

GEOG/NRES 412/812
Fall 2011

Introduction to Geographic Information Systems (GIS)

Lectures: 9:30-10:45 T R, 228 Hardin Hall
Laboratory: 2:00-4:50 T, 142 Hardin Hall
2:00-4:50 R, 142 Hardin Hall

Instructor: Dr. Qingfeng (Gene) Guan
Office: 324 Hardin Hall; **Telephone:** 472-4002
Email: gguan2@unl.edu (please feel free to correspond with me using e-mail!)
Office hours: By appointment

Laboratory Instructor: Glenn Humphress
Office: 223 Hardin Hall; **Telephone:** 429-2080
Email: glenn.humphress@huskers.unl.edu
Office hours: 1:00-2:00 T R, 223 Hardin Hall

Recommended text: Chang, Kang-Tsung. 2011. *Introduction to Geographic Information Systems* (Sixth Edition) New York: McGraw-Hill. ISBN: 0077465431

Readings: There will be many handouts provided during the semester. In addition, there are **readings** assigned for each major section of the course. Most can be accessed on-line (see Attachment 1). All students will be responsible for reading this material. Readings will be covered on exams.

Blackboard: The syllabus, copies of Powerpoint slides and other materials (e.g., handouts, selected readings and labs) will be posted on Blackboard.

Grading: Grading will be based upon two one-hour exams and a final exam, completion of **all** assigned laboratory projects (see below), and a *GIS Applications Brief*. **Final grades** will be based on approximately the following distribution, but I will also be taking into account grade trends, class participation, completion of all assignments and other **subjective** criteria:

Two one-hour exams (100 points each) and final exam (150 points)	350 points
Satisfactory completion of Labs 1-10 (15 points each)	150 points
Final "comprehensive" project (Lab 11)	75 points
GIS Applications Brief	50 points
Total possible points	625 points

Note: To do well in this course, you need to perform well on all facets of the course! Successful completion of all exams, the applications brief and lab assignments (handed in on time!) is mandatory in order to earn a course grade of "D" or higher! **Graduate Students: In addition to the requirements noted above, you are expected to (1) address special instructions in preparation of the Applications Brief, and (2) demonstrate leadership in the teams formed to complete Lab 11. Additional details on Lab 11 will be provided by your lab instructor. Additional instructions on the Applications Brief are found on pages 3-5.**

GIS Labs

Labs: The laboratory exercises will provide you an opportunity to apply the theoretical and practical components of GIS presented in lecture and the readings. Successful completion of all lab assignments is mandatory. Assigned labs will be due by the next lab period unless otherwise indicated (see lab schedule or discuss with lab instructor). The labs are an extremely important part of the course and may sometimes require more than the scheduled 2 hours to complete. Lab assignments will be posted on Blackboard prior to the scheduled lab. You should review the lab assignment before coming to lab! Note that all GEOG/NRES 412/812 students have access to room 162 Hardin Hall, a 24/7 lab that can be used outside of regularly scheduled lab times. Your lab instructor will give you additional details during your initial lab meeting.

Resources for learning to use ArcGIS: Most of the labs will involve work with ArcGIS software. Labs 1-10 are substantially self-guided (i.e., instructions are provided in the lab handouts). However, to supplement the lab handouts, several useful handouts dealing with ArcGIS have been posted on Blackboard. Two excellent on-line tutorials on ArcGIS are at <http://libinfo.uark.edu/gis/tutorial.asp> and <http://www.pasda.psu.edu/tutorials/arcgis.asp> . Another good ArcGIS help resource is <http://help.arcgis.com/en/arcgisdesktop/10.0/help/index.html> (also available on ArcGIS Desktop software)

Although no textbooks are required for the lab, some of you may wish to acquire one or more of the following:

- Ormsby, T., J. Napoleon, R. Burke, C. Groessl, and L. Bowden. 2010. *Getting to Know ArcGIS Desktop (for ArcGIS 10)*. Redlands, CA: ESRI Press.
- Gorr, W.L. and K.S. Kurland. 2010. *GIS Tutorial 1: Basic Workbook (for ArcGIS 10)*. Redlands, CA: ESRI Press.
- Allen, D. W. 2010. *GIS Tutorial 2: Spatial Analysis Workbook (for ArcGIS 10)*. Redlands, CA: ESRI Press.
- Allen, D. W. and J.M. Coffey. 2010. *GIS Tutorial 3: Advanced Workbook (for ArcGIS 10)*. Redlands, CA: ESRI Press.

Many other excellent books about ArcGIS are available from the ESRI Press (<http://esripress.esri.com>).

Extensive information on ArcGIS is also available on the ESRI web site (e.g., see <http://www.esri.com/news/index.html>) and through the Help menus available in the software. If you get stuck, a good tactic is to use Google (or another browser) to search for information on ArcMap or ArcGIS (e.g., type *ArcGIS and Excel* to locate information on using Excel files with ArcGIS).

There are also many videos about ArcGIS available on YouTube (try searching). ESRITV is the name of ESRI's YouTube channel where there are tips for using ESRI software products, interviews with GIS users and developers and many other topics (see <http://www.youtube.com/user/esritv>).

The ESRI Virtual Campus (<http://training.esri.com>) offers self-study classes, web casts, podcasts (see http://www.esri.com/news/podcasts/instructional_series.html), instructor-led training, and blogs (see

<http://blogs.esri.com/Support/blogs/esritrainingmatters/>). Some of the materials are available for free, but the in-depth training is usually only available for a fee. Another popular online option is the ESRI Users Forum (<http://support.esri.com/index.cfm?fa=forums.gateway>), which does not offer formal training but rather lets users learn about GIS by reading postings about problems other users have encountered and what ESRI staff and other users recommend they do to fix them.

ESRI's Mapping Center web site contains information aimed at helping improve your cartography skills. In the "Blog" section, ESRI employees host a blog in which they give tips on how to make good maps, demonstrate methods of accomplishing mapping techniques, and answer questions from users. The "Maps" page contains a map library with examples of different kinds of maps. There's even a section called "Ask a Cartographer", in which readers can, you guessed it, submit cartography questions to Mapping Center staff (see <http://mappingcenter.esri.com/>).

Lab grading: Most of the labs are **instructional, not evaluative**. That is, Labs 1-10 are generally "self-guided." By contrast, the final lab is evaluative, since relatively little explicit guidance is provided, and since the final lab requires planning, initiative and application of software, methods and principles learned during the semester.

- Labs 1-10 are worth 10 points each
- The final lab (Lab 11) is worth 50 points
- Late labs: 10 percent will be deducted for each day the lab is late (weekends included).

Note: The highest score possible on a lab will be awarded only when the following criteria are met: lab is complete, instructions are followed, answers are correct and responses show thought; lab is turned in on time; work is neat and legible. Other factors that will be taken into account in assigning grades include attendance in labs, extent to which all directions are followed, cooperation and sharing of responsibilities with lab partner, and care of materials and lab equipment.

Successful completion of all lab assignments is mandatory in order to earn a course grade of D or higher!! **Graduate Students:** In addition to the requirements noted above, you are expected to demonstrate leadership in the teams formed to complete Lab 11. Additional details on Lab 11 will be provided by your lab instructor.

GIS Applications Brief

Assignment: Each person will select a GIS application of interest to investigate (see examples of some topics below). Your goal is to become acquainted with the ways in which GIS is currently being used in an area of work related to your personal interests. You will summarize what you have found in a paper **due no later than Nov. 17, 2011. All papers should be provided via email in Microsoft Word format (see detailed instructions below).**

Your task: Undergraduates will identify a minimum of five recent references that deal with current uses of GIS in the application area you select. Graduate students will identify a minimum of ten recent references that deal with current uses of GIS in the application area you select. “Recent” generally means references published since 2000. These references may be journal or magazine articles, books, chapters in books or other sources (e.g., WWW sites, commercial literature, personal interviews). Select references that provide a good representative range of applications in the area you select. No more than two of the five (or three of the ten) references that you review should come from the same source (i.e., from the same book or journal or from ESRI sources); also, do not cite only references from the WWW. You should have a mix of source materials. **NOTE:** Excellent starting points for your research are the ESRI “Industries” web site (<http://www.esri.com/industries.html>), the ESRI best management guides (see <http://www.esri.com/showcase/best-practices/index.html>) and the ESRI on-line GIS bibliography (<http://training.esri.com/gateway/index.cfm>). To use the bibliography, click on the "Library" tab, and then enter key words appropriate to your interest (elk habitat, birds, highways, forestry, water quality), or use the “browse” option.

Detailed Instructions: Prepare a paper that summarizes your research about the GIS application you select. Undergraduates will prepare a paper of about 10-12 pages plus [i.e., not including] your title page, list of references and optional illustrations. Graduate students will prepare a paper of about 12-15 pages plus [i.e., not including] your title page, list of references and optional illustrations. The paper should be in narrative format, and should be well-organized, well-written and set forth logically. **Topics must be approved by (or before) Sep. 22, 2011. Please send me e-mail indicating your paper topic, your name and student ID number.** I’ll let you know if I think your proposed topic is acceptable, or if it is too broad, too narrow or otherwise unacceptable. **Final papers are no later than Nov. 17, 2011. Plan ahead! Missed deadlines will result in reduction of grades.**

Some possible topics (note that there are many other possibilities; select a topic that interests you!):

urban planning	solid waste disposal
managing urban growth	railroad industry
transportation planning and management (e.g., highways)	crop production
police or fire protection	wine and vineyards
public schools	crop diseases and pests
property appraisal	natural hazards (drought, wildfire, hurricanes)
politics, elections, redistricting	business geographics; marketing
public health; disease (e.g., West Nile virus)	sustainable forest management
wildlife management (focus on specific species such as waterfowl, elk or wolves)	homeland security
air pollution	military applications
global warming	grazing and range management
surface water pollution	soil conservation
groundwater pollution	local government
	forest fires

gas and oil exploration and production
 protecting critical wildlife habitats; conserving biodiversity
 endangered species
 invasive species (plants, animals)
 park management; recreation
 wetlands

fisheries
 coral reefs
 coastal zone protection and management
 utilities (gas, electric, sewer, or telephone)
 GIS and the courts (legal issues)
 Internet Map Services

Format: All papers should be provided to me via email in Microsoft Word format. Use a font such as Arial or Times New Roman (either 11 or 12 point). The papers should be *double-spaced*. Use **subheadings (in bold)** to separate major sections of your paper. Number your pages (except for page 1) in the top center of each page. On page 1 (title page) - center the following (**in bold**) at the top:

Title of Paper

Your Name

E-mail (e.g., yourname@netmail.org)

Date (e.g., March 28, 2010)

Content: In the introduction to the paper you should identify and define the area you investigated. Most of your paper should focus on what you discovered in your research. Refer to your references in the text by including author and date in parentheses (e.g., Doe and Deer, 2007). Conclude the paper with a summary of what you learned.

Other guidelines: I expect the paper to be well-written. Writing will count in the grading! Check spelling, sentence/paragraph structure, grammar and syntax carefully. Be sure to define all acronyms on first use. Also note the following:

- don't just list applications or uses of GIS; provide details about how and why applications are implemented; discuss implications of using GIS (advantages or problems).
- remote sensing and GPS are technologies closely related to GIS; you may briefly discuss them if relevant, but keep the emphasis of the paper on GIS.
- don't quote long passages of text from your references; put things in your own words to illustrate that you have understood what you have read.
- list all references at the end of the paper using the format outlined below.
- arrange references alphabetically by author's last name; if an author has more than one citation, list the citation having the most recent date first.
- in the text - avoid use of "etc." (be specific); don't keep telling me what you are going to do in the paper; don't explain or define GIS; focus on the applications of GIS (give details).
- if you use tables or illustrations (e.g., maps or charts), give them table or figure numbers and cite them in the text (e.g., Fig. 1 or Table 1).
- remember that one sentence does not comprise a paragraph.

Format for citations: Refer to your references in the text by including author and date in parentheses (e.g., Doe and Deer 2007). Note the following examples:

- Federal Express and UPS Corporations routinely use ArcGIS routing tools to establish delivery of packages (Sibold 2005).
- Doe and Deer (2007) used ArcGIS neighborhood analysis to assess fragmentation of land cover, mapped using 30-meter Landsat TM data
- HAZUS is a standardized GIS-based methodology developed by the Federal Emergency Management Agency (FEMA) to estimate potential losses from earthquakes, hurricanes and floods (Federal

Emergency Management Agency 2009).

Format for references: List alphabetically by author's name

Journal/magazine article:

Doe, Jane E. and John S. Deer. 2007. *GIS and Wildlife Management*. **Journal of Applied Wildlife Ecology**, 10: 234-245.

Book:

Sibold, Robert G. 2005. **Business Geographics**. New York: Hawthorne and Sons, Inc.

Chapter in a book:

Brown, Lionel C. 2008. *Using Scanners*, Chapter 4 in **Introduction to Data Conversion** (J.A. Harn, editor). New York: John Wiley, 45-67.

WWW:

Federal Emergency Management Agency. 2009. **HAZUS home page**.
<http://www.fema.gov/plan/prevent/hazus/index.shtm> (accessed February 12, 2010).

Personal interview (Note: an "interview" may be conducted in person or via e-mail or phone).

Anderson, T.D. 2010. GIS manager, City of Grand Island, NE Public Works Department. Personal Interview, February 25, 2010.

TENTATIVE LECTURE SCHEDULE
Readings from Attachment 1 are noted in parentheses

Aug 23	Course introduction and overview
Aug 25-Sep 1	Introduction to GIS (Read sections 1-3)
Sep 1-Sep 20	Georeferencing, coordinate systems and map projections (Read sections 4-6)
Sep 22	Application Brief Topics due
Sep 22-Oct 6	Data structures (Read section 7)
Oct 11	FIRST EXAM
Oct 13-Oct 27	Introduction to geospatial data analysis (Read sections 9-10; begin exploring section 8) Principles of map design - map types, map elements, legends, color conventions
Oct 18	Fall Break
Nov 1- 8	Geospatial data analysis - buffering, reclassification, neighborhood operations; overlay, network analyses
Nov 10	SECOND EXAM
Nov 17	Application Briefs due
Nov 15-Nov 29	Sources and characteristics of geospatial data; data capture (Read sections 8 and 11)
Nov 24	Thanksgiving
Nov 29-Dec 1	Data quality; error assessment (Read section 12)
Dec 1-Dec 6	Technical, institutional, and economic considerations (Read section 13)
Dec 8	State and federal GIS activity; Future of GIS (Read sections 14-15)
December 14	<u>FINAL EXAM</u> (10:00 am – 12:00 noon)

TENTATIVE LAB SCHEDULE

(Additional details will be provided by your Lab Instructor)

<u>Week Beginning</u>	<u>Topic</u>
August 22	No Lab
August 29	Lab 1 - Map Orientation and Coordinate Systems (take home) - <u>Due the week of September 12</u>
	Lab 2 - Getting Started with ArcGIS: Introduction to ArcCatalog and ArcMap
September 5	Lab 3 - Find, Download, and Change Projections of GIS Data
September 12	Labs 1 & 3 (continued) - <u>Due by 4:50pm on the scheduled day for each section</u>
September 19	Lab 4 - Queries in GIS Analysis and Map Design
September 26	Lab 5 - An Introduction to Digitizing, Hyperlinks, Graphs, and DEMs
October 3	Lab 6 - Geocoding Addresses and Adding X,Y Data
October 10	Lab 7 - Mapping Census Data - <u>Due by 4:50pm Thursday October 20 for both sections</u>
October 17	Tuesday: Fall Break - No Lab Thursday: Lab 7 (continued) - <u>Lab 7 due by 4:50pm Thursday October 20 for both sections</u>
October 24	Lab 8 - Vector Analysis
October 31	Lab 9 - Raster Spatial Analysis (Part 1) - <u>Due the week of November 14</u>
November 7	Lab 10 - Raster Spatial Analysis (Part 2) - <u>Due the week of November 14</u>
November 14	Lab 11 - Spatial Analysis Final Project - <u>Labs 9 & 10 due by 2:00pm on the scheduled day for each section</u>
November 21	Tuesday: Lab 11 - Spatial Analysis Final Project (continued) Thursday: Thanksgiving Break - No Lab
November 28	Lab 11 - Spatial Analysis Final Project (continued)
December 5	Lab 11 - Spatial Analysis Final Project (continued) – <u>Due no later than 5:00pm December 9 (digital and hard copy) for both lab sections. The digital copy of the lab should be stored in your group folder.</u>

Attachment 1

GEOG/NRES 412/812 - Reading Assignments**1. Fundamentals of Mapping**

USGS Maps (follow and read the links on this web page)

<http://topomaps.usgs.gov/>

Map Scale

<http://erg.usgs.gov/isb/pubs/factsheets/fs01502.html>

2. Introduction to GIS

The Changing Geospatial Landscape, a Report of the National Geospatial Advisory Committee, January 2009

<http://www.fgdc.gov/ngac/NGAC%20Report%20-%20The%20Changing%20Geospatial%20Landscape.pdf>

Also available on Blackboard/Course Documents/Readings

What is GIS?

<http://www.gis.com/content/what-gis> and all subtopics listed under “Key GIS Concepts”

USGS – Geographic Information Systems

http://erg.usgs.gov/isb/pubs/gis_poster/

Beyond Mapping: Meeting National Needs Through Enhanced Geographic Information Science (read Chapter 1 – pp. 7-26)

http://books.nap.edu/catalog.php?record_id=11687

Optional - Harvard videos – Introduction to GIS (watch all 3 videos)

<http://hcl.harvard.edu/libraries/maps/gis/tutorials.html>

3. Introduction to ArcGIS (see also the material on Blackboard)

Explore, and become familiar with, the ESRI web site at <http://www.esri.com>

Pay special attention to material dealing with Desktop GIS (<http://www.esri.com/software/arcgis/>)

NOTE: you don't need to read everything, but become familiar with what is available on the web site.

ArcGIS brochure (also posted on Blackboard)

<http://www.esri.com/library/brochures/pdfs/arcgis.pdf>

4. Coordinate Systems, Projections and Grids

Map Projections

http://www.nationalatlas.gov/articles/mapping/a_projections.html

The Universal Transverse Mercator (UTM) Grid
<http://erg.usgs.gov/isb/pubs/factsheets/fs07701.html>

The State Plane Coordinate System
<http://vterrain.org/Projections/spcs.html>

The Public Land Survey System
http://www.nationalatlas.gov/articles/boundaries/a_plss.html

Why don't my layers "line-up" in ArcGIS?
<http://www.gsd.harvard.edu/gis/manual/projections/index.htm>

5. **Optional - Global Positioning System (GPS)**

Trimble GPS Tutorial (requires Macromedia Shockwave plug-in)
<http://www.trimble.com/gps/>

6. **Digital Orthophotos**

Digital Orthophoto Quadrangles
<http://erg.usgs.gov/isb/pubs/factsheets/fs05701.html>

Digital Orthophoto FAQs
<http://nationalmap.gov/digitalbackyard/faqsnew.html>

National Digital Orthophoto Program (explore the *goals*, *maintenance* and *data* sections)
<http://www.ndop.gov>

7. **Data Structures**

Raster-based GIS
http://www.sli.unimelb.edu.au/gisweb/GISModule/GIST_Raster.htm

Vector-based GIS
http://www.sli.unimelb.edu.au/gisweb/GISModule/GIST_Vector.htm

8. Sources of Geospatial Data. First, explore the excellent guides to geospatial data can be found at <http://libinfo.uark.edu/gis/us.asp> and <http://libraries.mit.edu/gis/data/datalinks/statedataweb.html>

Then explore the following web sites:

- Geospatial One-Stop <http://gos2.geodata.gov/wps/portal/gos>

- The Geography Network (being replaced by ArcGIS on-line)
<http://www.geographynetwork.com/> or <http://www.arcgisonline.com/home/>
- USGS - The National Map (explore the data available through the Viewers – see
<http://nationalmap.gov/viewers.html> and <http://nationalmap.gov/>)
- USGS Seamless Data Server <http://seamless.usgs.gov/>
- USDA Geospatial Data Gateway <http://datagateway.nrcs.usda.gov/>
- National Wetlands Inventory <http://www.fws.gov/wetlands/>
- U.S. Bureau of the Census <http://www.census.gov/geo/www/>
- Nebraska Department of Natural Resources <http://www.dnr.state.ne.us/databank/spat.html>
- UNL School of Natural Resources <http://snr.unl.edu/data/geographygis/NebrGISdata.asp>
- NebraskaMAP <http://www.nebraskamap.gov/dnn/>

9. Map Design and Thematic Mapping

Introduction to Map Design (browse this article)

<http://www.esri.com/industries/k-12/PDFs/intrcart.pdf>

Thematic Mapping

http://www.pop.psu.edu/gia-core/pdfs/gis_rd_05-70.pdf

Making Maps (browse the PDF excerpts)

<http://makingmaps.owu.edu/>

ColorBrewer (see how it works)

http://www.personal.psu.edu/cab38/ColorBrewer/ColorBrewer_intro.html

10. Spatial Data Analysis

Answering Questions with GIS

<http://www.gis.com/whatisgis/gisanalysis.html>

Flowchart Tutorial (available on **Blackboard**)

Introduction to Data Analysis using GIS (read all four sections)

<http://www.extension.umn.edu/distribution/naturalresources/DD5740.html#i>

ArcGIS Spatial Analyst (read selections on “Key Features” – for each, click “learn more”)

<http://www.esri.com/software/arcgis/extensions/spatialanalyst/index.html>

Analyzing Data in ArcGIS

<http://libinfo.uark.edu/GIS/tutorials/tutorial5.pdf>

ArcGIS Spatial Analyst: Advanced GIS Spatial Analysis

http://www.esri.com/library/whitepapers/pdfs/arcgis_spatial_analyst.pdf

11. Data Capture

Data Sources

<http://www.innovativegis.com/basis/primer/sources.html#Data%20Input%20Techniques>

Geospatial Metadata (available on **Blackboard**)

Three Tab Metadata Editor

<http://gis.cdatribe-nsn.gov/ThreeTabMetadataEditor/>

12. Error and Uncertainty

Error, Accuracy and Precision

http://www.colorado.edu/geography/gcraft/notes/error/error_f.html

13. Establishing a GIS

Implementing a GIS (click on, and read about, each of the ten steps)

http://www.gis.com/implementing_gis/index.html

14. State and Federal GIS Activity

Beyond Mapping: Meeting National Needs Through Enhanced Geographic Information Science (review Chapter 1)

http://books.nap.edu/catalog.php?record_id=11687

Explore the following web sites:

- The Federal Geographic Data Committee (FGDC) - <http://www.fgdc.gov/>
- National States Geographic Information Council (NSGIC) - <http://www.nsgic.org/>
- Nebraska GIS Council - <http://www.cio.nebraska.gov/gis/index.html>

Optional - 2009 Annual Report of the Federal Geographic Data Committee

<http://www.fgdc.gov/fgdc-news/2009-fgdc-annual-report> (also on Blackboard)

15. Future of GIS

University Consortium for Geographic Information Science (browse this site; under Priorities – Research, browse some of the documents that interest you)

<http://www.ucgis.org/>

Certification and Ethics in the GIS Profession

<http://urisa.org/Journal/protect/Vol15No1/huxhold.pdf>

Beyond Mapping: Meeting National Needs Through Enhanced Geographic Information Science (read Chapter 3)

http://books.nap.edu/catalog.php?record_id=11687

Attachment 2

GEOGRAPHIC INFORMATION SYSTEMS
Some Recommended Books

Note: Designations such as **Love CC83.I58** (see below) indicate the location of books and periodicals in the library system at the University of Nebraska-Lincoln.

Bernhardsen, T. 2002. *Geographic Information Systems: An Introduction*, Third Edition. New York: John Wiley and Sons. **Love G70.2 B47**

Bettinger, P. and M.G. Wing. 2004. *Geographic Information Systems: Applications in Forestry and Natural Resources Management*. New York: McGraw-Hill.

Bolstad, P. 2008. *GIS Fundamentals: A First Text on Geographic Information Systems*. White Bear Lake, MN: Eider Press.

Chang, Kang-Tsung. 2009. *Introduction to Geographic Information Systems*, Fifth Edition. New York: McGraw-Hill.

Chrisman, N. 2002. *Exploring Geographic Information Systems*, Second Edition. New York: John Wiley and Sons

Clarke, K.C. 2003. *Getting Started with Geographic Information Systems*, Fourth Edition. Upper Saddle River, NJ: Prentice-Hall, Inc. **Arch G70.212 .C57**

DeMers, M.N. 2005. *Fundamentals of Geographic Information Systems*, Second Edition. New York: John Wiley and Sons **Geol G70.212 .D46**

Heywood, I., S. Cornelius and S. Carver. 2002. *An Introduction to Geographical Information Systems*. Essex, England: Addison Wesley Longman, Ltd. **Arch G70.212 .H49**

Kennedy, M. 2006. *Introducing Geographic Information Systems with ArcGIS*. New York: John Wiley and Sons.

Lo, C.P. and A. K. Yeung. 2007. *Concepts and Techniques in Geographic Information Systems*. Upper Saddle River, NJ: Prentice-Hall, Inc.

Longley, P.A., M.F. Goodchild, P.A. Maguire and D.W. Rhind. 2005. *Geographic Information Systems and Science*. New York: John Wiley and Sons, Inc.

Madden, M. (ed.). 2009. *Manual of Geographic Information Systems*. Bethesda, MD: American Society for Photogrammetry and Remote Sensing.

Mitchell, A. 2001. *The ESRI Guide to GIS Analysis, Volume 1: Geographic Patterns and Relationships*. Redlands, CA: ESRI Press.

Mitchell, A. 2002. *The ESRI Guide to GIS Analysis, Volume 2: Spatial Measurements and Statistics*. Redlands, CA: ESRI Press.

Theobald, D. M. 2009. *GIS Concepts and ArcGIS Methods*, Fourth Edition. Fort Collins, CO: Conservation Planning Technologies.