UNDERGENERALIZATION AND FIGURE-GROUND RELATIONSHIPS IN STATISTICAL MAPPING

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INTRODUCTION

Every statistical map is a device by which the author (cartographer) attempts to communicate spatial information to mapreaders. The cartographer translates his understanding of the subject matter into a graphic statement by controlling such design elements as content, contrast, symbology, scale, etc. If these concepts are transferred to the mapreader with little or no distortion, the map can be judged to be a success, but if for some reason the reader obtains a highly distorted version of the spatial information, there is a breakdown in communication.

Breakdowns in graphic communication which are related to the psychological, physiological or environmental state of the mapreader tend to be beyond the control of the mapmaker. The cartographer cannot know who will read his map or when it will be read, nor can he control the conditions under which it is read. Since these are the realities of the map user situation, it then seems reasonable to assume that the greatest improvements in cartographic communication will come about by increasing the capabilities of the mapmaker and by broadening his knowledge of the psychophysical characteristics of the "average mapreader."

Spatial information on a statistical map can be broken down into two quite different classes: specific facts about selected places or agglomerative facts which become apparent when specific knowledge is suppressed so that areal patterns become visually dominant. 1/ This dichotomy of spatial information gives rise to three different mapmaking objectives. The cartographer may elect to 1) facilitate data retrieval, 2) maximize perception of spatial features, or 3) attempt to combine both data retrieval and pattern perception. Many cartographers select the third objective, and some create maps which are rather successful in communicating both types of information. Many others fail, however, and the failure can often be linked to undergeneralization and a misunderstanding of the figure-ground relationships on statistical maps. 2/

UNDERGENERALIZATIONS

In the process of creating a statistical map the cartographer normally uses two sources of information: a base map and a statistical table. Information on the base map may include point, line, or areal places and their identification. The section of the Bureau of the Census base map shown in Figure 1 is a good example of the nature and content of a base map source. 3/ Tabular sources of information are

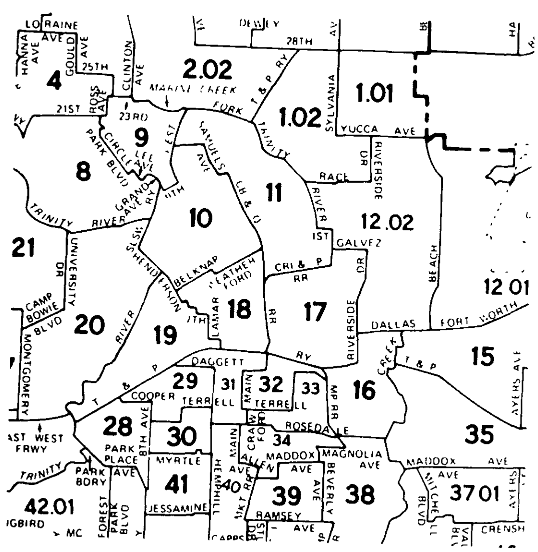

Figure 1. A section of the United States Bureau of the Census base map for the Fort Worth portion of the Dallas-Fort Worth Standard Metropolitan Statistical Area. Census tract tabular data for this area are keyed to the bold identification numbers.

composed of enumerated or measured facts which pertain to an area of concern. Obviously, to be useful in map construction the base map and the tabular data must be for the same area and the data and the base map identification must be keyed to each other.

Statistical maps are normally small-scale representations which are designed to communicate information about a single phenomenon. Even though the subject matter is limited, the amount of information available from the source materials is greater than can be accommodated. Because space is limited and because suitable cartographic symbols cover relatively larger areas on the map than the phenomena they represent occupy on the earth, the data must be reduced in amount and kind. This data transformation process is known as cartographic generalization and it includes selection or omission of information, and simplification or classification of information. The objective of the generalization process should be to retain only that information which is deemed to be essential to the map message, but unfortunately human nature, being what it is, causes us to hesitate to throw "good data" away. The significance of this undergeneralization becomes clear when the nature of the relationships between figure and ground on statistical maps is reviewed.

FIGURE-GROUND RELATIONSHIPS IN STATISTICAL MAPPING

In psychological terms the figure of a statistical map is composed of the myriad of symbols which represent the distribution being mapped. 4/ The ground is the field upon which the figure is displayed and it must contain the locational information necessary to put the symbolized data into a spatial framework. The interrelationships between figure and ground determine the quality of a map design because two different graphic elements are superposed within the same spatial domain or body of the map. Even though the figure and ground are separate elements of a statistical map they must work together so that the eye can organize and the mind understand the nature of the distribution.

Undergeneralization can inhibit the transfer of certain spatial information because the eye may be unable to differentiate the symbols or the complexity of map detail may obscure the patterns. In the latter case "we cannot see the forest for the trees" because individual symbolic features refuse to be visually blended into regional unity. In other instances, the eye does not differentiate and, thus, the content of the symbology fails to reach the mind of the mapreader. The two maps shown in Figure 2 are illustrative of this situation. Many mapreaders think that

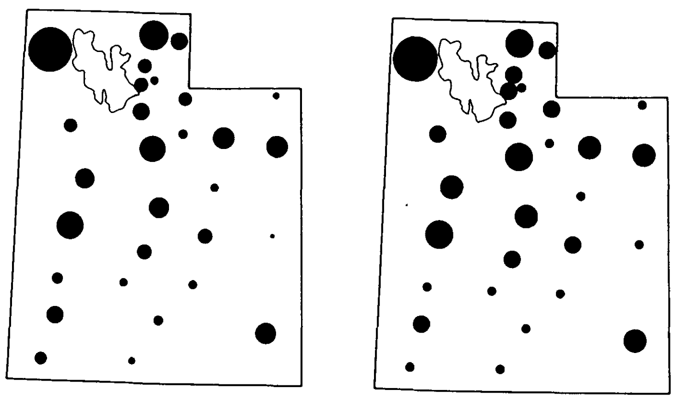

Figure 2. At first glance these simple proportional circle maps of Utah appear to be identical. There are 20 different sizes of circles on the left-hand map while only 5 different sizes are used on the right-hand map. Many think that these two maps communicate identical spatial messages.

these two maps communicate the same information and, insofar as these readers are concerned, the maps are identical. From a technical point of view, however, the maps are quite different since there are 20 different-sized circles on the left-hand map and only 5 different sizes of circles on the right-hand map.

The figure-ground relationships of the maps in Figure 2 are simple and easily understood because the ground has been kept simple and there is a high degree of contrast between figure and ground. If the reader will look at the dot maps shown in Figure 3 of the article entitled "Contemporary Statistical Maps--Evidence of Spatial and Graphic Igorance" (see p. 53), a similar figure-ground relationship can be seen. Compare the distributional patterns on this map with those evidenced in Figure 4 of the same article. Notice the fuzziness in the spatial pattern which has resulted from the increased informational load of the ground on this map. The design of the map in Figure 3 was developed to emphasize pattern while the objective of the map in Figure 4 was to provide for both information retrieval and pattern information.

Figure-ground relationships are particularly important in choropleth mapping as can be seen on the pairs of maps shown in Figures 3 and 4 (this article). The ground of the left-hand map satisfies the design objective of spatial pattern emphasis, while that of the right-hand map is for dual purpose information transfer. In the case of the left-hand map only those census tract boundaries which separate tones on the final map are retained while all tract boundaries were kept on the right-hand map. When the same shading patterns (figure) are combined with the grounds of the two maps very different impressions are created. Pattern information is clearly and easily perceived on the left-hand map, while a muddier and less definite pattern emerges on the right-hand map.

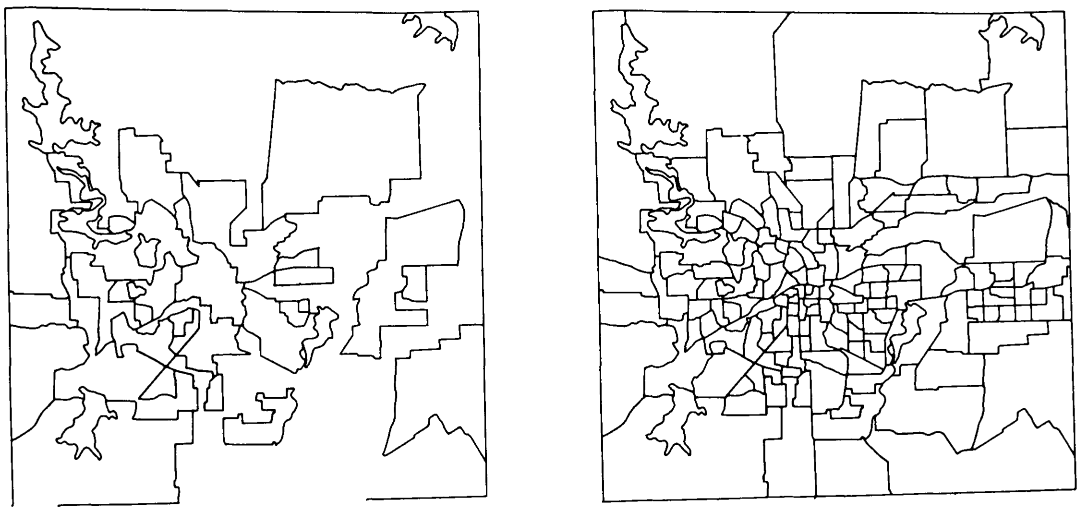

Figure 3. Two base maps prepared for part of the Fort Worth area. Only the census tract boundaries needed to separate classes have been retained on the left-hand map while all of the tract boundaries are shown on the other map. In terms of numbers of separate areal units, total length of line, or the amount of area covered with ink, the right-hand map must be considered to be much more complex than the left-hand map.

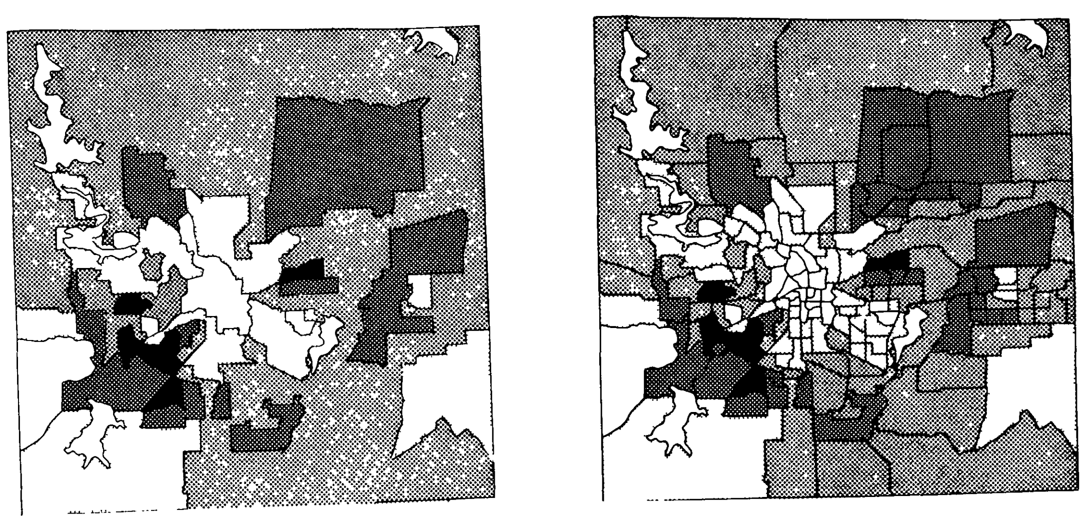

Figure 4. The figures (shading patterns) on these maps are identical. The maps look very different because of the ground (base map) complexity. Spatial patterns are more clearly seen on the left-hand map because there is less visual noise in the ground.

The proportional circle, dot and choropleth maps that have been used to illustrate the importance of the ground in the transfer of spatial information indicate why dual-purpose map designs are difficult to render, particularly when the graphic media available are limited. The visual separation of figure and ground becomes increasingly more difficult as the complexity and amount of information in the ground is increased. Furthermore, increased symbolic usage in the ground decreases the contrast and further inhibits figure and ground separation. It is clear that the designer of statistical maps should be particularly parsimonious when symbolizing ground and under no circumstances should he keep any details which are not vitally important for the transmission of the map message. In other words, err on the side of overgeneralization rather than retain more detail than is needed.

The ten maps of Louisiana shown in Figure 5 illustrate another aspect of undergeneralization which ought to be studied so that better statistical maps may be constructed. The four maps on the top row and the four maps on the bottom row of

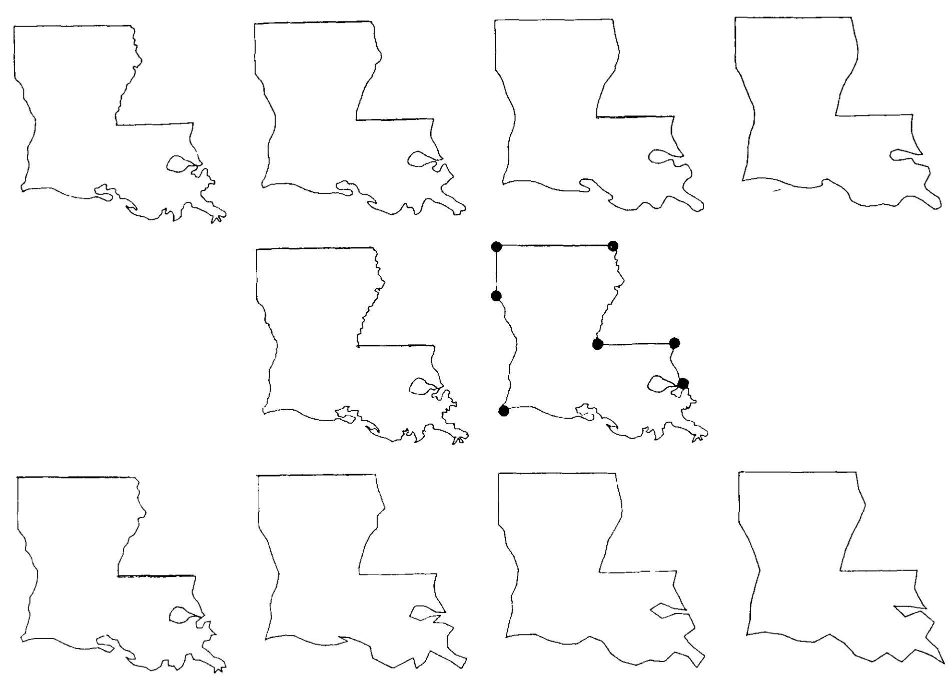

Figure 5. The maps in the top row are three point moving average simplifications and the four maps on the bottom row are polygonal simplifications of the left-hand map in the middle row. The black dots on the right-hand map of the middle row are essential topological points and these points are held constant on all maps. If statistical maps were created with more generalized outlines than is the usual case, spatial pattern perception might be enhanced.

Figure 5 are generalizations of the two maps on the middle row. Normally cartographers designing choroplethic maps of the United States use a base map with detail similar to that found on the maps in the middle row. As can be seen these maps contain a wealth of information along the coastline. Might it not be better to use a more generalized base map, especially when the subject matter has no relationship to the geomorphology of the coast?

Visualize if you can, the base maps shown in Figure 3 after a linear simplification similar to that shown on the upper right hand of Figure 5. Such a generalization would probably have enhanced the spatial patterns of both maps presented in Figure 4. Most of the base maps used in statistical mapping are undergeneralized and improved communication might well result from some linear simplification.

SUMMARY

Statistical mapmakers face numerous problems in designing the single subject small-scale representations that they create. Scale and symbolic limitations are formidable design obstacles and, as a result, careful analysis of map objective and map content are imperative. In this evaluation the clarity of the map message must be the overriding factor because this means the development of suitable visual figure-ground relationships. From a personal point of view the map designer must put his "pack rat" tendencies on the back burner lest he become an undergeneralizer and the producer of illegible and distorted map messages.

REFERENCES

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