Environment Agency

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1930s Land utilisation mapping: an improved evidence-base for policy?

Science Report: SC050031

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Steve Killeen

Head of Science

Executive Summary

- Mainly between 1931 and 1934, the Land Utilisation Survey of Great Britain recorded land use field by field for Great Britain. Although data were gathered mainly by schoolchildren supervised by teachers, they were then extensively checked by Stamp and his academic collaborators.
- The survey recorded a limited number of land use types: farmland was divided into arable and permanent pasture; built-up areas divide into “houses with gardens” and “agriculturally unproductive”; other areas appear as “rough grazing”, woodland, water and transport. These types are shown as different colours on the maps. Instructions to volunteer surveyors did not give detailed guidance on, for example, distinguishing between permanent pasture and rough grazing, but such problems are not unique to the LUSGB.

- A comparison between county-level statistics from the LUSGB and the 1931 Agricultural Census shows a very close correspondence between the areas of arable, pasture and rough grazing from the two sources, despite their very different methods of gathering data.
- From interviews with various agencies, some of whom have already made limited use of the LUSGB maps, there are a series of clear potential policy applications, from the identification of isolated small habitats to large scale water quality management. Most require that the information in the maps be converted to more structured form.
- High resolution colour scans of all the LUSGB maps have already been created, mainly funded by the Environment Agency and DEFRA with unpublished Scottish sheets scanned more recently using a grant from a charity. All can be viewed on the Vision of Britain web site:

  http://www.VisionOfBritain.org.uk/maps

- The LUSGB maps were printed over a long period by several different printers, and overlaid coloured land use information on base maps supplied by the Ordnance Survey, containing contour lines and much black lettering. This complicates automated identification of land use categories, and means that some manual intervention is essential.
- “Supervised classification”, separately calibrated for each sheet, dealt effectively with colour variation. Applying successive filters, ‘focal majority’ and ‘nibble’, within our GIS software, removed much of the background clutter but some manual editing is still needed. Aggressive automated filtering would cause many real features on the map, such as farm buildings in the middle of fields, to be removed. We had limited time to work on this and it is likely that better, cheaper, methods can be developed.
- A business case for vectorisation of land use data has been developed in collaboration with English Nature, English Heritage and the Countryside Agency, and with limited dialogue with Scottish Natural Heritage.
- The report concludes with an assessment of the costs (financial and in terms of methods and staff skills) entailed in developing hardcopy maps into vector data for all of England with possible

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1. Introduction

1.1 The Land Utilisation Survey of Great Britain

From the early nineteenth century onwards, the Ordnance Survey systematically recorded landscape *features*, whether natural like rivers or man-made like building, but did not describe the use of the land itself, with the important exception of woodland. From 1866 onwards, the Agricultural Census or Survey, often called the "June Census", has gathered systematic data, by farm, on numbers of animals and acreages of crops, but ignored non-farmed areas. The only systematic sources of data, acre by acre, on land use in Britain prior to modern remote sensed data are therefore two surveys organised not by the government but by individual academic researchers. The second of these, directed during the 1960s by Professor Alice Coleman, is of considerable interest but the results are not easily accessible and it is not further discussed here.

The first systematic survey of land use was directed by Professor L. Dudley Stamp. Although based at the London School of Economics, the Land Utilisation Survey of Great Britain was Stamp's personal responsibility and the results were published by his own company, Geographical Publications Ltd. Planning began in 1929 and work was organised by administrative county, the first contact usually being with the Director of Education. Arrangements were in place for most English counties by the summer of 1931, and for most Welsh and Scottish counties a year later. The first of the resulting one inch to one mile maps was published in January 1933. By the autumn of 1934, 90% of the field survey maps had been returned, but two problems were emerging. Firstly, it proved impossible to find local volunteers for many areas and the Survey had had to organise university students and its own staff to fill the gaps; the very last area to be surveyed was part of the Isle of Arran in September 1941, all other areas being completed before the outbreak of war.

The second and more serious problem was funding the publication of the maps. One problem was the cost of reproducing the Ordnance Survey base maps. Even with government assistance during WWII, when Stamp's team was absorbed into the Ministry of Agriculture, the last published map did not appear until 1949. Between 1933 and 1949, nine separate printers were used, leading to variations in the inks and paper used. Stamp was never able to fund publication of 56 sheets covering upland areas of Scotland, although he did prepare very carefully hand-painted maps for these areas which were deposited with the Royal Geographical Society. Despite these problems, completion of the survey was an extraordinary achievement, and the bulk of the data were gathered in just three years.

1.2 Existing Research

In 2003, the Environment Agency funded a pilot project led by the University of Portsmouth in collaboration with the Centre for Environment and Hydrology at Monks Wood. One strand investigated the history of the LUSGB, listed the published maps and, crucially, made contact with the copyright holder and obtained permission for their use by not-for-profit UK projects. The other strand made an initial assessment of the potential for digitisation, identifying three necessary stages: image scanning, geo-rectification and, most labour intensively, vectorisation. These stages were undertaken for two small sample areas. This pilot project was entirely limited to the published maps, making no use of the unpublished materials the current project uses.

In 2004, the Environment Agency and the Department for Environment, Food and Rural Affairs (DEFRA) jointly funded a project at the University of Portsmouth to scan and geo-rectify a complete set of the maps published by the LUSGB. This project was successfully completed, partly thanks to very extensive assistance from map librarians around Britain. The resulting digital mapping has been archived by DEFRA, and some use of it has already been made by bodies such as the Countryside Agency. It has also been made available to the general public via the Vision of Britain web site operated by the University of Portsmouth, although that provides access only to quite small areas at any one time and is not designed to support analytic use.

In 2005, a grant from the Frederick Soddy Trust to the University of Portsmouth supported an investigation of the unpublished records of the LUSGB. This project located the colour separations and correspondence files used in the current project. A supplementary grant from the Soddy Trust enabled us to scan and geo-rectify the 56 sheets covering upland Scotland mentioned above. This material has been added to the Vision of Britain web site, meaning that for the first time ever the whole of the Land Utilisation Survey has been published. NB the Environment Agency and DEFRA do not hold any rights in the Scottish mapping.

Also in 2005, the Countryside Agency funded a very preliminary assessment of the records of the 1941 National Farm Survey, further discussed below.

1.3 Current Programme of Research

The current project was designed to further explore the case for a full digitisation project, partly by analysing some of the unpublished materials identified in 2005. It has eight objectives, which can be conveniently divided into the technical and the non-technical:

1.3.1 Technical objectives

Sections 2 of this report, on "methods", and 3, on "results and observations", are entirely focused on establishing how best to fully computerise the LUSGB maps, and assessing the cost of such a project:

Investigate options, and their costs and benefits, for 'cleaning' the pre-existing scanned and geo-referenced images (i.e. removing town names, etc.)

Investigate options and their costs and benefits for interpreting the inconsistent colour tones on the various printed Dudley Stamp maps (a major issue due to use of different printers and the effects of ageing) when 'polygonising' land use

These two tasks are very closely related, involving identifying the best combination of automated image processing and manual editing of the data. Our assessment of the accuracy of the techniques is based on comparing our results obtained by processing sampled of the published maps with data from the unpublished colour separations covering the same areas.

Carry out data conversion in a targeted locality as a case study to support all objectives. This will be with reference to a defined area or issue

Our primary case study is based on the south-east quadrant of the *Salisbury and Bulford* sheet, covering the city of Salisbury and the water meadows of the river Avon, as well as parts of Salisbury Plain. An additional case study covers the *Birmingham* sheet.

Develop a specification for digitising the full set of geo-referenced maps, including a breakdown of the costs and the experience required

A series of costed options are presented.

1.3.2 Non-technical objectives

Coverage of this more diverse programme of work is contained entirely within section 4 of this report, "Analysis and Discussion".

Work with potential end-users to assess the range of likely applications for the dataset once completed and tested

This involved meetings and other contacts with the Countryside Agency, English Nature and Scottish Natural Heritage.

Interpret the colour codes on the original maps, linking these where appropriate to contemporaneous agricultural statistics and land-use data

To establish more clearly how the LUSGB defined their land use categories, we reviewed the instructions sent out to the schools carrying out the fieldwork, Stamp's own description of the work, and the Survey's unpublished correspondence with selected counties.

Identify the other contemporaneous data on agricultural land-use that could be linked and add value in the interpretation of the land classsification described by the maps

We describe what related information was gathered by the 1931 Census of Population, the annual Agricultural Census, and the 1941 Farm Survey. A limited comparison of selected county-level statistics from 1931 Agricultural Census and the LUSGB is presented.

Make recommendations for dissemination of the geo-referenced maps for not-for-profit uses

We describe the dissemination routes already established via the *Vision of Britain* web site and by our collaborators in the University of Edinburgh's EDINA service, and discuss what additiona facilities might be developed.

2 Methods

2.1 Overview

One of the main objectives of this project is concerned with scanning and classifying the land use maps into a form, which can then be converted into a vector data format. This work builds on the approach outlined by Southall et al (2003). The aim of this process is to design a semi-automated approach to extract the relevant data. The current project was designed to further explore the case for a full digitisation project, partly by analysing some of the unpublished materials identified in 2005. It has eight objectives, which can be conveniently divided into the technical and the non-technical. One of the principal technical objectives involves identifying a reliable methodology which, with a minimum of error, can convert the raster data into a vector format. Clearly, the best method would be manual digitising of the entire data set, but this would require a considerable period of time and high intensity of labour. Therefore, a semi-automated approach has been the main method pursued although other are highlighted in this report. The technical aspect of this project is also concerned with an investigation of the separate colour layers of the LUS maps, some of which still exist.

2.2 Image scanning

The first stage of the process of the conversion of the data is the scanning of the paper maps. The hard copies invariably have distortions caused by map production, printing and medium storage distortion. Scanning these maps also adds further distortions, although these can be reduced by using a high quality map scanner. The scanning process introduces errors including variable stretch and compression in a vertical direction, variable stretch and compression in a horizontal direction and ordinary skew.

Figure 2.1: A section of the Birmingham LUS sheet.

A usual resolution for scanning large maps is between 300 – 400 dots per inch and at a colour depth of 8 bits per channel (24 bit colour). Obviously, this resolution can be increased but is in part, determined by the storage capacity available to the project, the physical size of the material, and the printing and dissemination techniques applied to the subsequent imagery. There is also a threshold to resolution where any further increase will not yield a noticeable improvement in quality. The 146 individual sheets had already been scanned and geo-referenced in a previous project. However, as part of this research, the colour separations of a number of sheets existed and were scanned by King's College London. The areas scanned for analysis were the *Salisbury and Bulford* sheet, the *Birmingham* sheet (Figure 2.1) and the *Dartmoor, Tavistock and Launceston* sheet. Also selected for analysis were the UK Summary sheets which because of their size were scanned in two sections.

2.3 Crisping the image

One technique which helps to improve the accuracy of the later stages of this method is to sharpen the image. For this project, the Imagine 8.7 Crisp tool was used. The Crisp filter sharpens the overall scene luminance without distorting the interband variance content of the image. This is a useful enhancement if the image is blurred or fuzzy at any point. The crisp tool helps to sharpen up the edges of the various LUS classes.

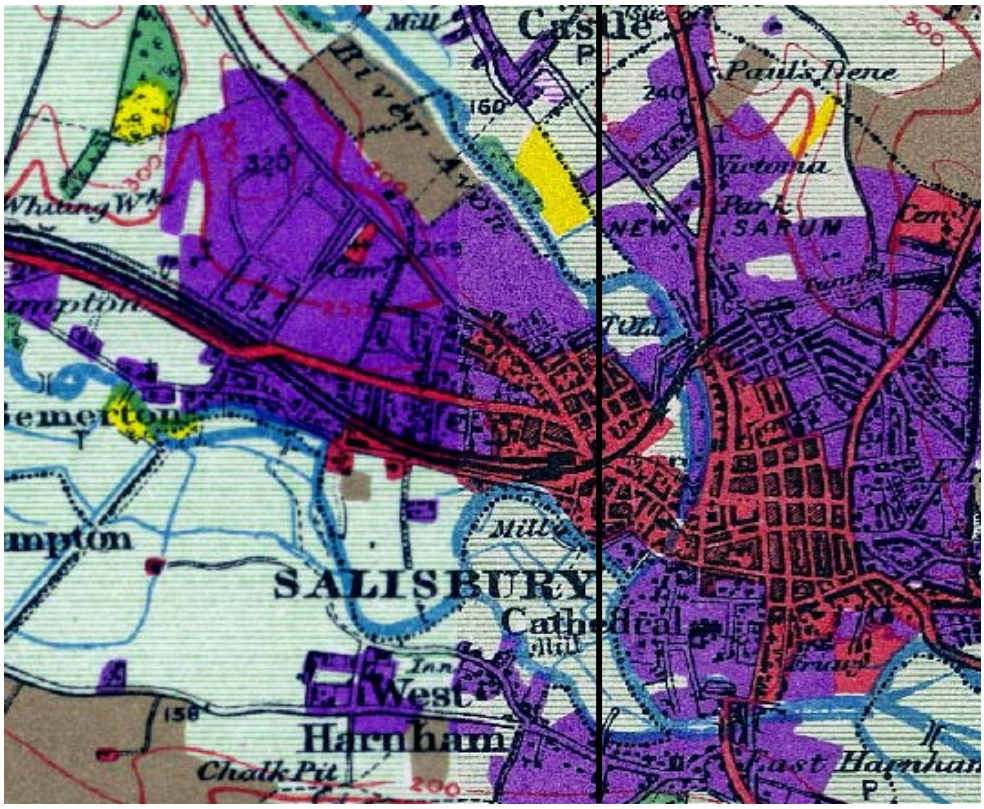


Figure 2.2 The unsharpened image to the left with the sharpened image to the right.

The algorithm used for this function is:

1) Calculate principal components of multiband input image.
2) Convolve PC-1 with summary filter.
3) Retransform to RGB space.

The logic of the algorithm is that the first principal component (PC-1) of an image is assumed to contain the overall scene luminance. The other PCs represent intra-scene variance. Thus, you can sharpen only PC-1 and then reverse the principal components calculation to reconstruct the original image. Luminance is sharpened, but variance is retained. A split image of a sharpened and unsharpened is shown in Figure 2.2.

2.4 Geo-referencing of the scanned maps

The digital files of the scanned maps are in image coordinates and therefore do not contain any projection information as to where the area represented on the map is located on the ground. This means that it is not possible to view, query or analyse the data with other geographic data, or indeed with any other of the scanned maps. In order to classify and compare the maps, it was necessary to geo-reference the maps using Imagine 8.7. Geo-referencing refers to the process of assigning map coordinates to image data. The image data may already be projected onto the desired plane, but not yet referenced to the proper coordinate system. Rectification, by definition, involves geo-referencing, since all map projection systems are associated with map coordinates. Image-to-image registration involves geo-referencing only if the reference image is already geo-referenced. Geo-referencing, by itself, involves changing only the map coordinate information in the image file. The grid of the image does not change.

The first stage of geo-referencing involves importing the scanned maps into an Imagine image format (*.img). The maps were then geo-referenced using the Imagine Geometric Correction tool. For this project, rectified maps already existed of the LUS individual whole sheets, albeit only the lower-resolution scans used for initial dissemination, and it was therefore possible to carry out an image-to-image registration. The complete sheets had been geo-referenced in a previous project and were therefore available for this research. One large major disadvantage of using a product from the Ordnance Survey to geo-reference the LUS images is that the resulting combination of information would probably be regarded by the OS as a ‘derived work’ in which they held a copyright, and could control dissemination. However, the GBH GIS project have created a complete set of geo-referenced 1”-to-the-mile maps that contain grid lines but were published more than fifty years ago, and are therefore free from OS copyright. These *New Popular Edition* maps from the 1940s were therefore used as the source of coordinate information for geo-referencing the whole LUS sheets. These maps were then in turn used to geo-reference the colour separations.

Image geometric correction involves identifying common points on the previously referenced whole sheets and the unreferenced colour separation. Normally, it would be possible to use the map grid lines, however, neither the published maps or the colour separations have these and therefore common features were measured instead. A first order polynomial transformation was used to transform the scanned image. Typically, between 15-20 control points were used for each map registration (Figure 2.3).

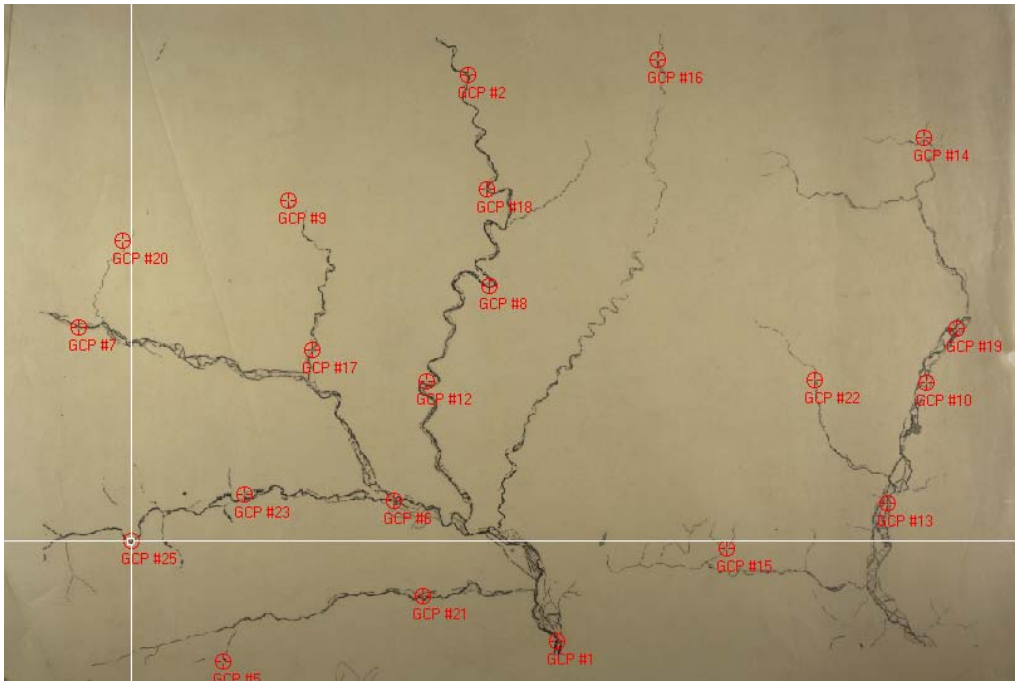


Figure 2.3 Blue layer sheet with the geocorrection control points from LUS 122.

The RMSE for each map was kept below 5 metres and points were added or deleted until this was achieved. The larger RMSE errors occurred at the edges of the maps, probably due to distortion of the original media. Once the images had been geocorrected they were compared against the original reference map to check for consistency (Figure 2.4).

Figure 2.4: An image swipe comparing the colour separation map against the previously geo-referenced map.

2.5 LUS Colour Separation maps

Figure 2.5: The 1/625,000 summary sheet for the light green layer

The production of each published land utilisation map required Stamp's team to create six colour separations, for red, yellow, blue, green, orange and purple layers, which were then used to progressively overprint the different colours onto black and white base maps created using printing plates from the Ordnance Survey. Most of these colour separations have not survived, and the majority were probably destroyed in 1942 when the LUSGB's main printer was hit by a German bomb. However, a substantial number of the separations, for twenty of the published maps, are preserved in the LSE's archives. These sheets are potentially very useful for ascertaining land use data as, unlike the published sheets, they are free from contour lines and black detail. This allows classification and vectorising techniques to be executed with a minimum of manual editing. This in turn removes the inevitable editing errors, which occur in particular the removal of small parcels of data from the digital classified map. For the purposes of this research the separation layers allow a direct comparison to be made with the layers extracted from the whole sheets. This should give an indication of the effects the classification and editing have on the final vectorised data.

For this research, separate colour layers were scanned for two main test areas (Birmingham, and Salisbury and Bulford). In addition, the separate layers were also extracted for the land utilisation summary sheets, which were generalised from the one inch to one mile sheets. The summary sheet covered the majority of England and Wales. These summary sheets

contained five colours, dark green, light green, red, brown and yellow (Figure 2.6). A list of the sheets scanned for this research is given in Table 2.5.1.

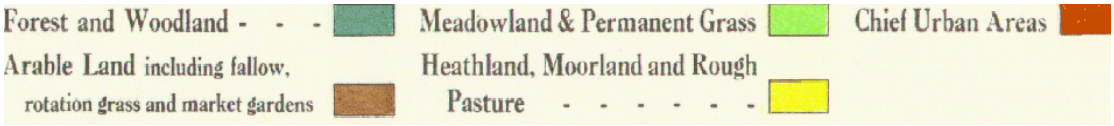


Figure 2.6 Colours and their relevant categories used in the land utilisation summary sheets

2.5.1 UK whole summary sheets

1. 11/625,000 Land Utilisation. Brown. Revision and Specials Department OSO Southampton OR11889 26 October 1942. 1st Proof
2. 1/526,000 Land Utilisation. Red. Revision and Specials Department OSO Southampton OR11889 26 October 1942. 1st Proof
3. 1/625,000 Land Utilisation. Dk Green. Revision and Specials Department OSO Southampton OR11889 26 October 1942. 1st Proof
4. 1/625,000 Land Utilisation. Lt Green. Revision and Specials Department OSO Southampton OR11889 26 October 1942. 1st Proof
5. 1/625,000 Land Utilisation. Yellow. Revision and Specials Department OSO Southampton OR11889 26 October 1942. 1st Proof
6. 1/625,000 Land Utilisation. Mauve. Revision and Specials Department OSO Southampton OR11889 26 October 1942. 1st Proof

2.5.2 Birmingham sheet

1. Birmingham green
2. Birmingham brown
3. Birmingham purple
4. Birmingham red

2.5.3 Salisbury and Bulford sheet
1. Salisbury green
2. Salisbury blue
3. Salisbury purple
4. Salisbury red
5. Salisbury yellow

Table 2.1 Scanned colour separation sheets

The large summary sheets were scanned in two sections because of their size. As a result, mosaicing of these images was required before they could be classified. The separation map layers for the UK summary sheets, Birmingham and Salisbury sheets were all geo-referenced using Imagine 8.7. The summary sheets were registered using previously rectified maps. The summary sheets were corrected using the two 1/625,000 sheets. Map distortion required that around fifty points were registered on each sheet to provide an accurate match to the registered whole sheets. The separation sheets were geo-referenced using the same whole sheets of the same area which had been previously corrected.

2.6 Extraction of land use information

One potential advantage of scanning and geo-referencing the maps is that it is then possible to automatically extract land use information. This procedure involves detecting and homogenising areas of colour within the map into discreet classes. This allows an image to be produced from which clutter such as text and contour lines has been removed. Classifying an image also allows the image to be converted from raster to vector data thereby creating a map of polygons for the whole study. From these data, it is then possible to derive land use statistics and comparisons with other geographic data sets.

Unfortunately, as discussed by Southall et al (2003), this process is complicated due to the nature of the maps. Automatic extraction of the various land use classes is difficult because of the 'black detail', contours and colour variations. Various approaches were investigated including unsupervised classification, manual digitising and supervised classification by Southall et al (2003). This project built upon these results and investigated their application to the colour separations and the Salisbury and Birmingham sheets. The main method used is supervised classification which utilises supervised training, which is closely controlled by the analyst. In this process, the analyst selects pixels that represent patterns or land cover features that can be recognized, or that can be identified with help from other sources. Knowledge of the data, and of the classes desired, is required before classification. By identifying patterns, it is possible to instruct the computer system to identify pixels with similar characteristics. If the classification is accurate, the resulting classes represent the categories within the data that you originally identified. The result of training is a set of signatures that defines a training sample or cluster. Each signature corresponds to a class, and is used with a decision rule to assign the pixels in the image file to a class.

Several training classes were identified for the whole sheets representing the various land use classes (Table 2.2).

For the colour separations only, one land class is represented for each colour in the groups identified in Table 2.2. Therefore, the supervised classification training for this involved the identification of the class represented in the separation map and a class representing the background. The colour separations were easier to classify as these are free from the clutter which is on the published LUS sheets.

Initial map class	**Colour / detail**
Black topological detail and text	Black - To be removed
Forest and woodland	Green with black symbols - combined from 3 subclasses
Meadowland and permanent grass	Light green (hatched line symbol)
Arable land	Brown
Water	Blue, sometimes with white lines
Heath and moorland	Yellow
Land agriculturally unproductive (e.g. Urban core)	Red
Gardens etc (e.g. suburban)	Purple

Table 2.2 The various land use classes extracted from the whole LUS sheets

Figure 2.7 shows a typical area identified for training purposes from the published maps. Rather than identifying a very clean area of colour, 'cluttered' areas were selected so that the software would learn to ignore the clutter during the classification process, thereby reducing the time spent cleaning up the data afterwards. Several training areas were selected for each map which were then merged into one class. The aim of this merging was to compensate for variations of colours within maps and differences which exited in symbolisation. This technique was also copied for the colour separation sheets to compensate for colour variation.

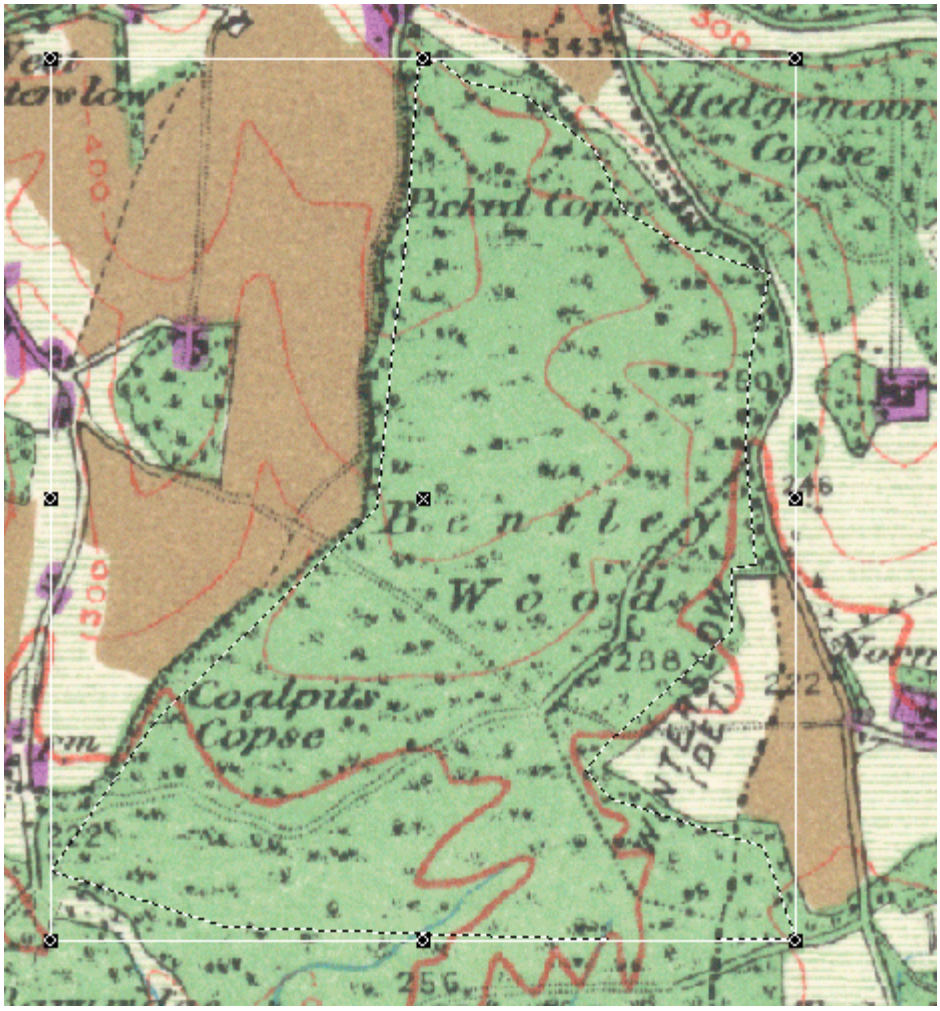


Figure 2.7. Showing an area of forest including clutter, extracted for training purposes

By overlaying the images in the same viewer it is possible to swipe or blend one against the other. This allows a superficial check to be made of the success or otherwise of the system. Figure 2.8 shows a classified image against the original colour separation. Unlike the whole sheets only minimal further editing will be required. One feature to note is that even though the separate layers require minimal editing there may still be some erroneous data in the map. In particular, ink accidentally marking the paper or text written on the maps may all be misrepresented. This should be visually checked before final editing commences.

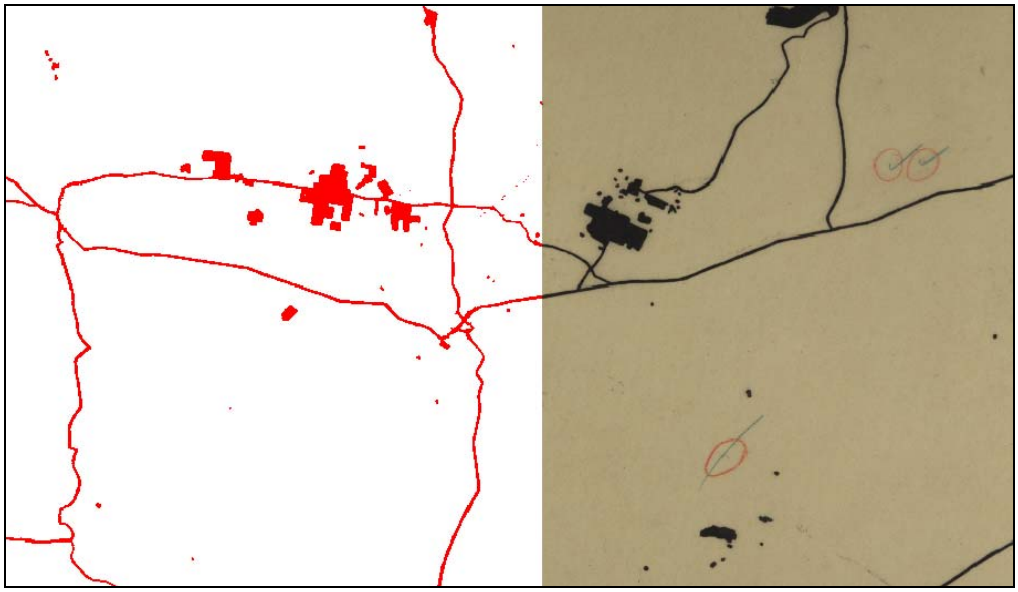


Figure 2.8. Showing a classified image (left) and the original colour separation for the Salisbury and Bulford map.

2.7 Further processing

Although the supervised classification technique is successful in ignoring much of the black detail in the published sheets, it was still necessary to undertake further cleaning of the resultant image in order to create clean land use polygons. It was noted that the land use types represented by more intense colours classified with more success than others. In particular, striped coloured areas (e.g. meadowland) produced mixed results, which require further refinement. Figure 2.9 shows an area of the classified image still exhibiting some clutter from the original map. This image also demonstrates the errors which are imported by the red contour lines which match the red used for the roads etc.

One method available for reducing some of the 'noise' in the image is to run a neighbourhood function. This dialog allows you to perform one of several analyses on class values on an image using a process similar to convolution filtering. Neighbourhood functions are specialized filtering functions that are designed for use on thematic layers. Each pixel is analysed with the pixels in its neighbourhood. The number and location of the pixels in the neighbourhood are determined by the size and shape of the filter, which you define. A 7X7 neighbourhood function was used which appeared to reduce the black detail and greatly improved the quality of the meadowland classified areas.

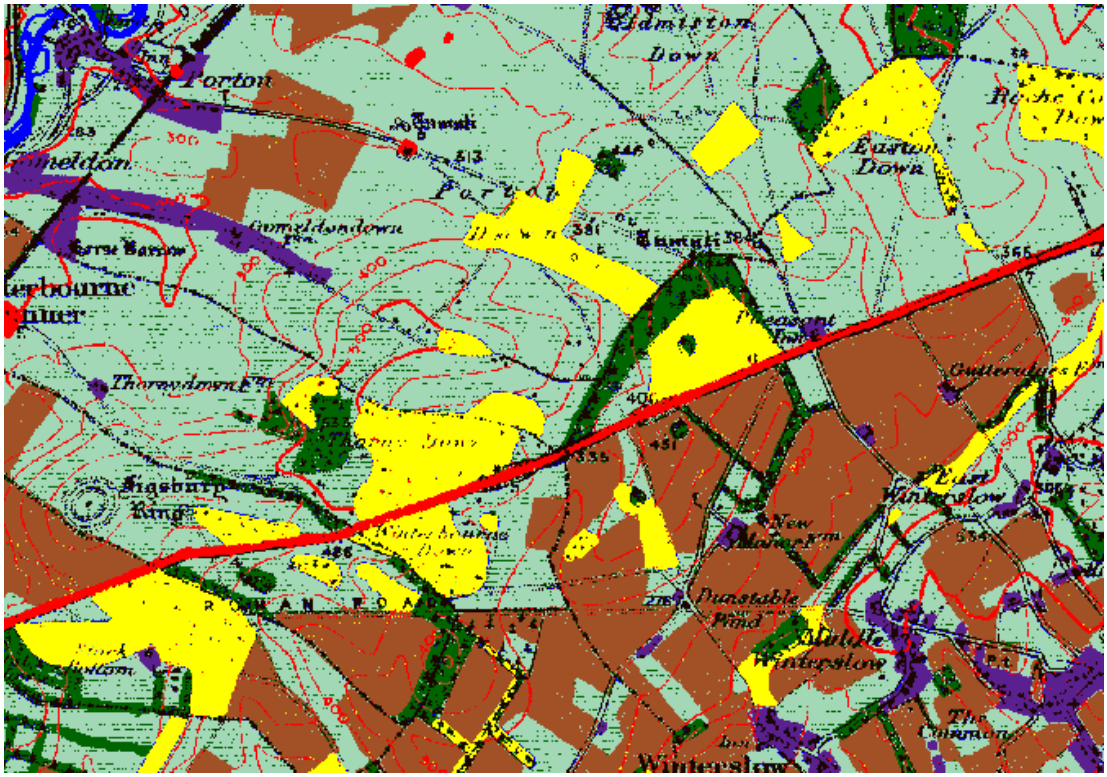


Figure 2.9 A classified image of part of the Salisbury and Bulford sheet

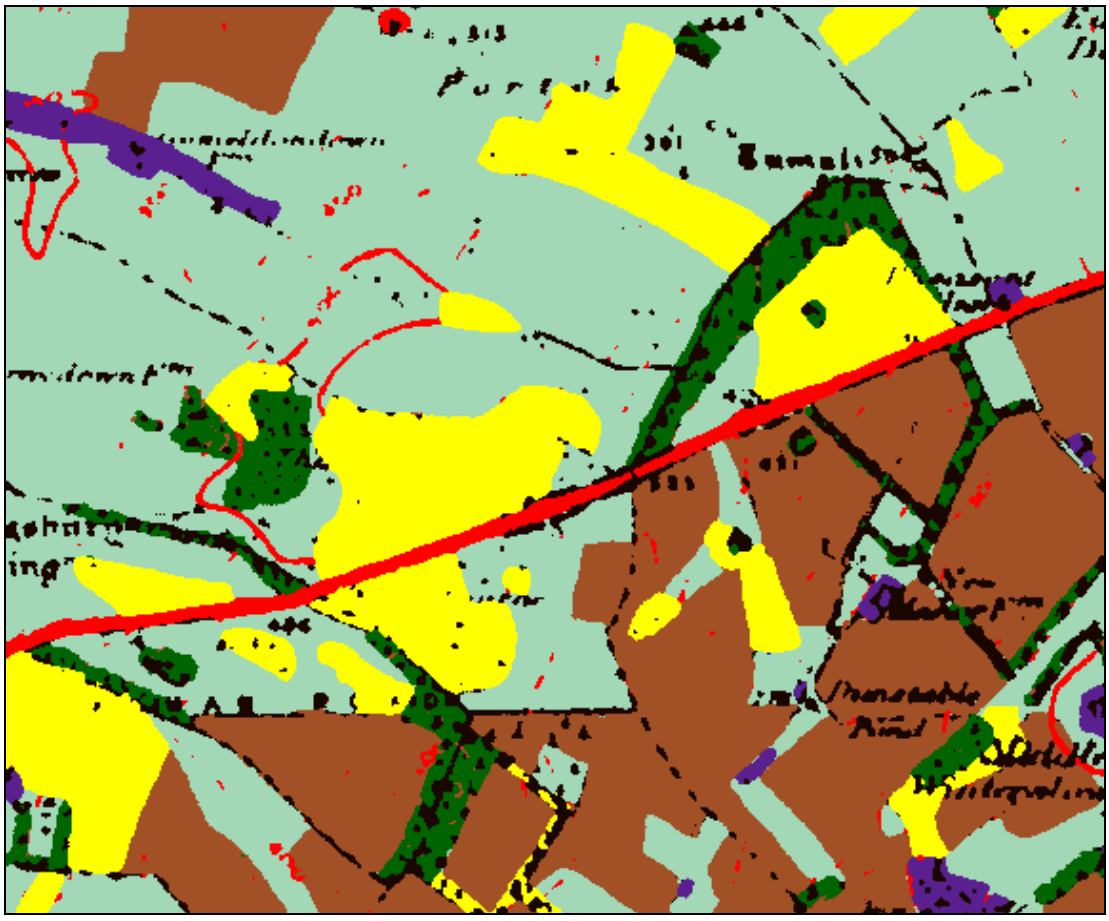


Figure 2.10 A classified image after the neighbourhood filter has been used

Further refinement of the image was still required to remove the remaining detail. It can be seen in the first classification example shown above, that although the basic class structure appears to be correct, there are some problems. As expected there is still rather a lot of black detail, which needs to be removed. There are also some other problems including the remaining contour lines etc. Many of these features will also be removed during either the dissolving process or in the later removal of small parcels. Some will need final interactive removal.

The removal of the unwanted black detail has been done as follows:

- Use Arc Grid 'focal majority' function with parameters: circle, 9 (variable), data. This successfully removes most linear features, such as road casings, and narrow text (with some remnants, especially where black was thick, such as on building symbols and larger text).

- Prepare files required for 'nibble' function. Make copy of output with black called 'nodata', and a second version where the remaining black pixels retain their original attribute. These two files are used in tandem during the subsequent 'nibble' process.

- Use ArcGrid 'nibble' function. This allows all other classes to eat into the black' nodata' areas, completely removing them.

2.8 Methodologies for interactive editing: Removal of anomalies

The most time consuming part of these procedures occurs when interactive analysis is necessary, therefore this methodology has tried to reduce this where possible. The state of the data at this stage is such that it requires the removal of a number of remaining 'anomalies'. Essentially there are two types of anomaly to be examined. There are small, unwanted parcels, remaining in the data that have not been removed by the previous processes. There also remain some data that have adopted the incorrect code: primarily these are smaller road parcels that have remained because they are red on the original maps. It was possible to automatically remove the smaller sections of the road, however larger road sections would need to be manually edited if there removal is required.

2.8.1 Removal of erroneous small parcels

The vector versions of the maps were examined in detail in relation to the original paper map information. The smallest individual parcels that were depicted on these original maps were examined. The smallest features depicted on the source maps are just over a quarter of a hectare in size. A threshold of 0.28 hectares was chosen, below which features have been dissolved into the background, using the 'eliminate' function of the GIS. This function dissolves parcels away, and replaces them with the attribute possessed by the adjoining parcel with the longest shared boundary line. This appeared to work well for the majority of the features however, in some instances, especially in relation to road detail, it is necessary to interactively, select an alternative adjoining value, in order to retain the cartographic integrity of the source map detail. The majority are unwanted small parcels derive from the remnants of black text etc. However, it should be noted that there is a danger when using automatic filtering functions that 'real' data is removed along with noise. In particular, small parcels of a land or farm buildings may be removed. A final interactive check is then necessary to ensure correct conversion from the source paper map to the final digital vector map has been achieved.

2.9 Extraction of Land Use Classes: Alternative Methodologies

A number of other alternative methodologies exist. Although these have not been used for the final data in this research the approaches required are highlighted below.

2.9.1 Class Reduction method

This method classifies the image into many colours and then reduces this down to the number of land use classes required by visually assigning each of the 100 classes to one of the target classes.

Method:

- Reduce number of colours in raster data to 100.
- Analyse all colours and assign them to a target land use class or 'other' class.
- Import basic raster data to a Geographical Information System for further refinement.
- Remove initial unwanted information such as black topographic detail.
- Convert to vector map and do further 'tidying up', e.g. removal of remaining unwanted detail.

Early investigations (Brown, 2000) reduced the number of colours present in the initial map scans to about 50 colours. Southall et al (2003), selected 100 colours which is a manageable number. Subsequent results suggested that this is sufficient to successfully separate out the main map classes.

The first step involves analysis of the 100 colours which have been created, which can be done in different software packages including Paintshop Pro or ArcView GIS. The procedure is similar in either package:

- Select a specific colour class,
- Display it in a bright colour to contrast with the rest of the source map,
- Decide on which target class it most clearly represents.

A large amount of black detail will remain which can be eliminated using the steps described earlier.

2.9.2 Manual digitising

This process involves manually tracing around the edges of each area of land use and then assigning the correct land use attribute to the resultant polygons. Due to the amount of time taken to carry out the image processing described above, it was considered that a viable alternative method may be to digitise land use classes by hand. This method has advantages over the other trials as it yields highly accurate results as well as requiring no further editing, other than edge-matching sheets together. Further advantages include being able to calculate how long it would take to digitise the whole country as well as enabling the comparison of these results with those produced by trials more automated methods.

Although time consuming, this method would give the most accurate vector representation of the sample area. However, it would be time consuming and a lot more expensive. It is estimated that it would take ninety three hours to digitise one map manually.

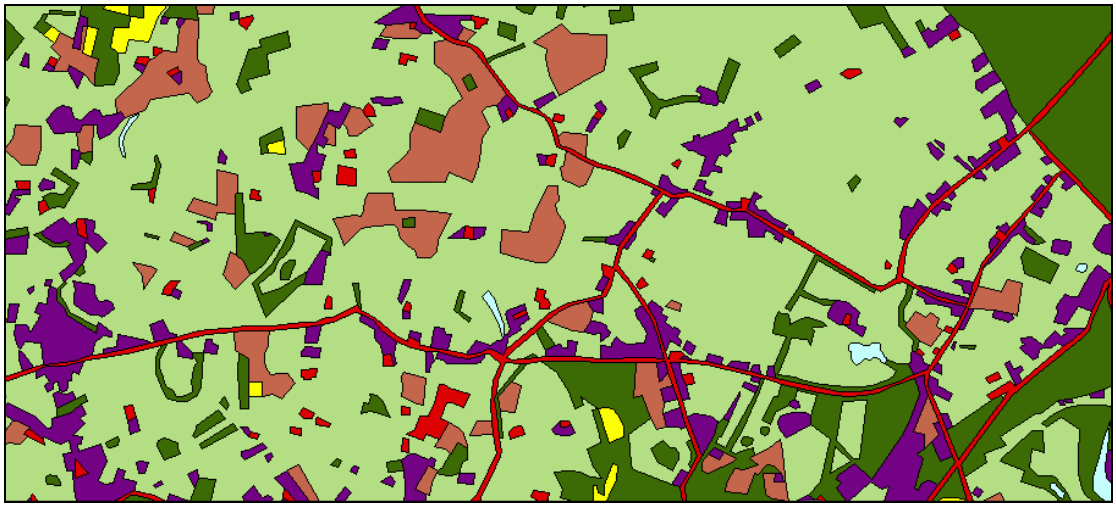


Figure 2.11 Example of a manually digitised area of the LUS map series.

3 Results and observations

3.1 Overview

The previous section identified a series of operations which we believe provide the most cost-effective, if not always the most accurate, method for extracting data from the LUSGB maps, based on supervised classification of colour areas, automated filtering to remove as much background clutter as possible, and finally manual editing. Having chosen our methods for computerising the LUSGB maps, how well do they work?

One limitation needs to be immediately stated. The keys to the Stamp maps distinguish different kinds of woodland – deciduous, coniferous and mixed – and different kinds of moorland and rough grazing, based on black symbols which form part of the Ordnance Survey base map and show through the overprinted colour. Unfortunately, our automated techniques make it impossible to distinguish these as the symbols form part of the "clutter" we have to filter out, so we can identify only the 'parent' classes indicated by the colours, i.e. woodland", or "rough grazing".

3.2 Comparing the published maps and the colour separations

A central element of our planned technical programme was a systematic statistical comparison of our final results for the 'Salisbury and Bulford' sheet, obtained via supervised classification, with similar results obtained from the original colour separations used in preparing the same sheet. Our working assumption was that the colour separations would provide 'the right answers' with no significant problems; i.e. the area of the map that was actually, for example, rough grazing and therefore coloured yellow. Any differences in the area computed from the published maps would therefore result from our inability to completely separate the different colours in the printed map, and remove background clutter.

One way of defining 'differences in area' between the two maps would be simply to find the total areas of yellow, of green and so on in each map, and compare these totals. However, our GIS software allows a better measure: how much of the area on one map with a given colour has the same colour on the other map. Obviously, it is perfectly possible for each map to have twenty per cent of its area coloured brown, but if the areas concerned are quite different there is no match.

Rather than compare our vectorised version of the published map with the vectorised version of each of the individual colour separations, we assembled the latter into a single "union map", showing all the different land uses. The following table shows firstly the area, in square kilometres, of each major land use on the published map, and then the proportion of that land use which was covered by the same land use on the "union map":

Land Use Type	(a): Area in km^2 covered by land use type on published map:	(b): Area covered by same category on "union map" of colour separations:	Overlap: (b) as percentage of (a)
Meadowland and Permanent Grass	238.24	231.92	97.34
Arable	195.39	186.67	95.54
Forest and Woodland	55.53	46.86	84.38
Gardens etc.	23.69	20.22	85.35
Rough Grazing	20.61	18.15	88.07
Water	13.33	10.99	82.46
Agriculturally Unproductive	10.78	7.44	69.01
Total Area	**557.57**	**522.25**	**93.67**

Table 3.1: Areas and Percentages for Land Use by Category on the South East quadrant of the published LUSGB map for 'Salisbury and Bulford', and on the corresponding "Union map"

Although the results for the two largest land uses are the most satisfactory, and much the worst result is for "agriculturally unproductive" land, which occupies a very small part of this particular sheet, the results are still worse than we had expected. They also did not correspond with our own visual assessment of the quality of our results working from the published sheet, so we investigated further.

It became clear that we could not view the colour separations as a secure benchmark. The largest problem is that the separate coloured layers were clearly designed to overlap slightly, to prevent any gaps in the final published map. Figure 3.1 shows how several layers can overlap, only one of which would be picked up in the classification of the whole sheet. Figure 3.2 demonstrates how even a few polygons have a spatial difference. The cumulative effect of these could be large over the whole sheet. This difference between the separations and whole sheets also makes geo-referencing more difficult as it is necessary to find points which are the same and not hidden on the whole sheet.

Similarly, in any geo-referencing of an image to another image there will always be an error between the two sheets. This will be shown in differences around the edges of the individual polygons. It is suggested, that if all the LUS maps were to be classified, that a random sample area on a few maps is hand digitised and compared to the automated classification technique to give an indication of similarity across the whole survey.

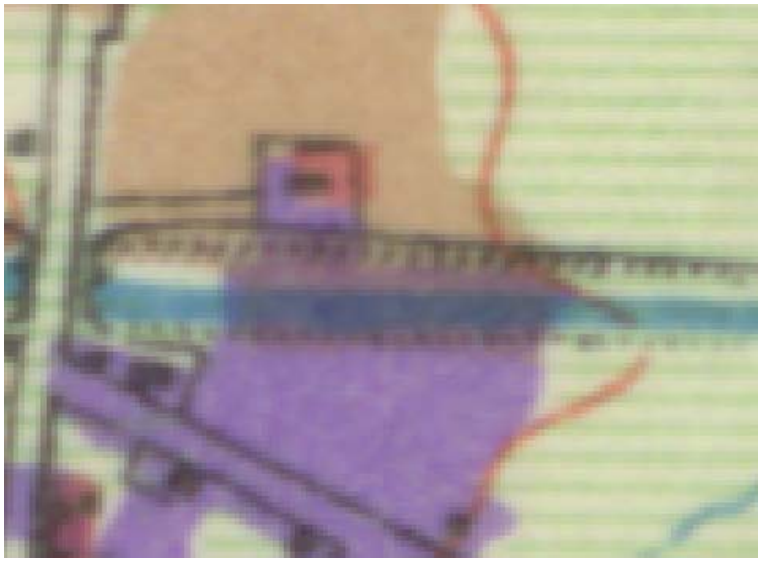


Figure 3.1: Blue, brown and purple overlap on a whole sheet. There is also overlap from the striped green layer

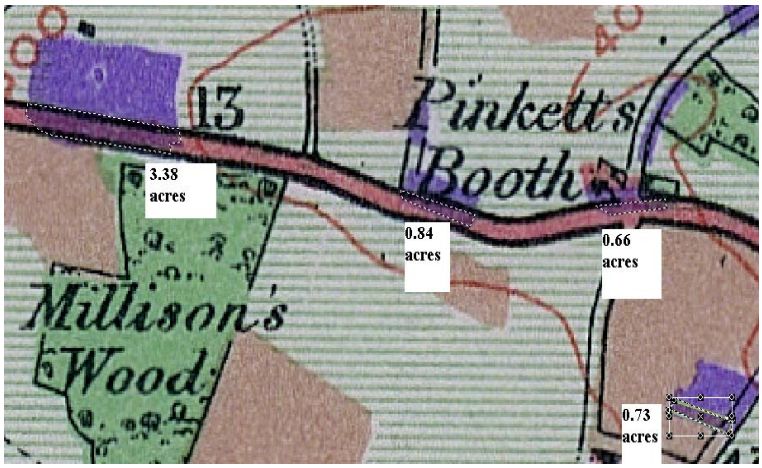


Figure 3.2: Area calculations for a small section of purple overlap

Other factors also cause poor matches between the printed maps and the colour separations. The particularly poor result for the red colour, i.e. 'agriculturally unproductive', is partly because the published maps also include red lines coming through from the Ordnance Survey base maps, showing roads. Another problem is that is that some of the colour separation sheets and therefore the union sheet contain polygons that are not fully enclosed. The categorisation therefore leaks into the border area, creating extra areas of the category. However, this does not appear to have a large effect on the overall percentages, especially as the category area being compared is that which covers exactly the same geographic area on both maps. Finally, the colour separations are all slightly larger than the published map, again presumably to ensure that no areas of the base map would be left uncoloured in the final printed version.

In summary, problems with the colour separations means we cannot say exactly how accurate our computation of overall areas of each land use from the published 'Salisbury and Bulford' map is, but we can say it is substantially better than 93.7% accurate, although certain land uses clearly pose additional problems. More careful construction of the union map, designed to minimise the impact of overlaps, might eventually produce a more accurate result. However, since final results for the whole country must be based on the published

maps, not the colour separations, it is hard to justify doing extensive further work on the latter.

3.3 LUSGB Summary Sheets

In his book *The Land of Britain: Its use and misuse*, Stamp outlines the approach used in compiling the summary sheets of 10miles to the inch. The information from the 1mile: 1inch map-sheets was used to generalise the land uses. Adjacent blocks of fields with the same land utilisation were aggregated ensuring the proportions remained true despite losing the exact field definitions. The resulting maps for all 235 sheets were then painstakingly transferred to a standard 1:625,000 Ordnance Survey outline map.

The resulting map was published in two sheets, the southern one covering Wales and most of England, while the northern one covered the north of England and all of Scotland. Much of the information remained the same using the National Grid, OS standard black outlines, orange contour lines and blue water features. Four of the six original colour categories from the '1 mile to 1 inch' map sheets were also repeated. Arable was coloured brown, permanent pasture and meadow was light green, heath, moor and rough grazing was yellow whilst forest and woodland, as updated by the forestry commission, was dark green. Unlike the larger scale maps, orchards and nursery gardens were coloured solid purple, rather than houses with gardens as on the 6inch map sheets and the chief urban areas are solid red and these include both closely built-up areas, as on the original 6inch sheets, and houses with gardens.

The available colour separations at the LSE included separations for the southern summary sheet, covering the whole of Wales and England south of the Lake District. Figure 3.3 shows the 'arable' layer. In analysing these sheets, we encountered the same problems as discussed earlier. In particular, geo-referencing presented problems possibly due to the high level of distortion in the scans of the separations. The geo-referencing error to the UK whole summary sheets was typically 16m. This could not be improved upon even though around 50 points were used for each rectification. Furthermore, because of their size the summary sheets were scanned in two sections which then had to be mosaiced together. This again will add an error to the spatial accuracy of the data. This error suggests that although the separation summary sheets can be used for area calculations, they should be treated with caution if a comparison with the whole sheet is required.

Figure 3.3: Mosaiced brown layer from the UK summary sheets

3.4 Removal of black detail from the classified maps

One possible way that the process of automatic classification could be improved is to automatically delete some of the black detail before the process of classification begins. An experiment was carried out using Imagine 8.7 Modeler to remove some of this detail automatically. A model was constructed which used a focal majority filter to remove some of the detail (Figure 3.4). The results were mixed but it is likely with further experimentation that a method could be automated which can remove large amounts of erroneous detail before classification. It is suggested if all the maps are to be vectorised that this approach is pursued further as it could also help reduce editing times.

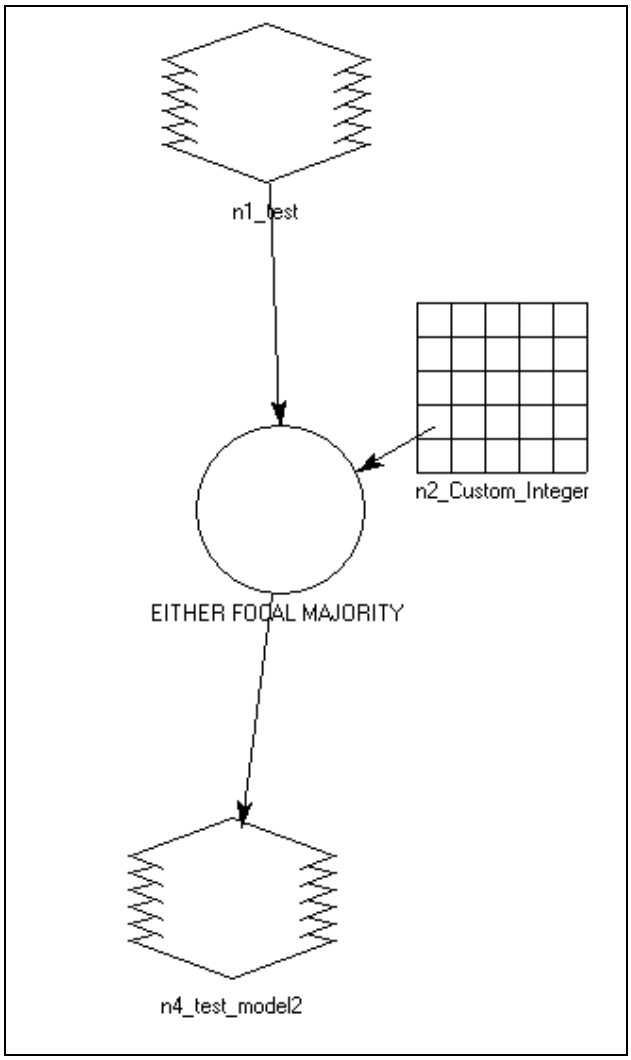


Figure 3.4: Graphical model constructed to remove black detail

3.5 Time estimates

During these and previous investigations, a detailed record was kept of the time taken for each step in the process. From these figures, averages have been calculated which provide reasonable estimates of the time taken to complete an average map sheet. These times have then been extrapolated in order to cover the various sheets for England, Wales and Scotland. Two temporal estimates have been provided, one for automated classification and one for manual digitising. Although other methods are available it was felt that these did not match the speed of automated classification or the accuracy of manual digitising. Inevitably, some information will be lost in automated editing and the level of manual editing would need to be decided upon. It seems likely that as staff became more experienced with the automated methods as applied to the LUSGB maps they would get faster, leaving even more time eventually for manual editing of erroneous data. (Subsequent calculations of resource requirements are conservative in that they do not assume increased speed, and final estimates of resource requirements also contain an additional 10% contingency to allow for unforeseen difficulties.)

Given the importance of manual editing, one of the key issues affecting both the cost of vectorisation and the quality of the final result is the type of staff employed. Our calculations are based on employing three distinct types of staff:

- Qualified GIS analyst: i.e. a researcher with a postgraduate qualification in GIS. They can be expected to make full use of automated features within the software, but will have the highest hourly cost and therefore should not be involved in manual editing.
- Inexperienced GIS technician: They will have basic training in the use of the manual editing tools. In our own context, this means primarily current Masters students in GIS.
- Experienced GIS technician: One clear conclusion of the work we have done, although hard to quantify, is that the relatively small additional cost of using an experienced technician on the manual editing is easily justified in terms of both speed and the quality of the end result.

Stages and time required for one map	
1.	**Registration** **Crisping** **Classification** **Neighbourhood function** *Time per map 2.5 hrs*
2.	**Automated editing** *Time per map 3 hrs*
3.	**Manual editing** *Time per map 4 hrs*
4.	**Final check, file writing etc.** *Time per map 2 hrs*
	TOTAL: ***Time per map 11.5 hrs*** ***Cost: £392.70***

Table 3.2: The stages and estimated time periods for the vectorisation of each map

Maps of England and border areas:	
118 maps x 11.5 hours = 1357 hours	**Cost: £46,338.60**
Stage 1: 295 hours Stage 2: 354 hours Stage 3: 472 hours Stage 4: 236 hours	
Maps of Wales:	
17 maps x 11.5 hours = 195.5 hours	**Cost: £6,675.90**
Stage 1: 42.5 hours Stage 2: 51 hours Stage 3: 68 hours Stage 4: 34 hours	
Maps of Scotland:	
37 maps x 11.5 hours = 425.5 hours	**Cost: £14,529.90**
Stage 1: 92.5 hours Stage 2: 111 hours Stage 3 (PC): 148 hours Stage 4 (PC): 74 hours	

Table 3.3 Time estimates for the vectorisation of England, Wales and Scotland using the supervised classification method

The above costs are based on a considerable level of automation. We believe this will lead to a high quality product, but automating the classification inevitably leads to some spurious polygons, as discussed above, and the only way to completely avoid this is purely manual digitisation by an experienced GIS technician. The following estimated costs would then apply:

Maps of England and border areas:	
118 maps x 93 hours = 10,974 hours	**Cost: £151,995.80**
Maps of Wales:	
17 maps x 93 hours = 1,581 hours	**Cost: £21,897.70**
Maps of Scotland:	
37 maps x 93 hours = 3,441 hours	**Cost: £47,659.70**

Table 3.4: Estimated times for map vectorisation using manual digitising

4 Analysis and discussion

4.1 End-user requirements

4.1.1 Countryside Agency

Dr. Southall visited the Agency in Cheltenham on March 17th 2006. The meeting was attended by Andrew Baker (Countryside Quality Counts project manager), Justin Martin (Countryside Agency Data Manager), as well as Jeremy Lake of English Heritage (Historic Farmsteads Lead; see below).

The Countryside Agency are concerned with the farmed area of Britain, and therefore with the large part of the country. Shifts in agricultural subsidy regimes mean that farmers will be rewarded for "countryside stewardship" rather than simply maximising output. In so far as "stewardship" means preserving traditional landscapes, the Agency need a baseline, and currently use data from the Agricultural Census (see below) for 1998 to 2002. A longer term perspective is highly desirable.

The Agency's need is for, ideally, more detailed information on types of agriculture than was gathered by the LUSGB, which explains why they have separately funded us to investigate the 1941 Farm Survey (see below). However, computerising this would be far more expensive than further work on the LUSGB, and they are already making some use of the LUSGB scans.

Much of their work is organised not by local authority areas but by Joint Character Areas, defined in terms of geology, soil and vegetation. Since the meeting a set of digital boundaries for JCAs have been down-loaded, and we see no problems in generating statistics for JCAs from the vectorised LUSGB maps.

A more specific focus is a set of seven lowland parishes which were originally studied by Westmacott and Worthington for the *New Agricultural Landscapes* report (1972), and re-analysed by three later studies. Also since the meeting, the CA have supplied us with boundaries for these and we will be exploring what data can be extracted.

A large part of the Countryside Agency is being merged with English Nature and a large part of DEFRA's Rural Development Service to create a new agency, Natural England. Until this is established it is unclear what resources may be available for computerisation projects.

4.1.2 English Heritage

Jeremy Lake of English Heritage (Historic Farmsteads Lead) was present during the meeting when Dr. Southall visited the Countryside Agency in Cheltenham on March 17th 2006.

Jeremy Lake commented on English Heritage's related activities. His focus is on farm *buildings*, but their new policy on historic farmsteads, to be published this May, aims to place them in the context of the surrounding farmland. This has already involved research into tithe maps, for example. More generally, historic map data helps English Heritage to predict where archaeological materials are likely.

4.1.3 English Nature

Dr. Southall visited English Nature in Peterborough on March 6th, 2006, and met Stephen Preston.

English Nature's requirements differ significantly from those of the Countryside Agency because they are mainly focused on quite small sites, actual or potential Sites of Special Scientific Interest. They are responsible for developing Biodiversity Action Plans for counties, which are generally based on partnerships with both public and voluntary sector bodies, such as the RSPB. Three examples of potential applications of the LUSGB mapping are:

- Work on traditional orchards, the habitats for particular species of beetles, in Evesham and Devon and Somerset. The land use maps help identify long-established orchards.
- Catchment Sensitive Farming, an aspect of implementing the EC Water Quality Directive. There is a need to reduce amounts of nitrates, "nitrate vulnerable zones" currently covering 20% of England. Given that reducing fertiliser use may make arable farming non-viable, identifying which areas and additional farms were traditionally pastoral and converted to arable during or after WWII is one way of targetting action.
- Habitat restoration of lowland heath areas in Suffolk. LUSGB maps were supplied to this project in 2004, and the project officer then gave us these comments:

> The project that I am working on is a heathland opportunity mapping project. We have basically been developing a scoring system to assess the priority areas for heathland re-creation across the East of England region. This scoring system has then been translated into computer models and this has been run through a GIS to score individual polygons for different attributes.
>
> The LUS maps have been a key part of the historical data that we have looked at. An important factor influencing the ease of heathland re-creation is the age since it was last heathland. I used the LUS maps to ascertain whether polygons were heathland in the 1930s - I digitised round the areas of heathland on these maps to provide a GIS layer for the project.
>
> To have the whole dataset available digitally is extremely valuable in my opinion. One of the big problems that I encountered with this project was a lack of digital data, so having this available in a digital format saved me a great deal of time. I also think that the importance of digital data is increasing as more and more studies use GIS, so to have these maps available as a digital tool would be extremely useful. Furthermore, if it were available as an interactive tool on the web I think that it's value would be even greater, as it would then be readily accessible to many more people.
>
> To get most value from the maps I would have to say that they would need to be converted into vector data if possible. I spent a great deal of time digitising round the heathland polygons, so if you could produce a dataset with polyonised vector data of the landcover I'm sure that this would be extremely useful for future projects.[1]

Stephen Preston confirmed that the existing scans of the LUSGB maps are not adequate, one limitation being that there is no way to search for areas of specific land uses other than visual scanning.

[1] e-mail from Sarah Eglington, 11/6/2004.

Like the Countryside Agency, English Nature cannot make funding commitments until Natural England is established.

4.1.4 Environment Agency

Dr. Southall was in extensive discussion with Environment Agency staff throughout this project, identifying a broad range of potential applications for the vector data. Key uses for these GIS-based data include:

- Characterisation and assessment of potential recovery benchmarks under the EU Water Framework Directive;
- Comparison of modern versus historic land use to assess likely impacts of control measures to address the EU Nitrates Directive;
- Identification of reference conditions for conservation works, including under the EU Habitats and Birds Directives;
- Determination of the likely contribution of land use to diffuse pollution;
- Providing a basis for assessing changes in the hydrological functioning of catchments, including opportunities for restoration of water storage or floodwater attenuation.

4.1.5 Other

Although it was not possible to make site visits, we attempted to establish the requirements of the two Scottish agencies most likely to have a use for historical land use data, Scottish Natural Heritage (SH) and the Scottish Environment Protection Agency (SEPA). We were unable to make a useful contact with SEPA.

At SNH, we made contact with Mark Robson (Inverness), and through him with Colin Stewart (Perth); both are GIS specialists. Colin advised us that SNH had already discussed use of the Stamp maps, and had concluded that the limited range of categories and the likely cost had decided them against further work. However, this decision had clearly not been based on an appraisal as detailed as ours, and we will recommend supplying them with a copy of this report.

4.2 Classification of land uses by the LUSGB

The original instruction leaflet sent out to schools, reproduced as Appendix 1, was fairly superficial and included many generalised statements. The front page gave the objective of the Survey as to create a permanent record of land use during a period of rapid change. This was referring to the economic circumstances prevalent during the Depression years during the 1920s and 1930s, which led farmers to convert much of their arable land to pasture in order to save money rather than grow crops they could not sell.

Each surveyor in England and Wales was expected to complete the whole of a quarter sheet of an Ordnance Survey 6 inch map, roughly an area of 3 miles by 2 miles. In Scotland a surveyor was expected to cover a whole 6inch sheet because quarter sheets were not produced. These units of measurement were stressed within the pamphlet in order to alleviate the problem of surveys only being done up to the parish boundaries and thus the extra maps and survey volunteers this would necessitate. The surveyors were advised of two possible approaches, either to hectograph or to use ordinary tracing or greaseproof paper to copy boundaries for particular sections of the map for individuals to use for their surveying in the field the results of which would then be copied up neatly on the original map after completion of the surveying or they could purchase two copies of the map one for rough work and one for the finished article. Once the Survey had received the finished map photograph copies were made and then the original returned to the surveyor or the county organiser if they wished.

There were some specific directives about classification. The fourth edition pamphlet published in June 1932 specified each finished survey map should be marked with the appropriate letters for each of the seven classification categories. The maps could also be coloured “with water colour or crayons” if desired, but it was emphasised that any such colouring should only be done very lightly otherwise the detail below including the lettering on the photographed copy might be obscured and lost. Surveyors were also directed to write their name, address and the date on the front of the sheet for easy reference. There were also specific notes for areas of possible misinterpretation. For example any areas of woodland or forest, especially those that had been newly planted had to be checked to ensure that observation on the ground matched the information supplied on the six-inch maps.

If grassland showed evidence of recent cultivation or if the land use was unclear to the surveyor then the farmer should be questioned and care had to be taken to ensure fallow or rotation grass was not included in permanent pasture. Rotation grass was suggested as

often being recognisable for its high proportion of clover. Professor Coleman, director of the second Survey, told us that when she spoke to Stamp about his classification methods, his intention had been that any land that was farmed using a crop rotation cycle and which happened to be under grass when surveyed should be classed as arable. However, using school children as surveyors meant he felt this instruction had proven to be problematic and was not reliably followed[2]. Given that the Survey was carried out in a period when the arable area was declining quite rapidly, it is arguable that not even the farmer knew whether a particular field being planted with grass would later return to other crops, or would remain as "permanent grass".

Directions were given on the pamphlets to mark market gardens down as arable, but specifically identified by the initials "M.G.". Gardens which were sufficiently big enough to merit growing a few vegetables or flowers within them were to be defined as Gardens, "G", as were allotments. Orchards were already marked as such on the base map, but the instructions said this information should be checked and that a specific "Orchard" label be added. Within "Orchards", surveyors were also required to note if the ground was used for grazing "G(M)" or for ground crops "G(A)" as well as for fruit trees. Special mention is made of public parks, sports grounds, golf courses and poultry farms and how they should be classified. Dr. Willatts, the Organising Secretary of the first Survey, when questioned about whether he wished the Survey had separated urban and industrial land into more detailed categories replied that there are always those kinds of wishes, but that "it would have been more difficult to do – more likely to involve much more subjective judgment"[3]. It seems that overall the Survey organisers did have concerns about the accuracy of the results and the manner in which the categorisation was done, but they also felt that there was little that could be done to improve the situation, given the constraints they were working under. Surveyors were advised to make notes giving further information on the nature of unproductive land, whether it be buildings, yards, cemeteries, mines and so on. They were also asked to record additional details of landscape circumstances, such as characteristics of moorland, field boundary materials, or condition of pastures and farmlands and to make sketch maps of new buildings and features such as roads.

Dudley Stamp deposited many of his papers in the University of Sussex special collections archive. These papers include correspondence files with each of the county organisers of the Survey. We read through all papers for the following counties to represent a cross-section of different types of predominant land uses: Devon for its mixed farming and large areas of moor-land, Durham for its mixed farming and industrial zones, Leicestershire for its pastoral farming, Yorkshire for its industrial areas in the West Riding and in fact the documents consulted all related to the West Riding. Huntingdon and the Lindsey part of Lincolnshire were also checked less thoroughly to add more depth to the coverage. The over-riding impression derived from these files is the limited amount of discussion of classification problems. Very few letters were written which even mentioned problems with assignment of land use type in any of these counties. This may reflect losses of much of the early correspondence during the London Blitz on 10 May 1941 or it may be because it either never existed or has been lost over the years.

There obviously could be some misunderstanding by the county co-ordinators of the original instructions sent out to Surveyors. Devon Education Authority sent out the guidance pamphlet to schools along with their maps and a letter to the head teacher of each school instructing them to liase with the neighbouring schools to ensure that duplication of surveying work did not occur and stating that it was not necessary for the children to physically leave

[2] Professor Alice Coleman spoke during a meeting about Land Utilisation Surveys held by the Great Britain Historical GIS Project at the London School of Economics, Monday 18 April 2005.

[3] Transcript of interview conducted by Dr. Rex Walford with Dr. E.C. Willatts, organising secretary of the survey 1931-1939 in Walford, R., Land Use – UK: A Survey for the 21st Century, p136.

the classroom, but instead the task could be completed from memory and that it was a simpler task than it appeared when the instructions were first viewed. The Land Utilisation Survey was made aware of this letter by a head teacher in one of the schools which received it and questioned its validity. It resulted in the Education Authority being visited to explain and then pass on the correct intended procedure when the children were sent out into the field[4].

The Lindsey part of Lincolnshire provided the most interesting material in terms of giving further instructions to schools over and above the instruction pamphlet provided by the Land Utilisation Survey because they state that the "official pamphlet [is] very vague in its classification…thus leaving a very wide range of shades from which a choice might be made". These include noting the importance of classifying and naming trees in forests so the information could be found to be useful to the Forestry Commission, noting "it is not necessary to colour the roads" and that cemeteries and burial grounds should be classified as gardens or outlined and labelled 'cemetery'[5]. The monthly progress report for Lindsey dated November 1931 draws attention to some interesting patterns emerging for the county; "the recent conversion of arable to pasture land in nearly every district, the afforestation of the Hardwick Hill area (previously common land)…the conversion of common and marshland by effective draining of pasture land and even in some places to arable land; the diminution of woodland, particularly near the large centres of population, due mainly to the purchase of the woods to be used for commercial purposes by the timber merchants…and the re-utilisation of disused ironstone mines as gardens, arable or pasture land"[6]. In a letter to a Yorkshire volunteer the Survey office state that where it is difficult to classify the best thing to do is make notes as well as symbols and they suggest for small grass open spaces probably use 'G' if the use is "aesthetic and recreational" whilst unproductive portions of farmsteads are 'W' (waste). This letter also notes that surveyors should be careful about areas concerned with poultry as they imply productivity[7].

The most frequent categorisation issue in the correspondence we looked at was how to classify school playing fields and school cricket pitches. The response to this was always that they should be marked as 'M' for meadow and qualified with a note such as (sports) or (cricket field). The categorisation of cemeteries was also questioned and enquirers were told to mark them as 'W' for wasteland and note them as a (cemetery). In none of the files did anything relate to the classification of marginal areas, either on the edges of moorland or at the edge of towns. Neither was there discussion of how to classify industrial sites. The only references to classification of moorland relate to Yorkshire and Westmorland, where correspondents suggested not mapping the area when all that would appear on the entire sheet would be 'H' for heath-land and buying the six-inch maps would be uneconomic. A letter from the Survey office to one volunteer surveyor suggested that if large areas of the map sheet surveyed were assigned 'W' for waste, explanatory notes should be added to describe what the areas were used for.[8]

A few correspondents included notes and observations about their survey area. For example Miss Edith Coulthard in Durham noted the difficulty in determining correctly the difference between permanent pasture and ley fields; "many fields are under grass now – permanently I think – It is a little difficult to distinguish between clover in rotation with other crops and the

[4] Letter to Land Utilisation Survey from a Devon teacher about instructions supplied to Devon schools by their Education Authority, November 1931
[5] Letter to schools attached to Monthly progress bulletin for Lindsey, August 1931 from Education Authority. 10/8/1931
[6] Monthly Report, Lindsey (Lincolnshire), November 1931
[7] Letter from the Organising secretary, LUS to Charles Ball of Senior School, Armthorpe, Yorkshire, 27/6/1932
[8] Letter from the Organising Secretary, LUS, to Miss Hilda Warren of Townsend Council School at Durford Bridge, Yorkshire, 25/4/1932

permanent meadow fields, but I have done my best to get this right"[9]. The headmistress of Whitchurch Council School in Devon commented "it is only during the last two or three years that much of the land about here has been ceased to be ploughed and 2/3 of many of the farmers are really arable but the fields are now in grass owing to the bad prices: the farmers call these fields "arable" and yet they have not been broken for many years?"[10]. Unfortunately the only response from the Survey office was to issue a revised instruction pamphlet and to state, "the fields in question should be marked 'arable', and any point of interest – for how many years the ground has ceased to be ploughed – and other points, should be marked in the margin"[11]. There is also a letter from the Secretary for Education in Devon stating that sheets relating to Dartmoor "where there have not been marked, you may take it that the area is of moorland – partly rocks and partly heath – used for grazing of cattle and sheep"[12].

Arable land, which was coloured brown by surveyors, included land that had just been ploughed, land with crops on, which included fields covered in grass as part of a crop rotation cycle, plus market gardens and small fruit producers. This eliminated the need for surveyors to distinguish between market gardens and fields with a rotation of crops and market vegetables. What did prove to be problematic for the surveyors was land that was simply allowed to grow grass after ploughing rather than being sown with grass seed. This scenario was very common during the Depression period and therefore the surveyor often had to ask the farmer for verification of land use and whether he intended to plough the field again when the economy improved. If the intention was to replant crops then the land was included in the "arable" category, unless the field had degenerated to such an extent that the only possible classification was "rough grazing". Regional variations in soils and customs also raised problems. In Scotland arable land was ploughed and cropped for three years and then left as grass for the following three years, whilst in the West Country land could be left as grass anything between three and fifteen years. For England and Wales where the problem was much more prevalent instructions were given that if the grass was temporary and had been there for less than three years then the land was arable. However if the field had been grass for over four years then the grass was permanent. This system generally had the effect that in areas where ley farming predominated more than half the farmed area was categorised as grass.

Heath land, coloured yellow, is categorised as spontaneously evolved semi-natural vegetation cover. The Survey commented that every effort was made to distinguish between old wasteland or common pasture, which in urban areas had commonly lost its rough vegetation and become well maintained. This category also included land enclosed and formerly improved or cultivated that had since been virtually abandoned and thus reverted to rough vegetation. The frequency with which it appears indicates its generally poor or marginal quality. Other land uses are also included such as shooting roughs or fox coverts and some rabbit warrens, abandoned quarries, industrial works and mining tip heaps where the land has become partly or wholly covered with vegetation.

Land that was agriculturally unproductive and was coloured red included areas of shooting land, marshes, swamps, roads, railway sidings, stations, quarries, sand pits, waste heaps, colliery pits, cemeteries and land with closely compacted buildings which left no room for agricultural production and comprised close housing, commercial and industrial premises.

[9] Letter from Miss Edith Coulthard of Bishop Auckland, Durham to the Organising Secretary, LUS, 20/7/1931

[10] Letter from Miss E. Henry of Whitchurch Council School, Devon to the Organising Secretary, LUS, 30/1/1932

[11] Letter from the Organising Secretary, LUS to Miss E. Henry of Whitchurch Council School, Devon, 12/2/1932

[12] Letter from R.N. Armfelt, secretary for Education on Devon County education Committee to the Organising Secretary, LUS, 5/12/1932

This category was specifically noted as not to include meadow or arable land temporarily abandoned. It is interesting that no distinction was made between land used for industry and land formerly used for such. Previously industrial sites were of just as little significance as current ones to the Survey unless they had reverted far enough back to its natural state to be classified as "rough grazing".

As many of the OS sheets had not been revised very recently many surveyors had to sketch onto their maps the approximate layout and expanse of new building developments. In certain locations, such as the larger towns and cities this could end up being a significant task. To ensure the reliability of the work checking was achieved by matching the edges of adjacent sheets and the level of compatibility between the two was taken to indicate the accuracy of the sheet in general as the Land Utilisation Survey considered the edges of the ¼ sheets to usually be the least well surveyed. Some of the work was inspected and checked by various trusted individuals, including Stamp and Willatts, but also people like Gordon Manley from the University of Durham who claimed to have covered 300 miles whilst driving around checking queries. He said, "There is much more arable land there than one would expect at first" and he goes on to specify the land use at several locations which had obviously needed confirmation[13]. Each checker would do a field check on a whole 1inch map sheet, fill in any remaining gaps and clear up queries, although a few small areas had to be completely re-surveyed. The editing consisted mostly of amending the differences arising from the different interpretation of guidance notes, especially discrepancies between local interpretations. A good example of this would be "in a well-farmed East Anglian county there was a tendency for the surveyor to record a neglected grass field with a growth of thistles as "rough grazing" whereas probably better than the best field of permanent grass on a hill farm of the west"[14].

The farmers were highly suspicious of the Survey and its intentions. They seem to have been especially guarded against giving information to Government or Local Government representatives, hence official forms tended to be completed with misleading information. This distrust recurs significantly in the records investigated and because of this the Survey issued its surveyors with official cards explaining their aims and the background to the Survey. This reaction by the farmers meant Stamp considered the Land Utilisation Survey records to be a more accurate reflection of real land use across Great Britain as they were based on real observations rather than official statistics.

4.3 Relationship with other sources

Three other sources from approximately the same period provide local statistics which can be compared with results from the LUSGB. In some cases, creating comparable data for parishes or Countryside Character Areas would require very large scale projects, but in every case an initial appraisal can be carried out by Administrative County. We are obviously not yet able to extract such data from the LUSGB maps, but fortunately Stamp tabulated the seven main land uses by county in *The Land of Britain*. The units he list are the same Administrative Counties as were used by the 1931 Census of Population, the only exception being that he did not divide Suffolk into the Administrative Counties of East Suffolk and West Suffolk.

[13] Letter from Mr Gordon Manley of the Geography Department at the University of Durham to the Organising Secretary, LUS, 7/8/1933

[14] Stamp, L.D., The Land of Britain: Its Use and Misuse, p25.

4.3.1 The Census of Population

The LUSGB is a record of land use, and therefore of economic activity. The other systematic record of the geographical distribution of economic activity, of what people in each locality did for a living, is the 1931 Census of Population, carried out on April 26th in the same year the LUSGB began its survey work. There will be no access to the data on individual people until 2032, but the 1931 census did create the most detailed published occupational and industrial statistics from any UK census ever. The occupational tables, which cover 1,798 local government districts across England and Wales, have already been computerised in their entirety by the Great Britain Historical GIS Project and contribute 502,965 data values to its Vision of Britain web site:

http://www.visionofbritain.org.uk/census/report_page.jsp?rpt_id=EW1931OCC

The industry tables, which classify individuals by their employer's business rather than their own particular role, are similarly detailed but have not yet been computerised. However, and unlike modern industry tables, for 1931 both industry and occupation tables counted people based on their place of residence and not their place of work. The sub-categories within "agriculture" in the two tables are also quite similar. In particular, much the largest sub-category within the Industry table was "Farming (not fruit or poultry) and stockrearing", followed by "Market gardening and fruit farming", while the three largest categories in the Occupations table were "Farmers", "Agricultural Labourers, Farm Servants: Not otherwise distinguished" and "Gardeners, Nurserymen, Seedsmen, Florists". Although the local government districts of 1931 were not as detailed a geography as modern wards, they are far more detailed than modern districts, and the general separation of "Rural Districts" from various kinds of urban units obviously assists in analysing agricultural patterns.

4.3.2 Agricultural Census

The Agricultural Census or Survey, often called the "June Survey", began in 1866 and has been repeated annually for most of the subsequent period. This gives it the enormous virtue of providing time series data.

Each farmer was asked to record the numbers of each kind of animal on the farm, and the acreage of each of a range of crops; the precise animals and crops named on the form inevitably changes somewhat over the years. With the exception of 1941 (see below), the farm-level returns have not been preserved. The published reports of the census present county-level totals, simply summing the farm returns, while parish-level totals have been preserved in the Public Record Office. From 1969 onwards much more detailed data are available in computerised form, while county-level statistics for earlier years ending in zero are downloadable from the DEFRA web site. Some use of the 1931 data is included below.

It is surprising how little use has been made of these data. The only substantial transcription of the parish-level data we know of was prepared by Professor Brian Short of Sussex University, who copied out all data for a set of 71 parishes in the High Weald of Sussex covering the period 1866 to 1953 as part of his doctoral research in the early 1970s. The Great Britain Historical GIS Project has computerised the changing parish boundaries of Britain since the 1880s, so these data are now mappable at a fairly local level, and a pilot project to computerise and map Professor Short's existing transcription is a very obvious next step.

4.3.3 1941 National Farm Survey

The 1941 Farm Survey has recently been the subject of a separate report to the Countryside Agency by Dr. Southall and Miss Aucott, which will shortly be available on the CQC website[15], so it will be only briefly described here. It was an extended version of the agricultural census, and one reason why it is important is simply that 1941 is the only year for which the farm-level data have been preserved. However, the usual questions on numbers of animals and acreages of crops were supplemented by supplementary schedules covering farm labour, machinery, market gardening activity, tenure and rent in greater detail. Further, each farm was visited by a surveyor who assessed the condition of the farm, the "quality" of the farmer, and changes made due to wartime need; farmers classified as "Bad" occupying "Good" land were to be dispossessed. All the forms, covering some 320,000 farms, have been preserved, as have about 36,000 six inch maps showing all their boundaries.

Computerising all this material would be a far larger project than vectorising the LUSGB maps, although it may be the only way to meet all the information needs of the Countryside Agency as discussed above. Data on a systematic sample of c. 40,000 farms was extracted at the time and encoded on Hollerith cards. It is deeply regrettable that these seem to have been destroyed, so the only 1941 information available in more accessible form are the county-level statistics in the published report of the survey.

4.3.4 Statistical comparison

The Census of Population and the 1941 Farm Survey broaden our knowledge of the period, but the Agricultural Census permits some direct comparisons as farmers were asked to report acreages of four categories of land, which appear to closely match the three main LUSGB categories for agriculturally-productive land:

Land utilisation Survey	**1931 Agricultural Census**
Arable	Arable land
Permanent grass	Permanent Grass. For hay + Permanent grass. Not for hay
Orchards	
Forests and woodland	
Rough grazing	Rough Grazings
Houses with gardens	
Land agriculturally unproductive	

Comparison between the statistics from the Land Utilisation survey and the Agricultural Census of 1931 presents some interesting points. Firstly a table of total areas in acreages was produced for each of the major land use categories; arable, grassland, rough grazing and a combined category for “other” land uses in order to make a direct comparison where the Agricultural Census lacked detail.

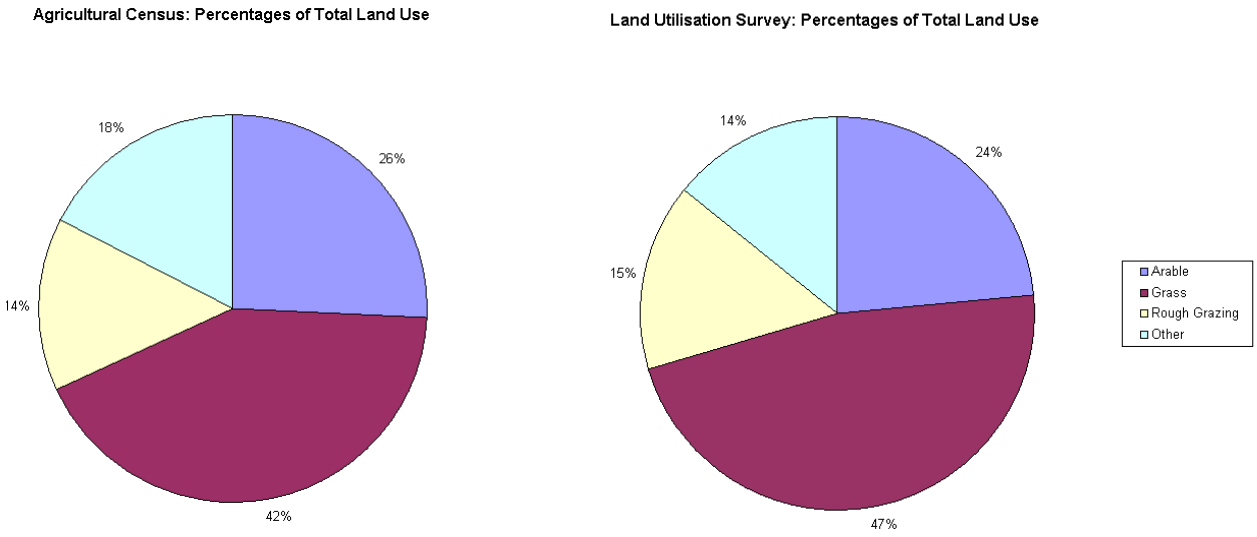
Land Use	**Total area**	**Arable**	**Grassland**	**Rough Grazing**	**Derived; Other**
LUS: Size in acres	37,261,767	8,940,778	17,431,045	5,753,845	5,333,031
AgCen: Size in acres	37,273,674	9,642,170	15,720,151	5,347,098	6,564,255

Table 4.1: Land Use in acres divided into four major categories for both Surveys

[15] http://www.cqc.org.uk

The following pie charts represent the total area of each major category of the Surveys as a percentage of its whole. Immediately apparent is the similarity between the two in the distribution of overall percentages. Although the statistics are not exactly the same, it does imply that the figures compiled for the Land Utilisation Survey were reasonably accurate.

Figure 4.1: Percentages of Land Use Categories within the Total Acreage



Further comparison was made between the acreages of individual categories in both surveys using percentages of the whole drawn onto scatter plots. In the first instance this was Arable. There is a general correlation between the proportional size of the county and the amount of arable being farmed within it. There is one notable exception on the graph, Cornwall. When a comparison is made between the total acreages given for both arable and pasture there seems to be a large difference between the two surveys with LUS attributing a much greater area to permanent grass while the agricultural survey reports a much larger arable area. This may be an example of farmers ascribing arable value to land that had been allowed to go to grass, but with the intention of later returning to the plough against what was actually evident by observation in the field. It could also be caused by surveyors struggling to differentiate between land that was fallow and that which was meadow and grassland. In Stamp's summary table Bedfordshire is also missing 100,000 acres from its sub-division of land into categories. The missing area does appear in the county report version as missing from 'Arable' so we treated it as a printing error and corrected it in these figures and graphs.

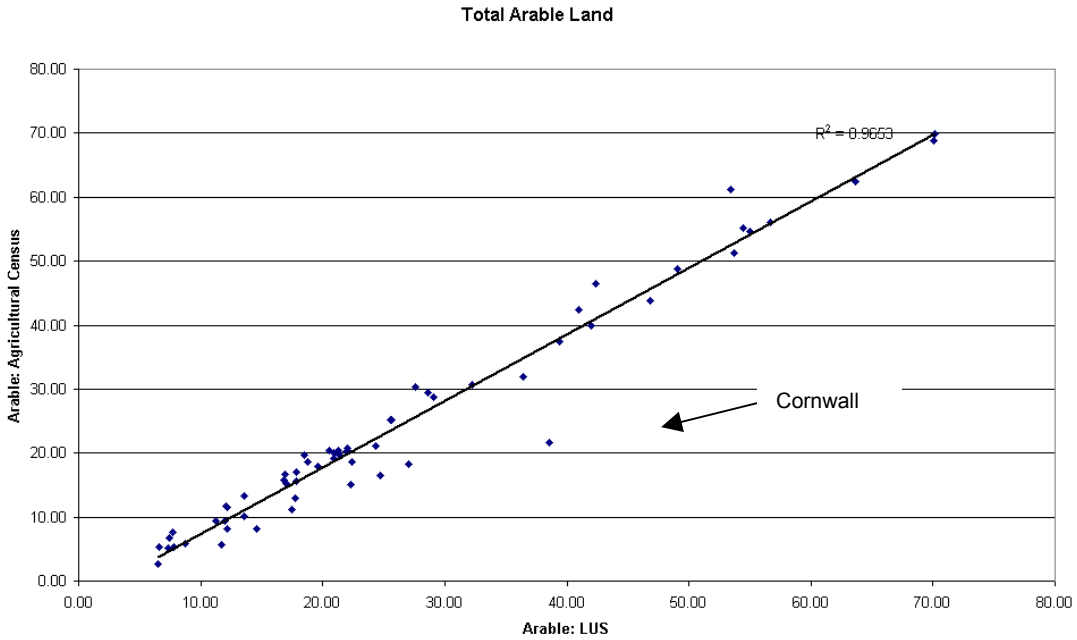


Figure 4.2: Correlation between Arable as a percentage of the total area for the two surveys

The comparison of the total areas of grassland produces a similar graph with the biggest outlier again being for Cornwall, so we further investigated the data for that county. The County Report was consulted and revealed several influencing factors. Within the report it states that "it is clear that the Land Utilisation surveyors have included as arable only land under crops or newly laid down to grass; all other grassland has been recorded as permanent grass (including long-ley) whilst some neglected grass returned by farmers as "rough grazing" has also been included as grassland. The Survey's total of rough grazing is nearly all true unenclosed moor, some of which escapes the agricultural returns."[16]. The report also notes that farms within Cornwall typically "have 25-30% of their acreage under crops, and the remainder under long-ley or permanent grassland. This long-ley grassland, which may be under grass for from four to eight years, is typical of Cornwall as it is of many other counties on the west side of Great Britain"[17]. Also noted is that "a large proportion of the six-inch maps used by the Survey in Devonshire were last revised in 1904-1906, and so were nearly thirty years old at the tie of the Survey. Many fields shown on them as improved had since reverted to rough pasture; on the other hand, many shown on the Ordnance Survey map as rough were found to be under the plough"[18]. This could well be true for Cornwall as well. However, it was not true that the surveyors were ill-trained children. Local volunteers only surveyed about a third of the county and "it became apparent that the survey could best by carried out by academically trained geographers"[19]. Stamp was particularly keen on the correct representation of Cornwall as he was a part-time resident himself[20]. Thus the variations from the correlation co-efficient evident in Cornwall appear to result from actual differences in the landscape rather than errors in the Surveying.

[16] Cornwall County Report, p465
[17] Cornwall County Report, p418
[18] Cornwall County Report, p418
[19] Cornwall County Report, p465
[20] Cornwall County Report, p408

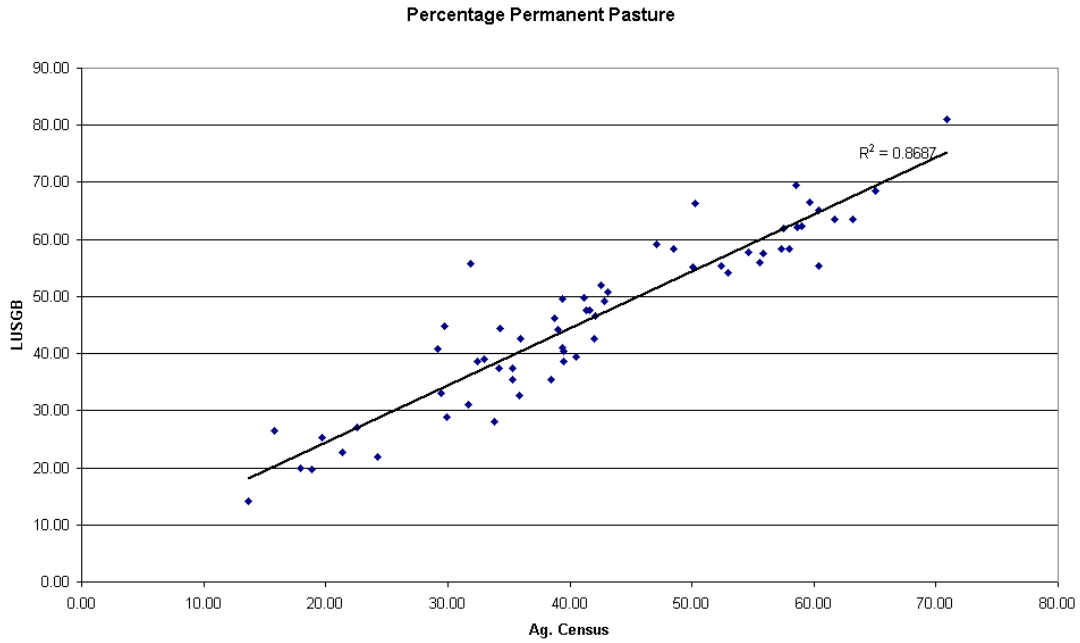


Figure 4.3: Correlation between Grassland as a percentage of the total area for the two surveys

Rough Grazing produces a similar trend to Arable land use. The two outlying points at the top of the graph relate to the counties of Brecon and Merioneth and probably fairly accurately reflect the level of moor and heath land within those counties. Slightly more puzzling is Wiltshire with a differential of 13.7%. Analysis of the statistics reveals the difference occurs between a larger area of rough grazing and smaller area of grassland in the Agricultural Census against the opposite in the LUS and again may reflect differences of opinion in classification by surveyors or observation verses the farmer's assessment.

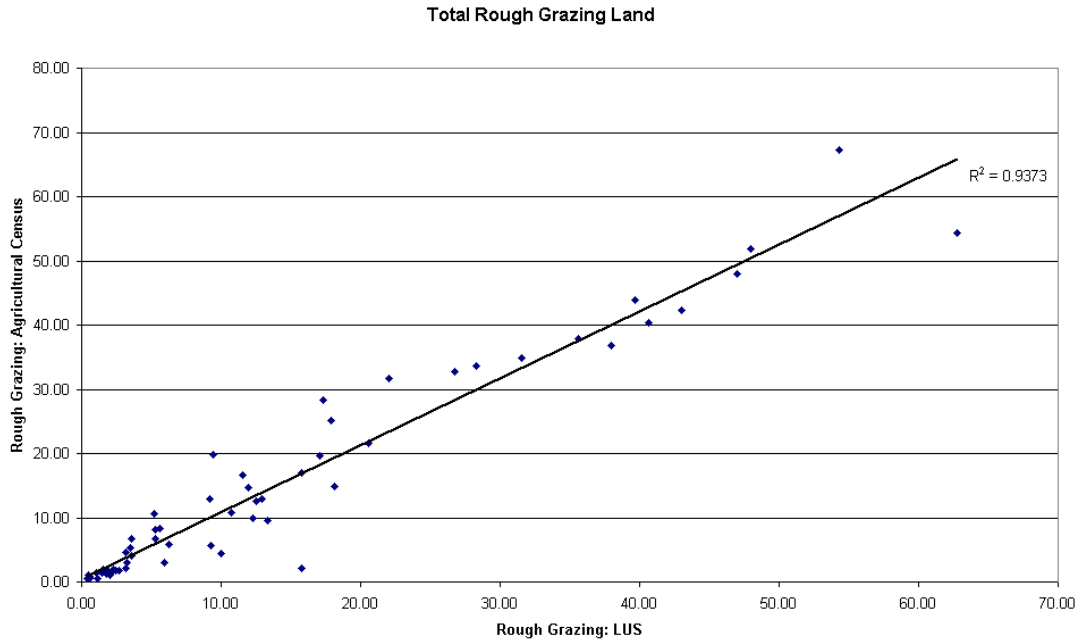


Figure 4.4: Correlation between Rough Grazing as a percentage of the total area for the two surveys

Given that the two sources gathered data by completely different methods, the LUSGB doing field surveys by schoolchildren while the census sent questionnaires to farmers, these

findings provide very strong support for the reliability of the Land Utilisation Survey, and for that of the census.

4.4 Dissemination

How can the results of computerising the LUSGB maps be made widely available for not-for-profit use? In fact, the results of the existing work to scan and geo-register the published maps are already being made available by several different routes, each with its limitations:

4.4.1 Vision of Britain

The University of Portsmouth was able to digitise the maps at low cost because the work was done by an existing team funded by the National Lottery, because many map librarians loaned or even donated maps to us at no charge, because English Heritage gave us free access to a large format scanner and, crucially, because the original copyright owners actively supported our work. All of this goodwill existed not because the EA and DEFRA were funding the work but because it had been agreed that the end results would be made freely available through the Vision of Britain web site, funded by the lottery:

http://www.VisionOfBritain.org.uk/maps

Vision of Britain is a completely open access web site, currently receiving about 50,000 unique users per month. Copyright notices within the site make it clear that the content may not be republished or used commercially. However, the main safeguard is simply that although users can view maps at various levels of magnification, they never see more than 450 by 450 pixels. In other words, the maps presented are very appropriate to illustrating a local history study but quite unsuited to analytic use.

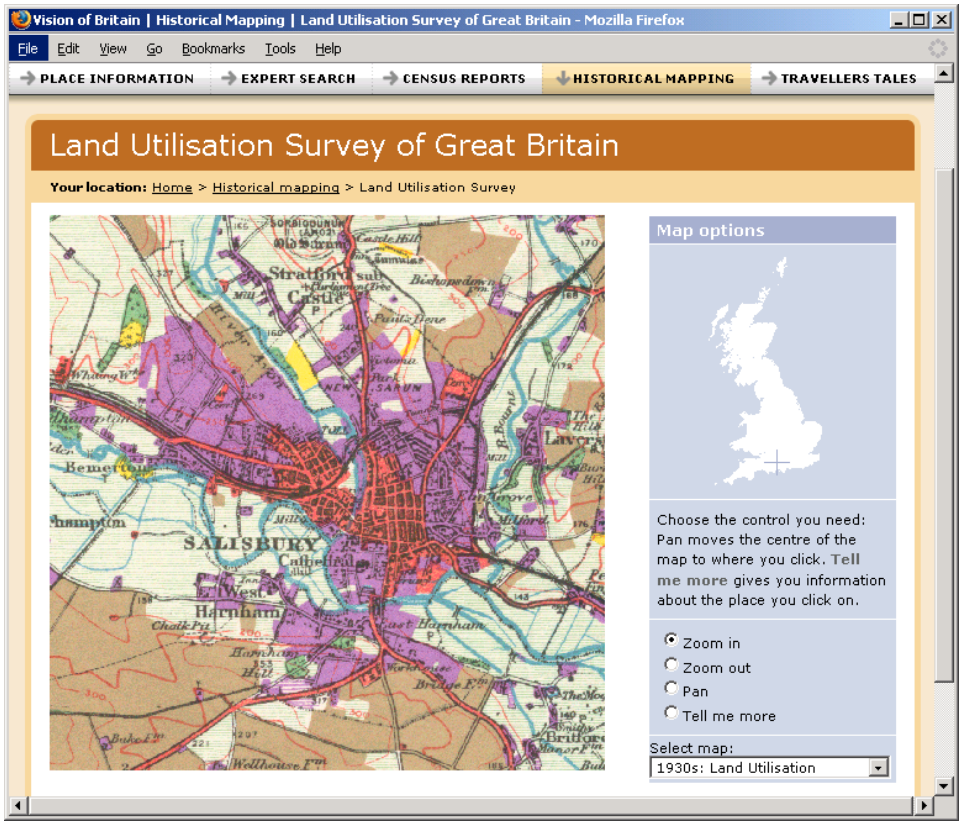


Figure 4.5: Geo-referenced LUSGB mapping displayed within Vision of Britain

The Vision of Britain interface is probably less relevant to disseminating vector data *per se*, but would be highly relevant to disseminating statistics generated from those vector data. Specifically, the overall system holds a great deal of vector data in the form of administrative boundaries which are used both to indicate the location of administrative units and to map the statistics which are the largest part of the system's content. The internal development version of Britain already has an additional statistical theme for "land use", and we are proposing to add the county-level LUSGB data analysed in the previous section to Vision of Britain. If a full vectorisation project went ahead, additional more detailed land use statistics could be generated for both modern and 1930s districts. If added into Vision of Britain, the system would automatically present them in maps and graphs.

4.4.2 Vision of Britain web map server

Vision of Britain offers a second interface to its scanned historic maps which is both more obscure and more powerful. The scanned maps are held not in our main Oracle database but in a quite separate system controlled by open source Mapserver software, developed by the University of Minnesota. Minnesota Mapserver supports the Web Map Server protocol developed by the Open Geospatial Consortium, and the Vision of Britain web site uses the WMS protocol to include images of the scanned maps within its pages. There are currently no access controls on our WMS, so any other system on the internet can also ask it to provide areas of our land use mapping. Those requests are not limited to 450 by 450 pixels, and the software making the request does not have to be a web browser, it could be a desktop GIS system.

In other words, anyone anywhere with the right GIS software can treat our scanned maps as if they were held locally on their own system. The WMS protocol understands spatial referencing, so users can accurately overlay their own spatial data on our maps. This may well be freer access than the Environment Agency or DEFRA would wish to promote to copyright content, but for now there are two major limitations. The first is that so far most GIS users have limited knowledge of the OGC protocols, and their software provides only limited support for them. The second is that we have given no publicity at all to this facility: security through obscurity. We do know of one not-for-profit UK project which worked out how to use the Vision of Britain WMS, but they are using our more conventional Ordnance Survey mapping.

At the time of writing, we are in active discussion with the DEFRA Geographic Information Unit in Leeds about the inclusion of the LUSGB scans within the MAGIC system, which they are proposing to implement via our WMS. They comment: that "IBM, on Defra's behalf, have begun to look at WMS technology as part of the Spatial Information Repository (SPIRE) Programme. SPIRE is a Defra-sponsored 3½ year programme, running to March 2007. Its main aim is to promote the use of GI as a corporate resource and so to support the Department's strategic sustainable development objectives for land, atmospheric, coastal and marine environments" (e-mail from Alison Dickson, 2/3/06).

Clearly, some policy decisions need to be made by Defra and the EA about either promoting or closing off the WMS access to the scanned maps. However, another major issue is simply whether Vision of Britain will still exist after September 30th 2007, which is the end of the period formally required by the lottery funding. Like the LUSGB itself, the system is the result of an initiative not by the government or even a university, but by an individual academic. It is popular with the general public, who ultimately paid for its construction, but it seems extremely unlikely that the British Library will continue to fund running costs beyond 2007. It should be noted that the WMS interface might be kept operational at much lower cost than the web site, partly because it uses no commercial software.

The WMS server could not be used to disseminate vector data, for the simple reason that the WMS protocol is concerned only with geo-referenced raster data. However, there is another more complex OGC standard for Web *Feature* Servers, and our understanding is that the Minnesota Mapserver software can also support this. Adding vector data to the system and implementing the WFS standard would clearly need some additional funding for development work. One general comment is that the OGC protocols are designed to support wide and flexible sharing of geographical information over the internet. Their impact in Britain has been limited by the fact that so much UK GI data is closely controlled by the Ordnance Survey. The information assembled by the GB Historical GIS project and contained in the Vision of Britain system is a systematic spatial framework for Britain that is broadly free of OS control, and could therefore play a significant role in jump-starting open access use of the OGC framework. The original copyright holders of the LUSGB material would broadly support this, but there are also of course EA and DEFRA copyrights involved.

4.4.3 EDINA Digimap Historic Map Collection

The Vision of Britain web site and the associated WMS are hosted for the University of Portsmouth by the EDINA service of the University of Edinburgh, but EDINA also operate many services of their own and the LUSGB material has a potential role in two of these.

Their **agcensus** service holds grid square data from the "June census", discussed in the previous section, for Great Britain from 1969 to the present. There is an obvious potential for adding land use data to this system. However, this service is offered by EDINA both to academic users and, as a commercial venture, to anyone else willing to pay. This commercial basis would seem to rule out inclusion of the land use data.

http://www.edina.ac.uk/agcensus

The **EDINA Digimap Historic Map Collection** was created to hold large scale Ordnance Survey maps scanned and geo-referenced by Landmark Information Group, in collaboration with the OS. It is operated by EDINA on behalf of the Joint Information Systems Committee, who licensed the data from Landmark. Access is free, but is controlled by the centralised ATHENS system, whose user IDs and passwords are restricted to staff and students in higher and further education institutions. Permission has been given by DEFRA and the original copyright holders for the LUSGB maps to be included within this service, and they are now available on-line . Crucially, this will allow users to download maps which they can then load into their own GIS software for analytic use. This is of course a less elegant way of working than using the OGC WMS protocol, but one that far more GIS users currently understand and have the software for.

http://www.edina.ac.uk/digimap

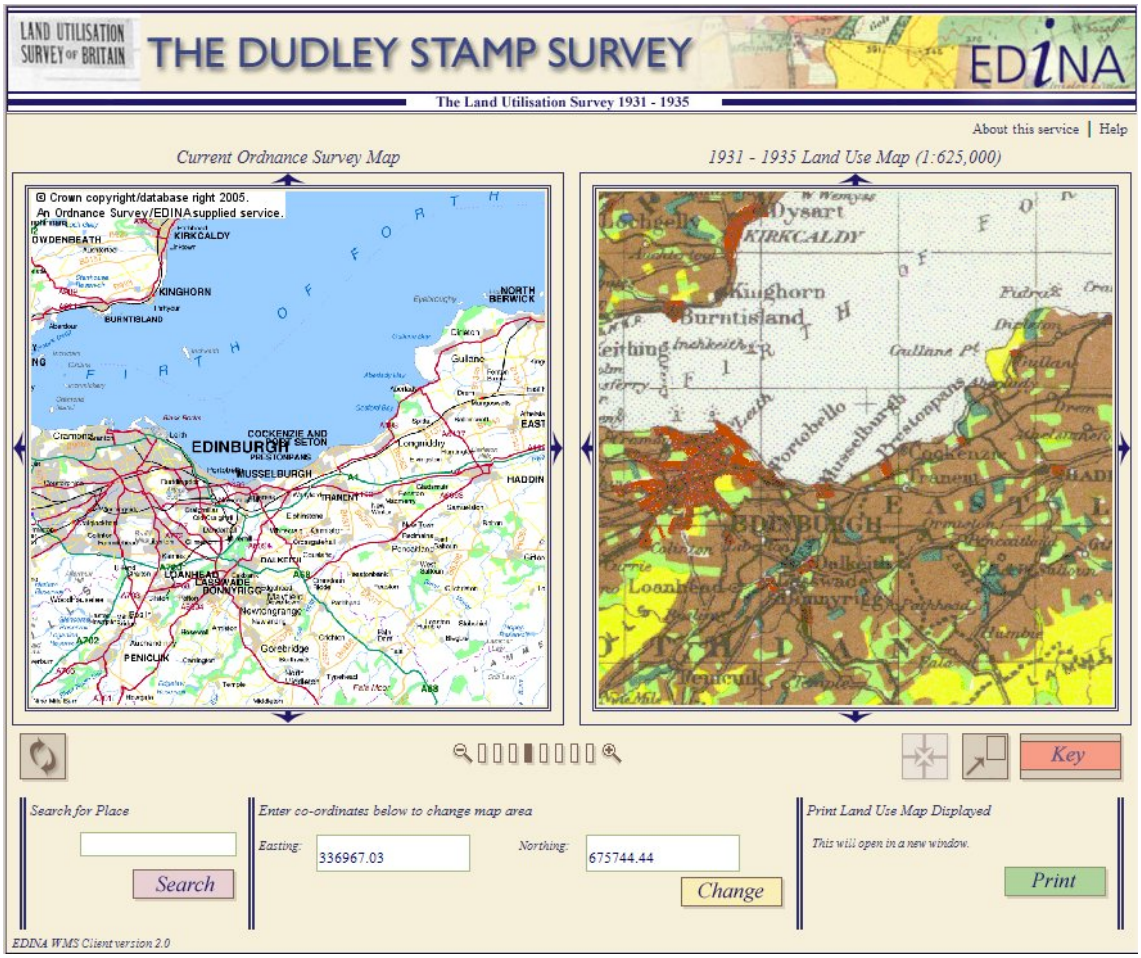


Figure 4.6: LUSGB Mapping presented within EDINA Digimap

The ATHENS controls on Digimap ensure that any users are in part of the not-for-profit sector, but they also mean that it is quite impossible to widen access beyond further and higher education: anyone issued with an ATHENS ID gains access to a very wide range of content which has been licensed by JISC on restrictive terms. The other obvious limitation is that the Digimap Historic Map Collection system specifically supports raster data, not vector downloads. EDINA's separate UKBORDERS system, which again requires an ATHENS ID and password, is designed to disseminate vector data although, like Vision of Britain, the detailed design of the system assumes that the vector data are specifically administrative boundaries.

4.4.4 Future Dissemination Plans

The EA/DEFRA project to scan and geo-reference the LUSGB maps was completed less than two years ago, but even without any specific initiative by the EA much has happened to make them available to a wide audience. Making the vector data similarly available raises some technical issues but none of them especially problematic. However, two major issues need to be addresses:

Firstly, the systems to disseminate the raster maps were developed with other funding, from the lottery and JISC, and could be extended to hold the LUSGB maps with **no** additional software development: the nature of rasters is that the software cannot "know" what the maps show, and the LUSGB maps cover the same geographical area as the content these systems were designed to handle. Existing systems for handling vector data within both

Vision of Britain and EDINA's own services are designed mainly to handle administrative boundaries, and significant development work would be needed to handle land use data. Who will pay for this, especially if dissemination is to extend beyond the education sector?

Secondly, once the raster data forms part of Vision of Britain or the Digimap service, there are no *additional* running costs. However, there are still very substantial overall running costs. JISC's funding of Digimap means there is no prospect of wider access, while the future of the Vision of Britain facility is very uncertain. One way forward would be to use EDINA's agcensus service, and accept that this is somewhat commercial. Another would be for the data to become part of MAGIC.

5 Conclusions and recommendations

This report tries to answer three distinct questions: how reliable is the data gathered by the Land Utilisation Survey of Great Britain; how accurately can it be computerised, and turned into statistics; and how useful will the final result be, and to whom? These conclusions try to answer each of these questions in turn.

However, it must first be emphasised that the resources available to us were limited, and while we did complete our original planned work programme it was not possible to answer all the important additional questions raised by our initial results. Two particular limitations should be noted:

- We both established the best results possible using our existing GIS software to filter out text and other clutter from the background layer, and made contact with the software supplier to see how the results could be improved by customising the software. Our supplier has supplied us with a better filtering system, but this did not arrive within the limited project period. As this may substantially reduce the overall cost of the project, we are still hoping to test it out in our own time.
- Use of the colour separations as a benchmark for checking the accuracy of data extracted from the published maps did not work as planned, because of areas of overlap between different colour layers for the same sheet. We were able to identify the problem and quantify it, but did not have time to return to the original task.

5.1 How reliable was the Stamp Survey?

While the idea of a major national survey carried out 'by schoolchildren' makes a good story, it is misleading. The children were of course supervised by their teachers, while a large part of the survey was in fact carried out by university students directly supervised by Stamp's collaborators. Most important of all, very extensive quality checking was done by the project's academic staff and collaborators. Stamp's description of being driven along country lanes by his wife, standing in the sun roof with field survey sheet in hand, is very striking.

There is still clearly a question of what exactly were they trying to record: the land-use categories they used were clearly broad, and not defined with great precision in either their standard instruction sheets or the more detailed correspondence we studied. However, this problem is not peculiar to the LUSGB; one Ministry of Agriculture minute discussing the 1941 Farm Survey said this about the distinction between permanent pasture and rough grazing: "We have never been able to get a satisfactory dividing line and our definition has not in practice amounted to much more than saying that rough grazings are grazings that are not smooth".[21]

Given this almost unavoidable imprecision, the findings presented above comparing county-level LUSGB data with the 1931 Agricultural Census are very striking. Despite the data being gathered using quite different methods, proportions of arable, of permanent pasture and of rough grazing are remarkably similar, and investigation of the few exceptions strengthened our confidence in Stamp's thoroughness. While we could not check the

[21] Minute of 28/7/1941, in MAF 38/211.

accuracy of non-rural land uses in the same way, to a considerable extent they reflect the information on the Ordnance Survey base maps which identify built-up areas, roads, rivers and lakes, and woodlands.

5.2 How accurately can the data be vectorised?

One answer, of course, is that with purely manual vectorising work it can be done very accurately indeed, but only at costs we assume are unacceptable. Unfortunately, unforeseen technical difficulties limited our use of the colour separations to fully quantify the accuracy of the vectorisation of the published maps. Given that restriction, we have to note that:

- Even with the automated classification and filtering, most of the cost comes from the final manual editing, and it is hard to define any particular amount of such manual work as entirely sufficient; taken to the limit, manual 'editing' would really mean manual vectorising. We believe that the proportions of automation and manual work we propose strike a reasonable balance between cost and quality.
- There is a second trade-off that has to be made, in the filtering out of base-map lettering and other clutter. An aggressive approach to automated filtering could remove most of the lettering quickly and cheaply, but would also remove many small actual features, such as farmsteads and small plots. Based on our meetings with potential users, it is precisely these features that are of particular importance in some policy applications, so we have set filtering thresholds which should leave intact the smallest features we observe on the maps. This of course increases the amount of manual editing needed, and its cost.

Even without the quantitative results we hoped to present, and subject to the above caveats about balancing cost, preservation of small features and output quality, we believe that the sample output clearly shows that acceptable results can be produced using the semi-automated methods we propose.

5.3 Can the Stamp Survey meet modern policy needs?

Firstly, it is quite clear that it cannot meet *all* current needs for historical benchmarks, because its classification of land uses was too crude. It tells us little about specific industrial activities, and therefore about pollution risks, all factories being classified simply as 'agriculturally unproductive'. Similarly, it tells us nothing about specific crops or animals, and therefore about changing agricultural activity. In many ways, the 1941 Farm Survey would provide a better guide to farming, although that of course tells us only about farms, not particular plots.

Secondly, there is an obvious danger that the LUSGB be seen as defining '*the* past'; and this risk is just as great if the 1941 Survey were analysed in isolation. Both surveys were carried out at very specific historical moments within an overall history of slow but continuous changes in land use. Specifically, the LUSGB took place at roughly the time when the arable area of Britain was at its lowest for several centuries, reflecting the inability of British farming to compete with cheap imports, while the 1941 Survey was part of the process by which the government actively reversed that decline in order to achieve self-sufficiency. Even if such rich data sets existed for every single year, it would clearly be uneconomic to computerise them all, but the annual Agricultural Census, available at county and parish levels, should be used to contextualise the more detailed data not just nationally but regionally.

With these two major qualifications, we believe it is clear that the Stamp Survey data can serve a substantial number of policy requirements. Some are highly local, such as English Heritage's interest in farmsteads and English Nature's use of it to identify specialised habitats. However, it also has a larger role in managing surface water and groundwater quality at the level of river catchments, habitat restoration and hydrological functioning, and assessing long-run patterns of urbanisation. It is fairly clear that the benefits of computerising the Survey would be spread across several different agencies; whilst this complicates funding it does offer considerable 'leverage' to individual organisations contributing to this larger-scale project.

While we believe that the LUSGB data can meet a number of policy requirements, it is for others to decide whether the cost of such a project would be justified. The final point we would emphasise is that compared to the costs of working with alternative sources such as the 1941 Survey or, more hypothetically given the access issues, the 1960s Second Land Utilisation Survey, a project to vectorise and generate statistics from the LUSGB maps is very cheap. Given that close to £38,000 has already been spent on the original 2003 feasibility study, the 2004 scanning project and the present study, it is hard not to conclude that the £46,000 cost of a vectorisation project limited to England is affordable.

Glossary of terms

classification—the process of assigning the pixels of a continuous raster image to discrete categories.

classification scheme—(or classification system) a set of target classes. The purpose of such a scheme is to provide a framework for organizing and categorizing the information that can be extracted from the data.

GCP matching—for image-to-image rectification, a GCP selected in one image is precisely matched to its counterpart in the other image using the spectral characteristics of the data and the transformation matrix.

geometric correction—the correction of errors of skew, rotation, and perspective in raw, remotely sensed data.

geo-referencing—the process of assigning map coordinates to image data and re-sampling the pixels of the image to conform to the map projection grid.

image—a picture or representation of an object or scene on paper, or a display screen. Remotely sensed images are digital representations of the Earth.

LSE—the London School of Economics, where the LUSGB was based.

LUSGB—Land Utilisation Survey of Great Britain There was an independent Land Utilisation Survey of Northern Ireland slightly later.

mosaicing—the process of piecing together images side by side, to create a larger image.

neighbourhood analysis—any image processing technique that takes surrounding pixels into consideration, such as convolution filtering and scanning.

RMSE—Root mean squared error.

Stamp Survey—Another name for the Land Utilisation Survey of Great Britain, using the name of its director, Professor L. Dudley Stamp.

supervised training—any method of generating signatures for classification, in which the analyst is directly involved in the pattern recognition process. Usually, supervised training requires the analyst to select training samples from the data that represent patterns to be classified.

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Appendix 1: LUSGB Instruction Leaflet

Please do not destroy this Leaflet, but hand it to someone who may be interested.

THE LAND UTILISATION SURVEY OF BRITAIN

Central Office:
London School of Economics, Houghton Street, London, W.C.2.
Telephone: Holborn 9783. *Telegrams*: Stamp, Poleconics, Estrand, London.

The Land Utilisation Survey of Britain is a voluntary organisation, which aims at making a complete survey of Britain, with the object of finding out exactly for what purposes the surface of the country is used. In these days when rapid changes are going on, and farmers are giving up their arable land, and converting much of their holdings into pasture, it is very desirable that a record should be made of the uses of the land in this country at the present time; so that in the future there will be a permanent record available for the years 1931/2, to which reference can be made just as we at the present date can refer in England to the survey described in Domesday Book, and in Scotland to the Old and New Statistical Accounts. The survey is being carried out on the Ordnance Maps issued by the Ordnance Survey Office on the scale of six inches to the mile, because on these maps every individual field is marked. The survey carried out on these maps will eventually be reduced to the scale of one inch to one mile for publication.

The success of the whole scheme depends on the co-operation of voluntary workers all over the country. There are about 22,000 quarter-sheets of the six inch maps to be covered, and 22,000 volunteers willing to devote two or three days' leisure are required. The work is being organised as far as possible on a county basis, and in most counties the Director of Education is in charge.

Any individuals who are willing to undertake a survey of their home area are requested to communicate, in the first instance, with the Organising Secretary, unless this leaflet has been received from a county headquarters.

FIGS. 4–7.—Reproduction of the Leaflet of Instructions issued to all helpers (4th edition).

The Survey has been organised under the auspices of the Geographical Association and the University of London, represented by the London School of Economics. Education Authorities recognise that the survey of local areas has not only a permanent value as a record, but is a very instructive exercise when carried out by parties of school-children under the supervision of a master or mistress. The scheme had the approval and support of Sir Charles Trevelyan and Dr. Lees-Smith former Presidents of the Board of Education, and the late Sir Donald Maclean (Minister for Education in the present Government) stated: "I am quite at one with my immediate predecessors at the Board in the opinion that the work in map reading and Local Geography, which is stimulated in the schools by The Land Utilisation Survey, can be of great educational value."

The Scottish Education Department has also shown its approval and given much practical help, and Sir Henry Richards, His Majesty's Chief Inspector for England, is actively supporting the work. The Ordnance Survey is doing is utmost to assist the Survey.

METHOD OF CARRYING OUT A SIMPLE SURVEY.

1. A definite area should be chosen, and convenient units are the quarter-sheets of the Ordnance Survey six inch maps, which are ideal for the purpose. Most of these maps are published as quarter-sheets, each of which covers an area measuring three miles by two. Some, however, especially in Scotland, are **only** published as full-sheets, covering four times this area.

Maps can be obtained from any Ordnance Survey Agent, but are obtainable for the purposes of the Land Utilisation Survey from the Central Office of the Survey at the reduced rate of one shilling and sixpence per quarter-sheet, or three shillings and ninepence per full-sheet (i.e., for a sheet only published in the full size). Maps so purchased remain the property of the surveyor; when completed they will be photographed by the Survey and the originals returned. The individual worker would be well advised to have two copies of each map, one for rough field work and the other for the finished copy. In the case of schools, a useful practice is to trace off the main lines, including field boundaries, and to hectograph sufficient copies for every pupil to have one. Another method widely adopted, which takes less time, is to trace off on tracing or greaseproof paper pieces of the map. These tracings can then be taken home by the children, and observations made independently by several groups, and the results recorded on the map kept in school.

2. The following classification of land must be adopted and is most important:—

The maps **MUST be marked with the letters as shown below,** and **may** in addition be coloured with water colour or crayons. **Such colouring must only be very light,** since heavy colouring obscures the detail on the underlying map, as well as the lettering on the photographed copy.

DESCRIPTION.	LETTER MARKING. (essential)	COLOUR MARKING.
(1) FOREST and Woodland to be marked	F	Dark Green.
(2) MEADOWLAND and permanent grass	M	Light Green.
(3) ARABLE or tilled land, fallow, rotation grass, and market gardens (*see note*)	A	Brown.
(4) HEATHLAND, moorland, commons, and rough hill pasture	H	Yellow.
(5) GARDENS, allotments, orchards, nurseries, etc. ...	G	Purple.
(6) LAND agriculturally unproductive, e.g., buildings, yards, mines, cemeteries, etc.	W	Red.
(7) PONDS, lakes, reservoirs, ditches, dykes, streams and anything containing water	P	Blue.

3. The completed map should have the **name and address** of the Surveyor and the date, written on the **FRONT of the sheet.**

NOTES ON THE CLASSIFICATION.

1. FORESTS and woodland are usually marked on the six-inch maps, but all the areas must be checked. Care must be taken to include the newly planted areas. When this has been done the woodland must be classified as follows:—

(*a*) **High Forest,** big trees, sufficiently close for their crowns to touch; also state whether the trees are **Coniferous, Deciduous, Mixed.**

(*b*) **Coppice,** or coppice with standards, woodland that is cut over every few years, for fencing, posts, etc.

(*c*) **Scrub,** any small bushes or trees unfit for cutting.

(*d*) **A Forest,** cut down and not replanted. This requires a note stating its present character.

A note should also be made against any forest or woodland which is not intended to supply timber, but is ornamental, for screening houses and gardens, etc.

In practice it has been found that the simplest way of dealing with forest or woodland on the field map is as follows:—Mark each piece of forest with the letter F; then distinguish its character according to the above classification as Fa, Fb, Fc, Fd. Then distinguish coniferous (c), deciduous (d), or mixed (m), thus: Fa^{c}, Fb^{d}, Fb^{m}, etc. Any woodland not intended to supply timber may be shown by underlining the symbol thus: $\underline{Fa^{d}}$. There is sometimes room to mention in brackets the chief trees, *e.g.* (oak) (beech), etc.

Plantations of trees intended for timber should be marked Fa, with a note "plantation."

2. MEADOWLAND AND PERMANENT GRASS. Care must be taken not to include rotation grass (grass grown in rotation with crops) under this classification.

3. ARABLE or tilled land includes rotation grass and fallow land. Rotation grass is often indicated by a large proportion of clover. At the present time, when much land which was recently arable is being converted to permanent grassland, its appearance, showing evidences of recent cultivation, gives rise to doubt as to whether it is Arable or Meadow. In such cases, information should be obtained from the farmer. A point, easily recorded, which may well be added to the map is the crop actually being grown at the date of the Survey. MARKET GARDENS are arable, being merely a special form of agriculture and should accordingly be marked A. Where it is quite clear that they are market gardens, they should be marked A (M.G.).

4. HEATHLAND, MOORLAND, COMMONS and ROUGH HILL PASTURE. This type of land is usually already distinguished on the six-inch maps. Swamps and marshes are often used as rough pasture, and should be included here. It is advisable to make a special note against any land where there is any doubt, saying what use is made of it.

5. GARDENS, ALLOTMENTS, ORCHARDS, NURSERIES, etc. Houses with gardens sufficiently large to grow a few vegetables or even flowers should be marked G (garden) since the area is productive. Backyards and other areas agriculturally unproductive should, however, be marked W. Allotments are merely gardens at a distance from the house. ORCHARDS are usually already distinguished on the maps (but should, of course, be checked). They must be marked G. In some orchards, in addition to the fruit trees, the ground is used for grazing or for agriculture. In such cases they should be marked G(M) when used for fruit and pasture, or G(A) when used for fruit and ground crops. The addition of the word "orchard" is useful.

6. UNPRODUCTIVE LAND. This includes buildings, yards, mines, cemeteries and waste land, *i.e.*, all ground of which the soil is not productively used. It is advisable to make a special note stating the character of all considerable areas marked (W).

OTHER POINTS.

Parks should be classified according to the use of the land, *e.g.*, pasture, woodland, gardens, etc. Public parks are large gardens used by the public, and should be marked G.

Golf Courses can sometimes be used for grazing, and then are permanent grassland (M). Others are heathland and moorland (H). Mark them also with the words " Golf Course."

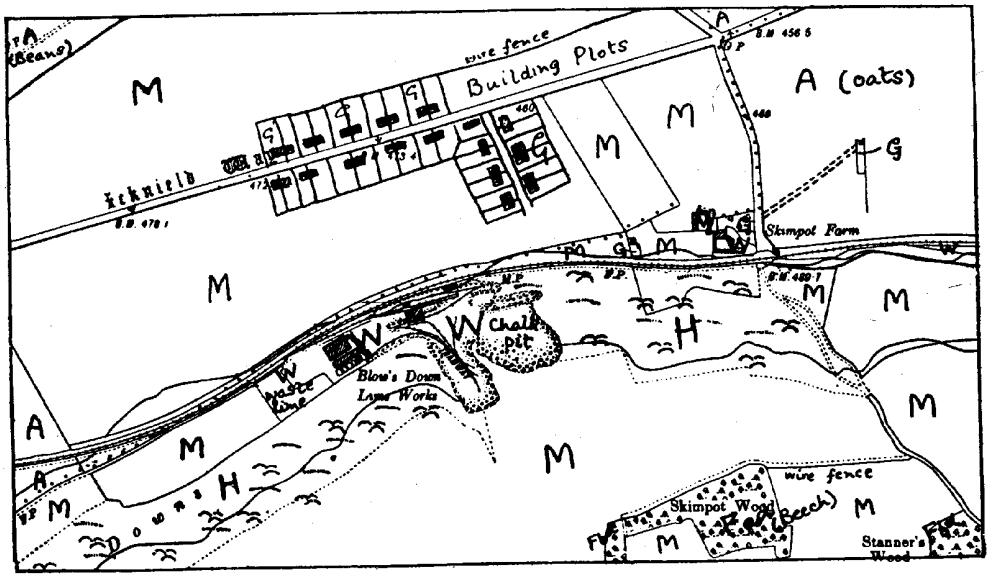
Sports Grounds are usually grassland, but where devoted entirely to sports, they should be specially distinguished, *e.g.*, M (Sports).

Poultry Farms usually occur on meadowland. A special note should be made against them.

New Buildings, Roads, etc., made since the map was printed should be sketched in as far as possible. In the case of a new building estate it is not necessary to mark in every house, but the general plan of the roads and lines of houses should be indicated, and in the case of undeveloped estates the approximate boundaries should be ascertained and a note made of the estates. When a whole area is marked off as " Building Estate " a note should be added as to whether it is undeveloped (lying waste), partly developed (scattered dwellings), or more fully developed.

SPECIMEN OF A FINISHED MAP.

N.B.—Notes and comments can be written in the margin of the map upon any points of interest or difficulty of interpretation.
Remarks concerning the types of field boundaries, kinds of crops and fruits, grazing animals, etc., are extremely useful.



(Based upon Ordnance Survey Map, with the sanction of the Controller of H.M. Stationery Office.)

Fourth Edition, June, 1932.

Appendix 2: Published LUSGB Maps

This checklist is taken primarily from Appendix IV of Stamp (1948), but has been re-ordered by sheet numbers in the *Popular Edition*. NB some of Stamp's maps contain parts of more than one *Popular* sheet, as indicated by the 'Oth.Sheets' column. 'Seq.' gives the sequence in which sheets were published within a particular year. Three sheets cover parts of both Scotland and England.

Nation	Pub.Yr.	Seq.	Sheet	Oth.Sheets	Area	Notes
E & W	1948-9	6	1		Lower Tweed	Same sheet as Scotland no. 81
E & W	1946	1	2		Holy Island	
E & W	1947	1	3		The Cheviot Hills	*Same sheet as Scotland no. 86*
E & W	1946	2	4		Alnwick & Rothbury	
E & W	1948-9	11	5		Solway Firth & River Esk	*Same sheet as Scotland no. 89*
E & W	1946	3	6		Hexham	
E & W	1936	1	7		Newcastle-upon-Tyne	
E & W	1947	8	8	pts 15 & 18	Workington & Cockermouth	
E & W	1946	4	9		Carlisle	
E & W	1946	5	10		Alston & Weardale	
E & W	1934	1	11		Durham & Sunderland	
E & W	1933	7	12		Keswick & Ambleside	
E & W	1946	6	13		Kirkby Stephen & Appleby	
E & W	1946	7	14	pt 15	Darlington & Middlesborough	
E & W	1938	1	16		Whitby & Saltburn	
E & W	1946	8	17		Isle of Man	
E & W	1946	9	18	19	Windermere	
E & W	1947	2	20		Kirkby Lonsdale & Hawes	
E & W	1946	10	21		Ripon & Northallerton	
E & W	1938	2	22		Pickering & Thirsk	
E & W	1944	1	23		Scarborough	
E & W	1946	11	24		Lancaster & Barrow	
E & W	1946	12	25		Ribblesdale	
E & W	1945	1	26		Harrogate	
E & W	1944	2	27		York	
E & W	1940	1	28		Great Driffield & Bridlington	
E & W	1936	2	29		Preston, Southport & Blackpool	
E & W	1937	1	30		Blackburn	
E & W	1938	3	31		Leeds & Bradford	
E & W	1940	2	32		Goole & Pontefract	
E & W	1938	4	33	34	Hull	
E & W	1933	4	35		Liverpool & Birkenhead	
E & W	1936	3	36		Bolton & Manchester	
E & W	1937	2	37		Barnsley & Sheffield	
E & W	1938	5	38		Doncaster	
E & W	1938	6	39		Scunthorpe & Market Rasen	
E & W	1942	1	40	48	Grimsby & Louth	
E & W	1944	3	41		Anglesey	
E & W	1943	3	42		Llandudno & Denbigh	

E & W	1937	3	43		Chester	

Nation	Pub.Yr.	Seq.	Sheet	Oth.Sheets	Area	Notes
E & W	1935	1	44		Northwich & Macclesfield	
E & W	1939	1	45		Buxton & Matlock	
E & W	1937	4	46		The Dukeries	
E & W	1940	3	47		Lincoln	
E & W	1944	4	49		Portmadoc & Criccieth	
E & W	1944	5	50		Bala	
E & W	1943	4	51		Wrexham & Oswestry	
E & W	1938	7	52		Stoke on Trent	
E & W	1939	2	53		Derby	
E & W	1935	8	54		Nottingham	
E & W	1935	2	55		Grantham	
E & W	1937	5	56		Boston	
E & W	1935	10	57		Fakenham	
E & W	1933	3	58		Cromer	
E & W	1945	2	59	pt 68	Dolgelly & Lake Vyrnwy	
E & W	1943	1	60		Shrewsbury & Welshpool	
E & W	1938	8	61		Wolverhampton	
E & W	1937	6	62		Burton & Walsall	
E & W	1935	9	63		Leicester	
E & W	1937	7	64		Peterborough	
E & W	1937	8	65		Wisbech & Kings Lynn	
E & W	1935	3	66		Swaffham & East Dereham	
E & W	1934	3	67		Norwich & Great Yarmouth	
E & W	1945	3	69	pt 68	Llanidloes	
E & W	1942	5	70		Bishop's Castle	
E & W	1939	3	71		Kidderminster	
E & W	1934	4	72		Birmingham	
E & W	1940	4	73		Rugby	
E & W	1942	2	74		Kettering & Huntingdon	
E & W	1940	5	75		Ely	
E & W	1935	11	76		Thetford	
E & W	1937	9	77		Lowestoft & Waveney Valley	
E & W	1946	13	78		Lampeter	
E & W	1947	3	79		Llandrindod Wells & Tregaron	
E & W	1942	6	80		Kington	
E & W	1937	10	81		Worcester	
E & W	1937	11	82		Stratford on Avon	
E & W	1942	3	83		Northampton	
E & W	1937	12	84		Bedford	
E & W	1938	8	85		Cambridge	
E & W	1939	4	86		Bury St Edmunds & Sudbury	
E & W	1933	5	87		Ipswich	
E & W	1936	4	88		St. David's & Cardigan	
E & W	1947	4	89		Carmarthen	
E & W	1947	5	90		Brecon & Llandovery	
E & W	1945	4	91		Abergavenny	
E & W	1942	7	92		Gloucester & Forest of Dean	
E & W	1942	8	93		Stow on the Wold	

Nation	Pub.Yr.	Seq.	Sheet	Oth.Sheets	Area	Notes
E & W	1942	4	94		Bicester	
E & W	1934	2	95		Luton	Reprinted in 1938
E & W	1937	13	96		Hertford & Bishop's Stortford	
E & W	1939	5	97	98	Colchester & Clacton on Sea	
E & W	1935	12	99		Pembroke	
E & W	1937	14	100		Llanelly	
E & W	1936	5	101		Swansea & Aberdare	
E & W	1936	6	102		Newport	
E & W	1935	18	103		Stroud & Chepstow	
E & W	1942	9	104		Swindon & Cirencester	
E & W	1940	6	105		Oxford & Henley on Thames	
E & W	1935	13	106		Watford	
E & W	1935	14	107		N.E.London & Epping Forest	
E & W	1937	15	108		Southend & District	
E & W	1936	7	109		Pontypridd & Barry	
E & W	1939	6	110	111	Bath & Bristol	
E & W	1935	15	112		Marlborough	
E & W	1936	8	113		Reading & Newbury	
E & W	1933	1	114		Windsor	
E & W	1935	16	115		S.E.London & Sevenoaks	
E & W	1938	11	116		Chatham & Maidstone	
E & W	1936	9	117		East Kent	
E & W	1945	5	118	119	Exmoor	
E & W	1936	10	120		Bridgwater & Quantock Hills	
E & W	1940	7	121		Wells & Frome	
E & W	1939	7	122		Salisbury & Bulford	
E & W	1936	11	123		Winchester	
E & W	1938	12	124		Guildford & Horsham	
E & W	1938	13	125		Tunbridge Wells	
E & W	1939	8	126	135	Weald of Kent & Hastings	
E & W	1945	6	127		River Torridge	
E & W	1945	7	128		Tiverton	
E & W	1943	6	129	139	Chard & Axminster	
E & W	1943	5	130	131	Yeovil & Blandford	
E & W	1937	16	132		Portsmouth & Southampton	
E & W	1936	12	133		Chichester & Worthing	
E & W	1936	13	134		Brighton & Eastbourne	
E & W	1946	14	136		Boscastle & Padstow	
E & W	1942	10	137		Dartmoor, Tavistock & Launceston	
E & W	1938	14	138		Dartmoor & Exeter	
E & W	1943	2	140		Weymouth & Dorchester	
E & W	1936	14	141		Bournemouth & Swanage	
E & W	1933	2	142		Isle of Wight	
E & W	1946	15	143		Truro & St Austell	
E & W	1942	11	144		Plymouth	
E & W	1946	16	145		Torquay & Dartmouth	
E & W	1935	4	146		Land's End & Lizard	

Nation	Pub.Yr.	Seq.	Sheet	Oth.Sheets	Area	Notes
Scot	1933	6	4		South Mainland (Shetland Islands)	
Scot	1939	9	6		Orkney Islands (Mainland)	
Scot	1936	15	12		Wick	
Scot	1940	8	28		Nairn & Cromarty	
Scot	1940	9	29		Elgin & Keith	
Scot	1948-9	1	30	pt 31	Banff & Fraserburgh	Peterhead on 31
Scot	1948-9	2	40	pt 31	Inverurie & Ellon	Peterhead on 31
Scot	1935	17	45		Aberdeen	
Scot	1948-9	3	51		Stonehaven & Brechin	
Scot	1935	5	53		Sound of Mull	
Scot	1948-9	4	58		Arbroath & Montrose	
Scot	1935	6	59		Iona & Colonsay	
Scot	1935	7	60		North Jura & Firth of Lorne	
Scot			63		Perth & Strath Earn	Listed as available by David Archer, although not in Stamp's list
Scot	1948-9	5	64		Dundee & St.Andrews	
Scot	1947	6	66		Loch Lomond	
Scot	1947	7	67		Stirling & Dunfermline	
Scot	1933	8	68		Firth of Forth	
Scot	1940	10	72		Glasgow	
Scot	1940	11	73		Falkirk & Motherwell	
Scot	1936	16	74		Edinburgh	
Scot	1944	7	75		Dunbar & Lammermuir	
Scot	1937	17	78		Kilmarnock & Ayr	
Scot	1945	8	79		Lanark	
Scot	1945	9	80		Peebles & Galashiels	
Scot	*1948-9*	*6*	*81*		*Kelso/Lower Tweed*	*(Same as E & W sheet 1)*
Scot	1948-9	7	82		Ailsa Craig & Girvan	
Scot	1948-9	8	83		Loch Doon	
Scot	1944	8	84		Nithsdale & Moffat	
Scot	1945	10	85		Hawick & Eskdale	
Scot	*1947*	*1*	86		*The Cheviot Hills*	*(Same as E & W sheet 3)*
Scot	1948-9	9	87		Newton Stewart	
Scot	1948-9	10	88		Dumfries	
Scot	*1948-9*	*11*	*89*		*Solway Firth & River Esk*	*(Same as E & W sheet 5)*
Scot	1948-9	12	90		Stranraer	
Scot	1948-9	13	91		Wigtown	

Appendix 3: Structure of GIS and image files

Finalpoly_UK folder.
Notes on Land Use Polygon files for the UK files in the Finalpoly_UK Folder.

All files created by Paula Aucott & Brian Baily, Geography Department, University of Portsmouth.
All files created March-April 2006.
All files created using ARC-GIS v9.1.
All files are shape files/thematic layer files/JPEGs.
All files are projected to the British National Grid.
All files are GIS files except in the JPEG folder where are all files are images.

Sub Folders:
layer_elim folder contains all thematic layer files for all shape files where eliminate has been used.
layer_wo_elim folder contains all thematic layer files for shape files that have not gone through eliminate function.
poly_elim folder contains all vector polygon shape files that have had eliminate used on them for NoData categories around the edge of the sheet.
poly_wo_elim folder contains all vector polygon shape files where no eliminate function has been used.
poly_wo_elim folder also contains Countryside Character Areas file.
uk_JPEGs folder contains jpeg images of all thematic layer files.

Within the poly_elim folder:
ukbr_poly = United Kingdom brown summary sheet vector polygon shape file: Arable
ukdgr_poly = United Kingdom dark green summary sheet vector polygon shape file: Forest and woodland
uklgr_poly = United Kingdom light green summary sheet vector polygon shape file: Meadowland and Permanent Grass
ukma_poly = United Kingdom mauve summary sheet vector polygon shape file: Houses with Gardens, Orchards and Nurseries
ukre_poly = United Kingdom red summary sheet vector polygon shape file: Agriculturally Unproductive Land
ukye_poly = United Kingdom yellow summary sheet vector polygon shape file: Heath and Moorland

Notes on files within poly_elim folder
All files beginning "UK" have NOT been through the eliminate function to remove areas less than 60metres (0.28ha) in area.
All files ending "_poly" have had the cropping line around the edge eliminated.

Within the poly_wo_elim folder:
ukbr_poly_woelim = United Kingdom brown summary sheet polygons not eliminated shape file: Arable
ukdgr_poly_woelim = United Kingdom dark green summary sheet vector polygons not eliminated shape file: Forest and woodland
uklgr_poly_woelim = United Kingdom light green summary sheet vector polygons not eliminated shape file: Meadowland and Permanent Grass

ukma_poly_woelim = United Kingdom mauve summary sheet vector polygons not eliminated shape file: Houses with Gardens, Orchards and Nurseries
ukre_poly_woelim = United Kingdom red summary sheet vector polygons not eliminated shape file: Agriculturally Unproductive Land
ukye_poly_woelim = United Kingdom yellow summary sheet vector polygons not eliminated shape file: Heath and Moorland
CA_Character_Areas = polygon sheet supplied by Countryside Agency depicting Character Areas

Notes on files within poly_wo_elim folder
All files ending "_poly_woelim" have not had the eliminate function used on them at all.

Within the layer_elim folder:
ukbr_layer = United Kingdom brown summary sheet thematic layer: Arable
ukdgr_layer = United Kingdom dark green summary sheet thematic layer: Forest and woodland
uklgr_layer = United Kingdom light green summary sheet thematic layer: Meadowland and Permanent Grass
ukma_layer = United Kingdom mauve summary sheet thematic layer: Houses with Gardens, Orchards and Nurseries
ukre_layer = United Kingdom red summary sheet thematic layer: Agriculturally Unproductive Land
ukye_layer = United Kingdom yellow summary sheet thematic layer: Heath and Moorland
CA_Character_layer = United Kingdom Countryside Agency Character Areas thematic layer

Within the layer_wo_elim folder:
ukbr_woelim_layer = United Kingdom brown summary sheet thematic layer without elimination: Arable
ukdgr_woelim_layer = United Kingdom dark green summary sheet thematic layer without elimination: Forest and woodland
uklgr_woelim_layer = United Kingdom light green summary sheet thematic layer without elimination: Meadowland and Permanent Grass
ukma_woelim_layer = United Kingdom mauve summary sheet thematic layer without elimination: Houses with Gardens, Orchards and Nurseries
ukre_woelim_layer = United Kingdom red summary sheet thematic layer without elimination: Agriculturally Unproductive Land
ukye_woelim_layer = United Kingdom yellow summary sheet thematic layer without elimination: Heath and Moorland
CA_Character_layer = United Kingdom Countryside Agency Character Areas thematic layer

Within the uk_JPEGs folder:
ukbr_image = Image of United Kingdom brown summary sheet thematic layer: Arable
ukdgr_image = Image of United Kingdom dark green summary sheet thematic layer: Forest and woodland
uklgr_image = Image of United Kingdom light green summary sheet thematic layer: Meadowland and Permanent Grass
ukma_image = Image of United Kingdom mauve summary sheet thematic layer: Houses with Gardens, Orchards and Nurseries
ukre_image = Image of United Kingdom red summary sheet thematic layer: Agriculturally Unproductive Land
ukye_image = Image of United Kingdom yellow summary sheet thematic layer: Heath and Moorland
ukbr_woelim_image = Image of United Kingdom brown summary sheet thematic layer without elimination: Arable
ukdgr_woelim_image = Image of United Kingdom dark green summary sheet thematic layer without elimination: Forest and woodland
uklgr_woelim_image = Image of United Kingdom light green summary sheet thematic layer without elimination: Meadowland and Permanent Grass
ukma_woelim_image = Image of United Kingdom mauve summary sheet thematic layer without elimination: Houses with Gardens, Orchards and Nurseries
ukre_woelim_image = Image of United Kingdom red summary sheet thematic layer without elimination: Agriculturally Unproductive Land

ukye_woelim_image = Image of United Kingdom yellow summary sheet thematic layer without elimination: Heath and Moorland
CA_Character_image = Image of United Kingdom Countryside Agency Character Areas thematic layer

General Notes
A Colour Separate can be converted straight to a shape file from a raster image and does not need to be converted to a coverage and back.
After becoming a shape file a Colour Separate requires a new attribute column and the projection adding and any elimination to be done.

Finalpoly_Bham folder.

Notes about Land Use Polygon files in the Finalpoly_Bham folder.

All files created by Paula Aucott & Brian Baily, Geography Department, University of Portsmouth.
All files created March-April 2006.
All files created using ARC-GIS v9.1.
All files are shape files/thematic layer files/JPEGs.
All files are projected to the British National Grid.
FocalMajority function used on all shape files. Parameters set as: circle, 9, data
Nibble Function used on all shape files.
Eliminate function used on shape files where specified.
All files are GIS files except in the JPEG folder where are all files are images.

Sub Folders:
layer_elim folder contains all thematic layer files, that have been through the eliminate funtion, plus the original scanned map image for Birmingham.
layer_wo_elim folder contains all thematic layer files for Birmingham that have not gone through the eliminate function.
poly_elim folder contains all vector polygon shape files that have been through eliminate.
poly_wo_elim folder contains all vector polygon shape files where no eliminate function has been used.
Bham_JPEGs folder contains jpeg versions of all thematic layers.

Within the poly_elim folder:
bhambr_poly = Birmingham brown colour separation sheet vector polygon shape file: Arable
bhamgr_poly = Birmingham green colour separation sheet: Forest and Woodland & Meadowland and Permanent Grass
bhampu_poly = Birmingham purple colour separation sheet: Gardens etc
bhamre_poly = Birmingham red colour separation sheet: Agriculturally Unproductive Land
bhamye_poly = Birmingham yellow colour separation sheet: Heath and Moorland
WHOLEbham_poly = Birmingham whole sheet
WHOLEwtbham_poly = Birmingham whole sheet with text removed during classification.

Notes relating to the poly_elim folder
All files ending "_poly", except for the one ending "wtbham_poly", have been through the eliminate function to remove areas less than 60metres (0.28ha) in area.
All files ending "_poly" have had the cropping line around the edge eliminated.
"WHOLEbham_poly" has had the NoData category eliminated completely.
"WHOLEwtbham_poly" took a very long time to run the eliminate function. The 2 NoData categories (0, 6) have been retained, but have been eliminated below a 60metres squared threshold.

Within the poly_wo_elim folder:
bhambr_poly_woelim = Birmingham brown colour separation sheet vector polygon not eliminated shape file: Arable
bhamgr_poly_woelim = Birmingham green colour separation sheet vector polygon not eliminated shape file: Forest and Woodland & Meadowland and Permanent Grass

bhampu_poly_woelim = Birmingham purple colour separation sheet vector polygon not eliminated shape file: Gardens etc
bhamre_poly_woelim = Birmingham red colour separation sheet vector polygon not eliminated shape file: Agriculturally Unproductive Land
bhamye_poly_woelim = Birmingham yellow colour separation sheet vector polygon not eliminated shape file: Heath and Moorland
WHOLEbham_poly_woelim = Birmingham whole sheet vector polygon not eliminated shape file
WHOLEwtbham_poly_woelim = Birmingham whole sheet with text removed during classification vector polygon not eliminated shape file.

Notes relating to the poly_woelim folder
All files ending "_poly_woelim" have not had the eliminate function used on them at all.

Within the layer_elim folder:
bham_lus = original raster image of Birmingham LUS published map sheet
bhambr_layer = Birmingham brown colour separation sheet thematic layer: Arable
bhamgr_layer = Birmingham green colour separation sheet thematic layer: Forest and Woodland & Meadowland and Permanent Grass
bhampu_layer = Birmingham purple colour separation sheet thematic layer: Gardens etc
bhamre_layer = Birmingham red colour separation sheet thematic layer: Agriculturally Unproductive Land
bhamye_layer = Birmingham yellow colour separation sheet thematic layer: Heath and Moorland
WHOLEbham_layer = Birmingham whole sheet thematic layer
WHOLEwtbham_layer = Birmingham whole sheet with text removed during classification thematic layer

Within the layer_wo_elim folder:
bhambr_woelim_layer = Birmingham brown colour separation sheet thematic layer without elimination: Arable
bhamgr_woelim_layer = Birmingham green colour separation sheet thematic layer without elimination: Forest and Woodland & Meadowland and Permanent Grass
bhampu_woelim_layer = Birmingham purple colour separation sheet thematic layer without elimination: Gardens etc
bhamre_woelim_layer = Birmingham red colour separation sheet thematic layer without elimination: Agriculturally Unproductive Land
bhamye_woelim_layer = Birmingham yellow colour separation sheet thematic layer without elimination: Heath and Moorland
WHOLEbham_woelim_layer = Birmingham whole sheet thematic layer without elimination
WHOLEwtbham_woelim_layer = Birmingham whole sheet with text removed during classification thematic layer without elimination.

Within the Bham_JPEGs folder:
bham_lus = original raster image of Birmingham LUS published map sheet
bhambr_image = Image of Birmingham brown colour separation sheet thematic layer: Arable
bhamgr_image = Image of Birmingham green colour separation sheet thematic layer: Forest and Woodland & Meadowland and Permanent Grass
bhampu_image = Image of Birmingham purple colour separation sheet thematic layer: Gardens etc
bhamre_image = Image of Birmingham red colour separation sheet thematic layer: Agriculturally Unproductive Land
bhamye_image = Image of Birmingham yellow colour separation sheet thematic layer: Heath and Moorland
WHOLEbham_image = Image of Birmingham whole sheet thematic layer
WHOLEwtbham_image = Image of Birmingham whole sheet with text removed during classification thematic layer
bhambr_woelim_image = Image of Birmingham brown colour separation sheet thematic layer without elimination: Arable
bhamgr_woelim_image = Image of Birmingham green colour separation sheet thematic layer without elimination: Forest and Woodland & Meadowland and Permanent Grass
bhampu_woelim_image = Image of Birmingham purple colour separation sheet thematic layer without elimination: Gardens etc

bhamre_woelim_image = Image of Birmingham red colour separation sheet thematic layer without elimination: Agriculturally Unproductive Land
bhamye_woelim_image = Image of Birmingham yellow colour separation sheet thematic layer without elimination: Heath and Moorland
WHOLEbham_woelim_image = Image of Birmingham whole sheet thematic layer without elimination
WHOLEwtbham_woelim_image = Image of Birmingham whole sheet with text removed during classification thematic layer without elimination

General Notes
There is no blue Birmingham colour separation sheet.

The elimination function on the Birmingham sheet with the text removed takes about 10 minutes to run every time.
It can also crash the program, but it will work if very small areas are selected at a time.
There are many more small polygons created than if the text had not removed and this makes the map appear messier and thus would take longer to clean up.

The threshold area of 60metres (0.28ha) was selected because it was chosen as the best threshold during the last pilot study.
For the Colour Separates a threshold of 200metres has been suggested as being better.

The automatic classification does have problems distinguishing areas where water (blue) runs through a narrow heathland area (yellow). Instead of entering them separately they become merged and appear as the forest (dark green) category.

Colour Separates require much less editing. They do not need focal majority or nibble functions. Colour Separates can be converted straight to a shape file from raster image and do not need to be converted to a coverage and back. After becoming a shape file they only need a new attribute column and the projection adding and any elimination to be done.

Finalpoly_Salis Fodler.

Notes about Land Use Polygon files in Finalpoly_Salis folder.

All files created by Paula Aucott & Brian Baily, Geography Department, University of Portsmouth.
All files created March-April 2006.
All files created using ARC-GIS v9.1.
All files are shape files/thematic layer files.
All files are projected to the British National Grid.
FocalMajority function used on all shape files. Parameters set as: circle, 10, data
Nibble Function used on all shape files.
Eliminate function used on shape files where specified.
Union function used on shape files where specified.
All files are GIS files except in the JPEG folder where are all files are images.

Sub Folders:
layer_elim folder contains all thematic layer files, plus original scanned map image for Salisbury.
poly_elim folder contains all vector polygon shape files.
poly_elim_diff folder contains all vector polygon shape files for areas of difference between published map and colour separations.
poly_elim_union folder contains all vector polygon shape files where colour separate and published map polygons are merged.
poly_wo_elim folder contains all vector polygon shape files where no eliminate function has been used.
Salis_JPEGs folder contains jpeg images of all thematic layer files.

Within the poly_elim folder:
SEsalisbl_poly = Salisbury blue colour separation sheet vector polygon shape file:
WaterSEsalisbr_poly = Salisbury brown colour separation sheet vector polygon shape file: Arable

SEsalisgr_poly = Salisbury green colour separation sheet vector polygon shape file: Forest and woodland & Meadowland and Permanent Grass
SEsalisgr_poly_grass = Salisbury green colour separation sheet vector polygon shape file: Meadowland and Permanent Grass
SEsalisgr_poly_wood = Salisbury green colour separation sheet vector polygon shape file: Forest and woodland
Sesalispu_poly = Salisbury purple colour separation sheet vector polygon shape file: Gardens etc
SEsalisre_poly = Salisbury red colour separation sheet vector polygon shape file: Agriculturally Unproductive Land
SEsalisye_poly = Salisbury yellow colour separation sheet vector polygon shape file: Heath and Moorland
SEsalis_poly = Salisbury South East quarter of whole sheet vector polygon shape file
SEsalis_poly_1hr = Salisbury South East quarter of whole sheet vector polygon shape file where 1 hour of manual editing done
SEsalis_poly_2hr = Salisbury South East quarter of whole sheet vector polygon shape file where 2 hours of manual editing done
SEsalisbl_same = Salisbury South East quarter of blue colour separation sheet vector polygon shape file of areas the same on both map sheets: Water
SEsalisbr_same = Salisbury South East quarter of brown colour separation sheet vector polygon shape file of areas the same on both map sheets: Arable
SEsalisgr_same_grass = Salisbury South East quarter of green colour separation vector polygon shape file of areas the same on both map sheets: Meadowland and Permanent Grass
SEsalisgr_same_wood = Salisbury South East quarter of green colour separation sheet vector polygon shape file of areas the same on both map sheets: Forest and woodland
SEsalispu_same = Salisbury South East quarter of purple colour separation sheet vector polygon shape file of areas the same on both map sheets: Gardens etc
SEsalisre_same = Salisbury South East quarter of red colour separation sheet vector polygon shape file of areas the same on both map sheets: Agriculturally Unproductive Land
SEsalisye_same = Salisbury South East quarter of yellow colour separation sheet vector polygon shape file of areas the same on both map sheets: Heath and Moorland
SEsalisbl_diff = Salisbury South East quarter of blue colour separation sheet vector polygon shape file of areas different between the 2 map sheets: Water
SEsalisbr_diff = Salisbury South East quarter of brown colour separation sheet vector polygon shape file of areas different between the 2 map sheets: Arable
SEsalisgr_diff_grass = Salisbury South East quarter of green colour separation sheet vector polygon shape file of areas different between the 2 map sheets: Meadowland and Permanent Grass
SEsalisgr_diff_wood = Salisbury South East quarter of green colour separation sheet vector polygon shape file of areas different between the 2 map sheets: Forest and woodland
SEsalispu_diff = Salisbury South East quarter of purple colour separation sheet vector polygon shape file of areas different between the 2 map sheets: Gardens etc
SEsalisre_diff = Salisbury South East quarter of red colour separation sheet vector polygon shape file of areas different between the 2 map sheets: Agriculturally Unproductive Land
SEsalisye_diff = Salisbury South East quarter of yellow colour separation sheet vector polygon shape file of areas different between the 2 map sheets: Heath and Moorland
SEsalisbl_Union1 = Salisbury South East quarter of blue colour separation sheet vector polygon Union shape file of the 2 map sheets: Water
SEsalisbr_Union1 = Salisbury South East quarter of brown colour separation sheet vector polygon Union shape file of the 2 map sheets: Arable
SEsalisgr_Union1_grass = Salisbury South East quarter of green colour separation sheet vector polygon Union shape file of the 2 map sheets: Meadowland and Permanent Grass
SEsalisgr_Union1_wood = Salisbury South East quarter of green colour separation sheet vector polygon Union shape file of the 2 map sheets: Forest and woodland
SEsalispu_Union1 = Salisbury South East quarter of purple colour separation sheet vector polygon Union shape file of the 2 map sheets: Gardens etc
SEsalisre_Union1 = Salisbury South East quarter of red colour separation sheet vector polygon Union shape file of the 2 map sheets: Agriculturally Unproductive Land
SEsalisye_Union1 = Salisbury South East quarter of yellow colour separation sheet vector polygon Union shape file of the 2 map sheets: Heath and Moorland

Notes relating to files within the poly_elim folder

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All files ending "_poly", have been through the eliminate function to remove areas less than 60metres (0.28ha) in area.
All files ending "_poly" have had the cropping line around the edge eliminated.
"SESalis_poly" has had the NoData category eliminated completely.

Within the poly_wo_elim folder:
salisbl_poly_woelim = Salisbury blue colour separation sheet vector polygon not eliminated shape file: Water
salisbr_poly_woelim = Salisbury brown colour separation sheet vector polygon not eliminated shape file: Arable
salisgr_poly_woelim = Salisbury green colour separation sheet vector polygon not eliminated shape file: Forest and woodland & Meadowland and Permanent Grass
salispu_poly_woelim = Salisbury purple colour separation sheet vector polygon not eliminated shape file: Gardens etc
salisre_poly_woelim = Salisbury red colour separation sheet vector polygon not eliminated shape file: Agriculturally Unproductive Land
salisye_poly_woelim = Salisbury yellow colour separation sheet vector polygon not eliminated shape file: Heath and Moorland
SEsalis_poly_woelim = Salisbury South East quarter of whole sheet vector polygon not eliminated shape file
salisgr_poly_woelim_grass = Salisbury green colour separation sheet vector polygon not eliminated shape file: Meadowland and Permanent Grass
salisgr_poly_woelim_wood = Salisbury green colour separation sheet: Forest and woodland

Note relating to files within the poly_wo_elim folder
All files ending "_poly_woelim" have not had the eliminate function used on them at all.

Within the layer_elim folder:
Salis_LUS: raster image of original Salisbury and Bulford published map sheet
SEsalisbl_layer = Salisbury South East quarter of blue colour separation sheet thematic layer: Water
SEsalisbr_layer = Salisbury South East quarter of brown colour separation sheet thematic layer: Arable
SEsalisgr_grass_layer = Salisbury South East quarter of green colour separation sheet thematic layer: Meadowland and Permanent Grass
SEsalisgr_wood_layer = Salisbury South East quarter of green colour separation sheet thematic layer: Forest and woodland
SEsalispu_layer = Salisbury South East quarter of purple colour separation sheet thematic layer: Gardens etc
SEsalisre_layer = Salisbury South East quarter of red colour separation sheet thematic layer: Agriculturally Unproductive Land
SEsalisye_layer = Salisbury South East quarter of yellow colour separation sheet thematic layer: Heath and Moorland
SEsalis_layer = Salisbury South East quarter of whole sheet thematic layer
SEsalis_1hr_layer = Salisbury South East quarter of whole sheet with 1 hour of manuel editing thematic layer
SEsalis_2hr_layer = Salisbury South East quarter of whole sheet with 2 hours of manuel editing thematic layer

Within the layer_wo_elim folder:
salisbl_woelim_layer = Salisbury blue colour separation sheet thematic layer without elimination: Water
salisbr_woelim_layer = Salisbury brown colour separation sheet thematic layer without elimination: Arable
salisgr_woelim_layer_grass = Salisbury green colour separation sheet thematic layer without elimination: Meadowland and Permanent Grass
salisgr_woelim_layer_wood = Salisbury green colour separation sheet thematic layer without elimination: Forest and woodland
salispu_woelim_layer = Salisbury purple colour separation sheet thematic layer without elimination: Gardens etc

salisre_woelim_layer = Salisbury red colour separation sheet thematic layer without elimination: Agriculturally Unproductive Land
salisye_woelim_layer = Salisbury yellow colour separation sheet thematic layer without elimination: Heath and Moorland
SEsalis_woelim_layer = Salisbury South East quarter of whole sheet thematic layer without elimination

Within the layer_same folder:
Salis_LUS: raster image of original Salisbury and Bulford published map sheet
SEsalisbl_same_layer = Salisbury South East quarter of blue colour separation sheet thematic layer of areas the same on both map sheets: Water
SEsalisbr_same_layer = Salisbury South East quarter of brown colour separation sheet thematic layer of areas the same on both map sheets: Arable
SEsalisgr_same_layer_grass = Salisbury South East quarter of green colour separation sheet thematic layer of areas the same on both map sheets: Meadowland and Permanent Grass
SEsalisgr_same_layer_wood = Salisbury South East quarter of green colour separation sheet thematic layer of areas the same on both map sheets: Forest and woodland
SEsalispu_same_layer = Salisbury South East quarter of purple colour separation sheet thematic layer of areas the same on both map sheets: Gardens etc
SEsalisre_same_layer = Salisbury South East quarter of red colour separation sheet thematic layer of areas the same on both map sheets: Agriculturally Unproductive Land
SEsalisye_same_layer = Salisbury South East quarter of yellow colour separation sheet thematic layer of areas the same on both map sheets: Heath and Moorland

Within the layer_diff folder:
SEsalisbl_diff_layer = Salisbury South East quarter of blue colour separation sheet thematic layer of areas different between the 2 map sheets: Water
SEsalisbr_diff_layer = Salisbury South East quarter of brown colour separation sheet thematic layer of areas different between the 2 map sheets: Arable
SEsalisgr_diff_layer_grass = Salisbury South East quarter of green colour separation sheet thematic layer of areas different between the 2 map sheets: Meadowland and Permanent Grass
SEsalisgr_diff_layer_wood = Salisbury South East quarter of green colour separation sheet thematic layer of areas different between the 2 map sheets: Forest and woodland
SEsalispu_diff_layer = Salisbury South East quarter of purple colour separation sheet thematic layer of areas different between the 2 map sheets: Gardens etc
SEsalisre_diff_layer = Salisbury South East quarter of red colour separation sheet thematic layer of areas different between the 2 map sheets: Agriculturally Unproductive Land
SEsalisye_diff_layer = Salisbury South East quarter of yellow colour separation sheet thematic layer of areas different between the 2 map sheets: Heath and Moorland

Within the Salis_JPEGs folder:
Salis_LUS: raster image of original Salisbury and Bulford published map sheet
SEsalisbl_image = Image of Salisbury blue colour separation sheet thematic layer: Water
SEsalisbr_image = Image of Salisbury brown colour separation sheet thematic layer: Arable
SEsalisgr_grass_image = Image of Salisbury green colour separation sheet thematic layer: Meadowland and Permanent Grass
SEsalisgr_wood_image = Image of Salisbury green colour separation sheet thematic layer: Forest and woodland
SEsalispu_image = Image of Salisbury purple colour separation sheet thematic layer: Gardens etc
SEsalisre_image = Image of Salisbury red colour separation sheet thematic layer: Agriculturally Unproductive Land
SEsalisye_image = Image of Salisbury yellow colour separation sheet thematic layer: Heath and Moorland
SEsalis_image = Image of Salisbury South East quarter of whole sheet thematic layer
SEsalis_1hr_image = Image of Salisbury South East quarter of whole sheet thematic layer where 1 hour of manual editing done
SEsalis_2hr_image = Image of Salisbury South East quarter of whole sheet thematic layer where 2 hours of manual editing done
salisbl_woelim_image = Image of Salisbury blue colour separation sheet thematic layer without elimination: Water

salisbr_woelim_image = Image of Salisbury brown colour separation sheet thematic layer without elimination: Arable
salisgr_woelim_grass_image = Image of Salisbury green colour separation sheet thematic layer without elimination: Meadowland and Permanent Grass
salisgr_woelim_wood_image = Image of Salisbury green colour separation sheet thematic layer without elimination: Forest and woodland
salispu_woelim_image = Image of Salisbury purple colour separation sheet thematic layer without elimination: Gardens etc
salisre_woelim_image = Image of Salisbury red colour separation sheet thematic layer without elimination: Agriculturally Unproductive Land
salisye_woelim_image = Image of Salisbury yellow colour separation sheet thematic layer without elimination: Heath and Moorland
SEsalis_woelim_image = Image of Salisbury South East quarter of whole sheet thematic layer without elimination
SEsalisbl_same_image = Image of Salisbury South East quarter of blue colour separation sheet thematic layer of areas the same on both map sheets: Water
SEsalisbr_same_image = Image of Salisbury South East quarter of brown colour separation sheet thematic layer of areas the same on both map sheets: Arable
SEsalisgr_same_grass_image = Image of Salisbury South East quarter of green colour separation sheet thematic layer of areas the same on both map sheets: Meadowland and Permanent Grass
SEsalisgr_same_wood_image = Image of Salisbury South East quarter of green colour separation sheet thematic layer of areas the same on both map sheets: Forest and woodland
SEsalispu_same_image = Image of Salisbury South East quarter of purple colour separation sheet thematic layer of areas the same on both map sheets: Gardens etc
SEsalisre_same_image = Image of Salisbury South East quarter of red colour separation sheet thematic layer of areas the same on both map sheets: Agriculturally Unproductive Land
SEsalisye_same_image = Image of Salisbury South East quarter of yellow colour separation sheet thematic layer of areas the same on both map sheets: Heath and Moorland
SEsalisbl_diff_image = Image of Salisbury South East quarter of blue colour separation sheet thematic layer of areas different between the 2 map sheets: Water
SEsalisbr_diff_image = Image of Salisbury South East quarter of brown colour separation sheet thematic layer of areas different between the 2 map sheets: Arable
SEsalisgr_diff_grass_image = Image of Salisbury South East quarter of green colour separation sheet thematic layer of areas different between the 2 map sheets: Meadowland and Permanent Grass
SEsalisgr_diff_wood_image = Image of Salisbury South East quarter of green colour separation sheet thematic layer of areas different between the 2 map sheets: Forest and woodland
SEsalispu_diff_image = Image of Salisbury South East quarter of purple colour separation sheet thematic layer of areas different between the 2 map sheets: Gardens etc
SEsalisre_diff_image = Image of Salisbury South East quarter of red colour separation sheet thematic layer of areas different between the 2 map sheets: Agriculturally Unproductive Land
SEsalisye_diff_image = Image of Salisbury South East quarter of yellow colour separation sheet thematic layer of areas different between the 2 map sheets: Heath and Moorland

General Notes
The colour separation sheets for Salisbury have been clipped to be the same size as the SE quadrant sheet for all files except those where eliminate function has not been used.

The threshold area of 60metres (0.28ha) was selected because it was selected as the best threshold last time.
For the Colour Separates a threshold of 200metres has been suggested as being better.

The automatic classification does have problems distinguishing areas where water (blue) runs through a narrow heathland area (yellow). Instead of entering them separately they become merged and appear as the forest (dark green) category.

Colour Separates require much less editing.
Colour Separates do not need focal majority or nibble functions.
They can be converted straight to a shape file from a raster image and do not need to be converted to a coverage and back.

We are The Environment Agency. It's our job to look after your environment and make it **a better place** – for you, and for future generations.

Your environment is the air you breathe, the water you drink and the ground you walk on. Working with business, Government and society as a whole, we are making your environment cleaner and healthier.

The Environment Agency. Out there, making your environment a better place.

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