The Visualisation of Spatial Social Structure

An introduction

During the 20th century, increasing amounts of information about the population were collected and analysed by statisticians, but often these were crudely mapped. The mapping methods of the 1980s would have required maps the size of football pitches to show all the detail of many data sets that then existed. What follows are pictures that made it possible to start seeing much of that very detailed data.

Technical information

This book uses images originally drawn for Danny Dorling's PhD concerning the mapping of detailed social data. Some 500 computer generated maps and diagrams that were first drawn in 1991. Some 185 of these are now being published in a new book: The Visualisation of Spatial Social Structure, published by Wiley, with new text written in hindsight. Until now many of these images were too complex to publish. The colour translation is still problematic.

A small selection of the illustrations in the book is presented in this PDF file as an introduction to it.

The first reference number on each page is the chapter and figure number in the book. The next is the figure number for the individual PDFs.

The Print number refers to the original PhD illustrations. Most of the illustrations were created using vector graphics. What follows was created by Danny's father, David Dorling, using the original computer files and software and converting that into PDF format, preserving the vector graphics. This format allows great magnification. Please use the zoom feature to study the illustrations in more detail. They were designed to be looked into, as well as looked at.

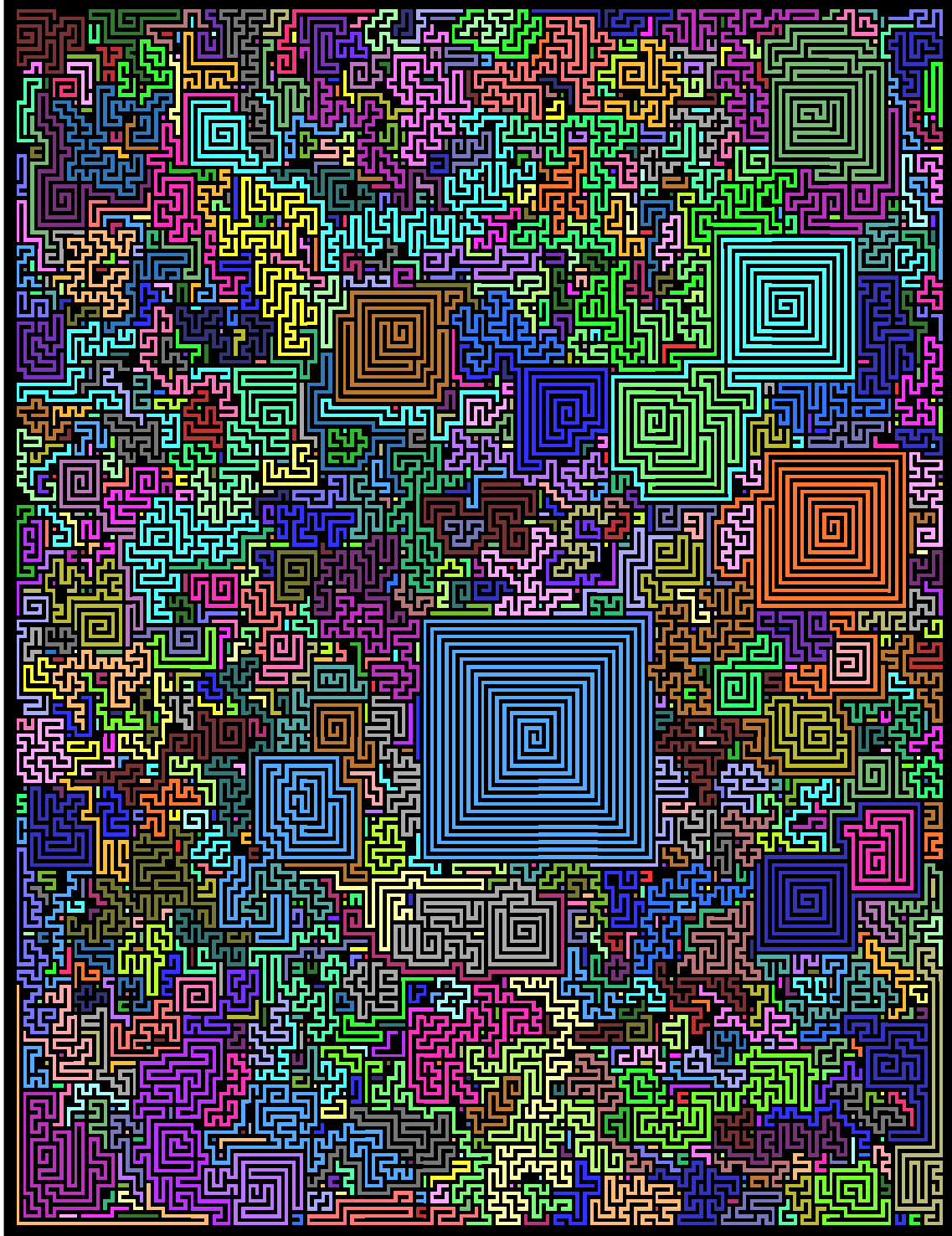
Visual Information

From computer generated graphics it was possible to show highly complex information visually what might now be descrbed as low resolution images. This image is too complex to describe in words or statistics, but it nevertheless contains patterns. All these patterns are, in fact, the result of random variation. What follows are attempts to show detailed social data as effectively.
Fig 1.5

Figure 022 Print 015

A Maze of Colour

The detail a low resolution image can show.



Land Area Maps

This image shows what would have been considered a high resolution map. It shows where in Britain people were born compared to the average for the whole of Britain. It appears to cover Britain, but it does not show the information for most of the people of Britain. It is a map of rural Britain. At this scale, most of the towns and cities where most people live are hardly visible. Even London is tiny.
Fig P.1

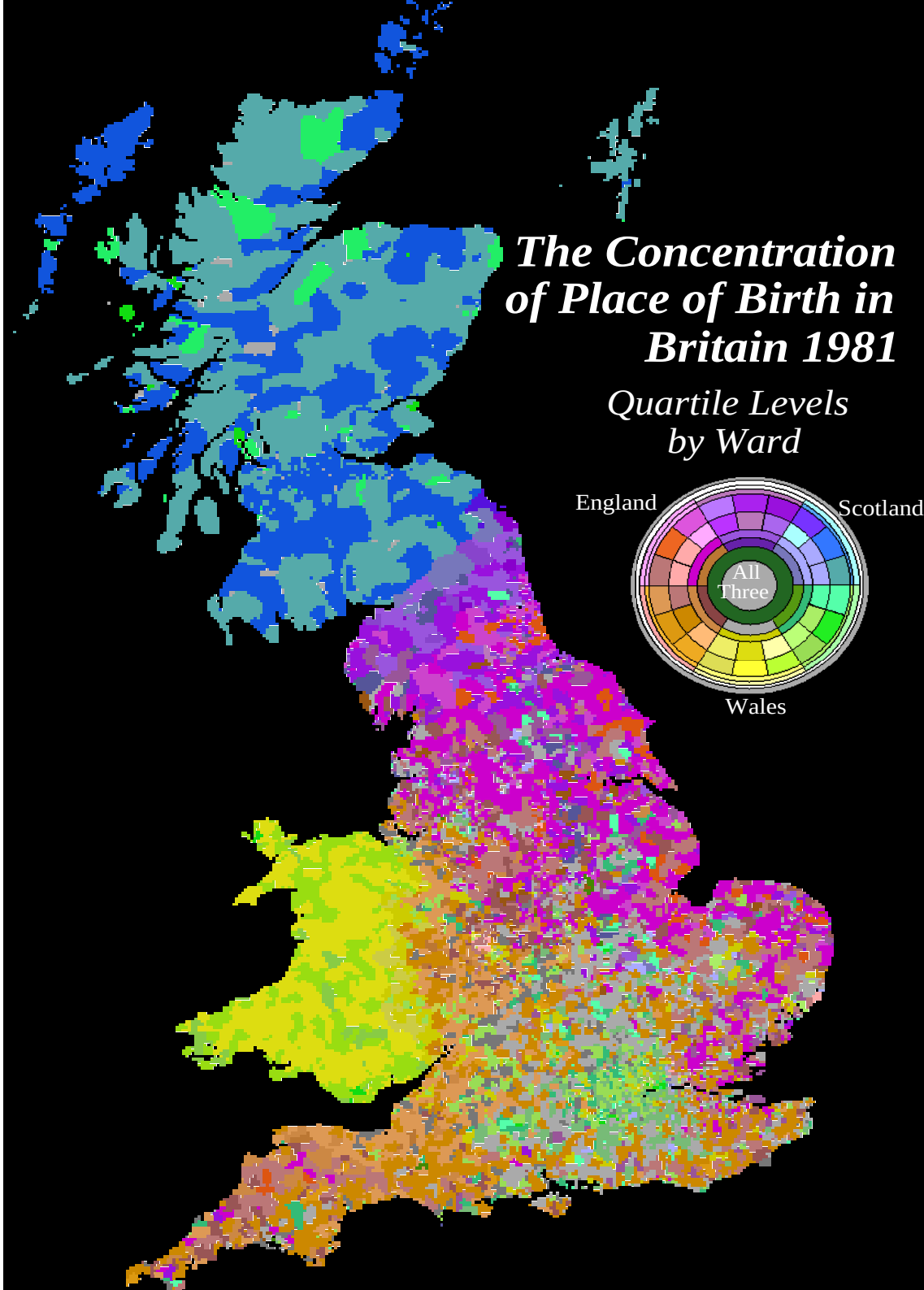


Figure 001 Print 019

Population cartograms

This picture uses the same data as the previous map, but every dot represents about 100 households, a very local neighbourhood. It is called a population cartogram. Equal areas in the picture are given to equal numbers of people, and everyone is included. It achieves this by Scotland shrinking but Glasgow becoming massive. North and Mid-Wales shrink. South Wales expands. London explodes. Fig P.2

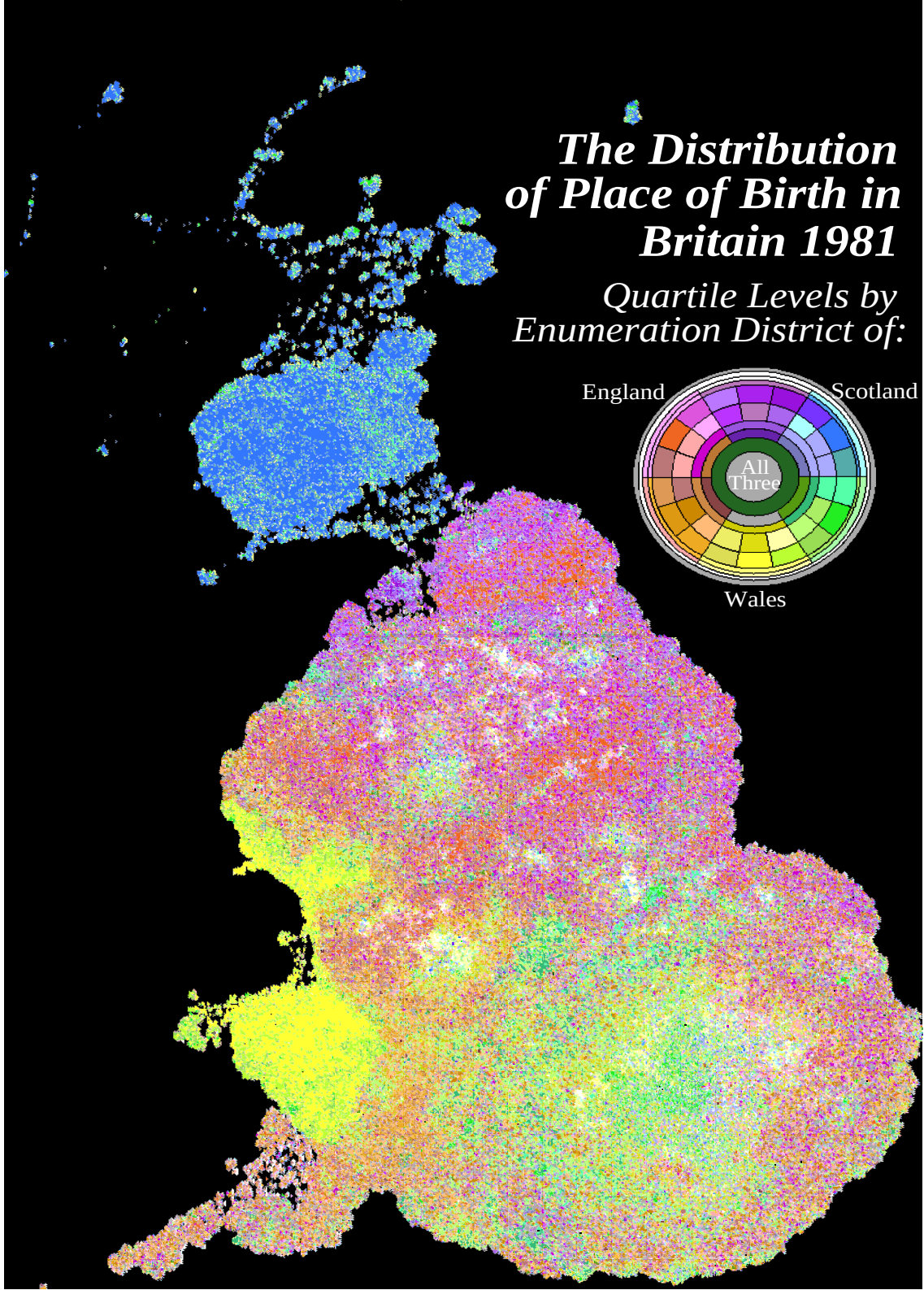


Figure 002 Print 072

Early Cartograms

Here are some of the earliest population cartograms produced just by a computer program. The areas are counties and major cities, the colours are simply to distinquish them. Starting with the map top left, three slightly different algorithms produce the three crude cartograms. The computer used only had 32 kilobytes of memory. The image showed what might be possible. Fig 3.1

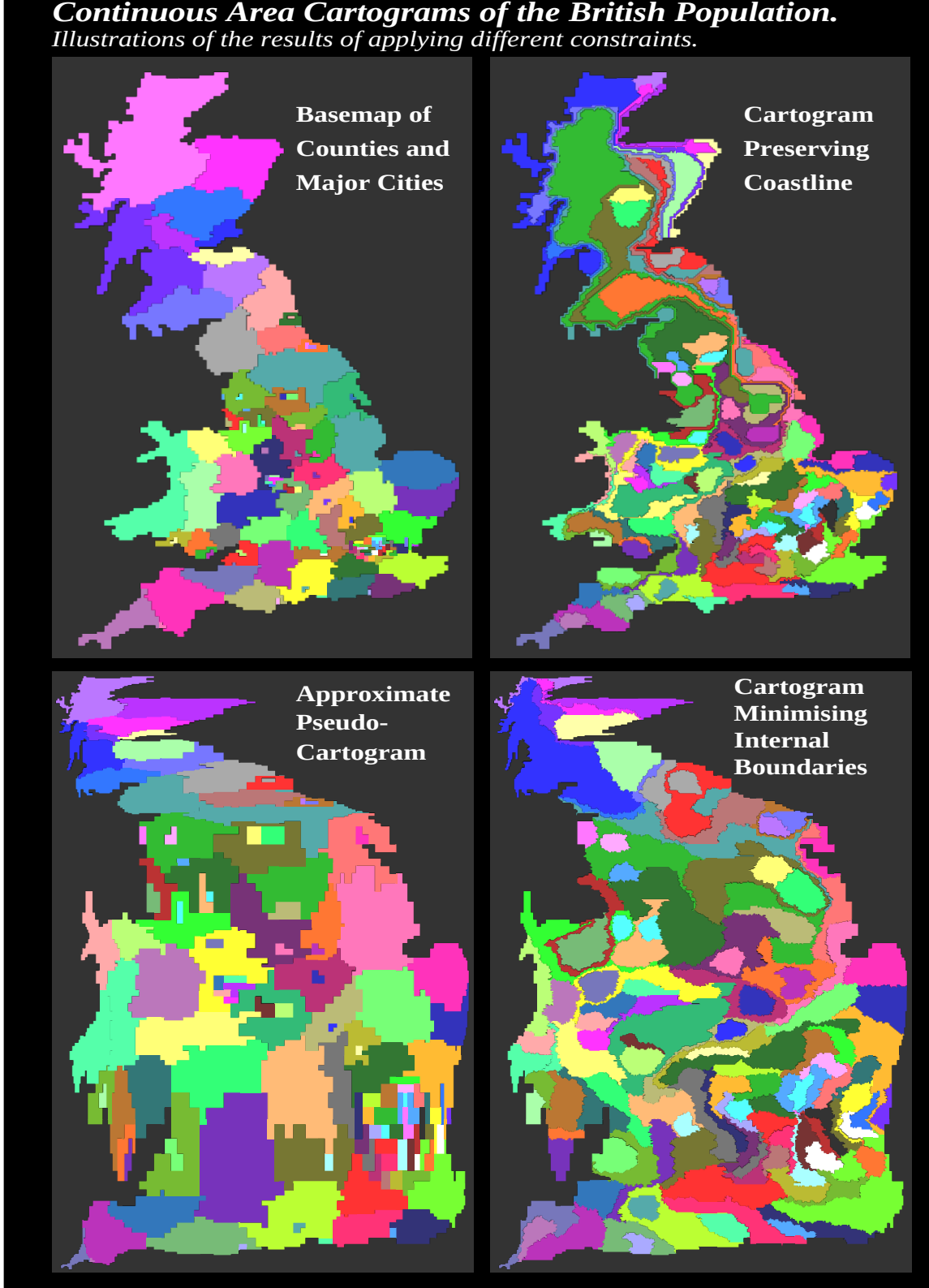
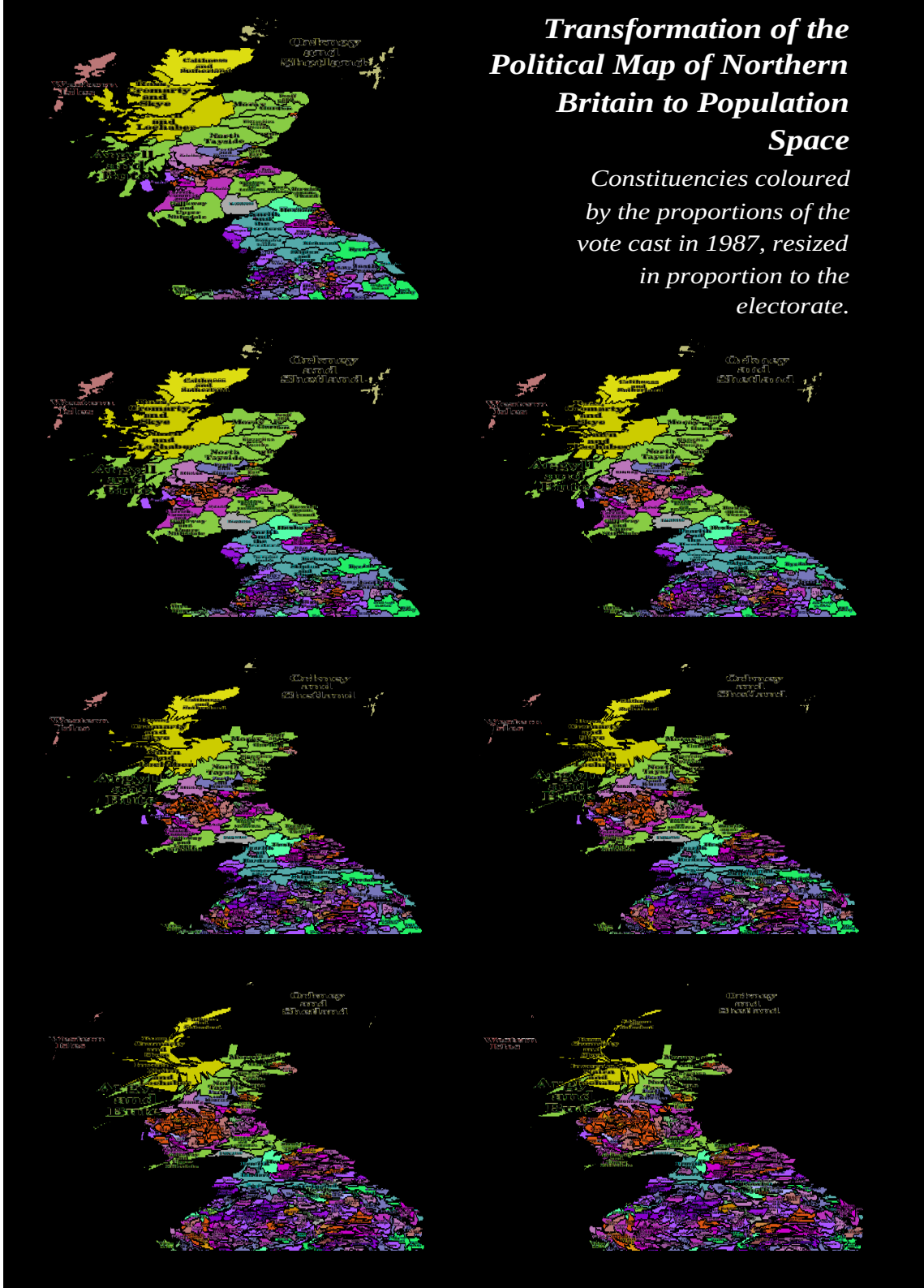


Figure 051 Print 049

Generating cartograms for Northern Britain

Here the areas are parliamentary constituencies and the colours correspond to the proportion of votes each party got in 1987. We start with the ordinary map, and watch it slowly morph into a population cartogram. Gradually you see how the bulk of the population voted, and the rural vote is reduced to its correct proportion.

Fig 10.7



Transformation of the Political Map of Northern Britain to Population Space

Constituencies coloured by the proportions of the vote cast in 1987, resized in proportion to the electorate.

Figure 181 Print 174

Generating cartograms for Southern Britain

Showing a sequence for Southern Britain where gradually all the constituencies become similar sizes, those with large land areas shrinking, and the densely populated ones expanding. From simply showing each individual constituency correctly coloured, you get the correct proportions of each political shade of colour across the map as a whole.
Fig 10.8

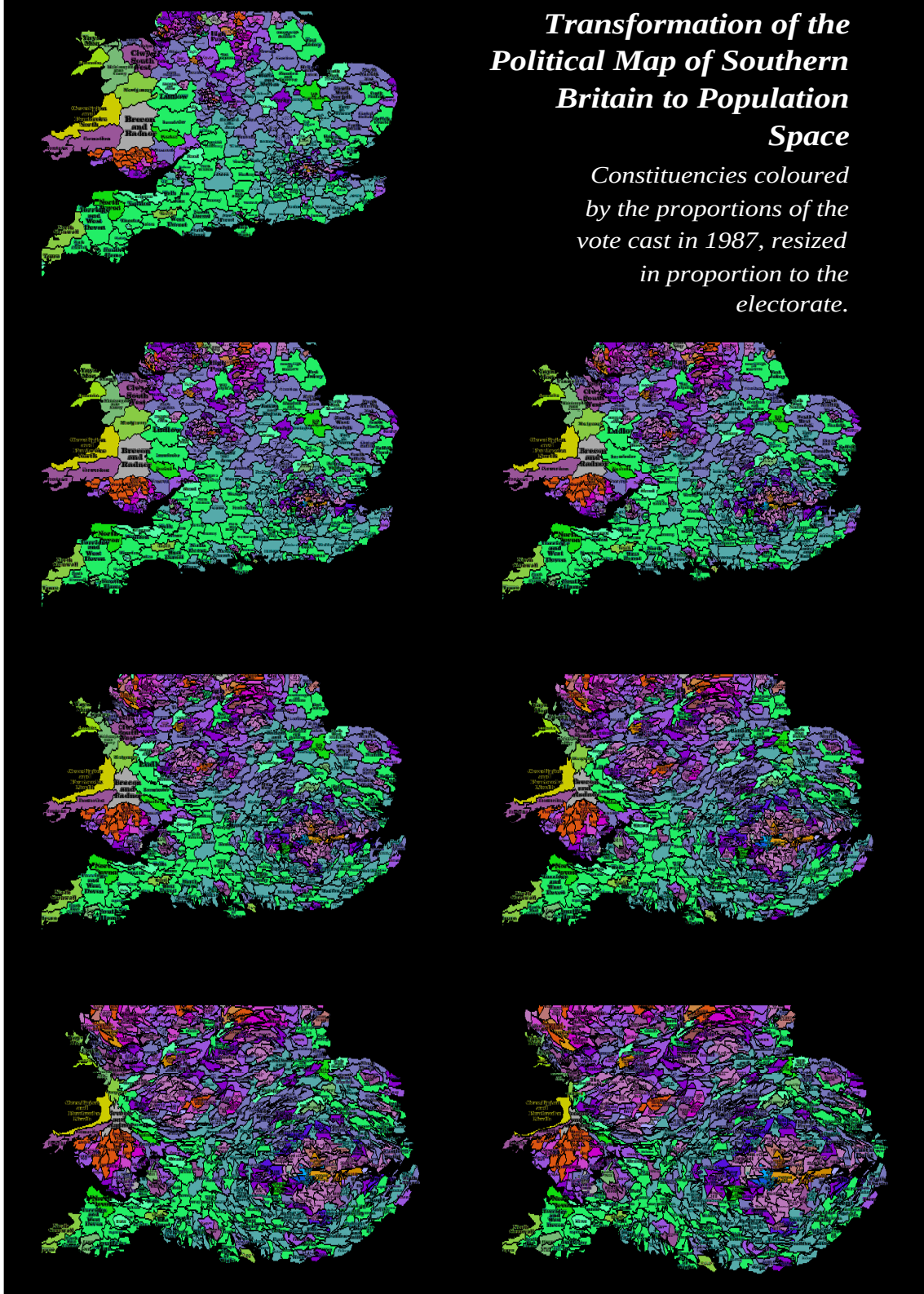


Figure 182 Print 175

Circular cartograms

The previous method resulted in areas often being confusingly odd shapes. They could all have the same shape, as long as its area is correct. Here each area is replaced initially by a faint solid grey circle proportional to its population. Many circles overlap, and others are isolated. They are jostled about to give each other room. The darkest circles are when a state of no overlap has been achieved.
Fig 3.3

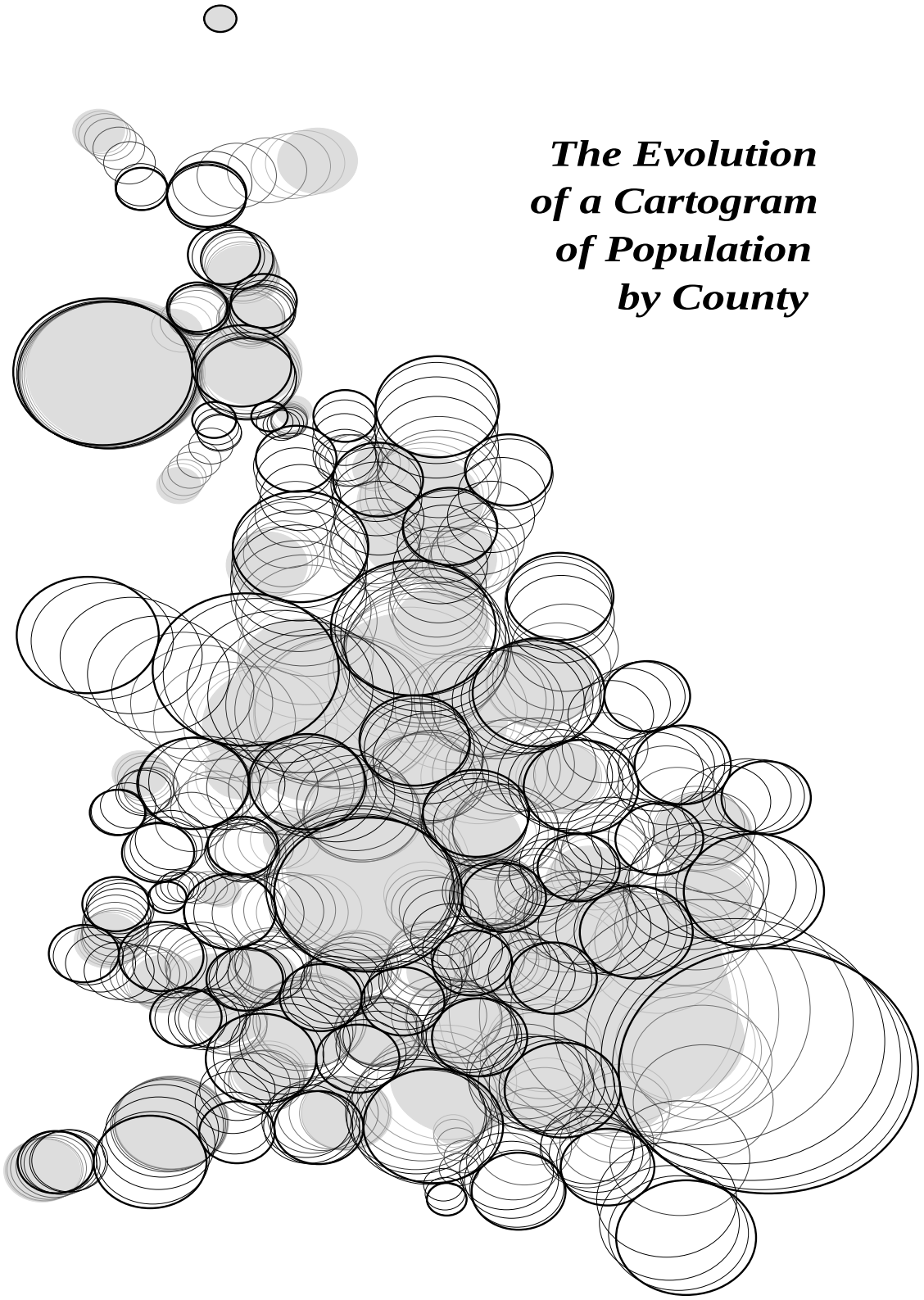


Figure 053 Print 051

Does the cartogram work?

Lines joining every pair of areas that originally had a common boundary are added here to the previous cartogram to see how well it has worked. Neighbours mostly still touch, or nearly touch each other. Take any place, and the places immediately north, south, east and west are usually the ones you would expect. Because of this, if the cartogram shows a pattern, it is a pattern about the geography.
Fig 3.4

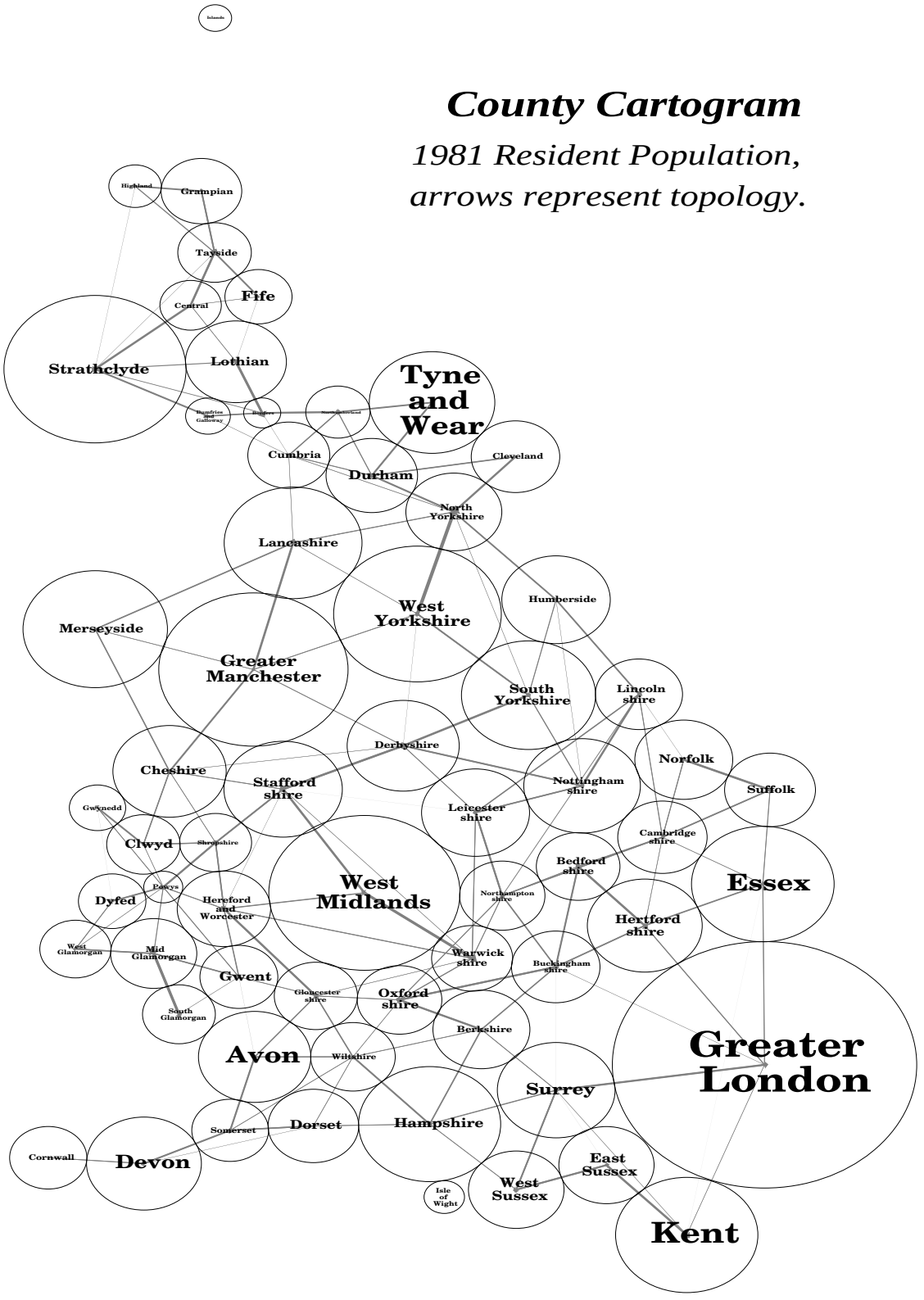


Figure 054 Print 052

A ward level cartogram

You can increase the resolution to show, for example, every ward. These are the areas used in local elections which councillors represent. One will be your local area. It is just possible to produce a look-up table to identify every one of them, but there are over ten thousand. On a land area map, say A4 size, most wards will not be visible. Wards in built-up areas tend to have larger populations.
Fig 3.11

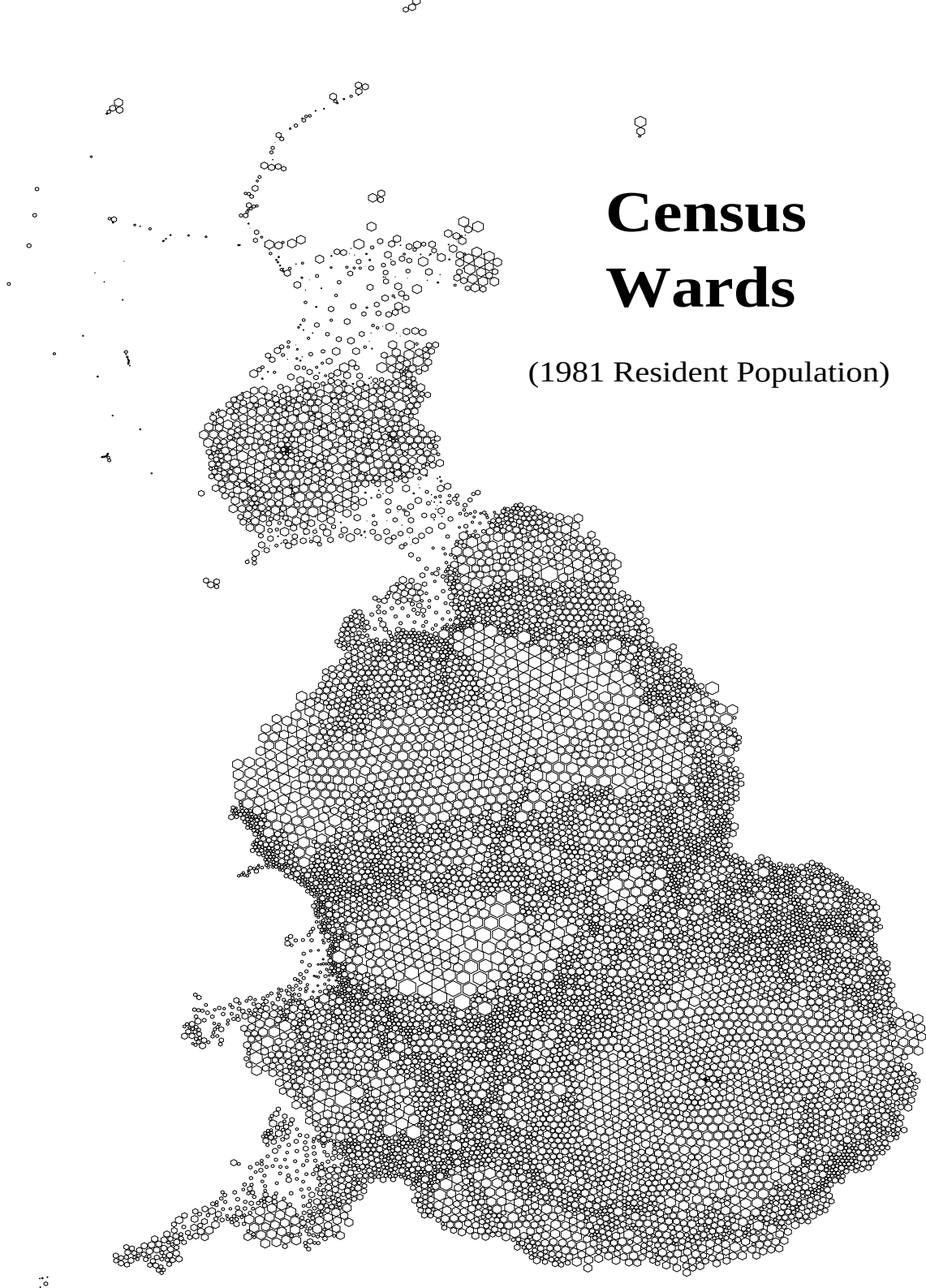


Figure 061 Print 059

Showing data on a cartogram

These cartograms can be used to map detail to an extent that was previously impossible. You can see the trend in various areas, ones which are unlikely to match any official administrative areas. You get an overall and a detailed picture of the statistics, because it is a picture. If you went to a state secondary school, the catchment area of you year group is shown by perhaps 5 distinct hexagons.
Fig 1.12

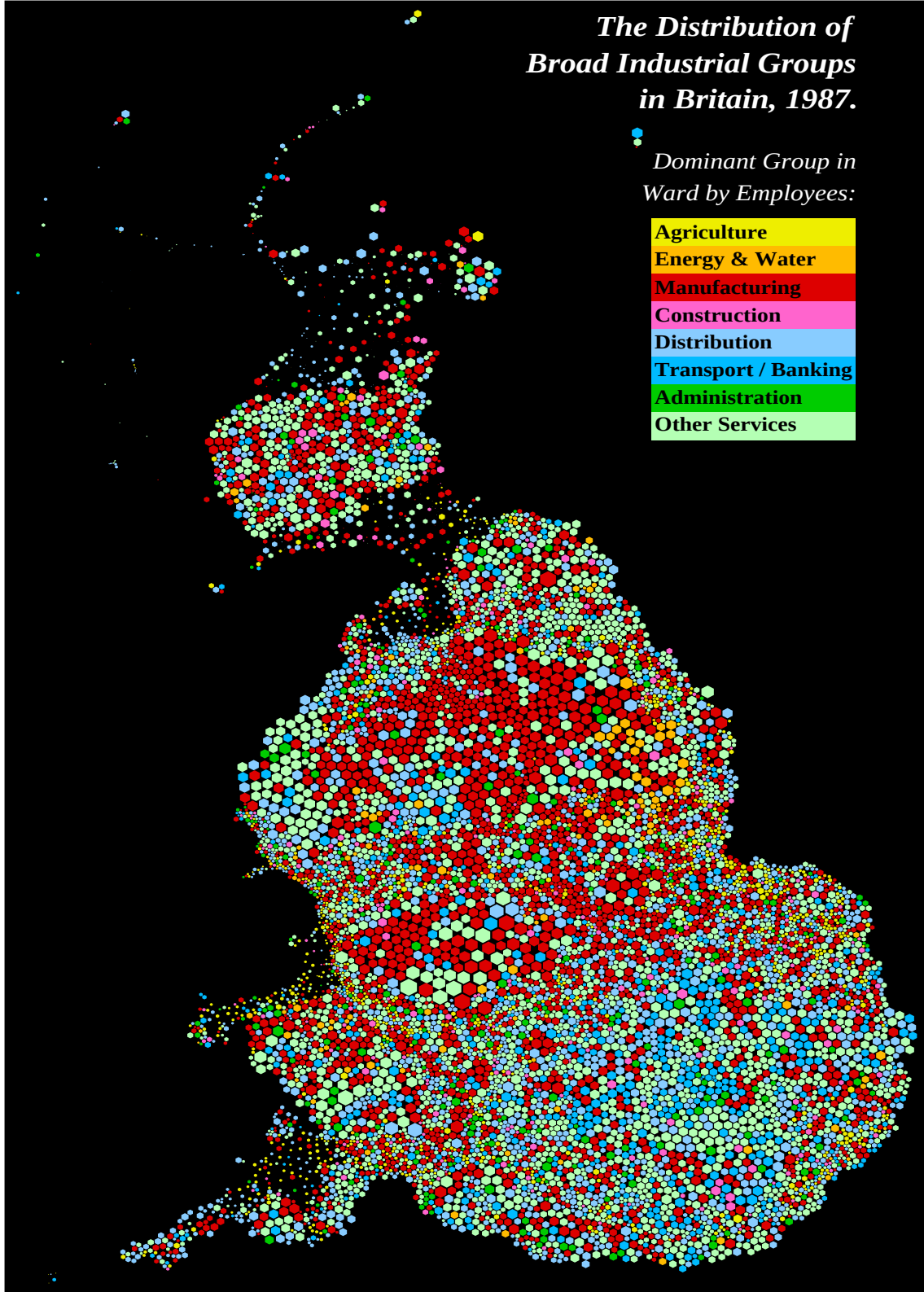
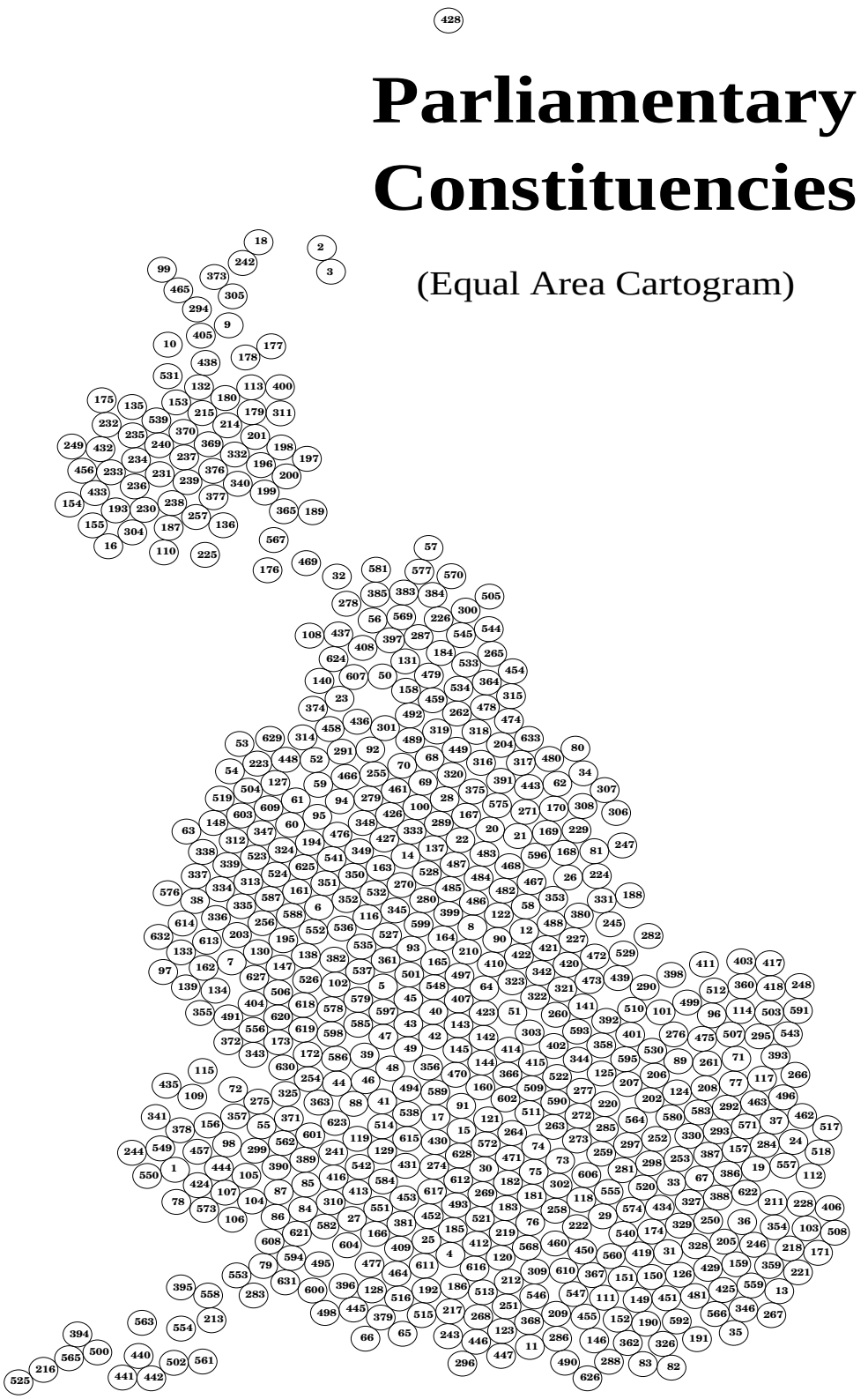


Figure 029 Print 023

A parliamentary constituency cartogram

Most people live in densely populated areas which are difficult to see at all on the previous map. Every constituency can be seen and identified on this cartogram. It uses the same index numbers. As in previous cartograms, topology is largely preserved, with the the expected constituencies to the North, South, East and West of any given constituency.
Fig 3.10

Figure 060 Print 058C



Parliamentary constituency map

The numbers on this map refer to an alphabetical list of the then 633 parliamentary constituencies. The size of the numbers reflects the different amount of space this map gives to each constituency. If you zoom in, you will find every one is numbered, even in London. This is not a useful picture to show how people voted, or much else except about the land that is available for ownership in each place.

Fig 3.8

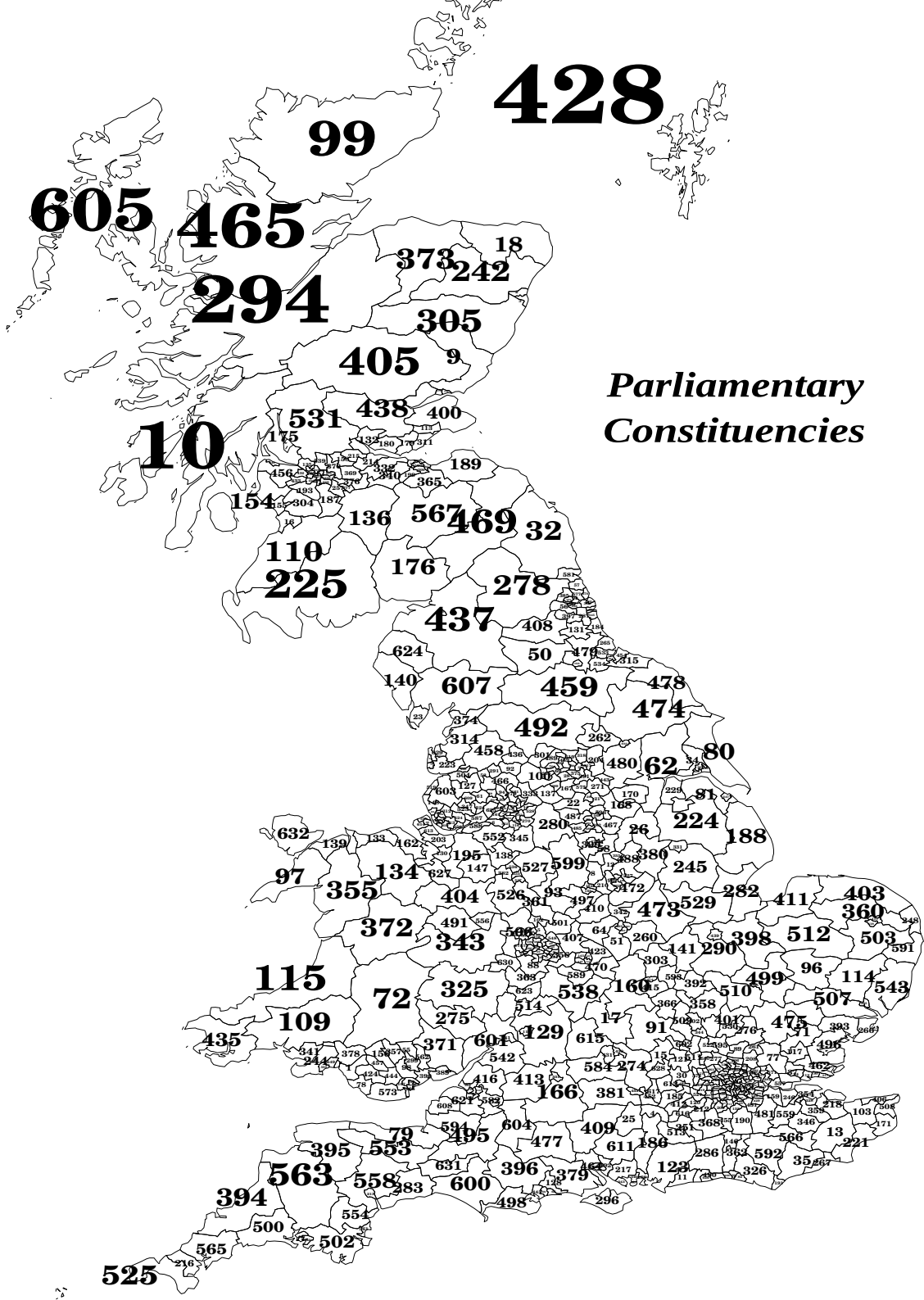


Figure 058 Print 056

Election results on a map

Now we give some political colour to the initial map. Unfortunately you can hardly see what is going on in Greater London and other major cities. The overall impression is consequently false. Labour had 31% of the popular vote and won 35% of the seats, but this is not apparent because their greatest support was in densely populated constituencies which are always the smallest on a map.
Fig 4.17

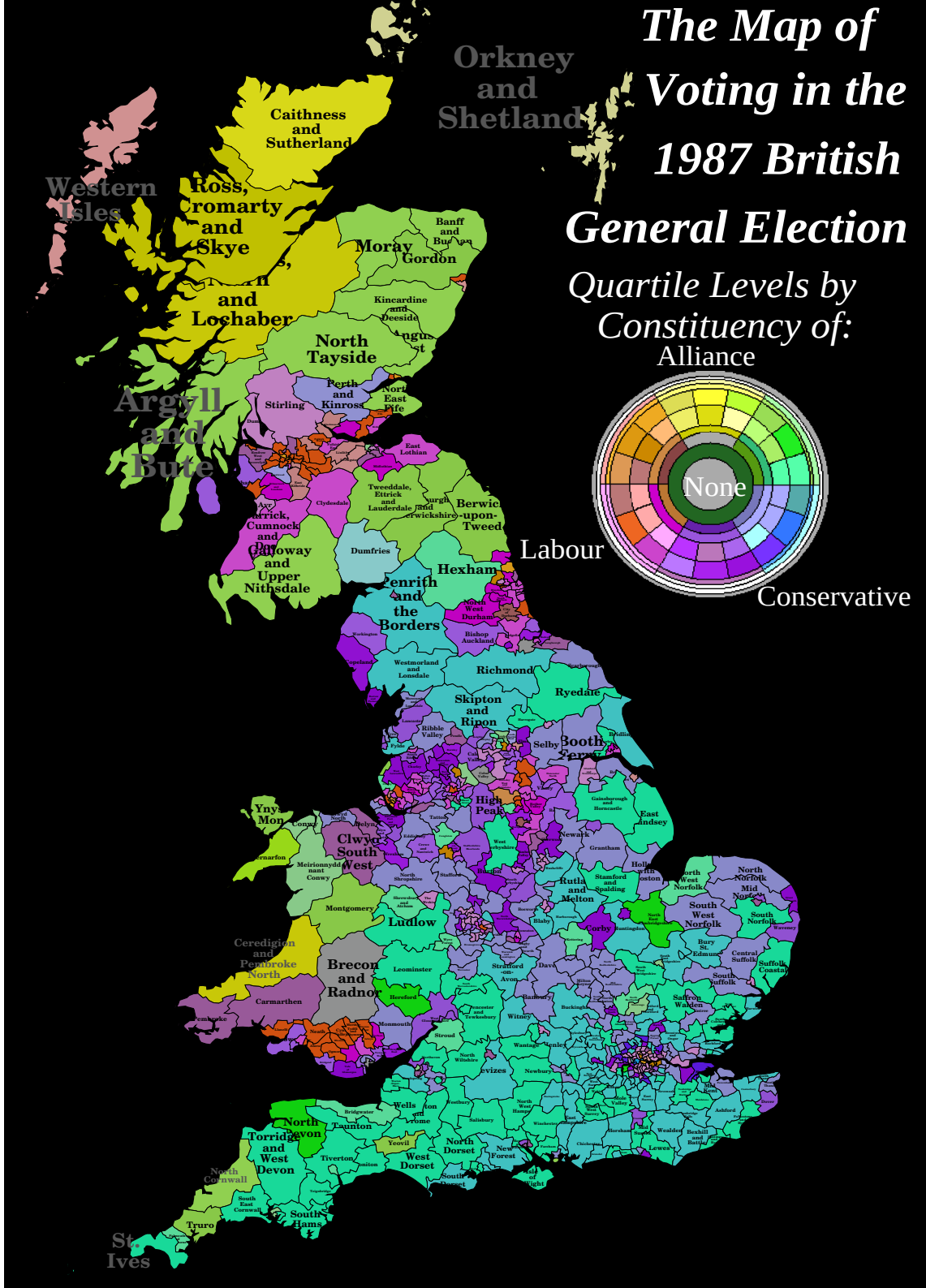


Figure 089 Print 082

Election results on a cartogram

On a population or constituency cartogram every constituency is easily seen. They achieve a picture which is fair to everyone. Unfortunately the colours that are produced here, due to technical factors, differ from what the original file produced when the image was printed on an unusual prototype printer-plotter in 1990. Printed with that device, the colour for labour was bright red.
Fig 4.16

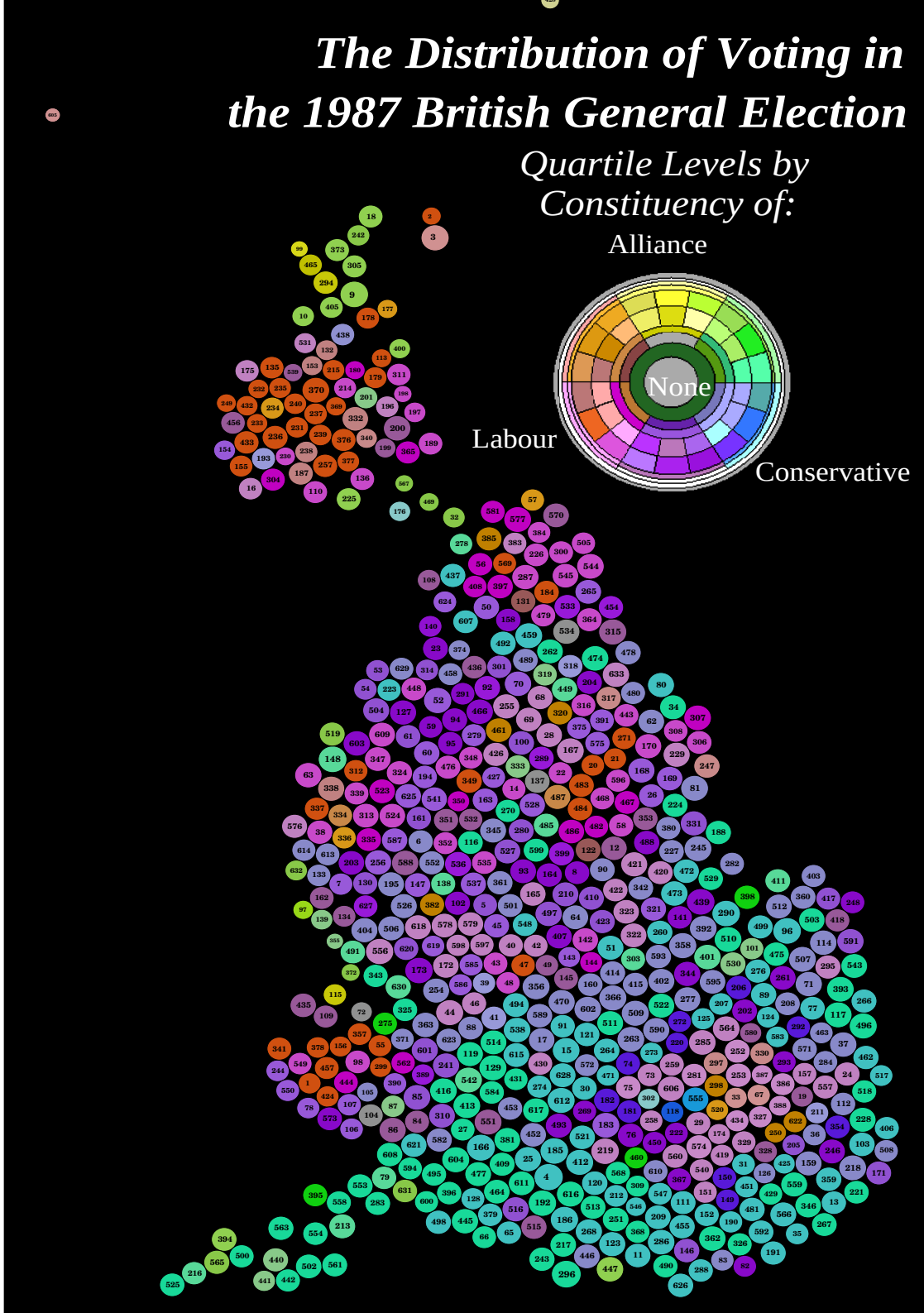


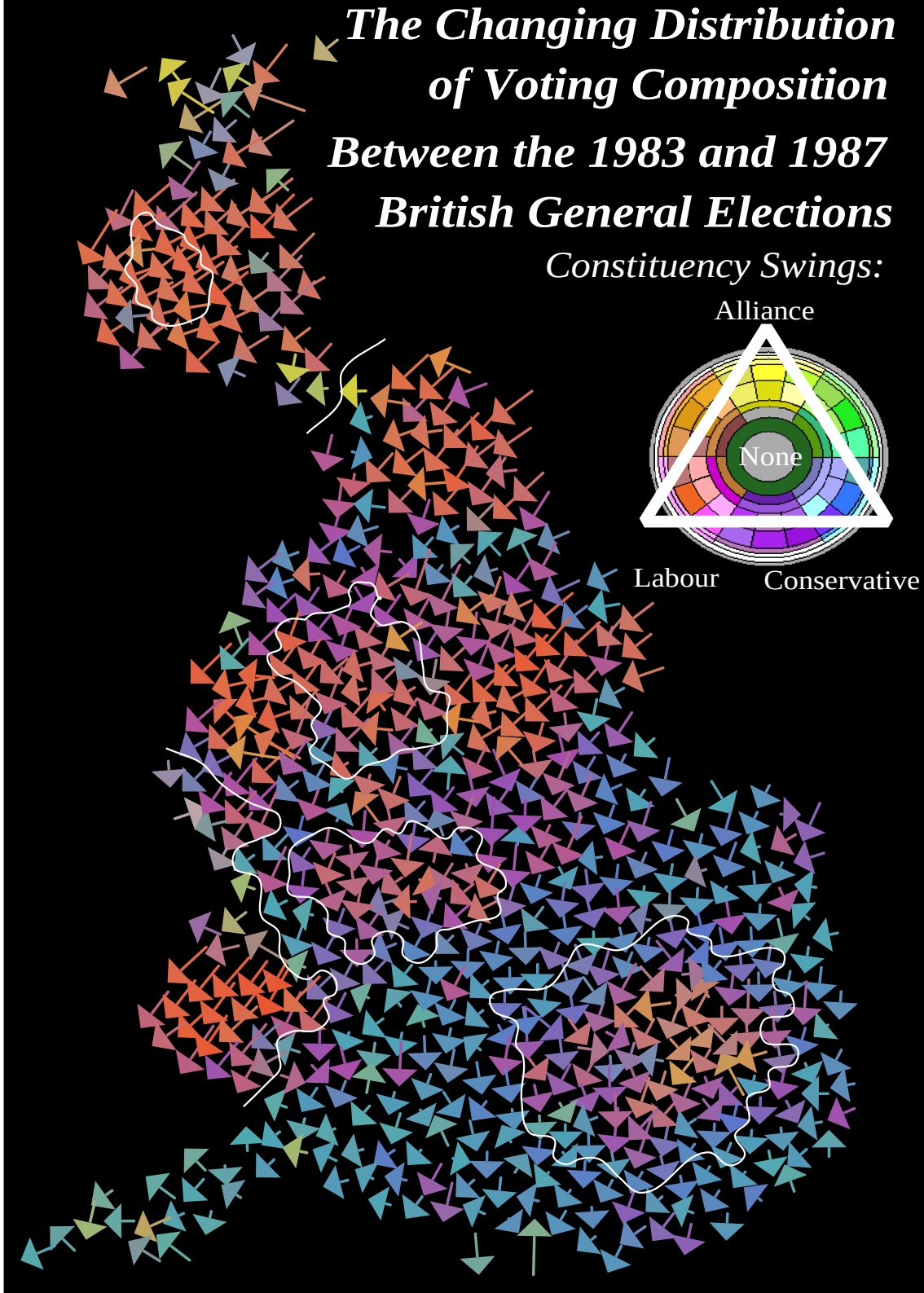
Figure 088 Print 081

Political swings

This cartogram shows the political swings as well as the final outcome of a general election. The previous circles are replaced by arrows in the same positions as before. They show the direction and extent of the swing through their direction and the length of each arrow. Their colour represents the final voting proportions, and arrowheads are proportional to the population in each constituency.

Fig 5.20

Figure 113 Print 145



Election winners

This cartogram of parliamentary constituencies uses hexagons instead of circles and also includes Northern Ireland. It is the picture of who won each seat rather than the more complicated one showing the proportion of votes for each party in each constituency. On the next image of the parties placed second, except for Northern Ireland, every hexagon changes colour, but to what?
Fig 4.18

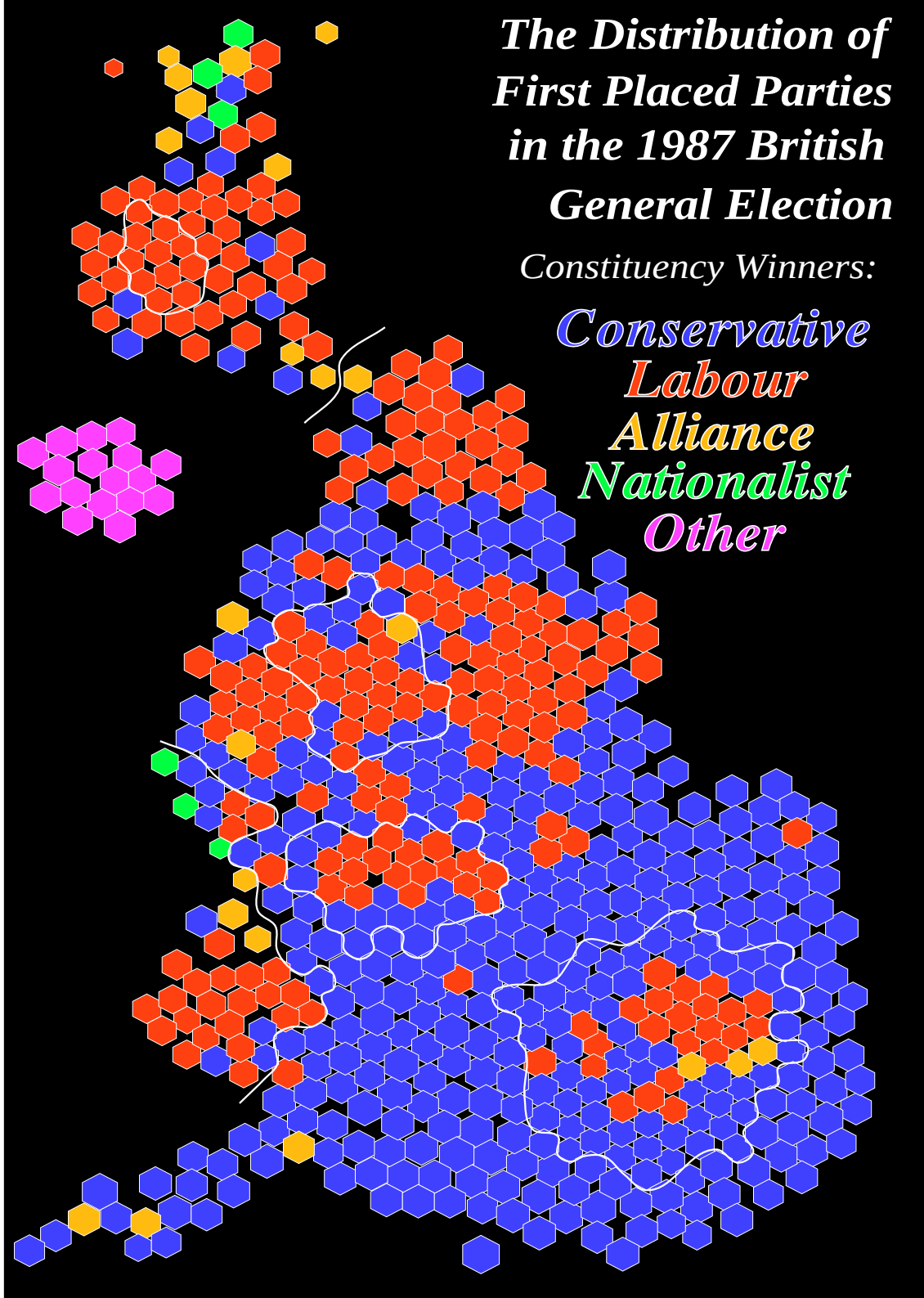
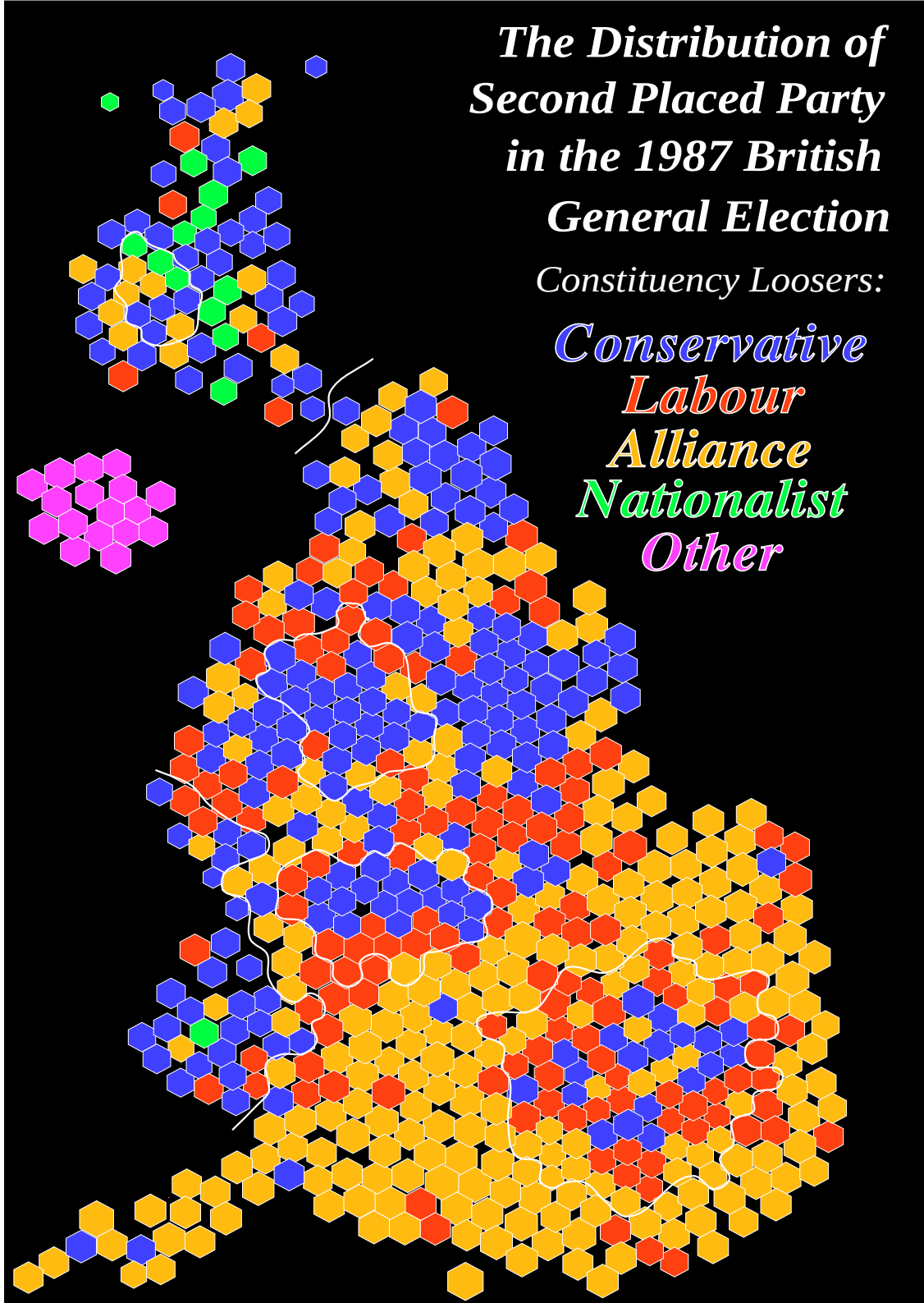


Figure 090 Print 083

Election runners up

Once the election is more than a two party contest, this picture - of which party came second in every place - is no longer the inverse of the winners' picture. The SDP-Liberal Alliance, which only won 22 seats, frequently was in second place in Britain in the late 1980s. It had become the main opposition not only in the Conservative south, but often wherever seats were won by the Conservatives.
Fig 4.19

Figure 091 Print 084



The seats which changed

Relatively few seats change party at most general elections. Only those which changed are coloured here, with the outside of the circle showing the party which won the seat previously, in 1983. The inside colour shows which party gained it in 1987. All losses and gains are shown by this method. The Conservative party lost over half its seats in Scotland in the 1987 general election.

Fig 5.15

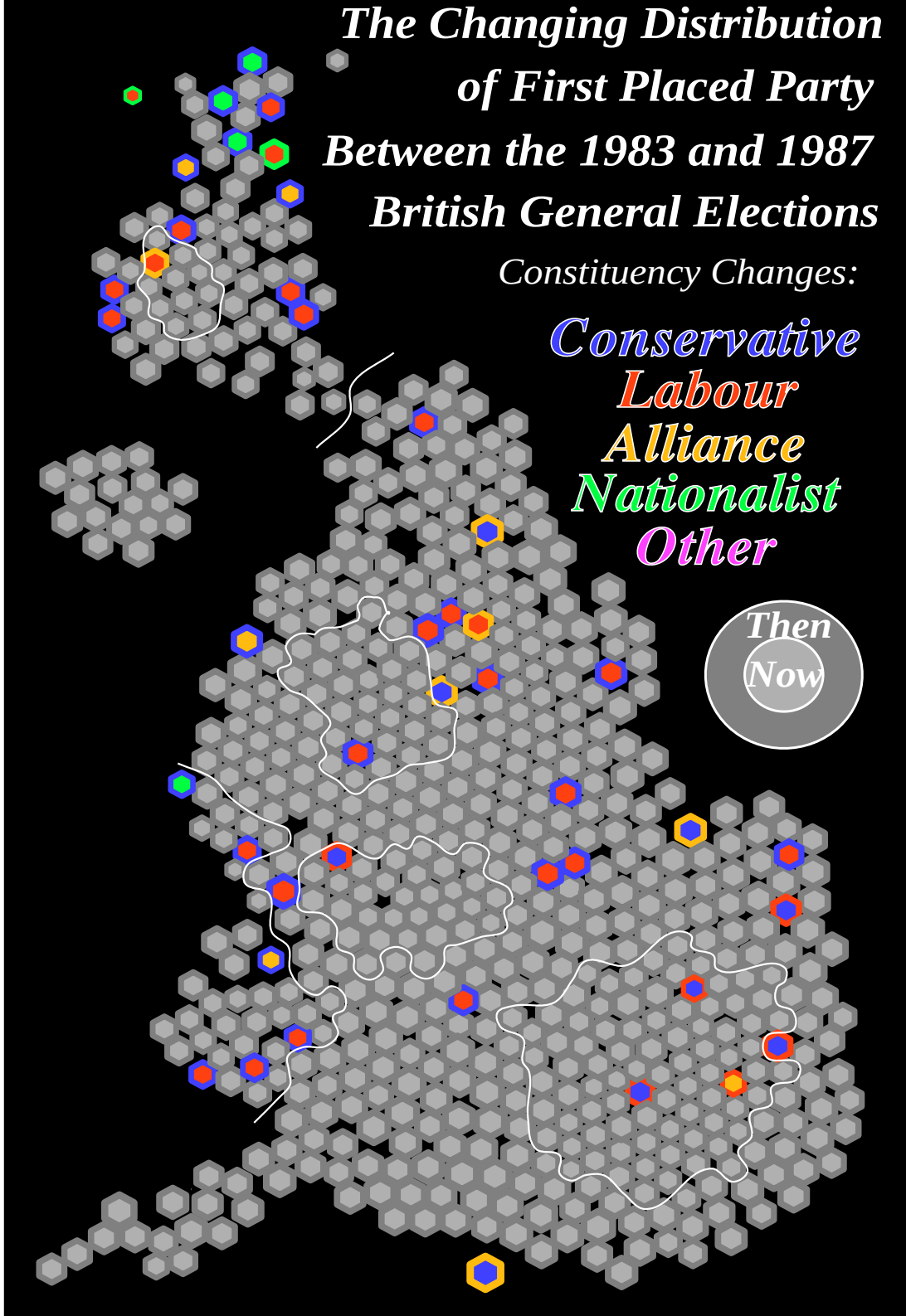


Figure 108 Print 138

Ten general election results

Up until now we have shown just one cartogram at a time. But the method is so efficient that here we show the results for every general election from 1955 to 1987. The cartogram labelled adjusted '79 shows a theoretical result of the subsequent boundary changes. With sequences over time, it is sometimes necessary to make adjustments for purely administrative changes.

Fig 5.17

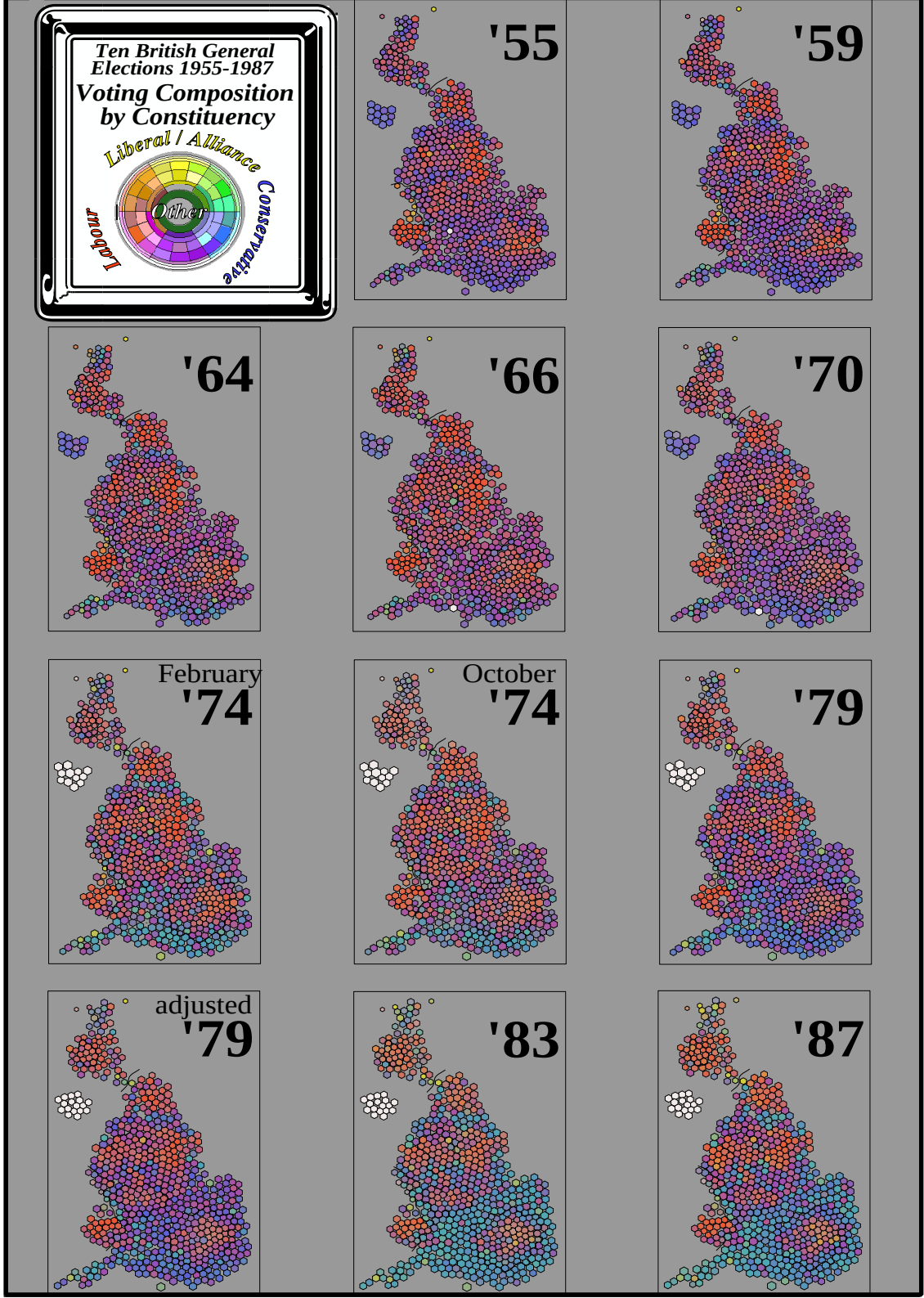


Figure 110 Print 100

Second placed parties, 1955-1987

Looking just at who came second in each of those same elections, shows again the rise of that third party, although our voting system did not reflect this in seats in parliament. This party came to control the balance of power in 2010. This colour scheme has no problem showing six political parties, which is not possible if the proportion of votes gained by each party is to be shown.
Fig 5.19

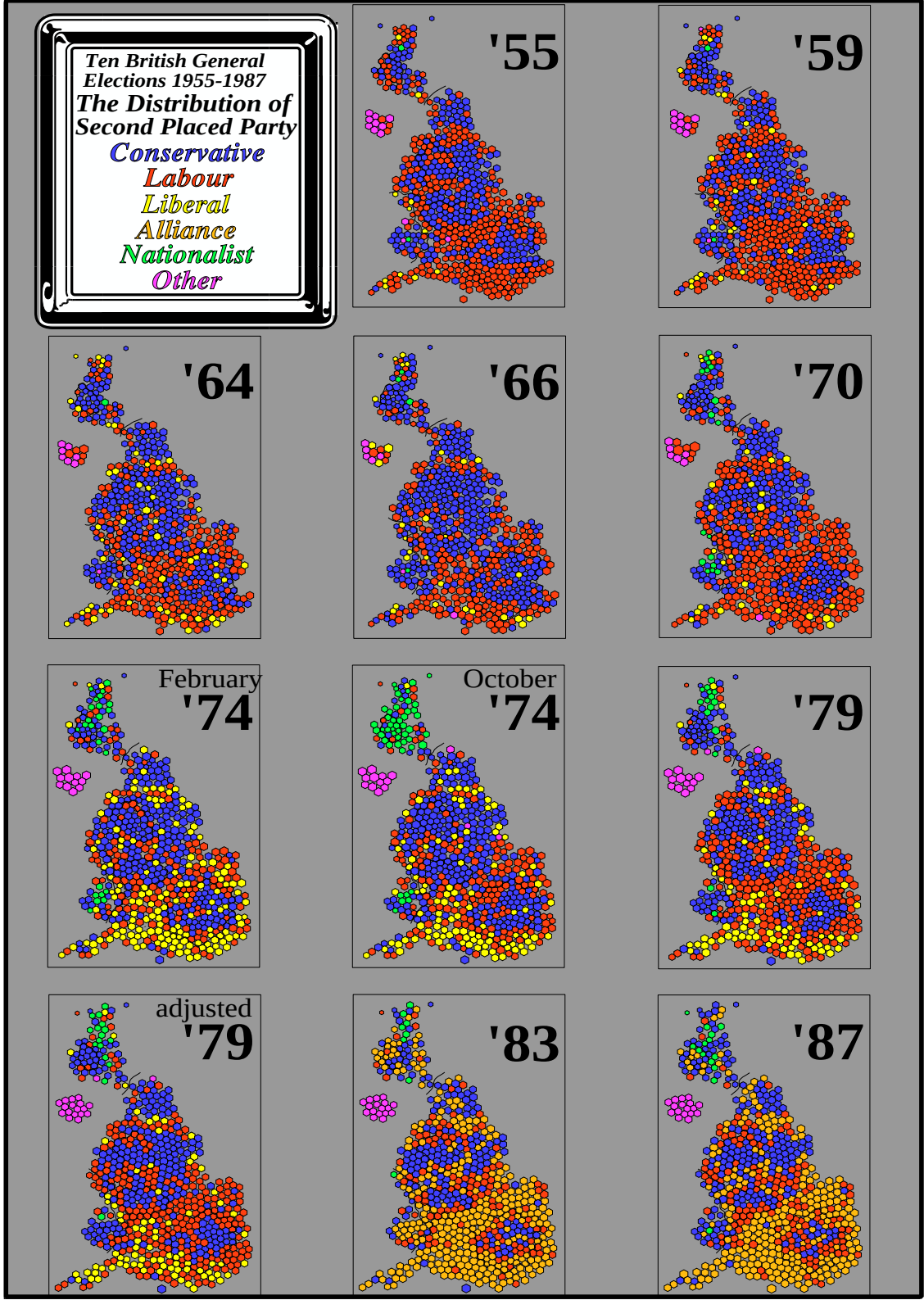


Figure 112 Print 102

Election turnout

Often forgotten is the number of registered electors who do not vote. This is not shown on the previous images. The national average percentage is given under each year, but it varies for a variety of reasons between constituencies. Adults are least likely to vote in the poorer parts of urban areas and that more so over time. Non-voters could have changed the results in almost all constituencies.

Fig 5.22

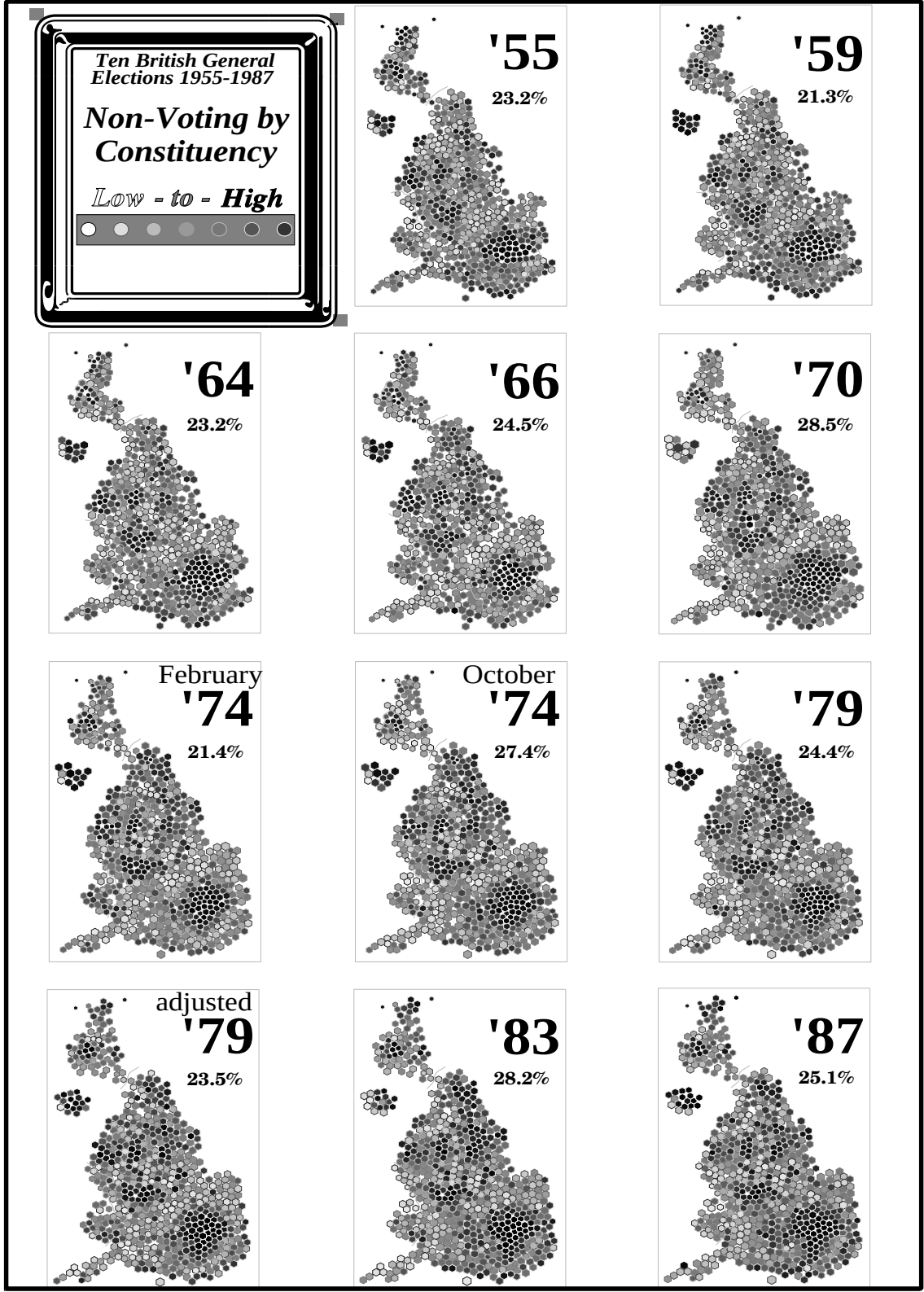


Figure 115 Print 103

Local elections

As well as more fairly depicting general elections, cartograms can be used to reveal all the detail of local elections. This cartogram has a simpler, but much clearer colouring scheme. In effect seats are shown as three-way marginals, two-way marginals, relatively safe, and safe seats. Colour mixing is used to show voting proportions. Only in safe seats, can you not see which party came seond.
Fig 4.21

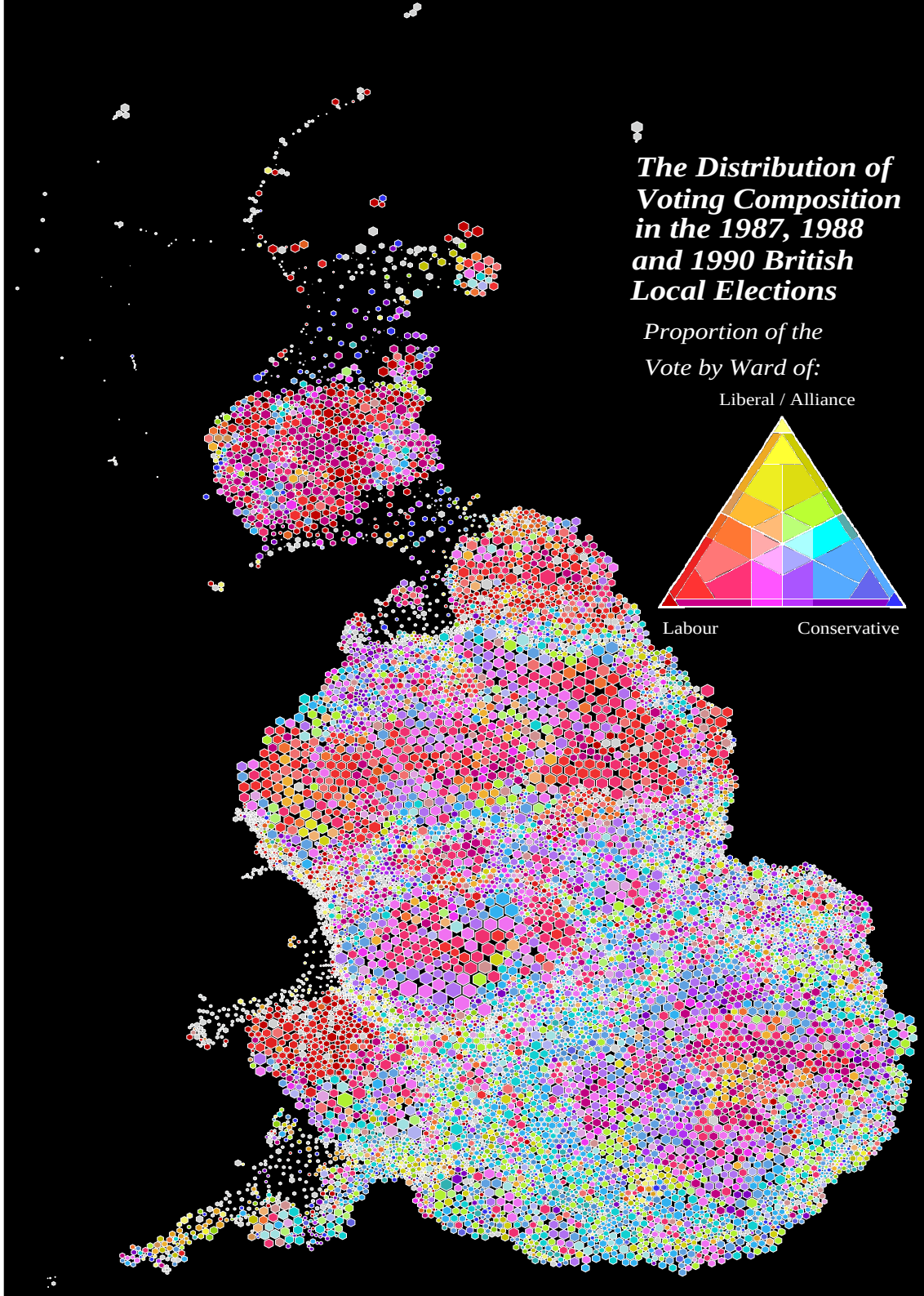


Figure 093 Print 086

Moving house map

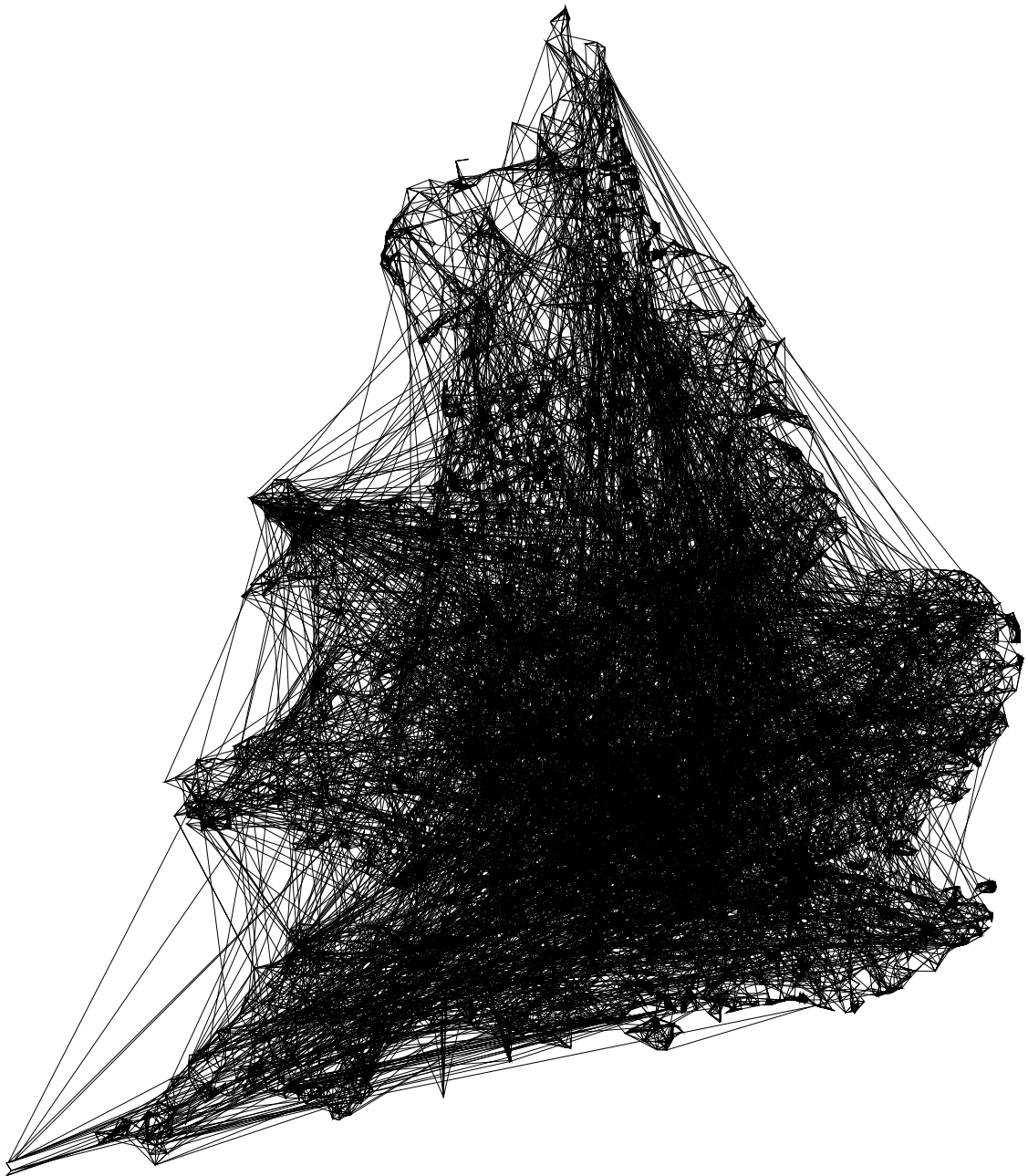
Here is a completely different subject. It is about people moving house. The image is based on an invisible map of local wards. The lines connect wards with a significant annual migratory flow of people between them. Apart from creating a rough shape of England and Wales, and showing the Isle of Wight, it does not reveal much. Even enlarged the centre remains very dark.
Fig P.3

Figure 003 Print 006A

Yearly Migration Flows Between English and Welsh Wards 1980/1981.

32% of all migrants included 1,352,520 people.

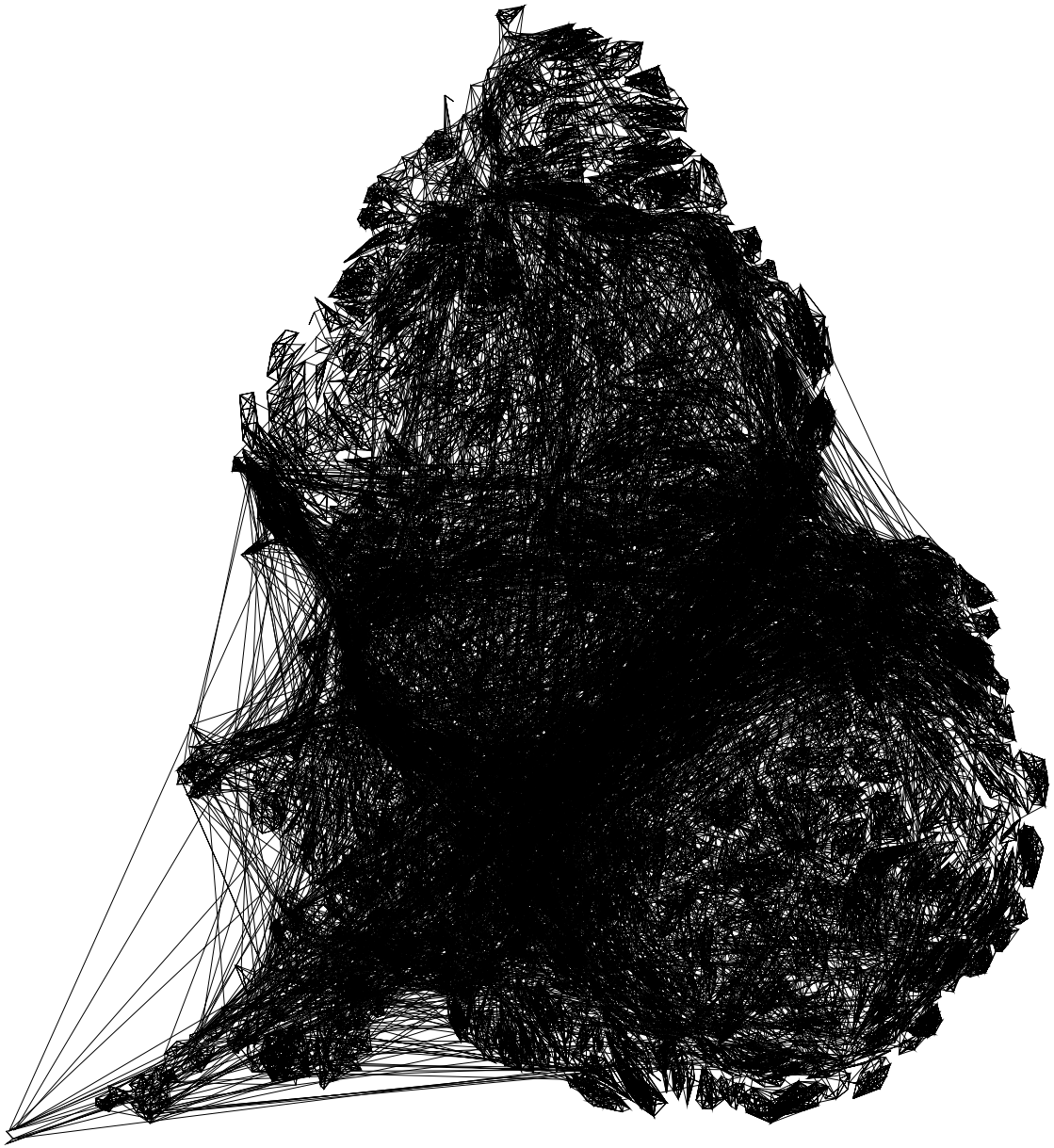
Flows of more than 0.2% of the geometric mean for the resident populations of the areas of origin and destination are drawn as thin lines, shown on an ***equal land area map.***



Moving house cartogram

These are the same lines, but drawn on an invisible ward population cartogram. Two groups show up. Inner city council tenants (this was 1980) who tended to move within a borough, shown by darker blobs, and people whose paths avoid the council estates and who live more on the outskirts of the conurbations. They tended to move home around them. This becomes clearer as you zoom in.
Fig P.4

Figure 004 Print 006B



Going to work map

This is about commuting. On an invisible map, lines show significant numbers of people commuting to the same ward. It shows people going into the cities, many of which can be identified simply from the spider's web of lines that converge on them. Occassionally there are some very long distance commutes that cross over sparsely populated areas and become prominent.
Fig 6.11

Daily Commuting Flows Between English and Welsh Wards in 1981.

50% of all commuters included 10,319,230 people.

Flows of more than 2% of the employed population at the area of residence are drawn as thin lines to their workplace, on a land area map.

Figure 126 Print 106

Going to work cartogram

This image shows the same lines of commuting just shown, but on an invisible ward population cartogram. It is much darker because on the cartogram far more area is given to the towns and cities which appear not as points but as substantial areas of employment. The areas between the urban conurbations are shrunk to narrow whiter bands. Zoom in for a clearer picture.
Fig 6.12

Figure 127 Print 107

Daily Commuting Flows Between English and Welsh Wards in 1981.

50% of all commuters included 10,319,230 people.

Flows of more than 2% of the employed population at the area of residence are drawn as thin lines to their workplace, ***on an equal area projection.***

Going to work in rural ares

The formula used for this ward cartogram results in showing more rural to work flows. It does this by reducing the significance, and therefore the number of lines shown, of flows to wards with a large daytime population. Thus large industrial, commercial and retail centres are suppressed. The cartogram can then show what routes other commuters take, all done by altering one formula.
Fig 6.13

Daily Commuting Flows Between English and Welsh Wards in 1981.

All flows which satisfy the following inequality are drawn as thin lines-

$$\frac{m_{ijst}}{p_{is}p_{jt}} > \frac{1}{50000}$$

Flows of over 1000 people drawn as thick lines.

Where-

m_{ijst} : The number of people moving from place i to j between times s and t.

p_{is} : The number of people at place i time s.

i: Place of residence.

j: Place of work.

s: Nighttime.

t: Daytime.

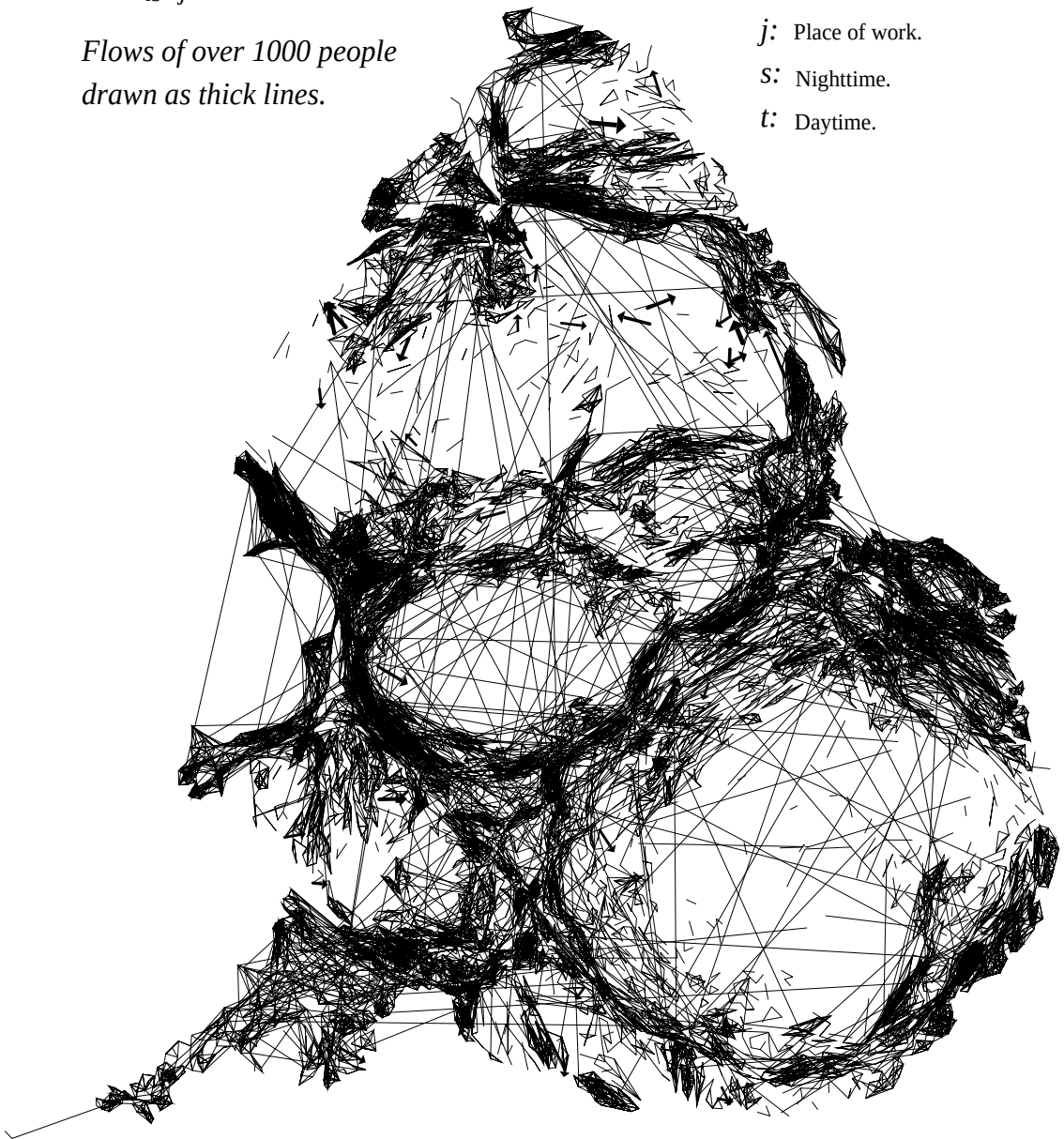


Figure 128 Print 108

Going to work in cities

This ward cartogram uses a formula that shows more commuting into areas with a low night-time population. City centres often have a much lower night-time than day-time population. Hull, central Manchester, but especially central London stand out most clearly as areas with a huge influx of workers each morning and exodus each night.
Fig 6.14

Figure 129 Print 109

Daily Commuting Flows Between English and Welsh Wards in 1981.

Where-

m_{ijst} : The number of people moving from place i to j between times s and t.

p_{is} : The number of people at place i time s.

i: Place of residence.

j: Place of work.

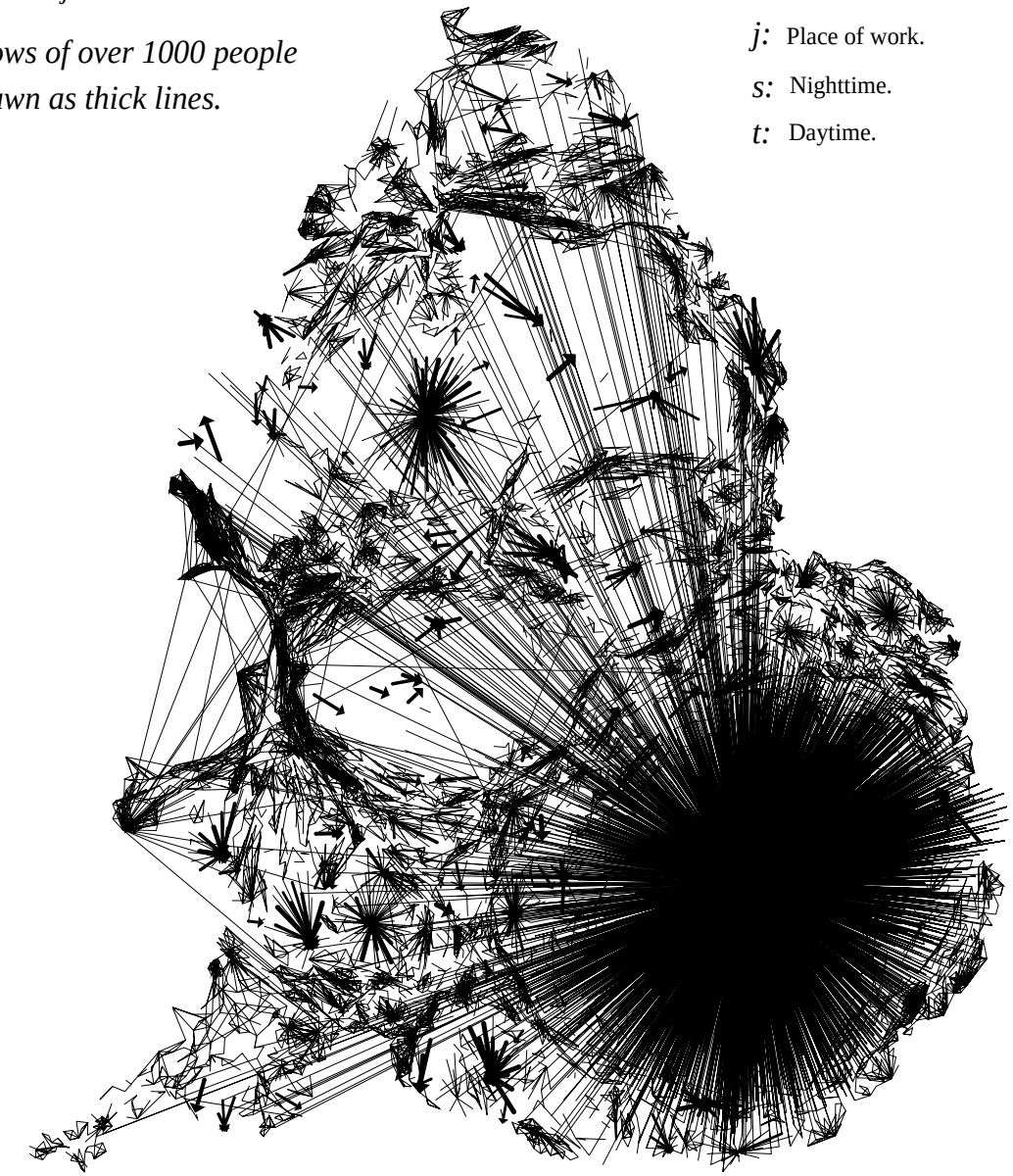
s: Nighttime.

t: Daytime.

All flows which satisfy the following inequality are drawn as thin lines-

$$\frac{m_{ijst}}{p_{is}p_{js}} > \frac{1}{25000}$$

Flows of over 1000 people drawn as thick lines.

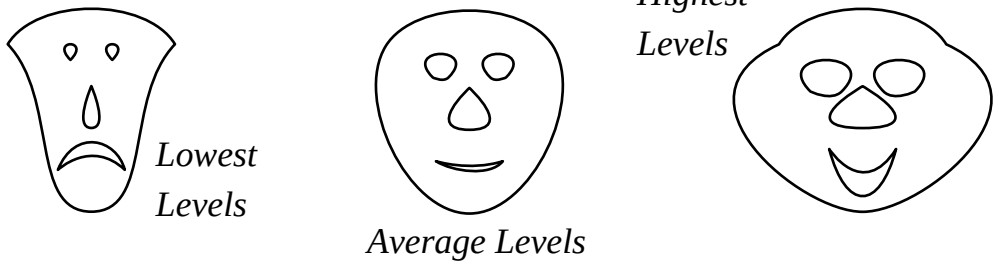


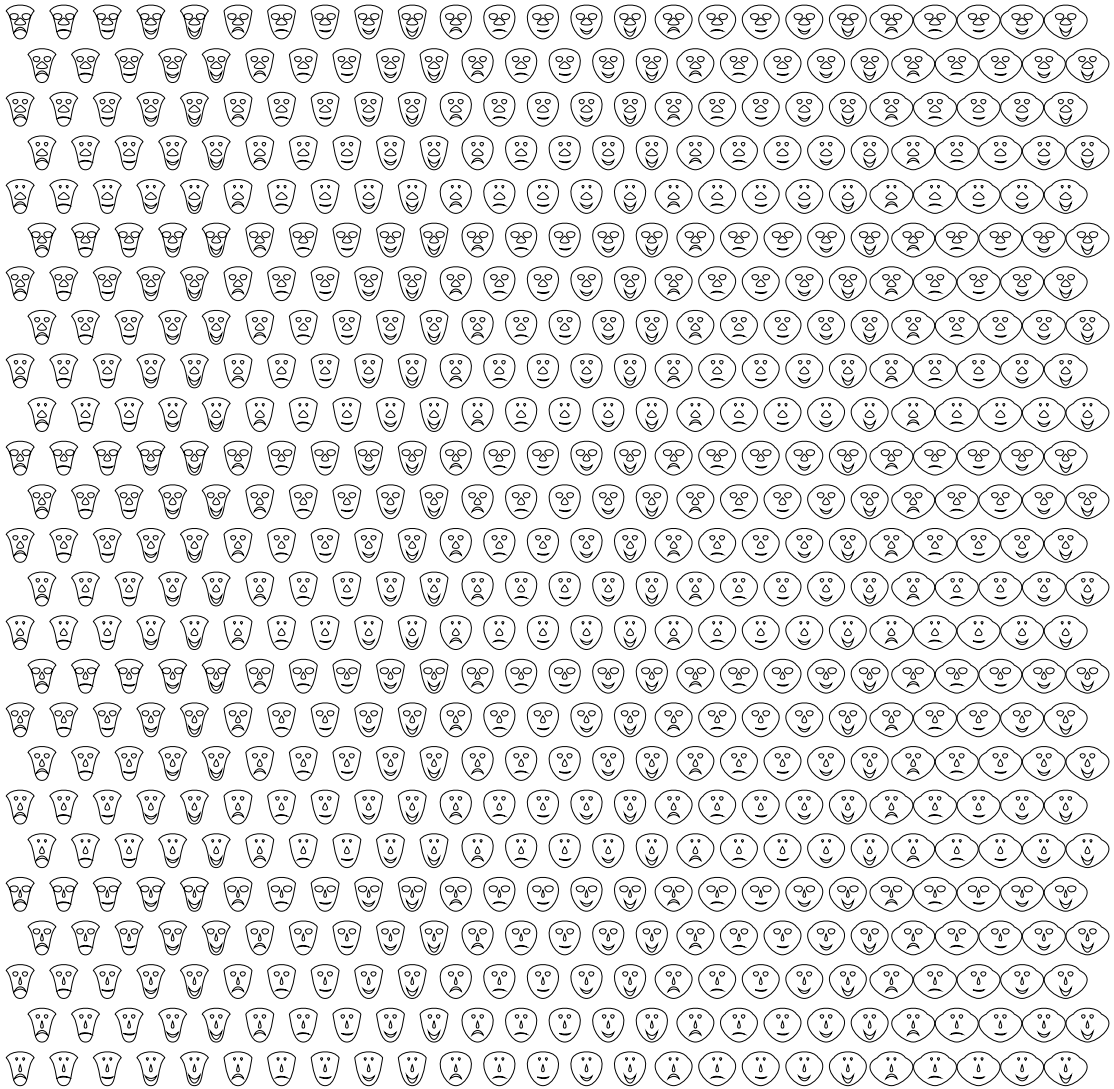
Cartoon faces

The faces shown here can be used to show values. The size of the eyes can represent the value of one variable, the width of the nose, the shape of the mouth and the fullness of the cheeks three other variables. Between each large face shown at the top, there is an intermediate one. With each variable having up to five values, there are up to 625 possible permutations of the features, depending on the data. Fig 8.7

Figure 154 Print 150

625 Chernoff Faces Showing All Permutations of 5 levels of four features - cheeks, eyes, nose and mouth.





Mapping using cartoon faces

This is a parliamentary constituency cartogram. A circle touching the top and bottom of each face would be proportional to the population. Four variables affect the features of each face; service industries the eyes, voting turnout the nose, unemployment the mouth and cost of housing the cheeks. Groups with similar features become apparent as you study the image.

Fig 8.11

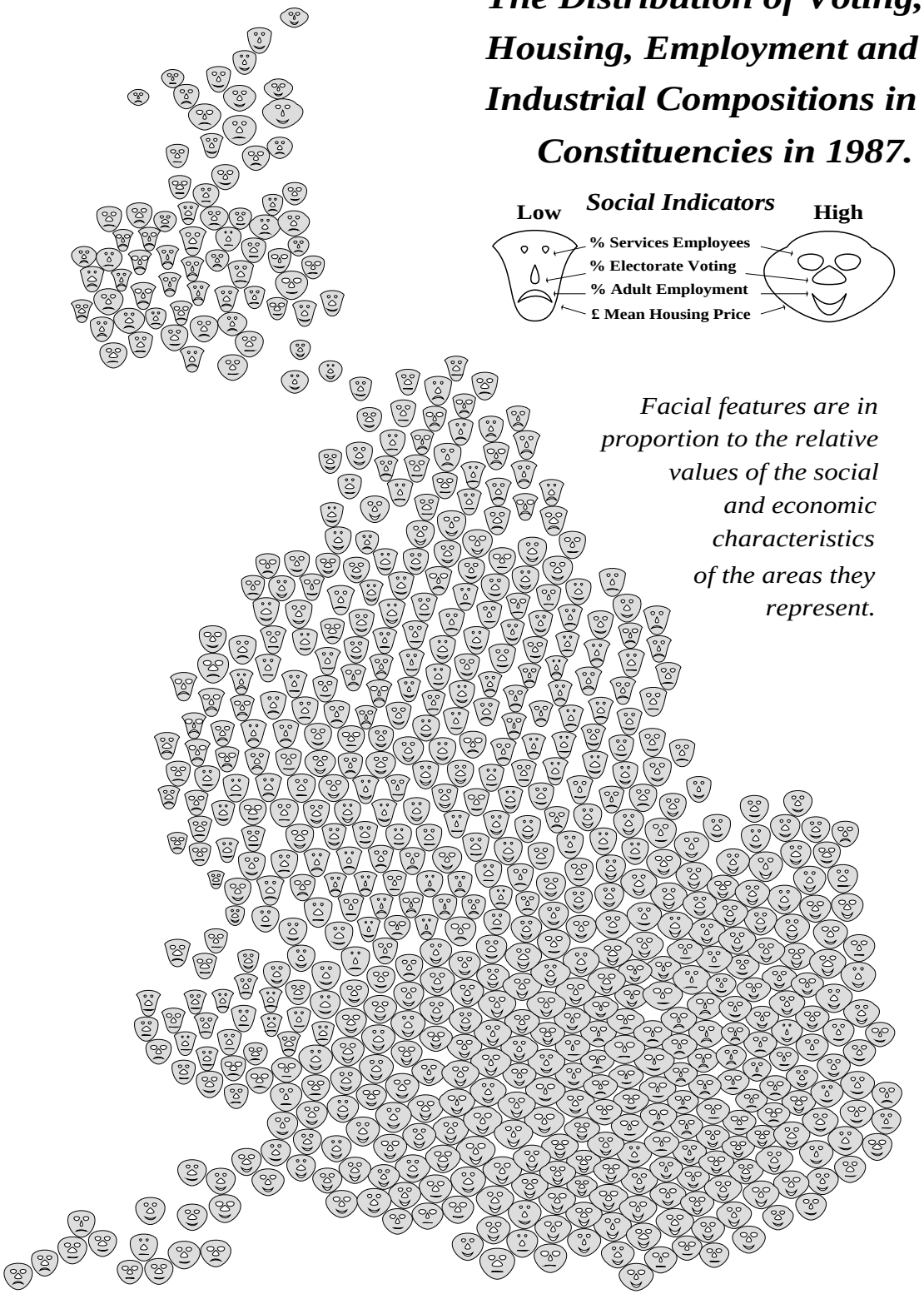


Figure 158 Print 152bw

Mapping with coloured faces

This is the previous parliamentary constituency cartogram, but coloured to show the voting composition in the general election of 1987. This tends to highlight the same groups that were previously apparent, because people's circumstances affect how they vote. The patterns often become clearer when colour is added, but you can also see faces that stand out in the crowd.

Fig 8.10

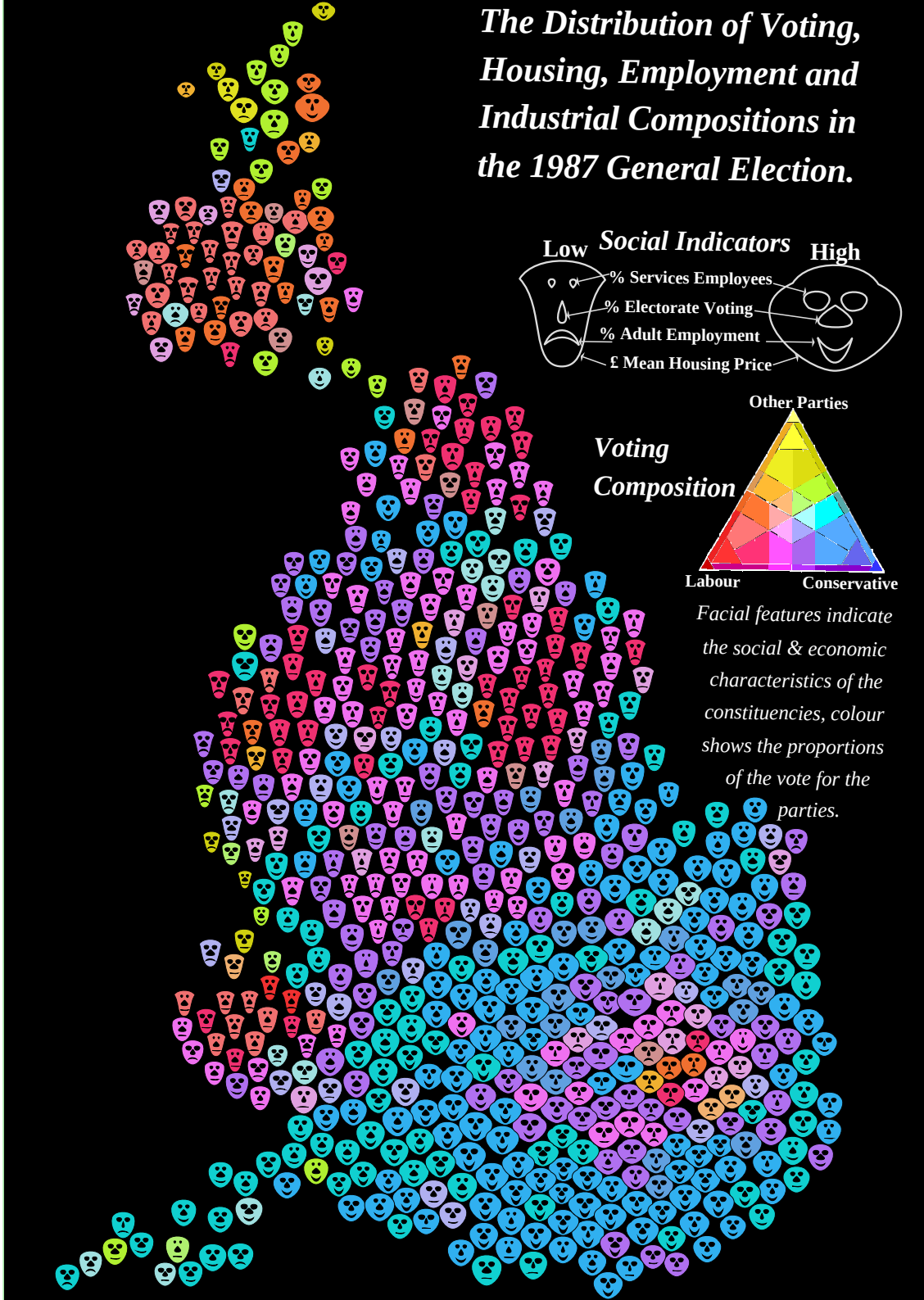


Figure 157 Print 152

Not the end

If you would like to see where some of these new mapping techniques have been use go to: http://en.wikipedia.org/wiki/Danny_Dorling#Atlases and follow the links.

For more of an international view, see: http://www.worldmapper.org/
There every map is a unique cartogram created by the data being shown, only the population maps are population cartograms.
For even more mapping techniques and 150 more illustrations, see:

The Visualisation of Spatial Structure