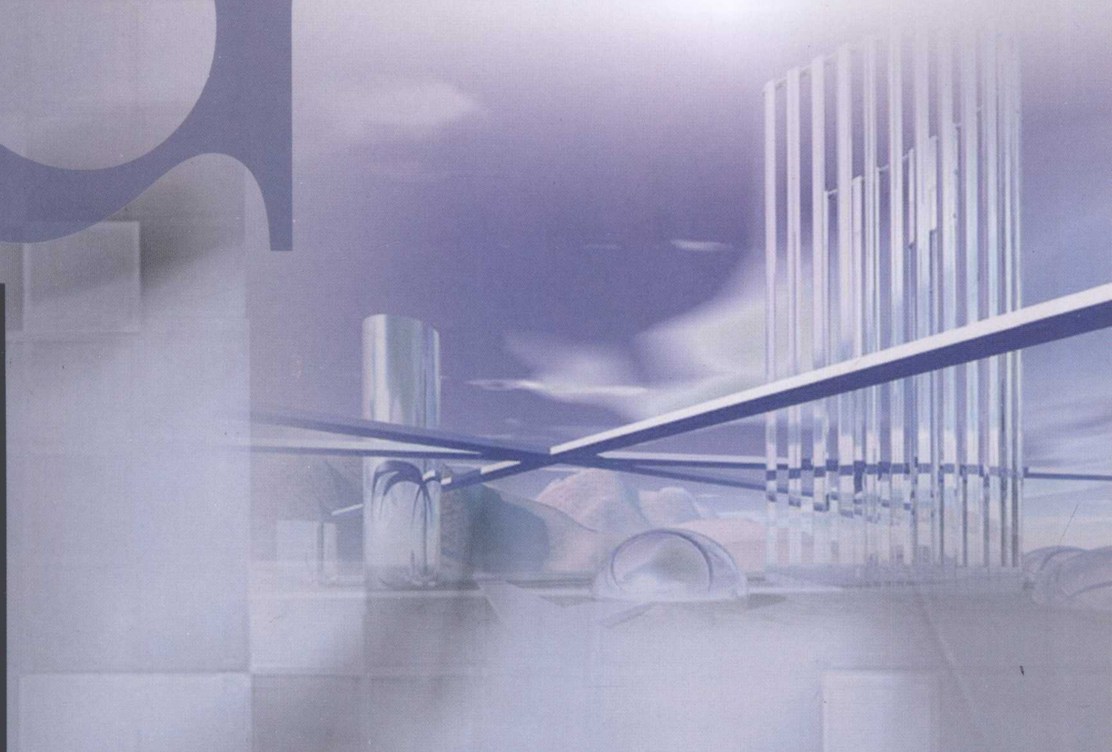
全国高等院校地理科学类精品规划教材

English for Geographical Information Science

地理信息科学专业英语

主编　卢　艳　　副主编　王金鑫　赫晓慧



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内 容 提 要

本书以培养学生地理信息科学专业英语文献阅读和翻译能力为主要目的，以地理信息系统、遥感、全球定位系统和3S集成理论与技术为主要内容，分为4个部分18章内容。第一部分为地理信息系统的基本原理、技术方法及应用，第二部分为遥感基本原理、技术方法及应用，第三部分为全球定位系统的基本原理、技术方法及应用，第四部分为3S集成理论、关键技术及应用。书中每章后均附有专业词汇和难点句子的翻译。

本书可以作为地理信息系统、遥感和全球定位系统等专业的本科生和研究生的教材，也可供相关专业的技术人员和教师参考使用。

图书在版编目(CIP)数据

地理信息科学专业英语 = English for Geographical Information Science/卢艳主编. —郑州：黄河水利出版社，2009.10

全国高等院校地理科学类精品规划教材

ISBN 978-7-80734-737-8

Ⅰ.地… Ⅱ.卢… Ⅲ.地理信息系统-英语-高等学校-教材 Ⅳ.H31

中国版本图书馆CIP数据核字(2009)第189872号

出 版 社：黄河水利出版社

地址：河南省郑州市顺河路黄委会综合楼14层　　邮政编码：450003

发行单位：黄河水利出版社

发行部电话：0371-66026940、66020550、66028024、66022620(传真)

E-mail：hhslcbs@126.com

承印单位：黄河水利委员会印刷厂

开本：787 mm×1 092 mm　1/16

印张：13.25

字数：368千字　　印数：1—2 000

版次：2009年10月第1版　　印次：2009年10月第1次印刷

定价：25.00元

前　言

地理信息系统（GIS）、遥感（RS）与全球定位系统（GPS）是地理空间技术的三大核心内容。近年来随着地理空间技术的发展，我国高等院校地理专业相继开设了地理信息、遥感与摄影测量等相关专业。为了使学生能够了解国外GIS、RS和GPS的发展历程及理论核心、培养学生的地理信息专业外语能力，同时随着我国高等教育教学改革深入发展的形势和地理信息双语教学课程对英文原版教材的需求，我们编写了本书，以利于学生掌握GIS、RS和GPS的理论和技术。

本书的内容主要包括四个部分：第一部分为地理信息系统，主要介绍了地理信息系统的基本原理、发展历程、地理空间参照、地理空间分析及应用等；第二部分为遥感，主要介绍了遥感的原理、主要的遥感平台、图像处理方法、图像解译与遥感应用等；第三部分为全球定位系统，主要介绍了全球定位系统的基本原理、发展历程、坐标系统和时间系统、信号误差、定位模式以及应用等内容；第四部分为3S集成，主要介绍了3S集成的基本概念、关键技术以及集成模式。

在编写过程中，我们参考并汲取了国内外有关权威教材、教程的部分内容，并力求突出地理空间技术的最新发展，既做到体现理论基础，又做到内容新颖丰富、原理介绍深入浅出，而且每部分都附有常用词汇的中英文对照与难点段落的中文翻译，十分适合作为高等学校地理信息及相关专业本科生和研究生专业外语的专用教材，也可作为双语学习的参考资料。

本书的编写分工为：第一部分由卢艳编写，第二部分由赫晓慧编写，第三、四部分由王金鑫编写，第四部分由卢艳修改。全书由卢艳统稿。

本书在编写过程中，得到郑州大学环境与水利学院杨玲霞院长的热心支持，郑州大学地理信息系张成才、郭同德、周振红等老师的真诚帮助。

由于时间仓促，加上编者专业和翻译水平有限，书中难免出现错漏之处，敬请不吝赐教。

编　者

2009年8月6日于郑州大学

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Part 3 Global Positioning System

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Part 1 Geographical Information Systems

Chapter 1 Overview of Geographical Information Systems

1.1 Introduction to Geographical Information Systems

Geographical information systems (GIS) as a new branch of geography science have been widely used for natural disaster investigations, resource surveying and management, urban development planning and global environmental change. For example, a GIS might allow emergency planners to quickly calculate emergency response times and display the potential vulnerable regions in digital map in the event of a natural disaster such as landslide or mud-rock flow, or a GIS might be used to find wetlands that need protection from pollution. Beyond its applications in the natural scientific fields, geographical information systems have also found its way into social sciences such as site selection in business, epidemic diseases prevention and control and so on.

1.1.1 What is GIS?

It is very difficult to give an absolute accurate definition of Geographical information systems since the new science comes to us as it represents the integration of many related subject areas like geography, computer science and so on. Practitioners can define a GIS including the procedures, operating personnel, and spatial data that go into the system.

A broadly accepted definition of GIS is the one provided by the National Centre of Geographical Information and Analysis (NCGIA):

GIS is a system of hardware, software and procedures to facilitate the management, manipulation, analysis, modeling, representation and display of geo-referenced data to solve complex problems regarding planning and management of resources (NCGIA).

Of course, a typical GIS can be well understood by the help of various definitions given below:

- GIS technology integrates common database operations such as query and statistical analysis with the unique visualization and geographical analysis benefits offered by maps. These abilities distinguish GIS from other information systems and make it valuable to a wide range of public and private enterprises for explaining events, predicting outcomes, and planning strategies (ESRI).

- A geographical information systems (GIS), in a narrow definition, is a computer system for the input, manipulation, storage and output of digital spatial data. In a more broad definition it is a digital system for the acquisition, management, analysis and visualization of spatial data for the purposes of planning, administering and monitoring the natural and socioeconomic environment. It represents a digital model of geography in its widest sense.

- A revised definition of GIS.

The organized activities by which people:

Measure aspects of geographical phenomena and processes.

Represent these measurements, usually in the form of a computer database, to emphasize spatial themes, entities, and relationships.

Operate upon these representations to produce more measurements and to discover new relationships by integrating disparate sources.

Transform these representations to conform to other frameworks of entities and relationships.

These activities reflect the larger context (institutions and cultures) in which these people carry out their work. In turn, the GIS may influence these structures.

An alternate short form. Geographical information systems: organized activities by which people measure and represent geographical phenomena then transform these representations into other forms while interacting with social structures.

- A Geographical information systems uses geographically referenced data as well as non-spatial data and includes operations which support spatial analysis:

  - In GIS, the common purpose is decision-making, for managing use of land, resources, transportation, retailing, oceans or any spatially distributed entities.

  - The connection between the elements of the system is geography, e. g., location, proximity, spatial distribution.

In this context, GIS can be seen as a system of hardware, software and procedures designed to support the capture, management, manipulation, analysis, modeling and display of spatially-referenced data for solving complex planning and management problems.

1.1.2 How does a GIS Work?

(1) Relating geographical information from different sources.

The attractive power of a GIS comes from the ability to relate different geographical information about different events exist or present on the earth's surface in a common spatial context and to reach a conclusion displayed in digital map conveying more detailed information. Most of the information we get about our every day life contains a location reference, placing that information at some point on the globe. For example, when sales volume per year in a supermarket is available, it is very critical to know where the supermarket is located. This is done by using a location reference system, such as Cartesian coordinate system or geographic coordinate system. Relating the sales volume to other information like other similar superstores, disposable income of households, or traffic conditions throughout the district, may tell us whether a new supermarket can be located in the same district. This information can guide us to take everything into full consideration on how site selection is interacted with surrounding factors. The information related together through GIS can lead us to a better decision-making.

GIS can combine different data sources from various related fields such as paper map or digital map, remote sensing imagery, and census or observations into a common geographic database to represent or analyze some event or phenomena on the earth (Figs. 1.1 ~ 1.7). A typical GIS has its own conversion system for importing existing digital information, which may not yet be in map form, into forms it can recognize and use. For example, digital satellite images can be analyzed to produce a map of digital information about land use and cover (Figs. 1.8 and 1.9). Likewise, census or population tabular data can be converted to a maplike form and serve as layers of thematic information in a GIS (Figs. 1.10 and 1.11).

Fig. 1.1 USGS DLG data of roads[1]

(2) Data capture.

Data used in GIS often come from many types, and are stored in different ways. A GIS provides tools and methods for the collection of different data into a format to be compared and analyzed. How can a GIS use the information in a map if the data to be used are not already

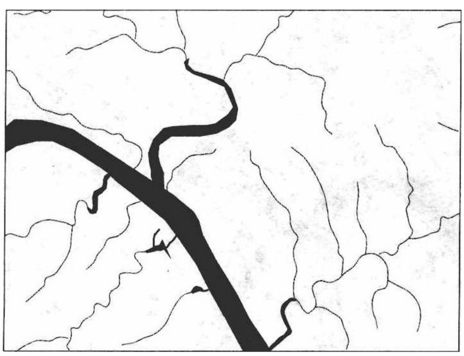

Fig. 1.2 USGS DLG data of rivers

Fig. 1.3 USGS DLG of contour lines (hypsography)

[1] USGS = US Geological Survey, DLG = Digital Line Graph.

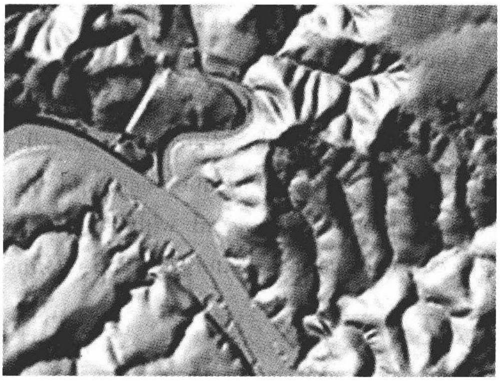

Fig. 1. 4　**USGS digital elevation models (DEM)**

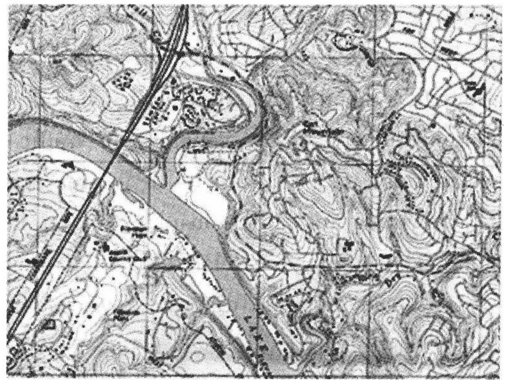

Fig. 1. 5　**USGS scanned, rectified topographic map called a digital raster graphic (DRG)**

Fig. 1. 6　**USGS digital orthophoto quadrangle (DOQ)**

Fig. 1. 7　**USGS geological map**

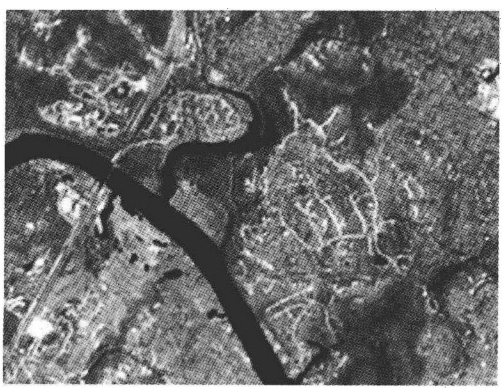

Fig. 1. 8　**Landsat 7 satellite image from which land cover information can be derived**

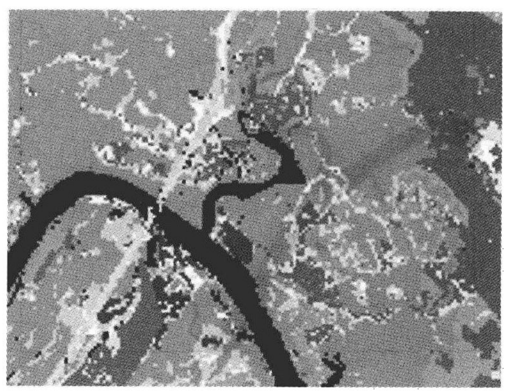

Fig. 1. 9　**Satellite image data in Fig. 1. 8 have been analyzed to indicate classes of land uses and cover**

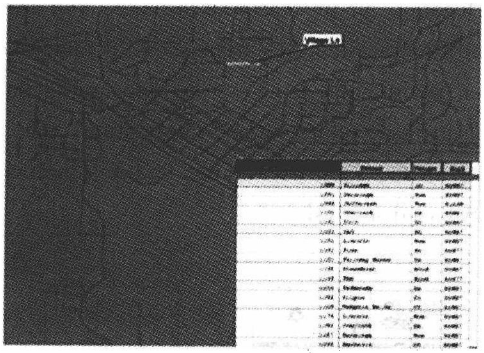

Fig. 1. 10 Part of a census data file containing address information

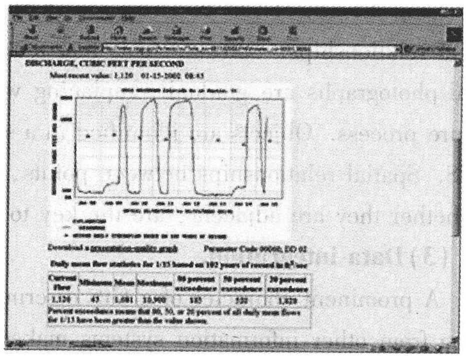

Fig. 1. 11 Part of a hydrologic data report indicating the discharge and amount of river flow recorded by a particular stream gage that has a known location

in digital form, that is, in a form the GIS software can recognize? Various techniques originating from GIS can obtain the information. Generally data are mainly obtained from manual digitization of paper map by hand-tracing with a computer mouse on the screen or on a digitizing tablet to collect coordinates of features (Fig. 1. 12), and coordinates from GPS receivers uploading into a GIS(Fig. 1. 13).

Fig. 1. 12 Scanning paper maps to produce digital data files for inputing into a GIS

Fig. 1. 13 Collecting latitude and longitude coordinates with a global positioning system (GPS) receiver

A GIS can be used to emphasize the spatial relationships among the objects being mapped. While a computer-aided mapping system may represent a road simply as a line, a GIS may also recognize that road as the boundary between wetland and urban development between two census statistical areas.

Data capture—importing the information into the system—involves the process of identifying the objects on the map, their absolute location on the earth's surface, and their spatial relationships. Software tools that automatically extract features from satellite images or aerial photographs are gradually replacing what has traditionally been a time-consuming data capture process. Objects are identified in a series of attribute tables—the "information" part of a GIS. Spatial relationships between points, lines or areas, such as whether features intersect or whether they are adjacent, are the key to all GIS-based analysis.

(3) Data integration.

A prominent character of a GIS discriminating from other information systems makes it possible to link, or integrate information that is difficult to associate through any other means. Thus, a GIS can use some combinations of remote sensing imagery, GPS data or socio-economic statistical data to build and analyze new information you want to work with (Fig. 1. 14).

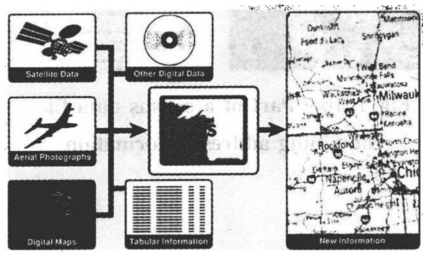

Fig. 1. 14 Data integration is the linking of information in different forms through a GIS

For example, Monitoring relationship between fast-growing urban areas and arable lands often requires information on various aspects of data covering the region, such as the socio-economic information, remotely sensed image, or data from GPS. This is done by a set of combined GIS procedures to integrate up-to-date information from remotely sensed data with demographic and socio-economic data in order to create a comprehensive spatial database for analyzing urban sprawling and its driving factors and modeling scenario in the coming years.

(4) Projection and registration.

A land use classification map at national level might be at a different scale than a city street map. Map information put into a GIS must be manipulated so that it registers, or fits, with information gathered from other maps. Before the digital data can be analyzed, they may have to undergo other manipulations—projection conversions, for example—that integrate them into a GIS.

Projection is a fundamental component of mapmaking. A projection is a mathematical means of transferring information from the earth's three-dimensional, curved surface to a two-dimensional medium—paper or a computer screen. Mathematically speaking, map projections are transformations of geographic coordinates (latitude, longitude) into the Cartesian (x, y) coordinate space of the map. All map projections can be represented by mathematical equations that convert geographic coordinates into map coordinates. Different projections are used for different types of maps because each projection is particularly appropriate for certain uses.

Since much of the information in a GIS comes from existing different maps, a GIS uses the processing power of the computer to transform digital information, gathered from sources with different projections, to a common projection (Figs. 1. 15 and 1. 16).

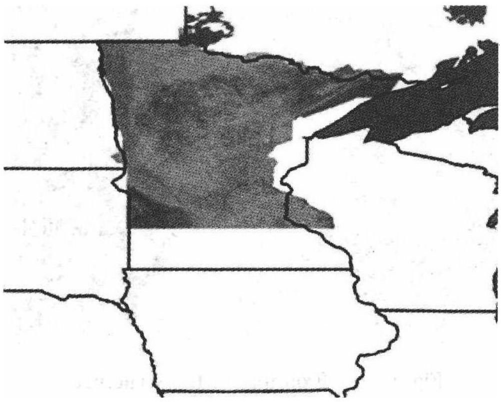

Fig. 1. 15 **An elevation image classified from a satellite image of Minnesota exists in a different scale and projection than the lines on the digital file of the State and province boundaries**

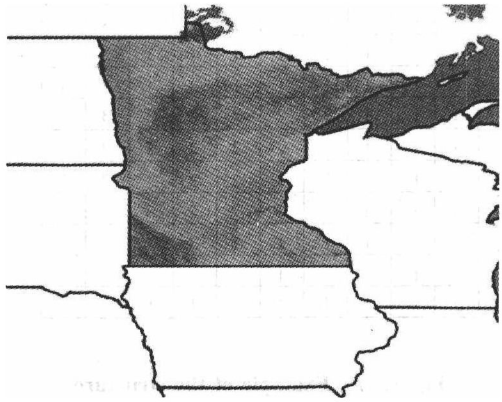

Fig. 1. 16 **The elevation image has been reprojected to match the projection and scale of the State and province boundaries**

(5) Data Structures.

Can a land use map covering one province be related to a satellite image? Yes, but because digital data are collected and stored in different ways, the two data sources may not be entirely compatible. Therefore, a GIS conversion system must be able to convert data from one structure to another.

Satellite image data that have been interpreted by a computer to produce a land use map can be "read into" the GIS in raster format. Raster data files consist of a large number of individual cells ordered in rows and columns. An example is land cover classification (Fig. 1. 17). Raster files can be manipulated quickly by the computer, but they are often less detailed and may be less visually appealing than vector data files, which can approximate the appearance of more traditional hand-drafted maps. Vector digital data have been captured as points, lines (a series of point coordinates), or areas (shapes bounded by lines) (Fig. 1. 18). An example of data typically held in a vector file would be the property boundaries for a particular housing subdivision.

Data restructuring can be performed by a GIS to convert data between different formats. For example, a GIS can be used to convert a satellite image map to a vector structure by generating lines around all cells with the same classification, while determining the spatial relationships of the cell, such as adjacency or inclusion (Fig. 1. 19 and 1. 20).

1	1	1	1	1	1	1	3	3	3
1	1	1	1	1	1	1	3	3	3
1	1	1	1	1	1	3	3	3	3
1	1	1	2	2	2	2	3	3	3
1	1	1	2	2	2	2	3	3	3
1	1	1	2	2	2	2	3	3	3
1	1	1	1	2	2	2	3	3	3
1	1	1	1	1	1	3	3	3	3
1	1	1	1	1	1	1	3	3	3
1	1	1	1	1	1	1	1	3	3

Fig. 1. 17 Example of the structure of a raster file

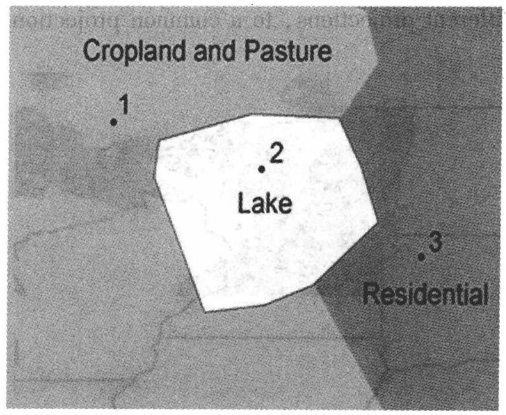

Fig. 1. 18 Example of the structure of a vector data file

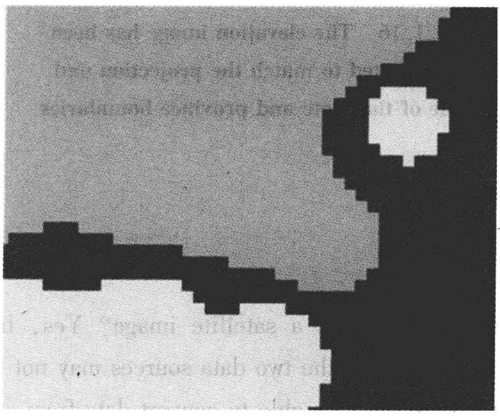

Fig. 1. 19 Magnified view of the same GIS data file, shown in raster format

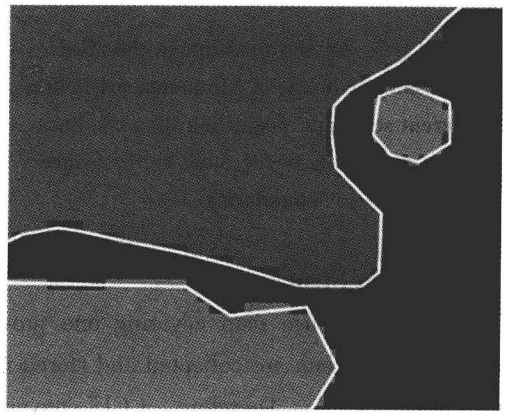

Fig. 1. 20 Magnified views of the same GIS data file converted into vector format

(6) Data modeling.

When we represent an event or phenomena present on the earth on the map, it is hardly possible to collect data over every square meter of the earth's surface. Therefore, samples must be taken at discrete locations and certain time intervals. A GIS can be used to depict two-dimensional and three-dimensional characteristics of the earth's surface, subsurface, and atmosphere from points where samples have been collected.

For example, a GIS can quickly generate a map with isolines that indicate the pH of soil from test points (Figs. 1. 21 and 1. 22). Such a map can be thought of as a soil pH contour map. Many sophisticated methods can estimate the characteristics of surfaces from a limited number of point measurements. Two-dimensional and three-dimensional contour maps created from the surface modeling of sample points from pH measurements can be analyzed together with any other map in a GIS covering the area.

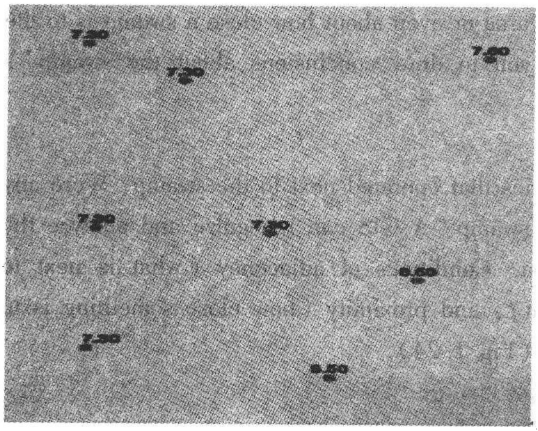

Fig. 1.21 Points with pH values of oil

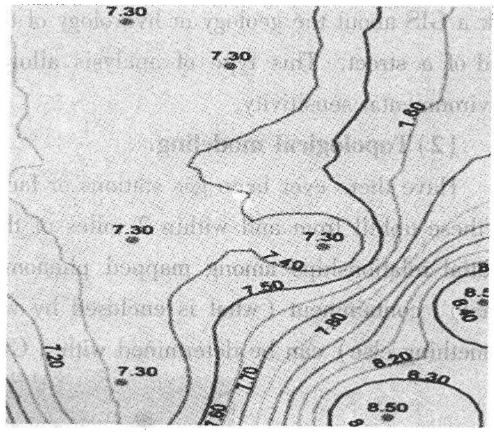

Fig. 1.22 Contour map made from soil pH values shown in Fig. 1.21

1.1.3 What is Special about a GIS?

Geographic information imported into GIS software which is organized or stored in layers makes it possible to carry out complex analyses.

(1) Information retrieval.

What do you know about the swampy area at the end of your street? With a GIS you can "point" at a location, object, or area on the screen and retrieve recorded information about it from offscreen files (Fig. 1.23). Using scanned aerial photographs as a visual guide, you can

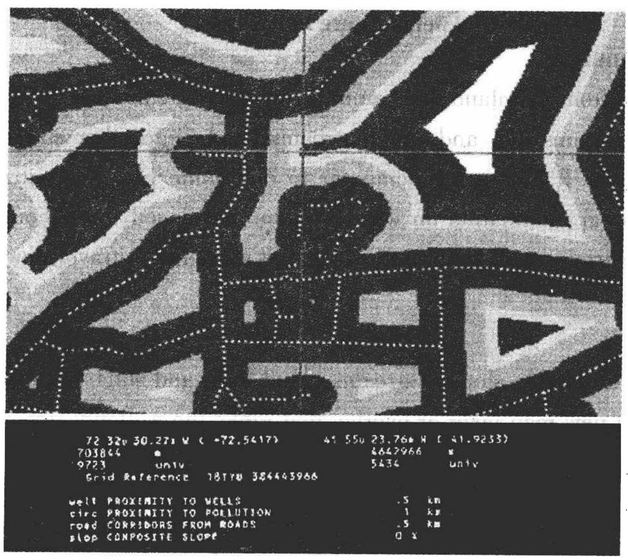

Fig. 1.23 A crosshair pointer (top) can be used to point at a location stored in a GIS The bottom illustration depicts a computer screen containing the kind of information stored about the location—for example, the latitude, longitude, projection, coordinates, closeness to wells, sources of production, roads, and slopes of land