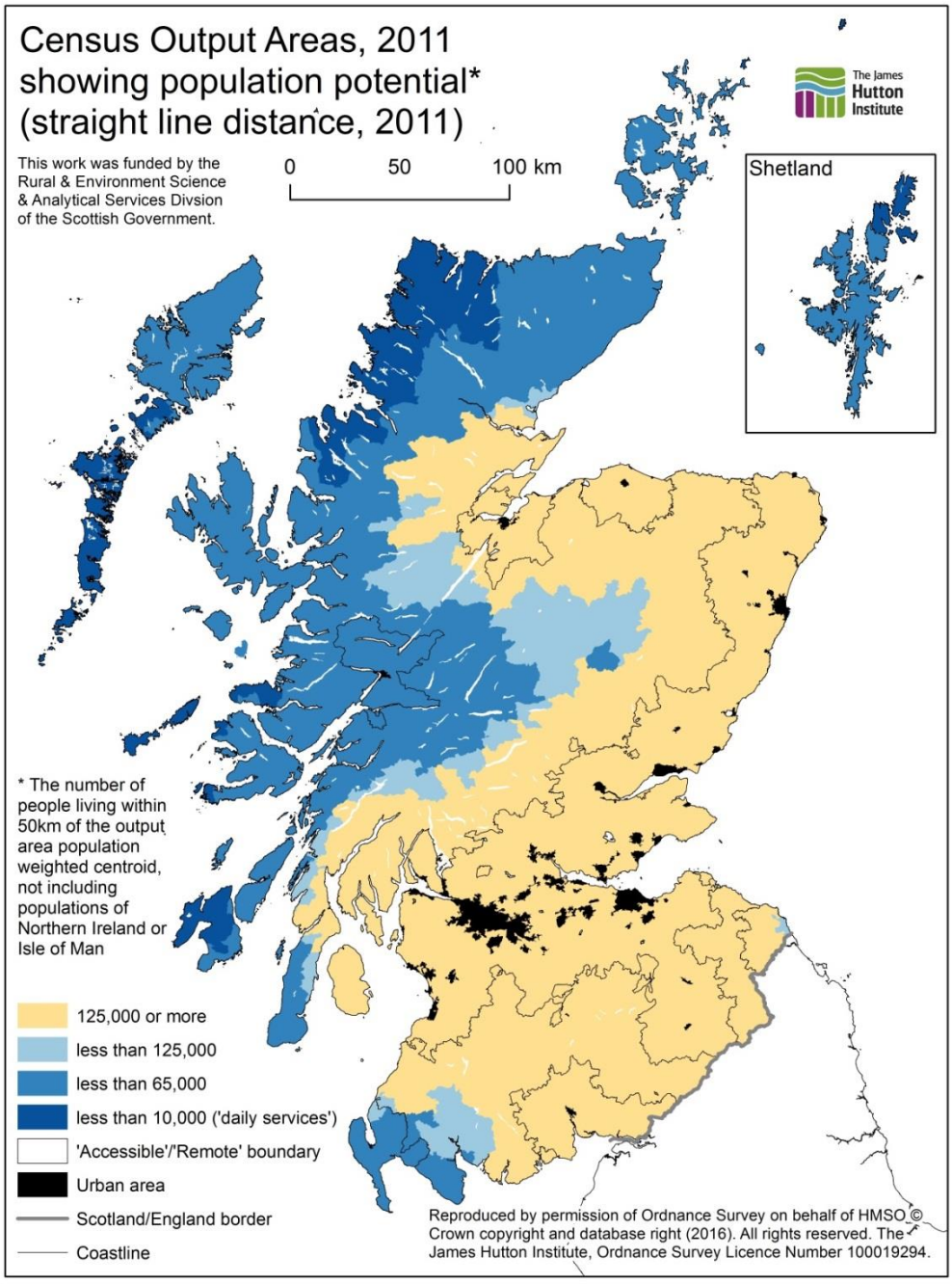
Results (Straight line distance model)

Map 3 shows the results of the first set of population potential analysis, which is the number of people living with 50 km of locations (Output Area centroids) in Scotland. The map uses 125,000 people as a threshold for sparse population: this is slightly above the 100,000 figure used in previous analysis (Gløersen et al., 2006) and is based on the size of settlements classified as Large Urban Areas within the Scottish Government's Urban Rural Classification[13]. The sparsely populated area covers almost all of the west coast of Scotland, most of the Highlands, Orkney, Shetland and all of the islands to the north of Argyll. The sparsely populated area covers slightly less than 4% of Scotland's population, but nearly half its area (Table 2). In addition, the far south west of Dumfries and Galloway (around Stranraer and Newton Stewart) is also defined as sparsely populated, as is a small isolated area near Eyemouth in the south east.

[11] Some of these journey times were modified, where travel time was given as a range, or where two different times were given for different journeys between two points.

[12] see http://desktop.arcgis.com/en/arcmap/latest/extensions/network-analyst/service-area.htm (Accessed 5th January 2017)

[13] see http://www.gov.scot/Topics/Statistics/About/Methodology/UrbanRuralClassification (Accessed 4th January 2017)



Population potential method based on Gløersen et al. (2006). Population potential based on geographical and population data from Scotland and England.
Spatial information shown: 2011 Output Area Boundaries: Clipped to the coastline (MHW) © Crown copyright. Data supplied by National Records of Scotland. Some areas classified by Scottish Government Urban Rural Classification 2013-2014, based on information in Lookup Files (http://www.gov.scot/Resource/0046/00464793.zip) © Crown copyright. Scotland/England border from Ordnance Survey Strategi® data, coastline from Ordnance Survey Boundary-Line™ data. Part of colour scheme derived from http://colorbrewer2.org/#type=sequential&scheme=Blues&n=6, http://colorbrewer2.org/#type=diverging&scheme=RdYlBu&n=6

Map 3: Population potential for rural areas and small towns in Scotland, calculated based on a 50 km radius ('straight line distance')

However, it is obvious that the very large population of the Central Belt and Ayrshire has a major distorting influence on population potential values, and that the 'straight line' distance measure does not effectively capture geographical remoteness. For instance, Arran and much of Argyll and Bute would not be defined as sparsely populated based on the 50 km distance. Additionally, large

areas of the Southern Uplands which are defined as remote rural areas and small towns by the Scottish Government would also not be included in the sparsely populated area.

Population potential values across rural areas and small towns range from 1,173 to over three million (Table 2): the highest value is found within the central belt between Glasgow, Edinburgh and Stirling. Parts of isolated islands (e.g. Output Areas in Islay, Tiree, Coll, Unst, South and North Uist) and locations in the far west and north-west of Scotland have population potentials below 10,000 people: this threshold is "…a hypothetical minimum population potential to run daily services" (Gløersen et al., 2006: 36).

Table 2: A summary of the sparsely populated area, defined by a population potential less than 125,000 (based on a 50 km straight line distance)

Sparsely populated area description	
Number of output areas in SPA	1,828 (3.9% of all Output Areas in Scotland)
Area covered by SPA*	35,869.2 km^2 (46.0% of Scotland)
Total population of SPA	204,018 (3.9% of all people in Scotland)
Population potential data (all rural and small town Output Areas)	
Minimum	1,173 (location: Fair Isle)
Maximum	3,063,794 (location: just north-west of Falkirk)
Mean (standard deviation)	1,081,906.1 (975,153.3)

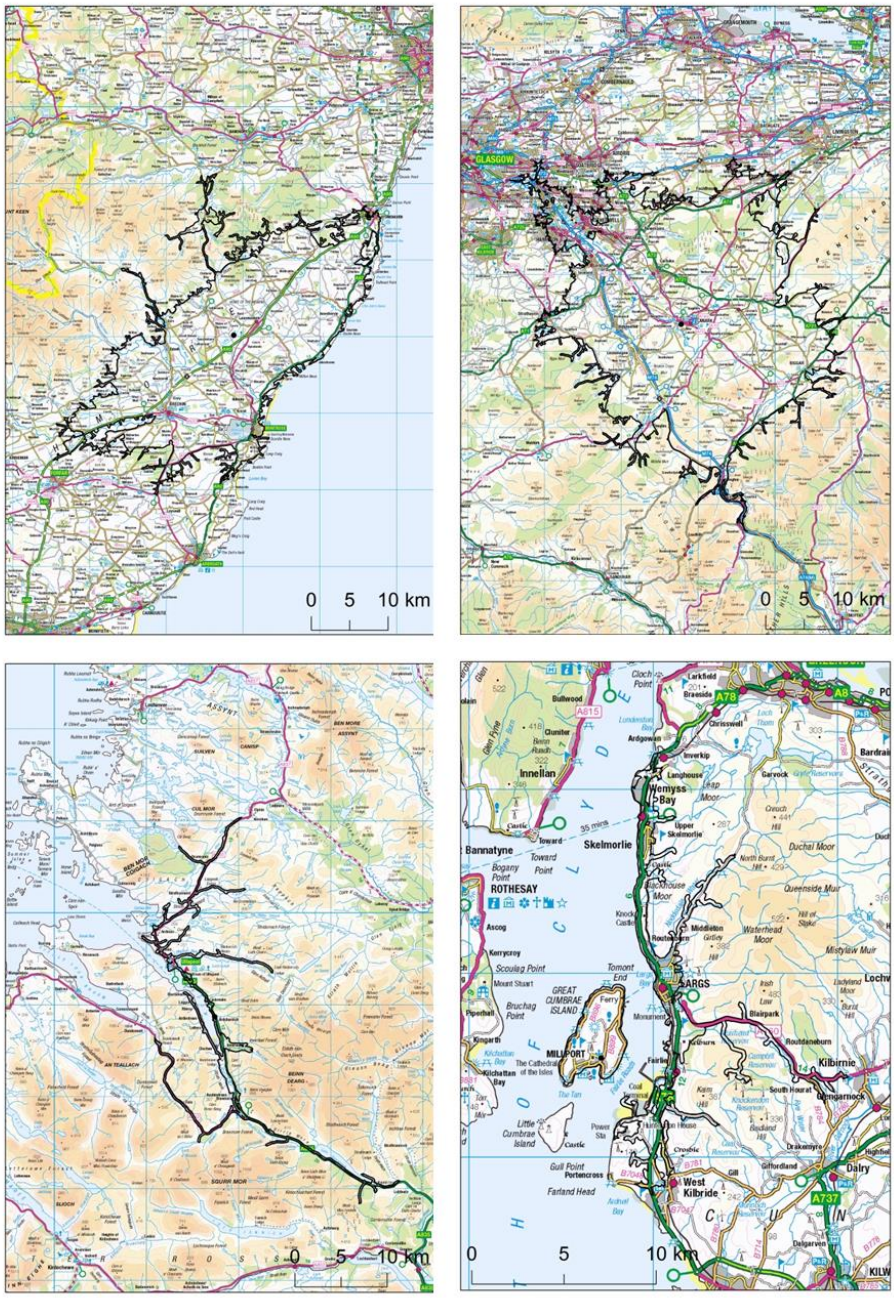
*-Areas derived from GIS calculation on Output Area boundaries. Data source: National Records of Scotland. 2011 Output Area Boundaries: Clipped to the coastline (MHW). Download: http://www.nrscotland.gov.uk/files/geography/output-area-2011-mhw.zip. © Crown copyright. Data supplied by National Records of Scotland.

Results (Transport network and travel time model)

Map 4 shows the areas within 30 minutes travel of four selected Output Area centroids within Scotland. This illustrates that the use of a transport network and travel time creates a more realistic measure of accessibility to a location than a 'straight line distance'. Accessibility clearly reduces considerably in areas where the transport network is poorly developed: for instance in mountainous areas or at coastlines. The 'bottom right' map on Map 4 shows an example of 30 minutes' travel distance away from an Output Area centroid on Great Cumbrae, where the accessible area covers all of the island and part of the mainland, due to the presence of a short ferry link. For some islands, a 30 minute travel time covers the whole of the road network on the island.

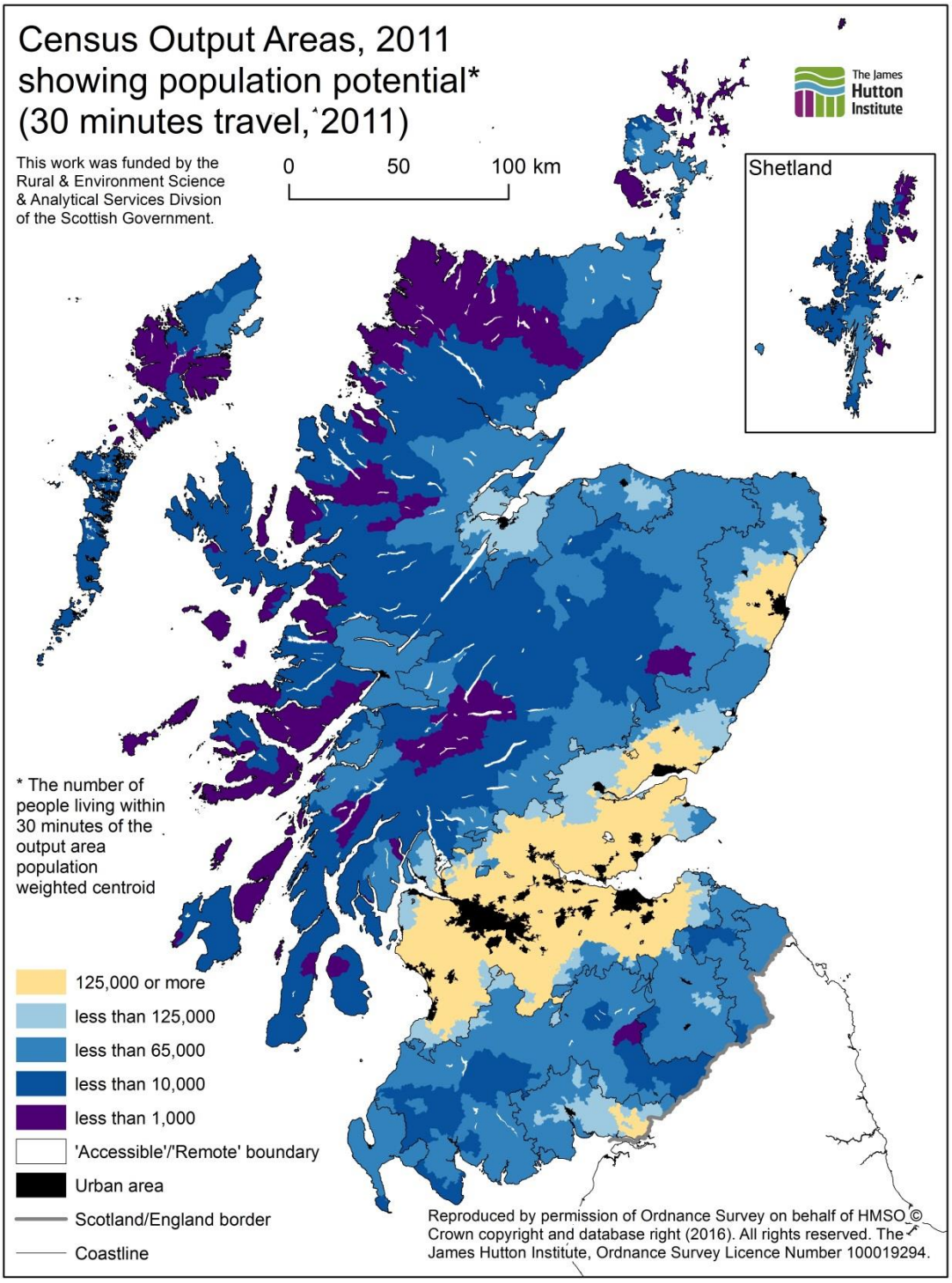
The areas within 30 minutes' travel from selected Output Areas

Black dots: population-weighted centroid of Output Area
Black line: limit of 30 minutes' travel



This work was funded by the Rural & Environment Science & Analytica Services Division of the Scottish Government.

Map 4: The areas within 30 minutes' travel from selected Output Areas, based on our analysis



Population potential method based on Gløersen et al. (2006). Population potential based on geographical and population data from Scotland and England, road network data, settlement positions, ferry routes, and travel speed information.
Spatial information shown: 2011 Output Area Boundaries: Clipped to the coastline (MHW) © Crown copyright. Data supplied by National Records of Scotland. Some areas classified by Scottish Government Urban Rural Classification 2013-2014, based on information in Lookup Files (http://www.gov.scot/Resource/0046/00464793.zip) © Crown copyright. Scotland/England border from Ordnance Survey Strategi® data, coastline from Ordnance Survey Boundary-Line™ data. Part of colour scheme derived from http://colorbrewer2.org/#type=sequential&scheme=Blues&n=6, http://colorbrewer2.org/#type=diverging&scheme=RdYlBu&n=6

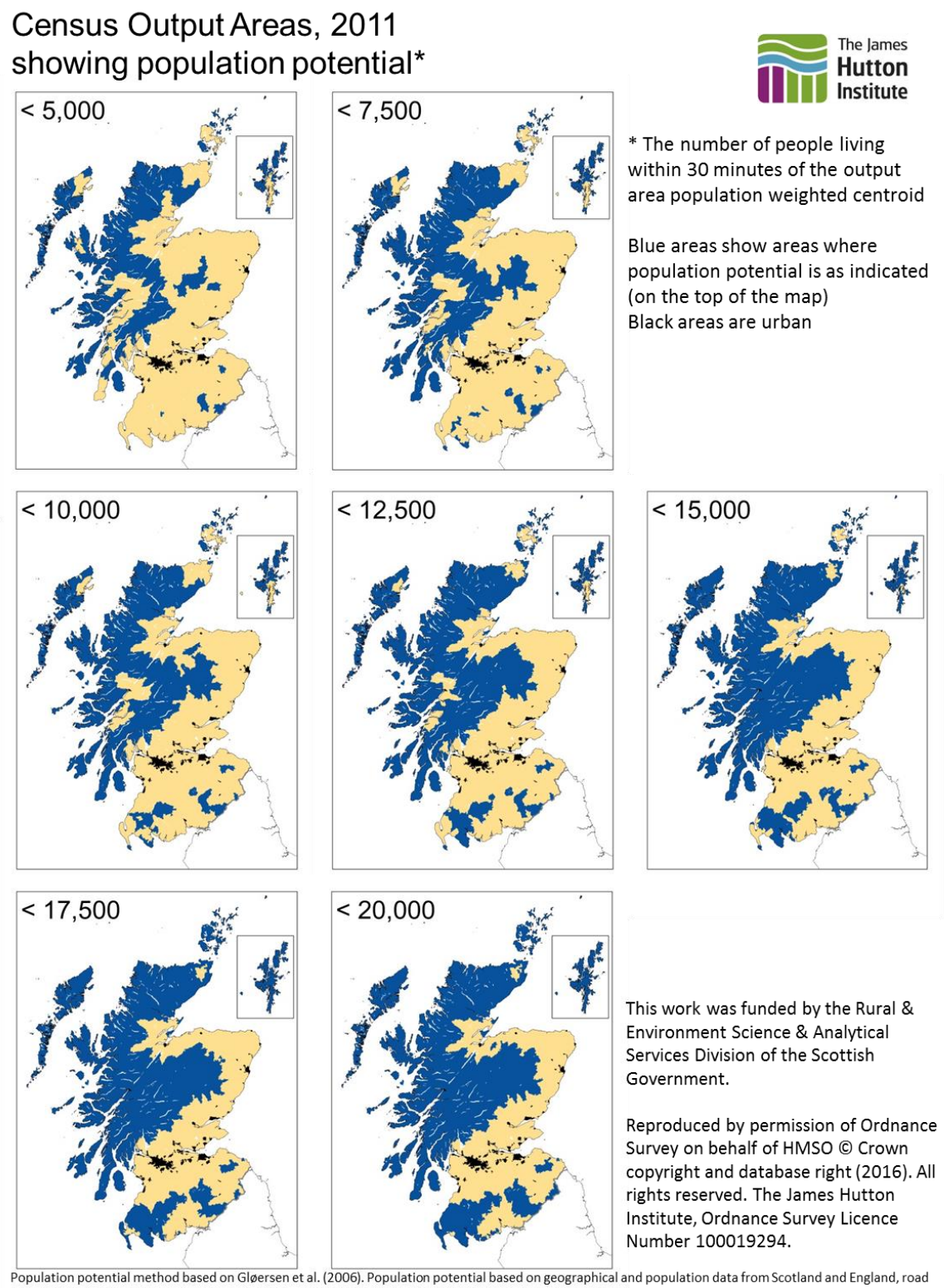
Map 5: Population potential for rural areas and small towns in Scotland, calculated based on a 30 minute travel time

Map 5 shows the calculated population potential values, defined as the population living within 30 minutes travel. The map uses the same thresholds as the map for straight line distance, with the addition of a "less than 1,000" category. It is clear that the threshold of 125,000 people covers a far larger area (equal to 89.3 % of Scotland's area) than it does for the straight line distance. It is also apparent that there is a spatial correlation between this threshold and the limit of 'accessible' areas within the Scottish Government's Urban Rural Classification: this is to be expected, as the 'accessible' distinction is based on a 30 minute travel time from urban settlements. Across all rural and small town Output Areas in Scotland, the mean population potential based is approximately 240,000 people (Table 3), compared with a mean of over one million people when the population potential was calculated based on a simple 50 km straight line distance. Similarly, while the minimum population potential recorded for any Output Area for the 50 km straight line distance approach was 1,173 (Table 2), when population potential was calculated for 30 minutes' travel time, 210 Output Areas had values below this. Indeed, for nine Output Areas, less than 100 people were accessible within 30 minutes' travel. These very low values (three of which are shown in Table 3) are associated with small islands in Shetland and Orkney, and the islands of Kerrera and Lismore in Argyll and Bute. The lower overall values for population potential based on a 30 minute travel time (compared with the 50 km distance) are as expected, as it presents a more restricted (and realistic) picture of access to people.

Table 3: A summary of the population potential data based on a 30 minute travel time

Population potential data (all rural and small town Output Areas)	
Lowest three values	55 (location: Kerrera (island, near Oban))
	61 (location: Fetlar, Shetland)
	68 (location: Fair Isle)
Maximum	1,787,883 (location: near Muirhead, just east of Glasgow)
Mean (standard deviation)	240,458.0 (334,541.7)

Based on the clear advantages of calculating population potential using a transport network, over the more crude approach of using a straight line distance, it was decided to pursue the 30 minute travel time approach as a means of defining a sparsely populated area. However, it is clear that a population potential threshold of 125,000 people would cover a very large area. As we aimed to define a study area which was relatively homogenous, we decided to investigate the potential use of lower thresholds to create a smaller area. Following further mapping of thresholds of 50,000, 25,000 and 20,000 people, we conducted a sensitivity analysis of the areas defined by population potential thresholds between 5,000 and 20,000 people. These areas are mapped below (Map 6) and data on the associated extent and total population of these areas, and those produced for some larger thresholds, is shown in Table 4.



Population potential method based on Gløersen et al. (2006). Population potential based on geographical and population data from Scotland and England, road network data, settlement positions, ferry routes, and travel speed information. Spatial information shown: 2011 Output Area Boundaries: Clipped to the coastline (MHW) © Crown copyright. Data supplied by National Records of Scotland. Some areas classified by Scottish Government Urban Rural Classification 2013-2014, based on information in Lookup Files (http://www.gov.scot/Resource/0046/00464793.zip) © Crown copyright. Scotland/England border from Ordnance Survey Strategi® data, coastline from Ordnance Survey Boundary-Line™ data. Part of colour scheme derived from http://colorbrewer2.org/#type=sequential&scheme=Blues&n=6, http://colorbrewer2.org/#type=diverging&scheme=RdYlBu&n=6

Map 6: Sensitivity analysis, showing Output Areas with population potentials as indicated.

Table 4: Sensitivity Analysis

Population potential threshold	Area covered (km^2)	Total population
125,000	68,430.5	906,853
50,000	60,380.2	582,805
25,000	51,836.7	329,690
20,000	49,717.2	295,700
17,500	48,125.2	277,482
15,000	45,843.5	243,271
12,500	41,491.0	181,705
10,000	37,354.7	137,542
7,500	33,867.6	116,308
5,000	28,095.0	81,134
All Scotland	77,937.1	5,295,403

*-Areas derived from GIS calculation on Output Area boundaries. Data source: National Records of Scotland. 2011 Output Area Boundaries: Clipped to the coastline (MHW). Download: http://www.nrscotland.gov.uk/files/geography/output-area-2011-mhw.zip. © Crown copyright. Data supplied by National Records of Scotland.

The mapping (Map 6) of the possible sparsely populated areas shows the effects of small changes in the population potential threshold from five to 20 thousand people. As the population potential threshold increases, the sparsely populated area expands and becomes more continuous. In particular, the areas surrounding remote small settlements (e.g. Stornoway, Fort William, Oban, Lerwick, Kirkwall) which were not classified as sparsely populated at very low thresholds, gradually 'fill in' as the size of the sparsely populated area grows. The most noticeable changes in the sparsely populated area between 5,000 and 20,000 people are in the Cairngorms and 'A9 corridor', and in the south of Scotland. In particular, the area of Dumfries and Galloway which is classified as sparsely populated increases dramatically over the series of maps.

Selection of the Preferred Version

Based on this exercise, and the overall objectives of this research, we suggest that a sparsely populated area based on a **population potential of less than 10,000 people accessible within 30 minutes' travel** would be most appropriate. This covers just under half (48.7 %) of Scotland's area, and 2.6 % of the population. We would argue that using this as the sparsely populated area has the following advantages:

- This area covers large areas of the west coast, and Highlands and Islands, but does not include the areas which surround important settlements in these remote areas. 'Excluded' areas include Stornoway, Kirkwall and much of the Orkney Mainland, Lerwick and the southern part of Mainland on Shetland, Thurso and Wick in the far north of Scotland, areas around Fort William and Oban, and Stranraer and its surrounding area. Due to their locations, these settlements are likely to have a concentration of economic activity and relatively strong service provision[14]. The areas further away from these locations (represented within the sparsely populated area) have a somewhat different context, with a contrast in challenges and pressures faced.

[14] Atterton (2012: 27) notes "To a greater or lesser extent, Scotland's towns provide a variety of functions for their local population and often for the population of a surrounding rural hinterland.... This service centre function is particularly important in remote areas, where the distance to travel to the nearest large urban centre may be considerable."

- The population potential figure (10,000) reflects the size of an urban settlement within the Scottish Government's Urban Rural Classification, and drive time to these settlements with 10,000 or more people is used to distinguish between accessible and remote rural areas in this typology[15]. In combination with the use of the 'accessible' drive time of 30 minutes, using the 10,000 threshold neatly builds on the existing area classification within Scotland: the sparsely populated area shows the region where the population equivalent in size to a small urban area is not accessible.

Best Fit Overlay Geographies for Key Data Sources

Not all types of data are available at the level of the 2011 Output Areas which were used to define the sparsely populated area. Therefore, lookups have been created with four larger geographical units: Data Zones (2011 and 2001 definitions), Sub-Council Area Projection (SCAP) Areas[16], and Agricultural Parishes. The Data Zones and SCAP Areas which had some population within the SPA were identified, along with the percentage of their population which was in the SPA. The Data Zones and SCAP Areas with some population in a) the part of rural and small town Scotland situated outside of the SPA, and b) urban areas were also identified, and the percentage of total population in these regions were calculated; similar lookup information was also produced for 'subregions' of the SPA and 'not in SPA' regions. **This information (on areas outside the SPA, and subregional breakdown) is used within following Working Papers. For clarity, descriptions of the 'not in SPA' and urban regions, and the way that the subregions were created, are only briefly mentioned below. The lookup with the SCAP Areas is used a slightly different way to other lookups; in the context of the production of population projections.**

For Agricultural Parishes in Scotland, the lookup to the regions and subregions described above was done on an area, rather than population, basis. GIS analysis was used to find the area in common (or 'intersect') between the 891 parishes and all (2011) Output Areas. Using the classification designated to each Output Area, the area associated with the 'SPA', 'not in SPA' and 'Urban' regions was calculated for each parish. If more than 50% of the common area was within one of these three classifications (as was the case for all parishes), then the parish was allocated to that classification. Then the subregions linked to that classification were identified, and the one with the largest area within the parish was also allocated to the parish (this would automatically equal "Urban" for the urban parishes).

The Appendix contains full details of the information used to create the lookup tables, and provides links to these tables. A summary of the results is shown in Maps 7-10 and in Table 5. For the larger geographies, Table 5 shows a summary of the total population and area of the units which are

[15] See http://www.gov.scot/Topics/Statistics/About/Methodology/UrbanRuralClassification (Accessed 9th January 2017). Note that the '2 fold' version of this classification defines urban areas as those with 3,000 or more people; however, the more detailed classifications distinguish between small towns (population: 3,000-9,999) and 'Other' and 'Large' Urban Areas (populations: 10,000-124,999, 125,000+ respectively)

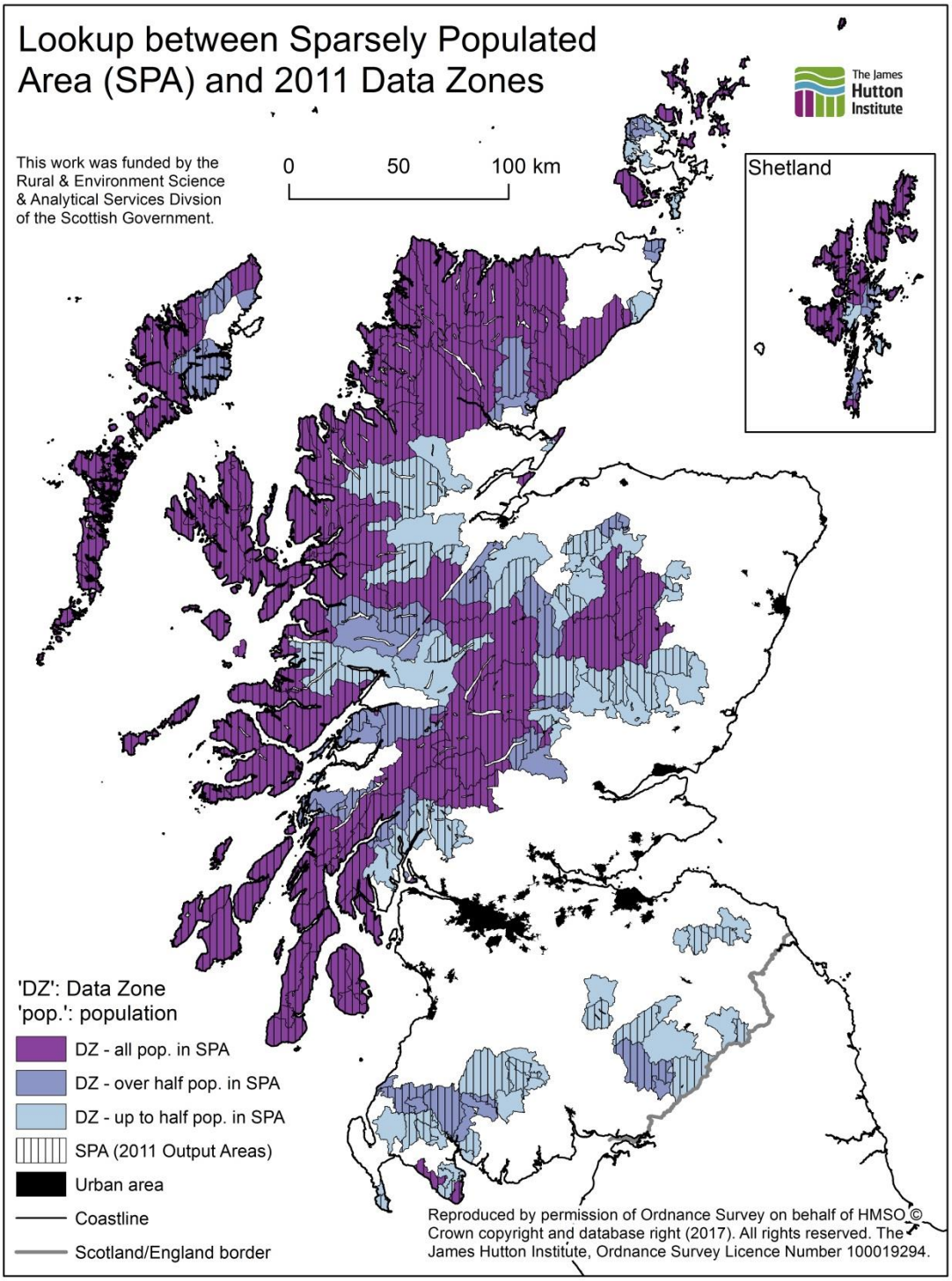
[16] Used by National Records of Scotland. See https://www.nrscotland.gov.uk/statistics-and-data/statistics/statistics-by-theme/population/population-projections/population-and-household-sub-council-area-projections/2012-based-population-and-household-projections/list-of-detailed-tables (Accessed 12th October 2017)

completely within the SPA (assessed by population or area, as described above) and the areas which are 'more than half in' the SPA. The quality of 'fit' is clearly higher for the smaller and more numerous Data Zones (6,505 designated in 2001, and 6,976 in 2011) than it is for the larger geographical classifications of SCAP Areas (n = 301) and Agricultural Parishes (n = 891). The maps show the relatively poor association between the SPA and other geographical units in southern Scotland.

Table 5: The SPA defined using 2011 Output Areas, and characteristics of the 'best fit' SPA produced from larger geographies.

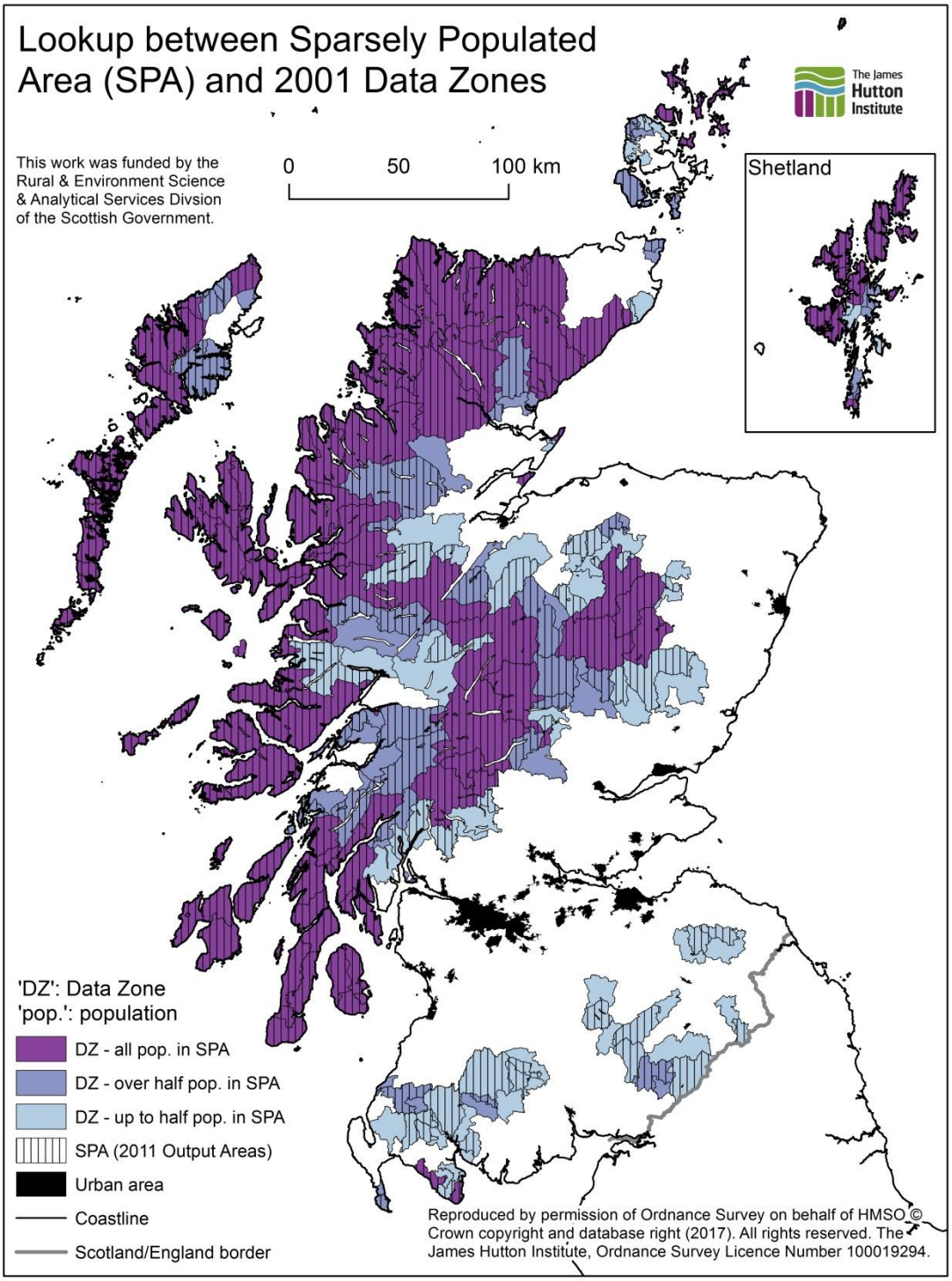
	Units 100% within* the SPA		Units over 50% within* the SPA	
SPA Definition	Area (km^2)	Population (2011)	Area (km^2)	Population (2011)
2011 Output Areas	37,354.7	137,542		
2011 Data Zones	27,169.8	113,991	33,066.0	133,803
2001 Data Zones	26,375.2	112,508	34,726.3	136,146
SCAP Areas	8,280.0	57,743	24,254.1	109,035
Agricultural Parishes	16,567.6	76,495	37,765.7	143,157

Areas given to one decimal place. *- 'within' means geographical units with 'x'% of their population in the SPA, or parishes where 'x'% of the parish area was within the SPA. All population data is for the year 2011. Note that population figures for Agricultural Parishes are subject to greater uncertainty, due to boundary differences between these parishes and the civil parishes for which population data is available.



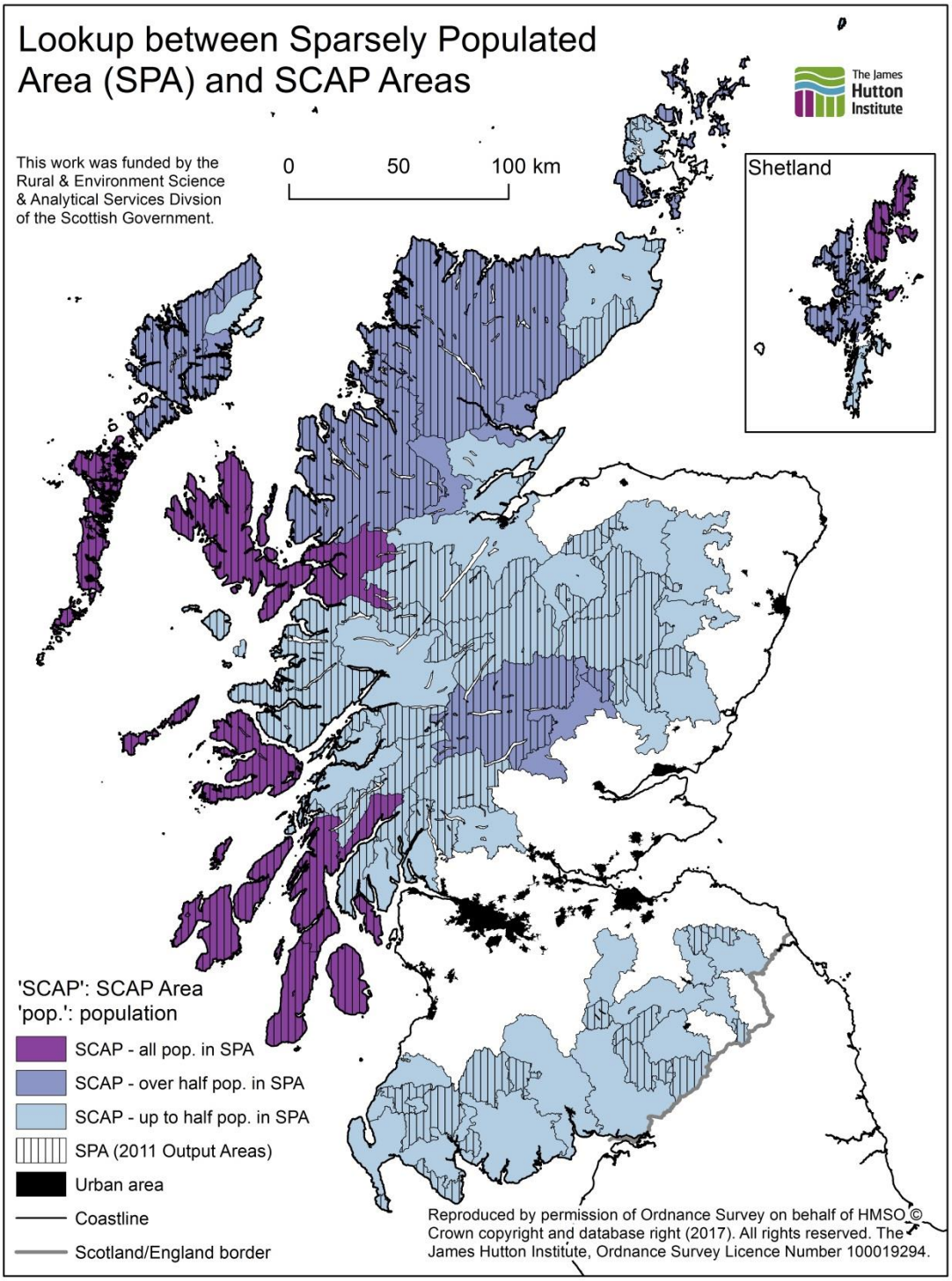
The calculation of the SPA is described in this Working Paper. The data sources used to produce this lookup are described within Appendix 1. Spatial data (2011 Output Areas, 2011 Data Zones) is also acknowledged in Appendix 1.
Some areas classified by Scottish Government Urban Rural Classification 2013-2014, based on information in Lookup Files (http://www.gov.scot/Resource/0046/00464793.zip) © Crown copyright. Contains public sector information licensed under the Open Government Licence v3.0. Scotland/England border from Ordnance Survey Strategl® data, coastline from Ordnance Survey Boundary-Line™ data. Part of colour scheme derived from information at http://colorbrewer2.org/ © Cynthia Brewer, Mark Harrower and The Pennsylvania State University.

Map 7: Lookup between SPA and 2011 Data Zones



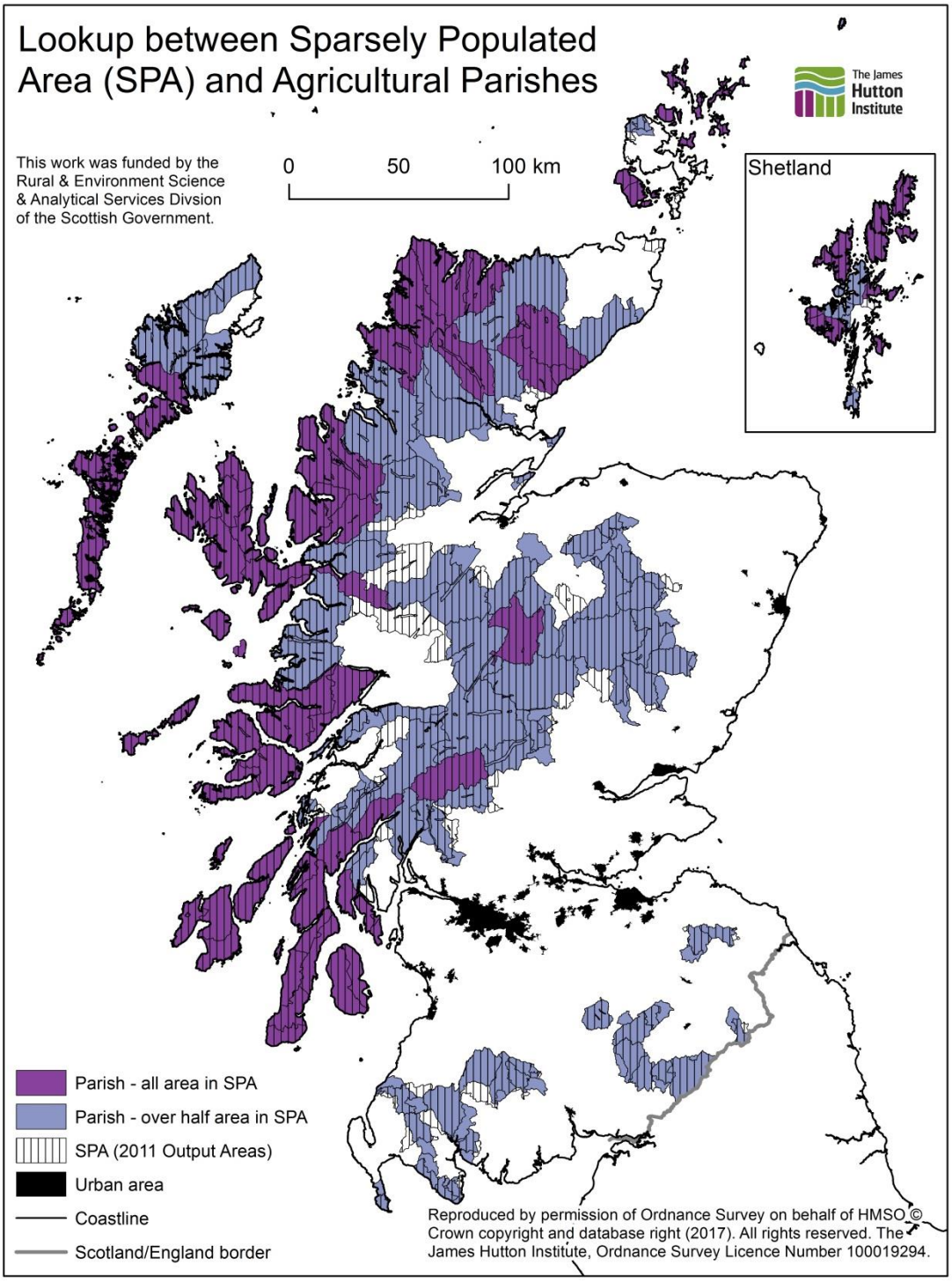
The calculation of the SPA is described in this Working Paper. The data sources used to produce this lookup are described within Appendix 1. Spatial data (2011 Output Areas, 2001 Data Zones) is also acknowledged in Appendix 1.
Some areas classified by Scottish Government Urban Rural Classification 2013-2014, based on information in Lookup Files (http://www.gov.scot/Resource/0046/00464793.zip) © Crown copyright. Contains public sector information licensed under the Open Government Licence v3.0. Scotland/England border from Ordnance Survey Strategl® data, coastline from Ordnance Survey Boundary-Line™ data. Part of colour scheme derived from information at http://colorbrewer2.org/ © Cynthia Brewer, Mark Harrower and The Pennsylvania State University.

Map 8: Lookup between SPA and 2001 Data Zones



The calculation of the SPA is described in this Working Paper. The data sources used to produce this lookup are described within Appendix 1. Spatial data (2011 Output Areas, SCAP Areas) is also acknowledged in Appendix 1.
Some areas classified by Scottish Government Urban Rural Classification 2013-2014, based on information in Lookup Files (http://www.gov.scot/Resource/0046/00464793.zip) © Crown copyright. Contains public sector information licensed under the Open Government Licence v3.0. Scotland/England border from Ordnance Survey Strategl® data, coastline from Ordnance Survey Boundary-Line™ data. Part of colour scheme derived from information at http://colorbrewer2.org/ © Cynthia Brewer, Mark Harrower and The Pennsylvania State University.

Map 9: Lookup between SPA and SCAP Areas



The calculation of the SPA is described in this Working Paper. The data sources used to produce this lookup are described within Appendix 1. Spatial data (2011 Output Areas, Agricultural Parishes) is also acknowledged in Appendix 1.
Some areas classified by Scottish Government Urban Rural Classification 2013-2014, based on information in Lookup Files (http://www.gov.scot/Resource/0046/00464793.zip) © Crown copyright. Contains public sector information licensed under the Open Government Licence v3.0. Scotland/England border from Ordnance Survey Strategl® data, coastline from Ordnance Survey Boundary-Line™ data. Part of colour scheme derived from information at http://colorbrewer2.org/ © Cynthia Brewer, Mark Harrower and The Pennsylvania State University.

Map 10: Lookup between SPA and Agricultural Parishes

Conclusions and Next Steps

This working paper has explained the procedure adopted to define the Scottish SPA for the purpose of our project, and the reasoning behind it. We propose that the SPA be defined by the output areas from which less than 10,000 people may be accessed within a 30 minute drivetime. This area comprises almost half the area of Scotland, but only 2.6% of its population. It is located mainly in the Higlands and Islands, - where it excludes areas in the immediate vicinity of towns such as Inverness, Fort William, Oban, Kirkwall, Stornoway and Lerwick -, together with smaller "enclaves" south of the Central Belt.

This is a foundation upon which much of the work of the next four years will be based. Having a precise definition of the Scottish SPA we can proceed to examine the characteristics of its population, land use, economic activity and environmental assets. It will make possible, for the first time, population projections and foresight tailored to the SPA, rather than to administrative areas which "straddle" the SPA.

References

Atterton, J. (2012) Towns and rural Scotland: vibrant or vulnerable? In: Skerratt, S., Atterton, J., Hall, C., McCracken, D., Renwick, A., Revoredo-Giha, C., Steinerowski, A., Thomson, S., Woolvin, M., Farrington, J, and Heesen, F. *Rural Scotland in Focus 2012*. Rural Policy Centre, Scottish Agricultural College, Edinburgh: 27-42.

Gløersen, E., Dubois, A., Copus A and Schürmann C (2006) *Northern peripheral, sparsely populated regions in the European Union*, Nordregio Report 2006:2, Stockholm. Available at http://www.nordregio.se/Templates/NordRegio/Pages/PublicationPage.aspx?id=493&epslanguage=en [Accessed 9th February 2017]

Appendix – Lookup tables, best Fit Overlay Geographies: data sources

As described within the section 'Best Fit Overlay Geographies for Key Data Sources', lookups have been produced to match other types of geographical area (Data Zones, SCAP Areas, Agricultural Parishes) to area definitions based on 2011 Output Areas: the regions of a) the Sparsely Populated Area (SPA), b) rural areas and small towns not defined as sparsely populated, and c) urban areas; and 'subregions' within the SPA and 'not in SPA' areas. These lookups enable statistics to be calculated for variables where data is not available for 2011 Output Areas. As a simple summary, the lookups identify the extent to which each larger geographical unit (i.e. each individual Data Zone, SCAP Area, or Agricultural Parish) is associated with the region and subregion definitions noted above. The information in the lookup tables can be used to adjust statistics which are available at the scale of larger geographical areas, in order to produce estimated values for the SPA and other regions and subregions. This analysis will be carried out within Working Paper 2. In addition, older Censuses (1991, 2001) used different definitions of Output Areas. In order to calculate population statistics for the SPA and other areas from older Census datasets, lookups were created using GIS-based methods.

As noted in the main text, for the analysis of population, demographic and agricultural changes contained in Working Paper 2, the SPA (defined using 2011 Output Areas) was broken down into six 'subregions', and other regions and subregions were created. The lookup tables were produced after these were defined. **For clarity, detailed descriptions of the nature of these subregions and the 'not in SPA' and urban regions are not included below.**

The first table (Table A1) in this Appendix shows data sources and methods used to create the lookup tables between the regions and subregion information, and other geographical units. These include the larger geographical units (Data Zones, SCAP Areas, Agricultural Parishes) and the Output Areas used for the 1991 and 2001 Censuses. The parts of these lookup tables showing the **geographical units associated with the SPA, only** are available for download at the project website for RD3.4.1 (Demographic change in remote areas) at http://www.hutton.ac.uk/research/projects/demographic-change-remote-areas, in the 'Research outputs from RD3.4.1…' section, and links are available here:

- SPA as defined using 2011 Output Areas - download
- SPA to 1991 Output Areas - download
- SPA to 2001 Output Areas - download
- SPA to 2011 Data Zones - download
- SPA to 2001 Data Zones - download
- SPA to SCAP Areas - download
- SPA to Agricultural Parishes - download

Note:

- The geographical units are shown in the lookup table as a code (Output Areas, Data Zones), a numerical identifier (the "AG_PARCODE" for the Agricultural Parishes) or a name (SCAP Areas). The lookup tables for the 1991 and 2001 Output Areas show two types of code for each Output Area, in the first two columns of the table. These codes were sourced from the spatial data for the older Output Areas shown in Table A1.
- Lookup tables related to Data Zones and SCAP Areas contain a column "PCTPOP", which shows the proportion of the total population (scaled between 0 and 1) of the larger unit within the SPA.
- The lookup table for Agricultural Parishes contains the column "PCT_PARISH_AREA" which shows the proportion of the parish area (scaled between 0 and 1) within the SPA.

The second table (Table A2) shows the population and spatial data sources used to calculate the figures on population and area included within Table 5 in the main text of this working paper. It also shows the spatial data shown on Maps 7-10 in the working paper. Table 5 provides an illustration of the quality or 'fit' of the match between the 'fine resolution' SPA (defined using the 2011 Output Areas) and 'best fit' SPAs produced for larger geographical areas using the lookup tables.

This analysis used the following software:

- ESRI (2013). ArcGIS 10.2.1 for Desktop. ESRI, Redlands.
- R Core Team (2016). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. https://www.R-project.org/
- R Core Team (2015). foreign: Read Data Stored by Minitab, S, SAS, SPSS, Stata, Systat, Weka, dBase, ... R package version 0.8-66. https://CRAN.R-project.org/package=foreign

Table A1: Data sources and methods used to create lookup tables.

Lookup to geography	Method, data sources (shown as bold text, bullet points)
1991 Output Areas	Spatial join technique (polygons to points) within ArcGIS, using 2011 Output Area boundaries (which included (as attributes) region and subregion information associated with rural and small town areas) and point locations representing the 1991 Output Areas. Each older output area was linked to the new output area (polygon) which was closest to it: in reality, almost all points were within polygons, but no 'intersect' was found for five of the 1991 Output Areas. 'Blank' region and subregion values, which corresponded with urban 2011 Output Areas, were recoded as such. • **National Records of Scotland. 2011 Output Area Boundaries: Clipped to the coastline (MHW). Download: http://www.nrscotland.gov.uk/files/geography/output-area-2011-mhw.zip. © Crown copyright. Data supplied by National Records of Scotland.** • **National Records of Scotland. 1991 Census Output Areas (OAs) Household Weighted Centroids. Download: https://www.nrscotland.gov.uk/files//geography/products/outputarea1991-hwc.zip Contains NRS data © Crown copyright and database right (2017), contains Ordnance Survey data © Crown copyright and database right (2017).** • **Scottish Government Urban Rural Classification 2013-2014 – lookup table for 2011 Output Areas. Scottish Government Urban Rural Classification 2013-2014 Lookup Files. Download: http://www.gov.scot/Resource/0046/00464793.zip © Crown copyright. Contains public sector information licensed under the Open Government Licence v3.0.**
2001	Spatial join technique (polygons to points) within ArcGIS, using 2011 Output Area boundaries

Output Areas	(which included (as attributes) region and subregion information associated with rural and small town areas) and point locations representing the 2001 Output Areas. Each older output area was linked to the new output area (polygon) which was closest to it: in reality, almost all points were within polygons, but no 'intersect' was found for one of the 2001 Output Areas. 'Blank' region and subregion values, which corresponded with urban 2011 Output Areas, were recoded as such. • **National Records of Scotland. 2011 Output Area Boundaries: Clipped to the coastline (MHW). Download: http://www.nrscotland.gov.uk/files/geography/output-area-2011-mhw.zip. © Crown copyright. Data supplied by National Records of Scotland.** • **National Records of Scotland. 2001 Census Output Areas (OAs) Household Weighted Centroids. Data provided by National Records of Scotland.** • **Scottish Government Urban Rural Classification 2013-2014 – lookup table for 2011 Output Areas. Scottish Government Urban Rural Classification 2013-2014 Lookup Files. Download: http://www.gov.scot/Resource/0046/00464793.zip © Crown copyright. Contains public sector information licensed under the Open Government Licence v3.0.**
2011 Data Zones	Link between 2011 Output Areas and larger Data Zones made using population data from the 2011 Census and a lookup table produced by National Records of Scotland which showed the Data Zone which each Output Area was associated with. The relationship between Output Areas and Data Zones is shown by the National Records of Scotland lookup table: this is a straightforward link, as Data Zones are formed of combinations of Output Areas. However, as the regions and subregions were defined at the level of the smaller Output Areas, it would be inappropriate to allocate the entire Data Zone population to a region in cases where only a portion of the Data Zone population was inside that region. Therefore, the population data for Output Areas, lookup table between Output Areas and Data Zones, and the 2011 Output Area to region and subregion classification produced within this work (with urban output areas added, and "Urban" added as a region and subregion for these) were combined and used to create separate Data Zone to region and Data Zone to subregion lookup tables. These tables showed the Data Zones which had some population within a region (in the first table), or had some population in one of the subregions (second table). They also showed the percentage of the Data Zone population within the region(s) (in the first table), or in subregion(s) (in the second table). These percentages can be used to adjust the 2011 Data Zone-level population statistics, to produce estimated populations for the regions and subregions. • **2011 Census data, available at Scotland's Census (http://www.scotlandscensus.gov.uk/). Bulletin Figures and Tables. Statistical Bulletin - Release 1C (part two), Table A2: Census day usually resident population and households by census output area, 2011. Download: http://www.scotlandscensus.gov.uk/documents/censusresults/release1c/rel1c2tableA2.csv © Crown copyright. Data supplied by National Records of Scotland.** • **2011 Census data, available at Scotland's Census (http://www.scotlandscensus.gov.uk/). Bulk data files, SNS Data Zone 2011. Table KS102SC. © Crown copyright. Data supplied by National Records of Scotland. (Data used for checking figures, only)** • **National Records of Scotland. Output Area 2011 to Data Zones and Intermediate Zones 2011. Download: https://www.nrscotland.gov.uk/files//geography/2011-census/OA_DZ_IZ_2011.xlsx © Crown copyright. Data supplied by National Records of Scotland.**
2001 Data Zones SCAP Areas	The link to these two geographies (SCAP Areas are defined using 2001 Data Zones) was created using the lookup between 2011 Output Areas and the 2001 Output Areas, described above. Population data for the 2001 Output Areas was downloaded from the 2001 Census; the links between the 2001 Output Areas and the two larger geographies was made using two lookup tables available from the National Records of Scotland website: the first from 2001 Output Areas to 2001 Data Zones, the second from the 2001 Data Zones to SCAP areas. The same approach as

	for the 2011 Data Zones was used, to produce tables showing the proportion of the larger areas' populations within the region and subregion definitions. • **2001 Census data, available at Scotland's Census (http://www.scotlandscensus.gov.uk/). Standard data files, Output Area. Table UV03. © Crown copyright. Data supplied by National Records of Scotland.** • **National Records of Scotland. 2001 Census Geographical Index. Download: https://www.nrscotland.gov.uk/files/geography/products/2001-oa-indexes-access02.zip. Table: OA_TO_HIGHER_AREAS. © Crown copyright. Data supplied by National Records of Scotland.** • **2001 Census data, available at Scotland's Census (http://www.scotlandscensus.gov.uk/). Standard data files, 2001 Datazones. Table UV03. © Crown copyright. Data supplied by National Records of Scotland. (Data used for checking figures, only)** • **National Records of Scotland. Population and Household Projections for Scottish sub-council areas (2012-based): 'A lookup table for 2001 data zones to the sub-council area projection geography used for this project'. Download: https://www.nrscotland.gov.uk/files//statistics/scap/datazone2001-to-scap-lookup.xlsx. © Crown copyright. Data supplied by National Records of Scotland.**
Agricultural Parishes	For agricultural parishes in Scotland, the lookup to the regions and subregions described above was done on an area, rather than population, basis. GIS analysis was used to find the area in common (or 'intersect') between the 891 parishes and all 2011 Output Areas. Using the region classification designated to each Output Area (with urban classifications added), the area associated with the 'SPA', 'not in SPA' and 'Urban' classifications was calculated for each parish. If more than 50% of the common area was within one of these three classifications (as was the case for all parishes), then the parish was allocated to that classification. Then the subregions linked to that classification were identified, and the one with the largest area within the parish was also allocated to the parish. • **National Records of Scotland. 2011 Output Area Boundaries: Clipped to the coastline (MHW). Download: http://www.nrscotland.gov.uk/files/geography/output-area-2011-mhw.zip. © Crown copyright. Data supplied by National Records of Scotland.** • **Agricultural Parishes - April 2016. Dataset derived from Civil Parish and Agricultural Parish datasets published by National Records of Scotland and The Scottish Government respectively. Coastline derived from Ordnance Survey MasterMap Topography Layer - Mean High Water (Springs) tide line extracted in January 2016. Some islands in OS tiles HW and HX derived from older Ordnance Survey MasterMap Topography Layer - Mean High Water (Springs) tide line source data. Some parish boundary lines also interpreted from OS 6 Inch to the mile 1st and 2nd edition 1890-1930. Scottish border interpreted from OS 1:10,000 scale mapping. Additional edits made by Douglas Wardell-Johnson and Dave Miller from The James Hutton Institute. Contains OS data © Crown copyright and database right (2016).**

Table A2: Data used to calculate areas and populations included within Table 5, also showing 'Area' data used on Maps 7-10.

Definition of SPA using…	Data used to calculate areas and populations included within Table 5. The 'Area' data is also used within Maps 7-10.
2011 Output Areas	**Area:** 2011 Output Area Boundaries: Clipped to the coastline (MHW). Download: https://www.nrscotland.gov.uk/files/geography/output-area-2011-mhw.zip. © Crown copyright. Data supplied by National Records of Scotland. **Population:** 2011 Census data, available at Scotland's Census

	(http://www.scotlandscensus.gov.uk/). Bulletin Figures and Tables. Statistical Bulletin - Release 1C (part two), Table A2: Census day usually resident population and households by census output area, 2011. Download: http://www.scotlandscensus.gov.uk/documents/censusresults/release1c/rel1c2tableA2.csv © Crown copyright. Data supplied by National Records of Scotland.
2011 Data Zones	**Area:** Data Zone Boundaries 2011. Download: http://sedsh127.sedsh.gov.uk/Atom_data/ScotGov/ZippedShapefiles/SG_DataZoneBdry_2011.zip. Copyright Scottish Government, contains Ordnance Survey data © Crown copyright and database right (2017). Available under the Ordnance Survey (OS) Open Data Licence (www.ordnancesurvey.co.uk/opendata/licence) **Population:** 2011 Census data, available at Scotland's Census (http://www.scotlandscensus.gov.uk/). Bulk data files, SNS Data Zone 2011. Table KS102SC. © Crown copyright. Data supplied by National Records of Scotland.
2001 Data Zones	**Area:** Data Zone Boundaries 2001. Download: http://sedsh127.sedsh.gov.uk/Atom_data/ScotGov/ZippedShapefiles/SG_DataZoneBdry_2001.zip. Copyright Scottish Government, contains Ordnance Survey data © Crown copyright and database right (2017). Available under the Ordnance Survey (OS) Open Data Licence (www.ordnancesurvey.co.uk/opendata/licence) **Population:** 2011 Census data, available at Scotland's Census (http://www.scotlandscensus.gov.uk/). Bulk data files, SNS Data Zone 2001. Table KS101SC. © Crown copyright. Data supplied by National Records of Scotland.
SCAP Areas	**Area:** spatial data for SCAP Areas derived from: • Data Zone Boundaries 2001. Download: http://sedsh127.sedsh.gov.uk/Atom_data/ScotGov/ZippedShapefiles/SG_DataZoneBdry_2001.zip. Copyright Scottish Government, contains Ordnance Survey data © Crown copyright and database right (2017). Available under the Ordnance Survey (OS) Open Data Licence (www.ordnancesurvey.co.uk/opendata/licence) • National Records of Scotland. Population and Household Projections for Scottish sub-council areas (2012-based): 'A lookup table for 2001 data zones to the sub-council area projection geography used for this project'. Download: https://www.nrscotland.gov.uk/files//statistics/scap/datazone2001-to-scap-lookup.xlsx. © Crown copyright. Data supplied by National Records of Scotland. **Population:** data calculated from: • 2011 Census data, available at Scotland's Census (http://www.scotlandscensus.gov.uk/). Bulk data files, SNS Data Zone 2001. Table KS101SC. © Crown copyright. Data supplied by National Records of Scotland. • National Records of Scotland. Population and Household Projections for Scottish sub-council areas (2012-based): 'A lookup table for 2001 data zones to the sub-council area projection geography used for this project'. Download: https://www.nrscotland.gov.uk/files//statistics/scap/datazone2001-to-scap-lookup.xlsx. © Crown copyright. Data supplied by National Records of Scotland
Agric. Parishes	**Area:** Agricultural Parishes - April 2016. Dataset derived from Civil Parish and Agricultural Parish datasets published by National Records of Scotland and The Scottish Government respectively. Coastline derived from Ordnance Survey MasterMap Topography Layer - Mean High Water (Springs) tide line extracted in January 2016. Some islands in OS tiles HW and HX derived from older Ordnance Survey

	MasterMap Topography Layer - Mean High Water (Springs) tide line source data. Some parish boundary lines also interpreted from OS 6 Inch to the mile 1st and 2nd edition 1890-1930. Scottish border interpreted from OS 1:10,000 scale mapping. Additional edits made by Douglas Wardell-Johnson and Dave Miller from The James Hutton Institute. Contains OS data © Crown copyright and database right (2016). **Population:** estimated from civil parish population figures and spatial assessment of civil parishes overlay with agricultural parishes: • 2011 Census data, available at Scotland's Census (http://www.scotlandscensus.gov.uk/). Bulletin Figures and Tables. Statistical Bulletin - Release 1C (part two), Table A2: Census day usually resident population and households by census output area, 2011. Download: http://www.scotlandscensus.gov.uk/documents/censusresults/release1c/rel1c2tableA2.csv © Crown copyright. Data supplied by National Records of Scotland. • Lookup table between 2011 Output Areas and Civil Parishes. National Records of Scotland. 2011 Census Indexes: Comma Separated Value (CSV) files: table OA_TO_HIGHER_AREAS. Download: https://www.nrscotland.gov.uk/files//geography/2011-census-indexes-csv.zip © Crown copyright. Data supplied by National Records of Scotland) • Lookup table between 2011 Output Areas and Civil Parishes. National Records of Scotland. 2011 Census Indexes: Comma Separated Value (CSV) files: table CIVIL PARISH 1930 LOOKUP. Download: https://www.nrscotland.gov.uk/files//geography/2011-census-indexes-csv.zip © Crown copyright. Data supplied by National Records of Scotland) • Civil Parish Polygons by Raymond Wilson, available at http://www.arcgis.com/home/item.html?id=5287a144fa4b4200a7109eab88514252)