Statistics for Mission – technical note

Introduction

The Statistics for Mission Group is a joint committee of the Mission and Discipleship and Ministries Councils. Tasked with helping the Church of Scotland interpret the results of Scotland's Census 2011, the Group produced congregational profiles with maps, charts and tables of the Census data pertaining to each and every congregation of the Kirk with a territorial parish in Scotland. This technical note is intended to accompany the profiles and gives details of the process and methodology used.

In order to produce individual profiles, we required an automatic way to move from Census data to congregational areas. This took five stages:

1. Digitise the parish boundaries of the Church of Scotland
2. Liaise with National Records of Scotland regarding Census data
3. Identify the Census Output Areas and data pertaining to each parish
4. Determine how reports would be made available
5. Construct and disseminate the reports.

Acknowledgements conclude this technical note.

Part 1: Digitising the parish boundaries

An earlier project, looking at levels of deprivation in rural areas, had commissioned digitisation of parish boundaries based on postcodes provided to the group working on the 2001 Census results. However, the postcode data was of very variable quality and did not cover the entire country, resulting in a considerable undercount. Certain parishes had claimed postcodes all over their Presbytery, leading to a fractured map. It was decided to re-do the digitisation based on the actual parish boundaries, not ones based on postcodes.

1.2 Parish-level work

A group of four members of the Statistics for Mission group (Norman Jamieson, David Lewis, Fiona Tweedie (convener), and Douglas Vallance) took on this task. Each volunteered to digitise the boundaries of certain Presbyteries, and then Fiona Tweedie would combine them to produce a national map. An initial meeting was held to establish common methods, and then each worked with their allocated Presbyteries to produce digitised maps.

The maintenance of parish boundaries is a Presbytery responsibility and the General Assembly of 2011 directed Presbyteries to provide details of the parishes within their bounds. Several Presbyteries were able to produce immediately their maps or written narratives of the boundaries while others required considerable assistance to fulfil this. Issues faced by the group included:

- **Maps** may have been in sections, or individual maps for each parish. In some cases these did not cover the whole area, with gaps or overlaps between parishes. Some maps were very old and it was difficult to align boundaries with the modern landscape. The website of

the National Library of Scotland was invaluable in lining up older maps with their modern equivalents. Other maps were of different scales and with different features marked, leading to other difficulties. Some maps were available online but in different formats to that being used centrally, and they required conversion through various programs, an area where David Lewis excelled.

- **Narratives** were provided in certain cases, sometimes in addition to maps. They were useful in sorting out some detail, but also suffered from age. There were many instances of places being referenced that no longer existed: railway lines, farms, and the like. Narrative descriptions also allowed for the possibility of gaps or overlaps around parishes when the complete picture is not visible.

- Where a Presbytery was unable to provide details of the parish boundaries, we were able to make use of the **Civil Parish boundaries**. The team is grateful to National Records of Scotland who provided a digitised set of these boundaries early in the process. In some areas the Civil Parish boundaries matched the ecclesiastical parish boundaries, particularly in rural areas where a parish might be defined by the villages it includes, rather than the exact boundary line with another village.

- Another source of information was the **postcode boundaries** as drawn up for the 2001 Census. They provided some information in areas where we had exhausted all other avenues.

- **Visits** to some Presbyteries were required to untangle complex cases, or to save considerable time in emailing maps back and forward. One Presbytery responded very well indeed to the offer of some **staff support** and Andrew Morrison, a Geography student at the University of Glasgow, was able to work with them to produce a set of boundaries for this process.

- Where a Presbytery was unable to provide details of parish boundaries, digitisation team members were very occasionally required to **estimate** parish boundaries using principles such as major roads, railway lines and rivers to divide areas. It should be noted that parish boundaries within Nairn and Kelso were derived in this way.

In all cases, once a Presbytery's boundaries had been digitised to the best ability of the digitiser given the information provided, a map was returned to the Presbytery for checking. Any gaps, overlaps, or areas of uncertainty were highlighted and the Presbytery asked to confirm solutions to those areas. The digitisation team is very grateful to Presbytery Clerks and others for their time and energy in assisting with this process.

Some areas are ministered to by more than one parish, these are:

- Stornoway High (442347),
  Stornoway Martin's Memorial (442348),
  Stornoway St Columba's (442349)
- Kirkwall East (452370),
  Kirkwall St Magnus' Cathedral (452371)
- Rothesay Trinity (201282),
  United Church of Bute (201287)
- Newmains Bonkle (171138),
  Newmains Coltness Memorial (171139).

In two further areas, we were advised by the Presbytery that no parish boundaries could be identified and that the towns should be treated as a single area. These are:

- **Fraserburgh**
  Fraserburgh Old (342016),
  Fraserburgh South (342017),
  Fraserburgh West (342018).
- **Hawick**
  Hawick Burnfoot (60350),
  Hawick St Mary's and Old (60366),
  Hawick Teviot and Roberton (60354 – data is available for Roberton),
  Hawick Trinity (60355),
  Hawick Wilton (60356).

Once the Presbytery had signed off on the boundaries, they could go forward to the national map.

1.3 Presbytery-level combinations

When a map for a Presbytery was completed, the data was sent to Fiona Tweedie who had the responsibility for producing the final map. New issues came to the fore in this phase, including differences in software packages and gaps and overlaps between Presbyteries.

Presbyteries in the west were generally digitised with software which drew a line around EACH region, while others were digitised with software which dealt with polygons, where there is a single boundary between areas. The "double-boundary" between parishes had to be removed to allow for any modifications in the final map.

A common format had to be agreed for information pertaining to each parish. The congregation name and congregation number were included for each parish. While the congregation number may suffice for internal purposes, the inclusion of both allows for checks to be made on the accuracy of this information.

As Presbyteries were merged into the single map, as with the parish-level maps, gaps and overlaps became evident. Some were minor and Kirk Sessions found themselves bemusedly agreeing to the inclusion or exclusion of part of a field or road junction, others were more serious and required liaison between the digitisation team and various Presbyteries. The vast majority of these were quickly cleared up. At the time of writing there is only one area outstanding where two Presbyteries claim the same piece of land. Given that there are around 1,400 parishes, this is remarkable.

1.4 Error-checking

Once the final Presbytery boundaries had been established and all of the congregational information entered the complete draft map was then checked for any gaps or overlaps of more than 5m^2. Such tiny gaps can occur easily in the digitisation process, and particularly where Presbytery maps are joined. There were hundreds of such errors in the full map. At this point the software was upgraded to use Arc-GIS 10.1 which made this process, and others considerably easier. All gaps and overlaps of more than 5m^2 were checked and assigned to one neighbouring parish or another. Gaps smaller than this were automatically merged into an adjacent parish.

This map formed the basis for all Census work thereafter. It is held as a shapefile and is available from Ministries Council.

Part 2: Liaison with National Records of Scotland

Throughout the process, we were grateful to the Geography Branch of the National Records of Scotland (NRS), particularly Blair White and Tricia Couper, for their advice and encouragement. Norman Jamieson attended various consultation events before and after the initial release of data. Changes to the order of small-area data release were made in response comments made by this group, followed by other users.

Norman Jamieson also attended meetings of the Population and Migration Statistics (PAMS) Users Group, and other members of the Group attended consultation and feedback events. Fiona Tweedie gave a presentation of the Group's work to the PAMS conference.

The Church of Scotland is unusual in being an organisation with national, but also small-area coverage. To our knowledge, no other organisation has provided Census data in such an accessible way to people in Scotland. National Records of Scotland are keen to link to our material as an example of Census usage.

Part 3: Analysing Census data

The completed map was sent to the Geography Branch within NRS. They were able to return to us a table showing which Census areas were within which parishes. The data obtained from the Census is disseminated by NRS at various levels of geography. The smallest unit for which most data is available is the Census Output Area. This is an area with around 50 households, with a minimum of 20 households and 50 individuals to ensure confidentiality. There are over 46,300 Output Areas within Scotland.

The data for a parish is produced by amalgamating the data for each of the Output Areas within the parish. This means that the parish profile is the profile of the Output Areas that best fit the parish, not the actual digitised parish boundary itself. In practise there is little difference as some extra houses in one Output Area are likely to be offset by some missing ones in another.

An Output Area is deemed to be within a parish if its Population Weighted Centroid (PWC) falls within the parish boundary. The PWC can be described as the point closest to the most people within an area, an "average location" for everyone in the area.

The parish profiles present some of the univariate tables from Releases 2A to 2C of Scotland's Census.[1] Further information will be disseminated in 2014 and beyond, but there are no plans at present to incorporate this into these profiles.

Census data required minimal pre-processing before being incorporated into the spreadsheets for the reports. Some headings had to be altered for clarity and "-" changed to "0" throughout. In order to provide meaningful profiles for all congregations in the diverse areas of Scotland, some table categories were merged or sub-categories omitted. Details are as follows:

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[1] www.scotlandscensus.gov.uk

- Page 3 – Population Data – Table KS102SC – age groups merged to generate lifestyle age groups: Pre school 0-4; Primary School 5-11; High School 12-15; Student Age 16-24; Young adult 25-44; Mature Adult 45-64; Elderly 65-85; Very elderly 85+. Note that in the second release the High School age was incorrectly 10-15, and the Very Elderly mis-labelled as 80+ although the data itself was correct, being 85+. These were corrected in the third release.
- Page 4 – Religious Affiliation – Table KS209SCb – The categories for Buddhist, Hindu, Jewish, Muslim and Sikh have been merged with the Other Religion category.
- Page 5 – Ethnicity – Table KS201SC – The categories for White: Irish, White: Gypsy/Traveller, White: Polish and White: Other White have been merged to form the White - Other category. All of the Asian categories have been amalgamated. The African and Caribbean categories have been merged with Other Ethnic Groups to give the Other Ethnic Groups figure.
- Page 6 – Education – Table KS501SC – The figures for 16 and 17 year olds in full-time education, and those in full-time education aged 18 and over have been added together.
- Page 8 – Household Tenure – Table QS405SC – Headline figures used, sub-categories deleted.
- Page 9 – Household Composition – Table KS105SC – In order to give coherent graphs, various categories have been amalgamated. “Couple” includes those married, co-habiting or in a same-sex civil partnership. A dependent child is either under 16, or aged 16-17 in full-time education. Households with only non-dependent children i.e. 16 and over, but not in full-time education, are merged into the relevant “Other” category.
- Page 10 – Economic activity – Table KS601SC – The two graphs are from the same table, and together sum to 100%. Note that the range of the “Economically Inactive” graph is considerably smaller than that of the “Economically Active” graph. Note also that these consider only people aged 16-74. The two lines of text on page 2 uses percentages of ALL people, not just the 16-74 year olds.
- Page 11 – Industrial activities – Table KS605SC – There are eighteen different categories in this classification. To produce a clear graph of all categories, when any given parish will be likely to have only a small number of the categories, would be extremely difficult. It was decided to replace a visual graphic with tables of the most common five industrial activities in the parish, Presbytery and Scotland. The coding required to produce this table was considerable, and again down to Craig Hawkins’ expertise and persistence.

The data is provided in CSV format by NRS and were downloaded and pre-processed by Fiona Tweedie.

Part 4: Methods of dissemination

One of the key requirements of this work was that it be as accessible as possible to people across the Church of Scotland. The group had wide-ranging discussions about the various ways of providing this information. Fiona Tweedie met with the Research and Statistics Group of the Archbishops' Council of the Church of England to learn how they were handling comparable material. Discussions with Alan Murray and Craig Hawkins regarding the practicalities of delivery, taking into account capacity within the web team and the IT Department, led to the decision to generate static PDF files for each parish. These would sit behind the ChurchFinder on the main Church of Scotland web site.[2] This reduced demand on the webserver side, and moved the work required towards the IT Department.

Part 5: Construction of the reports for each parish area

The parish and Presbytery maps on each profile were generated by the data-driven maps functionality in Arc-GIS 10.1. Each parish in the map layer gave rise to its own map, with appropriate labels and scale, and a consistent format. While memory constrains production to twenty or so at a time, the saving in time is considerable with this software. Presbytery maps were constructed in a similar way. Each is saved as "parish_map_" followed by the congregation number, equivalently for Presbytery maps, and the profile generation picks up the appropriate maps for that place.

Release 1

The first release of parish profiles was a single A4 page with details of the parish map and the parish population and the number of households that it contained. The parish area was also included. All of these figures were produced by Arc-GIS using a spatial join – output areas whose population weighted centroid is within the parish boundary are assigned to that parish. The parish maps were produced using the data-driven maps capacity of Arc-GIS and included in the report.

The profiles are generated from an Excel Workbook. This format was chosen primarily because of Excel's capabilities with graph-production, something that would be heavily utilised within the later profiles. Although Excel's programmatic abilities are limited, it was felt that the ease with which graphs could be produced would compensate for this limitation.

Links were added in the online ChurchFinder to "Parish Statistics" and people within the Kirk alerted to its presence on 13 September 2013.

This first release enabled the team to iron out issues with delivery via the ChurchFinder and began to highlight any issues around parish boundaries. Emendations to parish boundaries were referred to Presbytery Clerks for confirmation before changes were made and the maps affected being re-produced. Some churches did not appear on the ChurchFinder, or appeared in the wrong place, and Craig Hawkins and Alan Murray worked to correct these errors.

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[2] http://cos.churchofscotland.org.uk/church_finder/index.php

Release 2

While the first release allowed us to test the web delivery and parish boundary data, the second release profiles used different methods and closely followed the dissemination of small area data from National Records of Scotland. We now had the lookup table provided by NRS and could make use of it to aggregate Output Area data to the parish level. The initial release had used a spatial join in Arc-GIS to achieve this.

The reports were entirely reconstructed to allow for graphs, charts and tables illustrating the parish community, with comparisons to the Presbytery area, and Scotland as a whole. A Presbytery map was added to the initial page. The coding required to produce these reports was considerable and we were hugely indebted to Craig Hawkins' experience with Windows programming (Visual Basic and .Net) in order to achieve this.

The Excel workbook which generate the profiles is directly linked to the processed census data (held at Output Area level), the NRS lookup table that converts output area to parish, and finally to the Church's own data for Congregation/Presbytery information. It brings all this information together, and then queries it at parish, Presbytery and national level to produce the charts and data tables held within the profile. A simple program held in the background of the workbook allows the profiles to be run for a range of parishes, whereby the workbook selects the relevant data, retrieves the relevant map images, refreshes the charts, and then outputs the workbook in PDF format to the web-server, before moving onto the next parish and repeating. To produce the profiles for all 1400+ congregations takes approximately a day. In all, given Excel's limitations, it is quite an elegant solution.

The new reports consisted of seven pages of material including:

- "If *parish* were a village of 100 people…."
- Age profile, by life-stage
- Religious affiliation
- Ethnicity and language use
- Perceived health and provision of unpaid care
- Household tenure

The reports were uploaded to the web site within a day of the small-area data becoming available. All Session Clerks and ministers were informed by email of the reports' availability in November 2013.

Informing so many people across the Kirk inevitably gave rise to a large number of queries and requests for corrections. Sheila Reeves, Craig Hawkins, Alan Murray and Fiona Tweedie worked patiently for weeks to resolve ones which required changes to be made. Revised profiles were uploaded to the website as necessary.

Release 3

The third and final release of profiles was made on 10 February 2014. Further small area data was disseminated by NRS on 18 December 2013 but considerable work was required by Craig Hawkins to produce the new profile pages. The final profiles consist of twelve pages, with additional information on:

- Those in full-time education and educational qualifications
- Occupation of household spaces and people in communal establishments
- Access to car or van
- Household composition
- Economic activity including those retired, students and working full or part time as well as the number of hours worked, type of occupation and industrial activity.

The coding required to produce the most common types of industrial activity at a parish, Presbytery and Scotland level was particularly complex. The data was such that presentation of every possible type of industrial activity on each profile would have led to unhelpful, sparse graphics, so the decision was taken to provide textual information about the most common activities in each parish and Presbytery.

A page of notes on further information was added to the end of the profile and minor stylistic changes made throughout. References were added to the Scotland's Census website and the Mission and Discipleship website.

Acknowledgements

The Statistics for Mission Group is grateful to National Records of Scotland for advice and encouragement throughout this process, and to the Research and Statistics Unit of the Archbishops' Council of the Church of England for advice, code and supportive encouragement over the last few years.

The Group is also grateful to all the people at all levels of the Church of Scotland who assisted with the digitisation of the parish boundaries.

Fiona J Tweedie
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