
CONTENTS

About the Authors xi

Preface xiii

PART I THEMATIC MAPPING ESSENTIALS 1

1 INTRODUCTION TO THEMATIC MAPPING 2

- The Realm of Maps 3
 The Map Defined 3
 What Is Cartography? 4
 Geographic Cartography 5
Atlas Mapping 5
 Kinds of Maps 6
General Purpose Maps 6
Thematic Maps 7
 Map Scale 11
 Modern Views of Map Communication 13
Map Communication and Visualization 13
The Importance of Meaning 15
 Cartography and Geographic Information Systems 16
Artistic Drawing Programs 16
Cartographic Abstraction and Generalization 16
 Selection 17
 Classification 17
 Simplification 17
 Symbolization 17
The Art in Cartography 18
Thematic Map Design 18
 What Is Map Design? 19
 Ethics in Cartography 19

2 BASIC GEODESY, COORDINATE SYSTEMS, AND SCALE 23

- Basic Geodesy 23
 The Size and Shape of the Earth 24
 Datums 26

Coordinate Geometry for the Cartographer 26

- Plane Coordinate Geometry* 27
 The Geographic Grid 28
Latitude Determination 28
Longitude Determination 29
The Complete Geographic Grid 30
Principal Geometric Relationships of the Earth's Geographic Grid 30
Scale Revisited 33
 Scale and Line Generalization 34

3 MAP PROJECTIONS 37

- The Map Projection Process 38
 Developable Surfaces 38
Projection Parameters 39
 Projection Families 40
Azimuthal Family 40
Cylindrical Family 41
Conic Family 44
Mathematical Family 44
 Map Projection Properties 44
Equal Area Mapping 44
Conformal Mapping 45
Equidistance Mapping 46
Azimuthal Mapping (Direction) 46
Minimum Error Projections 47
 Determining Deformation and its Distribution Over the Projection 47
Standard Lines and Points, Scale Factor 48
Employment of Map Projections 49
 Essential Questions 50
 World Projections 50
Mathematical, Equivalent Projections 50

vi CONTENTS

Minimum Error Projections	51
Cylindrical Projections	52
<i>Projections for Mapping Continents</i>	53
<i>Mapping Multiple Size Countries at Mid-Latitudes</i>	55
<i>Mapping at Low Latitudes</i>	55
<i>Projected Coordinate Systems</i>	56
State Plane Coordinate (SPC) System	56
Universal Transverse Mercator (UTM) System	56
<i>Adjustments in Projection Parameters</i>	60

4 THE NATURE OF GEOGRAPHIC DATA AND THE SELECTION OF THEMATIC MAP SYMBOLS 63

The Nature of Data	64
<i>Data Characteristics</i>	65
Location	65
Form	66
Time	67
<i>Data Transformations</i>	68
Scale	68
Form	68
Boundary Changes	68
Data Measurement	69
<i>Nominal</i>	69
<i>Ordinal</i>	69
<i>Interval</i>	69
<i>Ratio</i>	70
Data: Thematic Map Relationships	70
<i>Map Symbols</i>	70
<i>Visual Variables</i>	71
Size	71
Shape	71
Orientation	73
Texture	73
Saturation and Value	74
Cartographic Error	74
<i>Source Error</i>	74

PART II TECHNIQUES OF QUANTITATIVE THEMATIC MAPPING 101**6 MAPPING ENUMERATION AND OTHER AREALLY AGGREGATED DATA: THE CHOROPLETH MAP 102**

Selecting The Choropleth Technique	102
<i>Mapping Rationale</i>	102
<i>Appropriateness of Data</i>	104
<i>When to Use the Choropleth Map</i>	105
<i>Preliminary Considerations in Choropleth Mapping</i>	105
Geographic Phenomena	105
Map Scale	105
Number and Kinds of Enumeration Units	106
Data Processing	106

<i>Processing Error</i>	75
<i>Cartographic Design Error</i>	75
Data Sources	76
<i>Data (GIS) Clearinghouses</i>	76
<i>Federal Governmental Agencies</i>	76
U.S. Census Bureau	76
U.S. Geological Survey	76
<i>Federal Information Processing Standards (FIPS)</i>	76
Potential Problems	77

5 DESCRIPTIVE STATISTICS AND DATA CLASSIFICATION 80

Overview of A Data Set	81
<i>Ratio, Proportion, Percent, and Rate</i>	81
<i>Descriptive Statistics</i>	82
Skewness	84
Kurtosis	85
Data Classification	85
<i>Selection of the Number of Classes</i>	85
Nothing Is Sacred	86
Values of Zero or No Data	86
Impact of the Number of Classes	86
<i>Data Classification Schemes</i>	86
Natural Breaks	87
Nested Means	89
Mean and Standard Deviation	90
Equal Interval	90
Equal Frequency	91
Arithmetic and Geometric Intervals	91
User Defined	92
<i>Assessment Indices</i>	92
<i>Things to Watch Out For</i>	93
Outliers and Data Truncation	93
Zero-Observation Classes	94
Summary and Comparison of Major Classification Methods	94

Data Classification Revisited	106
<i>Classification Methods Compared</i>	108
<i>Data Truncation and Outliers</i>	109
<i>Different Maps from the Same Data</i>	109
<i>Unclassed Choropleth Maps</i>	109
Legend Design, Areal Symbolization, And Base Map Design	111
<i>Sources of Map-Reading Error and the Need for Accurate Design Response</i>	111
<i>Legend Design</i>	111
Box Shape, Size, Orientation, and Range Placement	111
Continuous and Noncontinuous Class Ranges	112

Class Range Formatting, Legend Titles, and Other Legend Information	112
Map Sequences and Animated Maps Considerations	113
<i>Symbolization for Choropleth Maps</i>	113
Black and White Mapping	113
Color Map Symbolization	114
Bipolar and Bivariate Symbolization	115
<i>Adding Other Reference Features to the Map</i>	115
Dasymetric Mapping	116

7 THE DOT DENSITY MAP 119

Mapping Technique	119
<i>Advantages and Disadvantages of Dot Density Mapping</i>	120
Data Suitability	121
The Mapping Activity	122
Size of Enumeration Unit	124
Dot Value and Size	125
Dot Placement	126
Legend Design	127
Other Dot Map Design Issues	128
Visual Impressions of Dot Maps: Questions of Numerousness And Density	129

8 FROM POINT TO POINT: THE PROPORTIONAL SYMBOL MAP 131

Conceptual Basis For Proportional Point Symbol Mapping	131
<i>When to Select this Method—Data Suitability</i>	131
<i>A Brief History of Proportional Point Symbols</i>	133
<i>A Variety of Symbol Choices</i>	133
Two-Dimensional Geometric Symbols	133
Three-Dimensional Geometric Symbols	134
Pictorial Symbols	135
Proportional Symbol Scaling	136
<i>Absolute and Apparent Magnitude Scaling:</i>	
<i>Psychophysical Examination of Quantitative Thematic Map Symbols</i>	137
Absolute Scaling with Circles	137
Apparent Magnitude Scaling with Circles	139
The Square Symbol	141
Absolute and Apparent Magnitude Scaling Design Implications	141
<i>Range Grading</i>	142
Proportional Midpoint Range Grading	143
Proportional Symbol Legend Design	144
Graphic Design Considerations For Proportional Point Symbol Maps	145
<i>Graphic Treatment of Proportional Symbols</i>	145
Overlapping Symbols	146
Labeling Symbols	147

<i>Bivariate and Multivariate Proportional Symbols</i>	147
Overloaded Proportional Point Symbols	147
Proportional Symbols and Choropleth Maps	148

9 MAPPING GEOGRAPHIC SURFACES: ISARITHMIC AND THREE-DIMENSIONAL MAPS 150

The Nature of Isarithmic and Three-Dimensional Mapping	150
Fundamental Concepts	150
<i>Isarithmic Categories and Terminology</i>	151
<i>The Basis of Isarithmic Construction</i>	152
<i>A Brief History of Isarithmic Mapping</i>	154
<i>When to Select the Isarithmic Method</i>	155
Isarithmic Practices	155
<i>Elements of Isarithmic Mapping</i>	155
Concepts in Isarithm Placement	155
Locating Data Points	155
Concept of Interpolation	156
<i>Automated Isarithmic Mapping</i>	157
Gridding Methods of Interpolation	158
Evaluating Grid Error	159
The Selection of Isarithmic Intervals	160
<i>Other Presentations of Continuous Surfaces</i>	162
Shaded Relief Maps	162
Wireframe and Surface Maps	162
Communicating Using Multiple Map Displays	163

Design Aspects For Isarithmic and Continuous Surface Maps	164
<i>Isolines and Figure-Ground Relationship</i>	164
<i>Isoline Labels</i>	164
<i>Legend Design</i>	165
<i>Other Useful Elements</i>	166

10 THE CARTOGRAM: VALUE-BY-AREA MAPPING 168

The Value-By-Area Cartogram Defined	168
<i>Brief History of the Method</i>	170
<i>Two Basic Forms Emerge</i>	171
Contiguous Cartograms	171
Noncontiguous Cartograms	172
<i>Mapping Requirements</i>	173
Data Limitations	176
Communicating With Cartograms	176
<i>Recognizing Shapes</i>	176
<i>Estimating Areas</i>	177
<i>A Communication Model</i>	177
Advantages and Disadvantages	178
<i>Design Strategies Recap—Legends, Inset Maps, and Labeling</i>	179
<i>Bivariate Cartograms</i>	180

viii CONTENTS

Cartogram Construction	181	Historical Highlights of The Method	191
<i>Manual Methods</i>	181	<i>Early Flow Maps</i>	191
<i>Automated Solutions</i>	182	<i>Flow Maps in Economic Geography</i>	191
11 DYNAMIC REPRESENTATION: THE DESIGN OF FLOW MAPS	188	Designing Flow Maps	192
The Purpose of Flow Mapping	188	<i>Map Organization and Figure-Ground</i>	193
<i>Quantitative Flow Maps</i>	189	Projection Selection	193
Data Suitability	189	Essential Design Strategies	194
Directed and Undirected Flows	189	<i>Line Scaling and Symbolization</i>	194
The Relevance of Flow Routes	190	Treatment of Symbols	196
		<i>Legend Design</i>	196
		<i>Innovative Solutions</i>	197
		Summary of Mapping Techniques	199

PART III DESIGNING THEMATIC MAPS 203

12 THE MAP DESIGN PROCESS AND THE ELEMENTS OF MAP COMPOSITION	204	<i>Strong Edges and Figure Development</i>	220
The Design Process	204	<i>The Interposition Phenomenon</i>	221
<i>Design Evaluation</i>	205	<i>Figures and Grounds in the Map Frame</i>	221
<i>Creativity and Visualization</i>	205	The Special Case of the Land-Water Contrast	222
Graphic Ideation	206	<i>Vignetting for Land-Water Differentiation</i>	223
<i>Experimentation</i>	206	Designing the Page-Size Map	223
<i>Map Aesthetics</i>	207		
The Map's Design Elements	207	13 MAKING THE MAP READABLE: THE INTELLIGENT USE OF TYPE	226
Design Levels on The Map	208	Functions of Map Lettering	226
Elements of Map Composition	209	The Elements of Type	227
<i>Purpose of Map Composition</i>	209	<i>Typeface Characteristics</i>	227
<i>Planar Organization of the Visual Elements</i>	209	Letterform Components	227
Balance	209	Typeface Style and Classification	228
Focus of Attention	212	The Personality of Type	230
Internal Organization	212	The Legibility of Type	231
<i>Contrast and Design</i>	213	<i>Cartographic Requirements</i>	232
Line Contrast	213	Type Font and Type Families	232
Texture Contrast	214	Type Size	233
Value Contrast	214	Type Form	234
Variation of Detail	214	Type Width	234
Color Contrast	214	Type Weight	234
<i>Vision Acuities</i>	215	Type Color	234
Visual Acuity	215	<i>Letter, Word, and Line Spacing</i>	235
Resolution Acuity	215	Guidelines For Type Selection and Placement	236
The Visual Hierarchy of Map Organization:		<i>The Use of Capital and Lowercase Letters</i>	237
Figure-Ground Relationship	215	<i>The Placement of Lettering</i>	237
<i>Visual Hierarchy Defined</i>	216	Point-Symbol Labeling	237
Customary Positions of Map Elements in the Hierarchy	216	Linear Feature Labeling	240
Achieving the Visual Hierarchy	217	Area Feature Labeling	241
<i>Fundamental Perceptual Organization of the Two-Dimensional Visual Field: Figure and Ground</i>	217	Placement and Design of Titles and Legends	241
Perceptual Grouping Principles	218	Scales and North Arrows	243
<i>Figure Formation and Closure</i>	219	Source and Author Information	243
		Practical Example	244

CONTENTS

ix

14 PRINCIPLES FOR COLOR THEMATIC MAPS 246

- Light and the Color Spectrum 247
- Color Perception 248
 - The Human Eye* 248
 - Physical Properties of Color* 248
- Color Theories 250
 - Additive Color Theory* 250
 - Subtractive Color Theory* 250
- The Desert Island Experiment 250
- Components of Color 251
 - Hue* 251
 - Saturation* 252
 - Value* 252
 - Munsell Approach* 252
- Color Models 253
 - HSV* 253
 - HSB/HSL* 254
 - RGB* 254
 - Cie Lab* 254
 - CMYK* 255
 - Grayscale* 256

Device Limitations 256

Web Safe Colors 257

Color Matching Systems 257

Color Interaction 257

Simultaneous Contrast 257

Successive Contrast 257

Color Constancy 258

Subjective Reactions to Color 258

Color Preferences 258

Colors in Combination 258

Connotative Meaning and Color 259*Advancing and Retreating**Colors* 259

Color in Cartographic Design 259

*The Functions of Color in**Design* 259*Design Strategies for the Use*
of Color 260

Developing Figure and Ground 260

The Use of Color Contrast 261

Developing Legibility 261

Color Conventions in Mapping 261

Color Harmony in Map Design 264

PART IV MAP PRODUCTION TECHNIQUES 267**15 PRINTING FUNDAMENTALS AND PREPRESS OPERATIONS FOR THE CARTOGRAPHER 268**

- Cartography and Digital Printing 269
 - Getting Started* 269
 - Color Model* 269
- Desktop Printing 269
 - Laser Printers* 269
 - Inkjet Printers* 270
 - Plotters* 270
 - Dye-Sublimation Printers* 270
- Commercial Printing Technology 270
 - Brief History of Commercial Printing* 270
 - Relief—Letterpress 270
 - Intaglio—Engraving 271
 - Planar—Lithography 271
 - Cartographic Design and the Printer* 272
- Commercial Printing 272
 - Prepress Map Editing* 272
 - File Preparation* 273
 - Service Bureau and Prepress Proofing* 273
- The Map Production Process 273
 - Modern Offset Lithography* 273
 - Step One: Design and Page Layout 274
 - Step Two: Printer's Precheck 275

Step Three: Color Separation and Plate Generation 275

Step Four: Digital Color Proof 276

Step Five: The Press Run 276

Step Six: Post-Press Operations 277

Digital Presses 278

Digital Printing Presses 278*Digital Production Presses* 278**16 INTRODUCTION TO VIRTUAL AND WEB MAPPING 280***Virtual and Web Mapping*
Introduction 280

Map Formats and Structures 282

Raster Graphics 282

Raster Concepts 283

Selected Raster Image Formats 284

Animated Raster Map Formats 286

Vector Graphics 286

Vector Concepts 286

Selected Vector Formats 287

Understanding the Medium 287

Key Internet Concepts 288

The World Wide Web 288

The Graphics Display Monitor 289

x CONTENTS

Design Implications for Thematic Mapping 291
Constraints of the Medium 292
Limited Screen Real Estate and Resolution
 Ramifications 292
Other Screen Resolution Issues 292

Display Monitor Variations Limit Predictability 292
Solutions and Opportunities 293
Map Interactivity 293
Animation 293
Cybercartography 295

PART V EFFECTIVE GRAPHING FOR CARTOGRAPHERS 299

17 EFFECTIVE GRAPHING FOR CARTOGRAPHERS 300

Brief History Of Graphing 301
Organization Of This Chapter 302
Graph Data 303
Graphical Excellence 303
Principles Of Design Applied To Graphs 303
 Elements of the Standard Graph 303
 Axis Types 305
 Arithmetic Scaling 305
 Semi-logarithmic Scaling 307
 Log-Log Scaling 307
 Graph Planning and the Visual Hierarchy 307
Graph Types 309
 Graphs of Numbers and Frequency 309
 Histograms 309

Box-Whisker Graphs 311
Scatter Plots 311
Line and Bar Graphs 313
Line Graphs 313
Bar Graphs 313
Three Axes Graphs 315
Graphs Without Axes 315
Pie Graphs 315
Clock Graph 316
Three-Dimensional Graphs 317
Concluding Remarks 318

APPENDIX A 321

APPENDIX B 324

INDEX 329