Qualitative Symbology:
An Evaluation of the Pictorial Signs of the National Park Service As Cartographic Symbols

by

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QUALITATIVE SYMBOLOGY:
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(ABSTRACT)

This study examines whether the use of pictorial signs as cartographic symbols are aids for map users in the comprehension of intended referent meaning. A history of the development and use of pictorial signs as cartographic symbols is traced from the origins of international highway signage to the Pictorial Sign/Symbol system of the National Park Service. The theoretical basis for examining qualitative symbolism in cartography is outlined as are the methodological evolution of the study and principles of symbol design. The NPS signs are tested in and out of a map environment to determine communication effectiveness. Results indicate that the NPS signs perform well as cartographic symbols for American college students and that map legends are used when provided. It is suggested that future testing of pictorial symbology might use semiotic and psychophysical research approaches to examine other co-existing symbol systems and discover more specific design principles for pictorial symbols.

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Qualitative symbolism has been an area ignored in cartographic research. The reason for this neglect is the difficulty of applying numerical analysis and absolute definitions to a qualitative entity. It has often been assumed that the artistic sense of the cartographer and the inclusion of explanatory legends on maps would resolve any user difficulties in understanding the symbolism. User surveys have indicated that the qualitative symbolism on travel maps, the maps most used by the general public, is often inadequate (Astley, 1969). This study examines the degree of mismatch between a symbol and its associated meaning on travel maps.

The need for research in qualitative symbolism is stated by Phillip Muehrcke.

> Centuries of experience with symbolic generalization has led to little beyond intuitive knowledge of the cartographic effectiveness of even such simple and commonly used geometric symbols as dots, circles, triangles, squares, et cetera. Information is particularly lacking when the problem is to select effective combinations of these symbols to produce multiple-factor maps. More attention has been devoted to pictograph type symbols where the graphic form is chosen to facilitate intuitive symbol/referent identification. Yet even pictograph design and deployment have been largely a personal matter on the part of "artistic" cartographers and have seldom been based on the results of experimental evaluation

(Muehrcke, 1972, p. 37).

A special call for studies of pictorial symbols or object-related symbols is made by British cartographer, Christopher Board.

> Some research may well be warranted on the suitability of pictorial or semi-pictorial symbols such as those used on tourist maps. Here we are dealing with recognition and the ability of the map reader to recall what different symbols stand for...(Board, 1978, p. 47).

Two developments over the past century highlight the need for research into qualitative symbolism. First, the theoretical basis of cartography has developed to encompass the science of graphic communication. The cartographer has become not only a craftsman in the art of mapmaking but a professional in the communication of spatial attributes. On the basis of cartographic communication theory, cartographers are showing greater concern for the users of maps. The transmission of information to users is now a centerpiece in the evaluation of cartographic products. The present study will stress that effective cartographic communication is dependent not only on the transmission of information but also on the transmission of meaning. This point is well stated by Rudolf Modley.

> A symbol becomes meaningful and evokes human responses when, and only when, a perceiver of that symbol projects meaning into it and responds to it in terms of the meaning which he has learned as appropriate for

> that symbol...Knowledge and acceptance of a symbol's meaning is a prerequisite of its effectiveness...the message will fail if the sender uses symbols which the potential recipients have not learned or have refused to accept...it would be wrong to assume that symbols which appear self-explanatory to some of us must be equally self-explanatory to others...There are only a few image-related symbols which are unique in meaning, clearly recognizable and permanent in time...Many image-related symbols will have only limited use geographically and historically (Modley, 1966, pp. 114-117).

The second major development has come with improved world communication and transportation systems. In order to speed the transfer of information and avoid costly mistakes, government leaders are showing an increased concern for symbol standardization. As a result, many pictorial sign systems have been developed by graphic artists in the employment of various government agencies. The basic assumption of these systems, that pictures are "international" communicators, is challenged by the present study. Jan Deregonski in "Pictorial Perception and Culture" writes,

> The ability to recognize objects in pictures is so common in most cultures that it is often taken for granted that such recognition is universal in man...If pictorial recognition is universal, do pictures offer us a lingua franca for intercultural communication? There is evidence that they do not: cross-cultural studies have shown that there are persistent differences in the way pictorial information is interpreted by people of various cultures (Deregonski, 1972, p. 1-8).

In the United States, the Department of Transportation and the National Park Service are each attempting to erect a standard pictorial sign system and discourage the use of many individual sign systems. For example, before the Department of Transportation's symbol system, each major airport had its own public sign system. Public administrators have assumed that the existence of several pictorial sign systems can only hinder communication to a traveler. Until recently, these public signs have not been a major concern of cartographers. However with their deployment on travel maps at a reduced scale and in a graphic form that can create a visual image of indistinguishable marks, the cartographer is called upon to make an assessment.

Map user surveys have indicated that travelers would like to have information represented that has not been traditionally included on most maps (Mason, 1975). Travelers desire to have such information as gas stations, rest areas, eating places, phones, and lodging shown on their maps. The need to symbolize new kinds of information on travel maps has caused some mapmakers to adopt signs from the public systems without a critical evaluation of their worth as map symbols. Rudolf Modley writes,

One reason for badly-conceived and ineffective public

> symbols is that administrators like to select symbols that have been used previously by others, and which thus have presumably been accepted by the public. This had led to the widespread adoption of some illegal or ambiguous symbols... (Modley, 1976, p. x, Introduction).

This study will examine the effectiveness of the pictorial sign system of the National Park Service in a specific context among a selected group of map users. The objective is to highlight the difficulties of using pictorial signs as map symbols and to show that even among a relatively homogenous group of users there are symbol/referent problems for "international symbols".

Table I outlines the study schema. Basic assumptions of this study are: (1) symbols are learned (Modley, 1966); (2) the contextual environment of a symbol is important for effective communication (a sign environment or a map environment); (3) the <u>ideal</u> symbol transmits correct information without the necessity of a map legend (Muehrcke, 1978); and (4) effective cartographic communication should be quick, efficient and direct.

In working towards the goal of effective communication, the cartographer must determine which symbols will be intelligible to the highest percentage of users. (Wood, 1972). He must become an expert in symbolic conventions for specific purposes and specific audiences. A prerequisite for improving symbol/referent associations and symbol design is to acquire a knowledge of symbolic conventions through surveys and the experimental testing of map users.

The professional cartographer needs more than an intuitive sense in the application of qualitative symbolism. Cartographers, public administrators, and graphic artists need to become aware that pictorial symbols can only be effective communicators if they are accepted by the intended users.

Table I. Study Schema of

"The Effectiveness of Pictorial Signs as Map Symbols"

Study Targets		Description
Theoretical Basis	:	Cartographic Communication, Cognitive Aspects
Symbolism	:	Qualitative Point Symbols
Type of Point Symbol	:	Pictorial, or Object-related
Symbol System	:	Sign System of the National Park Service
Experimental Task	:	Symbol Identification
Test Condition I	:	Symbol Identification in Legend Context
Test Condition II	:	Symbol Identification in Map Context
Subjects	:	American College Students

II. A HISTORY OF PICTORIAL SIGN/SYMBOL SYSTEMS

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Pictorial symbols have been instrumental in the birth of most modes of communication among men. Anthropologists point to the prehistoric paintings of early men as a first step towards the written languages of Babylonia and Egypt, historians write of the pictorial signage of Medieval Europe which served as visual guides for a largely illerate population, and cartographers find pictorial map symbols predominate on the earliest existing maps.

> The only abstract symbol that occasionally occurs on medieval topographical maps is the dot or tiny circle to mark towns. Once symbols stopped being simply pictorial some explanation of their meaning was needed (Harvey, 1980, p. 183).

It appears that as an accepted mode of communication develops among its adherents its expressive character changes from image-related forms of symbology to more abstract forms of symbology.

In figure 1, the Krampen classification system of graphic symbols has been modified to illustrate several graphic communication modes (Modley, 1966). The basic distinction between phonograms, symbols dependent on sounds, and logograms symbols independent of sounds is retained. Added are the symbolic communication modes most prevalent in Western cultures and of relevance to this study. It is

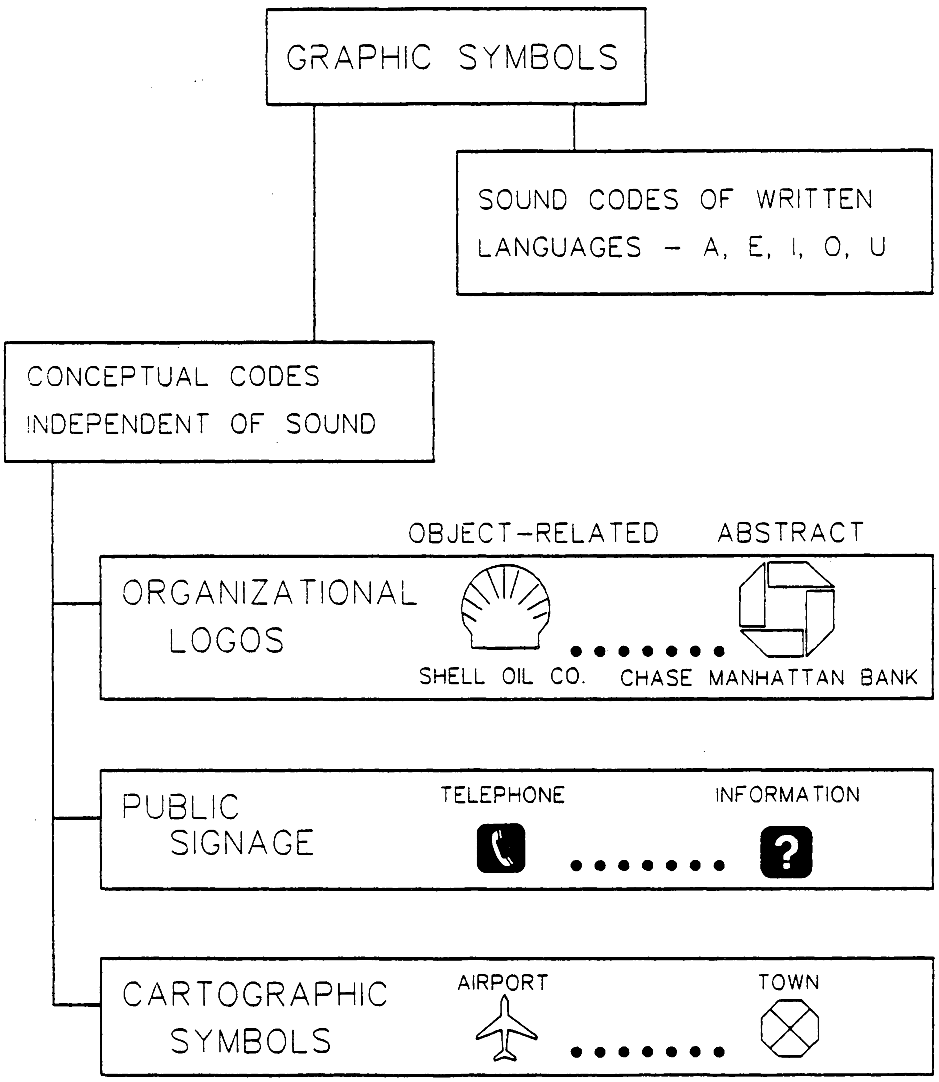

Figure 1. Communication Modes of Graphic Signs (Modified by Johnson, 1983).

readily apparent that there are no pure modes of graphic communication. Each has been mixed with the others. As a result, classification of graphic symbols as pictorial, associative, or geometric, as has been common in cartography, is blurred and often misleading (Robinson, Sale, and Morrison, 1978). If symbols are to be classified, it is better to give relative characterizations based on contextual use and a descriptive continuum running from object-related to abstract forms of expression.

The history of pictorial sign/symbol systems is a story of the development of two communication modes and their merger in the early 1970's. The main impetus of development is from: (1) government officials and graphic artists seeking to develop symbols that are international communicators; and (2), cartographers hoping to standardize the symbology of topological, economic, and travel maps. Both developments have coincided with increased international contacts due to improved world transportation and communication networks and with increased cultural diversity within nation states.

A history of pictorial symbolism in public signage and maps cannot ignore the role of cartography's most influential patrons, centralized governments. The cartographer has often been an employee of central governments working to aide administrators in conceiving a geographic realm. Official awareness of cultural diversity as a threat to self-preservation is an added dimension to a traditional interest in mapping as a tool to consolidate rule over territories, collect taxes, and exploit known resources. Beginning in recent history with the rise of nation states in 16th century Europe and witnessed today in the independence of the multi-national states of Asia and Africa, the continued authority of many governments is dependent on bridging the cultural barriers of its inhabitants. Even the older nation states are experiencing increasing diversity in their populations. Note Great Britain's foreign nationals from her fallen Empire, the large Turkish population of West Germany, and the growing Latin population of the United States.

THE DEVELOPMENT OF PICTORIAL SIGNAGE

Many government officials have assumed that pictorial perception and cognition is universal and can be used to promote uniform national, cultural, and economic standards. The development of standard pictorial symbols for signage particularily highway signs has been at the forefront of this trend.

The automobile has provided the focus for both sign standardization and map symbol standardization. The first modern sign system was developed in 1895 by the Italian Touring Club (Modley, 1976). In the years immediately following, European nations made many proposals and counterproposals through the Congress of the International League of Towing Organizations for road sign standardization. Finally in 1909, nine European governments agreed on the first international sign system (figure 2) consisting of four pictorial symbols for bump, curve, intersection, and grade-level railroad crossing (Modley, 1976). During the period of the world wars, intensive work lead to the expansion of the first four international signs into the present European Road Sign System of some ninety-four symbols (figure 3).

The United States independently developed its own road signage after years of urging by the American Automobile Association and large mapping firms such as Rand McNally. It must be remembered that at the time of the first automobiles, America was a rural nation, largely dependent on railroads, and with hard-surfaced roads only in and around the larger cities. At best, a traveler had to rely on bulky photo-auto guides consisting of lengthy descriptions of road intersections and landmarks, but mostly

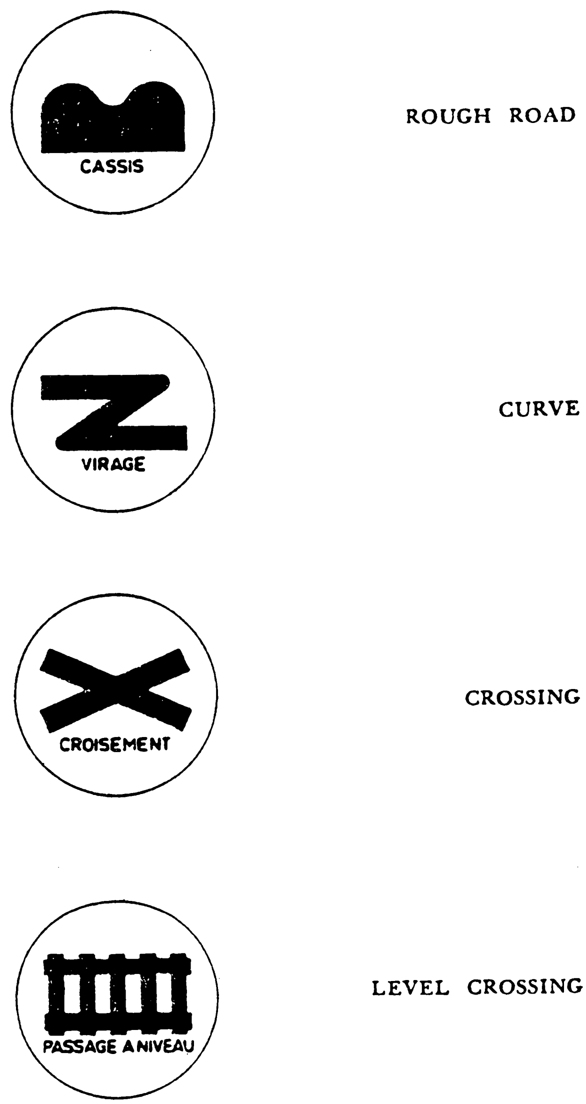

Figure 2. The First International Sign System (Modley, 1966).

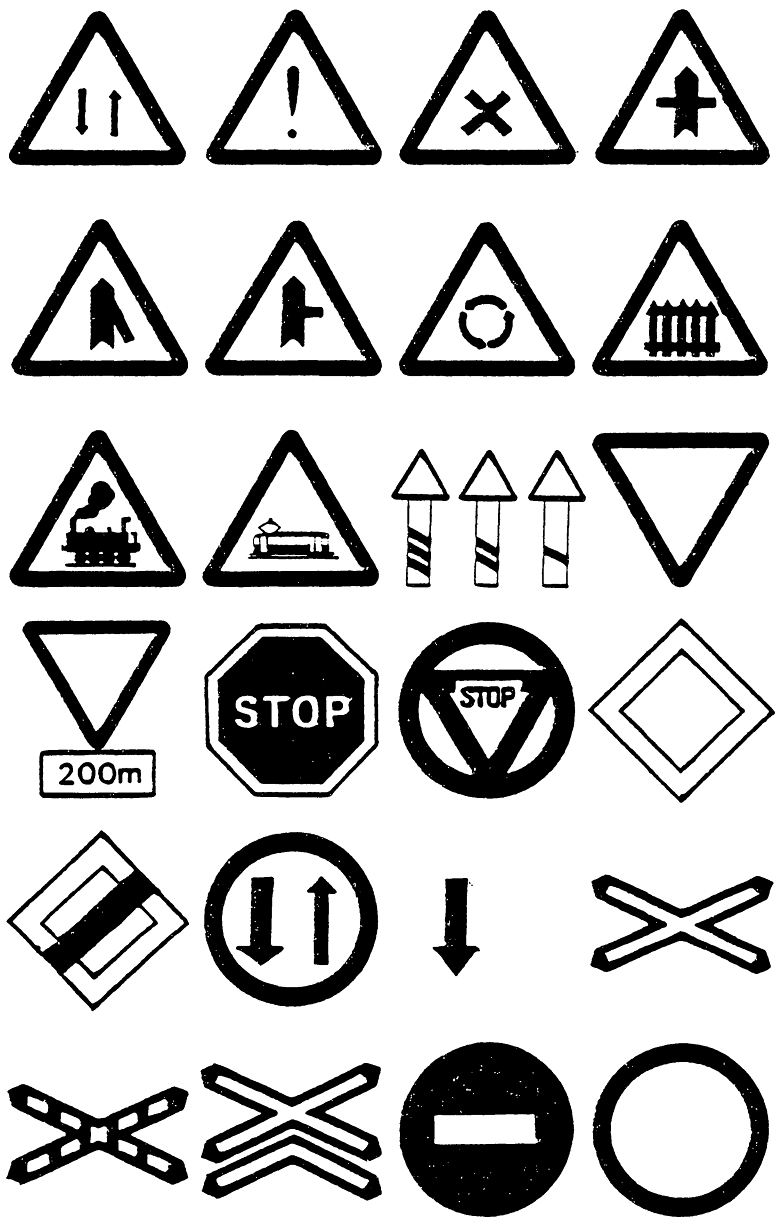

Figure 3. Signs From the European Road Sign System (Modley, 1976).

navigation depended on instinct and chance (Ristow, 1946). Early efforts at erecting standard road signage consisted merely of marking roads by a uniform numbering system and placing mileage and directional signs along major inter-city through fares.

By the early 1970's with the Interstate Highway System largely completed, federal highway officials for reasons of safety recognized the need to standardized highway signs across the nation. In 1974, two graphic artists, Cook and Shanosky, under the direction of the American Institute of Graphic Arts and the U.S. Department of Transportation created a pictorial sign system of thirty-four symbols. Since 1974, the DOT has added several signs to the system. The DOT signs are currently in use on all U.S. highways, in most major airports, and have been adopted by several nations around the world.

Other leading organizations in the promotion and development of pictorial signage are: the American National Standards Institute, the Olympic Games, the United Nations, the International Organization for Standardization, and the Netherlands Foundation for Statistics. Important persons in the field of pictography are: Otto Newrath, an Austrian, who founded the Social and Economic Museum in Vienna; and

Katzumie Massaru, a Japanese art director of the 1964 Olympic Games in Tokyo (Modley, 1976). As the world becomes more interdependent, interest in pictography grows among the world's political and economic interests.

STANDARDIZATION OF CARTOGRAPHIC SYMBOLS

In recent decades, symbol standardization for thematic and topographical maps has become an issue among cartographers. The lines are drawn between cartographers who seek effective communication through the standardization of symbology and cartographers opposed to standardization as a restriction to their artistic freedom to design good maps. The opponents also believe that symbol standardization is an impractical precept given the diverse applications of mapping and the diverse background of map users. European cartographers have been strong advocates for the development of universal symbol systems for maps. They have been first to recognize the fact that similar objects are represented differently from country to country. The lack of consistency in symbology can result in much wasted effort and time in the identification of map symbols (Ratajski, 1971).

Proposals for symbol standardization range from simple classification schemas to long lists of symbols for every conceivable object and activity. For example in 1966, French cartographers, Fernand Joly and Stephane Brommer, proposed a standardized system of 250 symbols for industrial and tourist activities (figure 4). Lech Ratajski proposed a similiar set of symbols along with a classification schema for economic maps in 1971. Ratajski writes that the choice of cartographic symbols has been purely arbitrary and that the use of many different symbols serves only to confuse the map user. To correct this situation, Ratajski creates a symbol classification system of three fundamental thematic-graphic groups. They are: (1) agriculture, where area symbols should be used; (2) industry, where point symbols should be used and (3) transportation, where line symbols should be used. Ratajski expends much effort describing in detail the symbols that should be used for each category. Such classification schemas have not been well-received because they limit a cartographer's artistic freedom and cannot be rigidly adhered to for all map purposes.

An alternative classification schema is that proposed by Erik Arnberger (1974). It is based on the four principles of cartographic representation identified in figure 5. The principles are: (1) the topographic principle; (2) the diagram principle; (3) the pictorial-

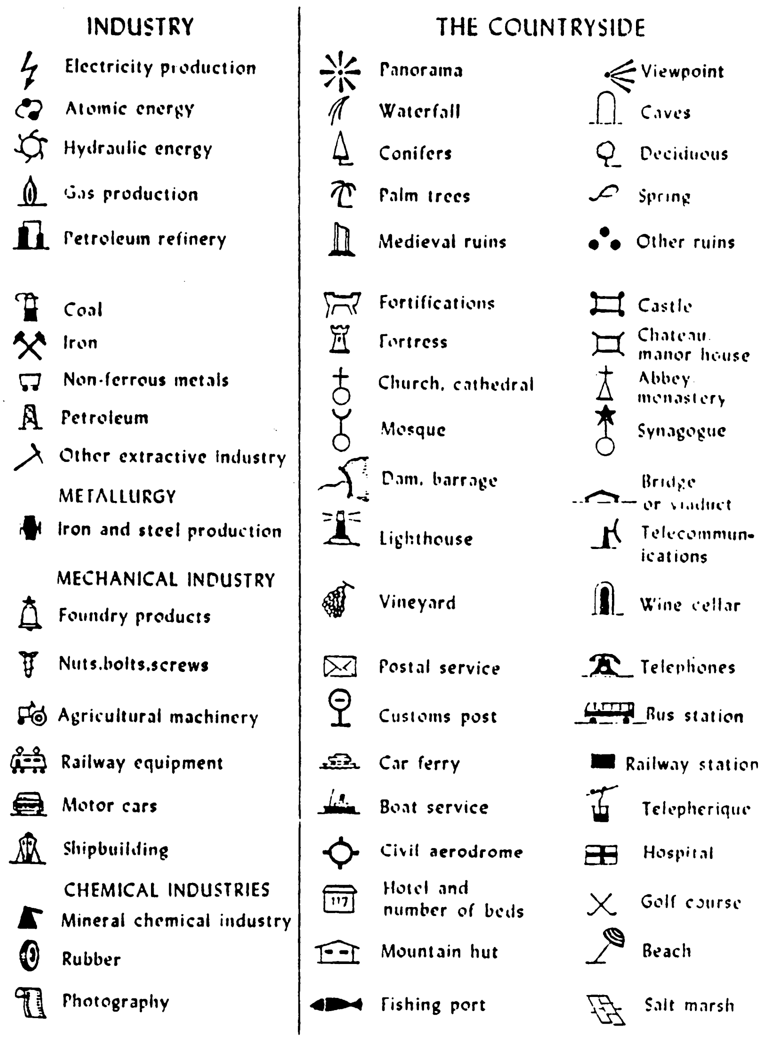

Figure 4. Standard Symbol System Proposed by Fernand Joly and Stephane de Brommer (1966).

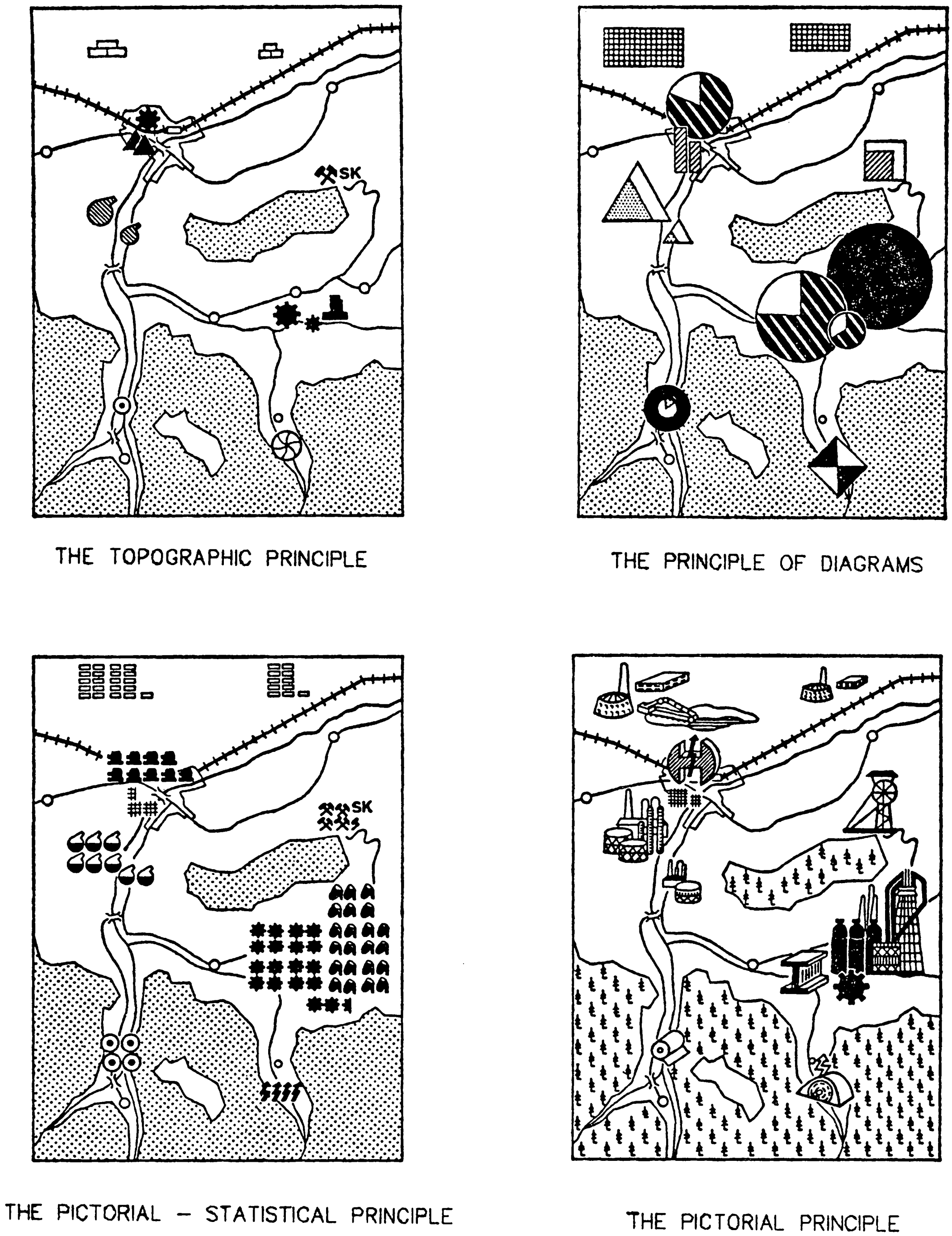

Figure 5. Basic Principles of Cartographic Representation According to Erik Arnberger (1974).

statistical principle; and (4) the pictorial principle. Arnberger's classification is very similiar to Harvey's symbol map, diagram map and picture map distinctions in his history of topological maps (Harvey, 1980). Although these classification schemes are valuable, in practice each principle is often difficult to distinguish because of mixed modes of graphic communication. Rigidness in a classification schema necessary for complete standardization often cripples the usefulness of a symbol system. Even Arnberger who welcomes efforts of international standardization of cartographic symbology recognizes map theme and map objective as factors working against fixation and unification of a symbol system. Arnberger warns that scientific cartography has not yet developed to the point where preparation can begin for complete standardization of map symbols.

Symbol systems such as those proposed by the Europeans would require symbol dictionaries and symbol translation courses for users. Furthermore, none of the proposed symbols have been tested for communication effectiveness. The idea of eliminating choices by giving a symbol dictatorial status may in fact diminish effective communications if that symbol is not accepted by map users (Robinson, 1973). Only two clear principles emerge from the literature on symbol standardization: (1) where possible keep existing symbols; and (2) do not use symbols with assigned meanings to represent other objects or activities (Board, 1973). Often in reality, these two principles are in conflict. Established symbols with different meanings can have the same graphic form.

Although standardization is impractical for most thematic mapping purposes, the area of large scale engineering maps is in desperate need of standard symbology that is also computer-compatible (Jacober, 1979). It is common to find utility firms with several mapping departments none of which share the same symbology. In many cases, the symbolism has evolved without any concerted effort towards uniformity, and the same graphic symbol has a different meaning from map to map, and sometimes even on the same map. It is best described as an Alice in Wonderland situation where a symbol can have any meaning. Shared symbolic conventions exist for one department for some maps for a particular firm. In such circumstances, a case can definitely be made for symbol standardization.

The history of map symbol standardization is a story of mixed success; depending on the mapping purpose. Overall, map symbol standardization has not been as successful as the development of standard public signage for several reasons: (1) map symbols are utilized for more diverse purposes than public signage and (2) control of maps symbology is not completely in the domain of most centralized governments.

THE UNION OF PUBLIC SIGNAGE AND MAP SYMBOLOGY

In the early 1970's another U.S. agency, the National Park Service (NPS) also developed a pictorial sign system to guide travelers, a caption on an NPS map explains,

> The National Park System uses a uniform signing system with easily recognized symbols for directions, locations, and activities. These symbols require less space than most phrases, and thus reduce the size of the signs, helping us preserve the natural and historic character of the parks. They also can be quickly understood not only by Americans but by persons from other nations (Government Printing Office: 1974 0 - 549 - 998).

The NPS system consists of 77 pictorial symbols (figure 6) representing 5 major categories of informations: (1) accommodations/services, (2) winter recreation, (3) water recreation, (4) land recreation, and (5) general information. In an attempt to avoid confusion, the National Park Service, which is responsible for posting public signage in the National Parks and for publishing a series of park guide maps, adopted the same pictorial sign system for public signage and cartographic symbolism.

Figure 6. The Sign/Symbol System of the National Park Service.

As a cartographic source of symbols for new categories of information on travel maps, the NPS signs have two advantages. First, the NPS signs have a recreational orientation and as a result offer more variety than most sign systems; and second, the NPS signs give better visual contrast as white symbol forms against black backgrounds than black forms on white as with the DOT symbols. Whether better visual contrast equates to greater clarity can only be determined by testing the symbols in a map environment.

The NPS signs have not been utilized to their fullest potential. Albert Ward (1977) of the CIA comments on the usefulness of employing the NPS signs on state road maps.

> "Symbols ... vary considerably; roadside rest stops, ski areas, boat ramps, and the like could be the same shape from state to state if not the same color. The National Park Service employs symbols on its maps which are so clear they hardly require a legend, but none of these appear to be in use on the state road maps (Ward, 1977, p. 7)."

The development of pictorial sign systems is continuing. They are appearing not only on public signs and park maps but in contextual environments as diverse as automobile dashboards, container packaging, and newspaper cartoons. The use of pictorial signs in map communication has not been questioned. After nearly ten years of use on maps, it is time a cartographic assessment be made of the effectiveness of the NPS signs as map symbols.

III. QUALITATIVE SYMBOLISM - IN SEARCH OF A THEORETICAL HERITAGE

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Graphic symbols in the form of written letters have allowed knowledge to be passed through time and between cultures (Robinson, Sale, and Morrison, 1978). The growth of modern civilizations is dependent on the accumulation of knowledge. For this reason, symbolism is an extremely broad area which falls to some degree within all the Liberal Arts disciplines. Each discipline has molded the subject to fit it's own needs and purposes. As a result, much of the literature is confusing and without a common terminology. Even within a discipline there are often conflicting philosophies and definitions concerning symbolism. Because of the specific focus of this study, an investigation into the communication effectiveness of public signage as cartographic symbology, some insight can be drawn from this massive body of information. Although inputs into this study are possible from nearly every field, the most relevant sources of information come from the areas of cartographic communication theory, cartographic evaluation, and graphic design.

A review of qualitative symbolism in the literature will follow in the next three chapters. It will focus first on the theoretical models of cartography considering the theoretical implications of a qualitative symbol study such as the present one. Second, the sources of the study's derived methodology will be outlined; and last, several principles of symbol and map design will be highlighted as important factors for assessing a qualitative symbol system.

A CARTOGRAPHIC SCHEMA

Cartographers are searching for organizational schemas to advance scientific cartography. Common organizational schemas are those based on: (1) graphical form (point, line, and area); (2) referent nature (qualitative or quantitative); (3) measurement scale (nominal, ordinal interval, or ratio); and (4) cartographic subject matter (topographic or thematic, descriptive or analytical).

One useful schema for cartography is that proposed by Ingrid Kretschmer (1978). Figure 7, shows Kretschmer's schema which is based on cartographic subject matter. The present study falls into the research area concerned with the development of methods of cartographic evaluation and the applied area called descriptive cartography directed towards the production of spatial information for broad communication.

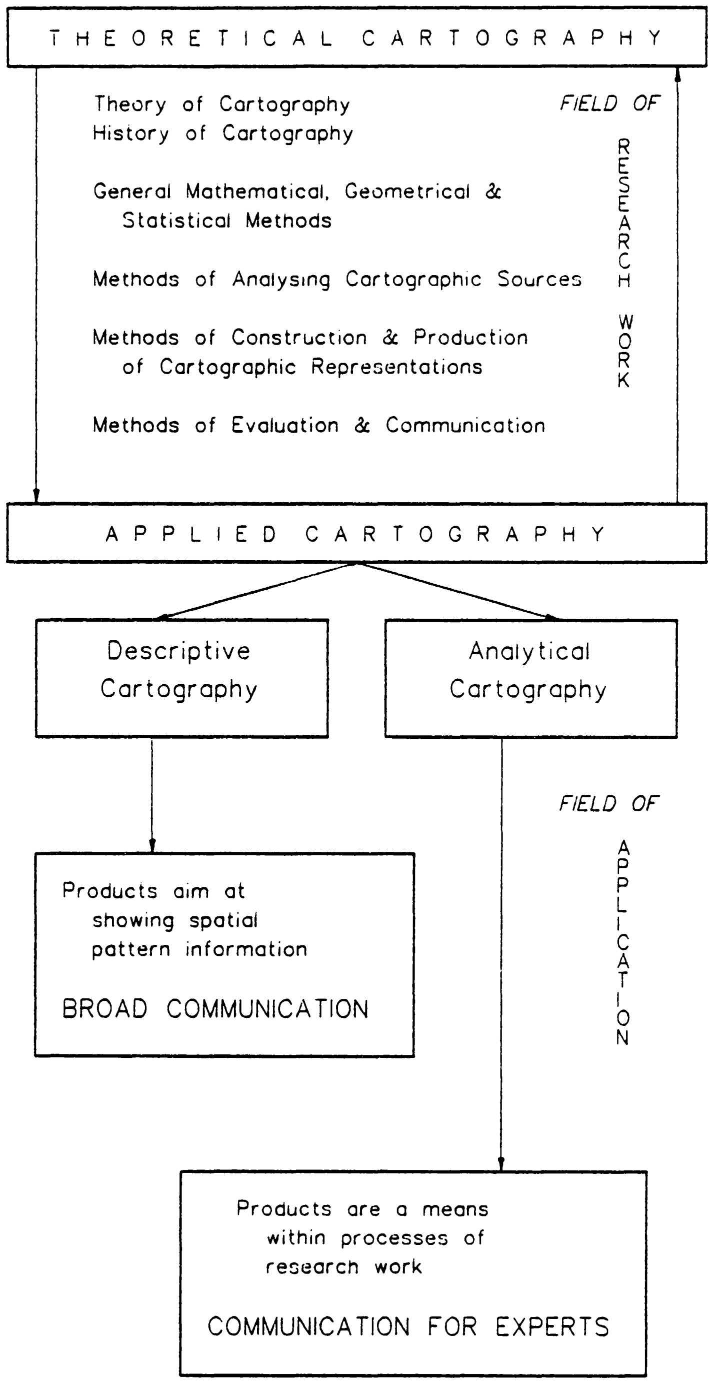


Figure 7. A Basic Schema of Cartography (Kretschmer, 1978) (Modified by Johnson, 1983).

More comprehensive organizational schemas are those proposed by Lech Ratajski (1973), Joel Morrison (1974) and Karl-Heinz Meine (1978). Ratajski has devised the most detailed organizational schemas and models for cartography. He divides cartography into two fields, theoretical and technological. For Ratajski, theoretical cartography is cartology. Cartology is concerned with codifying the norms determining research procedures and analyzing various systems models of cartography as a science. Ratajski has been the main proponent of cartography as a metascience or deductive science formalized with theories (Ratajski, 1973). A combination of an organizational schema based on cartographic subject matter with a mathematical model of information transmission yields Ratajski's structural model of cartology. The result is an extremely complicated model and structure for theoretical cartography. Ratajski's terminology and divisions of cartology make the model difficult to use (see figures 8 & 9). It is an example of a model that attempts to describe everything and in doing so blurrs important distinctions.

Joel Morrison (1974) calls upon cartographers to agree on a theoretical structure as a basis for deducing semantic rules of a cartographic language. The belief is that symbol standardization cannot be successful until a syntactic

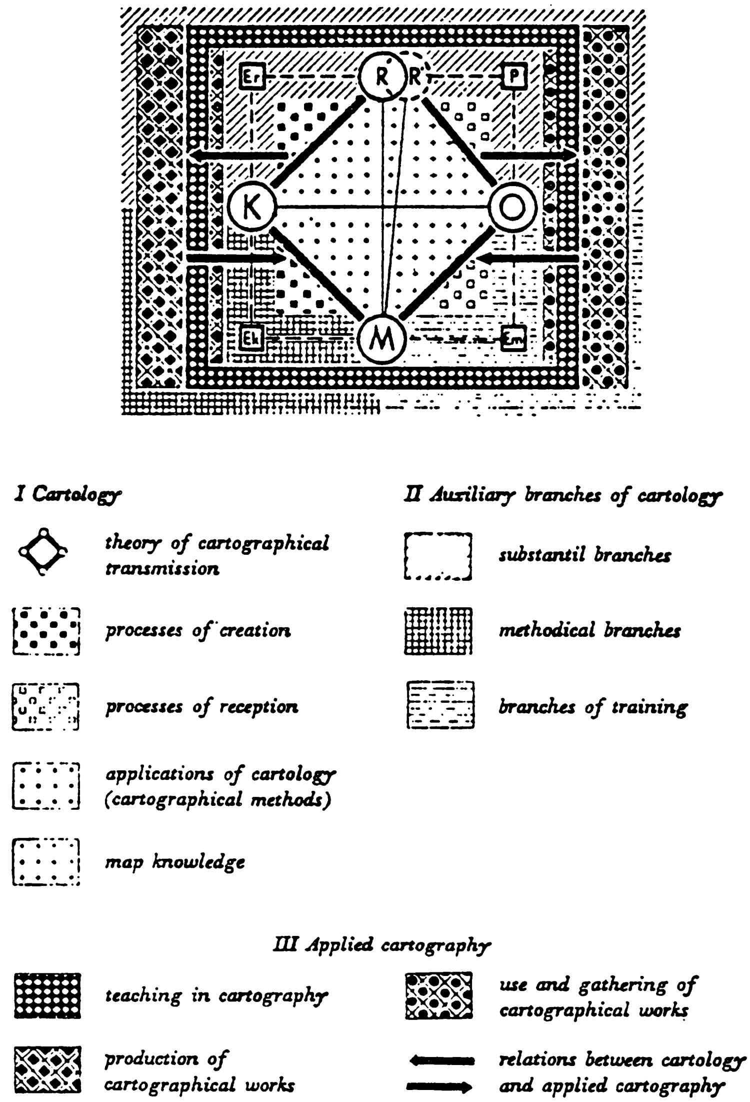


Figure 8. A Research Structure for Theoretical Cartography (Ratajski, 1973).

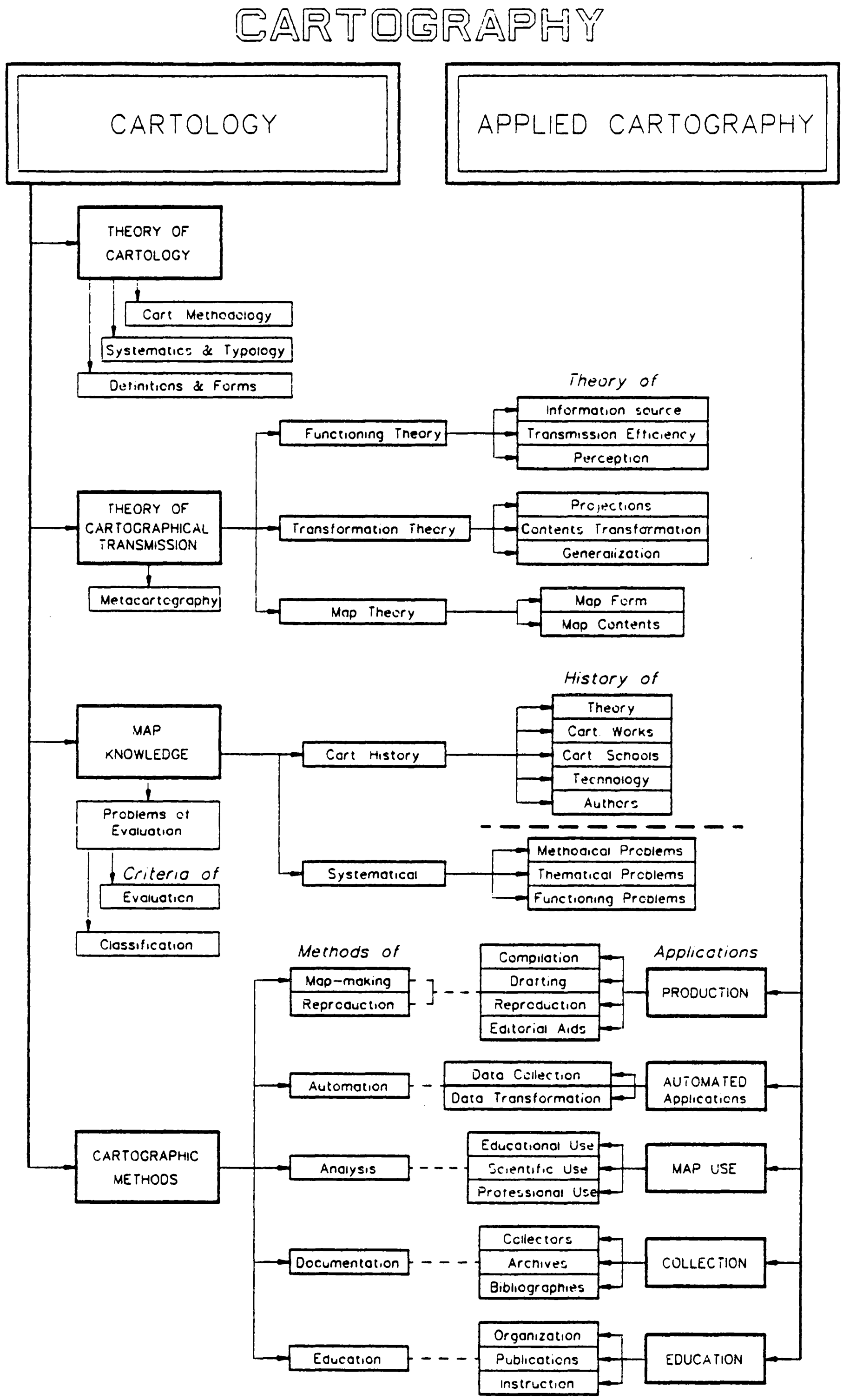


Figure 9. Ratajski's Schema of Cartography (1973) (Modified by Johnson, 1983).

structure is found for cartography. Morrison develops a multi-dimensional structure based on: (1) graphical type (point, line, and area); (2) symbol dimension (size, shape, pattern, and color); and (3) the cartographic processes of generalization (classification, simplication, symbolization, and induction). Morrison's list of possible symbol dimensions (figure 10) are important factors in the production of point symbols for broad communication.

Rather than settle for a single organization schema or model, Karl Meine proposes several. They are: (1) a schema dividing cartography into scientific and technical processes; (2) a schema highlighting the chains of communication within cartography and between cartography and other disciplines; (3) a schema focusing on generalization as the basis for building a cartographic alphabet for the three graphic types (point, line, and area); (4) a schema showing generalization as it relates to scale, map evaluation, and map users plus the important attributes for each use and scale; and finally, (5) a schema depicting cartography as a science in the development of cartographic methods for improving map communication. The multitude of organizational schemas or blueprints existing for cartography illustrates the diversity of purposes and applications for cartographic products.

Symbol Dimensions for Symbolization

Symbol Type & Data Element	Available Symbol Dimension: *Black & White*	*Color*	Other Dimensions (not recommended)
Point Symbols			
nominal	shape		
	pattern orientation	hue	pattern texture
	pattern arrangement		
ordinal interval ratio	size	value	shape
	pattern texture	intensity	
Line Symbols			
nominal	shape	hue	pattern orientation
			pattern arrangement
ordinal interval ratio	size	value	shape
	pattern texture	intensity	
Polygon/ Volume Symbols			
nominal	pattern orientation	hue	pattern texture
	pattern arrangement		
ordinal interval ratio	pattern texture	value	
		intensity	

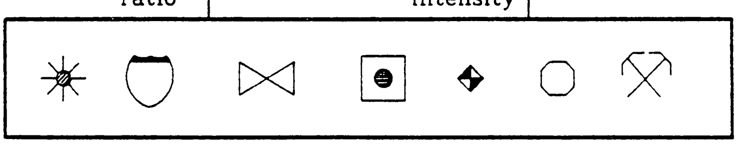


Figure 10. A Syntactical Structure of Symbol Dimensions (Morrison, 1974). (Modified by Johnson, 1983).

Nevertheless, several themes emerge from the literature concerning an organizational and theoretical structure for cartography. First, most authors who develop an organizational schema see cartography as an independent science separate from geography, computer science, and psychology. They ask cartographers to conduct original research and apply original methods to the special problems of cartographic communication. Second, most structural proponents believe that once a cartographic language is derived symbol standardization would soon follow. They fail to comprehend or consider that the spatial aspect of maps is a factor unparalleled in written language. Often spatial combinations result in a growth of information not known to occur in the page format of books. Third, cartographic communication surfaces as the main basis on which to establish the foundations of theoretical cartography. The mission is to optimize cartographic symbols and in doing so discover methods and rules for the transformation of spatial data into cartographic representations.

CARTOGRAPHIC COMMUNICATION THEORY

Cartographic communication theory is the basis for most research currently being conducted in cartography. The emphasis of cartography as a science of cartographic communication is clear in Joel Morrison's statement.

> A cartographer who still believes that cartography is the making of maps cannot find any true area of research except perhaps historical cartography (Morrison, 1972, p. 8).

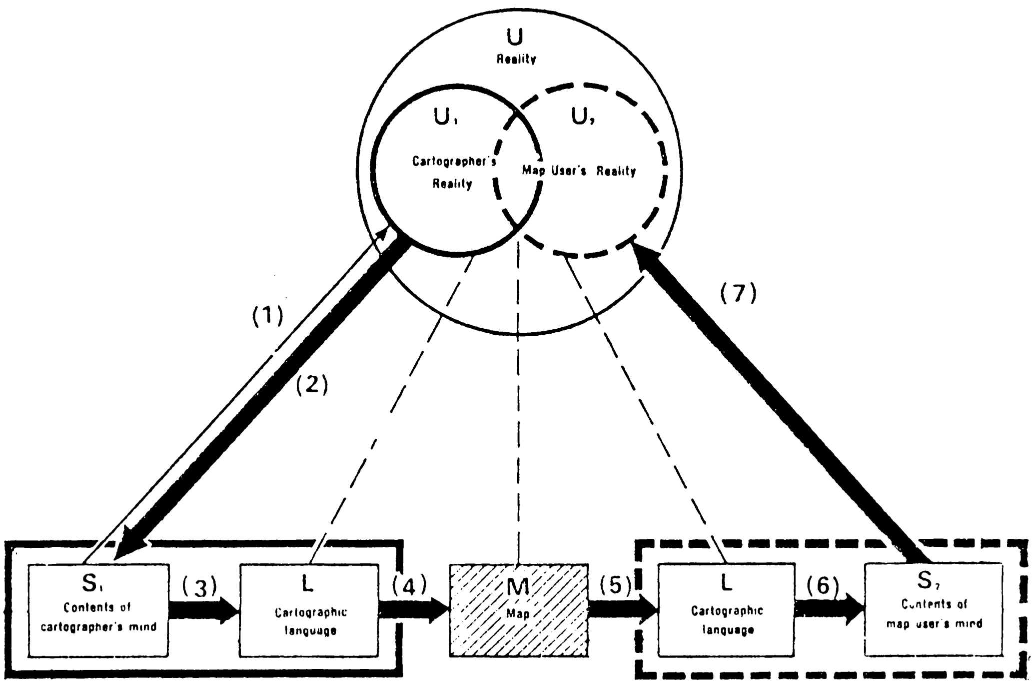
Several research branches have developed based upon cartographic communication theory. The differing research approaches are derived from varying interpretations of graphic, mathematical, and descriptive research models. Under the umbrella of cartographic communication theory falls: (1) information theory, (2) semiology, (3) modelling theory, (4) psychophysical theory, and (5) cognition theory (Ratajski, 1978). To understand the special research and theoretical basis of the present study, it is important to review each research orientation. Cartographic communication is not a simple process but rather a totality of processes constituting modelling, semiotics, and information theory (Salichtchev, 1978). Although this study is largely cognitive in scope, it does not ignore the existence of other research approaches.

Information Theory

Information theory began in 1928 at Bell Laboratories. It is based on a mathematical formula designed for evaluating the capacity of a telecommunication system for transmitting electronic signals representing verbal language (Robinson and Petchenik, 1975). An important point often forgotten is that the theory includes a principle of uncertainty where given greater uncertainty, information capacity increases simply because more choices are available. Therefore, greater information capacity may mean more noise between a source and a recipient.

In 1969, Antonin Kolacny developed a model of cartographic communication based on information theory. The model became a prototype and catalyst for research into a previously unexplored area. Figure 11 shows Kolacny's information model. It is a diagram showing the intersection of two circles within a larger circle representing the universe. The two smaller circles illustrate the intersection of the universe as seen by a cartographer with an environment as seen by a map user. The circles are connected to a flow diagram showing the flow of information from a cartographer's mind through the language of a map to a map user's mind. Kolacny's model made many cartographers aware of the need to assess the communicative aspects of their products. He states,

> There prevails the tacit assumption that the user will simply learn to work with any map which the cartographer makes. In other words, the map user is



<u>Factors of Communication</u>

U_1 - reality as seen by the cartographer

S_1 - the cartographer

L - cartographic language of symbols

M - the map

S_2 - the map user

U_2 - reality as seen by the map user

I_c - cartographic communication

<u>Processes of Communication</u>

1. - observation of reality
2. - effect of selected information
3. - cartographer transforms selected information into a two-dimensional intellectual model
4. - cartographer expresses the intellectual model by producing a map
5. - map produces an informative effect upon the user
6. - map user creates in his mind a multi-dimensional model of reality
7. - map user acts on the strength of cartographic information

Figure 11. Kolacny's (1969) Model of Cartographic Communication Based on Information Theory.

> expected to submit, more or less to the cartographer's conditions...if the cartographer is to achieve the optimum effect of cartographic information, which in essence amounts to the achievement of the optimum efficiency of maps, he has to become acquainted with all the aspects and the entire width of the process indicated above by which cartographic information is communicated (Kolacny, 1969, pp. 47-49).

Information theory has lead to three developments in cartography: (1) the creation of cartographic models of information transmission, (2) the application of mathematical formulae to determine the information capacity of maps, and (3) the analysis of information losses due to system noise.

Information theory has come under attack for being too narrow to cover the complexities of cartographic communication. It has been noted that the assumption of linearity in the transmission of information does not necessarily apply to maps (Robinson and Petchenik, 1975). Lawrence Frank writes,

> We need a larger conception of communication than that provided by the formula of stimulus and response ... or Information Theory (Frank, 1966, p. 6).

A service - channel - recipient communication process is too simplistic to be employed in a conceptual investigation. A linear structure disregards the consequences of information gains of a map in a unified interrelated form of a Gestalt.

Knowledge is often gained by a map user on discovering the relationships between objects presented in a graphical and spatial context. Analytical gains from map reading make measures of information content based on counting exercises seem futile. An example of information bit counts is:

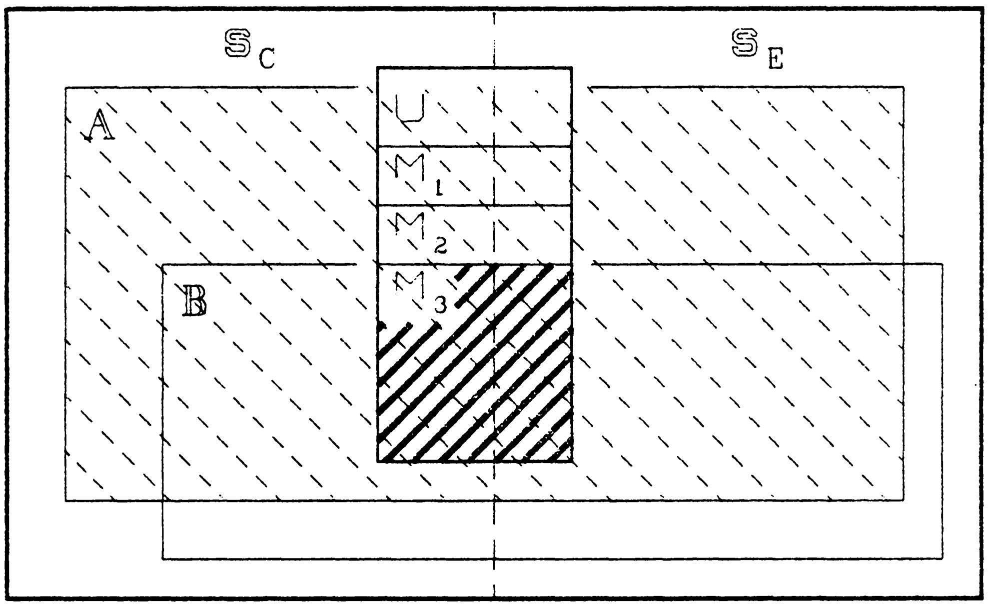
> The transmission capacity of the map is ... much larger than that of a book ... the entropy per centimetre of a band was calculated at 71.8 bits for an altas sheet and 31.0 bits for a book (Balsubramenyan, 1971, p. 177).

Other problems in information theory stem from the concept of noise. In information theory, noise does not mean a loss of information but might indicate greater system capacity. Noise in a map context lengthens reception time and can exist as an element inherent to the communication system or external to the system as in the conditions of poor vision, poor lighting, or even intervening cultural filters. The selection by a cartographer of inappropriate symbolism or graphic representations not accepted by map users is a common source of system noise. User feedback is a prerequisite for reducing that noise (Robinson and Petchenik, 1975). Cartographic analysis based on information transmission is not enough, cartographers need to evaluate the quality of communication by examining the transmission of meaning as well.

Due to the above concerns and the need to account for other factors in cartographic communication, models similiar to Kolacny's model have been proposed by Christopher Board, Lech Ratajski, Phillip Muehrcke, Arthur Robinson and Barbara Petchenik (1975). Figure 12 shows a further development of a communication model by Robinson and Petchenik (1975). Rather than illustrate a linear flow of communication, the model summarizes the relationship of cognitive elements within a communication channel. "M" of this model concerns a review process but no elaboration is given about a break in the linear flow of information from cartographer to map user. Most models neglect to account for the influence of a patron or client in the creation of a cartographic product for others. It is an important point as long as traditional cartographic products are used. A government agency, not the public and probably not at the advice of a cartographer, selected the NPS signs for use on maps.

Semiology

Semiology in the field of cartography is an area of study that seeks to build a general theory for cartographic symbology. The foremost cartographic work drawing on the concepts of semiology is Jacques Bertin's Semiologie Graphique, the language of graphic symbols. The goal in



<u>Diagram Elements</u>

S_c - correct conception of the milieu

S_e - erroneous conception of the milieu

A - conception held by the cartographer

B - conception held by the map percipient

M - map prepared by the cartographer and viewed by the map percipient

M_1 - part of map previously conceived by the map percipient

M_2 - part of map newly comprehended by the map percipient

M_3 - part of map not comprehended by the map percipient

U - increase in conception of the milieu by the map percipient not directly portrayed by the map

Figure 12. A Venn Diagram Showing the Cognitive Elements in Cartographic Communication (Robinson and Petchenik, 1975).

semiology is to construct a map language based on structural concepts borrowed from linquistics. The research is directed towards the discovery of meaning, structure and psycho-physical components of a map language. Symbol standardization and the search for an alphabet of signs is often connected in the literature, Phillip Muehrcke uses a linguistic research paradigm as a basis for dividing the study of cartographic symbology. From a semiotic viewpoint, the areas of cartographic study are: (1) symbol/referent relationships or semantics, (2) symbol/symbol structural relationships or syntactics, and symbol/user relationships or pragmatics (Muehrcke, 1972).

In the context of a map, the divisions of semiotic research (figure 13) are difficult to isolate. For this reason and the belief that there is little similiarity between a structured language and cartographic elements, this study does not use a semiotic approach. To reduce the complexities of a map to a linguistic structure of information flow may be misleading.

Much of the literature concerning semiology fails to make an important distinction between signs and symbols. More precise definitions are given by Rudolf Modley (1966). Signs refer to objects and percepts and serve to modify

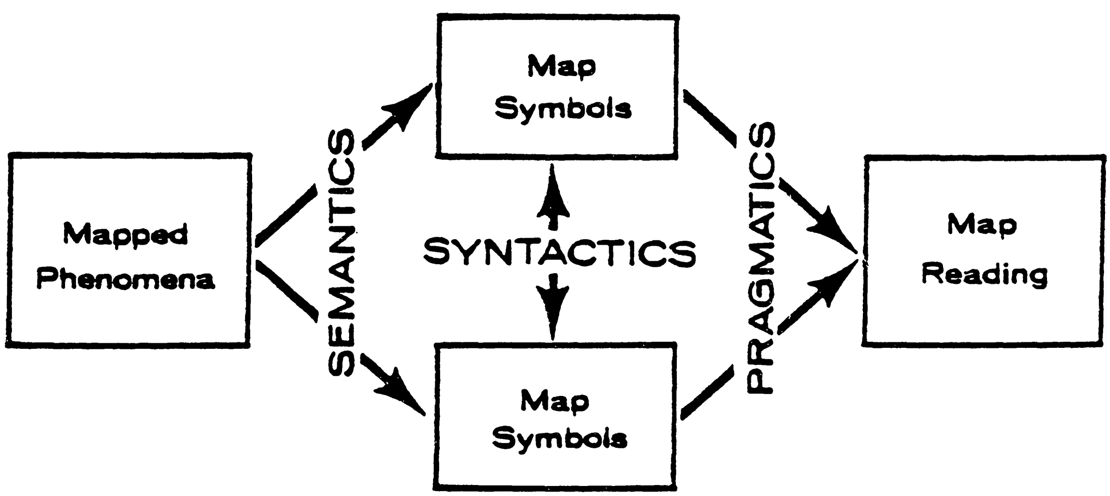


Figure 13. A Cartographic Interpretation of the Theory of Signs (Muehrcke, 1972).

actions while symbols refer to concepts and ideas and serve to initiate and facilitate mental computations. As designators, symbols are part of the human world of meaning and are used as collectors to pass knowledge through the generations (Frank, 1966). In reference to the NPS sign/symbol system, the distinction between concepts (ideas) and objects is not always clear; signs are symbols and symbols are signs. A distinction based on a modular context of communication, public signage or cartographic symbols, is clearer and more useful (figure 1).

Modelling Theory

To understand Modelling Theory it is necessary to know what constitutes an icon. An icon is a representation or symbol that is regarded as having taken onto itself the characteristics of the object it portrays. In cartographic terms, a map can be viewed as an iconic model of reality. The idea of a map as an icon has wide acceptance in the U.S.S.R. where iconic pictures of Christian personages play central roles in the Russian Orthodox Church. The comprehension of an icon gives believers a degree of control over forces normally beyond their control.

In the West, Christopher Board was the first to bring attention to the concept of an iconic map, which represents the essential qualities of a geographical reality. The iconic map can be of three types: (1) it can be a control model of logic and graphics (Euclidian geometry); (2) it can be a control model of space and knowledge (distance and location); and (3) it can be a control model of images and ideas (rivers and mountains) (Ratajski, 1978).

The theoreticians have been drawn to the map - model concept. Rudolf Arnheim (1966,1976) in stressing the role of imagery in thinking considers a map to be an iconic image. Arnheim believes the pictorial image is a product of the mind rather than a deposit of the physical object. This concept forms the basis for a school of art known as Impressionism. Arnheim approaches the problem of meaning in perception by dividing it into: (1) intellectual meaning and (2) meaning drawn from past and present images. Important to the analysis of this study is Arnheim's statement that images and associated meanings are learned through experience but only images have a direct influence on images. In other words, a person's mental legend can only be modified or altered by the image of an object, not directly by the object. As a consequence, the success of an international pictorial sign/symbol system is dependent on a common learned imagery which at present is culturally determined and, as a result, is conditioned by position in time and space.

Arnheim's search for meaning in perception confuses accepted definitions of perception and cognition. More reasonable definitions follow. Perception is the process, act, or faculty of being aware directly through the senses. It may result in knowledge gained by insight and intuition. Cognition is the mental process by which knowledge is acquired. It includes knowledge gained by perception, intuition, or reasoning. Meaning in perception equates to insight while in cognition meaning equates to intellectual knowledge (Petchnik, 1978).

The iconic map stresses the map as a tool in research and cognition and stands counter to the formal approach of information theory and the structural comparative approach of semiology (Ratajski, 1978).

This difference in approach has not gone unnoticed among Soviet cartographers. According to K. A. Salichtchev (1978), information theory cannot be the basis of a general theory of cartography. He finds it unacceptable to base mapping processes upon a mathematical theory of information. The approach reduces cartography to analysis of information losses in a communication channel, excluding concern for the expansion of information. Cartographic communication entails not only the transmission of information but also the enrichment of information.

The iconic map is an integral part of cognitive research in the Soviet Union where cartography is defined as a means of acquiring knowledge from spatial images (Kretschmer, 1980). Pictorial symbols might have iconic qualities for some subjects. Personal experience with an object or activity may account for better symbol performance via brilliant mental images. It is a factor worth considering in the present study of qualitative symbology and meaning.

Psychophysical Theory

Closely related to information theory in many cartographic studies is psychophysical theory where research is concerned with how an organism responds to the environment via its sensory receptors. The transmission of information by electronic signals between a source and a recipient is considered to be similar to the transmission of neural impulses from sensory receptors to the brain. The measurement of sensory experiences in cartography is found in the perceptual studies of graduated symbology. Such studies have focused on finding psychophysical power functions or the quantitative relationships between the magnitude of a physical stimulus and the magnitude of a corresponding perceptual experience (Gilmartin, 1981b). The identification of psychophysical power functions has led academic cartographers to suggest rescaling procedures for some cartographic symbols to compensate for the value misjudgments of map users.

Although such knowledge is useful, it is limited. Power functions do not reveal how meaning is derived from a spatial distribution of marks. Behavioristic orientations where people are viewed as passive and mechanical receivers of information has been characteristic of many psychophysical studies. The emphasis on the perceptual elements of map reading at the neglect of cognitive processes cannot reveal the processes of an interactive dialogue occurring between a map user and his or her map.

Historically, theories of psychophysics have expanded to become theories of cognition (Gilmartin, 1981b). Because the perception of information is a basic cognitive activity, there is no clear-cut edge between the perception of information and the mental processing of information into meaning. As a consequence, cartographic investigations should use integrated approaches and not rely entirely on psychophysical data to understand a cartographic process of communication (Gilmartin, 1981b).

Cartographers need to go beyond psychophysical theory and study the higher mental processes of cognition. The need for such studies will become more apparent as the age of interactive computer graphics unfolds. Map users will be both initiators and active participants in a process of cartographic communication. For the above reasons and those outlined in the following sections, the present study is primarily a cognitive investigation.

Cognitive Theory

Cognitive theory in the field of cartography is concerned with the mental phenomena used to process map elements. The theory has developed from two different bases in the U.S.S.R. and the West. In the Soviet Union, cognitive theory has been based largely on philosophical speculations; while in the West, cognitive theory has developed from experimental testing associated with psychological concepts (Ratajski, 1978). The graduated circle studies of the 1970's are representative of cartographers borrowing psychological procedures and concepts to study a cartographic problem. Because of the popularity of information theory during the same period, most cartographic investigations of psychophysical character can be characterized as being reductionist and concerned with behavioristic processes.

As cartography in the U.S. has developed, there has been a growing concern about the cognitive element in maps (Ratajski, 1978). Cartographers familiar with the earlier psychophysical investigations of cartographic symbolism are again turning to psychology to find a means to analyze a cartographic problem. Under the guidance of Barbara Petchenik and Judy Olson, cognitive theory in the U.S. has emerged with broader concerns and holistic assumptions concerning the mental processing of map elements. Petchenik (1975) attacks the unit by unit basis of a linear sequence of knowledge acquisition preferring a simultaneous complex, gestalt comprehension of visual stimuli at several levels. Judy Olson (1979) adds that a cognitive approach is a concern about categories, images, and ideas rather than a behavioral orientation about responses and reinforcements. One difficulty of cognitive research is that cognitive processes can only be observed indirectly and most studies must be time-oriented in order to discover the order of mental processing if it has occurred at all.

There is a direct association between cognitive theory and a concern with the cartographic transmission of meaning. Barbara Petchenik writes,

> We must be concerned with meaning in cartography to an extent far greater than that to which we have been in the past. If the function of a map is to trigger meaning, then meaning becomes all important (Petchenik, 1975, p. 185).

An important aspect of meaning is context. Context and meaning are inseparable. Unless a map user can comprehend the context of a graphic symbol in a map, the symbol will have little or no meaning. The possible difference in meaning of a graphic symbol in the context of a public sign or cartographic symbol cannot be overly stressed.

The above approaches to the examination and understanding of cartographic communication are not always distinct and separable components in a research problem. As a carrier of information and several modes of meaning, a map entails semiotic, modelling and cognitive implications (Ratajski, 1978). For the present study, the fundamental difference of approach between information theory and cognitive theory is important. In other words, the cognitive concern with changes in transmitted meaning will be emphasized rather than the flow of information as is information theory. The communication effectiveness of the NPS signs as cartographic symbols is best examined from a cognitive perspective for several reasons: (1) graphical symbols are not only links in an information channel but modes for the release of meaning; (2) a holistic approach provides a more practical and direct examination than intellectual exercises which attempt to discover new relationships by inventing terminology for qualitative entities; and (3) the communication mode of a symbol is usually not taken into account using more traditional approaches (Figure 1).

IV. CARTOGRAPHIC EVALUATION, THE COMPONENTS FOR ACCESSING QUALITATIVE SYMBOLOGY

IV. CARTOGRAPHIC EVALUATION, THE COMPONENTS FOR ACCESSING QUALITATIVE SYMBOLOGY

Cartographic products have been analyzed using nearly every conceivable method. Examinations span a continuum from descriptive commentaries of maps as works of art to mathematical analysis using computers to process numerical variables. To understand the structural components of the present study, a review of several methods of evaluation is necessary. Because Qualitative Symbolism is an uncharted frontier and its nature nebulous in character, traditional research approaches alone will not provide meaningful answers for cartographic problems.

Two major approaches to cartographic evaluation are: (1) task-oriented investigations and (2) surveys of map use and map user requirements (Robinson, 1977) (A. Morrison, 1975). The task-oriented investigations borrow heavily from the research procedures of psychology while user surveys borrow sampling techniques from sociology. In some cases, a grey area exists between the two approaches. For example, a symbol preference test requires a subject to select a symbol in responding to a questionnaire about map user requirements (Epp, 1978).

Due to the complexity of evaluating cartographic products, cartographers should use hybrid approaches for more complete investigations. Scientific cartographers should not hold to an illusion that verbal descriptions have no role in modern methods of cartographic evaluation. Cartographers should seek diversity in cartographic evaluation because the look of a map is the result of artistic, technological, functional, and conceptual variables (Petchenik, 1974).

CARTOGRAPHIC INVESTIGATIONS AND EXPERIMENTAL PSYCHOLOGY

Psychophysical testing procedures borrowed from psychology have been the basis of many cartographic investigations. Areas of investigation include: (1) the perception of graduated symbols such as circles, squares, and ellipses, (Flannery, 1971; Crawford, 1973; Jenks, 1975; Olson, 1975; Carlyle and Carlyle, 1977; Dodson, 1980); (2) the perception of dot map distributions, (Olson, 1975, 1977); (3) the influence of eye movements during map reading, (Jenks, 1973; Steinke, 1973); (4) the effect of irradiation on the perception of map symbology, (Greenberg, 1971) and map complexity studies comparing perceptional variables against mathematical measures of visual complexity, (MacEachren, 1982).

The psychophysical studies try to isolate various factors of map reading in a controlled test situation. Graduated symbol studies were the first studies of this kind because of the ease of extracting point symbols from a map context and the ease of examining a relationship between a quantitative value for a symbol and the perception of that symbol by a map user. Researchers have found that map users generally underestimate the value of a graduated circle. To improve the perception of a graduated circle, rescaling formulae have been applied to the construction of graduated circles. The accepted psychophysical function in use is $R = KS^{X}$ where R is the response or estimated quantity, S is the stimulus or actual quantity, K is a linear constant dependent on the units of measurement used, and X is the power constant determined from user testing (Olson, 1977).

Most psychophysical studies of quantitative symbols have been done outside of a map context. These have come under attack because of the uncertainty of extrapolating the results to a real map reading situation (Board and Buchanan, 1974). The most convincing results are those which include the evaluation of cartographic symbolism both outside and inside a realistic map situation. Without testing in a map, many factors such as those of eye flow and visual clustering would be ignored (Gilmartin, 1981a).

Another example of a potential factor influencing the design and selection of point symbols is the factor of irradiation (Greenberg, 1971). Irradiation is a visual illusion where light images against a dark background appear larger than they actually are. The detectability of the NPS symbols with white forms on black grounds may be enhanced by the irradiation factor. Psychophysical testing of the irradiation factor would be less than complete without the use of a test map.

Maps in Memory Studies

Although some cartographers have been guilty of not using maps in their investigations, the psychologists have not (Thorndyke and Stasz, 1980; Tversky, 1981). The memory studies of the psychologists have spawn innovative uses of maps for purposes beyond most cartographic interests. The psychologists have been acquiring knowledge about mental processes and individual differences rather than seeking to improve a visual cartographic product (Olson, 1979). Among the subjects of study are recall and recognition memory. These two types of memory may have some bearing on the results of the present study. Recall memory is accessed by an individual when he or she is asked to produce some information previously stored in memory while recognition memory requires a person to determine whether some stimulus (or object) has been seen before and to identify that stimulus (Loftus and Loftus, 1976). The test procedures of the recall studies generally follow this format: (1) show stimulus map to subject, (2) remove map, (3) ask questions or task to be performed, and (4) analyze memory performance based on the degree of recall (Thorndyke and Stasz, 1979;

Gatrell, 1980; Cole, 1981).

When designing a test map it is important to consider research findings related to real and artificial maps. For example, in a series of experiments, Barbara Tversky (1981) found two factors that facilitated the memory of absolute location of visual forms: (1) alignment, the relative location of figures to each other; and (2) rotation, the relative location of figures along directional axes, north-south or east-west. Test maps for a qualitative study, therefore, should probably avoid the positioning of symbols other than at a horizontal angle and avoid unconventional directional orientations for the map sheet.

Other memory studies reveal additional factors to consider when creating a test map. In a unique map format, Anthony Gatrell (1974) designed a map jigsaw experiment to evaluate the complexity of visual forms. Like many cartographic problems, the study finds map complexity to be a multidimensional phenomenon. Cartographers should consider unconventional map formats and their use so that new and innovative ways of examining cartographic problems might be found.

Most of the memory studies conclude with findings concerning the various mental schemata and learning strategies of individuals. For example, Thorndyke and Stasz (1980) found six learning procedures operating among their subjects in several map memory tests. The learning procedures were: (1) partitioning, the concentration on subsets of map information; (2) imagery, the focusing on frames such as county boundaries; (3) directed sampling, the selection of elements that will be most difficult to recall; (4) pattern encoding, the focusing on visual shapes and clusters; (5) relation encoding, the concentration on the recall of relationships between map elements; and (6) evaluation, remembering visual elements by assessing their worth or value.

Thorndyke and Stasz measured an ability called field - independence. The ability is measured by having subjects locate simple figures within a complex design. Individuals who overcame the visual context and easily found the figures are said to be field independent in their perception of graphical forms. Field independence would not be a practical ability to test in a Qualitative symbol study. Few cartographers could hope to tailor special-purpose maps and symbology to users having or lacking this specific ability. In addition to differences in ability, the experimenters found subject differences in processing procedures and of prior knowledge related to the task. All these differences can be reflected in a map user's performance.

Because of the cartographic goal to improve a map product, factors influencing subject performance should be accounted for when designing tests to examine symbol effectiveness. Rather than simply accounting for these subject-related variables, some cartographers forget the cartographic problems at hand and try to unravel the details and mysteries of human thought processes (Olson, 1979). Although the psychologists offer insights into individual abilities and learning procedures, most findings cannot be directly applied to solving cartographic design problems. For example, map products cannot exist specifically for users who are field-independent and use a partitioning strategy to recall map elements. Also, most of these studies concentrate on the recall of a location or pattern and not, as in the present study, on the ability to recognize a cartographic symbol in a map previously seen in a legend. The problems of examining human memory processes and the ability to perform map reading tasks, given a specific set of symbols, are quite different.

The Processes of Map Reading

There have been many attempts by cartographers to identify the perceptual and cognitive processes involved in map reading (Keates, 1972; Wood, 1972; Olson, 1976; J. Morrison, 1976, 1978). John Keates writes,

> If the conventional sign approach is inadequate, are there any other possibilities? To look for a possible answer, it is desirable to inquire more closely into the method by which the map user extracts information from the map; that is how he deduces meaning from graphic forms (Keates, 1972, p. 77).

Michael Wood adds,

> The ... experimental approach seeks to examine the ways a user searches for, detects, and recognizes the coded symbols on the map - the first step toward the understanding of human information processing...visual search is only superficially considered by cartographic workers (Wood, 1972, pp. 126-127).

According to John Keates (1982), several processes need to be examined in the search for better map symbolism. He calls the first process, detection; the second, discrimination; and the third, recognition or identification, where a map symbol is matched against a mental vocabulary and/or a map legend if it has been provided.

In contrast Joel Morrison (1976,1978) identifies three tasks and four processes used in map reading and analysis. The map reading tasks are search, locate and identify. The processes involved are : (1) detection, or discovery of information; (2) discrimination, the awareness of differences between map symbols; (3) recognition, the identification of a specific symbol plus a comprehension of distinct information about the target symbol; and (4) estimation, or value judgement of a symbol's characteristics in terms of amount or size. In terms of qualitative symbolism, estimation can only be a value judgement in terms of importance or worth and not in terms of a numerical entity. Morrison makes a further distinction between map reading and map analysis. Map reading takes place in the communication channel while map analysis occurs within the cognitive realm of the map reader.

Phillip Muehrcke (1974) takes another view and writes that symbol identification, positional location, and navigation constitute the essence of map analysis. It appears that the line between map reading and map analysis is not always clear nor is the line distinct in all cases between the perceptual and cognitive processes involved. Symbol identification, the focus of the present study, bridges both lines.

Other cartographers see different stages, processes or tasks used in map reading. For example, Henry Castner

(1979) outlines five stages of map reading: (1) the appearance of forms; (2) the discrimination and identification of the symbol; (3) the processing of information; (4) the editing of the image; and (5) the making of a decision. The resulting schema is much broader than that proposed by Morrison.

From a different perspective, Judy Olson (1976) identifies three map reading tasks to use in map evaluation. The tasks are: (1) comparison between individual symbols, as in the graduated circle studies; (2) comparison between symbol groups as in the visual clustering studies of George Jenks (1975) and (3) analysis of symbol-referent relationships as witnessed in the present study. Olson's tasks are very similar to the semantic-syntactic areas of semiology.

The foregoing discussion illustrates the reductionist nature of much of the research being conducted in cartography and psychology from psychophysical investigation to memory studies to the identification of the perceptual and cognitive processes of map reading. Each of these previous studies has contributed to the present study in the following ways: (1) more holistic approaches are needed to break new research frontiers, (2) maps should be used in cartographic testing, (3) symbol identification is a task that bridges both perceptual and cognitive processes of map reading, and (4) the distinction between recognition and recall based tasks of map reading must be made.

QUALITATIVE SYMBOL STUDIES

There have been few qualitative symbol studies of note. None has the special research and testing orientation of the present study on NPS symbols.

Qualitative Symbols in a Thematic Map

John Kilcoyne (1974) conducted a study in which he compared the communication efficiency of press-on point symbols in the context of a thematic map of Illinois. The study's stated goal was to test the effectiveness of pictorial symbols against more commonly used geometric symbols. However as the study unfolds, Kilcoyne's attention shifts to the influence of grey tone backgrounds on the amount of time required to read symbol displays. The concern of background tones as noise in communication falls clearly in the realm of information theory.

Kilcoyne attaches little importance to symbol-referent relationships. The thirty pictorial test symbols were selected on the basis of recognizable ratings given by only ten test subjects. This selection process highlights the difficulty of choosing test symbols when no standards exist. Kilcoyne does not elaborate on the conditions of the selections, but it can be assumed that the symbols were examined outside of a map environment. The twenty geometric test symbols were not given the same scrutiny as the pictorial symbols and were simply selected on the basis of availability on a press-on sheet.

Although Kilcoyne uses a test map, the test is no more realistic than testing outside of a map context. After removing all information except the pictorial symbols and rearranging the actual spatial distribution, Kilcoyne's test maps are merely symbol arrays in the shape of Illinois. Little information is given about the testing procedure - who was tested; how many tests were conducted; or the map reading tasks assigned. Other than a measure of accuracy based on speed of counting target symbols, Kilcoyne's various measures of efficiency are not clarified.

Kilcoyne concludes that given different background tones pictorial symbols consistently out-perform geometric symbols. He also found that symbol performance was best using undifferentiated white backgrounds. In accordance with Kilcoyne's findings, the test maps of the present study show symbols on undifferentiated white backgrounds to avoid background noise in cartographic communication.

Qualitative Symbols in Topographical Maps

R. M. Taylor's (1975) study of qualitative symbols in topographical maps is the most direct and comprehensive application of information theory to the evaluation of qualitative symbology. Believing that the binary system of measurement used in information theory is a valid approach to map evaluation, Taylor derives several mathematical measures for the communication effectiveness of qualitative data. The measures are: (1) the mean amount of information transmitted, and (2) the mean number of correct user identifications. Previous to Taylor's study, qualitative analysis based on information theory had been limited to information content measures such as bit counts. Taylor's study is important for two reasons: (1) first, it shows that qualitative symbols can be objectively tested; and (2) second, it presents a direct application of information theory to the evaluation of symbol performance.

Basic to symbol evaluation is symbol comparison.

Taylor suggests three rules: (1) comparisons should be made in a real map context; (2) comparisons should be restricted to a representative sample of symbols with specified associated meanings; and (3) the examples tested should be clearly specified to avoid detection failures (Taylor, 1975).

The present study uses a realistic test map, a standard symbol system, and symbol legends to comply with Taylor's rules.

Taylor tested qualitative symbols on topographical maps in the context of their use for high speed, low altitude flight. Taylor and Board (1977) comment,

> In high-speed flight at a low altitude there is little time to verify anything but the pilot's mental map. Similar problems face the motorist driving at high speed and in heavy traffic (Taylor and Board, p. 23).

The test was similar to a Skinnerian pigeon test. The test procedure was as follows: (1) test maps at a scale of 1:250,000 were showed on a projected display, (2) point, line, and area symbols were masked on a key map, (3) subjects were asked to read the number of a mask, (4) locate the mask on the key map, (5) match the masked area to an unmasked map, (6) refer to a map legend, and (7) push a button to identify the masked symbol. Response time was recorded automatically for 27 trials. Original and new symbol designs were tested and compared by this procedure. Taylor used two groups of 24 male subjects.

Like Kilcoyne (1975), speed of task performance was considered an important indicator of symbol efficiency; but unlike Kilcoyne, Taylor also analyzed identification errors. The present NPS study will use the number of alternative identifications for a symbol from an official standard as an indicator of symbol performance and communication effectiveness. For a cognitive investigation focused on symbol meaning, knowledge of a mental legend's content is more important than the speed and processes of accessing the mental legend.

Repeating Point Symbols to Highlight Linear Routes

Harry Epp's (1978) study of repeating point symbols to highlight thru-streets on large scale urban maps has implications for better qualitative symbol design. Before summarizing his study, a correction in terminology is needed. Epp calls his line types pictographic symbols when they are actually linear formats of repeating geometric point symbols.

For his study, Epp contructed test maps and overlays of the Washington, D.C. street network. Subjects were given a base map to study for 20 seconds followed by an overlay of a thru-street to study another 20 seconds. Test materials were then removed and subjects were asked to trace the route on a blank map. Epp solicited additional information by means of a questionnaire asking subjects for personal data and symbol preferences. All twenty-five subjects had driver's licenses and none were college students. Of the four test symbols, a star, a square, a diamond, and an asterisk, the asterisk and the star performed best. In many studies, star-like symbols consistently outperform other symbol forms. Whenever possible, symbol systems should include variations of this graphic form.

Epp analyzed the response maps by rating the traced routes as correct, correct within one block, or lost. The results indicate that the use of repeating point symbols to highlight thru-streets is an effective aid for urban map users. Graphic contrast achieved by varying symbol form improves cartographic communication when keyed to a specific use.

Computer-Compatible Map Symbology for Large-Scale Engineering Maps.

A study by Robert Jacober, Jr. (1979) illustrates the need for computer-compatible map symbology for engineering applications. Jacober approaches the problem by reviewing the engineering symbology currently in use. The stated goal of the study is to develop a standard symbology for the map scales ranging from 1:200 to 1:5000. Although Jacober uses no subject testing, analysis of the symbols themselves leads to specific recommendations. Jacober recommends the use of U.S.G.S. map symbols where possible and the voluntary use of the symbology established by the American National Standards Institute. Acceptable symbology must also be easy to adopt to computer graphics. Due to the growing use of computer graphics, cartographic studies of all kinds should give some consideration to whether the symbology being evaluated is computer-compatible.

Learning Positional Information From Maps

The final qualitative symbol study of note is a study by Dr. Joseph Shimron of the University of Haifa in Israel (1978). The study is representative of research based on cognitive theory. Shimron's concern is to investigate the psychological processes involved in learning positional information from maps. Positional information is a specific type of learning which can be accessed via tasks or questions dealing with the positions of symbols on a map. For example, cardinal direction can be sampled via a task such as: "Name the most northern city."; proximity can be sampled via a task such as: "Which city is between Humbolt and Maysville?"; and categorial sets of items can be sampled via a task such as: "Name two cities on Route 5." Although the present study uses map reading tasks similar to Shimron, the studies differ in one important aspect. Shimron's study focuses on the recall of positions to determine the psychological processes involved in learning positional information, while the present study focuses on the recognition of cartographic symbols and the identification of their associated meanings.

Shimron's test map is shown in figure 14. Cities and highway numbers served as target clues. He conducted three experiments to assess: (1) the order of the acquisition of information, (2) the impact of learning category-by-category as opposed to learning section-by-section, and (3) the effect of storytelling and map copying as aids in learning positional information (Shimron, 1978).

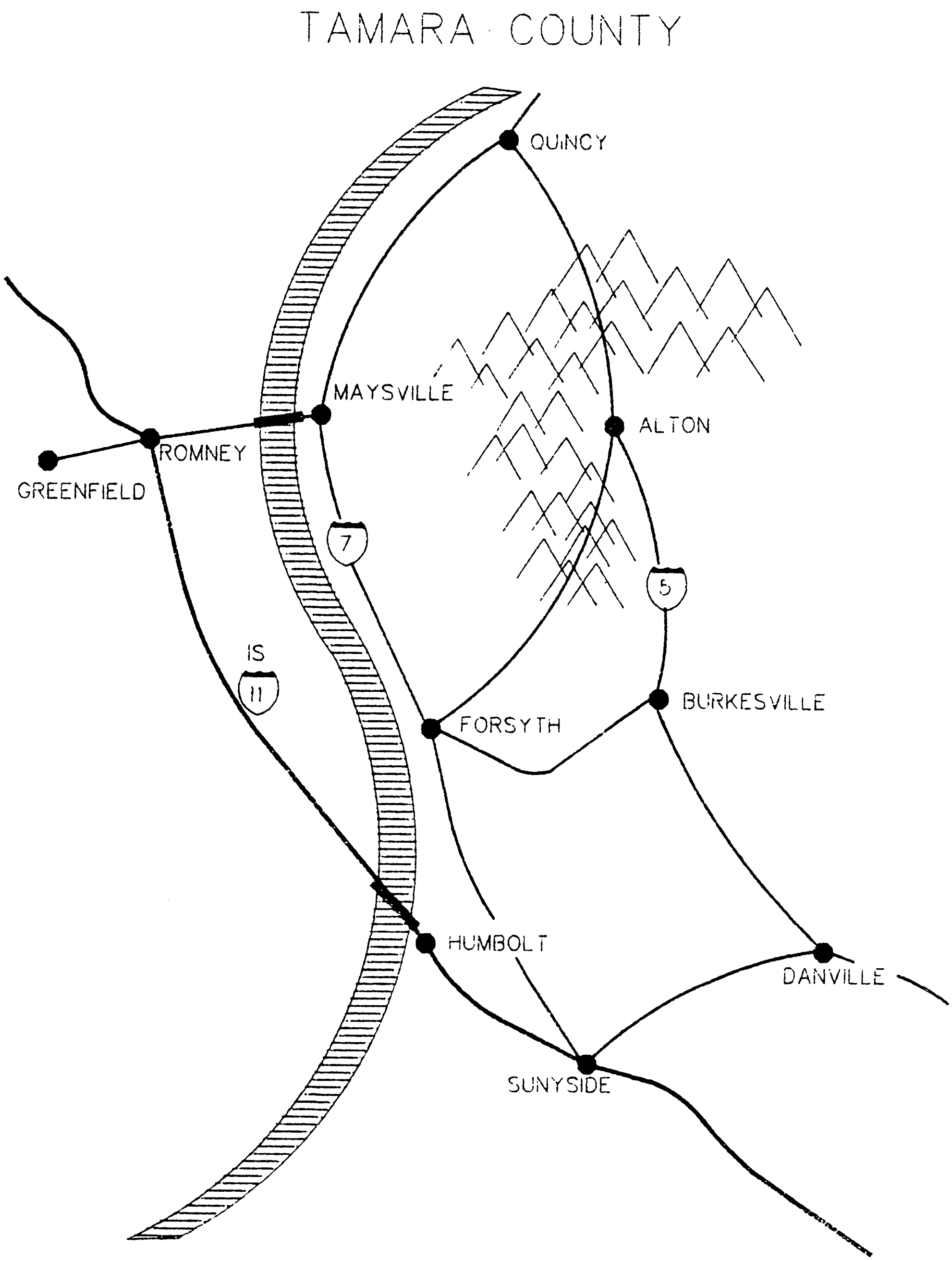


Figure 14. Joseph Shimron's (1978) Test Map.

In the first experiment concerning learning by themes, Shimron used two groups of subjects; an unlimited time group of 14 college students and a limited time group of 13 college students. The unlimited time group studied the test map for approximately twelve minutes before answering twenty-three questions. Answer sheets were provided in a book format. Subjects were required to turn the answer sheets simultaneously while the questions were presented orally. Shimron does not say how long it took to perform this procedure.

The test procedure for the limited time group varied only in the length of time allowed to study the test map. Subjects were given 6 rather than 12 minutes for map study. Shimron discovered: (1) that limiting time did not effect memory of local connections between cities; (2) that limiting time did not hamper the identification of the most remote cities; (3) that cities were better positional clues than highway numbers; and (4) that the general order of learning positional information proceeds from local connections to the learning of more comprehensive integrative networks of information.

In the second experiment, two new groups of subjects were presented test maps with different data layers overlayed at 3 minute intervals. The maps differed by showing information either by item categories or by map sections. Subject response indicated that the section-by-section presentation of information demanding the learning of a multischematic configuration simultaneously was easier to learn than the category-by-category presentations. For cartographers who are often faced with layered data in the form of map flaps or digital files, it an important finding to discover subjects having difficulty with layered information. If map users are to be their own cartographers in a computerized age, the concept of layered data is fundamental to effective map use.

The third experiment tested the effect on memory of increasing the number of associations between map elements. This was accomplished by presenting a map with a story. Shimron finds that verbal associations facilitate the organization and acquisition of map information for most subjects.

The present study draws heavily from Shimron. Emphasis is placed on the identification of symbols via tasks similar to Shimron's. Identification by cardinal direction, proximity and categorical sets of items is the basis of evaluation rather than the amount of time or psychological processes involved in human learning and memory. The identification of point symbols by asking positional questions provides a means to analyze the effectiveness of the symbol-referent relationships within the pictorial sign/symbol system of the National Park Service.

Important contributing factors to the present study from the foregoing qualitative studies are: (1) use undifferentiated white backgrounds on test maps; (2) test in a realistic map environment; (3) use legends and standard symbol systems in testing; and (4) consider symbol designs that are computer-compatible.

USER SURVEYS

User surveys provide an important tool for evaluating cartographic products. The surveys are usually based on responses to a questionnaire. The results of these questionnaires provide useful guidelines for the design of test maps.

Surveys by Joseph Mason (1975) and R. W. Astley (1969) indicate the need to symbolize new kinds of data on road maps. The Mason survey of American motorists using the interstate highway system found that motorists wanted more accessible information on gas stations, food and lodging. In addition, American motorists requested multipurpose information centers along the highway and emergency roadside phones. In a similar survey of road users in Great Britain, Astley found a strong desire to have 24-hour service stations, eating places, hotels, hospitals, and public toilets marked on travel maps. The British users did not want rivers, railways, churches, and ancient monuments to clutter their maps.

The Jacqueline Anderson (1977) survey of the 1974 Official Map of Alberta revealed that 80% of the map users consulted the map legend. It is uncertain whether they did so because of map reader sophistication or inadequate map symbolism. The Canadians saw little use for dams, city elevations and administrative boundaries to be shown on their maps. They desired, instead, inclusion of 24-hour restaurants, gas stations, historic sites and radio frequencies.

The failure to provide the desired map symbolism is matched by a lack of certain special purpose map products. A general survey conducted by R.P. Kirby (1970) found a need for single-sheet historical maps, improved road maps, and leisure maps.

Most surveys reveal that users want more detail than is possible to show given the map scale. However, Sheppard and Adams (1971) found that British drivers preferred Phillip's Road Maps to Ordinance maps because they were clearer, showed less detail, were easier to read having plain backgrounds and no disconcerting contours.

Although often contradictory, user surveys provide important feedback for cartographers, the insight provided can in many cases be more easily applied than the knowledge gained through psychological testing. A union of the two methods is essential for more complete communication from map users to cartographers. In order to design maps for people, more extensive survey and testing studies are needed to identify what map formats and symbology are required for special purposes.

V. PRINCIPLES OF GRAPHIC DESIGN

V. PRINCIPLES OF GRAPHIC DESIGN

A cartographic study of map symbolism such as the present one is molded by three major factors: a theoretical basis and organization, a research methodology, and principles of graphic design. Graphic Design encompasses the artistic element of cartography. The pictorial nature of the NPS signs makes artistic factors important to the outcome of the present study. With the growth and development of scientific cartography in this century, cartographers have been guilty of neglecting the art in maps (Karssen, 1980b). Increasingly graphic artists have been utilized to meet the demand for symbols and maps that are visually effective. The visual presence of graphic artists is seen in the public pictorial sign systems and in television news maps. To the dismay of cartographers, map function has often been sacrificed by graphic artists in attempts to stimulate the visual thinking of an audience. Cornelis Koeman (1971) writes,

> The distinction between the graphic artist and the cartographer (is) the latter is forced to think functionally, while the first creates according to his artistic judgement (Koeman, 1971, p. 174).

In reality, the distinction is not so clear. While the graphic artist seeks to stimulate visual thinking, the cartographer seeks symbology that matches as nearly as possible the mental legends of an audience. Visual thinking and effective cartographic communication are not mutually exclusive. The accomplishment of either objective requires an understanding of the cultural realities affecting an intended audience.

In the search for principles of good graphic design, the functional orientation of the cartographer can benefit from the artistic consciousness of the graphic artist. Cartographers need to become more aware that functional maps need artistic elements to be good maps and graphic artists should awaken to the reality that good graphics may not be well designed if functional factors are discarded.

Several design principles emerge from the literature of cartographic and graphic design. These principles are important when creating symbols and maps, evaluating cartographic products, and analyzing the results of subject testing and user surveys. Scientific cartographers should supplement their rigorous investigations with verbal descriptions concerning the artistic factors influencing the maps, symbology, or user responses under their scrutiny.

Symbol Design

Useful but sometimes contradictory principles of symbol design emerge from a consideration of the literature.

Arch Gerlach (1971) gives three symbol design principles: (1) use meaningful symbols, (2) avoid large pictorial symbols which give maps an elementary appearance, and (3) use widely accepted symbols to assist rapid visual recognition. The problem in many cases is that the cartographer does not know which symbols are meaningful and widely accepted by an intended audience.

Art Karssen (1980a), a cartographer who is concerned about what he terms the lost art of cartography writes that good maps can only be designed by cartographers with adequate graphic-artistic talents. He adds that clarity is the key to the recognition and identification of a graphic element and that clear, easy to recognize symbols, with simple graphic shapes are a prerequisite for good design. The Karssen design principle requiring clear, but simple, shapes is an inadequate criterion for assessing the object-related symbols of the National Park Service. The NPS signs do not have simple shapes; but nevertheless, may be clear and easy to recognize.

In contrast to Gerlach, Jerry and Wieslaw Ostrowski recommend the use of pictorial signs for point symbols,

> For objects located at points the use of symbolic or pictorial signs seems to be the best solution. Some editorial forms use, however, geometric signs taken without any reason, leading thus to various difficulties in using the maps. The choice of some signs can be substantiated by their common use beyond the cartography (1975, p. 127).

A more complete list of symbol design principles is provided by Gerald McGrath (1967): (1) a symbol should be of simple design, (2) a symbol should bear a close relationship to the feature it portrays, (3) confusion should be avoided by using a symbol for only one feature, (4) a symbol should be precise in its meaning, without there being a need for accompanying notation, and (5) a symbol should be easily perceived in terms of size, color and background.

A complementary list of traits for good symbols is given by Gregg Berryman (1979), a graphic artist. A symbol should have: (1) positive association, (2) easy identification, (3) closed gestalt, (4) negative space, (5) symbol weight which aids internal eye flow, and (6) graphic characteristics such as trapped white space which focuses eye flow. The testing configurations of the present study consider how well the NPS signs adhere to the above principles and the possible effect of each principle on the effectiveness of the NPS symbols.

Travel Map Design

To design an appropriate test map, it was found necessary to consult the cartographic literature for principles helpful in the map's creation. It was discovered that the design of travel maps has not been a top priority of cartographers. Since the advent of America's most popular travel map, the highway map, at the beginning of the 20th century, travel map design has been largely based on the public image goals of the large oil companies (Bay, 1952). If a map was evaluated, it was usually assessed in terms of sales and distribution and not in terms of graphic design. Only rarely has consumer research been conducted for travel maps. Cartographers had little input in overall design other than in technical knowledge concerning limitations of materials and processes used in map production. Many articles on travel map design continue in this tradition and consist merely of descriptions outlining map production processes (Gatrell, 1966).

Altair Morrison's surveys (1966, 1971, 1974, 1975, 1980) evaluating the design effectiveness of road speed maps are examples of the consumer research approach. Consumer surveys are important elements of cartographic evaluations directed towards creating map products based on human factors engineering. The survey-questionnaire approach should not be neglected in searching for hybrid methods of cartographic evaluation for complex subjects such as qualitative symbolism. Before the advent of Scientific Cartography, traditional design approaches could reveal only one conclusive design principle - a map should be clear and all graphic elements united to form a balanced integrated whole.

VI. EVOLUTION OF A QUALITATIVE SYMBOL STUDY

VI. EVOLUTION OF A QUALITATIVE SYMBOL STUDY

The foregoing look at cartographic theory, cartographic evaluation and graphic design provides a context within which the present study can be placed. Based on these considerations, this evaluation of the National Park Service sign/symbol system: (1) is largely cognitive in scope; (2) is a task-oriented investigation borrowing from both map reading tests and surveys of map use; (3) focusses on the map reading task of symbol identification; (4) deals with positional information in a map context; and (5) takes into consideration artistic elements in the design of map symbology. Over time, specific testing methods developed within the context of the above orientations. The following chapters outline that development.

The present study has evolved over a period of three years. It first attempted to address the larger issues of cultural influences on the cognition of graphic forms and universal meaning. It was soon discovered that the controls necessary for isolating cultural factors in an experimental situation were an impossible undertaking. Through many twists and turns the present study focusing on the National Park Service signs as cartographic symbols has emerged.

Only one original objective has remained - The evaluation of qualitative symbolism by experimental tests both in and out of a map context.

The first testing phase was conducted in the Spring of 1981. Table 2 shows the testing configuration of this early study. The test was based on the selection of ten categories (figures 15 and 16) of information that travellers found desirable to have marked on their maps. These categories were determined from user surveys conducted in Great Britain and the United States (Astley, 1969; Mason, 1975). The test symbols were selected from compiled lists of symbols found on state road maps, in public pictorial sign systems, and on maps published by major cartographic firms such as Rand McNally, the American Automobile Association, and the National Geographic Society. Four symbols representative of each of the ten categories were selected from the symbol lists. In some cases, the selection of four test symbols, representative but of different form, was relatively easy; in other cases, major variations in form did not exist. The most variation of form was found on the official state highway maps while the least variation was found on the maps of the large mapping firms where some standardization has occurred. In addition, abstract information such as "place of interest" had many

Table II. The Symbol Preference/Test Configuration

Test Factors	Description
Cartographic Element Tested:	
	Qualitative Point Symbols
Type of Point Symbol:	
	Geometric and Image-related symbols from: 1. road maps, and 2. public pictorial sign systems
Test Materials - Mode of Presentation:	
	1. Four 8-1/2 x 11 test sheets with 10 categories of information. Positioned next to each labelled category were four representative symbols. Symbols were presented by four different arrangements to eliminate bias of order (figures 15 and 16). 2. Answer sheet with instructions and one blank for each category (figure 17).
Experimental Session:	
	1. Each subject received a test and answer sheet. 2. Subjects were asked to mark on the answer sheet an identifying letter for the symbol that best represented each category. 3. To insure correct correspondence between answer and test sheet, subjects were also required to mark test sheet identification letters on the answer sheet.
Testing Time:	
	Subjects given unlimited time took on average five minutes to make their selections.
The Sample:	
	100 college students from introductory history and geography classes at Virginia Polytechnic Institute and State University.

Figure 15. Test Sheet WZF of the Symbol Preference Configuration.
(60% reduction of the original).

Figure 16. Test Sheet DKL of the Symbol Preference Configuration.
(60% reduction of the original).

Identification Letters __________

Mark the symbol that best represents the category. Please do not change your first response.

1. __________
2. __________
3. __________
4. __________
5. __________
6. __________
7. __________
8. __________
9. __________
10. __________

What is your major?

Figure 17. Answer Sheet of the Symbol Preference Configuration.
(60% reduction of the original).

graphic forms mostly geometric in character. For information not traditionally represented, such as eating establishments, some graphic representations had to be taken from the public pictorial sign systems.

Several difficulties emerged from the symbol preference test. First, the forced-choice structure of the test limited subject selection for a category to only four graphic forms. As a consequence, the results of the test can only indicate which symbol among four was best, worst, or as good as the others (Figure 18). Second, since no map reading task was clearly identified, no firm conclusions can be made or inferred either graphically or conceptually as to why some symbol forms were preferred over others. And third, the unsystematic mixing of geometric and image-related symbols taken from various sources produced no graphic standard from which to evaluate symbol effectiveness.

This early test was valuable for providing several guides for future testing: (1) avoid a force-choice test structure (figure 17) in order to give subjects as much latitude as possible in test responses; (2) clearly identify the map-reading task to be tested; (3) use a standard symbol system as a testing standard and avoid

Figure 18. Results of the Symbol Preference Test.

mixing symbol kinds; and (4) use a map legend for realism and to establish a decision criterion for test subjects similiar to those in effect during actual map reading (Shortridge and Welch, 1980).

VII. THE SYMBOL/LEGEND TEST CONFIGURATION

VII. THE SYMBOL/LEGEND TEST CONFIGURATION

The symbol/legend test was designed and conducted in the Spring of 1982. It was designed to simulate actual map reading situations where a map user must identify symbols with little or no access to a map legend. Good symbols should convey accurate information to map users in the absence of a legend. The test objective was to find those NPS symbols that can have other or alternative identifications to those assigned and, as a consequence, find which NPS meanings are difficult to remember. It is assumed that symbols and meanings easy to remember are accepted by a user and probably match closely to symbolic conventions previously learned. Symbol identification is fundamental to any map reading process and is a bridge between the perceptual and cognitive realms of a map user. Identification includes: (1) feature extraction, and (2) template matching against a map legend and/or a mental legend (Claus and Claus, 1974). Subject response is usually a joint function of a perceptual sensitivity and a decision criterion.

The symbol/legend test is best described as a simple matching test where subjects match symbols with standard referent meanings. Assuming that most maps are presented with a legend and that map legends are used by map users, the subjects were presented a legend of 30 NPS symbols and their official meanings. Following a brief period of study, the legend was removed and subjects were asked to match the 30 symbols against the 77 possible NPS symbol meanings (Table III). The identification list was provided to examine problems of semantics within the NPS sign/symbol system.

In the symbol/legend test, the task of symbol identification is examined outside of a map context so that the results might be compared to those of testing in a map environment. By comparing the results of the symbol/legend and symbol/map tests of this study some insight might be gained as to which method is best or how each method contributes to an evaluation of qualitative symbology.

TEST DESIGN

Symbol Selection

Thirty symbols were selected from seventy-seven pictorial signs of the National Park Service. Symbol selection was based on user surveys which indicated what information users desired to have marked on travel maps

Table III. The Symbol/Legend Test Configuration

Test Factors	Description
Cartographic Element Tested:	Qualitative Point Symbols
Type of Point Symbol:	Pictorial Signs of the National Park Service
Test Materials - Mode of Presentation:	1. Three 8-1/2 x 11 legend sheets with 30 symbols and their official meanings arranged in two columns. The Symbols were presented by three different arrangements, identified by the first element in each as: a. the marina arrangement b. the campground arrangement, and c. the ski-bobbing arrangement 2. A randomized identification list 3. Thirty response cards
Experimental Session:	1. Each subject received a test packet with a legend sheet and a smaller envelope containing an identification list and test cards. 2. Subjects removed the legend and studied it for two minutes. 3. When time was called, subjects returned the legend sheet to the packet and opened the smaller envelope. 4. Subjects identified the test symbols by writing the number corresponding to a referent meaning on the response cards.
Testing Task:	Symbol Identification
Testing Time:	A two minute time period to review the legend plus fifteen minutes to perform the tasks.
The Sample:	100 college students from introductory geography classes at the University of North Carolina at Greensboro.

(Astley, 1969; Mason, 1975). Selection was also based on an attempt to examine two potential problem areas: (1) symbol to symbol comparison, where graphical forms with different meanings are not easily distinguished; and (2) cognitive meaning, where forms do not correspond to intended meaning for easy identification.

Test Materials

Legend sheets, identification lists, and response cards were designed for the symbol/legend test (Table III). Test symbols 5 mm. in size were arranged in two columns on a legend sheet. Figures 19 - 21 show the three different legend sheets designed to negate possible bias of order. An identification list of seventy-seven choices (Figure 22) was compiled to provide subjects with a criteria range. The seventy-seven referent meanings were taken from the official meanings of the National Park Service. The choices were numbered so that subjects would refer to specific labels on the identification list. Preliminary testing without numbered identifications indicated that many subjects did not refer to the list. The desire was not to simply test subject recall but to find accepted symbol-referent relationships among a fairly homogeneous population. Thirty 1.5 x 2.5 cards each with a test symbol and a blank were

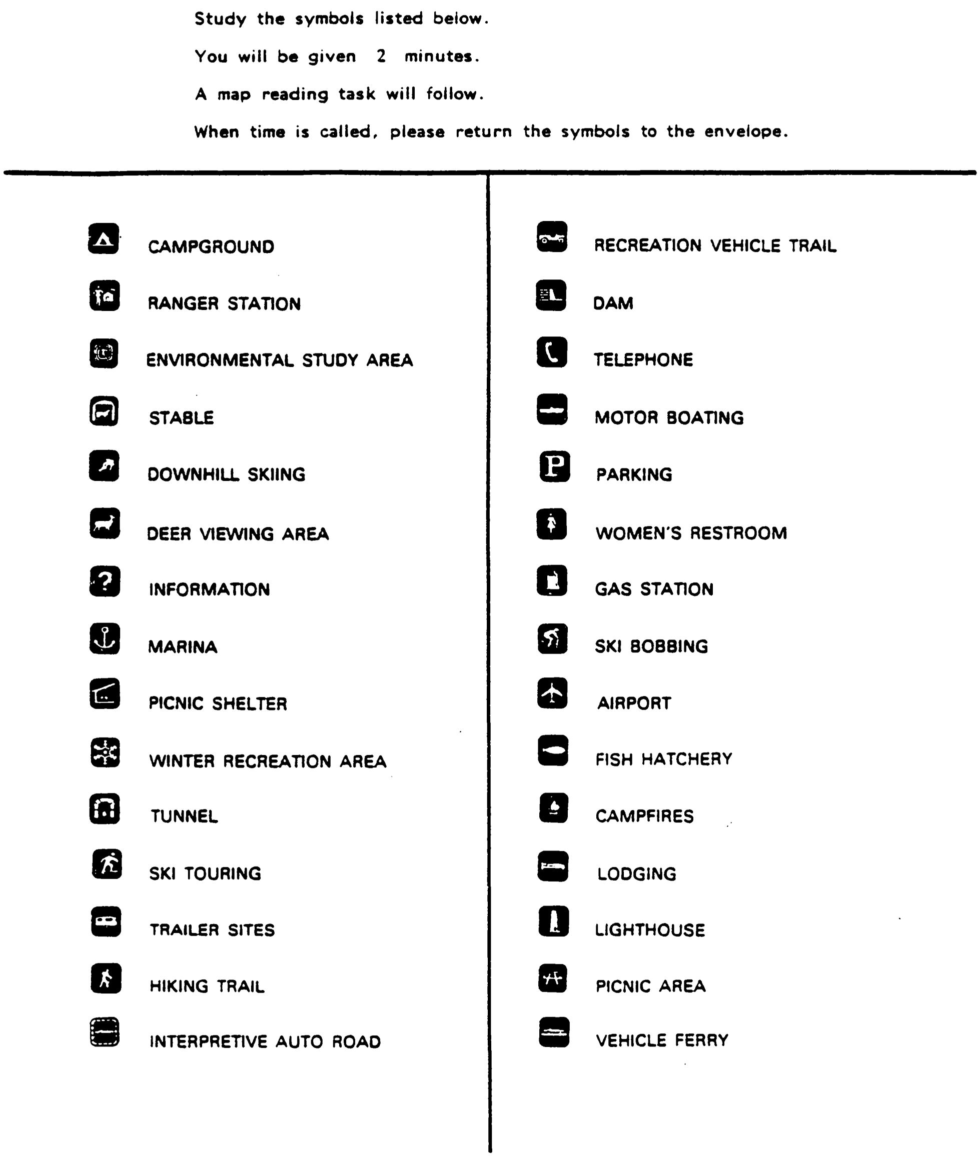


Figure 19. The Campground Arrangement of the Symbol/Legend Test. (60% reduction of the original).

Study the symbols listed below.

You will be given 2 minutes.

A map reading task will follow.

When time is called, please return the symbols to the envelope.

Figure 20. The Marina Arrangement of the Symbol/Legend Test. (60% reduction of the original).

Study the symbols listed below.

You will be given 2 minutes.

A map reading task will follow.

When time is called, please return the symbols to the envelope.

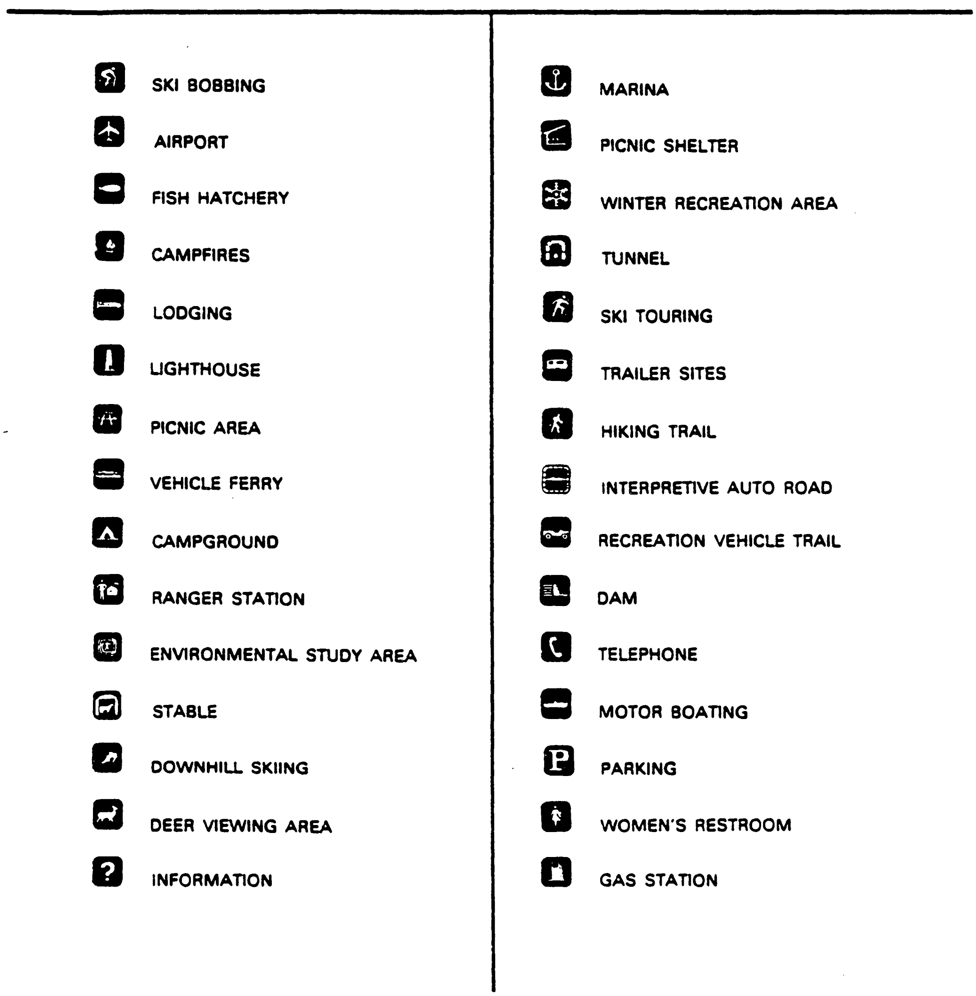


Figure 21. The Ski Bobbing Arrangement of the Symbol/Legend Test. (60% reduction of the original).

Using the words listed below, please identify the enclosed symbols.

Write the identification NUMBER on the blank following the symbol.

1	PEDESTRIAN CROSSING	40	POST OFFICE
2	FOOD SERVICE	41	SAILBOATING
3	PICNIC SHELTER	42	INTERPRETIVE TRAIL
4	SLEDDING	43	FISH HATCHERY
5	SCUBA DIVING	44	GROCERY STORE
6	PLAYGROUND	45	WATER SKIING
7	TRUCKS	46	RECREATION VEHICLE TRAIL
8	LOCKERS	47	FIREARMS
9	TRAIL SHELTER	48	SHOWERS
10	LAUNCHING RAMP	49	KENNEL
11	HUNTING	50	HORSE TRAIL
12	LIGHTHOUSE	51	BEAR VIEWING AREA
13	MECHANIC	52	HANDICAPPED
14	TRAILER SANITARY STATION	53	TRAILER SITES
15	DOWNHILL SKIING	54	TRAMWAY
16	FIRST AID	55	DEER VIEWING AREA
17	SKI BOBBING	56	SLEEPING SHELTER
18	MOTOR BOATING	57	SURFING
19	HIKING TRAIL	58	STABLE
20	SMOKING	59	RANGER STATION
21	TELEPHONE	60	GAS STATION
22	CAMPGROUND	61	INTERPRETIVE AUTO ROAD
23	DIVING	62	WOMEN'S RESTROOM
24	BICYCLE TRAIL	63	ROWBOATING
25	PETS ON LEASH	64	ENVIRONMENTAL STUDY AREA
26	BUS STOP	65	PICNIC AREA
27	ICE SKATING	66	INFORMATION
28	MARINA	67	SKI TOURING
29	LOOKOUT TOWER	68	MEN'S RESTROOM
30	LODGING	69	VEHICLE FERRY
31	CAMP FIRES	70	AMPHITHEATER
32	WINTER RECREATION AREA	71	DRINKING WATER
33	AUTOMOBILES	72	RESTROOMS
34	PARKING	73	VIEWING AREA
35	SNOWMOBLING	74	SKI JUMPING
36	FISHING	75	TRAIL BIKE TRAIL
37	TUNNEL	76	AIRPORT
38	FALLING ROCKS	77	SWIMMING
39	DAM		

Figure 22. The Identification List of the Symbol/Legend Test. (60% reduction of the original).

made to collect subject responses. The cards were randomly shuffled to eliminate bias of order, then bound by a rubber band into a deck of response cards.

For ease in administering the test, test packets were assembled containing: (1) a legend sheet and (2) a smaller envelope with an identification list and response cards. Identifical numbers were placed on the packets and interior envelopes so that the results could later be tabulated according to legend sheet arrangement.

Legend Access and Factors of Time

In many circumstances, interstate highway travel for instance, a map user is forced by factors of time to quickly review a map legend if it can be found at all. To test symbol performance under similiar conditions, subjects were required to review a legend for a limited time. Preliminary testing in an introductory cartography class using a five-minute time factor was shown to be unsatisfactory. Subjects showed restlessness during such a lengthy time period. Use of a two-minute time factor was found to be standard procedure in several of the psychological studies using maps (Thorndyke and Stasz, 1979; Gatrell, 1980). As a result, it was decided that future testing using either an identification list or test map would use a two-minute time period.

The Sample

One hundred introductory geography students at the University of North Carolina at Greensboro participated in the experiment. A student population was sampled because of: (1) accessibility and (2) controlled classroom environments for mass testing.

EXPERIMENTAL SESSION

Each subject received a test packet and was asked to remove the legend sheet to study for two minutes. The test instructions indicated that a map reading task would follow. When time was called, subjects returned the legend sheet to the packet and opened the smaller envelope containing the identification sheet and response cards. By referring to the identification list, subjects assigned a label to the symbols by marking the symbol's identification number on the response cards. On completion of the task, the subjects placed all materials in the packet which was then collected by the test administrator. Subjects took an average of 15 minutes to perform the identification tasks.

RESULTS

Figure 23 shows the number of incorrect or alternative identifications selected for each symbol tested. The number of alternative identifications for a symbol ranged from zero to 24 out of 100 possible responses. Overall, the NPS signs can be considered to have performed successfully. Problems occur where principles of symbol design have been violated (Berryman, 1979; McGrath, 1967). The use of pictorial signs without accompanying labels and at a reduced size makes positive association difficult when fine graphic distinctions are necessary for identification. For example, the four symbols dominated by a human form were often confused, as were the three symbols showing automobiles. Table IV shows the amount of confusion arising in the human and auto symbol sets. Surprisingly, the elongated lighthouse symbol was confused with the elongated gas pump. Without test results using a map context, we can theorize that in a map there would be less confusion between a lighthouse and a gas station because geographical location would provide additional clues for identification. The fact remains that symbols of similiar form attempting to make referent distinctions do not succeed. Had only one ski symbol appeared in the test, its performance rating would certainly have been much improved.

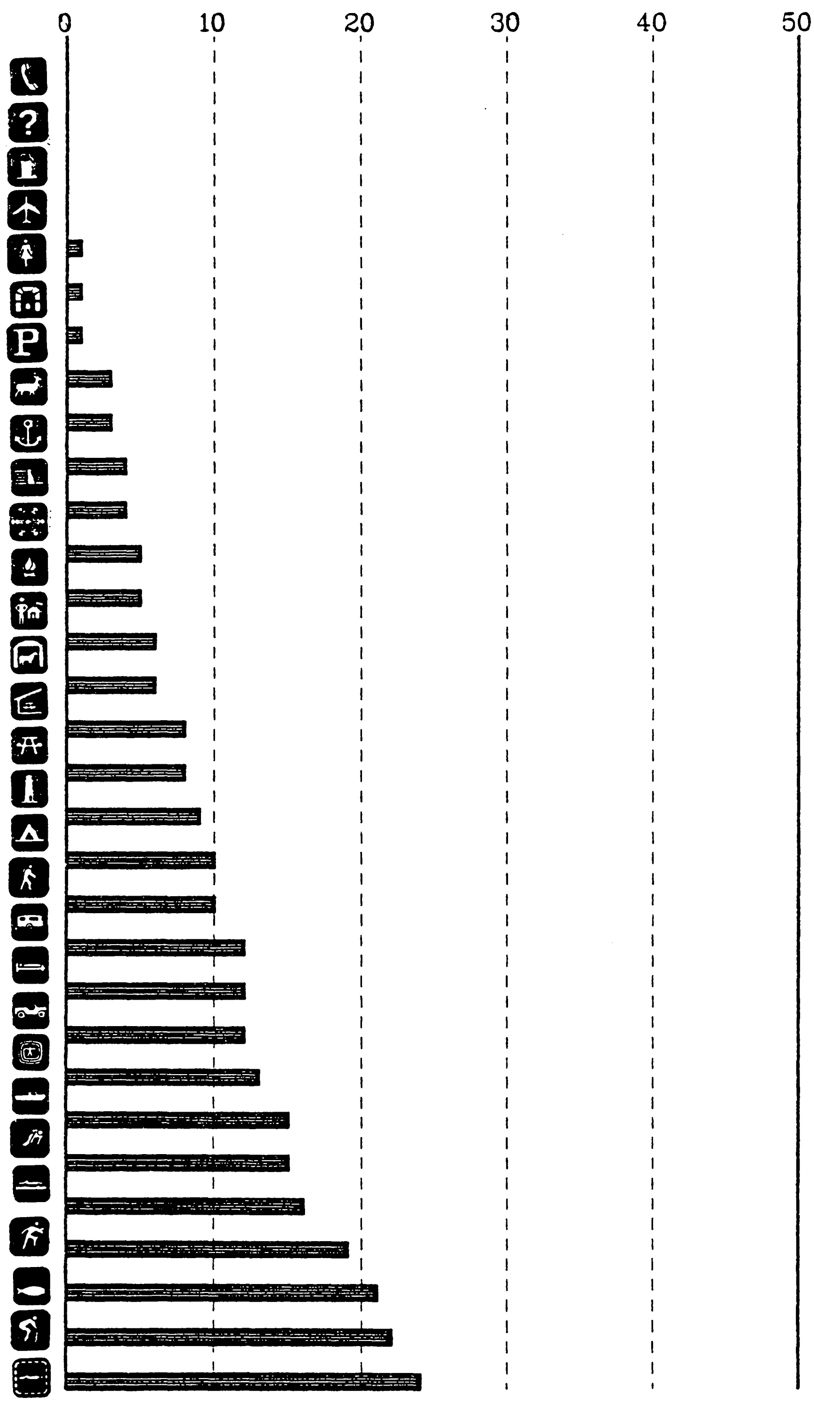


Figure 23. The Number of Alternative Identifications for Each Symbol Tested.

Table IV. Alternative Identifications Due to Confusion Between Similiar Graphical Forms

Test Symbol and Official Meaning	Alternative ID's	Occurrences Out of 100
Ski Touring:	Ski Bobbing	11
	Downhill Skiing	2
Ski Bobbing:	Downhill Skiing	9
	Ski Touring	2
Downhill Skiing:	Ski Bobbing	4
	Ski Touring	4
Hiking Trail:	Ski Touring	6
	Ski Bobbing	2
Recreation Vehicle Trail:	Vehicle Ferry	2
Vehicle Ferry:	Recreation Vehicle Trail	3
	Interpretive Auto Road	3
Interpretive Auto Road:	Recreation Vehicle Trail	4
	Vehicle Ferry	2
Lighthouse:	Gas Station	5

The frequent occurrence of cross-outs, erasures, or question marks given for test responses indicate that some subjects found it difficult to accept the official definition for a symbol. Several possible reasons exist for this difficulty: (1) the subjects do not accept the NPS referent definitions; and/or (2) the subjects have not learned to associate the referent meaning with the object because of experience with other symbolic schemes. Disagreement occurred over the symbology shown in Table V. A symbolic consensus for objects, different but similiar in nature, such as campground, trailer site, and picnic area has not been aided by the symbolic choices of the major map producers. For example, the National Geographic Society uses a fire symbol for campgrounds while several states produce highway maps showing trailer symbols for campgrounds.

Table VI shows alternative identifications that had no associated symbol presented to the test subjects. Most of the alternative identifications are logical and do not fall far from the official meanings. The most diverse alternative identifications were given for abstract symbols such as those for interpretative auto road and environmental study area. In Figure 24, the diversity of graphical form for a referent meaning is shown.

Table V. Alternative Identifications Due to Confusion Between Different Graphical Forms

Test Symbol and Meaning	Alternative ID's	Occurrences Out of 100
Trailer Sites:	Campground	4
	Recreation Vehicle Trail	2
Lodging:	Campground	1
Campground:	Campfires	2
Campfires:	Campground	3
Picnic Shelter:	Picnic Area	2
Picnic Area:	Picnic Shelter	3
	Campground	1
Environmental Study Area:	Ski Touring	1

Table VI. Comparison of Test Symbols and Intended Meanings to Alternative Identifications With No Associated Test Symbol.

Symbol	Alternative ID's	Occurrences Out of 100
Airport:	Launching Ramp	1
Parking:	Pedestrian Crossing	1
Deer Viewing:	Hunting	1
Marina:	Fishing	1
	Sailboating	1
Dam:	Interpretive Trail	1
	Sailboating	1
Winter Recreation:	Ice Skating	1
	Sledding	1
	Snowmobiling	2
Ranger Station:	Trail Shelter	1
Stable:	Kennel	1
	Horse Trail	2
Motorboating:	Rowboating	2
	Sailboating	3
	Launching Ramp	3
Downhill Skiing:	Ski Jumping	6
	Water Skiing	1
Vehicle Ferry:	Automobiles	4
	Interpretative Trail	1
	Launching Ramp	1
Ski Towing:	Water Skiing	3
Fish Hatchery:	Fishing	21
Ski Bobbing:	Snowmobiling	2
	Ski Jumping	4
	Water Skiing	1

Table VI. Continued

Symbol	Alternative ID's	Occurrences Out of 100
Interpretive Auto Road:	Automobiles	3
	Interpretive Trail	4
	Parking	1
	Row Boating	1
	Launching Ramp	1
Picnic Shelter:	Trail Shelter	2
	Viewing Area	1
Lighthouse:	Lookout Tower	2
Campground:	Sleeping Shelter	1
	Viewing Area	1
	Trail Shelter	1
Trailer Sites:	Trail Shelter	2
	Trailer Sanitary Station	1
Lodging:	Sleeping Shelter	9
Recreation Vehicle Trail:	Automobiles	6
	Interpretive Trail	1
*Environmental Study Area:	First Aid	1
	Trail Shelter	1
	Interpretive Trail	1
	Bicycle Trail	1
	Playground	1
	Viewing Area	1

Ranger Station

Picnic Shelter

Campground

Trailer Sites

Environmental Study Area

For some subjects the above symbols symbolize a Trail Shelter.

For other subjects the following symbols represent a Launching Ramp.

Airport

Motor Boating

Vehicle Ferry

Interpretive Auto Road.

And those below mean Sailboating:

Dam

Marina

Motor Boating

Figure 24. Test Results Showing the Diversity of Symbology Possible For An Object or Activity Out of 100 College Students.

The three most successful symbols were those for telephone, information, and gas station (Figure 25). It is interesting to note that all three symbols represent categories of information most desired by travelers in the user surveys.

Successful Performance of the NPS Signs

The fact that over half the test subjects made no more than one alternative identification indicates the successful performance of the NPS signs as graphic symbols (Figure 26). Additional calculations also support this finding: (1) the average number of alternative identifications for all test subjects was 2.65 and (2) the average varied little from a low of 2.09 for the Marina arrangement to highs of 2.9 for the Campground and Ski Bobbing arrangements.

All evidence points to the successful performance of the NPS signs in a symbol/legend test configuration. For the American college students tested, there is little disagreement with the official referent meanings of the National Park Service. Most problems in symbol identification are encountered when symbols of similiar design are used to make fine distinction. Increasing graphic contrast in symbol design and avoiding the

Symbol	Alternative Identifications
 Telephone	0
 Information	0
 Gas Station	0

Figure 25. The Most Successful NPS Symbols.

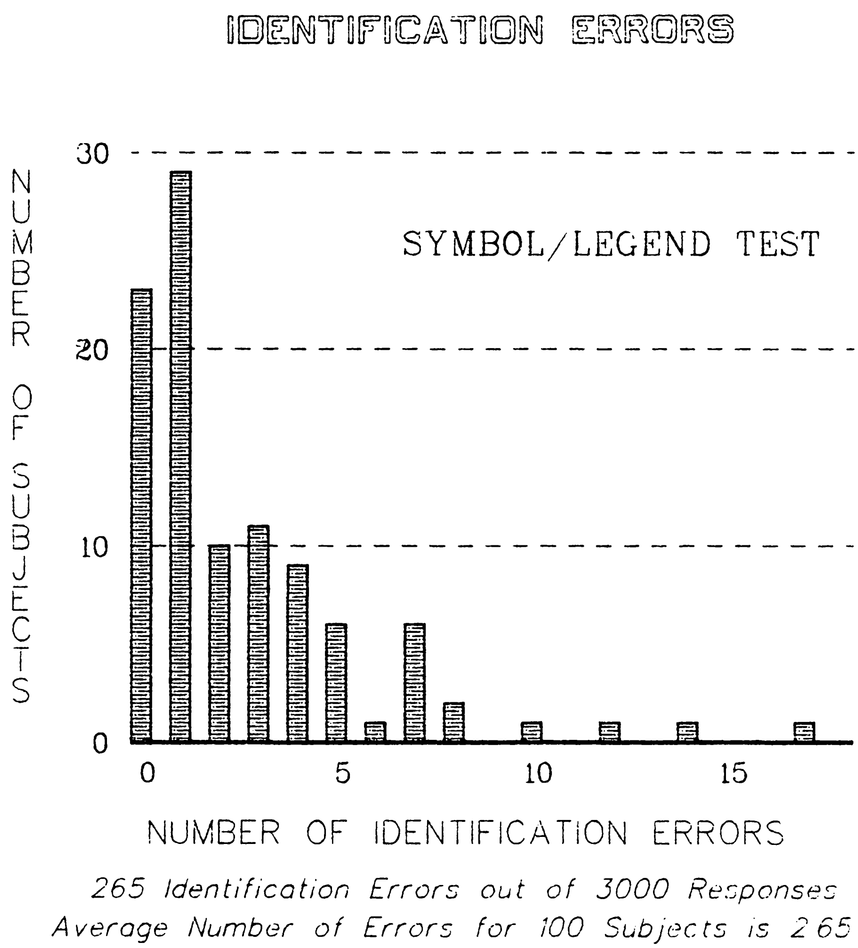


Figure 26. The Number of Subjects to the Number of Alternative Identifications.

proliferation of human and car forms would improve the NPS sign system. These thirty NPS signs will next be examined in a map context.

VIII. THE SYMBOL/MAP TEST CONFIGURATION

VIII. THE SYMBOL/MAP TEST CONFIGURATION

The issue of cartographic testing in the context of a geographical medium and utilizing realistic map reading tasks is important as illustrated by the following comments:

> It is insufficient to examine symbols in isolation, they must be studied in the context of the map, where meaning is given to shapes (M. Wood, 1968, p. 61).

> Studies of the effectiveness of maps cannot ignore either map maker or map user, nor can symbolization be tested in isolation from the process of communicating geographical information for particular purposes (Board and Taylor, 1977, p. 2).

and finally,

> Previous research...has usually attempted to isolate the effect of one particular factor by taking it out of a real map context and testing it in a more controlled situation. The obvious problem with this approach is that it is difficult to extrapolate the results to a real situation, and to practical applications (Rhind, Shaw, and Howarth, 1973, p. 115).

In order to assess the importance of testing in the environment of a map, the present study examines the NPS signs both in and out of a map context.

The symbol/map test was designed and administered in a period lasting from March 1982 to February 1983. The test was constructed to simulate map reading conditions where positional information is dependent on the identification of qualitative point symbols. Two conditions were tested: condition A, where subjects were given 20 minutes to read a map with an accompanying legend while answering 18 questions; and condition B, where subjects studied a legend for two minutes and, with legend removed, were given an unlimited time to answer the questions using only the map. It was expected that the subjects under condition A, despite having an average of 1.1 minutes to answer each question, would have no difficulty answering all the questions correctly because the legend was present. Subjects under condition B were expected to show a greater variety in responses having to recognize the symbols previously seen in the legend or previously learned from experience.

Due to their special purpose and their variety of formats, travel maps, perhaps more often than other types of maps, are probably read under less than ideal conditions. The issue of qualitative symbol performance is then dependent on factors of (1) time, (2) access to a legend, and (3) symbolic conventions previously learned by the user. These factors are mentioned again and again in the literature of qualitative symbolism and map reading. Examples are:

> In aircraft, much of the navigation is done from the mental map developed during pre-flight planning. The mental map is a reference system. In high-speed flight at a low altitude, there is little time to verify anything but the pilot's mental map. Similar problems face the motorist driving at high speed and in heavy traffic. (Board and Taylor, 1977, p. 23).

> Information about routes, direction of travel, location of exits, and of necessary services is unavailable in any other form that approaches the accessibility of a sign. Maps are an alternate source of some of this information; but in high-speed situations, the motorist who pulls off the road to consult his map may be placing himself and other drivers in grave danger. (Claus and Claus, 1974, p. 123).

> If the time given for learning the map is limited, some organizational aspects will be more affected than others. (Shimron, 1970, p. 13).

A means of gaining some insight into these factors of symbol performance is to test subjects by a questionnaire - map reading procedure. The present experiment required subjects to perform symbol identification tasks by locating symbols in a map context by cardinal direction, proximity, and categorial sets of items. This procedure was borrowed from the map learning experiments of Joseph Shimron (1978).

TEST DESIGN

Symbol and Map Selection

The thirty symbols previously selected for the Symbol/Legend test configuration were positioned on a test map. Symbols 5 mm in size were constructed because this is a standard size found on most NPS maps.

Travel maps can be divided into three major groups: (1) small-scale state and regional road maps; (2) medium-scale park and recreation maps including strip maps; and (3) large-scale city tourist maps. Due to availability and a desire to reduce reproduction costs, a black and white regional road map of 1 inch to 2640 feet produced by the Virginia Department of Highways was selected. The source document showing the City of Waynesboro is labelled "Supplement B of Augusta County". The map was altered in the following ways: (1) secondary roads were removed so as not to clutter the map and distract attention away from the NPS symbols; (2) unlabelled water bodies were added so that the dam, lighthouse, marina and motorboating symbols could be positioned with some realism; (4) villages were added so that route-tracing questions could be more easily constructed; and (5) the city name and boundaries were changed so that Virginia test subjects might would not recognize the area. A map format of 10 x 16 inches was selected for easy handling and a cost-effective printing size. A printed map maintained uniformity and quality on all test maps.

Symbol Placement

Much consideration went into the positioning of the NPS symbols on the test maps. Placement factors were: (1) realism - for example, camping symbols were placed outside the city and boating symbols along bodies of water; (2) the performance rating of the symbol on the map legend test - for example, symbols that performed badly were positioned near the legend and good symbols were positioned farther from the legend; and (3) relative distance between symbols so that no sector of the map was vacant.

Special attention was given to the positioning of the ski and automobile symbols often confused in the first test. To test the validity of symbol placement relative to the legend, the ski symbols were clustered near the legend and scattered across the north edge of the map while the interpretive auto road and recreation vehicle trail were placed near and far from the legend. It was expected that the symbols closer to the legend would have a better performance rating for test condition A, where subjects had unlimited access to the map legend.

The Map Legend

An elongated legend was selected because this format is commonly used on National Park Service Maps. The Marina arrangement, the arrangement that performed best in the map/legend test, was used to order the symbols from 1st to last position. The prevalence of right-handedness in Western cultures dictated the legend's placement along the right edge of the map. Elements that come immediately to mind for future testing to improve symbol identification are legend design, categorical classification of symbols, and legend placement.

The Questionnaire and Answer Sheet

The test questions were designed to access positional information while requiring the identification of the NPS point symbols. Eighteen questions were devised. Identification tasks required subjects to (1) locate and place marks over specific map symbols, (2) name the symbols along a route, (3) identify symbols according to cardinal direction from a location or route, (4) name a symbol nearest a specific location, and (5) identify symbols by groups. The tasks fall under the three kinds of positional information identified by Joseph Shimron (1978). These are cardinal direction, proximity, and categorial sets of items. The two types of memory having bearing on this investigation are recognition memory, where a subject knows by some retrieval cue that an object has been seen before; and recall memory, where a subject must produce in fuller detail information stored in the past (Loftus and Loftus, 1976). The symbol/map tests ask subjects to recognize cartographic symbols and identify their associated meanings.

Figure 27 shows the questionnaire and correct responses for test condition A. The questionnaire is identical to the one for test condition B accept for the header (see figure 31). The correct responses marked on the test map are shown in Figure 28. The number of times each symbol was requested is shown in Figure 29.

Test Time

The limited time period of 20 minutes for test condition A was derived from six preliminary tests conducted among co-workers, mostly computer programmers at Synercom

PICTORIAL MAP SYMBOLS

You will be given 20 minutes to complete the following map reading tasks. When time is called, please place your answers and map in the envelope.

---

1. Mark an X over the GAS STATIONS.

   3 responses

2. Identify in order from east to west the pictorial symbols along Route 250.

   (a) Tunnel (c) Lodging (e) Stable
   (b) Information (d) Gas Station (f) Picnic
Shelter

3. Name the pictorial symbols on Route 622.

   (a) Interpretive Auto Road (b) Recreation Vehicle Trail

4. On what route is an AIRPORT?

   Route 1006

5. Mark a circle around the CAMPGROUND nearest the AIRPORT.

   1 response

6. Identify the pictorial symbols south of Interstate 64.

   (a) Trailer Sites (d) Campfires (g) Vehicle Ferry
   (b) Marina (e) Picnic Area (h) Motor Boating
   (c) Information (f) Lighthouse (i) Marina

7. Name the 4 most northern pictorial symbols.

   Ranger Station Campground
   Ski Bobbing Gas Station

8. Mark a slash through all the SKI symbols.

   6 responses

9. On what route is located a WINTER RECREATION AREA?

   Route 640

Figure 27. The Questionnaire and Correct Responses for the Symbol/Map Configuration (60% reduction of the original).

10. Identify in order from north to south the pictorial symbols along the South River.

    (a) Campground (d) Fish Hatchery
    (b) Campfires (e) Women's Restroom
    (c) Parking

11. Mark two circles around the DAM.

    1 response

12. Which pictorial symbol is southwest of the DAM?

    Environmental Study Area

13. Name the pictorial symbols on Route 640.

    (a) Recreation Vehicle Trail (c) Winter Recreation Area
    (b) Deer Viewing Area (d) Gas Station

14. Mark a box around the symbols for lodging.

    2 responses

15. Identify the symbols from Powell to Ladd along Route 340.

    (a) Trailer Sites (d) Lodging
    (b) Gas Station (e) Telephone
    (c) Parking

16. A HIKING TRAIL connects what two roads?

    Route 254 and Route 865

17. Name the two symbols on the Campbellville city line.

    Gas Station Interpretative Auto Road

18. Identify the five pictorial symbols north and adjacent to Interstate 64.

    Picnic Shelter Picnic Area
    Women's Restroom Ski Bobbing
    Environmental Study Area

Figure 27. Continued.
(60% reduction of the original).

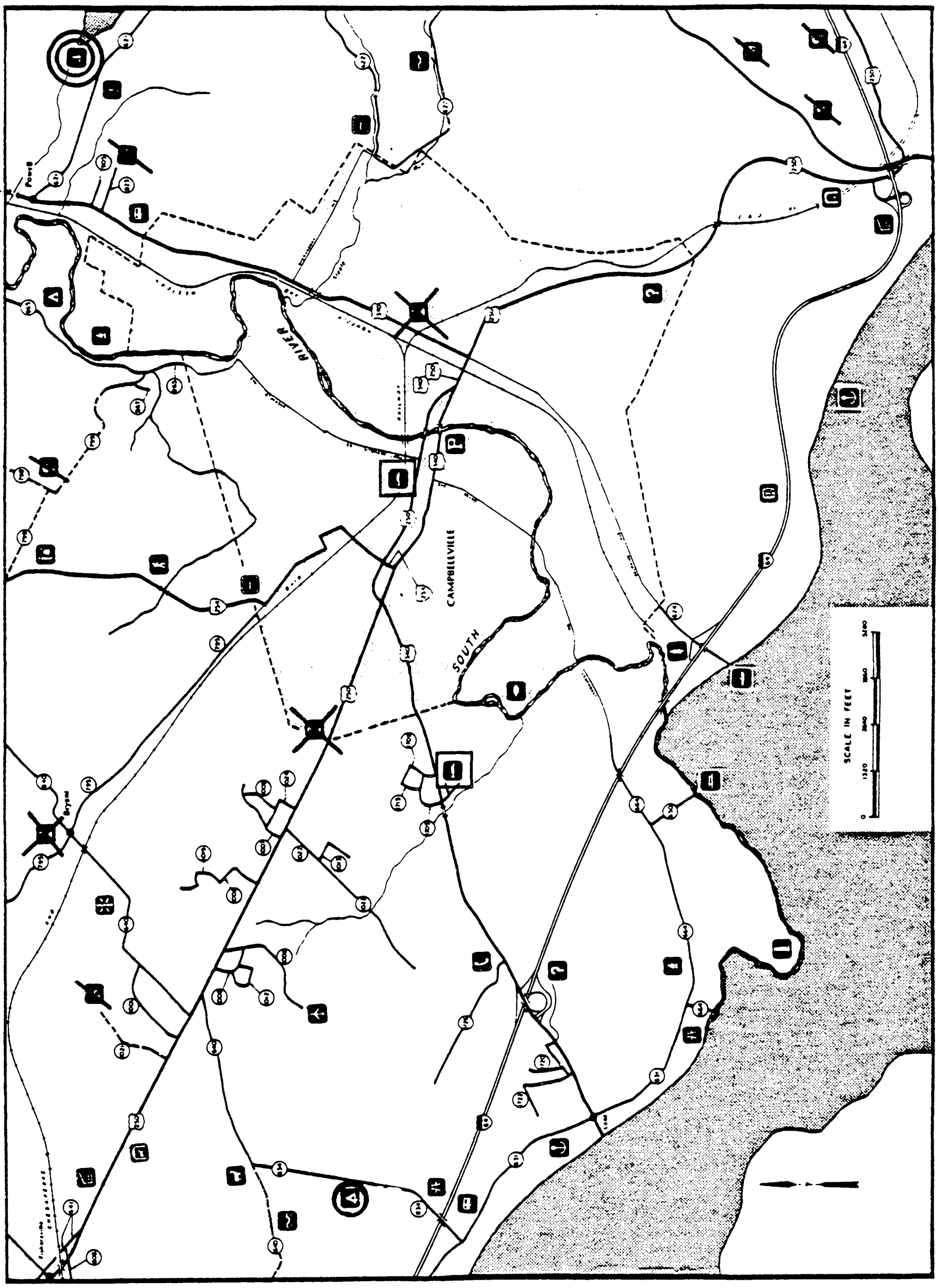


Figure 28. Test Map Showing Correct Responses for the Symbol-Spotting Tasks.
(48% reduction of the original).

No. of Times Requstd.	Symbol	No. of Times Requstd.	Symbol
3	CAMPGROUND	2	RECREATION VEHICLE TRAIL
1	RANGER STATION	1	DAM
2	ENVIRONMENTAL STUDY AREA	1	TELEPHONE
1	STABLE	1	MOTOR BOATING
2	DOWNHILL SKIING	2	PARKING
1	DEER VIEWING AREA	2	WOMEN'S RESTROOM
2	INFORMATION	8	GAS STATION
2	MARINA	4	SKI BOBBING
2	PICNIC SHELTER	1	AIRPORT
2	WINTER RECREATION AREA	1	FISH HATCHERY
1	TUNNEL	2	CAMPFIRES
2	SKI TOURING	4	LODGING
2	TRAILER SITES	1	LIGHTHOUSE
1	HIKING TRAIL	2	PICNIC AREA
2	INTERPRETIVE AUTO ROAD	1	VEHICLE FERRY

Figure 29. Number of Times Each Symbol Was Identified in the Symbol/Map Test.

Technology in Houston, Texas. The average time for completion was 17 minutes. As a consequence of this result and a desire to use a realistic time limit, a 20 minute time period was determined to be sufficient and used in the testing.

Experimental Session

Two test conditions were constructed so that some of the multiple factors of reading a map might be isolated and compared. One condition had the advantage of constant access to the legend while the second condition had the advantage of unlimited time in responding to the questionnaire. Another consideration was to conduct an experimental session as similar as possible to the map/legend test configuration described previously so that insight might be gained as to the applicability of the results from the simpler legend testing experiment to an actual map reading situation.

Table VII outlines the experimental sessions of test conditions A and B. Condition A simply gave subjects a map and questionnaire to be completed in twenty minutes. Condition B in a procedure similar to the map/legend test configuration required subjects to study a map legend for

Table VII. The Symbol/Map test Configuration

Test Factors	Description
Cartographic Element Tested:	
	Qualitative Point Symbols
Type of Point Symbol:	
	Pictorial Signs of the National Park Service
Condition A	
Test Materials - Mode of Presentation:	
	1. A 10 x 16 inch test map with a geographical distribution of 47 symbols representing 30 identified meanings in a map legend
	2. Two 8-1/2 x 11 inch questionnaire sheets with 18 questions asking for positional information according to coordinate position, proximity, and categorical relationships.
Experimental Session:	
	1. Each subject received a test packet containing a test map and questionnaire sheets.
	2. Subjects opened the packet and were asked to complete the assigned symbol identification tasks.
Testing Time:	
	A twenty minute time limit
The Sample:	
	40 college students from introductory geography classes at Virginia Polytechnic Institute and State University.

Table VII. Cont'd

Condition B

Test Materials - Mode of Presentation:

1. An 8-1/2 x 11 inch sheet with an attached map legend for 30 NPS symbols
2. A 10 x 14 inch test map with no legend showing a geographical distribution of 47 symbols representing 30 identified meanings.
3. Two 8-1/2 x 11 inch questionnaire sheets with 18 questions asking for positional information according to coordinate position, proximity, and categorical relationships.

Experimental Session:

1. Each subject received a test packet with a map legend and a smaller envelope containing a map and questionnaire sheets
2. Subjects removed the legend and studied it for two minutes.
3. When time was called, subjects returned the legend sheet to the packet and opened the smaller envelope.
4. Subjects answered the questionnaire using only the map.

Testing Time:

A two minute study time plus unlimited time to complete the questionnaire. Most subjects finished in twenty minutes or less.

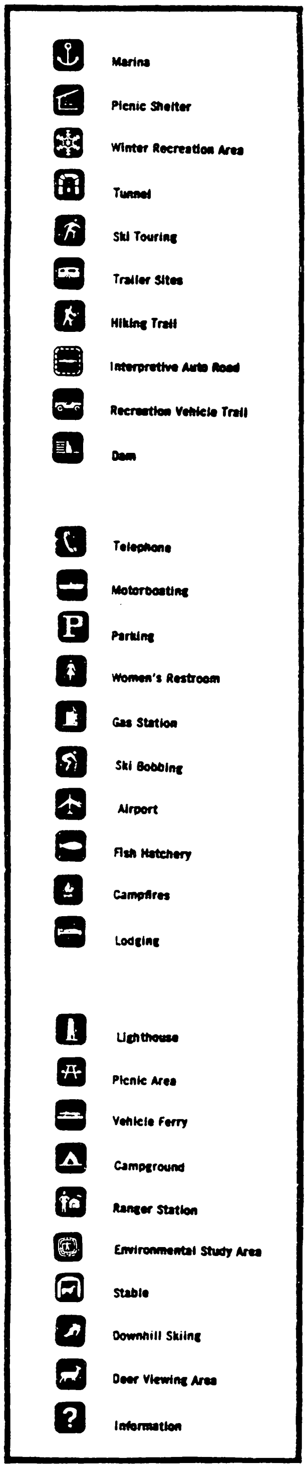
The Sample:

42 college students from introductory geography classes at Virginia Polytechnic Institute and State University.

two minutes (figure 30) and then gave subjects an unlimited time to complete the identification tasks (figure 31) using only the map and any legend learned and stored in memory.

As recommended by Barbara Shortridge and Robert Welch (1980), the test conditions attempt to elicit decision criterion similar to those in effect during actual map reading. In condition A, access to legend makes the official identifications the predominate criterion for map reading; and in condition B, the absence of the legend gives the reader a broader decision criterion based on the official identifications recalled from memory or from symbolic conventions previously learned. In many circumstances, map readers are forced by limitations of legend access and time to identify symbols from a previously-stored mental legend. Condition B differs from the map/legend test in that the subjects were not given a reference list of 77 meanings. It was expected that responses would vary most with condition B, least with condition A, and the map/legend test falling somewhere in between.

Figures 26, 32, and 35 show that the decision criterion allowed in testing affects the range of alternative identifications given by test subjects. It appears that



Study the symbols listed on the attached map legend.

You will be given 2 minutes.

Several map reading tasks will follow.

When time is called, please return the map legend to the envelope.

Figure 30. Legend Sheet Presented For Two Minutes Under Test Condition B. (75% reduction of the original).

PICTORIAL MAP SYMBOLS

Please perform the following map reading tasks using the enclosed map.

When time is called, place your answers and map in the envelope.

---

1. Mark an X over the GAS STATIONS.
2. Identify in order from east to west the pictorial symbols along Route 250.
3. Name the pictorial symbols on Route 622.
4. On what route is an AIRPORT?
5. Mark a circle around the CAMPGROUND nearest the AIRPORT.
6. Identify the pictorial symbols south of Interstate 64.
7. Name the 4 most northern pictorial symbols.
8. Mark a slash through all the SKI symbols.
9. On what route is located a WINTER RECREATION AREA?

Figure 31. First Page of Questionnaire and Answer Sheet for Test Condition B.

differing test designs rather than the specific use of a map context has a greater impact on test results. However, good symbols (Figures 23, 33 and 34) prevail despite instructions and context.

RESULTS

Appendix I shows symbol performance by question for test conditions A and B, while Appendix II shows the performance of each symbol. An added dimension of symbol testing within a map environment over testing without a map context is the ability to determine whether detection errors have occurred. Subject responses indicate that some symbols were simply not found. In other words, these were not questions left blank, and the tasks were understood as indicated by the identification of other symbols for a particular question. Figure 32 shows the number of subjects to the number of detection errors for test conditions A and B. In raw numbers, 139 symbols were missed by subjects under Condition A (legend access), while 177 symbols were missed by subjects under Condition B (unlimited time). This indicates that symbol to symbol comparison from map to legend can outweigh factors of limited time. For Condition A, detection errors did not necessarily increase for questions at the end of the test, nor did they decrease

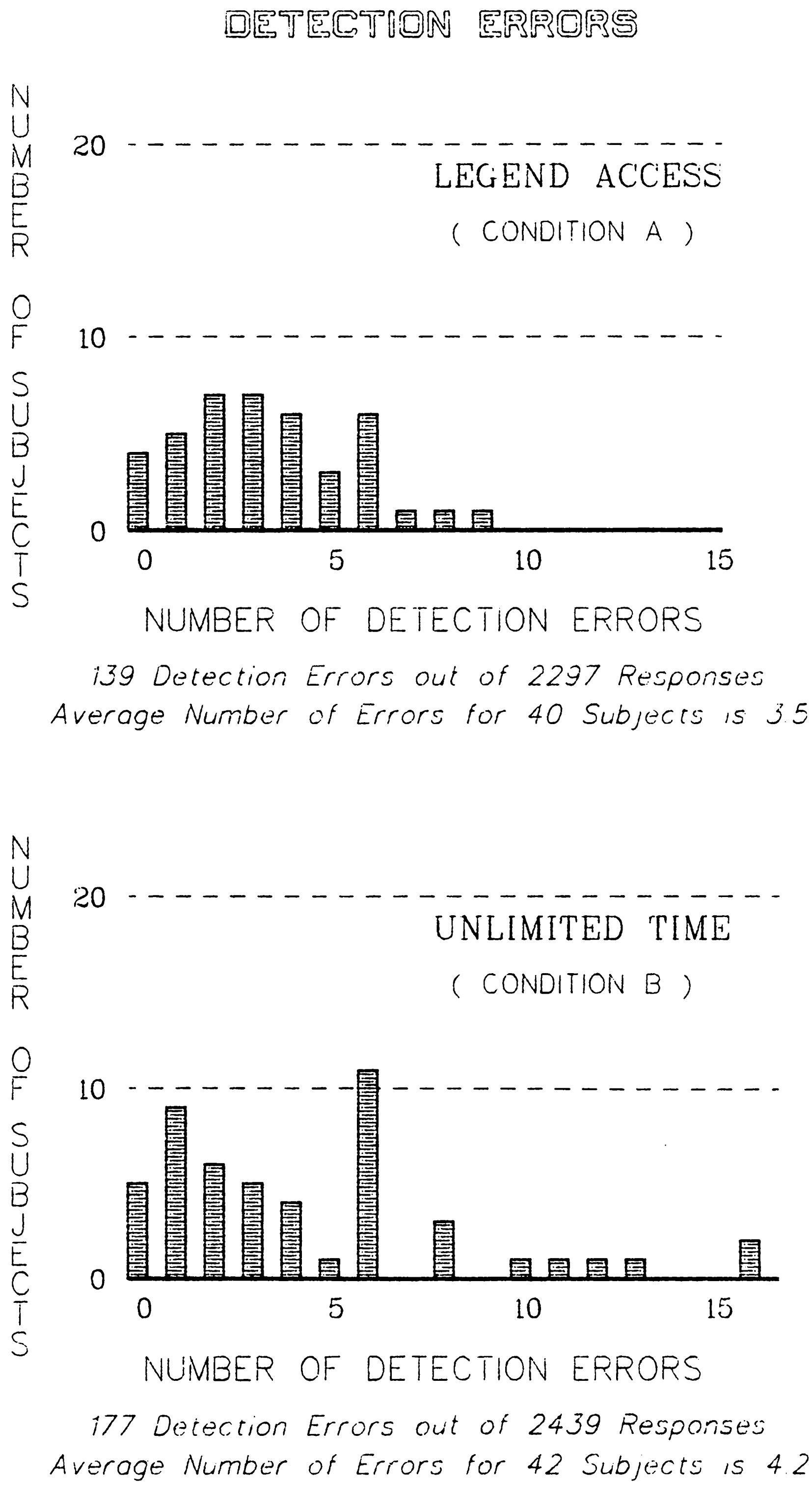


Figure 32. The Number of Subjects to the Number of Detection Errors for Test Conditions A and B.

under test Condition B where subjects had an unlimited time to find the symbols (see Appendix II). Type of test question appears to have had a greater impact than factors of time or legend access. Subjects under both conditions show the greatest number of detection errors responding to route-following tasks. In most cases, subjects failed to detect route numbers and, as a consequence, missed pictorial symbols. For example, subjects had difficulty following routes 250 and 340 through the town of Campbellville and following route 640 through the change from a dirt to a paved road and through the discontinuous crossing at route 250.

Type of question also had a heavy influence on identification errors. Appendix II shows that subjects had little difficulty with categorical items or spotting tasks where symbols were simply recognized and selected out from other map components. Spotting tasks always improved symbol performance. Increasing the degree of mental processing required resulted in lower symbol performance for the proximity and cardinal direction type questions. Proximity tasks were more difficult, being dependent on a subject finding a linear route and determining how close a symbol should be to be located along or near a route. More confusion resulted from cardinal direction questions than any other type of question. Symbol identification according to cardinal direction is a more abstract task than following a route or spotting point symbols. In all cases but four, cardinal direction questions decreased symbol performance (Appendix II). In three out of these four cases, the symbols lighthouse, motorboating, and vehicle ferry, are symbols positioned on or near bodies of water. It can be argued that geographical positioning aided the identification of these symbols. However, as in the symbol/legend test, although subjects confused a lighthouse with a gas station, never was a gas station identified as a lighthouse. Symbol form can and does take precedence over geographical clues. The confusion between human and automobile forms prevails. The ski symbols show better performance only because subjects were asked to spot them as a group on the test map. This supports the idea that the NPS sign/symbol system can be improved, if meaning were not dependent on fine graphical distinctions. In addition, subjects resisted following routes right to left or east to west. Most seem to approach map reading as if they were reading a book from left to right. This tendency might have important implications for the orientation of travel maps.

Figures 33 and 34 show the detection and identification error rates for each symbol tested under Conditions A and B.

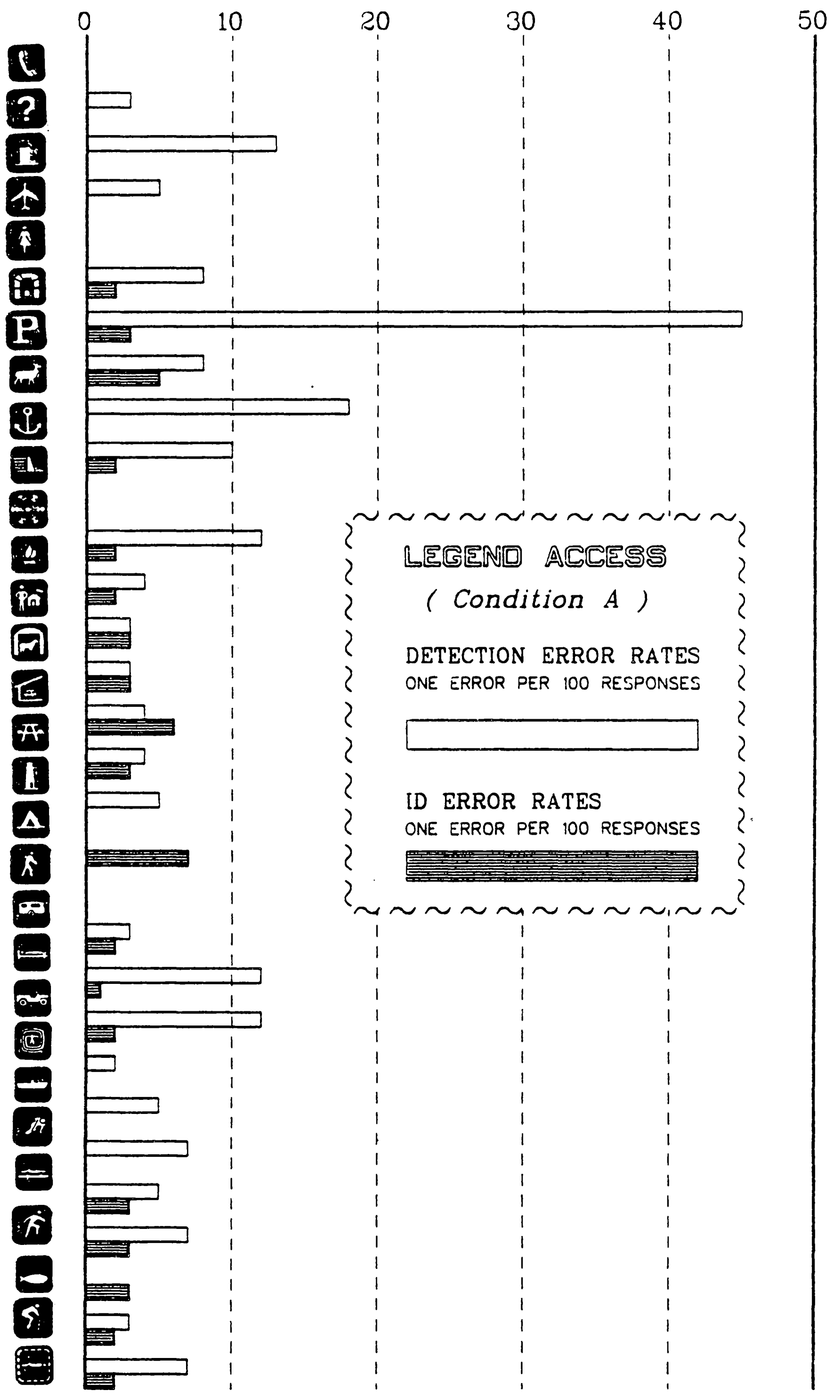


Figure 33. The Detection and Identification Rates per 100 Responses for Each Symbol Tested Under Condition A.

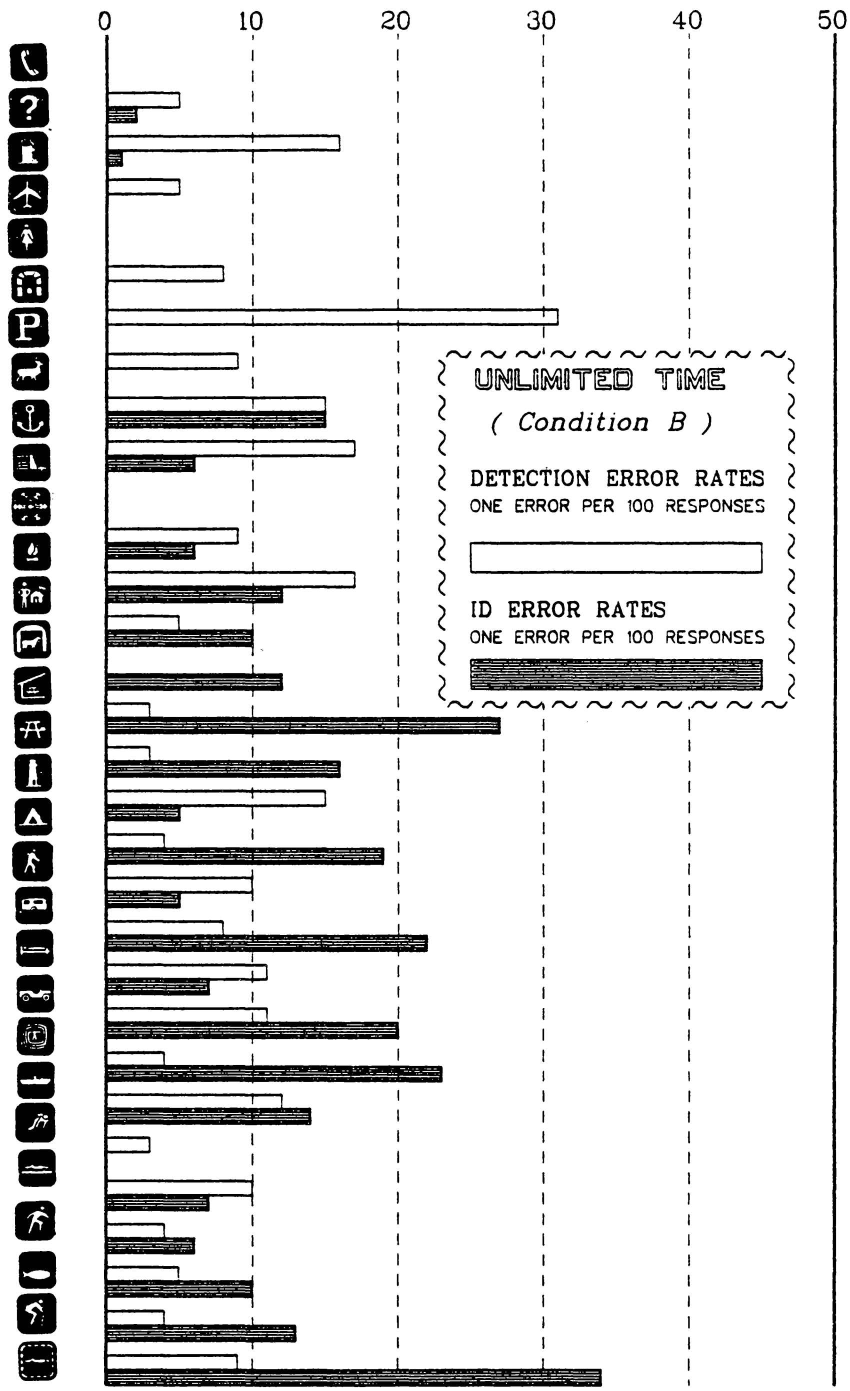
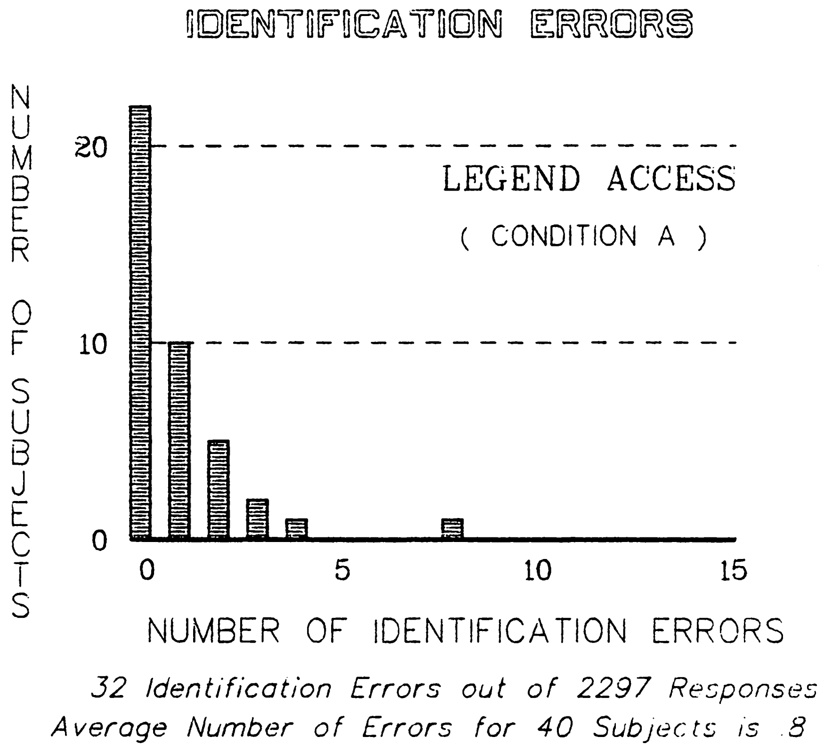


Figure 34. The Detection and Identification Error Rates per 100 Responses For Each Symbol Tested Under Condition B.

Symbol performance under Condition A where subject had legend access or a restricted criteria range was excellent. All symbols performed well except the symbols for parking, campground and picnic shelter (Figure 33). In all but one case, subjects did use the provided legend. For nearly all responses, that subject gave answers different from the meanings of the official legend. Only one Condition A subject did not finish the identification tasks, as compared to eight incompletes under Condition B where subjects had unlimited time but no legend access. It seems that subjects under Condition B grew weary of having to rely on their mental legends.

Test Condition B without legend access and, therefore, allowing a broad criteria range is a better indicator of what a graphic form means to a map user. The subject has more freedom to respond and is assumed to rely more on previously-learned symbol conventions than on uncommon meanings, difficult to remember, from an official legend. Figure 35 shows the wider range of identification errors existing for test condition B against those for test condition A clustered at one end of the scale. In both test conditions, the number of identification errors is extremely small out of the total number of responses.



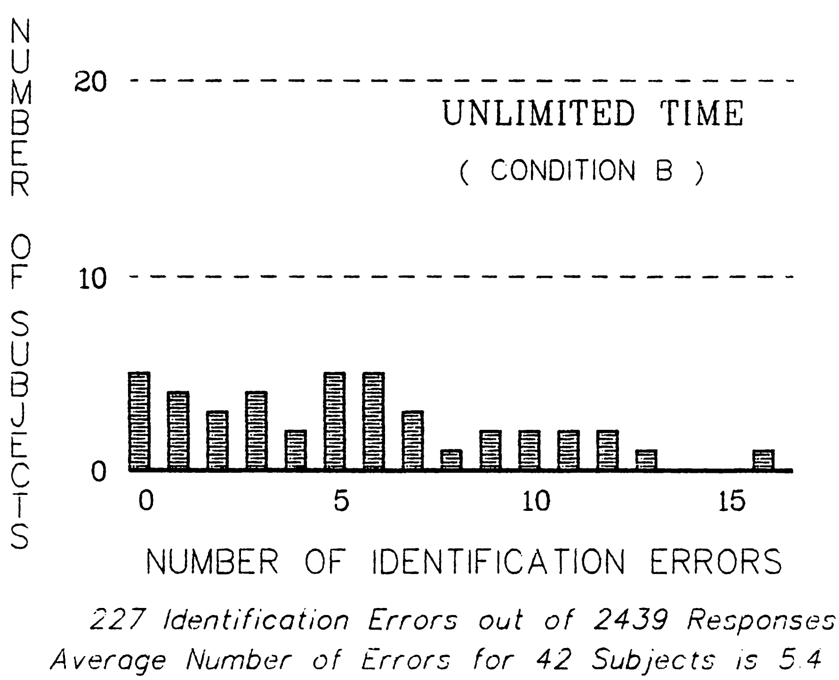


Figure 35. The Number of Subjects to the Number of Identification Errors For Test Conditions A and B.

Overall, the results indicate that no real advantages were gained by testing the NPS symbols in a map context. A general ranking of symbols from good to bad can be acquired without a test map. However, the use of a map context did show that the NPS symbols perform well across a range of conditions and contexts, at least for American college students. The very best and the very worst symbols are indicated no matter what the question or the context. Other symbols falling on the continuum are more dependent on test instructions and context. The NPS symbols can be improved by avoiding the use of human and auto forms for a multitude of meanings and avoiding uncommon terms such as "ski bobbing" and "interpretive auto road" for official meanings. Confusion was apparent when it was necessary to rely completely on the official NPS legends, because meanings were not commonly known.

It is difficult to relate these results to earlier studies of qualitative and/or pictorial symbols. The study was not designed to measure the influence of grey tone backgrounds on the time required to read a symbol display (Kilcoyne, 1974), yet symbols positioned near bodies of water had lower detection errors. Numerical entities of information content were not acquired as in Taylor's study (1975), but the very best and worst symbols of the NPS system have been revealed through the testing phases. Star-like symbols such as the snow flake designating winter recreation areas did indeed perform very well, supporting the results of Epp's (1978) study using star symbols to highlight linear routes.

A simple visual assessment indicates that the NPS symbols are not computer-compatible, given the current computer technology. Shaded symbology would slow the display, editing, and maintenance of even moderately sized data bases. And finally, the order of learning or acquiring the meaning of a symbol is not known, but the results clearly indicate that the NPS signs perform well as cartographic symbols for American college students.

The complexity of testing with a map was perhaps most valuable in showing areas for future investigation. These include the areas of legend design, legend positioning, map orientation for route following, and tasks formulated to elicit specific information from map readers. In sum, criticism of a study for not using a map is not a valid criticism in and of itself. A more appropriate analysis would be to consider the symbolism and tasks to be tested and ask what would be gained or lost by testing in a map context. Nevertheless, cartographers should not dodge the use of a map context by saying it is to complex and cannot be done. To advance knowledge, cartographers should be willing to gamble with the unknown and push forward the cartographic frontier.

IX. CONCLUSION AND A LOOK TOWARDS THE FUTURE

IX. CONCLUSION AND A LOOK TOWARDS THE FUTURE

This study has emphasized the need to consider meaning as an important factor in the design and use of qualitative point symbols. Although pictures alone may not communicate to all, it was found that the pictorial signs of the National Park Service perform very well for American college students. Few identification errors were made when the signs were reduced to cartographic symbols in and out of a map context. Variation in the degree of identification errors from test to test can be attributed more to differences in test design than mismatches of graphic form to referent meaning. Although it is purely conjecture until similar testing is conducted for map users of other cultural backgrounds, the NPS signs cannot be considered to be international communicators. For instance, would the same degree of identification errors occur for a group of map users in Japan or Korea? The NPS signs are effective for a specific group of map users. This does not rule out the possibility that other symbol systems may be equally effective for the same group of users. For example, the upper and lower letters of the English language are equally effective in communication. A semiotic research approach might reveal more specific knowledge about the semantic relationships of not one but several co-existing cartographic languages.

The NPS test results indicate that map users do utilize a map legend when provided. To aid the comprehension of qualitative meaning, official legends should avoid subtle differences and correspond as much as possible to the mental legends of map users. Further research should be conducted to determine how a cartographer can maximize the usefulness of a map legend in the communication process. A legend is perhaps a cartographer's only opportunity to teach an intended user how to read the map. Due to technological constraints and automated mapping systems developed by persons with little or no cartographic training, map legends are noticeably absent from many computer-generated maps.

The high performance of the NPS symbols might be further improved with legends grouping symbols by informational categories. For example, the ski symbols might be listed under a winter recreation category. Also, symbols with uncommon referent meanings might have more comprehensive and complete legend definitions.

The NPS tests reveal that the graphic form of a symbol has a direct influence in two areas: (1) the detachability of the symbol from its surroundings, and (2) the discrimination of the symbol from other symbols. These findings support the map reading and analysis processes outlined by John Keates (1982) and Joel Morrison (1976, 1978). Symbols are detected, discriminated, identified, and judged by a map user. Psychophysical investigations might provide answers to questions concerning the levels of visual thresholds necessary for further improvement of the NPS sign/symbol system. Symbol dimensions (Figure 10) such as size and shape variation would be important areas for testing. The square exterior shapes of the NPS signs may be optimal shapes for highway signs but not for cartographic symbols. The black squares may trap white space and focus eye flow for detection but may hinder discrimination between symbols.

The magnitude of complexity allowed for a pictorial symbol is probably greater than that possible for a geometric symbol. This probability violates Gerald McGrath's (1967) principle that a symbol should be of simple design. However, at the same time, it allows a symbol to have a closer relationship to the feature it portrays, decreases confusion with symbols representing other objects or activities, and, as a result, is more precise in meaning.

In the present as well as in the future, the traditional means of providing information through a static map format will not be sufficient to meet the needs of a traveller. Studies like the present one and those of quantitative symbols may in part become obsolete as new technologies are perfected and combined for new applications.

The technologies for a new cartographic era already exist in the micro-computer, Honda Motor Company's Dashboard Navigator, and Synercom's Intellegent Map. The Dashboard Navigator uses an electronic gyroscope to sense a car's speed and position which is shown on a small cathode-ray tube display screen. This system, however, cannot determine for a person where he or she may want to go. Symbols on the map provide the choices; the navigation system then aids the traveller to the chosen destination. Synercom's Intellegent Map attaches a record or list of information to a graphical element in a map. This information can be interactively accessed by a map user. For example, a record for a qualitative symbol might indicate the type of establishment, the size of the establishment, the distance away from a major interchange, and the hours open for business. Such a capability would leave little room for the mismatch of symbol and meaning while providing the precise information now available at information centers. A combination of the above technologies would give persons a fifth sense. The device would be portable, showing the location of a car or individual; it would give current graphical displays in the formats of a sheet-index map and/or in the format of a strip map; the symbolism would be user-defined, thus matching the mental legends of the user and perhaps avoiding the confusion of a multitude of human and auto forms; and precise information about a geographical entity would be readily available as tabular reports or selected graphical displays. All the advantages of a map over tables of coordinates or other means would, however, be lost if people could not interpret enough information visually (without asking for details) to make preliminary choices. The intelligent map is certainly a significant improvement but cannot eliminate the need for good, logically-designed symbols. Optimally designed symbols would eliminate all the time needed to query the system for details. Proper symbols plus the intelligent map feature to confirm assumed definitions and obtain additional information should provide an ideal mix.

Studies such as this one will not be completely for naught. As the new technologies become available and map users become their own cartographers, the need to teach principles of map and symbol design will grow in importance.

The best symbols will have fewer cognitive and technical limitations.

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XI. APPENDIX I

Appendix I. NPS Symbol Performance By Question

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1. Mark an X over the GAS STATIONS.

Type of Question : Item Category

Condition A	Condition B
40 Samples	42 Samples
120 Total Responses	126 Total Responses

GAS STATION

Error	Id.	Detection	Id.	Detection
Number	0	3	2	2
Rate/100	0.0	2.5	1.6	1.6
			Lighthouse - 2	

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2. Identify in order from east to west the pictorial symbols along Route 250.

Type of Question : Proximity

Condition A	Condition B
40 Samples	42 Samples
240 Total Responses	258 Total Responses

TUNNEL

Error	Id.	Detection	Id.	Detection
Number	1	18	0	13
Rate/100	2.5	45.0	0.0	30.9
	Over Railroad - 1			

Appendix I. Continued

INFORMATION

Error	Id.	Detection	Id.	Detection
Number	0	7	1	3
Rate/100	0.0	17.5	2.4	7.1
			Question - 1	

LODGING

Error	Id.	Detection	Id.	Detection
Number	1	11	5	10
Rate/100	2.5	27.5	11.9	23.8
			Campground - 1 Hotel/motel - 2 Rest area - 1 Sleep - 1	

GAS STATION

Error	Id.	Detection	Id.	Detection
Number	0	0	0	1
Rate/100	0.0	0.0	0.0	2.4

STABLE

Error	Id.	Detection	Id.	Detection
Number	1	1	5	0
Rate/100	2.5	2.5	11.9	0.0
	Horse in barn - 1		Horse shelter - 3 Animal shelter - 1 Horse stall - 1	

Appendix I. Continued

PICNIC SHELTER

Error	Id.	Detection	Id.	Detection
Number	2	0	12	0
Rate/100	5.0	0.0	28.6	0.0
	Picnic tables - 1 Picnic area - 1		Campground - 1 Picnic area - 5 Restaurant - 2 Recreation area - 2 Trail shelter - 1 Family shelter - 1	

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3. Name the pictorial symbols on Route 622.

Type of Question : Proximity

Condition A	Condition B
40 Samples	42 Samples
80 Total Responses	84 Total Responses

INTERPRETIVE AUTO ROAD

Error	Id.	Detection	Id.	Detection
Number	1	2	11	5
Rate/100	2.5	5.0	26.2	11.9
	Paved road - 1		Garage - 1 Intermittent vehicle road - 3 ? - 2 Restricted vehicle road - 1 Car something - 1 Auto car - 1 Interpretive motor way - 1 Interpretive auto race - 1	

Appendix I. Continued

RECREATION VEHICLE TRAIL

Error	Id.	Detection	Id.	Detection
Number	1	2	9	3
Rate/100	2.5	5.0	21.4	7.1
	Dirt road - 1		Offroad vehicles - 4 Jeep trail - 2 Auto recreation trail - 2 Info vehicle trail - 1	

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4. On what route is an AIRPORT?

Type of Question : Proximity

Condition A	Condition B
40 Samples	42 Samples
40 Total Responses	42 Total Responses

AIRPORT

Error	Id.	Detection	Id.	Detection
Number	0	0	0	0
Rate/100	0.0	0.0	0.0	0.0

Appendix I. Continued

5. Mark a circle around the CAMPGROUND nearest the AIRPORT.

Type of Question	: Proximity
Condition A	Condition B
40 Samples	42 Samples
40 Total Responses	42 Total Responses

CAMPGROUND

Error	Id.	Detection	Id.	Detection
Number	0	0	4	0
Rate/100	0.0	0.0	9.5	0.0
			Ranger station - 1 Picnic shelter - 2 Hiking trail - 1	

Appendix I. Continued

6. <u>Identify the pictorial symbols south of Interstate 64</u>.

Type of Question : Cardinal Direction

Condition A	Condition B
40 Samples	42 Samples
360 Total Responses	378 Total Responses

TRAILER SITES

Error	Id.	Detection	Id.	Detection
Number	0	1	10	5
Rate/100	0.0	2.5	23.8	11.9
			Camper station - 6 Trailer allowed - 1 Trailer hitch - 1 Recreation vehicle lot- 2	

MARINA

Error	Id.	Detection	Id.	Detection
Number	1	8	5	14
Rate/100	1.25	10.0	5.95	6.7
	Boat dock - 1		Boat landing - 2 Harbor - 2 Marine area - 1	

INFORMATION

Error	Id.	Detection	Id.	Detection
Number	0	3	0	10
Rate/100	0.0	7.5	0.0	23.8

Appendix I. Continued

CAMPFIRES

Error	Id.	Detection	Id.	Detection
Number	0	3	2	12
Rate/100	0.0	7.5	4.8	28.6
			Rest area - 1 Outdoor fires - 1	

PICNIC AREA

Error	Id.	Detection	Id.	Detection
Number	1	2	9	2
Rate/100	2.5	5.0	21.4	4.8
	Picnic table - 1		Picnic table - 4 Picnic grounds - 2 Picnicking - 1 Picnic shelter - 1 Picnic site - 1	

LIGHTHOUSE

Error	Id.	Detection	Id.	Detection
Number	0	2	2	6
Rate/100	0.0	5.0	4.8	14.3
			Gas station - 1 Oil rig - 1	

Appendix I. Continued

VEHICLE FERRY

Error	Id.	Detection	Id.	Detection
Number	1	2	3	4
Rate/100	2.5	5.0	7.1	9.5
	Car ferry - 1		Boat ferry - 2 Ferry crossing - 1	

MOTOR BOATING

Error	Id.	Detection	Id.	Detection
Number	0	2	6	5
Rate/100	0.0	5.0	14.3	11.9
			Recreation boating - 3 Dock - 2 Power boating - 1	

Appendix I. Continued

7. Name the 4 most northern pictorial symbols.

Type of Question : Cardinal Direction

Condition A	Condition B
40 Samples	42 Samples
150 Total Responses	128 Total Responses

RANGER STATION

Error	Id.	Detection	Id.	Detection
Number	1	1	4	2
Rate/100	2.5	2.5	9.5	4.8

Condition A	Condition B
Police - 1	Campground - 1 Ranger house - 1 Forest ranger - 1 Farming - 1

Appendix I. Continued

SKI BOBBING

Error	Id.	Detection	Id.	Detection
Number	2	1	10	0
Rate/100	5.0	2.5	23.8	0.0
	Downhill skiing - 2		Downhill skiing - 4 Ski lift - 1 Tobogganing - 1 Ski trails - 1 Ski bounding - 1 Ski slope - 1 Ski cross country - 1	

CAMPGROUND

Error	Id.	Detection	Id.	Detection
Number	3	0	10	2
Rate/100	7.5	0.0	23.8	4.8
	Lodging - 1 Camping - 2		Camping - 8 Tent camping - 1 Caution area - 1	

GAS STATION

Error	Id.	Detection	Id.	Detection
Number	0	0	0	0
Rate/100	0.0	0.0	0.0	0.0

Appendix I. Continued

8. Mark a slash through all the SKI symbols.

Type of Question	:	Item Category
Condition A		Condition B
40 Samples		42 Samples
240 Total Responses		252 Total Responses

DOWNHILL SKIING

Error	Id.	Detection	Id.	Detection
Number	0	5	0	2
Rate/100	0.0	6.25	0.0	2.4

SKI BOBBING

Error	Id.	Detection	Id.	Detection
Number	0	2	0	4
Rate/100	0.0	2.5	0.0	4.8

SKI TOURING

Error	Id.	Detection	Id.	Detection
Number	2	6	5	3
Rate/100	2.5	7.5	5.9	3.6

Hiking Trail - 2   Hiking Trail - 5

Appendix I. Continued

9. On what route is located a WINTER RECREATION AREA?

Type of Question :	Proximity
Condition A	Condition B
40 Samples	42 Samples
40 Total Responses	42 Total Responses

WINTER RECREATION

Error	Id.	Detection	Id.	Detection
Number	1	0	1	0
Rate/100	2.5	0.0	2.3	0.0
	Ski Touring - 1		Ski Touring - 1	

10. Identify in order from north to south the pictorial symbols along the South River.

Type of Question	Proximity
Condition A	Condition B
40 Samples	42 Samples
200 Total Responses	210 Total Responses

CAMPGROUND

Error	Id.	Detection	Id.	Detection
Number	5	0	10	3
Rate/100	12.5	0.0	23.8	7.1
	Camping - 1 Campsite - 4		Camping - 5 Campsite - 4 Caution area - 1	

Appendix I. Continued

CAMPFIRES

Error	Id.	Detection	Id.	Detection
Number	1	0	8	2
Rate/100	2.5	0.0	19.0	4.8
	Grill - 1		? - 1 Camping - 3 Fireplace - 1 Open air, Outdoor fires - 2 Rest area - 1	

PARKING

Error	Id.	Detection	Id.	Detection
Number	2	0	0	2
Rate/100	5.0	0.0	0.0	4.8
	Police - 1 Information - 1			

FISH HATCHERY

Error	Id.	Detection	Id.	Detection
Number	1	0	4	2
Rate/100	2.5	0.0	9.5	4.8
	Fishing - 1		Fishing - 4	

WOMEN'S RESTROOM

Error	Id.	Detection	Id.	Detection
Number	0	5	0	4
Rate/100	0.0	12.5	0.0	9.5

Appendix I. Continued

11. Mark two circles around the DAM.

Type of Question	:	Item Category
39 Samples		42 Samples
39 Total Responses 1 Incomplete		42 Total Responses

DAM

Error	Id.	Detection	Id.	Detection
Number	0	0	0	0
Rate/100	0.0	0.0	0.0	0.0

12. Which pictorial symbol is southwest of the DAM?

Type of Question	:	Cardinal Direction
39 Samples		42 Samples
39 Total Responses 1 Incomplete		42 Total Responses

ENVIRONMENT

Error	Id.	Detection	Id.	Detection
Number	0	0	11	1
Rate/100	0.0	0.0	26.2	2.4

Entertainment area - 1
Environmental:
Communication - 1
Viewing station
(something like that)- 1
Thing - 1
Concern - 1
Lodging - 1
? - 5

Appendix I. Continued

13. Name the pictorial symbols on Route 640.

Type of Question	:	Proximity
Condition A		Condition B
39 Samples		42 Samples
156 Total Responses		168 Total Responses
1 Incomplete		

RECREATIONAL VEHICLE TRAIL

Error	Id.	Detection	Id.	Detection
Number	0	7	7	6
Rate/100	0.0	17.9	16.7	14.3
	Jeep trail - 1		Jeep trail - 1 Offground vehicles - 3 4WD trail - 1 Scenic car route - 2	

DEER VIEWING AREA

Error	Id.	Detection	Id.	Detection
Number	0	7	6	6
Rate/100	0.0	17.9	14.3	14.3
			Animal range - 1 Deer crossing - 3 Deer hunting - 1 Deer ground - 1	

Appendix I. Continued

WINTER RECREATION AREA

Error	Id.	Detection	Id.	Detection
Number	0	9	4	7
Rate/100	0.0	23.1	9.5	16.7

Snow recreation area - 2
Winter resort - 2

GAS STATION

Error	Id.	Detection	Id.	Detection
Number	0	9	1	7
Rate/100	0.0	23.1	2.4	16.7

Service station - 1

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14. Mark a box around the symbols for lodging.

Type of Question : Item Category

Condition A	Condition B
39 Samples	42 Samples
78 Total Responses	84 Total Responses
1 Incomplete	

LODGING

Error	Id.	Detection	Id.	Detection
Number	0	1	2	3
Rate/100	0.0	1.3	2.4	3.6

Picnic shelter - 1
Trailer site - 1

Appendix I. Continued

15. <u>Identify the symbols from Powell to Ladd along Route 340.</u>

Type of Question :	Proximity
Condition A	Condition B
39 Samples	42 Samples
195 Total Responses 1 Incomplete	210 Total Responses

TRAILER SITES

Error	Id.	Detection	Id.	Detection
Number	1	1	8	1
Rate/100	2.6	2.6	19	2.4
	Trailer camping - 1		Camping trailer - 3 Camperstation - 1 Recreation vehicle park - 2 Trailer hitch area - 2	

GAS STATION

Error	Id.	Detection	Id.	Detection
Number	0	1	0	1
Rate/100	0.0	2.6	0.0	2.6

PARKING

Error	Id.	Detection	Id.	Detection
Number	2	6	0	5
Rate/100	5.1	15.4	0.0	11.9
	Police - 1 Information - 1			

Appendix I. Continued

LODGING

Error	Id.	Detection	Id.	Detection
Number	0	3	2	2
Rate/100	0.0	7.7	4.8	4.8
			Sleep - 1 Motel - 1	

TELEPHONE

Error	Id.	Detection	Id.	Detection
Number	0	1	0	2
Rate/100	0.0	2.6	0.0	4.8

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16. A HIKING TRAIL connects what two roads?

Type of Question : Proximity

Condition A	Condition B
39 Samples	42 Samples
39 (2) Total Responses	42 (2) Total Responses
1 Incomplete	

HIKING TRAIL

Error	Id.	Detection	Id.	Detection
Number	0	0	2	4
Rate/100	0.0	0.0	4.8	9.5
			? - 1 Ski towing - 1	

Appendix I. Continued

17. Name the two symbols on the Campbellville city line.

Type of Question : Proximity

Condition A	Condition B
38 Samples	42 Samples
76 Total Responses	84 Total Responses
1 Incomplete	

GAS STATION

Error	Id.	Detection	Id.	Detection
Number	0	0	1	1
Rate/100	0.0	0.0	2.4	2.4
			Service station - 1	

INTERPRETIVE AUTO ROAD

Error	Id.	Detection	Id.	Detection
Number	0	3	17	2
Rate/100	0.0	7.9	40.5	4.8

? - 4
Garage - 1
Raceway - 2
Intermittant auto road - 5
Informational road - 1
Car recreation - 2

Appendix I. Continued

18. Identify the five pictorial symbols north and adjacent to Interstate 64.

Type of Question	:	Proximity
Condition A		Condition B
33 Samples		41 Samples
165 Total Responses		205 Total Responses
7 Incompletes		1 Incomplete

PICNIC SHELTER

Error	Id.	Detection	Id.	Detection
Number	2	0	10	2
Rate/100	6.1	0.0	24.4	4.9

Picnic area - 1
Covered picnic table - 1

Recreation area - 1
Restaurant - 1
Picnic area - 7
Family shelter - 1

WOMEN'S RESTROOM

Error	Id.	Detection	Id.	Detection
Number	0	1	0	2
Rate/100	0.0	3.0	0.0	4.9

Appendix I. Continued

ENVIRONMENTAL STUDY AREA

Error	Id.	Detection	Id.	Detection
Number	0	1	8	2
Rate/100	0.0	3.0	19.5	4.9

Entertainment - 1
Environmental:
Communication - 1
Concern - 1
Interpretative display - 1
Information area - 1
? - 3

PICNIC AREA

Error	Id.	Detection	Id.	Detection
Number	1	1	4	0
Rate/100	3.0	3.0	9.8	0.0

Picnic table - 1

Picnic table - 3
Picnic site - 1

SKI BOBBING

Error	Id.	Detection	Id.	Detection
Number	0	1	6	2
Rate/100	0.0	3.0	14.6	4.9

Downhill skiing - 1
Ski lift - 1
Ski slope - 1
Ski bounding - 1
Ski crossing - 1
Tobogganing - 1

XII. APPENDIX II

Appendix II. Performance of Each NPS Symbol.

Symbol	Question No. and Type	Id Error rate/100 A	Id Error rate/100 B	Detection Error rate/100 A	Detection Error rate/100 B
Marina	#6 (cardinal direction)	1.25	5.95	10.0	16.7
Picnic Shelter	#2 (proximity)	5.0	28.6	0.0	0.0
	#18 (proximity)	6.1	24.4	6.1	4.9
Winter Recreation Area	#9 (proximity)	2.5	2.3	0.0	0.0
	#13 (proximity)	0.0	9.5	23.1	16.7
Tunnel	#2 (proximity)	2.5	0.0	45.0	30.9
Ski Touring	#8 (item category)	2.5	5.9	7.5	3.6
Trailer Sites	#6 (cardinal direction)	0.0	23.8	2.5	11.9
	#15 (proximity)	2.6	19.0	2.6	2.4
Hiking Trail	#16 (proximity)	0.0	4.8	0.0	9.5
Interpretative Auto Road	#3 (proximity)	2.5	26.2	5.0	11.9
	#17 (proximity)	0.0	40.5	7.9	4.8
Recreation Vehicle Trail	#3 (proximity)	2.5	21.4	5.0	7.1
	#13 (proximity)	0.0	16.7	17.9	14.3
Dam	#11 (item category)	0.0	0.0	0.0	0.0
Telephone	#15 (proximity)	0.0	0.0	2.6	4.8

Appendix II. Continued

Symbol	Question No. and Type	Id Error rate/100 A	Id Error rate/100 B	Detection Error rate/100 A	Detection Error rate/100 B
Motorboating	#6 (cardinal direction)	0.0	14.3	5.0	11.9
Parking	#10 (proximity)	5.0	0.0	0.0	4.8
	#15 (proximity)	5.1	0.0	15.4	11.9
Women's Restroom	#10 (proximity)	0.0	0.0	12.5	9.5
	#18 (proximity)	3.0	0.0	3.0	4.9
Gas Station	#1 (item category)	0.0	1.6	2.5	1.6
	#2 (proximity)	0.0	0.0	0.0	2.4
	#7 (cardinal direction)	0.0	0.0	0.0	0.0
	#13 (proximity)	0.0	2.4	23.1	16.7
	#15 (proximity)	0.0	0.0	2.6	2.6
	#17 (proximity)	0.0	2.4	0.0	2.4
Ski Bobbing	#7 (cardinal direction)	5.0	23.8	2.5	0.0
	#8 (item category)	0.0	0.0	2.5	4.8
	#18 (proximity)	0.0	14.6	3.0	4.9
Airport	#4 (proximity)	0.0	0.0	0.0	0.0
Fish Hatchery	#10 (proximity)	2.5	9.5	0.0	4.8

Appendix II. Continued

Symbol	Question No. and Type	Id Error A	rate/100 B	Detection Error A	rate/100 B
Campfires	#6 (cardinal direction)	0.0	4.8	7.5	28.6
	#10 (proximity)	2.5	19.0	0.0	4.8
Lodging	#2 (proximity)	2.5	11.9	27.5	23.8
	#14 (item category)	0.0	2.4	1.3	3.6
	#15 (proximity)	0.0	4.8	7.7	4.8
Lighthouse	#6 (cardinal direction)	0.0	4.8	5.0	14.3
Picnic Area	#6 (cardinal direction)	2.5	21.4	5.0	4.8
	#18 (proximity)	3.0	9.8	3.0	0.0
Vehicle Ferry	#6 (cardinal direction)	2.5	7.1	5.0	9.5
Campground	#5 (proximity)	0.0	9.5	0.0	0.0
	#7 (cardinal direction)	7.5	23.8	0.0	4.8
	#10 (proximity)	12.5	23.8	0.0	7.1
Ranger Station	#7 (cardinal direction)	2.5	9.5	2.5	4.8
Environmental Study Area	#12 (cardinal direction)	0.0	26.2	0.0	2.4
	#18 (proximity)	0.0	19.5	3.0	4.9

Appendix II. Continued

Symbol	Question No. and Type	Id Error A	rate/100	Id Error B	Detection Error A	rate/100	Detection Error B
Stable	#2 (proximity)	2.5		11.9	2.5		0.0
Downhill Skiing	#8 (item category)	0.0		0.0	6.25		2.4
Deer Viewing Area	#13 (proximity)	0.0		14.3	17.9		14.3
Information	#2 (proximity)	0.0		2.4	17.5		7.1
	#6 (cardinal direction)	0.0		0.0	7.5		23.8

XIII. VITA

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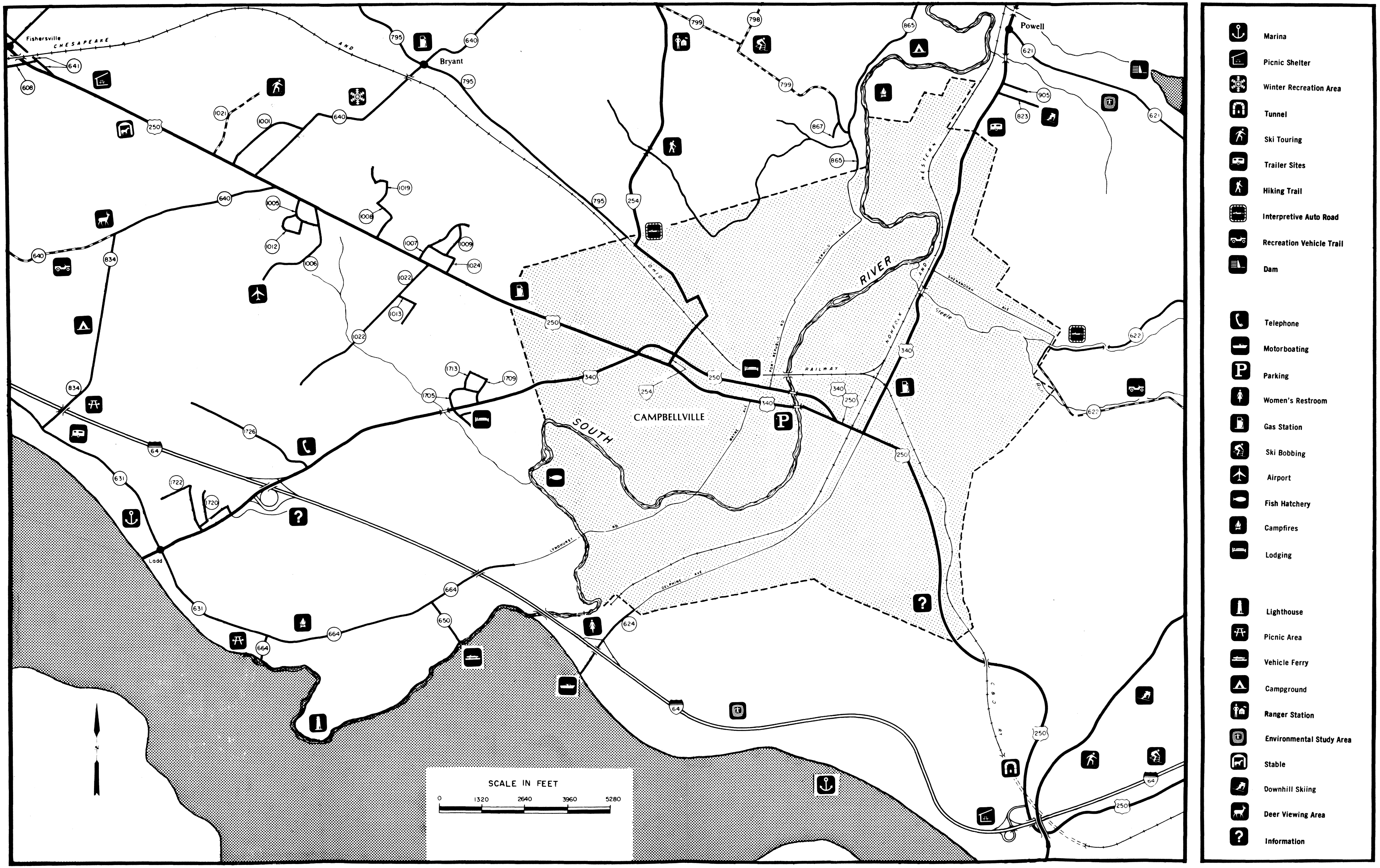

Fishersville
CHESAPEAKE
AND
OHIO
Bryant
Powell
CAMPBELLVILLE
SOUTH
RIVER
NORFOLK
AND
WESTERN
SHENANDOAH
RAILWAY
Ladd
250
340
254
64
SCALE IN FEET
0
1320
2640
3960
5280
Marina
Picnic Shelter
Winter Recreation Area
Tunnel
Ski Touring
Trailer Sites
Hiking Trail
Interpretive Auto Road
Recreation Vehicle Trail
Dam
Telephone
Motorboating
Parking
Women's Restroom
Gas Station
Ski Bobbing
Airport
Fish Hatchery
Campfires
Lodging
Lighthouse
Picnic Area
Vehicle Ferry
Campground
Ranger Station
Environmental Study Area
Stable
Downhill Skiing
Deer Viewing Area
Information