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GIS

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- Design and implement a GIS

Michael N. DeMers

*Associate Professor of Geography,
New Mexico State University*



GIS FOR **DUMMIES®**

by Michael N. DeMers



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About the Author

Michael DeMers is an Associate Professor of Geography at New Mexico State University and has been teaching GIS-related courses since 1983. He is the author of *Fundamentals of Geographic Information Systems* (4th Edition), which has been translated into both Russian and simple Chinese, and *GIS Modeling in Raster*, currently being translated into Arabic.

Dedication

To all who have taught me, including my teachers, my students,
my colleagues, and those I have known only through their writings.

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Some of the people who helped bring this book to market include the following:

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Editors: Leah P. Cameron,
Colleen Totz Diamond, Laura Miller
Senior Acquisitions Editor: Katie Feltman
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Editorial Assistant: Amanda Foxworth
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Cartoons: Rich Tennant (www.the5thwave.com)

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Layout and Graphics: Shawn Frazier,
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Contents at a Glance

<i>Introduction</i>	<i>1</i>
<i>Part I: GIS: Geography on Steroids.....</i>	<i>7</i>
Chapter 1: Seeing the Scope of GIS.....	9
Chapter 2: Recognizing How Maps Show Information	23
Chapter 3: Reading, Analyzing, and Interpreting Maps	39
<i>Part II: Geography Goes Digital.....</i>	<i>57</i>
Chapter 4: Creating a Conceptual Model.....	59
Chapter 5: Understanding the GIS Data Models.....	73
Chapter 6: Keeping Track of Data Descriptions.....	93
Chapter 7: Managing Multiple Maps.....	109
Chapter 8: Gathering and Digitizing Geographic Data	117
<i>Part III: Retrieving, Counting, and Characterizing Geography</i>	<i>135</i>
Chapter 9: Finding Information in Raster Systems.....	137
Chapter 10: Finding Features in Vector Systems.....	147
Chapter 11: Searching for Geographic Objects, Distributions, and Groups	165
<i>Part IV: Analyzing Geographic Patterns</i>	<i>181</i>
Chapter 12: Measuring Distance	183
Chapter 13: Working with Statistical Surfaces	199
Chapter 14: Exploring Topographical Surfaces	213
Chapter 15: Working with Networks	225
Chapter 16: Comparing Multiple Maps	239
Chapter 17: Map Algebra and Model Building	253
<i>Part V: GIS Output and Application</i>	<i>277</i>
Chapter 18: Producing Cartographic Output	279
Chapter 19: Generating Non-Cartographic Output.....	293
Chapter 20: GIS in Organizations	301

<i>Part VI: The Part of Tens</i>	315
Chapter 21: Ten GIS Software Vendors	317
Chapter 22: Ten Questions to Ask Potential Vendors	329
Chapter 23: Ten GIS Data Sources	333
<i>Index</i>	343

Table of Contents

Introduction 1

About This Book.....	1
Conventions Used in This Book.....	1
What You're Not to Read.....	2
Foolish Assumptions.....	2
How This Book Is Organized	3
Part I: GIS: Geography on Steroids.....	3
Part II: Geography Goes Digital	3
Part III: Retrieving, Counting, and Characterizing Geography	3
Part IV: Analyzing Geographic Patterns.....	4
Part V: GIS Output and Application	4
Part VI: The Part of Tens.....	4
Icons Used in This Book	4
Where to Go from Here.....	5

Part I: GIS: Geography on Steroids 7

Chapter 1: Seeing the Scope of GIS 9

Getting a Feel for GIS.....	10
Meeting the GIS Collective.....	11
Accumulating geographic data	11
Adding the right computing power	12
Providing display and representation.....	13
Working with people	14
Knowing How to Think Spatially.....	15
Recognizing the spatial nature of questions	16
Discovering what's so special about spatial data.....	17
At Least 101 Uses of GIS.....	20
Managing business activities.....	20
Planning city operations and expansion.....	21
Providing protection and emergency services	21
Land management and conservation	21
Military and defense-related tasks.....	21
A treasure chest of possibilities	22

Chapter 2: Recognizing How Maps Show Information 23

Knowing How Maps Represent Geography.....	23
Understanding scale.....	24
Interpreting symbols	25
Incorporating symbols into your map	26



Recognizing the Different Types of Maps	27
Reading reference maps	28
Using thematic maps	29
Grasping the importance of scale	30
Working with Projections and Datums	31
Picking the right projections	32
Good projections depend on accurate datums	33
Working with Coordinate Systems and Land Subdivisions	34
Meeting the Universal Transverse Mercator (I know you want to)	35
Measuring the land	36

Chapter 3: Reading, Analyzing, and Interpreting Maps. 39

Making Sense of Symbols	40
Categorizing the space on a map	40
Understanding levels of measurement	41
Understanding the relationship between symbolology and data measurement	42
Recognizing Patterns	44
Identifying random distributional patterns	45
Finding clustered distributional patterns	46
Observing uniform distributional patterns	47
Seeing patterns among dissimilar features	47
Describing patterns with linear features	48
Understanding the repeated sequence of shapes	48
Analyzing and Quantifying Patterns	50
Knowing your geometry and patterns	51
Using GIS software for the analysis	52
Determining the type of pattern	52
Identifying even more patterns	55
Interpreting the Results and Making Decisions	55

Part II: Geography Goes Digital..... 57

Chapter 4: Creating a Conceptual Model. 59

Helping Computers Read Maps	60
Embracing the Model-Creation Process	60
Defining Your Map's Contents	61
Choosing a theme to map	61
Applying the methodology to any GIS project	62
Breaking down the data you want to include	63
Verifying your data's characteristics	65

Converting from Map to Computer	66
Deciding how to represent your map.....	66
Weighing the benefits: Raster versus vector.....	71
Chapter 5: Understanding the GIS Data Models	73
Examining Raster Models and Structure	73
Representing dimension when everything is square	74
Making a quality difference with resolution.....	75
Finding objects by coordinates.....	76
Finding grid cells by category	77
Working with map layers	78
Linking objects and descriptions.....	79
Exploring Vector Representation	79
Simple forms of vector representation	79
Complex forms of vector representation.....	81
Dealing with Surfaces	89
Storing surface data in a raster model.....	89
Representing surfaces in a vector model	90
Chapter 6: Keeping Track of Data Descriptions	93
Knowing the Simple Systems for Tracking Descriptions.....	94
Understanding computer-assisted cartography	94
Using computer-aided design.....	95
Exploring raster systems	96
Working with Tables and Database Management Systems.....	98
Structuring simple relational data.....	98
Getting more complex with relational joins	100
Managing data in Vector GIS	101
Storing data in Raster GIS	102
Searching with SQL in any GIS	103
Understanding Object-Oriented Systems	104
Storing attributes with object-oriented systems	104
Using object orientation to enhance descriptive information.....	105
Knowing the packaging descriptions for different objects	105
Chapter 7: Managing Multiple Maps	109
Layering Data in GIS Models	110
Comparing the Map-Handling Capabilities of GIS System Models	110
Checking out a hybrid system model.....	111
Eliminating pointers with integrated system models	113
Getting better control with object-oriented system models.....	114
Opting for an Object-Oriented Model	115

Chapter 8: Gathering and Digitizing Geographic Data117

Identifying Quality Data	117
Importing Statistical and Sensory Data	118
Getting information from GPS data.....	119
Using remote sensing to create maps	120
Collecting field data	123
Working with census data	124
Getting Existing Map Data into the Computer	125
Forms of digitizing	125
Preparing your map for digitizing.....	129
Deciding what to digitize	130
Cleaning up after digitizing.....	131
Building the metadata	132

***Part III: Retrieving, Counting, and
Characterizing Geography*** **135**

Chapter 9: Finding Information in Raster Systems137

Creating a Search Strategy	138
Locating objects on a map.....	138
Searching for linear features	140
Searching for areas and distributions.....	140
Using the Software to Perform a Search.....	141
Searching in simple raster systems.....	141
Searching DBMS-supported raster systems	143
Counting and Tabulating the Search Results.....	144
Getting simple statistics.....	144
Interpreting the results	145

Chapter 10: Finding Features in Vector Systems147

Getting Explicit with Vector Data	148
Seeing How Data Structure Affects Retrieval.....	149
Deciding How to Search the Systems.....	151
Targeting the right data source	152
Keeping the expected result in mind	152
Locating Specific Features with SQL.....	152
Getting to the point(s).....	153
Keeping your searches.....	157
What's my line?	158
Searching Vector Systems using Geography	160
Counting, Tabulation, and Summary Statistics	161
Validating the Results	162

Chapter 11: Searching for Geographic Objects, Distributions, and Groups 165

Searching Polygons in a GIS	166
Searching for the Right Objects	166
Extracting specific information	167
Knowing the size of each polygon	168
Working with concentrations of point objects	168
Reorganizing data	169
Locating 2-D Map Objects.....	170
Searching based on category	170
Finding polygons based on level.....	171
Looking for polygons based on value	173
Locating polygons based on size, shape, and orientation	173
Finding polygons based on location and position.....	175
Defining the Groups You Want to Find	176
Looking for common properties	176
Looking for common positioning.....	177
Grouping by what you already know	179

Part IV: Analyzing Geographic Patterns 181

Chapter 12: Measuring Distance 183

Taking Absolute Measurement	183
Finding the shortest straight-line path	184
Measuring Manhattan distance.....	187
Calculating distance along networks.....	188
Working with buffers	188
Establishing Relative Measurement	191
Adjacency and nearness	191
Separation and isolation	192
Containment and surroundedness	193
Measuring Functional Distance	194
Anisotropy (whew!) — non-uniformity	195
Accounting for physical parameters	195
Based on intangibles	196
Creating the functional surface.....	196
Calculating the functional distance.....	198

Chapter 13: Working with Statistical Surfaces 199

Examining the Character of Statistical Surfaces.....	199
Understanding discrete and continuous surfaces.....	201
Exploring rugged and smooth surfaces	201
Climbing steep surfaces	202
Determining slope and orientation.....	203

Working with Surface Data	204
Collecting surface data for entire areas	204
Sampling statistical surfaces	205
Displaying and analyzing Z values	207
Ignoring the rules	208
Predicting Values with Interpolation	209
Determining values with linear interpolation	209
Using non-linear interpolation	210
Estimating values with distance-weighted interpolation	211
Knowing the other exact interpolation methods	212

Chapter 14: Exploring Topographical Surfaces213

Modeling Visibility with Viewsheds	213
The importance of viewshed analysis	214
Using ray tracing	215
Finding and Using Basins	217
Knowing how basins work	217
Working with basins in your GIS	218
Characterizing Flow	219
Knowing the importance of flow	219
Modeling and using flow	220
Defining Streams	222
Finding and quantifying streams	222
Identifying methods that work for you	224

Chapter 15: Working with Networks225

Measuring Connectivity	225
Recognizing the importance of connectivity	226
Measuring and using connectivity	226
Working with Impedance Values	227
Knowing when your paths are fast or slow	227
Modeling impedance for traffic flow	228
Working with One-Way Paths	229
Understanding unidirectional paths	229
Modeling unidirectional paths	229
Characterizing Circuitry	230
Knowing when lines create circuits	230
Measuring and modeling circuits	231
Working with Turns and Intersections	232
Recognizing the importance of turns and intersections	232
Encoding and using turns and intersections	232
Directing Traffic and Exploiting Networks	234
Finding the shortest path, or route	234
Finding the fastest path	235
Finding the nicest path	237
Finding the service areas	237

Chapter 16: Comparing Multiple Maps.239

Exploring Methods of Map Overlay.....	240
Finding points in polygons	241
Finding lines on polygons	243
Using Logical Overlay to Compare Polygons.....	245
Searching with union overlay.....	245
Using intersection overlay.....	246
Understanding complement or symmetrical difference overlay	247
Using identity overlay	248
Comparing geometry with clip overlay.....	249
Understanding Raster Overlay.....	250
Comparing Features with Selective Overlay	250

Chapter 17: Map Algebra and Model Building253

Creating Cartographic Models.....	253
Understanding Map Algebra	254
The Language of Map Algebra	256
Performing Functions with Map Algebra.....	256
Exercising control.....	257
Using local functions	258
Using focal functions	259
Exploring zonal functions	264
Understanding block functions.....	268
Using global functions.....	269
Formulating a Model	270
Making a formulation flowchart.....	271
Basing your database on your flowchart.....	273
Implementing a Model	273
Testing a Model	275
Determining whether the software is working correctly.....	275
Assessing whether the model gives adequate results	276
Gauging whether your model makes sense.....	276
Ensuring that your model satisfies the user.....	276

Part V: GIS Output and Application 277**Chapter 18: Producing Cartographic Output279**

Exploring Traditional Maps.....	280
Mapping qualitative data	280
Mapping quantitative data.....	281
Creating classes	283
Using map elements	284
Factoring in graphic map design	286

Understanding Cartograms	287
Attracting attention with area cartograms	288
Distorting distance with linear cartograms	290
Mapping sequence with routed line cartograms	290

Chapter 19: Generating Non-Cartographic Output293

Looking for Routings and Travel Directions	294
Getting Customer Lists and Statistical Data	294
Producing Alarms and Signals (Audio and Video)	297
Benefiting from Virtual Output	297
Animating your maps	297
Getting the most from flythroughs	298

Chapter 20: GIS in Organizations301

Understanding How Your Organization's Interactions Change	301
Categorizing the Types of Organizations That Use GIS	302
Private/commercial	303
Government	304
Non-profit/educational	305
Designing and Introducing a GIS for Your Organization	306
Understanding how technology affects organizations	307
Managing people problems	308
Planning for integration	309
Looking Before You Leap (And Afterwards, Too)	310
Performing needs analysis	310
Performing a cost/benefit analysis	311
Understanding initial versus ongoing analysis	313
Using Change Detection	313
Technological change	314
Institutional change	314

Part VI: The Part of Tens 315

Chapter 21: Ten GIS Software Vendors317

Environmental Systems Research Institute	317
PitneyBowes MapInfo Incorporated	320
Intergraph	321
Clark Laboratories	323
Autodesk, Inc.	324
GE Smallworld	324
PCI Geomatics	325
Leica Geosystems	326
Bentley GIS	327
GRASS GIS	327

Chapter 22: Ten Questions to Ask Potential Vendors 329

What Services Do You Offer?	329
Can You Show How Your Product Will Meet My Needs?	330
What Data Formats Does Your Product Support?	330
How Do You Handle Communications and Change Requests?	330
What Hardware Expertise Do You Have?	331
What Does the Price Include?	331
How Long Until the System Is Operational?	331
What Happens If the System Crashes?	332
What Are Your Quality-Control Procedures?	332
What Are Your Performance Guarantees?	332

Chapter 23: Ten GIS Data Sources 333

GIS Data Depot	336
Environmental Systems Research Institute	337
National Geospatial Data Clearinghouse	337
Center for International Earth Science Information Network (CIESIN)	339
Go-Geo!	339
Instituto Nacional de Estadística Geografía e Informática (INEGI)	340
CGIAR Consortium for Spatial Information (CGIAR-CSI)	340
Australian Consortium for the Asian Spatial Information and Analysis Network (ACASIAN)	340
Geoscience Australia	341
Canada Geospatial Data Infrastructure	341

***Index* 343**

Introduction

Do you plan to purchase a geographic information system (GIS) in the near future? Are you curious about what it can do for you and how you can get the most out of it? Do you need to use the software, or do you need to supervise others who use it? Do you have concerns about how GIS might change the way your organization functions?

If you answered yes to any of these questions, *GIS For Dummies* is the right book for you. GIS is some of the most exciting software to come along in ages, and I want to get you as excited about the possibilities GIS offers as I am. This book can help you start thinking about how you can use maps and harness the awesome power of this new technology.

About This Book

Unlike many books on GIS, this one isn't meant to keep you spellbound for days or weeks. Instead, you can use this book when you need to answer basic questions or figure out what questions to ask your GIS-specialist friends. Think of this book as a reference you can use to find what you need when you need it.

The book gives you a big picture look at GIS — everything from the parts that make up the systems (see Chapter 1) to the spatial information products (see Chapter 20) that the systems produce. So wherever your interests in GIS point you, find those topics in the Table of Contents or Index and jump right in.

Conventions Used in This Book

GIS terminology can get a bit confusing, especially with computer terms. I use the term *raster* to represent both a GIS data structure (composed of square grid cells) and the software based on that structure. When I talk about *vector*, I'm also referring to both the data structure (based on points, lines, and polygons) and software that uses the structure.

When I define a term for you, that term appears in *italics*. Also, I show URLs in monospace typeface to set them apart from the regular text.

What You're Not to Read

You may feel the urge, every now and then, to explore some of the more advanced features of the GIS software. The GIS crowd might recognize these features and understand the details, but I don't expect everyone to have (or want to have) that specialized knowledge. Most GIS analysis is based on pretty basic ideas about how things work in geographic space. Sometimes, GIS gets technical and uses fancier methods including mathematical procedures that you probably don't need to understand in depth. So, keep an eye out for the Technical Stuff icons and skip them if you want.

Also, I like to illustrate certain points with extra examples that appear in the book as sidebars. I think you'll find the examples interesting, but they're not essential to your understanding of the basics.

Foolish Assumptions

I'm going to assume that you've heard about GIS but don't know all that much about its inner workings and hidden mechanisms. Many people think GIS (geographic information system) means GPS (global positioning system) because more people have heard the term GPS. In reality, GPS is just a part of GIS, and I tell you about that in Chapter 8. I assume you have something more than a casual interest in GIS, so I explain what GIS is, what it does, and how it can help you with what you do in your organization. Here are a few other assumptions I make:

- ✔ **You know what a map is.** GIS relies heavily on maps and map-related data. I assume that you have used a map of some kind, but aren't an expert in either making or using maps. I provide all the background you need to become familiar with how maps represent the real-world geography.
- ✔ **You know what geography is.** I assume that you've taken a geography class at some point in your life, but I don't assume that you're a geographer or that you think like a geographer. So I guide you on that path, as well. After you figure out how to think like a geographer (in mapping terms), GIS can become your friend and ally. You might even find it fun to use.
- ✔ **You use some form of computer from time to time.** GIS relies on computers. I don't expect that you're a computer technician, but I do assume that you know what data files and software programs are and how to use a computer interface. Beyond that, I explain some of the inner workings of the GIS software and databases so that you can ask intelligent questions of the GIS experts.

How This Book Is Organized

GIS For Dummies contains six parts. They move from general background in geography and mapping in Part I, to the use of computers for maps in Part II, GIS data retrieval in Parts III, pattern identification and analysis in Part IV, a look at GIS output in Part V, and some helpful info about GIS vendors and data sources in the Part of Tens (Part VI).

Part I: GIS: Geography on Steroids

If you're brand new to GIS, you may want to start here. Part I provides a general overview of the book, explains the basic geography background needed to understand how maps represent the real world, and introduces you to some of the mapping terminology that you need to know to understand GIS-speak. It covers map reading, symbolism, *projections* (moving from 3-D to 2-D), *datums* (starting points for measurement), scale issues, and generalization. You can see the power of map data and how getting them into your computer really improves your ability to make use of information contain in maps.

Part II: Geography Goes Digital

Part II deals with how you get data from your paper maps into the computer. If you're unsure about how GIS data work inside the computer, this part can give you the answers. In this part, I show you the two basic models used for digital map representation (grids, called *raster*; and points, lines, and polygons, called *vector*). You find out how these different models enable you to keep track of the geographic features you include in your GIS and how the models link these features to the descriptive information that eventually winds up in your GIS output (such as a map legend).

Part III: Retrieving, Counting, and Characterizing Geography

Part III is for people who want to know how to use GIS to answer questions. It includes information about how to find the geographic features that you put in your GIS database, different ways of searching for features, how to count them up when you find them, and how you can describe what you find. In this part, you discover how to locate and characterize features by type or category, by their sizes and shapes, by measurements that describe them, and even by where they're located relative to each other in geographic space.

Part IV: Analyzing Geographic Patterns

GIS does its most powerful work when analyzing the patterns that you identify, and Part IV focuses on that subject. You see how to measure lengths, areas, distances, and volumes; as well as how to work with networks, such as highways and streets. I explain both topographic and non-topographic surfaces, how to analyze rivers and determine where water will flow during flooding, and how to determine places that an observer can and can't see from a certain point. I even show you how to combine maps and use a powerful map analysis language called *map algebra*.

This part can't make you an expert in GIS analysis, but it can help you figure out enough to start your analyses and talk knowledgeably with the experts.

Part V: GIS Output and Application

In Part V, I show you how to make the most of all your GIS queries and analysis. You can find out about the various types of map output, as well as non-map output, that you can use to help explain the results of your work. I tell you how GIS can generate travel directions, customer lists, alarms, and even movies that show maps through time. Finally, I show you how to smoothly incorporate this high-level technology into your organization so that you can quickly take advantage of its power.

Part VI: The Part of Tens

In the Part of Tens, I introduce ten GIS software vendors and explain what other products and services they provide. I also provide a handy list of questions to ask those vendors before you decide where to purchase software, products, and services. Finally, I also provide a list of sources of GIS data from government and private companies — both free and for purchase.

Icons Used in This Book

GIS For Dummies uses little pictures, or *icons*, that help direct your reading. These little graphics can save you time by letting you find all the high points quickly.



The Tip icon provides a few helpful hints about shortcuts, best practices, and just plain common sense when it comes to GIS. GIS tips help you do the right things at the right time for the right reasons. Each tip comes with an explanation about why it's a good idea, too.



I use the Warning icon to keep you from making mistakes that are very hard to recover from. Unfortunately, GIS doesn't come with many built-in safety mechanisms, so I try to point out potential problem points.



The Remember icon is sort of like a summary of important points that you need to focus on. In some cases, I remind you of things I cover recently in the chapter, and in other cases, I highlight material from other parts of the book and explain how it applies to that specific discussion. Think of them like tiny refresher courses.



The Real World GIS icon highlights all the places that you can find out how people use GIS to accomplish real tasks in the real world.



When you see the Technical Stuff icon, you don't have to read the technical information to understand the surrounding text — but you might want to look at it and get a sense of all the possibilities of GIS.

Where to Go from Here

Because GIS software changes all the time, the user community requires constant updating and retraining. Many fine community colleges, technical schools, colleges, and universities provide formal education in GIS, and some provide continuing education courses to help you keep up with what's going on. Some vendors offer face-to-face and online courses (largely geared toward their product line, of course).

You can also keep updated by interacting with other users. In the past, you'd make these contacts through professional meetings, trade shows, and user group meetings (which still draw plenty of users). Today's technology provides you with a supplemental method of keeping current. Blogs, wikis, forums, and RSS feeds now provide a vast array of methods that you can use to obtain just the right answer in a timely fashion without ever having to leave your computer. Even the vendors themselves often provide audio and video podcasts that give updates on the newest software wrinkles. Here are a few prominent Web-based resources that you can use to continue your GIS education:

- ✓ **GIS Café** (www.giscafe.com): A general online GIS community that contains all things GIS, including forums, data providers, and much more.
- ✓ **GIS Data Depot** (<http://data.geocomm.com>): Another general online GIS community which is focused mostly on data sharing.
- ✓ **GIS Lounge** (<http://gislounge.com>): Similar to GIS Café, but with a somewhat more educational and informational spin.
- ✓ **Directions Magazine** (www.directionsmag.com): A forum and online GIS magazine that focuses on keeping the reader up to date on research, innovations, software, and hardware related to GIS.
- ✓ **VerySpatial** (www.verspatial.com): A podcast that generally covers the larger discipline of geography, but with a large amount of GIS content.
- ✓ **ESRI Podcasts** (www.esri.com/news/podcasts/index.html): ESRI's podcasts include both an instructional series and a speaker series.

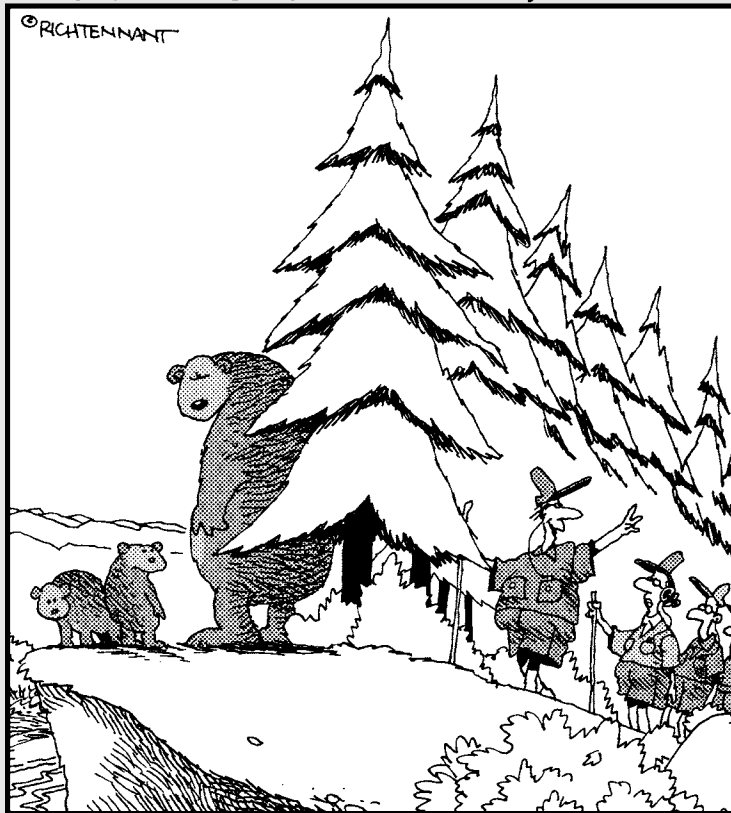
GIS forums and podcasts will continue to increase, both in number and in focus. An occasional search on your favorite Internet browser can keep you reading and listening about GIS for a long time to come.

Part I

GIS: Geography on Steroids

The 5th Wave

By Rich Tennant



"According to the GIS generated route, 'Peaceful Haven Overlook' should be just up ahead on the right."

In this part . . .

No, I'm not advocating the use of steroids, but I am advocating GIS. In this part, I provide an introduction to all the geography and map-related capabilities that underlie the enormous power of GIS. You find out how GIS has merged the speed and strength of a computer with a geographer's robust toolkit. And even more impressive, you see how this merger has produced one of the most transforming technologies of the 21st century.

Chapter 1

Seeing the Scope of GIS

In This Chapter

- ▶ Getting GIS basics
- ▶ Understanding how all the parts of GIS technology work together
- ▶ Knowing how to think like a geographer
- ▶ Seeing the many applications of GIS

Everything you experience from day to day happens somewhere in geographic space. As a result, you can represent your world and your experiences in it by using maps. You use those maps to find places, save time while traveling, decide where to locate a new store, plan cities, guide the development of wildlife preserves, and satisfy hundreds of other applications.

In this day of digitized everything, the maps you use to represent the world reside inside the computer, and you now have at your fingertips the ability to search those maps, find objects and routes, and plan related activities. The computer systems that enable you to store and access all this information are collectively called *geographic information systems (GIS)*. This book is all about GIS and how it helps you make decisions.

To recognize how important this tool is, you only have to think about how people use maps today and how adding the power of a computer can help you make both better and faster decisions. Here are a few quick examples:

- ✓ **For business owners and marketers:** You want to put up a new toy store in a location that gives you access to a lot of customers. To find the right location for your store, you need to know who your customers are (parents of children) and where they live (so that you can locate near them). GIS software can find your customers and identify suitable nearby locations where you can locate your store.
- ✓ **For urban planners:** Say that you're a land-use planner trying to figure out the best way to use a new parcel of land just annexed to the city. To make such decisions, you use mapped information stored in the computer to compare the characteristics of the new parcel to existing land uses and facilities. You can even create a map that shows what the final zoning map should look like.

- ✓ **For merchandise distributors:** Suppose you work for a wholesale grocer, and you need to move your trucks quickly from store to store by using existing road networks. GIS makes a very complex task — picking the fastest routes for different times of day — very easy for you.

In this chapter, I help you get a feel for how a GIS is organized and how you can use it to make many kinds of decisions — effectively, faster, and with better outcomes than you can with traditional maps alone. Jump in and get ready to enjoy the exciting world of GIS.

Getting a Feel for GIS

A GIS is an operational system that allows resource managers to use some of the tools and skills that geographers use, and a little bit more. Using GIS software, you can put maps and other geographic data into the computer. After you have the data in the computer, you can store, retrieve, and edit that data. You can analyze it (for example, find geographic features, measure distances, or compare patterns) and produce output from it (create new maps from what you find).

Here are some of the things you can do with GIS software:

- ✓ Selectively retrieve bits and pieces of one or more maps.
- ✓ Count, group, reclassify, isolate, and quantify features and their patterns on the landscape.
- ✓ Measure lengths, widths, distances, heights, and volumes of features.
- ✓ Overlay one map on another to compare features and create new maps.
- ✓ Visualize, interpolate (predict missing values), slice, cross-section, and generalize surfaces of all kinds.
- ✓ Track movements and changes in patterns, and predict and exploit pattern change.
- ✓ Find the shortest, fastest, or most beautiful path, identify potential customers, and locate businesses.
- ✓ Perform various topographic feature analyses, such as groundwater (subsurface movement of liquid), surface flow (liquids running on the surface), accumulation (liquid gathering in low spots), visibility (places you can see from a specific location), and a host of other analyses.

As the preceding list shows you, GIS is a diverse and powerful tool. In fact, GIS is among the most complex software ever written. It's so complex because it deals with techniques that geographers and related professionals have been devising to analyze maps and map-related data for over 2,500 years. Because of the advances in computer speed and efficiency, new techniques are being