SECTION THREE

Cartographic Aesthetics and Map Design

3.1

Introductory Essay: Cartographic Aesthetics and Map Design

Chris Perkins, Martin Dodge and Rob Kitchin

Introduction

If there is one thing that upsets professional cartographers more than anything else it is a poorly designed map; a map that lacks conventions such as a scale bar, or legend, or fails to follow convention with respect to symbology, name placing and colour schemes, or is aesthetically unpleasing to the eye. In contrast, a well designed map not only follows conventions, but is beautiful to behold. It is perhaps no surprise then that cartography has often been called both a science and an art. A map is something that is crafted using scientific principles, which aims not only to faithfully represent the spatial relations of the world, but also to be aesthetically pleasing. Balancing these concerns is not straightforward and much research has been conducted to find map design principles that enhance both the communication and look of maps. In particular, such research gained prominence in the second half of the twentieth century after the publication of Arthur H. Robinson's monograph *The Look of Maps* in 1952 (excerpted here as Chapter 3.3).

This introductory essay explores some of the dimensions across which aesthetics and design matters, and delineates and explains how they are changing. Firstly, we consider some of the philosophical issues raised by focusing in different ways of understanding the design and 'the look' of the map. We then move on to consider the changing impacts of technology on map design and, in particular, upon the deployment of different kinds of thematic displays, before suggesting that technology alone offers only a partial means for explaining the deployment of changing visual techniques. We finish with a consideration of some of the practices and social contexts in which aesthetics and designs are most apparent, suggesting the subjective is still important in mapping and that more work needs to be undertaken into how mapping functions as a suite of social practices within wider visual culture. We conclude that earlier distinctions between artistic and scientific approaches to mapping may be rather unhelpful, and that that tensions between everyday practicalities and theoretical concerns are often overstated.

The nature of design and aesthetics

Robinson's work spelt out the need for a visual approach to cartography, grounded in a view of the discipline concerned above all else with communication. His research delineated many of the aesthetic factors that might be significant in effective map design. The resulting Robinsonian conceptualisation of cartography was strongly imbued with a functionalist rhetoric. Here, the primary role of the cartographer was to encode information in an optimal map design, such that the map reader would be better able to receive the cartographic message (Robinson and Petchenik 1976, excerpted as Chapter 1.3). For Robinson, aesthetic concerns were narrowly defined in distinctly normative terms: art had a purpose and the purpose was to raise the communicative efficiency of the map. Robinson argued treating maps as art could lead to arbitrary design

The Map Reader: Theories of Mapping Practice and Cartographic Representation, First Edition. Edited by Martin Dodge, Rob Kitchin and Chris Perkins.

decisions and that mapping needed to be based upon an objective application of best design practice.

Robinson posited that the process of map design can be broken down into sequences of different encoding and decoding operations. Visual matters play little role in data collection: it is in the abstraction, generalisation and symbolisation of information that design becomes important. Generalisation is itself often still a matter of aesthetics and compromise: the look of the map dictates what works best when considering how much simplification is required and may be particularly significant when maps depict specialist variables (Jenks 1963, excerpted as Chapter 3.4). Maps comprise combinations of line work, symbols, lettering and colours. These are all deployed through metrics that represent and control space: maps are projected, sometimes gridded, usually uniformly scaled. Map design and projection choice inevitably impacts on the look of a map, a fact exploited by all the protagonists in the 'map wars' over the Peters projection (an equal area map that displayed the boundaries of countries in proportion to the size of their relative land mass – which looks distinctly different to the more common Mercator projection). Indeed, it was the unconventional look of the map that initially sparked the controversy (Crampton 1994; Monmonier 2004).

The 'success' of a symbol clearly impacts on overall design quality: decisions need to be taken on matters such as placement, sizing, an appropriate measurement level, the choice of a qualitative or quantitative representation and iconicity. In addition, Robinson *et al.* (1995) spelt out what might be termed the more gestalt-like features of a design, which work together to create an impression, including legibility, visual contrast, figure-ground effects, visual hierarchy and balance, and, rather as an after-thought, what are termed contextual items, but which largely elide anything beyond the surface of the map artefact itself.

This Robinsonian orthodoxy pervaded the emergence of academic cartography in North America, and continues to be reflected in the narrative of cartographic textbooks. Compare, for example, the sixth and final edition of the discipline-defining *Elements of Cartography* (Robinson *et al.* 1995) with a recent text aimed at the North American market (Tyner 2010). Neither spends much time on the elements of cartography that are most aesthetic, and, where they do, the aesthetic is defined in scientific rather than artistic terms. The principles of cartographic design, based upon a scientific understanding of how visual cognition works, are set out in systematic fashion, with the aim of reducing the chances of 'inappropriate' design choices.

In contrast, a different approach to information design comes from the work of Jacques Bertin and, in particular, the influential text *La Sémiologie Graphique* (1967, excerpted as Chapter 1.2). Bertin defined what came to be known as visual variables: primitives that designers can vary in order to construct the various visual codes which come together in map symbols and indeed complete maps. Alan MacEachren (1994, 1995, excerpted as Chapter 3.6) and others have subsequently expanded on Bertin's work, integrating cognitive and semiotic approaches to develop an approach to cartography centred on scientific visualisation. This also led to a focus on mapping processes, rather than simply optimal map design.

The rise of critical cartography in the 1990s generated a number of challenges to supposed scientific approaches to map design. On the one hand, social constructivist approaches argued that map design was infused with ideological and subjective decisions, even if it was framed scientifically. On the other, there was a concern that a focus on power relations inherent in design issues would push the focus towards exploring how power was embedded in maps, thus relegating issues of 'good design' to the margins. Krygier (1996) suggested that these challenges, along with technological change, made it more possible to escape the art/science dualism, by encouraging a focus on mapping as a 'sense making process' encompassing both. So, a concern for the aesthetic in cartography (Kent 2006) may be expressed through science as well as through art; see for example the consideration by Dykes and Wood (2008, excerpted as Chapter 3.12), where the elegant simplicity and intellectual focus of a tree map reflects beauty, and where the science of information visualisation is shown to work best through artistic registers. And Huffman (1996) who explored ways in which design might still matter in the relativistic postmodern world.

Forms of mapping and aesthetics

As well as significantly shaping the approach to map design, Robinson's work also influenced the form of mapping undertaken, and by default the look of maps. *Elements of Cartography* first published in 1953, and running to six subsequent revised editions, elided topographic matters. Instead, thematic mapping based on quantitative data dominates the text. As a result, the distinction into thematic mapping, and topographic survey or general purpose mapping, became reified in the day-to-day practices of cartography as a profession: cartographers were most likely to be trained in the design of the former, not the latter. It is perhaps unsurprising then that most subsequent Anglo-American textbooks have also had very little to say about the design of topographic maps. And perhaps these trends are exacerbated in the real world production of maps, with a gradual retreat from state-funded national

surveys in the face of increasing competition from commercialised and globalised map sources such as TeleAtlas (underpinning much of Google Maps coverage). So, maybe what has been termed the 'blandscape' of multinationally sourced and internet-served mapping will increasingly supplant the national design imaginary offered by printed topographic products (Kent 2009).

The profusion of thematic cartography over the last century certainly reflects a changing aesthetic. Examining the timeline of significant data visualisation techniques, constructed by Michael Friendly and his collaborators, one is struck by the diversity of techniques that have been invented across many disciplines (Friendly and Denis 2010). Academic cartographers deploy choropleths, dasymmetric and dot distribution maps, isarithmic maps, proportional symbol maps, and cartograms, along with more novel multivariate geovisualisations encompassing the animated and multimediated data displays (Slocum *et al.* 2008). However, in practice, very few of these techniques have been deployed very much, or very well. Technological shifts such as desktop mapping packages and online geovisualisation have facilitated an emerging and radically different aesthetic, but paradoxically the same shifts have encouraged the mass profusion of often poorly designed thematic map output, centring around the use of off-the-shelf GI defaults and a limited number of map types.

Notable amongst these techniques has been the choropleth map. First named in 1938 by J.K. Wright, the technique creates maps that depict an average value for each area. Areas allocated to the same class are shaded the same: data are classified. So the designer can change the number of classes, the classification algorithm and the nature of the shading variation or sequencing (Evans 1977). Many of these issues are related to data generalisation, a fact developed long ago by Jenks (1963, excerpted as Chapter 3.4). Choropleths have probably been more researched than any other cartographic technique: their inadequacies were well documented by Wright in 1938, and have been extensively researched by academic cartographers in the years since. The technique hides any variation within the spatial frame of each enumeration district and is very often used in an inappropriate manner. An unimaginable number of possible displays may be made from the same data (but all the evidence suggests most users are unaware of this wide range); and all too often the sampling frame, the spatial units themselves, are a given and not available for the user to change.

Nevertheless, choropleth's are a ubiquitous design of data display. Martin (2005) found that 60% of all maps published in leading public health journals (published between 2000 and 2004) was comprised of choropleth maps. This over reliance on choropleth mapping reflects in their seeming simplicity and ease of construction, but also the social roles into which the maps are enrolled. So the classification of space and people, which this kind of thematic display facilitates, has been a useful aesthetic of governance (Crampton 2004).

However the increasing dominance of uniform national map designs, and the development of a thematic tradition, may well be much less pervasive than is supposed. In central Europe, Eduard Imhof exerted significant influence on cartographic practice and training. His classic 1965 work, *Kartographische Geländerdarstellung* (Chapter 3.2, excepted from an English language translation first published in 1982) implicitly recognised the complex interrelationship between symbols and the affective and emotional power of an evocative map design. Imhof noted, for example, that there can be a striking synergy of interest between cartographers and artists in their imitative images of mountains. The Swiss cartographic design tradition has continued to be applied to the depiction of relief in topographic mapping, and some of the most spectacular and aesthetic maps are produced under the influence of Imhof's ideas (for a recent overview of work in this field see Hurni *et al.* 2001).

The Dutch cartographic tradition also placed greater emphasis upon aesthetic issues in cartographic design (Kraak and Ormeling 2010), as did John Keates's work in the United Kingdom (Keates 1984, 1993, 1996). Other researchers continued to emphasise the role of subjective decision making and craft in producing aesthetically pleasing map designs (Wood 1993), including critiques of published topographic mapping from researchers such as Collier *et al.* (2003). Consequently, the survival of different visual styles and designs of topographic maps in the face of often considerable pressure towards standardisation suggests topographic surveys continue to reflect national cultural values with map designs continuing to embody aesthetic conceptions of landscape (Kent and Vujakovic 2009). See Colour Plate One, page xx, for historically minded instigation.

The role of technologies

The visual appeal of maps mirror the age when the image was produced. At one level this aesthetic variation reflects technological change. In Woodward's (1987) monograph about art and the history of cartography, the focus is largely upon an era prior to print production and mass consumption, when individualistic and artistic imagery was self-evident in mapping that clearly reflected its unique, craft origins. The worlds of the artist and cartographer were the same until the gradual emerging trade of military surveying

began to encourage separation, a process facilitated, in part, by the application of new technologies. In contrast, contemporary mapping could be scripted as scientific, in particular after the nineteenth century invention of the thematic map (Robinson 1982). This historical generalisation has recently been challenged by an emerging focus on practice (for example, Edney (1993), excerpted here as Chapter 1.10), who argues against narrowly progressive readings of map history, and in Cosgrove's (2005, excerpted as Chapter 3.9) analysis, which suggests that even in the twentieth century the worlds of artists and cartographers saw a continuing and active cross fertilisation.

However, it is undeniable that automation of mapmaking procedures in the mid-twentieth century encouraged a professionalisation of mapping that separated the worlds of the scientific mapmaker from those of the map user. The user simply read the map, whilst the maker sought to follow best professional practice. Only after the emergence of collaborative cartography and the widespread diffusion since early 2000s of online mapping tools have distinctions between map users and makers become rather more blurred in a noted upsurge of DIY mapping. This has led to a concern amongst many cartographers that we are entering an age of poorly designed, DIY maps.

Indeed, two recent trends highlight a growing recognition of the need to continue to focus on map design. The first is an emerging focus on the design of 'expert systems' that take map designers using a desktop or online GIS through design options, highlighting strategies that work, and those that might be inappropriate. For example Harrower and Brewer (2003, excerpted as Chapter 3.8) explore how colour might be deployed in choropleth displays (Colour Plate Four, page xx). Their web-based ColorBrewer interface guides an unskilled user through the complex design choices available, offering help with an appropriate choice of sequence, matching colour schemes to display media and supporting output of colour specifications for appropriate use. Similar systems have been designed to guide novice designers through lettering and scale options. A second strategy has been to encourage better map design by taking design skills beyond the traditional academy and cartographic audience to try to get at amateur mapmakers in other professions (Darke and Spence 2008), and, in particular, by offering 'training' in visualisation aimed at the GI community. Many cartographic design texts are now targeted at this cross-over user group (Brewer 2008; Krygier and Wood 2005).

Technological change also facilitates shifts towards different and more diverse thematic displays. Dorling (1996, excerpted as Chapter 3.7) charts changes in the cartogram as a map form. The cartogram rescales representational space, so that the size of an area reflects a value ascribed to it rather than its geographical extent. The rather ugly blocky appearance of early cartograms, along with difficulties in designing them and the problems of recognising the places being mapped, may have hindered its widespread adoption, but the popularisation of an algorithm that preserved shape whilst converting areas into values, was influential on the publication of subsequent cartograms (see Gastner and Newman 2004 for the algorithm; Dorling, Newman and Barford 2008 for recent applications of this in the form of a global atlas).

More radical design challenges are faced if the designer wants to animate a display. Monmonier (1990, excerpted as Chapter 3.5) illustrates some of the many possible techniques for representing change in mapping. In the twenty years since this paper the web in particular has allowed many of these techniques to become commonplace, and the moving power of a map is increasingly deployed to depict changing phenomena across different media (Cartwright 1999, excerpted as Chapter 2.11). An overview of the state of knowledge around the design of these displays is provided by Lobben (2008).

Geovisualisation offers an emerging research agenda that has seen the development of many novel approaches and data display techniques (Dykes *et al.* 2005; MacEachren and Kraak 1997, excerpted as Chapter 1.11). Notable amongst these techniques are approaches to information visualisation, where different dimensions of variation in data, without any necessary spatial dimension, are visualised (Skupin and Fabrikant 2003). For example Dykes and Wood (2009, excerpted as Chapter 3.12) deploy tree maps as a technique to represent geographic characteristics of a geo-referenced photographic archive (Colour Plate Four, page xx).

Technical advances and new ways of representing data are then still being discovered and deployed. The creative impulse is important in this kind of process and the worlds and art and science are no longer separate, if indeed they ever really were in mapping. Cosgrove (2005, excerpted as Chapter 3.9) suggests an overlap between the world of popular cartography, and in particular in the making of three-dimensional pictorial media maps, and the concerns of artists, in the period around the second world war in the United States that belies claims of objective rule-based design. Not only do cartographers deploy creative energy to design their functional maps, modern artists also deploy the apparently objective and scientific map to say something about the world. The recent upsurge in mapping by modern artists, charted by Harman (2009), reflects a set of concerns about living in the world that mirror those of a designer searching for an elegant design decision. And it is in the situated contextual practice of mapping that these issues come to a head.

The contexts, politics and practice of design

Whilst maps have always been displayed in different ways and through different media, recently there has been multiplication in display formats and the context in which the map operates. For example, the same map will be read in very different ways if it is printed, folded, projected, mounted *in situ* in a 'You are Here' format, displayed in an exhibition, deployed as a graphic in association with other printed materials, displayed on a television screen, or a web site, or on a small screen of a mobile device or satnav system. A significant trend has been an emerging focus on context-specific design, from innovative work on web map design at the start of the new millennium (Kraak and Brown 2001) to a burgeoning research field relating to ubiquitous, or mobile cartography. A good example of the need for context-sensitive design is provided by Meng (2005, excerpted as Chapter 3.11), who explores the specific contextual requirements that flow from designing a map for display on a small mobile device, where use is likely to be personal, placed and transitory.

Contextually-informed design focuses on more than the map. Instead it considers factors such as the size of the display area, the nature of lighting, the nature of user interaction, the degree to which use might be individual or collaborative, the extent to which a display might be immersive, and the degree to which a design is fixed or under a user's control. Very few of these has yet received sufficient attention from the design literature and it has recently been argued that usability engineering approaches will be needed to ensure map designs work effectively given the diversity of contexts in which mapping is deployed (Haklay 2010). Instead of artificially simplified experiments, multiple methodologies, including speak-aloud protocols, video coding, participant observation, interviews and questionnaires, are likely to be deployed during investigations of real world map and geovisualisation display scenarios. Ethnographies of design practice will begin to reveal what designers actually do, instead of shoe horning their practice into pre-established rule structures. And this kind of situated design is much more likely to reflect on the politics of the aesthetic process, instead of pretending that everything can be known by the appliance of neutral science.

What practicing cartographers actually say about their skills and craft may indeed be as revealing as edicts from the academy. In 1999, The British Cartographic Society Design Group investigated best practice in map design. They identified five core principles: 'concept before compilation'; 'hierarchy with harmony'; 'simplicity from sacrifice'; 'maximum information at minimum cost'; and 'engage the emotion to engage the understanding'. These reflect a continuing focus on qualities that are much more likely to be associated with art than science, with rather zen-like slogans, encouraging creativity, reflection and holistic thinking (British Cartographic Society 1999).

Designers have probably always realised the emotional power that can work through mapping. And technological change opens up the possibilities for this kind of active engagement with 'affect'. Aitken and Craine (2006, excerpted as Chapter 3.10) highlight that mapmakers have much to learn in our designs from film-makers, who have long appreciated that they are working in a dream factory, where products are designed to do so much more than convey information. The moving image has a particular capacity to move its audience, and especially when accompanied by music. The animated and multimediated possibilities of new geovisualisations may be particularly effective if they engage with Aitken and Craine's suggestions and if they implement some of the practices in the British Cartographic Society guidelines.

However, static fixed historical displays also have the capacity to engage emotions. Look at the stark red and black imagery of William Bunge's nuclear war atlas (Colour Plate Six, page xx) and imagine its impact in the fearful world of the cold war. Its persuasive angry agitprop style offers a passionate cry of protest against the insanity of mutually-assured-destruction and the arms race. Technology has facilitated a resurgence of this kind of bottom-up counter-map design (Peluso 1995, excerpted as Chapter 5.6), and Wiki mechanisms exist for sharing and developing best practice in this field (Goodchild 2007, excerpted as Chapter 4.10, for an exploration of the changes this brings, and the Cloudmade web site at http://maps.cloudmade.com/editor for an example of a user-controlled design interface). It remains to be seen how researchers' work can be incorporated into these new design worlds, and how tensions between researched and professional design practice and everyday design practice might be resolved.

References

Aitken, S. and Craine, J. (2006) Affective geovisualizations. *Directions: A Magazine for GIS Professionals*, 7 February, www.directionsmag.com. (Excerpted as Chapter 3.10.)

Bertin, J. (1967) *La Sémiologie Graphique*, Gauthier-Villars, Paris, France.

Brewer, C.A. (2008) *Designed Maps: A Sourcebook for GIS Users*, ESRI Press, Redlands, CA.

British Cartographic Society (1999) *Five Principles of Map Design*, British Cartographic Society, London.

Cartwright, W. (1999) Extending the map metaphor using Web-delivered multimedia. *International Journal of Geographical Information Science*, **13** (4), 335–353. (Excerpted here as Chapter 2.11.)

Collier, P., Forrest, D. and Pearson, A. (2003) The representation of topographic information on maps: the depiction of relief. *The Cartographic Journal*, **40**, 17–26.

Cosgrove, D. (2005) Maps, mapping, modernity: art and cartography in the twentieth century. *Imago Mundi*, **57** (1), 35–54. (Excerpted as Chapter 3.9.)

Crampton, J.W. (1994) Cartography's defining moment: the Peters projection controversy, 1974–1990. *Cartographica*, **31**, 16–32.

Crampton, J.W. (2004) GIS and geographic governance: reconstructing the choropleth map. *Cartographica*, **39** (1), 41–53.

Darke, G. and Spence, M. (2008) *Cartography: An Introduction*, British Cartographic Society, London.

Dorling, D. (1996) Area cartograms: their use and creation. *Concepts and Techniques in Modern Geography*, **59**, http://qmrg.org.uk/files/2008/11/59-area-cartograms.pdf. (Excerpted as Chapter 3.7.)

Dorling, D., Newman, M. and Barford, A. (2008) *Atlas of The Real World*, Thames and Hudson, London.

Dykes, J. and Wood, J. (2009) The geographic beauty of a photographic archive, in *Beautiful Data: The Stories Behind Elegant Data Solutions* (eds T. Segaran and J. Hammerbacher), O'Reilly, Sebastopol, CA, pp. 85–104. (Excerpted as Chapter 3.12.)

Dykes, J., MacEachren, A. and Kraak, M.-J. (2005) *Exploring Geovisualization*, Elsevier, Amsterdam, The Netherlands.

Edney, M.H. (1993) Cartography without 'progress': reinterpreting the nature and historical development of mapmaking. *Cartographica*, **30** (2/3) 54–68. (Excerpted as Chapter 1.10.)

Evans, I.S. (1977) The selection of class intervals. *Transactions of the Institute of British Geographers, New Series*, **2** (1), 98–124.

Friendly, M. and Denis, D.J. (2010) Milestones in the History of Thematic Cartography, Statistical Graphics, and Data Visualization. www.datavis.ca/milestones/.

Gastner, M.T. and Newman, M.E.J. (2004) Diffusion-based method for producing density-equalizing maps. *Proceedings of the National Academy of Sciences*, **101** (20), 7499–7504.

Godchild, M.F. (1997) Citizens as sensors: the world of volunteered geography. *GeoJournal*, **69** (4), 211–221.

Haklay, M. (2010) *Interacting with Geospatial Technologies*, John Wiley & Sons, Ltd, Chichester, UK.

Harman, K. (2009) *The Map as Art: Contemporary Artists Explore Cartography*, Princeton Architectural Press, Princeton, NJ.

Harrower, M. and Brewer, C.A. (2003) ColorBrewerorg: an online tool for selecting colour schemes for maps. *The Cartographic Journal*, **40** (1), 27–37. (Excerpted as Chapter 3.8.)

Huffman, N. (1996) You can't get here from there: reconstructing the relevance of design in postmodernism, in *Cartographic Design: Theoretical and Practical Perspectives* (eds C. Wood and C. Keller), John Wiley & Sons, Ltd, Chichester, UK.

Hurni, L., Kritz, K., Patterson, T. and Wheate, R. (2001) Special Issue: ICA Commission on Mountain Cartography. *Cartographica*, **38** (1–2).

Imhof, E. (1982) *Cartographic Relief Presentation*, de Gruyter, Berlin, Germany. (Excerpted as Chapter 3.2.)

Jenks, G. (1963) Generalization in statistical mapping. *Annals of the Association of American Geographers*, **53** (1), 15–26. (Excerpted as Chapter 3.4)

Keates, J.S. (1984) The cartographic art. *Cartographica*, **21** (1), 37–43.

Keates, J. (1993) Some reflections on cartographic design. *The Cartographic Journal*, **30** (2), 199–202.

Keates, J.S. (1996) *Understanding Maps, 2nd edn*, Longman, Harlow, UK.

Kent, A.J. (2006) Aesthetics: a lost cause in cartographic theory? *The Cartographic Journal*, **42** (2), 182–188.

Kent, A.J. (2009) Cartographic blandscapes and the new noise: finding the good view in a topographical mashup. *Society of Cartographers Bulletin*, **42**, 29–37.

Kent, A.J. and Vujakovic, P. (2009) Stylistic diversity in European state 1:50 000 topographic maps. *The Cartographic Journal*, **46** (3), 179–213.

Kraak M.-J. and Brown, A. (2001) *Web Cartography: Developments and Prospects*, Taylor & Francis, New York.

Kraak, M.-J. and Ormeling, F. (2010) *Cartography: Visualization of Spatial Data*, 3rd edn, Pearson, Harlow, UK.

Krygier, J. (1994) Sound and geographic visualization, in *Visualization in Modern Cartography* (eds A. MacEachren and D.R.F. Taylor), Pergamon, New York, pp. 149–66.

Krygier, J. (1996) Cartography as an art and a science? *The Cartographic Journal*, **32** (6), 3–10.

Krygier, J. and Wood, D. (2005) *Making Maps: A Visual Guide to Map Design for GIS*, Guilford, New York.

Lobben, A. (2008) Influence of data properties on animated maps. *Annals of the Association of American Geographers*, **98** (3), 583–603.

MacEachren, A.M. (1994) *Some Truth with Maps: A Primer on Symbolization and Design*, Association of American Geographers, Washington, DC. (Excerpted as Chapter 3.6.)

MacEachren, A.M. (1995) *How Maps Work*, Guilford, New York.

MacEachren, A.M. and Kraak, M.-J. (1997) Exploratory cartographic visualization: advancing the agenda. *Computers &*

Geosciences, **23** (4), 335–343. (Excerpted here as Chapter 1.11.)

Martin, S. (2005) Cartography, discourse and disease: how maps shape scientific knowledge about disease. Unpublished Masters thesis. Anthropology and Geography, Georgia State University, Atlanta.

Meng, L. (2005) Egocentric design of map-based mobile services. *The Cartographic Journal*, **42** (1), 5–13. (Excerpted as Chapter 3.11.)

Monmonier, M. (1990) Strategies for the visualization of geographic time-series data. *Cartographica*, **27** (1), 30–45. (Excerpted as Chapter 3.5.)

Monmonier, M. (2004) *Rhumb Lines and Map Wars: A Social History of the Mercator Projection*, The University of Chicago Press, Chicago, IL.

Peluso, N. (1995) Whose woods are these? Counter mapping forest territories in Kalimantan Indonesia. *Antipode*, **27** (4), 383–405. (Excerpted as Chapter 5.6.)

Robinson, A.H. (1952) *The Look of Maps*, University of Wisconsin Press, Madison, WI. (Excerpted as Chapter 3.3.)

Robinson, A.H. (1953) *Elements of Cartography*, John Wiley & Sons, Inc., New York.

Robinson, A.H. (1982) *Early Thematic Mapping in the History of Cartography*, University of Chicago Press, Chicago, IL.

Robinson, A.H. and Petchenik, B.B. (1976) *The Nature of Maps: Essays Toward Understanding Maps and Mapping*, Chicago University Press, Chicago, IL. (Excerpted as Chapter 1.3.)

Robinson, A.H., Morrison, J.L., Muehrcke, P.C. *et al.* (1995) *Elements of Cartography*, 6th edn, John Wiley & Sons, Inc., New York.

Skupin, A. and Fabrikant, S.I. (2003) Spatialization methods: a cartographic research agenda for non-geographic information visualization. *Cartography and Geographic Information Science*, **30**, 99–119.

Slocum, T.A., McMaster, RB., Kessler, F.C. and Howard, H.H. (2008) *Thematic Cartography and Geo-Visualization, 3rd edn*, Pearson, London.

Tyner, J. (2010) *Map Design*, Guilford, New York.

Wood, M. (1993) The map user's response to map design. *The Cartographic Journal*, **30** (2), 149–153.

Woodward, D. (1987) *Art and Cartography*, Chicago University Press, Chicago, IL.

Wright, J.K. (1938) Problems in population mapping, in *Notes on Statistical Mapping, with Special Reference to the Mapping of Population Phenomenon* (ed. J. Wright), American Geographical Society and Population Association of America, New York, pp. 1–18.