Creating small area measures of urban deprivation

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Abstract. In recent years, the scale and pace of urban change have been associated with fine-scale fragmentation of the lifestyles of urban populations. One manifestation of this is that households of diverse means and circumstances may be found living in proximity to one another, particularly in urban areas. In this paper we argue that in these changed circumstances conventional deprivation indicators fail adequately to detect within and between small area variations in socioeconomic and environmental conditions. Using a case study of Bristol, England, we develop an analysis around Gordon and Forrest’s Breadline Britain indicator in order to reveal the diversity of economic conditions that exist within wards that might be labelled as either affluent or deprived. We argue that adequate representation of diversity requires a greater sensitivity to difference at fine scales. In this context, we begin to evaluate the claims of marketeers who use commercial sources of data to model incomes at unit postcode and even household scales. We undertake an evaluation of such data and extend their application to calculation of Breadline Britain index scores. The results suggest some potential for using unconventional sources of data to ‘freshen up’ census information and provide direct, meaningful, measures of deprivation.

1 Introduction

“Almost always ... we experience our neighbourhood as a smaller area than the formally designated town, electoral ward or borough. This small-scale focus was crucial when it came to targeting social deprivation. According to the action plan: ‘looking at a larger scale, such as a region of local authority, conceals the most extreme pockets of deprivation’.”

NRU (2002, page 5)

In the United Kingdom the Neighbourhood Renewal Unit (NRU) is working to “breathe new life into our deprived neighbourhoods” (www.neighbourhood.gov.uk). To support this initiative the on-line Neighbourhood Statistics Service (NSS) has been created with the purpose of providing ‘better information’ about the social conditions of small areas (www.statistics.gov.uk/neighbourhood/). On the NSS website, small area indicators are described as essential at both the national and the local level:

“They are important at a national level in deciding where to target new initiatives and in evaluating each initiative. Different areas across the country, targeted by a particular initiative, can be compared. The indicators are also used at a local level to assess the conditions in local areas, to target resources effectively, to provide a baseline against which future progress can be monitored, and to set outcome targets.”

At present, information selection at the NSS is offered only for local authority or ward geographies. The government’s index of multiple deprivation 2000 (IMD 2000), for example, is a ward-level index [though higher aggregation, district-level summaries are also available (DETR, 2000)]. The presumption is that deprivation is best measured at the ward scale. As a consequence, the boundaries of ‘neighbourhoods’
are treated as coincident with ward boundaries. This is contentious, as the UK Social Exclusion Unit (SEU) recognises: “some wards include several neighbourhoods and some neighbourhoods cross ward boundaries” (reported by the NRU, 2002, page 5).

With that in mind, we attempt in this paper to take a direct look at the geography of deprivation in Bristol, England, and at fine scales. We argue that the perceived lack of conventional survey alternatives has led to reliance on the census as the only viable source of fine-scale, socioeconomic data. Increasingly, however, that view is challenged by commercial marketing companies that have differing perspectives on what is necessary and sufficient to create measures that are fit for purpose and ‘actionable’. In the academic domain, for example, Green (1997, page 181) laments the “dearth of spatially disaggregated [income] data at the local (particularly sub-county) scale”. By contrast, private sector companies such as EuroDirect offer commercial products that allow unit postcodes to be selected on the basis of the household income levels found within them (EuroDirect, 1999). A recent study by the market research group CACI also focused upon household income and claimed to give a truer picture of wealth differentials at disaggregated scales than do the official measures provided by the unemployment register (Baldwin, 1999). The motivations and traditions of the academic and business sectors are quite different and there is a clear need for objective evaluation of the claims of marketeers, framed realistically within the context of the paucity of small area data from public sector sources. Here we develop a case study of the 175 wards within the former County of Avon, which include the City and County of Bristol, England. Following a discussion of the limitations of the UK census for measuring deprivation, our analysis falls broadly into two parts. The first gauges the internal consistency of the Breadline Britain estimates of deprivation at different geographical scales and entirely using 1991 Census data. This reveals patterns of socioeconomic diversity within apparently wholly deprived wards. The second part seeks to cross-validate the Breadline Britain measures with commercial, ‘lifestyle’ data on income. There we present evidence of heterogeneity within census enumeration districts (EDs), considering also the potential and pitfalls of lifestyle data in policy-oriented research. We begin by looking briefly at the contentious task of defining and quantifying deprivation.

2 Measures of deprivation

We acknowledge at the outset that definitions of deprivation are contested, with different conceptions leading to different geographical representations of physical and social conditions. The United Nations defines absolute poverty as being deprived of access to food, clean water, health, shelter, and education. In more affluent societies, deprivation and poverty thresholds often are defined relative to mean or median household incomes. This shifts emphasis towards relative inequalities between the most and least affluent. Other measures of inequality draw away from a purely economic scale being based on data indicative of prevailing lifestyles. A recent Joseph Rowntree Foundation (JRF) study incorporated ownership of a refrigerator as part of a measure of poverty and social exclusion in the United Kingdom (Gordon et al, 2000). Such studies can be met with hostility by those who measure poverty against more absolute benchmarks:

“the JRF says it is ‘shocked’ at this ‘evidence’ that more people (80 per cent of them wearing new clothes and owning both a microwave and a VCR) ‘live in poverty’ than at any time for 20 years. ... Shock is the right response to the report: shock at its abuse of statistics, its assault on what words mean and the insult it offers the genuinely poor” (Daily Telegraph 2000).
In all cases, the way deprivation is conceived conditions the way that it is measured. There is neither a ‘pure object’ that is indisputably deprivation nor any objective and apolitical measures that are independent of prevailing interests or value systems (Yapa, 1998). Lee et al (1995), in a review of best practice, reach the following conclusions. Multivariate indices, designed to represent numerous facets of deprivation, identify different populations and areas from those highlighted by univariate measures, which identify restricted aspects of deprivation. Nevertheless, multivariate indices do tend to highlight a large proportion of the households identified with use of univariate measures such as unemployment or overcrowding. At the census district scale of analysis, different indices for measuring and mapping deprivation produce similar deprivation profiles and identify similar lists of the most deprived areas. However, at the ward level and below the opposite is true—different indices produce quite different results. Consequently, Lee (1999, page 178) can show that of the 10% most deprived wards in England and Wales, as defined by the (then) Department of Environment’s index of local conditions (DoE, 1981), 40% are located in the Greater London and South East regions. By comparison, a second measure (namely, the Breadline Britain index; see section 3 below) allocates only 24% of the most deprived wards to those two regions. Last, Lee et al (1995) showed that indices differ significantly in terms of how they are constructed, what their constituent variables are supposed to represent, and how they are weighted.

Even if the correlates of deprivation and their meaning could be agreed on, the geographical definition of ‘neighbourhoods’—the zones to which social and physical characteristics are ascribed—will still influence the apparent intensity and extent of deprived conditions. Scale and aggregation effects and the power of the map ‘to lie’ are well documented (Monmonier, 1996; Openshaw, 1984). Hence, differences of conception compound choices of scale and the vagaries of measurement to produce competing geographical representations of ‘the’ deprived areas.

There are no easy answers to the issues described above. In this paper we tend to Hall and Pfeiffer’s (2000, page 82) view that “income differences remain the most important indicator of inequality”. We also take the pragmatic position that it is easier to aggregate up from fine scales to identify broader geographical patterns than it is to try to reverse-engineer, or ‘deaggregate’, coarse, aggregate datasets. However, this is possible only where disaggregated data are available, and generally they are not. Notwithstanding the privacy and ethical issues of personal data usage (Curry, 1998; Longley et al, 2001, chapter 19) the lack of detailed socioeconomic data is a cause for concern given evidence that the scale and pace of urban change has led to fine-scale fragmentation of the lifestyles of urban populations (for example, Longley and Harris, 1999) and hence also to the scale at which deprivation persists. Some welfare and taxation policies have responded to these changes by becoming more targeted (for example, the UK zero-rate stamp duty exemption in the 2001 budget). However, key measures that direct policy and funding, including IMD 2000, remain tied to coarse, imprecise, and nontargeted conceptions of neighbourhood and deprivation. Most problematically, existing deprivation indicators are not sufficient to meet the task of measuring variations in social, economic, and environmental conditions within and between genuinely small areas.

(1) Lee et al considered the following measures: the (then) Department of the Environment’s 1981 and 1991 indices (DoE, 1981; 1994), Jarman scores (Jarman, 1983), the Townsend index (Townsend et al, 1988), and an index developed from the Breadline Britain poverty study (Gordon and Forrest, 1995; Gordon and Pantazis, 1995).
3 Breadline and the limits to census measurement

In the United Kingdom, the 1991 Census of Population is recognised as the only comprehensive data source for mapping indicators of deprivation (Lee, 1999, page 172). However, there are at least four limitations of using this census in such a way. Of the limitations outlined, only the first and third will be resolved (partially) when 2001 Census data become available in 2003.(2)

First, most commentators agree that “income or wealth would be an obvious starting point in mapping poor areas” (Lee et al, 1995, page 16) but such information is absent from the census, partly for fear of increasing nonresponse (Rees, 1999). To redress this issue the UK government’s “preferred approach is to identify alternative means of securing relevant information” (ONS, 1999, page 6). However, there is no compelling evidence that any ‘alternative means’ are currently available at fine spatial scales from conventional public sources. Furthermore, the census does not include information on a wider class of indicators that could otherwise be used to reveal individual and household ability to participate fully in the (consumer) society (through ownership of goods such as microwave ovens).

Second, some deprivation indices use surrogate indicator variables (of socioeconomic grouping) that are derived from a 10% sample of census returns for each small area (defined post-1991 as census EDs, or as output areas in Scotland).(3) To avoid small absolute sample sizes the 10% statistics should be used at the ward scale of analysis or at other still coarser scales (for example, census districts).(4) Yet these are not necessarily the scales at which deprivation is best measured. Indeed, there is increasing evidence that the characteristics of census populations are not uniformly distributed within wards or EDs (Cosijin and Brown, 1993a; 1993b; Harris, 1999b; Longley and Harris, 1999; Mitchell et al, 1998). Not all persons or households within an area broadly labelled as ‘poor’ will actually exhibit similar levels of deprivation, and clustered occurrences of low-income households can be hidden within wards or even EDs of moderate or high average affluence.

Third, the design of census zones hitherto has been rather ad hoc and coarse (Martin, 1998a; 2000). This may impose artificial partitions upon communities and localities and obscure small area variability in conditions. Before 2001, census data were disseminated with respect to a zonal geography that was designed primarily for administrative purposes—to balance the workloads of enumerators—and has limited geographical meaning in many areas (Openshaw, 1984). There are no strong reasons to suppose that geographies of deprivation match partitioning of socioeconomic space that is made primarily for purposes of census administration. Indeed, as the SEU recognised, deprivation need not respect ward boundaries (see section 1).

(2) Research has been undertaken to validate proxies for income, based on the census rehearsal data which do include an income question (see http://www.pcweb.liv.ac.uk/william/income/). It is the intent of the NSS eventually to provide income estimates for small areas based on 2001 Census output areas (http://www.statistics.gov.uk/neighbourhood/downloads/nssrev5.pdf). The output areas for the 2001 Census will be designed as ‘homogeneous’ aggregations of unit postcodes, designed by using data on housing tenure and dwelling type (Martin, 1998b; Martin et al, 2001). Whether such aggregations will be more or less heterogeneous on all other deprivation-relevant variables remains largely unknown.

(3) After the 1991 Census there were, in England and Wales, approximately 100,000 EDs, each containing an average of 183 constituent households but varying in size from about 20 to 200 houses (Openshaw, 1995). Census geography is hierarchical, so these EDs ‘nest’ into 9509 wards at a higher level of aggregation. Wards have an average household population of 2081, but again vary: from a minimum household population of 153 to a maximum population of size of 9591.

(4) Given an average of 183 households per ED, then the 10% statistics at the ED level draw a sample size of about 18 households.
Fourth, the census is undertaken only once every ten years and the data usually take at least a further two years to process and collate. The full 2001 Census information will probably be available to researchers about mid-2003, by which time the 1991 Census data will be over 12 years old!

One measure that seeks to use census variables to estimate incidences of deprivation is the Breadline Britain index. According to Lee et al’s (1995) assessment, this is the best index for identifying the most deprived wards at a national level because it statistically estimates weights for the component indicators and produces an easily interpretable index. The index is based on the results of the 1990 Breadline Britain poverty survey and is available to registered census users at http://census.ac.uk/.

The Breadline Britain definition of poverty is reported by a number of commentators (see Gordon and Forrest, 1995; Gordon and Pantazis, 1995; 1997a; 1997b; Gordon et al, 2000). Here it is sufficient to note that a quota sample of 1831 individuals (aged 16 years or more) were interviewed to define a range of activities and possessions felt necessary for everyday living. Items attracting 50% or more support from the sample were deemed as socially perceived necessities. The poverty line was then set at households lacking three or more of the necessities. Subsequently, the sample (now classified into an ‘in poverty’ versus ‘not in poverty’ dichotomy) was linked to the 1991 Census small area statistics by using variables common to both. A logit analysis was undertaken at the household scale, with deprived or not deprived as the response variable and with the socioeconomic indicators as the explanatory variables. The regression parameters arising from this analysis were then transferred from the household to more aggregate scales and used to weight the corresponding census variables. The resulting Breadline Britain index has been used to estimate the percentage of ‘poor households’ at both the census ward and census district scales (Lee et al, 1995).

The estimate is obtained by using the following regression relation:

\[
y^* = 0.2025 x_1 + 0.2174 x_2 + 0.1597 x_3 + 0.1585 x_4 + 0.0943 x_5 + 0.1079 x_6 ,
\]

where \( y^* \) is the estimated percentage of poor households, and \( x_1 \) to \( x_6 \) refer to the following 1991 Census variables: \( x_1 \), percentage households not owner-occupied; \( x_2 \), percentage households with no car; \( x_3 \), percentage lone-parent households; \( x_4 \), percentage households where the household head is in a partly skilled or unskilled occupation; \( x_5 \), percentage economically active population unemployed; \( x_6 \), percentage households containing a person with a limiting long-term illness. Each percentage figure pertains to a census ward or a census district, depending on the chosen scale of analysis. The parameter estimates in equation (1) assign each of the components a different weight; thus the percentage of households not owner-occupied is given over double the weight (0.2025) relative to the percentage of economically active population unemployed (0.0943).

The Breadline Britain methodology is an innovative attempt to link more generic census data to a meaningful and specific definition of poverty. A shortcoming, however, is that the scale transfer from the household to census geographies can be achieved only by using indirect indicators and in a geographically invariant way. The linkage

\(^{(5)}\) Since the Breadline Britain studies this ‘consensual’ method of defining poverty (Mack and Lansley, 1985) has also been used to calculate the levels of deprivation reported in the 2000 Poverty and Social Exclusion Survey, published by the JRF (the report to which the Daily Telegraph took umbrage). Items deemed as necessities in both the 1990 Breadline Survey and the 2000 Poverty and Social Exclusion Survey are listed by Gordon et al (2000)—the most important being a damp-free home and heating.

\(^{(6)}\) Note that equation (1) does not contain an intercept term. Presumably this is to permit zero deprivation in some wards or districts and also to assure no wards or districts are attributed negative deprivation.
mechanism may be more appropriate in some local contexts than in others and imposes a single national set of parameter estimates on the entire dataset. Orford (1999), Fotheringham and Wegener (2000), and Fotheringham et al (2000) illustrate that the weighting assigned to property attributes in house-price models varies spatially, and it is likely that similar geographical awareness should characterise deprivation scoring. Furthermore, empirical research (for example, Fotheringham and Wong, 1991; Wrigley et al, 1996) suggests that scale and aggregation effects would lead to fluctuations in the magnitude and even sign of the regression parameters at different scales. It is likely, though not certain, that the parameters shown in equation (1) would not change appreciably with aggregation on an ordinal (rank-ordered) scale, but it is extremely unlikely that the same precise values (for example, of 0.2025 for the ‘percentage households not owner-occupied’ parameter, \(x_1\)) would be obtained were the regression relation calibrated at anything other than the original, household, scale. In short, the parameters of the Breadline Britain index have a spurious precision when used to estimate the percentage of poor households at either the ward or the district level.

4 Diversity within census wards

In the preceding section we discussed the problem of transferring parameter estimates across different levels of aggregation. The issue, often referred to as the modifiable areal unit problem (MAUP), has been known at least since the 1950s (Robinson, 1950). Socioeconomic data that are aggregated into zones describe the overall characteristics of whole-area populations rather than the specific detail of any one individual; confounding the two levels of aggregation is known as ‘ecological fallacy’. If area populations are homogeneous in socioeconomic terms then the dangers of ecological fallacy are likely to be small. Yet, there is no reason to anticipate that all census districts, wards, or even EDs are homogeneous internally. The derivation of the 1991 Census zones provides no clear suggestion as to the degree of likely heterogeneity of socioeconomic characteristics, and census data provide no univariate or multivariate measures of within-area variation at either the ED scale or the ward scale. However, some indication of the problem of within-area heterogeneity can be illustrated by examining the variation in ED attributes that is obscured by ward-scale estimates [essentially, the same kind of empirical approach to scale and aggregation used by Fotheringham and Wong (1991)].

In figure 1 we show a 1991 Census ward map of Breadline Britain scores calculated from equation (1). The wards have been grouped into quintiles according to their Breadline Britain scores and shaded accordingly. The uppermost quintile (darkest shading) has an estimated 21%–38% ‘poor households’; those wards in the lowest quintile (lightest shading) have 5%–10% of their households defined as poor.

To explore the proposition that wards are more heterogeneous than the map suggests we have applied the Breadline Britain formula at the ED level (which, in terms of scale and aggregation effects, is actually closer to the household scale at which the formula was originally calibrated; see section 3). Thus, for example, where \(x_1\) in equation (1) previously defined the percentage of all households per ward not owner-occupied, \(x_1\) now denotes the percentage of all households per ED not owner-occupied. To our knowledge, the Breadline Britain formula has not previously been applied at this scale. This may reflect a conscious decision on the part of users to avoid the small numbers and sampling errors

(7) Indeed, there is at least one precedent in the calculation of Jarman (1983) scores, in which the ethnic-origin census component was dropped from Welsh districts and substituted with a Welsh house condition survey variable because the original variable was not appropriate to the Welsh context.

(8) Mitchell et al (1998) present an interesting example of how the district-level sample of anonymised records can be used to predict the internal social composition of EDs.
associated with the Breadline Britain variable that is taken from the 1991 Census 10% sample tables and gives the percentage of households with head of partly-skilled or unskilled occupation. However, it may also reflect a climate of opinion in policy that seeks only to represent variability in social conditions by using a coarse mesh.

In figure 2(b), see over, we show the new Breadline Britain scores, calculated at the ED level for EDs within wards of the uppermost quintile in figure 1 (most deprived) and also within the City of Bristol. To aid comparison, the EDs have been shaded with use of the same system as that applied to the wards. From visual inspection of figure 2, comparing figure 2(b) with figure 2(a), it is apparent that not all of the most deprived EDs lie within the most deprived wards and thus that rates of deprivation cannot be assumed to be uniform within wards. In numerical terms, and calculating for EDs and wards in the City of Bristol, it is true that of the 253 EDs within wards with Breadline Britain scores of 10% or less (most affluent), a clear majority of 187 (74%) also have scores in the same range. Similarly, at the other extreme, of the 534 EDs within wards with Breadline Britain scores over 20% (most deprived), 367 (69%) have ED-level scores in the same range. Yet there is also diversity at the subward scale. The most deprived EDs (in terms of the Breadline Britain classification, greater than 20% households poor) are not always found in the most deprived wards. In fact, only 60% are (see table 1, over). Furthermore, only 35% of the least deprived EDs are located in the least deprived wards.

Figure 3 also demonstrates the existence of within-ward heterogeneity (at the ED level). Each vertical line represents a ward within the former County of Avon.
The endpoints of each line identify the maximum and minimum ED Breadline Britain scores within each ward. The breakpoint between the descending (darker coloured) and ascending (lighter coloured) lines for each ward is the ward-level score. Figure 3 suggests that high concentrations of apparently poor households can be concentrated within parts of wards that have unremarkable scores at the ward scale. Conversely, by no means all EDs within high-scoring wards are necessarily poor.
Figure 3. Minimum and maximum Breadline Britain scores [at the enumeration district (ED) level], within Bristol wards. Note: the top of the vertical line indicates the maximum ED-level score within the ward; the bottom of the vertical line indicates the minimum ED-level score within the ward; the point where the darker-coloured and lighter-coloured portions of the line meet indicate the ward-level score.
5 Considering lifestyle data as a source of small area income information

We have reflected that income is, in many respects, the most relevant predictor of deprivation. If that assertion is correct then we would expect any small area measure of concentration of low-income households to correlate positively with our ED-level Breadline Britain. Such a correlation would also serve to validate the formula and its application at the ED scale. Unfortunately, reliable and geographically comprehensive small area income data are not available for the United Kingdom from public sector sources. Inference from coarser scale sources is possible but is unlikely to capture the degree of small area heterogeneity that we have shown to exist.

Alternative socioeconomic sources are the so-called lifestyle datasets (Sleight, 1997). Such data are compiled from mailed returns to national consumer surveys undertaken by the marketing industry. The respondents to such surveys are a self-selecting sample of the population (it is up to a member of a household whether to choose to return the questionnaire or not and also how much of the form to complete). Although it is quite correct to state that the collection and dissemination of these data fly in the face of scientific orthodoxy (Goodchild and Longley, 1999; Longley, 1998) the data are nevertheless disaggregated, detailed, and up-to-date (most are updated annually through mailing campaigns). Lifestyle data are increasingly used by the private sector in the USA and Europe to supplement, and even partially to substitute for, conventional small area geodemographic typologies (Batey and Brown, 1995) derived from census data.

The database we have was compiled by a commercial organisation in the late summer of 1996. Its characteristics are described more fully elsewhere (Harris, 1999a; Longley and Harris, 1999) and are summarised in table 2. Here it is sufficient to note that the dataset consists of 51,882 households records, of which 43,278 (83%) include income information. Each of the household records is georeferenced to the

Table 2. Some characteristics of the lifestyle dataset compared with the 1991 Census (source: Longley and Harris, 1999).

| Lifestyle data | Census data |
|---------------|-------------|
| Date of survey | Summer 1996 | April 1991 |
| Enumeration   | Postal      | Mainly door-to-door |
| Output area   | Household but georeferenced to postcode | Census ED |
| Population coverage | 13.5% of households in Bristol | 100% or 10%, depending on variable |
| Sampling      | Self-selecting | 100%, or 10% random sample |
| Information types | Wide range of socioeconomic, behavioural, and consumption indicators | Socioeconomic and demographic |
| Income question? | Yes | No |
| Compatibility with postcode geography | Perfect | 70%–80% (using ED/postcode directories) |
| Compatibility with census geography | Imperfect | Perfect |
| Bias          | Underenumeration of HMOs and non-ER registrants. Response bias likely to be multivariate and difficult to quantify. Uneven response to survey questions: some attract greater refusal rate | The ‘missing millions’ (see Champion, 1995) |

Note: ED, enumeration district; HMOs, houses in multiple occupation; ER, Electoral Register.
unit postcode scale (the full residential address of each respondent is not known to us, though it is to the data-supplying company). The ED/postcode directory allows these 43278 households to be assigned [imperfectly (Martin, 1992)] to 1656 EDs across a study region, defined as areas having a BS (Bristol) postcode. The 1991 Census gives a total count of 320531 households living in this region, so the size of the overall response rate to the lifestyle survey is equal to 16.2% of the census population in the BS region (or 13.5% when only those yielding income information are considered). This self-selecting sampling fraction is not, however, uniform across the study region (Longley and Harris, 1999, and below).

The lifestyle survey is typical of other commercial and composite datasets that contain multiple response and sampling biases that are complex and difficult to quantify. Response bias is partly systematic: certain groups in society are likely to be more willing or able to complete such surveys; some are more likely to be swayed to do so by the incentives offered for return of the questionnaire. However, there is also a random component to the response because it is ultimately up to the recipients whether to return the survey form or not. For this survey there was a further systematic sampling bias, with the methodology tending to exclude houses in multiple occupation (HMOs) (Longley and Harris, 1999).

The data in table 3 confirm a bias in the lifestyle dataset against households in rented accommodation (often HMOs). In this table we show the results of a regression

### Table 3. Regression line to estimate variation in the lifestyle-survey ‘response rates’ [see footnote (10), over].

| Census indicator | Coeff. | sd  | $t$  | $p$  |
|------------------|--------|-----|------|------|
| Ward-level analysis ($N = 144$) | | | | |
| PoH not owner-occupied | $-48.80$ | $5.20$ | $-9.38$ | 0.00 |
| PoH who moved since last census | $60.96$ | $9.439$ | 6.46 | 0.00 |
| PoH in local authority or housing association properties | $-21.87$ | $3.89$ | $-5.63$ | 0.00 |
| PoH with heads who are not white | $-39.03$ | $10.41$ | $-3.75$ | 0.00 |
| PoH with lone parent | $73.67$ | $25.30$ | 2.91 | 0.00 |
| PoH without a car | $13.07$ | $4.96$ | 2.64 | 0.01 |
| PoEAP unemployed | $12.58$ | $16.83$ | 0.75 | 0.46 |
| PoH in terraced properties | $-0.26$ | $1.45$ | $-0.18$ | 0.86 |
| Constant | $10.76$ | | | |
| $R^2$ statistic (%) | 52.0 | | | |

| ED-level analysis ($N = 1656$) | | | | |
| PoH not owner-occupied | $-42.05$ | $2.09$ | $-20.12$ | 0.00 |
| PoH who moved since last census | $87.12$ | $1.87$ | 46.55 | 0.00 |
| PoH in local authority or housing association properties | $-8.89$ | $1.66$ | $-5.36$ | 0.00 |
| PoH with heads who are not white | $-15.37$ | $3.76$ | $-4.09$ | 0.00 |
| PoH with lone parent | $-8.01$ | $7.24$ | $-1.11$ | 0.27 |
| PoH without a car | $3.13$ | $2.14$ | 1.46 | 0.14 |
| PoEAP unemployed | $11.25$ | $5.30$ | 2.12 | 0.03 |
| PoH in terraced properties | $0.86$ | $0.65$ | 1.32 | 0.19 |
| Constant | $10.79$ | | | |
| $R^2$ statistic (%) | 59.1 | | | |

Note: ED, enumeration district; PoH, proportion of households; PoEAP, proportion of economically active persons; coeff, regression coefficient; sd, standard deviation; $t$, $t$-statistic; $p$, probability statistic.

(9) The survey considered here offered the chance to win free National Lottery tickets as an incentive; others offer chances to win holidays or shopping vouchers.
analysis in which eight different census variables were selected (following Harris, 1999b) to explain some of the variation in ward-scale ‘response rates’, defined as the number of respondents to the 1996 lifestyle survey expressed as a proportion of the 1991 Census household counts. It can be seen that the ‘not owner-occupied variable’ has the t-ratio of greatest magnitude (at [9.38]) and is negatively related to the response rate. This result was broadly expected given the sampling methodology employed by the data vendor (generally excluding HMOs) and given that residents of (privately) rented properties tend to be a more transitory population that is often hard to survey. What is more surprising, however, is the significant positive parameter pertaining to proportions of households that had moved since the previous census. It is counterintuitive that greater population movement should result in increased levels of enumeration by the lifestyle survey. The apparent paradox can be resolved if it is the ‘middle-income’ households and families who are the most mobile among non-HMO households (because of job relocations or climbing the property ladder) and also the most inclined to complete a lifestyle survey. This would be consistent with the view that a lifestyle survey underenumerates at the extremes (that is, the most deprived and the most affluent; Harris, 1999b).

In table 3 we also report the results of the regression analysis when conducted using the same range of indicators but at the ED level. The dependent variable at this scale is the number of 1996 survey respondents assigned to an ED by using the ED/postcode directory, as a proportion of the 1991 Census count of households for the same ED. The variability in the response rates that is explained by the eight selected census variables is similar at the ward and ED levels ($R^2 = 52.0\%$ at the ward scale, and 59.1\% at the ED level). However, the magnitude of the regression coefficients and their significance (as determined by the t-ratios) are different at the ward and ED scales, providing further evidence of scale and aggregation effects in geographical analysis.

The data in table 3 suggest that, at both the ED level and the ward level, a little over half the variability in the lifestyle-survey response rates is accounted for by the eight variables in the regression. It would be possible to try to accommodate the response and survey bias by post-stratification reweighting of the lifestyle sample. That is counter to good survey research practice, however, and reweighting against 1991 Census data would have the effect of distorting the lifestyle data to fit a picture of how Bristol looked, at an aggregate scale, over ten years ago.

With consideration to establishing reliable small area deprivation measures, the sources of bias in the lifestyle data make them a less attractive proposition than the census. However, there are a number of other aspects to be considered that relate to the content and to the spatial and temporal precision of lifestyle data:

1. anonymised lifestyle data are available to describe households at the scale of the unit postcode, freeing analysis of heterogeneity in social conditions from the outdated ‘mosaic metaphor’ that underpins much census-based urban geography (Johnston, 1999; Raper, 2000);
2. the data are more up-to-date (when updated annually) and could present a more relevant picture of conditions in fast-changing urban systems;
3. the lifestyle dataset does have an income question, the nature of which we consider below.

It is disingenuous to overlook these advantages. Essentially, there is a trade-off between precision and accuracy; between the richness and relevance of lifestyle data and the respected scientific foundations of the census. We acknowledge (Longley and Harris, 1999, with reference to Goodchild and Longley, 1999) that the data-rich

(10) This is not the true response rate which we cannot calculate without knowing how many surveys were sent to each ward. For the same reason we cannot calculate the sampling fraction.
analysis offered by lifestyle data is clearly unscientific yet also signal the need to unlock the potential benefit of such data. We now proceed in that spirit, examining the correspondence between Breadline Britain scores and responses to an income question on the lifestyle survey.

6 Investigating the relationship between Breadline Britain scores and income

The lifestyle questionnaire contains the income question, ‘What is your approximate family income each year?’, to which the respondent replies by ticking the box appropriate to his or her circumstances: under £5000, £5000–£9999, £10 000–£14 999, £15 000–£19 999, £20 000–£29 999, £30 000–£39 999, £40 000 or above.

In total there were 13 444 respondents to the lifestyle survey who indicated a household income of less than £10 000—31% of the total number of respondents who answered the income question. With the survey information we calculated the number of family respondents with income less than £10 000 as a proportion of all families responding to the income question in each ward. We then ranked the 143 wards of the study area from the highest incidence (rank 1) to lowest incidence (rank 143) of low-income families. This ranking was then compared with a second ranking of wards—by their Breadline Britain scores.

In table 4 we present the results of the comparison. It can be seen that, although the highest-ranked (most-income-deprived) ward identified by the lifestyle data is not that identified by Breadline Britain, the highest ranked ward in Breadline Britain (highest estimated percentage of poor households) does appear in the top three in the lifestyle ranking. In fact, the three most deprived wards according to Breadline Britain and the lifestyle data are the same, although they are ordered differently. Four of the top five most deprived wards according to Breadline Britain are amongst the top five low-income wards for the lifestyle survey. All of the top-five ranked wards in Breadline Britain are ranked in the top ten for the lifestyle survey. Seven of the ten most deprived in Breadline Britain are in the top-ten low-income wards in the lifestyle survey.

Table 4. Ranked comparison of wards: position in lifestyle income ranking of most deprived wards compared with the Breadline Britain ranking.

| Rank by lifestyle scorea | Ward | Breadline Britain score | Commonality |
|-------------------------|------|------------------------|-------------|
|                         | 1    | 3 5 10 25 50 100       |             |
| 1                       | 0    |                        |             |
| 3                       | 1 3  |                        |             |
| 5                       | 1 3 4|                        |             |
| 10                      | 1 3 5 7|                       |             |
| 25                      | 1 3 5 9 19|                     |             |
| 50                      | 1 3 5 10 25 42|                   |             |
| 100                     | 1 3 5 10 25 49 89|                  |             |
| Correspondence (%)      | 100 80 70 76 84 89|                   |             |
| Mean                    | 0.83 |                        |             |
| Weighted averageb       | 0.85 |                        |             |

a Lifestyle-survey ranking according to the proportion of low-income households. A rank of 1 indicates the highest-ranked (most-income-deprived) ward.

b Weighted average: this weights the row values in proportion to the range of the ranking (the weights are 1, 3, 5, 10, 25, 50, and 100, respectively, down the column).

Note on interpretation: row 3 (of main body of table) indicates that 4 of the top 5 most deprived wards in Breadline Britain are among the top-5 low-income wards in the lifestyle survey; row 4 indicates that 7 of the 10 most deprived wards in Breadline Britain are in the top-10 low-income wards in the lifestyle survey, and so on.
survey, and nine of the ten in Breadline Britain are ranked in the top twenty five for the lifestyle survey. Based on these rankings, a crude correspondence between the Breadline Britain index and the lifestyle-survey measure of low income is determined to be in the order of about 83% – 85% at the ward level (see table 4 for derivation).

When we shift scale to the ED level, this correspondence breaks down (table 5). For example, the highest ranked (most-deprived) ED under the Breadline Britain index is barely within the top twenty five in the lifestyle-survey measure. Similarly, only two of the top-ten highest ranked EDs under Breadline Britain are in the top twenty five for the lifestyle data and little over half (54%) of the top one hundred ranked EDs under Breadline Britain are in the top one hundred for the lifestyle survey. Part of the discrepancy may be that the lifestyle-survey income measure includes the elderly on low pensions, whereas the Breadline Britain score has no indicator that refers directly to age. Breadline Britain will therefore tend to ‘overlook’ the elderly who are also deprived.

We can test whether this might be the case by modifying the lifestyle-survey measure to calculate, for each ED, respondent households with an annual income less than £10,000 and without a member aged 65 years or over as a proportion of all households indicating an income but without a member aged 65 years or over. This desensitises the lifestyle-survey measure to low-income elderly households. The resulting scores are again ranked and compared with the (unmodified) Breadline Britain values (table 6). There is some improvement in the commonality of the two measures. For example, the highest-ranked ED under the Breadline Britain index is now within the top three under the lifestyles-survey measure; and six of the top-ten highest ranked EDs under Breadline Britain are in the top twenty-five for the lifestyle survey. However, still a little over half (57%) of the top one hundred EDs under Breadline Britain are in the top one hundred for the lifestyle survey. The two highest ranked EDs under Breadline Britain are, in fact, ranked 404 and 194, respectively, under the lifestyle survey.

Even allowing for low-income elderly households, the question remains: why does the broadly high level of correspondence between the low-income lifestyle scores and Breadline Britain observed at the ward level diminish markedly at the ED level? There are three factors that might contribute to an explanation:

Table 5. Ranked comparison of enumeration districts (EDs): position in lifestyle income ranking of most deprived EDs compared with the Breadline Britain ranking.

| Rank by lifestyle score | ED Breadline Britain score | Commonality |
|-------------------------|-----------------------------|-------------|
|                         | 1 | 3 | 5 | 10 | 25 | 50 | 100 |
| 1                       | 0 |   |   |    |    |    |     |
| 3                       | 0 | 1 |   |    |    |    |     |
| 5                       | 0 | 1 | 1 |    |    |    |     |
| 10                      | 0 | 1 | 1 | 1  |    |    |     |
| 25                      | 1 | 2 | 2 | 2  | 5  |    |     |
| 50                      | 1 | 4 | 4 | 7  | 12 | 21 |     |
| 100                     | 1 | 4 | 4 | 9  | 18 | 31 | 54  |

Correspondence (%)  | 33 | 20 | 10 | 20 | 42 | 54 |
Mean                  | 0.30 |
Weighted average      | 0.43 |

Lifestyle-survey ranking according to the proportion of low-income households. A rank of 1 indicates the highest-ranked (most-income-deprived) ED.

The calculation of the weighted average gives greatest weight to the 1–50 and 1–100 rank values, hence emphasising the improved commonality over those ranges.

Note on interpretation: the interpretation of these data is similar to that for table 4.
(a) The Breadline Britain formula may not be strongly correlated with income at any scale; the higher observed commonality at the ward scale reflects the tendency for correlations to increase at coarser scales (Openshaw, 1984).

(b) The low-income (lifestyle-survey) estimates become unreliable at the ED level because of the effects of response bias and small sample sizes (on average, about twenty households per ED are sampled by the lifestyle survey).

(c) Additional uncertainty is generated by the inability of the ED/postcode directory to match perfectly unit postcodes to EDs (Martin, 1992). It is known that approximately one quarter of BS unit postcodes cross ED boundaries (Longley and Harris, 1999).

The individual effects of these factors are difficult to quantify in isolation. However, it is possible to consider the combined effects of small sample size and geographical misassignment by undertaking a more direct comparison between the census and lifestyle-survey data. Ranking the wards and EDs according to the proportion of households living in owner-occupied properties generates the results shown in tables 7 and 8 (see over), respectively. The overall correspondence at the ward scale is about 85%–87% (table 7). This certainly falls at the ED level (table 8), though 76 of the 100 EDs with the highest rates of owner-occupancy defined by the census data are also in the top one hundred using the lifestyle-survey information. Hence the crude and weighted correspondence between the census and lifestyle-survey rankings is estimated to be about 67% at the ED level for owner-occupancy (table 8). Note that table 8 has the most marked difference between weighted and nonweighted values. The difference arises because although the census and lifestyle-survey measures do not correspond well over the highest rankings (1 to 10) they do correspond much better in the rankings from 11 to 100, which also have the greater weightings.

To test for a ‘small numbers’ problem we have recalculated table 8, but included only the 25% (412) of EDs with the highest (calculated) response rates to the lifestyle survey (at 18.8% or above). This raises the commonality between the census and lifestyle-survey measure of owner-occupancy at the ED level to the order of 75%–76%. This does indicate there is a ‘small numbers’ problem when using the lifestyle-survey data for calculating the rates of a given attribute in certain EDs. Nonetheless, it remains likely that the apparent breakdown in the correspondence between Breadline Britain and the lifestyle-survey income measure at the ED level is not the result of a single factor but to all three listed above.

### Table 6. Ranked comparison of enumeration districts (EDs): lifestyle-survey ranking excluding households with a member aged over 65 years.

| Rank by lifestyle score | ED Breadline Britain score | Commonality |
|-------------------------|---------------------------|-------------|
|                         | 1  | 3  | 5  | 10 | 25 | 50 | 100 |
| 1                       |    |    |    |    |    |    | 0   |
| 3                       | 1  | 1  |    |    |    |    | 1 ÷ 3 = 0.33 |
| 5                       | 1  | 1  | 2  |    |    |    | 1 ÷ 2 = 0.40 |
| 10                      | 1  | 1  | 2  | 5  |    |    | 5 ÷ 10 = 0.50 |
| 25                      | 1  | 2  | 3  | 6  | 8  |    | 8 ÷ 25 = 0.32 |
| 50                      | 1  | 3  | 5  | 9  | 15 | 20 | 20 ÷ 50 = 0.40 |
| 100                     | 1  | 3  | 5  | 10 | 22 | 36 | 57  |
| Correspondence (%)      | 33 | 40 | 50 | 32 | 40 | 57 | 57 ÷ 100 = 0.57 |
| Mean                    | 0.42|
| Weighted averageb       | 0.48|

Notes. See table 5.
Clearly, we cannot ‘write off’ the difficulties we have associated with using the lifestyle-survey data, but nor do we consider it a satisfactory ‘fallback position’ to use official sources of aggregate data—no matter how well collected—when no measures of small area heterogeneity are included. Examination of figure 4 confirms that we have good reason to suspect a diversity of socioeconomic conditions at fine scales: in over 70% of Bristol EDs, six or seven of the seven income groups defined by the lifestyle survey (and ranging from under £5000 per year to over £40 000 per year) can be found. In other words, in any one ED it is not impossible to find both a lifestyle-survey respondent reporting an annual household income of less than £5000 and another reporting an annual household income over £40 000.

It has been suggested that the key to unlocking the potential of lifestyle-survey data for policy-oriented research is to aggregate the data into clusters of robust sample size but—critically—in ways that are sensitive to the geographical context and not constrained to fit within other administrative geographies (Harris and Frost, 2002). However, no definition has been given as to what level of aggregation is required to meet the criteria (see Harris and Frost, 2002), and this is an area of ongoing research. Nevertheless, the broad argument is that lifestyle-survey data can be used to identify the

### Table 7. Ranked comparison of wards by owner-occupancy.

| Rank | Ward census score | Commonality |
|------|-------------------|-------------|
|      | 1 3 5 10 25 50 100 |
| 1    | 1                 | 1.00        |
| 3    | 1 3               | 0.80        |
| 5    | 1 3 4             | 0.70        |
| 10   | 1 3 4 7           | 0.84        |
| 25   | 1 3 4 9 21        | 0.86        |
| 50   | 1 3 4 9 24 43     | 0.91        |

Correspondence (%) 100 80 70 84 86 91
Mean 0.85
Weighted average 0.87

*a* Lifestyle-survey ranking according to proportion of owner-occupied households. A rank of 1 indicates the highest-ranked ward (that is, the ward with the most owner-occupation). For other notes see table 4.

### Table 8. Ranked comparison of enumeration districts (EDs) by owner-occupancy.

| Rank | ED Census score | Commonality |
|------|-----------------|-------------|
|      | 1 3 5 10 25 50 100 |
| 1    | 0                | 0.33        |
| 3    | 0 1              | 0.20        |
| 5    | 0 1 1            | 0.10        |
| 10   | 1 1 1 1 1       | 0.60        |
| 25   | 1 3 5 7 15     | 0.72        |
| 50   | 1 3 5 8 22 36  76 |

Correspondence (%) 33 20 10 60 72 76
Mean 0.45
Weighted average 0.67

*a* Lifestyle-survey ranking according to the proportion of owner-occupied households. A rank of 1 indicates the highest-ranked ED (that is, the ED with the most owner-occupation). For other notes see table 5.
location of every survey respondent who has indicated their annual family income to be less than £10,000, at the unit postcode level, for a given study region. If those locations can be shown to be clustered spatially, then there is cause to believe that there is a clear areal basis to income deprivation. Moreover, we can gain confidence in the results of such an analysis if a reasonable number of the clusters are shown to be within, or in proximity to, wards identified as deprived according to more accepted measures. From this earlier work (Harris and Frost, 2002), and using the sort of simple, ‘point pattern’ and aggregation analysis to be found in most conventional geographical information systems (GIS), we identify in figure 5 (see over) the geographical centres of localised clusters of households that responded to the lifestyle survey and indicated a family income of less than £10,000 per year. The part of the study region shown corresponds to the City and County of Bristol. In figure 5, the 25 clusters with the highest numbers of low-income households have been labelled. A total of 21 of the 25 are located within wards identified as having high deprivation rates under the Breadline Britain classification. Interestingly, the remaining four (numbered 22, 23, 24 and 26 in figure 5) are located on the boundaries between two wards, emphasising the sometimes artificial-ity of 1991 Census boundaries. Note that the map in figure 5 can be compared with the official map of priority neighbourhoods for renewal in Bristol (see www.bristol-city.gov.uk).

6 Conclusions
In this paper we have sought to demonstrate the increasing fission of household circumstances at fine geographical scales. We noted the aim of the UK Neighbourhood Statistics Service (NSS) to provide better small area information for use in assessing the conditions of local areas and to target resources effectively. Sympathetic to the intentions of the NSS we have argued the case for creating viable measures of deprivation that are highly disaggregated in spatial terms, sufficiently updatable to accommodate the rate of change in urban systems, and pertinent enough to provide direct measures of household circumstances.

We have argued, with particular reference to the census, that traditional public sector sources do not permit the flexibility in modelling and analysis that is required to assess persistent or changing patterns of deprivation within the United Kingdom.
This is particularly the case where deprivation exists at localised scales or where more broad clusters of deprivation are artificially segregated by the boundaries of census geographies. Nevertheless, the coarser scale public sector data do provide an immensely valuable framework against which the characteristics of more ‘uncertain’ information sources can be gauged. Here we sought to cross-reference a lifestyle-survey dataset against the census-based Breadline Britain index of deprivation and also

![Figure 5. Local concentrations of low-income households according to the lifestyle survey (clusters 1–25) and according to the Breadline Britain scores (shaded areas).](attachment:figure5.png)
against an owner-occupancy variable. This led to the conclusion that there is reasonable correlation, at the ward level, between the Breadline Britain definition of poverty and a univariate measure of low income taken from the lifestyle-survey data. However, caution should be applied when trying to fit the survey data to an ED geography, as problems associated with response and sample bias, differences in data specifications, and the incongruous census and postal geographies emerge. Our contention is that lifestyle-survey data offer the opportunity for a ‘bottom-up’ approach to analysis, but only if aggregated in ways that are sensitive to local geographical patterns within the data and are not constrained to fit within any one, specific, administrative geography. This is an area for further research, though some first steps have been made in that direction (Harris, 2001; and Harris and Frost, 2001).

The abiding message of our empirical analysis is that scale and aggregation effects are manifest in the Breadline Britain measures of deprivation at both the ward scale and the ED scale. Because neither of these administrative units is ‘natural’ for the measurement of deprivation, so the same arguments can be extended to the index of multiple deprivation [IMD 2000 (DETR, 2000)] available at the NSS (DETR, 2000) and to other census-based measures. However, there is an element of ‘horses for courses’ here. Deprivation indicators such as Breadline Britain and IMD 2000 are essential for drawing out broad geographical trends and for comparing different administrative areas. Our argument is not against such indicators per se, rather it is for harnessing the flexibility that new datasets and new data-handling technologies present to developing measures of deprivation across a less restricted range of geographical scales.

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References
Baldwin P, 1999, “Postcodes chart growing income divide” The Guardian 25 October, page 5
Batey P W J, Brown P J B, 1995, “From human ecology to customer targeting: the evolution of geodemographics”, in GIS for Business and Service Planning Eds P Longley, G Clarke (GeoInformation International, Cambridge) pp 77 – 103
Champion A G, 1995, “Analysis of change through time”, in Census Users’ Handbook Ed. S Openshaw (GeoInformation International, Cambridge) pp 307 – 335
Cosijin P N C, Brown P, 1993a, “Comparison of an individual level and aggregate level market analysis system: performance of the lifestyles selector and Super Profiles classification. Part 1: sources and classification of data” Journal of Targeting, Measurement and Analysis for Marketing 1 257 – 272
Cosijin P N C, Brown P, 1993b, “Comparison of an individual level and aggregate level market analysis system: performance of the lifestyles selector and Super Profiles classification. Part 2: discriminatory and penetrative power” Journal of Targeting, Measurement and Analysis for Marketing 1 355 – 365
Curry M, 1998 Digital Places: Living with Geographic Information Technologies (Taylor and Francis, London)
Daily Telegraph 2000, “‘Absolute poverty’ of language”, 11 September, page 1
DETR, 2000, “Indices of deprivation 2000”, Department of the Environment, Transport and the Regions; now available from Department of Transport, Local Government and the Regions, www.regeneration.dtr.gov.uk
DoE, 1981, “Information note no. 2”, Department of Environment
DoE, 1994, “Information note on index of local conditions”, Department of the Environment EuroDirect, 1999, Promotional material (Eurodirect, Bradford, Yorks)
Fotheringham A S, Wegener M (Eds), 2000 Spatial Models and GIS: New Potential and New Models (Taylor and Francis, London)
Fotheringham A S, Wong D W S, 1991, “The modifiable areal unit problem in multivariate statistical analysis” Environment and Planning A 23 1025 – 1044
Fotheringham S, Brunsdon C, Charlton M, 2000 Quantitative Geography: Perspectives on Spatial Data Analysis (Sage, London)

Goodchild M, Longley P, 1999, “The future of GIS and spatial analysis”, in Geographical Information Systems: Principles, Techniques, Applications, and Management 2nd edition, Eds P A Longley, M F Goodchild, D J Maguire, D W Rhind (John Wiley, New York) pp 567 – 580

Gordon D, Forrest R, 1995, “People and places 2: social and economic distinctions in England”, School for Policy Studies, University of Bristol, Bristol

Gordon D, Pantazis C, 1995 Breadline Britain in the 1990s (Joseph Rowntree Foundation, York)

Gordon D, Pantazis C, 1997a, “Appendix I: technical appendix”, in Breadline Britain in the 1990s Eds D Gordon, C Pantazis (Ashgate, Aldershot, Hants) pp 269 – 272

Gordon D, Pantazis C, 1997b, “Measuring poverty: Breadline Britain in the 1990s”, in Breadline Britain in the 1990s Eds D Gordon, C Pantazis (Ashgate, Aldershot, Hants) pp 5 – 47

Gordon D, Adelman L, Ashworth K, Bradshaw J, Levitas R, Middleton S, Pantazis C, Patsios D, Payne S, Townsend P, Williams J, 2000 Poverty and Social Exclusion in Britain (Joseph Rowntree Foundation, York)

Green A, 1997, “Income and wealth”, in Britain’s Cities: Geographies of Division in Urban Britain Ed. M Pacione (Routledge, London) pp 179 – 202

Hall P, Pfeiffer U, 2000 Urban Future 21: A Global Agenda for Twenty-first Century Cities (E & FN Spon, London)

Harris R, 1999a, “Geo-demographics and geo-lifestyles: a comparative review” Journal of Targeting, Measurement and Analysis for Marketing 8 164 – 178

Harris R J, 1999b Geodemographics and the Analysis of Urban Lifestyles unpublished PhD thesis, School of Geographical Sciences, University of Bristol, Bristol

Harris R, 2001, “On the diversity of diversity: is there still a place for small area classifications?” Area 33 329 – 335

Harris R, Frost M, 2002, “Indicators of urban deprivation for policy analysis in GIS: going beyond wards”, in Socio-economic Applications of Geographic Information Science Eds D Kidner, G Higgs, S White (Taylor and Francis, London) in press

Jarman B, 1983, “Identification of underprivileged areas” British Medical Journal 286 1705 – 1709

Johnston R J, 1999, “Geography and GIS”, in Geographical Information Systems: Principles, Techniques, Applications, and Management 2nd edition, Eds P A Longley, M F Goodchild, D J Maguire, D W Rhind (John Wiley, New York) pp 39 – 47

Lee P, 1999, “Where are the deprived? Measuring deprivation in cities and regions”, in Statistics in Society: The Arithmetic of Politics Eds D Dorling, S Simpson (Arnold, London) pp 172 – 180

Lee P, Murie A, Gordon D, 1995, “Area measures of deprivation: a study of current and best practice in the identification of poor areas in Great Britain”, Centre for Urban and Regional Studies, University of Birmingham, Birmingham

Longley P A, 1998, “Foundations”, in Geocomputation: A Primer Eds P A Longley, S M Brooks, R McDonnell (John Wiley, Chichester, Sussex) pp 3 – 15

Longley P A, Harris R J, 1999, “Towards a new digital data infrastructure for urban analysis and modelling” Environment and Planning B: Planning and Design 26 855 – 878

Longley P A, Goodchild M F, Maguire D J, Rhind D W, 2001 Geographic Information Systems and Science (John Wiley, Chichester, Sussex)

Mack J, Lansley S, 1985 Poor Britain (Allen and Unwin, London)

Martin D, 1992, “Postcodes and the 1991 Census of Population: issues, problems and prospects” Transactions of the Institute of British Geographers: New Series 17 107 – 120

Martin D, 1998a, “Automatic neighbourhood identification from population surfaces” Computers, Environment and Urban Systems 22 107 – 120

Martin D, 1998b, “2001 Census output areas: from concept to prototype” Population Trends 94 19 – 24

Martin D, 2000, “Towards the geographies of the 2001 UK Census of Population” Transactions of the Institute of British Geographers: New Series 25 321 – 332

Martin D, Nolan A, Tranmer M, 2001, “The application of zone-design methodology in the 2001 UK Census” Environment and Planning A 33 1949 – 1962

Mitchell R, Martin D, Foody G M, 1998, “Unmixing aggregate data: estimating the social composition of enumeration districts” Environment and Planning A 30 1929 – 1941

Monmonier M, 1996 How to Lie with Maps 2nd edition (Chicago University Press, Chicago, IL)

NRU, 2002, “Neighbourhood renewal”, Neighbourhood Renewal Unit The Independent 23 January (special supplement)
Creating small area measures of urban deprivation

ONS, 1999 Census News March, Office for National Statistics, 1 Drummond Gate, London SW1V 2QQ
Openshaw S, 1984 Concepts and Techniques in Modern Geography: 38. The Modifiable Areal Unit Problem (Geo Books, Norwich)
Openshaw S (Ed.), 1995 Census Users’ Handbook (GeoInformation International, Cambridge)
Orford S, 1999 Valuing the Built Environment (Ashgate, Aldershot, Hants)
Raper J, 2000 Multidimensional Geographic Information Science (Taylor and Francis, London)
Rees P, 1999, “The 2001 Census of Population: what does the White Paper propose?” Environment and Planning A 31 1141 – 1148
Robinson W S, 1950, “Ecological correlations and the behaviour of individuals” American Sociological Review 15 351 – 357
Sleight P, 1997 Targeting Customers: How to Use Geodemographic and Lifestyle Data in Your Business 2nd edition (NTC Publications, Henley-on-Thames, Oxon)
Townsend P, Phillimore P, Beattie A, 1988 Health and Deprivation: Inequality and the North (Croom Helm, London)
Wrigley N, Holt T, Steel D, Tranmer M, 1996, “Analysing, modelling, and resolving the ecological fallacy”, in Spatial Analysis: Modelling in a GIS Environment Eds P Longley, M Batty (GeoInformation International, Cambridge) pp 25 – 40
Yapa L, 1998, “Why GIS needs postmodern social theory, and vice versa”, in Policy Issues in Modern Cartography Ed. D R Fraser Taylor (Pergamon Press, Oxford) pp 249 – 269