

FUNDAMENTALS OF

GEOGRAPHIC

INFORMATION

SYSTEMS

MICHAEL N. DEMERS

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Michael N. DeMers

New Mexico State University



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PREFACE

Geographic information systems (GIS) in their automated form, originated in the 1960s. During the early days of the technology their use was limited to a small group of practitioners. GIS instruction was even more limited to a select few universities fortunate enough to have faculty who were aware of the potential of these systems. Since then the numbers and types of systems, the potential users, and the types of technical training and conceptual education have all increased at a rate that must amaze even the originators. In fact, the letters GIS now also stand for geographic information science—a recognition that this discipline has gone well beyond a set of techniques and tools to a field of scientific investigation in its own right.

My purpose in writing this book is to serve two educational missions, both reflecting the current growth of GIS technology and its intellectual content. The challenge is to provide a conceptual level of understanding of spatial analysis through the implementation of modern GIS software while presenting useful material for technical training. Thus, I have provided wherever possible, functional links between the technician and the academic. In this way, I help technicians understand that a knowledge of fundamental geographic concepts will enhance their ability to perform the day-to-day tasks required of the software. At the same time, I show academics how the tasks they request of technicians are made easier if they can formulate their models with an understanding of the technical limitations of the software and the hardware.

My approach is notably a geographic one, as one might expect given my background. Accordingly, in my estimation, anyone who studies and employs the techniques of GIS is a geographer, at least, by avocation if not by vocation. The applications for which GIS are currently applied are likely far fewer than they will be in the future. As these applications grow so will an understanding of the role that automated geography can play in spatial decision making.

For this reason, I have written this book from the perspective of geographic exploration. My intent is to share the enjoyment I have experienced by discovering new lands and new settings within the geographic databases I see in my own GIS work. My objective throughout the book is to show that a well-prepared GIS professional is a precious resource, capable of providing a set of decision-making tools far beyond what was available only a few short decades ago. This book is designed to provide the basics of those GIS skills, somewhat independent of the technology.

Although this book is intended to be an introduction to GIS, it is important for instructors and users to supplement any course lecture material with hands-on practical exercises using some form of GIS. Some will want to use high-powered professional software, especially those who are learning GIS as a set of techniques. Others, especially those whose education in GIS will extend to

multiple courses at different levels, may be more comfortable with software that is easily accessible to the student but that maintains the essential operational capabilities of a professional package. Depending on the particular situation, laboratory exercises should be adaptable to the general concepts and ideas in this book. The text is purposely designed to be software (and data) independent, trusting that course instructors will use whatever software and hardware are most applicable to the course mission and available to them. I have provided some sources for software, data, and GIS output in Appendix A, which should prove useful in either a classroom or a self-learning situation.

Finally, I recognize that a comprehensive book such as this is likely to contain errors, minor inconsistencies, and misunderstandings. I have provided a point of contact through the World Wide Web in Appendix B that allows instructors or students to ask questions or to clarify information. My hope is that readers will share information, methods, laboratories, and learning techniques with others so that we all gain from our experiences. In so doing, users of this book will play a role in enhancing the preparations of all future GIS professionals.

Michael N. DeMers

ACKNOWLEDGMENTS

It is no small irony that, after having written nearly 200,000 words for this textbook, I find myself struggling with the acknowledgments. Perhaps it is because I am painfully aware that I owe so many people an enormous debt. I hope that this work will, in some way, show them the measure of the gratitude I have for them.

I offer this work first to William A. Dando, who put my feet on the path of geographical knowledge and who has been an unwavering supporter of my work. He not only shared his knowledge and skills with me but, more importantly, he shared his time, his family and, above all, his love. No student ever received so much from an adviser. His has been the pattern that I have tried to emulate.

Much of my early understanding of GIS came from two of my former teachers as well as from two who were unaware that they taught me. Kang Tsung Chang, who taught me both manual and automated cartography, was a model of patience and understanding. His insights are still with me today. T. H. Lee Williams provided a structured, incremental, well-designed educational framework for both remote sensing and GIS. He also provided many unique opportunities to learn about the techniques of geography through seminars, directed readings, and mixes of topical and regional geography. More importantly, he allowed me the freedom to pursue my own interests in my own way. His faith in my abilities kept me going when the clouds of self-doubt threatened. Some of the material he used to teach me about GIS was derived from seminars and short courses taught by C. Dana Tomlin and Joseph K. Berry. Many of their ideas are scattered throughout this book because they are part of the way I view GIS. So, in a sense, they, too, have been my teachers. I hope that all of these fine educators continue to share their approaches through their classes, seminars, and writings. The field is better for having them.

Isaac Newton once wrote, "If I have seen further it is by standing upon the shoulders of giants."* This is certainly true of the textbook you now hold in your hands. During the many long days I spent throwing words at the computer, I pondered who the muse was who provided me with the material that you will soon read. Perhaps it was not a single muse but rather all those whose research and ideas continue to expand the field of automated geography. Because this discipline is relatively new, I am fortunate that many of these key players are still expanding our knowledge. I have been blessed by knowing some of them and by being able to count them among my friends.

Those who have befriended me include Duane Marble with whom I had the great good fortune to work for six years and whom I consider to be one of my

*Letter to Robert Hooke, February 5, 1675.

best friends. I doubt whether my knowledge of GIS would have grown enough to consider writing this book without his continued support, his demand for excellence, and his willingness to share his ideas, experience, time, and writings. Much of the last chapter of this book can be attributed to his seminal work on GIS design. Among my good friends and most ardent supporters I am also fortunate to include Vince Robinson, who shared his ideas and writings, and who has probably written more letters in support of my efforts than anyone. The efforts of Michael Goodchild for recommending me as a possible candidate for academic posts are gratefully acknowledged—perhaps, even more than some others because he was unaware that I knew of this kindness. Jerome Dobson also requires many thanks for suggesting me for the science advisory panel of the NOAA C-CAP program, for writing letters in support of my career, and for his continued encouragement of my efforts to link traditional geography to automated geography. He also deserves credit for the term automated geography, which I believe is the correct term for what I do.

Thanks are also due to Nicholas Chrisman, who encouraged me during some very difficult times and from whose work I have drawn many insights over the years. I am also grateful to him for having given me the opportunity to share my own musings on the first draft of his upcoming GIS textbook, *Exploring Geographic Information* (Wiley, 1997). My hope is that, as our two books share space on the publisher's display, we too, may share in our mutual goal of producing the next generation of GIS professionals.

Another friend who has supported my work and who has gained my professional and personal respect is Peter Fisher. I have learned much in my short professional association with him and perhaps even more by my personal association. Many other friends are responsible for this book through their academic research efforts and their personal encouragement. Robert Aangenbrug, David Cowen, Lee De Cola, Earl Epstein, John Jensen, David Mark, and Donna Peuquet are those who readily come to mind. To them and to all who have supported me, I offer this book as a way of thanking them for their continued efforts on behalf of the field of geography.

I thank all of my GIS students, many of whom have waded through the larval stages of this work in the form of fragmented and often incomplete course notes. My thanks also to the graduate teaching assistants who produced new laboratory exercises and improved on some existing ones for my GIS courses. Without their efforts this work would be an empty shell of facts. The College of Arts and Sciences and the Department of Geography at New Mexico State University provided me with an environment conducive to producing this work. I am grateful to Dean René Casillias, Robert Czerniak, Jerry Mueller, Albert Peters, and Jack Wright for their support and continued encouragement.

I thank the following reviewers of my manuscript for their diligence and professionalism: D. G. Barber, Bryan Baker, Alan Forsberg, Michael Hodgson and Keith Rice. Reviewing someone else's manuscript can be a tedious task that rewards the author more than the reviewer. The reviewers should be reminded that any success that is attendant upon this book is in large part the result of their efforts. The folks at Wiley have been nothing short of spectacular in their efforts to keep this manuscript moving forward. Thanks to my geography editors—Frank Lyman for believing in my book proposal and Nanette Kauffman for supporting that belief—and to the production and manufacturing staffs for their efforts at turning this manuscript into a bound volume.

Finally, a special thank-you is due to my loving wife Dolores, who fervently believed that this was a work that needed to be performed and that I was the right person to do it. While resisting every effort to become interested in automated geography, she has remained steadfast in her support of my writing. Without her the daunting task of completing this project would have loomed ever larger. She gave up many hours of her time to take care of things that might have distracted me from writing, gave up vacations so there would be no interruption of the work, and has had to endure an endless flood of "what I did on my book today" stories. While I spent fewer and fewer hours with her while I worked on the manuscript, my love grew stronger because I knew she was always there. This one's for you, but you don't have to read it.

M. N. D.

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