

Review: *How Maps Work: Representation, Visualization, and Design*, Alan M. MacEachren. New York: The Guilford Press, 1995. 526 pages, 221 maps and illustrations, bibliography, author index, subject index. \$42.00, hardbound. (ISBN 0-89862-589-0).

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Article:

If you are searching for a detailed guide to contemporary cartographic research issues, *How Maps Work* is the book you need. This encyclopedia volume covers many of the major ideas currently being examined by academic cartographers. The goal of the book, as stated by MacEachren, is to provide a basis from which cartographers might begin to build an understanding of how maps work. As he clearly points out in the preface "Understanding how and why maps work (or do not work) as representations in their own right and as prompts to further representations, and what it means for a map to work, are critical issues as we embark on a visual information age" (p. v).

To accomplish this daunting task, MacEachren has constructed a view of spatial representations that consists of multiple levels and has organized his book around this structure. *How Maps Work* consists of three main sections: *How Meaning is Derived from Maps*, *How Maps are Imbued with Meaning*, and *How Maps are Used: Applications in Geographic Visualization*. The first two sections of the book consider cartographic research from two complementary perspectives: a private/ perceptual-cognitive view and a public/social view. The former is concerned primarily with how we "see" maps and how we derive meaning from them; the latter employs semiotics to develop logical symbolization systems and provide a framework for understanding how we interpret and assign meaning to map symbols. The final section provides a case study, geographic visualization (GVIS), through which this multiple-level approach is applied.

Part I, *How Meaning is Derived from Maps*, consists of three chapters that outline an information-processing approach to vision and visual cognition and discuss its potential application for the study of maps. In Chapter Two, *An Information-Processing View of Vision and Visual Cognition*, MacEachren begins by describing David Marr's information-processing model of vision. He then offers Steven Pinker's theory of graph comprehension as an example of an information-processing approach to visual cognition, and discusses the work of several cartographers who have developed similar, but less formal models.

In Chapter Three, *How Maps are Seen*, MacEachren provides a detailed synthesis of the eye-brain system and examines its limitations for processing information about the basic visual variables used in cartographic representation. Much of this chapter is devoted to the research that has been conducted on low-level visual processes, with an emphasis on how they affect cartography's use of visual variables in the design of maps. Here, MacEachren has pulled together research from a variety of disciplines ". . . to build an understanding of how maps are seen that can serve as a framework for research on and guidelines for map symbolization and design" (p. 147). Processes that are discussed include Gestalt grouping principles, selective attention theory, visual search models, perceptual categorization, and depth perception. MacEachren also provides several examples of the application of these principles in cartographic research and testing.

The emphasis on low-level perceptual processes in Chapter Three sets the stage for Chapter Four, *How Maps are Understood*. In this chapter, it is the interaction between the visual descriptions of maps, which result from how we "see" maps, and our existing knowledge that is stressed. MacEachren uses the mechanism of knowledge schemata as a way of linking these visual descriptions with our existing knowledge. Discussion begins with the topic of mental categorization, since categories underlie our ability to form schemata. Aspects of categorization that are detailed include prototype theory, family resemblance, fuzzy categories and basic-level theory. MacEachren then examines the issue of general knowledge representation and highlights the basic theories (propositional, analogical, and procedural) that attempt to describe the structures used in long-term memory representation. He proposes three types of schemata as linking mechanisms between these long-term representations and visual descriptions: propositional, image, and event schemata. Details of each of these schemata are complemented with examples of how they might be used in a cartographic context. The chapter ends with an exploration of issues related to the development of cognitive map schemata. Using an isarithmic representation of terrain as an example, MacEachren generates hypotheses for how map schemata develop, how they are selected for specific map tasks, and how they are used in interpreting spatial information.

Part Two, *How Maps are Imbued with Meaning*, uses a semiotic perspective in considering the public/social aspects of cartographic representation. According to MacEachren, "Cartographic inquiry can profit from a semiotic. . . approach for two reasons. First, semiotics provides a conceptual framework for developing a cartographic representation logic that can take advantage of what we know about cognitive representations, mental categories, and knowledge schemata. Second, aspects of semiotics that deal with meaning offer a way to integrate approaches to map representation that emphasize both explicit and implicit meaning, logical and expressive meaning, denotation and connotation, and more" (p. 214). Chapter Five, *A Primer on Semiotics for Understanding Map Representation*, is the first of three chapters in this section and is essentially a primer on the semiotic concepts relevant to cartography. MacEachren begins the chapter by establishing some basic terminology and then proceeds to examine two fundamental semiotic issues: the relationships between map marks and their referents, and the relationships among map signs. Examples of topics that are covered include: Peirce's typology of signs in which the relationship of the sign-vehicle to the referent is explored from the viewpoint of the interpretant; Morris' typology of discourse that examines how signs influence behavior; and Morris' three dimensions of semiosis—syntactics, semantics, and pragmatics. Also examined are a number of cartographic efforts to adapt these concepts to spatial representations.

In Chapter Six, *A Functional Approach to Map Representation*, the focus is on the categorization of "stand-for" relationships in mapping (mapping semantics) and sign system specification (mapping syntactics). The sections dealing with map semantics consider individual sign relations from the perspective of a triadic model. Using this model of signs, MacEachren shows how separate perspectives can put emphasis on particular cartographic issues, such as the link between symbol and meaning or the role of map signs in promoting understanding between the cartographer and the map user. He then discusses the syntactics of mapping, an area in which cartographers have worked to develop typologies of symbol categories and rules for matching these categories to those of geographic features. His example for this section examines the most fundamental cartographic typology, the level of visual variables. Here, he introduces the reader to Bertin's original set of graphic variables, outlines a number of extensions for that set, and then suggests a mapping syntactic that is based on their logical application.

Chapter Seven, *A Lexical Approach to Map Representation*, provides a complementary perspective to the one taken in the previous chapter. The emphasis is on explaining how map users interpret symbols and symbol groups on maps, as well as entire maps themselves. In organizing this chapter, MacEachren has chosen to address meaning and map representation from two perspectives: meanings *in* maps and meanings *of* maps. Meaning in maps is defined as those denotative meanings that are directly specified on a map, such as in the map legend. MacEachren covers several issues related to this type of meaning, the most important of which is a basic taxonomy that categorizes meaning *in* maps into three levels: meanings about space, space-time, and attributes in space-time. Other issues examined include the specificity of signs, the concreteness of signs, and how the meaning *of* map signs changes across cultures and across time. Meaning of maps, on the other hand, are

connotative meanings. The difference between the two can be thought of as the difference between ". . . knowing what things are (explicitly) versus what they stand for (implicitly)" (p. 331). MacEachren describes this idea by examining a typology of connotation and by exploring various types of connotations on maps, such as those of veracity, integrity and power.

The last section of *How Maps Work* is titled *How Maps are Used: Applications in Geographic Visualization*. This section also has three chapters, each devoted to exploring how the multi-perspective approach of Parts I and II can be applied to GVIS. In Chapter Eight, *GVIS: Facilitating Visual Thinking*, the emphasis is on the application of these approaches to a low-level task, feature identification. MacEachren begins the chapter by presenting and elaborating on a model for feature matching. He then uses this model to integrate some of the ideas discussed in the first two sections of the book. The reader's attention is directed to several cognitive concepts, such as attention and categorization, that are related to functional representations in the GVIS environment. Related topics that are covered include the position of space and time in perceptual organization, the role of scale and resolution in GVIS displays, the influence of static graphic variables on the emergence of pattern, and the role of schemata in defining what is "seen. "

Chapter Nine, *GVIS: Relationships in Space and Time*, extends the approach taken in Chapter Eight to more complex tasks such as spatial comparisons across multiple features or multiple times. Highlighted here are the attempts of several researchers to build the tools necessary to make such comparisons in a GVIS environment. Sections are included on the use of space, orientation, color, time, focus, and sound as potential GVIS tools. Also discussed in this context are space-time processes, which present yet another level of complexity.

The final chapter, *GVIS: Should We Believe What We See?*, concludes the book with a discussion of how to judge truth in GVIS and how to determine what truth means in a visualization environment. The discussion here revolves around two questions: How can truth be judged in the displays that GVIS provides? and What is truth in the context of GVIS? The first question is addressed both at the level of individual signs as well as at the level of the map itself. The answer to the second question, MacEachren contends, depends on the questions the user is trying to answer. As such, he poses answers for two fundamental categories of uses: those in the private realm and those in the public realm.

How Maps Work is a comprehensive account of recent issues being explored in cartographic research. It is clear, concise, and well-written. MacEachren has integrated research from several highly respected and well-known researchers from a diversity of fields. He has taken their results and established clear links from their research to issues that are also of importance to the study of maps. He consistently supports his contentions and ideas with a variety of cartographic examples designed to emphasize these links. One weakness in the subject matter is the necessity of the reader to overcome jargon associated with some topics. Although MacEachren clearly made an effort to minimize this problem, there are still some sections that will be difficult to comprehend without a more thorough background in the specific subject area.

How Maps Work is a gold mine of information and well-worth the sticker price. While not appropriate for introductory or intermediate level cartography classes, it would serve well as a basis for graduate research seminars and is an excellent reference source. Every cartographic researcher should own a copy.