THE IMPACT OF ADVANCES IN INFORMATION TECHNOLOGY ON THE CARTOGRAPHIC INTERFACE IN SOCIAL PLANNING

by

M. VISVALINGAM

Department of Geography, University of Hull.

and

G. H. KIRBY

Department of Computer Studies, University of Hull.

Department of Geography,

University of Hull, 1984

DEPARTMENT OF GEOGRAPHY, UNIVERSITY OF HULL.

General Editor : R. C. Ward.

Professor of Geography in the University of Hull.

Miscellaneous Series No. 27.

ISBN 0 - 85958 - 113 - 6

CONTENTS

1. INTRODUCTION

To date, advances in Information Technology have had little impact on the analytical, compared with the display, use of cartography in social planning. This in part forms the rationale for an SERC-funded research project on "Graphical information systems (GIS) on personal workstations with enhanced graphic facilities", undertaken by the authors.

Our research is based on three propositions. We believe that the cartographic interface is of value in social planning when this draws on large multivariate data sets; that currently available software for computer cartography is based on inadequate models of information flow; and, that advances in Information Technology offer some considerable scope for extending these models and for providing an improved context for Man-Machine Interplay (Visvalingam and Kirby, 1984).

This report begins with a definition of some terms in cartography and a brief review of the functions of maps (Section 2). It then examines the essential processes in map-making and map use (Section 3). Section 4 sketches the impact of computer cartography to date, the potential benefits of more recent developments in Information Technology and the primary aims of the research on GIS. The disparate themes and ideas are illustrated with an example of the use of graphics for concept refinement in social planning (Section 5). The conclusion (Section 6) provides a summary of the more significant points raised and expands on some academic applications of Graphical Information Systems (GIS).

2. CARTOGRAPHY AND MAPS

Cartography is the discipline concerned with the making of maps and charts (Oxford English Dictionary). A cartogram is defined as a map representing statistical information in diagrammatic form (Chambers Twentieth Century Dictionary). To most people, a cartographic map is a representation in outline form of the surface features of the earth or of the distribution of some phenomenon upon it. Within cartography, a map may be a representation, a schema or an epitome of the disposition or arrangement of anything in graphic form.

Cartography is concerned with the philosophical and theoretical bases, the principles, materials and rules for the graphic encoding (and subsequent decoding) of spatial information in different types of maps. The latter include the Ordnance Survey Topographic Map and other reference maps and cartograms, such as flow diagrams, wind roses, pie-charts, Lorenz curves and histograms (Monkhouse and Wilkinson, 1971; Robinson, 1960; Dickinson, 1973; Cuff and Mattson, 1982).

Maps and cartograms serve several functions. Traditionally, they have been used for the storage, dissemination and communication of spatial information for example, on location, direction, distance, height or magnitude, density, gradient, shape, composition and pattern.

They convey information on connectivity, contiguity, juxtaposition, heirarchy and spatial association. They are unique and irreplaceable for portraying and comprehending spatial attributes and relationships in a holistic form. They, therefore, perform a function which cannot adequately be performed by words and numbers alone (Muehrcke, 1981).

Maps are, firstly, models of data. The data may be qualitative or quantitative, and need not be confined to physical entities and/or geographic space alone. Maps may also represent conceptual entities in measurement space.

Maps are not just models of data. They are also regarded as models of reality itself. However, there is some considerable variation in the concepts of reality and aims of map-making. Table 1 provides a simplistic illustration of some differences between scientific and sociological perspectives; it must be remembered that the latter are characterised by many conflicting schools of thought.

In the 1950s cartography was considered as art, science or technology but Robinson et. al. (1977) stressed that "the scientific basis for a discipline of cartography will receive considerable attention in the future" (p 5).

The 'scientific' approach to cartography is akin to the derivation (using photogrammetry) of line maps from , or the artistic touching-up (as in orthophotomaps) of, photographs; see Thrower and Jensen (1976) and Petrie (1977) for orthophomaps. The emphasis is on an objective and faithful

TABLE 1 : Some variations in concepts of reality and aims in map making

Characteristics of map model	APPROACH scientific	sociological
reality	absolute	man-made
requirement	must be objective	can be subjective or even mental models
emphasis	faithful image of reality	communication of message or even functional schema
detail	can be very complex	must be succinct and clear
purpose	general purpose; for reference	for customised communication
expectations of user	proficiency in map reading, analysis and interpretation	little map skill but familiarity with subject
examples	Ordnance Survey Topographic Map; Geological Maps; Admiralty Charts	Thematic maps and business graphics, often depicting results of analysis and synthesis

representation of highlighted aspects of a reality, which is independent of the map maker and user.

In social planning, the focus is generally on subjective views of man-made reality, using thematic maps (which are more concerned with the distribution of themes of interest, such as unemployment, age or sex composition, or deaths by various causes); although elements from reference maps are often included for purposes of orientation and location. The emphasis is on the direct and immediate communication of a message; which must be perceived almost intuitively rather than through a laborious process of map reading and analysis. Decision makers, such as elected councillors, may not be proficient in map use or have the time to study the map in any great detail. In this context, realistic and visually pleasing maps may not always be the most useful or informative; 'caricature' maps , based on techniques of selection (of detail), exaggeration (of the most important characteristics) and simplification (of background detail), may be more appropriate.

Taylor (1974, p 35-36) drew a distinction between 'automated cartography', a process for replicating the production of reference-type maps, and 'computer cartography', the process of generating creative experimental thematic maps. Rhind (1977) dismissed this distinction as a potentially "dangerous and misleading one which obscures the identical nature of the data-handling in both 'fields' at the machine level and the considerable overlap of the subject areas" (p 71). His emphasis is on technology and methodology as related to the acquisition, storage, retrieval, manipulation and display of spatial data. Emphasis on such common denominators could well disregard the distinction between digital mapping and computer-aided design (CAD), two quite different applications of computer graphics. Taylor intuitively appreciated that computer cartography must ultimately transcend the requirements of map-making and respond to the then, and still, largely vague potential for map use.

3. ESSENTIAL PROCESSES IN MAP-MAKING AND MAP USE

3.1 Map-making and the information industry

Map-making is often viewed as a cyclic activity (Board, 1981). The map maker starts off with his view of some aspect of reality. The graphic communication of this view of reality involves four types of activities, namely the collection of relevant data, the processing and analysis of this data, the display of the results of analysis in graphic form, and the evaluation of the graphic product, which may require iteration through some of the preceding processes.

Planning agents rely where possible on the services of a primary sector within the information industry, which collects and disseminates 'raw' statistics on a variety of social issues. Whilst such independent observations, such as the Small Area Statistics provided by the Office of Population Censuses and Surveys, are impartial, they present only snapshots of reality and may be limited by their substantive content and sampling framework. The onus is thus on the user to ensure that the data are free of bias and errors and relevant with respect to geographic scale and substantive categories.

The secondary sector within the information industry is concerned largely with the processing and analysis of spatial data. The processing may be very simple, involving the aggregation of counts for areas and/or categories, the derivation of primitive social indicators, and the transformation and ordering of data areas. It may also involve the application of complex mathematical procedures, for example to elicit the socio-spatial structure of places. Vendors of value-added spatial data, such as CACI and Pinpoint (Computer Weekly, 1984), are only just beginning to sell their products in graphic form.

The tertiary sector within the information industry has concentrated on the provision of computerised tools for the production of cartographic displays. These range from a collection of device-independent FORTRAN subroutines as illustrated by GINO-F and GINO-GRAF, to command driven packages such as GIMMS, ASPEX and DISSPLA. Again, the onus is on the user to ensure that the cartographic language, i.e the symbolisation used for the graphic encoding and decoding of data, is appropriate.

Thus, the graphic product must be carefully evaluated to trap noise, bias and artifacts, which may be introduced at any of the above stages in map-making. Without the tertiary sector, the information industry servicing the empirical requirements of social planning would rely almost entirely on mathematical and statistical analysis. This was the case in the 1950s and 1960s when cartography was almost abandoned by geographers as a passive discipline, incapable of contributing to theory (see Muehrcke, 1981; Board, 1981).

The emphasis on statistical model building was encouraged by the prevailing scientific paradigms, the availability of computer power for number-crunching and easy access to large ready-made, computer-readable data banks. Computer graphics was then still in its infancy and it was expedient to discredit the role of cartography in the race to publish or perish.

Even today, in many commercial applications trendy graphics play a peripheral role and, like pretty maidens, remain eye-catching pointers to a separate message. In many serious applications though, graphics offer an alternative perspective on reality to that provided by complementary text and tables. In conventional cartography we have had to accept that there is a further loss of 'raw' data in the abstraction and display of spatial relationships and patterns. However, as we shall see later, this need not be so in graphical information systems.

More importantly, computer cartography provides a powerful tool for validation through visualisation. In the pre-planned production of maps, it is not always possible to visualise the outcome of the map-making processes. For the resultant map image is much more than the sum of the contributions from various component processes. If thematic maps have the intrinsic capacity to provide insight and clarity they also have the power to mislead and distort reality.

However, the distortions may not necessarily be the result of cartographic processes but may stem from deficiencies in data or in statistical concepts. Without adequate validation techniques, statistical analyses have confused as much as clarified social issues (Irvine et. al., 1979; Visvalingam, 1983a, 1983b). Edwards (1975) expressed that the uncritical application of sophisticated statistical techniques to the study of multiple deprivation was as meaningful as using a micrometer to measure a marshmallow.

3.2 Map-use

Map use must be considered within its proper context. Social planning is not an objective, rule based and value-free activity. Irrational and primitive elements are known to influence both motivating beliefs and policy decisions (Masser, 1980). Provisions for public participation in planning recognise that there may be many equally valid even if competing and conflicting views of man-made reality, visions of the future and claims for resources.

It is generally assumed that empiricism provides hard evidence and impartiality in the formulation, implementation and evaluation of policy. It provides a means of reaching a decision for instituting action, even if not consensus. Within this context, maps, portraying alternate views of reality, become part of a process of arbitration.

However, in policy formulation there is a need to assess not just the validity of evidence but also its relevance to issues of policy. Whilst graphic abstractions are useful for focussing attention, the implementation and evaluation of policy require the retrieval and processing of underlying statistics as prompted by map observation.

Currently available software facilitates the production of customised maps. It does not allow the map maker-cum-user to use the map medium to recover vital statistics since it is based on pre-computer era models of information flow in cartographic communication (Board, 1981). These associate with maps their traditional functions, regarding maps as media for the storage, dissemination and communication of spatial information. They are largely concerned with the processes by which the cartographer conveys his view of reality to the map user.

The information flow is cyclic, since the latter can communicate his reading, analysis and interpretation of the map to the former so that noise factors in the encoding and decoding of the map medium could be recognised and eliminated where possible. This is an adequate schema of information flow in the production and use of some reference maps. Map makers, such as the Ordnance, Geological and Soil Surveys, are also collectors of the primary data, which have until very recently been made available only in printed map form. However, policy researchers and implementers interact not so much with the map but with the data through the map and the computer. Thus, models of information flow in cartographic communication will need to be extended to reflect the changing role of digital mapping in planning research.

4. TECHNOLOGY AND CARTOGRAPHY

The merits and impact of digital mapping on environmental and social planning have been reviewed elsewhere (Rhind, 1977; Dudycha, 1981, Teicholz and Berry, 1983). It speeds up many of the mechanical processes in map-making and there have been some tremendous developments in the computer production of reference maps (Ordnance Survey, 1983).

In addition, developments in graphics hardware and software have extended capability; what was previously impractical is now possible. For example, data for thousands of spatial units can now be mapped at a very high resolution (C.R.U/O.P.C.S./G.R.O., 1980) so that both intra-urban as well as inter-urban and regional patterns may be observed on the same map of Britain. Not only is it possible to compute and display complex cartograms but it is also possible to view objects and point-clouds rotating in three-dimensional space (Donoho <u>et.</u> <u>al.</u>, 1981).

Computer cartography has also led to a specialisation in map functions. Maps may be customised for different purposes (Kirby and Visvalingam, 1982). More importantly, it is now possible to use the map for those functions that it is best suited for, e.g. the comprehension and communication of spatial characteristics, since the computer is now the storehouse of both the data and the latent information within it.

In theory, computer cartography offers some considerable scope for innovation and the identification of the perspectives which best match different purposes via experimentation. In practice, there is little encouragement for exploration, cross-reference and validation of data; for assessing the latent information potential in datasets; or, for projecting alternative information perspectives on such data.

Commonly available command-driven software packages inhibit data exploration. All too frequently, they offer a poor man-machine interface and assume that users have a programmer's mentality. Instead of the computer making the task easier for the user, package designers have tended to expect the user to make their task easier. Users generally tend to identify procedures which make the package work for them and then stick to this format, often through the use of front-end macros provided by someone else with programming ability. This encourages a pre-planned approach to the production of maps. Ephemeral displays are generally used to check the product for errors in user input rather than to evaluate the information content and meaning of the display or of the underlying data and reality.

Even when there has been a man-machine interface lift, the intention has been to reduce the scope for erroneous input by altering the form of the dialogue. There has been little change in the framework for man-machine interaction, which remains inadequate. This has been due to at least two contributory factors, namely the subconscious stranglehold of an earlier emphasis on the emulation of established methodology during the growth years of the discipline of digital mapping and the limits set by prevailing technology.

Since the generation of displays has itself been an onerous task, digital mapping has been largely influenced by the requirements of map-makers rather than the users. They have focussed especially on the production of facsimile reference maps, or elements of such maps. These have traditionally been compiled at prescribed scales, which determine both map format and content. Even the production of digitial elevation models is undertaken within a puzzle, as opposed to a problem, solving paradigm (Kuhn, 1970). Software development has assumed well-defined boundary conditions and goals.

Although the end-products of computer cartography are much more variable, unpredictable and often derived through a process of trial and error, the packages for thematic mapping have, by necessity, provided for the production of only a subset of cartograms as described in standard texts. Many of these maps and diagrams were devised for relatively coarse-grained data. Data on a variety of topics are becoming available at progressively finer resolution and will, with concomitant developments in graphics hardware, no doubt lead to the development of new techniques for cartographic communication.

Thus, digital mapping, which subsumes both automated and computer cartography has implicitly stressed digital map-making rather than map-use. Users' evidence to the Sub-Committee, on Remote Sensing and Digital Mapping, of the House of Lords Select Committee on Science and Technology (1984) demonstrates that they forsee a demand for digital map use in general but that they cannot yet spell out their specific future requirements. The Lords Report is consequently optimistic, but only in vague terms, about future applications (p 42-44), and this is especially so in social planning.

The recommendations (p 71-75) instead focus on current problems, and advocate standards for digitising and data exchange, the extention of the cartographic data base, and research into data structures. Some expert witnesses have stressed that digital mapping is still in its infancy and that standards may inhibit development. There is to date very little experience in the substantive use of digital maps.

We consider digital cartography as the discipline concerned with the creation and use of digital maps and their displays. As stressed previously, user interaction in digital cartography is not so much with the display, as with the 'raw', related and synthesised data through the display. Map reading, analysis and interpretation already involve different operations in different applications and it is extremely difficult to predict future requirements. Thus, future cartographic software will have to provide not only for variety but also uncertainty.

Existing software, such as GIMMS (Waugh and McCalden, 1983), are already over-complex for the average user, partly because the user manual is not altogether successful in presenting an overview of the package. It is quite likely that no single package for map-making and map-use can be 'all-singing and all-dancing' as advocated by Rhind (1976); nor should it be.

Research into the design of future cartographic software has been limited not only by the emphasis on map-making, but also by the limitations of yesterday's technology, which in practice is still in use. Multi-user interactive graphic systems are too slow. Eight-bit micro-computers do not offer the memory and screen-format convenient for planning applications which rely on large data sets (ESRC Survey Archive, 1984).

However, the emergence of powerful single-user personal workstations with enhanced graphic facilities is just one of the developments which is likely to change the role of computer cartography in social planning. Such decentralised systems offer prospects for optimising all operations towards one application. They already feature high-resolution large-format screens. Further, developments in network technology permit rapid access to large, shared data sets on data servers or on systems elsewhere on a network.

These single-user systems already support concurrent processing, which considerably eases not just the development of complex graphical information systems but also their use; parallel processing hardware is likely to upgrade speed rather than functionality in information systems. What is seriously lacking, and urgently needed, is a relatively inexpensive high-resolution colour capability.

Research and development in enabling technologies will lead to the computerisation of many tedious cross-referencing functions in data exploration. These are only semi-automated at present, slowing down and often cutting out methodological research when confronted with planning deadlines. Future systems need new software concepts. We already have the necessary minimal capability to undertake investigations into high-level cartographic software.

We, at Hull, are investigating the feasibility of a socio-technical system, wherein a set of maps can be used to a) stimulate insight, b) derive the perspectives on data which are most relevant to policy issues, and c) act as pointers to data. This requires the transfer of the data storage function from the map to the computer, so that the map can be used for the funtions that it is best suited for, namely the comprehension and customised communication of spatial relationships in a holistic form. The map can instead become part of the front-end to database systems - a front-end which will include graphic query functions to retrieve 'raw' or related data in a natural way.

5. CONCEPT REFINEMENT THROUGH VISUALISATION

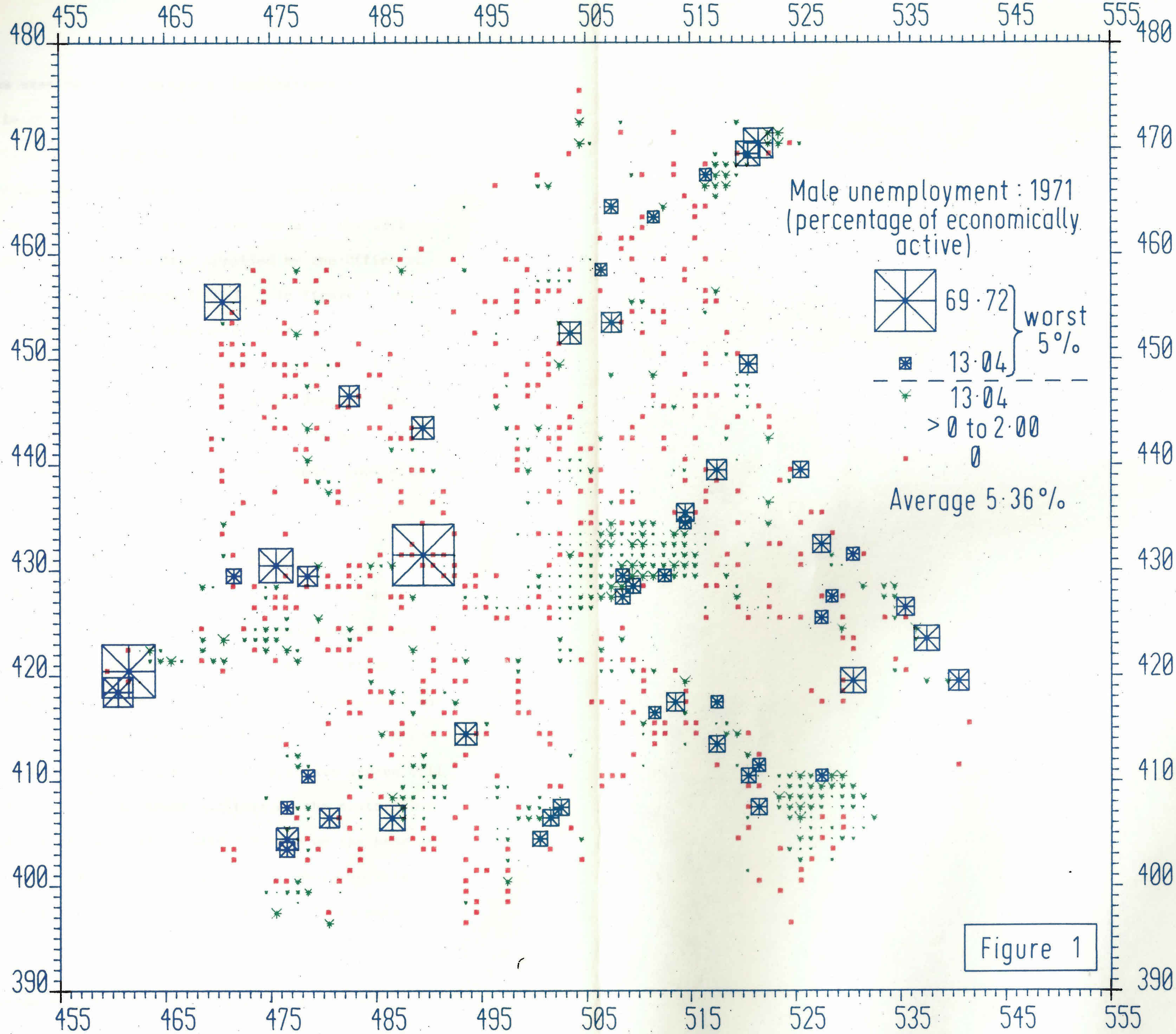
Maps as pointers to data and the notion of concept exploration through visualisation can be illustrated with a very simple example. Area-based policies often involve the identification of priority or target areas, for example for purposes of positive discrimination or for product promotion. Target areas are usually identified with composite indices based on some forty or so variables. The method is extremely simple if we consider the bare bones of the approach ignoring sophistications.

Firstly, there is a need to specify the central concept, e.g. <u>poverty</u> in policies of social reform or <u>market potential</u> in product promotion. Such concepts are difficult to define precisely, let alone measure directly. Thus, surrogate measures such as income become candidate indicators of both poverty and buying power. Data on income is not directly measured in many countries and is often suspect even when available. Thus, proxy measures, such as data on unemployment, are used in their diagnostic, not descriptive, capacity (Visvalingam, 1983b).

Operational values are then derived from the selected data, for instance on male unemployment. Policies directed at individuals and generally intended as relief measures feature statistics on the numbers unemployed; they are based on the concept of absolute deprivation. Policies of social reform, on the other hand, operate on the concept of relative deprivation and have traditionally used ratio indicators in the identification of priority areas.

Areas can now be sorted on these operational values and 'best' and 'worst' areas be identified, using some system for determining cut-off values. The characteristics of extreme areas can then be assessed.

The following assumptions are implicit in this procedure. Johnston (1980) argued that "spatial variations in the human condition can be measured on a generally acceptable metric, irrespective of how that metric is interpreted by the value system of the perceiver". Further, it is assumed that each surrogate or proxy measure, however crude, bears at the very least a monotonic relationship to a selected dimension of the underlying theme. Geographic areas, or for that matter any set of samples or subpopulations, can be deemed to be ranked unequivocally on a good to bad scale only if we accept the above assumptions.


Male unemployment : 1971
(percentage of economically active)
69·72
worst 5%
13·04
13·04
> 0 to 2·00
0
Average 5·36%
455 465 475 485 495 505 515 525 535 545 555
480 470 460 450 440 430 420 410 400 390
Figure 1

Let us examine some conceptual implications of variations in the definition of some low-level primitive social indicators. The original colour versions of black and white geographic maps published in Visvalingam (1983c), are reproduced here. The illustrations are based on the 1971 grid based population census data supplied by the Office of Population Censuses and Surveys (OPCS). In Figure 1, which is based on number of males unemployed, male unemployment is suggested to be particularly serious in urban areas. The worst 5 per cent of areas are shown in blue. However, the worst areas of male unemployment, measured using per cent economically unemployed, occur in rural and small populations (Figure 2).

A scatterplot of percentage against number of unemployed (Figure 3) not only highlights these two trends but also draws immediate attention to the existence of two outliers. It would be extremely useful if these various displays could be simultaneously viewed on a large screen and if the geographic areas which produce these anomalies could be rapidly identified. The graphical information system will allow the user to point to these outliers on the scatterplot and will respond by indicating their location on the maps and by displaying the required statistics. This would quickly locate the two outliers as being in areas which had male Borstals in 1971.

The propensity for a mismatch between many proxy measures and underlying concepts has already been documented

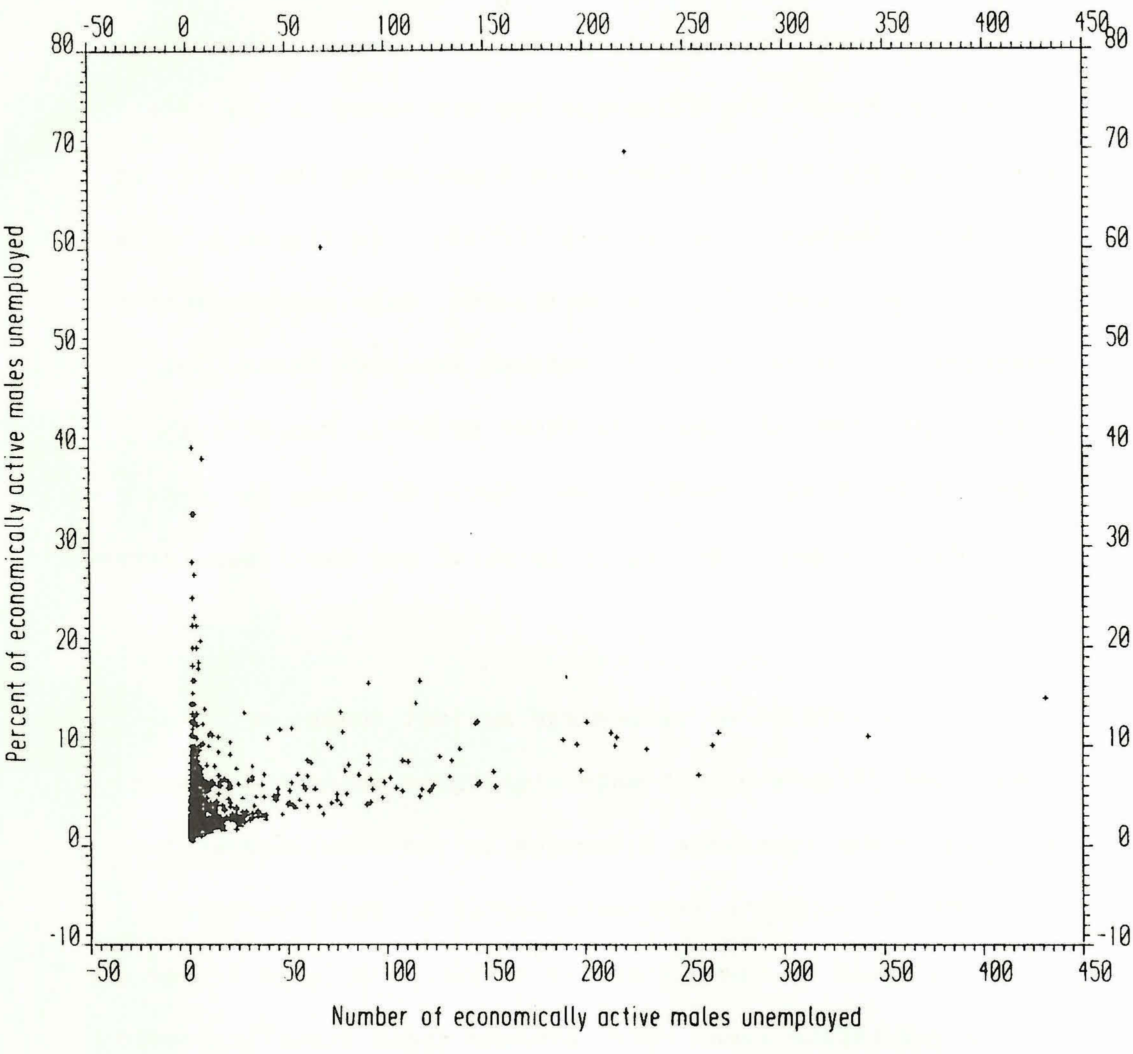


Figure 3: A scatterplot of percent unemployed males against number of unemployed males.

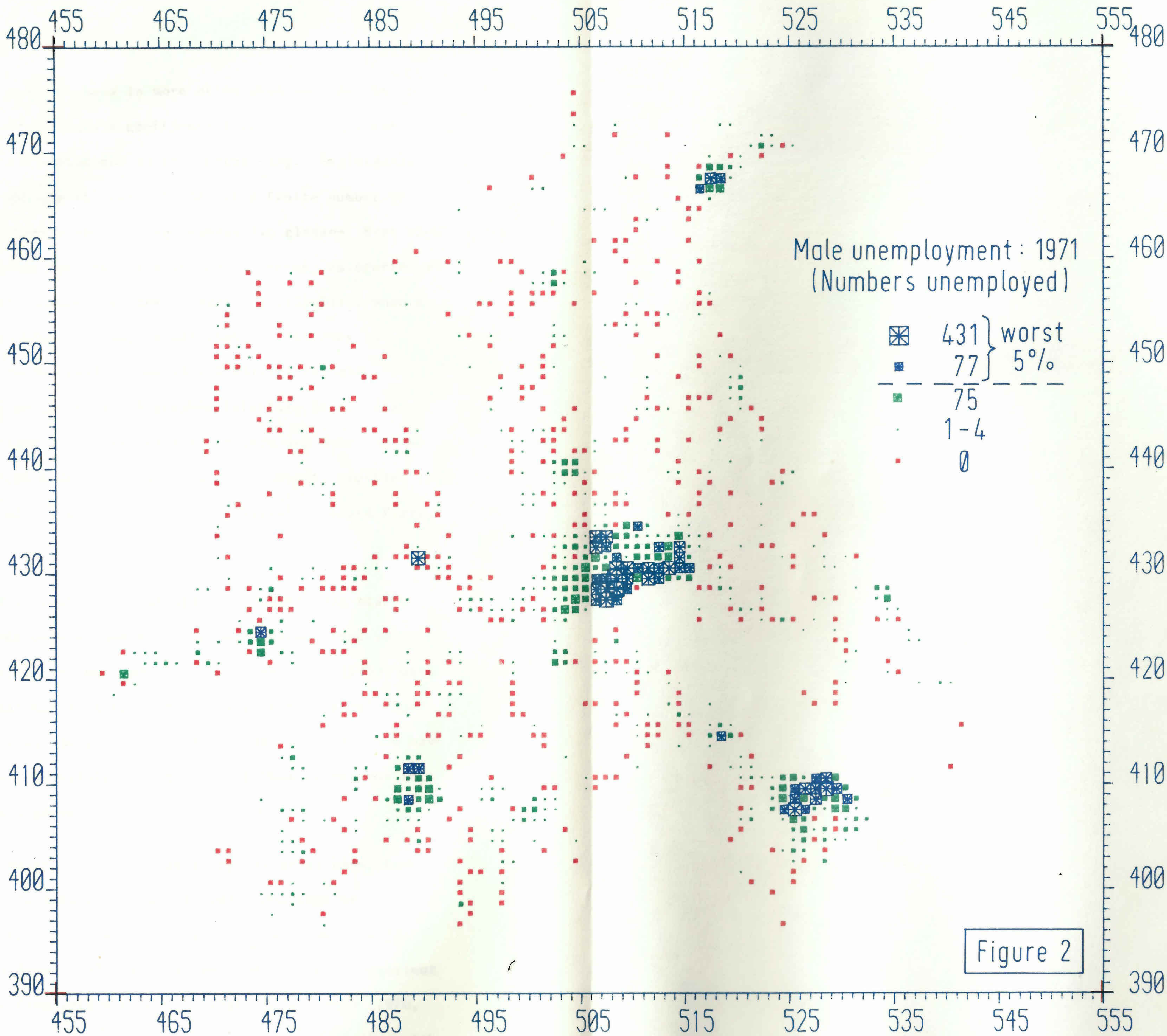

Male unemployment : 1971
(Numbers unemployed)
431
77
worst 5%
75
1-4
0
455 465 475 485 495 505 515 525 535 545 555
480 470 460 450 440 430 420 410 400 390

Figure 2

by several workers. Data is more often than not sold in aggregate form to ensure confidentiality of personal and household information and to ease processing. Individuals and households are allocated to one of a finite number of mutually exclusive and together exhaustive classes. Even when categorisations are devised after consultation, categories of interest may include unwelcome elements particularly when a 100 per cent sample survey is undertaken. The onus is ultimately on the user to ensure the correctness and suitability of the data. A graphic interface is expedient for identifying and investigating outliers and deducing the proxy value of nominal classes; in some cases it provides the only means of detecting missing data (Visvalingam and Perry, 1976).

It is widely known that absolute numbers are biased towards large populations and that ratio values tend to be to be more extreme in small populations. Choynowski (1959) used maps to point out this ratio bias but this has largely been ignored in many sophisticated statistical analyses. Some have used population weighting to counteract this effect but this is not always adequate.

Editors of thematic atlases, on the other hand, have been forced to acknowledge and either camouflage or compensate for this bias, which is often obvious on maps. Dewdney and Rhind (1975) omitted the most offending smallest populations from grid-square choropleth maps. Howe (1970, 1981) tried to indicate the size of the base population with embellished or proportional symbols and shaded them according to their ratio class.

These approaches were influenced by the need to preserve the data storehouse function of the map so that map users could determine an area's data values or data class. This function of maps could be performed more effectively by other means when electronic publishing extends to atlases (Monmonier, 1981). The above cosmetic changes, which are largely instituted within the secondary stages of information production, are also influenced by the need to preserve the aesthetic quality of maps in general purpose atlases. Even within the tertiary stages of graphic encoding, aesthetic quality is of secondary importance to information perception in planning maps (Kirby and Visvalingam, 1982). More importantly, the above procedures do not yield an acceptable technique for the ranking of populations.

Even more important than the differential bias is the lack of correspondence between operational definitions and issues of policy. Propositions concerning the equity and efficacy of area-based policies of positive discrimination (Holtermann, 1975) require the simultaneous consideration of three forms of concentration of deprivations, namely absolute, relative and density. Area-based marketing requires the same. Ratios and absolute numbers operationalise only one each of these requirements.

The signed chi-square measure (Visvalingam, 1983a) is

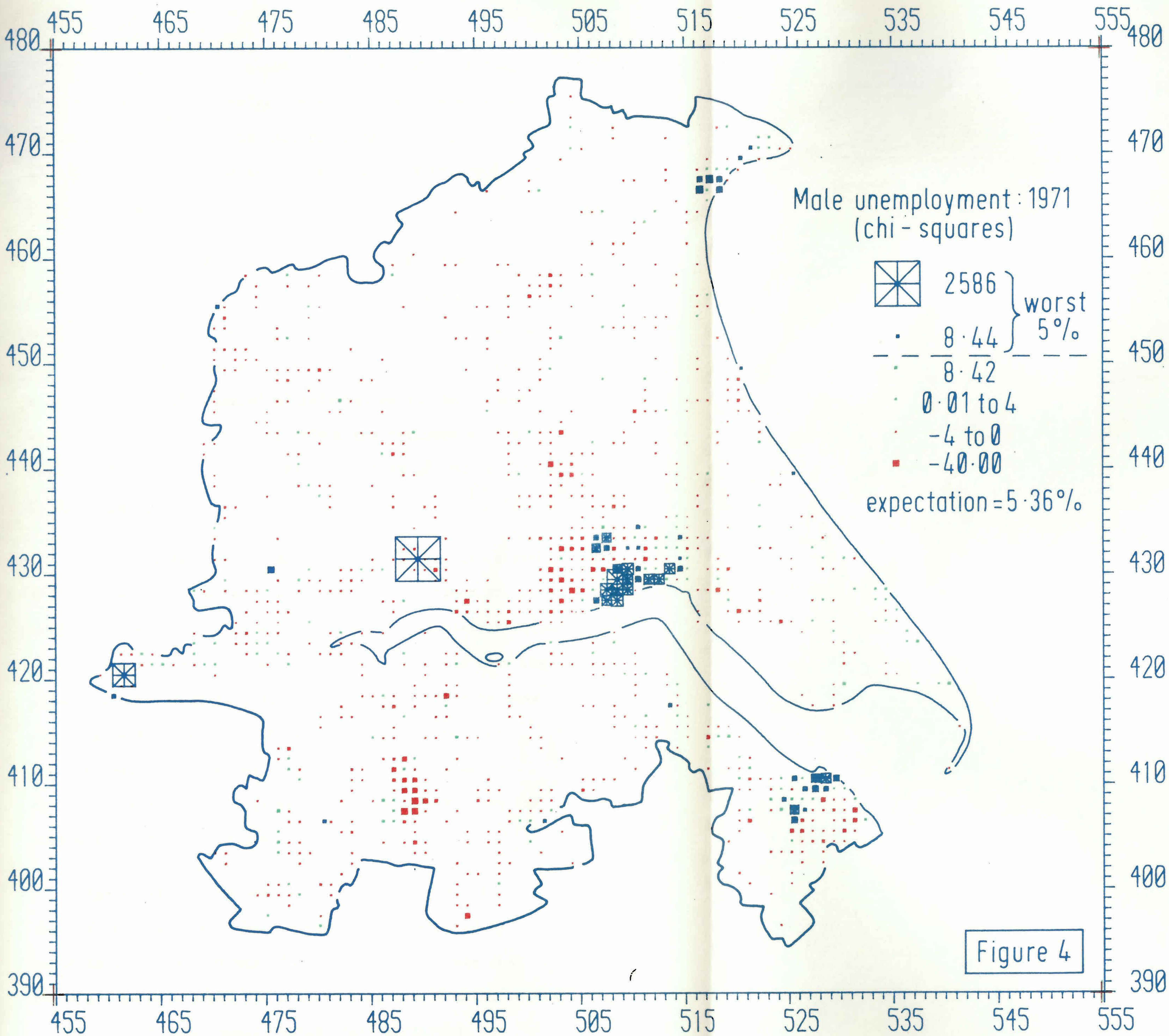

Male unemployment: 1971
(chi - squares)
2586
worst
5%
8·44
8·42
0·01 to 4
-4 to 0
-40·00
expectation = 5·36%

Figure 4

also arbitrary but it is capable of considering all three requirements simultaneously. The spatial pattern of male unemployment based on this measure is markedly different to that portrayed by ratios and numbers (compare Figure 4 with Figures 1 and 2).

Lorenz curves are useful for comparing these performance indicators. In Figure 5a, each Lorenz curve plots the cumulative proportion of unemployed males against the areas, ranked using the three indicators. Here, again it would be useful if a graphical information system enables the analyst to select cut-off values and responds with a tabulation of the specified characteristics of 'worst' areas on each indicator.

At the 'worst' end, signed chi-square produces a ranking which, even if not perfect, is intermediate between and more acceptable than ratios or absolute numbers. However, studies which are more concerned with the 'best' end would find the Lorenz curves rather perplexing. The graphs instantly show that the best 10 per cent of areas, using this measure, include some 13 percent of the unemployed when some 45 percent of areas enjoy full employment as indicated by the curves for ratios and numbers.

Again, it will be useful if the characteristics of these different sets of best areas can be retrieved by pointing to cut-off values. The statistics indicate that there are between 2 and 364 economically active males in the areas with full employment. Whilst full employment for 364

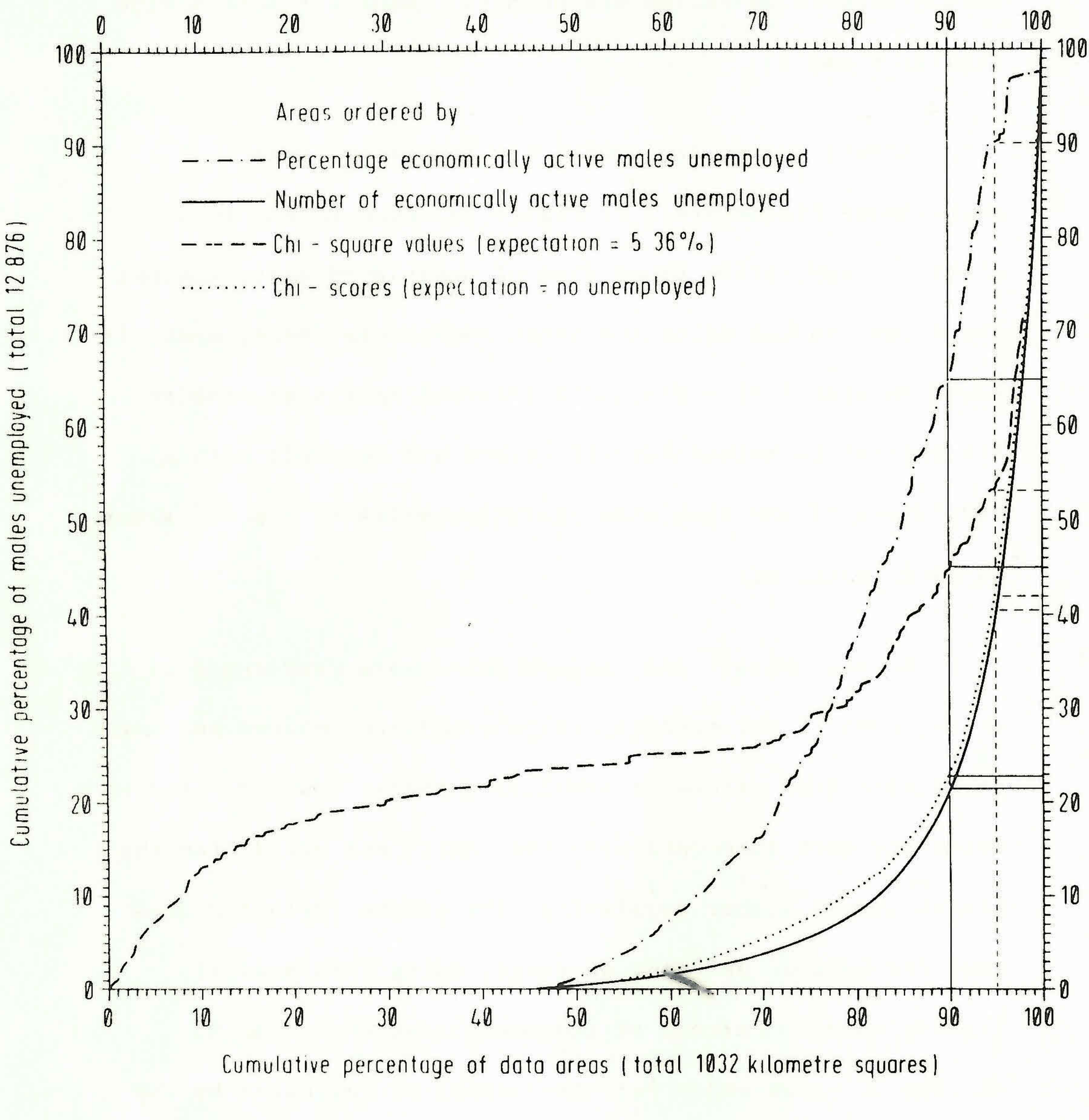


Figure 5a: The cumulative percentage of unemployed males in kilometre squares ranked by various measures.

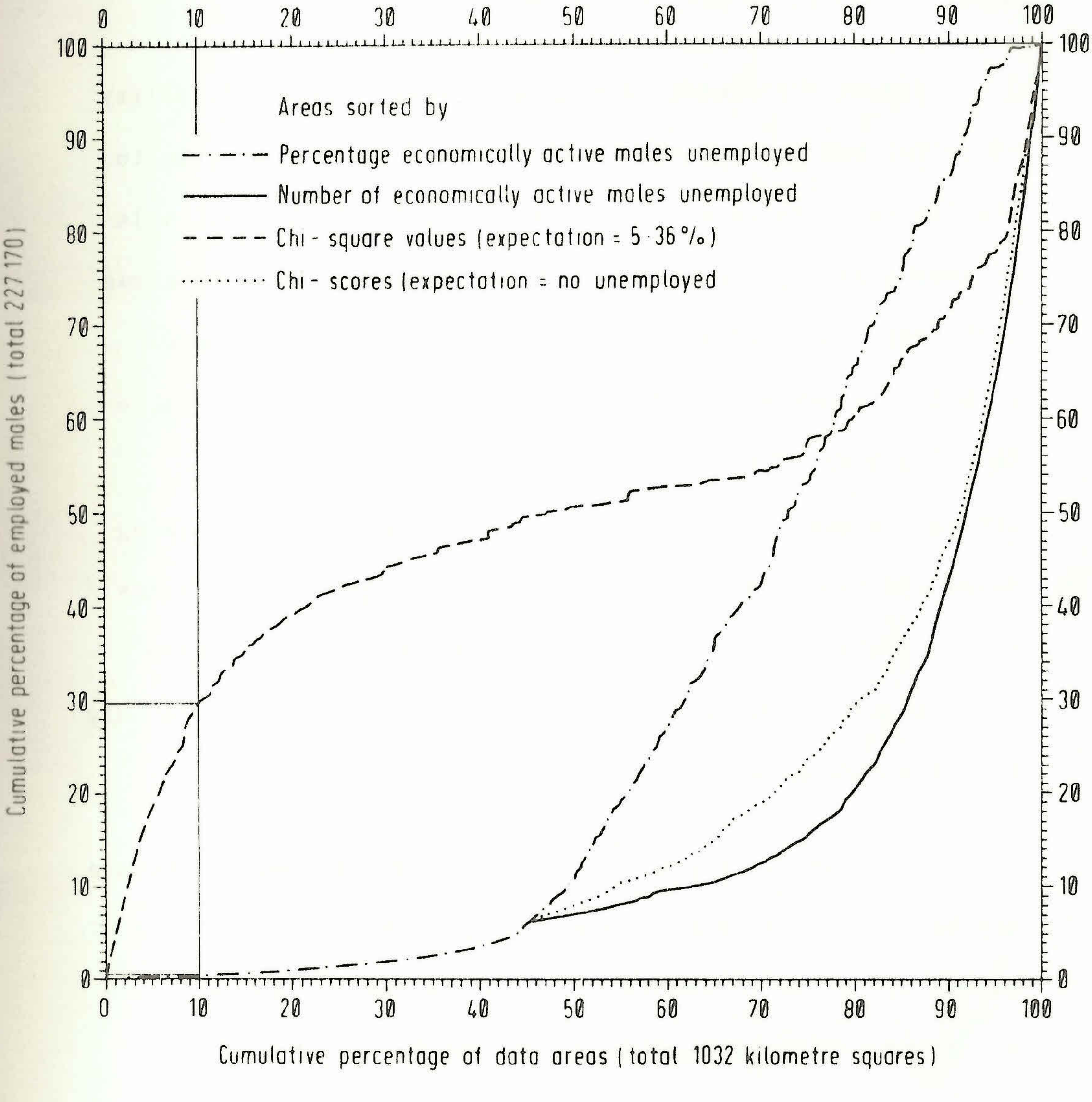


Figure 5b: The cumulative percentage of employed males in kilometre squares ranked by various measures.

males is significant as an indicator of buying power, full employment for two is not worth considering, particularly since the addition of one unemployed school-leaver would cause a jump to 33 per cent unemployed.

Signed chi-square is thus a measure of the reliability of ratios and corresponds to the binomial test statistic in the two-category case. In areas with above-expected levels of unemployment, the emphasis is on the unemployed; in areas with below-expected levels, the focus is on the employed. This is obvious on Lorenz curves for employed males (Figure 5b). The best 10 per cent of areas, using the signed chi-square measure, include some thirty per cent of working males and are located in the relatively higher status areas in Humberside. In contrast, the 45 per cent of areas with full employment occur in dispersed locations and capture only some six percent of working males.

It therefore appears that the signed chi-square measure may be more suitable for commercial purposes when there is a marked variation in sample sizes. Since the key issue in the use of probabilistic indicators is the formulation of expectation, it would be pertinent to consider the impact of alternative reference points. Performance indicators, based on statistical averages, summarise the net effect of past and prevailing processes; this is adequate for commercial ventures which merely seek to exploit the existing socio-spatial structure of society. It is not the overt intention of such programmes to change the existing fabric of

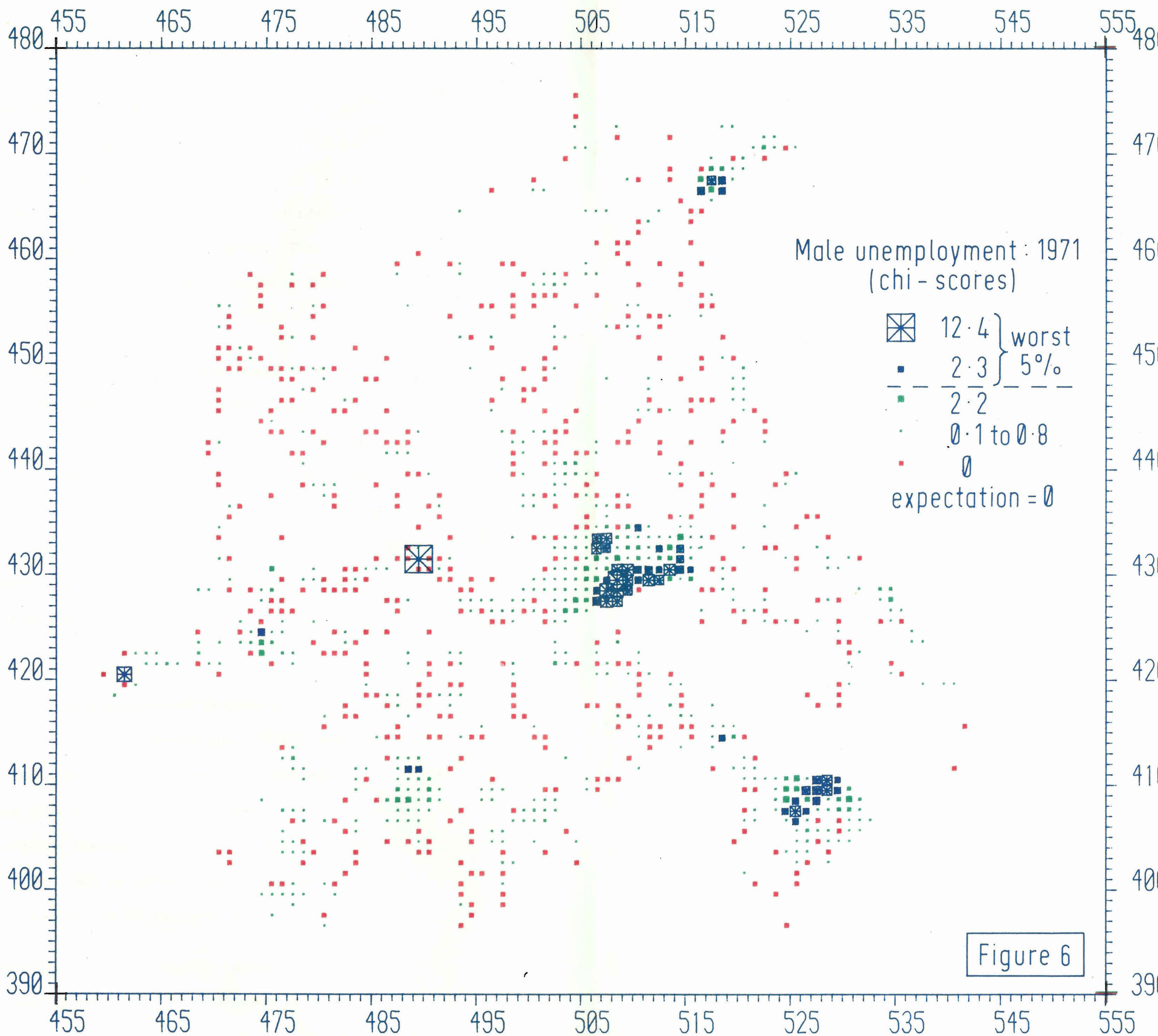

Male unemployment: 1971
(chi - scores)
12·4
2·3
worst 5%
2·2
0·1 to 0·8
0
expectation = 0
455
465
475
485
495
505
515
525
535
545
555
480
470
460
450
440
430
420
410
400
390

Figure 6

society. Policies of social reform are construed as instruments of socio-spatial engineering. Thus it is necessary to investigate the utility of social or political norms, such as the level of unemployment considered to be tolerable in a given state of the economy. These produce more useful measures of the disparity between existing and more acceptable conditions.

Figure 6 shows the distribution based on an expectation of full employment. All areas with full employment again revert to having the same status as shown in red. This necessitates the articulation of further assumptions. Policies of social reform are largely concerned with the 'bad' end of the distribution. In this context, areas with full employment are regarded as 'non-problem' areas, regardless of the numbers involved.

Even with only two inversely correlated items of data per sample there are even further perspectives if we shift to data for irregular units (Visvalingam, 1983a), such as enumeration and administrative districts instead of constant-area grid squares. Policies which focus on rural settlement require the explicit articulation of other assumptions. The implications of such changes to perspectives have yet to be explored and clarified.

The derivation of performance indicators from descriptive statistics is only one process within the secondary stages of information production. The aim of our research is to equip the policy analyst with an environment wherein the impact of changes to the data content, processing, analysis and graphic encoding can be immedietly assessed. An operator of the graphical information system will not only change the appearance and information impact of data, in much the same way that a user of word-processing software alters the layout and appearance of text, but also will go on to ask questions of the display and the data.

6. CONCLUSION

Statistical evidence can project a misleading perspective on even pertinent data; this may not always be intentional. A graphical information system, based on advances in Information Technology, should facilitate an experimental approach to the exploration of large quantities of relevant data and thereby promote the clarification of nuances in policy issues. At the very least, this requires friendly functions for retrieving selected statistics by pointing to maps and for cross-referencing elements in different displays. Within this context, existing cartographic software is excellent for the communication of well-defined perspectives but is inadequate for the formulation and refinement of concepts and methods.

The graphical information system involves research into the design of complex socio-technical systems based on extended models of information flow in the creation and use of digital maps. It will expedite academic research into social measurement and cartographic communication, and it could be linked to front-ends to demonstrate and teach the principles of cartography and basic statistical techniques. It could provide a working environment within which cognitive processes involved in the abstraction of knowledge from graphics can be studied.

REFERENCES

Board, C. (1981) "Cartographic communication", Cartographica 18, 42 - 78.

Choynowski, M. (1959) "Maps based on probabilities", J. Am. Statist. Ass. 54, 385 - 388.

Computer Weekly (1984) "How shops can be put on the retail map", Issue No 910, 21.

C.R.U./O.P.C.S./G.R.O. (1980) People in Britain - census atlas (H.M.S.O., London).

Cuff, D.J. and Mattson, M.T. (1982) Thematic maps - their design and production (Methuen, New York).

Dewney, J.C. and Rhind, D.W. (1975) People in Durham - a census atlas, Department of Geography, University of Durham.

Dickinson, G.C. (1973) Statistical Mapping and the Presentation of Statistics (Edward Arnold, London).

Donoho, D., Huber, P.J. and Thoma, H.M. (1981) "The use of kinematic displays to represent high dimensional data", in Eddy, W.F. (ed.) Computer Science and Statistics, Proc. of the 13th symposium on the Interface (Springer-Verlag, New York).

Dudycha, D.J. (1981) "The impact of computer cartography", Cartographica 18, 187 - 213.

ESRC Data Archive (1984) "Thematic mapping using micro-computers", ESRC Data Archive Bulletin 28, 53 - 54.

Holtermann, S. (1975) "Areas of urban deprivation in Great Britain : an analysis of the 1971 census data", Social Trends 6, 33 - 47.

House of Lords Select Committee on Science and Technology (1983/84) 1st Report of the Subcommittee on Remote Sensing and Digital Mapping, HL 98 (i - ii) (H.M.S.O., London).

Howe, M. G. (1970) National Atlas of Disease and Mortality in the United Kingdom (Nelson, London).

Howe, M. G. (1981) "Mortality from selected malignant neoplasms in the British Isles : the spatial perspecive", Soc. Sci. Med. 15D, 199 - 211.

Irvine, J., Miles, I. and Evans, J. (eds.) (1979) Demystifying Social Statistics (Pluto, London).

Johnston, R.J. (1980) "On the nature of explanation in human geography", Trans. I. B. G. NS 5, 402 - 12.

Kirby, G.H. and Visvalingam, M. (1982) " The representation and use of multivariate data in graphic form", in Greenaway, D.S. and Warman, E.A. (eds.) Eurographics '82 (North-Holland, Amsterdam).

Kuhn, T.S. (1970) The Structure of Scientific Revolutions (Chicago University Press, Chicago).

Masser, I. (1980) "The limits to planning", Town Planning Review 51 (1), 1 - 41.

Thrower, N. S. W. and Jensen, J. R. (1976) "The orthophoto and the orthophoto map : characteristics, development and application", Am. Cartographer 3, 39 - 56.

Visvalingam, M. (1983a) "The operational definition of area-based social indicators", Environment and Planning A 15, 831-839.

Visvalingam, M. (1983b) " An examination of some criticisms of area based policies", Census Research Unit WP 22, Dept. of Geography, University of Durham.

Visvalingam, M. (1983c)" Area-based social indicators : signed chi-square as an alternative to ratios", Soc. Ind. Res. 13, 311-329.

Visvalingam, M. and Kirby, G.H. (1984) "Communications over a network : MMI issues in a PERQ PNX (UNIX) environment" Department of Computer Studies Report No. 84/3, University of Hull.

Visvalingam, M. and Perry, B.J. (1976) "Storage of the grid-square based 1971 GB census data : checking procedures", Census Research Unit WP 7, Dept. of Geography, University of Durham (1976).

Waugh, T. C. and McCalden, J. (1983) GIMMS Reference Manual (GIMMS Ltd., Edinburgh EH3 9E4), Edn. 4.5.