Environmental Scientists and Geoscientists

(0*NET 19-2041.00, 19-2042.01, 19-2043.00)

Significant Points

- Work at remote field sites is common.
- Federal, State, and local governments employ nearly one-half of all environmental scientists and geoscientists.
- A bachelor's degree is adequate for a few entry-level jobs, but a master's degree is usually the minimum educational requirement; a Ph.D. degree is required for most high-level research positions.
- Employment of geoscientists is expected to grow as fast as average, while environmental scientists and hydrologists will experience faster than average growth.

Nature of the Work

Environmental scientists and geoscientists use their knowledge of the physical makeup and history of the Earth to protect the environment; locate water, mineral, and energy resources; predict future geologic hazards; and offer advice on construction and land-use projects.

Environmental scientists conduct research to identify and abate or eliminate sources of pollutants that affect people, wildlife, and their environments. These workers analyze and report measurements and observations of air, water, soil, and other sources and make recommendations on how best to clean and preserve the environment. Understanding the issues involved in protecting the environment—degradation, conservation, recycling, and replenishment—is central to the work of environmental scientists, who often use their skills and knowledge to design and monitor waste disposal sites, preserve water supplies, and reclaim contaminated land and water to comply with Federal environmental regulations.

Many environmental scientists do work and have training that is similar to other physical or life scientists, but is applied to environmental areas. Many specialize in some specific area, such as environmental ecology and conservation, environmental chemistry, environmental biology, or fisheries science. Most environmental scientists are further classified by the specific activity they perform (although recent advances in the understanding of basic life processes within the ecosystem have blurred some traditional classifications). For example, *environmental ecologists* study the relationships between organisms and their environments and the effects of influences such as population size, pollutants, rainfall, temperature, and altitude. Utilizing their knowledge of various scientific disciplines, they may collect, study, and report data on air, food, soil, and water. *Ecological modelers* study ecosystems, the control of environmental pollution, and the management of resources. These environmental scientists may use mathematical modeling, systems analysis, thermodynamics, and computer techniques. *Environmental chemists* may study the toxicity of various chemicals—how those chemicals affect plants, animals, and people. *Geochemists* study the nature and distribution of chemical elements in ground water and Earth materials.

Some environmental scientists work in managerial positions, usually after spending some time performing research or learning about environmental laws and regulations. Many work as consultants to business firms or to government agencies, helping them comply with environmental policy, particularly with regard to ground-water contamination and flood control. Environmental scientists who determine policy may help identify how human behavior can be modified in the future to avoid such problems as ground-water contamination and depletion of the ozone layer.

Geoscientists study the composition, structure, and other physical aspects of the Earth. With the use of sophisticated instruments and by analyzing the composition of the earth and water, geoscientists study the Earth's geologic past and present. Many geoscientists are involved in searching for oil and gas, while others work closely with environmental scientists in preserving and cleaning up the environment.

Geoscientists usually study, and are subsequently classified into, one of several closely related fields of geoscience. *Geologists* study the composition, processes, and history of the Earth. They try to find out how rocks were formed and what has happened to them since their formation. They also study the evolution of life by analyzing plant and animal fossils. *Geophysicists* use the principles of physics, mathematics, and chemistry to

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study not only the Earth's surface, but also its internal composition; ground and surface waters; atmosphere; oceans; and magnetic, electrical, and gravitational forces.

Oceanographers use their knowledge of geology and geophysics, in addition to biology and chemistry, to study the world's oceans and coastal waters. They study the motion and circulation of the ocean waters; the physical and chemical properties of the oceans; and how these properties affect coastal areas, climate, and weather. Oceanographers are further broken down according to their areas of expertise. For example, *physical oceanographers* study the ocean tides, waves, currents, temperatures, density, and salinity. They examine the interaction of various forms of energy, such as light, radar, sound, heat, and wind, with the sea, in addition to investigating the relationship between the sea, weather, and climate. *Chemical oceanographers* study the distribution of chemical compounds and chemical interactions that occur in the ocean and on the sea floor. They may investigate how pollution affects the chemistry of the ocean. *Geological and geophysical oceanographers* study the topographic features and the physical makeup of the ocean floor. Their knowledge can help companies find oil and gas off coastal waters. (*Biological oceanographers*, often called marine biologists, study the distribution and migration patterns of the many diverse forms of sea life in the ocean, but because they are considered biological scientists, they are not covered in this statement on environmental scientists and geoscientists. See instead the statement on biological scientists elsewhere in the *Handbook*.)

Geoscientists can spend a large part of their time in the field, identifying and examining rocks, studying information collected by remote sensing instruments in satellites, conducting geological surveys, constructing field maps, and using instruments to measure the Earth's gravity and magnetic field. For example, they often perform seismic studies, which involve bouncing energy waves off buried rock layers, to search for oil and gas or to understand the structure of subsurface rock layers. Seismic signals generated by an earthquake are used to determine the earthquake's location and intensity. In laboratories, geologists and geophysicists examine the chemical and physical properties of specimens. They study fossil remains of animal and plant life or experiment with the flow of water and oil through rocks.

Numerous specialties that further differentiate the type of work geoscientists do fall under the two major disciplines of geology and geophysics. For example, *petroleum geologists* explore for oil and gas deposits by studying and mapping the subsurface of the ocean or land. They use sophisticated geophysical instrumentation and computers to interpret geological information. *Engineering geologists* apply geologic principles to the fields of civil and environmental engineering, offering advice on major construction projects and assisting in environmental remediation and natural hazard reduction projects. *Mineralogists* analyze and classify minerals and precious stones according to their composition and structure. They study the environment surrounding rocks in order to find new mineral resources. *Paleontologists* study fossils found in geological formations to trace the evolution of plant and animal life and the geologic history of the Earth. *Stratigraphers* examine the formation and layering of rocks to understand the environment in which they were formed. *Volcanologists* investigate volcanoes and volcanic phenomena to try to predict the potential for future eruptions and possible hazards to human health and welfare. *Hydrologists* study the quantity, distribution, circulation, and physical properties of underground and surface waters. They examine the form and intensity of precipitation, its rate of infiltration into the soil, its movement through the earth, and its return to the ocean and atmosphere. The work hydrologists do is particularly important in environmental preservation, remediation, and flood control.

Geophysicists specialize in areas such as geodesy, seismology, or magnetic geophysics. *Geodesists* study the Earth's size, shape, gravitational field, tides, polar motion, and rotation. *Seismologists* interpret data from seismographs and other geophysical instruments to detect earthquakes and locate earthquake-related faults. *Geomagnetists* measure the Earth's magnetic field and use measurements taken over the past few centuries to devise theoretical models that explain the Earth's origin. *Paleomagnetists* interpret fossil magnetization in rocks and sediments from the continents and oceans to record the spreading of the sea floor, the wandering of the continents, and the many reversals of polarity that the Earth's magnetic field has undergone through time. Other geophysicists study atmospheric sciences and space physics. (See the statements on atmospheric scientists, and physicists and astronomers, elsewhere in the *Handbook*.)

Working Conditions

Some environmental scientists and geoscientists spend the majority of their time in an office, but many others divide their time between fieldwork and office or laboratory work. Many environmental scientists, such as environmental ecologists, environmental chemists, and hydrologists, often take field trips that involve physical activity. Environmental scientists in the field may work in warm or cold climates, in all kinds of weather. In their research, they may dig or chip with a hammer, scoop with a net, and carry equipment in a backpack. Oceanographers may spend considerable time at sea on academic research ships. Fieldwork often requires working long hours. Geologists frequently travel to remote field sites by helicopter or four-wheel-drive vehicles and cover large areas on foot. An increasing number of exploration geologists and geophysicists work in foreign countries, sometimes in remote areas and under difficult conditions. Travel often is required to meet with prospective clients or investors.

Environmental scientists and geoscientists in research positions with the Federal Government or in colleges and universities frequently are required to design programs and write grant proposals in order to continue their data collection and research. Environmental scientists and geoscientists in consulting jobs face similar pressures to market their skills and write proposals so that they will have steady work.

Employment

Environmental scientists and geoscientists held about 101,000 jobs in 2002. Environmental scientists accounted for 65,000 of the total; geoscientists, 28,000; and hydrologists, 8,000. Many more individuals held environmental science and geoscience faculty positions in colleges and universities, but they are classified as college and university faculty. (See the statement on teachers-postsecondary elsewhere in the *Handbook*.)

About 47 percent of environmental scientists were employed in State and local governments, 14 percent in architectural, engineering and related services, 13 percent in management, scientific, and technical consulting services, and 9 percent in the Federal Government. About 1,900 were self-employed.

Among geoscientists, 30 percent were employed in architectural, engineering, and related services, and 15 percent worked for oil and gas extraction companies. In 2002, the Federal Government employed about 3,000 geoscientists, including geologists, geophysicists, and oceanographers, mostly within the U.S. Department of the Interior for the U.S. Geological Survey (USGS) and within the U.S. Department of Defense. Another 3,400 worked for State agencies, such as State geological surveys and State departments of conservation. Nearly 3 percent of geoscientists were self-employed, most as consultants to industry or government.

Approximately 32 percent of hydrologists worked in the Federal Government in 2002, another 21 percent in architectural, engineering, and related services, 17 percent worked in management, scientific, and technical consulting services, and 16 percent for State governments.

Training, Other Qualifications, and Advancement

A bachelor's degree is adequate for a few entry-level positions, but environmental scientists and geoscientists increasingly need a master's degree in a natural science. A master's degree also is the minimum educational requirement for most entry-level research positions in private industry, Federal agencies, and State geological surveys. A doctoral degree is necessary for most high-level research positions.

Many environmental scientists earn degrees in life science, chemistry, geology, geophysics, atmospheric science, or physics and then, either through further education or through their research interests and work experience, apply their education to environmental areas. Others earn a degree in environmental science. A bachelor's degree in environmental science offers an interdisciplinary approach to the natural sciences, with an emphasis on biology, chemistry, and geology. In addition, undergraduate environmental science majors should focus on data analysis and physical geography, particularly if they are interested in studying pollution abatement, water resources, or ecosystem protection, restoration, or management. Those students interested in working in the environmental or regulatory fields, either in environmental consulting firms or for Federal or State governments, should take courses in hydrology, hazardous waste management, environmental legislation, chemistry, fluid mechanics, and geologic logging. An understanding of environmental regulations and government permit issues also is valuable for those planning to work in mining and oil and gas extraction. Hydrologists and environmental scientists should have some knowledge of the potential liabilities associated with some environmental work. Students interested in the field of hydrology should take courses in the physical sciences, geophysics, chemistry, engineering science, soils, mathematics, aquatic biology, atmospheric science, meteorology, geology, oceanography, or the management or conservation of water resources. In some cases, graduates with a bachelor's degree in a hydrologic science are qualified for positions in environmental consulting and planning regarding water quality or waste-water treatment. Curricula for advanced degrees often emphasize the natural sciences, but not all universities offer all curricula.

Traditional geoscience courses emphasizing classical geologic methods and topics (such as mineralogy, petrology, paleontology, stratigraphy, and structural geology) are important for all geoscientists. Persons studying physics, chemistry, biology, mathematics, engineering, or computer science may also qualify for some geoscience positions if their course work includes study in geology or natural sciences.

Computer skills are essential for prospective environmental scientists and geoscientists; students who have some experience with computer modeling, data analysis and integration, digital mapping, remote sensing, and geographic information systems will be the most prepared entering the job market. A knowledge of the Global Information System (GIS) and Global Positioning System (GPS)—a locator system that uses satellites—also is very helpful. Some employers seek applicants with field experience, so a summer internship may be beneficial to prospective geoscientists.

Environmental scientists and geoscientists must have excellent interpersonal skills, because they usually work as part of a team with other scientists, engineers, and technicians. Strong oral and written communication skills also are important, because writing technical reports and research proposals, as well as communicating research results to others, are important aspects of the work. Because many jobs require foreign travel, knowledge of a second language is becoming an important attribute to employers. Geoscientists must be inquisitive, be able to think logically, and have an open mind. Those involved in fieldwork must have physical stamina.

Environmental scientists and geoscientists often begin their careers in field exploration or as research assistants or technicians in laboratories or offices. They are given more difficult assignments as they gain experience. Eventually, they may be promoted to project leader, program manager, or some other management and research position.

Job Outlook

Overall employment of environmental scientists and geoscientists is expected to grow about as fast as the average for all occupations through 2012. Driving job growth will be public policy, which will force companies and organizations to comply with environmental laws and regulations, particularly those regarding ground-water contamination, clean air, and flood control.

Projected employment growth varies by occupational specialty. Environmental scientists and hydrologists are expected to grow faster than average. A general heightened awareness regarding the need to monitor the quality of the environment, to interpret the impact of human actions on terrestrial and aquatic ecosystems, and to develop strategies for ecosystem restoration are all increasingly important issues that will drive demand for environmental scientists. Issues related to water conservation, deteriorating coastal environments, and rising sea levels also will stimulate employment growth of these workers. As the population increases and moves to more environmentally sensitive locations, environmental scientists and hydrologists will be needed to assess building sites for potential geologic hazards, to mitigate the effects of natural hazards such as floods, tornadoes, and earthquakes, and to address issues related to pollution control and waste disposal. Hydrologists and environmental scientists also will be needed to conduct research on hazardous-waste sites in order to determine the impact of hazardous pollutants on soil and ground water so that engineers can design remediation systems. Demand is growing for environmental scientists who understand both the science and engineering aspects of waste remediation.

In contrast to employment of environmental scientists and hydrologists, that of geoscientists is expected to grow about as fast as the average for all occupations. In the past, employment of geologists and some other geoscientists has been cyclical and largely affected by the price of oil and gas. When prices were low, oil and gas producers curtailed exploration activities and laid off geologists. When prices were higher, companies had the funds and incentive to renew exploration efforts and hire geoscientists in large numbers. In recent years, a growing worldwide demand for oil and gas and for new exploration and recovery techniques—particularly in deep water and previously inaccessible sites—has returned a modicum of stability to the petroleum industry. Growth in this area, though, will be limited due to increasing efficiencies in finding oil and gas. Geoscientists who speak a foreign language and who are willing to work abroad should enjoy the best opportunities. An expected increase in highway building and other infrastructure projects will be a source of jobs for engineering geologists. The need to replace geoscientists who retire also will result in job openings over the next decade.

Earnings

Median annual earnings of environmental scientists were $47,600 in 2002. The middle 50 percent earned between $36,820 and $62,400. The lowest 10 percent earned less than $29,920, and the highest 10 percent earned more than $78,200.

Median annual earnings of geoscientists were $67,470 in 2002. The middle 50 percent earned between $48,370 and $102,120; the lowest 10 percent, less than $36,580 and the highest 10 percent more than $133,310.

Median annual earnings of hydrologists were $56,530 in 2002, with the middle 50 percent earning between $44,080 and $70,160, the lowest 10 percent less than $36,790, and the highest 10 percent more than $86,620.

Median annual earnings in the industries employing the largest number of environmental scientists in 2002 were as follows:

Federal Government	$66,190
Management, scientific, and technical consulting services	45,560
Local government	45,270
Architectural, engineering, and related services	44,590
State government	44,580

According to the National Association of Colleges and Employers, beginning salary offers in 2003 for graduates with bachelor's degrees in geology and related sciences averaged about $32,828 a year; graduates with a master's degree averaged $47,981, and graduates with a doctoral degree averaged $61,050.

In 2003, the Federal Government's average salary for geologists in managerial, supervisory, and nonsupervisory positions was $76,389 for geologists, $86,809 for geophysicists, $70,525 for hydrologists, and $79,023 for oceanographers.

The petroleum, mineral, and mining industries are vulnerable to recessions and to changes in oil and gas prices, among other factors, and usually release workers when exploration and drilling slow down. Consequently, they offer higher salaries, but less job security, than do other industries.

Related Occupations

Many geoscientists work in the petroleum and natural gas industry, an industry that also employs many other workers in the scientific and technical aspects of petroleum and natural gas exploration and extraction. Among these other workers are engineering technicians, science technicians, petroleum engineers, surveyors, cartographers, photogrammetrists, and surveying technicians. Also, some physicists, chemists, and atmospheric scientists—as well as mathematicians, computer systems analysts, database administrators, and computer scientists—perform related work both in petroleum and natural gas exploration and extraction and in environment-related activities.

Sources of Additional Information

Information on training and career opportunities for geologists is available from either of the following organizations:

➤American Geological Institute, 4220 King St., Alexandria, VA 22302-1502. Internet: **http://www.agiweb.org**

➤American Association of Petroleum Geologists, P.O. Box 979, Tulsa, OK 74101. Internet: **http://www.aapg.org**

A packet of free career information and a list of education and training programs in oceanography and related fields, priced at $6.00, is available from

➤Marine Technology Society, 5565 Sterrett Place, Suite 108, Columbia, MD 21004. Telephone: (410) 884-5330. Internet: **http://www.mtsociety.org**

Information on applying for a job as a geologist, a geophysicist, a hydrologist, or an oceanographer with the Federal Government may be obtained through a telephone-based system from the Office of Personnel Management. Consult your telephone directory under "U.S. Government" for a local number, or call (703) 724-1850 or Federal Relay Service (800) 877-8339. This number is not toll free, and charges may accrue. Information also is available from the Internet site **http://www.usajobs.opm.gov**.