# Some GIS Analysis of Roberts and Wrathmell's *Atlas of Rural Settlement in England*

Andrew G. Lowerre[1]

[1]English Heritage, Fort Cumberland, Fort Cumberland Road, Portsmouth PO4 9LD
Tel. +44 (0)2392 856765 Fax +44 (0)2392 856701
andrew.lowerre@english-heritage.org.uk

**Summary:** This paper describes the results of a project to use the maps of terrain and nineteenth-century rural settlement published in Roberts and Wrathmell's An Atlas of Rural Settlement in England to create data ready for use in GIS. The first part summarises the process by which the maps have been converted from their original format to GIS data. The second part examines how the data on settlement nucleation and dispersion have been re-analysed using raster-based analytical tools to examine patterns of rural settlement at a national scale.

**KEYWORDS:** Data migration; rural settlement; spatial patterning; unsupervised classification; historic landscape characterisation

## 1. Introduction

Since its publication, Brian K Roberts and Stuart Wrathmell's *An Atlas of Rural Settlement in England* (2000) has become a major point of reference for understanding the development of rural settlement in England and the historic character of the landscape. Their aim was to portray complex patterns of settlement organisation at a national scale, contrasting nucleated settlement (where houses, farms, churches and so on stand in compact groups) and dispersed settlement (where such structures are spread far more widely across the landscape), and the subtle gradations between the two.

Roberts and Wrathmell created the maps printed in the *Atlas* using vector graphics software, but the resulting files were not in a GIS-compatible format. GIS is now extensively used in the study and management of the historic environment, and access to 'geobrowser' software like Google Earth™ is widespread. English Heritage wanted to make it possible to use Roberts and Wrathmell's materials in spatially-aware digital formats, enabling users to examine, query and re-interpret Roberts and Wrathmell's results in new ways.

Roberts and Wrathmell prepared their maps through a process of interpretation and characterisation of the landscape of England, using as a source the nineteenth-century Ordnance Survey 'Old Series' 1:63,360 (one inch to one mile) scale maps. Using a method involving, as they put it, 'little science but much logic' (ibid, 13), they delineated an overlapping, hierarchical set of settlement provinces, sub-provinces and local regions. Similarly, the maps of terrain they created are a generalised, synthetic portrayal of the physical landscape of England. Their intent was to build a national mosaic, in which the description of the landscape would be consistent whether one looked at Cornwall or Cumbria, all regarded with an eye to contextualise the settlement regions derived from the Old Series mapping.

## 2. Creating GIS data from vector graphics files

Using copies of the original vector graphics files supplied by Brian Roberts, my colleague Eddie Lyons and I constructed GIS-ready spatial and attribute data. The process involved migrating the files from Aldus FreeHand to Adobe Illustrator format and then AutoCAD DWG. Eddie Lyons undertook preliminary cleaning of the files in AutoCAD and georeferenced the maps. The author imported the DWG files into ArcGIS and carried out further data cleaning before constructing the GIS data. The linework in the original maps was not topologically 'clean,' and numerous overlapping lines

('spaghetti') had to be painstakingly unpicked before building the spatial data.

Terrain types and zones and settlement provinces, sub-provinces, local regions are depicted using polygons, terrain escarpments are shown as lines, and the nucleated settlements and sample areas where Roberts and Wrathmell quantified the degree of settlement dispersion are represented using points. Attribute values identifying the various elements were assigned to the relevant polygons and points using the published maps and additional information kindly provided by Brian Roberts.

The *Atlas of Rural Settlement in England* GIS data, metadata and documentation can now be freely downloaded via the Internet (Lowerre *et al* 2011). The spatial and attribute data are available in Esri Shapefile format, as well as Google/Open Geospatial Consortium KMZ, making it possible to view the data in software such as Esri's ArcGIS Explorer and Google Earth™.

## 3. New visualisations of *Atlas* data

With the information from Roberts and Wrathmell's maps in GIS-enabled form, one can rapidly re-examine the materials, displaying different layers in colours and combinations not depicted in the printed *Atlas*. For example, Figure 1 illustrates how nucleated settlements are distributed across the broad terrain types – Uplands, Intermediate Lands and Lowlands.

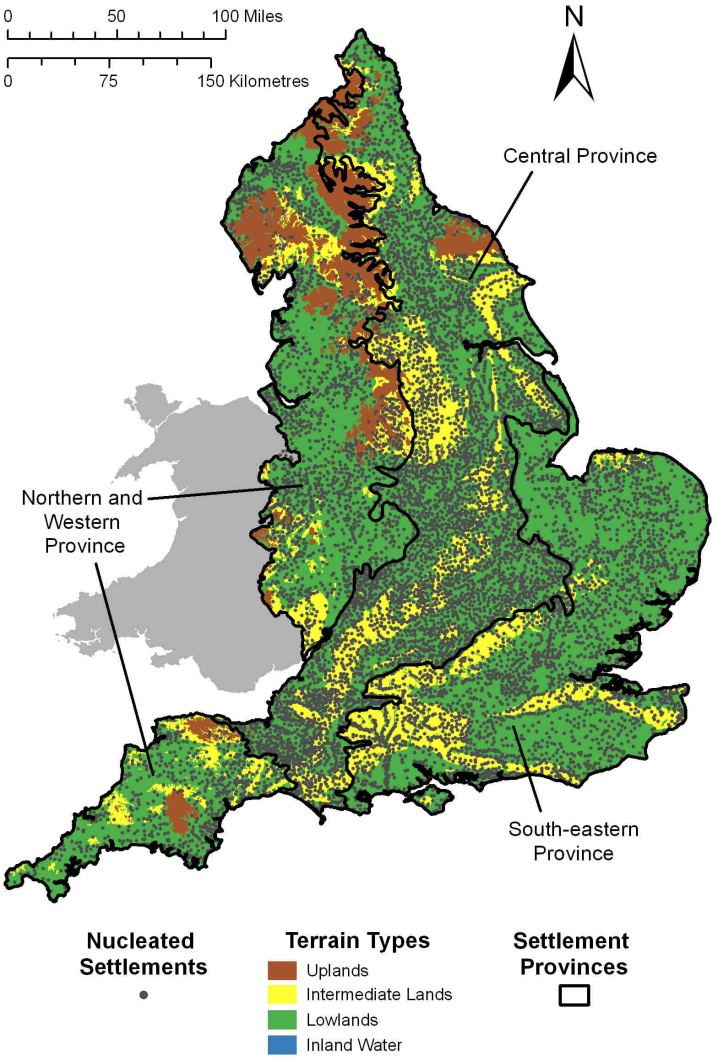


**Figure 1.** Nucleated settlements displayed over broad terrain types

Overlaying Roberts and Wrathmell's settlement provinces and sub-provinces on the detailed terrain zones, as in Figure 2, helps illuminate where changes in the physical landscape may have influenced differences in patterns of settlement.

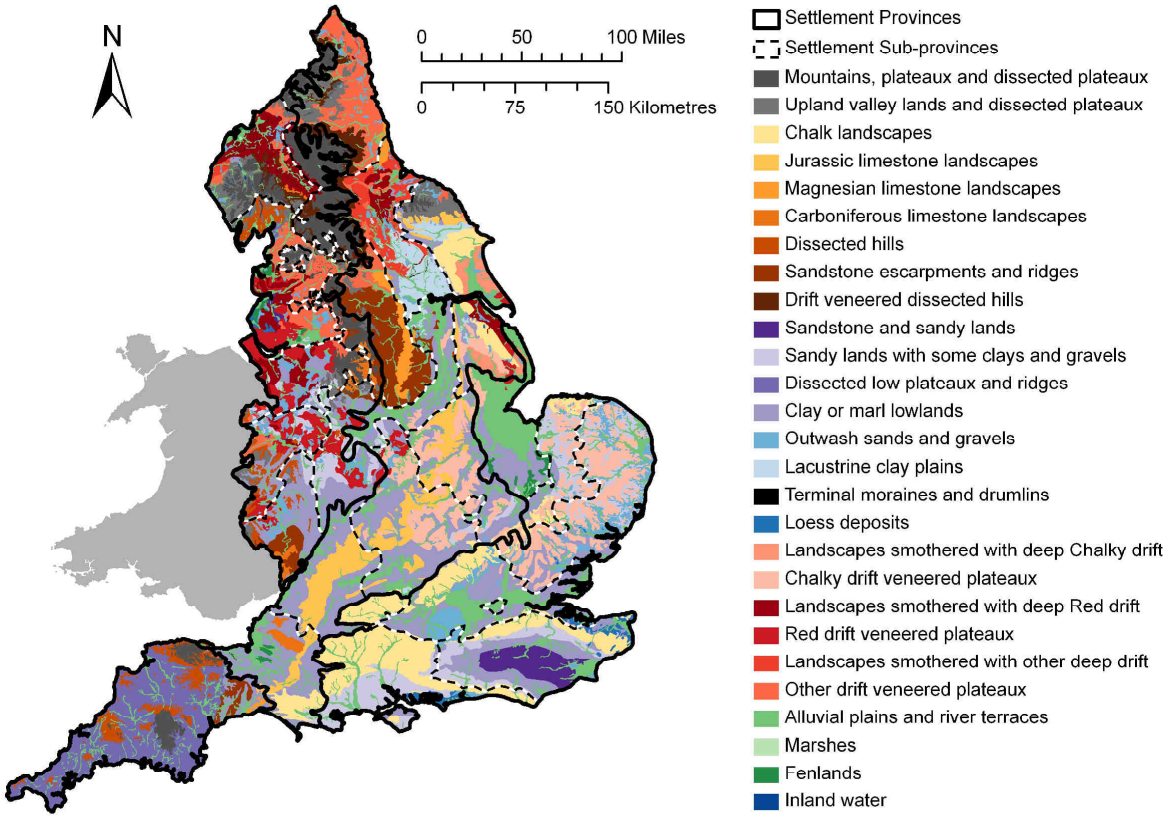


**Figure 2.** Settlement provinces and sub-provinces overlaid on more detailed terrain zones

## 4. Deriving new raster data

Roberts and Wrathmell defined their settlement provinces, sub-provinces and local regions through visual inspection of the point data they captured from the historic OS maps. As they acknowledged, the process was subjective, and other interpreters of the data would likely produce somewhat different results. With their data in GIS format, it becomes possible to apply a range of spatial analytical techniques, using methods more explicitly definable and reproducible than Roberts and Wrathmell's approach.

The various point layers can be treated as sources from which to interpolate raster surfaces. The most straightforward raster datasets to derive from the *Atlas* GIS data are simple Euclidean distance surfaces based on the points representing nucleated settlements. These surfaces give an impression of the concentration of nucleations across the country. The grid cell size used was two by two kilometres, mirroring the size of the sample areas Roberts and Wrathmell used when quantifying settlement dispersion (Roberts and Wrathmell 2000, 12-13). Calculating the simple distance to nucleations was preferred to calculating the density of nucleations because of the problems caused by edge effects. The difference in the number of nucleation points along the coast and the borders on the one hand and the number of points in central England on the other is such that density values along the 'edges' would be profoundly suspect. Roberts and Wrathmell designated five categories of nucleations (set out in Table 1), and separate raster surfaces were created for each. Figure 3 illustrates the distance rasters depicting the concentration of each category of nucleation, as well as a distance surface derived from the category B, C and D nucleations taken together.

**Table 1.** Categories of nucleated settlements (from Roberts and Wrathmell 2000, 11)

| Category | Description |
|---|---|
| A | Major towns |
| B | Large villages and small towns |
| C | Normal/average villages |
| D | Hamlets and small villages |
| E | Small hamlets |

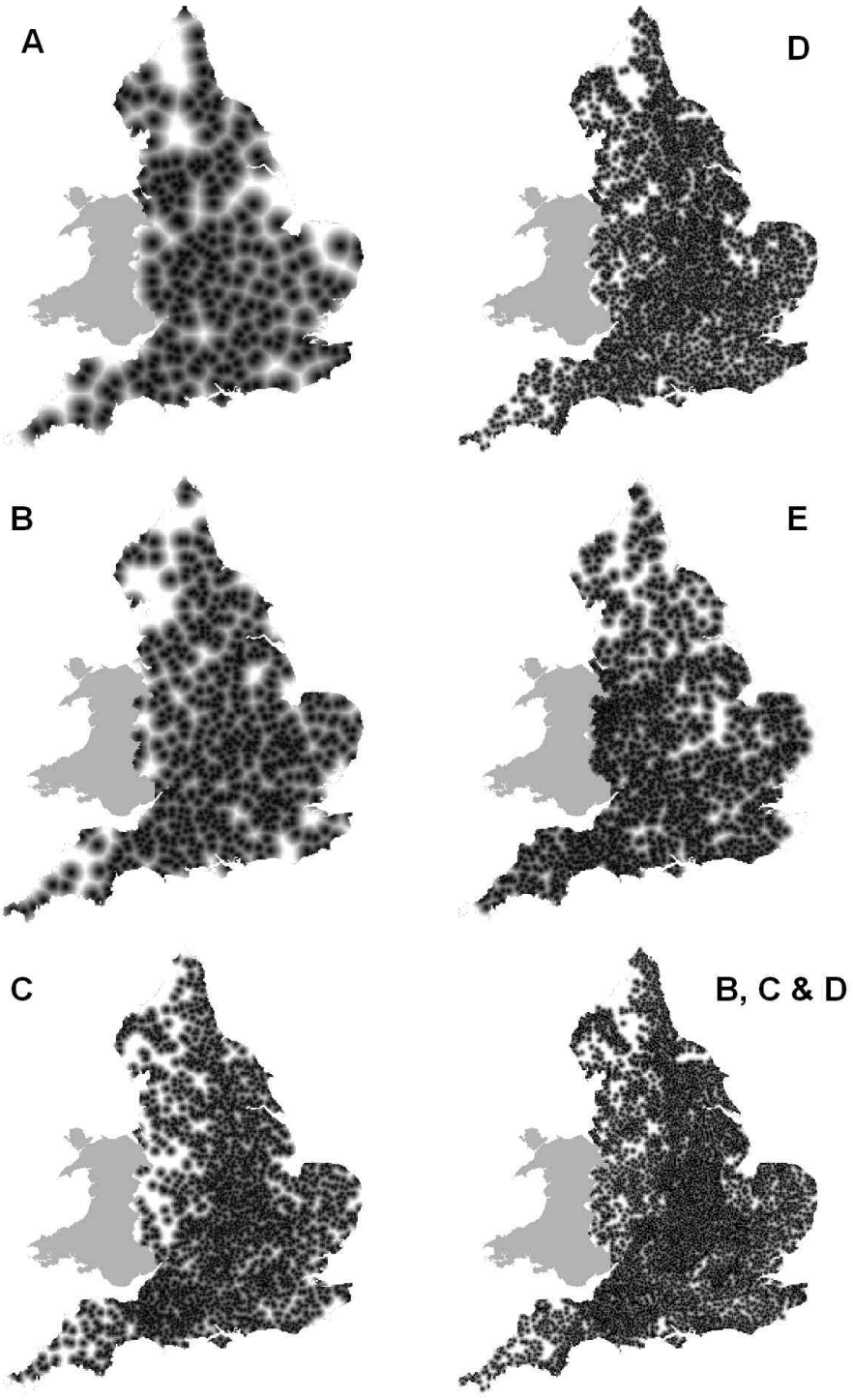


**Figure 3.** Distance to nucleated settlements, by settlement category. Darker = closer to nucleation

The sample locations at which Roberts and Wrathmell recorded dispersion scores and hamlet counts were also used to interpolate surfaces. The former represent the number of individual houses, farmsteads, cottages and the like outside nucleated settlements; the latter are a count of tiny settlement groups larger than the single buildings recorded in the dispersion scores but smaller than the smallest nucleated settlements. The surfaces were created using the Inverse Distance Weighted (IDW) method, with a search radius of 20 km and weights based on the square of the inverse distance. As Figure 4 shows, the broad outlines of Roberts and Wrathmell's three provinces are readily discernible in both the interpolated datasets, but the variation within each is also clear.

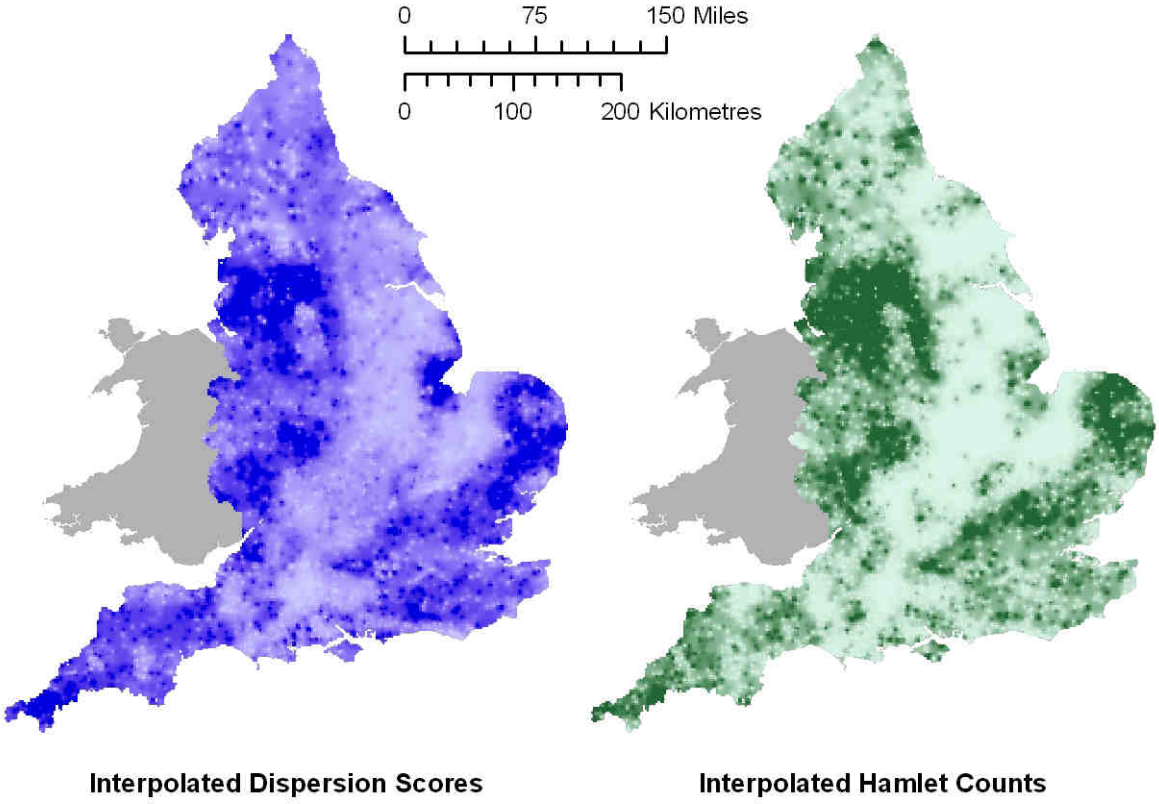


**Figure 4.** Interpolated Dispersion Scores and Hamlet Counts. Darker = higher score/count, meaning greater degree of dispersed settlement

## 5. Integrating raster datasets to revisit Roberts and Wrathmell's interpretations

Deriving surfaces from each of the different categories of data Roberts and Wrathmell used to create their characterisation of the landscape is instructive, providing an impression of how each element contributed to their final interpretation. By integrating the various individual raster surfaces, the combined data can be depicted and analysed together, allowing one to visualise Roberts and Wrathmell's material in new ways.

One approach employed was to reclassify the rasters of distance to B, C and D nucleations, interpolated dispersion scores and interpolated hamlet counts to a common scale (0-100). Combining the three reclassified single-band rasters into a multi-band raster enables viewing the data as an RGB composite (cf Kvamme 2007, 356-8). The RGB composite and Roberts and Wrathmell's own results – shown in Figure 5 – are broadly similar, but the RGB composite is considerably more complex and challenging to interpret. This exercise demonstrates that there is often more variation within Roberts and Wrathmell's zones than might be assumed from the printed maps.

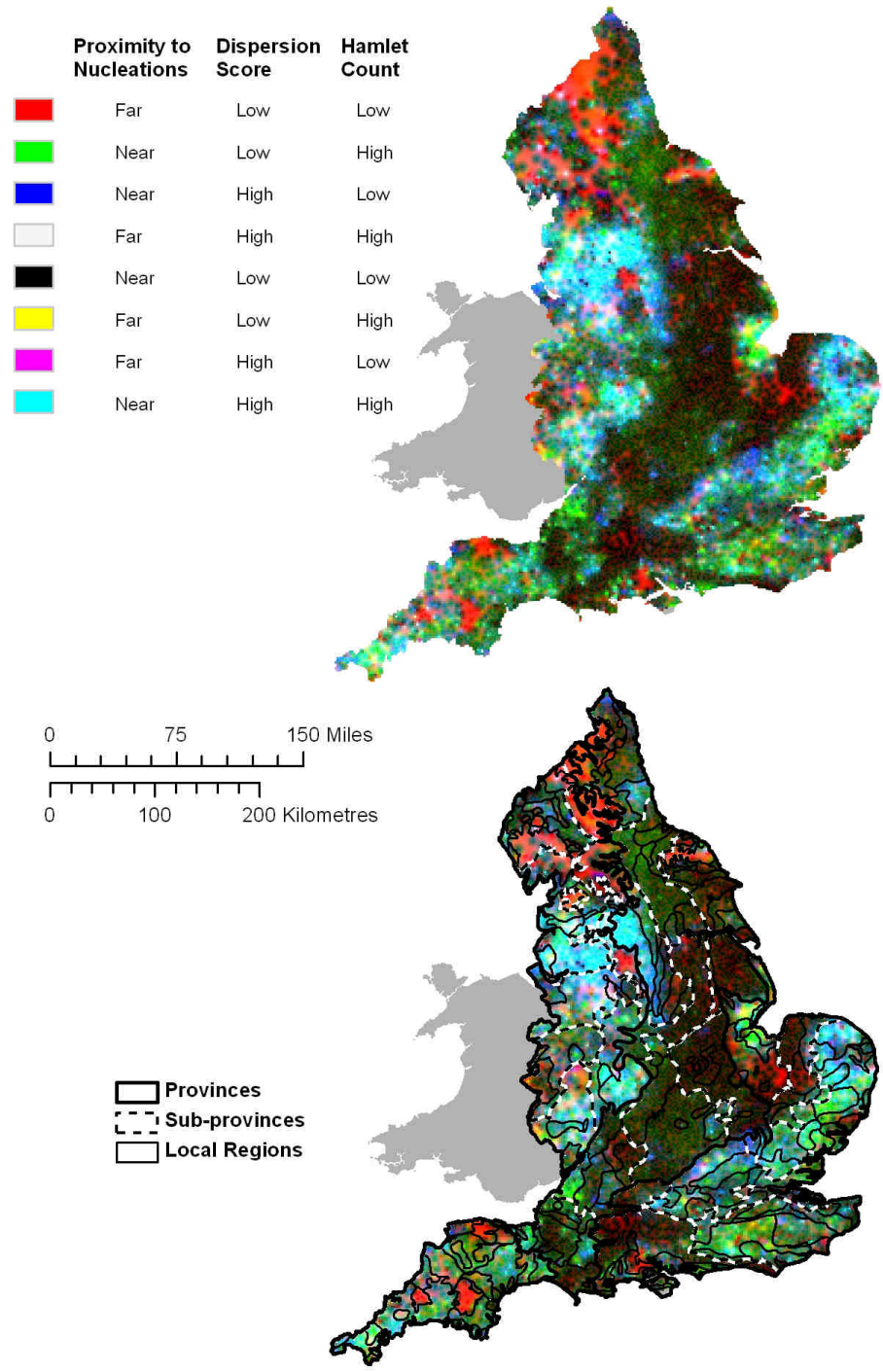


**Figure 5.** RGB colour composite based on distance to B, C & D nucleations, dispersion scores and hamlet counts

Unsupervised classification (Conolly and Lake 2006, 147-8; Parcak 2009, 95-6) can also help tease out patterns in the data. The values in the five distance-to-nucleations rasters and the two interpolated settlement dispersion rasters were standardised and then an IsoData or K-Means clustering algorithm applied to produce a series of classified outputs, using between three and seven clusters. As can be seen in Figure 6, the results are comparable, but not identical, to Roberts and Wrathmell's division of the English landscape into provinces, sub-provinces and local regions. The similarities attest to the robustness of Roberts and Wrathmell's characterisations, while the differences point to areas where further research into patterns of rural settlement might be particularly enlightening.

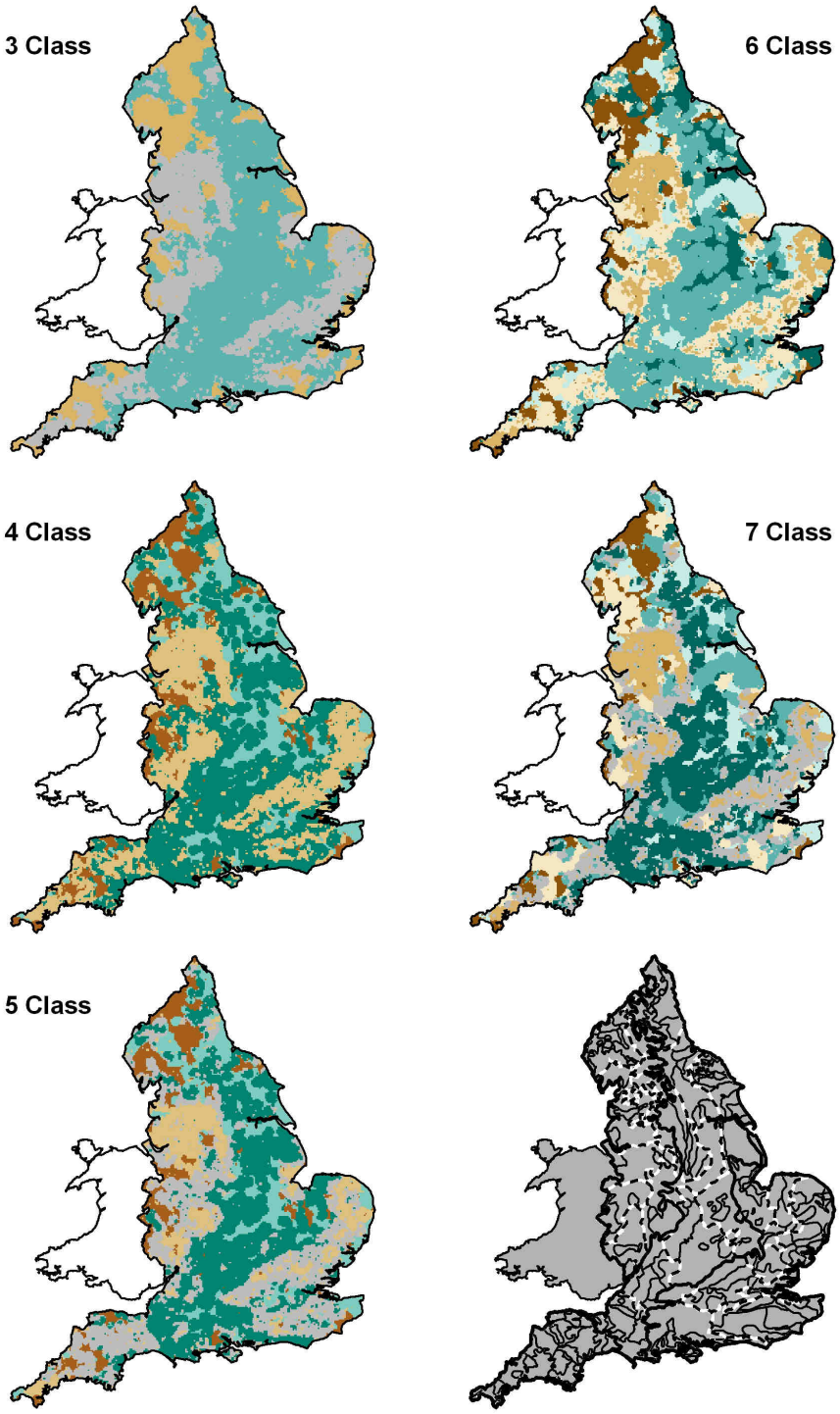


**Figure 6.** Results of unsupervised classification

## 6. Conclusions

The analytical methods and results discussed here do not, by any means, exhaust the possibilities for reinterpreting Roberts and Wrathmell's data, but they do show the potential for reinterpretation. Using raster data derived from Roberts and Wrathmell's nucleation and dispersion data demonstrates the strength of their interpretations, but also highlights a level of settlement heterogeneity which is not always clear in the printed Atlas. Looking ahead, creating the Atlas of Rural Settlement in England GIS will open up opportunities to combine the Atlas materials with other relevant GIS data, facilitating and stimulating future work on historic settlement patterns and landscape character.

## 7. Acknowledgements

My thanks to Brian Roberts and Eddie Lyons for their help in creating the *Atlas* GIS data collection.

## 8. References

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## 9. Biography

Dr Andrew Lowerre is Archaeologist (Spatial Analysis) with English Heritage. His main research interests are in the history and archaeology of Anglo-Saxon and medieval settlement and fortification, and in the use of GIS. His current long-term project is the development of a comprehensive, GIS-ready dataset based on Domesday Book.