Network Analysis in Geography, by Peter Haggett and Richard J. Chorley New York: St. Martin's Press, London: Edward Arnold, 1969, xii + 348 pages.

It is now more than a quarter of a century ago that the first fundamental contributions to network analysis were published: among others, Koenig's [3] book on graphs, Horton's [2] work on the development of drainage patterns, and Hitchcock's [1] papers on transportation flows. They initiated a startling growth of network theory which today occupies a solid position in research (operations research, geology, graph theory and others) as well as in urban and regional planning. Even geography has begun to utilize at least part of the body of theory now available, and come up with some theoretical contributions on its own. Ample evidence is provided by the more than 400 items listed in the bibliography of "Network Analysis in Geography," some 40 percent of which are publications by geographers or in geographic journals.

A vast variety of spatial phenomena can formally be described by patterns of interconnected lines: pipelines, subways, rails, roads, drainage systems, political districts, economic regions, among others. The first chapter of the book treats these networks as graphs and provides elementary concepts and measures to study their topological structure: connectivity matrix, stream number and order, bifurcation ratio, various network indices, the generation of shortest path matrices and combinatorial cell arrangements. Chapter two extends the graph theoretical approach by introducing metric concepts like length, shape, area, density, circuitry and sinuosity. Obviously, the definition of network concepts cannot be a purpose in itself; they must be related to and interpreted in terms of other (geographic) variables. That this can and has been done is demonstrated through several examples of applications. In a scientific context, however, the definition of concepts serves the construction of theory, and the few examples given in the book are essentially restricted to Horton's various laws for stream networks and Shreve's corresponding deductions assuming randomness as the principal force.

The subject of chapters three and four is the evaluation of network structures. The section on the efficiency of transportation networks in terms of the flow pattern they carry is short and disappointing in view of the existing literature. It includes the comparison of several alternative network designs with regard to the resulting flow distribution; some simulation results are reported. The following section re-

views research findings regarding the interrelation of river channel measures, discharge, drainage density and environmental variables, again with emphasis on the Horton model. As throughout the book, there are only a few cross-references to structurally comparable phenomena in human transportation systems, as for example, the partial analogy between the speed/transport relationship in a controlled channel and the fundamental diagram of traffic theory (flow per unit time vs. density per unit length). The final section of chapter three is concerned with flow forecasting and assignment. Although the abstract mode model as well as other regression approaches are missing, most of the principal elements from land use and traffic generation to the final flow pattern prediction are well summarized. Somewhat unexpectedly (but most welcome), a review of short-term feedbacks (congestion, traffic flow theory) and long-term feedbacks (economic impact of transportation) has been added. The section concludes with a discussion of the relationship between rainstorms and the resulting distribution of discharge in river basins (flood forecasting via hydrographs).

For the geographer, the efficiency of networks is primarily a locational problem. Chapter four, "Location of Networks," contains most of the material missing in the previous section on network efficiency (optimal link addition, algorithms to find matrix solutions of shortest paths, minimum cost shipment through networks, networks of minimum lengths and geodesic paths of minimum cost design). After the location of routes, the location of boundaries is studied, with emphasis on taxonomic problems and spatial grouping procedures: variance, cluster, discriminant analysis and other techniques with examples. As throughout the book, there is little or no elaboration on the methodology.

The last part of the book is devoted to the structural change of networks and presents some descriptive and speculative models on the growth of networks over time. Probably because of the relatively simpler structure of stream pattern development, its analysis is once again more advanced and successful than the transportation network growth models. Haggett's attempt to decompose transportation networks into trees which in turn are subject to analysis analogue to stream network theory shows promising results and might very well define a new research frontier in geographic network analysis. Woldenberg's efforts to explain drainage basin patterns in terms of Christaller's mixed hexagonal hierarchies remain a highly speculative construct. His convergent mean model, supposedly "so powerful in predicting basin areas of given order," permits the generation of such a vast number of numerical sequences that a good fit can be found for almost any geometrical progression.

Criticism of the book is easier than would be desirable, both at the professional and the trivial level. As to the latter, the text contains an almost impressive collection of mistakes and deficiencies. A few examples: The table of contents does not always agree with the text. In line with a longstanding geographic tradition, the text to the many figures often repeats in detail what is obvious by looking at the figures. Some concepts are not defined, or their application precedes definition. Circuit and barrier networks are classified as topologically different, which is incorrect, and the terms "topologically identical" and "topologically similar" are assumed to describe the same relationship between networks, at least according to Figure 1.4

and the corresponding text. On page 51, the unit square is converted into "a rectangle of similar area but with two of its sides twice as long as the others." If similar means similar, the comparison of area and shape is meaningless; if similar means equal, the numerical values for perimeter and diameter given in the text are false. But if the reader hopes that at least the mistakes are consistent with each other, he will again be disappointed. "Experimentation demonstrates" the relationship between rectangular shape and perimeter and diameter, respectively. According to page 66–67, "Nystuen (1966) has drawn attention to a critical theorem by Courant (1937), page 277) . . . ," but neither is that age old theorem (the length of curves with continuous derivative) by Courant nor does Nystuen claim it to be. The data reported in Table 4.5 for Figure 4.18 do not fit. They do, however, fit the figure which the text claims 4.18 to be—which, however, it is not. On page 115 and 194, Beckmann's mistake regarding the general five point network design from 1960 is once more repeated (after Bunge and again Haggett) and should soon be an integral part of geographic theory. Sometimes the trouble is only negligent language (page 85): "Belgium . . . was about thirty times as dense a network as the world mean, while Luxembourg with the highest railway network was only about twenty times as dense as the world mean."

Fortunately, most of these shortcomings do not seriously affect the book as a source of information. But there are several other problems. Some of the remarkable research achievements are lost in favor of extremely simple approaches of questionable value. It is not clear how the restriction to "geographic" networks guided the selection of the literature to be reviewed, because the text neither explicitly nor implicitly specifies how geography's position is seen in contrast to other disciplines participating in network analysis. The book confines itself largely to the task of summarizing the content of selected research papers; an evaluative discrimination among and critique of the papers is sparse. At the same time, many of these summaries are excellent, as is the organization of the material and the readability of the text in general. The authors are quite aware of the book's limitations: From page v ". . . we lay no claims to completeness or rigor: we have drawn our models from our own areas of experience and the mathematical level is elementary." From the reader's point of view it might then seem that some of the material covered (together with the locational index that lists places mentioned in the text) is dispensable and could have profitably been replaced by a supplementary chapter introducing him into more (and more rigorous) methods as well as advanced topics on the analysis of geographic networks.

In summary (and disregarding the mostly trivial deficiencies), the book can be described as a well organized and integrated review of the more elementary papers dealing with theoretical concepts and network models of streams, transportation patterns, and geographical boundaries. As such, it fills a major gap on the book market; it provides a fairly comprehensive text for undergraduate classwork; it introduces the interested geographer into the peculiar world of nodes and links; and it assists the professional to maintain a general view of his field.

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