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LA THÈSE A ÉTÉ
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ACCURACY OF JUDGEMENT IN SIZE OF THREE-DIMENSIONAL
BARS IN PERSPECTIVE USING THE PILLAR MAPPING PROGRAM

by

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B.A. (Honours), University of Ottawa, Ottawa,
Canada, 1977

THESIS

Submitted in partial fulfillment of the
requirements for the degree of Master of Arts
in Geography in the Faculty of Graduate
Studies and Research of the
University of Ottawa
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John Michael Smyrnew, Ottawa, Canada, 1984.



UNIVERSITÉ D'OTTAWA
UNIVERSITY OF OTTAWA

This thesis is dedicated to Halyna
and our first baby, Larissa.

Abstract

The design and production of improved maps is intended to present and clarify spatial representation of quantitative types of data. This representation must be based on precise knowledge of the relationship between the capabilities and perception of the user and the characteristics of the symbols that are incorporated into maps. This knowledge is fundamental in developing principles of effective cartographic design that could be employed in creating maps.

In this study, a summary and analysis of literature has been provided on the characteristics and use of the three-dimensional bar as a symbol for displaying spatial differences and similarities of quantities. The functional usefulness of this symbol is dependent on the ability of map readers to compare and classify them according to the quantities they represent.

Using survey and statistical measurement techniques, a method was developed to provide information that could be used towards more effective presentation of three-dimensional bars when employed for data presentation.

Results of the study suggested that respondents:

- (1) most accurately judged the height of three-dimensional bars at angle of 34° ;
- (2) viewed three-dimensional bars no differently in the distance than in the forefront, and;
- (3) were highly dependent on the legend to make height estimates.

Résumé

Le tracé et la production de cartes améliorées a pour but de présenter et de clarifier la représentation spatiale des types quantitatifs d'information, laquelle représentation doit se baser sur une connaissance précise de la relation existant entre les aptitudes et la perception de l'utilisateur, et les caractéristiques des symboles incorporés dans les cartes. Cette connaissance est essentielle à l'élaboration des principes d'un tracé cartographique efficace pouvant servir à l'établissement des cartes.

Nous proposons un sommaire et une analyse d'études portant sur les caractéristiques des barres tridimensionnelles et leur emploi comme symbole représentant les différences spatiales et les similarités de quantités - l'utilité fonctionnelle de ce symbole dépendant de la capacité dont disposent les lecteurs pour les comparer et les classer selon les quantités qu'il représente.

Nous inspirant des techniques d'enquête et de mesures statistiques, nous avons mis au point une méthode permettant de recueillir des renseignements destinés à une représentation plus efficace des barres tridimensionnelles dans la présentation de données.

Les résultats obtenus suggèrent:

- (1) que la hauteur des barres tridimensionnelles présentées sous un angle de 34° se juge avec le plus d'exactitude;
- (2) que le plan où se situent les barres tridimensionnelles - premier plan ou arrière plan - n'affecte pas la manière dont elles sont perçues, et;
- (3) que la légende remplit un rôle primordial dans l'interprétation des hauteurs.

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To all these people, I promise not to procrastinate so much next time and not to think about doctoral studies for at least two years.

CHAPTER 1

INTRODUCTION

The map symbol is an important part of the cartographic communication system and as part of a system, it cannot be examined in a vacuum. It must be related to the other parts of the system.

Yoeli and Loon (1972) suggested that when considering the map within a communication system you should be careful not to simplify the process. The map does not communicate a simple message. In addition, the message received depends on the knowledge, background and environment of the receiver (the map-user). In the cartographic system it is also possible that the receiver perceives some messages that the sender did not foresee. This is not a result of any technical errors or deficiencies in the map, but because of the particular knowledge and experience of the receiver.

Given this perspective on cartographic communication, academic cartographers and geographers have often looked to ways in which the efficiency of the communication process might be improved. One such proposition (Balchin, 1972, 1976; Balchin and Coleman, 1966) is that the effectiveness of maps

may be increased by improving the graphic literacy of map users. However, as Carswell (1971) has shown, map reading education has really not been effective in improving students' map reading abilities. Carswell argues that there have not been enough attempts to understand students' abilities to comprehend maps. Without that background information the development of effective educational programmes is hampered.

On the other hand, rather than depending on Balchin's suggestion of modifying the consumer to fit the product, we may modify the product to fit the consumer. This latter choice is the direction that will be pursued in this thesis.

According to Brandes (1976), the principal approach that research cartographers have used to determine the most effective types of symbology has been an attempt to improve the understanding of the map user's perception of cartographic symbols (see Castner and Robinson, 1969; Hopkin and Taylor, 1979; Chang, 1977, 1978, and; Flannery, 1956, 1971). In recent years there has been a dramatic increase in the quantity of perceptual research related to cartography. However, little attention has been given to the evaluation and improvement of those products created by computer mapping software

through empirical research (see Rhind, 1973).¹ The importance and need for this type of research in cartography is implicitly underlined by the findings of Haber (1970), that pictorial messages have the potential of being virtually unforgettable. More specifically, the persuasiveness of the map (Tyner, 1974; Boggs, 1947), augmented by the aura of infallibility that surrounds computer-produced output (Cancro and Slotnick, 1970; Peterson, 1979), would lead one to conclude that this type of map message might become highly irresistible (Williams, 1976).

It is difficult to peruse any cartographic text or geographic journal without being exposed to examples of computer-produced maps. The quality of the maps are often comparable to many types of manually-produced maps and, in some instances, have been found to be more aesthetically pleasing (Cancro and Slotnick, 1970). As output devices improve and more intelligent software is written, the use of a computer will undoubtedly be the cartographer's major tool of the future (Morrison, 1974; Boyle, 1979). In the meantime, however, guidelines governing such things as the perceptual effects of symbolism on an audience will have to be derived for computer algorithms

¹ The few notable exceptions are Hsu, M.L. and Porter, P. (1971), Liebenberg, E. (1976), and Morrison, J. (1974).

(see Mackworth, 1978). Too frequently there is evidence that systems to produce computer maps are the creation of cartographers lacking in computer technique or, possibly much worse, computer scientists in ignorance of the requirements of cartographic presentation (see Taylor, 1971; Arnold, 1977; Muller, 1983).

This thesis will address itself to evaluating the three-dimensional bar symbolism produced by the Pillar computer mapping program.² The intention is to provide some guidelines for its effective use and display by developing an experimental framework to analyze audience reaction.

The Pillar computer mapping program produces a geographical distribution of an absolute data value by generating and plotting a perspective view of a scene composed of square-based columns standing on a map surface. Of primary concern to this thesis will be to determine how accurately audiences judge the size of the three-dimensional quantitative bars produced by Pillar in the following environments:

² Developed by David H. Douglas, Assistant Professor, Department of Geography, University of Ottawa, Ottawa, Ontario, K1N 6N5. This project was supported in part by funding from the *Ministry of State for Urban Affairs and Statistics Canada*.

- (1) bars without a base map;
- (2) bars with a base map;
- (3) shaded bars with a base map, and;
- (4) all three of the above with varying viewing angles.

Much of the above is based on a preliminary investigation by Weiss (1978) of the three-dimensional symbolism produced by Pillar, that identified numerous areas of potential research and speculated on some of the factors that might affect accuracy of judgement.³ These factors included how a potential map user might view the three-dimensional bar as a result of:

- (1) foreshortening, clustering, and thickness of the bars;
- (2) spatial resolution and aggregation of the bars in both map and non-map environments, and;
- (3) construction and placement of a legend.

It should be recognized that this thesis only considers a small subset of the numerous problems inherent in viewing three-dimensional quantitative bars.

³ Before the map appearing in Figure 7 was officially released, an ad hoc survey of several well known cartographers from across North America was conducted, requesting feedback on this map. The letters in response to the survey were provided courtesy of Carolyn Weiss, Research and Development Officer, Spatial Systems Section, Statistics Canada.

In essence, this thesis contributes the following to cartographic research:

- (1) determination of some problems and effects of viewing three-dimensional bars in a map environment;
- (2) method for improvement of the efficiency with which a map user might view three-dimensional bars in a map environment, and;
- (3) the provision of a methodological basis for future research related to the present study on the effective use of thematic maps.

Each of the above are acknowledged in this thesis with an inclusive overview of the important issues in cartographic communication, a comprehensive review of the pertinent literature from cartography, psychology, geography, and statistics, and a concise description of the procedure used to undertake this research.

CHAPTER 2

CARTOGRAPHIC COMMUNICATION

As a point of departure, we may state that the aim of the communication process in cartography is to gain a sense of the structure of geographic phenomena; that is, the aim is an attempt to see the parts as an integrated whole as described by Guelke (1976). When speaking of structure, we are referring to the network of relationships and spatial distributions represented on the map (see Robinson and Petchenik, 1976, pp. 108-123). Yoeli and Loon (1972) explain that spatial distributions could be zero-dimensional (point symbols), one-dimensional (line symbols), two-dimensional (area symbols) or, as in this thesis, three-dimensional (area or line symbols).

A map is an illusion, in that we are asked to look at a reality (the symbols) and then we are asked to reject this reality and to "see" the phenomena symbolised. The whole sense of the structure of geographic phenomena may be lost as our attention is concentrated on or drawn to the symbols as objects in themselves and not on the semantic aspect of the symbols (that is, the connection between symbol and meaning may be ambiguous). These symbols

need not be unique and specific to particular geographic phenomena but may be explicitly defined from map series to map series. In quantitative maps there is a greater stability between the symbol and the phenomena being represented and less so in qualitative maps (Dickinson, 1973, p. 39).

According to Robinson, et al. (1978, p. 181) all maps are "distribution maps" in the sense that it is impossible to represent relative geographical location without showing a distribution of something. Here the word 'distribution' emphasizes that often the main point is not the quantity at any one geographic location, but the arrangement of the various items in the spatial plane. As a result the aim of the map should be to create a visual image, whereby selected patterns and relationships may be seen as a whole and patterns and relationships readily apparent. Many maps are packed too full of information and the visual presentation of the symbols makes it difficult to separate the various (often superimposed) patterns and relationships. In this regard, we should investigate ways of presenting various patterns and relationships on different visual planes. For example, the dot map is capable of showing more clearly than any other type of map the details of locational character of a distribution (see McCleary, 1978). While the map reader may obtain precise

values for specific locations, such a form of information extraction is of less importance than the reading or perceiving of relative variations in the complete pattern of the mapped data. What characteristics of these patterns will a map reader see on a dot map? Jenks (1975) has examined this problem, noting that readers not only see several different regions but also delimit them differently (see Figure 1).

The map-user comes into the system with his own particular knowledge and background, and views the map in a particular environment. These factors, in addition to the quality of the message and visual interference within the system, affect the message he receives as well as its interpretation.

The map-user should clearly understand the limitations of graphical representation, the illusion created by maps and the problems of symbolization. In his approach to the map, he should be "relation-minded" and not "object-minded". Above all he should remember that he is dealing with fallible information. Skoda (1975) has remarked that the cartographic communication system should be looked upon as a feedback system (see Figure 2). Consequently, the map-maker should be made aware of the map-user's requirements, and should test whether the user receives the information that

was meant to be communicated in a particular situation.

As a result, we should regard the symbolism as only part of the overall cartographic communication system. At one end of this system we have the real world and at the other end we have the map-user's mental image of this real world. Between these two extremes we have the map. The map is a vehicle for communicating. A map is not meant merely to be viewed, but is intended to graphically information. The map is the conveyor of a message and is designed by the map-maker, interpreted by the map-user and their common language is the cartographic symbol.

The cartographic symbol is the common factor between encoding and decoding stages in the cartographic system (see Figure 3). This system may be regarded as a noisy circuit over which messages are passed. Our central problem is to investigate how to enhance the signal to best help the reception and interpretation of the message over the noisy circuit (Board, 1977; Ratajski, 1973; Robinson and Petchenik, 1975).

The specific details of how a cartographic symbol functions in the cartographic system may be quite different in terms of the dimensions of symbolization: points (Douglas, 1979; Levy, et al., 1970; Moellering, 1973), lines (Phillips

and Noyes, 1978; Sampson, 1978), areas (Jancaitis and Moore, 1978), and volume (Franklin, 1979; Taylor, 1978; Worth and Board, 1978). According to Hodgkiss (1970), cartographic symbols may be divided into two main categories, qualitative and quantitative. The qualitative cartographic symbol illustrates the location and type of phenomena without attempting to represent a value, while the quantitative cartographic symbol shows not only location and kind, but also represents a value. Each of these major categories may in turn be sub-divided into three classes (see Figure 4):

- (1) the indication of features occurring at a point;
- (2) the indication of features occurring along a line, and;
- (3) the indication of features occurring within specified areas.

Since qualitative and quantitative cartographic symbols have different functions, they are used for distinctly different types of presentations. More simply, difference in the type of phenomena being displayed merely requires a change in the appearance of the qualitative cartographic symbol. But to display differences in quantity the quantitative cartographic symbol must also vary in size, frequency, or visual intensity (Chang, 1969).

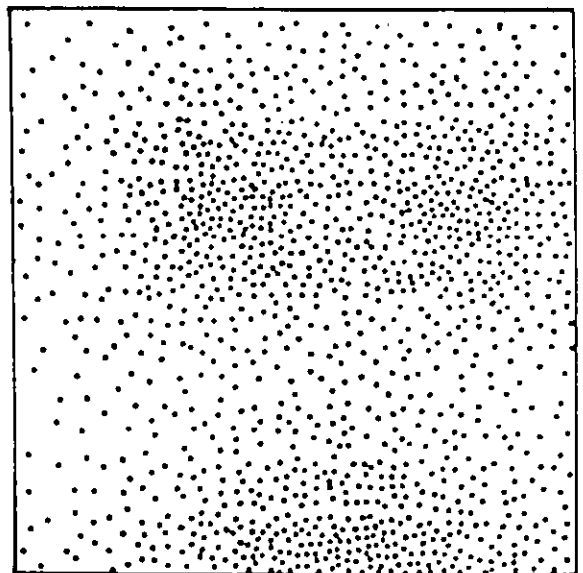
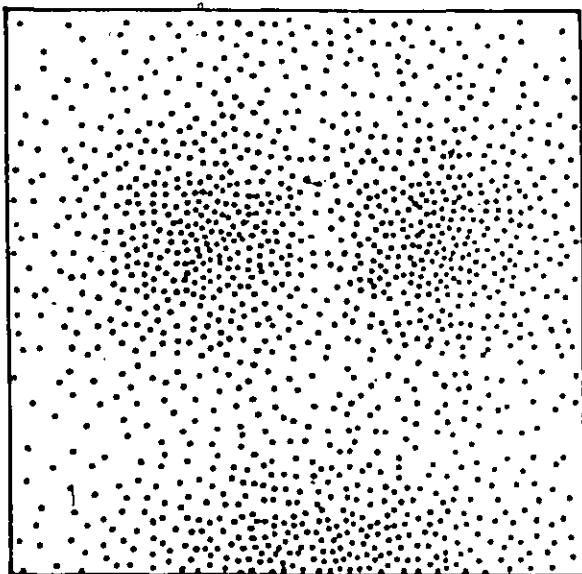
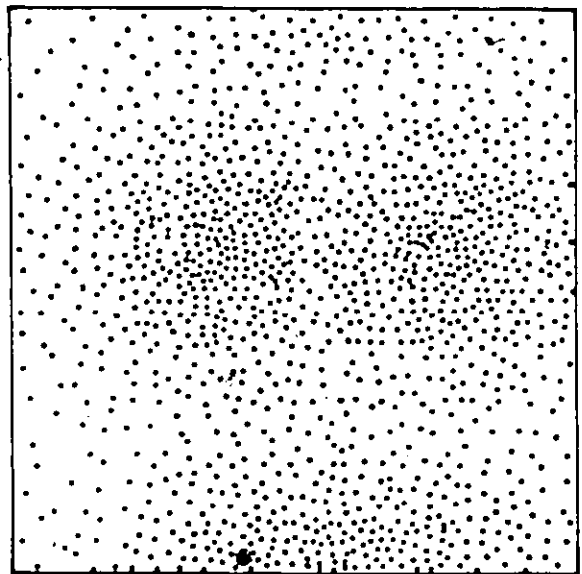
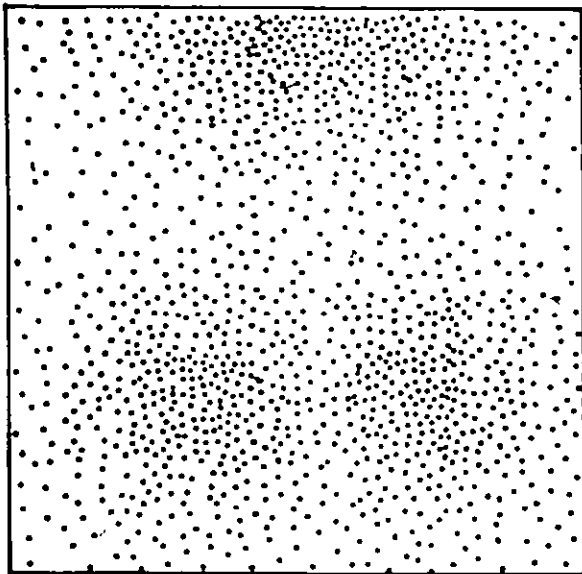
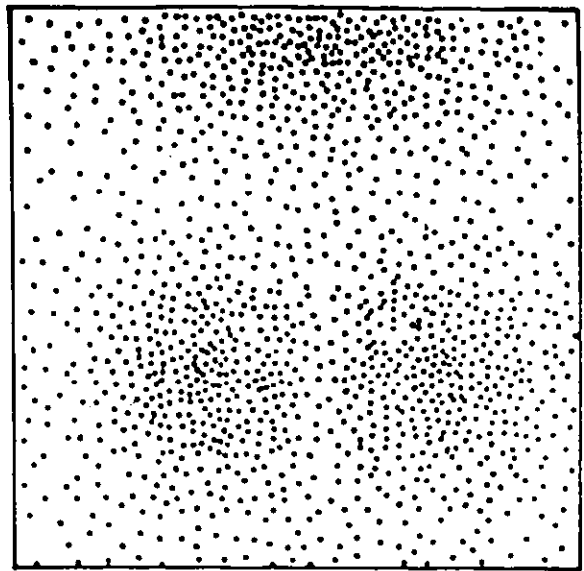
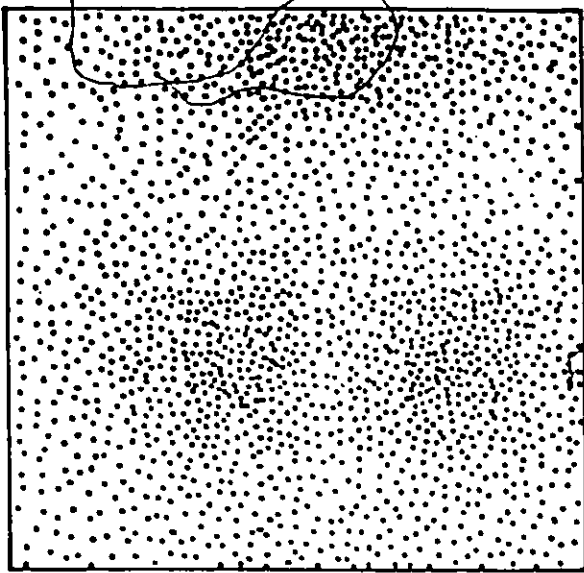


Figure 1. Given the task of identifying regions from most of the distribution of dots above it is highly unlikely any two responses would be exactly the same.

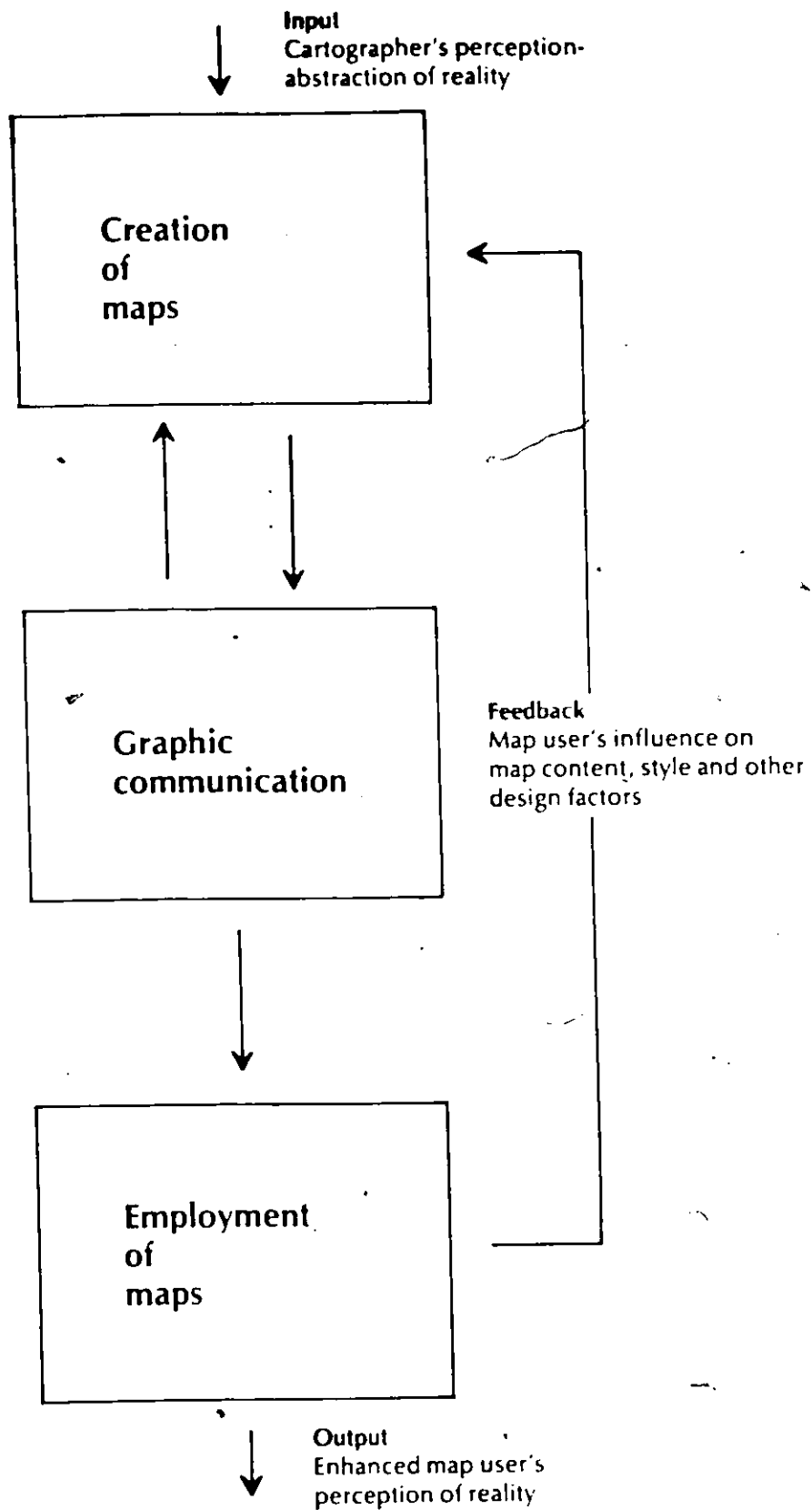


Figure 2. The system of cartography (after Skoda, 1975).

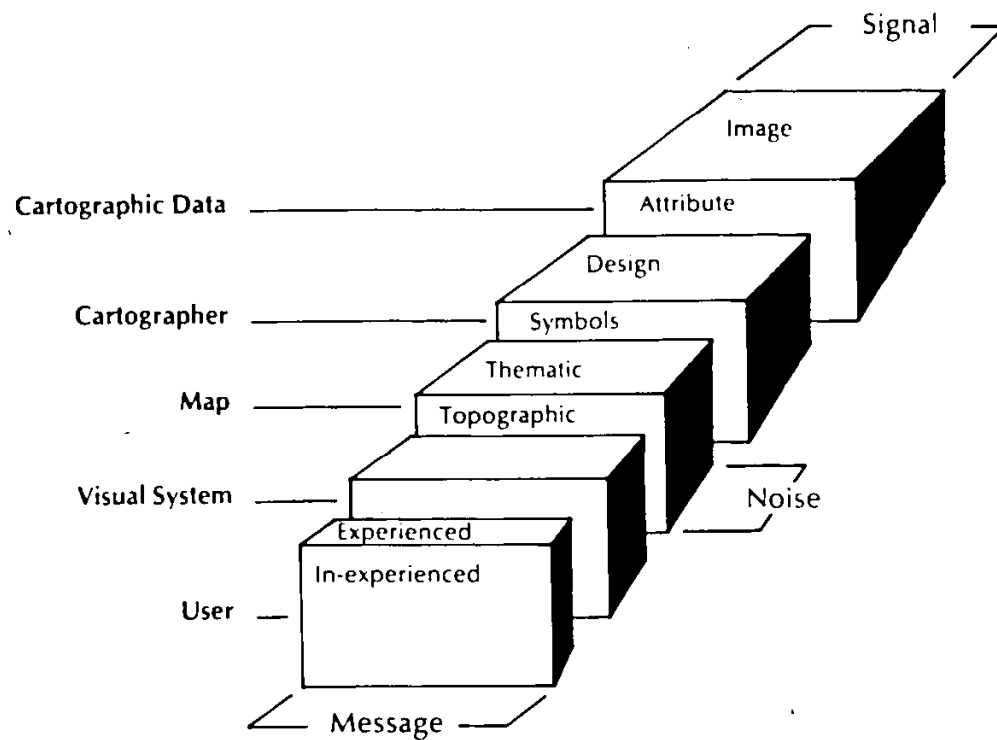


Figure 3. The simple cartographic communication system



















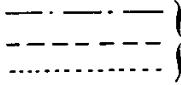
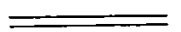
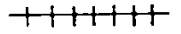


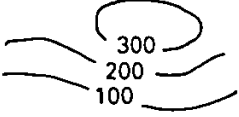
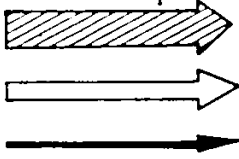



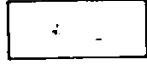
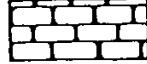
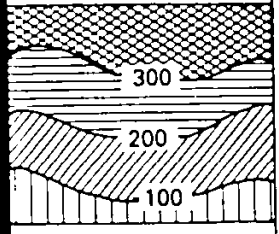

Statistical Mapping	
Qualitative	Quantitative
Show kind and location only, not quantity or value	Show value or quantity as well as location and kind
Features occurring at various points	
 Church  Triangulation Station  Site of antiquity  Bench mark  Watermill  Windmill  Camping site	 P.O. Post Office  Quarry  Sand pit  Gravel pit  Factory  Battle  Hospital
	Multiple unit symbol (each dot represents given quantity)  One dimensional symbol (bars of proportional length) accommodate small range of values only  Range of values increased by introducing second dimension (symbols of proportional area)  Range increased still further by using symbols whose value is proportional to their value 
Features occurring along given lines	
 Boundary  Road  Railway  Canal  River and stream	 Line of constant value e.g. contour  Flow lines (width proportional to amount of traffic etc.)
Features occurring within given areas	
 Deciduous woodland  Marsh  Heath  Desert  Limestone	<div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <p>Areas between isolines tinted</p>  <p>Lines are important</p> </div> <div style="width: 45%;"> <p>Choropleth or density map-areas with shadings graded to indicate density per unit of area</p>  <p>Areas are important</p> </div> </div>

Figure 4. Main categories of qualitative and quantitative map symbols (after Hodgkiss, 1970)

Thematic maps often use quantitative symbols and are usually referred to as "statistical maps" (Hodgkiss, 1970, p. 109; Raisz, 1962, p. 195) These types of maps were defined by Jenks (1973) as being a small scale, highly generalized, special purpose map used by an author to communicate information about a geographical distribution. On a statistical map there is usually one symbol to represent the single distribution involved in the topic. For example, one may use dots, proportional circles, or proportional bars to display the population distribution within a geographic region.

The question arises about how accurately the map reader (through the presentation of quantitative symbols) perceives the magnitude of numerical values intended by the cartographer. For example, in Figure 5 given the bars of 10,000 and 100,000 inhabitants, will the map reader accurately perceive that the magnitude of the latter is 10 times greater than that of the former?

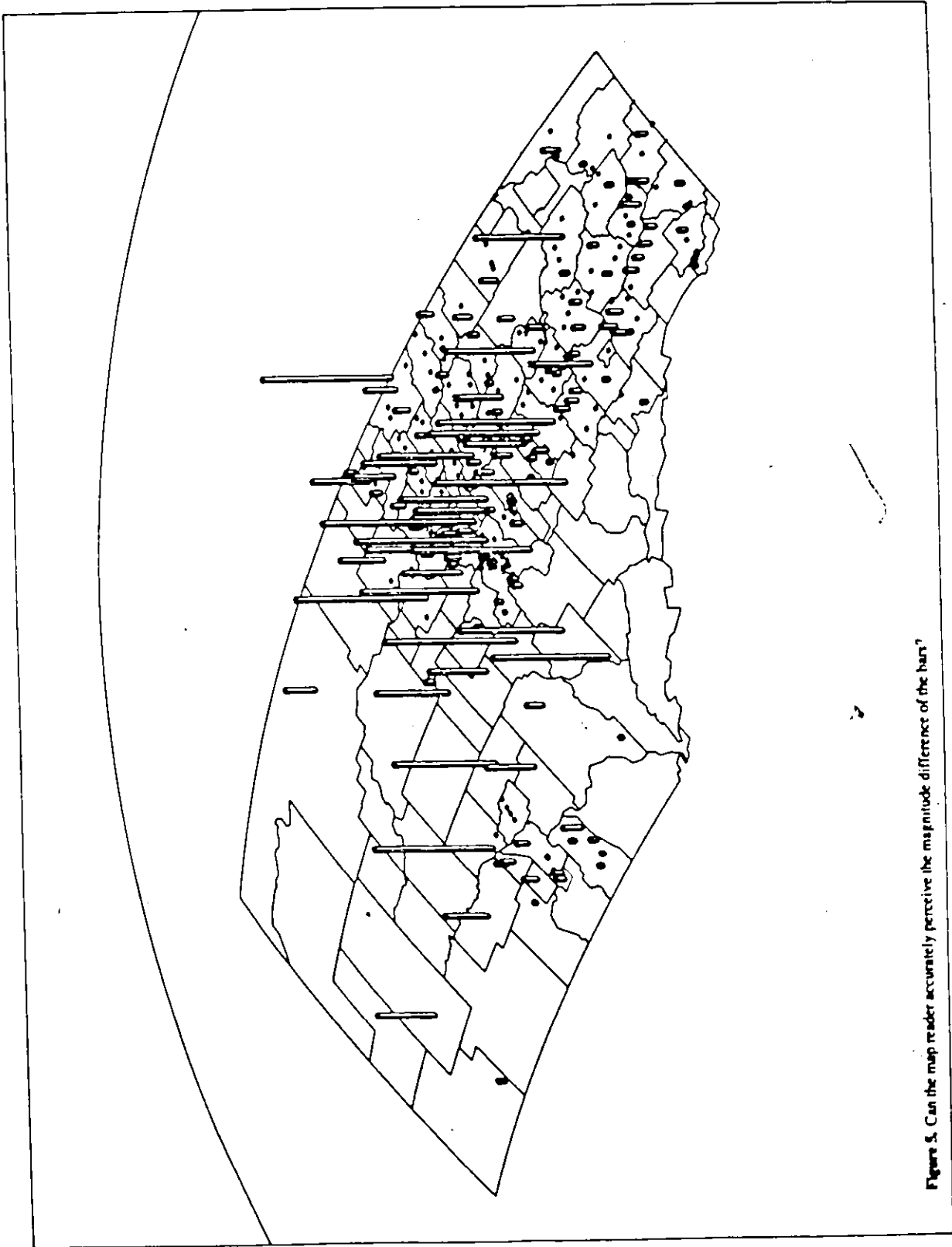


Figure 5. Can the map reader accurately perceive the magnitude difference of the bars?

CHAPTER 3

PREVIOUS STUDIES

The purpose of this chapter is to review previous studies that have a bearing on the research topic of concern in this thesis. A amount portion of the literature related to the topic was found outside the disciplines of cartography and geography, primarily psychology and statistics (see Appendix 6 for a summary). That is not to conclude that cartographic research was lacking on the topic, but rather to observe much work is also being done in other disciplines that do not appear directly related to cartography. The psychological work was mostly oriented towards perception, cognition, and human factors research, and the statistical literature tended to be directed towards the history of graphics and its use as an effective communications tool.

In 1926, Eells published results of the first experiment with graphical forms, comparative tests of pie charts and subdivided bar charts. For the next several years there ensued many experiments with graphical forms in statistics including papers by Croxton (1927), and Croxton, et al. (1927, 1932), Huhn (1927), and Washburne (1927). The 1932 study by Croxton and Stein was the

earliest to consider the problem of perception in the statistical comparison of bars, squares, circles, and cubes. Their results showed that bars were the best symbol for purposes of comparison when used in a business graphics type of display.

The advent of World War II saw interest in graphical methods decline among persons using descriptive statistics. This trend did not begin to reverse again until developments in computer technology made possible the manipulation and analysis of large data sets. Recent developments, mostly restricted to the application of graphics to statistics, are provided in a detailed literature survey by Beniger and Robyn (1978) and the social graphics project at the Bureau of Social Science Research (Feinberg and Franklin, 1975).

It was only during the early 1950's that the first map-based studies of symbolism conducted by Mackay (1953, 1954) appeared. In the former study, Mackay suggested an optimal projection for cubes to be one with a square front, sides inclined 30° to 50° , and sizes $3/5$ the length of the front. As well, he cited that this projection would be easy to draw, showed a good resemblance to the solid form, and could be compared relatively accurately. Soon afterwards, Williams (1956) published the results of his experimental study on

point, line, pattern and tone, and word symbols. Major results of his study were:

- (1) the development of a comparative size "scale" for different-shaped point symbols (black and coloured) representing the same visual value;
- (2) an equation for computing proportionate values,

$$Y = X^{0.8}$$

where Y is the size that the symbol should
be drawn to appear "X" times
greater than a given unit symbol;

- (3) that three-dimensional symbols are judged the same as if they were plane symbols.

The foremost study of quantitative point symbols is that of Flannery (1956). It was Flannery who first thoroughly researched the circle as a cartographic symbol and judged it to be desirable for both its visual and non-visual characteristics (see Flannery, 1956, pp. 62-63). However, much of his argument is based on the observation that it is simpler and faster to produce circles relative to other symbols - an insignificant argument given the high speed of computers and sophisticated software used in mapping today. But of greatest importance was his derivation of the following formula:

$$Y^{**}C = 0.98365 X^{**}(0.8747)$$

where $Y^{**}C$ = a computed apparent relative size value, and

X = the logarithm of the actual relative size.

This formula is the basis of the method outlined by Robinson, et al. (1978, pp. 416-417) and is widely used for scaling proportional circles.

Clarke (1959) conducted a test of the visual evaluation of proportional symbols and found that the greater the difference between the testing symbols and the key symbol, the greater was the error and the less accurate the visual evaluation.

In a more recent report, Flannery (1971) also found that the relationship between perceived size and actual size is nonlinear for circles and wedges. But, that bars should be graduated on a linear basis. Flannery noted the following: bars function effectively (even more so than circles) when graduated in a linear series and require no apparent size scale; bars use map space less efficiently, take more time to draw, and have less aesthetic appeal than circles.

Ekman and Junge (1961) studied judgements of subjective length, area and volume in three experiments using a psychophysical paradigm. They

found that exponents of the psychophysical power functions scattered around 1.0 for perceptions of "real" space. For perspective drawings of cubes and spheres, however, the exponents were about 0.75. From a further analysis of the data it was tentatively concluded that perspective and shadow are insufficient cues to visual volume, and that the subjective scale reflects perception of area rather than volume, especially for small stimuli.

Ekman, et al. (1961) conducted a study that was exclusively concerned with the perception of projected volume in such geometric forms as cubes and spheres constructed with perspective and shading. Results suggested small cubes with background (which is their natural cartographic environment) were superior from the cartographic point of view to all other symbols used in this experiment. They also concluded that estimates of volume of cartographic symbols were almost exclusively estimates of perceived area, which in turn, is not far from being proportional to the geometric area covered by the symbols.

Meihoefer (1968) in his doctoral dissertation provided a comprehensive summary and analysis of literature on the characteristics and use of the circle as a symbol for displaying spatial differences and similarities of quantitative data. He determined that the functioning of circle symbols is dependent on

the ability of map readers to compare and classify like and unlike circles about the quantities they represent. This was accomplished by placing circles in a map environment so that the visual complex presented to subjects was the same as for an individual attempting to pair quantity and a circle symbol representing that quantity.

Crawford (1973) studied the average map readers' perception of the relative magnitude of graduated square symbols designed for small scale thematic maps. He found that the average map reader could correctly estimate the relative area of graduated squares within a range of sizes appropriate for use on small scale thematic maps. Given these results, Crawford questioned the use of proportional circles and suggested that proportional squares might be more suitable.

Jenks (1975) highlighted several aspects of visual comparison of maps using proportional circles as cartographic symbols. He determined that potential map readers see sets of circles in clusters (regions) and that readers are reasonably consistent in their visual ranking of proportional circles. The area of circles and the distance among them on a proportional circle map appear to be easily interpreted. He also demonstrated that maps that seem to be visu-

ally different are rated as such, and those that have similar patterns are judged to be similar. Between these extremes there is a lesser degree of consistency.

Cox (1976) conducted an experiment to evaluate the relative effectiveness of apparent value scaling and the use of several legend symbols in eliminating the underestimation of symbol size ratios. It was hypothesized that estimates of symbol size result from an adaptation level based on a neutral reference point, and that legend symbols act as anchoring stimuli (focal point of graphic image) by pulling the adaptation level in the direction of the legend symbol. The results of the experiment showed that apparent value scaling does not compensate for the anchor effects of assimilation and that anchor effects occur with both circles and squares. In effect, the use of several legend symbols seems to be more effective and efficient for more correct estimation than does apparent value scaling.

In an experiment by Cerny and Wilson (1976), the effects of map orientation on geographic recognition were examined. Orientation of maps with north at the top is a cartographic convention, though many notable exceptions

exist.¹ Several outline maps were presented to geography and psychology students in both normal and rotated orientations. It was their finding that the only significant factor affecting map recognition was discipline membership. As might be expected geography students were found to be better at recognizing normally oriented maps. But the groups were discovered to be more similar in recognizing rotated maps.

Shepard and Metzler (1971) carried out an experiment that was designed to measure the time that subjects required to determine identity of shape as a function of the angular difference in the portrayed orientations of two three-dimensional objects. Reaction time was found to increase linearly with the angular difference in portrayed orientation and to be no longer for a rotation in depth than for a rotation merely in the picture plane. These findings appear to place severe constraints on how well subjects can determine identity of shape for differently-oriented objects. Results suggest that 80 per cent of a typical reaction time may reflect a process termed "mental rotation" rather

¹ There are numerous maps with uncommon orientations in high quality publications. For example, in *Canadian Urban Trends: National Perspective* by Ray, et al. (1976) and in the *Junior Atlas of Alberta* produced by Alberta Education (1979), there are several maps that have a north to south orientation of North America. In addition, Gould and White (1974), Downs and Stea (1973, 1977) and Bunge (1973) have made major contributions towards the understanding of spatial orientation and recognition through their research in cognitive mapping and perception.

than a preliminary process of preparation or search.

Research efforts on the study of three-dimensional symbolism by cartographers and psychologists has concentrated on the iconicity and viewing angle choice for three-dimensional surfaces. Many symbols have both arbitrary and iconic characteristics. In iconic representation the symbol "looks like" the feature it represents (Huggins and Entwisle, 1974; Lodding, 1983). A bar representing a city may be arbitrary in that the geometric form provides no physical or logical relationship to the outline of the city. However, it is iconic if the size of the bar is correlated with the physical or population size of the city. As such, an iconic symbol in a given map display is not necessarily the shape most discriminated from the background, nor the shape more quickly located.

In a study investigating degree of iconicity of map symbols already in use, subjects were asked to draw their own symbols for 30 map features (Berry, 1960). Less than 50 per cent of the respondents created symbols similar to the standard key symbols for 20 of the 30 features. In 11 of 20 cases, the test group drew topographic features as three-dimensional objects viewed from ground level, which is in contrast to the conventional cartographic representa-

tion presenting all features as if viewed from above.

Another study on iconicity undertaken by Berry (1961) explored size judgements for different types of symbols. Some of the findings were:

- (1) there is no appreciable difference in size judgements between solid and outline symbols;
- (2) symbols drawn to appear to have a third dimension were judged the same as if they were plane symbols, and;
- (3) the relationship between perceived size and actual size is nonlinear.

Jenks and Crawford (1967) in an experimental study of the viewing angle problem, recommended angles of 30° and 40° and proposed that there are three desirable qualities of three-dimensional maps, namely clarity, realism, and aesthetic quality. Worth (1978) advised that an angle of 35° be used for viewing of most three-dimensional surfaces. A vertical exaggeration necessary for a three-dimensional representation of a contoured map to look "realistic" for experienced map readers is also described by Jenks and Caspall (1967) in the equation:

$$\text{Vertical Exaggeration} = 6.87 - 2.82 \log \text{ contour interval (feet).}$$

Moreover, as noted by Lo (1973), the employment of three-dimensional techniques for mapping urban environments are invaluable in uniquely representing information. However, their effectiveness and "realism" are directly linked to the selection of a suitable exaggeration and viewing point (or angle of projection). As well, clarity of presentation is related to the extent of having "dead areas" or hidden objects in three-dimensional maps. This may only be minimized by increasing the angle of viewing. On the other hand, realism is increased by lowering the viewing point because it is nearer to the familiar "ground" of the object. Therefore, the aesthetic quality may only result as a compromise between these two conflicting requirements.

Finally, one would be remiss to overlook the role of training and experience in facilitating a map reader's ability to interpret a map properly. Dickinson (1973, pp. 76-77) and Olson (1975) carried out testing programs in which subjects were given training in map symbol reading. In particular, Olson's experiment, using graduated circles, demonstrated the importance of training in the interpretation of map symbology, and also brought out the indirect benefit of training, namely clarifying the nature of the task and thereby improving performance at it.

This chapter has outlined how most map users might interpret certain types of three-dimensional symbolism, what they look for, and some of the inherent preconceptions that influence where they might look on a map or any other display. The precise effects of these tendencies remain obscure because of a lack of data about what people do when scanning a map, and especially how their behaviour is changed by factors such as familiarity or alterations in required tasks (see Dobson, 1977, 1979; Hopkin and Taylor, 1979).

A major methodological difficulty in studying this aspect of cartographic communication is that of measurement. That is, for reasons of variability in geographic training and perception of reality, the map readers' interpretation are by definition subjective. Consequently, any investigation of factors that might affect the accuracy of judging the size of three-dimensional bar symbols is constrained by the difficulties associated with the reliability and validity of subjective data. In the following chapter, a methodology to determine the accuracy of information extracted from viewing three-dimensional bars situated in map and non-map environments is discussed.

CHAPTER 4

METHOD

To examine the perception of three-dimensional bars it is necessary to examine them first as symbols in simpler conditions, that is, outside the map environment. The experiments described in this study are designed to allow for a more complex treatment of three-dimensional bar perception in the map environment. It was assumed that if suitable tests could be devised at a simple level, their results would guide the formulation of tests of perception in map situations. Such an approach is both necessary and desirable to determine what factors are involved in the perception of these symbols. These factors, once identified, could then be more easily controlled when the symbols were tested in their cartographic context.

Attention in the following discussion is focused on how map readers might discern variations in three-dimensional bar sizes. It is generally acknowledged that the purpose of a thematic map is to communicate a basic message or trend to a map reader. The tools used to assist in the communication process are often some form of cartographic generalization such as

classification, induction, simplification, and symbolization. As a result, the importance of perceiving small changes in three-dimensional bar sizes by a map reader might be considered secondary to the completeness and quality of the actual message perceived.

Since the dimensions of three-dimensional bars may be varied to correspond with small variations in quantities represented, it is therefore technically possible to use three-dimensional bars to represent data with great precision. However, small changes in three-dimensional bar sizes cannot be perceived by the map reader - a fact that sets limits to the visual presentation of quantities. The following experimental situations were designed to determine what major variations in three-dimensional bar sizes might be perceived by map readers. A survey and a questionnaire were developed to gather the necessary data about those perceived variations in three-dimensional bar sizes. Characteristics of the sample design, an explanation, and a justification of its use are provided below.

1. Experiment 1

The primary objective of this experiment was to ascertain the threshold value or point at which individuals are able to discriminate between three-

dimensional bar sizes, and groups of three-dimensional bars of identical size. No special measuring apparatus was used. The stimuli was designed to consist of open three-dimensional bars on a white background (see Appendix 7). Subjects were asked to select and note on their questionnaires the following information about the graphic:

- (1) the three highest bars and their estimated values;
- (2) the three lowest bars and their estimated values, and;
- (3) the estimated values of five randomly specified bars.

This process was repeated for Experiments 2 and 3. Even though three-dimensional bars may be drawn in a variety of colours, most three-dimensional bars used in thematic maps are open or black bars on a white background (see McKay, 1975; Schmid and Schmid, 1972). It was assumed that what may be true for open three-dimensional bars on a white background is likely true of black, grey or patterned three-dimensional bars on a variety of backgrounds.¹

The three-dimensional bars presented in this experiment were out of map context. They were drawn as simple three-dimensional bars not surrounded

¹ The same cannot be said for coloured three-dimensional bars (see Bevan and Dukes, 1953; Stelmack, 1970; Doslak and Crawford, 1977).

by symbols commonly present on base maps, such as coastlines, boundary lines, drainage channels and other features. Since the appreciation of three-dimensional bar sizes under simple conditions may not differ much from the appreciation of three-dimensional bars in the map environment, tests were later conducted to test the perception of three-dimensional bars under these different and more complex conditions.

2. Experiment 2

A map represents cultural or physical features that are distributed on the earth's surface in an almost endless variety of densities, shapes, sizes and patterns (Keates, 1976, p. 59). What is shown on the map is inevitably an intricate display of selected point, line and area symbols. It is possible, therefore, that guidelines derived from testing symbols abstracted from the complexities of map reading may prove of limited value when put to work in a more realistic context. Therefore, if the results of this study are to be of any practical value to cartographers, the findings based on the testing of the three-dimensional bar outside the map environment should be further examined within the complex conditions of selected map environments.

Owing to the complexity and infinite diversity of the map environment, the selection of representative situations for testing purposes is a difficult task. The problem may be reduced to manageable proportions, and the findings may be more generally applicable to a greater variety of situations, if the test maps are simplified by excluding such variables as lettering and other types of symbols. Therefore, only the three-dimensional bar with one other variable, namely the line symbols, will be considered here. The line was chosen because it is the most common symbol found on maps, and is generally the basis for identifying the areal unit of the earth's surface being portrayed.

Real maps from the literature could be selected to display the symbols, but the map reader might recognize places or boundaries that would allow him or her to locate areas geographically. This would permit the map reader to select a convention using previous geographic knowledge (experience) rather than using cartographic knowledge. To control for previous geographic knowledge, fictitious maps with no real world counterpart were generated for the experiment.

Values represented by three-dimensional bars cannot be accurately estimated by most persons because of visual inspection and comparison of

three-dimensional bar size differences. As a result, some adjustments must be made to the three-dimensional bar for it to retain its utility as an effective map symbol. The key would be to devise a system that map viewers could make quantitatively accurate comparisons of three-dimensional bars of different sizes. The most effective method to achieve this would be to incorporate within the graphic, a legend or scale based on apparent three-dimensional bar size differences recognizable by most map readers. The experiments described in this thesis have been designed to establish an effective and appropriate scale of this kind.

Three distinct elements make up the structure of the tests:

- (1) a distributional pattern of three-dimensional bars based on mathematically generated centroids of randomly selected areas;
- (2) three sets of base maps, each with different viewing angles, and;
- (3) an incorporated scale to assist the map reader in the estimation process.

All the test procedures are the same as those outlined for Experiment 1 and the section entitled "Questionnaire Design", except for slight modifications in the instructions accompanying the tests.

3. Experiment 3

The attention of this thesis so far has been on the visual perception of open quantitative three-dimensional bars. Many published three-dimensional bar maps use this design, but other varieties of three-dimensional bars are sometimes used on black and white maps. The most frequently used are black; in other cases, various tones of grey. The following tests are meant to determine the significance of the difference, if any, between the open three-dimensional bars on a white background and various other combinations (figure-ground relationship).

The main objective of the tests in Experiment 3 is to find if the established scale (determined from previous experiments) remains valid for other three-dimensional bar types. If the scale holds true for all three-dimensional bars regardless of shade, then the versatility of the three-dimensional bar is thereby clearly increased. That is, the three-dimensional bar could then be used to describe more than one phenomenon on the same map. For example, within the same map the quantity of product A may be shown with open three-dimensional bars while the quantity of product B may be described with a grey scale. The test procedures used for this experiment are the same as

those outlined for Experiments 1 and 2.

4. Map Audience

The size of the map audience has long been known to depend on the type of map being presented. Among maps that may be loosely defined as general reference type, road, topographic, and tourist maps are acknowledged to be used in the largest quantities (Fisher, 1978b). In contrast, it has been determined and thoroughly documented by several authors (King-bury, 1969; Lawrence, 1971; Peucker, 1972; Robinson, 1966, 1970) that thematic maps, except those appearing in the mass communication media, are usually oriented towards a specialized audience.² Because thematic maps are designed for numbers of specialized users, cartographers are able to make use of large varieties and types of symbology (Bachi, 1968; Bertin, 1983, Wood, 1978). Such being the case, thematic maps are likely to be complicated in ways that tend to require considerable geographic and cartographic knowledge.

² The "mass communication media" referred to includes television, videotex systems, and print. Graphics as maps often appear in the media and are usually produced by visual designers or graphic artists. Informative articles on the current state of computer graphics and its effective use in television and with videotex systems, have been written by Black and Caldwell (1981) and Nisenholtz (1982).

These particular types of maps are most often used to complement statistics in reports, and more recently have become recognized as a valuable component in computerized "decision support" systems (Carlson, 1974; Dalton, et al., 1979; Nicholson, 1981). The most common applications are planning (Schmid and Schmid, 1972; Wells, 1980), marketing (Bell and Zabriskie, 1978; Takeuchi and Schmidt, 1980), environmental modelling (Shepard, 1970; Langford, 1981) and statistical reporting (Ray, et al., 1976; Statistics Canada, 1977). However, these these applications are often only used by a single person or, at most, within a small interest group.

5. Sample Design

Since the main intent of this study is to examine how accurately map users interpret a specific type of map symbol, it is necessary to empirically study their reactions. Time and financial constraints forced the selection of a sample population of map users.

The decision to use mail questionnaires instead of another survey method was based on several factors. This approach has not been widely used by cartographers, but responses to mail questionnaires are generally as accurate as those obtained from controlled situations (Scott, 1961; Fillion, 1980) and has

been successfully used by Skoda (1975). Obvious advantages of this method include a somewhat simple procedure by comparison to involving classrooms of students or conducting personal interviews, and significant savings in manpower and money. The mail questionnaire is able to canvass a national sample and yet be controlled from a central location. It also may be used to reach virtually all persons selected regardless of personal characteristics, and allows for a more typical map reading situation to occur.

A relatively complete mailing list of individuals, judged to be "potential map users" from throughout North America, was made available for this study.³ To eliminate much of the cost associated with administering the survey to a large sample, a systematic sample of "n" subjects from a population of 1200 (N) individuals on a mailing list was selected. Systematic, or one-in-k, sampling consists of selecting one element from the first k elements in the population and every k-th element thereafter. Systematic sampling is easier to apply and is generally less subject to error than simple random sampling. Frequently a systematic sample is spread more uniformly over the entire population and, therefore, may provide more information about the population than

³ The *National Commission for Cartography* mailing list consists of people interested in receiving literature pertaining to cartography in Canada

an equivalent amount of data contained in a simple random sample.⁴ In populations that are random, that is, in no particular order such as alphabetic lists, systematic sampling would provide the same accuracy as simple random sampling. The sample size required to estimate the proportion "p" of people representative of the entire population with a bound "B" of 5 per cent of the error of estimation is found using the sample size formula in Figure 6. that assumes simple random sampling.

An approximate sample size may be found by replacing "p" with an estimated value. Since no previous information was available on the individuals to estimate "p", a conservative sample size may be obtained by setting $p=0.5$ (see Mendenhall, 1974).

The required sample size may be found by using the equation in Figure 6. Although no previous data are available on these particular map-users, an approximate sample size may be assigned. Substituting "p" with 0.5 according to the equation outlined in Figure 6, results in:

$$D = \frac{B^2}{4} = \frac{(.05)^2}{4} = .000625$$

⁴ For a detailed discussion on the choice of a sampling method for an application and its

Sample size required to estimate "p" within a bound "B" on the error of estimation:

$$n = \frac{Npq}{(N-1)D + pq}$$

where

$$q = 1 - p \text{ and } D = \frac{B^2}{4}$$

Figure 6. Sample size function.

then the required sample size is

$$\begin{aligned} n &= \frac{Npq}{(N-1)D + pq} \\ &= \frac{1200 (.5)(.5)}{1199 (.000625) + (.5)(.5)} \\ &= 300.18 \end{aligned}$$

Hence, to insure an accuracy to within 5 per cent error, a sample size of 300 individuals is required.

According to systematic sampling rules, "k" must be less than or equal to " N/n ". Therefore, in this study, the choice must be less than or equal to 4
 implementation see Mendenhall, et al., (1971).

(i.e. 1200/300). The decision was made to have to have "k" equal to 4. That is, one element (individual) was chosen from the first four individuals on the mailing list and then every fourth individual was selected thereafter.

6. Questionnaire Design

The questionnaire was divided into four parts. Subjects were asked to make ordinal and absolute size estimates of three-dimensional bars in the first three parts of the questionnaire that corresponded to Experiments 1 to 3:

Experiment 1 - outside a map environment;

Experiment 2 - inside a map environment, and;

Experiment 3 - inside a map environment and using shaded
three-dimensional bars.

All questions in this section of the questionnaire could be answered by entering a numeric value. The latter part or "Questions About Yourself" was designed to provide background data on the personal characteristics of respondents for statistical purposes, and could be answered by with a check mark or a short narrative. In addition, opinions on colour, design, and textual information

about an attached colour map of Canada (see Figure 7) were solicited for Statistics Canada, a co-sponsor of the questionnaire.

Copies of the schedules comprising of three experimental questionnaires and covering letters are displayed in Appendix 7. The three experimental questionnaires were identical except that significantly different viewing angles of 25°, 34°, and 45° were used in each questionnaire. The choice of viewing angles used was based on the literature related to viewing of three-dimensional surfaces (see Jenks and Crawford, 1967; Worth, 1978). All questions were designed and administered according to guidelines given by Filion (1978). The entire schedule (which included a covering letter and the questionnaire) was reviewed and revised several times before pretesting.

Pretesting of all three schedules was done by randomly administering them to 60 high school geography students using the direct application method. All care was taken to simulate the conditions of a mail survey. No direct verbal instructions were given and no time limit (except within the duration of class time) was enforced for the completion of the questionnaire.

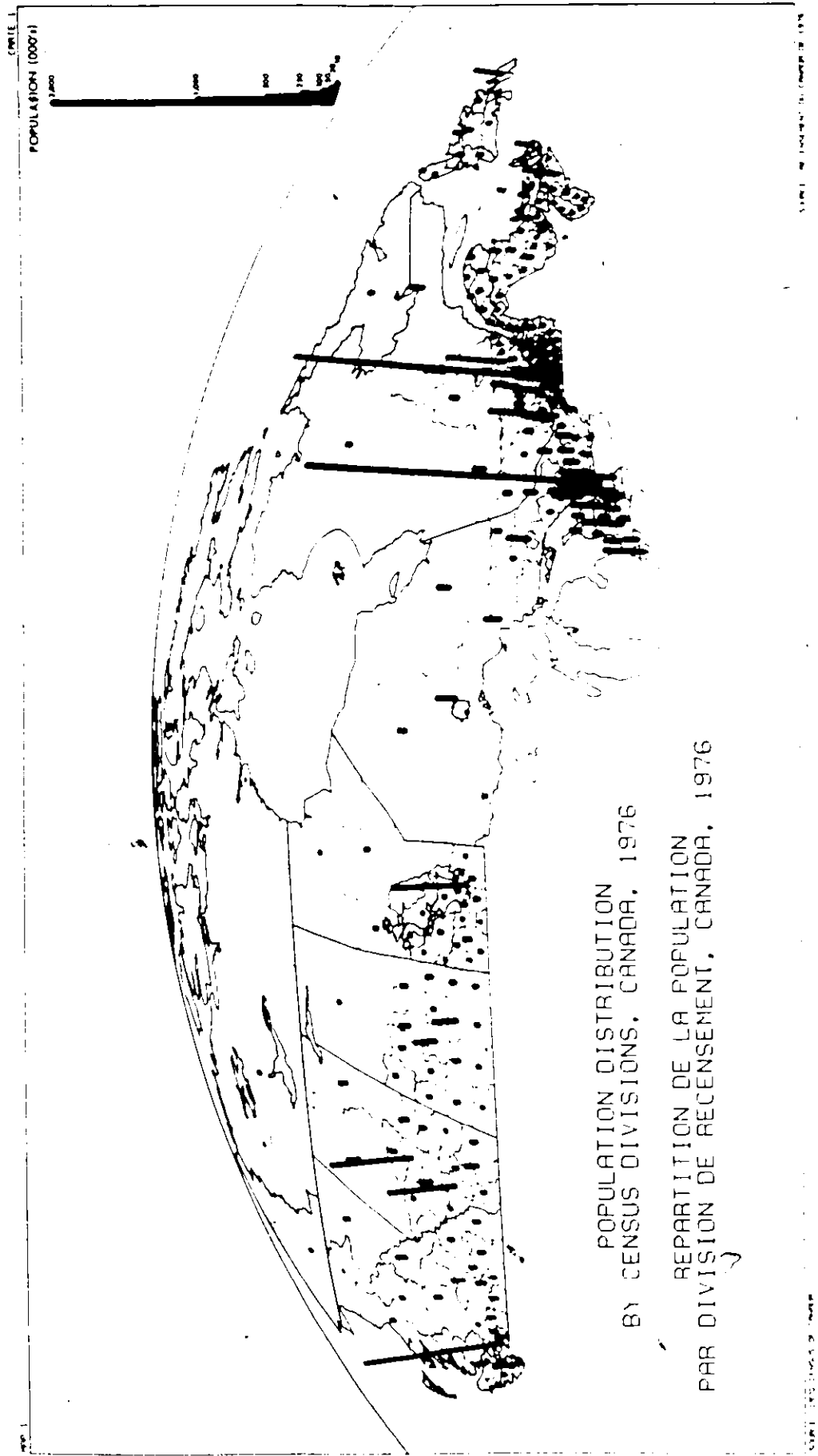


Figure 7. Population Distribution by Census Divisions, Canada, 1976.

The sole purpose of pretesting was to highlight format and wording problems with the questionnaire in advance to final mailing. No significant findings of a negative nature were determined and it was therefore decided to use the questionnaire.

7. Survey Procedures

The schedule package was mailed during the last week of May, 1978. The package consisted of a covering letter, questionnaire and a coded postage paid return envelope (first class mail). A reminder letter was forwarded one week later to the subject. One follow-up mailing of the package was made in late June to non-respondents from the first mailing.

A weekly tally of completed and undeliverable questionnaires was maintained to determine nonresponse bias and for general statistical information. Completed questionnaires were edited and coded manually onto keypunch forms. As well, data consisting of the respondents' unique-identification number, mailing wave, date of return and viewing angle were coded from the front of the postage paid returned envelopes onto corresponding keypunch forms. The data were then keypunched, iteratively machine-edited by a computer program, manually corrected until clean, and transferred to magnetic

tape for storage. Record layout information for Parts 1 to 4 of the questionnaire data may be found in Appendices 1 to 3. Statistical analysis and graphics were generated by the Statistical Package for the Social Sciences (Nie, et al., 1975) and the Display Intergrated Software System and Plotting Language (ISSCO, 1981).

CHAPTER 5

RESULTS

The purpose of the research presented in this thesis was to determine how accurately a potential map user might judge size of three-dimensional bars in and outside of a map environment. Assessment of how accurately map users judged sizes involved measurement of subject performance on three independent tests. The success of each presentation technique was measured by comparing the extent of quantitative errors and the variation in the subjects' responses with the desired or intended response for each graphic presented. Since the type of information and method of portrayal for all the graphics were identical, the differences in the responses to questions were assumed to be a result of graphic change. It is hypothesized that the graphic technique that delivered the intended information most accurately would be the graphic in which there was the smallest deviation and fewest incorrect responses to the questions.

1. Survey Response

Of the 300 questionnaires sent, 170 were completed and 17 were returned undelivered for a final response rate of 60.7 per cent (based on a deliverable mailing of 283). A detailed account of responses by week may be found in Table 1. There was no significant difference in response rates among the three questionnaire types (see Table 2). About 72 per cent of the respondents returned their questionnaires within 4 weeks of the original mailing, that suggested a high interest among potential map users about the subject matter. This is verified in Question 4 of the "Questions About Yourself" section where 98.2 per cent of the respondents noted that they were either "interested" or "extremely interested" in maps. Of all respondents, 83.9 per cent said that they used maps "extremely often" or "quite often".

By far the largest group of respondents were from the first mailing wave (88.2 per cent). All respondents from the second mailing wave responded in a time frame greater than 8 weeks after original mailing. Item response rate for experiment questions was lowest for Question 3.5 in Experiment 3 (94.1 per cent). For that matter, response was observed to be generally low among all Experiment 3 type questions. This would seem to indicate that response bar-

den might have started to affect respondents at this point in the questionnaire. From the "Questions About Yourself" section, missing responses were found to be extremely high for Questions 8 through 12f. The large number of missing responses might be interpreted as a result of several factors including misunderstanding of the questions, response burden and the respondents' feelings of irrelevancy with respect to Experiments 1 to 3.

2. Nonresponse Bias

Depending on the type of survey, both direct and inverse relationships have often been found between responsiveness and age, profession, place of residence or other personal characteristics of respondents (Filion, 1974). As a result, response to the successive waves returned are viewed as being distinct groups forming a continuum of respondent types. For example, respondents to Wave 1 are considered to be early respondents having a high response probability, whereas respondents to later waves are considered to be late respondents with a medium to low response probability and should be regarded as potential nonrespondents. The continuum from highly motivated persons to individuals who normally would not have cooperated potentially indicates the direction and extent of error because of nonresponse and that extrapolation

would reflect the characteristics of a "hard core" group of nonrespondents.

To determine the effect of nonresponse on the questionnaire returns, the following procedure was followed. It was assumed that returns from the first and second mailing waves were two distinct populations and questionnaire responses should be treated as such. The returns from the first mailing wave were assumed to represent the highly motivated response group and the second mailing wave to be, with a high probability, representative of a nonrespondent population. A chi-square test (X^2) was performed using as dependent variables the responses to personal characteristics questions from the "Questions About Yourself" section to determine whether significant differences existed between the respondents of the first and second mailing waves. If this test proved significant, a further series of (X^2) tests would be done between the dependent variable and other questions. When differences between means were examined such as those responses found in Experiments 1 to 3, an F-test was employed.

Levels of statistical significance such as 0.05 and 0.01 are commonly used in survey analysis. Because of the exploratory nature of this study, and for numerous other statistical reasons (see Labovitz, 1968), it was decided to note

only those results that are significant at the 0.10 level. Since the objective of significance testing is to discern biases, it was thought that too stringent a significance level would allow the detection of only the more obvious biases. In this study, where the sample is small, this would result in possible biases remaining unnoticed.

Only Question 4 ("How interested are you in maps?") from the "Questions About Yourself" section indicated statistically significant responses between the first and second mailing waves of returned questionnaires ($\chi^2 = 10.9$, d.f. = 4 and $p < 0.05$). Just over two-thirds (68 per cent) of the respondents from the first mailing expressed "extreme interest" as compared to only 45 per cent of those responding to the second mailing wave (see Table 7). Further testing and analysis of Question 4 among all other variables in the questionnaire (Experiments 1 to 3 and Questions About Yourself) yielded no further statistically significant differences (see Tables 3 to 6, 8 to 10). With a high degree of confidence, it was concluded that the effects of nonresponse bias did not alter the results of this questionnaire.

Table 1.
Questionnaires Returned by Month and Week

Month and Week	Questionnaires Returned	Cumulative Returned	Cumulative Per Cent Returned
June 4-8	17	17	6.00
11-15	22	39	13.78
18-22	57	96	33.92
25-29	27	123	43.46
July 2-6	8	131	46.29
9-13	9	140	49.47
16-20	1	141	49.82
23 +	29	170	60.07
Total	170	170	60.07

Table 2.
Questionnaires Returned by
Mailing Wave and Map Type

Mailing Wave	Responses	Per Cent
First	150	88.2
Second	20	11.8
Total	170	100.0

Map Type	Responses	Per Cent
One (45°)	53	31.2
Two (34°)	60	35.3
Three (24°)	57	33.5
Total	170	100.0

Table 3.
Mailing Wave Returns by Map Type

Mailing Wave	Map Type One (45%)	Map Type Two (34%)	Map Type Three (25%)	Row Total
First	45 (30.0%)	52 (34.7%)	53 (35.3%)	150 (88.2%)
Second	8 (40.0%)	8 (40.0%)	4 (20.0%)	20 (11.8%)
Column Total	53 (31.2%)	60 (35.3%)	57 (33.5%)	170 (100.0%)

Table 4.
Mailing Wave Returns by Age Distribution

Mailing Wave	20-29	30-39	40-49	50-59	60+	Row Total
First	37 (24.8%)	44 (29.5%)	34 (22.8%)	23 (15.4%)	11 (7.4%)	149 (88.2%)
Second	5 (25.0%)	8 (40.0%)	1 (5.0%)	3 (15.0%)	3 (15.0%)	20 (11.8%)
Column Total	42 (24.9%)	52 (30.8%)	35 (20.7%)	26 (15.4%)	14 (8.3%)	169 (100.0%)

Table 5.
Mailing Wave Returns by Sex

Mailing Wave	Male	Female	Row Total
First	124 (82.6%)	26 (17.4%)	150 (88.2%)
Second	14 (70.0%)	6 (30.0%)	20 (11.8%)
Column Total	138 (81.2%)	32 (18.8%)	170 (100.0%)

Table 6.
Mailing Wave Returns by Corrective Lenses Use

Mailing Wave	Yes	No	Row Total
First	83 (55.3%)	67 (44.7%)	150 (88.2%)
Second	11 (55.0%)	9 (45.0%)	20 (11.8%)
Column Total	94 (55.3%)	76 (44.7%)	170 (100.0%)

Table 7.
Mailing Wave Returns by Map Interest

Mailing Wave	Extremely Interested	Quite Interested	Slightly Interested	Quite Uninterested	Row Total
First	101 (67.3%)	47 (31.3%)	1 (.7%)	1 (.7%)	150 (88.2%)
Second	9 (45.0%)	10 (50.0%)	-	1 (5.0%)	20 (11.8%)
Column Total	110 (64.7%)	57 (33.5%)	1 (.6%)	2 (1.2%)	170 (100.0)

Table 8.
Mailing Wave Returns by Map Use

Mailing Wave	Extremely Often	Quite Often	Often	Row Total
First	96 (64.9%)	30 (20.3%)	22 (14.9%)	148 (88.1%)
Second	12 (60.0%)	3 (15.0%)	5 (25.0%)	20 (11.9%)
Column Total	108 (64.3%)	33 (19.6%)	27 (16.1%)	168 (100.0%)

Table 9.
Mailing Wave Returns By Position Title

Position Title	First	Second	Row Total
Professor	18 (12.2%)	3 (15.0%)	21 (12.6%)
Systems programmer/analyst	1 (.7%)	-	1 (.6%)
Teaching assistant	4 (2.7%)	1 (5.0%)	5 (3.0%)
Statistician	1 (.7%)	-	1 (.6%)
Librarian	9 (6.1%)	2 (10.0%)	11 (6.6%)
Engineer	5 (3.4%)	1 (5.0%)	6 (3.6%)
Draftsman/woman	39 (26.5%)	4 (20.0)	43 (25.7%)
Research scientist	6 (4.1%)	1 (5.0%)	7 (4.2%)
Consultant	2 (1.4%)	1 (5.0%)	3 (1.8%)
Student	8 (5.4%)	1 (5.0%)	9 (5.4%)
Other	54 (36.8%)	6 (30.0%)	60 (35.9%)
Column Total	147 (88.0%)	20 (12.0%)	167 (100.0%)

Table 10.
Mailing Wave Returns by Employer

Employer	First	Second	Row Total
Industry	11 (7.5%)	4 (22.2%)	15 (9.1%)
Private laboratory	1 (.7%)	-	1 (.6%)
University or college	47 (32.2%)	6 (33.3%)	53 (32.3%)
Military	4 (2.7%)	-	4 (2.4%)
Research institution	2 (1.4%)	-	2 (1.2%)
Government	69 (47.3%)	8 (44.4%)	77 (47.0%)
Marketing or sales	2 (1.4%)	-	2 (1.2%)
Other	10 (6.8%)	-	10 (6.1%)
Column Total	146 (89.0%)	18 (11.0%)	164 (100.0)

3. Homogeneity

In this experiment, cursory and easily applied criteria for homogeneity such as age, sex, level of education, use of corrective lenses and professional experience were used. Not that it should be thought that such obvious characteristics are relevant, but evidence here and in the literature (Shaw, 1972) suggests that many other sources of variability, which are less easy to predict, might influence a particular type of response.¹

To test for homogeneity between characteristic groups and mean responses to the height estimation questions of Experiments 1 to 3, an F-test was performed. Each of the experiments showed that even when the respondents were grouped according to the characteristics given above, based on F-test probabilities, there were still wide variations within each group. There was usually as much variability between respondents in the same characteristic group, as between respondents in different characteristic groups. There were also greater differences between individuals within each separate group, for example in the map and shaded bar experiment (Experiment 3), than among

¹ It might also be commented that little is known about the so-called basic characteristics of a "good" map reader. This topic has not been extensively researched by cartographers. However, some good background work identifying the need for this type of research in cartography has been addressed by Fisher (1978a, 1978b).

the characteristic groups themselves (see Tables 11 to 13). A similar trend was observed from the analysis of results from the bar and map/bar experiments (Experiments 1 and 2).

The lack of major differences between groups would also seem to indicate a high degree of homogeneity among respondents, giving wider validity to the results of this study. As a result, the comparison and integration of findings from these experiments with particular groups to other test groups might be possible, though it should be acknowledged that those subjects tested here and in other similar experiments are often differently motivated compared to real life users. It was also recognized that the effect of motivation on performance could be considerable. However, owing to the inherent complexity of the motivation issue, it was not pursued in this study.

4. Characteristics of Respondents

The age of respondents was recorded according to categorized groups (see Figure 8). By a small margin, the largest number of respondents (30.6 per cent) was made up of persons in the 30-39 age group. Over three-quarters (75 per cent) of the respondents were 49 years of age and younger.

Figure 8. Age distribution of respondents by map type

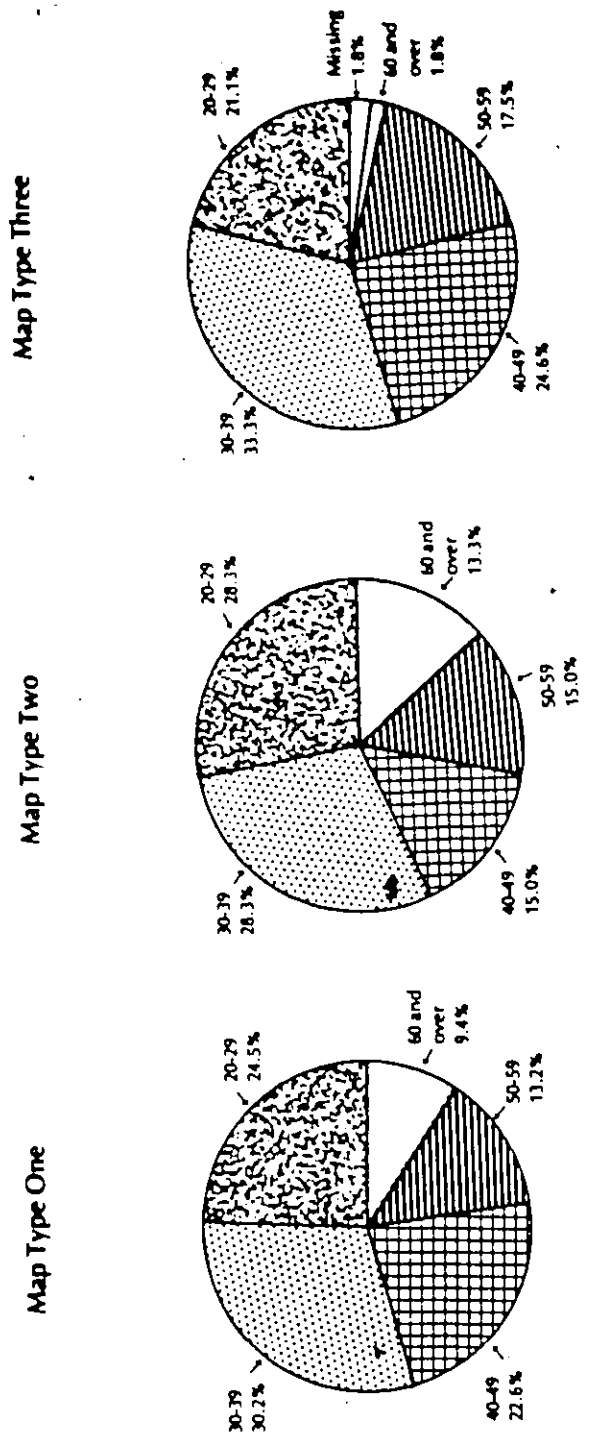
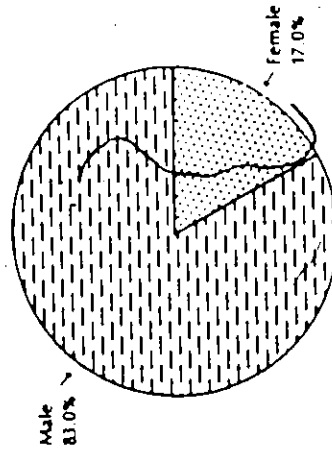
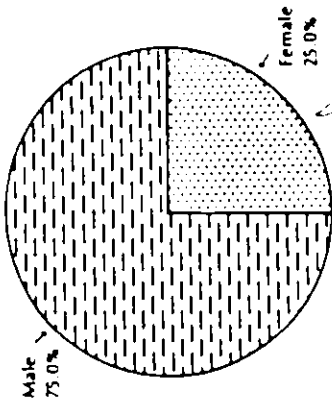


Figure 9. Sex of respondents by map type

Map Type One



Map Type Two



Map Type Three

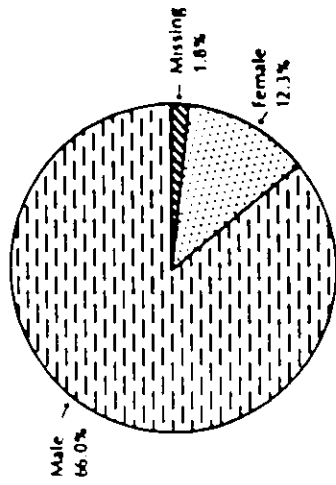
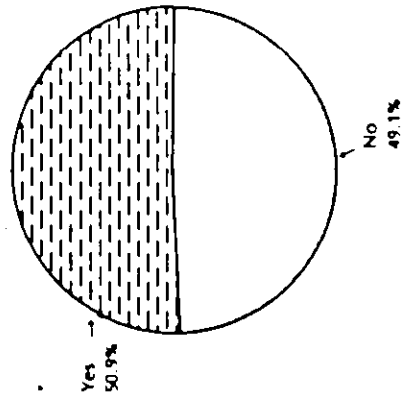
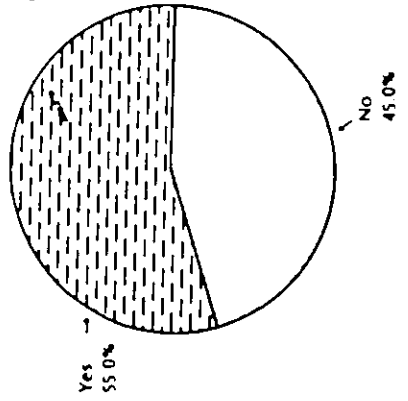


Figure 10. Corrective lenses use by respondents by map type

Map Type One



Map Type Two



Map Type Three

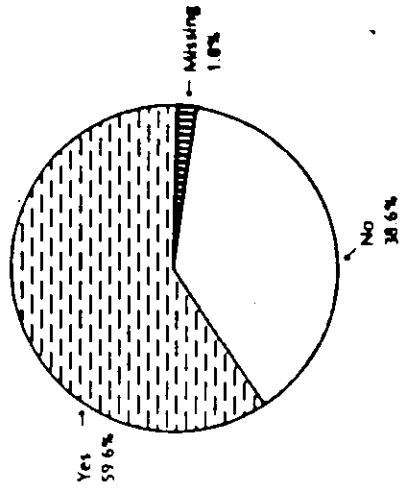


Table 11.
F-test Probabilities for Characteristics
of Respondents and Experiment I

Question	Age	Sex	Corrective Lenses	Map Interest	Map Use	Position Title	Employer	Mailing Wave	Map Type
1.1b	.3510	.7747	.7260	.0721	.8834	.5705	.7791	.3870	.0000
1.2b	.8325	.4273	.0204	.0000	.5370	.8204	.8972	.5100	.0001
1.3b	.4341	.8810	.1770	.0000	.8686	.5402	.4901	.7335	.0000
2.1b	.0976	.3477	.4445	.8849	.1051	.2002	.3444	.8706	.1716
2.2b	.4769	.2153	.9165	.6817	.3063	.4982	.7158	.4758	.0006
2.3b	.0207	.9808	.9443	.7948	.0119	.3255	.7270	.8144	.0043
3.1	.0223	.9323	.1547	.2140	.6178	.9935	.8873	.3396	.0000
3.2	.0734	.0533	.4305	.0145	.7122	.2742	.5903	1.000	.0797
3.3	.2560	.3594	.2703	.7370	.6213	.8133	.9982	.4213	.0000
3.4	.3139	.1997	.7891	.8891	.9608	.7929	.9079	.5948	.2881
3.5	.0998	.4775	.3374	.0000	.5434	.8941	.9918	.8534	.0000
Mean	.2707	.5118	.4748	.4444	.5613	.6117	.7572	.6364	.0493

Table 12
 F-test Probabilities for Characteristics
 of Respondents and Experiment 2

Question	Age	Sex	Corrective Lenses	Map Interest	Map Use	Position Title	Employer	Mailing Wave	Map Type
1.1b	.3070	.8804	.9105	.7957	.8630	.6381	.9505	.0092	.0000
1.2b	.4400	.4100	.4624	.0000	.5460	.8018	.9748	.4407	.0001
1.3b	.5329	.6725	.2217	.0001	.0033	.6098	.9604	.7474	.0001
2.1b	.5889	.0688	.7113	.5087	.0561	.4738	.0385	.7771	.2022
2.2b	.9728	.2228	.3046	.8439	.1081	.8636	.5755	.6476	.0325
2.3b	.2971	.5333	.7567	.0046	.2479	.9644	.7492	.9053	.4051
3.1	.7007	.7730	.3197	.9221	.9094	1.0000	.9645	.3555	.0000
3.2	.0208	.9776	.7157	.8779	.7346	.9924	.6393	.2026	.3102
3.3	.3183	.3146	.9418	.7113	.8596	.9119	.7738	.5720	.0000
3.4	.4356	.4250	.7567	.7614	.6493	.8132	.9801	.6847	.0000
3.5	.2360	.0571	.2023	.8230	.6124	.9066	.8088	.2280	.0000
Mean	.4415	.4856	.5730	.5681	.5191	.8100	.7650	.5064	.0864

Table.13.
F-test Probabilities for Characteristics
of Respondents and Experiment 3

Question	Age	Sex	Corrective Lenses	Map Interest	Map Use	Position Title	Employer	Mailing Wave	Map Type
1.1b	.2186	.3065	.6915	.4111	.7803	.5826	.9892	.1405	.0000
1.2b	.1968	.8293	.4150	.5097	.7792	.1507	.9783	.7015	.0000
1.3b	.5963	.7010	.8799	.7181	.4298	.3311	.8336	.8403	.0014
2.1b	.1779	.9356	.1809	.4231	.5795	.8128	.6634	.4309	.0188
2.2b	.2714	.9347	.3275	.9104	.3339	.8571	.9289	.4398	.0854
2.3b	.5191	.3747	.1158	.9086	.6370	.7842	.6975	.5638	.0083
3.1	.1398	.4869	.4678	.9655	.6305	.9283	.4541	.8417	.3910
3.2	.0237	.6231	.8927	.9813	.5550	.7827	.7882	.6845	.1200
3.3	.1493	.9059	.0524	.9140	.3922	.6908	.4246	.5290	.8961
3.4	.1971	.6074	.9609	.8589	.3770	.6999	.7059	.4359	.0731
3.5	.7026	.6803	.9308	.8749	.5368	.9478	.1418	.9353	.0846
Mean	.2902	.6715	.5383	.7760	.5490	.6885	.6914	.5948	.1534

Although females made up only 18.2 per cent of the respondent population (see Figure 9), on the whole they were significantly younger ($X^2 = 17.23, 4 \text{ d.f. and } p < 0.01$) than their male counterparts. Of all female respondents, 50 per cent were in the 20-29 age group compared to only 19.6 per cent of males. Most males (71 per cent) were found to be within the 30-59 age group as opposed to 46.9 per cent of females within the same age group.

A slight majority of respondents (55.8 per cent) required the use of corrective lenses while responding to Experiments 1 through 3 (see Figure 10). Significantly, of all respondents 50 years of age and older, those who wore corrective lenses outnumbered those who did not by a factor of almost 3 to 1 (17.9 per cent to 5.9 per cent). The largest significant difference found between those requiring correctives lenses and those not needing them was in the 50-59 years and older age group ($X^2 = 8.10, 4 \text{ d.f. and } p < 0.10$) where 73.1 per cent and 78.6 per cent, of respondents from these age groups reported that they used corrective lenses while responding to Experiments 1 through 3. Of those respondents who did not use corrective lenses during the experiments, 86.7 per cent were less than 50 years of age, compared to 68.1 per cent who did wear corrective lenses from the same age group. However, of all respondents less

than 50 years of age, 37.9 per cent wore corrective lenses and 38.5 per cent did not.

The age profile of respondents by position title showed significant differences ($X^2 = 69.30$, 48 d.f. and $p < 0.05$) among three major occupations. These are professors, draftpersons and individuals grouped as other. Of all draftpersons, 83.7 per cent were younger than 50 years of age, followed by 72.4 per cent of the respondents classified as other and 63.7 per cent of professors. Just over one-quarter of all respondents (25.2 per cent) were classified as other and younger than 30 years of age, followed by 21.6 per cent of draftpersons and only 8.4 per cent of professors (based on a content analysis of written responses to this question, the "other" respondents were found to be mainly planners, surveyors, and administrators). Conversely, 4.2 per cent of all respondents were professors and draftpersons 50 years of age or older, followed by 9.6 per cent of those occupations classified as other.

Slightly more males (56.5 per cent) than females (51.6 per cent) wore corrective lenses during testing ($X^2 = 170.25$, 4 d.f., $p < 0.01$). Just over two-thirds of males (66.7 per cent) showed that they were very interested in maps, as opposed to 58.1 per cent of females ($X^2 = 91.54$, 6 d.f., $p < 0.01$). When

2

responding to the question about position title, several positions were dominated by one of the genders ($\chi^2 = 34.59$, 12 d.f., $p < 0.01$). For example, only 3.2 per cent of female respondents reported a position title of professor compared to 14.7 per cent of their male counterparts. On the other hand, 22.6 per cent of females noted an occupation of librarian, whereas only 2.9 per cent of males reported such an occupation. Except for draftpersons where there was a 27.2 per cent to 19.4 per cent breakdown of males and females respectively, all other position title groups showed an equal representation.

Of persons who required corrective lenses during the testing, 61.7 per cent expressed "extreme interest" in maps compared to 69.3 per cent of those who did not require corrective lenses ($\chi^2 = 87.316$ d.f., $p < 0.01$). A significantly smaller number of respondents (37.2 per cent) who wore corrective lenses reported that they were "quite interested" as compared to 29.3 per cent who did not require such help. Of all respondents who wore corrective lenses, just under two-thirds (65.6 per cent) used maps "extremely often", 14.0 per cent "quite often" and 20.4 per cent only "often". On the other hand persons who did not wear glasses and used maps "extremely often" were about equal (62.7 per cent) in representation to those who wore glasses, but over one-quarter

(20.7 per cent) used maps "quite often" and only 10.7 per cent used them "often" ($\chi^2 = 5.92, 2 \text{ d.f.}, p < 0.10$)

No significant differences were found among the questions referring to map use, map interest, position title, and employer. However, a graphical description of respondents according to these characteristics are found in Figures 11.1-11.4.

3. Size of Bars

The accuracy with which respondents were able to judge the size of bars is measured using two methods. The first method involved converting the estimated values reported in Experiments 1 to 3 to "actual error" values by using the following formula:

$$N = (B-A)/A * 100$$

where A = actual value of bar,

B = estimated value of bar and

N = actual error value.

For example, if the actual value of the bar is 100

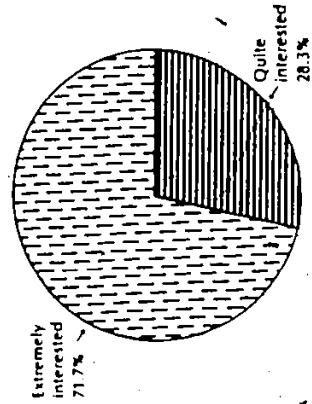
preted to indicate that the respondents had underestimated the value of the bar by a certain percentage from the actual value of the bar and vice versa when a non-negative actual error value was determined. The second method was simply to determine if the respondents had correctly ranked the three highest and three lowest bars in each of the three experiments. This would provide information on how well respondents were able to make relative size judgements.

On the average, respondents judged the value of bars often within 7 per cent of the actual value of a bar. The map and shaded bar experiment (Experiment 3) was found to have the widest range of actual error values (14.66 per cent) based on grand means of the three map types. However, this range was only about 2 percentage points larger than those calculated for Experiments 1 and 2.

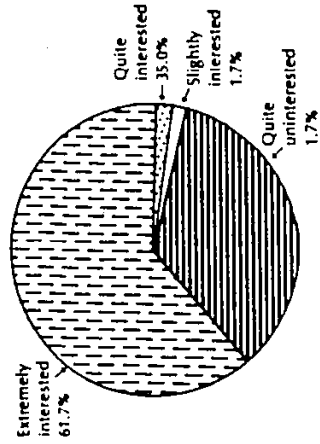
Additionally, there appeared to be no particular question that was either consistently poorly or well judged among the map types. Those anomalies that did occur such as the actual error value of 16.08 per cent for Question 3.5 of Experiment 3 with a viewing angle of 25° (see Table 17) were observed to be random in pattern when compared to other anomalous responses.

Figure 11. Map interest of respondents by map type

Map Type One



Map Type Two



Map Type Three

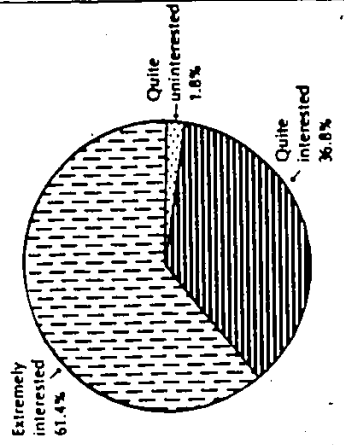


Figure 12. Map use of respondents by map type

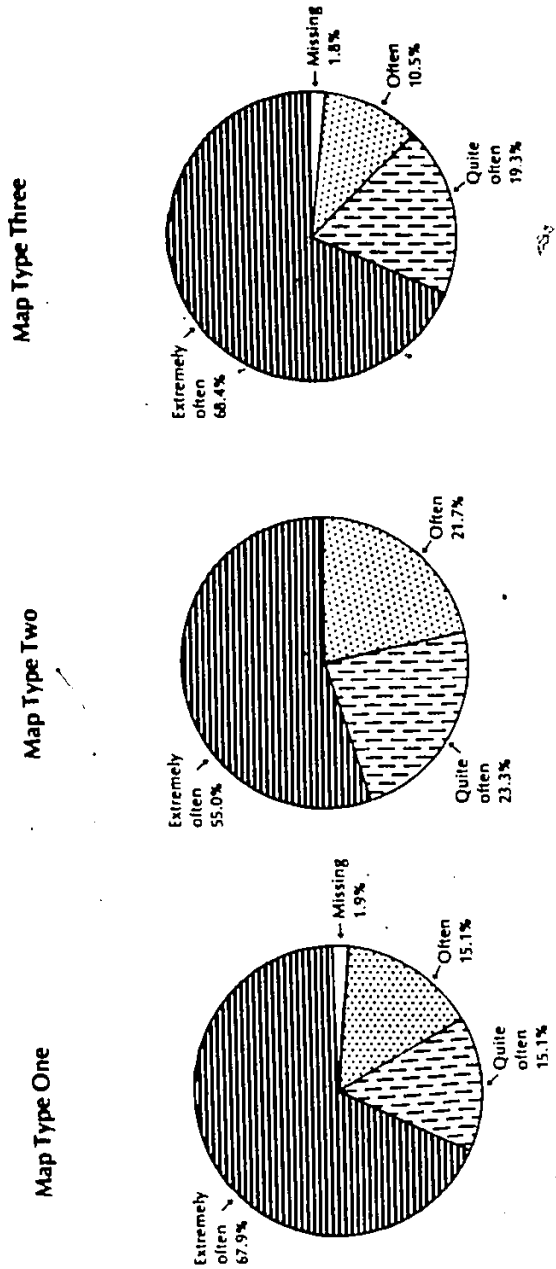


Figure 13. Position title of respondents by map type

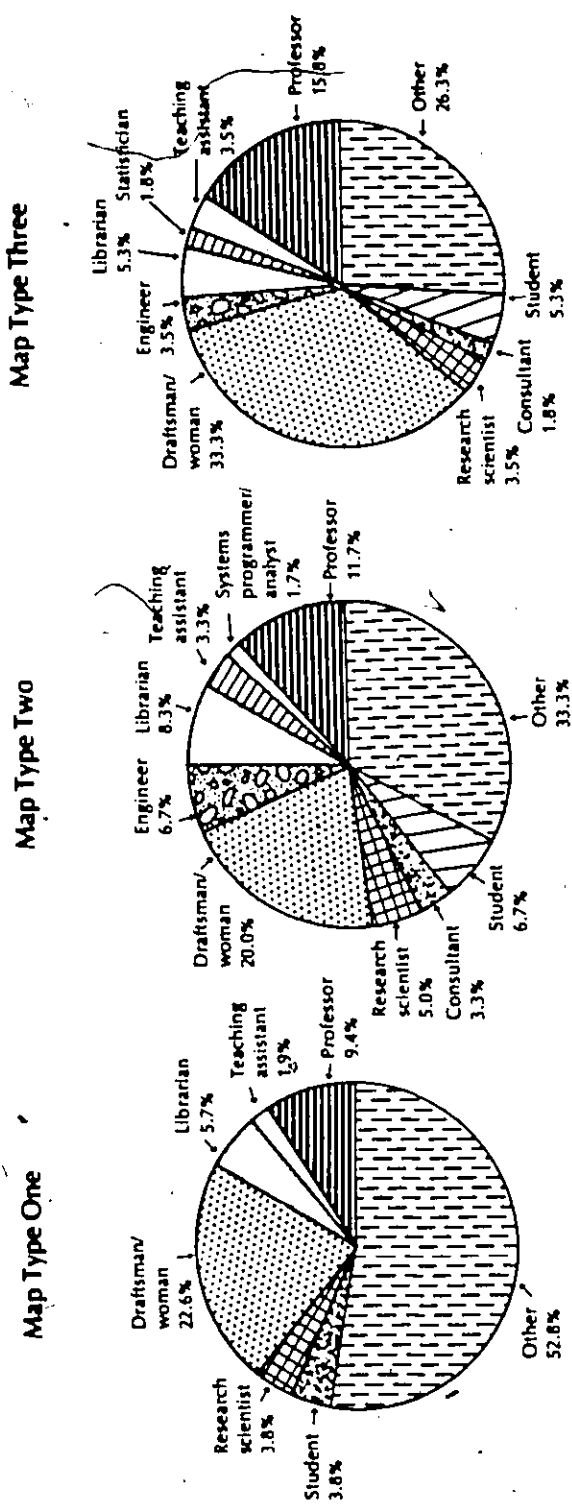
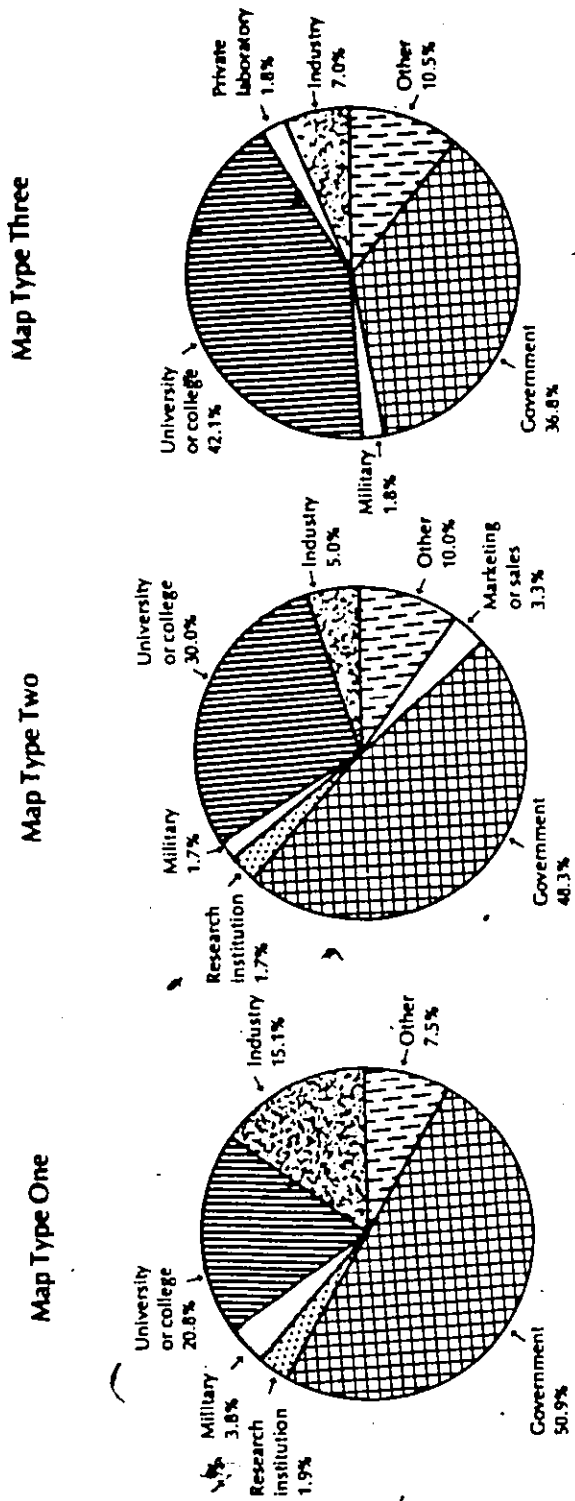


Figure 14. Employer of respondents by map type



The most significant result from analyzing estimated values was the high degree of accuracy that respondents to map type two were able to judge the value of bars. The lowest actual error values or most accurate judgements were obtained from responses to this map type. For each of the three experiments, grand means of actual error values from map type two were less than 1 per cent. In fact, the grand mean actual error for map type two in Experiment 2 (see Table 16) was only .07 per cent.

When responses to relative size judgements were analyzed, it was discovered that respondents had little difficulty in correctly choosing the highest and lowest bars (in the neighbourhood of 80-100 per cent correct). However, when requested to make relative size judgements on the second and third highest-lowest bars, respondents had considerable more difficulty in making correct assessments (see Table 14). The difference between correct responses for highest-lowest bars and the second-third bars was often about 50 per cent. It was also observed that the percentage of correct responses dropped markedly between the second and third highest-lowest bars. There no significant deviation from this trend among the responses to the three map types.

Table 14.
Correct Choice of Highest and Lowest Bars
for Experiments 1 to 3

Question	Relative Size	Map Type One (45') Responses			Map Type Two (34') Responses			Map Type Three (25') Responses		
		Per Cent Correct	Per Cent Correct	Per Cent Correct	Per Cent Correct	Per Cent Correct	Per Cent Correct	Per Cent Correct	Per Cent Correct	Per Cent Correct
Experiment 1										
1.1a	Highest	100	98	100	98	100	96	100	96	100
1.2a	Second Highest	36	54	36	54	41	54	41	54	41
1.3a	Third Highest	25	37	25	37	36	37	36	37	36
2.1a	Lowest	100	97	100	97	93	97	93	97	93
2.2a	Second Lowest	79	64	79	64	40	64	40	64	40
2.3a	Third Lowest	49	47	49	47	26	47	26	47	26
Experiment 2										
1.1a	Highest	100	98	100	98	96	98	96	98	96
1.2a	Second Highest	96	90	96	90	86	90	86	90	86
1.3a	Third Highest	66	53	66	53	53	53	53	53	53
2.1a	Lowest	100	97	100	97	98	97	98	97	98
2.2a	Second Lowest	83	86	83	86	96	86	96	86	96
2.3a	Third Lowest	53	75	53	75	89	75	89	75	89
Experiment 3										
1.1a	Highest	100	100	100	100	96	100	96	100	96
1.2a	Second Highest	98	80	98	80	67	80	67	80	67
1.3a	Third Highest	83	70	83	70	57	70	57	70	57
2.1a	Lowest	53	80	53	80	68	80	68	80	68
2.2a	Second Lowest	45	56	45	56	26	56	26	56	26
2.3a	Third Lowest	62	66	62	66	21	66	21	66	21

Table 15.
Mean Actual Error of Estimated Values
for Experiment 1

Question	Map Type One (45°)	Map Type Two (34°)	Map Type Three (25°)
	Per Cent Actual Error	Per Cent Actual Error	Per Cent Actual Error
1.1b	- 7.10	1.85	4.28
1.2b	- 7.31	1.74	6.04
1.3b	- 8.57	2.28	6.24
2.1b	- 4.58	- 1.47	3.88
2.2b	- 9.24	- 1.86	7.14
3.3b	- 6.39	- 1.52	9.39
Mean	- 7.20	.17	6.17
3.1	- 8.68	2.24	4.09
3.2	- 5.83	.54	3.09
3.3	- 4.76	1.20	6.13
3.4	- 2.78	- .73	1.74
3.5	- 6.09	5.16	10.18
Mean	- 5.63	1.68	5.21
Grand Mean	- 6.48	.86	5.73

Table 16.
 Mean Actual Error of Estimated Values
 for Experiment 2

Question	Map Type One (45°) Per Cent Actual Error	Map Type Two (34°) Per Cent Actual Error	Map Type Three (25°) Per Cent Actual Error
1.1b	- 7.93	1.22	5.77
1.2b	- 7.53	.59	4.10
1.3b	- 8.27	.92	6.65
2.1b	- 3.06	- 1.44	5.20
2.2b	- 6.15	.89	6.55
3.3b	- 4.14	1.50	2.05
Mean	- 6.18	.61	5.05
3.1	- 8.08	- .92	7.71
3.2	- 0.86	.89	1.53
3.3	- 9.01	- .19	9.89
3.4	- 6.75	- .32	5.17
3.5	- 9.31	- 2.38	6.69
Mean	- 6.80	- .58	6.20
Grand Mean	- 6.46	.07	5.57

Table 17
 Mean Actual Error of Estimated Values
 for Experiment 3

Question	Map Type One (45°)	Map Type Two (34°)	Map Type Three (25°)
	Per Cent Actual Error	Per Cent Actual Error	Per Cent Actual Error
1.1b	- 9.45	- .86	9.10
1.2b	- 11.37	- .39	9.34
1.3b	- 6.67	- 2.44	7.36
2.1b	- 3.97	- 6.39	7.52
2.2b	- 3.52	- 2.03	6.23
3.3b	- 7.59	.31	8.29
Mean	- 7.10	- 1.97	7.97
3.1	- 0.60	- 2.59	4.01
3.2	- 9.76	- .69	7.67
3.3	- 3.56	- 1.42	6.03
3.4	- 8.72	3.57	9.54
3.5	- 4.86	- 7.40	16.08
Mean	- 5.50	1.82	8.67
Grand Mean	- 6.37	- .25	8.29

Table 18.
 Mean Actual Response and Mean Actual Error
 of Estimated Values for Experiment I

Question	Correct Response	Map Type One (45')		Map Type Two (34')		Map Type Three (25')	
		Actual Response	Actual Error	Actual Response	Actual Error	Actual Response	Actual Error
1.1b	76,500	81,934	- 5,434	75,083	1417	73,223	3,277
1.2b	52,500	56,340	- 3,840	51,858	915	49,304	3,196
1.3b	48,000	52,113	- 4,113	46,908	1092	45,005	2,995
2.1b	17,000	17,779	- 779	17,250	250	16,341	659
2.2b	20,500	22,394	- 1,894	20,881	381	19,036	1,464
3.3b	23,000	24,471	- 1,471	23,350	350	20,841	2,159
3.1	20,000	28,257	- 2,257	25,417	583	24,936	1,064
3.2	17,000	17,990	- 990	16,908	92	16,336	664
3.3	76,500	80,141	- 3,642	75,583	917	71,809	4,691
3.4	35,500	36,486	- 986	35,758	258	34,882	618
3.5	52,000	55,698	- 3,198	49,792	2708	47,155	5,354

Table 19.
Mean Actual Response and Mean Actual Error
of Estimated Values for Experiment 2

Question	Correct Response	Map Type One (45')		Map Type Two (34')		Map Type Three (25')	
		Actual Response	Actual Error	Actual Response	Actual Error	Actual Response	Actual Error
1.1b	60,000	64,755	- 4,755	59,267	733	58,536	3,465
2.1.2b	50,500	54,303	- 3,803	50,200	300	48,429	2,071
2.1.3b	43,500	57,096	- 3,596	43,102	398	40,607	2,893 ⁴
2.2.1b	11,000	11,337	- 337	11,158	- 158	10,429	571
2.2.2b	15,000	15,923	- 923	14,866	134	14,018	982
2.3.3b	17,000	17,704	- 704	16,746	254	16,652	348
2.3.1	25,000	27,019	- 2,019	25,229	- 229	23,073	1,927
2.3.2	22,000	22,189	- 189	21,805	195	21,664	336
2.3.3	35,500	38,698	- 3,198	35,508	- 68	31,991	3,509
2.3.4	50,500	53,907	- 3,407	50,661	- 161	47,891	2,609
2.3.5	43,500	47,548	- 4,049	44,534	- 1,034	40,591	2,909

Table 20.
Mean Actual Response and Mean Actual Error
of Estimated Values for Experiment 3

Question	Correct Response	Map Type One (45')		Map Type Two (34')		Map Type Three (25')	
		Actual Response	Actual Error	Actual Response	Actual Error	Actual Response	Actual Error
3.1.1b	58,500	64,029	- 5,529	59,000	- 500	53,175	5,325
3.1.2b	45,500	50,673	- 5,173	45,675	- 175	41,249	4,251
3.1.3b	39,500	42,135	- 2,635	40,462	- 963	36,591	2,909
3.2.1b	15,000	15,596	- 596	15,958	- 958	13,871	1,129
3.2.2b	17,500	18,115	- 615	17,855	- 355	16,409	1,091
3.3.3b	19,500	20,981	- 1,481	19,440	- 60	17,884	1,616
3.3.1	34,000	34,204	- 204	34,879	- 879	32,636	1,364
3.3.2	25,000	27,439	- 2,439	25,172	- 172	23,082	1,918
3.3.3	17,500	18,122	- 623	17,251	- 249	16,445	1,055
3.3.4	58,500	63,602	- 5,104	56,414	- 2,086	52,918	5,582
3.3.5	19,500	20,448	- 948	18,058	- 1,442	16,364	3,136

CHAPTER 6

CONCLUSION

Numerous conclusions follow from results. Most of the conclusions were derived from the empirical analysis of test questions from Experiments 1 to 3 and "Questions About Yourself" sections of the schedule. Some of the conclusions were substantiated from the handling of information that was gathered in questionnaires.

1. Viewing Angle and Bar Size

It was determined that of the three viewing angles tested (45° , 34° and 25°), an angle of 34° for viewing the perspective bar symbolism appeared to promote more accurate responses. Responses by those subjects viewing the perspective bar symbolism at 34° were on the average less than 1 per cent from the real value, as compared to significantly higher error percentages by the other subjects for other angles of presentation. Overestimation always occurred with the 25° viewing angle, whereas underestimation always occurred with the 45° viewing angle. In terms of error, subjects viewing the

perspective bar symbolism at 45° were on the average underestimating bar heights by 5 to 7 per cent and those at 25° were on the average overestimating bar heights by 5 to 8 per cent (see Figure 15). This conclusion is consistent with that reported by Jenks and Crawford (1967) and with several other studies cited previously (Jenks and Caspall, 1976; Worth, 1978; Worth and Board, 1978) related to perspective surfaces. However, when the bars were viewed as relative to each other, they appeared to be judged independent of viewing angle. Results indicated that respondents were able to choose the highest and lowest bars quite successfully. It was considerably more difficult to judge the relative size of bars in between the highest and lowest bars. It would seem that two different and concurrent viewing processes were at work while the respondents were looking at the bars - one attempting to estimate the value of the bars and the other trying to rank the size of the bars in some order.

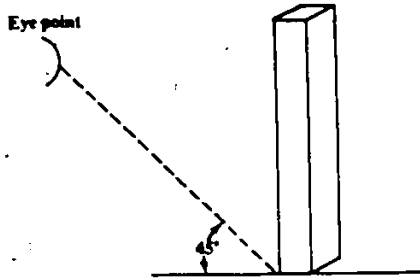
Results of this study also tend to refute the notion that three-dimensional bars in perspective when viewed in the distance tend to be underestimated and that bars in the forefront tend to be overestimated. This conclusion is based on the observation that the variance of the actual error among questions of the

same map type were insignificant. Those anomalies that did occur, after verification, were found to be random.

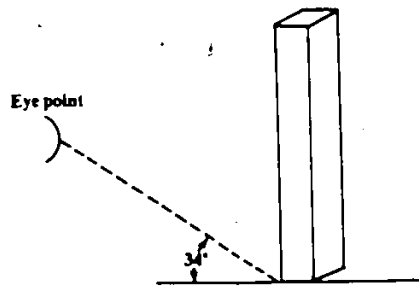
Finally, a combination content analysis of narrative type questionnaire responses to the "Questions About Yourself" section, and an empirical analysis of results from Experiments 1 to 3, indicated that estimation of bar sizes in perspective for both map and non-map environments, tended to be closely linked to where the legend is anchored on the map and how the class intervals were derived. It was concluded that responses to Experiments 1 to 3 were highly influenced by the real numbers on the legend. In many instances, responses were either taken directly from a value on the legend or based on a rough estimation of the closest legend value. For example, when the real value was 42,000 and the closest legend value was 50,000, the latter would be reported.

2. Map Environment

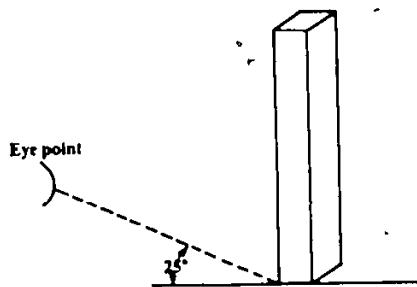
No significant difference was determined among responses to all three map environments considered in Experiments 1 to 3. It was thought that accuracy of responses would be affected by the need to have a map to anchor the three-dimensional bars. Although some respondents tended to react



At 45° respondents underestimated bar heights
5-7 per cent.



At 34° respondents estimated bar heights
usually within 1 per cent of the correct
response.



At 25° respondent overestimated bar heights
5-8 per cent

Figure 15. The effect of viewing angle on how accurately respondents judged the heights of three-dimensional bars

differently to Experiments 1 and 2 compared to Experiment 3, based on their "map interest" (suggesting an indifference to the maps portrayed in Experiments 1 and 2; see F-test probabilities in Tables 11 to 13), in general there was a non-significant variance among responses to Experiments 1 to 3.

3. Mail Surveys

This study confirmed the usefulness of the mail survey method for testing of map users where time is not a factor and soliciting feedback on a cartographic product. Many past studies have been carried out in clinical types of environments, with little regard for sampling and consideration of the map user. The mail survey is an established and valuable measurement tool, that could be used with confidence in future mail surveys of map users.

4. Future Study

The fields of symbolism and perception are extremely complex and have been studied in a detailed way only by psychologists. Unfortunately, the work of psychologists has been clinical in nature and has dealt little with researching real life processes, that a map reader undergoes to abstract or to conceptualize

and to portray (Chapanis, 1967). Psychophysical research into cartographic symbolism by cartographers has been fragmented (Monmonier, 1982) and contributed little to providing a study framework and to finalizing an all encompassing model, for cartographic communication such as proposed by Ratajski (1972, 1973) and Morrison (1976). There might now be renewed incentive for cartographers to find or evolve methods from "human factors" research for improving the communication of information through maps, and be combined with the interest shown by cartographers and geographers in teaching map skills (Boardman, 1983).

The recent human factors research for the design and evaluation of aviation maps by Hopkin and Taylor (1979) might be a breakthrough in that a more comprehensive framework to study the effectiveness of maps is now available. The study of human factors as applied to a discipline has progressed to a stage where definitive handbooks (McCormick, 1970; Van Cott and Kinkade, 1972) are now available that present certain standards and findings from a large number of experiments. Another important area that should be followed closely is that of vision research in artificial intelligence (Marr, 1979; Caldwell, 1982; Foley and Van Dam, 1982) and its application to carto-

graphic symbology. This research may be classified into the fields of signal processing, classification, and understanding. Scene analysis which is a sub-field of understanding has only been addressed by a handful of researchers interested specifically in cartographic applications (Mackworth, 1977, 1978; Rosenfeld, 1978; Lavin, 1979; Horn and Bachman, 1979). Mackworth (1978) has proposed a vision research strategy that combines research on natural sciences that are approached through laws of optics, and work on clear man-made images that possess well-defined conventions. However, the future of vision research and its usefulness to cartography rests in the ability of cartographers to develop models and adopt conventions such as those emphasized by Wood (1972).

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Appendix 1.

Physical Record Layout of Questionnaire Data

Appendix 2:

Detailed Record Layout for Data from Experiments 1 to 3

Record Number	Column Number	Variable Name	Code	
1	1-4	Identification Number	0001-0350	
	5	Record Number	1	
	6	Mailing Wave	1 = first wave 2 = second wave	
	7-8	Map Type	01 = map one 02 = map two 03 = map three	
	9-10	Week Returned Experiment 3	01-15	
	11-12	Question 1.1a	01-15	
	13-17	Question 1.1b	01000-95000	
	18-19	Question 1.2a	01-15	
	20-24	Question 1.2b	01000-95000	
	25-26	Question 1.3a	01-15	
	27-31	Question 1.3b	01000-95000	
	32-33	Question 2.1a	01-15	
	34-38	Question 2.1b	01000-95000	
	39-40	Question 2.2a	01-15	
	41-45	Question 2.2b	01000-95000	
	46-47	Question 2.3a	01-15	
	48-52	Question 2.3b	01000-95000	
	53-57	Question 3.1	01000-95000	
	58-62	Question 3.2	01000-95000	
	63-67	Question 3.3	01000-95000	
	68-72	Question 3.4	01000-95000	
	73-77	Question 3.5	01000-95000	
	2		Experiment 2	
		1-4	Identification Number	0901-0350
		5	Record Number	2
		6-7	Question 1.1a	01-15
		8-12	Question 1.1b	01000-95000
13-14		Question 1.2a	01-15	
15-19		Question 1.2b	01000-95000	
20-21	Question 1.3a	01-15		

22-26	Question 1.3b	01000-95000
27-28	Question 2.1a	01-15
29-33	Question 2.1b	01000-95000
34-35	Question 2.2a	01-15
36-40	Question 2.2b	01000-95000
41-42	Question 2.3a	01-15
43-47	Question 2.3b	01000-95000
48-52	Question 3.1	01000-95000
53-57	Question 3.2	01000-95000
58-62	Question 3.3	01000-95000
63-67	Question 3.4	01000-95000
68-72	Question 3.5	01000-95000

Experiment 3

3	1-4	Identification Number	0001-0350
	5	Record Number	3
	6-7	Question 1.1a	01-15
	8-12	Question 1.1b	01000-95000
	13-14	Question 1.2a	01-15
	15-19	Question 1.2b	01000-95000
	20-21	Question 1.3a	01-15
	22-26	Question 1.3b	01000-95000
	27-28	Question 2.1a	01-15
	29-33	Question 2.1b	01000-95000
	34-35	Question 2.2a	01-15
	36-40	Question 2.2b	01000-95000
	41-42	Question 2.3a	01-15
	43-47	Question 2.3b	01000-95000
	48-52	Question 3.1	01000-95000
	53-57	Question 3.2	01000-95000
	58-62	Question 3.3	01000-95000
	63-67	Question 3.4	01000-95000
	68-72	Question 3.5	01000-95000

Appendix 3.

Detailed Record Layout for Data from "Questions About Yourself"

Record Number	Column Number	Variable Name	Code
4	1-4	Identification Number	0001-0350
	5	Record Number	4
	6	Question 1	1 = less than 20 2 = 20-29 3 = 30-39 4 = 40-49 5 = 50-59 6 = 60 > 9 = missing
	7	Question 2	1 = male 2 = female 9 = missing
	8	Question 3	1 = yes 2 = no 9 = missing
	9	Question 4	1 = extremely interesting 2 = quite interested 3 = slightly interested 4 = neither interested or uninterested 5 = quite interested 6 = extremely interested 9 = missing
	10	Question 5	1 = extremely often 2 = quite often 3 = often 4 = almost never 5 = never 9 = missing
	11-12	Question 6	1 = professor 2 = systems programmer/ analyst 3 = teaching assistant 4 = statistician 5 = librarian

		6 = engineer
		7 = drafts/person
		8 = research scientist
		9 = consultant
		10 = student
		11 = other
		99 = missing
13	Question 7	1 = industry
		2 = private
		3 = university or college
		4 = military
		5 = research institution
		6 = government
		7 = marketing or sales
		8 = other
		9 = missing
14	Question 8	1 = geography
		2 = psychology
		3 = mathematics
		4 = engineering
		5 = geology
		6 = planning
		7 = other
		9 = missing
15-16	Question 9a	00-25,99
17-18	Question 9b	00-25,99
19-20	Question 9c	00-25,99
21-22	Question 9d	00-25,99
23-24	Question 9e	00-25,99
25	Question 10	1 = unrelated whole
		2 = unified whole
		3 = neither
		9 = missing
26	Question 11	1 = yes
		2 = no
		9 = missing
28-33	Question 12a-f	1 = blue
		2 = red

- 3 = yellow
4 = brown
5 = green
6 = orange
7 = violet
8 = other
9 = missing
- 34 Question 13
1 = not enough text
2 = too much text
3 = suitable amount of text
9 = missing
- 35 Question 14
1 = yes
2 = no
9 = missing
- 36 Question 15
1 = yes
2 = no
9 = missing
- 37 Question 16
1 = yes
2 = no
9 = missing
- 38 Question 17
1 = yes
9 = missing
- 39 Name
1 = yes
9 = missing

7

Appendix 4.

Correct Responses for Experiments 1 to 3

Experiment Question Number	1 Correct Response	Experiment Question Number	2 Correct Response	Experiment Question Number	3 Correct Response
1.1a	3	1.1a	9	1.1a	4
1.1b	76,500	1.1b	60,000	1.1b	58,500
1.2a	5	1.2a	4	1.2a	7
1.2b	52,500	1.2b	50,500	1.2b	45,500
1.3a	14	2.1.3a	5	3.1.3a	9
1.3b	48,000	1.3b	43,500	1.3b	39,500
2.1a	2	2.1a	11	2.1a	14
2.1b	17,000	2.1b	11,000	2.1b	15,000
2.2a	12	2.2a	13	2.2a	3
2.2b	20,500	2.2b	15,000	2.2b	17,500
2.3a	13	2.3a	15	2.3a	5
2.3b	23,000	2.3b	17,000	2.3b	19,500
3.1	26,000	3.1	25,000	3.1	34,000
3.2	17,000	3.2	22,000	3.2	25,000
3.3	76,500	3.3	35,500	3.3	17,500
3.4	35,500	3.4	50,500	3.4	58,500
3.5	52,000	3.5	43,500	3.5	19,500

Appendix 5.

Summary of Responses to "Questions About Yourself"

Most of the questions in this section of the questionnaire can be answered with a check mark in a box beside the answer which suits you best. Occasionally you will be asked to write an answer or some numbers. Please follow all directions carefully. Feel free to add comments wherever you wish.

1. What is your age? (n = 169)

less than 20	-	20 - 29	24.9%
30 - 39	30.8%	40 - 49	20.7%
50 - 59	15.4%	60 and over	8.6%

2. Are you: (n = 169)

male 81.8% or female 18.2%

3. Did you use corrective lenses while completing the first part of this questionnaire i.e. eye glasses or contact lenses? (n = 169)

yes 55.8% no 44.1%

4. How interested are you in maps? (check one) (n = 170)

extremely interested 64.7% quite interested 33.5%

slightly interested 0.6% neither interested
or uninterested

quite uninterested 1.2% extremely uninterested

5. How often do you utilize any kind of maps? (check one)
(n = 168)



extremely often 61.3% quite often 19.6%
 often 16.1% almost never
 never

6. Check the title which most closely describes your position:
 (n = 167)

professor 12.9% systems programmer/analyst 0.6%
 teaching assistant 3.0% statistician 0.6%
 librarian 6.6% engineer 3.6%
 draftsman/woman 26.3% research scientist 4.2%
 consultant 1.8% student 5.4%
 other (please specify) 34.7%

7. Please check the type of organization or employer with
 which you are associated. (n = 164)

industry 9.1% private laboratory 0.6%
 university or college 32.3% military 2.4%
 research institution 1.2% government 47.0%
 marketing or sales 1.2% other (please specify) 6.1%

8. If you are a student, please specify your academic major
 i.e., mathematics, psychology, geography: (n = 18)

geography	83.3%	engineering	5.6%
planning	5.6%	other	5.6%

9. How many courses, including those you are now taking, have you taken in:

13.2%	geography	(n = 86)
5.0%	cartography or map reading	(n = 106)
4.3%	mechanical drawing	(n = 56)
4.4%	art or design	(n = 40)
3.0%	photography or graphics arts	(n = 34)

For questions 10 to 17 please consult the attached colour map of Canada. Please keep it when you are finished, with our compliments.

10. With regard to the initial overall visual impact of the map, which of the following best sums up your reaction? (n = 168)

the map is an assembly of unrelated parts 3.6%

the map appears as a unified whole 73.8%

neither of the above 3.6%

11. The map represents population information through the use of vertical bar symbolism. Do you find the symbolism unclear or unsuitable? (n = 168)

yes 33.9% no 66.1%

12. Are there any colours on the map that you feel are inappropriate? (n = 167)

yes 38.3% no 61.7%

13. Information on the map is presented in two forms, i.e. graphic and textual. With respect to textual information, i.e. map names, legend explanations and text, do you find that the map contains: (n = 168)

not enough textual material? 24.4%

too much textual material? 3.0%

a suitable amount of textual material? 3.0%

14. Is there any additional pertinent information which you feel should have been included on the map? (n = 162)

yes 37.7% no 61.7%

15. Is there information on the map which could have been left off? (n = 168)

yes 17.3% no 82.7%

16. Did you find any unclear or misleading textual or graphic statements on the map? (n = 166)

yes 38.0% no 61.4%

17. Any additional comments and/or criticism you might like to make on any aspect of the map not covered by the questionnaire are welcomed and appreciated. (n = 82)

Please return the questionnaire as soon as you can in the enclosed prepaid envelope. Thank you again!

Appendix 6.

Summary of Previous Studies

Author	Date	Discipline	Research
Eells	1926	Statistics	graphical forms in statistics
Croxton	1927	Statistics	graphical forms in statistics
Croxton and Stryker	1927	Statistics	graphical forms in statistics
Croxton and Stein	1932	Statistics	graphical forms in statistics
Huhn	1927	Statistics	graphical forms in statistics
Washburne	1927	Statistics	graphical forms in statistics
Beniger and Robyn	1978	Statistics	graphical presentation of statistics
Feinberg and Franklin	1975	Statistics	graphical presentation of statistics
Mackay	1953,1954	Cartography	optimal viewing of cubes
Williams	1956	Cartography	use of symbology
Flannery	1956,1971	Cartography	perception of circle sizes
Robinson, et al.	1978	Cartography	method for scaling proportional circles
Clarke	1959	Cartography	visual evaluation of proportional circles
Ekman and Junge	1901	Psychology	judgements of subjective length, area, and volume
Ekman, et al.	1961	Psychology	projected volume of geometric forms
Meilhoefer	1908	Cartography	use of circle for displaying quantitative data
Crawford	1973	Cartography	perception of graduated square symbols
Jenks	1975	Cartography	visual comparison of maps using proportional circles
Cox	1976	Cartography	effective use of legend value scaling
Cerny and Wilson	1976	Cartography	map orientation on geographic orientation
Shepard and Metzler	1971	Psychology	identification of rotated three-dimensional objects
Huggins and	1974	Psychology	use of iconic types of

Entwisle Lodding	1983	Computing Science	symbology use of iconic types of symbology
Berry	1960,1961	Cartography	use of iconic types of symbology
Jenks and Crawford	1967	Cartography	viewing angle of three- dimensional maps
Worth	1978	Cartography	viewing angle of three- dimensional maps
Jenks and Caspall	1967	Cartography	vertical exaggeration of three-dimensional maps
Lo	1973	Planning	vertical exaggeration and viewing point of three-dimensional maps
Dickinson	1973	Cartography	effect of training and experience on map reading
Olson	1975	Cartography	effect of training and experience on map reading
Dobson	1977,1979	Cartography	behaviour of map readers
Hopkih and Taylor	1979	Psychology	human factors in aviation maps

Appendix 7.

Sample of "Potential Map User Survey" Schedule

UNIVERSITÉ D'OTTAWA



UNIVERSITY OF OTTAWA

FACULTÉ DES ARTS

OTTAWA ONTARIO
CANADA K1N 6N5

FACULTY OF ARTS

GÉOGRAPHIE

GEOGRAPHY

August 1, 1979

Dear Respondent,

I am asking you for a few moments of your valuable time to complete this questionnaire. The purpose of this survey is to provide data which may be used to increase the understanding of how accurately potential map users interpret a particular thematic map symbol and to identify the unique characteristics of this symbol. Such an understanding is essential if we are to improve the reliability of the map message.

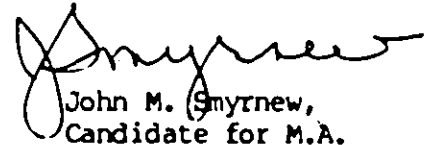
Your candid and thoughtful answers are of considerable importance to us, as they will give us an insight into the situation of many other potential map users like yourself. Your replies will be used only for statistical purposes in combination with the answers of others.

When this survey is completed, there will be a short report available, which you may receive on request. If you wish to receive a complimentary copy please fill in your name and address in the space provided at the end of the questionnaire.

Please return the questionnaire as soon as you can in the enclosed prepaid envelope.

Thank you for your cooperation.

Yours truly,


John M. Smyrnew,
Candidate for M.A.

Survey endorsed by:

Dr. Michel Phipps,
Chairman, Department of Geography.

Mr. David H. Douglas,
Assistant Professor, Department of Geography.

Mr. Pierre Hubert,
Chief, Spatial Systems, Statistics Canada.

Encl.

UNIVERSITÉ D'OTTAWA



OTTAWA ONTARIO
CANADA K1N 6N5

UNIVERSITY OF OTTAWA

FACULTÉ DES ARTS

GÉOGRAPHIE

FACULTY OF ARTS

GEOGRAPHY

August 1, 1979

TO WHOM IT MAY CONCERN:

This is to certify that the questionnaire attached herewith is a component part of a research project under the supervision of the Department of Geography of the University of Ottawa. Mr. John Smyrnew is officially entitled to administrate the questionnaire and we would be very thankful if you would give this questionnaire a part of your time.

A handwritten signature in black ink, appearing to read 'M. Phipps'.

M. Phipps,
Chairman.

MP:dg

UNIVERSITÉ D'OTTAWA



UNIVERSITY OF OTTAWA

FACULTÉ DES ARTS

FACULTY OF ARTS

GÉOGRAPHIE

GEOGRAPHY

SURVEY OF POTENTIAL
MAP USERS

PURPOSE

The purposes of this questionnaire are:

- (a) to determine how accurately potential map users interpret a particular thematic map symbol,
- (b) to identify the characteristics of a potential map user population,
- (c) to gauge the overall acceptance of a particular widely distributed thematic map.

We feel that with your collaboration we can achieve our goal of producing maps that can be more easily and accurately used by different consumers. We hope in this way to overcome the problem of map user education by creating a new and better product.

INSTRUCTIONS

You are asked to consult the maps and answer questions in this questionnaire in the order they are presented (maps immediately follow questions on next page). Once you have completed a section, please do not return to it.

Keep in mind that this is not a test for right and wrong answers, but only a questionnaire to determine how accurately people view a certain type of thematic map symbolism. Please do not use instruments to measure the symbol.

The test is not long. Please take your time and complete each part as well as you can.

Finally, please fill out the QUESTIONS ABOUT YOURSELF section.

Question 1- Please indicate in the spaces provided the three vertical bars (identified by numbers) which you think have the three highest values. Then indicate what you think those values are by placing the appropriate number in the space provided. Please do not use more than one number in each space and do not indicate tie results.

1. (a) Which vertical bar has the highest value? _____
(b) What value does it have? _____
2. (a) Which vertical bar has the second highest value? _____
(b) What value does it have? _____
3. (a) Which vertical bar has the third highest value? _____
(b) What value does it have? _____

Question 2- Indicate in the spaces provided the three vertical bars which you think have the three lowest values. Again use one number and do not show tie results.

1. (a) Which vertical bar has the lowest value? _____
(b) What value does it have? _____
2. (a) Which vertical bar has the second lowest value? _____
(b) What value does it have? _____
3. (a) Which vertical bar has the third lowest value? _____
(b) What value does it have? _____

Question 3- What are the values of the following vertical bars? These vertical bars may or may not have been used above.

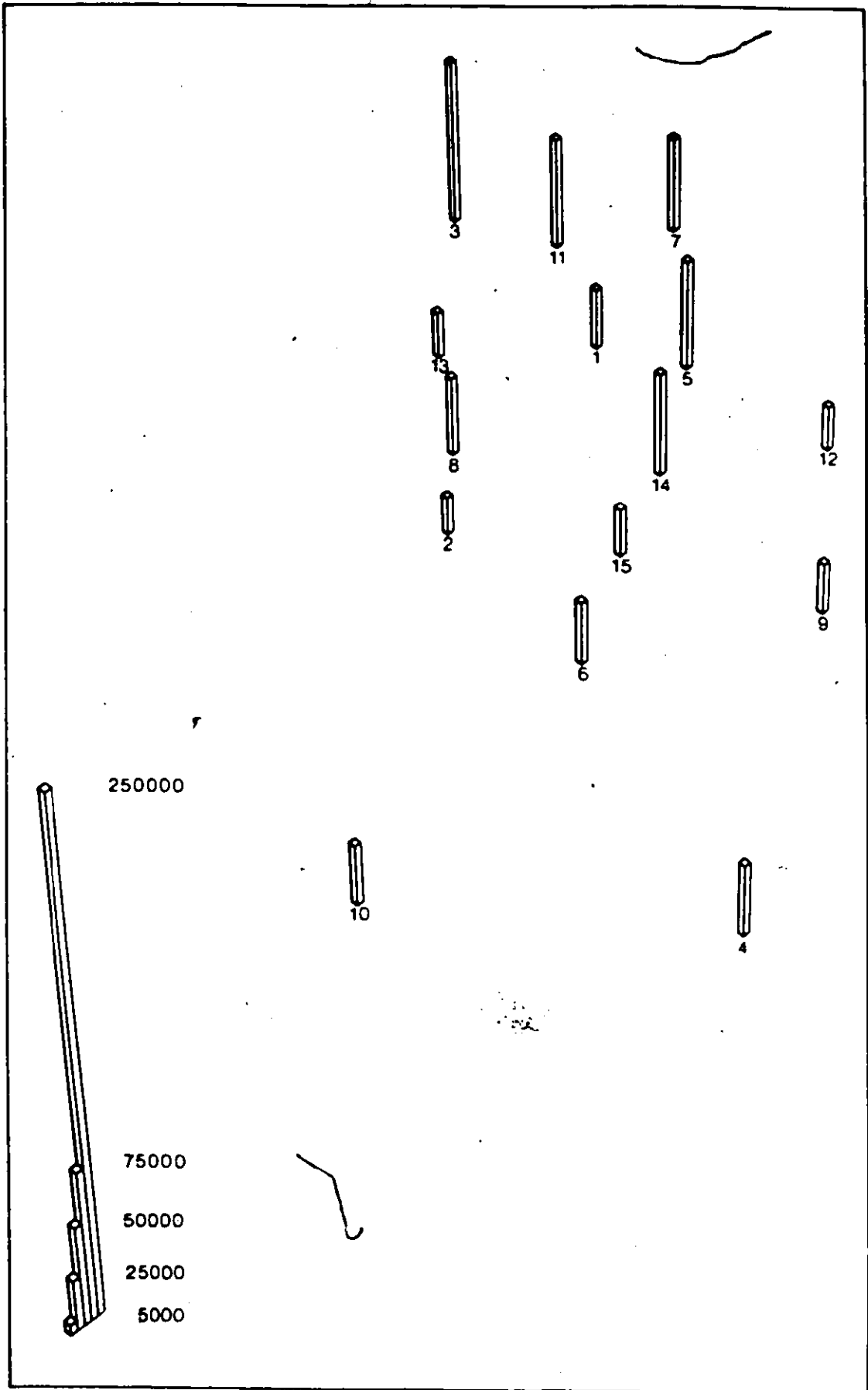
Bar 1 _____.

Bar 2 _____.

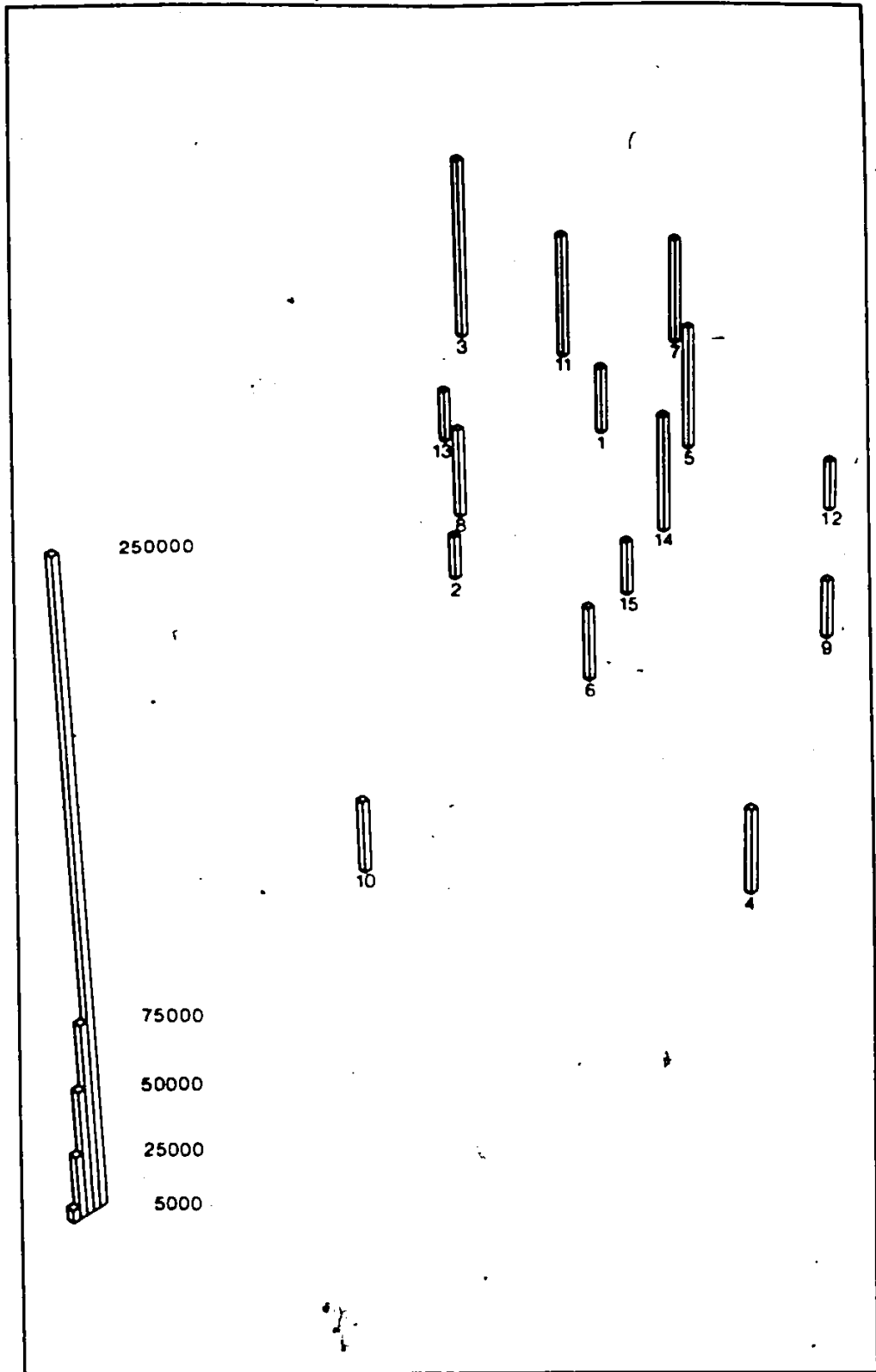
Bar 3 _____.

Bar 4 _____.

Bar 5 _____.



Map Type One (45°)



Map Type Two (34°)

Question 1- Please indicate in the spaces provided the three districts (identified by numbers) which you think have the three highest values. Then indicate what you think those values are by placing the appropriate number in the space provided. Please do not use more than one number in each space and do not indicate tie results.

1. (a) Which district has the highest value? _____
(b) What value does it have? _____
2. (a) Which district has the second highest value? _____
(b) What value does it have? _____
3. (a) Which district has the third highest value? _____
(b) What value does it have? _____

Question 2- Indicate in the spaces provided the three districts which you think have the three lowest values. Again use one number and do not show tie results.

1. (a) Which district has the lowest value? _____
(b) What value does it have? _____
2. (a) Which district has the second lowest value? _____
(b) What value does it have? _____
3. (a) Which district has the third lowest value? _____
(b) What value does it have? _____

Question 3- What are the values of the following districts? These districts may or may not have been used above.

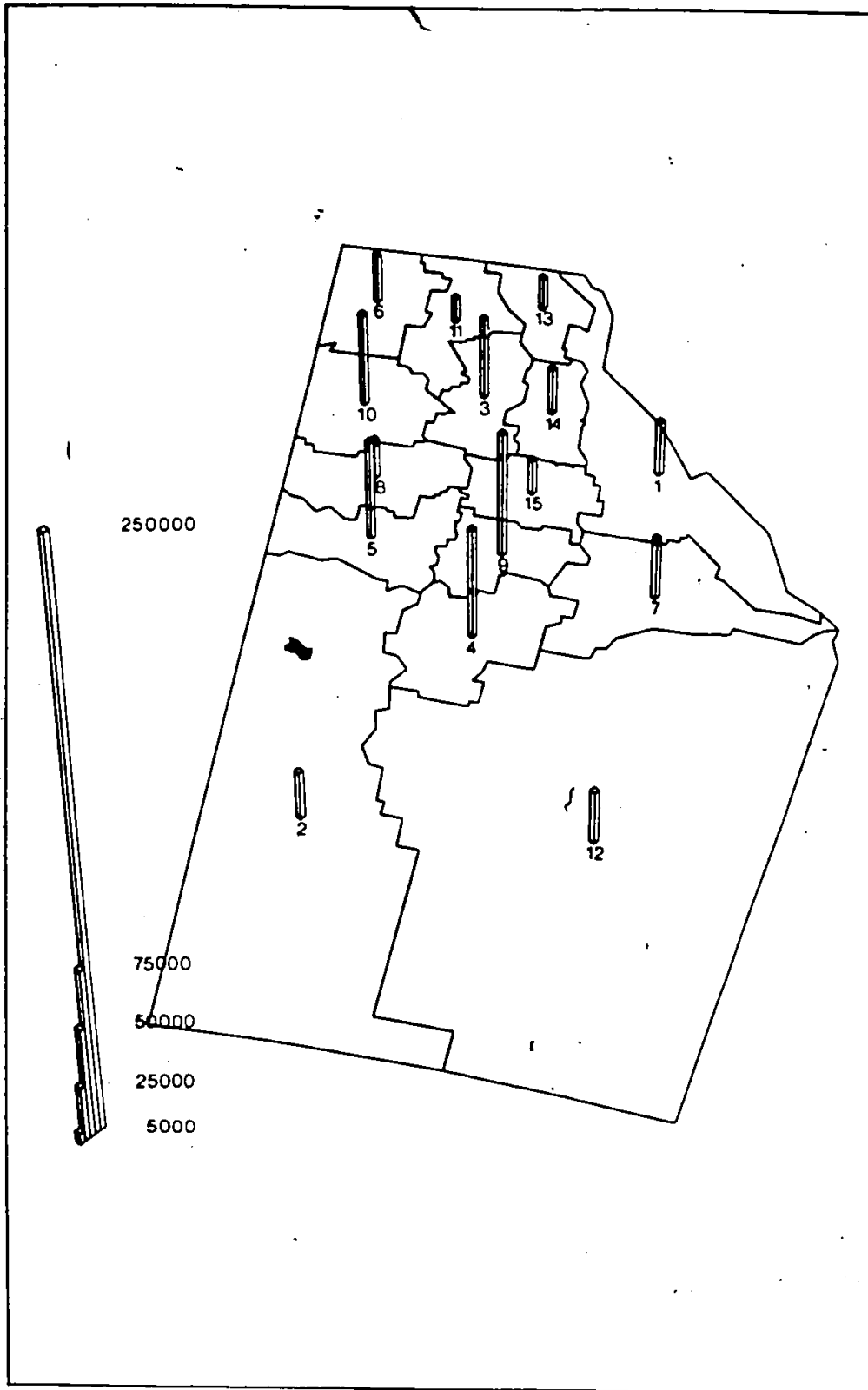
District 1 _____.

District 2 _____.

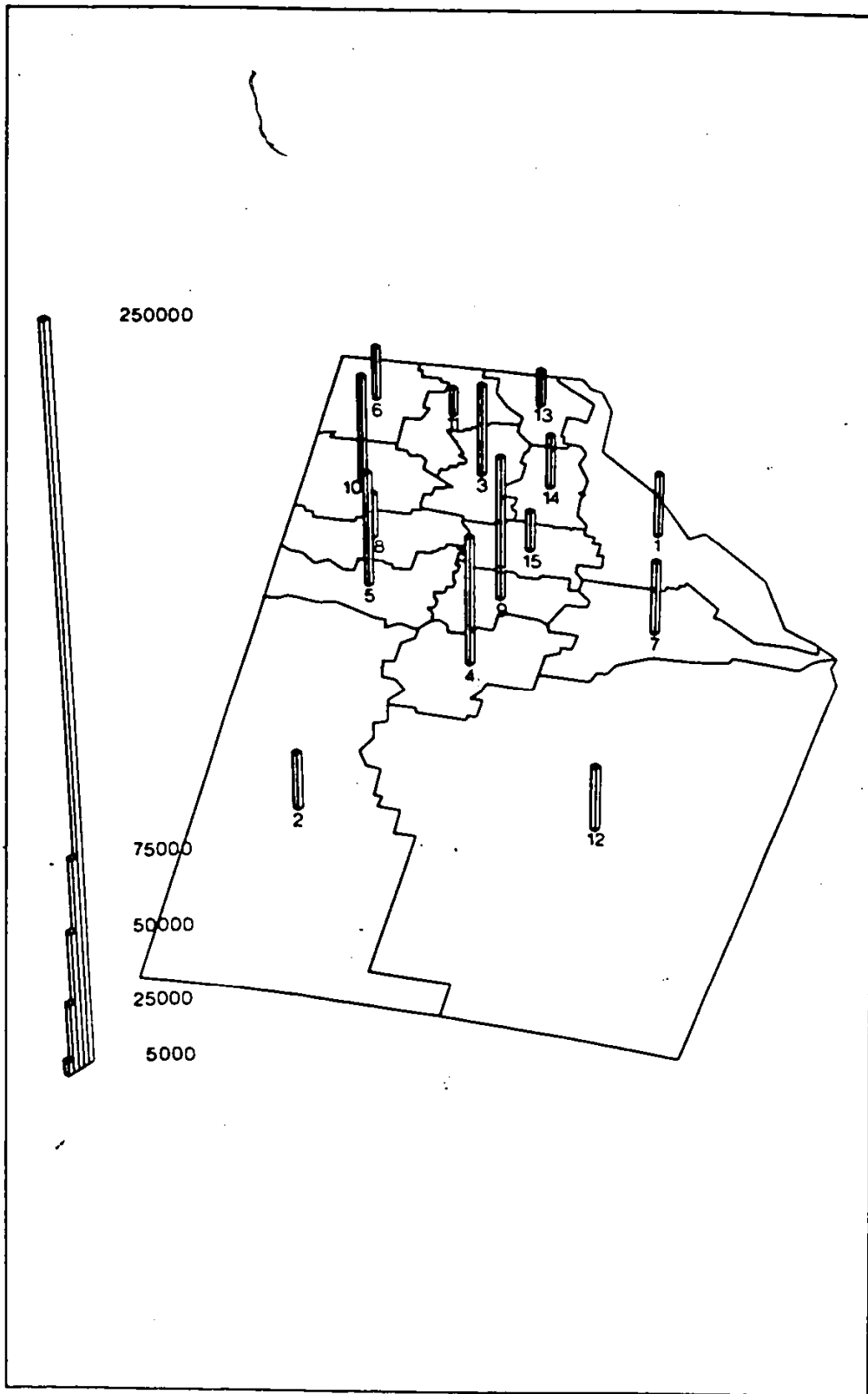
District 3 _____.

District 4 _____.

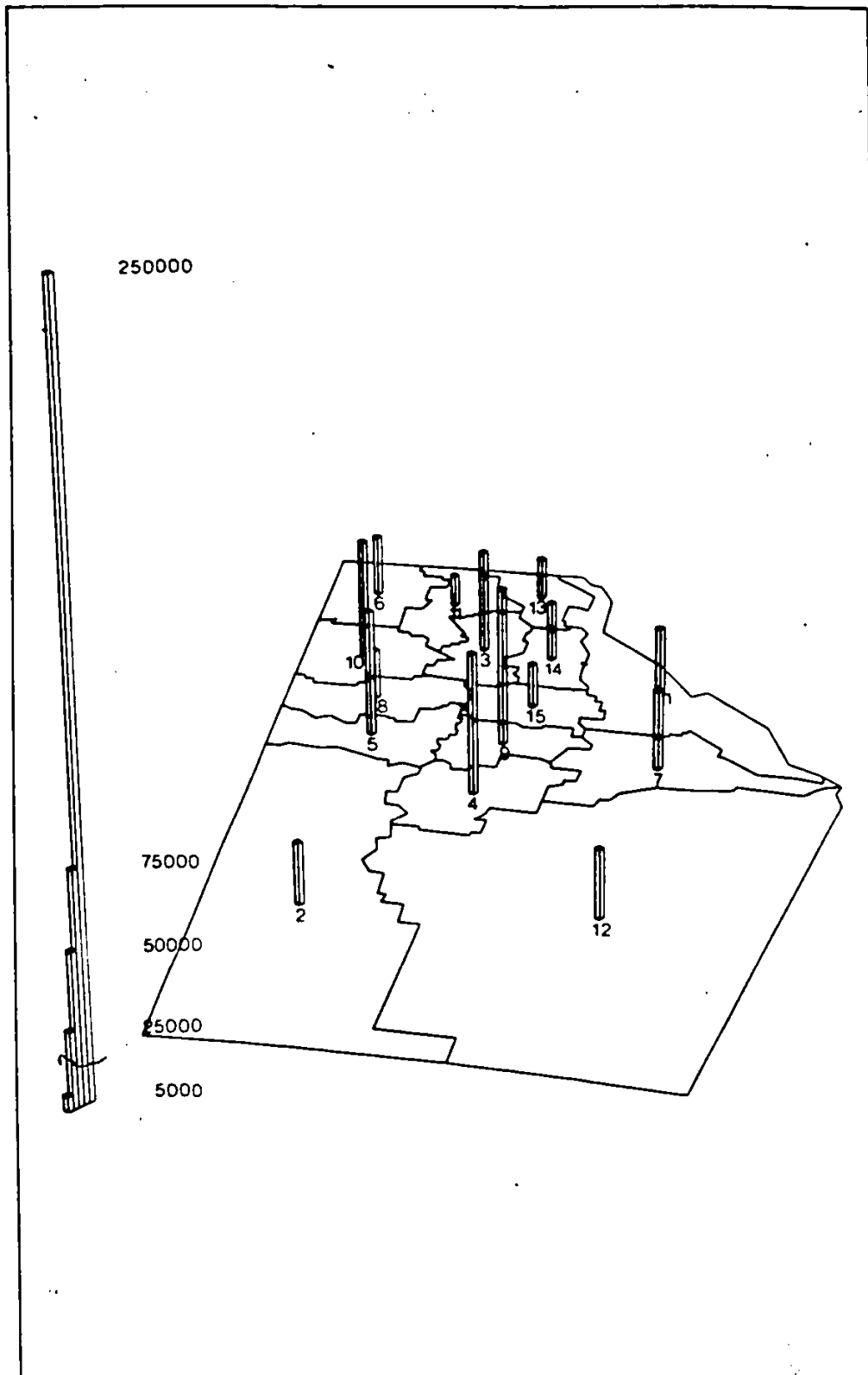
District 5 _____.



Map Type One (45°)



Map Type Two (34°)



Map Type Three (25°)

Question 1- Please indicate in the spaces provided the three districts (identified by numbers) which you think have the three highest values. Then indicate what you think those values are by placing the appropriate number in the space provided. Please do not use more than one number in each space and do not indicate tie results.

1. (a) Which district has the highest value? _____
(b) What value does it have? _____
2. (a) Which district has the second highest value? _____
(b) What value does it have? _____
3. (a) Which district has the third highest value? _____
(b) What value does it have? _____

Question 2- Indicate in the spaces provided the three districts which you think have the three lowest values. Again use one number and do not show tie results.

1. (a) Which district has the lowest value? _____
(b) What value does it have? _____
2. (a) Which district has the second lowest value? _____
(b) What value does it have? _____
3. (a) Which district has the third lowest value? _____
(b) What value does it have? _____

Question 3- What are the values of the following districts? These districts may or may not have been used above.

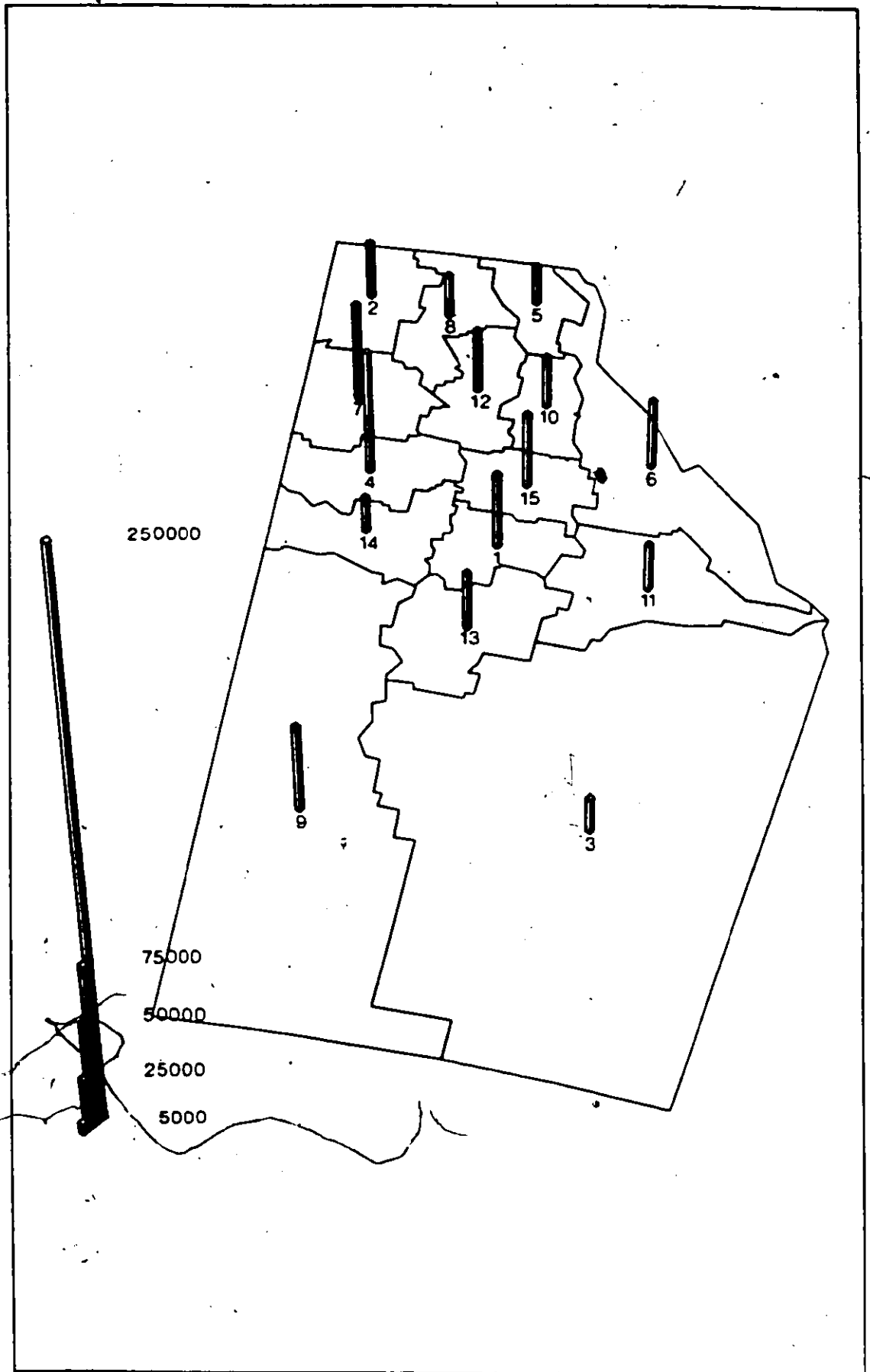
District 1 _____.

District 2 _____.

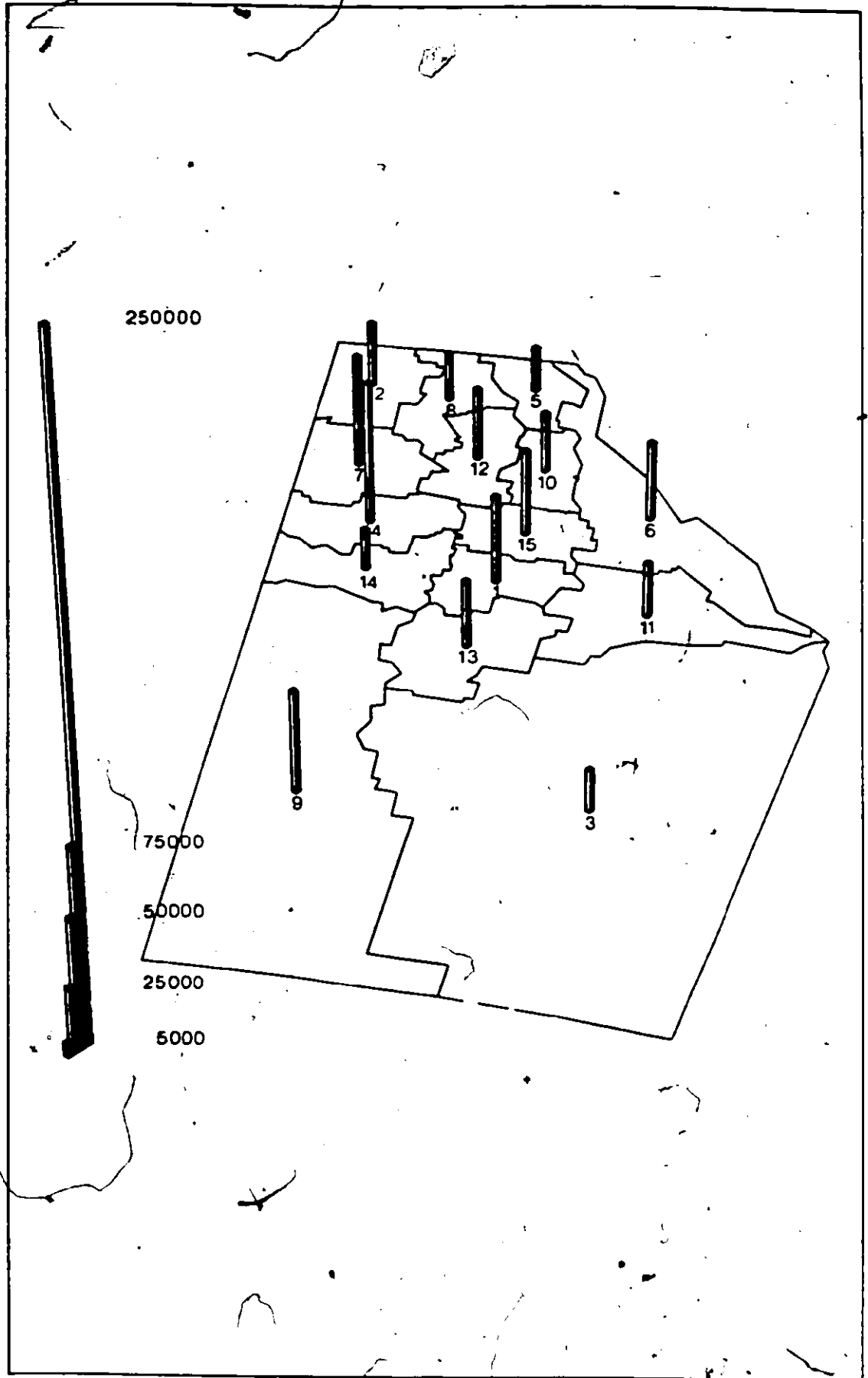
District 3 _____.

District 4 _____.

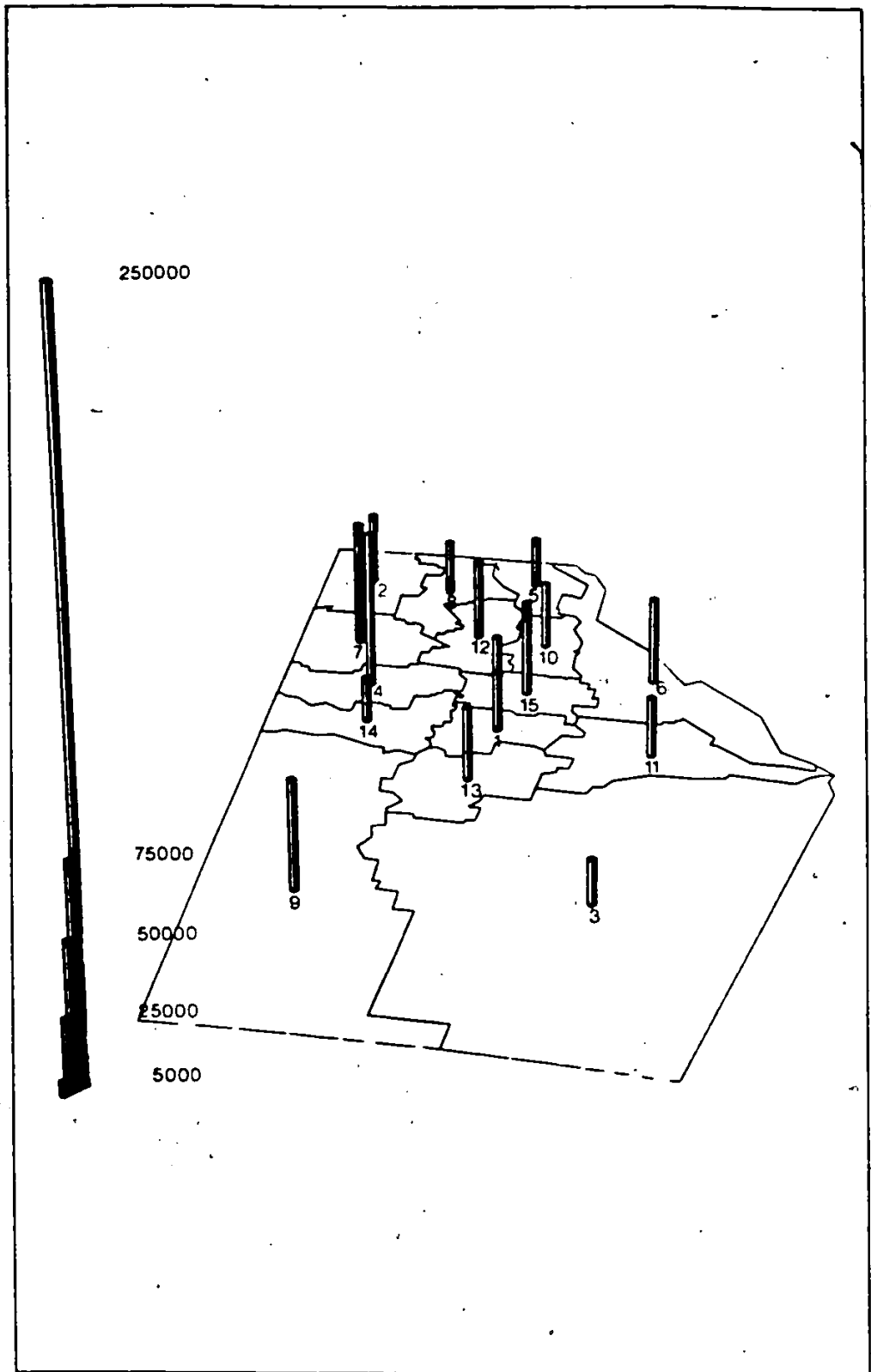
District 5 _____.



Map Type One (45°)



Map Type Two (34°)



Map Type Three (25°)

QUESTIONS ABOUT YOURSELF

Most of the questions in this section of the questionnaire can be answered with a check mark in a box [] beside the answer which suits you best. Occasionally you will be asked to write an answer or some numbers. Please follow all directions carefully. Feel free to add comments wherever you wish.

1. What is your age?

less than 20 []1

20 - 29 []2

30 - 39 []3

40 - 49 []4

50 - 59 []5

60 and over []6

2. Are you:

male []

or

female []

3. Did you use corrective lenses while completing the first part of this questionnaire i.e. eye glasses or contact lenses?

yes []

no []

4. How interested are you in maps? (check one)

extremely interested []1

quite interested []2

slightly interested []3

neither interested []4
or uninterested

quite uninterested []5

extremely uninterested []6

5. How often do you utilize any kind of maps? (check one)

extremely often []1

quite often []2

often []3

almost never []4

never []5

6. Check the title which most closely describes your position:

- | | |
|------------------------------|-------------------------------------|
| professor []1 | systems programmer/ []2
analyst |
| teaching assistant []3 | statistician []4 |
| librarian []5 | engineer []6 |
| draftsman/woman []7 | research scientist []8 |
| consultant []9 | student []10 |
| other (please specify) []11 | |
-

7. Please check the type of organization or employer with which you are associated.

- | | |
|----------------------------|-----------------------------|
| industry []1 | private laboratory []2 |
| university or college []3 | military []4 |
| research institution []5 | government []6 |
| marketing or sales []7 | other (please specify) []8 |
-

8. If you are a student, please specify your academic major i.e., mathematics, psychology, geography:

2

9. How many courses, including those you are now taking, have you taken in:

- _____ geography
- _____ cartography or map reading
- _____ mechanical drawing
- _____ art or design
- _____ photography or graphic arts

For questions 10 to 17 please consult the attached colour map of Canada. Please keep it when you are finished, with our compliments.

10. With regard to the initial overall visual impact of the map, which of the following best sums up your reaction?

the map is an assembly of unrelated parts []1

the map appears as a unified whole []2

neither of the above []3

If 'neither of the above', please describe your initial reaction to the map.

11. The map represents population information through the use of vertical bar symbolism. Do you find the symbolism unclear or unsuitable?

yes []

no []

If 'yes', please list your choice as an alternative and why?

12. Are there any colours on the map that you feel are inappropriate?

yes []

no []

If 'yes', please list the colours that are inappropriate and indicate colours that would be more suitable.

Inappropriate colours _____

Colours preferred _____

13. Information on the map is presented in two forms, i.e. graphic and textual. With respect to textual information, i.e. map names, legend explanations and text, do you find that the map contains:

not enough textual material? []1

too much textual material? []2

a suitable amount of textual material? []3

Please list specific comments and criticisms you have about this aspect of the map presentation.

14. Is there any additional pertinent information which you feel should have been included on the map?

yes []

no []

If 'yes', would you please specify what information should have been included.

15. Is there any information on the map which could have been left off?

yes []

no []

If 'yes', please specify what could have been left off?

16. Did you find any unclear or misleading textual or graphic statements on the maps?

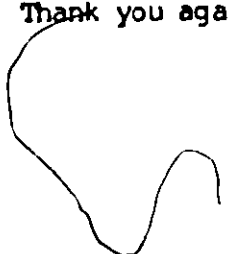
yes []

no []

If 'yes', please specify these.

17. Any additional comments and/or criticisms you might like to make on any aspect of the map not covered by the questionnaire are welcomed and appreciated.

Please return the questionnaire as soon as you can in the enclosed prepaid envelope. Thank you again!



If you wish to receive a complimentary copy of the survey report, please fill in your name, institutional affiliation, and address in the space provided below.

Your name:

Institutional
Affiliation:

Address:

UNIVERSITÉ D'OTTAWA



UNIVERSITY OF OTTAWA

FACULTÉ DES ARTS

GÉOGRAPHIE

FACULTY OF ARTS

GEOGRAPHY

June 1, 1979

Potential Map User Survey,
Department of Geography,
University of Ottawa,
Ottawa, Ontario -
K1N 9Z9
CANADA

Dear Potential Map User,

A few days ago we sent you a questionnaire concerning your use of maps. This is a reminder inviting you to please answer the questionnaire and return it as soon as possible. Your answers are very important because you are part of a small group of potential map users chosen to represent potential map users across North America.

If you have not yet answered won't you please do so today? If you have already returned the questionnaire, we thank you very much for your cooperation.

Yours truly,

A handwritten signature in cursive script, appearing to read "John M. Sayrnew".

John M. Sayrnew,
Candidate for M.A.

Survey endorsed by:

Dr. Michel Phipps,
Chairman, Department of Geography.

Mr. David H. Douglas,
Assistant Professor, Department of Geography.

Mr. Pierre Hubert,
Chief, Spatial Systems, Statistics Canada.

Three handwritten signatures in cursive script, corresponding to the names listed in the endorsement section: Michel Phipps, David H. Douglas, and Pierre Hubert.

7

Draft of statement to be sent to CHRONICLE

POTENTIAL MAP USER SURVEY

A North American wide mail survey to provide data which may be used to increase the understanding of how accurately potential map users interpret a particular thematic map symbol is being carried out through the Department of Geography, at the University of Ottawa, by John M. Smyrnew. We all agree that such an understanding is essential if we are to improve the reliability of the map message. The candid and thoughtful answers of respondents are of considerable importance to us, as they will give us an insight into the situation of many other potential map users. Please watch for the questionnaire. If and when you receive it, please answer and return it at your earliest convenience in the enclosed prepaid envelope. When the survey is completed, there will be a short report available to respondents.

David H. Douglas,
Assistant Professor,
Department of Geography,
University of Ottawa.