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Visualising Social Processes

Criticism and Construction of Maps

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Visualising Social Processes – Criticism and Construction of Maps

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Introduction

The term visualisation can refer to several different processes. In its most basic form, it means "the construction of a mental image or representation without the stimulus of direct perception" (Keates 1982, pg. 54). With the advent of computer graphics, the concept of visualising data has received extensive coverage in literature discussing multi-media software, (e.g. Claramunt, Jiang et al. 2000; Sven 2000; Lamine and John 2001). Much of this work has focussed on the use of visualisation in communication, though some researchers have investigated the use of graphic construction in the earlier stages of research, such as in Pundt and Brinkkötter-Runde's (2000) call for increased utilisation of the skills of visualisation in field based use of GIS.

Some investigators take the view that "verbal processing is essential to thought, and therefore to memory" (Keates 1982, pg. 54). Visual images can be remembered in a way that is non-verbal, and memory can be enhanced with association with visual images. The essential role of visual processing of ideas in design (essentially a creative problem solving exercise, and as such of relevance to research techniques) is recognised in design studies literature, such as in Casakin (1999), Dahl (2001) and van der Lugt (2000). Two seminal thinkers provide a framework for improving the use of visualisation data, Bertin and Tufte. Their work provides useful insights into thinking and communication that can be applied to Geographic Information Systems, the representation of social data and research techniques in general.

Advantages of visualisation

> *"Clarity and excellence in thinking is very much like clarity and excellence in the display of data. When principles of design replicate principles of thought, the act of arranging information becomes an act of insight" (Tufte 1997, pg. 9).*

In addition to their uses in stimulation thought and questions about data, graphics have a 'tremendous communicative power ' (Tufte 1983, pg. 87).

Such an awareness is not new, as evidenced by the eighteenth century statistical diagrams of Playfair celebrated in Tufte's writings, and by an early, pre computer graphics, introduction to the use of statistics by one of the early Statisticians to the British Cotton Industry Research Association, in which Tippett (1943, pg. 26) states, "The chief importance [of the use of diagrams and charts in statistics] is that they give a picture of the broad statistical facts that is more readily taken in than in a table". He goes on to suggest that magnitudes and figures are more readily understood and remembered as images.

The possibility of using statistical diagrams to misrepresent data was not missing from these early writings, which call for an attention to the way in which diagrams are made and to the use of proportional representations of data, such that 'misleading impressions' are avoided (Tippett 1943). Tufte (1983, pg. 53) reminds us that "Data graphics are no different from words in this regard [distortion of underlying truth], for any means of communication can be used to deceive". He goes on to outline several key points for ensuring integrity of data representation, which form the basis of the Mind Map ® [1] 'Visualisation - Key Concepts 'used to analyse graphics in this essay.

Organisation of essay

In the process of synthesising the complex information surrounding the ideas of visualisation of social processes, I constructed several Mind Maps to show the elements of good graphic construction. These are largely adapted from the work of Bertin and Tufte, and Barr's seminars on the 'Visualisation of Social Processes' (MA seminars, Geography Department, University of Manchester). In doing so, I began to see how they could be used as a planning and analysis tool for visualisation. They have been used in the detailed analysis of a map from the literature of the Mersey Basin Campaign, with an accompanying illustrated textual discussion of the main points raised in this analysis[2]. In order to facilitate the reading of these Mind Maps, I have included a graphic about how to read Mind Maps. The conceptual framework developed in these mind maps inform the brief discussion of one further map from the Mersey Basin Campaign Literature and a set of maps created by the author.

The first analysis mind map is entitled 'The Basics of Graphic Construction', and can be used for an in-depth analysis of the visual tool, with a particular focus on the nature of data and the means to represent the data (based on the work of Bertin). The second, entitled 'Visualisation- Key Concepts', is largely based on Tufte's work, and provides a tool for assessing or planning the overall layout and execution of a graphic display. The third Mind Map, 'Types of Graphics' provides more detailed information about particular types of graphics displays.

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[1] 4. A **Mind Map®** is a graphic technique for representing ideas, based on natural patterns and how we perceive information and think. The Mind Map Book Buzan, T. and Barry (1993). The Mind Map Book. London, U.K., BBC Books.

[2] These mind maps were made using MindManager software. Note, this is my first time to use this software, so there are a few clumsy uses of graphics that I haven't yet ironed out.

The basics of graphic construction

Like most thinking processes, from research to creative design, the quality of visualisation is improved with a careful attention to the goals of the visualisation at the beginning. This requires the researcher to ask the question, what is this visualisation for?

Attention to Process

There have been several critiques of scientific and geographic visualisation that they are based more on the propensities and range of software than on an overall theoretical framework that encourages high quality research and data analysis. Thinkers about thinking, such as de Bono (1992) and Buzan (1993), suggest that to draw an idea down can be to fix it, such that it becomes difficult for the author or reader to see alternative arrangements. Echoing Bertin's (1981, pg. 5) assertion that "it is the internal mobility of the image which characterizes modern graphics" several authors have offered a process orientated view of visualisation to counteract this tendency.

Martin (1996) suggests a model for GIS which focuses on four main stages of interaction with data: data collection and input storage, manipulation, output and display. Maceachren (1994) calls for an increased attention to be paid to the process of communication and cognition, echoing Bertin's emphasis on the process of permuting graphics in order to discover underlying patterns in the data, and Barr's assertion that the single most common mistake in visualising data lies in not exploring the data thoroughly first (Barr, Robert, seminar, 2001).

The central role of the process of visualisation in enhancing creative thought has long been understood in research into design processes (e.g. Arnheim 1969; White 1983; Rowe 1987; van der Lugt 2000). This understanding is being extended into the design of GIS software, with Blaser (2000) calling for the integration of sketching and visual problem solving into the early stages of GIS use, referring to the original use of the term visualisation to mean "attempt to build a mental image of something, rather than merely representing graphical results on a computer screen" (pg. 58).

The use of computer can help to make the permutation of data much more rapid, and obviate the need for laborious redrawing by hand. As Bertin (1981, pg. 5) states (perhaps a little optimistically in 1981), "Remember that we live in an age of computers and electronic display screens, and that all such permutations can now be carried out by pressing a button". The challenge is to learn how to use software to its best advantage, using it to organise and find complex data, to permutate and rearrange data quickly, and to add structure to the visible data, so that meta-data and cross references are encoded in the underlying structure of the data.

At the same time, an awareness of the tendency to allow default settings of computers to determine graphic displays, categories and classes and ways of representing data, needs to be cultivated. These may seem trivial points at first, but we are reminded that "grouping can affect the impression created by the data" (Tippett 1943, pg. 25). The exploration I made of Manchester census data also showed how important it is to pay attention to the default clustering of data in cartograms and dot density maps, especially when making a range of maps for comparison, as the default clustering of numbers into cartograms will not necessarily be the same for each map, thus easily creating a confusing impression by not maintaining a valid sense of proportion between the maps.

Spatial Display of Information

Maps are not simply accurate pictures of reality. The process of mapmaking is one of selection and of choosing meaningful symbols. Certain conventions hold with regards to maps, and are commonly part of our education system. Graphic language is not necessarily a universal given, however, and care must be taken to check and see if viewers and communicators are 'speaking the same language'. Even once the conventions are learned, they do require interpretation. This is often made easier by showing the relationship between what humans can perceive in the 'real world' and the map, as illustrated in Tippett (2001), in which he shows OS maps in relationship to actual photos of the landscape features that they represent in order to help people gain a sense of what map symbols, such as contours, mean. When working with social aspects of geographic representation, concepts are even more abstract, and need to be complemented by verbal descriptions.

A critique of two maps

Weaver Valley Project

Figure 0-1 Weaver Valley Project – Map on loan from Weaver River Valley Coordinator, Mersey Basin Campaign, © Cheshire County Council, Environmental Planning

Processes

Writing about understanding maps, Keates (1982, pg. 10) suggests that "it is the connection between the map and what the user is trying to do that is most important". Critiques of this map are grounded in a perception that there is a lack of clarity as to the purpose of the map, it does not seem to have been designed with a particular question in mind. In critiquing a map, it is hard to see the underlying processes behind the map's construction. In this instance, I did talk to the Weaver Valley Initiative coordinator for the Mersey Basin Campaign, and asked what the process was behind the social indicators used and the way in which she can interact with the map (covering the issues of data manipulation, storage and display in Martin's (1996) transformation model of GIS). The coordinator, who is an important player in the Weaver Valley project, said that she did not know how the social data were constructed (Bates, Anne, pers. comm., 2001).

In this instance, there is a need to supplement spatial maps with statistical information, charts and diagrams. As Monmonier (1993, pg. 58) suggests, many geographic relationships are most thoroughly understood when portrayed both in the 'geographic space' of the map and the 'attribute space' of the data graph". The coordinator can request copies of the map, but is not able to interact with the data held in the GIS model in any other way, not having access to the software, data model or the training to be able to do so.

This map does make an attempt to show many different variables, and to relate social data to ecological information in a spatial context. It shows a high degree of information, and the coordinator who uses the map says she finds it useful in her project planning work (Bates, pers comm.). Bertin (1981, pg. 15) suggests that, "The efficacy of a graphic construction is revealed by the level of question that receives an immediate response". In this map, there is a high degree of information, but it is difficult to gain an immediate response to questions at almost any level of reading, either the overall view of patterns and trends, or a detailed view of what is happening at a particular place. However, an application of the theory of graphical construction to this map could produce a tool of more use as well as a map that is easier to read .

Nature of Data

This map appears to be constructed from a raster scanned OS map sheet, with thematic information laid over the top of this base map. This poses many problems, in particular of legibility, as the base map is not muted, but is full of 'chart-junk'. The use of an OS base map provides a slight advantage, in that most people are familiar with reading these maps, and the areas denoted relate to real areas in a way that the coordinator can understand. The use of such a detailed base map could be of help to coordinators in finding their way to sites that s/he is working on, but this task could be performed more effectively with the purchase of the relevant OS or road atlas map to use in tandem with the thematic map. However, these advantages are far outweighed by the lack of legibility and the fact that the thematic information is all but lost. This is what Bertin terms a 'reading map', as opposed to a 'seeing map'.

Instead, he suggests that "The base map must be presented in low profile. For the new thematic information to be as visible as possible, an efficient base map excludes any sign which stands out" (Bertin 1981, pg. 145). Instead, clear labelling of key features, in particular of nature reserves, rivers and possibly also towns, could provide much of the orientating advantage of the OS map sheet, whilst clarifying and elucidating the thematic information.

Variables

Quantity

The location of the derelict land, both already reclaimed and to be reclaimed, is fairly easy to discern from the symbols in use, see Figure 0-2. However, it is hard to discern from these pictograms what the relative areas of these sites are. Underlining the difficulties inherent in depicting quantitative differences on maps, Bertin (1981, pg. 205) states, "The representation of quantities by corresponding surface areas is the least bad quantitative analogy that we can construct in z". Such a representation is hampered by the use of a symbol with a difficult to determine area.

It is easier to discern magnitude from circles. In this instance, if the information was available, it may have been helpful instead to show actual boundaries of the sites and use a bright colour to denote the areas, rather than symbols. This would be possible and still legible if the base map was muted. It is useful that the sign shows the actual number of sites.

Figure 0-2 Symbols used to show derelict land

The legend (see Figure 0-3) highlights the difficulty of discerning the relative sizes of the stars. The divisions of land size are also confusing and seemingly arbitrary. If there was a reason for this classification, it should be mentioned in the legend, increasing the data density of the map.

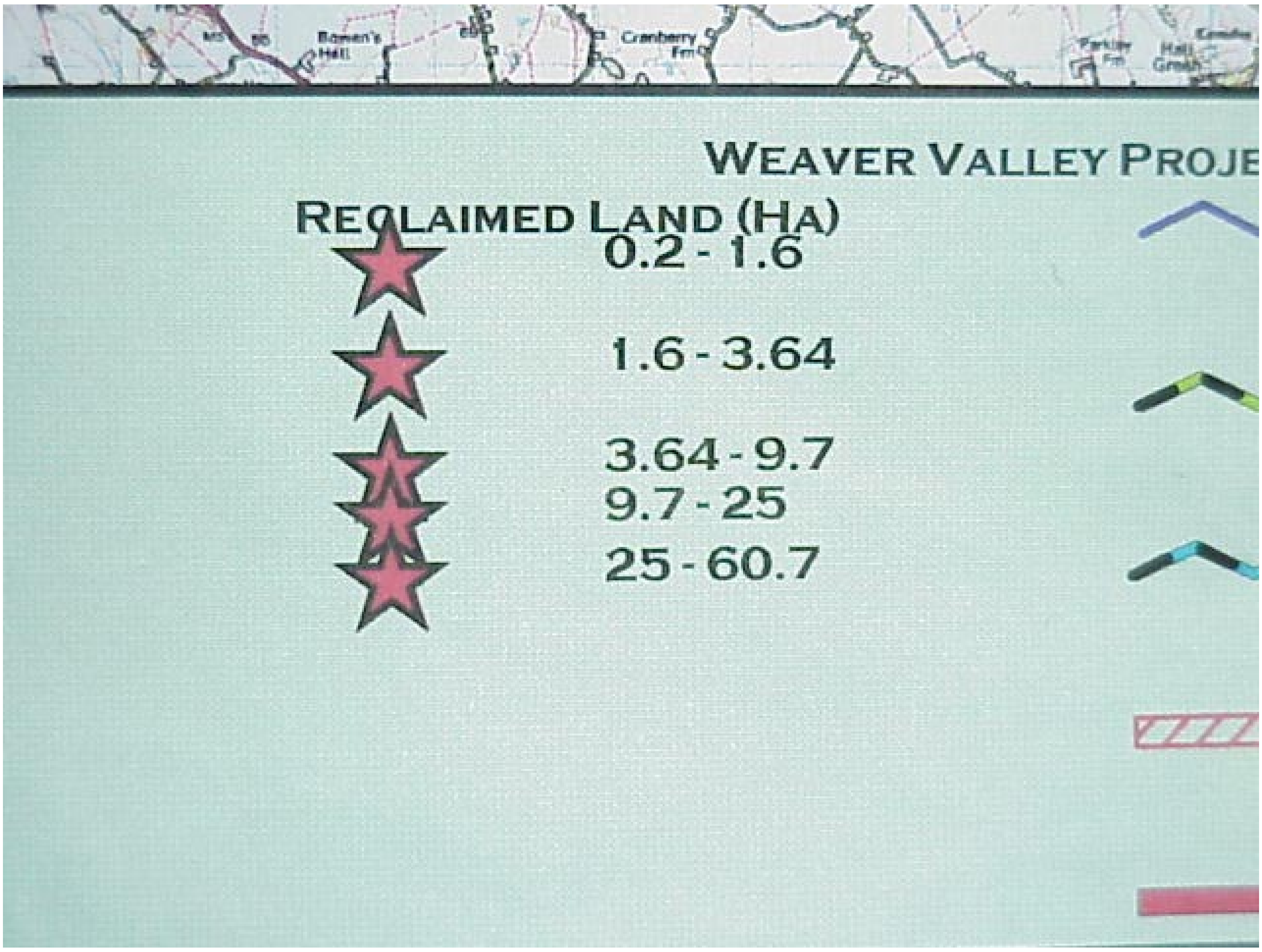

Figure 0-3 Legend for derelict land

Layers of Interpretation

The overall reading of this map is confusing and misleading. This is largely due to the large green band, which is supposed to denote the boundary of the project, and has a very low data ink to information ratio. The use of the colour green is misleading, as the first reading of this map could suggest that this is an existing or proposed area of protected green belt. This is a prime example of what Tufte (1983)terms 'chart junk' and provides not only a misleading impression but also the dominant visual impression of the map, and one which covers over and obscures other, important information.

The overall reading is further diminished in accuracy due to an inconsistent use of colour and texture to signify different thematic areas, see Figure 0-4. In some areas, denoting the 'Areas of Special County Value', the colour is used as an opaque block, and thus obscures underlying information. This gives the impression that the area is one large area of natural site, as it lies in stark contrast to the roads and villages visible in the adjacent areas. This is misleading, as many of these areas are populated, and are not large nature reserves.

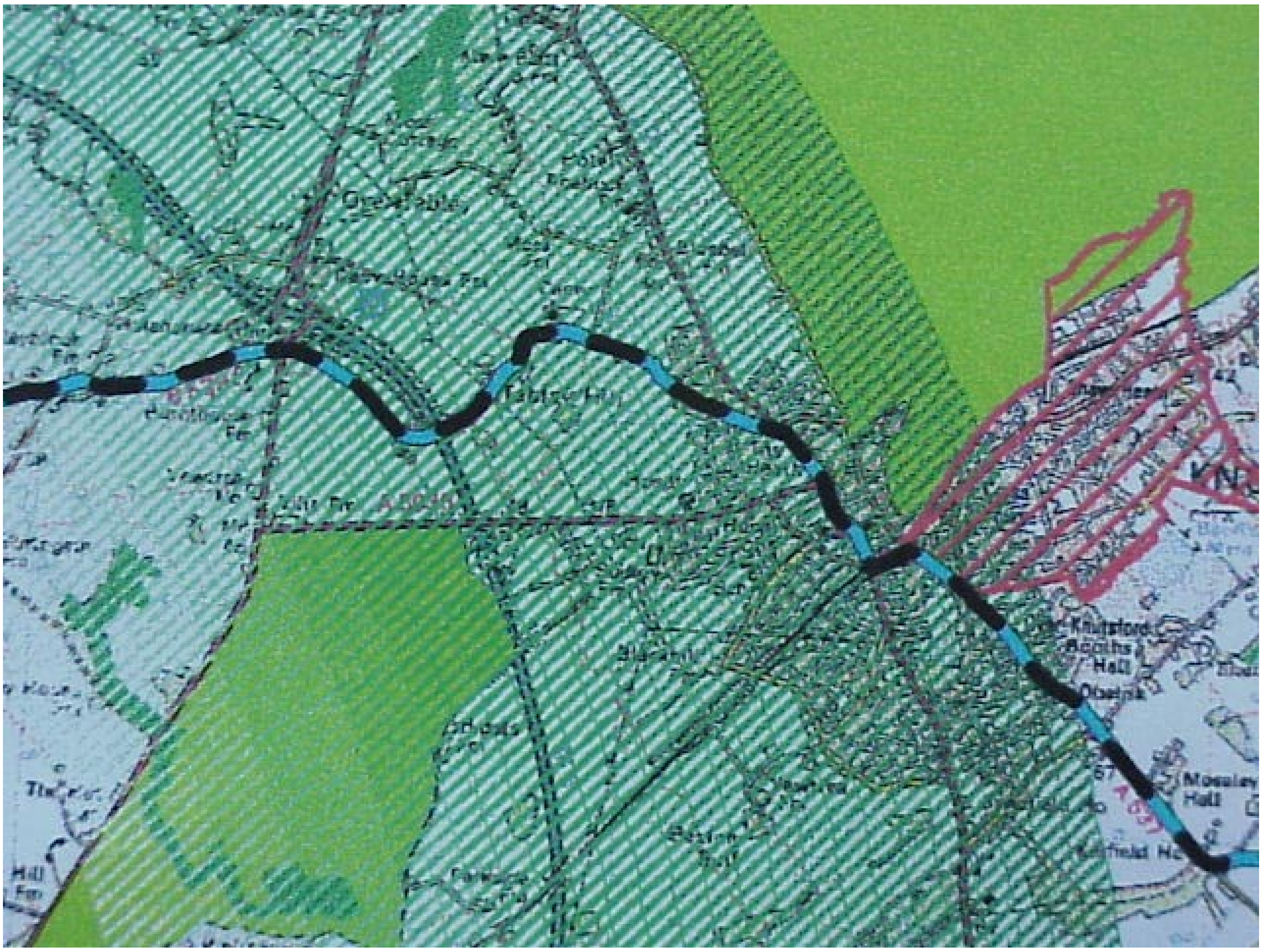

Figure 0-4 Confusing use of block colour

At the same time as showing far too much detail, this map actually leaves out may pertinent details, hindering the micro-macro reading. As Miles and Huberman (1994, pg.) reiterate, citing Tufte, "to clarify, add detail". In this case, the relevant detail, which could build a greater level of understanding, is information about what it is that makes the Areas of Special County Value (ASCV) unique. Lewis (1996) developed this concept in his elaboration of McHarg's (1992) process of ecologically informed design. He encouraged people in an area to develop icons of perception of local value (cultural, historical, ecological), which were used to build up an image on overlays on maps, thus highlighting areas that should be protected, celebrated and enhanced in the planning process. Such a patina of detail would add to the picture being built in this map, which aims to inform project planning in the area, as well as investigating the possibility of developing a regional park.

There is also no use of gradation of value in the colour scheme to denote difference of degree or ratios in the underlying data which inform the thematic mapping. Such a gradation, showing areas of particular significance, could add to the micro reading and the overall impression of the map. These could be used for the nature reserve, with estimation of biological value (e.g. biodiversity status), and for the areas of derelict, land, perhaps showing a gradation of the severity of contamination and likely risks from this land. A more detailed display would be possible given a less cluttered base map, and the use of small multiples to clearly display the various themes which build up the poly-thematic map.

Elements of Transcription

As discussed above, there is very little use of numbers in this mapping, and the use of symbols, though easily recognisable, does not assist the reading of quantitative information, such as actual area of derelict land. Better use of labelling could be made, with less overall words (again the over detailed base map), but with words used in areas which are important.

A major problem with this map is its confusing use of colour (see Figure 0-5). Red and green are used to make essential distinctions, rendering the map inaccessible to the colour blind. The colours used to denote different areas are neither related to the data under discussion (e.g. the use of different types of green to show different areas of natural value), nor internally consistent, for example, red is used to denote both nature reserves and areas of family stress, two quite different types of information which thus end up being graphically confused. If motorways, which use blue, were not shown on this map, then blue could be used for the river, a more 'natural' and thus easily legible colour to show water features.

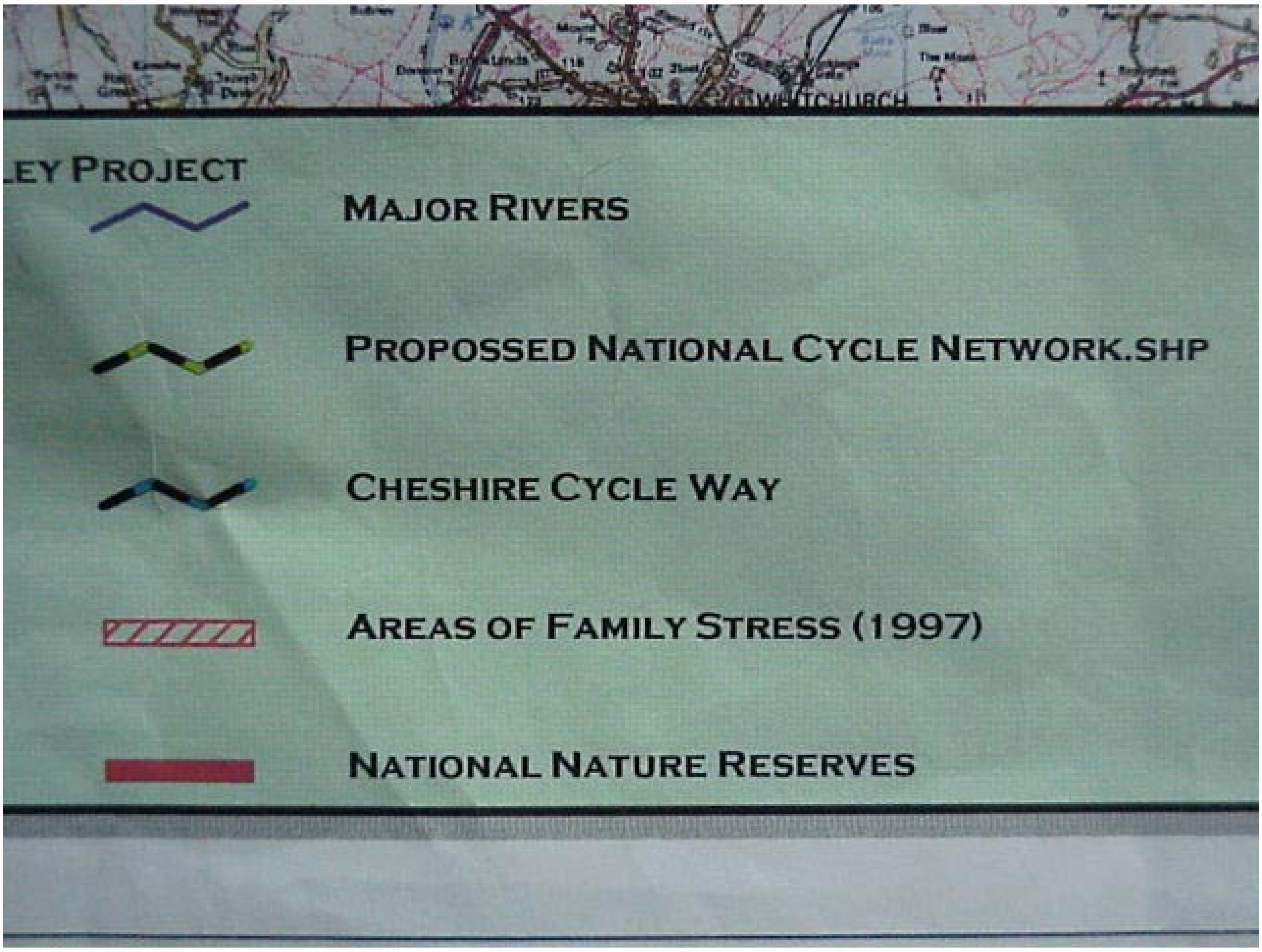

Figure 0-5 Confusing use of colour in legend

Key Concepts in Visualisation

An analysis of this map using the key concepts of visualisation, as developed by Tufte (e.g. Tufte 1983; Tufte 1990; Tufte 1997) and in the literature on the use of spatial information (e.g. Bertin 1981; Monmonier and Schnell 1988; Monmonier 1993), highlights a fundamental flaw in its design.

When using maps to display thematic information, the author is offered a basic choice, to display one characteristic per map or to attempt to display poly-thematic information in a superimposed map. This choice requires asking the question – is this map to show what characteristic appears where, or, what characteristics are there at a particular point in space? While a poly-thematic map can display many relational variables, "superimposition of visual characteristics poses the problem of visual selection" (Bertin 1981, pg. 168).

Tufte and Bertin suggest that it is usually preferable to make several maps, so that the reader can ask both of the questions: what is in a specific place, and where is a given characteristic? This is summarised in Tufte's concept of parallelism, and the idea that the human eye can discern a high degree of information in a small space if the graphic is designed with an awareness of the way in which visual discernment and comprehension take place.

Ideally, a series of small mono-thematic maps would be complemented by one or more larger maps, which show many of the superimpositions and relationships. By including it with the monothematic maps, it can be understood as a composite of the small multiples. This Weaver Valley Project map should probably still have a poly-thematic superimposition as its central piece, as it is to be used for project planning in an inherently multivariate situation. This map would be greatly strengthened by a series of small monothematic maps showing the main themes in isolation, supplemented with maps which show several similar themes superimpose – e.g. all areas of natural value on one map. As Bertin (1981) suggests, this should not involve hugely more work, as each layer has been created in order to make the composite map. A decision as to which layers to show would be aided by asking the question – what are the relevant variables and relationships that could be explored with this map? These could include:

- Actual surface area of 'natural areas'
- Connectivity of natural areas – is it possible to create wildlife corridors
- Proximity of derelict land to 'natural areas' – can they be integrated into park scheme?
- Proximity to water features – natural areas and derelict land (possible contamination)
- Proximity to areas of population - natural areas and derelict land (built up areas and/or population density)
- Proximity to areas of social deprivation - natural areas and derelict land
- Accessibility by cycle path and footpath - recreation

Further critique of this map from a theoretical perspective can be found in the Mind Map entitled 'Visualisation - Key Concepts - Weaver Valley Project'.

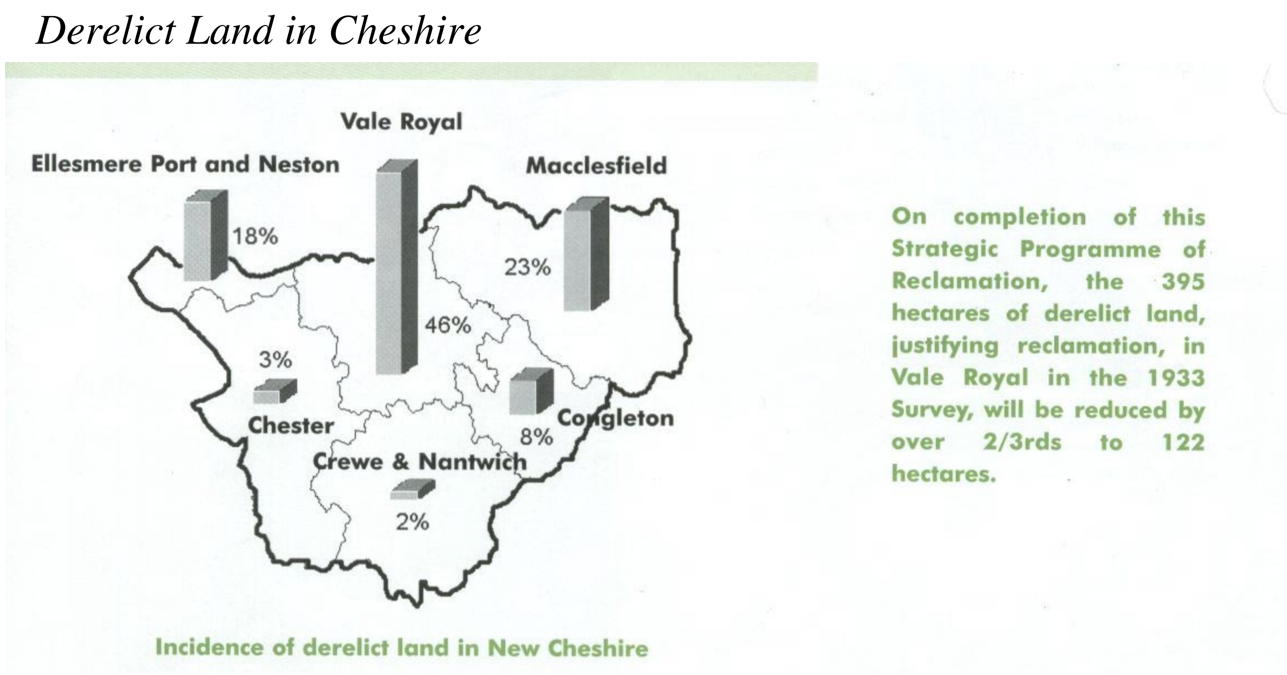

Figure 0-6 Cheshire County Council Strategic Programme of Reclamation, The Legacy of the Salt Dependent Chemical Industry in Cheshire (Thornley 1998)

Tufte (1983, pg. 178) echoes Bertin in his assertion, "The only worse design than a pie chart is several of them, for then the viewer is asked to compare quantities located in spatial disarray both within and between pies". However, there is possibly one design worse than several pie charts, this example of a geographic/floating three-dimensional bar chart that is simultaneously difficult to decipher and very data-thin. In this instance, a pie chart showing percentages would have been simpler to decipher, and while not revealing very much more information than a simple table, would at least not be misleading. If percentages of land mass is the only variable to be shown, this may be a good time to use a decagraph, a polygon with 10 sides, which can be used to estimate percentages. Monmonier (1988, pg. 173) suggests that such a diagram would make a good substitute for pie charts.

The goal of this map is somewhat unclear. The fact that it is in an informational brochure produced by the County Council suggests that it is supposed to communicate. It could be being used to inform the reader as to why Vale Royal has been chosen for an intensive process of land reclamation.

This map is not a 'seeing map' (Bertin 1981). The use of bars to represent physical reality requires an attention to relative heights. This requires a base line, so that the differences in heights between the bars can be discerned. The graphic does not adhere to principles of data integrity. A three-dimensional bar is used to represent a one dimensional data measurement (percentage of area), making it difficult to gauge the actual difference between the percentages of derelict land in each area. It is not clear from the graphic is it is 46% of Vale Royal's total land mass which is derelict, or if Vale Royal contains 46% of the derelict land in New Cheshire. In a graphic showing different areas in space, the use of cartograms, or area to show difference, is more easily discerned. "As a rule, 'chart maps', that is diagrams scattered over a map, are totally useless for reading overall relationships and insufficient for elementary reading" (Bertin 1981, pg. 155). These maps, are, however, relatively easy to construct using GIS software, and are superficially attractive due to their seeming graphic sophistication. This graphic is a good example of what Tufte terms "We-Used-A-Computer-To-Build-A-Duck Syndrome" (Tufte 1983, pg. 120).

This graphic is data thin. In order to work out actual land area which is derelict, and that which is to be reclaimed in this programme, the reader must scan the entire page. This information could easily be presented in the form of an easy-to-read, data thick graphic. Simple questioning as to which variables may be of interest and significance to the reader could lead to a list such as:

- What is the actual land area under discussion?
- What is the proportion of land that will undergo reclamation in each district?
- What land area will be reclaimed in what time scale?
- How does the current land mass of dereliction compare with the historical stock (time series).
- What is the cost per acre?
- Does this vary over the geographical spread?

While this may seem like extra work for a simple graphic, it has to be hoped that such a level of analysis has already been undertaken by the Environmental Planning department in the decision making process leading up to the strategic land reclamation programme, so such data should be available. Not all of these variables need to be displayed, but some could easily be shown in the same space, using simple comparative bar charts, or cartogram maps showing both area and distribution. The message of percentage of land dereliction can easily be conveyed through data labelling.

Tufte suggests that designers treat readers with a higher degree of respect for their ability to read graphic information, and recommends that graphics be data rich and sophisticated, allowing both for a rapid reading, which reveal the key points, and a more in depth reading, which rewards a more in depth analysis. In this case, an easier to read graphic in the same amount of space could get across the main point that this graphic makes (Vale Royal holds 46% of the derelict land in New Cheshire) and other relevant and interesting information. This would increase its data-ink to information ratio (Tufte 1983).

As this graphic is constructed, there is very little point in using a map to display this information. All the map tells us is where each district lies in relationship to the other districts. It does not offer any specifically spatial or geographical information, which may be relevant to decision making about derelict land, such as whether or not the areas contain watercourses which could be affected by chemical run-off from derelict sites. Spatial information is far from irrelevant in the case of land dereliction, but if a spatial graphic is used, it should make some attempt to show spatially relevant data, such as:

- How many sites are there?
- Are they widely geographically distributed?
- Are they in proximity to element of significance? (e.g. water course, ecologically sensitive area, area of social deprivation, area of high population)
- Are they near my house? (this booklet is of local relevance, it has been distributed to interested parties in Cheshire)
- Will these areas of reclamation create an inter-connected park system?
- Will people be able to access these areas – e.g cycle paths?

A discussion of a set of maps created by author

Ethnicity and Unemployment

This series of maps was created to see if there was a relationship between ethnicity and unemployment in Manchester, using 1991 census data and both statistical and spatial exploration. I aimed to produce a graphic which had a high data intensity, which showed several different factors but still allowed for simple comparisons, and which retained data integrity. I used dot density maps to show most of the information, as these offer the advantages of showing a high level of data, absolute numbers and well as relative location.

Monmonier (1988, pg. 169) suggests that dot maps - mustn't overlap "Ideally the dots should barely coalesce in the region with the greatest density". After analysing the numbers in the data table, I chose the smallest unit of people that would allow both for an overall reading in the maps with high density of population, and still show the distribution of people with lower populations (in this case 10 people per dot). the use of inset maps at areas of greater detail, in the highly populated areas would strengthen these maps.

In order to see if there was a relationship between the percentage of non-ethnic minorities people and the percentage of unemployed people, I constructed a choropleth map, which was then used in a superimposition of a dot density map of total unemployed and a cartogram map showing the percentage of unemployed people (as absolute numbers of unemployed may be misleading due to differences in overall population density). For this reason, I included a dot density map of total population, so that readers could discern areas of lower population.

A more careful analysis of the data and more familiarity with the numbers involved and the use of the software would allow me to create choropleth and cartogram depictions with what Monmonier (1993, pg. 169) terms "Carefully chosen breaks between categories allow the viewer to identify areas above or below a meaningful value, such as a national, provincial, or state average rate".

In analysis of population data, the creation of daysymetric maps, which are refinements of choropleth maps, either with boundaries approximating transition zones in the distribution, blanking out uninhabited areas, or showing population density per area can provide for a more accurate representation of actual geographic distribution (Monmonier and Schnell 1988, pg. 182).

I arranged the data in the bar charts along an x axis of wards arranged by percentage of unemployment, to see if any meaningful patterns in ethnicity emerged from this arrangement and so that each bar chart could be compared to the other. (I only made maps for selected ethnicities, this should be carried out for all of the ethnicities in a research exercise). The main violation of data integrity which this series displays is the fact that the y axes of the charts are not shown to the same scale (there was too great a range for me to work out a graphically readable way of doing this within the scope of this essay). Thus an analysis of absolute numbers of populations between the ethnicities could be misleading. The actual proportions are written into the labels, and the bar charts are arranged in descending order of population.

Conclusion

This exercise has proved fruitful in terms of learning the complexities of producing maps. Using the Mind Maps which I created of 'principles and processes of good graphical construction and analysis' provided a clearer insight into the theoretical concepts which underpin the graphic display of information. These Mind Maps will be useful in the future, and I intend to explore their use in planning and executing graphical constructions. Using them in a detailed analysis of the Weaver Valley Project Map showed that they would have been helpful in constructing the maps which I produced for this essay, as they provided a clear and convenient synthesis of the theory behind graphical construction.

Thus, several different permutations can be made, tested and interrogated against criteria of graphical excellence and integrity. This would act as a valuable complement to the searching for patterns and relationships in data through permutations and alternative graphic arrangements.

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