

The U.S. Geological Survey Recent Highlights—Environmental Effects on Human and Wildlife Health

Introduction

Natural resource scientists have not traditionally played a substantial role in addressing human health issues. An increasing proportion of the Federal budget, however, is dedicated to health issues, and many chronic health issues may relate directly to Earth processes and the environment. As the Nation's natural resource science agency, the U.S. Geological Survey (USGS) can play a significant role in understanding environmental contributions to diseases and human health. Strong partnerships with traditional health and environmental agencies will be necessary to collaborate on problem solving.

Infectious disease is the leading cause of human death worldwide. Gone is the euphoric perspective of the mid-1970's that significant infectious diseases affecting humans in developed Nations were essentially problems of the past. The reemergence of infectious disease has continued to gain momentum since the mid-1980's. Disease events affecting natural resources have paralleled the eruption of infectious disease in human populations. Both situations are reasons for concern and have a common causative bond of ecological change.

Ecosystem Health, An Environmental Barometer for Human Health

The occurrence of significant forms of disease among wildlife can be an indication of deteriorating ecosystem health. Disease emergence is an early warning of challenges to the integrity of the biological systems that comprise ecosystem sustainability and provide for economic growth and healthy human populations.

The USGS, enhanced by the addition of the biological science capabilities of the Biological Resources Division to its physical science programs, is uniquely qualified to evaluate environmental changes that often lead to the occurrence of disease. Contributions include monitoring environmental quality and changes that are occurring, developing predictive models for assessing impacts associated with environmental change, and conducting investigations that lead to enhanced understanding of the environmental aspects of specific diseases. Findings contribute to societal needs for developing environmentally sound scientific strategies that enhance disease prevention and control in wildlife and humans alike. The USGS is carrying out a wide variety of investigations and activities, as indicated by the following highlights:

- During the summer of 1995, a group of Minnesota school children involved in wetland studies reported observations of deformed and otherwise abnormal-appearing frogs. Confirmation by biologists of these observations and reports of similar findings from other areas of the United States and Canada resulted in public concern regarding the causes and implications for human health. USGS leadership in investigating this situation has included collaborative surveys and other investigations that have disclosed a high rate and wide range of abnormalities, including missing, partial, or deformed digits, feet, and limbs; missing or unusual placement of eyes; jaw deformities; retained tails; and extra limbs (fig. 1). A USGS workshop involving scientists from across the Nation produced a strategic plan to guide scientific investigations.



Figure 1.—A mink frog from Minnesota with an extra limb. This is one of several types of deformities being found in a high percentage of amphibians at various North American locations.

A standard reporting form for gathering information was collaboratively developed and a North American Reporting Center for Amphibian Malformations established to provide a centralized database that is accessible at <URL: <http://www.npsc.nbs.gov/narcam>>. Pathological evaluations have documented the different types of deformities, and associated studies have gathered information on environmental contaminants, bacteria, viruses, and parasites present in the tissues of affected and nonaffected amphibians. Additional investigations are ongoing.

- At the Salton Sea in California, USGS scientists are studying this important ecosystem. Ecosystem stress is indicated by periodic die-offs that have killed as many as 150,000 waterbirds in a single event, by frequent large-scale fish kills, and by human health advisories owing to microorganisms and chemicals found in surface waters and wildlife tissues. Moreover, rising water levels and deteriorating water quality are adversely affecting recreational opportunities and economic development of the surrounding lands.

A USGS-sponsored workshop involving all major stakeholders produced a strategy document for returning the Salton Sea ecosystem to a healthier status, and an additional workshop has provided a scientific strategy for obtaining the environmental information needed to guide decision makers. USGS scientists are also monitoring water quality and investigating fish and bird mortality events to determine the specific causes involved and identify the ecological factors to help resolve these problems.

Across the Nation, USGS scientists are conducting other investigations to provide the scientific basis for addressing a multitude of ecosystem health and disease issues. These include such diverse activities as studies on sources and pathways of mercury contamination through food chains to recreational fishers in New England; endocrine disruptors in species from fish to the endangered Florida panther; brucellosis in elk and bison of the Greater Yellowstone ecosystem; the occurrence since 1992 of Newcastle disease in cormorants of the Great Lakes, the Great Salt Lake, the Columbia River, the Salton Sea, and other areas; the 1995 occurrence of whirling disease in rainbow trout within Montana's famed Madison River; the recent emergence of infectious disease as a major cause of mortality in the California sea otter, including two diseases that infect humans; and the national and international expansion of avian botulism, a disease directly associated with water quality. Numerous other wildlife and ecosystem health issues and problems are also being investigated by USGS scientists. Findings are made available to others through the Internet and other information transfer processes so that this information can be applied to the management of the issues being addressed.

Pathogenic Microorganisms in Public Water Supplies

Source waters for drinking-water supplies are coming under increased scrutiny. The largest waterborne disease outbreak in U.S. history occurred in Milwaukee in 1993. In that outbreak,



Figure 2.—1994 NAWQA study units participating in microbial pilot project.

403,000 people became ill and 104 died of Cryptosporidiosis, a disease caused by the protozoan *Cryptosporidium*. However, problems with the sanitary quality of U.S. water supplies and source waters were well-known even before the Milwaukee outbreak. Various estimates suggest that between 900,000 and 2 million people become ill each year in the United States by ingesting protozoan, bacterial, and viral pathogens in incompletely treated and untreated drinking water.

As part of a pilot project, USGS scientists are measuring microbiological waterborne pathogens and their indicators in six areas of the United States. These data are being collected at sites that were established as part of the USGS National Water Quality Assessment (NAWQA) Program. The data collected will be used by the U.S. Environmental Protection Agency (USEPA) to develop estimates of national occurrences of microorganisms entering water treatment plants; these estimates will aid in the development of drinking-water treatment requirements. The information gathered will also determine the feasibility and cost of conducting similar monitoring in other areas of the country.

Microbiological monitoring determines the sanitary quality of water and the public health risk from waterborne disease. Samples were collected and analyzed for bacterial and viral indicators of fecal contamination at 18 stream-water sites and 137 ground-water wells in six

NAWQA study areas. The study areas were selected to provide good geographic coverage of the United States and have a range of hydroclimatic and land use settings (fig. 2). Priority was given to those stream sites located near withdrawal points for community drinking-water supplies and to ground water wells that serve as household water supplies. The USGS will relate the data collected from streams and aquifers to human and natural factors that may affect the sanitary quality of water. This knowledge provides a better understanding of pathogen sources to water utilities and the public.

The NAWQA program of the USGS determines the status and trends in water quality of streams and aquifers of the United States. The USGS returns to these areas once each decade to establish patterns of changing water quality.

Fish Health and *Pfiesteria* in the Chesapeake Bay

Fish lesions and kills have been linked to the presence of *Pfiesteria*-like dinoflagellates, naturally occurring microorganisms that have been associated with fish kills in North Carolina. The health effects on researchers working with *P. piscicida* cultures in the laboratory are well documented and include neurological damage such as short-term memory loss. Watermen in the Chesapeake Bay area and North Carolina have reported symptoms such as skin lesions, fatigue, and light-headedness



Figure 3.—Fish with lesions (photograph courtesy of the North Carolina State University Aquatic Botany Laboratory).

after exposure to water containing the organism in its toxic form.

The incidence of fish health problems, ranging from lesions and sores to fish kills, may be on the rise in the Chesapeake Bay and its tributaries. Nutrient enrichment, point sources of nutrients, contaminants, and toxicants, toxic dinoflagellates, and other disease or disease-related organisms have been suggested as possible causes of fish health problems in the Bay (fig. 3). Scientists from the USGS and other Federal and State agencies involved in Chesapeake Bay studies are working together to understand the delivery of nutrients from the land into the Bay and the relation of nutrients to *Pfiesteria*-like organisms, fish health, and ultimately to human health. The USGS is examining fish health and the occurrence of lesions and disease organisms baywide, and potential links of fish health problems to land use, water quality, and stream flow patterns.

USGS scientists participate in the interdisciplinary Chesapeake Bay Ecosystem Program, which is closely coordinated with the Chesapeake Bay Program, a multiagency effort for Bay restoration. The objectives of the Ecosystem Program are to better understand the effects of natural and human-induced activities on the water quality and living resources of the Bay and to provide resource managers with information that is based on sound scientific investigations.

More information on USGS work in the Chesapeake Bay may be found at <URL: <http://chesapeake.usgs.gov/chesbay/>>

Health Impacts of Domestic Coal Combustion in China

Domestic coal combustion is the primary source of energy for hundreds of millions of people worldwide. In many developing countries such as China, unventilated stoves are commonly used. Emissions from the unvented coal fires are known to cause a variety of health problems that affect tens of millions of people in China alone (fig. 4).

The USGS has entered into collaborative research projects to deal with some of these serious health issues in China. The USGS and the Institute of Geochemistry (IGC), Chinese Academy of Sciences, are collaborating on the characterization of mineralized coals in Guizhou Province in southern China. Use of these coals in unvented stoves is believed by some to have caused several thousand cases of severe arsenic poisoning and as many as 10 million cases of fluorine poisoning. In addition, it is possible that mobilization of mercury, thallium, antimony, and other toxic elements from use of these coals may have affected the health of people in this region. Moreover, several cases of selenium poisoning in this area have been attributed to the use of coaly shale.

Initial results by the USGS indicate that some of the coal samples from the Guizhou Province have as much as 35,000 parts per million (ppm) arsenic. Several samples have more than 50 ppm mercury and more than 200 ppm antimony. These values are about 1,000 times the concentration found in most other coals.

The collaboration between the USGS and the IGC is part of a larger effort to study these significant health problems. Biomedical researchers from the University of Arizona, the Armed Forces Institute of Pathology, USEPA, the Department of Agriculture, and other organizations are working on epidemiological, pathological, toxicological, and pharmacological aspects of these health problems. We are seeking to understand the behavior of the different forms of arsenic and other elements during



Figure 4.—Unvented coal-burning oven in Guizhou Province, China. Exposure to toxic elements is believed to be due primarily to ingestion (note chili peppers hanging directly over the oven) and to inhalation (note scorch marks on wall).

combustion, the interaction of volatile compounds and soot with foods being dried over coal embers, the primary pathways for exposure, and the health effects caused by the different levels of exposure.

The USGS is also collaborating with the National Cancer Institute to determine the characteristics of Chinese coals that are believed by some to cause lung and esophageal cancer. The cancers have been attributed to the formation of organic compounds during coal combustion.

The information being generated on coals in China is similar to information that the USGS has generated over the past 20 years on the quality of domestic coals. The USGS maintains the U.S. Coal Quality Database that has been recently used by USEPA to address issues related to U.S. air quality. Information on the USGS U.S. Coal Quality Database may be found at <URL: <http://energy.er.usgs.gov/products/databases/CoalQual/intro.html>>

Geographic Information Science and Human Health

Effective research in medical care epidemiology; assessment of health risks, status, and services; disease surveillance systems; and efficacy studies involve not only the medical disciplines, but also those of geographic information science. For example, data from remote sensing satellites can be used to identify landscape features favorable to mosquitoes carrying the malaria parasite or ticks harboring Lyme disease bacterium. Satellite information about the characteristics of coastal waters may be useful in predicting the risk of cholera outbreaks.

The USGS is helping the Centers for Disease Control and Prevention to organize the 1998 Geographic Information Systems (GIS) in Public Health Conference. Topics to be discussed include the relationship of water quality (and specific chemicals) to medical conditions, the use of GIS software to analyze the spatial distribution of various diseases to determine if patterns exist and if those patterns are correlated with factors in the physical environment, and the geographic analysis of socioeconomic data with site information (such as treatment clinics or hazardous material storage facilities) to determine if inequities exist. From tracking the spread of the winter flu season to pinpointing outbreaks of the Ebola virus, human health issues are geographic issues as well. USGS geographic scientists are working with scientific colleagues in the health profession to bring the tools of remote sensing and geographic analysis to bear on their problems.

USGS scientists, working with the U.S. Agency for International Development (USAID), have developed a Famine Early Warning System (FEWS). FEWS, established in the mid-1980's and funded by USAID, is a GIS designed to help decision makers prevent famine in Sub-Saharan Africa. FEWS specialists in the United States and Africa assess remotely sensed data and ground-based meteorological, crop, and rangeland conditions for early indications of potential famine areas.

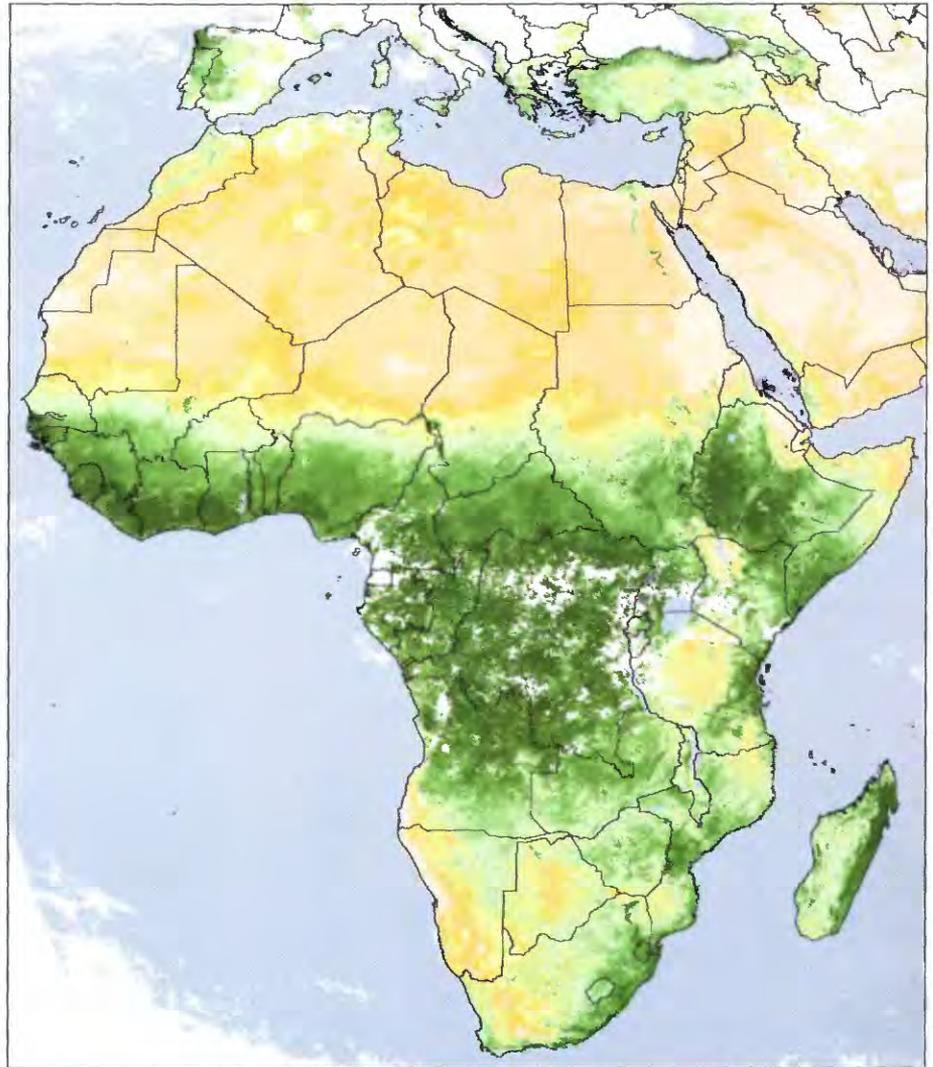


Figure 5.—USGS provides public access to latest satellites image of Africa, such as this from late October 1997, which shows the distribution of growing vegetation. A new image is staged every 10 days.

The Africa Data Dissemination Service (ADDS) is an outgrowth of the FEWS project. The USGS provides technical support to the FEWS project, which includes long-term data archive and distribution services. The ADDS was developed to provide easy access to the data collected by the FEWS project since 1985. The ADDS provides maps (administrative boundary, roads, cities, rivers, land use, and so on), tabular data (rainfall, commodity prices, and agricultural production) and PC-based software developed to analyze the tabular data. Additionally, the ADDS contains an archive of satellite data and is updated every 10 days with the most recent satellite images showing the seasonal development and distribution of vegetation and rainfall across the continent (fig. 5). These data provide researchers and decision makers with the most up-to-date insights into the potential of food shortages on the African continent.

The ADDS may be reached at
<URL: <http://edcintl.cr.usgs.gov/adds/adds.html>>

INFORMATION

For information on these and other USGS products and services, call 1-800-USA-MAPS, or use the EARTHFAX fax-on-demand system, which is available 24 hours a day at 703-648-4888.

Please visit the USGS home page at
<URL: <http://www.usgs.gov/>>.

The address for the Environment Theme pages is
<URL: <http://www.usgs.gov/themes/enviro.html>>.