NEW WAYS OF MAPPING OLD INFORMATION

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Abstract

This paper demonstrates how new visualization techniques are being used to analyze the results of British censuses and mortality, election and employment records. The purpose of analyzing these statistics is to show how communities have developed over time and to explore how the different facets of life in Britain, which these statistics reflect, may be geographically related to one another.

The argument for developing these new techniques is that complex questions concerning spatial change across many aspects of society can only be answered in a trivial manner by conventional quantitative techniques. This is because the nature of the relationships are unlikely to be simple enough to be presentable in tables or by equations. Detailed maps are needed to show how different processes occur in different places while global patterns need also to be seen without generalizing out local detail. Neither traditional thematic mapping nor commercial geographic information systems can do justice to the wealth of data that has become accessible to researchers in recent years.

Introduction

Several years ago a paper was published which argued that, since 1800, developments in statistical graphics were primarily the result of an expanding amount of quantitative data available to be analyzed (Beniger and Robyn 1978). The decade following that publication saw the rapid development of Geographical Information Systems primarily, it could be argued, because so much new geographical information became available so quickly. Geographical Information Systems came to depend increasingly on computer graphics. These changes to the way in which geographical data is analyzed cannot be understood in isolation because they are part of a science-wide shift for which the term "visualization"

was adopted (Fisher et al 1993). What all these developments had in common was the invention of new forms of "statistical graphics." However, the graphics introduced into most Geographical Information Systems were not particularly innovative. They were often only poor screen imitations of traditional topographic maps. Very few attempts have been made to use the computer to produce graphics which could not be drawn by hand by cartographers, and very little attention has been paid to visualizing subjects other than physical geography. Here an attempt is made to introduce innovative graphics which could not be created without a computer and which may be of wider use in understanding human geography.

The paper is organized according to the topics being studied: population, mortality, elections and employment. These are just a sample of the variables which a social scientist in Britain can now gain access to with relative ease. A decade ago considerable effort would have been required to collect only a fraction of the information displayed here. The illustrations shown here are brought together to illustrate some of the problems and limits for visualizing socioeconomic data over time and space. New ways of mapping old information are best evaluated by what they can reveal about topics of practical interest.

Population

As the availability of data in digital form has grown, new graphical methods have developed to make the ever more complex statistics derived from them visible. Figure 1 portrays the finest resolution information available in Britain on population changes over the course of this century. For the first year of each decade (other than 1941 when the census was canceled due to war) the population has been estimated for each local authority district as it was constituted following the boundary changes of 1974 (Mounsey 1982). Eight periods of change can be discerned. To be compared, all of these maps must be visible simultaneously. The simplest solution is to place eight maps side-by-side on a page, each map showing each district shaded according to the percentage change in its population over a particular period. On conventional maps (printed in the space available here) the most densely populated districts containing the majority of the population would not be visible. The thickness of the lines needed to drawn these districts boundaries would be wider than the districts themselves. This is just one reason why population cartograms are used here--other arguments for their adoption have been given elsewhere (Dorling 1993). Each

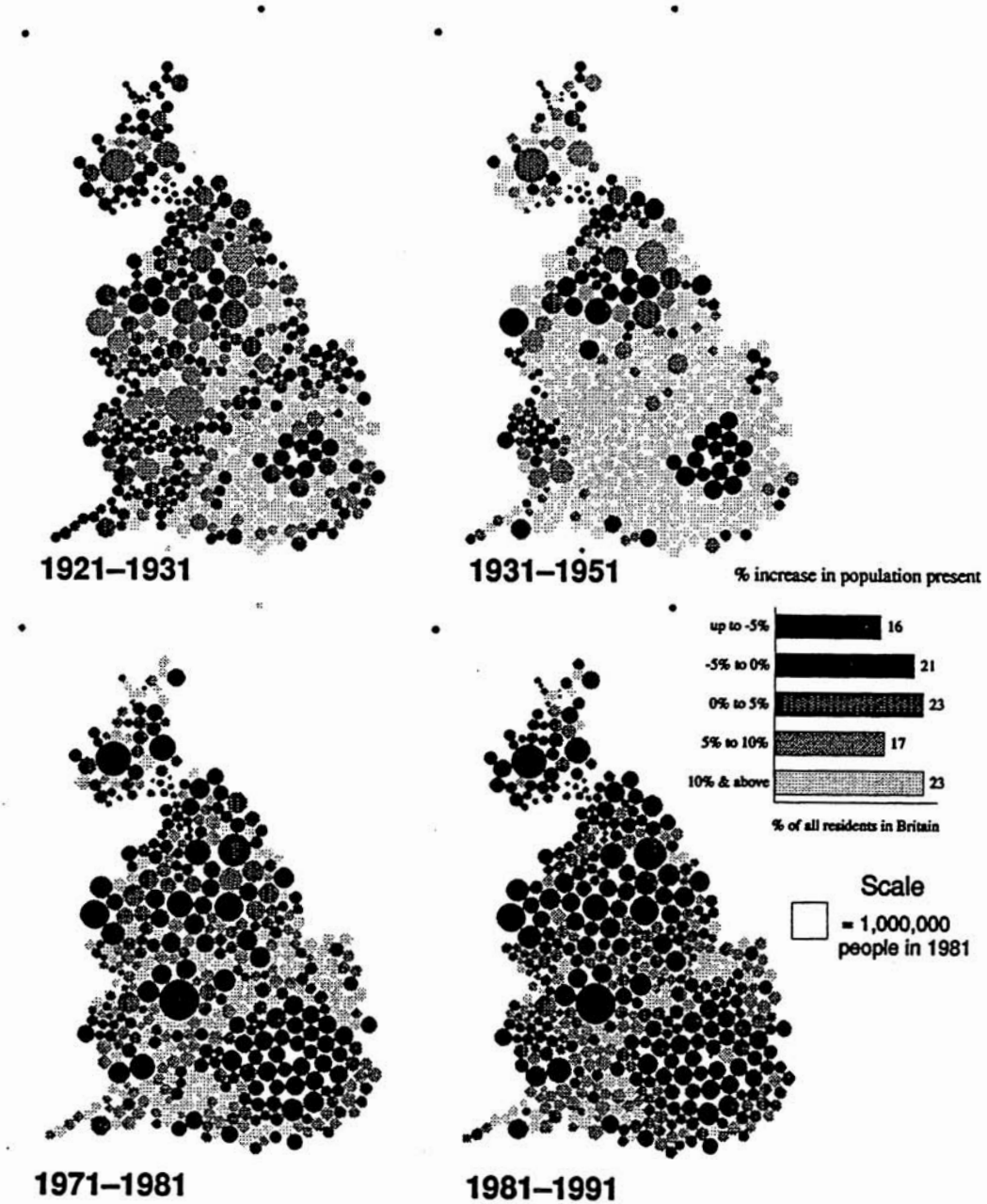
district is drawn in proportion to its population in 1981. A key is given in Figure 2, which shows how many districts were used to create the previous illustration.

The cartograms show how Inner London has been declining in population over the whole of this century with the single exception being an increase in Tower Hamlets recorded by the last census. The fate of individual districts can be traced. For instance Birmingham (Figure 1, circle 33, just left of center) grew in population until the 1960s after which it declined by over 5% per decade. Individual decades can also be contrasted. What marked the 1920s most was suburbanization of the Outer London boroughs, whereas the 1980s has seen strong growth only in a few small rural districts around the home counties. To make observations such as these, however, the new mental map of Britain depicted by this cartography has to be learned. Another problem with this method of depiction is understanding how the population of a group of districts changed in a region such as Scotland. The eye has to follow each district individually across the decades, giving the mind time to forget the assimilated pattern.

Population shifts occur at a much finer scale than administrative districts, which might well obscure subtle changes through the modifiable areal unit problem (Openshaw 1982). Visualization has been seen as one possible palliative for the adverse influence of areal unit boundaries on changing population patterns (Fotheringham 1989), but to visualize detail we first need fine data. Only since the 1971 census have we had fine resolution socioeconomic data which could be compared with later censuses. Just as the population count was reaggregated from each census of this century to a consistent set of areal units, so the small area statistics of the last three censuses have been reaggregated for the same areal units. The wards from one census (1981) have been *frozen* and the enumeration district statistics of the previous and subsequent censuses aggregated into them using a Geographical Information System. Some programming and a great deal of manual effort was also required to achieve this (Atkins et al 1993). This situation contrasts strongly with the geography of the American census which has been frozen at the county level for many decades.

Figure 3 shows the 1991 distribution of English born residents on a population cartogram in which each 1981 ward is drawn with its area in proportion to its population. County boundaries are shown as black lines corresponding to the key map in Figure 3. This key also appears in subsequent figures as appropriate. Scotland and Wales obviously have the lowest

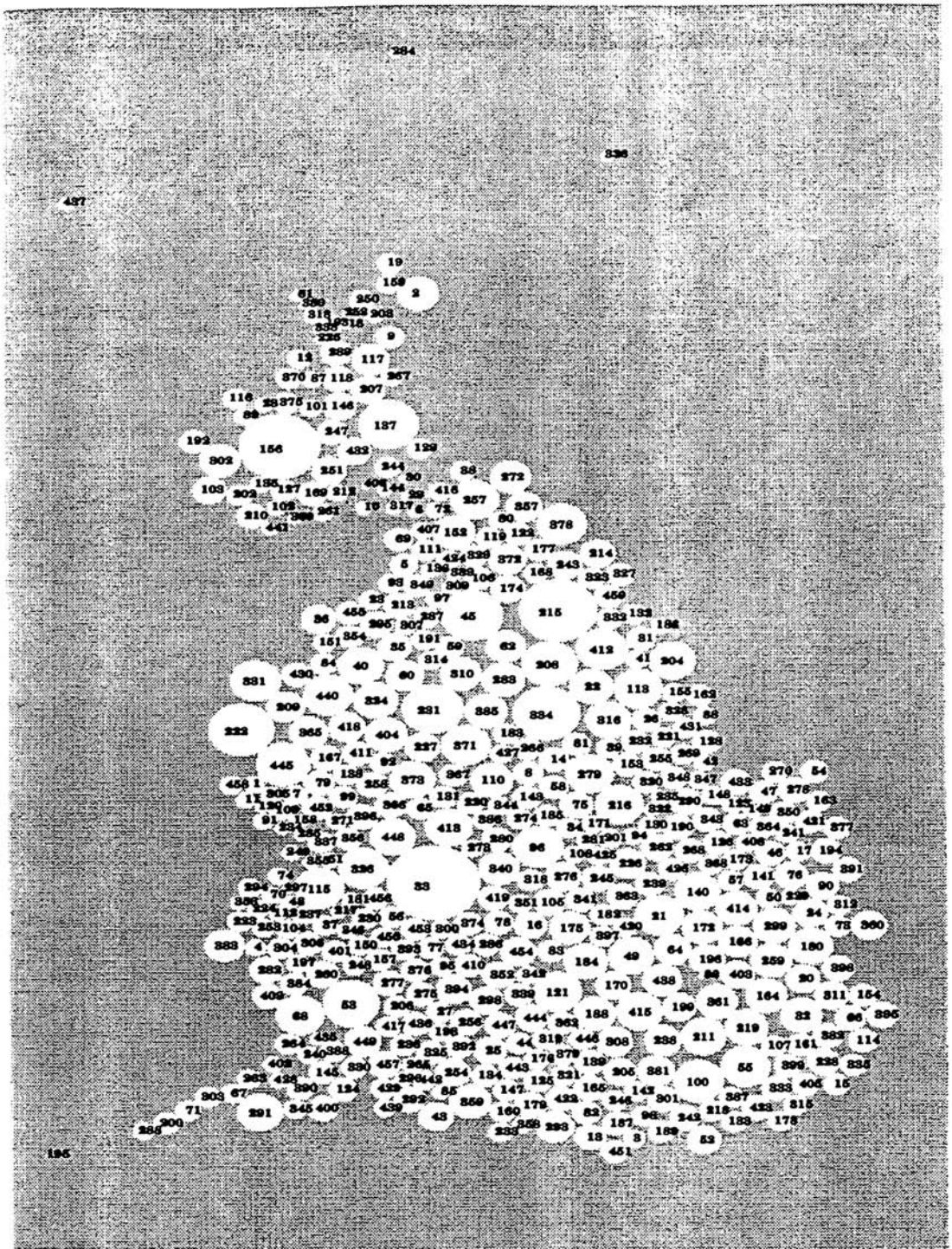
Figure 1. Population Change 1901 to 1991 (shown within 1981 local authority district boundaries)


1921–1931
1931–1951
% increase in population present
up to -5%
16
-5% to 0%
21
0% to 5%
23
5% to 10%
17
10% & above
23
% of all residents in Britain
Scale
= 1,000,000 people in 1981
1971–1981
1981–1991

Local Authority Districts

1 Aberconwy
2 Aberdeen City
3 Adur
4 Alan
5 Allerdale
6 Alnwick
7 Alyn and Deeside
8 Amber Valley
9 Angus
10 Annandale and Eskdale
11 Arfon
12 Argyll and Bute
13 Arun
14 Ashfield
15 Ashford
16 Aylesbury Vale
17 Babergh
18 Badenoch and Strathspey
19 Banff and Buchan
20 Barking and Dagenham
21 Barnet
22 Barnsley
23 Barrow-in-Furness
24 Basildon
25 Basingstoke and Deane
26 Bassetlaw
27 Bath
28 Bearsden and Milngavie
29 Berwick-upon-Tweed
30 Berwickshire
31 Beverley
32 Bexley
33 Birmingham
34 Blaby
35 Blackburn
36 Blackpool
37 Blaenau Gwent
38 Blyth Valley
39 Bolsover
40 Bolton
41 Boothferry
42 Boston
43 Bournemouth
44 Bracknell
45 Bradford
46 Braintree
47 Breckland
48 Brecknock
49 Brent
50 Brentwood
51 Bridgnorth
52 Brighton
53 Bristol
54 Broadland
55 Bromley
56 Bromsgrove
57 Broxbourne
58 Broxtowe
59 Burnley
60 Bury
61 Caithness
62 Calderdale
63 Cambridge
64 Camden
65 Cannock Chase
66 Canterbury
67 Caradon
68 Cardiff
69 Carlisle
70 Carmarthen
71 Carrick
72 Castle Morpeth
73 Castle Point
74 Ceredigion
75 Charnwood
76 Chelmsford
77 Cheltenham
78 Cherwell
79 Chester
80 Chester-le-Street
81 Chesterfield
82 Chichester
83 Chiltern
84 Chorley
85 Christchurch
86 City of London
87 Clackmannan
88 Cleethorpes
89 Clydebank
90 Colchester
91 Colwyn
92 Congleton
93 Copeland
94 Corby
95 Cotswold
96 Coventry
97 Craven
98 Crawley
99 Crewe and Nantwich
100 Croydon
101 Cumbernauld and Kilsyth
102 Cumnock and Doon Valley
103 Cunninghame
104 Cynon Valley
105 Dacorum
106 Darlington
107 Dartford
108 Daventry
109 Delyn
110 Derby
111 Derwentside
112 Dinefwr
113 Doncaster
114 Dover
115 Dudley
116 Dumbarton
117 Dundee City
118 Dunfermline
119 Durham
120 Dwyfor
121 Ealing
122 Easington
123 East Cambridgeshire
124 East Devon
125 East Hampshire
126 East Hertfordshire
127 East Kilbride
128 East Lindsey
129 East Lothian
130 East Northamptonshire
131 East Staffordshire
132 East Yorkshire
133 Eastbourne
134 Eastleigh
135 Eastwood
136 Eden
137 Edinburgh City
138 Ellesmere Port and Neston
139 Elmbridge
140 Enfield
141 Epping Forest
142 Epsom and Ewell
143 Erewash
144 Ettrick and Lauderdale
145 Exeter
146 Falkirk
147 Fareham
148 Fenland
149 Forest Heath
150 Forest of Dean
151 Fylde
152 Gateshead
153 Gedling
154 Gillingham
155 Glanford
156 Glasgow City
157 Gloucester
158 Glyndwr
159 Gordon
160 Gosport
161 Gravesham
162 Great Grimsby
163 Great Yarmouth
164 Greenwich
165 Guildford
166 Hackney
167 Halton
168 Hambleton
169 Hamilton
170 Hammersmith and Fulham
171 Harborough
172 Haringey
173 Harlow
174 Harrogate
175 Harrow
176 Hart
177 Hartlepool
178 Hastings
179 Havant
180 Haverring
181 Hereford
182 Hertsmere
183 High Peak
184 Hillingdon
185 Hinckley and Bosworth
186 Holderness
187 Horsham
188 Hounslow
189 Hove
190 Huntingdon
191 Hyndburn
192 Inverclyde
193 Inverness
194 Ipswich
195 Isles of Scilly
196 Islington
197 Islwyn
198 Kennet
199 Kensington and Chelsea
200 Kerrier
201 Kettering
202 Kilmarnock and Loudoun
203 Kincardine and Deeside
204 Kingston upon Hull
205 Kingston upon Thames
206 Kingswood
207 Kirkcaldy
208 Kirklees
209 Knowsley
210 Kyle and Carrick
211 Lambeth
212 Lanark(now Clydesdale)
213 Lancaster
214 Langbaurgh
215 Leeds
216 Leicester
217 Leominster
218 Lewes
219 Lewisham
220 Lichfield
221 Lincoln
222 Liverpool
223 Llanelli
224 Llw Valley
225 Lochaber
226 Luton
227 Macclesfield
228 Maidstone
229 Maldon
230 Malvern Hills
231 Manchester
232 Mansfield
233 Medina
234 Meirionnydd
235 Melton
236 Mendip
237 Merthyr Tydfil
238 Merton
239 Mid Bedfordshire
240 Mid Devon
241 Mid Suffolk
242 Mid Sussex
243 Middlesbrough
244 Midlothian
245 Milton Keynes
246 Mole Valley
247 Monklands
248 Monmouth
249 Montgomery
250 Moray
251 Motherwell
252 Naim
253 Neath
254 New Forest
255 Newark
256 Newbury
257 Newcastle upon Tyne
258 Newcastle-under-Lyme
259 Newham
260 Newport
261 Nithsdale
262 North Bedfordshire
263 North Cornwall
264 North Devon
265 North Dorset
266 North East Derbyshire
267 North East Fife
268 North Hertfordshire
269 North Kesteven
270 North Norfolk
271 North Shropshire
272 North Tyneside
273 North Warwickshire
274 North West Leicestershire
275 North Wiltshire
276 Northampton
277 Northavon
278 Norwich
279 Nottingham
280 Nuneaton and Bedworth
281 Oadby and Wigston
282 Ogwr
283 Oldham
284 Orkney Islands
285 Oswestry
286 Oxford
287 Pendle
288 Penwith
289 Perth and Kinross
290 Peterborough
291 Plymouth
292 Poole
293 Portsmouth
294 Preseli
295 Preston
296 Purbeck
297 Radnor
298 Reading
299 Redbridge
300 Redditch
301 Reigate and Banstead
302 Renfrew
303 Restormel
304 Rhondda
305 Rhuddlan
306 Rhymney Valley
307 Ribble Valley
308 Richmond upon Thames
309 Richmondshire
310 Rochdale
311 Rochester upon Medway
312 Rochford
313 Ross and Cromarty
314 Rossendale
315 Rother
316 Rotherham
317 Roxburgh
318 Rugby
319 Runnymede
320 Rushcliffe
321 Rushmoor
322 Rutland
323 Ryedale
324 Salford
325 Salisbury
326 Sandwell
327 Scarborough
328 Scunthorpe
329 Sedgefield
330 Sedgemoor
331 Sefton
332 Selby
333 Sevenoaks
334 Sheffield
335 Shepway
336 Shetland Islands
337 Shrewsbury and Atcham
338 Skye and Lochalsh
339 Slough
340 Solihull
341 South Bedfordshire
342 South Bucks
343 South Cambridgeshire
344 South Derbyshire
345 South Hams
346 South Herefordshire
347 South Holland
348 South Kesteven
349 South Lakeland
350 South Norfolk
351 South Northamptonshire
352 South Oxfordshire
353 South Pembrokeshire
354 South Ribble
355 South Shropshire
356 South Staffordshire
357 South Tyneside
358 South Wight
359 Southampton
360 Southend-on-Sea
361 Southwark
362 Spelthorne
363 St Albans
364 St Edmundsbury
365 St Helens
366 Stafford
367 Staffordshire Moorlands
368 Stevenage
369 Stewartby
370 Stirling
371 Stockport
372 Stockton-on-Tees
373 Stoke-on-Trent
374 Stratford-on-Avon
375 Strathkelvin
376 Stroud
377 Suffolk Coastal
378 Sunderland
379 Surrey Heath
380 Sutherland
381 Sutton
382 Swale
383 Swansea
384 Taff-Ely
385 Tameside
386 Tamworth
387 Tandridge
388 Taunton Deane
389 Teesdale
390 Teignbridge
391 Tendring
392 Test Valley
393 Tewkesbury
394 Thamesdown
395 Thanet
396 The Wrekin
397 Three Rivers
398 Thurrock
399 Tonbridge and Malling
400 Torbay
401 Torfaen
402 Torridge
403 Tower Hamlets
404 Trafford
405 Tunbridge Wells
406 Tweeddale
407 Tynedale
408 Uttlesford
409 Vale of Glamorgan
410 Vale of White Horse
411 Vale Royal
412 Wakefield
413 Walsall
414 Waltham Forest
415 Wandsworth
416 Wansbeck
417 Wansdyke
418 Warrington
419 Warwick
420 Watford
421 Waveney
422 Waverley
423 Wealden
424 Wear Valley
425 Wellingborough
426 Welwyn Hatfield
427 West Derbyshire
428 West Devon
429 West Dorset
430 West Lancashire
431 West Lindsey
432 West Lothian
433 West Norfolk
434 West Oxfordshire
435 West Somerset
436 West Wiltshire
437 Western Isles Islands
438 Westminster,City of
439 Weymouth and Portland
440 Wigan
441 Wigtown
442 Wimborne
443 Winchester
444 Windsor and Maidenhead
445 Wirral
446 Woking
447 Wokingham
448 Wolverhampton
449 Woodspring
450 Worcester
451 Worthing
452 Wrexham Maelor
453 Wychavon
454 Wycombe
455 Wyre
456 Wyre Forest
457 Yeovil
458 Ynys Mon-Isle of Anglesey
459 York

Figure 2. A Population Cartogram of Britain by Local Authority District (using 1981 populations)



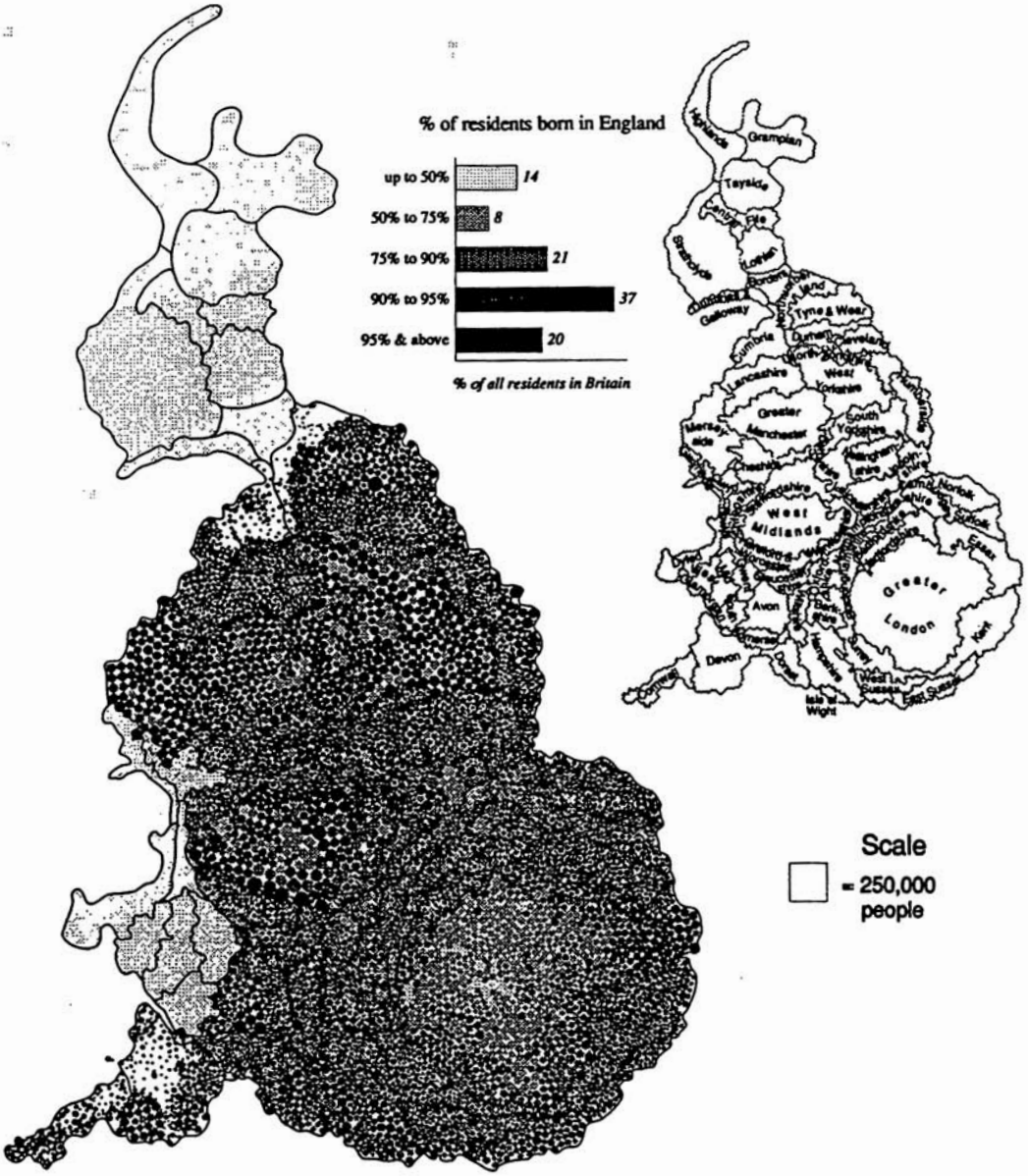


Figure 3. Residents born in England 1991 (showing them as a proportion of each ward's populations)

proportions of English born residents in each of their wards. It is evident from the figure that inside England only a few wards in London (and the home counties in general) do people live in areas where more than 90% of the population was born inside England. Further from the "Heart of England," near the Welsh border, and in the suburbs of the North West, Yorkshire and the North East, more than 95% of the population being English born is the norm. The southern shire counties, traditionally depicted as the epitome of all that is English are not, in a demographic sense, the most English parts of England.

Having census information available on a consistent basis makes comparisons of such small areas over a twenty year period possible. Changes over this length of time show how such areas have slowly altered over a generation, highlighting even slight shifts which might be imperceptible to many of the people living there. By showing net population change, Figure 4 suggests where the English have moved to and from over the last two decades. Rural Scotland and Wales have seen the greatest influx, whereas a distinct ring of wards between Outer and Inner London have seen the most concentrated decline in the proportion of their populations born in England. Despite the apparent sophistication of the illustration, this method of showing change over time is still crude, not allowing us to tell whether the cause is primarily excess immigration, or (English born) out-migration or mortality. We are also only looking at one variable for one time period and for one sub-group of the population.

Mortality

Census information is particularly useful when combined with other data. An example is medical statistics, in particular mortality data, which has been postcoded (and hence accurately grid-referenced) since 1981 and can thus be related to 1981 census wards in England and Wales[1]. Having linked the 1991 census data to these wards, it becomes possible to calculate variables at ward level for the 1980s using population data from two censuses and information on age and place of death in Britain up to 1989 (the latest year available at the time of writing). Figure 5 shows how little variation there is in average life expectancy across Britain (excluding Scotland). The graph by the figure shows that only 1.3% of the population live in wards where average life expectancy is less than seventy, whereas 8.1% live in areas where life expectancy is more than seventy

[1] Thanks are due to Prof Jarman and Dr. Bajakal of St. Mary's Hospital who helped make the mortality data available for this project.

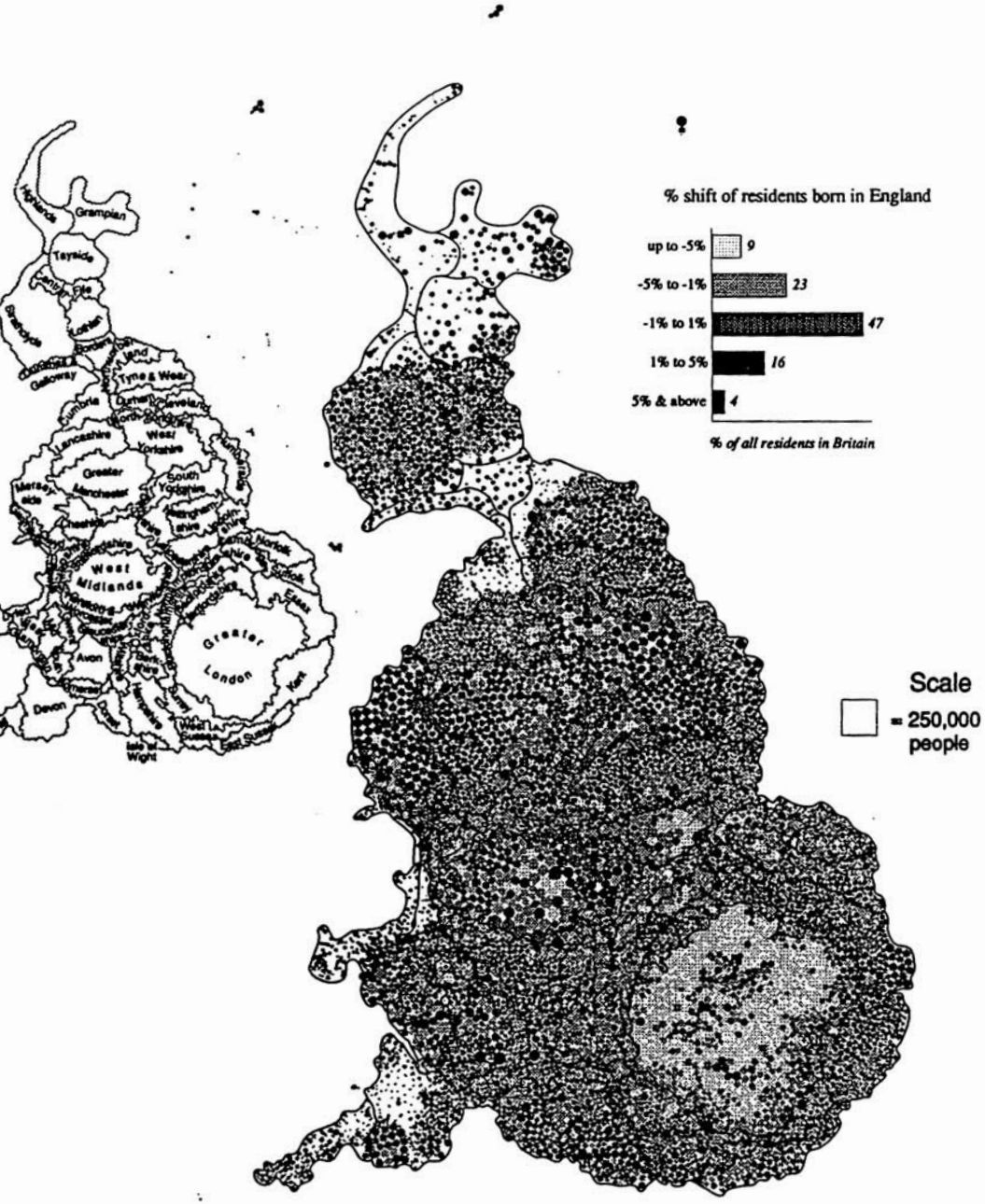


Figure 4. Residents born in England 1971 to 1991 (showing change in proprortion of ward populations)

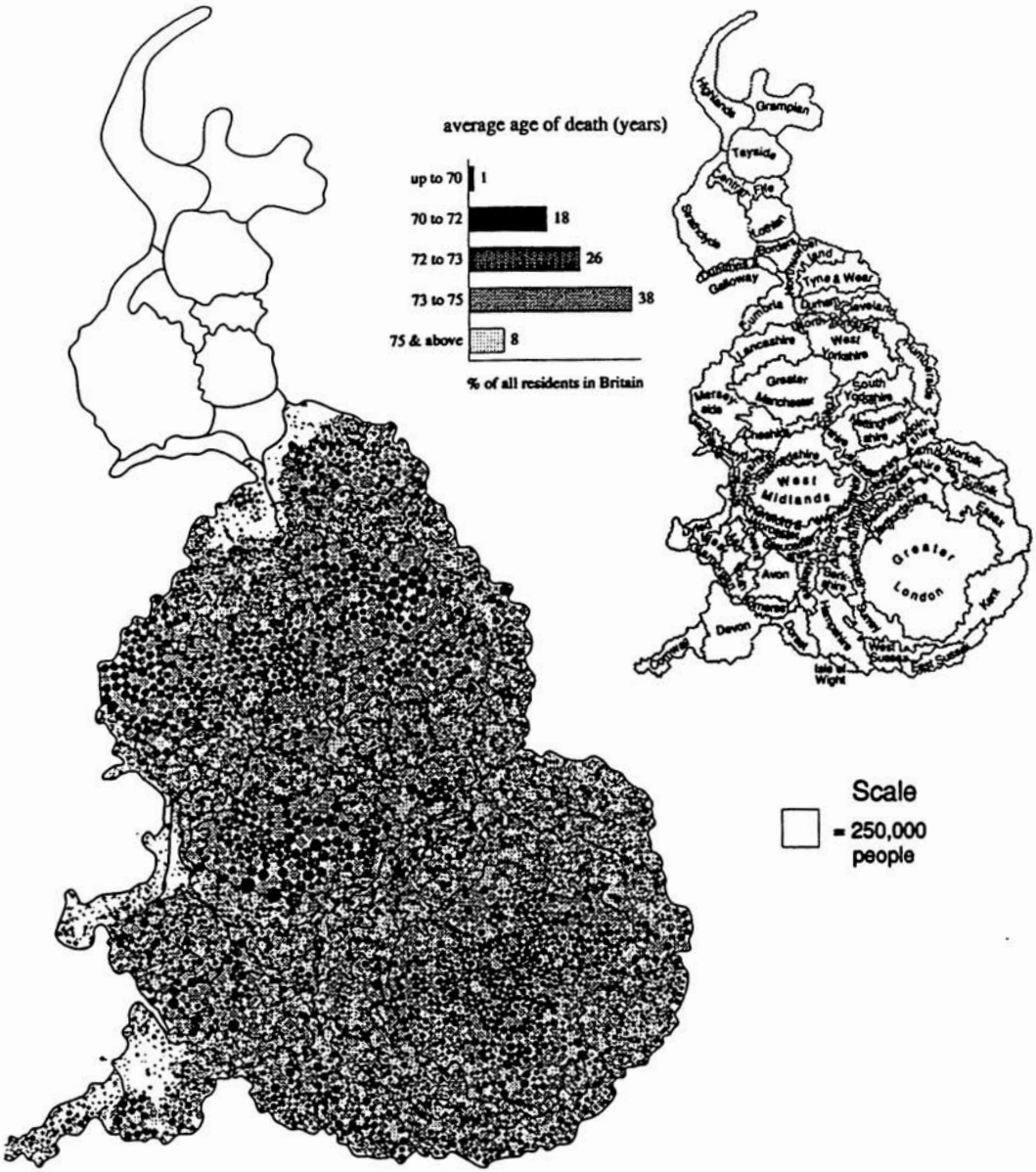


Figure 5. Average life expectancy by 1989 (showing ages standardized by ward age/sex distributions)

five. Despite this very low level of variation, an inner-city/outer-city divide is still evident.

Figure 6 shows how this divide grew during the 1980s. For confidentiality reasons mortality data at this spatial scale is only given with a temporal resolution of several years. The 1981 census distribution of people by age and sex was used to calculate standard mortality rates for the first half of the decade while the 1991 census was used as a basis for calculating the expected number of deaths according to the age and sex distribution of the population in each ward between 1986 and 1989 (Cliff & Haggett 1988). Standardized mortality rates rose at the centers of all the large conurbations and declined in rural areas. Again readers need to learn the geography of these cartograms to discern this information. Although it is true that for some wards the change in the standardized rate may well not be statistically significant, it is unlikely that a large group of contiguous wards showing an extreme change would arise out of random variation. The inner-city concentration of underenumeration in the 1991 census could lead to expected death rates being too low there, so the severity of the polarization shown by this figure should be viewed with some caution although the older age groups, who are most important to the estimation, are generally thought to have been well recorded (Dorling and Simpson 1993).

Standardized Mortality Ratios are particularly revealing when specific groups of diseases are being studied. Again the census ward age and sex distributions are needed for both 1981 and 1991 to be able to say with any confidence whether a particular ward had an above or below average number of deaths from one group of causes. Here just the static distributions are shown. Figures 7 and 8 show the geographical distribution of deaths from the two most common groups of causes, cardiovascular diseases and cancers, respectively. The former is clearly typified by a north-south divide, even when displayed at this fine spatial scale. The latter can be seen to be concentrated most amongst people living in the highly populated inner-city areas. These patterns would not be apparent on a conventional equal-area projection of the country. On the cartogram, for example, it is evident the old industrial areas along the River Tyne and the Thames stand out as having rates more than 25% above average. If it were possible to identify both the physical and human geography of these places simultaneously, by drawing the major rivers in, for example, speculation over possible environmental as well as social correlates could be made.

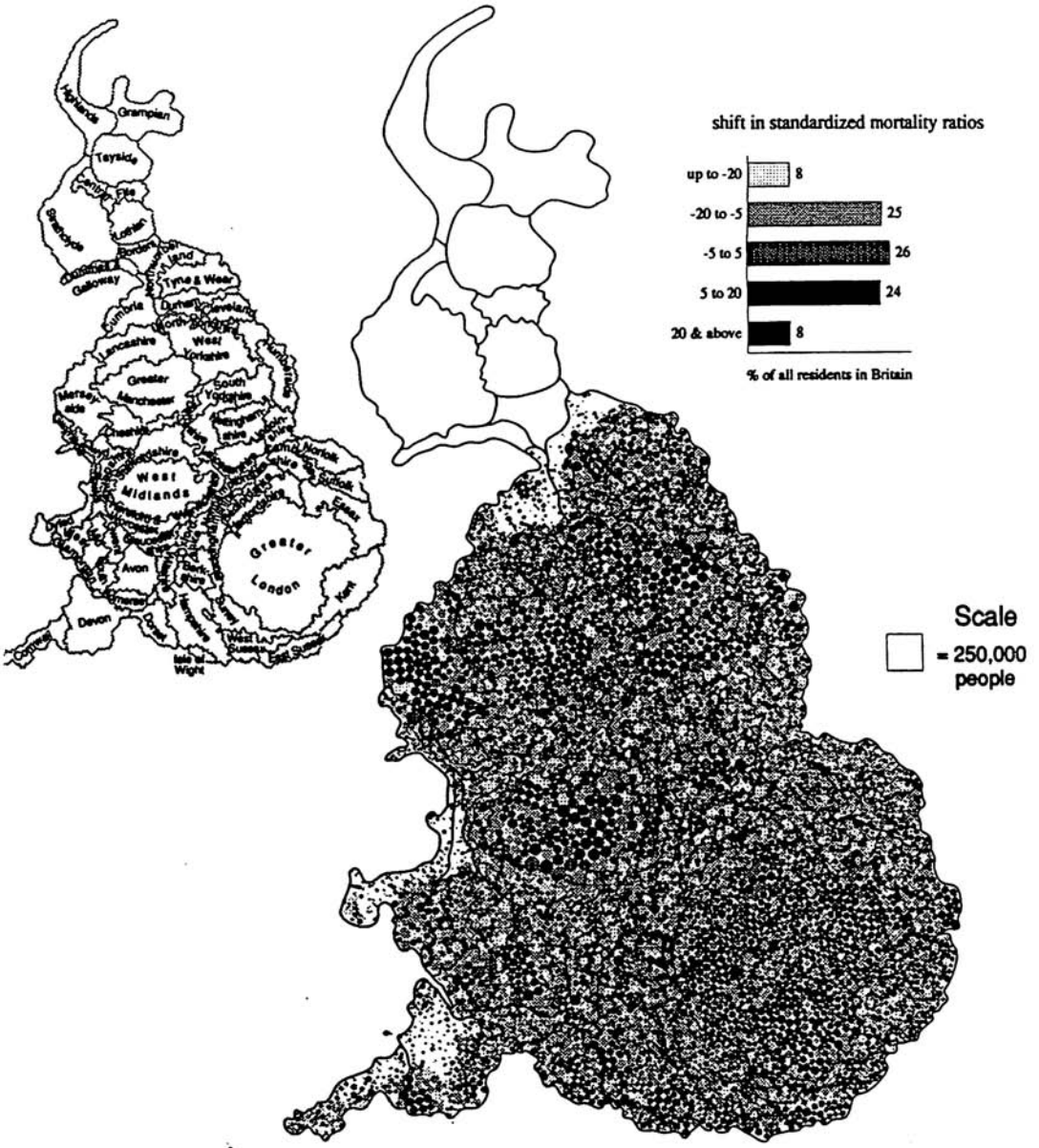


Figure 6. Mortality from all causes 1981-85 to 1986-89 (showing change in risk for ward populations)

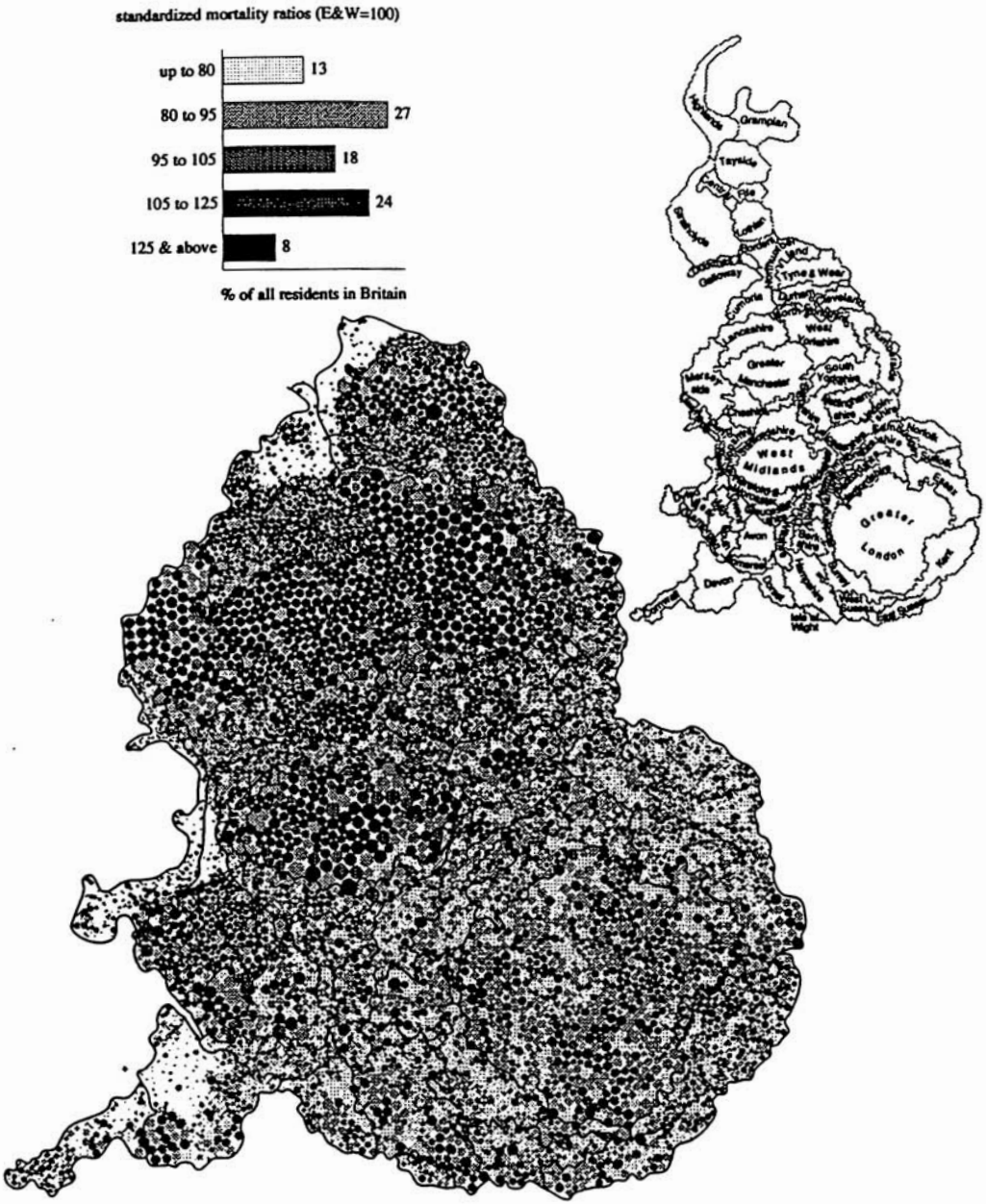


Figure 7. Mortality from Cardiovascular Diseases 1981-89 (showing relative risk for ward populations)

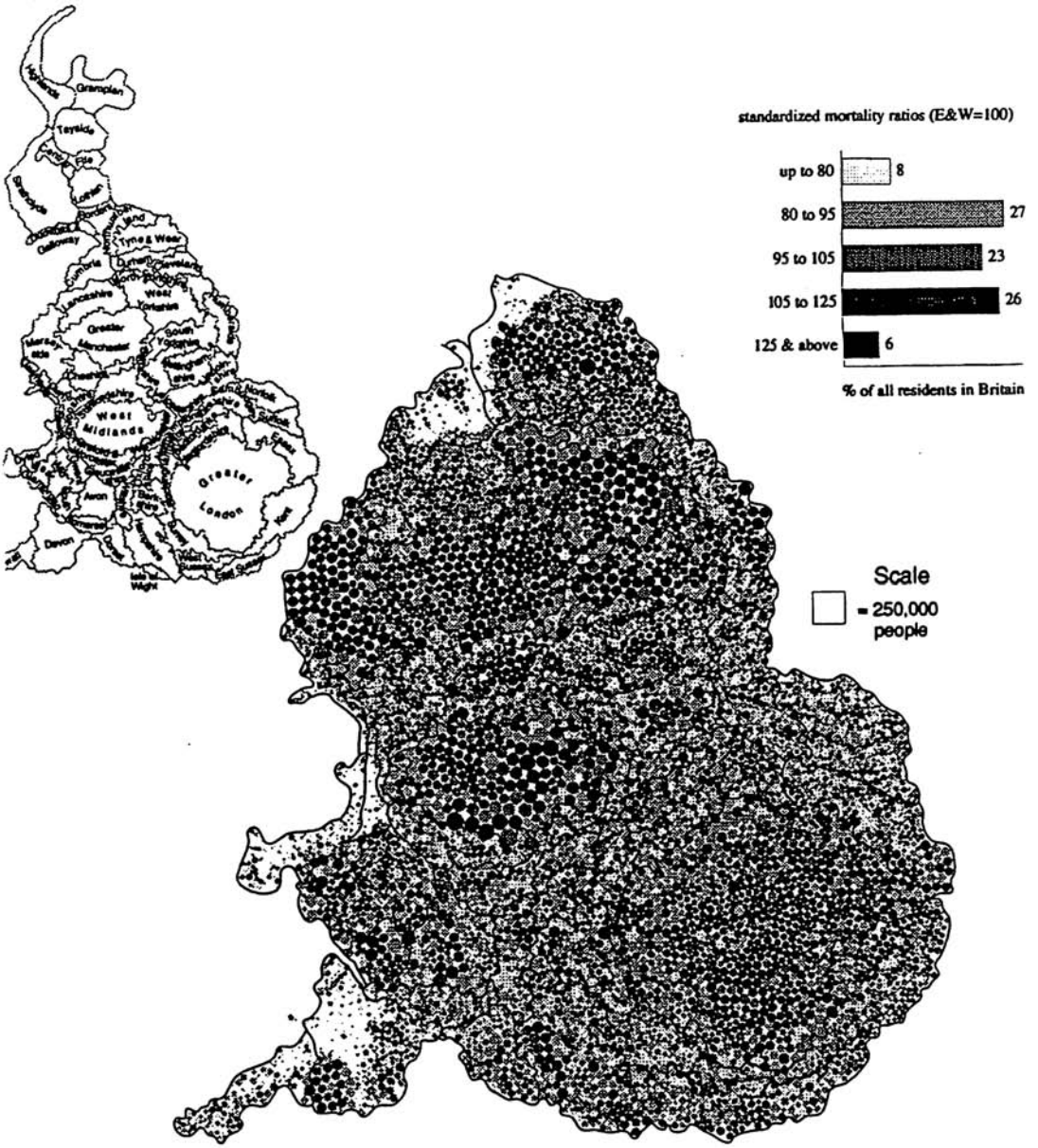


Figure 8. Mortality from Cancers 1981-89 (showing relative risk for ward populations)

Elections

Spatially detailed information on mortality has only been recorded during the last decade. If long time series of information are of interest then, in Britain, voting is the best recorded. In a country with three major parties colour mixing can be used to display how the votes are mixed between them. The major parties–Conservative, Labour and Liberal–can be represented by the primary colours of blue, red and yellow. A marginal Labour-Liberal seat can then be shown as orange, Liberal-Conservative as green and Conservative-Labour as purple and many shades between can be used to highlight more marginal and safe seats. This colour scheme results in a thirty-six pastel shade key (Dorling 1993) which was used in the original version of Figure 9. For clarity in this version of that figure the key has been simplified to show only four outcomes-demonstrating where each of the parties won the most votes in the British local elections leading up to 1991. Nevertheless the patterns are interesting, particularly when compared with the previous figures. Even more interesting are those which show how the electoral system is changing over time.

Figure 10 is a montage displaying the results of the eleven last general elections for each of over six hundred constituencies in the United Kingdom. It does not show which party won each seat, instead the party coming second is shown using four shades of grey. The two party system of the fifties and sixties can be seen to have evolved into a geographically distinct four party system by 1992, at least in terms of who comes second. In Scotland the Nationalists came second in more seats than any other party. Across the South it was the Liberal Democrats, relegating Labour's best chances to Outer London and the Midlands, and the Conservative's to the North and Wales.

This Figure is a little different in design when compared to Figure 1 as the shape of the cartogram changes over the decades, with the changing sizes of the electorates in each seat altering their constituencies' areas and positions on the paper. A population cartogram needs to be updated much more quickly than does a conventional map as population changes faster than topography. Two redistributions of seats had also to be incorporated in this illustration so between 1970 and 1974, and 1979 and 1983 some circles have disappeared and others have emerged in areas of population growth. Further details of this electoral series are given in Cornford et al (1993) which also uses this series of election results to project plausible future outcomes purely on historical precedent. Providing a key to this figure is not easy as the locations of constituencies move in population

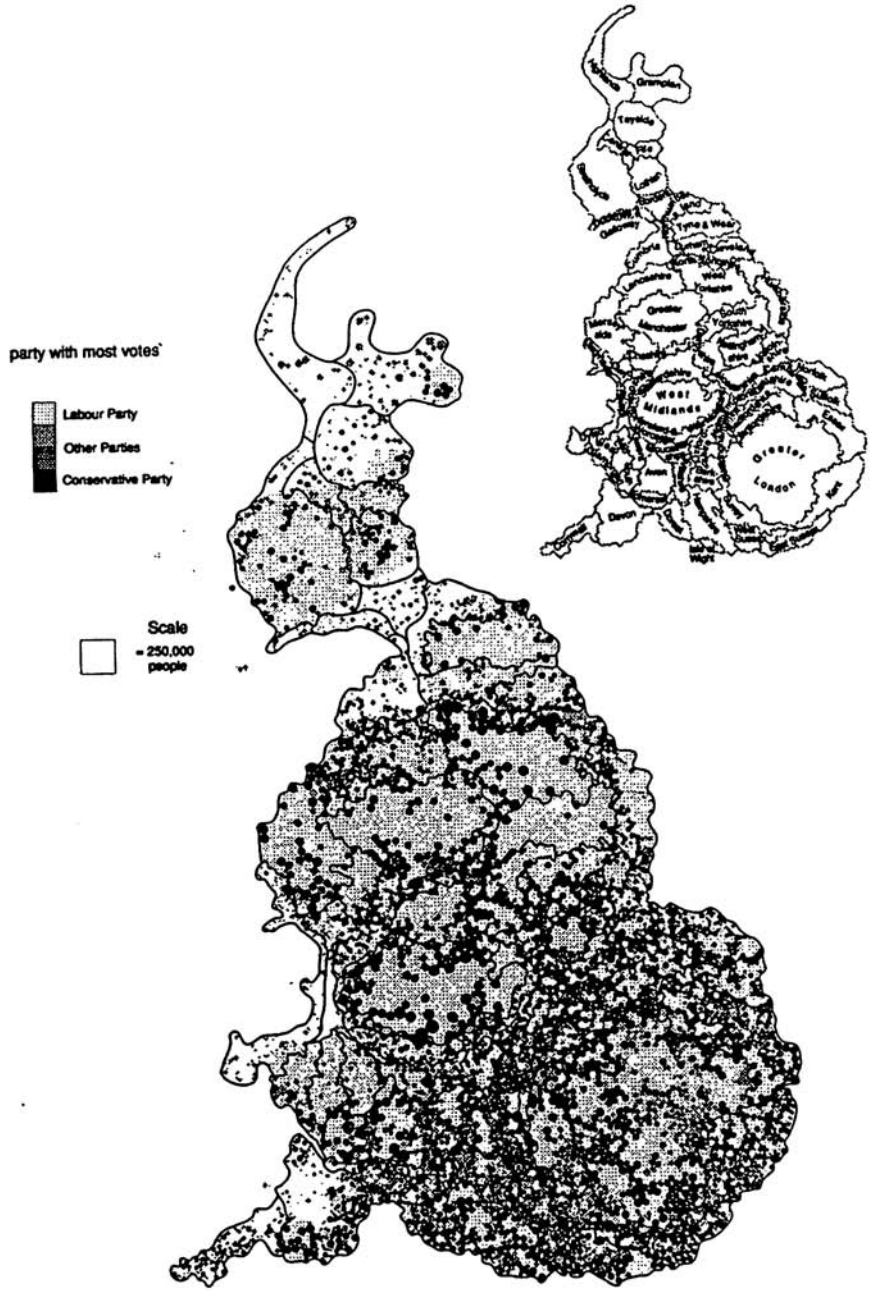


Figure 9. Winning Parties (showing party with most votes per ward in the 1987-1990 local elections)

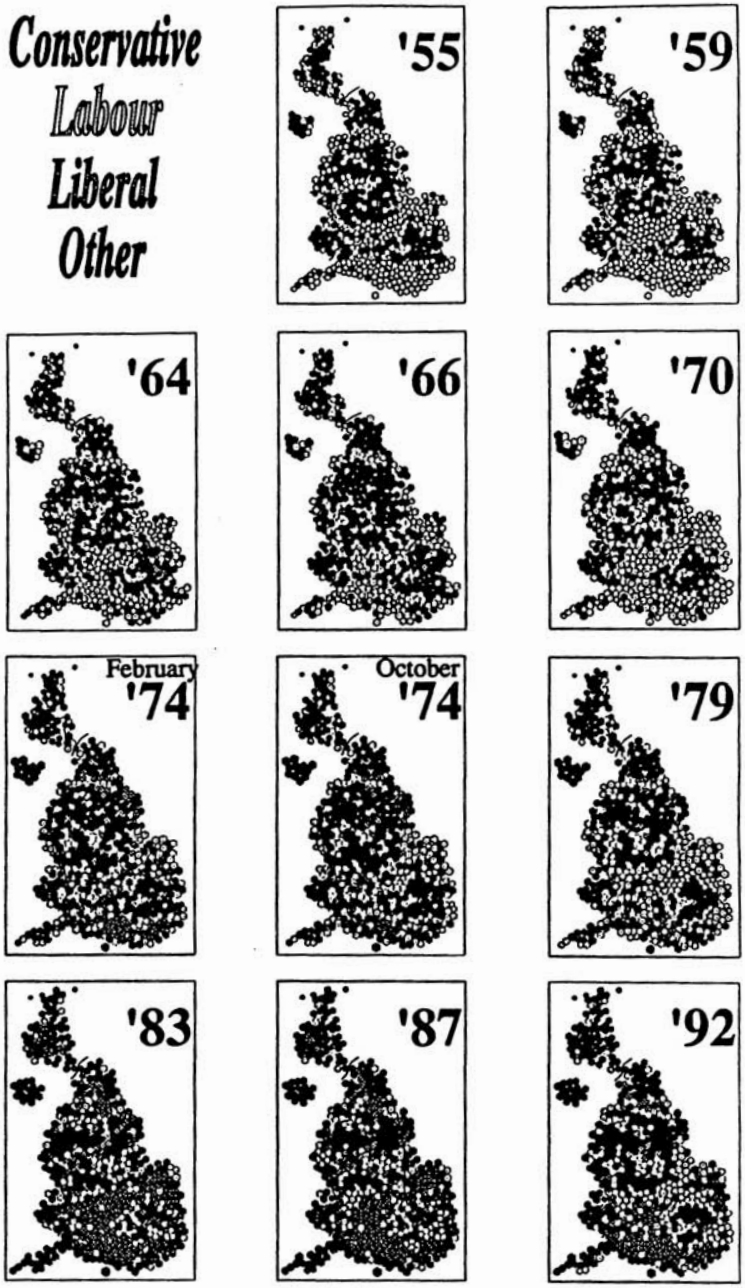


Figure 10. The Distribution of second placed party for eleven British General Elections 1955-1992

space over time. Animating the series of maps and some variants is possible. However that still does not allow you to easily grasp how particular regions have evolved (Dorling 1992). Although the eye is excellent for analyzing an individual image it is not good at analyzing a long series of related pictures presented either spatially or temporally as in an animation. The more change over time is considered the more evident it becomes how difficult it is to depict.

Employment

If there is one subject for which more information is available than voting it is employment[2] . Every month for every ward in Britain the number of people entering and leaving the unemployment register, their ages and how long they have been out of work are made available. Here, then, is a challenge for visualizing a great deal of socioeconomic information, most of which is otherwise unlikely ever to be studied other than in gross aggregate form or for individual locality studies.

The simplest employment statistic is the unemployment rate for which an estimate of the size of the workforce needs to be made using the decennial census. Figure 11 shows the national distribution of people seeking work in 1991 (for which the unemployed and those on a government scheme have to be combined). The pattern should by now be familiar: prosperous home counties and rural rings surrounding urban cores where more than one in six of the workforce in dozens of contiguous wards are seeking work. This pattern is to be expected. However the similarities with aspects of the distributions of voting, mortality and population change are all striking.

The long term change in unemployment is a little more surprising however. Figure 12 attempts to show the detailed geographical distribution of the change in rate of growth in unemployment. Nationally it increased from 4.0% of the workforce in 1971 to 8.8% in 1981 and then 10.6% in 1991. These are the self-reported rates taken from the censuses. In some areas it has increased faster than these rates across both decades while in others it has never increased so rapidly. In the suburban north unemployment was growing above average in the 1970s but below average in the 1980s. Around Outer London and in the Yorkshire and Nottinghamshire coalfields unemployment growth was below average in the 1970s but above average in the 1980s. Those are areas where the

[2] Detailed unemployment data is available the National On-line Manpower Information System, every month for every ward.

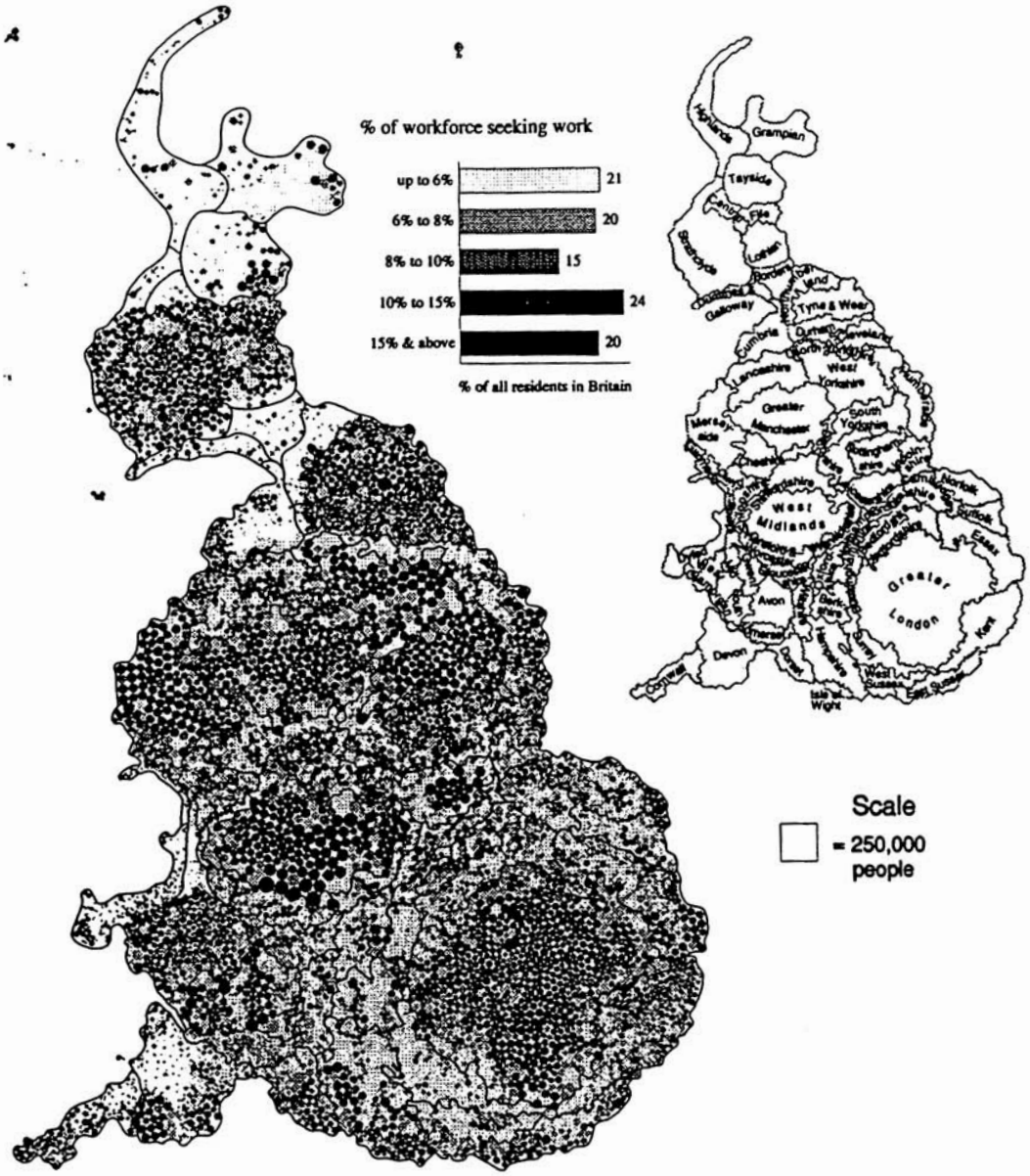


Figure 11. Unemployment in 1991 (showing the proportion of people in the ward who are out of work)

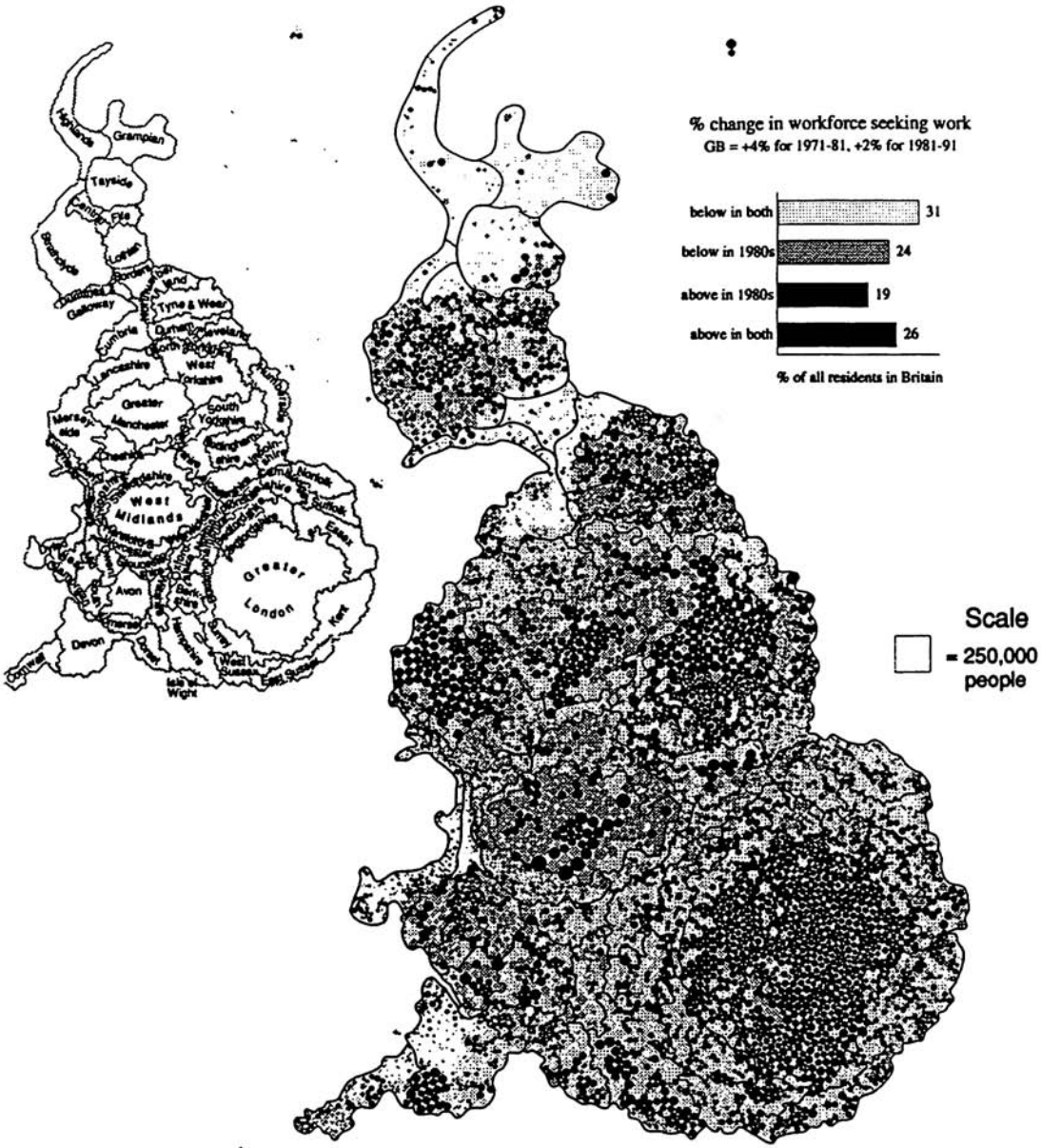


Figure 12. Unemployment 1971-81 and 1981-91 (showing ward change compared to the national change)

Labour party is now second, which are not doing too badly in terms of health, and where people are still prepared to migrate to, but which are now beginning to lose population overall. These are areas which have lost out over the last decade in terms of employment.

Finally, Figure 13 shows how levels of unemployment have changed over the last sixteen years. The changes over 852 areas are shown by cartograms depicting the situation for each year. Because the spatial pattern has changed only subtly, deviation from what the expected unemployment level would be for a given place in a given year is the statistic used here. Hence Liverpool (the largest area on the left of each cartogram) was doing particularly well by 1993, not because its unemployment level has fallen but because, for that place in relation to other places, given its track record, its level then was low. The figure shows how the pattern has changed from an out-of-work Celtic Fringe in the 1970s to a prosperous Home Counties ring developing in the 1980s and then to the collapse of the Southern labour market in the 1990s. In terms of deviation from space-time independence, at least, the British North-South divide has gone into reverse.

Conclusion

All the figures shown here have used the same basic formula of choropleth mapping--colouring areas according to particular values and showing different maps for different time periods. The map projections may be unfamiliar, the amount of data used unusual, and some statistics peculiar, but the basic formula is not very different and its advantages and limitations are shown through these illustrations. With more than a few thousand places or a few dozen time periods to study, this method of data depiction becomes ineffective and many maps are needed to show the patterns of only a few variables across time. However this paper has shown how fresh insights and connections can be made across many aspects of human geography by displaying detailed pictures of the spatial structure of society in which all people's experiences are treated equitably.

New visualization methods will be developed, driven by the availability of reams more numbers in the near future. They are also likely to be even less familiar than those presented here. Simultaneously, as the amount of "old" data increases, the need for more "new" ways of studying it will grow proportionately. The aim of new visualization techniques should be to learn more about the nature of the subject under study not to produce stunning images

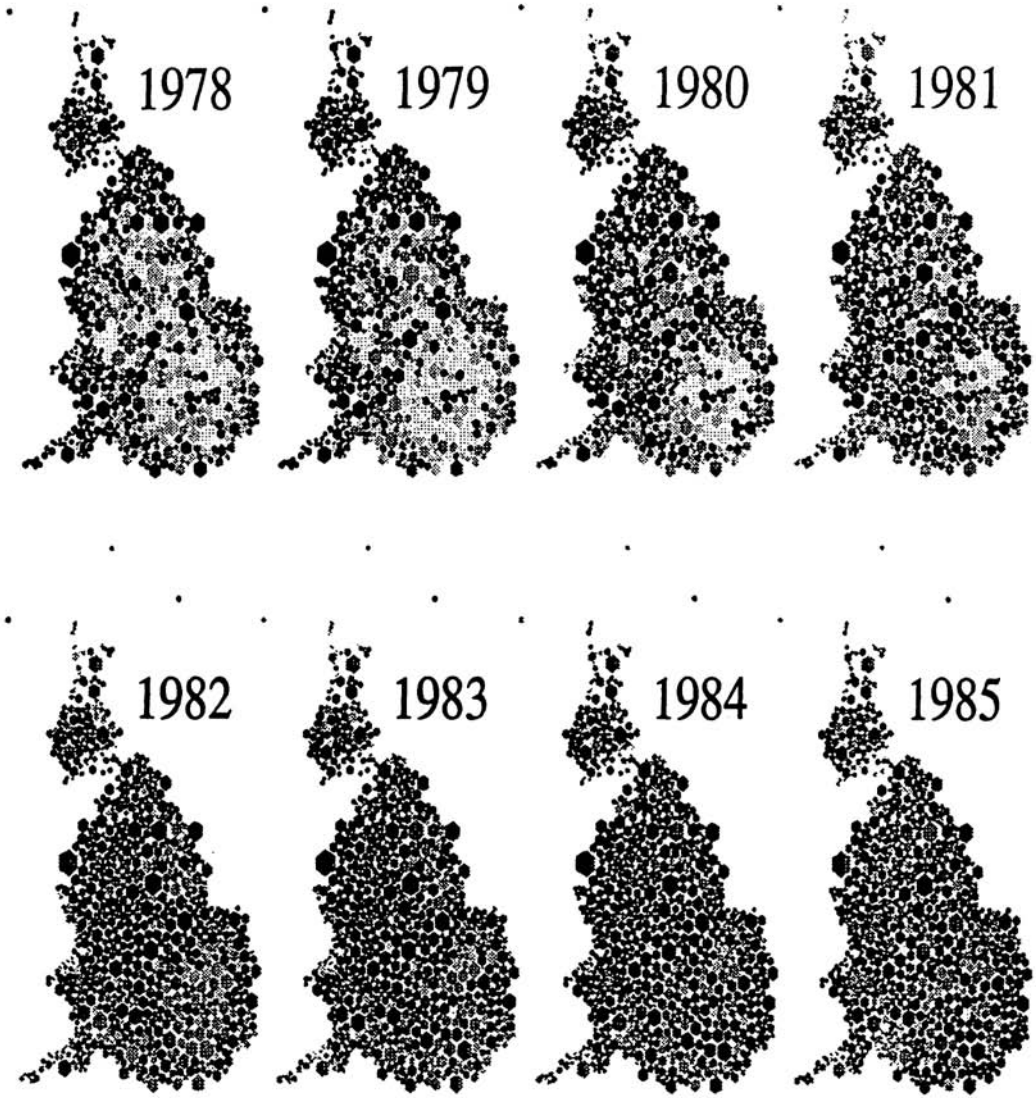


Figure 13. The spacetime trend of unemployment in Britain, 1978-1993 by Amalgamated Office Areas: grey shades indicate deviation from spacetime independence, dark for over- and light for under-average employment.

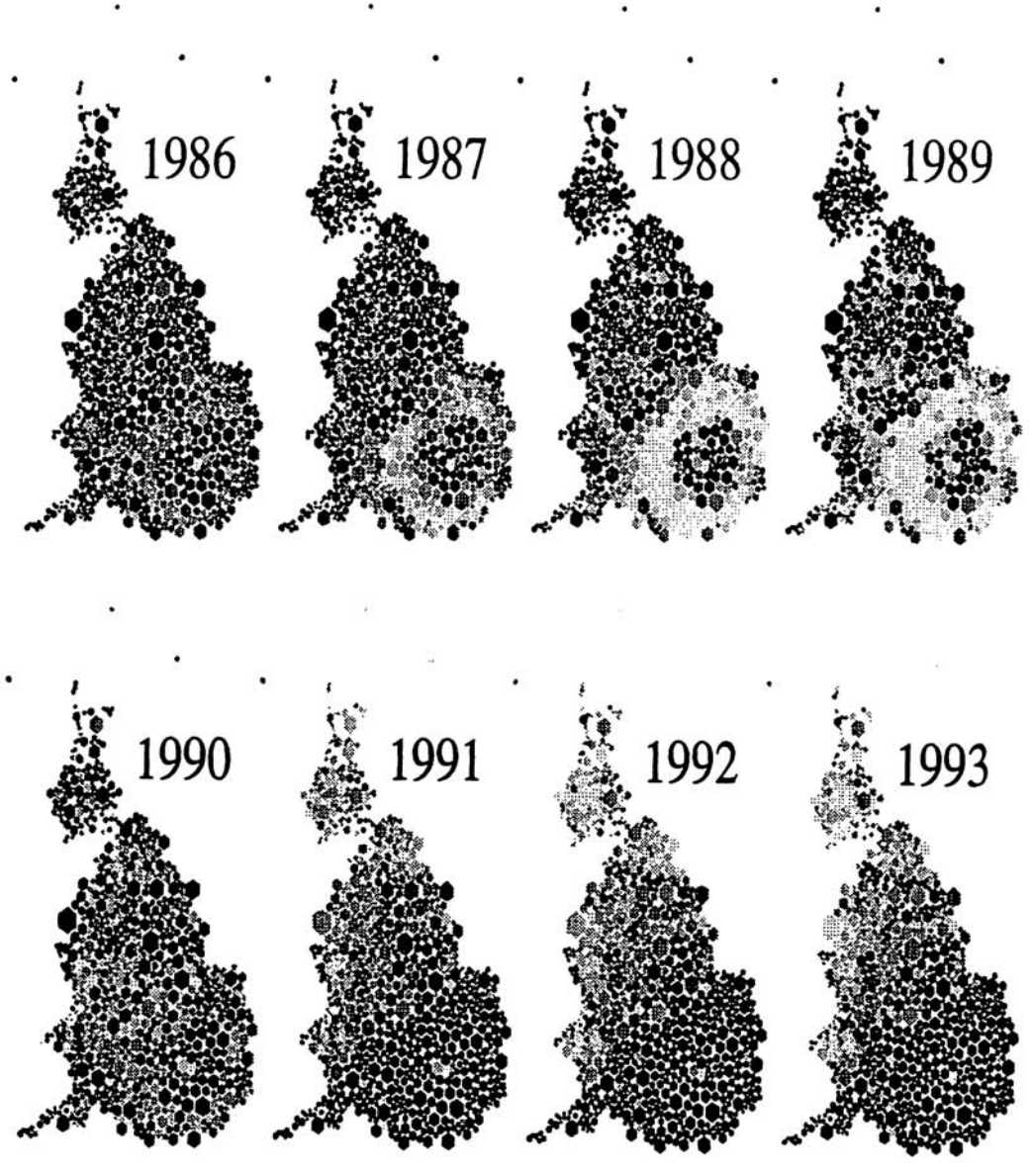


Figure 13. (cont'd)

and animations which, in practice, look nice but convey little relevant information.

Note:
The census data used in this study is Crown Copyright.

References

Atkins D., Charlton, M., Dorling, D. & Wymer C., 1993, "Connecting the 1981 and 1991 censuses," North East Regional Research Laboratory working paper 93/9, Department of Geography, University of Newcastle upon Tyne.

Beniger, J.R. & Robyn D.L., 1978, "Quantitative Graphics In Statistics: A Brief History," The American Statistician, Vol. 32, No. 1, pp. 1-11.

Cornford, J.R., Dorling D. & Tether B. (1993) "Historical Precedent and British Electoral Prospects," Seminar Paper, No. 63, Department of Geography, University of Newcastle upon Tyne.

Cliff, A.D. & Haggett, P., 1988, Atlas of Disease Distributions: Analytic Approaches to Epidemiological Data, Basil Blackwell Ltd, Oxford.

Dorling, D. (1992) "Stretching Space and Splicing Time: From Cartographic Animation to Interactive Visualization," Cartography and Geographical Information Systems, Vol. 19, No. 4, pp. 215-227, 267-270.

Dorling, D., 1993, "Map Design for Census Mapping," The Cartographic Journal, Vol. 30, No. 2.

Dorling, D. & Simpson, S. (1993) "The Census Missing Millions: Implications Across Social Statistics," Radical Statistics Newsletter, No. 55, pp. 14-35.

Fisher, P., Dykes, J. & Wood, J., 1993, "Map Design and Visualization," The Cartographic Journal, Vol. 30, pp. 136-142.

Mounsey, H.M., 1982, "The Cartography of Time-Changing Phenomena: The Animated Map," PhD., Department of Geography, University of Durham.

Fotheringham, A.S., 1989, "Scale-Independent Spatial Analysis," M. Goodchild & S. Gopal (eds) The Accuracy of Spatial Databases, Chapter 19, Taylor & Francis, New York.

Openshaw, S., 1982, "The Modifiable Areal Unit Problem," Concepts and Techniques in Modern Geography, No. 38, Geo Books.