

CAREERS IN CARTOGRAPHY AND GIS



A brochure published for high school and college students considering a career in cartography and Geographic Information Science by the American Congress on Surveying and Mapping and the Cartographic and Geographic Information Society

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Careers in Cartography and GIS is published jointly by the American Congress of Surveying and Mapping (ACSM) and the Cartographic and Geographic Information Society (CaGIS). ACSM is a non-profit educational organization comprised of four member organizations, one of which is CaGIS. CaGIS serves professionals who are employed in the fields of cartography and GIS. The brochure is an updated version (2001) of the one printed in 1998. For printed copies of this publication, contact:

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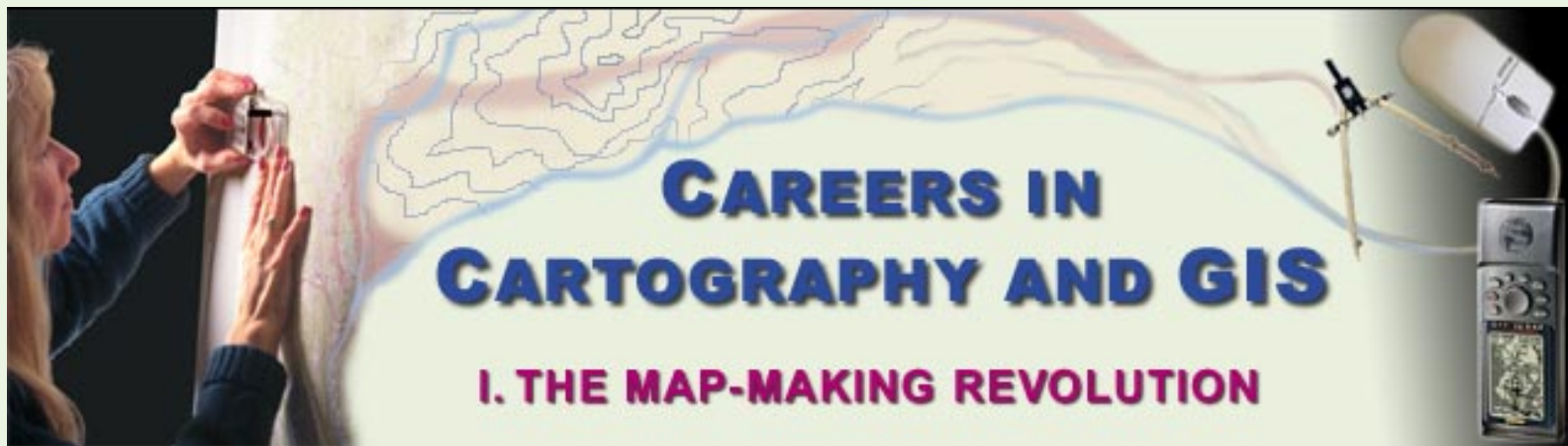
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- A line of thunderstorms rolls across rural Texas. Residents fearing tornados check weather maps and plan their escape routes.
- In coastal Massachusetts, scientists study the movement of toxic chemicals from abandoned factories into sensitive watersheds and wetlands.
- In Virginia, a student sends an announcement of an upcoming graduation party by e-mail to her friends—and attaches a customized map to the location.
- In Los Angeles, a shop owner plans the location of her second store by compiling a map of her competitors on a computer.
- In Colorado, mountain bikers follow an old gold mining trail, and keep track of their route with a satellite receiver.

These people all have one thing in common: they are using maps. In some cases, they are making new maps from existing information. They are using products created by cartographers and geographic information specialists. The map-making profession may be thousands of years old, but it is in the midst of a digital revolution, one that has created an unprecedented demand for people who understand how to make and use maps.

1- Seeing Information in Relation to Space

Most people think that cartography deals with the design, creation, and use of maps. Although the term “cartography” did not emerge until the mid 19th century, surveyors, explorers, and scientists had been making maps for thousands of years. Over the centuries, many types of maps have been developed to suit the needs of engineers, recreationists, scientists, navigators, city planners and others concerned with the geographical character of the environment. Today, maps may appear in static printed form, or they may appear as dynamic (interactive or animated) images on a computer display screen. But always, regardless of form, the aim of maps is geographical visualization—seeing environmental features in their relationship to geographical space. In this way, maps differ fundamentally from language and mathematical descriptions of the geographical setting.

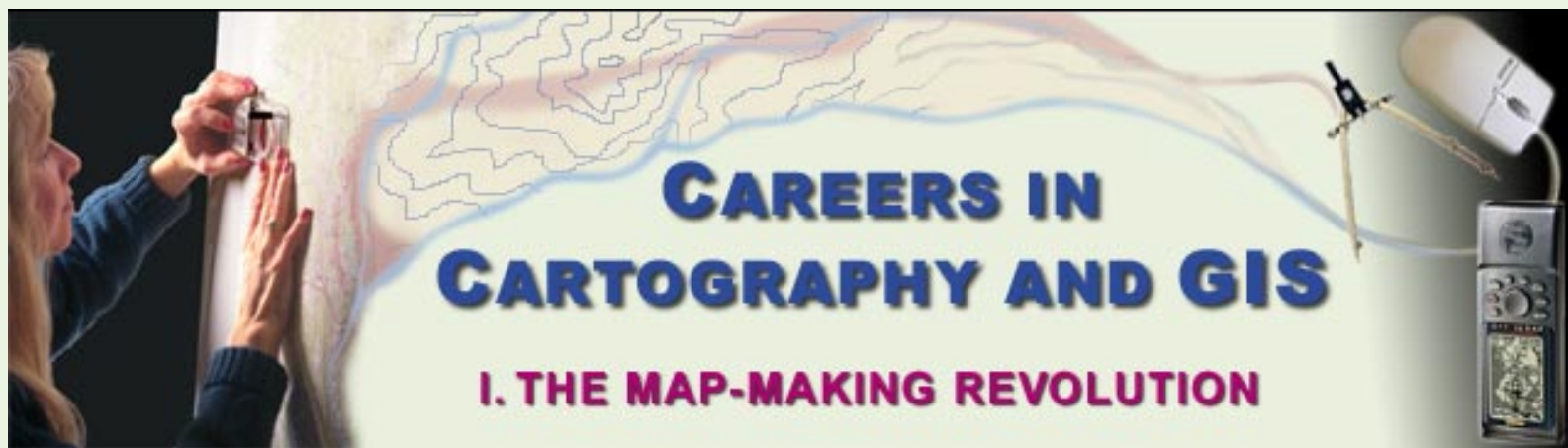
It is impossible to discuss present-day cartography without reference to the related field of geographic information systems (GIS). GIS focuses on the collection, storage, retrieval, analysis and modeling of data;

cartographers specialize in the best way to visualize and present the information. The two disciplines are closely related to other disciplines like surveying, photogrammetry and remote sensing, which concentrate on ways to measure accurately and collect information about features on the Earth's surface. Together, these fields constitute the high-tech mapping sciences or geographic information science.

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2- A Changing Profession

Only 50 years ago, mapmakers struggled to obtain enough information to make a map. Today, massive amounts of data can be registered to the Earth's surface, mapped and analyzed.

Cartography has undergone a revolution brought on by the widespread availability of automated techniques, including GIS technology. In the past, the tasks of the mapmaker altered little from one generation to the next. No longer. Few aspects of this complex field have escaped the impact of digital technology. In fact, the pens, ink, drafting tables, large format cameras, and darkrooms that characterized map production facilities a generation ago have largely disappeared. They have been replaced by scanners, workstations, mass storage devices, and plotters. Modern techniques, especially aerial photography and satellite imagery, now provide almost infinite amounts of map-like information or data that can be registered to the Earth's surface. The problem is to manage and display the flood of new data.



A very strong commercial marketplace has developed to provide the new breed of cartographers and GIS specialists with exciting, powerful hardware and software tools to process and display data. People entering these professions today can look forward to practically unlimited capabilities for handling vast amounts of geographic information, analyzing data to help solve important problems, and generating maps that aid in critical decision making. Cartographers will need a variety of skills, including visualization techniques, data processing, database management, computer programming, as well as methods for assuring data quality.

The increased speed and reduced costs gained through modern map-making technology and GIS techniques are fundamentally changing the nature of cartography. New topics, particularly short-lived phenomena such as tornados, floods, or hazardous air quality can now be mapped quickly enough to be of immediate use in disaster response efforts and risk assessment. GIS technology enables planners to predict and visualize future land use patterns and determine which areas are most suitable for new development or susceptible to hazards, congestion or adverse environmental conditions.



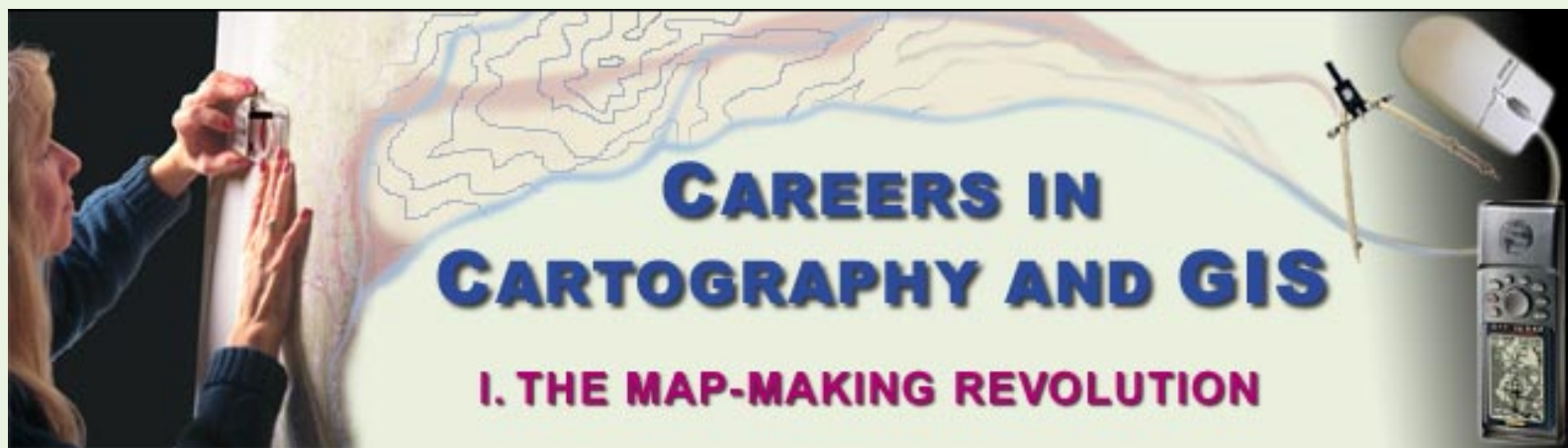
Throughout the history of cartography, map types have changed to reflect the needs of the time. Thus, early maps depicted concrete, tangible features such as coastlines, rivers, mountains, roads and towns. Later, the focus was on the spatial distribution of environmental phenomena (such as vegetation, soils, geology, and climate) and societal issues (such as population and disease). Most recently, attention has shifted to short-lived phenomena such as tornados, air pollution and floods, and to visualization of the results of conceptual modeling of environmental phenomena such as groundwater contamination. The trend has been one of shifting from simply mapping obvious features to discovering relationships between different levels and layers of geographic information.

Mapping has become more conceptual and imaginative. The scope of mapping possibilities has expanded in the process, so that at present more people find maps relevant to their life and work than ever before, and maps are being produced on demand to an ever-expanding market.

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3- Cartography, GIS, and Visualization

Geographic information systems (GIS) are automated systems used to capture, edit, store, manipulate, analyze and display an infinite variety of spatial data. A GIS has three major components: a data base, a spatial analysis and modeling capability, and a means for graphic display. Cartography serves GIS technology in several ways. Data inputs to geographical information systems are commonly retrieved from existing maps through digitizing or scanning procedures. Converting cartographic information into geographical databases represents a major portion of GIS development. Data may be geographically referenced as it is collected through the use of Global Positioning System satellites (a network of satellites that send positioning data anywhere on earth) or through the use of automated procedures that assign geographic coordinates to street addresses. The link between maps and geographic information systems occurs in the graphical communication of the output of the GIS models.

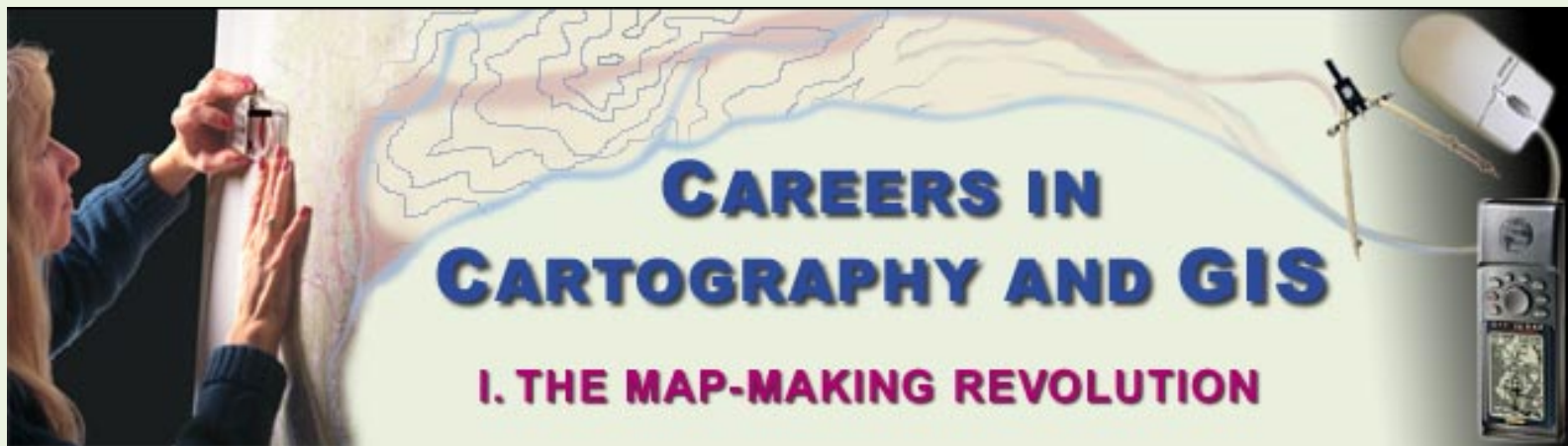
Today cartography is closely associated with the broader field of **scientific visualization**. This technique takes the map reader beyond the printed page and shows them terrain as if they were flying in a helicopter, displays the predicted dispersion of oil days or months after a spill, or models the future growth of an urban area. Since the limitations of a paper map no longer exist, today's cartographers learn how to best display data, information, and the relationships between different data sets. Relationships that are difficult to show on a paper map may be more easily displayed on a computer display.

GIS has become the major tool for a wide range of applications. These include the analysis of phenomena and processes that affect our daily lives. Examples range from weather, politics, crime, real estate development, forest management and business decisions. The true power of GIS is its ability to combine and synthesize any form of geographic information.

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CAREERS IN CARTOGRAPHY AND GIS

I. THE MAP-MAKING REVOLUTION

4- What Cartographers Do

The role of the cartographer is to visualize and effectively display complex spatial and socio-economic interrelationships. Cartographers can be involved in many phases of the art and science of mapping. These may include the design, production and use of maps, charts, and special graphics from physical, economic, social and cultural data supplied by field surveys, census, remote sensing and existing maps. Cartographers conduct research in ways to improve the mapping process. They also work to develop more efficient ways of representing geographic features, creating and storing complex spatial objects, handling the features that change through time, developing new map projections and measuring the error in maps.

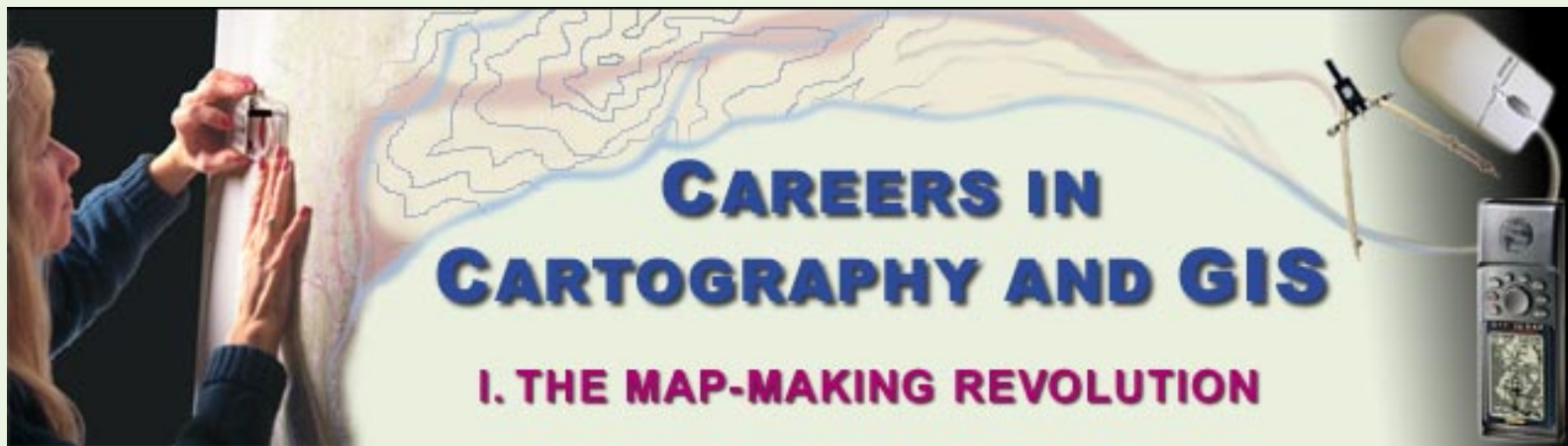
Some cartographers conduct detailed studies of how people perceive the information they see on maps and how the placement and format of the features on maps can influence the message that the map conveys. As a result we know how to make maps more efficiently and we know more about the elements of good map design. These studies have greatly improved our ability to efficiently produce entire map series that are both aesthetically pleasing and easy to read.

Cartographers need to be familiar with all aspects of the study of maps, including the types of map uses anticipated, the principles and controls guiding the map design process, and the elements of cartographic abstraction or generalization. Cartographers should also have a general appreciation of the historical evolution of maps and their makers.

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5- A Map of the Profession

Jobs in cartography can be viewed across a spectrum of interests and duties. At one end are the **GIS researchers** and **professional cartographers** who are primarily concerned with taking data gathered by one group of people and creating effective cartographic visualizations for use by other groups of people. Professional cartographers draw heavily on knowledge of the mapping sciences, including surveying, geodesy, remote sensing, and photogrammetry. A working knowledge of the graphic arts, computer science and the cognitive sciences is desirable. In addition, it is valuable to understand the importance of maps to users, including those working in environmental sciences, planning, recreation, and government.

The **GIS analyst** often will have expertise in a particular area such as the use and management of natural resources, urban and regional planning, or business. Timber companies and real estate firms are good examples of businesses with a growing need for GIS specialists. While GIS specialists may focus on ways to combine and analyze data, it is important that they understand the principles of good map design.

Corporate cartographers and **business GIS analysts** generate specialized maps and analyses to aid problem solving and support decision-making. This rapidly expanding specialty has been aided by the widespread availability of geographic data from government and commercial sources. Demand for GIS analysts will continue to grow as more businesses venture into generating their own maps and GIS analysis. Cartographers and GIS specialists in this market are likely to be working in an environment where geographic data, demographic information, statistical procedures, and graphic visualization (including mapping) methods have all been integrated and made accessible through automation.



As in earlier times, there are cartographers who are concerned with the distribution of maps and related sources. Jobs in this category can include **map librarians**, **map dealers**, and **merchants** of map products. Digitization has had its effect on this group as well. Today's map library is likely to include a series of CD-ROMs with spatial data bases and computers that enable users to generate their own customized maps. Facilities may be repositories or clearinghouses for data collected by other organizations. In these settings, the cartographer becomes an **information specialist** and must be well versed in information management as well as maps and geographic data.

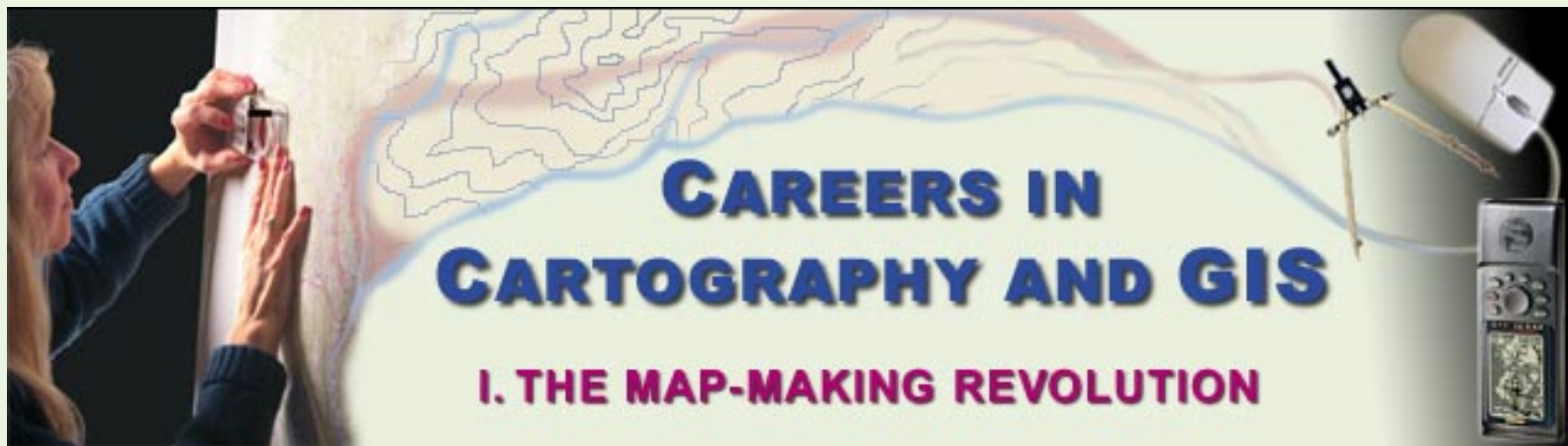
A wide variety of cartographic positions are available along this employment spectrum to satisfy job seekers with

a diversity of interests and skills. Those who enjoy working with computers, graphic arts, mathematics and statistics, in either human or physical domains, can all find a challenging place in the field. There is room for both the generalist and the specialist.

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6- Mapping Specialties

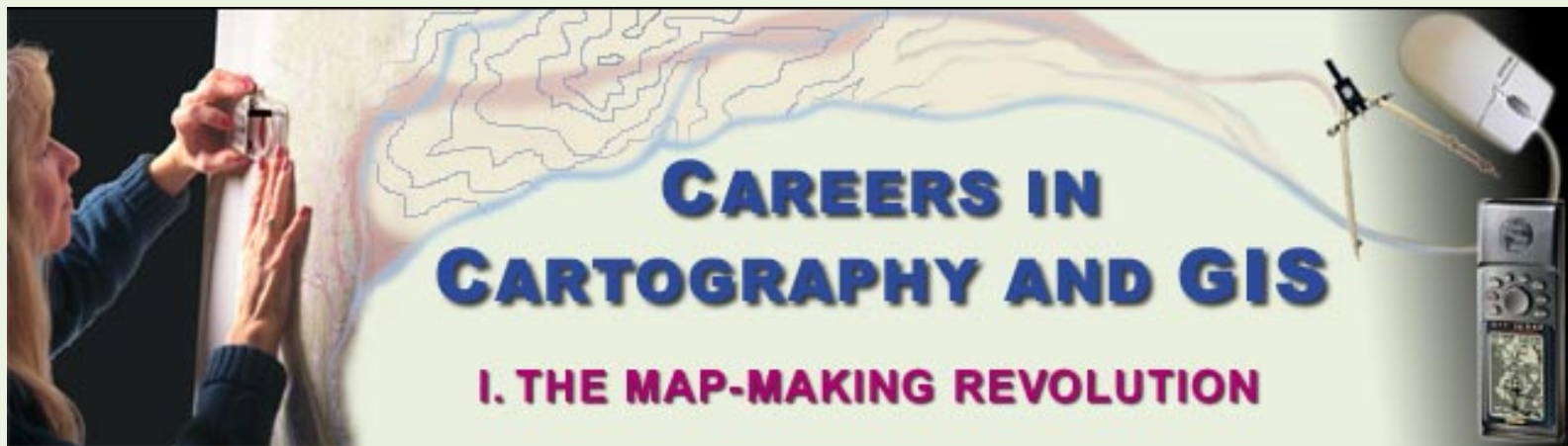
Several specialized areas have evolved to make maps for specific uses, and although they may use the same information, their requirements are different.

For instance, **cadastral mapping** is the branch of the field that deals with recording and delineating legal property lines. Cadastral maps are critical to the operation of local governments. They also provide a basis for planning, emergency response efforts, and real estate activities. **Topographic mapping** is concerned with the representation of all important features on the landscape which, in addition to elevation contours, includes vegetation, buildings, transportation lines, boundary lines, water bodies, and place names. **Nautical and aeronautical charting** provides critical information about the elevation of terrain and the depth of water bodies. These maps are designed specifically for sea and air navigation. **Image-based mapping** involves the enhancement of remotely sensed imagery and combination with other data, such as reference grids or roads derived from conventional geometric map sources. **Thematic cartography** is concerned with creating maps that portray the geographical distribution of specific geographic features such as soils, vegetation, or geology. **Statistical mapping** involves the manipulation and portrayal of quantitative data such as population density, tax rates, or air quality. Maps are also the best way to display the results of computer models that are used to forecast changes in weather, sea temperature (El Niño), global warming, or greenhouse gases. These displays, often in three dimensions, represent an exciting new category of maps made possible through elaborate mathematical computations performed on supercomputers.

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7- The Making of Maps

No matter what the purpose, making a map requires similar steps. Here is a summary of some of the major steps involved in producing a map.

Step 1: Collect the Data

The first step in creating a map is to collect accurate data. Research may involve the collection and evaluation of mappable information firsthand through field work, or secondhand from existing maps, aerial photographs, statistical reports, computerized data files, or other data sources. Research also may involve the development of new cartographic methods and symbols, as well as the evaluation of their accuracy and effectiveness in representing the original data and communicating these to the map user.

Step 2: Compile a Base Map

Existing maps, such as U. S. Geological Survey topographic quadrangles, may serve as a base upon which geologic, land use and other information can be added. A photomap also may be assembled, and special features highlighted to form a base map. Sometimes very precise instruments are used to compile the information from aerial photography. If suitable base map data are not available in digital form, then geographic data need to be digitized and edited as the first step of base map compilation. This can be a time-consuming process that is often done by outside contractors who specialize in such services. The trend is toward more direct field data coding, especially with the use of Global Positioning System (GPS) satellite data.

Data collection can be very expensive, but with good design the same database can be used by many organizations for a wide range of purposes. Once the digital records have been created they can be entered into a digital database that can be used repeatedly. For example, in the 1980's the U.S. Geological Survey was able to create digital versions of its maps that were then used by the U.S. Bureau of the Census for the 1990 and 2000 Census of Housing and Population. These same digital maps are now widely used for land use planning, automated routing and map production.

In many parts of the U.S. and Europe, local governments have established consortia to generate large scale digital photographs with resolutions as small as one meter. With sophisticated computer processing and highly accurate ground control points these digital photographs provide excellent bases for generating base maps of roads, buildings, water bodies, and land use. They also provide the base for generating digital elevation files.

When complex color maps are being prepared, an assortment of prepress color proofing systems allows careful color control before printing. A growing number of maps are produced specifically for users of the Internet. These are usually printed at the user's workstation or displayed on a screen.

GIS databases are critical for making decisions about a range of activities including zoning, permits, location of facilities, road construction, school planning and routing of buses and emergency vehicles. Because the data are so important to community operations, it is important that they be developed according to rigorous standards and carefully edited and maintained.

Step 3: Design the Map

Map and chart design involves the planning of every detail and step of a specific cartographic project. Cartographers must select the appropriate geographic data. During the data collection stage, they must ensure that the appropriate data are available. They then must make decisions regarding map projection, scale, symbols, fonts, and placement of text, as well as the methods of production and printing.

The cartographer must balance the requirements of effective design against those of time and cost. At this stage he or she often prepares rough or detailed prototypes. Traditionally, changes in maps have been expensive and complicated. Design with computer assistance or GIS technology provides a much wider range of choices than traditional methods, allowing mapmakers to consider many alternatives.

Step 4: Prepare the Artwork

The combination of increased processing power and reduction in cost have made digital map production economically feasible without sacrificing quality. The advancements in speed and resolution of new printing technology have made production of color maps dramatically faster and less expensive. The aesthetic quality of graphics produced by computer-driven printers and plotters has surpassed that achieved by painstaking hand drawing, particularly in shading and relief.

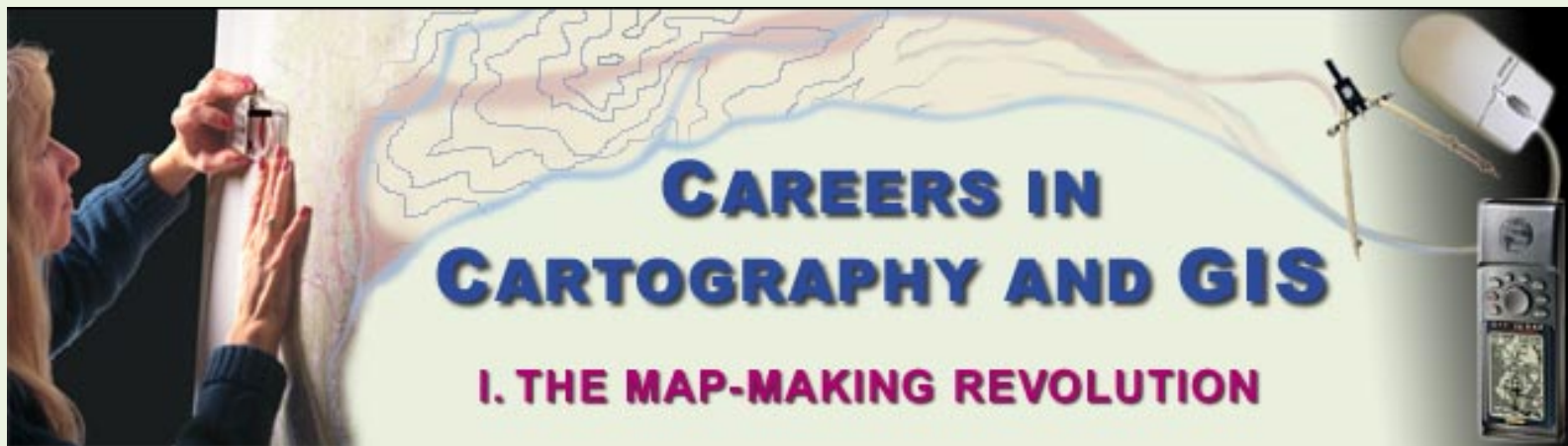
Step 5: Print or Distribute the Map

Maps to be reproduced in large quantities are usually printed by offset lithography, but with digital methods, maps can be created on demand and customized to meet the customer's requirements. While the cartographer may not be directly responsible for printing the map, close cooperation with the printer will be necessary in the checking of proofs, making final adjustments in color selection and registration of the plates.

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8- A Demand for Mapmakers

All of the steps in making maps have benefitted immensely from computers, geographic information systems, and telecommunication technology, but automation has certainly not decreased the need for cartographers. Indeed, the demand has increased for trained professionals who can identify projects and processes that can be automated efficiently and who can implement suitable techniques. There is also strong demand for individuals who can intelligently edit the masses of data being collected by automated means.

With growing frequency, maps are being tailor-made to suit specific needs by taking advantage of the powerful analytical and design capabilities provided by a variety of geographic information systems. Image-based maps on which remotely sensed data are enhanced with information such as roads or political boundaries are one of the more dramatic cartographic products of geographic information system technology.

The dramatic reduction in the cost of digital technology means that even small companies and local government agencies can afford to maintain their own cartography and GIS capabilities. In fact, one suburban county in South Carolina has nine different organizations using these capabilities. GIS programs, once limited to high-powered computer workstations, are moving toward desktop systems. At the same time, desktop computers are becoming faster and more powerful. The result is that many more people can use geographic information systems programs and data.

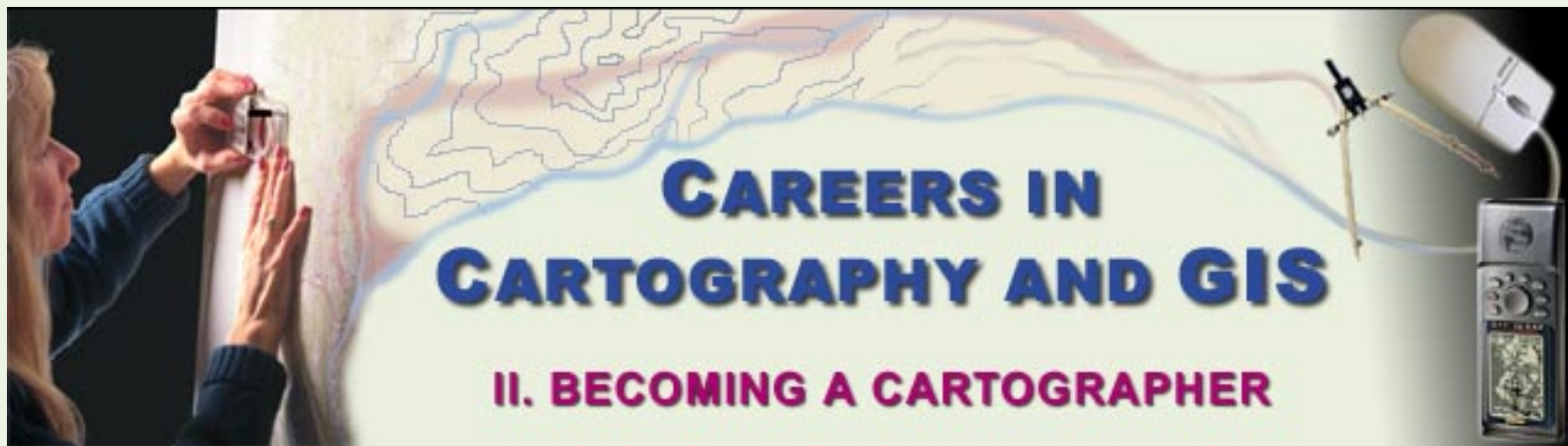
The employment outlook is outstanding for cartographic and GIS professionals. In many parts of the U.S. and Canada, there is a scarcity of qualified employees. Many two-year technical colleges are starting to offer programs in order to meet the demand. There is also a shortage of qualified instructors and educators. Some practicing professionals have found extra income by teaching GIS courses at their local community college.

On the next few pages, we list some specific facts regarding high school, college, and professional requirements to enter this exciting field. Good luck!

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1- High School

While in high school you should take:

Biology
Chemistry
Physics

English (4 units)
Fine Arts/Humanities
Foreign Languages(2-3 units)
Social Studies (3 units)

Algebra I &II
Calculus
Geometry
Trigonometry

Computer Applications or Programming

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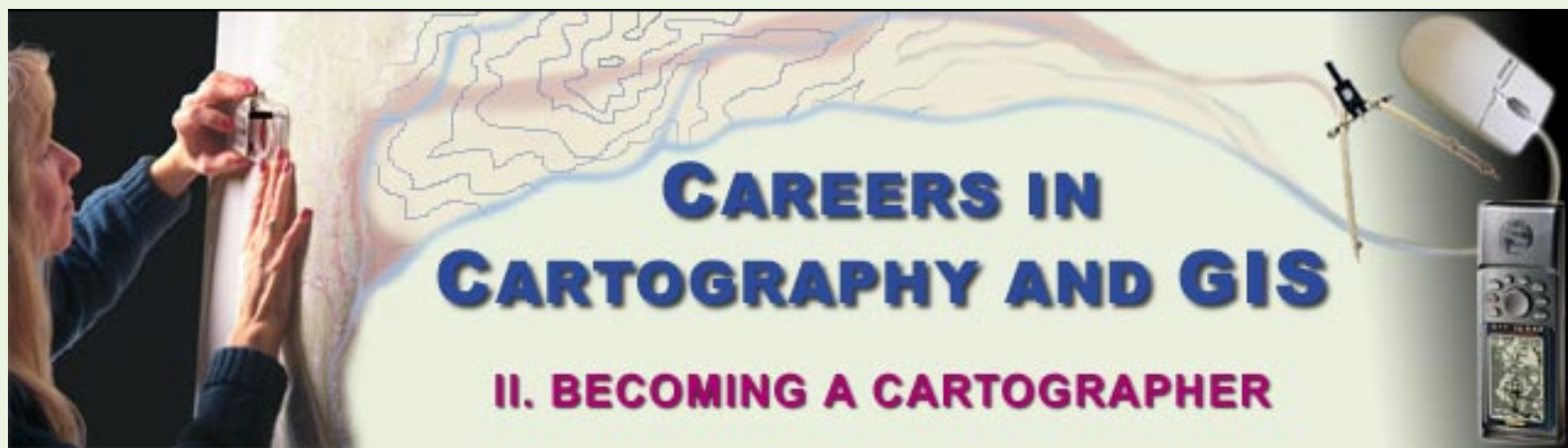
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2- Higher Education

More than 800 colleges and universities offer courses in geographic information systems. These are usually offered through the Geography Department. An increasing number of community colleges and technical colleges offer two-year associate degrees in mapping, surveying and GIS skills. These programs are designed to train students in such areas as data gathering, digitizing, or other forms of map preparation and editing.

Most jobs in cartography and GIS, however, require a bachelor's or master's degree in cartography, geography, or some area of civil or surveying engineering. Other disciplines such as forestry, geology, landscape architecture, environmental engineering, urban or environmental planning, transportation planning, and public administration now offer course work in GIS. With a bachelor's degree, one can expect to obtain an entry-level position working as part of a group that produces maps or performs GIS functions. With experience, employees can expect more responsibilities and will be able to manage projects. Individuals with master's degrees are often expected to assume considerable responsibility as soon as they are hired. They may be given their own projects to manage. In some smaller organizations, they find that they are expected to design and implement new procedures and systems.

Those who decide to earn a doctoral degree (Ph.D.) usually are seeking positions in a university or as research scientists. The rapid growth of GIS programs at the university level has resulted in a healthy market for graduates with doctorates. There also is a substantial demand for such individuals with consulting firms, software development firms, and scientific laboratories. In all these cases, students who pursue a Ph.D. are expected to make significant new contributions to the advancement of current technology, develop new ways to analyze information, or contribute to scientific research and discoveries.

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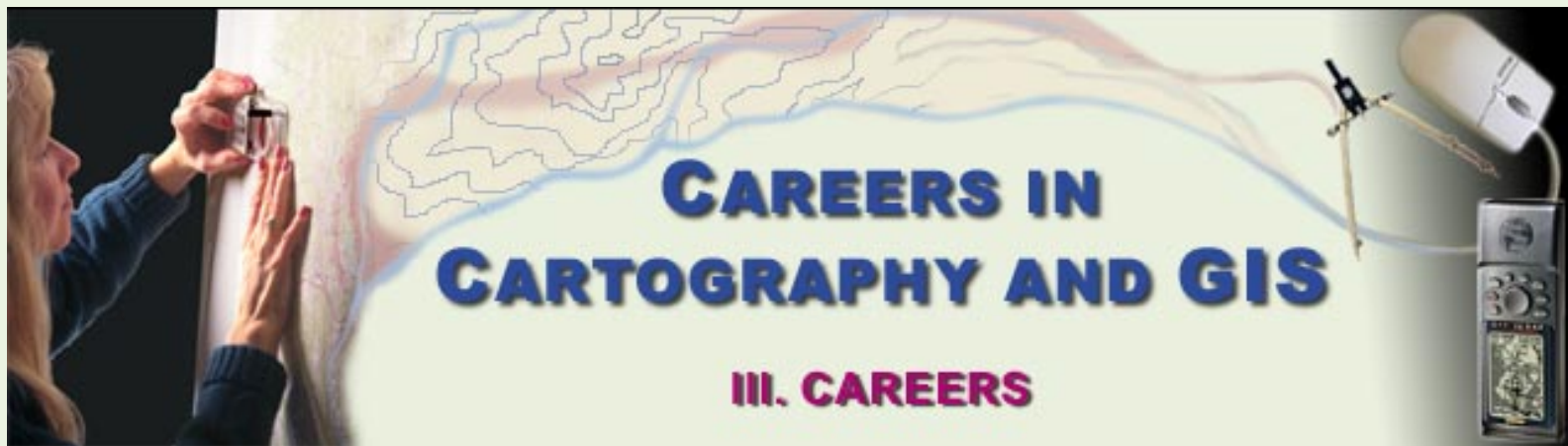
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1- Private Sector Jobs

Many of the present-day careers in cartography and GIS are found in the commercial sector. Because of the growing demand for software tools, individuals are needed who are well versed in geographical and cartographic concepts but also feel comfortable working with the hardware and software that drive the applications. These positions reflect the growing importance of GIS in all sectors of society and require a unique combination of education and skills.

Job Titles in the Private Sector

- GIS Coordinator/Assistant Director of Development
- Technical Support Analyst
- Database Analysts
- Consultant/Project Manager
- Project Manager
- Software Engineer
- Internet Product Software Engineer
- Applications Programmer
- GIS Software Product Specialist
- Industry Marketing Manager
- GIS Instructors
- Data Publisher

- Database and System Integrator
- Computer Mapping Technician
- GIS Database Administrator & GIS Systems Analyst
- GIS Manager/Information Services Planner
- GIS Manager/Senior Level
- GIS Specialist
- GIS Data Manager
- Senior GIS Analyst
- Senior Software Engineer
- GIS Sales Manager
- GIS Analyst II
- GIS Coordinator/Assistant Director of Development

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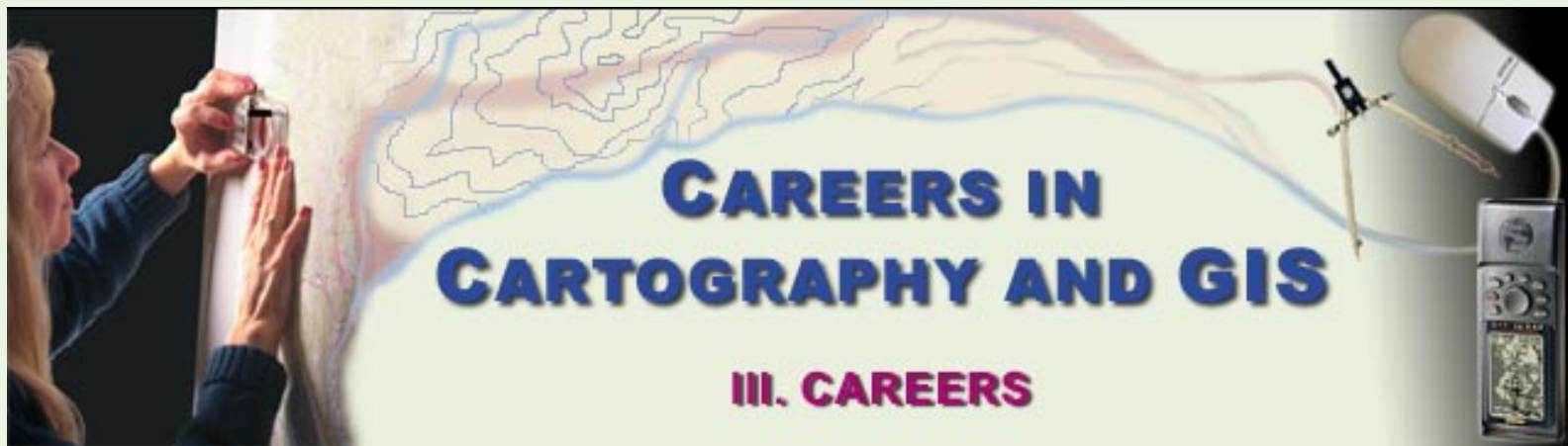
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3- State Government Jobs

The following examples are from the State of South Carolina.

Cartographer I

Performs specialized cartographic drafting work for mapping and topography. Salary: \$21,359 to \$39,516 per year.

Knowledge, Skills and Abilities:

- Knowledge of standard and specialized cartographic processes and techniques.
- Skill in the use of drawing instruments and drafting materials.
- Ability to read and interpret maps, plans and survey notes.
- Ability to execute complex cartographic projects.
- Ability to train other employees in proper cartographic drafting procedures.

Cartographer II

Performs advanced cartographic drafting duties or plans and coordinates mapping and topographic work. Salary: \$25,989 to \$48,083 per year.

Knowledge, Skills and Abilities:

- Knowledge of the principles and techniques of cartography.
- Knowledge of state and federal mapping procedures and regulations.
- Skill in the use of cartographic drafting equipment, instruments and materials.
- Ability to plan, schedule and supervise the work of others.
- Ability to train lower-level workers in cartographic drafting processes and techniques.

GIS Analyst

Uses a geographic information system (GIS) to generate graphic products and facilitate spatial analysis. Salary: \$25,989 to \$48,083 per year.

Knowledge, Skills and Abilities:

- Knowledge of spatial analysis techniques and cartography.
- Knowledge of graphic hardware and GIS software.
- Ability to operate GIS equipment.

Minimum Requirements:

A bachelor's degree in geography or a related field; or an associate degree in geography or a related field and experience in the use of GIS software.

GIS Manager II

Directs the staffing, development and implementation of a geographic information system (GIS). Salary: \$38,478 to \$71,187

Examples of Work:

- Supervises a GIS staff and manages GIS facilities and programs.
- Develops goals and implements long range plans, policies and procedures to guide GIS operations.
- Establishes and implements cooperative efforts with other governmental and public organizations to accomplish program objectives.
- Develops budgets and identifies sources of additional funding.
- Serves as the staff expert on GIS matters.

Knowledge, Skills and Abilities:

- Knowledge of GIS hardware and software standards, capabilities and applications.
- Knowledge of applicable state and federal regulatory programs.
- Knowledge of state administrative, legislative and budgetary procedures.
- Ability to plan and oversee the activities of others.
- Ability to develop and manage grant funding.
- Ability to communicate effectively.

Minimum Requirements:

A bachelor's degree in geography or a related field and experience in the management and application of a geographic information system.

Wage Variation by State

Salaries vary considerably from one location to another. Below is a table of salary midranges for Surveying and Mapping Technicians in various states, gleaned from the website America's CareerInfoNet (<http://www.acinet.org/acinet/>). The data is from 1998 surveys, so salaries are likely to be a little higher now.

Location	Midrange Annual Salary 1998
United States	\$20,500 - \$34,400
Alaska	\$33,400 - \$46,200
California	\$31,300 - \$52,700
Florida	\$17,800 - \$30,100
Hawaii	\$25,400 - \$36,200
Mississippi	\$16,500 - \$26,900
New York	\$21,900 - \$35,700
Texas	\$16,300 - \$29,700
Washington	\$27,800 - \$41,700

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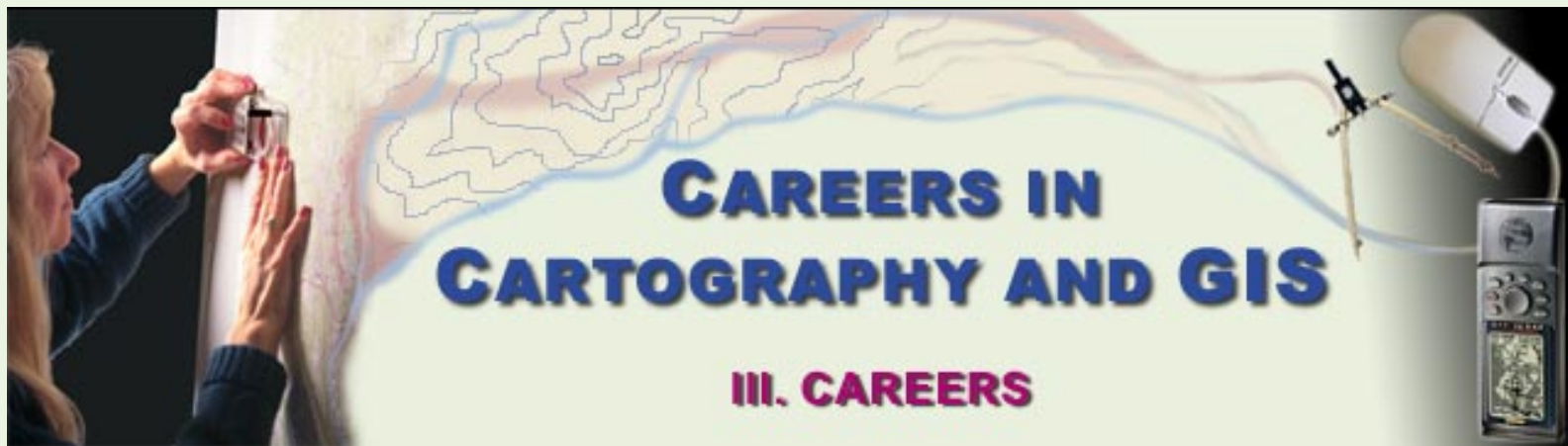
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Sidebar:

A Sampling of Organizations Using Cartography and GIS

You're not likely to find Cartography in the Yellow Pages. However, thousands of cartographers are employed by a variety of organizations. Here is a sample:

Public Sector

- City and county Geographic Information Systems divisions
- State departments of natural resources
- State, county, and city planning commissions
- City and county public works departments, engineering, water and sewer agencies, emergency 911 centers, tax assessment departments, planning and zoning departments, land records, public access, transportation modeling and planning, and law enforcement agencies
- Federal government within various agencies (see text about [federal jobs](#))

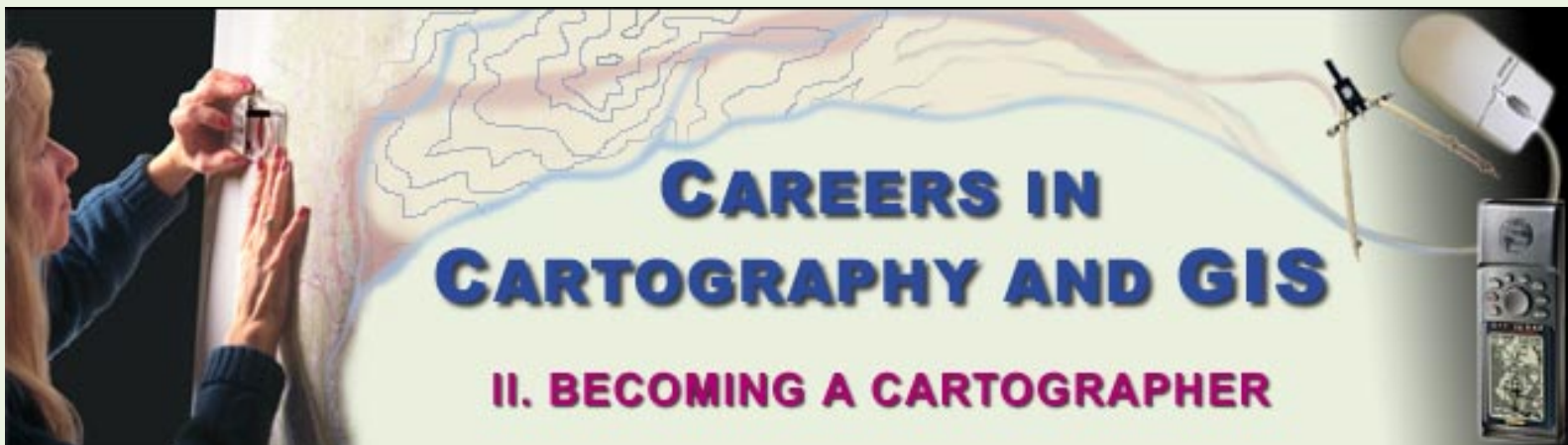
Private Sector

- Specialty mapping firms
- Newspaper and magazine publishers
- Televisions stations and networks
- Surveyors and land information companies
- Surveying equipment manufacturers
- Land development/housing market analysis firms
- Oil, electric and gas utilities
- Environmental consulting firms
- Health care firms
- Banks and insurance companies
- Transportation providers and consultants
- Real estate agents and brokers
- Retail organizations with multiple locations
- Telecommunications firms
- Software development companies
- Internet service providers
- Local and regional guidebook publishers

Non-Profit Organizations

- Environmental and civic organizations
- Schools and educational institutions
- Associations and journal publishers
- Professional societies and foundations
- International “think tanks”

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Sidebar:
**Academic Programs:
Some Colleges and Universities in the U.S. and Canada
with Cartography/GIS Programs**

Within each section, United States and Canada, the schools are organized alphabetically by state.

Many schools are members of the University Consortium for Geographic Information Science, indicated in the listings below as *U* and the NCGIA, listed as *N*. These organizations may be found on the Internet at:

- <http://www.ucgis.org>
- <http://www.ncgia.ucsb.edu>

United States

University of California, Santa Barbara (*U, N*), Department of Geography, Santa Barbara, CA 93106 <http://www.geog.ucsb.edu/>

San Diego State University (*U*), Department of Geography, 5500 Campanile Drive, San Diego, CA 92182 <http://typhoon.sdsu.edu/>

University of Colorado at Boulder, Department of Geography, 260 UCB, Boulder, CO 80309 <http://www.colorado.edu/geography/>

University of Idaho, Department of Geography, Moscow, ID 83843 <http://www.mines.uidaho.edu/geography/>

Northern Illinois University. Department of Geography, Dekalb, IL 60115 <http://globe.geog.niu.edu/>

University of Kansas, Department of Geography, Lawrence, KS 66045 <http://www.geog.ukans.edu/>

University of Maine, Dept. of Spatial Information Science and Engineering (*U, N*), Orono, ME 04469 <http://www.spatial.maine.edu/homens.htm>

University of Maryland, Department of Geography (*U*), College Park, MD 20742 <http://www.inform.umd.edu/geog/>

Salem State College, Department of Geography, Salem, Massachusetts 01970 <http://www.dgl.salemstate.edu/>

Michigan State University, Department of Geography (*U*), East Lansing, MI 28824 <http://www.geo.msu.edu/>

University of Minnesota, Department of Geography (*U*), Minneapolis, Minnesota 55455 <http://www.geog.umn.edu/>

University of Nebraska, Department of Geography (*U*), Lincoln, NE 68588 <http://www.unl.edu/unlgeog/home.htm>

State Univ of New York-Buffalo, Department of Geography (*U, N*), Amherst, NY 14260 <http://www.geog.buffalo.edu/>

Syracuse University, Department of Geography (*U*), Syracuse, NY 13210 <http://www.maxwell.syr.edu/geo/indexgeo.htm>

University of Akron, Department of Geography and Planning, Akron, OH 44325 <http://www.uakron.edu/geography/>

The Ohio State University, Department of Geography (*U*), Columbus, OH 43210 <http://thoth.sbs.ohio-state.edu/>

East Central University, Department of Cartography and Geography, Ada, OK 74820 <http://www.ecok.edu/dept/cartogeo/>

Oregon State University, Department of Geosciences (*U*), Corvallis, OR 97331-5506 <http://osu.orst.edu/Dept/geosciences/>

University of Oregon, Department of Geography, Eugene, OR 97402-1251 <http://geography.uoregon.edu/>

Pennsylvania State University, Department of Geography (*U*) University Park, PA 16820 <http://www.geog.psu.edu/>

University of South Carolina, Department of Geography (*U*), Columbia, SC 29280 <http://www.cla.sc.edu/geog/>

Southwest Texas State University, Department of Geography & Planning, 601 University Drive, San Marcos, TX 78666 <http://www.geo.swt.edu/index.html>

University of Washington, Department of Geography (*U*), Seattle, WA 98195 <http://depts.washington.edu/geog/>

University of Wisconsin, Department of Geography, (U) Madison, WI 53706 <http://feature.geography.wisc.edu/>

Canada

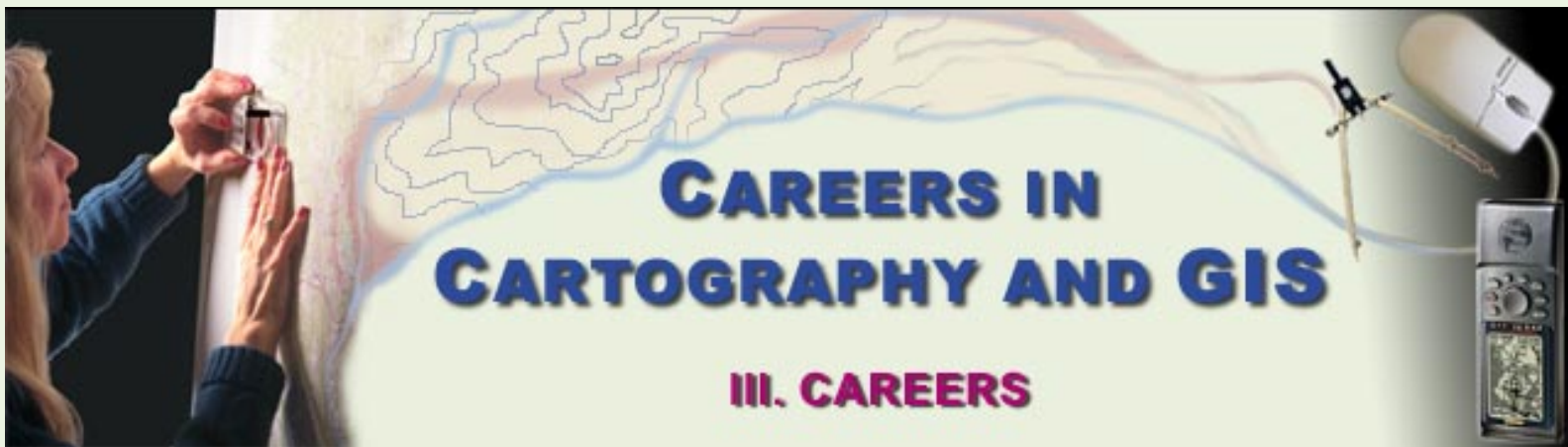
Sir Sandford Fleming College, Cartography and GIS programs, P.O. Box 8000 Lindsay, Ontario K9V 5E6 <http://www.flemingc.on.ca/programs/natres/>

University of British Columbia, Vancouver, British Columbia V6T 1Z2 <http://www.geog.ubc.ca/>

University of Waterloo, Waterloo, Ontario <http://www.fes.uwaterloo.ca/geography/>

Memorial University of Newfoundland, St. John's, Newfoundland <http://www.mun.ca/geog/>

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Sidebar:

Aerial Monitoring of Channel Islands national Marine Sanctuary

The National Oceanic and Atmospheric Administration (NOAA) keeps tabs on activity within the Channel Islands National Marine Sanctuary, a region six nautical miles out from five of the Santa Barbara Channel Islands. Once a week, plus some weekends, NOAA staff fly transects over the sanctuary, cruising at 1,000 feet, collecting data and mapping. In the event of an oil spill, they may map the channel every few hours.



The airplane, a Lake Renegade SeaWolf (a military version of a Lake amphibian aircraft), is equipped with GPS. The controls, to which Ben Waltenberger (NOAA Physical Scientist) is pointing in the photo, are in the cockpit dash. Connected to the GPS, a laptop computer has data collection and mapping software. As Ben inputs the data, maps are generated in



ArcView.

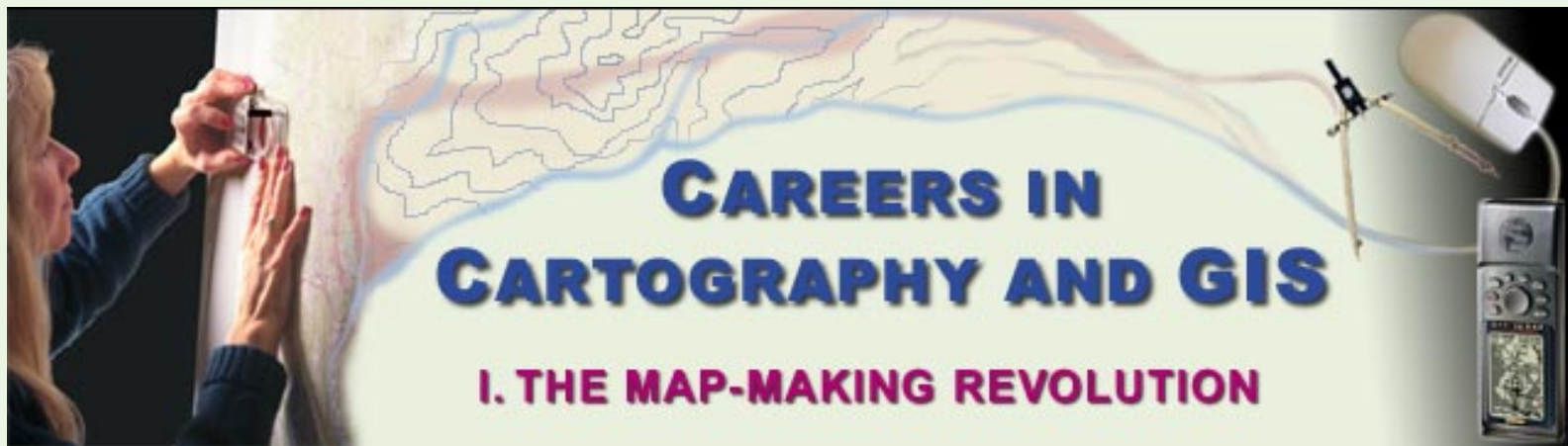


Data collection is detailed. Conditions such as weather, glare, water temperature and color are recorded. When there are sightings, specifics about the kind of marine mammal or vessel, and what exactly it is doing, are logged. Two of the laptop touch screens are pictured to the left: the first for recording environmental conditions, the second for specifying the type of whale sighted. Below is a generalized map of gray whale migration to the south, which was generated by the computer as sightings data was recorded.

We can better care for our oceans if we more accurately know what's going on. And, of course, it's good to catch the errant oil tanker that shouldn't be entering the channel, and essential to know when and where an oil slick will reach shore.



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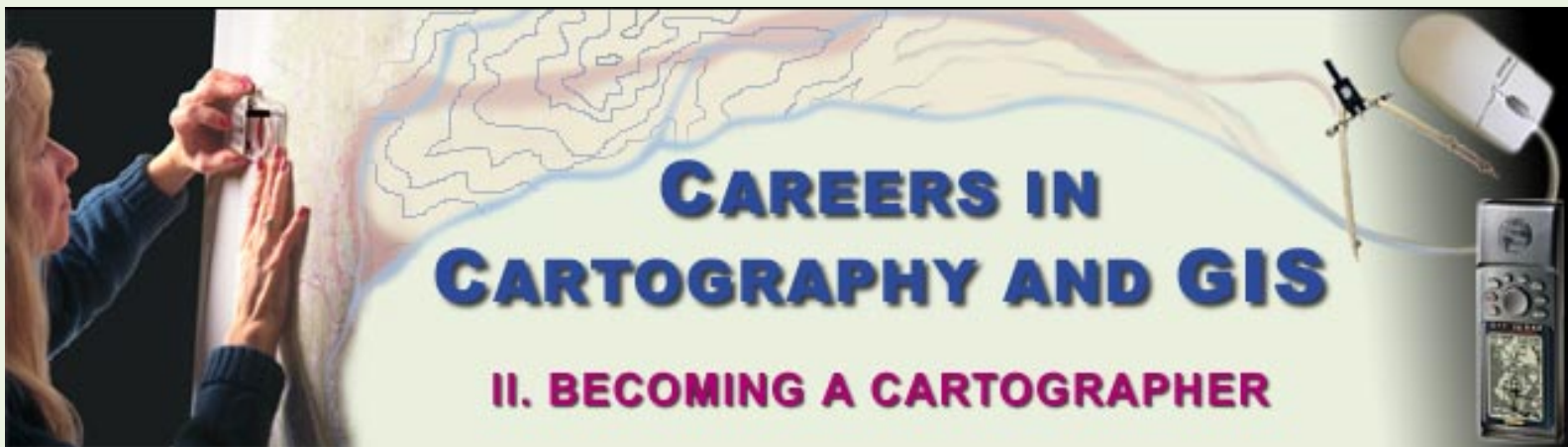
Sidebar:

Definitions of Cartography and Geographic Information Systems (GIS)

Cartography is concerned with all aspects of the mapping process. It has artistic, scientific and technical dimensions. It includes the gathering, storage, retrieval, evaluation, and visualization of geographic information. It also includes the abstraction or generalization of data to suit the mapping scale, purpose and audience.

Geographic information systems (GIS) are automated systems used to capture, edit, store, manipulate, analyze and display a variety of spatial data. A GIS has three major components: a data base, a spatial analysis and modeling capability, and a means for graphic display. See [Section 3](#) for more on the relationship between cartography and GIS.

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Sidebar:
Many Routes to Cartography

Maps.com is a private company that creates maps. Founded in 1991, the company's first national maps were based on CIA public domain files. Now, GeoCart data usually provides the base map. Cartographers then utilize FreeHand, Illustrator, and Photoshop to tailor the maps to clients' needs.



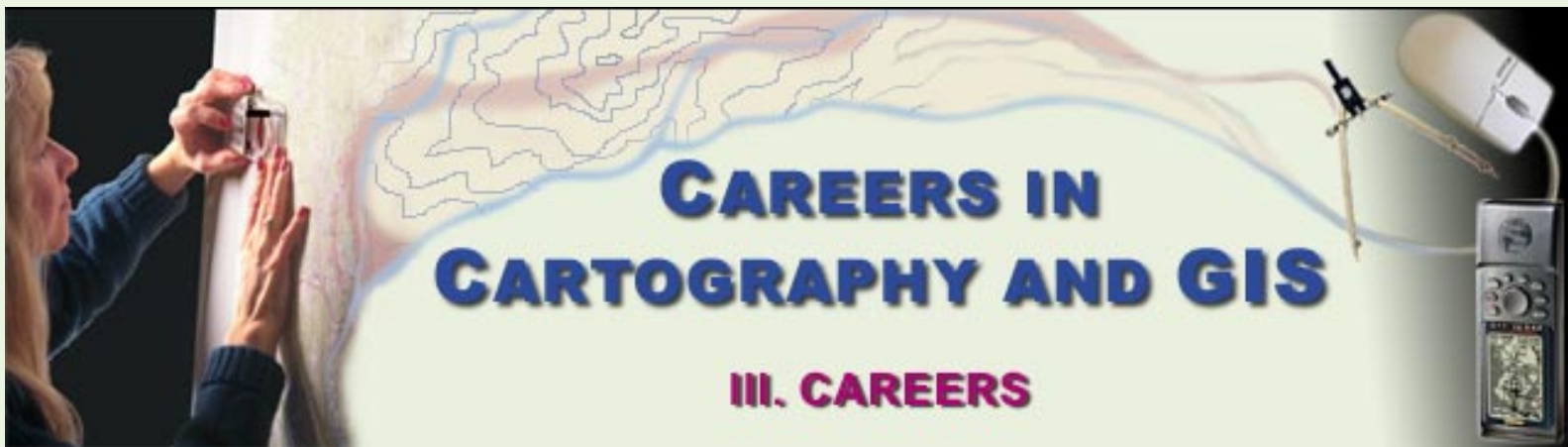
The kinds of maps are extremely varied. In the photos, Mike Powers (above left) is working on a bicycle map; Hiromi Tabei (above right), textbook maps; Martha Bostwick (below left), a Chamber of Commerce map for Minnetonka, Minnesota; and Brad Janke (below right), a cruise ship map. Sue Irwin, Manager of Mapping Services, says, even with the abundance of maps available, people continue to need different ones. They want them to emphasize different information or be in different colors or styles.



How employees come to Maps.com is also varied. Mike earned BAs in Geography and Art Studio at UC Santa Barbara, and he took an internship at Maps.com through the Art Department. The internship was the foot in the door. Hiromi earned a BS in Geography in Eugene, Oregon, then did an unpaid internship for the University of

Oregon, making an atlas. The professor for whom she did the atlas introduced her to the president of Maps.com. Martha attended the Center of Geographic Sciences, a cartography school in Nova Scotia, and sent an application. Brad earned a BA in Geography and a BS in Environmental Science at UC Santa Barbara, and applied. Sue was “all over the map” before hiring on. She waitressed for many years, traveled extensively, worked in a graphics shop, then did freelance book design, editing, and graphics. Robbie Wagner, Digital Content Assistant, was an EMT for nine years before starting at Maps.com. Strong in computer skills, he knew nothing about cartography. He says it was a personal connection that made the crucial difference. While education is an excellent strategy, there are many routes to cartography.

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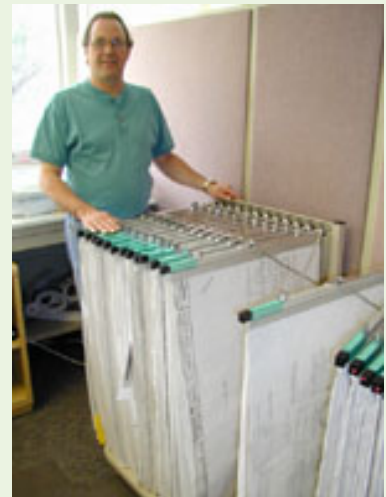


Sidebar:
Mapping and GIS in Private Industry

Founded in 1946, Penfield & Smith is an engineering and surveying firm in Santa Barbara, California. Mark Shadburn (right) is a GIS Manager, and Claudia Muzzio (left), a GIS Specialist.



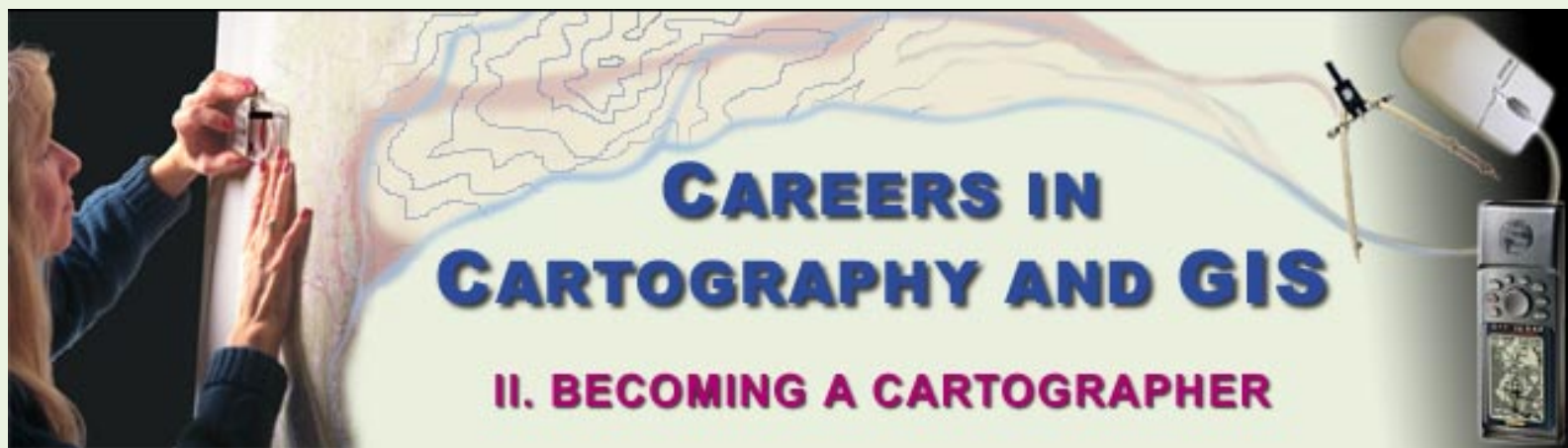
A recent project Mark and Claudia completed was digitizing information about the drainage conduits in the City of Santa Barbara. Information on racks and racks of paper maps was digitized. Printouts in hand, field crews took GPS equipment to every manhole, catch basin, creek – every surface entrance to the drainage – pinpointed its location and collected information, like the diameter of the pipe, direction and angle of flow. All this was entered into the computer.



The City's drainage is now mapped. It can overlay detailed air photos, as shown at right. Each point in the map is queryable. This is very useful in the City's quest to clean up creek and ocean pollution.



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Sidebar:
Introductory Publications

Berhardsen, Tor, *Geographic Information Systems: An Introduction*. John Wiley & Sons, Inc, 1999.

Burrough, P A and R A McDonnell, *Principles of Geographical Information Systems*. Oxford University Press, 1998.

Campbell, John, *Map Use and Analysis*. Wm C Brown, 1993.

Chrisman, Nicholas, *Exploring Geographic Information Systems*. John Wiley & Sons, 2001.

Clarke, Keith C, *Getting Started with Geographic Information Systems*. Prentice Hall, Inc, 2000.

Dent, B D, *Cartography: Thematic Map Design*. Wm C Brown, Dubuque, IA, 1999.

DeMers, Michael N, *Fundamentals of Geographic Information Systems*. John Wiley & Sons, Inc, 1999.

Heatley, Ralph, *GIS/GPS Resources*. Advanstar Communications, 1995.

Korte, George B, *The GIS Book*. Third Edition. OnWord Press, 2000.

Longley, Paul A; Michael Goodchild; David Maguire; David Wm Rhind; *Geographical Information Systems: Principles, Techniques, Applications and Management*. Second Edition. John Wiley & Sons, Inc, 1999.

Morgan, John III, Bobby Fleury; Richard Becker; *Directory of Academic GIS Education*. Kendall/Hunt, 1997.

Monmonier, Mark, *Maps with the News*. University of Chicago Press, 1999.

Robinson, Arthur; Randall D Sale; Joel L Morrison; Phillip C Muehrcke; *Elements of Cartography*. John Wiley & Sons, 1996.

Slocum, Terry A, *Thematic Cartography and Visualization*. Prentice Hall, Inc, 1998.

Worboys, Michael F, *GIS: A Computer Science Perspective*. Taylor & Francis, 1995.

These and many other titles on cartography and GIS are available from ACSM. To sample the catalog, visit <http://www.acsm.net>.

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