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AUTHOR	Meade, Melinda S.; Washburn, Sarah; Holman, Jeremy T.
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ABSTRACT

This learning module aims to engage students in problem solving, critical thinking, scientific inquiry, and cooperative learning. The module is appropriate for use in any introductory or intermediate undergraduate course that focuses on human-environment relationships. The module states that human health is a product of complex interactions among population, environment, technology, and culture, all of which are affected by global change. It explains that, for example, changes in climate or land use/land cover can affect the reproductive cycles of arthropods that transmit disease, the availability of water for hygiene and sanitation, and/or the concentration of chemical pollutants in the air, water, and soil. It also states that infectious diseases, which cause more than half the mortalities in tropical developing countries and are resurgent in developed ones, are also potentially affected by global environmental changes. According to the module, changes associated with urbanization, globalization, and population growth and mobility encourage disease diffusion and a globalization of health risks. The module introduces students to these issues and illustrates the complex relationships among human health and global change. The module contains 5 tables, 6 figures, a list of acronyms, a guide, a summary, an overview, a glossary, references for all units, supporting materials, and appendixes with additional sources. It is divided into thematically coherent units, each of which consists of background information, teaching suggestions, and student worksheets. (BT)

HANDS-ON!

Human Health in the Balance

An Active Learning Module on the Human Dimensions of Global Change

HANDS-ON!

DEVELOPING ACTIVE
LEARNING MODULES ON THE
HUMAN DIMENSIONS OF GLOBAL CHANGE

Human Health In The Balance

Module developed for the AAG/CCG2 Project
"Developing Active Learning Modules on the Human Dimensions of Global Change"

by

Melinda S. Meade and Sarah Washburn
Department of Geography
University of North Carolina at Chapel Hill

and by

Jeremy T. Holman
Graduate School of Geography
Clark University
Worcester, MA 01610

Significant revisions were contributed by CCG2 Summer 1996 workshop participants Sarah Bednarz (Texas A&M University), Susan Blickstein (Clark University), Osa Brand (AAG), Jimmie Eflin (Ball State University), Lisa Graumlich (University of Arizona), Audrey Levenson (Clark University), Jerry Mitchell (University of South Carolina), Jim Proctor (University of California, Santa Barbara), Frances Slater (University of London), and James Wysong (Hillsborough Community College, Tampa).

Developing Active Learning Modules on the Human Dimensions of Global Change
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1710 Sixteenth Street NW
Washington, DC 20009-3198
Phone: (202) 234-1450
Fax: (202) 234-2744
Internet: gaia@aag.org

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Editor's Note

A major goal of this project "Developing Active Learning Modules on the Human Dimensions of Global Change," is to disseminate instructional materials that actively engage students in problem solving, challenge them to think critically, invite students to participate in the process of scientific inquiry, and involve them in cooperative learning. The materials are appropriate for use in any introductory and intermediate undergraduate course that focuses on human-environment relationships.

We have designed this module so that instructors can adapt it to a wide range of student abilities and institutional settings. Because the module includes more student activities and more suggested readings than most instructors will have time to cover in their courses, instructors will need to select those readings and activities best suited to the local teaching conditions.

Many people in addition to the principle authors have contributed to the development of this module. In addition to the project staff at Clark University, the participants in the 1996 summer workshop helped to make these materials accessible to students and faculty in a variety of settings. Their important contributions are recognized on the title page. This module is the result of a truly collaborative process, one that we hope will enable the widespread use of these materials in diverse undergraduate classrooms. We have already incorporated the feedback we have received from the instructors and students who have used this module, and we intend to continue revising and updating the materials.

I invite you to become part of this collaborative venture by sending your comments, reactions, and suggested revisions to us at Clark. To commmicate with other instructors using hands-on modules, we invite you to join the Hands-on listserve we have established. We look forward to hearing from you and hope that you will enjoy using this module.

Susan Hanson
Project Director

School of Geography
Clark University
950 Main St.
Worcester, MA 01610-1477
ccg2@clarku.edu

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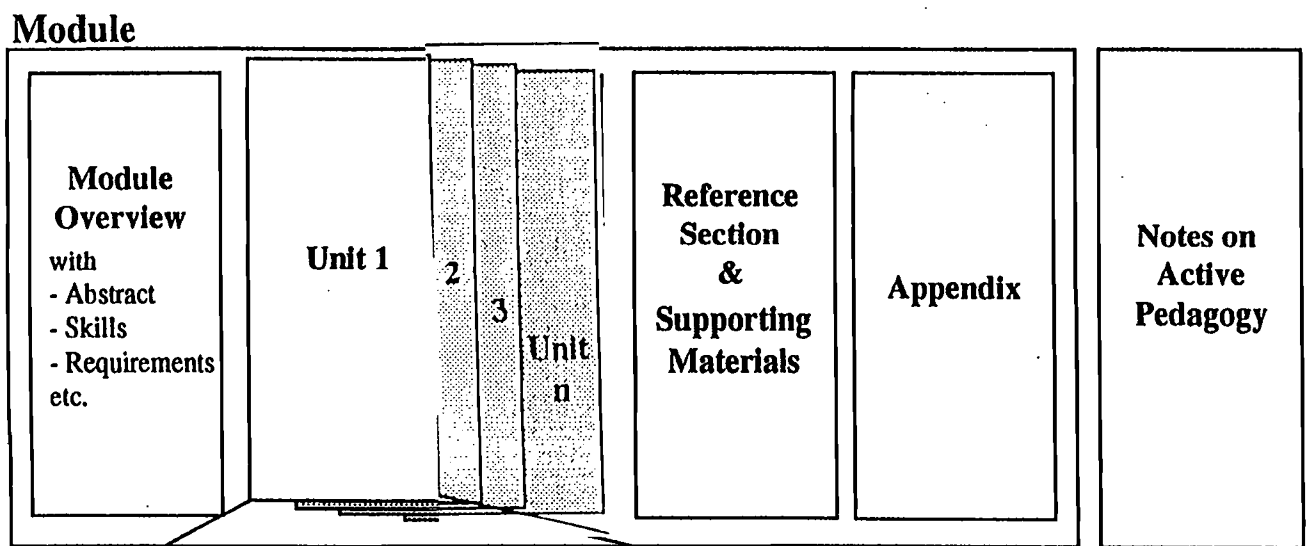
List of Acronyms

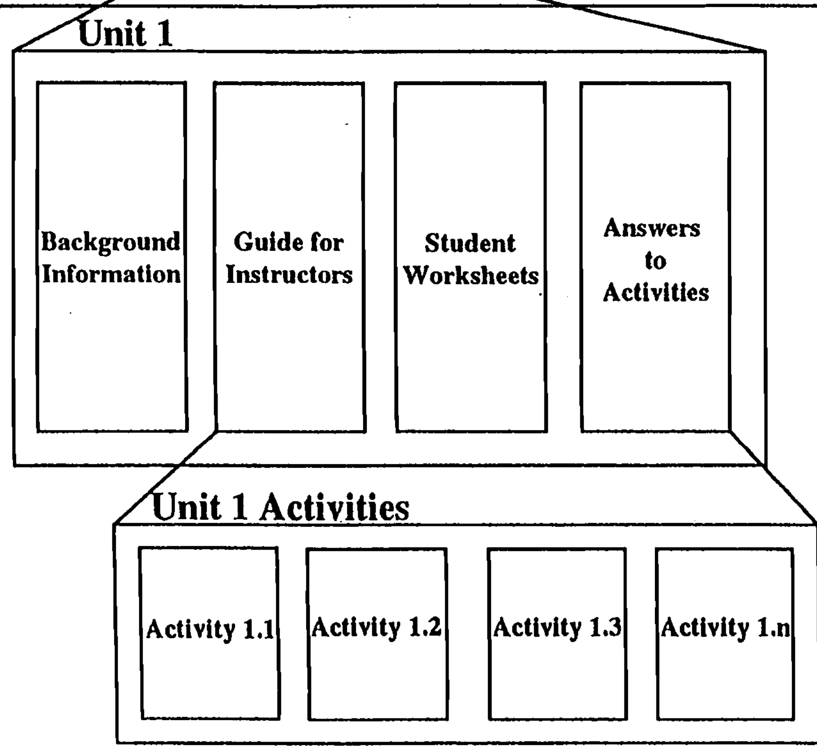
AIDS	acquired immune deficiency syndrome
HIV	human immunodeficiency virus
LDC	lesser developed country
MDC	more developed country
ORT	oral rehydration therapy
TB	tuberculosis
WHO	World Health Organization
WWW	World Wide Web

Guide to this Module

This guide is meant to help you navigate this module.



The module is divided into Units, i.e., sections that are thematically coherent and that could, if necessary, stand alone. In addition, the module contains a Reference Section, Supporting Materials and an Appendix. The Supporting Materials can be used to facilitate the teaching of this module or simply to augment it with interesting ideas and information. Additional sections with further information may or may not be present, e.g., a list of accronyms, or a glossary. A separate section on Active Pedagogy comes with every module purchase.



Each Unit consists of Background Information that can be used as a hand-out for students or as the basis for an in-class presentation; an Instructor's Guide, consisting of suggestions on how to teach the various learning activities associated with a given Unit; Student Worksheets; and the Answers expected for each activity.

Each activity has its own Student Worksheet for ease of preparing hand-outs for students.

The activities are geared toward the theme(s) and concepts discussed in a particular Unit. The particular skills and themes emphasized vary among the activities. Choose one or more activities per unit to fit your class size, time, resources, overall course topics, and student skill levels. Be sure to vary the types of activities you choose throughout the module.

Summary: Human Health in the Balance

Abstract

Human health is a product of complex interactions among population, environment, technology, and culture, all of which are affected by global change. For example, changes in climate or land use/land cover can affect the reproductive cycles of arthropods that transmit disease, the availability of water for hygiene and sanitation, and/or the concentration of chemical pollutants in the air, water, and soil. Infectious diseases, which cause more than half the mortalities in tropical developing countries and are resurgent in economically developed ones, are also potentially affected by global environmental changes. Changes associated with urbanization, globalization, population growth, and increasing population mobility encourage disease diffusion and a globalization of health risks. This module introduces students to these issues and illustrates the complex relationships among human health and global change.

General Module Objectives

- To introduce the basic geographic concepts of cultural ecology and demographic change.
- To help students understand the impact of infectious and other diseases, their changing ecology, and future risks.
- To provide a framework for understanding the ways that global environmental, demographic, and economic change affect human health.
- To involve students in analyzing the geographic occurrence and diffusion of disease both internationally and locally through data collection, mapping, analysis, and assessment.
- To emphasize the importance of interactive feedback, adjustment, and causation between human cultural processes and physical environmental processes.

Skills

- Identifying important relationships and classifying and locating the places where they have major impact.
- Making relevant observations, identifying important distributions, and assessing relationships in an integrative manner.
- Finding relevant information from various sources, such as the Internet and library documents.
- Compiling, analyzing, and synthesizing statistical, qualitative, descriptive, and theoretical information
- Creating and interpreting analytical tools such as population pyramids and maps.
- Working cooperatively on group projects to formulate problems and to communicate ideas.

Activities

The types of activities in this module include:

- ✓ mapping
- ✓ group discussions
- ✓ text comprehension
- ✓ data analysis and interpretation
- ✓ graph production and interpretation
- ✓ poster session
- ✓ writing for target audiences
- ✓ local research and participation
- ✓ Internet/WWW research

Material Requirements

- Student worksheets (provided)
- Suggested readings (some provided)
- Calculators
- Pencils
- Data on disease incidence (some provided)

- Mortality data (some provided)
- US map (provided)
- World map (provided)
- Internet access (if available)

Human Dimensions of Global Change Concepts

- Interactions between culture and environment
- Population as driving force and response
- Global-to-local relationships

Geography Concepts

- Interactions between culture and environment
- Mobility and diffusion
- Global patterns and interconnectivity
- Regional and local integration

Time Requirements

7 to 14 class days, depending on the number and type of activities chosen. Some activities require additional time outside of class.

Difficulty

Introductory to intermediate; requires ability to abstract, to integrate concepts, and to analyze critically; requires ability to work in groups and to conduct research independently.

Module Overview

Global changes in climate, land use, urbanization, diets, industrial production, agricultural practices, and demographics will bring about changes in the characteristics and distribution of human health and disease. Changes in technology, in economic and social organization, and in beliefs about causes and treatment of ill-health continually change human interactions with the environment and the factors that produce states of health or disease.

This module is about the nature of these relationships; it has several objectives:

- to provide an overview of the concepts of human health and disease and their relationship to geography and global change;
- to emphasize the changing world distribution of major infectious diseases and the emergence of new ones;
- to provide a conceptual framework for integrating population, environment, technology, and culture in thinking about global change and disease and health status;
- to develop skills in accessing, structuring, analyzing, and interpreting qualitative and quantitative data from various perspectives;
- to broaden each student's understanding of global processes and of his or her own action in a local context; and
- to build students' understanding of equity and policy issues in human health and global change.

The first unit explores what is meant by health and disease and looks at how geographers have studied these issues. The activities are designed to raise student awareness of world demographic and disease patterns, to get students thinking critically about data, and to involve students in mapping disease/health data.

Unit 2 explores conceptual frameworks for addressing human-environment interactions and the dynamics and context of population change. We discuss the interactions among population, environment, culture, and technology that result in health status, and we introduce the concept of the demographic transition to build student understanding of the interactions among these four factors. This unit focuses on two examples of infectious disease and global change: water-related disease and mobility-related contagious diseases.

Unit 3 addresses equity and policy issues of human health and global change; the unit uses HIV/AIDS as an example of the ways that policy concerns intersect with health status. Unit 4 contains a case study of plague in India. The module activities emphasize data collection, assessment, mapping, and analysis; critical thinking; working in groups; and interviewing.

1 Disease Has a Changing Ecology

Background Information

Global Changes and Human Health

Why should you be concerned about human health and global change? After all, you are aware of basic health risks, you've been immunized against many diseases, and you probably have access to basic health care resources. Consider for a moment the fate of a 20-year old former high school track star, who died suddenly on the way to his girlfriend's funeral. His girlfriend had died just as mysteriously only days earlier. In total, at least 16 previously healthy young adults and teenagers died from an outbreak of hantavirus[1] in the Four Corners area of the US (the region where Colorado, New Mexico, Arizona, and Utah come together) in 1993. Take a moment to consider another example. In July 1994, 24 cases of **malaria**[2] were reported in Houston, Texas. The species of mosquito that transmits malaria is present in the US and needed only warm weather (which can increase reproduction and larval development) and the introduction of malaria in an infected person to start a local **epidemic**.

What lessons have researchers learned from studying emergent and re-emerging diseases? First, known viruses are only a small fraction of the total number that are thought to exist in nature. Many diseases, such as the hantavirus of Four Corners, are not actually new but are infecting people in new locations. After a period during which **infectious diseases** were thought to be well under control, as we approach the end of the century disease-causing agents are breaking out all over the globe. Infectious diseases kill more than 16.5 million people per year, despite major advances in sanitation, medical care, and public education (Platt 1995). Globally, 3.3 million people die from **tuberculosis** each year. Another two million die from malaria, predominantly, but not exclusively, in tropical regions. Global changes in climate, settlement, land use, industrialization, and urbanization lead to changes in the incidence and pattern of infectious disease.

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[1]Investigators found that a deermouse native to most of North America harbored a strain of the hantavirus (named for Korea's Hanta River where it was first discovered) which causes severe pulmonary tract and lung damage (Platt 1995). It wasn't entirely clear at first, however, why this animal, which rarely came into contact with people, began to appear in greater numbers. One theory is that the pinon tree,which usually blooms once in a lifetime, had a rare mass blooming that spring because of the unusually wet winter. The rodent population, attracted to the pinon's nuts and other food sources made more abundant by the wet winter, was exceptionally large (Henig 1993). The presence of a large rodent population creates more opportunities for people to come into contact with infected rodents, and hence the virus (Morse 1994).

[2] Words that appear in bold are defined in the *Glossary*.

If we add chronic and degenerative diseases, such as cancers and cardiovascular illness, to the infectious disease picture, the global health outlook is less than rosy. Cancers of the liver, the esophagus, and the nasopharynx are major causes of death in China, but are very rare in the United States; no one knows why. The incidence rates of degenerative diseases that take years or decades to develop (e.g., cancer and heart disease) are beginning to show the effects of increases in industrial poisons, air pollution, and behavioral changes such as exercise, diet, or the use of more effective pharmaceutical drugs.

At the same time, the global human population is growing exponentially at more than 1.5% per year. Although this rate is slowing each year as populations move through the **demographic transition** (discussed in Unit 2), patterns of population growth have consequences for human health. For example, the health status of a population can vary depending upon the proportion of the population that is elderly, young, or of working age. Age is strongly related to immunological status, nutritional status, accumulation of exposures and health risks, propensity for sex or violence, and simple wear and tear on the body. Behavior changes as people age, as do a host of health risks. Reproductive risks are also changing; being pregnant ten, fifteen, or even twenty times can cause serious health problems for women and substantial maternal mortality. These risks are reduced greatly when women have fewer, more widely spaced pregnancies. In those countries early in the demographic transition, death in childbirth and the consequences for children already alive remain serious problems; where fertility rates are low women now outlive men.

Beyond the impacts of demographic change on human health are the fundamental effects of human activity on the environment. The need to produce more food has resulted in changes in agricultural technology to produce, preserve, and transport food. These technological changes can also pose risks to human health -- fertilizers can pollute water sources and pesticides can be carcinogenic. In addition, new and often marginal land is cleared in forests, highlands, and swamps around the world for agricultural, commercial, and residential use. These land cover changes remove the vegetative sponge that allows rainfall to soak into the soil and recharge the ground water tables and can result in floods. The impoundment of water for generating electricity or for extending irrigation systems can also cause salinization, desertification, and the loss of biodiversity. Each of these changes that affect land and water resources can produce a variety of changes in the ecology of water-related diseases.

Changes in population mobility associated with technological change and economic globalization also have fundamentally affected the international diffusion of disease. The rate of rural-to-urban migration in lesser developed countries (LDCs) and the increase in air travel and global tourism contribute to the potential rapid spread of disease. An infectious agent that evolves or is transferred from an animal **host** in a remote rural area, perhaps as the result of forest clearing that brings humans into contact with the host in new areas, has greater potential than ever to reach urban population centers. The result is that even if a certain animal has always carried a particular virus, the increased chance of contact with humans increases the likelihood of an outbreak. The conditions created by rapid urbanization are conducive to the transmission of existing agents and the emergence of new, or newly **virulent**, agents. By 2025, an estimated 61% of the earth's population will live in urban areas (WRI 1996), compared to only about 20% a century ago. The difficulties of housing people in cities, and the crowded conditions that often result, continue to create health problems for urban residents. Rural-to-urban migrants often have no choice but to settle in "squatter" housing with no potable water, sewerage, or electricity. Problems from malnutrition can become severe. Crime, violence, and alcohol and drug abuse are frequent companions of these difficult conditions.

Is There a Geography to Human Health and Disease?

Is there a geography to human health and disease? To answer this question, we must first define the concepts of health and disease. A dictionary might define health as the condition in which an organism or one of its parts performs its vital functions properly. Health would thus be a state of sound mind and body. Disease could be considered an impairment of this normal state, something that interrupts or modifies the performance of vital functions. Another definition of health is found in the preamble to the 1946 Charter of the World Health Organization that states, "health is a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity." Likewise, disease may better be conceptualized as "that alteration of living cells or tissues that jeopardizes survival in one's environment" (May 1961). Rene Dubos (1965) introduced the concept of health as the quality of *adaptability* into the field of medicine and human ecology.

Throughout history, geographers and the general public have sought connections between health and place. Summer homes outside urban areas in the United States were selected for their healthful environments -- near lakes, hot springs, or in the mountains. Fresh air was thought to cure the ills of urban life. Traditionally, geographers concentrated on researching the relationship between ill-health and environmental conditions. Hippocrates himself addressed the subject in the Fifth Century B.C. Early medical geographies were written by physicians because, before germs were discovered, many diseases were thought to be caused by emanations from the earth or by plants present in air or water. After the age of exploration, physicians and geographers such as Alexander von Humboldt attempted to explain the occurrence of diseases around the earth through links to the terrain, vegetation, and human races. In the 1800's, 'medical topography' began to relate climatic and topographic influences to the health of individuals and societies. To this end, the cartographic representation of the distribution and diffusion of disease was advanced. Mapping the spread of disease geographically continues to be a powerful tool to aid in the discovery of the causes of disease and to suggest points and processes of interventions (Gilbert 1958; Thomas 1992).

The successful application of medical cartography is at odds with the failed geographic concept of **environmental determinism** which sees the environment as determining or influencing human activity. The development of possibilism eased the determinists' strict control of the environment on human activity. Possibilism is a **paradigm** or way of organizing human/nature interactions, in which the environment acts to restrict human activities to a range of possibilities. Moving even further away from the influence of the environment on human activity, a behavioral approach gained favor. In the behavioral paradigm, humans were viewed as detached from the environment, or alternatively, as able to ameliorate the environment through technological advances. The recent emergence of **cultural ecology** represents a more holistic framework of human-environment interactions. Cultural ecology incorporates notions drawn from ecosystem analysis and general systems theory to study cultural practices as related to broader movements in ecological and human systems, with the overall goal of ensuring environmental sustainability.

Geographers, recognizing a need for cross-disciplinary research, have investigated health and disease considering both physical and human factors that together influence bodily and mental health. Two traditions of inquiry have emerged: (1) disease ecology, which investigates the causes of ill-health, and (2) the geography of medical care and its accessibility (Hunter 1974). Health researchers of all kinds classify types of health problems into several broad categories. These are briefly discussed below with examples illustrating the influence of global environmental change.

Nutrition

Proper nutrition is essential to health and well-being. Dietary problems such as vitamin deficiencies exist throughout much of the world including your own town or neighborhood. In many parts of the world, these problems result from a combination of population growth, food scarcity from poor farming and land management techniques, and inequities in access to resources. Famines often result from human-induced droughts and can lead to debilitating diseases of malnutrition, such as kwashiorkor, a protein deficiency disorder in children prevalent in densely populated parts of the world where the diet consists mainly of starchy vegetables, especially cassava (also called manioc or tapioca). Because such a diet is deficient in certain amino acids that make up proteins vital for growth and for maintaining the immune system, the disease's manifestations include increased susceptibility to infection, skin changes, edema, severely bloated abdomen, diarrhea, and retarded development. Several crops, when eaten as a staple food by the poor between growing seasons, are associated with specific vitamin deficiencies. For example, reliance on corn can lead to **pellagra**, a disease marked by inflammation and scaling of the skin, digestive disturbances, and sometimes mental disorders. The power milling of rice to remove the brown bran also removes the nutrient thiamin and has caused **beriberi** to spread like an epidemic in Asia, following the transportation routes of the mills.

Technological change, urbanization, and the globalization of economic activity can affect nutritional diseases in diverse ways. For example, global economic trends that require women to work outside the home may result in the reduction or elimination of breast feeding and the substitution of bottle feeding. Because breastfeeding is one of the most important preventative measures for diarrheal disease in infants, this reduction has an impact on the health and nutrition of children. In addition, the introduction and development of a cash economy can result in the elimination of local cultivation of vegetables and livestock as money is spent on canned food and alcohol (Meade 1988, 130-132).

Global environmental changes such as climate change may also affect nutritional diseases. Shifts in precipitation regimes throughout the world (leading to reduced rainfall in some areas and increased rainfall in others) are likely to affect agricultural productivity and food availability. Likewise, the transformation of agriculturally productive land into urban residential or commercial land uses may reduce our ability to feed the earth's population.

Infectious Disease

Infectious diseases remain the leading cause of death in the world. They may be spread by **contagion**, person to person, by ingestion of contaminated food or water, or by injection into humans from the bite of insects that have acquired the infectious agent from the blood of other infected people. Many infectious diseases will continue to increase as strains of the disease agents become resistant to medication (such as antibiotic resistant strains of tuberculosis), as people crowd into tighter urban spaces, and as the need for land results in people moving into new, possibly infectious, areas. The processes of their changing geography is explored more fully in Unit 2.

Chronic or Degenerative Disease

As countries and regions become more developed economically, the incidence of chronic or degenerative diseases such as heart disease, increases significantly. In the United States, cardiovascular and other diseases, arising in part from sedentary lifestyles, have surpassed infectious disease as the number one cause of death. Also as areas experience rapid economic growth and an influx of western culture and products, people emulate behavior from other areas that are detrimental to their health (e.g., smoking). Smoking-related illness, already prevalent in the United States, is likely to continue increasing in Asia as smoking rates increase among the younger population.

Psychosocial Disease

Psychosocial disease, often referred to as mental illness, has social, psychological, and biological roots. Stresses and hypertension due to overcrowding, poor working and/or economic conditions fall within this category, as do mental illnesses, which research has increasingly shown to be linked to biochemical processes. During the process of urbanization, in which migrants from diverse cultures move into cities from rural areas, people may feel that they have lost their traditions and their ways of life. These new forms of stress may promote suicide, domestic abuse, and substance abuse.

Genetics

Some health problems are caused by genetics -- that is, they are inherited as a result of a genetic trait. These may be as mild as allergies or as deadly as **Huntington's Disease**. **Lactose intolerance**, a genetic health problem, may affect nutrition and cause diarrhea. Some genetic traits seem to have evolved as a defense against malaria infection. One examples is the sickle shape of blood cells under oxygen tension and the associated **anemia** among Africans; another is the severe allergic reaction and destruction of blood cells that can result among Mediterranean people from eating fava beans. Although genetic causation is quite rare, genetic susceptibility to health problems that others are more able to resist is more common. The factor that people are susceptible to must be determined. Sometimes geographic pattern offers the best causal clue, as when a **carcinogen** and cancers are associated with air pollution, eating smoked fish, or proximity to a contaminated river water source. Genetic susceptibility has been suggested for several important diseases such as multiple sclerosis and **Parkinson's Disease**, but they remain disease of unknown **etiology** because the factor to which people are susceptible remains elusive.

Biometeorology/Bioclimatology

Biometerological and bioclimatological factors that influence human health include altitude, solar radiation, cold and heat waves, and the incidence of drought and flooding. The importance of these factors is illustrated by the simple example of vitamin D (needed for the normal development of bones and teeth) that is synthesized in humans with the aid of exposure to the sun or ultraviolet radiation. On a larger scale, the potential impacts of global and regional climate change on human health have been widely studied. Disease patterns may be significantly affected by global warming trends as **vectors** previously unknown or rare in particular regions survive and thrive in modified climates. Increased incidence of skin disease (particularly cancer) and eye disease are also anticipated as the level of stratospheric ozone is diminished and more ultraviolet radiation penetrates the earth's atmosphere. Increased temperatures in some areas as a result of climate change and the human-induced **greenhouse effect** may cause additional heat-related deaths, particularly among the elderly.

Environmental Contamination

Natural and human-made toxins are present in the environment. We now risk contact with dangerous chemicals in soil, water, air, our workplaces, and our homes. Cancers and respiratory ailments are possible consequences of such pollution. Indoor air quality in offices and the problems associated with computer use (eye strain, carpal tunnel syndrome) are also considered environmental factors, as are the poor health conditions associated with substandard housing.

Health Care Delivery and Access

The availability of health care resources, including access to information and physical facilities, is critical for local, regional, national, and international responses to health problems. Health resources also have a cultural dimension including access to modern, "Western," and traditional healing methods and issues of utilization. Do people know what care is available and where? What are the impediments -- economic, social, or cultural -- that prevent people from using available services?

It should be clear from these few examples that human health is endangered through many different pathways of exposure. One aspect alone does not produce ill-health, and accordingly, geographic research on human health and global change must explore a variety of pathways. Jones and Moon (1993) state that

> the intersection of health and health care research with the geographical must retain a concern with differences between and within locations and with distance, mobility, and spread, but it must also concern itself with the structure of meaning and understanding in the places where people live, experience sickness, and use health services.

We can see the continued importance of geography to understanding disease and the potential impacts of global environmental change on human health. But it is also important to examine and understand the places where people live and the cultural norms and traditions that guide their daily lives. These places continue to change, on a local and a global scale, as a result of social, cultural, ecological, and biophysical forces. Is there a geography to health and disease? Clearly there is and it is constantly changing. The forces of global environmental change may lessen some human health effects, may exacerbate others, and will continue to profoundly influence the distribution and severity of disease around the earth. The processes of interaction among environment, population, culture, and technology that contribute to the state and spread of disease are examined in Unit 2 as we develop a conceptual framework for thinking about human health and global change interactions.

1 Disease Has a Changing Ecology

Instructor's Guide to Activities

Goal
The activities in Unit 1 are designed to help students explore what health and disease mean. Students examine their own perceptions and stereotypes about health and disease and become familiar with the collection and mapping of disease data.

Learning Outcomes
After completing the exercises associated with this Unit, students should:
- know that health and well-being can be affected by many sources including infectious disease, psychosocial disease, and environmental contamination;
- understand that health impacts can vary with location and behavior;
- be able to identify the relationships between their own health and their lifestyle;
- know how to locate and use health data; and
- be able to map disease incidence data.

Choice of Activities
It is neither necessary nor feasible in most cases to complete all activities in each unit. Select those that are most appropriate for your classroom setting and that cover a range of activity types, skills, genres of reading materials, writing assignments, and other activity outcomes. This unit contains the following activities:

1.1 How's Your Health?	-- In-class writing assignment and group discussion
1.2 It Could Happen to You -- Bringing Health Home	-- Narrative analysis, team work, and group discussion
1.3 Disease Diffusion and Mapping	-- Analysis, mapping, and interpretation of disease incidence rates

Suggested Readings
The following readings accompany the activities for this unit. Choose those readings most appropriate for the activities you select and those most adequate for the skill level of your students.
- Unit 1: Disease Has a Changing Ecology (provided).
  The background information to Unit 1 that all students should read.
- The Lancet. 1994. *Health and climate change*. London: Devonshire Press.
  Each chapter explores a different aspect of the impacts of climate change on human health.

- Meade, Melinda; John Florin, and Wilbert Gesler. 1988. *Medical geography*. New York, NY: Guilford Press.
  Classic text on medical geography that may be useful in making links between geography and human health. May also be used as additional reading for other units of this module.
- World Health Organization. 1990. *Potential health effects of climatic change*. Geneva: World Health Organization.
  Several chapters help explain some of the links between climate change and human health

Activity 1.1 How's Your Health?

Goals
Students learn to think of health as more than being free from disease, but as a state of well-being both physically and mentally. This activity helps students understand the many possible forms in which health problems are manifest and that well-being is influenced by multiple global environmental changes.

Skills
✓ analytical thinking
✓ group discussion skills

Material Requirements
- *Student Worksheet 1.1* (provided)

Time Requirements
25-30 minutes

Tasks
This short in-class writing assignment can be used as a starter activity. Students write individually for five minutes followed by a brief class discussion of their ideas. The activity is intended to help students realize that health means different things to different people and that factors other than infectious diseases can cause a loss of well-being. Lifestyle choices, technology, and where we live all affect what health afflictions we are exposed to and in turn, expose others to. Students also begin to understand that actions of others elsewhere can have an impact on their well-being. Once students see that there are many different conceptions of health and disease, they will be more receptive to understanding the human health effects of global environmental change.

The questions below are also provided on the student worksheet.
- What do you consider "health" and "disease" to mean?
- Do you consider yourself "healthy?"
- Do you feel that you are at risk from anything that would make you "unhealthy?" How does where you live, work, and play affect the risks to your health?
- Who is responsible for your health? Who should be?

Activity 1.2 It Could Happen To You – Bringing Health Home

Goals
Students recognize some widespread misconceptions about the nature and distribution of disease/illness and the availability of health care resources. Students examine how ethnocentrism and socio-economic status affect the perception of heath risk in and by individuals.

Skills
- ✓ listening comprehension
- ✓ interpersonal communication
- ✓ analytical thinking
- ✓ synthesis
- ✓ oral presentation

Material Requirements
- *Student Worksheet 1.2* (provided)
- Narratives (provided in *Supporting Material 1.2*)

Time Requirements
One class period (50 minutes)

Tasks
To begin, present the short narratives in *Supporting Material 1.2*. These illustrate that conditions and afflictions commonly associated with less developed nations or less affluent socio-economic groups are problems in the US and other developed countries. You can either read these narratives aloud or photocopy them and provide them to students. After the narrative presentations, students work together in groups of two or three people to respond to the questions for each narrative on the student worksheet. (If you read the narratives to the students, allow students time to answer the questions for each narrative immediately after you've finished reading it.) After students have finished, reconvene the class for a brief follow-up discussion of their responses.

Activity 1.3 Disease Diffusion and Mapping

Goals
Students use disease incidence rates to map the distribution of diseases at various geographic scales.

Skills
- ✓ analytical thinking
- ✓ data collection and analysis
- ✓ frequency distributions

✓ application of understanding of local health conditions
✓ map creation and interpretation
✓ WWW/Internet research (optional)

Material Requirements

- *Student Worksheet 1.3* (provided)
- color pencils or markers
- calculator
- For Part B: A map of your state with county boundaries, a map of the United States (provided in *Supporting Material 1.3a*), and/or a map of the world (provided in *Supporting Material 1.3b*)
- For Part B: Incidence data by county, state, region, country and/or continent for a disease that is either water related (a disease of pollution, e.g., giardia, bladder cancer, encephalitis) or mobility related (e.g., tuberculosis, HIV/AIDS). State level incidence rates for TB are provided in *Supporting Material 1.3c*. For information on data sources, see *Appendix B* and *Appendix C*.

Time Requirements

Part A: One class period (50 minutes); Part A also works well as a homework assignment.
Part B: 7 to 10 days outside of class.

Tasks

Depending on your time constraints, class size, and students' familiarity with the subject, you can ask students to complete only Part A or Part B of this activity. Divide the class into small groups for either part. If you decide to do both parts, students can use Part A as a guide for the analysis in Part B.

Part A: Tinytown

Students use the student worksheet to follow the process outlined below:

1. Students use the incidence rates for Yukilosis in Tinytown to produce a frequency distribution, ranking the incidence rates from high to low.
2. Students then break the data into groups. It is recommend that they break it into three or four categories according to natural breaks in the data or quantiles (if Tinytown had more than thirty districts, you could use standard deviations from the mean).
3. Students are asked to justify in a few sentences the method of breaking down the data.
4. Using the map provided on the worksheet, students shade the districts using a dark color or dense pattern of lines for the highest category and a slightly less intense color or pattern for each of the next lowest categories.

When steps 1 through 4 are complete, students answer several questions on the worksheet about their findings and the distribution of Yukilosis on their maps.

Part B: Your County, State, Country, Continent, or World

In Part B, students collect and analyze disease data on a larger scale than Part A. You can either choose a disease for students to investigate or allow them to decide. If you want students to map disease incidence at the world, regional, and state scales, you may need to choose the disease for them in order to insure that data are available for each scale of analysis. If you allow students to choose the disease, you can give them the option of mapping the incidence rates at one or two different scales of their choice, based on the disease and the data they are able to find.

Among the diseases you can choose for this activity are cancers (for which data is usually accurate and well-reported as a cause of death), heart disease, stroke, TB, or even diabetes (a good example of a disease that crosses age categories). In addition, a disease that most students are aware of is HIV/AIDS. Using this part of the activity to research, map, and analyze domestic and global diffusion of AIDS is an excellent way for students to dispel the notion that AIDS is a "gay only" disease and to prepare students for Unit 3, which uses HIV/AIDS as an example of the policy implications of human health and global change. HIV/AIDS data, however, may not be available at all scales of analysis (i.e., some states do not report county-level HIV/AIDS data and in some cases, doctors do not report it as a cause of death).

Encourage students to use a variety of sources to find disease incidence data. If students have access to the Internet/WWW, they can check out the sites for your state health department, as well as the World Health Organization and other sites specific to the disease they select. (See *Appendix C* for a partial listing of Internet sites of interest.) State-level incidence rates for TB are provided in *Supporting Material 1.3*. You can use these data to do a shorter version of this activity in which students only look at one geographic scale. Or, you can use the data to get students started, and ask them to find data at other scales. Use the data sources suggested in *Appendix B* or recommend them to students to aid their search.

The following process is not outlined in the student worksheet. It is provided simply as a guide for introducing Part B of this activity.

1. Based on the scale(s) of analysis you wish to consider in this activity, provide students with a map of your state with county boundaries, a map of the United States (provided in *Supporting Material 1.3*), a map of North America, and/or a world map with country boundaries delineated (provided in *Supporting Material 1.3*).
2. Choose (or allow students to choose) a disease that has relevance to students' lives and that can be linked to either environmental factors or to changes in mobility. Also, choose one for which data are available at the scale(s) of analysis you want students to consider. As previously noted, AIDS, cancers, heart disease, diabetes, or TB are good examples. Depending on the size of your class, you can ask each group to consider a different disease or you can ask different groups to focus on different scales for the same disease. In either case, when you bring the class together to present their findings they will get a global picture of disease(s).
3. Locate, or have students locate, standardized incidence rates for this disease. You may have to contact your state health department, the World Health Organization and other

local, regional, or international resources on the Internet/WWW or through library resources.

4. Students use the data to construct a frequency distribution from high to low rates for their area or region.
5. Students then break the data into quantiles, standard deviations from the mean, or natural breaks and justify their design choice in a paragraph or two.
6. Ask students to map the data on the appropriate map.

Once these steps are completed, ask students to answer the following questions:

- What does your map say about the disease you have chosen? Is it localized, regional, global? Do different factors affect its spread in different places?
- Does it cluster or follow rivers? Is it clustered in urban areas or certain world regions? Why/why not?
- Does a clear pattern emerges? Why/why not?
- How might this pattern be related to the mobility changes or environmental features that helped you to choose this disease?

1 Disease Has a Changing Ecology

Student Worksheet 1.1 Name:

Activity 1.1 How's Your Health?

This is a short, in-class writing assignment to introduce you to health and disease. Use no more than a few minutes for each question to write a brief response. A class discussion will follow.

1. What do 'health' and 'disease' mean?

2. Do you consider yourself to be healthy? ___________ If yes, why? If no, why not?

3. Do you feel that you are at risk from anything that would make you unhealthy?

4. How does where you live, work, and play affect the risks to your health?

5. **Who is responsible for your health? Who should be?**

Student Worksheet 1.2 Name: ______________________

Activity 1.2: It Could Happen To You – Bringing Health Home

Your instructor will provide you with three short narratives. After each narrative, pause to answer the following questions, first individually, then as a group.

Narrative 1 Questions

A. Are John and Margaret poor? ______________________

B. Do John and Margaret fit the stereotypical victim of hunger? Explain.

____

____

____

C. How could their nutritional circumstances lead to further problems?

____

____

____

D. What geographic factors are important in this scenario? ______________________

____

____

____

E. Who is to blame for the couple's plight? ______________________

____

____

F. What aspects of global change affect the lives of John and Margaret?

____

Narrative 2 Questions:

A. Where might Ann have come in contact with a person with an active case of tuberculosis?

B. Why did Ann discount the possibility of exposure to this disease?

C. What stereotypes do you have regarding TB?

D. What geographic factors are important in this scenario?

E. What connections does Ann's disturbing news have with global change?

30

Narrative 3 Questions:

A. Is there a hidden threat in Emilio's workplace? ____________ If so, describe it:

____

____

B. What is the state of Emilio's health? ____

____

____

____

C. Are white collar workers immune from health risks in their workplace? Why or why not?

____

____

____

D. Identify as many geographic factors as you can that are important in this story.

____

____

____

E. How have global changes affected the state of health in Emilio's town?

____

____

____

____

F. Does Emilio have insurance? ____

____

____

G. How many Americans do you think have no health insurance (your best guess, very few, one-third, half, three-fourths)? ____

Student Worksheet 1.3 Name:

Activity 1.3 TinyTown

The data below are incidence rates of a hypothetical disease known as Yukilosis for the fictitious city of Tinytown. The incidence rate is the number of individuals affected by the disease per 100,000 people in that area.

Table 1: Incidence of Yukilosis in Tinytown

Location	Rate
A	4.6
B	2.7
C	3.4
D	6.1
E	1.2
F	1.9

Location	Rate
G	7.2
H	5.7
I	6.7
J	2.2
K	3.5
L	6.3

1. Using the data above, produce a frequency distribution of the incidence rates for Tinytown. Begin by dividing the range of data into classes of equal width. For example, if the range is from 1 to 24, you could divide the data into six classes of four units. Next, for each class, count the number of areas where the incidence rate falls within that range. For example, for the class of 0 to 1, there are 0 areas that have that incidence rate. Do this for each of the classes you have created. Prepare a frequency table on a separate piece of paper that contains your classes and the frequencies.

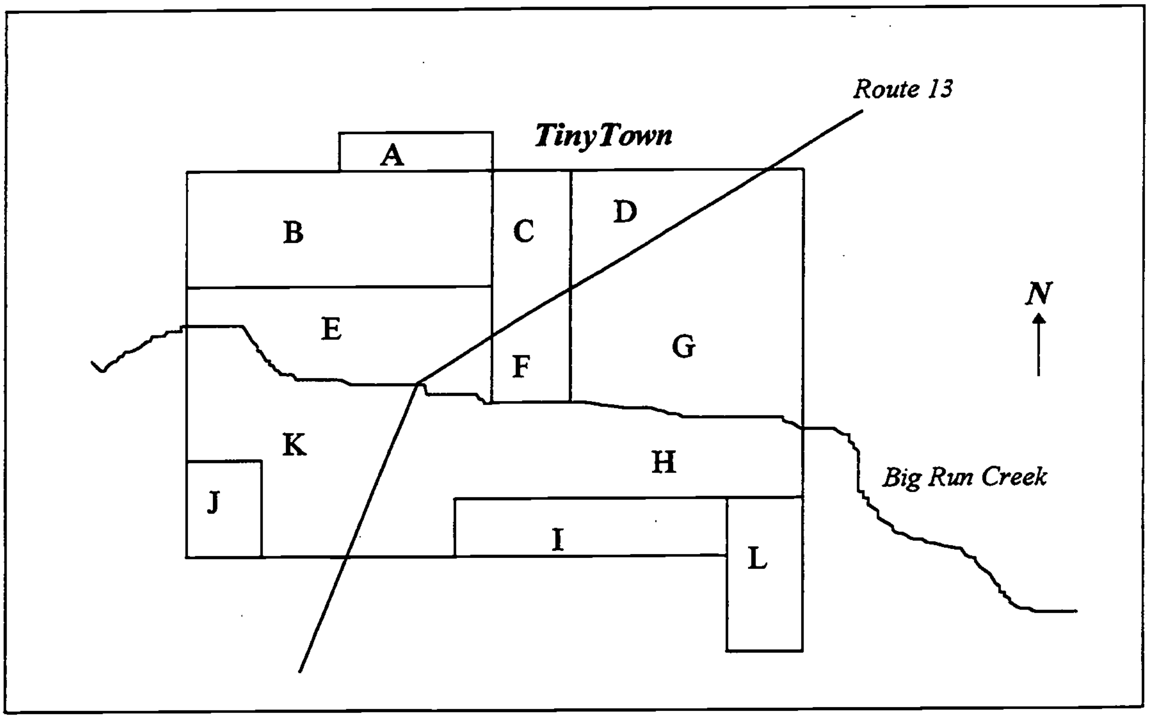
2. To map the data, begin by dividing the range of data into three or four categories based on natural "breaks" in the data or by **quantiles** (these may or may not be the same categories you used for the frequency distribution in #1). Justify the method you used for dividing the data.

3. Based on the three or four categories you just created, assign a color to each and shade the areas on the map in Figure 1 according to the category within which it falls. The highest categories should be shaded with the most intense color, and the lowest category with the lightest.

4. Finally, use your map to answer the following questions in the space provided below:

- What area of Tinytown has the highest rates of Yukilosis?
- Is Yukilosis clustered in a particular area?
- What impact did your choice of data categories have in depicting this pattern? In other words, if you had categorized the data differently, would you have gotten a different pattern?

Figure 1: Map of Tinytown



1 Disease Has a Changing Ecology

Answers to Activities

Activity 1.1 How's Your Health?

Students can provide many answers and reasons for the first two questions. The point of the questions is that people's perceptions of health and disease are different. Prompt students to explain why they do not feel at risk from some afflictions, yet are concerned about others. Ask them to consider not only infectious diseases, but also chronic disease, such as heart disease. Students should also consider nutritional deficiencies as causes of disease; psychosocial stress, bioclimatology, and environmental contamination as risks or stresses that may can affect their health; genetic susceptibility as a factor in disease development; and access to health services as a factor in health status. Examples of each of these are provided in the module text.

This activity also provides an opportunity for you to bring geography into the discussion. Many students will likely feel that they are not at risk to some health problems due to their location. Students in the United States may not feel at risk from dengue fever, but may mention heart attacks or cancer. You can broaden their concept of risk by suggesting its changing nature in light of global environmental changes (i.e., the shrinking space-time continuum, with airline travel speeding up the diffusion of disease and changing the areas in which a disease could be introduced). Dengue has occurred in the US -- on wagon trains heading west it was called "breakbone fever" -- and there is now an increased likelihood of dengue epidemics because it is again spreading in the Caribbean and because the Asian mosquito, *Aedes albopictus*, has been introduced and is spreading in the US (it survives cold better than other species and bites animals as well as people, so it can spread infection between them).

Concerning health responsibility, when students begin this exercise they are likely to think that they alone are responsible for their health. The discussion and the questions should help students begin to see the complexity of health and to realize that everyone cannot be responsible for her or his own health. Students should get a sense of community responsibility for health.

Activity 1.2 It Could Happen to You -- Bringing Health Home

A variety of responses are possible for the questions posed after each narrative in this activity. The following answers should be used only as a guide to assessing students' responses.

Narrative 1:

A. Yes, they are, in relative terms.

B. There are many stereotypes of victims of hunger, including that of a homeless person, an unemployed person, or a starving child from a lesser developed country. John and Margaret do not fit any of these stereotypes. They have a home and some form of income.

C. Any number of problems could arise from John and Margaret's nutritional circumstances. They could be susceptible to diseases like osteoporosis resulting from vitamin or mineral deficiencies, or they could be at risk of contracting influenza or pneumonia due to weakened immune systems.

D. John and Margaret live in an area that requires them to own an automobile and therefore they must spend some of their income for maintenance and insurance for the car. The fact that their daughter is unable to assist them because she lives in Tulsa illustrates the impact of increased mobility on the family unit and the health of family members.

E. Blame is a difficult and complex notion to assess, and in this case there are many factors that have produced John and Margaret's circumstances. They did not have savings adequate to support themselves during retirement. They do not have private medical insurance, most likely because John was self-employed and did not have the benefit of employer-assisted insurance programs. Social Security has proven to be inadequate to cover their costs of living, and in fact, the entire program may face bankruptcy early in the next century without some reforms. John and Margaret also do not have the "safety net" that has traditionally been provided by one's children and extended family. Their daughter lives several hundred miles away and is unaware of their situation.

F. One aspect of global change is the increasing mobility that has allowed John and Margaret to be separated from their family by several hundred miles. Another (which may not be global) is the growth of suburbs in the US where public transportation and other public support facilities may not be easily accessible.

Narrative 2

A. Ann could have contracted TB from a number of locations, including her office in New York City, her Connecticut suburban community, on an airplane to vacation locations, in London, in Miami, on her Caribbean Cruise, at her company health club, or any other place in which she often comes in contact with people, like the New York subway.

B. Ann's last statement makes it clear that she assumes TB to be a disease of the poor. She appears to believe that her wealth can keep her immune to the disease. Her surprise may also be explained by the fact that she makes an effort to keep herself healthy and fit by working out at the health club and by taking stress-relieving vacations around the world.

C. This question will depend entirely upon the student and may include some of the same stereotypes that Ann has (see above).

D. The key geographic factor is Ann's global travel, which exposes her to many different individuals, in many different locations. She also works and lives in a very densely populated urban location, where she comes in contact with many people on a daily basis.

E. This narrative illustrates the role of increasing mobility in the (re)emergence of infectious diseases, like tuberculosis.

Narrative 3

A. Yes there is a hidden threat at Emilio's workplace. It could be any number of things, but the narrative suggests that it may be carpal tunnel syndrome, a condition often affects the wrists of individuals who use computer terminals or who perform data entry for much of their workday.

B. Emilio may be in decent physical shape, but his mental health is deteriorating. He has become depressed from his job and his father's death and has turned to alcohol.

C. Yes. Emilio's last comment illustrates this notion of immunity. He believes that since he isn't doing hard physical labor or anything "dangerous" that his health may not be at risk.

D. Emilio lives in the Midwest, and from the description, we can assume that he lives in a small town or rural area. Urbanization has resulted in many job opportunities being relocated to urban areas; therefore, those in rural areas may find their career options somewhat limited, as Emilio did. Also, those living in rural areas or small towns may not have access to the bigger universities often found in larger cities.

E. As mentioned above, urbanization has resulted in the loss of job opportunities in rural areas. To make a living, people often find it necessary to migrate to the city. Those who do not move may find that the local economy is stagnant and their career and educational options limited. Emilio and his friends appear to be experiencing these effects, as they all are described as depressed, discouraged, living for the day, and abusing alcohol.

F. Because he is a part-time or temporary employee, Emilio most likely does not receive any employer-provided benefits like health insurance.

Activity 1.3 Disease Diffusion and Mapping

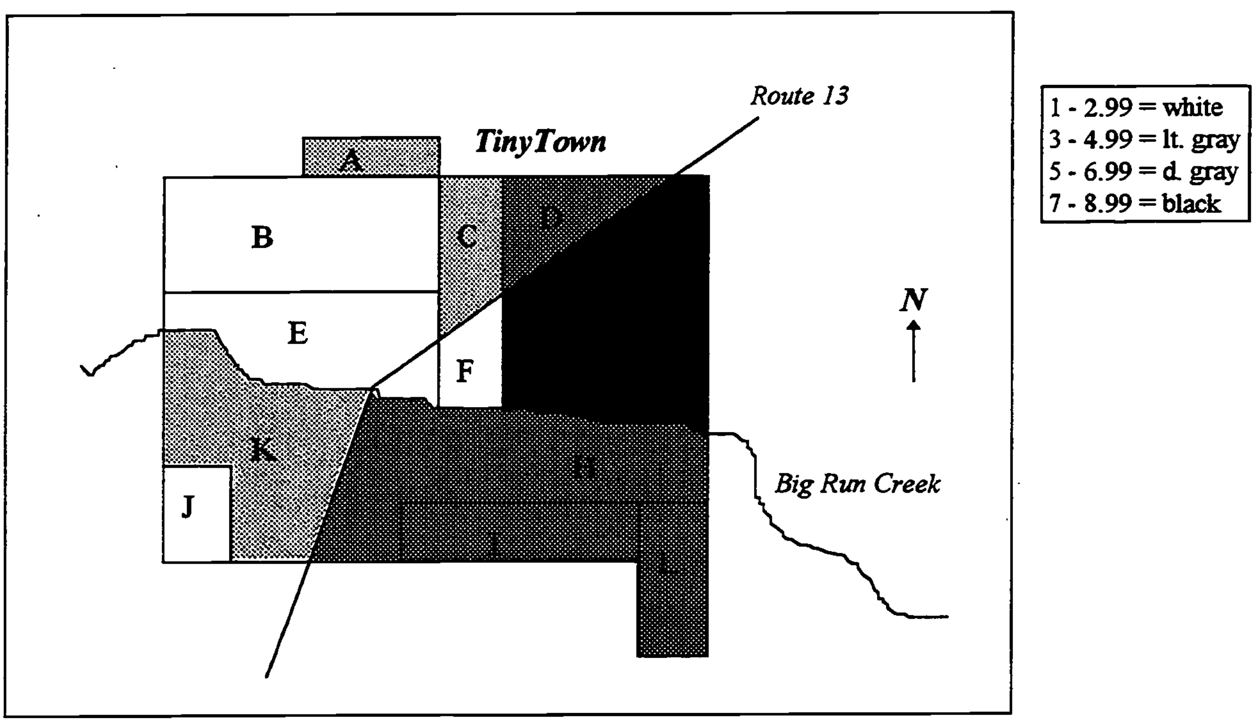
Part A:

1. Students should create a table similar to the one shown below. Note that the ranges they choose for their data classes may vary from this example.

Range	Frequency
1 - 2.99	4
3 - 4.99	3
5 - 6.99	4
7 - 7.99	1

2. The categories that students chose will vary. For simplicity, we have used the same categories as those listed for question #1.

3. Based on the four categories used in #1 and #2, and the color scheme on the right margin, the map would look like the following:



4. The area with the highest incidence rates is area G on the eastern part of the town, bordered by Route 13 to the north and Big Run Creek to the south. In general terms, Yukilosis is found in all parts of the town, but the highest rates appear mainly on the eastern part of the town. If different categories were used, we would see a somewhat different picture. For

example, the one area of highest incidence may have been subsumed under a different category, thus making the eastern portion more uniform. More detail could be shown if more categories with smaller ranges were used.

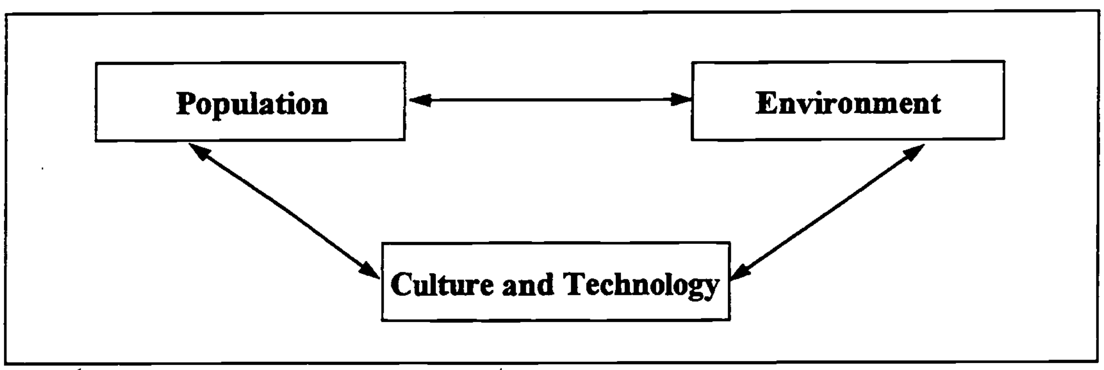
2 The State of Health: Interactions in Place

Background Information

Interacting Factors: Toward an Explanatory Framework

Figure 2 illustrates one of many explanatory framework for health and disease. In the sections that follow, we examine in more detail each of the factors in the framework.

Figure 2: An Explanatory Framework for Health and Disease



Population

As organisms, humans have different levels of nutritional or immunologic status, and different strengths and susceptibilities. When we consider biology, the first thing that usually comes to mind is genetics. Genetics is not so important in actually causing disease, which is rare, but rather in explaining genetic susceptibility (how resistant someone is to an infection or how severe her or his reaction is to a health risk). A person can be immune, that is, unable to contract a disease even when infected by the disease agent, because of the ability of the immune system to recognize the agent and destroy it. This may simply be due to previous exposures or it can be the result of genetic differences in enzymes and biological reactions. In fact, even individuals who are susceptible to developing a disease can have varying levels of resistance to it. That is, a person may contract a milder form of the disease because of good nutrition or because of a genetically given balance of enzymes and free elements in the bloodstream that affects the agent's proliferation. Gender and age are also important because these variables are associated with hormonal and other biochemical differences (e.g., different nutritional needs). For example, the major female reproductive hormone, estrogen, is implicated in protecting the cardiovascular system from cholesterol, promoting calcium metabolism and strong bones, and causing breast cancer. Dietary needs for iron, calcium, and other nutrients vary by gender and age.

The age structure of an entire population (the proportions of the population in the various age categories) is an important component. Over time, people accumulate different experiences and exposures as they play various age-dependent life roles. Age is often important in how one reacts to an infection or trauma. In most medical studies, data must be standardized for age differences because age is related to many factors that affect the incidence of disease.

Environment

Environment in the explanatory framework refers to a host of factors that are place-based and influence a person's risk of contracting a disease or becoming ill. These include place, scale, the natural environment, and the built environment. On a global scale the human habitat is the ecumene, the inhabitable world. When people think of habitat what often comes to mind is the natural environment: rainfall, forest and other land cover, plants and animals, soils and land forms, altitude, sun, and climate. It includes the composition of the breathable atmosphere, soils, and water resources. This natural world also includes organisms that can affect human health such as mosquitoes and ticks, viruses, **bacteria**, **protozoa**, and helminthic **parasites**.

Human habitat is more than the natural world, however. We also live within structures and landscapes that humans have constructed. Water and sewerage systems, transportation and communication infrastructure, and institutions such as hospitals and schools are all part of the human habitat. The social environment also contributes to the local habitat; it may contain danger; it may contain a sweat shop; it may contain good music on the radio or a good book; it may contain friends and relatives, or it may not. This whole habitat affects the population that lives within it. People may feel fear or love, for example, while itching from the detergent in their synthetic fiber shirt, breathing air from an automobile's exhaust, basking in the warm, light of spring, and slapping at the season's first mosquito.

Culture and Technology

Habitat conditions are largely created or modified by culture -- the beliefs, values, and organization of the population. Culture encompasses a range of values, such as those governing education, religion, attitudes toward the environment and technology, and even beliefs about disease causation. Culture is itself affected by habitat, most noticeably by perceptions of space and distance and by the varying experiences of different habitat conditions. Human behavior is greatly affected by culture and is the manifestation of economic constraints, social norms, political structures, and individual psychology.

Behavior mediated by culture exposes people (individuals, groups, populations) to some hazards or experiences and protects them from others. Therefore, our health is often related to the roles we play (i.e., as child or adult, man or woman, teacher or student, farmer, or executive) and the types of work or behavior associated with them. For example, weeding a vegetable field can expose an individual to pesticides; long hours of cleaning poultry or typing can encourage the development of **carpal tunnel syndrome**; and selling products in crowded market places can increase exposure to respiratory infections like tuberculosis. It is clear that who develops sicknesses from these experiences (i.e., mutated sperm, nerve damaged hands, or tuberculosis) depends in large part on who it is that does such things. Empowering women to go to school, to control their own reproduction, or to work in industries or the military, affects their exposure to or protection from various health hazards.

Culture is also an important factor to consider in addressing public health education and responses to disease. Cultural practices that may make a population more susceptible to certain illnesses need to be understood. Public health efforts need to reflect the cultural norms of the people at which they are aimed; otherwise, such efforts are likely to fail.

Finally, technologies are closely related to culture and have implications for human health. While damming a river to provide water for drinking and agricultural purposes may serve a public need, for example, it may also expose a population to water-related disease. The choice of technologies and the associated health risks can be highly dependent upon cultural context. For example, in France, nuclear energy is the primary source of electricity while in the US, coal burning is much more prevalent. One can argue that this difference reflects in part the different cultural contexts and the related opinions, beliefs, and values about technology, health, and risk.

Examples of Disease Ecology and Environment-Culture/Technology-Population Interactions

The three factors in the framework above are interrelated; none is entirely separate from the other. The best way to think of these interactions is with reference to a specific geographical context. At any particular place and time, demographic, environmental, social, cultural, and technological factors intersect in specific ways. In other words, it's probably not possible to determine which one of these factors is the most important. That can only be understood in terms of a specific place and incidence of disease. Even then, a range of primary, secondary, and tertiary interacting factors can probably be identified.

Before we conclude this section, let's consider two examples of disease ecology drawn from different conditions to illustrate these interactions. The first example concerns intestinal **parasites**. Young adult women in many developing countries have high rates of roundworm infection, but low rates of hookworm infection. In contrast, young adult males have high rates of hookworm infection but lower roundworm infection rates. Current male hookworm rates, however, are much lower than they were in previous generations, and in some places the parasite has disappeared. How can this be explained? Both intestinal worms pass their eggs through human defecation, but the transmission pathways to humans differ. Roundworms are transmitted to humans when dried fecal matter in dirt or dust containing roundworm eggs is ingested. Roundworm is thus considered a disease of the toilet and is often transmitted through handling small children. Even if women drink tea (boiled water) as a cultural buffer against water-borne infections and practice good hygiene, the dust-borne roundworm eggs are ingested by small children, deposited by them, and may contaminate the mother. Hookworm, in contrast, hatches from eggs deposited on the soil and the larvae have to survive various habitat conditions: sun, wetness, soil pH, vegetation, and being eaten by **arthropods**. The larvae are most likely to survive in shaded areas of fields, where, if stepped on, they penetrate the skin of the foot. The larvae is then transported by the blood to the lung, where it is coughed up into the mouth and swallowed. It then metamorphosizes in stomach acid into an adult that hooks on to the intestine and sucks blood, often causing **anemia**. Hookworm commonly infects young boys who herd goats or water buffalo in the fields. Since worms live for years, they accumulate and reach higher levels in young adult males. Young men today, however, have a potent new cultural buffer -- they are likely to wear thonged rubber soles (flip-flops) even if they can't afford shoes. This universally accessible rubber barrier has lowered infection rates around the world.

In a second example, the death rate of males in the US from cardiovascular disease has begun to decrease in recent years, after decades of increase that raised the degenerative disease to the number one cause of death. This is in part because American culture has begun to promote and pursue more healthy behavior. Millions of people have stopped smoking (although smoking rates are again up among teenagers), lowered their fat consumption, and many have even taken up jogging or other aerobic exercise. Mortality rates are responding to these behavior changes. Because access to information and health care resources tends to be greater among better educated and wealthier segments of the population, there is an increasing divergence of mortality rates by economic class.

The Demographic Transition

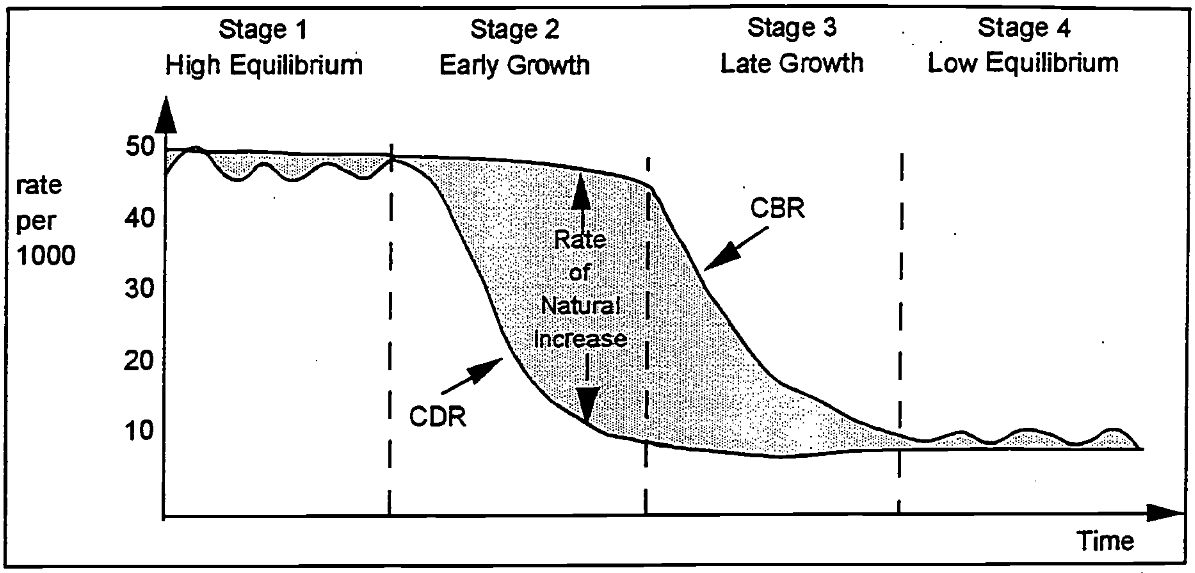
Exponential growth of the earth's human population is one of the driving forces of global change. At mid-century, the earth had a population of around two billion. It is now almost six billion. Depending on the assumptions made and the policies implemented, in 50 years the earth's population will grow to around nine or ten billion. Yet it is not just population growth, but the associated consumptive needs and wishes (the impact of culture and technology) that result in changes in land use, depletion of resources, increased energy consumption, shortage of housing, and sometimes social and political strife. In health terms, a decrease in deaths from infectious diseases, especially early childhood deaths, enables population totals to grow.

One theory that scientists and demographers have used to explain global population trends and regional population differences is the **demographic transition theory**. The theory is based on the historical experiences of Western, industrialized countries and describes the process of change from high birth and death rates to low birth and death rates related to increases in levels of economic development. As this process occurs, a similar transition occurs, known as the epidemiologic transition. The **epidemiologic transition theory** describes the changes in patterns of health and disease in a society associated with social, economic, and technological developments that occur during the demographic transition. Therefore, the demographic transition (and the associated epidemiologic transition) provides a useful framework for thinking about health and disease geographically. By examining changes in such factors as the causes of death, the age structure of the population, the number of children born, and the types and trends of mobility that occur in different areas, we can better understand world health patterns and global dynamics.

As mentioned earlier, the demographic transition is the transition from high birth and death rates to low birth and death rates. High birth and death rates, which the human race has experienced for millennia, are rates of over 40 per 1,000 people. That is, for every thousand people in a place, more than 40 die and more than 40 are born in a year. Low birth and death rates (about 20 per 1,000 people) are characteristic of the later stage of the transition. Because the demographic transition theory was developed based on the historical experiences of industrialized countries in Europe and North America, there is some disagreement about its applicability to contemporary, less-developed countries (LDCs). For example, some European countries took several centuries to complete the transition, while some LDCs are proceeding much more quickly. In addition, many European countries experienced a high level of economic growth as they went through the transition, a process that some LDCs have not always replicated.

From a theoretical perspective, these examples show that there are differences in how the transition proceeds and what causes changes in each population characteristic in different places. Although each place is different, the overall changes in population structure and dynamics that result can usually be predicted. Figure 3 below illustrates the demographic transition and the four general stages of the process. The following sections describe the four stages of the transition, with a specific focus on factors related to the health of a population within each stage.

Figure 3: The Demographic Transition



Source: Kuby, M. 1996. *Population growth, energy use, and pollution: Understanding the driving forces of global change*. Washington, DC: Association of American Geographers.

In Stage 1 of the transition, birth and death rates are high. The infant mortality rate is also high, with more than 200 per 1,000 infants dying in their first year of life. The causes of death are overwhelmingly infectious diseases, such as **dysentery**, **whooping cough**, and malaria. Another 20% or more of children commonly die before they reach school age. With couples typically having six or seven children (the total fertility rate), the age structure of the population is young. Up to half the population consists of children under 15 years of age. Only around 2% of the population is 65 or older.

During Stage 1, the mobility of the population is mostly limited to local "circulation," (i.e., movements that return home) such as short-distance trips for marketing, religious practices, or animal herding. Almost everyone dies within a few miles of where he or she was born. The only significant migration is at the time of marriage when, according to local cultural norms, either bride or groom move to the home community of their spouse.

As mortality from infectious disease is reduced, death rates begin to fall and the population moves into Stage 2 of the transition. Safe drinking water, sanitary removal of human waste, improved nutrition and food supply, better housing, protection against diseases transmitted by biting insects (such as screens for windows), and increased vaccinations help reduce death rates from infectious diseases. Birth rates stay high as couples continue to have six or seven children. As a consequence, the population grows through **natural increase** -- the difference between the birth and death rates (see Figure 3). As population pressure on the land and the need for jobs increases, the population's mobility changes. People begin to migrate to marginal agricultural lands or frontiers, to urban areas, and/or to international locations either permanently or as contracted wage labor.

In Stage 3, rural-to-urban migration continues, education and job opportunities for women increase, and consequently couples have fewer children. As birth rates fall, a smaller proportion of the population is composed of children. The population "ages." Degenerative diseases such as heart disease, stroke, cancer, or kidney failure become the predominant causes of death. Marginal agricultural lands may collapse with people moving to cities, but as the transition progresses and fertility falls, the rate of urbanization slows simply because the majority of the population has already migrated to cities. International migration gradually ceases, but circulation continues to increase in intensity, including the added international dimension of tourism and business travel.

The relationship between the decrease in birth rates in Stage 3 and literacy, urbanization, industrialization, child survival, and the provision of health care and family planning have been the subject of decades of social science research and recent international conferences (in Cairo, the World Population and Development Conference; in Beijing in 1995, the International Conference on Women). Many contentious issues surround the role of governments in promoting lower fertility rates and faster movement through the transition. In Cairo, the world consensus was that education should be extended to girls even in places where they are now not encouraged to go to school. However, women's control of their own reproductive health through access to contraception even without their husbands' knowledge was much more contested. Any such changes in education, economic activity, or the physiologic burden of pregnancy and childbirth would have profound impact of the health of women and children.

A population reaches the final stage of the transition when births rates fall into equilibrium with the low death rate. Death rates fall below 20 per 1,000 people overall, and infant mortality rates drop to less than 15 per 1,000 births. Most of the deaths in a population at this stage are older people and the predominant cause of death is degenerative diseases. The population structure has aged, with less than 20% under the age of 15 and more than 15% over 65 years of age. The population is also very urban. Instead of serving as a source of out-migration, the country now becomes the destination of in-migration from other countries in the growth stage of the transition. The population is mobile, and circulation for purposes such as recreation, tourism, and business is intense.

Population Mobility and the Demographic Transition

An important implication of the demographic transition for our purposes is the resulting change in population mobility and its effects on people's health. During the second stage of the demographic transition, migration has three distinct types of destinations. First, people move to the agricultural frontier as farmers search for new agricultural land. Migration up mountain slopes, deep into rainforests, and to the edges of the plowable grasslands can cause considerable environmental degradation and disrupt biological associations, exposing people to the infections of animals through the biting of various arthropod vectors and setting up concentrations of people within which infections can circulate.

Second, people migrate from fragmented rural farms to cities in search of work and opportunity. This brings susceptible people into large concentrations under settlement conditions conducive to contagious disease.

Finally, people migrating in search of jobs occurs increasingly on an international scale, with some moving permanently and others for shorter periods. Given that the more developed countries with older age structures need laborers and the less developed countries with younger age structures need jobs, it is not surprising that the greatest redistribution of global population in centuries is now under way. Each year millions of people migrate between countries. More than 100 million people (2% of the world's population) is living outside their country of birth. In addition, in 1995 there were more than 15 million international refugees. At the same time, the circulation of people from economically developed countries to Third World countries for business and recreation has exceeded 200 million. The technology of air transportation is especially important because it has nearly defeated the age-old social controls of **quarantine**. People today who become infected with a disease in one location can travel around the world, potentially exposing thousands along the way before they themselves even develop symptoms.

These changing patterns of human mobility expose susceptible people to new infections from ecological disturbance and environmental degradation. Important consequences are the emergence and rapid global diffusion of antibiotic-resistant strains of disease agents and the emergence of new disease agents from other animals and remote places. There is a growing need for long-range surveillance, laboratory capability, and epidemiological response even as we strive to develop new technologies to balance the global changes resulting from human-environment interactions.

Changing Mobility and Environmental Change

The health consequences that may result from global environmental changes are often considered in terms of the impacts to human settlements. In particular, the catastrophic movements of environmental refugees fleeing land degradation or even sea level rise will contribute to the already present housing difficulties for rural-urban migrants in the rapidly expanding cities. The inevitable results including lack of shelter, overcrowding, poor sanitation, poor diet, and malnutrition are clearly detrimental to health. The approach taken in this paragraph, however common, confuses two separate dimensions: population mobility and urban settlement as habitat. It also entirely neglects the important global process of urbanization itself.

As explained in Unit 1, the majority of the world's people will live in cities within a decade, and more than 60% will live in cities within 25 years. Several of these cities will have more than 20 million people each. Given the scale and pace of this development and the fact that most of the growth will occur in poorer countries, the built environment as a habitat for contagious disease takes on a new and frightening dimension. At the same time, the mobility of population continues to grow, adding another factor to the global health picture.

Table 2: Contagious, Mobility-Related Diseases (1993)

Disease	Deaths (in millions)	Incidence (in millions)
Acute Respiratory Infections	4.1	248
Tuberculosis (TB)	2.7	8.8
Measles	1.2	45
Hepatitis B	1.0	2.2
HIV/AIDS	0.7	2 to 3
Whooping cough	0.36	4.3
Bacterial meningitis	0.21	1.2

Source: Data extracted from L. Brown. 1996. *State of the world 1996.* Worldwatch Institute, Table 7-1. Data originally from World Health Organization. 1996. *The world health report 1995.*

The contagious diseases that spread in conditions of crowding and poor housing include **pneumonia**, whooping cough, **diphtheria**, measles, and tuberculosis (the plague of urbanizing 19th century Europe) (see Table 2). To this list we can add a relatively new disease, HIV/AIDS. Many squatter settlements once perceived by government bureaucrats as hopelessly disrupted and chaotic are now recognized as having viable structures of social organization. The people in such settlements usually respond to opportunities to improve their communities and to receive vaccination and medical care when they are offered. With the support of several agencies of the United Nations, governments have largely changed policy from "bulldozing the festering sores" to empowering communities to improve their built environment. Better construction materials, septic tanks, a safe water supply from a stand pipe, access to electricity, and cooking fuels are often provided. One reason for this growing support for slum improvement is that whatever diseases are spawned by conditions in the settlements will not remain contained within them. Rather than the conditions of urban housing and squatter communities themselves, we must also consider the global implications of the larger process they are embedded within -- global changes in mobility.

Global changes in population mobility are increasing the spread of many contagious diseases, and they are facilitating the introduction of new diseases into global mainstream circulation from isolated forest and agricultural regions. It is often said among disease ecologists that all ecological disruptions tip the balance between microbes and people in favor of the microbes, and that agricultural development and other land use changes are causing widespread disruptions. There are now many "emergent disease": AIDS, Ebola virus, hanta viruses, Lyme disease, Argentine **hemorrhagic fever** are just a few. In Unit 3 we look at one of these emergent diseases, HIV/AIDS, and some of the complex policy issues associated with it, including equity and access to resources. In the next two sections of this unit, we look at diseases related to changes in fresh water resources and how particular environmental changes, like climate change, urbanization, or changes in technology will affect the distribution and impact of these diseases.

Global Change and the Ecology of Water-Related Diseases

Water is essential to life. Humans can do without food far longer than they can do without water. We need both fresh water and salt to survive. We build our houses, villages, and cities next to and around water. Water enables life but it can also contain health risks, such as arthropod vectors, viruses, protozoa, and **helminths** that are parasitic upon humans, and other contaminants. In this section, we consider diseases associated with water resources and how they may be affected by global environmental change.

Table 3 lists several diseases that are associated with water resources and that pose some of the most serious health risks to human populations. Infectious diseases remain the leading cause of death in the world. They are the primary cause of infant and preschool age deaths. Diarrhea, which has many disease agents, is one of the two most important causes of death for those under five. The second, pulmonary infections in general and especially pneumonia, is also deadly to weakened individuals and the elderly. Diarrhea kills by dehydration. The diffusion in the past decade of a simple and affordable new technology, Oral Rehydration Therapy (ORT), has been successful in increasing survival from prolonged diarrhea in young children. ORT uses an inexpensive and readily available mixture of salt, sugar, and boiled water to stop dehydration. Nevertheless, even with increased child survival, the causes of diarrhea are so widespread, common, and varied that it continues to kill.

Table 3: Water-related Diseases (1993)

Disease	Deaths	Incidence
Diarrheal diseases	3.0 million	1.8 billion
Cholera	6,800	380,000
Polio	5,500	110,000
Malaria	2.0 million	300-500 million (prevalence)
Schistosomiasis	200,000	200 million (prevalence)
Yellow Fever	30,000	200,000
Dengue/ DHF	23,000	560,000
Japanese encephalitis	11,000	40,000

Source: Data extracted from L. Brown. 1996. *State of the world 1996*. Worldwatch Institute, Table 7-1. Data originally from World Health Organization. 1996. *The world health report 1995*.

With their municipal water and sewerage systems, developed countries may feel secure from typhoid and cholera, but intestinal viruses, bacteria, and protozoa pose an increasing hazard even to them. *Salmonella* and *Escherichia coli (e-coli)*, an ubiquitous intestinal bacterium, are developing antibiotic-resistant strains. Protozoa, such as *Cryptosporidium* from the intestinal tract of cattle and *Giardia*, often survive municipal chlorination unscathed and cause epidemics and mortality even in American cities.

There is another set of diseases associated with water. Many dangerous disease agents (viruses, bacteria, protozoa, even **helminths**) do not infect people by being ingested but by being injected by an **arthropod**. When an arthropod sucks blood from a person (a "blood meal"), it can pick up disease agents with the blood, and later when it sucks blood from another person, it can incidentally inject the agents into the host. Insects and other arthropods that transmit disease like this are called vectors. These insects are not just "mechanical" vectors, like a dirty finger, but rather are biological vectors because they are essential to the life cycle of the disease agents that grow and reproduce within them. Ticks, lice, fleas, and several species of biting flies are associated with the transmission of various diseases, but by far the most dangerous is the mosquito. Only a few of the tens of thousands of species of mosquito are involved in transmitting human disease, but they account for a lot of it. There are also a few diseases, most notably **schistosomiasis**, in which the disease agent has to spend part of its life cycle in another animal (termed an intermediate **host**) before again infecting humans.

There are concerns that global warming will expand the area in which vectored diseases can occur. It is true that a lessening of winter's severity might allow a species of mosquito, for example, to expand its range into new territory. In most cases, however, the arthropod is already present in that territory (in which the disease of concern does not occur) and the disease can currently be transmitted. The mosquito *Anopheles quadrimaculatus*, for example, is widespread in the US and is quite capable of transmitting malaria, as it did during the nineteenth century from Minnesota to Arizona. Changes in behavior and habitat eliminated malaria from most of the US before people even knew that a protozoa vectored by a mosquito caused it. These changes included building houses of brick, using glass or screen for windows, and developing new transportation technologies that shifted people away from canal and river water to railroads and planes. Mosquito habitats (e.g., wetlands) were fundamentally altered by human activity such as draining or filling for agricultural use. Under warmer conditions arthropods reproduce faster and hence take more frequent blood meals which could result in transmission to more people.

Future changes in impoundment and irrigation technologies, social organization, and/or the built environment are likely to be more important to the expansion of malaria than a few degrees of warming of the average global temperature *per se*. The impoundment of water behind dams to generate electric power or provide perennial irrigation creates open and stagnant bodies of water suitable for several species of *Anopheles*, the mosquitoes that vector malaria. If sea levels rise as a consequence of global climate change and tens of millions of people are displaced from deltas and river valleys, the mass migration of environmental refugees could introduce infections that any of them have to new populations of people and mosquitoes; enough social disruptions might enable malaria to spread to middle latitudes again as the cultural buffers (mosquito-proof housing or indoor water supply) break down. Mosquitoes that breed in containers like old tires or empty cans (e.g., *Aedes aegypti*, which transmits dengue fever, yellow fever, and many other arboviruses) or those that breed in sewerage-contaminated ditches and puddles (e.g., *Culex spp*., which transmits **filariasis** and some encephalitis viruses) will proliferate in disturbed conditions and refugee settlements.

The impact of global climate change on precipitation regimes and water availability is a much more important issue than warmer temperatures themselves. Any global changes in climate are likely to cause some areas on earth to become wetter and others to become drier than they are currently. Drier conditions will affect not only agriculture, but sanitation and hygiene. Wetter conditions will affect breeding areas for many arthropods, some of which vector human diseases.

The following classification of diseases into water-borne (and ingested), unwashed (those preventable by washing and hygiene), and water-based (and vectored) follows the approach of the World Health Organization's clean water programs in the 1980s and is used as a framework for the remaining sections in this unit. These diseases provide good examples of the possible effects of global environmental change on their distribution.

Table 4: Some Major Water-Related Diseases

Water-borne	Water-unwashed	Water-based
typhoid	intestinal worms	malaria
cholera	amebic dysentery	filariasis
hepatitis A	colds	mosquito-vectored arboviruses
E. coli	salmonella poisoning	river blindness (onchocerciasis)
polio	typhus (louse vectored)	schistosomiasis
cryptosporidium	plague (flea vectored)	
fertilizer indigestibility	pesticide contamination	heavy metal poisoning

Source: Adapted from United Nations Environment Programme. 1993. *Environmental Data Report 1993-1994*. Oxford: Blackwell Publishers, pp. 256-257.

Water-borne Diseases

Water-borne diseases are contracted by ingesting the disease agent. The potential is great for extensive epidemic spread of these types of diseases. The peak of infection in much of the world is during the dry season, when wells dry up and people concentrate around easily contaminated water sources. In some places, the arrival of the rainy season may wash animal and human waste into water supplies. Municipal water treatment (where available) is designed to prevent these diseases; but organisms resistant to chlorination, such as cryptosporidium or giardia, can continue to be a problem with extension of centralized water systems. In addition, the repeated treatment and passage of water through scores of plants and millions of people in its downriver course produces a concentration of contaminants of its own. Non-biotic chemicals can also cause death, as when nitrogen fertilizers interfere with digestion and produce toxic substances in infant intestines. Tetrachloride and other forms of chlorine linked to the chlorination of water have also been implicated as human carcinogens.

Water-unwashed Diseases

Water-unwashed diseases are those that can be prevented by hygiene and sanitation. People with abundant running hot and cold tap water and laundry facilities are rarely troubled by diseases vectored by fleas or lice. The worm eggs that can contaminate dust, money, fruit, and hands can be eliminated by frequent washing, especially before meals. Even several diseases generally associated with respiratory contagion, such as the common cold, are spread most commonly through contaminated materials and surfaces that contact the face through dirty hands. When wells are remote or dry and water is scarce, it is difficult to maintain bodily hygiene, especially for children. It can be almost impossible to get enough water to do laundry frequently or to wash floors or other dust-contaminated surfaces.

Water-based Diseases

Water-based diseases are, for the most part, vectored diseases in which the arthropod vector spends its larval stage in water. By far the largest class of these are the mosquito-borne diseases: protozoa-caused malaria, helminth-caused filariasis, and the numerous and deadly arthropod-borne viruses (**arboviruses**) such as **yellow fever**, **dengue fever**, **lassa fever**, **Rift Valley fever**, and all the place-associated types of **encephalitis**: Japanese, California, and Eastern equine, among others. Female mosquitoes, which do all of the people-biting, consume blood in association with making and laying eggs. They must do this in close proximity to a water source as mosquito larvae live in water. A wide variety of habitats can be involved; some species, for example, require clear water in shaded containers and others require large bodies of organically charged water in the sun. Since mosquitoes have a limited flight range, foci of infection are concentrated around water sites that are used for breeding. This is also true for the biting black flies whose larvae require flowing, oxygen-rich water in streams. River blindness (**onchocerciasis**) is caused by the microscopic larvae of the filarial worm (a helminth which lives in mated pairs under the skin), which wanders around near the surface of the body waiting for the fly vector (*Simulium damnosum*) to stick its proboscis in and suck them up. When these worms make their way to the eyes they cause lesions, scarification, and eventually blindness. Because the flies cannot go far from the streams where they are hatched and where they need to lay their own eggs, the disease has been named by its habitat.

Schistosomiasis, one of the most rapidly spreading serious diseases in the world, is not formally a vectored disease. The schistosome, a fluke (helminth) must spend a life stage inside a host snail. Since the snail does not inject anyone, it is not really a vector. The schistosome, which infests the veins around bladder or intestine, puts out prodigious amounts of eggs through a person's urine or feces into, usually, water. These hatch into a schistosome stage that seek out certain species of snails in which it multiplies and eventually metamorphosizes again. Breaking from the dead snail, the infectious form of the schistosome (called a cercaria) swims in search of a person and then penetrates directly through the skin into a new human host. The snail is an intermediate host, but the system of transmission can be modeled as though it were a vectored disease.

Finally, in industrialized countries, and increasingly in developing countries, changes in technology have introduced non-biotic contaminants into rivers, air, and soils. Heavy metals such as mercury, cadmium, and lead, which can persist in sediments and accumulate in the food chain, are the most important of these non-biotic contaminants. Long before the water "dies," the fish become unfit for consumption. In North America, such contaminants pose a health hazard from the Great Lakes to the everglades in Florida. Along with sewerage contamination and fertilizer-induced toxic algae "blooms," industrial pollution has caused not only lakes but estuaries, bays, and extensive offshore areas to be closed to fishing. In Eastern European countries of the former Soviet Union, industrial processes have polluted large areas and killed major rivers. These health hazards are spreading to newly industrializing areas that have seen much success in the global economy, especially southeastern China, where agricultural chemicals and industrial poisons have become greater health hazards in the rice paddy than mosquitoes or snails.

These water-related diseases are especially susceptible to global changes in climate, land cover, and water supply. Extension of irrigation usually expands the territory of schistosomiasis as well as diseases (e.g., encephalitis and filariasis) vectored by mosquitoes that like slow, nutrient-rich irrigation waters. Building reservoirs behind dams creates ideal breeding conditions for the *Anopheles* mosquitoes that transmit malaria. Deforestation from either commercial logging or agricultural clearing (as part of the mobility transition) removes the trees and their roots that break the fall of the rain and allow it to seep down and recharge the ground water. Without this living sponge, hard tropical rains run off, eroding soil and gathering into sheet wash that turns even normal rainfall amounts into river floodwaters. The flood backwaters often result in outbreaks of mosquito-borne arboviruses. At the same time, in areas where the rainfall fails to soak in, wells may dry up, local droughts sometimes result, and water-borne and water-unwashed diseases can become epidemic. In urban areas, the concentration of rural-urban migrants in squatter settlements without services creates great public health hazards. People forced to live in these settlements are at great risk of contracting water-borne infections and possibly spreading these infections throughout the city. In developed countries, on the other hand, the level of industrial contamination can cause municipalities to truck in water for consumption. As world population becomes more concentrated and urbanized, agricultural production becomes more intensive, and climatic change affects the abundance and distribution of water, water-related diseases are likely to pose serious threats to human health.

2 The State of Health: Interactions in Place

Instructor's Guide to Activities

Goal

The activities in Unit 2 are designed to provide students with a basic understanding of the ways that population, culture/technology, and environment interact to produce states of health or disease. Specifically, students become aware of the links among health and the following factors: the demographic and epidemiologic transitions; migration and mobility; geographic location; and water pollution and water scarcity. Students also learn about disease and the agencies and efforts that exist to address health concerns in their local community.

Learning Outcomes

After completing the activities associated with this unit, students should be able to:

- identify relationships among various factors that contribute to the state of health;
- use and understand various forms of demographic data, including birth and death rates, fertility rates, mortality rates, and population pyramids;
- understand the demographic and epidemiologic transition and their connection to patterns of health and disease;
- create death pyramids from mortality statistics and understand of how age and gender affect causes of death;
- create basic choropleth maps and assess patterns within them;
- identify and map the geographic extent of a disease and relate this distribution to the environment and potential environmental changes;
- produce and present an effective poster illustrating research conducted in a group; and
- identify and map routes of international migration and link these to the spread of disease.

Choice of Activities

It is neither necessary nor feasible in most cases to complete all activities in each unit. Select those that are most appropriate for your classroom setting and that cover a range of activity types, skills, genres of reading materials, writing assignments, and other activity outcomes. This unit contains the following activities:

2.1 Frames of Reference: Thinking About Disease in a Place	-- Text comprehension, concept mapping, and group discussion
2.2 Demographics and Disease	-- Data collection and interpretation; construction of death pyramids
2.3 Pollution, Water, and Disease	-- Analysis of water pollution data, choropleth mapping, and pattern analysis

2.4 Water Scarcity? Water-washed Diseases	-- Group research and discussion of a disease, basic mapping, group presentation
2.5 Don't Drink the Water: Health, Water, and Your Community	-- Research and participation in local health-related activities, audience-specific writing
2.6 The Agricultural Frontier: Transformation of Landscape and Transformation of Health	-- Text comprehension, group research, and poster presentation
2.7 Migration and Disease: *New Guinea Tape Worms and Jewish Grandmothers*	-- Text comprehension, group discussion, and basic mapping of migration patterns

Suggested Readings

The following readings accompany the activities for this unit. Choose those readings most appropriate for the activities you select and those most adequate for the skill level of your students.

- Unit 2: The State of Health: Interactions In Place (provided)
  The background information to Unit 2 that all students should read.
- Desowitz, Robert. 1981. On New Guinea tape worms and Jewish grandmothers. *New Guinea tape worms and Jewish grandmothers*. New York, NY: W.W. Norton, pp. 36-45. (provided)
  Reading to accompany Activity 2.7
- Hall, Bob and Mary Lee Kerr. 1993. 1991-1992 Green Index: A state-by-state guide to the nation's environmental health. Washington, DC: Island Press, pp. 27-41. (provided)
  Reading on water pollution, including data sets, to accompany Activity 2.3
- Hillerman, Tony. 1973. We all fall down. *The great Taos bank robbery and other Indian Country affairs*. Albuquerque, NM: University of New Mexico Press, pp. 26-40.
  Reading to accompany Activity 2.1
- Jones, Huw. 1990. Population geography. New York, NY: Guilford Press, pp. 18-27, 96-99.
  Reading to accompany Activity 2.2. Includes discussion of demographic transition, measures of mortality, and measures of fertility.
- Martin, Philip and Jonas Widgren. 1996. International migration: A global challenge. *Population Bulletin* 51, 1 (April): 2-47.
  Reading to accompany Activity 2.6 and 2.7.
- Meade, Melinda. 1980. The rise and demise of malaria: Some reflections on southern landscapes. *Southeastern Geographer* 20: 77-99.
  Reading to accompany Activity 2.6
- Omran, Abdel. 1982. Epidemiologic transition. In J. Ross, ed. *The international encylopedia of population*. New York, NY: The Free Press, pp. 172-183.
  Reading to accompany Activity 2.2 that defines the epidemiologic transition.
- Ross, J., ed. 1982. Epidemiologic transition. *International encylopedia of population*. New York, NY: The Free Press, pp. 172-183.
- United Nations Environment Programme. 1993. Human health. *Environmental data report 1993-94*. Oxford: Blackwell Publishers, Part 5, pp. 231-270.

Data and Map Sources

- Goldman, Benjamin. 1992. *The truth about where you live: An atlas for action on toxins and mortality*. New York, NY: Times Books/Random House.
  A source of maps for students to use for the comparison exercise in Activity 2.3.
- Mason, Thomas and Frank McKay. 1974. *US cancer mortality by county: 1950-1969*. Washington, DC: US Government Printing Office.
  A source of maps for students to use for the comparison exercise in Activity 2.3.
- McKay, Frank, Margot Hanson, and Robert Miller. 1982. *Cancer mortality in the United States, 1950-1979*. Bethesda, MD: US Department of Health and Human Services, National Institutes of Health, and National Cancer Institute.
  A source of maps for students to use for the comparison exercise in Activity 2.3.
- Population Reference Bureau. 1996. 1996 Population Data Sheet of the Population Reference Bureau. Washington, DC: Population Reference Bureau.
  Data needed for Activity 2.2, Part A.
- United Nations Environment Programme. 1993. Table 4.3 Demographic data for selected countries and major world regions, around 1950 and 1990. Environmental Data Report 1993-94. Oxford: Blackwell Publishers, pp. 216-220. (provided)
  Data needed for Activity 2.2., Part A.
- US Department of Health and Human Services. 1994. Table 8-5. Deaths from 72 selected causes, by 5-year age groups, race, and sex: United States, 1990. *Vital Statistics of the United States 1990*. Volume II -- Mortality. Part B. Hyattsville, MD: Center for Disease Control and Prevention and National Center for Health Statistics, pp. 176-201. (provided)
  Data needed for Activity 2.2, Part B.
- US Department of Health and Human Services. 1981. *An atlas of mortality from selected diseases*. Bethesda, MD: National Institutes of Health.
  A source of maps for students to use for the comparison exercise in Activity 2.3.

Activity 2.1 Frames of Reference -- Thinking About Disease in a Place

Goal
Students use the conceptual framework (environment - population - technology - culture) to think about chains of explanation and relationships among various factors that contribute to the state of health.

Skills
- ✓ critical reading
- ✓ mapping
- ✓ abstract thinking with graphical expression
- ✓ group discussion
- ✓ post-activity reflection (re-learning)

Material Requirements

- Suggested reading: Hillerman (1973)
- Map of New Mexico showing general physiography, major highways, and towns/cities

Time Requirements

One class period (50 minutes), with the reading assigned as homework to be read before class

Tasks

Assign the suggested reading "We all fall down" by Hillerman (1973) as homework for students to gain an understanding of the propagation of an infectious vector-related disease in a real time and place. As they read the narrative, students should consult the map of the area. As part of the homework assignment, ask students to draw their own sketch map of the area, pinpointing the places discussed and linking them with arrows to get a feel for the geography of the outbreaks.

In the next class period, review the basic framework identified in Unit 2 and ask students to make a list of terms/factors they feel are important concepts that help to explain/understand the spread of any infectious disease (including, but not limited to the disease in the suggested reading).

Using their list, students sketch a diagram, flow chart, or concept map that links the factors and illustrates their interconnectivity. Students should consider which factors are most significant and which are secondary or tertiary factors.

After they have created their own diagrams, divide students into small groups of three to five students to share and discuss their concept maps and to learn how others thought about the concepts and their relationships. Discuss with them (with links to the article) why their concept maps help provide an understanding of the outbreak of bubonic plague in northern New Mexico, as well as how they might help provide an understanding of outbreaks of other diseases in other places. Ask students to arrive at a consensus concept map within their group, redraw it, and prepare to share it with the class. You can ask students to draw their consensus concept maps on the board or on a transparency. Ask each group to explain the reasoning behind their consensus maps and to describe which points were most difficult to agree on. Finally, ask them to reflect for a moment on what they have learned about perspectives on human health and disease in a geographic context.

Activity 2.2 Demographics and Disease

Goals

Students understand the demographic factors in patterns of health and disease. In Part A, students apply their understanding of the demographic transition to countries in different world regions. In Part B, students construct death pyramids for an infectious disease, a degenerative disease, and a violent cause of death to understand better how causes of death are related to age and gender.

Skills

- ✓ data collection and interpretation
- ✓ group discussion
- ✓ representation of statistical information in graphic form
- ✓ interpretation of graphical materials

Material Requirements

- *Student Worksheet 2.2* (provided)
- The Population Sheet of the Population Reference Bureau (annual), United Nation *Demographic Year Book*, or any other source that contains birth rates and death rates by country.
- Vital statistics by cause of death and by sex and age (e.g., United States Department of Health and Human Services: *1990 Vital Statistics of the United States vol. 2. Mortality part B*)
- Optional reading: Ross (1982)

Time Requirements

This activity works well as a homework assignment. Allow one to two days for students to locate the necessary data and to complete the worksheet. If done in class, allow 30-45 minutes for each part (assuming you provide the data sources).

Tasks

Part A: The Demographic Transition
Encourage students to reread the section of Unit 2 on the demographic transition and to identify the key features associated with each stage. Students then look up birth and death rates for ten countries from different world regions and determine where in the demographic transition these countries are located.

Students are also introduced to population pyramids and answer several short questions based on a diagram of four pyramids illustrating different stages of the demographic transition.[3] This brief introduction should help them complete Part B, in which they construct graphs similar to the population pyramids.

Part B: Death Pyramids
Students locate data on causes of death by sex and age in the United States. You can modify this activity to include any country or region you wish so that students can see some geographic variation in causes of death. From this data, students select one infectious disease, one violent cause of death, and one degenerative disease and create population (death) pyramids using the worksheet provided. If students are familiar with standard PC spreadsheet software, they can use

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[3] This activity on population pyramids has been adapted from a similar activity found in the *Population Growth, Energy Use, and Pollution* module in this series (Kuby 1996).

these programs to create the pyramids instead. Students will also answer several questions on the worksheet to help them interpret the pyramids.

Activity 2.3 Pollution, Water, and Disease

Goals

Students make connections between the geographic distribution of water pollution and the distribution of other forms of disease like cancer. They map three data sets for water pollution and compare these maps to those that depict mortality rates or incidence of cancer.

Skills

- ✓ data interpretation
- ✓ data representation
- ✓ choropleth mapping of water pollution
- ✓ theoretical supposition or hypothesis generation
- ✓ pattern analysis and hypothesis refinement

Material Requirements

- *Student Worksheet 2.3*
- Selected reading: Hall and Lee (1993) (provided)
- A blank map of the United States (you can use the US map found in *Supporting Material 1.3* or you may wish to find one that has major US rivers on it; students will need at least three copies)
- One or more of the following (or similar) map sources:
  - Goldman, Benjamin. 1992. *The truth about where you live: An atlas for action on toxins and mortality*. New York, NY: Times Books/Random House.
  - Mason, Thomas and Frank McKay. 1974. *US cancer mortality by county: 1950-1969*. Washington, DC: US Government Printing Office.
  - McKay, Frank, Margot Hanson, and Robert Miller. 1982. *Cancer mortality in the United States, 1950-1979*. Bethesda, MD: US Department of Health and Human Services, National Institutes of Health, and National Cancer Institute.
  - US Department of Health and Human Services. 1981. *An atlas of mortality from selected diseases*. Bethesda, MD: National Institutes of Health.

Time Requirements

One class period (50 minutes) to get students started on the activity. Allow additional time before class for students to read the suggested reading, and additional time after class for students to complete their maps and answer the written questions.

Tasks

Students begin the activity by reading the suggested reading by Hall and Kerr (1993) and by reviewing the data set that accompanies the reading. Students will then create three choropleth maps using the following variables from the data set: (1) *Summary for 9 Toxic Indicators*; (2) *Pesticide Contaminated Water*; and (3) *Composite Water Pollution.*

From the maps, students generate hypotheses that link the patterns they find to cancers and other illnesses. Students use existing data sources from the library (cancer atlases or mortality atlases for the US suggested above) to assess whether the patterns that exist match what they expected to find based upon their water pollution maps. Students also consider the difficulties associated with using aggregate data to draw conclusions about individual-level incidence of cancers and other illnesses.

Activity 2.4 Water scarcity? Water-washed diseases.

Goal
Students research a disease related to water scarcity and determine its current geographic extent and its potential geographic extent resulting from global changes.

Skills
- ✓ analytical thinking
- ✓ group discussion
- ✓ data collection
- ✓ Internet/WWW research (optional)

Material Requirements
- *Student Worksheet 2.4* (provided)
- library databases/resources
- access to the Internet/WWW (see *Appendix C* for suggested sites) (optional)
- world map (provided in *Supporting Material 1.3*)

Time Requirements
Ten minutes to introduce activity and an additional one-half class period (25-30 minutes) for students to present their findings to the class; allow students at least two to three days for research outside of class.

Tasks:
Divide students into groups of three to six people and ask them to identify and research a disease that is prevalent where or when there is a scarcity of water. Suggest that they use the background information, suggested readings, the WWW, or other library sources to identify the disease, to answer the questions on the worksheet, and to map its geographic extent.

The questions students will consider include:

1. Why is this disease prevalent when there is a scarcity of water and what are the specifics of this relationship?

2. Where does this disease usually occur in the world? On the blank world map, draw the usual geographic extent of the disease using a solid black line.

3. What conditions contribute to or trigger this disease's geographic expansion or movement? Are any of these conditions subject to or threatened by global environmental changes? If so, how might the disease's geographic extent change? On the blank world map, draw the extended geographic extent of the disease with a dotted black line.

After students have completed the activity, they will make brief (three to five minute) presentations to the class of their findings.

Activity 2.5 Don't Drink the Water: Health, Water, and Your Community

Goal
Students investigate a local water-related health issue (role playing as a member of a local neighborhood or civic association) to determine the extent of the problem, the people at risk, and the organizations and efforts in place to address the problem.

Skills
- ✓ data collection
- ✓ critical thinking
- ✓ analysis of biases (including personal)
- ✓ interviewing techniques
- ✓ telephone courtesy
- ✓ persistence and time management
- ✓ field exploration
- ✓ writing to a target audience

Material Requirements
- *Student Worksheet 2.5* (provided)
- local newspapers (Part A)
- telephone (Part B)
- notebook and pen
- tape recorder (optional)
- written permission petitions for interview purposes (optional)

Time Requirements
Three to four days outside of class (Part A only)
10-14 days outside of class (Parts A and B)

Tasks
This activity is divided into two parts. You may choose to use only Part A if time is limited or to use both parts as one large activity. Part A contains a written assignment of two-three pages, and Part B contains a written assignment of three to four pages. If you choose to do both parts of the activity, the assignments can be combined into one report of about four to six pages.

Part A
In this part of the activity, students act as members of a neighborhood or civic association. They identify through local sources, a water-related health problem in their community, a nearby city, or region, and prepare a two- to three-page report to the members of their organization that addresses the following questions:

1. How is this a water-related health problem?
2. Does this health problem pose a greater risk to certain segments of the community? In other words, are any groups of people more vulnerable than others?
3. What groups, agencies, and organizations are concerned about this problem?
4. Why do they think it is a problem?
5. What groups think it is a less pressing issue? What is their reasoning?
6. What are these groups doing to address this issue (generally)?
7. Are these local groups or do these groups have extra-local or broader support?
8. For each group, agency, or organization you mention, provide an address and telephone number if they are available.

Part B
Students contact at least one of the agencies working to address the health issue considered in Part A and find out more about what that group is doing. For example, are there organizational meetings, newsletters, petitions, data publications, WWW sites? If so, students are asked to participate in two of these activities. They can join the mailing list, go to a meeting, request data from them, or download their web site information. At least one of the activities they choose must involve speaking with another person about the organization and its activities concerning this health issue.

Students should take detailed field notes on their interaction with people on the telephone or at the meetings and be as specific as possible about what happened during those interactions and how they felt about these activities. Was it hard to reach people? Were they wearing suits or birkenstocks? Did the student agree or disagree with their position on the health issue?

From their field notes, students will write a three- to four-page report that outlines their assessment of the organization's efforts in addressing the health issue. You should encourage students' opinions in this writing assignment. Students should comment on their own role with respect to this issue. Is this merely a local issue or does it involve larger-scale organizations (e.g.

the state, multinational corporations) Students should explain what sides of the issue they find themselves on and how they see themselves becoming involved to address this problem.

Activity 2.6 The Agricultural Frontier: Transformation of Landscape and Transformation of Health

Goal

Students research an area of the world where migration to the agricultural frontier is occurring and examine the links among migration, health, and environmental and social change in this area.

Skills

- ✓ data collection
- ✓ analytical thinking
- ✓ graphic display and presentation
- ✓ group learning and communication
- ✓ writing skills

Material Requirements

- *Student Worksheet 2.6* (provided)
- Suggested reading: Meade (1980)
- Suggested reading: Martin and Widgren (1986) (provided; also used in Activity 2.7)
- additional journal articles on agricultural migration and health selected at instructor's discretion

Time Requirements

A minimum of 18 to 21 days outside of class; allow one class period (50 minutes) for the poster session

Task

Divide students into groups of two to four people and ask them to locate an area of the world where migration to the agricultural frontier is occurring. Students can use the suggested readings or their own research to identify such an area. If students have difficulty, suggest one of the following: transmigration in Indonesia from Java to the Outer Islands; Latin American agricultural migration from the altiplano to the Amazon Basin; or farm migration within the United States. In groups, students design and implement a research plan to find out:

- What diseases occur in that area?
- What are the characteristics of the migration stream into that area (how many people are moving to the area)?
- What diseases or health conditions do people bring with them and what diseases will people be newly exposed to?
- Are there any changes occurring with migration, urbanization, or changes in technology (i.e., land degradation, changes in water use, changes in land cover and land use, changes in infrastructure)?
- What are some of the health consequences of these environmental and social changes? What public health services are provided there?

Students then present their findings in poster format. Encourage them to be as creative as they wish. During a designated class period, hold a poster session to display the groups' research findings and invite other students and faculty to attend.

Activity 2.7 Migration and Disease: *New Guinea Tape Worms and Jewish Grandmothers*[4]

Goal
Students understand the impacts of culture, socio-economic conditions, and international migration on human health.

Skills
- ✓ analytical thinking
- ✓ representation of migration patterns at the global scale
- ✓ application of previous knowledge and introductory concepts
- ✓ group discussion

Material Requirements
- Suggested reading: Martin and Widgren (1996) (also used in Activity 2.6)
- Suggested reading: Desowitz (1981) (provided)
- world map (provided in *Supporting Material 1.3*)
- additional readings on migration and health consequences selected at instructor's discretion

Time Requirements
One class period (50 minutes); assign the suggested readings several days before class

Tasks
Assign students the suggested readings (and any others that the instructor feels necessary). When students come to class, divide them into small groups of four to eight people depending on your class size. Give each group a blank world map (*Supporting Material 1.3*), and ask them to draw lines on the map that illustrate international migration.

While in groups, prompt the students to discuss the readings and to use the map to assess the various demographic, occupational, and cultural characteristics of different migrating populations. Suggest that they begin with a rural villager in a country of choice and the prevalent disease conditions at his or her point of origin, and follow them through international migration patterns to a destination work country. Describe which diseases people were exposed to at home, from other travelers, and at the destination locale. What might they transmit, receive or bring home? Compare different migration and health profiles.

[4] Title taken from: Desowitz, Robert S. 1981 *New Guinea Tape Worms and Jewish Grandmothers.* New York: W.W. Norton.

2 The State of Health: Interactions in Place

Student Worksheet 2.1

Activity 2.1 Frames of Reference: Thinking About Disease in a Place

Begin this activity by reading the chapter from Hillerman (1973). As you read the narrative, consult the map of the area provided by your instructor and draw your own sketch map of the area of focus. Pinpoint the places discussed and link them with arrows to get a feel for the geography of the outbreaks.

In the next class period, make a list of terms or factors that you feel are important in explaining or understanding the spread of any infectious disease (including, but not limited to bubonic plague).

Using this list, sketch a diagram, flow chart, or concept map that links these factors and illustrates their interconnectivity. Consider which factors are most significant and which are secondary or tertiary.

After you've finished your diagram, team up with several of your classmates and discuss your concept maps. Focus on how others in your group thought about the concepts and their interrelationships. Together, arrive at a consensus concept map within your group and draw it on an overhead transparency or on the chalkboard. Be prepared to discuss your concept map with the class, including your reasoning behind it and the points that were difficult to come to agreement on.

Student Worksheet 2.2 Name:

Activity 2.2 Demographics and Disease

Part A: The Demographic Transition

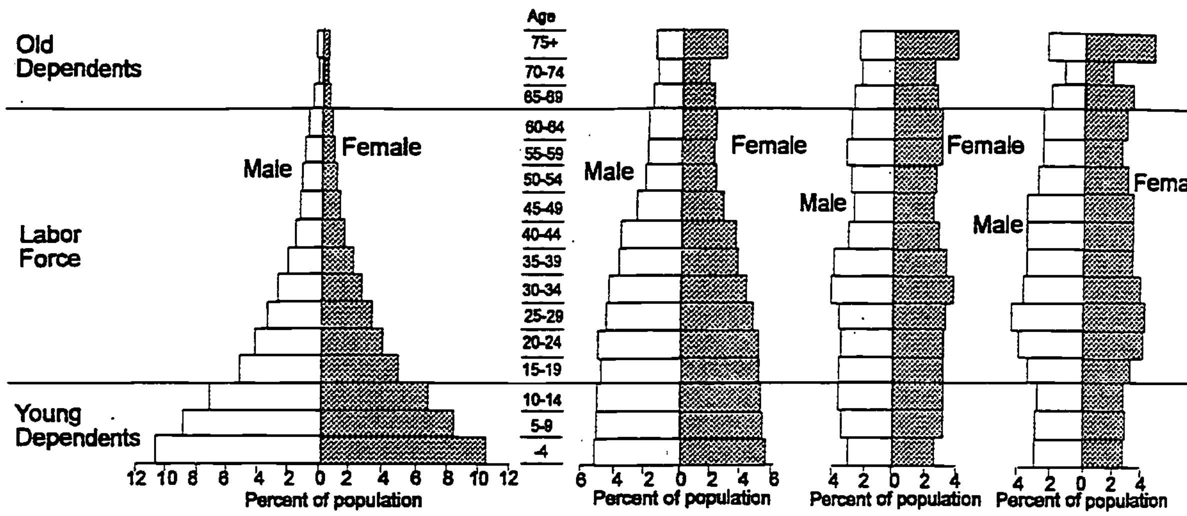
In this part of the activity, you will research ten countries and determine what stage of the demographic transition they are in. Review the sections in the Background Information for Unit 2 on the demographic transition and identify the variables you need to know to determine what stage a country is in. Your instructor will provide you with data sources or suggest how you can find the data on your own. With the data you collect, complete the table below. Be sure to fill in the name of each variable you used to make your decision.

Table 5: Ten Countries and the Demographic Transition

Country	Variable 1	Variable 2	Variable 3	Variable 4	Variable 5	Stage of Transition

Next you will learn a little about a common way to display population data -- the population pyramid. Population pyramids tell us a lot about whether or not a population is growing, and how fast or how slow it is doing so. The population pyramid is a two-sided bar chart showing the number of people in a population within each age group, by sex. The horizontal axis measures numbers of people (usually as a percentage of the total population) and the vertical axis measures age. Figure 4 below illustrates four different population pyramids. Based on what you know about the demographic transition, answer the questions that follow.

Figure 4: Population Pyramids



Source: Adapted from Fellman, J. A. Getis, and J. Getis. 1995. *Human Geography: Landscapes of human activities*, 104. 4th ed. Dubuque, IA: William C. Brown. Reprinted with the permission of the William C. Brown Times Mirror Company.

1. Which population do you think is:

growing slowly? _______________ declining? _______________

growing rapidly? _______________ stable? _______________

2. How can you tell?

____

____

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Part B: Death Pyramids

In this part of the activity, you will research the number of deaths by age and sex for three different causes of death in the United States. Select one infectious disease, one degenerative disease, and one violent cause of death. Your instructor will provide you with data sources or with information on how you can find the data on your own.

Using the data you find, create three death pyramids on the blank graphs provided below. If you are familiar with standard PC spreadsheet software, you can use these programs to create your pyramids instead. If you use the graphs below, be sure to fill in the age group categories, add a scale to the bottom indicating the number of deaths, and draw in the horizontal bars that make up the pyramids. Your pyramids will resemble the population pyramids you saw in Part A of this activity.

Pyramid #1: An Infectious Disease: ______________________________

Age	Male	Female

Pyramid #2: A Degenerative Disease: ____________________

Age	Male	Female

Pyramid #3: A Violent Cause of Death: ____________________

Age	Male	Female

Based on the pyramids you created, answer the following questions:

3. Which age and sex groups are most affected by each disease?

	Age Group	Sex Group
Infectious:	________	________
Violent:	________	________
Degenerative:	________	________

4. What are some of the similarities and differences in your pyramids?

____

____

____

____

____

5. What might explain these similarities or differences?

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Student Worksheet 2.3

Activity 2.3 Pollution, Water, and Disease

In this activity, you will examine water pollution data in the US and create several maps to illustrate the geographic distribution of this pollution. Using your maps, you will be able to make some general hypotheses about the relationship between water pollution and the distribution of cancer and other forms of disease. Before you begin this activity, be sure to read Hall and Lee (1993) and look over the accompanying data sets. Then follow the steps below:

1. From the data sets provided in the reading, select the following three variables for your map: Summary for 9 Toxic Indicators; Pesticide Contaminated Groundwater; and Composite Water Pollution (use the "rank" values, not the "scores"). These three data sets are actually rankings of the 50 states, with 50 being the highest ranking and 1 being the lowest.

2. For each data set, divide the data into four groups (quartiles), each representing one-quarter of the 50 ranks. For example, one group will represent the highest 25% of the states (ranks 50 through ~38), the second group will represent the next lowest 25% of the states, and so on. Assign a color to each of the four groups that you will use on your maps. It is common to use a darker color for the higher groups and a lighter color for the lower groups. Do this for each of the three data sets. To be consistent, the color or shade you use for the highest group on one map should be the same for each map. This will allow you to compare them more easily.

3. You will now create three choropleth maps using the blank US maps provided by your instructor. Give each map a title based on the data set it represents. Shade or color each state with the color you chose to represent its ranking.

After you've completed your maps, answer the following questions on a separate sheet of paper.

4. Make a list of hypotheses that link the pollution data to cancers or other illnesses. Given your hypotheses and the patterns you see in your maps, what patterns would you expect to find in maps of cancers or other illnesses?

5. Review several cancer or mortality atlases for the United States (your instructor will provide these or tell you how you can find them in your library). Are the patterns shown in the atlases the ones you expected from your hypotheses?

6. Does the appearance of an expected pattern necessarily show an association? What does the absence of a pattern show?

7. What might be some of the reasons for any discrepancies between your hypotheses and what you found in the atlases? Consider data problems, hypothesis problems, and problems in representing data graphically.

8. Are there any problems using state-level data to make claims about individual incidences of cancer or other illnesses? Explain.

Student Worksheet 2.4

Activity 2.4 Water Scarcity? Water-washed Diseases

In this activity, you will team up with several of your classmates to research a disease that is prevalent in times or places of water scarcity. Use the background information, suggested readings, or the World Wide Web to identify a disease, learn more about it, and answer the questions below. Discuss the questions as a group and prepare one set of written responses. You will also use the blank world map provided by your instructor to illustrate the geographic extent of the disease. Be prepared to present your findings as a group to the class in a short presentation.

---

1. Why is this disease prevalent when there is a scarcity of water and what are the specifics of this relationship?

2. Where does this disease usually occur in the world? On the blank world map, draw the present geographic extent of the disease using a solid black line.

3. What conditions contribute to or trigger this disease's geographic expansion or movement? Are any of these conditions likely to change with global environmental change? If so, how might the disease's geographic extent change? On the blank world map, draw the extended geographic extent of the disease with a dotted black line. Assess the uncertainties asssociated with the line you've drawn.

Student Worksheet 2.5

Activity 2.5 Don't Drink the Water: Health, Water, and Your Community

You are a member of a local neighborhood association who has decided to investigate local water-related health problems in your community or city. Use local sources such as newspapers or health officials to identify a problem for additional research. You will then need to conduct some in-depth research on the issue using a variety of sources including the library, community experts, and the Internet/WWW.

The neighborhood association has asked you to prepare a report to present to members; the report should consider the questions below. (Note: This activity has two parts; your instructor will tell you which parts you are expected to complete.)

Part A

In a two- to three-page report to the members of the association, address the following questions:

1. How is this a water-related health problem?
2. Does this health problem pose a greater risk to certain segments of the community? In other words, are any groups of people more vulnerable than others?
3. What groups, agencies, and organizations are concerned about this problem?
4. Why do they think it is a problem?
5. What groups think it is a less pressing issue? What is their reasoning?
6. What are these groups doing to address this issue (generally)?
7. Are these local groups or do these groups have extra-local or broader support?
8. For each group, agency, or organization you mention, provide an address and telephone number if they are available.

Part B

Contact one of the agencies that is working to address the health issue you've identified and find out more about their activities. For example, are there organizational meetings, newsletters, petitions, data publications, WWW sites? If so, participate in two of these activities. You can join the mailing list, go to a meeting, request data from them, or download their web site information. At least one of the activities you choose must involve speaking with a person from the organization about its activities concerning this health issue.

Take detailed field notes of your interactions with people on the telephone or at meetings and describe what happened during those interactions and how you felt about these activities. Was it hard to reach people? Were they wearing suits and ties or shirts and birkenstocks? Did you agree or disagree with their position on the health issue? From your field notes, write a three- four-page report to the members of your neighborhood association describing your assessment of the organization's efforts. Your personal opinion is welcome in this reflection. Comment on your own role in this issue. Is this merely a local issue or does it involve larger scale organizations (e.g. the state, multinational corporations)? Explain what sides of the issue you find yourself on and how you see yourself addressing this problem. How could you become more involved?

Student Worksheet 2.6

Activity 2.6 The Agricultural Frontier: Transformation of Landscape and Transformation of Health

Your instructor will divide your class into small research teams. Together with your team members, select an area of the world where migration to the agricultural frontier is taking place and assess the health and environment-related changes that are occurring there. Your instructor will provide you with some readings, sources, or citations to help you select an area for study.

In your teams, design a research plan and assign tasks to each team member. In your research, consider the following questions:

- What diseases occur in that area?
- What are the characteristics of the migration stream into that area (how many people are heading to that area)?
- What diseases or health conditions do people bring with them and what diseases will they be newly exposed to?
- Are there any changes occurring with migration (i.e., land degradation, changes in water use, changes in land cover and land use, changes in infrastructure)?
- What are some of the health consequences of these environmental and social changes? What public health services are provided there?

When you've finished your research, present your findings in poster format during a special poster session scheduled by your instructor. Be as creative as you can in designing your poster(s). You can use text, photos, diagrams, maps, or any other graphics that help you convey clearly in a small amount of space what you've found.

2 The State of Health: Interactions in Place

Answers to Activities

Activity 2.1 Frames of Reference: Thinking About Disease in a Place

Students should be able to list several factors that are important in explaining or understanding the spread of a disease. Students may use the three-part framework introduced in Unit 2 to help them structure their list. The list below is an example of just some of the factors that could be considered.

Environment	Population	Technology	Culture	Disease
temperature precipitation land cover (habitat) urban vs. rural	density mobility age jobs	air transportation land transportation pesticides antibiotics	hunters campers frontier mentality traditions means of living	vector agent symptoms treatment latency

The diagrams that students prepare should make links between the factors they identify. For example, population mobility is linked to the availability of air and land transportation, which in turn may be linked to levels of economic development; the disease vector is linked to environmental factors, while its treatment may be linked to technology and culture. There are no right or wrong answers to this activity, but students should be able to make some of the more basic connections among these factors.

Activity 2.2 Demographics and Disease

Part A:
Student answers will vary depending on the ten countries chosen for analysis. Make sure that students choose countries from a variety of regions. The variables they consider for each country should include: birth rate, death rate, natural increase, infant mortality, and fertility rate.

1. growing slowly = B
   growing rapidly = A
   declining = D
   stable = C

2. The answers to question 1 can be determined by looking at the age structure of the pyramid. A pyramid with a wide "base" represents a growing population with a very young age structure. A pyramid with a wide but not as steep a base, indicates that the population is aging and growing more slowly. A fairly rectangular pyramid represents an even age structure and a stable population. And finally, a pyramid with a base that is more narrow than the upper portions indicates that the population is aging, and perhaps declining in size.

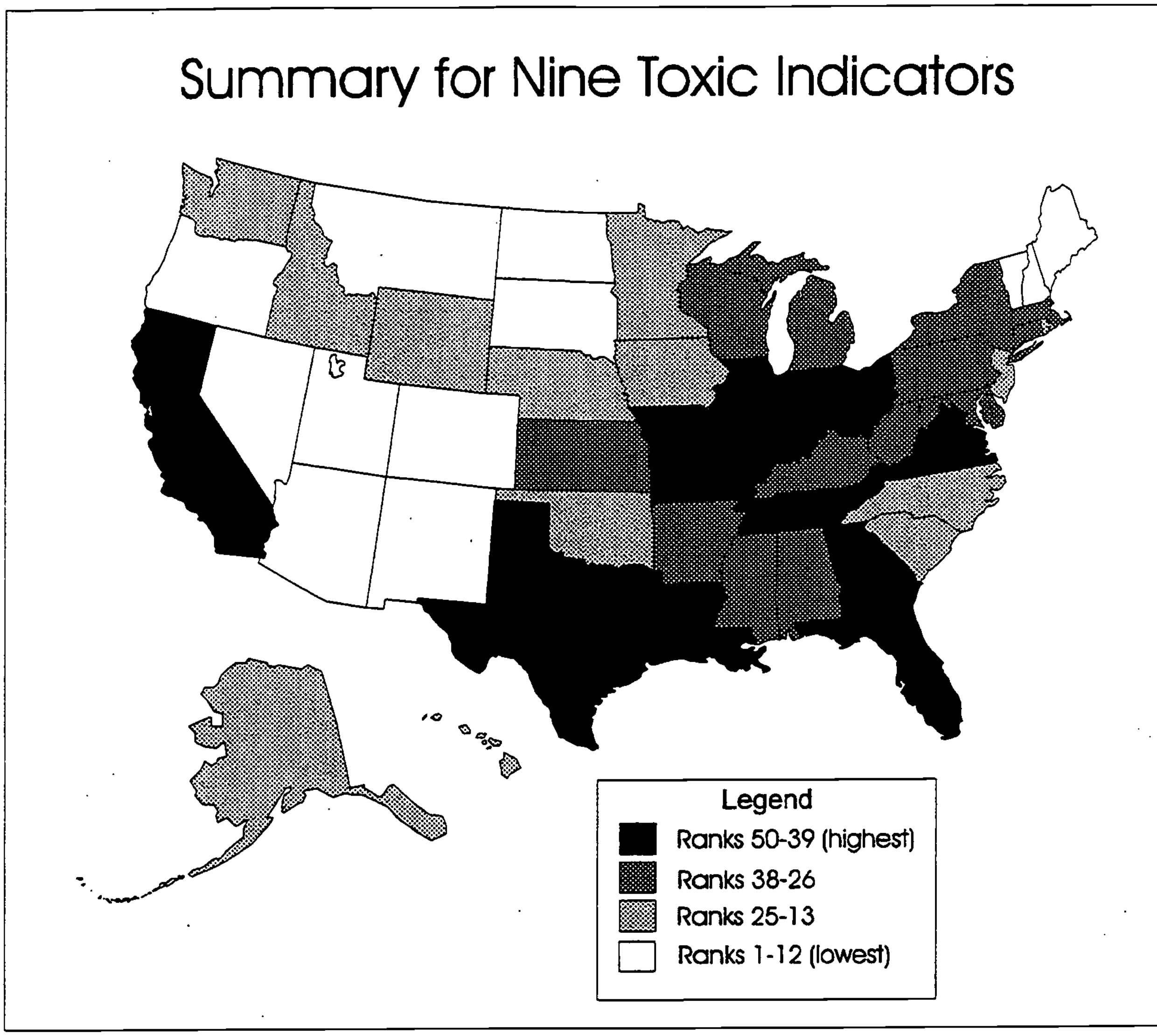
Part B:

The death pyramids that students create will vary depending on the cause of death that they choose to investigate. Students' pyramids should resemble the example below for tuberculosis.

Responses to questions 3 through 5 are based on the death pyramids that students create and will vary depending upon the diseases chosen for investigation.

Activity 2.3 Pollution, Water, and Disease

The map below is an example of the types of maps students will create in this activity. Students' hypotheses about the relationships between the pollution data and cancer and other illnesses will vary depending on the cancer and mortality atlases they use for comparison. In their writing and in the class discussion, be certain that students identify the difficulties in making claims about individual health risks based on aggregate data.



Activity 2.4 Water Scarcity? Water-washed Diseases

Responses to the questions in this activity will vary based upon the water scarcity-related disease that students choose. Use the following general comments as guides for assessing students' work:

1. For this question, students should describe the links between the scarcity of water and the presence of the disease. Students should be very specific about this relationship. For example, does a certain disease vector thrive in the absence of water, or does water scarcity remove a natural predator?

2. Diseases that are heavily linked to environmental conditions (i.e., precipitation, humidity, temperature, land cover) can be easily mapped based on common climatic classifications of the world's biomes. Students should provide a general diagram of the disease's extent, using lines of latitude and longitude as guides.

3. Responses to this question depend upon the relationship that is identified in question 1. Students should be able to make the link between the conditions that provide for a disease's occurrence and the potential impacts to this relationship resulting from global changes. For example, changes in precipitation regimes as a result of climate change may alter the range of habitat for the disease vector. Students should be able to map the potential change in the geographic distribution of the disease based upon their research.

Activity 2.5 Don't Drink the Water: Health, Water, and Your Community

Students' papers will vary depending upon the local water-related health problem they choose to investigate. They should be written with the target audience in mind and should address the entire list of questions on the student worksheet. For Part B of the activity, make certain that students provide sufficient evidence that they have participated in the activities of a local organization and have made contacts with a representative from these groups.

Activity 2.6 The Agricultural Frontier: Transformation of Landscape and Transformation of Health

Students' work in this activity will vary depending upon the area of the world they choose to research. You can reaffirm the importance of this project and insure that students will be creative by scheduling a poster session in which their work will be displayed. Or, arrange to have their work displayed on bulletin boards in the department. As you assess the students' posters, use the following guidelines:

- Did the students consider all of the questions posed on the student worksheet?
- Do the answers to these questions come through on the poster?
- Is the poster neat, professional, and effective?
- Have students made appropriate use of graphics, diagrams, photos, or other visual media?
- Does it appear that all members of the group contributed to the product?
- Have the students been creative and is this conveyed by their poster?

3 Equity and Policy Issues of Human Health and Global Change

Background Information

Will global changes take place evenly around the world? Will everyone equally experience the effects of climate change, land use change, urbanization, or changes in population mobility? The answer is probably no. The processes of global change will have profoundly varied effects on different people. To examine the relationships between human health and global change, we must consider the wide array of social, political, and economic contexts in which global changes will occur. Issues of human health are linked to politics, legislation, morality, human values, and economics, all of which can create inequities in health care, health status, or an individual's general well-being within a society. For example, access to quality health care, a fundamental aspect of maintaining good health, is often affected by an individual's gender, race, social status, wealth, job security, marital status, and/or age. For these reasons, a complete analysis of an individual's health must consider every aspect of a person's daily life and the forces that act upon him or her.

As we saw in Unit 2, global changes in population mobility, climate, or land use have the potential to change the geographic distribution of populations and diseases and even to move some infections rapidly into global circulation. In this unit, we use the global epidemic of HIV/AIDS to illustrate (1) how health and disease are embedded within a complex web of social, economic, political, and cultural factors that can produce inequities in access to health care or in an individual's health, and (2) how global changes can quickly bring a disease to epidemic proportions.

HIV and AIDS

Acquired immune deficiency syndrome (AIDS) is a disease caused by the human immunodeficiency virus (HIV). In the nearly two decades since its first appearance in the US, the virus has spread worldwide. HIV is transmitted by the exchange of bodily fluids (i.e., semen, vaginal fluids, breast milk, and blood) from one person to another, especially through sexual intercourse, but also through intravenous drug use, and less frequently through blood transfusions.[5] Babies can also be infected with the virus in the womb, but not all children born to parents with HIV develop the virus. HIV is actually a retrovirus; it cannot multiply on its own, but rather infiltrates healthy cells and takes over their reproduction processes. Specifically, HIV uses T_4 cells -- white blood cells essential to the human immune system. HIV devastates the immune system because, in using the T_4 cell to reproduce new virus, it destroys the cell in the process. With significantly reduced T_4 cell counts, the body is essentially defenseless against a number of opportunistic infections, including certain forms of pneumonia and cancer, as well as other viruses. At this stage, an individual is considered to have AIDS.

There are currently an estimated 22.6 million people worldwide with HIV and an additional 6.4 million people have already died as a result of AIDS (Purvis 1996). Sub-Saharan Africa accounts for nearly 60% of the people currently living with HIV. In North America an estimated 750,000 people have the virus. There is neither a cure for HIV, nor a vaccine to prevent its transmission. There are, however, treatments that can extend the life and health of individuals living with HIV/AIDS. For example, antiviral drugs like AZT slow the replication of the virus in some people. In addition, a number of combination therapies or drug "cocktails" combine agents known as protease inhibitors with drugs such as AZT to fight HIV during its life cycle within cells. Treatments are extremely expensive and can cost as much as $20,000 per year, putting them out of reach of almost 90% of the people living with the virus. For example, the average Kenyan would exhaust his annual income in less than a week on the combination therapy treatments available in the US (Purvis 1996).

Government Responses

HIV/AIDS first appeared in the US in predominantly white, homosexual male communities and as a consequence, the disease has been a highly charged issue, subject to emotional, moral, and religious debates. Because of this early connection to homosexuality, people with AIDS and their families were ostracized, and responses to the crisis by politicians and public health officials were inexcusably delayed, resulting in the infection of thousands of people before sufficient resources were allocated to identify the virus and its mode of transmission. While it is now known that all groups of people are susceptible to the virus, the stigma still exists. Outdated notions about who is at risk for acquiring the virus and ignorance of the ways in which the virus is transmitted have kept many people from taking necessary steps to protect themselves and others.

After years of struggle, protest, and intense political pressure, HIV/AIDS is no longer ignored by the American government as it was during the early 1980s -- the critical, early years of the epidemic. Delays in action, however, were not confined to the US. Governments in other parts of the world have also refused to acknowledge that a problem existed or that their citizens were at risk. Thailand and India both provide important examples of how government action or inaction can directly affect the health of its citizens.

[5] The risk of contracting HIV through a blood transfusion in the United States has been signficantly reduced (but not eliminated) through the screening of all blood donations since 1985. All blood donations are tested for antibodies to HIV and those that test positive are destroyed.

HIV was introduced to Thailand through intravenous drug use in the ports of Bangkok and quickly spread to commercial sex workers. From the build-up of a commercial sex industry to service GIs during the Vietnam War to the current marketing of sex tourism to Japanese businessmen, the potential for introduction of HIV into commercial sex workers in Bangkok and dissemination throughout the country was enormous. In 1991, a military regime came to power in Thailand, and all AIDS programs came to a halt (Garrett 1994). The government in 1991 officially reported only a few hundred cases of AIDS, although several thousand commercial sex workers had already tested positive. The authorities and parliament (dominated by the military regime) suppressed the information in order to protect one of Thailand's main sources of foreign exchange -- its general tourist industry.

Student and civilian agitation in that same year led to new elections and a new government. The new prime minister installed Mechai Viravaidhya, the leader of the national family planning movement and condom promoter, to head the AIDS information campaign. The campaign has been quite successful, and the dissemination of information, tighter control of the sex industry, increased testing, and the promotion of condom use has led to a recent stabilization of the epidemic. But the loss of those first five years of the epidemic, however, has cost the country dearly. The disease has spread to the clients of sex workers and from the clients to their spouses, partners, and eventually their children. In less than a decade, more than 840,000 people in Thailand have been infected with HIV (Brown and Sittitrai 1995). Currently, more than 2% of women attending prenatal care clinics in Thailand are testing HIV positive (Brown and Sittitrai 1995).

In India, the situation could be even more disastrous. HIV was introduced into South Asia in the mid-1980s, and already there are five million infected adults (Purvis 1996). It is predicted that within ten years, more people will be living with AIDS in India than in all of sub-Saharan Africa (Garrett 1994). Although these numbers seem large, getting government bureaucrats or physicians to take the epidemic seriously has proven difficult because the numbers are actually relatively small compared to other health needs in India. For example, efforts to increase surveillance and blood testing or to launch major educational efforts on HIV/AIDS are hard to justify when money is not available for testing blood for malaria, or screening it for TB or lead, all of which presently affect hundreds of millions. The difficult choices that India faces are clear.

By underestimating or ignoring the risks of HIV infection, governments in effect deny their citizens access to life-saving information and set them up to be hard hit by HIV/AIDS. In places where governments have acknowledged the potential risks of HIV/AIDS, political and legislative reactions to people with HIV/AIDS have sometimes been extreme. Restrictions on travel and employment, lifetime quarantines, and mandatory testing of people considered to be at risk are all actions that have been taken in response to the epidemic. Fears of such actions may prevent many people who are at risk of infection from being tested.

Stopping the Epidemic: Treatment and Prevention

If we consider for a moment the global diffusion of the HIV virus, it is easy to see how technological advancements and increased mobility have made its spread easier and its containment more difficult. In Africa, the spread of HIV along truck routes used by rural-to-urban migrants is well documented. With improvements in road networks and increased availability of transcontinental travel, it is virtually impossible to contain the virus. Borders are more porous today than ever, and quarantine doesn't appear to present an acceptable alternative.

One approach to curbing the spread of HIV/AIDS is to focus on the conditions that put people at risk and to educate them about how their actions can be modified to reduce their risk of infection. Efforts of this type inevitably face several barriers to success. As mentioned earlier, cultural factors such as religion, morals, values, and traditions can be difficult obstacles in the fight against the disease. Economic conditions are another barrier to effective prevention efforts. Poverty, in the US and worldwide, is inextricably linked to poor health and affliction with disease. Living in conditions of poverty with limited or no access to health care, clean water, adequate food supplies, or quality educational materials puts people at a greater risk for contracting HIV/AIDS. Intravenous drug use and prostitution, both closely tied to conditions of poverty and/or social oppression, often produce the same effect. Dealing with the immediate consequences and daily concerns of a life in poverty often outweigh any concern for the potential for future illness.

As mentioned above, once an individual has contracted HIV, treatment of the many conditions associated with HIV/AIDS is extremely costly. In some countries, medications cost more per treatment than the annual per capita health care budget expenditure.
Loss of life from HIV/AIDS can also have severe economic effects on families and entire communities. In many African countries a generation is being lost. In rural areas where condoms are unknown or unavailable, young children are frequently orphaned and left without grandparents to help them maintain their farms and their livelihoods. Beyond the impacts to families, a Zimbabwean businessman addressed the inevitable worker shortage his industry will face when he stated that, "more apprentices should be recruited by the printing industry in Zimbabwe to replace those workers who die from AIDS in the coming years" (South 1991).

Differences in perception also pose problems in implementing effective educational and preventative campaigns. In the US where the first cases of AIDS were diagnosed in gay men, HIV/AIDS was originally thought of as a "gay disease," making it difficult to comminicate the risk to all groups of people. Comparatively, in some parts of Africa where entire families and villages have been stricken by the virus, AIDS is considered a "family disease." In Yugoslavia the disease is spread foremost through intravenous drug use while in Romania most of the HIV/AIDS infected people are children who received contaminated blood products (South 1991).

Perspectives on appropriate prevention methods differ as well. In the scientific community, it is known that condoms provide highly effective protection against the sexual transmission of the virus. In the US, campaigns have been instituted to promote the use of condoms, but not without years of intense struggle and debate. Americans were forced to confront their cultural taboos and religious and moral beliefs surrounding notions of sex and homosexuality. Consider for a moment the intense public debates that continue to surface over condom advertisements on television, sex and sexuality education in public schools, and the distribution of condoms. Other parts of the world face similar problems. In areas of the Middle East, suggesting the use of condoms goes against firm religious beliefs that preclude discussion of any sexual practices -- heterosexual or homosexual. Programs sponsored by the World Health Organization in such parts of the world promote condom use as a family planning method as opposed to an AIDS prevention method in order to work around these limitations. Such culturally sensitive approaches are important worldwide. In the US community outreach groups often employ diverse approaches in campaigns for different target groups. Hispanic populations, significantly hard hit by intravenous drug use, are now being targeted by curricula specifically designed for drug users in the Hispanic community (AIDS Reference Guide 1996).

This unit has focused on how impacts from global changes will be experienced differently across populations, and specifically, how human health issues and responses to health crises are embedded in a number of social, cultural, and economic contexts that shape perceptions, impacts, and responses. In Unit 4, we turn to a case study of plague in India to explore the processes through which a disease, like bubonic plague, is spread.

3 Equity and Policy Issues of Human Health and Global Change

Instructor's Guide to Activities

Goal
The activities in Unit 3 are designed to help students understand the links between human health and the social, cultural, and political factors in society. Students explore this point in three activities that consider (1) the treatment of people with TB, (2) equity and fairness in the siting of locally unwanted land uses, like pollution sources or landfills, and (3) the provision of services for people living with HIV/AIDS.

Learning Outcomes
After completing the activities associated with this unit, students should be able to:
- identify rights-based concerns linked to issues of human health;
- discuss and defend a position in a debate;
- collect and analyze basic census data;
- do local research on the provision of health services; and
- understand the connections between global change, human health, and socio-political issues like equity, fairness, and access to resources.

Choice of Activities
It is neither necessary nor feasible in most cases to complete all activities in each unit. Select those that are most appropriate for your classroom setting and that cover a range of activity types, skills, genres of reading materials, writing assignments, and other activity outcomes. This unit contains the following activities:

3.1 TB in a Fishbowl	-- Text comprehension and classroom "fishbowl" debate
3.2 Streets of Hope, Streets of Despair	-- Basic equity analysis including mapping noxious facilities and analyzing census data
3.3 The Geography of HIV/AIDS and Service Provision	-- HIV/AIDS data collection, local research, interviewing, and writing assignment

Suggested Readings

The following readings accompany the activities for this unit. Choose those readings most appropriate for the activities you select and those most adequate for the skill level of your students.

- Unit 3: Equity and Policy Issues of Human Health and Global Change (provided)
  The background information to Unit 3 that all students should read
- Annas, George. 1993. Control of tuberculosis -- The law and the public's health. *The New England Journal of Medicine* v.328,n.8 (25 February): 585-588.
  Article to accompany Activity 3.1
- Bowen, William, Mark Salling, Kingsley Haynes, and Ellen Cyran. 1995. Toward environmental justice: Spatial equity in Ohio and Cleveland. *Annals of the Association of American Geographers* 85, 4 (December): 641-663. (provided)
  Article to accompany Activity 3.2
- Bullard, Robert. 1990. *Dumping in Dixie: Race, class, and environmental quality*. Boulder: Westview Press, selected chapters.
  Book to accompany Activity 3.2
- Iseman, Michael, David Cohn, and John Sbarbaro. 1993. Directly observed treatment of tuberculosis: We can't afford not to try it. *The New England Journal of Medicine* v.328,n.8 (25 February): 576-578.
  Article to accompany Activity 3.1
- US General Accounting Office. 1983. *Siting of hazardous waste landfills and their correlation with racial and economic status of surrounding communities*. Washington, DC: US Government Printing Office.
  Article to accompany Activity 3.2

Activity 3.1 TB in a Fishbowl

Goals

Students learn about issues involved in the resurgence of tuberculosis and the treatment of patients with tuberculosis. Students are sensitized to issues of privacy and constitutional rights in the realm of public health. The activity also helps students relate the resurgence of tuberculosis to global change.

Skills

- ✓ critical thinking
- ✓ debate
- ✓ synthesis of ideas

Material Requirements

- *Student Worksheet 3.1* (provided)
- Suggested reading: Annas (1993) and Iseman et al. (1993)
- Chalkboard or overhead projector, overhead transparencies, and markers

Time Requirements
One class period (50 minutes), with the suggested readings assigned before class

Tasks
Students should read the suggested articles as a homework assignment and be prepared to argue for and against both confinement of patients and directly observed therapy for TB patients.

In the next class session, use the topics covered in the readings to begin a "fishbowl debate." In this activity, two students begin the debate in the center of a circle, one arguing for confinement of patients and the other arguing for directly observed therapy. Every few minutes, rotate two new students into their positions, continuing until all students have taken part. If you have a larger class, you could rotate in pairs.

After all students have rotated into the debate, bring the class together as a whole and ask the students to summarize the major arguments that were presented during the debate, writing them on the board or an overhead transparency. Finish with a discussion centered around the larger objectives of the activity noted above.

Activity 3.2 Streets of Hope, Streets of Despair

Goals
Students investigate the spatial and social inequities in siting hazardous or noxious facilities and the ways in which these inequities may affect human health. Students also become aware that different social groups have differentially powerful voices in speaking for their own health concerns.

Skills
- ✓ data acquisition
- ✓ group discussion
- ✓ oral presentations

Material Requirements
- *Student Worksheet 3.2* (provided)
- Suggested readings: (Bowen et al. 1995), Bullard (1990), and US GAO (1983)
- Additional readings on environmental racism and inequities (see *Appendix A* for suggested sources)
- A list of local landfills, hazardous waste sites, power plants, waste incinerators, industrial complexes, and trash transfer stations from your local Planning Department
- Local census tract map
- Local street map

Time Requirements

Two class periods (100 minutes); one period to introduce activity, and one period to discuss students' findings. Allow additional time for students to complete the homework portion.

Tasks

Ask students to read the suggested readings and any other readings on environmental racism and inequities you feel necessary. Find a local street map and census tract map and display them in the classroom. Present students with a list of local facilities mentioned above. Depending on the scale you choose for analysis, there may or may not be multiple facilities within a certain category (i.e., there may be several electric power plants, many landfills, or only one power plant, one landfill). If there are multiple facilities, ask each student to select one category or type of facility and have students locate each facility on the street map and determine the corresponding census tract numbers. If there is only one of each type of facility, ask students to focus exclusively on that facility. (More than one student can focus on the same facility while working independently. In a large class, students can work in pairs or small groups.)

Once all of the facilities have been mapped, each student should write down the number(s) of the census tract(s) that contain the facility(ies) they mapped. They should also select one or two census tracts that do not have that facility. As a homework assignment, students will find the following census data for the areas they investigate (the census tract(s) with the facility(ies) and the ones without):

- racial composition
- ethnic composition
- age composition
- income distribution
- employment status
- home-ownership status

Students may choose to create a table to display the data and to compare the census tracts side by side.

In addition to the census data, students should also investigate the types of human health impacts that may be associated with their facility or category of facilities. For example, a local landfill may release toxics into the water supply, it may increase traffic in the local neighborhood, and it may be loud and have an unpleasant odor. Each of these characteristics will have a unique impact on human health. Students will need to conduct their own library research to determine these specific health effects.

In the designated class period, students present their general findings to the class. After the groups have finished, initiate a class discussion by asking students to make some generalizations about what they've learned. Discuss with them some of the reasons why it might be easier to site noxious facilities in low-income and/or minority neighborhoods. How might these communities prevent inequities?

Activity 3.3 The Geography of HIV/AIDS and Service Provision

Goals

Students learn about the incidence of HIV and AIDS in their community and examine the provision of health care and social services for people with AIDS. Students also become aware of the ways in which various societal factors influence the ways that we meet the specific needs of people with HIV/AIDS.

Skills

- ✓ data acquisition
- ✓ analysis of materials
- ✓ role identification
- ✓ informal interviewing
- ✓ decision making
- ✓ group writing

Material Requirements

- *Student Worksheet 3.3* (provided)
- Local or state AIDS data (mortality from AIDS by age and sex -- check with a local or state health departments of HIV/AIDS centers for data sources)

Time Requirements

15-20 minutes to introduce activity and one class period (50 minutes) for students to present their findings. Allow at least seven to ten days for students to complete the homework portion of this activity.

Tasks

A large factor in determining an individual's health status is access to health care. This activity asks students to examine the provision of HIV/AIDS services in their community, with some attention to the number of deaths from AIDS in their community, city, or state.

For this activity students should be divided into groups of about five students. Since they will be contacting local agencies, clinics, testing facilities, and treatment programs, a group approach will prevent students from overwhelming these facilities with information requests.

The groups' first task is to gather local HIV/AIDS statistics focusing on age and sex and geographic distribution of mortality from AIDS. HIV incidence data (meaning those who have the virus, but don't necessarily have AIDS) may be difficult to find, so students may choose to focus on death statistics. Some states provide this data at the county level, while others may not. If necessary, students can collect state-level data and using local population numbers, derive an estimate. Students can also find data on the Web (see *Appendix C* for some suggested sites).

Next, students should identify and locate the services that are locally available to people with HIV/AIDS. These include testing centers, treatment and counseling facilities, shelters, support groups, research facilities, and clinics. Recommend that they start with the phone book and branch out from there, asking the first contact to refer them to others. Once students have contacts at different facilities, they should schedule in-person interviews to gain more detailed information about the specific services. What populations does this service target and serve and where are these populations located? What does it offer to these people? What special needs do these populations have, i.e. day care needs? Do local physicians treat people with AIDS or do they refer them to state hospitals?

Finally, groups should prepare a three- to five-page report outlining the services currently available and the location of services vis à vis clients. The report should also include recommendations for improving access to and quality of services for the population as a whole and for the specific subpopulations they learned about in their interviews. For example, what special needs might women have in terms of access? In what ways do different ethnic populations need differing intervention and treatment approaches? Set aside one class period for groups to present and discuss their findings.

3 Equity and Policy Issues of Human Health and Global Change

Student Worksheet 3.1

Activity 3.1 TB in a Fishbowl

For homework, read the articles provided by your instructor. The authors discuss the conflict we face in the US concerning the treatment of people with TB. The two options presented are (1) the containment or quarantine of patients and (2) directly observed therapy. Be prepared to argue for and against each of these options in the next class session.

In the next class session, you will take part in a "fishbowl debate." Two students will begin the debate, one supporting containment and the other supporting directly observed therapy. Every few minutes, two new students will be rotated into the debate positions until all have taken part.

After the debate, you will summarize and discuss the major arguments presented during the debate. Think about why this issue matters to you and how it affects you directly and indirectly. Also think about the ways in which the resurgence of TB in the US is related to processes of global change.

Student Worksheet 3.2 Name:

Activity 3.2 Streets of Hope, Streets of Despair

The following activity is intended to highlight some of the factors that affect an individual's health status and the ways in which a person's economic and political well-being is directly tied to his/her ability to stay healthy.

Part A: Read the suggested articles provided by your instructor. In class, you will look at the types of noxious and hazardous facilities that are located in your community. Your instructor will give you the addresses of facilities to locate on the local street map. After you have located your facilities, use the census tract map that your instructor has provided to identify which census tracts your facilities are located in. Write down the corresponding census tract numbers below -- you will need them to locate relevant information about the census tracts for the second part of this exercise. After all of the facilities have been mapped on the street map, find several census tracts in which no facilities have been located. Write these numbers down below too.

Census Tracts with Facility ______________________________

____

Census Tracts without Facility ______________________________

____

Part B: For homework, use 1990 census data to find out information about the population within the census tracts you have listed above. You may be able to find census data in your school's library or on the World Wide Web. Consider the following variables:

- racial composition
- ethnic composition
- age distribution
- income distribution
- employment status
- home-ownership status

Present the data you find in a neat and coherent table. Compare the data between the census tracts with the facilities and those without the facilities. What differences do you see? You may need to do some basic statistical work with your data, like finding the average value for a certain variable in each set of census tracts. Provide a summary of your data analysis and interpretation on a separate sheet of paper.

While doing your research, investigate the range of health effects that are associated with your facility and others like it. For example, if you lived next to an coal-fired electric plant, what kinds of things about it would worry you? In what ways could it affect your health? List the characteristics of the facility and its potential impacts underneath the table of data you will prepare. You may need to do additional library research to identify the health effects associated with your facility.

Finally, comment on the role of geographic scale and boundaries in your data analysis and in your research on the health affects associated with your facility. For example, how might your analysis change if you examined data at a different scale? Does the geographic unit you used in your analysis accurately reflect the boundaries of the possible health risks posed by your facility?

Part C: In class, you will present the data that you found for the census tracts and the additional research you conducted. As you hear other students' findings, see if you can identify any common themes or general conclusions. For example, which census tracts have higher income levels -- those with or without hazardous facilities? And what are the general population characteristics of tracts with and without such facilities?

Student Worksheet 3.3

Activity 3.3 The Geography of HIV/AIDS and Service Provision

This unit has addressed the issue of access to health care and the direct effects of the level of access on an individual's health. In the case of HIV/AIDS, we face a host of economic, social, cultural, and political concerns in conjunction with a health issue. This activity highlights the access and quality of health care options across populations.

Part A: In this activity you will work as a part of a group. Your first assignment is to gather recent data on HIV/AIDS in your county, city, and/or state. Your instructor will provide you with additional details. You may be able to find this information using the Internet/WWW, your student health center, your school library, state or local health departments, or HIV/AIDS agencies. For these agencies, start with the phone book and branch out from there, asking the first contact for any additional sources you may tap.

Part B: Next, locate services available to people with HIV/AIDS in the area. This includes testing centers, treatment and counseling facilities, shelters, support groups, research facilities, and clinics. Again, start with the phone book and branch out from there. After you identify facilities, locate them on a map of an appropriate scale. How are they distributed and in what neighborhoods? Once you have contacts at different facilities, schedule an interview with an agency representative to gain more detailed information about their specific services. What populations do they target? Men? Women? Minorities? What special needs do their clients have? What is the range of services offered? Document your interviews and findings in writing. Be sure to include the date of the interview, the interviewee's name and affiliation, and any other pertinent information. All members of your group should participate in at least one interview, but the entire group does not have to attend each one. Divide this task evenly among yourselves.

Part C: With your group, prepare a three- to five-page report that outlines the data you've found, the current levels of service provided, and the location of services vis à vis clients. Include your map and interview documentations from Part B in an appendix. In the main text, consider the following questions. What are the data limitations? What problems did you have finding data? Why? Concerning levels of service, think about the issue of access and how the affected population fares in this respect. Include your group's recommendations for improving services and access to health care. Are deficiencies something that can be taken care of locally, or is this a larger problem? If so, discuss these larger connections. Be prepared to discuss your report with the class.

3 Equity and Policy Issues of Human Health and Global Change

Answers to Activities

Activity 3.1 TB in a Fishbowl

Because this activity involves a classroom debate, there are no right or wrong answers. Students will either defend confinement or directly observed therapy during the debate. As you facilitate the debate, pay close attention to time, allowing each pair of students to speak for just a few minutes. This will keep the conversation from dragging. If the discussion stalls, you may need to suggest points of debate.

Activity 3.2 Streets of Hope, Streets of Despair

The products from this activity will vary depending on your local area and the facilities chosen for investigation. The census variables that students should research are provided on the worksheet. Students should provide a clear and detailed table that includes all of the data they found for each set of census tracts. Students should also have performed some basic mathematical manipulations on the data. For example, if they looked at multiple tracts, in order to compare the minority population of census tracts with a facility to census tracts without a facility, students will need to find the average minority population within each group of tracts.

Several national studies have found significant correlations between race and socio-economic status and the occurrence of hazardous facilities and others have found no correlation (see *Appendix A* for citations). Studies have been criticized on various points, including statistical techniques and the geographic unit of analysis. It is possible that students will not find any significant difference between tracts with or without facilities. If this is the case, lead into a discussion about the significance of their findings. What implications does this have for the national studies that have been conducted?

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Activity 3.3 The Geography of HIV/AIDS and Service Provision

Students' reports will vary depending on your geographic location and the services available there. If you're located in a large urban area, there may be a large number of services available within close proximity. If you're in a rural area, services may be few in number and at a farther distance. You can use the following factors as a guide to assessing students' reports:

- Does the report contain data on the incidence of HIV/AIDS in your county, city, or state? Was the data well cited and well presented?
- Did the group use a variety of sources for the data?
- Did the group discuss the data limitations or the difficulties they encountered in finding it?
- Is the assessment of local services for people living with HIV/AIDS exhaustive?
- Were all possible types of services considered, such as shelters, support groups, hospitals, clinics, etc.?
- Is the local research well documented?
- Does the report contain a map of services?
- Are the recommendations for improving services realistic and well thought out?
- Were students able to make links between the local provision of services and larger scale issues like health insurance, funding crises, or societal attitudes?

See *Notes on Active Pedagogy* for additional suggestions on evaluating students' written work.

4 Putting It All Together: A Case Study Analysis

Background Information

Unit 4 is a case study of a plague outbreak in Surat, India in 1994 and 1995. The case study, extracted from an on-going research project (Susarla 1996), illustrates many of the issues that have been covered in this module (e.g., disease ecology, population mobility, and policy issues) and is a useful way to conclude our investigation of human health and global change. The activities associated with this unit are all based on this case study. Before we begin the case study, let's learn a bit more about the bubonic plague.

The Bubonic Plague

Bubonic plague is caused by the bacteria *Yersinia pestis*. This bacteria primarily infects rodents and evolved in the grasslands of central Asia where it was vectored among burrowing rodents by fleas. Occasionally throughout history, the fleas were transported to cities in China or Mesopotamia and spread great epidemics among the rodents and people there. Between 1345 and 1360 the epidemic known as the Black Death in Europe killed an estimated one-quarter of the world's known human population, which at that time was about 24 million.

The plague bacteria has now become naturalized among burrowing rodents (e.g., prairie dogs and ground squirrels) in the American southwest, among gerbils in South Africa, and among marmots in Siberia and Manchuria. Human exposure is usually from the bite of *Xenopsylla cheopis*, the oriental rat flea. When the flea bite introduces the bacteria into the blood stream, the lymph glands become infected and swollen (buboes). These buboes release a discharge, and infection (septicemia) spreads in the blood stream throughout the body. This is the bubonic plague. Untreated, the case fatality rate today is about 50%, although primary septicemia is invariably fatal. Early in its development, the disease can be treated with tetracycline and fatality rates can be reduced.

As the infection spreads through the body, there may be a secondary involvement with the lungs. Bacteria in the lungs occasionally reach such levels that aerosolized droplets of sputum may spread the infection to another person. This is known as pneumonic plague, which, freed of its connection to fleas, is highly contagious among people. There is an incubation period of about two to six days before a person develops symptoms or becomes infectious.

International law (International Health Regulations, Class I) requires governments to notify the World Health Organization and adjacent countries within 24 hours of the first case of plague in any area previously free of the disease, including newly reactivated cases among rodents (Benenson 1990). Patients with bubonic plague (and no cough) must be isolated and their clothing and premises treated with insecticide. Those with pneumonic plague must be isolated with strict precautions against airborne spread until antibiotic therapy has been completed. International regulations require that prior to departure on an international voyage from an epidemic area, suspect travelers be placed in isolation for six days; on arrival of a suspect vehicle, it may be disinfected and travelers may be kept under surveillance for a period of not more than six days.

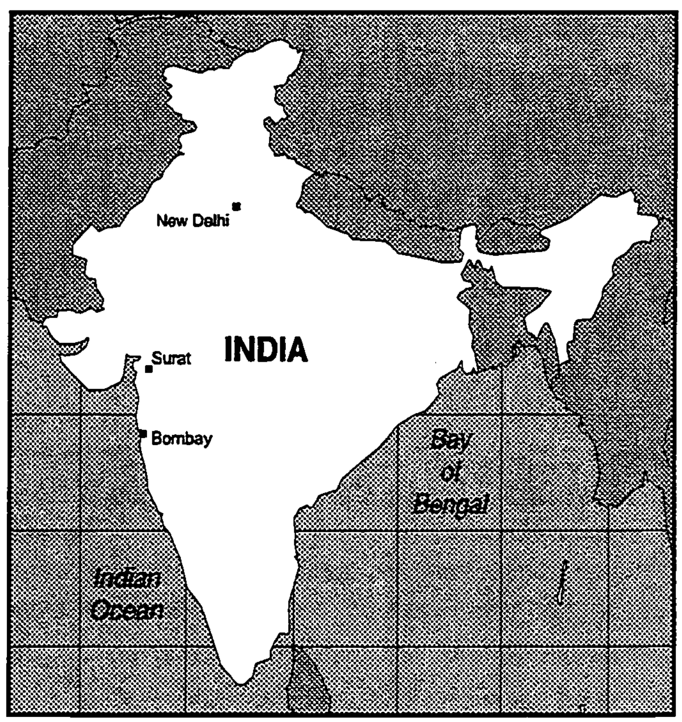
Case Study: Bubonic Plague in India

The city of Surat is located in western India near the Indian Ocean and has a population of 1.8 million people (see Figure 5). Its major industries include diamond polishing, diamond exporting, and the production of textiles, yarn, dyes, and other chemicals. These industries employ the inhabitants of the city as well as a large number of migrant laborers from nearby states.

In 1994 the spread of bubonic plague in the city of Surat resulted in the deaths of 57 people, significant economic losses, and social and political effects. It is estimated that at its peak, over 300,000 people deserted the city and hundreds of people reported to hospitals. In addition, a number of suspected victims were admitted to hospitals in various towns and cities across the country. Figure 6 and the following discussion provide a brief illustration of the route by which the plague generally spread.

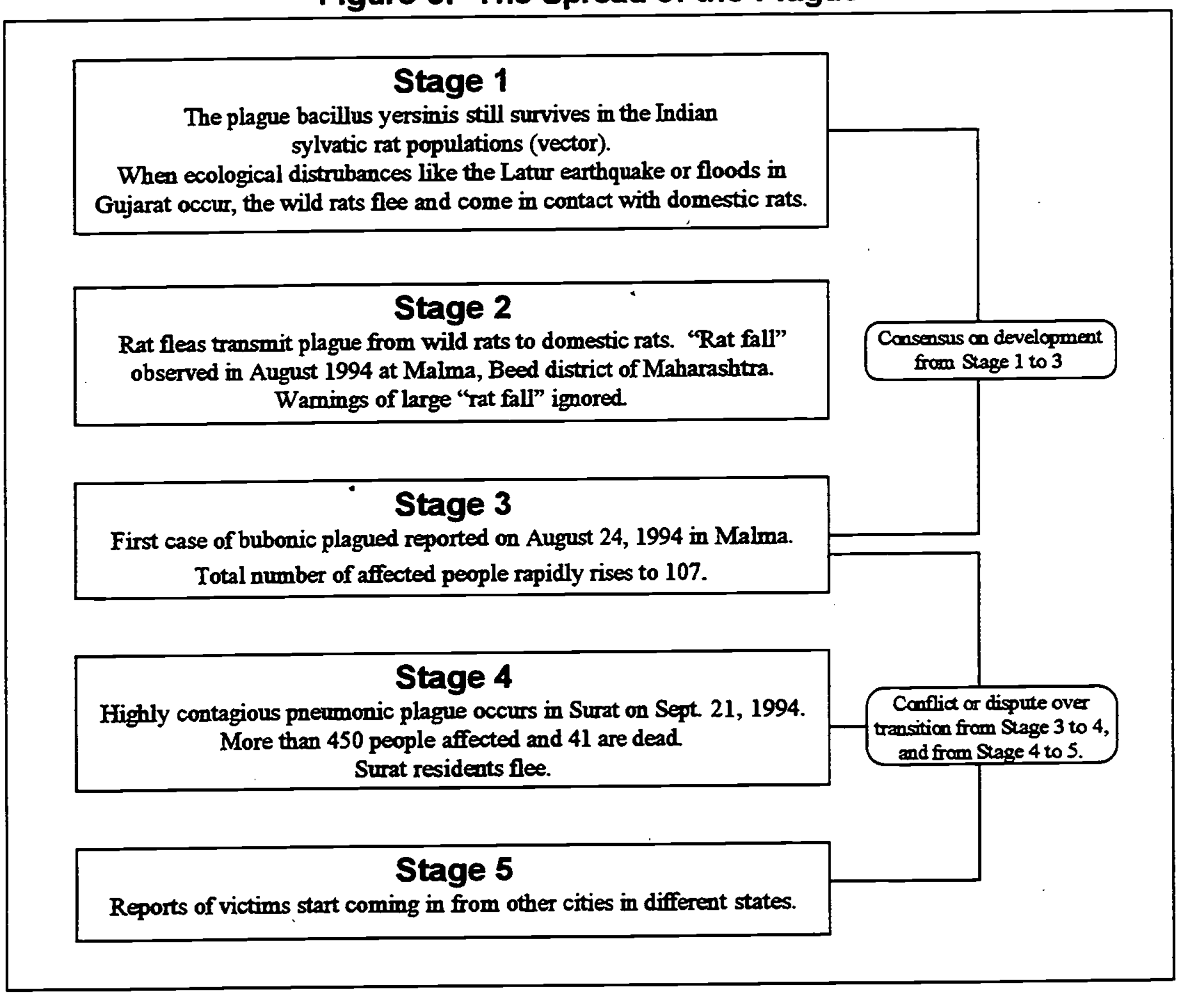
In the first week of August 1994, health officials reported an unusually large number of deaths of domestic rats in Malma village in Maharashtra state, about 150 kilometers southeast of Surat. Three weeks later when the public health officials visited the village, the first case of suspected bubonic plague was diagnosed.

Figure 5: The Indian Subcontinent



On September 21, 1994, the Deputy Municipal Commissioner of Health (DMCH) in Surat received word that a patient had just died from a chest complication that "seemed" to be a case of pneumonic plague. The DMCH immediately informed his superiors and alerted the medical community in the area where the suspected plague victim resided. Later the same day, a worried caller informed the DMCH of more than ten deaths among the residents of Ved Road in Surat city and of another 50 patients who were seriously ill and had been admitted to the local hospital. By 11:30 p.m. four medical teams were assisting residents of Ved Road. Once patients were identified, family members were given a prophylactic dose of tetracycline, and their homes and surroundings were dusted with pesticides. The team then explained the seriousness of the situation to the local community and asked them to report any case of suspected fever, blood-stained sputum, breathlessness, chest pain, sore throat, or even persistent cough. Two victims were taken for post mortem analysis and another nine suspected cases were shifted to an isolation ward in the New Civil Hospital. Local physicians were told to refer all suspected cases of pneumonic plague to new Civil Hospital.

Figure 6: The Spread of the Plague



Rumors spread quickly that the deaths were the result of poisoning of the city's water supply. Citizens became concerned, and communication lines were jammed by the large number of telephone calls. The administration of Surat sent vans equipped with public address systems around the city to deny the rumor, to ask people to stay calm, and to explain that the deaths were thought to be the result of the plague. This announcement, according to press reports, resulted in extreme responses among members of the public.

Citizens forced pharmacies across the city to open, and within hours they depleted the entire stock of tetracycline. By the morning of September 22, 1994 the exodus of people from Surat had begun. Because of rumors that Surat would be quarantined, over 300,000 people deserted the city in the next two days. Several doctors and paramedical staff are also alleged to have fled the city. Meanwhile, hundreds began reporting to the Civil Hospital which was almost entirely converted into an isolation ward. At other cities in various parts of India, check points were established at railway stations and airports to monitor incoming Surat inhabitants. Passengers from Surat and neighboring areas were reportedly received, in some cases, by medical teams as a precautionary measure. Likewise, hospitals in a number of cities were alerted for possible arrivals of plague-infected patients.

The incidence in Surat had large impacts on other major cities of India. In the capital of New Delhi, the lack of public information on how to deal with the spread and contamination of the plague resulted in a rush for surgical masks, tetracycline, and quick remedies. As a precaution, the administration ordered the closure of all schools and public entertainment places. This action alarmed many people; some chose to stay indoors and others who ventured out did so with masks covering their faces.

It is estimated that as a result of the plague businesses in Surat city incurred losses of over US$260 million because the episode occurred just before the major Hindu festival Deepawali, when business sales usually reach a peak. In addition, one of India's major markets (agricultural exports) was jeopardized by a decision by the United Arab Emirates to suspend all cargo transshipment from India. For example, 500,000 tons of Indian fruit is shipped daily to the United Arab Emirates.

The incident also resulted in the loss of investor confidence. In London, Global Depository Receipts (GDRs) crashed after the BBC and CNN media agencies reported on the plague situation. In the local stock exchange, agricultural exporters saw their share value tumble. An official tour of India by the Mauritian minister for tourism was postponed. Foreign journalists and tour operators were offered free travel and hospitality to assess the situation for themselves, but few responded.

Several countries imposed plague-related travel restrictions on Indian travelers. For example, Indians traveling to the US from plague affected areas had to fill out special forms upon arrival. Aircraft were fumigated on arrival at airports in Rome and Milan and passengers were subjected to special health checks. In Moscow, authorities ordered six-day quarantines for passengers from India and banned travel to India. In addition, an estimated 25% of the people who were going from India to the Gulf region in search of jobs were stranded; because their departure was delayed, people from other countries secured the available jobs.

Several other decisions and actions influenced societal responses to this event. Health officials in Surat city declared a plague epidemic before it was known if the plague was pneumonic. Authorities are required to report the first cases of plague, but the declaration of an epidemic caused panic. Daily statistics about suspected cases provided by the official agencies added to a mountain of misinformation. The Union Health Minister did not issue any statements to clarify the situation or to calm the country's or international community's anxieties. Press statements issued by local politicians also did not help the situation. For example, at the time when the plague was considered to be at its peak, the Chief Minister of Gujarat claimed that the plague in Surat was pneumonic and not bubonic, perhaps not realizing that pneumonic plague is more infectious than bubonic plague. To emphasize his point he quoted that "rat fall" (a technical definition indicating large numbers of deaths of domestic rats) in Surat was not very high.

The local and international media also played an important role in this case. Local newspapers reported highly exaggerated death tolls. Many official press statements were reproduced without assessing the accuracy of the information they contained. International media only added to the confusion. For example, a foreign journalist reported in the Independent, London that efforts to halt the plague were hampered by the Hindu's veneration of the rat!

Failure of monitoring systems undoubtedly contributed to the spread of the plague. Rat surveillance units that monitor "rat fall" in various districts had been dismantled in 1987 in the state of Maharashtra, where the first case of bubonic plague was reported. Financial constraints and prioritization of limited resources was a major reason for closing the surveillance units. Urban health infrastructure was poorly maintained, and its decay over a period of time resulted in the public's increased susceptibility to various health hazards. Public health facilities had not kept pace with demand. Because of poor financial capacity, municipal corporations were not able to respond effectively; no emergency plan to deal with such situations had even been prepared.

As this case study shows, this plague outbreak had severe economic, social, and political impacts. Although the spread of the plague was contained effectively in spatial and temporal terms, societal responses resulted in broader consequences.

4 Putting It All Together: A Case Study Analysis

Instructor's Guide to Activities

Goal
Students use the case study of plague in India to bring together many of the concepts discussed throughout this module, including disease ecology, mobility, and global change.

Learning Outcomes
After completing the activities associated with this unit, students should be able to:
- identify and model the factors critical to the spread of an infectious disease;
- collect and analyze relevant data on a disease; and
- research the epidemiology of a disease, identify points of intervention, and recommend response options;

Choice of Activities
It is neither necessary nor feasible in most cases to complete all activities in each unit. Select those that are most appropriate for your classroom setting and that cover a range of activity types, skills, genres of reading materials, writing assignments, and other activity outcomes. This unit contains the following activities:

4.1 Plague Outbreak	-- Text comprehension, group discussion, modeling causal factors of disease spread
4.2 Containing the Plague -- Response Options	-- Writing assignment considering points of intervention in model of plague outbreak
4.3 Ecology of Disease	-- Capstone activity considering a disease, its epidemiology, and response options

Suggested Readings
The following readings accompany the activities for this unit. Choose those readings most appropriate for the activities you select and those most adequate for the skill level of your students.
- Unit 4: Putting It All Together: A Case Study Analysis (provided)
  The background information to Unit 4 that all students should read.
- Lin, Sharat. 1995. Geopolitics of communicable diseases: Plague in Surat, 1994. *Economic and Political Weekly*, v. 30, n. 46 (November 18): 2912-2914.
  Reading to accompany Activity 4.1
- Platt, Anne. 1995. The resurgence of infectious diseases. *Worldwatch* (July/August): 26-32.

Activity 4.1 Plague Outbreak

Goals
Students gain an understanding of the factors related to the spread of an infectious disease and the responses taken by different parties. Students also learn about factors that may lead to risk amplification/attenuation and to possible conflicts among stakeholders in health policy decisions.

Skills
- ✓ analytical thinking
- ✓ oral presentation
- ✓ effective communication (listening, clearly formulating ideas/appropriately responding to others)

Material Requirements
- Suggested reading: Lin (1995)
- Unit 4: Putting It All Together: A Case Study Analysis (provided)
- Chalkboard or large paper and markers

Time Requirements
One class period (50 minutes)

Tasks
The case study presented in Unit 4 provides details of the plague outbreak in Surat, India and the effects in that country and around the world. The lesson is that decisions made in response to such an outbreak have economic, political, and social consequences. This activity encourages students to identify these effects and their causes.

Ask students to read the case study for homework prior to class. In the next class session, divide the class into groups of approximately five students. Ask them to discuss the essence of the case study for five or ten minutes. You may want to help them begin their discussion by posing a question like "Identify one action taken by citizens of Surat in response to the plague outbreak that occurred there."

After the discussion, ask students to draw a flow chart of the causal factors they've identified as important in the plague outbreak and its effects. The group should designate a spokesperson to present the group's diagram to the rest of the class (2-3 minute presentation).

Activity 4.2 Containing the Plague–Response Options

Goals
Students consider the response options to a public health crisis using the causal relationships found in the case study. The activity demonstrates the importance of communication and a multi-faceted approach to dealing with public health issues.

Skills
- ✓ critical thinking
- ✓ role identification
- ✓ synthesis of ideas and organization of arguments
- ✓ decision making

Material Requirements
- *Student Worksheet 4.2* (provided)
- Unit 4: Putting It All Together: A Case Study Analysis (provided)
- Model flow chart (created by students in Activity 4.1, an example is provided in *Answers to Activities*, Activity 4.1)

Time Requirements
Five to ten minutes to introduce activity; one class period (50 minutes) for students to present summaries of their response papers; additional time for students to complete the paper outside of class.

Tasks
This exercise can be used alone or as an extension of Activity 4.1. If you use both activities, students should use the flow chart that their group created in Activity 4.1. If you choose to use only Activity 4.2, give students the example flow chart provided in the *Answers to Activities*, Activity 4.1.

In this activity, students act as a consultant to the Indian government to assess the plague outbreak situation in Surat, India. Ask each student to choose one box from the flow chart as the focus of a two-page report in which s/he will (1) consider response options to the specific factor in the Surat plague outbreak they've chosen, and (2) identify points of intervention, types of intervention, and the anticipated impacts of those actions.

In the next class period, divide the class into small groups and ask each student to present to the group the factor s/he focused on and the solutions s/he came up with. Students will see how their specific response options affect other factors in the flow chart. Students should be encouraged to think about how another person's response options might affect the factor they have examined and the ideas they have formulated for intervention. For example, one solution may cause a new and different problem down the line. Each student should prepare a hand-written appendix to his/her report that considers how the response options of the other group members affect the options s/he originally identified.

Activity 4.3 Ecology of Disease

Goals

This activity serves as a "capstone" in which students synthesize many of the concepts in this module. Through their own research, students begin to understand the complex and multi-faceted approach that is necessary to address the human health effects of global change.

Skills

- ✓ research/writing
- ✓ data gathering
- ✓ mapping
- ✓ critical analysis
- ✓ synthesis of ideas

Material Requirements

- *Student Worksheet 4.3* (provided)

Time Requirements

This activity is intended as a capstone activity for the entire module; therefore, it does not have a limited time requirement like other activities. You may choose to use this activity as a mid-term or final project if it does not fit within the allotted time for this module during your class.

Tasks

Students research a disease to draw together the concepts considered in this module. While any disease can be chosen, focusing on a disease like HIV/AIDS, cancer, or TB in different countries provides the opportunity to highlight cross-cultural perspectives on a current issue. You can either allow students to choose a disease on their own or create a list of diseases for students to select from.

In this activity, students will go from data collection, to mapping, to the formulation of policy and intervention techniques while addressing issues of access, politics, equity, ecology, and the environment. The product of this activity is a five- to seven-page research paper, including maps and graphs.

Part A: Students gather quantitative data on the disease they have selected, including incidence and mortality rates, age distribution, sex distribution, and geographic distribution. Using the incidence data, students produce a frequency distribution and map the incidence rates by sex and age. To produce the frequency distribution, students first draw an *x/y* graph with "time" along the *x*-axis and incidence rates along the *y*-axis. They then plot the annual frequency for each year for which they have data. They can use dots and connect them with a line or draw bars for each year where the length of the bar represents the number of cases. Students are responsible for finding or creating their own base maps.

Part B: Students research the epidemiology of the disease and consider the following questions:

- How did it get to its current location(s)? How long ago?
- What competing explanations exist?
- What is the risk of further infection within the already susceptible population?
- What is the risk of disease diffusion into new populations or areas? Is mobility important?
- What measures have individuals, public health officials, and governments taken to address the spread of the disease?
- Have any places passed specific legislation in response to the disease?
- What types of attention have the media given to the subject?
- What are people doing, or not doing, to protect themselves?
- What role does the natural environment and global change have in the spread of the disease?

Part C: In the final portion of their research, students should explore and recommend intervention measures by considering the following questions:

- What intervention measures are there and which would you recommend? Why?
- Toward whom would they be aimed?
- When would they be appropriate?
- What would they cost (economically and socially)?
- What are the differential effects of the interventions and responses you propose?
- What role does global change play in formulating the interventions and responses?

4 Putting it All Together: A Case Study Analysis

Student Worksheet 4.2

Activity 4.2 Containing the Plague – Response Options

You have been hired by the Indian government to assess the plague outbreak situation in Surat, India. If you have completed Activity 4.1, you will need the flow chart your group created for that activity in order to complete this assignment. If you did not complete Activity 4.1, take some time to understand the flow chart provided by your instructor.

Choose one box or factor from the flow chart and, with that factor in mind, write a two- to three-page report describing possible response options for the Indian government, business owners, citizens, and governments of other countries in reference to that factor. Be sure to include specific points of intervention. You may want to consider the following questions:

- When would each response be needed or most appropriate?
- Toward whom would they be aimed?
- What resources would they require?
- What impacts will your responses have? Specifically, who would be affected and how?

In your final report, include a copy of the flow chart with the factor you considered clearly identified.

In the next class session, your instructor will divide the class into small groups and you will present your ideas to the other members of your group. Be sure to listen to the response options your classmates have developed. How do these affect the issues you have dealt with? Are the other intervention measures they propose harmful to your agenda? What, if any, conflicts of interest do you see? Discuss these issues within your group and reevaluate your response options in light of what you've heard. Create a hand-written appendix to your initial report noting which of your original proposals will need to be changed in order for your responses to work with those proposed by other members of your group.

Student Worksheet 4.3

Activity 4.3 Ecology of Disease

In this activity, you will research a disease in depth in order to synthesize the concepts covered in this module. The product of your research is a five- to seven-page research paper, including maps and graphs that you create. Use the outline below to structure your research and your paper.

Part A: Collect quantitative data for the disease you are researching, including incidence or mortality rates over as long a period as possible; age distribution; sex distribution; and geographic distribution. You should be able to discuss who is getting the disease, where, and how often. If your disease is global, select a particular region for study.

As you begin your data collection, you may want to use the World Wide Web for the most recent data available. Other sources of information include World Health Organization reports, health atlases, and academic literature.

Using the incidence data, produce a frequency distribution and map the incidence rates by sex and age. To produce the frequency distribution, first draw an *x/y* graph with time along the *x*-axis and incidence rates along the *y*-axis. Next, plot the annual frequency for each year for which you have data. You can use dots and connect them with a line or draw bars for each year where the length of the bar represents the number of cases. You can use a computer-based spreadsheet or database program to do this part of the activity if you wish.

To map the incidence rates by sex and age, you will need two blank maps of the region or parts of the world that you are studying. You should have incidence rates for males and females and incidence rates per age group. Divide each data set into reasonable classes and assign colors or patterns to each class. Use these colors or patterns to map the data on your base maps. Don't forget to include a key or legend on each map that defines your color categories.

Part B: Explore the epidemiology of the disease you are studying and look for information that can help you answer the following questions:

- How did it get to its current location(s)? How long ago?
- What competing explanations exist?
- What is the risk of further infection within the already susceptible population?
- What is the risk of disease diffusion into new populations or areas? Is mobility important?
- What measures have individuals, public health officials, and governments taken to address the spread of the disease?
- Have any places passed specific legislation in response to the disease?
- What types of attention have the media given to the subject?

- What are people doing, or not doing, to protect themselves?
- What role does the natural environment and global change have in the spread of the disease?

Part C: In the last part of your research, you should explore intervention measures and responses. Consider the following questions as you conduct your research and prepare your final paper:

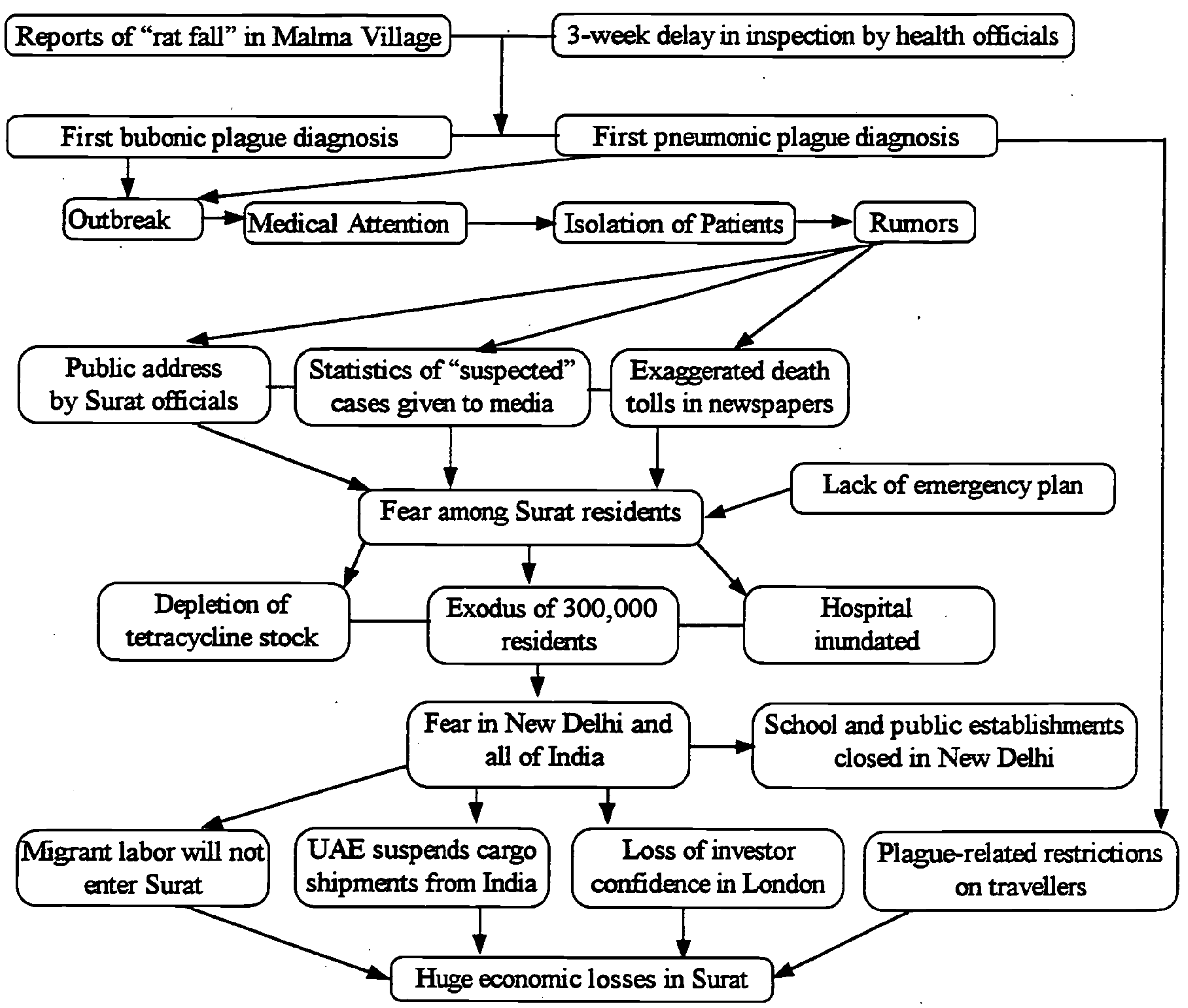
- What intervention measures are there and which would you recommend? Why?
- Toward whom would they be aimed?
- When would they be appropriate?
- What would they cost (economically and socially)?
- What are the differential effects of the interventions and responses you propose?
- What role does global change play in formulating the interventions and responses?

4 Putting it All Together: A Case Study Analysis

Answers to Activities

Activity 4.1 Plague Outbreak

The following flow chart is an example of the kind students will create for this activity.



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Activity 4.2 Containing the Plague -- Response Options

Student papers will vary depending on which aspect of the flow chart they choose to focus on. As you review their work, be certain that students addressed the questions posed on the worksheet and that they have written the paper to the target audience (the Indian government). In addition, students should provide an appendix to their original paper in which they have revised their work in response to their group's comments. See *Notes on Active Pedagogy* for additional suggestions for evaluating student work.

Activity 4.3 Ecology of Disease

Answers for this activity will vary based upon the disease the student chooses and upon how the activity is used in class (i.e., as a mid-term or a semester project). Some of the following points may help you assess their work:

- Is the data well researched and well presented?
- Have maps been included?
- Is the research on disease epidemiology thorough?
- Have a variety of resources been consulted, and are they cited?
- Is the range of response options extensive?
- Have the connections among the disease, the environment, and global change been considered adequately?
- Is the paper well written and concise?

Glossary

Note: Terms that appear in bold in the right column are explained elsewhere in the glossary.

anemia	condition resulting from a lack of hemoglobin or red blood cells, or by a loss of blood; symptoms include weakness, pallor, palpitation of the heart, and a tendency to fatigue.
arbovirus	a **virus** transmitted by **arthropods** (i.e., mosquitoes); **yellow fever**, **dengue fever**, and equine **encephalitis** are caused by arboviruses.
arthropod	any of a phylum of invertebrate animals that have a jointed exoskeleton and paired, jointed legs including Arachnida and Insecta; many species are important medically as **parasites** or as **vectors** of organisms capable of causing disease.
bacteria	a large group of one-celled microorganisms that multiply by fission or by forming spores; certain species cause diseases in humans.
bacterial meningitis	an inflammation of the protective membranes that surround the brain (meninges) and the spinal cord caused by a **bacteria** and resulting in an acute, and sometimes fatal, illness.
beriberi	a **disease** caused by a deficiency in thiamin (vitamin B1) and characterized by muscular paralysis, weakness, and extreme loss of weight; the epidemic form is found in areas where white (polished) rice is the staple food.
carcinogen	any substance or agent that produces cancer.
contagion	the communication of **disease** from one individual to another; a **contagious disease**.
contagious disease	a **disease** transmitted by contact.
cultural ecology	an approach to the study of the relations between a cultural group and the natural environment proposing that configurations of environment and technology are related to social organization.

demographic transition theory — a theory based on the historical experience of Western industrialized countries that describes the process of change from high birth rates and death rates to low birth and death rates in a population as related to changes in economic development.

dengue fever — an infectious fever with severe pain in the head, joints, and muscles and usually a skin rash; caused by a virus transmitted by mosquitoes from the genus *Aedes*.

diphtheria — an acute, **infectious disease** of the throat caused by a bacillus **bacteria**, usually accompanied by a high fever and the formation of a membranous substance that hinders respiration.

disease — any deviation from or interruption in the normal structure or function of any part, organ, or system of the body manifested by a set of characteristic symptoms and signs.

dysentery — disease of the intestines that produces diarrhea.

Ebola virus — one of the most pathogenic viruses known to science spread by direct contact with the blood, secretions, organs, or semen of infected persons. The virus produces Ebola hemorrhagic fever characterized by fever, weakness, muscle pain, headache, and sore throat followed by vomiting, diarrhea, rash, internal and external bleeding, and death.

encephalitis — inflammation of the brain.

endemic — present or usually prevalent in a population or geographical area at all times.

environmental determinism — a doctrine holding that human activities are controlled by the environment.

epidemic — appearing suddenly in numbers clearly in excess of normal expectancy.

etiology — the study or theory of the factors that cause disease.

filariae — any family of threadlike, parasitic nematode worms whose larvae develop in mosquitoes and other arthropods and are transmitted to the blood and tissues of humans and other vertebrates causing diseases.

filariasis	a disease condition caused by the presence of **filariae** in the blood, tissues, and especially the lymph system.
greenhouse effect	the role of various trace components of the atmosphere (e.g., H_2O, CO_2,) in reabsorbing certain wavelengths of the energy spectrum radiated from the earth's surface and thereby increasing the global temperature. This effect occurs naturally, but is augmented by human activities such as burning of fossil fuels and land cover changes since these changes emit trace gases that become further concentrated in the atmosphere (enhanced greenhouse effect). Humans have also added a new class of greenhouse gases called chlorofluorocarbons.
hanta virus	a genus of Bunyaviridae responsible for **pneumonia and hemorrhagic fevers**; an outbreak of the hantavirus infection causing severe and often fatal pulmonary symptoms occurred in the Four Corners region of the USA in 1993.
hemorrhagic fever	a group of diverse, severe **epidemic** viral infections of worldwide distribution, but occurring mainly in tropical climates, usually transmitted by to humans by **arthropod** bites or by contact with infected rodents; marked by fever, shock, hemorrhagic manifestations, and neurological disturbances.
hepatitis B	a viral disease resulting in inflammation of the liver; caused by the hepatitis B virus that is **endemic** worldwide and is transmitted through blood transfusions, needle sharing among intravenous drug users, sexual contact, and from mother to fetus.
helminth	a parasitic worm.
host	an animal or plant that harbors or nourishes another organism **(parasite)**.
Huntington's disease	a disease characterized by involuntary jerking or writhing of the limbs and face and mental deterioration; usually results in death within 15 years.
infectious disease	a disease by or capable of being communicated by the invasion and multiplication of microorganisms in the body tissues (infection).
lactose intolerance	the inability to digest a sugar found in milk known as lactose.

lassa fever	an acute, highly fatal infectious disease caused by a virus occurring epidemically in parts of Africa, transmitted by the multimammate rat which sheds the virus in its urine. Symptoms include fever, abdominal pain, vomiting, and fatal shock.
malaria	an infectious disease **endemic** to parts of Africa, Asia, Central and South America that is spread by the bite of an infected anopheline mosquito. It is characterized by high fever, shaking chills, sweating, and **anemia**.
natural increase	the increase in population that results from the positive difference between high birth rates and low death rates; prominent during Stage 2 and Stage 3 of the **demographic transition**.
onchocerciasis	an infection caused by the worm *Onchocerca volvulus*; characterized by a rash, thickening or wrinkling of the skin, and lesions.
paradigm	the working assumptions, procedures, and findings routinely accepted and employed by a group of people; a paradigm defines one's world view and the approach one takes to defining, researching, and solving problems.
parasite	a plant or animal that lives upon or within another living organism.
pellagra	a condition resulting from a deficiency of niacin and characterized by dermatitis, inflammation of mucous membranes, diarrhea, and psychic disturbances.
pneumonia	a **disease** in which the lung becomes inflamed, often accompanied by chills, a pain in the chest, a hard dry cough, and a high fever.
protozoa	microscopic organisms, like amebas and paramecia, that belong to the Protozoa phylum of protists and which reproduce by fission.
quantile	any number of groups of equal size that divide a frequency distribution.
quarantine	to confine away from others for a period of time to prevent the spread of an **infectious disease**.

Rift Valley fever	an acute infection of domestic animals and humans caused by a **virus** transmitted by mosquitoes of the *Aedes*, *Culex*, and *Erethmapodites* genera. In humans, it is characterized by flu-like symptoms; in severe cases it may be associated with **encephalitis** or **hemorrhagic fever**.
tuberculosis (TB)	an **infectious disease** caused by a species of *Mycobacterium* characterized by the formation of tubercules (small, rounded, granular lesions). In humans, the lung is the organ primarily infected and is the portal through which the infection spreads to other organs. Tuberculosis has a tendency to be a chronic ailment.
vector	a carrier (animal or **arthropod**) that transfers an infective agent from one host to another.
virulent	characterized by a rapid and severe infectious condition.
virus	one of a group of minute infectious agents characterized by a lack of an independent metabolism and by the ability to replicate only within living host cells.
whooping cough	an acute, highly contagious infection of the respiratory tract which commonly affects young children; the symptoms begin with a slight fever, and a dry cough, eventually leading to a persistent, quick cough marked by long-drawn, shrill, whooping noises resulting from spasmodic closure of the vocal chords.
yellow fever	an acute, **infectious disease** caused by a **virus** that is transmitted to humans by mosquitoes, which acquires the virus either from humans or from animals; occurs endemically and epidemically in the Americas and Africa. The disease in its severe form is marked by fever, jaundice, and kidney and liver damage.

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Supporting Materials

The materials included in this section are meant to support the materials covered in this module, especially its activities. Each supporting material is numbered according to the section or activity in which it may be used. For example, *Supporting Material 1.1* accompanies *Activity 1.1* Materials that are intended to support the *Background Information* in the module, such as overhead originals or other documents, are numbered according to the unit. For example, *Supporting Material 3* accompanies the *Background Information* for Unit 3.

Narratives

Narrative 1: Hunger and Poverty in the Land of Plenty?

John and Margaret have been married for 47 years. Now retired, John worked most of his life as a self-employed electrician. Margaret never worked outside of the home, choosing instead to remain at home with their only child, Sally, who is now married and lives in Tulsa. Neighborhood property values have declined in recent years, diminishing the worth of the couple's principal asset -- their home. Most of the couple's bank savings were depleted by Medicare co-payments and other costs not covered after Margaret fell and broke her hip three years ago. John and Margaret's only other significant asset is their car. A car is a necessity in the Florida community where they live, but the cost of maintenance and insurance have skyrocketed and the couple has contemplated selling the 1982 Dodge and relying instead on taxis. Some months the modest sum they receive from Social Security falls short of their needs. Tea and toast have to do when the cupboard is bare. "We're survivors -- we remember the Great Depression," John states proudly. "It's just that we didn't expect to end out our days this way. Retiring to Florida was always a dream for us." Their daughter doesn't realize her parents go to bed hungry some nights. Why should she? They are living in a land of plenty.

Narrative 2: "I Can't Have TB"

Ann is an executive for a large bankcard company in New York City. She earns a high salary, lives in a Connecticut suburban community, and travels occasionally to London on business. Her lifestyle sometimes proves stressful, but she always makes a point to reward herself with time away. This past spring she took a Caribbean cruise, sailing from Miami. Ann tries to be health conscience . She regularly works out at the company health club and always gets an annual physical examination. During her most recent examination Ann was given some shocking news -- she tested positive for tuberculosis. "How can this be?" Ann demands of the doctor. "I live in Connecticut, I work in the City, I make $100,000 a year - I can't have TB!"

Some Background Information on TB

Tuberculosis is an infectious disease caused by the tubercle bacillus and affects the respiratory system, but other parts of the body such as gastrointestinal, genitourinary tracts, bones, joints, nervous system, lymph nodes and skin can also be affected. Three types of the bacteria exist: human, bovine (cattle), and avian (birds). Humans can become infected by any of the three types, although in the United States, the human strain predominates. The infection is usually acquired from aerosol droplets or sputum from an infected person or through drinking unpasteurized milk from an infected cow.

Narrative 3: The Future Ain't What it Used To Be

Emilio liked growing up in the Midwest. His family had a comfortable lifestyle, supported by his father's job as a pipefitter at the mill, and his mother's work as a teacher at the local high school. After graduation, Emilio enrolled at the local community college in a data processing program. After receiving his AS degree, Emilio discovered that the same downsizing that forced his father into early retirement meant that he could do little better than find part-time and temporary work at local firms as a data entry clerk. He made enough money when he did work to get by, but the lack of job security and the limited opportunities in his home town were very discouraging. Emilio and his friends from high school increasingly found themselves "living for the day" and this often meant drowning their sorrows at the local pub. Emilio's depression became deeper still with the loss of his father to mesothelioma -- a cancer brought on by his exposure to asbestos on the job. Emilio knew the mill job took a physical toll on his father, but to see him die that way from the effects of fibers too small to see was hard. A bottle of beer slipped through Emilio's hand and crashed to the floor. "One too many?," inquired a friend. "No, my hand is just a little numb after nine hours at the terminal," responded Emilio. "I'm fine, really. It's not like I'm doing anything dangerous -- just crunching numbers on a stupid computer," he chortled.

US Map

World Map

Supporting Material 1.3b

Tuberculosis Incidence Data, 1994

State	Cases	Population Estimate
Alabama	433	4,219,000
Alaska	93	606,000
Arizona	249	4,075,000
Arkansas	284	2,453,000
California	4859	31,431,000
Colorado	94	3,656,000
Connecticut	148	3,275,000
Delaware	57	706,000
District of Columbia	121	570,000
Florida	1762	13,953,000
Georgia	740	7,055,000
Hawaii	247	1,179,000
Idaho	13	1,133,000
Illinois	1117	11,752,000
Indiana	211	5,752,000
Iowa	66	2,829,000
Kansas	84	2,554,000
Kentucky	347	3,827,000
Louisiana	433	4,315,000
Maine	35	1,240,000
Maryland	363	5,006,000
Massachusetts	329	6,041,000
Michigan	462	9,496,000
Minnesota	140	4,567,000
Mississippi	278	2,689,000
Missouri	280	8,278,000
Montana	24	856,000
Nebraska	22	1,623,000
Nevada	126	1,457,000
New Hampshire	17	1,137,000
New Jersey	855	7,904,000
New Mexico	81	1,654,000
New York	3636	18,169,000
North Carolina	585	7,070,000
North Dakota	10	838,000
Ohio	337	11,102,000
Oklahoma	261	3,258,000
Oregon	165	3,086,000
Pennsylvania	621	12,052,000
Rhode Island	58	997,000
South Carolina	387	3,684,000
South Dakota	28	721,000
Tennessee	520	5,175,000
Texas	2542	18,378,000
Utah	55	1,908,000
Vermont	10	580,000
Virginia	372	8,552,000
Washington	264	5,343,000
West Virginia	80	1,822,000
Wisconsin	109	5,082,000
Wyoming	12	476,000

Note: This table includes the number of cases, not incidence rates. To get an incidence rate, divide the population by 100,000. Divide the # of cases by this number to get incidence/100,000 people.

Source: Centers for Disease Control. 1996. *Morbidity and Mortality Weekly Report* 46 (May 10): 366.

Appendices

Appendix A: Additional Texts and Articles

Human Health and Global Change

Clayton, Patti, William Glaze, and Richard Andrews. 1990. *Environmental Impact Assessment Review* 10,4 (December). Special Issue. Environmental change and public health: The next fifty years.

Colwell, Rita. 1996. Global climate and infectious disease: The cholera paradigm. *Science* 274 (20 December): 2025-2031.

Dowlatabadi, Hadi. 1996. Assessing the health impacts of climate change. *Degrees of Change* 1, 6 (September): 1-4.

Epstein, Paul. 1997. Environmental changes and human health. *Consequences* 3,2.

Hall, Ross. 1990. *Health and the global environment.* Cambridge: Polity Press.

Longstreth, Janice. 1991. Anticipated public health consequences of global climate change. *Environmental Health Perspectives* 96: 139-144.

Martens, W., T. Jetten, J. Rotmans, and L. Niessen. 1995. Climate change and vector-borne diseases: A global modeling perspective. *Global Environmental Change* 5, 3: 195-209.

McMichael, Anthony. 1993. *Planetary overload: Global environmental change and the health of the human species.* New York: Cambridge University Press.

Murray, Christopher and Alan Lopez. 1996. Evidence-based health policy -- Lessons from the global burden of disease study. *Science* 274 (1 November): 740-743.

Real, Leslie. Sustainability and the ecology of infectious disease. 1996. *Bioscience* 46, 2 (February): 88-97.

Sanderson, George. 1992. Climate change: The threat to human health. *The Futurist* 26, 2: 34-38.

Stone, Richard. 1995. If the mercury soars, so may health hazards. *Science* 267 (17 February): 957-958.

Taubes, Gary. 1997. Apocalypse not. *Science* 278 (7 November): 1004-1006.

Emergent Diseases

Garnett, Geoffrey and Edward Holmes. 1996. The ecology of emergent infectious disease. *Bioscience* 46,2: 135.

Garrett, Laurie. 1994. *The coming plague.: Newly emergent diseases in a world out of balance.* New York: Penguin Books.

Gould, Peter. 1993. *The slow plague: A geography of the AIDS pandemic.* New York, NY: Blackwell.

Shilts, Randy. 1987. *And the band played on: Politics, people, and the AIDS epidemic.* New York: St. Martin's Press.

Wilson, Mary, Richard Levins, and Andrew Spillman, eds. 1994. Disease in evolution: Global changes and emergence of infectious diseases. *Annals of the New York Academy of Sciences* 740, December 15.

Equity, Justice, and Human Health Hazards

Bowen, William, Mark Salling, Kingsley Haynes, and Ellen Cyran. 1995. Toward environmental justice: Spatial equity in Ohio and Cleveland. *Annals of the Association of American Geographers* 85, 4 (December): 641-663.

Bryant, Bunyan and Paul Mohai, eds. 1992. *Race and the incidence of environmental hazards.* Boulder, CO: Westview Press.

Bullard, Robert. 1993. *Confronting environmental racism: Voices from the grassroots.* Boston, MA: South End Press.

________. 1990. *Dumping in Dixie: Race, class, and environmental quality.* Boulder, CO: Westview Press.

Goldman, Benjamin. 1991. *The truth about where you live: An atlas for action on toxins and mortality.* New York: Random House.

Medoff, Peter and Holly Sklar. 1994. *Streets of hope: The fall and rise of an urban neighborhood.* Boston, MA: South End Press.

Szasz, Andrew. 1994. *EcoPopulism: Toxic waste and the movement for environmental justice.* Minneapolis, MN: University of Minnesota Press.

United Church of Christ Commission for Racial Justice. 1987. *Toxic waste and race in the United States*. New York, NY: United Church of Christ.

United States General Accounting Office. 1983. *Siting of hazardous waste landfills and their correlation with racial and economic status of surrounding communities*. Washington, DC: Government Printing Office.

Health Care Access

Fosu, Gabriel. 1989. Access to health care in urban areas of developing societies. *Journal of Health and Social Behavior* 30 (December): 398-411.

Gesler, Wilbert. 1984. *Health care in developing countries*. State College, PA: Commercial Printing.

Hardoy, Jorge, Sandy Cairncross, and David Satterthwaite. 1990. *The poor die young: Housing and health in Third World cities*. London: Earthscan Publications Ltd.

Medical Geography

Meade, Melinda S., John W. Florin, and Wilbert M. Gesler. 1988. *Medical geography*. New York: Guilford Press.

International Health Issues and the North-South Divide

Mosley, W. Henry and Peter Cowley. 1991. The challenge of world health. Population Bulletin 46, 4. Washington, DC: Population Reference Bureau, Inc.

Pan American Health Organization. 1992. *International health: A north-south debate*. Washington, DC: PAHO.

Appendix B: Additional Data Sources

Food and Agriculture Organization. 1995. *Dimensions of need: An atlas of food and agriculture*. London: Banson.

Population Reference Bureau. 1996. *World population data sheet.* Washington, DC: Population Reference Bureau.

Population Reference Bureau. Annual publications catalog. For information on publications, contact them at Circulation Department, Population Reference Bureau, PO Box 96152, Washington, DC 20090-6152, or look for their homepage on the Internet.

Smallman-Raynor, Matthew, Andrew Cliff, and Peter Haggett. 1992. *Atlas of AIDS.* Cambridge, MA: Blackwell Publishers.

United Nations Environment Program. 1993. *Environmental data report 1993-94*. Oxford: Blackwell Publishers.

US Bureau of the Census. 1994. *Trends and patterns of HIV/AIDS infection in selected developing countries.* Washington, DC: US Bureau of the Census, Population Division.

US Department of Health and Human Services. 1994. *Vital statistics of the United States 1990.* Volume II, Mortality, Part B. Hyattsville, MD: US Department of Health and Human Services, Centers for Disease Control, and National Center for Health Statistics.

See also *Appendix C*.

Appendix C: Selected WWW/Internet Sources

The following WWW sites are just a sample of those relevant to this module; they have been chosen because they may provide data useful to students for a number of the activities in this module. In addition, any of the various Internet search engines will also yield numerous sites of interest. The URL addresses provided below were valid as of this printing. Because websites often move, please verify these addresses before suggesting them to your students.

- **HIV/AIDS Information Outreach Project**
  http://www.aidsnyc.org/index.htm
  Information about HIV/AIDS, including medical, housing, drug approval, children, nutrition, and access to treatments.

- **HIV/AIDS Surveillance Database**
  http://www.ciesin.org/datasets/hivaids/hivaids-home/html
  Compilation of information from studies appearing in medical and scientific literature, presented at international conferences, and appearing in the press.

- **Infectious Disease Weblink**
  http://pages.prodigy.com/idweblink
  A website dedicated to infectious disease resources on the WWW; provides links to numerous other websites.

- **National Cancer Institute**
  http://www-seer.ims.nci.nih.gov/
  Cancer incidence and survival data.

- **Stratospheric Ozone and Human Health**
  http://sedac.ciesin.org/ozone
  Contains a Human Health Data Resources service, providing access to State Cancer Registries in the United States, and the North American Association of Central Cancer Registries.

- **Tuberculosis and Airborne Disease Weekly**
  http://www.homepage.holowww.com/x1t.htm
  On-line newsweekly about TB.

- **UN AIDS**
  http://www.unaids.org
  HIV/AIDS figures and trends. Students can find global and regional estimates of AIDS cases, as well as background information on the disease.

- **World Health Organization**
  http://www.who.ch
  Homepage of the World Health Organization with search engines and links.

- **World Health Organization Emerging and Other Communicable Diseases**
  http://www.who.ch/programmes/emc/ebola/emc_home/htm
  This site provides listings of reported disease outbreaks and the number of cases, as well as fact sheets about various diseases (e.g., cholera, dengue fever, ebola, influenza, etc.)

Appendix D: Suggested Readings

The AAG was able to obtain reprint permission from the original publishers for only some of the readings suggested in the activities of this module. To avoid copyright problems, we suggest you make these readings available to your students by putting them on reserve. The following readings are enclosed:

- Bowen, William, Mark Salling, Kingsley Haynes, and Ellen Cyran. 1995. Toward environmental justice: Spatial equity in Ohio and Cleveland. *Annals of the Association of American Geographers* 85, 4 (December): 641-663. Reprinted with the permission of the Association of American Geographers, Washington, DC.

- Desowitz, Robert. 1981. On New Guinea tape worms and Jewish grandmothers. *New Guinea tape worms and Jewish grandmothers*. New York, NY: W.W. Norton, pp. 36-45. Reprinted by permission of W.W. Norton. Robert Desowitz.

- Hall, Bob and Mary Lee Kerr. 1993. Water pollution. *1991-1992 Green index: A state by state guide to the nation's environmental health*. Washington, DC: Island Press, pp. 27-41. Reprinted with permission from *The 1991-1992 Green Index*, Bob Hall and Mary Kerr. 1993. Published by Island Press, Washington, DC and Covelo, CA.

Toward Environmental Justice: Spatial Equity in Ohio and Cleveland

William M. Bowen,* Mark J. Salling,* Kingsley E. Haynes,** and Ellen J. Cyran*

*Levin College of Urban Affairs, Cleveland State University
**The Institute of Public Policy, George Mason University

The inequitable impact of environmental hazards on poor and minority communities is well-documented. In the policy arena, these findings are commonly identified as issues of "environmental equity" or "environmental racism." This paper focuses on one aspect of this debate—the association between race, income, and toxic emissions—via an examination of the spatial distributions of toxic industrial pollution and demographic groups in Ohio and, more specifically, in Ohio's most populous county which includes the City of Cleveland.

The Public-Policy Framework

When President Clinton signed Executive Order 12898 on February 11, 1994, he officially acknowledged the gravity of an environmental issue that has been stirring in the media and public-policy community over the past decade. As a logical sequel to the establishment in 1992 of the Office of Environmental Equity (now the Office of Environmental Justice) in the U.S. Environmental Protection Agency (EPA), Clinton's order (Clinton 1994) required federal agencies to develop a plan within the year "that identifies and addresses disproportionately high and adverse human health or environmental effects of its programs, policies and activities." In so doing, the President directed "federal agencies to make environmental justice a part of all that they do" (Lee 1994).

Environmental justice is the policy rubric within which issues such as environmental equity, environmental discrimination, and environmental racism are embedded (Torres 1994; Gelobter 1994). From the standpoint of politics this rubric acknowledges that environmental decisionmaking involves the role of power and conflict; that decisions about the environment are not simply a trade-off with the economy in terms of efficiency and jobs, but rather are fundamental issues for societal welfare (Taylor 1992). This rubric also acknowledges that society has reason for concern as long as economic activity utilizes common pool resources—often un-priced or under-priced—and generates negative externalities (pollution and waste). In these cases, society has an interest in the levels of production as well as the horizontal (spatial) and vertical incidence of benefits and costs from such activity. Furthermore, since technology is not benign from all social perspectives, the public has a responsibility for guiding or at least responding to the adverse consequences of job loss or pollution generation. Whatever the mode of resolution, be it the traditional regulatory approach or the more recently developed compensation procedure (Boerner and Lambert 1994), a social response to the impacts of environmental hazards is required.

Environmental equity is premised on the notion of fairness in the distribution of environmental hazards, particularly those of a technological origin (Tarlock 1994). The problem of technological hazards has attracted the attention of geographers for over two decades (Zeigler, Johnson, and Brunn 1983), but more recently this literature has focused on more specific operational problems such as airborne toxic releases (Cutter 1987), the emergency management of toxic chemical spills by applying spatial search procedures (Gould, Tatham, and Savitsky 1988), and evacuation planning for technological hazards (Johnson and Zeigler 1986). Geographers have also used GIS for modeling community vulnerability to hazardous materials (McMaster 1990; Marr and Schoolmaster 1988). Scholars in other disciplines also have dealt with these issues (Brown 1987; Goldman 1991; Hadden 1989; Lappe

Annals of the Association of American Geographers, 85(4), 1995, pp. 641–661

Published by Blackwell Publishers, 238 Main Street, Cambridge, MA 02142, and 108 Cowley Road, Oxford, OX4 1JF, UK.

1992). And as all of this research accumulated, the EPA issued guidelines and findings on toxic dangers to communities and the need for appropriate response strategies. These initiatives soon coalesced around EPA's earlier concerns with risk assessment, risk communication, and risk response to technologically based hazards (Wilson 1991; Cutter 1993). These concerns were reinforced by federal legislation which ensured that a community's right-to-know constitutes a central element in new regulations (Reilly 1992). These new requirements for the collection of data on toxic-chemical release combined with GIS applications inventorying these and collateral data made possible systematic spatial analyses of equity issues (Stockwell et al. 1993; Burke 1993; Glickman 1994).

Although environmental racism was propelled to the forefront of the policy agenda by anecdotal evidence of environmental discrimination in the 1980s and 1990s—some of which had strong racial overtones—the roots of this controversial issue go much deeper. As early as 1971 the President's Council on Environmental Quality (CEQ) broached the issue of equity in the distribution of environmental hazards (CEQ 1971). These concerns were followed up in the Conservation Foundation's publication on environmental hazards in urban areas (Smith 1974). In 1983, the Government Accounting Office (GAO) explored the social, economic, and racial correlates of hazardous-landfill siting (GAO 1983), and four years later the United Church of Christ (1987) coined the term "environmental racism." The scholarly climax came with Bullard's book *Dumping in Dixie: Race, Class and Environmental Quality* (1990) which helped to politicize the issues of racial discrimination in hazardous-waste siting. Although protests aimed at stopping a landfill project in the predominantly minority county of Warren County, North Carolina (1992) were successful, Greenpeace had already noted a similar national bias in the siting of waste incinerators in minority communities (Costner and Thornton 1990). And in his sequel to *Dumping in Dixie*, Bullard's *Confronting Environmental Racism: Voices from the Grassroots* (1993) launched an even more pointed attack on environmental discrimination.

These popular movements on behalf of environmental justice found support in federal law, namely the mandate of the *Civil Rights Act of 1964*. This act requires federal programs to be non-discriminatory, and thus it encompasses federal environmental protection activities. Although research on toxic, hazardous, and commercial waste had long-documented inequalities in the siting of waste facilities (Collins 1992), the federal court first considered these inequalities as a point of law in a case involving the disproportionate placement of landfills among black residents near Richmond, Virginia (*R.I.S.E. v. Kay* 1991). Although illegal discrimination was not proven, owing to "the intent issue" (i.e., the plaintiff's necessity to demonstrate "racial animus" or racist intent in order to sustain a charge of discrimination), this case clarified the terms of the legal debate. In cases of environmental equity, unlike other cases of discrimination, the federal courts have not resolved the evidentiary presumption that the totality of circumstances can be used to prove intent in cases of racially based environmental discrimination.

Research Issues in Environmental Equity

Much of the debate surrounding the policy issue of environmental equity is highly emotive. The controversy pivots on two factors: 1) the extent of the spatial coincidence between the locations of environmental disamenities and minority residence; and 2) the causal interpretation of these relationships. This paper deals exclusively with the first of these two factors. More specifically, it attempts to describe the spatial association between the locations of industrial toxic emissions and the racial and economic status of surrounding populations. Utilizing data from the EPA's Toxic Release Inventory (TRI) and the 1990 Census of Population and Housing, we attempt to evaluate the associations observed in the context of contemporary methodological controversies on causality and industrial location theory.

The landmark study on race and environmental quality was issued by The United Church of Christ's (UCC) Commission for Racial Justice (1987). This study, covering 27 commercial hazardous waste facilities nationwide and approximately 10,000 uncontrolled hazardous waste sites (by zip code), concluded that more than half of all blacks and Hispanics in the United States lived in communities having at least one closed or abandoned hazardous waste dump site. It has since been pointed out, however, that these conclusions should be qualified by the fact that 78 percent of the hazardous waste landfills surveyed in the UCC study are located in areas with larger proportions of whites than minorities—a finding that raises doubts about the impartiality of the UCC's conclusions on environmental racism (Rees 1992). These doubts notwithstanding, other studies dating to the early 1970s have documented inequities in the spatial distribution of environmental quality (Freeman 1972; Asch and Seneca 1978; Gianessi, Peskin, and Wolff 1979). And more recent studies corroborate these findings (Bullard 1983; Bullard and Wright 1987; 1989; Goldman 1991; Nieves and Nieves 1992). After reviewing fifteen studies on the topic and examining their various conclusions, Mohai and Bryant (1992) conclude that these studies provide "clear and unequivocal evidence that income and racial biases in the distribution of environmental hazards exist."

In their empirical examination of environmental inequities, Nieves and Nieves (1992) employ nationwide county-level population data and a large range of facility types. Their study reports weak but statistically significant direct correlations between facility-category densities and the proportions of blacks and of Asian Americans. In addition, they document a "moderate to strong relationship between minority population concentration and most facility categories, with the exception of all subgroups in the South and Hispanics in the West." Their conclusion that minorities tend to be over-represented in counties with greater concentrations of noxious facilities comes with the caveat that research at the sub-county level may be needed in order to obtain the degree of geographical specificity that is required for capturing inequity's most glaring effects.

Recent studies have attended to the Nieves' caveat by employing census tracts as their units of analysis. Anderton et al. (1994) do so in comparing race, income, housing value and age, and employment in tracts with and without commercial facilities for treatment, storage, and disposal of hazardous wastes. The authors report that tracts containing these facilities are *not* more likely to have higher concentrations of minorities and that the aggregation of tracts around these facilities affects the results. Geographic scale, in other words, is an important methodological issue for students of environmental equity (Clark and Avery 1976; Fotheringham and Wong 1991). Burke's (1993) tract-level analysis of EPA's Toxic Release Inventory (TRI) for Los Angeles relates the tract location of chemical release sites with the distribution of racial and demographic characteristics. She reports a significant association with minority distributions. Glickman's (1994) study of Allegheny County, Pennsylvania (the Pittsburgh area) also reports higher proportions of nonwhites and the poor in areas in close proximity to TRI sites than in more distant areas.

The present study also focuses on toxic chemical releases as reported in the Toxic Release Inventory (TRI). We begin with a statewide study of Ohio which, like Nieves and Nieves (1992), employs the county as the geographic unit of analysis. Then, following the recommendations of the Nieves (1992) and Burke (1993), we turn to an examination of TRI data at the sub-county (sub-urban) scale, employing census tracts in Cuyahoga County as the units of analysis and Cuyahoga County as our case in point. Cuyahoga, which includes Cleveland, is Ohio's most industrial, urban, and populous county. Unlike the analyses of Burke (1993) and Glickman (1994), however, we address both the amounts of chemicals released and the differences in level of chemical toxicity. Our study also identifies important nuances in spatial statistics that are essential for appropriate identification assessment. Finally, we include TRI chemicals which are released on-site as well as those which are transferred off-site to other locations in the state and county. These two categories of data are treated separately and in combination. For our purposes, the off-site data are of lesser importance because in an urbanized place such as Cuyahoga County, a large proportion of the releases are destined for treatment facilities.

Ohio merits examination of environmental equity. From the standpoint of population in Ohio in 1990, whites accounted for over seventy percent of Ohioans living in poverty and blacks had a poverty rate more than three times higher than whites. And from the standpoint of environmental hazards, Ohio occupied first rank in the nation in hazardous waste exports (82.7 million pounds in 1990) and in imports (91.6 million pounds); second rank in the releases of: 1) toxic chemicals into the air (136.5 million pounds); 2) chemicals known or suspected in causing birth defects (87.6 million pounds); and 3) known or suspected carcinogens (34.1 million pounds); third rank in total toxic releases; and fourth rank in carbon dioxide emissions (*The Ohio Almanac* 1992). In sum, Ohio is one of the nation's leading TRI releasers (EPA 1992) into the air, surface water, land, underground, public sewage, and via off-site transfers.

Within Ohio, Cuyahoga County is especially apt for a more detailed sub-county analysis of toxic releases. The county has the highest proportion of minority residents (either black or Hispanic) in the state (26.8 percent). And in its main city, Cleveland, more than one half of the black population lives in poverty (*Ohio Poverty Indicators* 1993). Cleveland also ranks among the most segregated cities in the United States (Horton and Smith 1990; Van Valey, Roof, and Wilcox 1977). To the extent that statistically significant spatial correlations between race, income, and toxic emissions can be found anywhere, Cuyahoga County and the City of Cleveland would seem to be likely candidates.

Methods

One of the motivations for this study is that scientific and empirical methodologies are needed to verify or dispel popular beliefs about socially relevant topics. For a variety of methodological and practical reasons, any scholarly evaluation of the spatial coincidence between environmental disamenities and minority residence is at best difficult, and at worst contentious.

That having been said, an *ideal* analysis of the spatial association between race, income, and industrial toxic releases would begin by measuring environmental degradation for each point on the surface of the region under examination. These measurements would then be used for testing the hypothesis that higher levels of degradation are directly associated with minority residence. In other words, given two households located at separate points having different levels of environmental degradation, yet otherwise identical in every respect save for ethnicity, the household at the more degraded site is more likely to be occupied by a minority person. Unfortunately, these idealized methodological conditions are rarely satisfied.

First is the problem of defining the unit of analysis for environmental degradation. The idealized analysis above assumes the existence of a single, unique, and cumulative measurement of all types of degradation for every *point* on the region's surface. This point unit must be defined before measurement is meaningful.

Second is the problem of dynamic processes. Given the multiple, interdependent, and changing nature of urban and regional landuse and spatial demographic patterns, the analysis is required to invoke the artificial controls of *ceteris paribus*. Although spatial statistics may address some of these problems, even the most sophisticated models of dynamic spatial processes result in uncertainties and over-simplifications.

A third problem concerns inferences based on the distance-decay functions of toxic releases. Though in reality these distance-decay effects occur prior to the point measurements of degradation, for all practical purposes the effects of distance on releases must be inferred. The distance-decay properties of air releases, for example, are different than those of water releases or land releases. Distance-decay also varies from substance to substance. In the absence of cumulative post-decay measurements of all types of toxic substances for every point on the region's surface, assumptions must be made about the decay functions of *particular* toxic substances in *particular* release venues. But these assumptions are practically untestable owing to the difficulty of measuring the distance-decay properties of particular toxic substances, the large numbers of chemicals involved, and the variability of landuse and topography between regions and within regions over time. Many of these complexities are masked by the scale-of-analysis assumption.

The TRI data, though the best and most comprehensive currently available on industrial sources of toxic chemicals anywhere in the world, are known to have accuracy problems. They do not include, for example, household-level data, hence aggregation effects cannot be evaluated. Even were household data available it is not clear how these could be translated into individual exposure levels given the variety of life styles that characterize community populations. Furthermore, the TRI data are reported as physical weights of toxic releases (measured in pounds of release) for the various chemicals, and these do not necessarily reflect their levels of toxicity. Recognition of these and other data problems gives methodological pause: Is it better to approach the matter scientifically using data with known shortcomings; should we wait for better data; or should we opt for a more qualitative approach emphasizing anecdotal evidence, personal experience, and common sense?

Geographic Scale of Analysis

As noted above, the study is two-pronged. First, the spatial associations between releases of toxic chemicals and race, poverty, and income measures are analyzed at the county level for the state of Ohio, the state's 88 counties serving as the spatial units of analysis. These counties display a wide range of demographic and economic characteristics as well as toxic chemical releases. This part of the analysis thus is comparable with others that use county-level aggregates (Nieves and Nieves 1992).

Second, because counties dwarf the size of toxic release facilities, we shift our focus to the smaller census tracts within one county. Conceptually, smaller units of spatial aggregation are more satisfying because they require more modest assumptions about causal and statistical variations in local phenomena. Also these units tend to reduce information loss regarding locational differences. Census tracts are delineated using several criteria, perhaps the most important of which, for Cuyahoga County, is the homogeneity of housing and population.[1] Census tracts in Cuyahoga thus tend to be representative of the demographic composition of neighborhoods either individually or in contiguous groups. Finally, because a comparison of tract-level to county-level results may provide insights on the appropriate geographic scale for analyses of environmental equity, we include an analysis which employs all 495 census tracts in Cleveland's Cuyahoga County.[2]

The Data: Toxic Releases, Threshold Limits, and Population

This study deploys three sources of data: 1) the 1987–1990 Toxic Release Inventory (TRI); 2) Threshold Limit Values (TLV); and 3) the 1990 Census of Population and Housing.

The Toxic Release Inventory. The TRI is an annual compilation of information on the quantity and location of industrial toxic releases for approximately 320 toxic chemicals. Authorized under Title III, Section 313 of the *Emergency Planning and Community Right-to-Know Act of 1986* in the *Superfund Amendments and Reauthorization Act of 1986* (P.L. 99-499), these data cover essentially all releases by manufacturing firms except those by federal facilities; by firms who are able to justify nondisclosure in order to protect trade secrets; by firms with fewer than ten full-time employees; and by firms with releases that fall below designated threshold levels. Every firm subject to the mandate is required to report, by location, the number of pounds of each of the approximately 320 chemicals released. Penalties of $25,000 per day per chemical for each reporting violation may be levied by the EPA; however, no verification of the firms' release data is required. The consequent issues over the quality and accuracy of the data are the subject of two recent EPA reports (EPA 1991; ViGYAN 1992).

The TRI data in this study include all toxic emissions in the United States and Ohio from 1987 through 1990, as reported in three categories: 1) chemicals originating outside of Ohio and transferred into the state for release; 2) chemicals originating within Ohio and released on that same site; and 3) chemicals originating within Ohio and transferred for release to another site in Ohio. We exclude those chemicals that originated in Ohio and were shipped out of the state or that had non-Ohio origins and destinations.[3] We examine the sum of releases over the four-year period in order to minimize annual fluctuations in actual release amounts or in the reporting of releases.

A practical limitation on the TRI data stems from the fact that the reports merely provide release weights, measured in pounds, for the various chemicals. They do not provide inherent toxicity levels for the various chemicals. Release weights alone can be misleading, however, because a small amount of a highly toxic material may be a more serious health hazard than a very large amount of a low toxicity material. Therefore estimates of inherent toxicities should be integrated into release comparisons.

Threshold Limit Values. Threshold Limit Values (TLVs) provide estimates of the inherent toxicity of various chemicals. TLVs are issued by the American Conference of Governmental Industrial Hygienists (ACGIH) to serve as guidelines to assist in the control of health hazards (ACGIH 1991).

Strictly speaking, TLVs refer to airborne concentrations of substances. Concentrations that fall below these limits represent conditions under which repeated exposure of nearly all workers will not result in adverse health effects. The problem with TLVs is that the amount and nature of the information available (and consequently the precision of a TLV) varies from substance to substance. This variation is partially attributable to the sizable differences in the research designs upon which these values are established. Some TLVs, for example, are based upon industrial experience; others are based on various experimental human and animal studies. Moreover, the TLVs are affected by divergent goals. Some are based on the goal of protecting against impairment of health, while others are based on reasonable freedom from irritation, narcosis, nuisance, or other forms of stress. Owing to these differences in study designs and goals, TLVs must be used with caution. They are not intended as fine lines between safe and dangerous concentrations of the chemicals. Yet these measures of inherent toxicity, with all of their imperfections, arguably remain the best estimates available given the current state of research in industrial toxicology.

TLVs are available for 84 percent of the chemicals on the TRI list. As for the rest, it is likely that these have not been assigned a TLV value due to their relatively low toxicity. We say this with some confidence because TLVs are estimated with the safety of workers in mind; hence if chemicals are extremely harmful, TLV values have been assigned. When TLVs are not available for particular chemicals, these are omitted from all of our analyses involving toxicity indices.

The 1990 Census. Census data are the most generally available and consistent (reliable) source of information on the demographic composition and geographic distribution of the population in the United States. Moreover, census data are available for relatively small geographic units of analysis, including the census tract. Collected every ten years, the census data for 1990 match up well with TRI data for 1987 through 1990.[4]

The Variables

Industrial Toxic Chemicals. In this analysis, toxic chemical releases are measured both in raw pounds and in pounds adjusted for toxicity. The TRI reports the raw poundage of chemicals releases; when these are scaled with the TLV data, we create a region-specific toxicity index in which:

$$T_i = \Sigma_j w_{ij} * r_j \qquad (1)$$

Where T_i is the aggregated estimate of toxicity (toxicity index) in region i; w_{ij} is the weight (converted to metric) of chemical j in region i by all TRI facilities in the region (summed for years 1987 through 1990); and r_j is the inverse of the TLV of chemical j.

In light of the aforementioned limitations of the TLV data, the toxicity index must be interpreted as a rough estimate of the total amount of toxicity of chemical releases in each region. When analyzing particular emissions of interest, such as land emissions in a particular census tract, only these emissions are included in the index. For ease of exposition, the toxicity index is referred to as the "toxicity" of release—that is, the TLV-weighted number of the kilograms of release—as distinguished from the raw weight of the release which is referred to as "pounds" of release.[5]

The toxic release variables are as follows:

(1) total toxicity released in the air;
(2) total number of pounds released in the air;
(3) total toxicity released in water;
(4) total number of pounds released in water;
(5) total toxicity released on land;
(6) total number of pounds released on land;
(7) total toxicity released on-site (air, water, and land);
(8) total number of pounds released on-site;
(9) total toxicity released off-site (measured at the destination);
(10) total pounds released off-site;
(11) total toxicity released in all venues combined; and
(12) total number of pounds released in all venues combined.

Demographic Variables. Seven census variables for 1990 are used in all analyses:

(1) population density;
(2) minority (black and/or Hispanic) concentration (density per square kilometer);
(3) minority proportion of the total population;
(4) poverty as a proportion of the total population;
(5) median value of owner-occupied housing;
(6) median household income; and
(7) median gross rent.

The logic for inclusion of this particular set of demographic variables is straightforward. A spatial association between toxic chemical releases and population concentration, for example, would raise concerns about potential exposure of the residential population to these environmental hazards.[6] Furthermore, a disproportionately high exposure to these potential environmental hazards among minorities, specifically blacks and Hispanics as well as the poor, would underline concerns for environmental equity. Similarly, the variables of median housing value and median gross rent provide insight on the adverse impacts of proximity to noxious facilities (such as the TRI sites) on residential land values and the spatial differentiation of income classes on the basis of housing choice. Median household income and the poverty rate, though related, are distinguishable as measures of economic status. Some working-class neighborhoods reporting, for example, relatively low incomes but high employment rates may have relatively low poverty rates. In addition, household income is partially a function of family life-cycle.[7]

Statistical Methods

We employ well-known quantitative methods to analyze the spatial distributions of the variables including, as appropriate, zero-order correlations, partial correlation analysis, and analysis of variance. Zero-order correlations measure the strength of linear association between two variables, ignoring statistical associations with other variables. Partial correlation analysis measures the strength of the relationship between a dependent variable and an independent variable after accounting for (removing the effects of) associations with other independent variables (Harnett 1982). We also employ Moran's I to test for spatial autocorrelation in the tract-level partial correlation analysis (Odland 1988; Upton and Fingleton 1985).[8] Analysis of variance is a method of estimating how much of the total variation in a variable is associated with a grouping of observations based on a criterion variable. The method provides a test for the difference in means between two or more groups.

Results: Counties and Census Tracts

This section presents the results first for the county-based statewide assessment and second for the census-tract urban assessment.

Statewide Assessment of County-Level Data

Zero-order correlations between demographic and toxic release variables for counties in Ohio indicate that population density and the two measures of minority concentration—areal density and proportion of population—exhibit strong associations with air, water, and off-site release measures (Table 1). These demographic variables tend not to be correlated with land releases (except for the association of the number of pounds of land release and minority concentration), nor with releases into water (except when these are weighted by inherent toxicity).

Variables associated with economic wealth exhibit much weaker associations with toxic releases. In the case of poverty and toxic releases, there are no statistically significant associations for the 88 Ohio counties; note, however, that all of these associations are negative, except for the poundage of water releases. Equally surprising is that both median household income and median housing value are positively associated with all release types, except unweighted water releases. But only in the cases of pounds of air releases and toxicity of off-site transfers are these associations statistically significant at the 95 percent confidence level. These results—that the greater the amount of release, the higher the household income and housing value—tend to run against the grain of conventional wisdom.

In order to isolate the relationship between each demographic variable and the toxic-re-

Table 1. Zero-Order Correlations of Toxic Releases and Socioeconomic Variables: Counties in Ohio (n = 88).

Release Venue	Persons/ Km^2	Minority Persons/ Km^2	Proportion Minority	Proportion Below Poverty	Median Household Income	Median Housing Value	Median Gross Rent
Toxicity Index							
On-Site Releases	0.117	0.120	0.151	−0.143	0.140	0.152	0.146
Air	0.379[b]	0.385[b]	0.379[b]	−0.086	0.163	0.158	0.217[b]
Water	0.547	0.556[b]	0.460[b]	−0.007	0.065	0.166	0.067
Land	−0.012	−0.009	0.025	-0.130	0.099	0.111	0.089
Off-Site Transfers	0.463[b]	0.434[b]	0.535[b]	−0.058	0.154	0.206[a]	0.240[b]
All Toxic Releases	0.355[b]	0.341[b]	0.421[b]	−0.136	0.190[a]	0.230[b]	0.246[b]
Number of Pounds							
On-Site Releases	0.311[b]	0.293[b]	0.422[b]	−0.042	0.075	0.090	0.128
Air	0.725[b]	0.686[b]	0.674[b]	−0.103	0.189[a]	0.268[b]	0.309[b]
Water	0.130	0.142	0.142	0.059	−0.060	−0.003	−0.032
Land	0.175	0.165	0.226[b]	−0.086	0.093	0.055	0.075
Off-Site Transfers	0.788[b]	0.814[b]	0.734[b]	−0.024	0.115	0.220[b]	0.208[a]
All Toxic Releases	0.681[b]	0.684[b]	0.720[b]	−0.042	0.118	0.192[a]	0.210[b]

Notes: Chemical releases are summed for the years 1987 through 1990. See text for explanation of toxicity index. Km^2 signifies squared kilometers.
[a]α significant at 0.05 level (one-tailed; r > 0.176).
[b]α significant at 0.01 level (one-tailed; r > 0.209).
Sources: *Toxic Release Inventory, 1987–1990* (U.S. EPA 1987; 1988, 1989, 1990); *1990 Census of Population and Housing* (U.S. Bureau of the Census 1990).

lease variables from the influence of other demographic variables, we also conducted a partial correlation analysis in which release amount is the dependent variable and each of the seven demographic variables is the independent variable, with the other six demographic variables held constant (sixth-order partial correlation). Results are presented in Table 2. Once the effects of other demographic variables are statistically removed, some of the associations noted above disappear and others emerge. The analysis thus yields the following associations:

(1) the toxicity index for water release is related to population density, housing value, and rent;
(2) the toxicity index for off-site releases is related to proportion minority;
(3) pounds of on-site releases is related to proportion minority;
(4) pounds of air release is related to population density;
(5) pounds of off-site release is related to proportion minority and median gross rent; and
(6) both the toxicity index and total pounds of release are related to proportion minority.

In sum, venue-specific associations of releases and demographic variables are few in number except for the associations with the proportion of the population that is minority. When TRI data are aggregated to the county level, statistical analysis offers *prima facie* evidence that higher levels of degradation are directly associated with minority residence.

Causality cannot be presumed on the basis of these statistical observations, however. Many variables remain unaccounted for, including those distinguishing urban and industrial counties from rural counties. We know, for example, that the bulk of the state's manufacturing and its population are located in counties containing cities such as Cleveland, Cincinnati, Columbus, Akron, Youngstown, Lorain-Elyria, and Toledo, and that the fourteen most "urban" counties also contain approximately 90 percent of the state's minority population. Figures 1 and 2 show the county-level distributions of toxic chemical releases and TLV-weighted chemical releases in the state summed over the four-year period. The more highly populated urban counties are among those counties with the greatest release amounts.

The statewide correlations may, therefore, be artifacts of differences between urban and industrial counties, on the one hand, and suburban and rural ones, on the other. To test this urban-rural hypothesis we employ an analysis

Table 2. Partial Correlations of Toxic Releases and Socioeconomic Variables: Counties in Ohio (n = 88).

Release Venue	Persons/ Km^2	Minority Persons/ Km^2	Proportion Minority	Proportion Below Poverty	Median Household Income	Median Housing Value	Median Gross Rent
Toxicity Index							
On-Site Releases	–0.0827	0.0587	0.1105	–0.1378	–0.1201	0.1058	0.0516
Air	–0.0512	0.1320	0.0561	0.1264	0.1564	–0.1748	0.0545
Water	0.2577[a]	–0.0946	0.0797	–0.0122	0.0333	0.2240[a]	–0.3810[b]
Land	–0.0856	0.0309	0.1008	–0.0898	–0.1798	0.1616	0.0566
Off-Site Transfers	0.0696	–0.0719	0.3058[b]	0.0306	0.0296	0.0392	–0.0677
All Toxic Releases	–0.0258	0.0059	0.2540[a]	–0.0904	–0.0770	0.1034	0.0026
Number of Pounds							
On-Site Releases	0.0395	–0.0863	0.3206[b]	–0.0502	–0.0319	0.0444	–0.0543
Air	0.2615[a]	–0.0947	0.2007	–0.0988	–0.0538	0.0814	–0.0912
Water	0.0168	–0.0193	0.0990	–0.0874	–0.1076	0.1344	–0.0562
Land	0.0489	–0.0409	0.1368	0.0245	0.0827	–0.0582	–0.0807
Off-Site Transfers	0.1235	0.1527	0.2362[a]	–0.0344	0.0075	0.1203	–0.2165[a]
All Toxic Releases	0.0974	0.0015	0.3889[b]	–0.0617	-0.0244	0.1001	-0.1592

Notes: These are sixth order partial correlations; each is computed using the release venue as the dependent variable, while holding all other variables constant. Chemical releases are summed for the years 1987 through 1990. See text for explanation of toxicity index. Km^2 signifies square kilometers.

[a] α significant at 0.05 level.

[b] α significant at 0.01 level.

Sources: *Toxic Release Inventory, 1987–1990* (U.S. EPA 1987, 1988, 1989, 1990); *1990 Census of Population and Housing* (U.S. Bureau of the Census 1990).

of variance that compares urban and rural counties.[9] Urban is defined as those counties which contained a 1990 MSA central city and rural as those which did not.

Measures of population density, minority density, and proportion minority all are significantly higher in the fourteen urban counties (Table 3). The urban counties also report significantly higher levels of toxic chemical releases. Thus, while the county-level data provide evidence confirming the hypothesis of racial bias in toxic releases, the associations between race and releases at this level of aggregation are also associated with factors which distinguish "urban" from "non-urban" counties.

Metropolitan Assessment of Tract-Level Data

Turning to the intra-metropolitan analysis, our assessment of the spatial association between toxic releases and demographic variables poses two questions at coarse and fine resolutions. First, given that many tracts contain no release sites while others contain one or more, we ask: do tracts with release sites differ in demographic composition from tracts without release sites?[10] Although Burke (1993) has previously examined the relationship between the *number* of sites and the demographic composition of tracts; her approach fails to distinguish between release facilities, either in terms of the quantity or the kind (how toxic) of material released into the environment. Our second question moves to a finer scale of resolution: what are the spatial associations at the census-tract scale between the amounts and toxicities of chemical releases and demographic variables? The first question is addressed using analysis of variance, the second using both zero-order correlations and partial correlations to identify the independent associations between toxic releases and demographic variables.

Demographic Characteristics of Tracts with and without Toxic Chemical Releases: Results of an Analysis of Variance. Figure 3 maps the distributions of TRI sites and minority population in Cuyahoga County. Visual inspection of this map invites one question above all others: Do areas (i.e., tracts) with TRI sites contain disproportionate concentrations of minority populations? This question is further refined to accommodate the spatial adjacency of demographic groups to tracts with TRI sites.

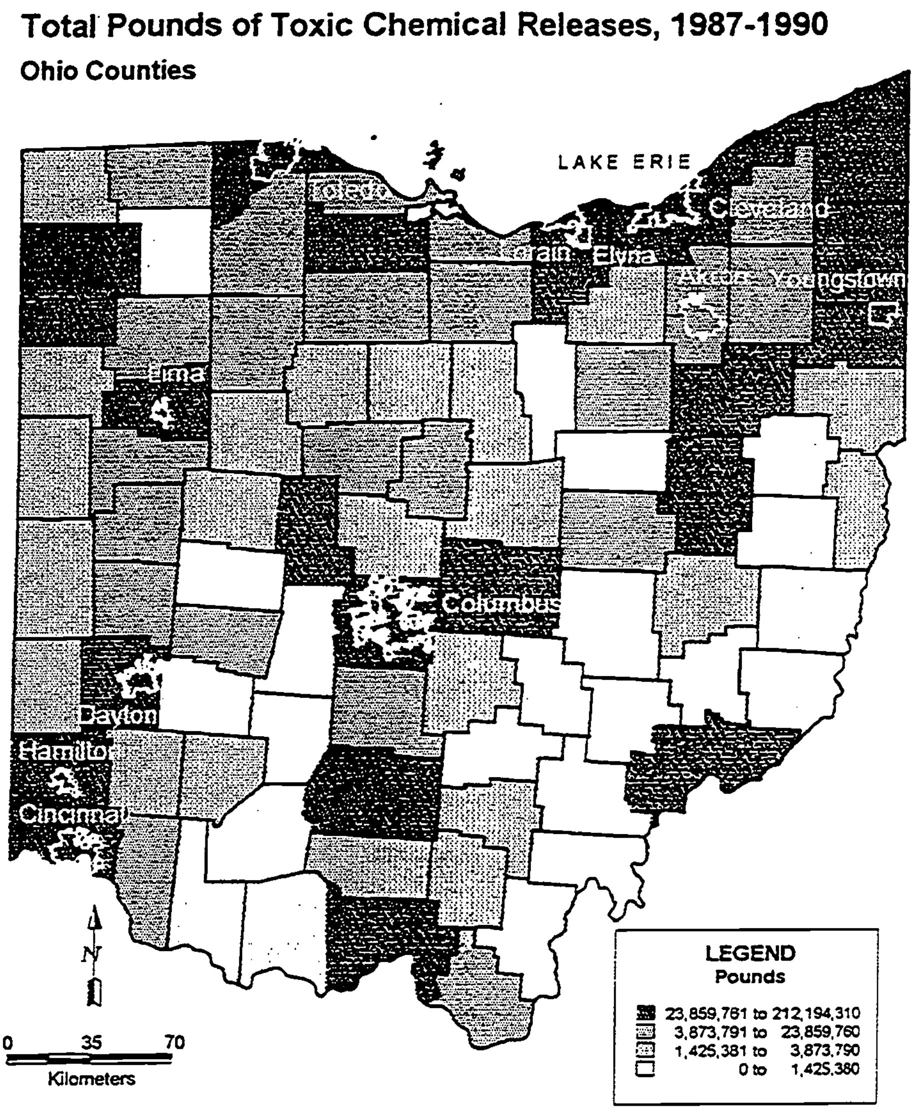

Figure 1. Total pounds of toxic chemical releases, 1987–1990, *Ohio counties*. Urban counties are among those with the greatest release amounts. Source: *Toxic Release Inventory* (EPA 1987–1990).

This question may be addressed by creating a typology of TRI-site tracts and testing for differences in the demographic characteristics of the various groups of tracts. Incorporating the spatial proximity of demographic groups to TRI sites into the typology yields three census-tract classes: 1) tracts with no TRI reported facilities (on-or-off-site) in them or in adjacent tracts; 2) tracts with toxic chemical releases or transfers in one or more adjacent tracts with releases; and 3) tracts with one or more toxic facilities. The first category depicts "clean" tracts with "clean" neighboring tracts. The second category depicts "potentially exposed" tracts. This category recognizes that a tract population may be exposed or endangered by releases from a TRI site nearby. Such is the case when TRI sites occur on or near the boundary of

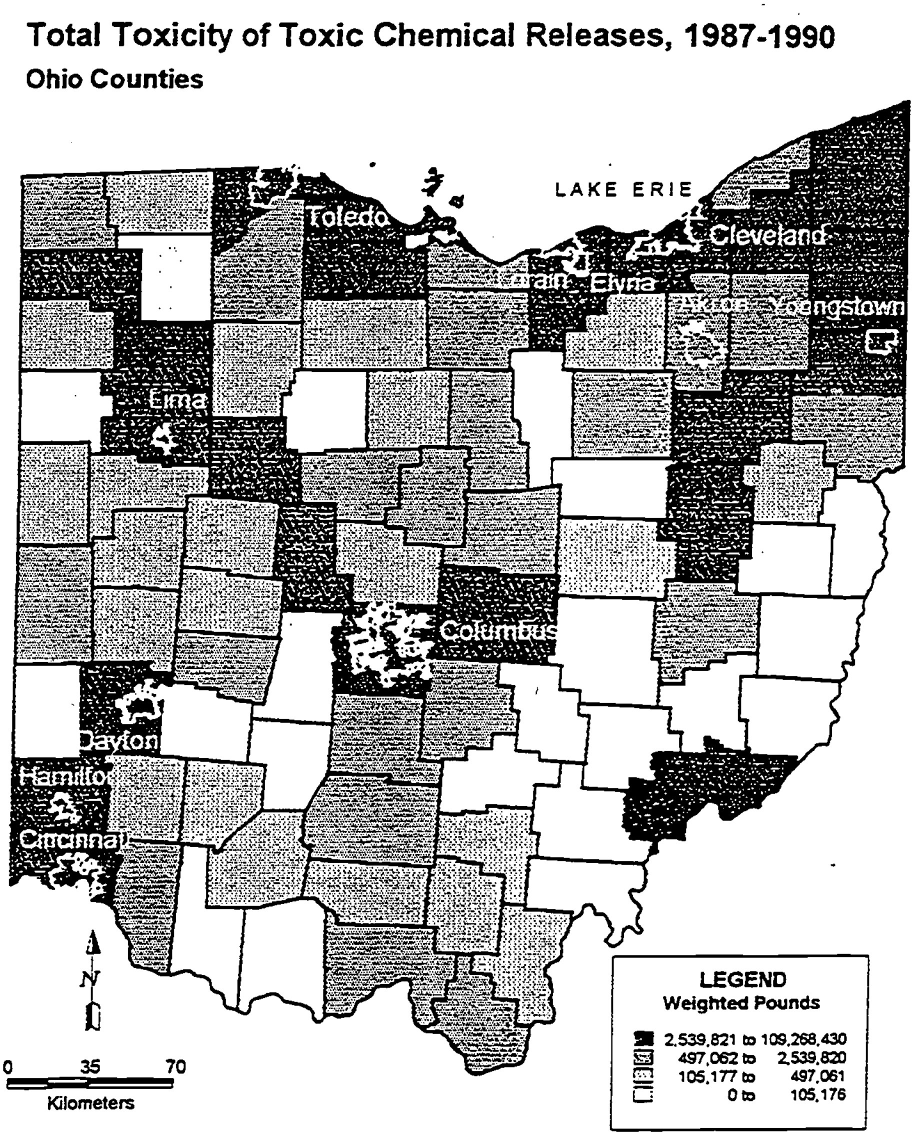

Figure 2. Total toxicity of toxic chemical releases, 1987–1990, Ohio counties. Urban counties are among those with the greatest toxicity index values. See text for explanation of toxicity index. Source: *Toxic Release Inventory* (EPA 1987–1990).

census tracts, for example. In addition, tracts with high concentrations of industry and TRI sites may be largely or entirely non-residential, as is the case for Cuyahoga's five tracts in the so-called "industrial flats" which have no population whatsoever. Yet residential neighborhoods on the fringe of these industrial areas house populations may experience greater exposure to released chemicals than do residents of neighborhoods farther away. In the absence of precise estimates of release decay functions, e.g., variable wind flows, particulate dispersion, and other toxic decay factors, this portion of our analysis represents merely a first approximation of the spatial association of residential populations and TRI sites.[11] The third

Table 3. Comparison of "Urban" and "Non-Urban" Counties in Ohio Using Analysis of Variance and Kruskal-Wallis Test

Variable		Means		Probability	
		"Urban" (n = 14)	"Non-Urban" (n = 74)	> F (ANOVA)	> Chi Square (Kruskal-Wallis)
Demographic					
Persons / Km^2		389.1	52.3	0.0001	0.0001
Minority Persons / Km^2		69.7	1.8	0.0001	0.0001
Proportion Minority		13.1	2.8	0.0001	0.0001
Proportion Below Poverty		65.9	61.1	0.5635	0.0716
Median Household Income		$28,026	$26,930	0.4574	0.3986
Median Housing Value		$59,900	$53,532	0.1134	0.0343
Median Gross Rent		$367	$337	0.0324	0.0225
Release Venue					
Toxicity Index	On-Site	4,549,606	2,411,053	0.5189	0.0001
	Air	3,050,492	799,350	0.0155	0.0002
	Water	389,973	11,398	0.0006	0.0001
	Land	858,523	1,598,479	0.0854	0.0001
	Off-Site	14,601,864	890,553	0.0001	0.0003
	All	19,151,469	3,301,605	0.0004	0.0001
Pounds	On-Site	42,380,891	5,550,318	0.0001	0.0001
	Air	18,968,880	3,489,109	0.0001	0.0001
	Water	2,581,669	688,604	0.0987	0.0001
	Land	6,717,903	1,161,143	0.0072	0.0001
	Off-Site	41,311,701	3,615,508	0.0001	0.0002
	All	83,692,592	9,165,856	0.0001	0.0001

Notes: "Urban" counties are those with a 1990 MSA central city and "Non-Urban" counties are all others. Chemical releases are summed for the years 1987 through 1990. See text for explanation of toxicity index. Km^2 signifies square kilometers.
Sources: *Toxic Release Inventory, 1987–1990* (EPA 1987, 1988, 1989, 1990); *1990 Census of Population and Housing* (U.S. Bureau of the Census 1990).

category depicts "dirty" tracts with toxic facility locations. Based on this typology, Cuyahoga County reports 123 "clean" tracts, 147 "dirty" tracts, and 225 tracts which are potentially exposed to releases in adjacent tracts.

Most of Cuyahoga's census tracts do not contain any toxic chemical release sites (70 percent), but 45 percent of all tracts are adjacent to one or more tracts that do (see Table 4). These "potentially exposed" tracts have, on average, the highest density of population (1,896 persons per square kilometer). "Dirty" tracts (at least one toxic release site), by contrast, have the lowest density (1,521 persons per square kilometer). "Clean" tracts (no toxic facility in or adjacent to the tract) have densities that fall between the other two groups. These results are consistent with conventional notions of urban spatial structure which hold that industrial areas have low population densities owing to competition for land (i.e., bid-rent curves differentiate landuse types); that residential areas near industrial concentrations have the highest densities of population, mainly consisting of working-class neighborhoods; and that areas further away from the industrial core include both high- and low-density residential neighborhoods.

Minority concentration, whether measured by areal density or proportion of population, is greatest in "clean" tracts and lowest in "dirty" ones. In the latter, minority density falls to just 623 per square kilometer, but the proportion of minorities is just slightly lower (28.9 percent) than in "potentially exposed" tracts (31.5 percent). "Clean" tracts have the highest density of minorities (1,613 per square kilometer) and the highest proportion of minorities (39.0 percent) in the population.[12]

Some caution is warranted concerning the interpretation of the relationship between the minority proportion and tract proximity to release sites. Because of significant racial housing segregation in the county (see Figure 3), the statistical distribution of the proportion minority is largely bimodal and skewed, i.e., non-normal in distribution. Most tracts, in other words, are virtually all white, while many other tracts are actually or virtually all black; relatively few tracts are integrated. Indeed the Kruskal-

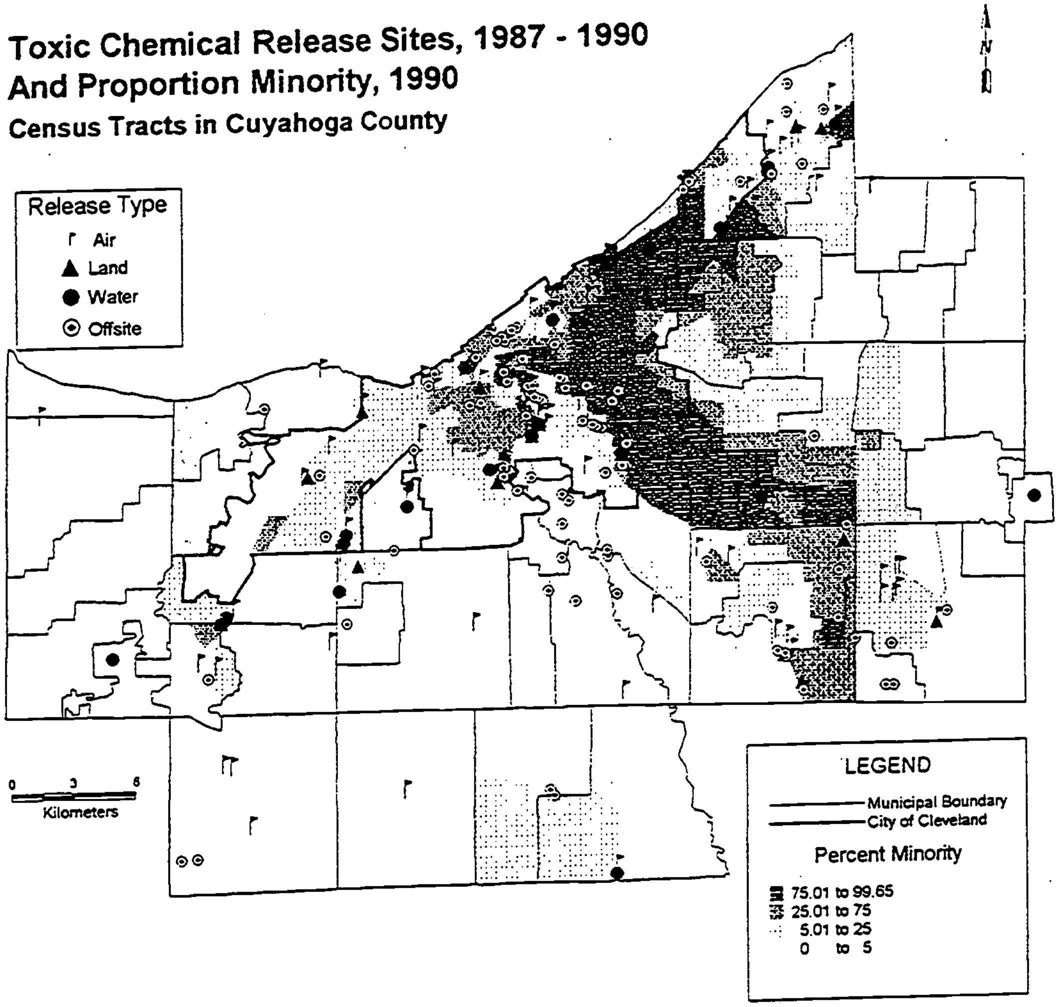

Figure 3. Toxic chemical release sites, 1987–1990, and proportion minority, 1990, census tracts in Cuyahoga County. Is there a spatial association between release sites and minority concentration? Sources: *Toxic Release Inventory* (EPA 1987–1990); *1990 Census of Population and Housing* (U.S. Bureau of Census 1990).

Wallis statistic (employed here because it is independent of any statistical distribution assumptions) indicates that the minority proportions for the three groups of tracts are not significantly different.

In terms of economic indicators, the poverty rate is greatest in "dirty" tracts (20.8 percent) or "potentially exposed" tracts (20.3 percent). Consistent with this finding, average median household income averages $33,431.00 in "clean" tracts and $24,824.00 in "dirty" tracts. Housing values and rents also decline in "potentially exposed" and "dirty" tract groups.

Zero-Order Correlations between Toxic Chemical Releases and Demographic Variables: An Estimate of Exposure Potential. These preliminary findings set the stage for more refined analyses. Given quantitative data on the amounts and kinds of toxic emissions at TRI sites, we take a closer look at the spatial relationship between tract release levels and demographic variables. Figures 4 and 5, respectively, map the distribution of total poundage of toxic chemical release in Cuyahoga County, and the TLV-weighted distribution of these chemicals. Toxic chemical release con-

Table 4. Comparison of "Clean," "Exposed," and "Dirty" Census Tracts in Cuyahoga County Using Analysis of Variance and Kruskal-Wallis Test.

	Group Mean						
Tract Grouping	Persons/ Km^2	Minority Persons/ Km^2	Proportion Minority	Proportion Below Poverty	Median Household Income	Median Housing Value	Median Gross Rent
"Clean": No toxic facility in tract or in adjacent tracts (n = 123)	1,653	1,613	0.39	0.14	$33,431	$78,341	$474
"Exposed": Toxic facility in adjacent tract (n = 225)	1,896	1,122	0.31	0.20	$27,587	$66,934	$419
"Dirty": Toxic facility in tract (n = 147)	1,521	623	0.29	0.21	$24,824	$54,858	$382
ANOVA (Probability > F)	0.0001	0.0001	0.0895	0.0126	0.0001	0.0001	0.0009
Kruskal-Wallis (Probability > CHISQ)	0.0001	0.0169	0.6000	0.0058	0.0001	0.0001	0.0001

Notes: Tract grouping is based on locations of TRI facility sites in any of the four years from 1987 through 1990. Km^2 signifies square kilometers.
Sources: *Toxic Release Inventory, 1987–1990* (EPA 1987, 1988, 1989, 1990); *1990 Census of Population and Housing* (U.S. Bureau of the Census 1990).

centrations are largely associated with the industrial Cuyahoga River Valley (in the south-central portion of the City of Cleveland) and the railroad lines running northeast-southwest through the City of Cleveland near Lake Erie and from the central part of the City toward the southeast corner of the County. Some extensive concentrations are found in suburban industrial development zones such as those found in the southeast corner of the County.

Examining the statistical associations between these two release distributions and the distributions of minorities (see Figure 3) and other demographic variables with zero-order correlations (see Table 5), we find that only one independent variable—population density—is consistently and significantly correlated with toxic chemical releases, both in terms of pounds and toxicity. Population density is significantly and inversely correlated with the toxicity levels and poundage of all releases on-site, of all releases off-site, and of all air releases. Water and land releases are also inversely correlated with population density, but these correlations are statistically insignificant. With respect to minority populations, minority density is negatively associated with the toxicities and pounds of all releases and with all venues of release, though only total release poundage is statistically significant. These correlations thus run in the opposite direction of the one posited by the hypothesis of environmental inequity. Similarly, all but one of the correlations with minority proportion (the toxicity of land releases) are negative, though none are statistically significant. These observations are clearly inconsistent with the hypothesis of environmental inequity which predicts higher levels of degradation in areas with larger proportions of minority residents.

Nor do the socioeconomic variables offer much support for the hypothesis. Correlations of income and housing values with venues of toxic chemical release are almost all negative, with only the poundage of air releases being statistically significant. In addition, the reason for the anomalous positive (but insignificant) association between toxicity-weighted water releases and housing values is not intuitively obvious. Perhaps the water releases are going in to Lake Erie where housing values are higher along the lakefront. Correlations between poverty and toxicity-weighted releases are generally negative and insignificant. The direction of this relationship appears to change when considering poundage, which suggests that chemical releases in Cuyahoga's higher poverty tracts tend to be less toxic per pound of release.

Partial Correlation Analysis. In order to evaluate the statistical relationships between toxic releases and individual demographic variables, we posited that toxic release is a linear function of the demographic variables. This en-

Table 5. Zero-Order Correlations of Toxic Releases and Socioeconomic Variables: Census Tracts in Cuyahoga County (n = 495).

Release Venue	Persons/ Km²	Minority Persons/ Km²	Proportion Minority	Proportion Below Poverty	Median Household Income	Median Housing Value	Median Gross Rent
<u>Toxicity Index</u>							
On-Site Releases	−0.087[a]	−0.043	−0.037	−0.017	−0.007	−0.017	−0.007
Air	−0.078[a]	−0.042	−0.039	−0.012	−0.004	−0.019	−0.011
Water	−0.056	−0.019	−0.012	−0.020	−0.020	0.042	0.047
Land	−0.041	−0.017	0.003	−0.019	−0.019	−0.007	0.000
Off-Site Transfers	−0.090[a]	−0.051	−0.009	−0.014	−0.015	−0.015	−0.026
All Toxic Releases	−0.113[a]	−0.063	−0.020	−0.018	−0.017	−0.020	−0.027
<u>Number of Pounds</u>							
On-Site Releases	−0.096[a]	−0.051	−0.033	0.0249	−0.061	−0.058	−0.052
Air	−0.130[b]	−0.070	−0.015	0.0408	−0.080[a]	−0.072	−0.069
Water	−0.043	−0.010	−0.019	0.0167	−0.036	−0.039	−0.030
Land	−0.060	−0.040	−0.049	0.0052	−0.037	−0.036	−0.031
Off-Site Transfers	−0.105[a]	−0.072	−0.060	-0.007	−0.029	−0.038	−0.047
All Toxic Releases	−0.138[b]	−0.088[a]	−0.068	0.068	−0.056	−0.062	−0.067

Notes: Chemical releases are summed for the years 1987 through 1990. See text for explanation of toxicity index. Km² signifies square kilometers.
[a]α significant at 0.05 level (one-tailed; $r > 0.074$).
[b]α significant at 0.01 level (one-tailed; $r > 0.104$).
Sources: *Toxic Release Inventory, 1987–1990* (U.S. EPA 1987; 1988, 1989, 1990); *1990 Census of Population and Housing* (U.S. Bureau of the Census 1990).

abled us to conduct partial correlation analyses to measure whether or not unit changes in particular demographic variables are statistically related to the levels of toxic releases, while holding all other demographic variables constant. This yields a total of twelve partial correlation analyses, one for each release venue. In each analysis, the demographic variables are the independent variables. Whenever Moran's I indicates the presence of significant spatial autocorrelation, we use first spatial differences for the dependent variable (Martin 1974).[13] The resulting partial correlations are reported in Table 6.

In terms of the race variables, the only significant relationships between race and releases are inverse. The significant relationships with the toxicities of off-site transfers and all toxic releases are due to the chemicals imported into the county and released, largely in treatment facilities located in the more peripheral areas. We also see a tendency for minorities to reside further away from the locations of air releases (measured in pounds). With regard to toxic release and race, we conclude that minorities in Cuyahoga County have, if anything, a slightly smaller likelihood of residing in the immediate vicinity of a release.

In terms of the income variables, all of the significant relationships reflect off-site transfers (these include receipts from out of the county). We observe negative relationships between: 1) poverty (percent) and off-site transfers (pounds); and 2) median household income and off-site transfers (toxicity). We also see a positive relationship between housing value and toxicity transfers off-site. These results suggest that the transfer sites are not located in the high-poverty tracts with the greatest levels of unemployment and most dilapidated housing (near the center of the city). Rather the sites are located in the more peripheral working-class tracts with slightly lower than average incomes and slightly higher than average housing values. No other statistically significant relationships are observed.

Conclusions

An issue as controversial as environmental equity requires research that assesses the spatial coincidence between environmental disamenities and minority or disadvantaged populations *prior to* an analysis of causation and the role of racial intent. Our results provide little evidence on behalf of an aggregate association between environmental disamenities

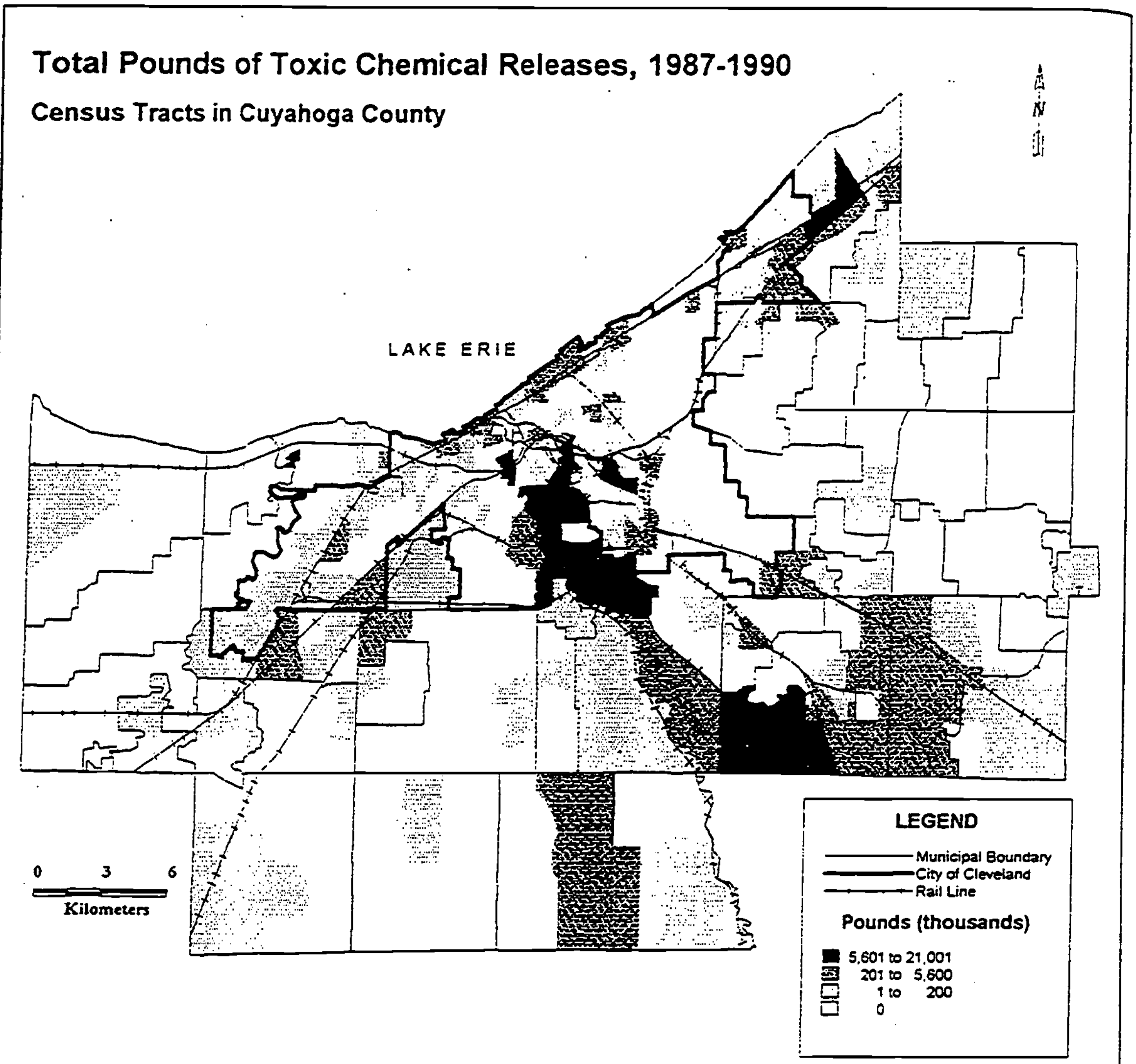

Figure 4. Total pounds of toxic chemical releases, 1987–1990, census tracts in Cuyahoga County. Concentrations are largely found in the industrial valley, along railroad and highway corridors, and in some outlying communities. Source: *Toxic Release Inventory* (EPA 1987–1990).

and minority concentration, nor do they suggest the systematic operation of racist intent with regard to site selection for industrial toxic releases. These findings do not, however, rule out environmental discrimination in particular cases or situations.

When viewing spatial associations at the state level (using counties as the spatial unit of analysis), the correlations between minority concentration and toxic release amounts are high. However, since industry, minority populations, and toxic releases are concentrated in urban areas, these correlations merely reflect their coincident concentration in urban counties with more industrial jobs. Owing to the coarseness of these spatial associations, we conclude that the issue of environmental equity is not amenable to a county-level analysis. Analyses using smaller spatial units are more appropriate.

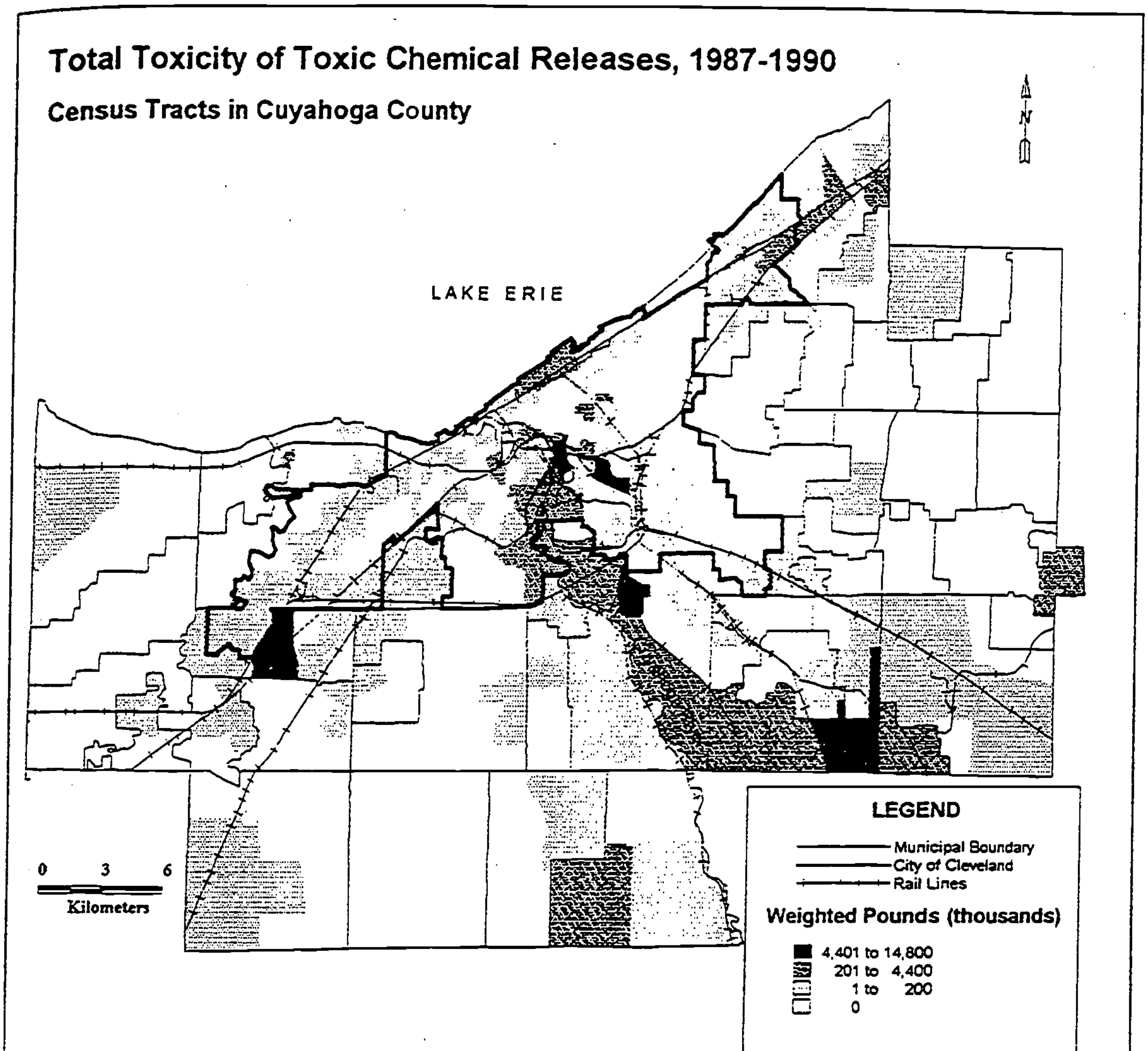

Figure 5. Total toxicity of toxic chemical releases, 1987–1990, census tracts in Cuyahoga County. Concentrations are largely found in the industrial valley, along railroad and highway corridors, and in some outlying communities. See text for explanation of toxicity index. Source: *Toxic Release Inventory* (EPA 1987–1990).

Our metropolitan-area census-tract analysis indicates that minority densities are inversely correlated with toxic chemical releases on-site and off-site. Minorities in Cuyahoga County do not, as a rule, reside in neighborhoods with greater industrial toxic chemical releases than do non-minorities. Conversely, we find some evidence of income discrimination with respect to the locations of toxic facilities and the amount of air releases. Toxic industrial release facilities in Cuyahoga County are, in other words, more likely to be located in poorer and less affluent areas than in areas with minority concentrations.

Causal inferences from these findings are more problematic, since economic and industrial location theory offers at least three distinct explanatory frameworks (Hamilton 1995), each with their own causal paths, interpretations, and policy implications. These have not been prejudged in this paper. Our intent instead has been to point out that the analysis of spatial

Table 6. Partial Correlations of Toxic Releases and Socioeconomic Variables: Tracts in Cuyahoga County (n = 495).

Release Venue	Persons/ Km^2	Minority Persons/ Km^2	Proportion Minority	Proportion Below Poverty	Median Household Income	Median Housing Value	Median Gross Rent
Toxicity Index							
On-Site Releases	−0.0049	−0.0253	−0.0066	−0.0770	0.0022	−0.0212	−0.0068
Air	−0.0025	−0.0158	−0.0182	0.0036	0.0201	−0.0345	−0.0130
Water	−0.0108	−0.0218	0.0167	−0.0002	−0.0643	0.0605	0.0534
Land	−0.0084	−0.0394	0.0425	−0.0489	−0.0564	0.0343	0.0099
Off-Site Transfers	−0.0214	−0.0932[a]	0.0631	−0.0733	−0.1567[b]	0.1112[a]	0.0185
All Toxic Releases	−0.0215	−0.0951[a]	0.0547	−0.0698	−0.1420[b]	0.0927[a]	0.0141
Number of Pounds							
On-Site Releases	−0.0084	−0.0423	−0.0164	0.0108	−0.0333	−0.0068	−0.0022
Air[c]	0.0762	−0.0887[a]	−0.0202	0.0650	−0.0294	0.0147	0.0054
Water	−0.0022	0.0110	−0.0374	0.0137	−0.0022	−0.0217	−0.0021
Land	−0.0050	0.0004	−0.0485	0.0123	−0.0153	−0.0139	−0.0042
Off-Site Transfers[c]	0.0278	−0.0613	−0.0350	−0.1055[a]	−0.0091	−0.0068	−0.0355
All Toxic Releases[c]	0.0339	−0.0698	−0.0458	−0.0723	−0.0185	−0.0011	−0.0235

Notes: These are sixth order partial correlations; each is computed using the release venue as the dependent variable, holding all other variables constant. Chemical releases are summed for the years 1987 through 1990. See text for explanation of toxicity index. Km^2 signifies square kilometers.
[a]α significant at 0.05 level.
[b]α significant at 0.01 level.
[c]First spatial difference of dependent variable is utilized due to spatial autocorrelation.
Sources: *Toxic Release Inventory, 1987–1990* (U.S. EPA 1987, 1988, 1989, 1990); *1990 Census of Population and Housing* (U.S. Bureau of the Census 1990).

patterns should be appropriate to the level of decisions that created these patterns. Without appropriate spatial scaling, statistical correlates become highly suspect. In the case of issues as complex as spatial equity and environmental justice, legitimate fears and concerns must be carefully assessed in terms of disaggregated analysis as specific as possible to site and situation. While our results do not negate findings in Los Angeles (Burke 1993) or elsewhere (Hamilton 1993), and are not proof that environmental discrimination within the Cleveland metropolitan area did not happen in specific cases, they do suggest that systematic environmental discrimination cannot be detected from spatial patterns and associations examined there at the census-tract level.

These findings suggest the need for further research. First is the need for more dynamic models. Our study, owing to data limitations, has been confined to investigation of a static pattern—a snapshot at one point in time. More insight on causality might result from analysis of the spatial dynamics of environmental hazards and their socio-economic correlates in terms of issues of environmental justice.

Second is the need to integrate these empirical findings with theories of urban structure. Some evidence suggests that urban cores or nearby urban core industrial sites (often representing earlier industrial location decisions) have been associated with the poor and minorities as wealthier, majority populations and industrial firms abandon the core and seek newer locations outside of the old urban core. Concurrently, firms in the urban core may seek new industrial waste sites that are further out in the suburbs owing to lower land costs in the urban fringe. In these cases, some large census tracts on the fringe may report a mixture of higher incomes, white majority populations, and newer TRI sites. This restructuring of urban geography implies a "U" shaped curve of toxic-waste site locations in which older toxic-waste sites are located in inner-city urbanized areas with high incidences of minority and poor housing, and the newer waste sites are located near higher-income suburbs.

It would be inappropriate, on the basis of this or any similar empirical study, to conclude that environmental disadvantages do not accrue to particular groups anywhere in the United States; our position is that the empirical evidence of systematic discrimination is not immediately apparent. Though we are convinced that many places in the United States do experience environmental inequity, we also believe that these controversial issues are too important to be relegated solely to the popular realms of anecdote and political opinion. Rather, the issues of environmental discrimination should be examined empirically, and as systematically and impartially as possible.

Acknowledgments

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Notes

1. Prior to each decennial census, the U.S. Bureau of the Census provides guidelines to local committees for delineating census tracts. Boundary criteria usually include considerations such as population size, types of boundary features, tract compactness (shape), and demographic homogeneity. Local committees use these flexible guidelines in making recommendations on tract delineations to the Bureau prior to each census of population and housing. The local committee in the Cleveland area placed an extremely high priority on delineating tracts with demographic homogeneity (Salling 1986).
2. Our analyses are not explicitly aimed at the role of scale. See Fotheringham and Wong (1991) for findings on the sensitivity of results to the scale of areal units of analysis. An analysis of the importance of scale on the spatial association between population and environmental hazards surely should include a case-study approach of site-specific releases and their immediately adjacent populations. This is not the approach taken here; our interest is in comparing statewide, county-level patterns with intra-urban, tract-level patterns.
3. This analysis assigns chemical releases to the county in the statewide assessment and to the census-tract level in the metropolitan assessment. TRI data include the longitude and latitude of on-site release facilities. For chemicals that are transferred off-site for treatment and disposal, the TRI report provides the address of the treatment/disposal site. Several sources of error are associated with assigning the data to geographic units: the respondent, the data-entry process, and the matching of addresses and coordinate data to a geographic reference file. For the statewide assessment, we use the county designation in the TRI database. For the on-site locations in Cuyahoga County, the authors obtained an enhanced dataset of facility longitudes and latitudes from Loren Hall of the Environmental Assistance Division of USEPA. These enhancements are documented by ViGYAN, Inc. (1992), an EPA consultant. The enhancement methodology includes error-checking routines that look for "gross errors." Coordinate locations are checked against locations derived from street-address fields in the TRI data. If gross errors (difference of 2 km or more) cannot be improved upon using street-address-defined coordinates, then area (e.g., zip code) centroids are provided. Clearly these coordinates may err somewhat with respect to the location of release sites. They may reflect, for example, office locations at some distance from the actual release sites. In addition, the geographic reference file used to assign latitude and longitude coordinates, the Census Bureau's TIGER Line™ file, has its own limitations in locational accuracy. Prior experience with TIGER data in Cuyahoga County indicates, however, that errors resulting from TIGER-file errors are probably few when the census tract is the aggregation unit. TIGER was also used to locate off-site addresses in Cuyahoga County. Address-range errors in the Cuyahoga TIGER line file are unlikely to result in many tract misassignments. Nevertheless, aggregating less-than-exact point locations and addresses into census tracts in Cuyahoga County is prone to some error. (See Haining and Arbia 1993 for a discussion of error in map operations.)
4. The spatial demographic patterns identified with the data used in this analysis are not likely to have undergone drastic change in the time period, particularly at the state-level of analysis. In Cuyahoga County, trends between 1980 and 1990 show that residential concentrations of blacks and Hispanics have expanded from inner-city neighborhoods to nearby inner-ring suburbs, particularly in directional paths. Poverty rates and housing costs also have increased in an outward, though less directional, fashion. These relatively short-term trends are less significant to the spatial associations of pollution and disadvantaged populations than are the longer-term trends of associations between industrial migration, population movement, housing and neighborhood segregation and decline, and the siting of noxious facilities. But explanation of these trends clearly exceeds the scope of this study.
5. The correlation between the pounds of TRI chemicals released and the aggregated toxicity of those chemicals varies considerably. When considering combined air, land, and water on-site releases in Ohio at the county level, the correlation (r) between pounds and toxicity is 0.132. The correlation with off-site releases is 0.630 and with on-site and off-site releases combined, 0.407. Differences in correlation also exist depending upon the venue. For air alone, the cor-

relation is 0.340; for land alone, 0.086; and for water alone, 0.088. The substantial variation in these correlations undoubtedly is due to differences in the distributions of chemical releases from county to county and from release venue to release venue. Some counties have larger releases of less toxic chemicals; other counties have smaller releases of more toxic ones.

6. However, census-tract data record the residential (largely evening) population distribution, not the day-time employment distribution. This is one of the advantages of the Glickman (1994) study which uses day-time and evening populations, derived from journey-to-work census tabulations by traffic zone.
7. The relationship between household income (and socio-economic status) and family life-cycle is conceptualized in models of urban spatial structure and is well documented in the literature on urban residential differentiation. See Timms (1971) for a thorough exposition.
8. Spatial autocorrelation is not of interest in an analysis of these associations at the county-level; these spatial units are too large in relation to the phenomena being measured (i.e., residential demographic patterns and toxic releases).
9. Both ANOVA and the Kruskal-Wallis Analysis of Variance are presented in Tables 3 and 4. Kruskal-Wallis is used in order to account for non-normal distributions in (among) the sampled population(s). It is a distribution-free test of medians (Siegel and Castellan, Jr. 1988).
10. This question is moot for the state-wide, county-level analysis since all 88 counties have toxic release sites.
11. The use of GIS holds promise for more complex spatial modeling. Glickman (1994) takes a step in this direction using the circular buffering function of geographic information systems to create a typology of areas based on distances (radii) from TRI sites in Allegheny County, Pennsylvania. Comparison of the demographic composition of the area inside the buffer zone, called the "close-proximity region," to the rest of the county indicates statistically significant differences; close-proximity areas have higher proportions of non-whites and of persons below the poverty level than do areas outside the close proximity areas.
12. Sample variances do not differ substantially among these variables. Most differences between high and low variances are less than 75 percent. The maximum difference in variance between groups for minority density is 237 percent.
13. Moran's I identifies the presence of spatial autocorrelation in the release measures in a region which would render unreliable any tests of statistical significance. Regression upon first spatial differences is utilized throughout the multivariate analyses for those variables with significant values of Moran's I. First spatial differences provides a reasonable, if approximate, way to eliminate spatial autocorrelation problems (Martin 1974). Moran's I indicates significant spatial autocorrelation between nearby tracts with regard to three of the toxic release measures (Table 7).

Table 7. Moran's I Statistics for Toxic Releases by Census Tract in Cuyahoga County.

Variable	Moran's I	Var(I)	z-score
Toxicity Index			
On-site Releases	−0.0076	0.0003	−0.562
Air	−0.0035	0.0002	−0.402
Water	−0.0021	0.0004	−0.208
Land	−0.0075	0.0004	−0.505
Off-Site Transfers	0.0149	0.0005	0.576
All Toxic Releases	0.0095	0.0006	0.305
Number of Pounds			
On-site Releases	0.0078	0.0003	0.315
Air	0.0433	0.0005	1.786[a]
Water	0.0010	0.0001	0.138
Land	−0.0059	0.0002	−0.563
Off-Site Transfers	0.1319	0.0006	5.302[b]
All Toxic Releases	0.1892	0.0006	7.641[b]

[a]significant at 0.10 level.
[b]significant at 0.01 level.

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Bowen, William M., Salling, Mark J., Haynes, Kingsley E., and Cyran, Ellen J. 1995. Toward Environmental Justice: Spatial Equity in Ohio and Cleveland. *Annals of the Association of American Geographers* 85(4):641–663. *Abstract.*

A growing body of research documents the inequitable impact of environmental hazards on poor and minority communities. This paper uses the United States Environmental Protection Agency's Toxic Release Inventory for 1987–1990 and the 1990 Census of Population and Housing to analyze the spatial distribution of toxic industrial pollution and demographic groups in Ohio. In apparent support of the previous body of research, we report high correlations between racial variables and level of toxic release at the county level. The highest levels of toxic release in Ohio occur in the state's most urban counties, fourteen of which contain approximately 90 percent of the state's minority population. However, a census-tract examination of the most urban of these counties, Cuyahoga, reveals no relationships between race and toxicity. The tract-level data do provide some evidence of income-environment inequity, and these findings prompt several methodological advisories for further research. The principal conclusion of the paper is that spatial scale is critical in studies of industrial environmental hazards and environmental justice. **Key Words:** environmental justice, hazardous siting, race, scale of analysis, toxic chemicals.

Correspondence: Levin College of Urban Affairs, Cleveland State University, Cleveland, Ohio, 44115-2403 (Bowen, Salling, and Cyran); The Institute of Public Policy, George Mason University, Fairfax, Virginia, 22030-4444 (Haynes).

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3

ON NEW GUINEA TAPEWORMS AND JEWISH GRANDMOTHERS

Even I confess to a coolness of heart toward tapeworms. But when the World Health Organization calls, all parasites are equal, regardless of race or region. And so I recently found myself in the central highlands of Irian Jaya, Indonesian New Guinea, as a WHO consultant on the control of a pig-transmitted tapeworm that was sending a good many of the Ekari of Enarotali into epileptic-like convulsions. Once again I was about to learn that in problems of public health, expert but alien reason is usually not reasonable to the people of another culture.

For the peoples of New Guinea the pig is more than pork. Throughout the large island, man and pig have a relationship that is intimate beyond domesticity. The pig is a quasi family member, a source of food, and ultimately a gift to propitiate the spirit world. Gory festivals that feature the consumption of great numbers of pigs are held to gain prestige, to pay off obligations, or to

celebrate a battle won. Pigs are in constant demand for ritual slaughter. One or more must be killed at the birth of a child or in any unfortunate circumstance or other perceived emergency requiring sacrifice to gods and ancestor spirits. Ritual slaughter represents something more than paying the premium for the insurance of good will: it reflects the absolute belief that life and sanity require harmony with the spirit world. Pig sacrifice is a major means of attaining that harmony. Hence, the introduction into New Guinea of the pork tapeworm, *Taenia solium*, was both a medical and a cultural disaster.

Pig and man share not only more habits than we like to admit but also two helminth parasites,* the nematode *Trichinella spiralis*, which causes trichinosis, and the tapeworm *Taenia solium*. Trichinosis, once common in the United States, can be an unpleasant, even fatal, infection; but in this piece the tapeworm is the villain.

The tapeworm is a gutless flatworm that absorbs nutrient directly through its body covering, or integument. In a sense, a tapeworm is a communal chain of individuals that keep in touch by means of common lateral nerve cords. Each mature segment in the chain comes complete with male and female sexual organs and an excretory pore to dispose of metabolic wastes.

The "head" of the tapeworm, a segment referred to as the scolex, has specialized structures—suckers, augmented in some species with hooks—to anchor the

*Parasitic invertebrates belonging to two phyla, Platyhelminthes and Nemathelminthes, are collectively referred to as worms or, more elegantly, as helminths. The platyhelminths include flukes and other flatworms (Trematoda, which are primitive animals lacking a mouth, a body cavity, and an anal opening to the digestive tract) and tapeworms (Cestoda, which have no digestive tract). The nemathelminths are cylindrical "wormy" creatures; they have a mouth and an anal opening to the digestive tract, and a type of body cavity known as a pseudocoelom.

worm to the host's intestinal wall. The scolex is also the germinal center from which the other segments of the tape arise. Near the scolex the segments are sexually immature; in the middle of the chain they are sexually functional; and at the terminal portion they are gravid—mere sacs of eggs. The gravid segments separate and either rupture and release their eggs inside the bowel or are passed whole with the feces.

To develop completely, a tapeworm requires one or more intermediate hosts. When a pig swallows the egg of a *Taenia* tapeworm, the egg hatches within the pig's intestine but does not develop into the adult tape. Instead, the microscopic embryo penetrates the intestinal wall and enters a small vein. Circulating blood carries the embryo to some part of the pig, where it develops into a bladderlike form (the cysticercus) with an invaginated structure that will eventually become the scolex. The tapeworm develops no further until a human ingests pork containing the cysticercus. Then, safe in its final home, the scolex pops out and attaches itself to the human intestinal wall, and the worm begins to grow to its full complement of segments.

Most tapeworms have a strict host-specific relationship; only man can serve as the definitive host (the host for the sexually mature stage) of *Taenia solium* and its close relative *Taenia saginata*. *T. solium* is known as the pork tapeworm and *T. saginata* as the beef tapeworm because the cysticerci are found respectively in the pig and in the cow.

Transmission of the disease occurs when infected humans defecate where cows or pigs feed. The animals ingest the eggs, which develop into cysticerci; and the cycle is completed when humans eat undercooked pork or tasty steak tartare. One highly important difference

between the pork tapeworm and the beef tapeworm is that humans can also act as intermediate hosts for the pork tapeworm. If a person swallows eggs of the beef tapeworm, the worm embryos die. But if a human ingests eggs of the pork tapeworm, they can develop into the bladderlike cysticerci, causing a disease known as cysticercosis.

While harboring a twenty-foot tapeworm may not be a pleasure (except perhaps that you could refer to yourself in the imperial style as "We"), most infections of this type cause little discomfort. People harboring a tapeworm are often unaware of the beast within, unless they notice segments in their stools.

It is not the worms, but the cysticerci that can be devastatingly pathogenic. After hatching from the eggs and entering the blood system, the embryos frequently establish themselves in the brain, where they grow into the bladder form. In time, an inflammatory reaction can lead to such neurological disorders as epileptiform convulsions and bizarre personality changes mimicking psychosis. These pathogenic manifestations often do not appear until two to five years after a person has contracted the infection. The condition is like a time bomb inexorably ticking away in the brain.

In 1971 two physicians at the small Enarotali general hospital reported a bewildering "epidemic" of severe burns among the Ekari. Some of the twenty-five to thirty cases each month were so bad that limbs had to be amputated. All the patients gave similar accounts. While sleeping, they had been overcome by an epileptic seizure and had fallen unconscious into the household fire.

Enarotali is piercingly cold at night. The village sits on the shore of one of the Paniai Lakes (formerly called the Wissel Lakes) at an altitude of five thousand feet, surrounded by the wild barricade of the east-central mountain range. Hardly overdressed for this climate, the local Ekari men wear only a long gourd penis sheath and the women a brief string girdle. A fire in the center of each rude thatch hut wards off the night chill, and they sleep on bunks around the fire.

The hospital staff had treated accidental burns before 1971, but never on this scale. The frequency of the epileptiform attacks was also unusual, and the suspicion arose that some new infectious agent had been introduced.

The pathogen came to light during a survey for intestinal parasites by a team of scientists from the Department of Parasitology of the University of Indonesia School of Medicine in Djakarta. In 8 percent of the fecal samples they were astonished to find, along with the usual intestinal zoo, eggs of the tapeworm *Taenia*. Although many parasitological surveys had been carried out in New Guinea over the years, this finding was the first instance of taeniasis. Moreover, the diagnostic technique of microscopic examination of fecal specimens has a low sensitivity for this parasite. For example, in one African study only 6 percent of the stools showed taeniasis, while autopsy examinations indicated that more than 60 percent of the population had the tapeworm. So undoubtedly, many more cases existed.

Subsequent clinical examinations of the Ekari revealed cysts under the skin, a sign of heavy, disseminated cysticercosis, and the discovery of the deadly, pearly globules of the cysticerci studded in the brain of a patient who had died confirmed that these were the cause of the neurological syndrome. Serological tests performed by my Indonesian colleagues and me in

1978 indicate that at least 25 percent of the Ekari adults and children have cysticercosis.

But where did the parasite come from? How was it introduced into such a remote, isolated area? Reconstruction of historical events indicates that the tapeworm came unseen, riding the anticolonial wave; the vehicles of transport were men and pigs.

In 1969 the United Nations directed the peoples of West New Guinea to decide whether to join the Republic of Indonesia. The Ekari were uncertain, to say the least, about the change in regime, and during the plebiscite, or shortly thereafter, the Indonesians sent troops to Enarotali. Some of the soldiers came from Bali. Indonesia's President Suharto softened the military action by sending a gift of pigs. The pigs, too, came from Bali, the area in which pig rearing is largely concentrated, since Bali is Hindu and the rest of Indonesia is mostly Muslim.

Whatever the political and social advantages of the gift, the medical result was an unforeseen tragedy. The pork tapeworm has been endemic in Bali for at least sixty years. A favorite Balinese dish is an undercooked pork preparation in which the cysticerci are cleverly disguised by the legendary spices of the Indies. However, the Balinese are fastidiously clean in their personal habits, so although the tapeworm infection is prevalent, cysticercosis is almost nonexistent. In contrast, the Ekari have Stone Age toilet habits and when the tapeworm came from Bali, the Ekari became infected through both meat and human feces.

Transcultural tapeworm traffic hasn't been confined to the Bali–New Guinea route, and I should like to digress for a moment to recount a somewhat similar occurrence much closer to home. Now that it is epidemiological history, the story is rather amusing. It might be entitled "A Tapeworm Tale of Two Cities." The cast of characters includes the fish tapeworm, Scandinavian fishermen, and Jewish grandmothers in New York City.

The fish tapeworm is big, reaching a length of up to forty-five feet, and its name, *Diphyllobothrium latum,* fits its size. The historical endemic focus of *D. latum* is Scandinavia, where infected fishermen defecate into the lakes. The first intermediate host, a copepod, eats the egg. The second intermediate host, a fresh-water fish, eats the copepod. A wormlike larva develops in the muscles of the fish, and humans become infected by eating a Nordic version of sashimi.

When Scandinavian fishermen came to the United States during the nineteenth century, many settled in the lake region of Minnesota and Wisconsin, and there they began to practice their trade (and habits). Shortly thereafter the fish in these lakes became infected.

Commerce in live fish took place regularly between the Midwest and New York City, at least until the late 1930s. I recall that during my boyhood in New York almost every market had a large holding tank full of live pike, pickerel, and carp. The chief customers were Jewish housewives, who magically transformed the fish into an ambrosial concoction called gefilte fish.

Basically, gefilte fish is an amalgam of minced fish, pressed into balls, and boiled until done. "Until done" is the tricky part. The grandmothers of that time, by whom the thermometer was considered high technology, would sample the fish until it was cooked just right. The early samples were still quite raw and if infected, contained viable worm larvae. In this way, many a nice old lady of Gotham unwittingly acquired a forty-foot Scandinavian immigrant in her digestive tract. The

introduction of fish inspection, sanitary practices, and thermometers, along with the gradual demise of the traditional Jewish grandmother's instinctive culinary arts, have made *D. latum* infections rare in the United States.

But to return from New York to highland New Guinea. By 1973 the main epidemiological factors governing the transmission of tapeworm disease were known, but the problem of control remained. In technically advanced countries, refrigerating the pork for the proper length of time kills the cysticerci. This is impossible in primitive Enarotali, but another effective method would be to cook the carcass thoroughly. Unfortunately, the traditional Ekari barbecue doesn't allow for thorough cooking. The Ekari throw the dead pig on the fire just long enough to warm it up. One reason for this haste is that, except at the big feasts, an Ekari wants the pig he slaughters to be all his. Neighbors are not customarily invited for dinner. The Ekari kills his pig secretly—or as secretly as a pig can be butchered—in the dead of night, following the kill with a quick turn on the fire. A fast-food meal takes place in stealth and gloom. (This and other customs have not endeared the Ekari to anthropologists, who have described them as greedy and avaricious, and as "primitive capitalists.")

Affliction with cysticercosis would seem a compelling enough reason to change cooking practice. With incontestable logic, the health educator from Djakarta, a dedicated woman trained at one of America's more prestigious schools of public health, tried to teach the new methods with all the zeal of a cordon bleau instructor. So there we were, the educator educating, the doctor expounding on the virtues of sanitation, and the Ekari nodding in pleasant agreement. After all, under the circumstances, who in his right mind could reject this appeal to common sense? Then one night it all fell apart and the cultural gap yawned into an abysmal chasm.

I was sitting by the fire drinking wine with the village elders. Through the translator, the chief expressed his bitterness that the disease introduced by foreigners had corrupted the tribe's pigs and religion. Then came the real shocker for me. He said: "We are not blind. We can see the seeds that give us the illness in the pig flesh. But no one lives forever, and if we must die, then we must die. Life is no longer a pleasure. We are only half men. The Indonesians will not let us make the warfare that gave us manhood. I no longer care if I eat the corrupt pig flesh.

"Even if this were not so, we still could not do as you say. You tell us not to eat the infected pig, to be careful, to cook it long. How can we do this? If a child is born at night we must sacrifice a pig immediately; there is no time to look and see if it has the seeds. The pig must be killed and eaten at once.

"When the missionaries brought us the coughing sickness many years ago [a whooping-cough epidemic in 1956], we rose in anger. This time we have no heart to do so."

After he concluded, the wine was passed around again. I couldn't remember ever having felt so lonely and helpless.

After I left Enarotali I flew to Djajapura, the provincial capital, to discuss the situation with the governor. He was highly sympathetic and concerned, particularly since we had clear evidence that the infection had now spread to other parts of Irian Jaya. We went over the possible remedies and the difficulty in implementing

them, and as I was about to leave the governor's mansion he remarked, "You know, they are not like you and me. They are very primitive, and it is extremely difficult to change their customs even for their better health." I was about to agree when I noticed that we were both smoking cigarettes.

Hall, Bob and Mary Lee Kerr. 1993. Water pollution. *1991-1992 Green index: A state by state guide to the nation's environmental health.* Washington, DC: Island Press, pp. 27-41. Reprinted with permission from *The 1991-1992 Green Index*, Bob Hall and Mary Kerr. 1993. Published by Island Press, Washington, DC and Covelo, CA.

CHAPTER 3

Water Pollution

INDICATORS

Per-capita water consumption
Toxic chemicals released to surface water
Toxic chemicals sent to public sewage systems
Toxic chemicals pumped into the ground
Sewage systems in noncompliance with EPA standards
Investment needed for adequate sewage systems
Miles of river and streams not meeting designated use
Acres of lakes not meeting designated use
Spending on water quality protection
Population dependent on groundwater
Households with their own wells
Households relying on septic tanks
Groundwater potentially contaminated with pesticides
Surface and groundwater potentially contaminated
Water systems violating Safe Drinking Water Act (SWDA)
Community water systems in significant noncompliance
Water used for drinking

Few substances affect our health and well-being as profoundly as water. The essential ingredient of life, it flows in vast underground aquifers and covers three-quarters of the Earth's surface in oceans, lakes, rivers, and streams. But this bountiful supply is now polluted enough to cause 10 million deaths a year worldwide.

About half the drinking water consumed in the United States comes from surface water — rivers, lakes, streams, and reservoirs. Although their pollution has been regulated since the 1950s, one-fourth of these waters now fail to meet their designated uses for drinking and recreation. Poorly treated factory effluent, run-off from farms, acid rain, as well as the chemicals, bacteria, oil, and dirt washed into aging sewers, all pollute our surface waters.

Wetlands act as nature's filter for water and a haven for wildlife, but they are fast disappearing. Fishing has been prohibited in many areas because the fish contain chemicals or metals (see chapter 7). Laws that should stop such destruction are enforced poorly, and the problems could get worse because lawmakers are preparing poorly for future sewage, land management, and water-use needs.

Surface water feeds and is fed in part by underground aquifers, or groundwater. Many urban residents and 97 percent of rural residents (about half of the population) depend on groundwater for drinking. Like surface water, groundwater is susceptible to contamination from agricultural and industrial chemicals. It is also vulnerable to leaking landfills, waste lagoons, and underground tanks. Groundwater moves slowly, often along an unpredictable path, and contaminants may concentrate in plumes for years, making cleanup difficult or impossible. Too often, water from our taps or wells contains some of these dangerous pollutants.

TOXIC TOILET

A third of industry's most toxic point-source water pollution (end-of-pipe effluent) comes from *direct factory discharges*. The remaining two-thirds pass through *public sewage treatment facilities* and then into our waterways. Because these facilities cannot neutralize most toxic pollutants, EPA requires generators to cleanse, or "pretreat," their waste before it reaches the public sewage system. However, an extensive survey by the U.S. General Accounting Office reveals that 41 percent of the pretreating companies exceeded one or more discharge limits during the study year.

Companies get rid of even more toxic chemicals through *underground injection*, which jeopardizes the purity of groundwater. Altogether, industry flushed away 2.2 billion pounds of toxic waste in 1988 through direct discharge into surface water, transfers to sewage systems, or underground injection. The Toxic Release Inventory (TRI) monitors all three mediums for wastewater disposal.

• *Direct Discharges to Water.* The 150-mile section of the Mississippi River between Baton Rouge and New Orleans, the toilet for at least 136 major industrial facilities, receives more toxins than any other stretch of water in the country. In fact, Louisiana has one-half of all chemical waste directly discharged into surface waters by TRI-monitored companies. Many local residents rely on the Mississippi for their drinking water and suffer a higher than normal incidence of cancer and miscarriages. By volume, most of the chemicals (71 percent of Louisiana's total and 36 percent of the national total) come from two plants belonging to one company in Saint James Parish — Freeport McMoran's Agrico Division. The company's wastewater includes phosphoric acid, ammonia, and sulfuric acid.

• *Direct Discharges Per Capita.* On a per-capita basis, Louisiana again ranks last in toxins piped to surface water. Alaska, Virginia, Arkansas, and Washington round out the bottom five. In Alaska (rank 49), Unocal Chemicals in Kenai discharges over 150,000 pounds of ammonia, which can cause lung damage, 8,000 pounds of ethylene glycol, which can cause birth defects and kidney damage, and 250 pounds of the carcinogen formaldehyde. The best five states of this and many other water indicators — Nevada, New Mexico, Arizona, North Dakota, and South Dakota — are relatively dry and less industrialized. Washington state more than doubled its TRI discharges to water between 1987 and 1988, putting it among the worst 10. Arkansas also experienced a substantial jump and joined the bottom 10 for the first time.

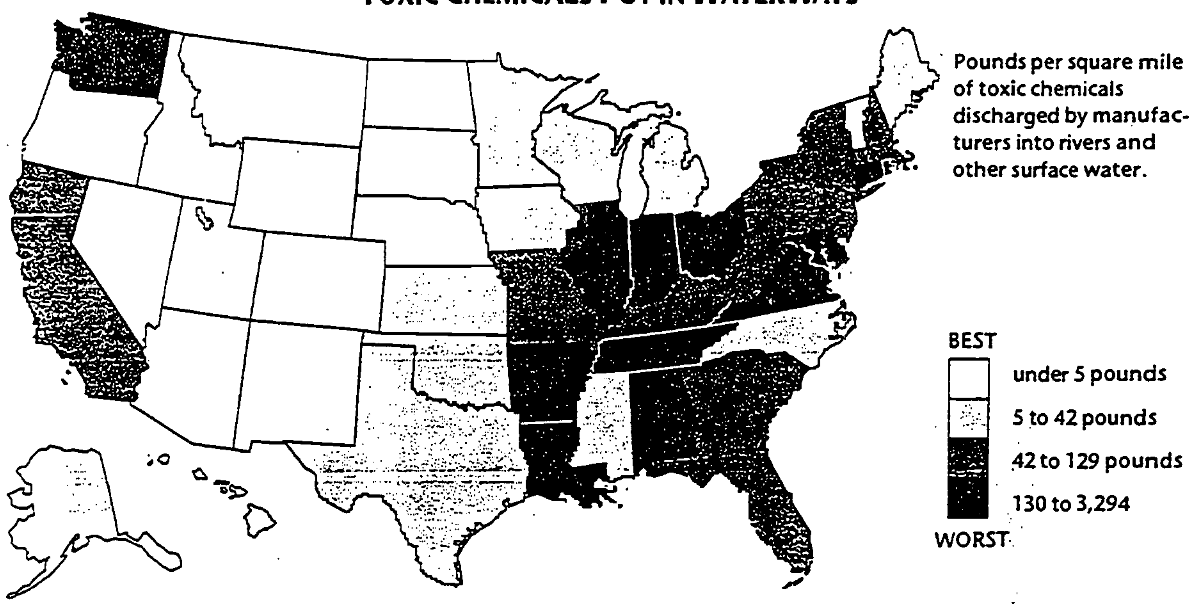
• *Direct Discharges Per Mile.* Louisiana is at the bottom, followed by the Eastern Seaboard states of Connecticut, Virginia, Maryland, Rhode Island, and Delaware. The waste from Maryland's two biggest water polluters, W.R. Grace and Bethlehem Steel, continues to forestall restoring the once fertile Chesapeake Bay. Even though thousands of fishers have lost jobs, Bethlehem Steel has used its workforce of 8,000 as leverage to negotiate reduced fines and repeated delays in meeting emission limits for various chemicals.

• *Toxic Transfers to Sewers.* Missouri sends the most chemicals to public sewage systems — 77.6 million pounds or 14 percent of the U.S. total, with 74 percent coming from St. Louis County alone. A single St. Louis company, Columbian Chemicals, accounts for 9 percent of the national total. According to the TRI, the company increased its ammonium sulfate transfer by more than 3.5 million pounds between 1987 and 1988. Monsanto Company, also in St. Louis, increased its discharge of the same chemical by 5.2 million pounds in the same period. Across the river in Cahokie, Illinois, another Monsanto plant decreased its transfer by 11.7 million pounds — but Illinois still ranks 49th on this indicator. Sewage systems in New Jersey, California, Texas, and Virginia also receive large volumes of industrial toxins, each accounting for 7 percent or more of the U.S. total.

• *Per-Capita Transfers to Sewers.* Missouri again ranks 50th in pounds per person of toxics sent to sewers. New Jersey, Virginia, Illinois, and Tennessee follow, each handling twice the national per-capita average. The Dakotas and several Rocky Mountain states (Montana, Nevada, Wyoming, New Mexico) rank best; like Alaska (rank 2), they lack the infrastructure or inclination to manage industrial waste through public sewage systems. By contrast, almost a third of New Jersey's total TRI emissions to air, water, or land pass through its public sewage treatment plants. The sheer volume of this waste helps explain why the state ranks 45th in sewage systems out of compliance with EPA standards, 44th in investment needed for adequate treatment facilities, and 2d in per-capita spending to protect water resources.

• *Per-Mile Transfers to Sewers.* New Jersey, Massachusetts, Rhode Island, Missouri, and Delaware send the most chemicals to sewage systems for their land area. Monsanto's Indian Orchard Plant in Springfield, Massachusetts discharged almost 7 million pounds of methanol, sodium hydroxide, sulfuric acid, and other chemicals to sewers in 1987. The Bay state ranks 40th in total transfers to sewage systems, 43d in per-capita transfers, and 49th per square mile; it also ranks 50th in the in-

TOXIC CHEMICALS PUT IN WATERWAYS



vestment required for its sewage facilities to meet the state's needs by the year 2008.

• *Toxics Injected Underground.* Texas and Louisiana create 69 percent of the toxins pumped underground, with Louisiana ranking last in injections per capita and per square mile, while Texas is 50th in total volume. In Alvin, Texas, Monsanto increased by 50 percent the amount of acrylonitrile, a probable carcinogen, it sent underground between 1987 and 1988. American Cyanamid in Westwego, Louisiana injected almost 27 million pounds of volatile organic chemicals into the ground in 1988, including over half a million pounds of acrylonitrile. Shell Oil, another major Louisiana polluter, put an astonishing 152 million pounds of hydrochloric acid into the ground in 1988.

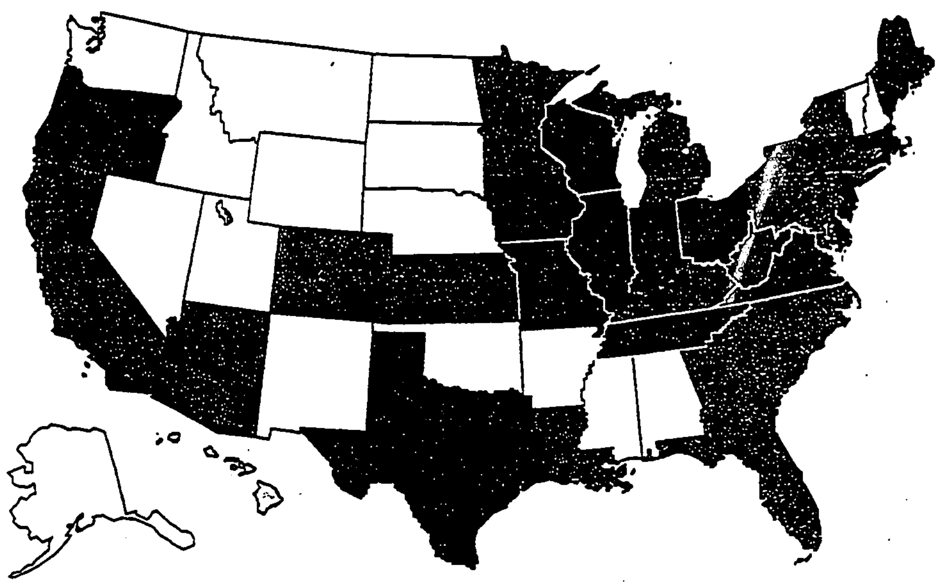
• *Injections Per Capita.* Wyoming, ranked 49th in underground injections per capita, hosts Wycon Chemical in Cheyenne. The company's waste includes ammonium nitrate, ammonia, hydrochloric acid, chlorine, ethylene glycol, and phosphoric acid. Like Wyoming, the other states with the most injections — Louisiana, Kansas, Texas, Mississippi, Tennessee, Kentucky, and Indiana — have major chemical plants that feed off fossil fuels and then pump their wastes back underground.

• *Injections Per Mile.* Texas, Ohio, Tennessee, and Kansas rank at the bottom (along with Louisiana) for pounds of toxic injections per square mile. Vulcan Chemicals of Wichita, Kansas sent over 90 million pounds of hydrochloric acid, sulfuric acid, and 22 other chemicals into the ground in 1988. Toxic injections in the state jumped an amazing 38 percent from 1987 to 1988. Because of Vulcan and another Wichita chemical company, Racon Inc., Sedgwick County is the third largest producer of TRI wastes in the nation (Louisiana's Jefferson and St. Charles parishes are first and second).

When the rankings for all nine of these toxic wastewater indicators are added and re-ranked, Tennessee emerges as the worst state overall. The biggest generators are the chemical companies, led by DuPont's two facilities in Memphis and New Johnsonville and Kodak's huge Tennessee Eastman plant in Kingsport. But a dozen other firms that span business lines, from food processing to textiles to papermaking, also send a million or more pounds of toxins to sewage systems, rivers, or underground caverns each year.

Too often, getting state and company officials to control, much less reduce, these wastes remains difficult, even when drinking water quality is at stake. Consider the example of Avtex Fiber in Virginia, another Southern state that ranks in the bottom five in overall water-borne toxins. In 1978, and for the next decade, Avtex Fibers consistently disregarded requests from Virginia's Water Control Board and EPA to clean up the toxic waste it dumped into the Shenandoah River. Located in the Blue Ridge Mountains, the plant was the sole producer of carbonized rayon for the Defense Depart-

TOXIC CHEMICALS DUMPED IN SEWERS



ment and space program. Its discharge included zinc, chlorine, sulfuric acid, and PCBs. Despite evidence of chemical pollution in wells across from the plant in 1981, high toxin levels in fish in 1985, and a PCB spill in 1986, the Water Control Board and EPA issued only weak warnings.

Finally, in late 1988, after the Natural Resources Defense Council threatened to sue the company, the state decided to sue Avtex itself. In November 1989, following new PCB emissions from the company, Avtex was shut down and fined $6 million. The cleanup is expected to cost at least $100 million. "So far, the state has failed to understand the basic problem with environmental pollution, that the price for environmental damage will be extracted," says David S. Bailey, former head of enforcement for Water Control Board and current director of the Environmental Defense Fund's Virginia office. "If you don't make the company pay for it, the environment will pay for it, and the citizens bear the cost."

TOXIC DRAINS

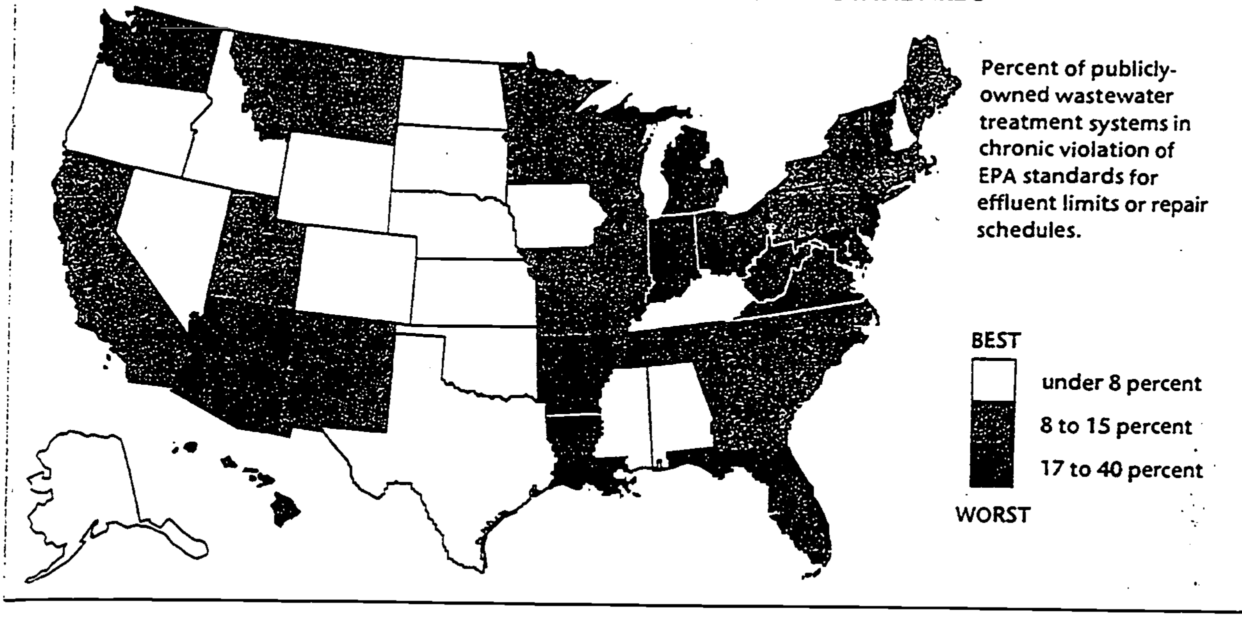
In addition to the danger posed by TRI chemicals created by industry, detergents, motor oil, fertilizer, construction waste, and pesticides wash off lawns and city streets into storm drains or sewers. If poorly treated, or not treated at all, these pollutants can threaten the health of our lakes, rivers, and harbors.

Throughout the country, aging sewage plants are failing to handle the waste load from new industry and more people. In 1988, some 6,250 of the nation's 15,600 treatment facilities reported water quality or public health problems. In Boston, 12 billion tons of raw or partially treated sewage reach Boston Harbor each year — about 500 million gallons per day. Construction of a secondary treatment facility to clean the water more thoroughly is underway but won't be completed until after the year 2000. Massachusetts' shortsightedness shows up on the indicator measuring funds required to manage each state's sewage. It ranks last, with $991 per capita needed to provide adequate sewage treatment through the year 2008. Other states that face large bills include Oregon, Washington, and Alaska in the West, and New Hampshire, New York, Connecticut, New Jersey, and Florida in the East.

Massachusetts, Florida, New Jersey, and Washington also rank poorly for public sewage plants violating EPA standards. Another New England state, Rhode Island, ranks even worse. With 40 percent of its sewers in noncompliance, the state falls to the bottom on this indicator. Century-old sewer overflow pipes in Pawtucket, Central Falls, Providence, Fall River, and Newport spew raw sewage into Narragansett Bay during heavy rainfalls, forcing the closing of local shellfishing beds.

Environmentalists have pressured Rhode Island cities to clean up. Most towns have made an effort to stop the pollution, but the expense is sometimes overwhelming. "They say it will cost

PUBLIC SEWAGE SYSTEMS VIOLATING EPA STANDARDS



$50 million to correct this in Pawtucket alone," says Mayor Brian J. Sarault. "The people in Pawtucket just can't afford it." Rhode Island ranks 40th in the investment needed for proper sewage systems. Since it ranks 42d in toxics piped to public sewers per square mile, it's a safe bet that the overflow and poorly treated sewage reaching the Narragansett Bay is laced with chemical toxins.

RIVERS AND LAKES

The toll such waste is taking on the nation's inland waters is difficult to gauge, but it's clear the impact is widespread. Ten percent of the river and stream miles assessed by the states are already ruined; they can no longer support their designated uses for fishing, recreation, and/or drinking. Another 20 percent only partially support their designated use. and a seventh of the remaining 70 percent face imminent danger of becoming impaired. The breakdown is about the same for acres of lakes and reservoirs. Most contaminants come from industry, development and urban sewers, agriculture and forestry, mining, landfills, and dredging.

The states ranking worst on fresh water quality are in the Great Lakes and Farmbelt (Ohio, Illinois, Wisconsin, Minnesota, and Iowa) or are mining states (West Virginia, Montana, New Mexico, Oklahoma, and Alaska). Among the best are Alabama, Mississippi, and Georgia, even though Alabama and Mississippi ranked among the worst 10 states for drinking water violations, and Alabama and Georgia ranked 42d and 41st in toxic discharges to surface water. The impairment rankings can be deceptive because each state decides how much to test and how to define fully, partially, or non-supporting waters.

In Minnesota, which is second only to Alaska in total surface water miles, monitoring includes an analysis of fish tissues. Nearly two-thirds of the state's rivers and streams fail to meet designated uses, ranking Minnesota 45th. Its lakes had a better standing (rank 24); but scientists identified serious problems with mercury and PCB contamination. Rain-borne mercury from coal-burning electric plants and incineration is accumulating in fish in the state's northeastern lakes, harming or killing fish-eating animals. The scientists also found high levels of toxic chemicals in fish down river from major municipalities. In June 1990, two Minneapolis-based environmental groups warned 28 companies that they were violating the Clean Water Act for excessive discharges of chromium, nickel, cyanide, and fecal coliform.

Dioxin, a deadly poison that can cause birth defects, miscarriages, and nerve damage, is another significant threat to surface water quality (see page 102). In 1908, when Champion International built the South's first paper mill on the banks of North Carolina's Pigeon River, the river was clear and full of trout. Today, the Pigeon is discolored, practically dead, and contaminated with dioxin from Champion's wastewater. Four major rivers in

Arkansas, recipients of waste from paper companies like Nekoosa Papers in Ashdown, also have dangerous levels of dioxin. Arkansas ranks 42d, with 58 percent of its assessed rivers and streams impaired.

Maine is one of the chief targets of dioxin reduction measures promoted by EPA. Two of the seven companies targeted, Scott Paper and James River Company, have filed suit, arguing that the standards are too stringent. Acid rain is another serious problem for surface water in Maine and other New England states. The region's lakes and rivers catch the brunt of sulfur dioxide emissions from more heavily industrial states to the south and west (see pages 19-20).

The greatest single threat to aquatic life in inland surface waters is agricultural run-off. Pesticides, herbicides, fertilizers, other nutrients, and sediment wash, dribble, or blow into the water, impairing 55 percent of the nation's river miles. A study by the U.S. Geological Survey released in January 1990 reveals that 98 percent of the streams tested in 10 Midwest states contain the pesticides atrazine and alachlor, both likely carcinogens. Of the 127 streams examined, 71 had atrazine levels above EPA safety limits and 44 exceeded the limit for alachlor.

Agriculture is also a major consumer of the nation's freshwater supply, especially in the Midwest and Rocky Mountains. Seven of the dozen states with the nation's highest per-capita consumption of water (Idaho, Wyoming, Nebraska, Colorado, Nevada, Kansas, New Mexico) are among the dozen that rely most heavily on artificial irrigation for their crops (see page 109). While Kansas and New Mexico have helped deplete the aquifers of the High Plains by more than half, several of the other states continue draining the Colorado River as their chief source of surface water.

THE NOT-SO GREAT LAKES

The Great Lakes hold one-fifth of the world's fresh water, furnishing 3 billion gallons a day for domestic use, yet they have become a toxic soup. Their wide expanse, strategic location, and neighboring natural resources turned the region into America's industrial heartland. People and pollution blossomed in Buffalo, Cleveland, Detroit, Chicago, Milwaukee, and all points between. Today, 73 percent of the five Great Lakes' shoreline miles fail to support designated uses for fishing, drinking, or recreation. While deeper waters in the Lakes' centers may be cleaner, only 372 of 4,479 shoreline miles assessed still fully support their intended uses.

Violations of metal pollution are the primary reason that much of Lake Erie's shoreline only partially supports intended uses. Right next to the lake, in Ecorse, Michigan, National Steel dumps thousands of pounds of zinc, manganese and lead compounds, aluminum oxide, ammonia, and ethylene glycol into surface water.

Fish in Lake Michigan contain dioxin, PCBs, DDT, dieldrin, and chlordane flushed through sewage plants or directly released by lakeshore industries. Studies show that babies born to mothers who eat Lake Michigan fish are more likely to be premature, underweight, and slow learners. The U.S. General Accounting Office (GAO) estimates it will cost $1.8 billion just to bring Michigan's Rouge River, one of the region's 42 major areas of concern, up to the state's public health standards by the year 2005.

Toxic reduction is as important as cleanup, says the GAO, and too little is being done. For example, Eastman Kodak in Rochester, New York, on Lake Ontario increased its wastewater discharge of cancer-causing dichloromethane by 16,200 pounds between 1987 and 1988. Levels of dioxin and PCBs found in Lake Ontario's fish still exceed safe-food limits.

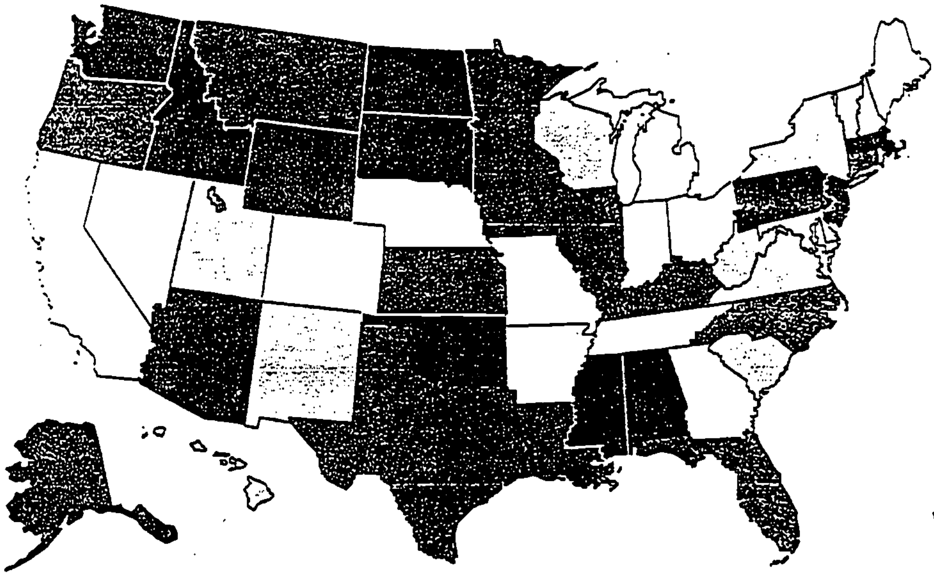
States bordering the Great Lakes, including Wisconsin, Illinois, Michigan, Ohio, and New York, score poorly on lakes and reservoirs supporting designated uses. All of the states monitor toxins in fish, and programs to reduce phosphorus levels in the Lakes have been successful; however, nitrogen levels are on the rise and sediment contamination continues to threaten the entire Lakes system.

DEEP THROAT

Underground aquifers in the United States contain up to 16 times as much water as the Great Lakes. They feed public water systems and private wells, and supply billions of gallons of free water daily to mining, industrial, and agribusiness concerns. In North Carolina, for example, Texasgulf's phosphate operation sucks out more water than is consumed by the entire city of Charlotte.

Groundwater pollution comes from many sources. Poisons leach from Superfund or other dump sites, and agricultural chemicals seep through the soil. Saltwater invades when coastal wetlands lose their recharging capacity. Underground storage tanks leak benzene and other dangerous substances. A 1986 EPA report estimated that 300,000 underground gasoline storage tanks

DRINKING WATER VIOLATING EPA STANDARDS



were leaking; one gallon of gasoline can contaminate a million gallons of water.

In 1980, at the behest of Senator Bennett Johnston of Louisiana, Congress exempted companies drilling for oil and gas from hazardous waste disposal laws. That decision has had a profoundly negative impact on the environment, especially the nation's groundwater. Under the exemption, oil producers can dump "non-hazardous" waste mud from their drilling into open pits, even though the sludge and brine contaminate groundwater. In addition, oil and gas producing states — such as Louisiana, Texas, Wyoming, Indiana. Kansas, Oklahoma, and Ohio — are dotted with injection wells holding wastes that make their way into shallow aquifers.

All seven of the states listed are also among the worst dozen for toxic chemicals pumped underground by manufacturers. In Ohio (rank 47), the 160-square-mile Great Miami Aquifer was contaminated by the Chem-Dyne Corporation in the 1970s and cleanup is still underway. Rat poisons, acids, cyanide sludges, and other hazardous chemicals were dropped in gravel pits over the aquifer, which supplies one-third of Ohio's groundwater. Over a million fish died in the Great Miami River as a result, and residents near the Chem-Dyne site have suffered a high rate of respiratory illness.

Pesticides, another potential groundwater pollutant, do their worse damage in the big agricultural states. Seven of these states — Iowa, Florida, Nebraska, Mississippi, Minnesota, Wisconsin, Idaho — are also among the 10 most dependent on groundwater for their drinking water. In Iowa and Kansas more than 20 percent of wells tested had unsafe levels of nitrates, the result of seepage from fertilizers, animal waste, and septic tanks. The problems are not limited to the big farm states. For example, nitrates and other organic pollutants have closed 20 public water supplies in upstate New York; on Long Island, 33 water systems closed and the pesticide aldicarb (used on potato fields) exceeds safe limits in a fourth of the wells tested.

Groundwater protection is largely left to the states. Out of necessity, Wisconsin, Iowa, California, Florida, and New York are among the states with the toughest legislation. Florida's Ground-Water Protection Strategy not only requires data collection, but implements federal underground injection and storage tank control programs, a groundwater discharge permitting program, septic tank regulations, and aquifer protection. Per-capita spending of federal and state funds to protect and improve water quality in the Sunshine state ranks 9th nationally.

Florida needs all the help it can get. It ranks 49th in pesticide contaminated groundwater, 47th in reliance on groundwater for drinking, 46th in public water systems and 39th in sewage systems in noncompliance, 46th in impaired lakes, and 43th on the composite toxic wastewater score. Overall, Florida takes last place on our clean water indicators. The dying Everglades, symbolic of the state's problems, feed the aquifer that feeds south

Florida's ballooning population, but state officials have stood by (or even helped) as the sugar and oil interests pollute, siphon, and otherwise destroy these unique wetlands.

DRINK WELL

Drinking water sources all across the nation face similar threats. Twenty-one hundred different chemicals turned up in a survey of public water systems between 1971 and 1985, and 111,228 cases of disease from drinking water were reported. The pollutants included 97 carcinogens and 93 other contaminants suspected of causing serious harm to humans. Currently, only 83 of these 190 health-threatening pollutants are regulated by federal law.

In 1974, Congress passed the Safe Drinking Water Act (SDWA), requiring states to monitor and enforce standards set by EPA. A 1986 amendment expanded the number of substances covered by the SDWA, but out of over 36,000 violations of EPA standards the following year, states took enforcement action on only 2.5 percent. In June 1990, the U.S. General Accounting Office reported that (a) "the number of violations is considerably understated," (b) water system operators are "inadequately trained or inexperienced" and occasionally engage in "intentional falsification of data," (c) state enforcement against systems with SWDA violations is "often neither timely nor appropriate," including in three-fourths of the cases involving significant noncompliance, (d) and "some [violators] posing health risks have persisted for years."

The worst five states for water systems with one or more SDWA violation in a year are Alaska (rank 50), New Jersey, Washington, Wyoming, and Arizona. Nevada, the Dakotas, Florida, Illinois, and Vermont are also among the worst 10 when it comes to states failing to act against systems with significant noncompliance. A study in Massachusetts, which ranks 44th for population served by violators, shows that residents who rely on public drinking water tainted with industrial chemicals have a significantly higher chance of developing leukemia.

Maine has one of the best drinking water programs in the country with only 2 percent of its water systems experiencing SWDA violations. A small population, relatively little industry, strict monitoring, and follow-up enforcement all enhance compliance with EPA standards. Only Minnesota ranks better; it has instituted a Local Water Planning Project to organize, fund, and provide technical assistance to local groups monitoring groundwater and surface water.

EPA regulations only apply to public water systems that serve 25 people or more for at least 60 days a year. Private wells, which serve one household in seven, are not monitored under the SDWA, even though evidence suggests many are contaminated. For example, a 1986 California study found that a quarter of the 8,000 wells tested contained pesticides. In Florida, over 1,000 wells were condemned following the discovery of groundwater laced with the pesticide ethylene dibromide.

Many rural states that depend the most on private wells also rely heavily on septic tanks, which can contaminate groundwater. Maine, New Hampshire, and Vermont score in the bottom five on both indicators. The problems are even worse for rural communities in Farmbelt states that also face pesticide contamination, or for those in Southern states like Tennessee, Mississippi, and Kentucky which allow huge injections of toxic chemicals beneath the ground.

The state with the largest percentage of its population served by wells is North Carolina. The Tarheel state also ranks 30th in surface and groundwater that may be contaminated and 49th in households using septic tanks. Some areas don't even enjoy the luxury of septic tanks. A small community of black families in Camden County, North Carolina lives in a swampy area where sewage from outhouses runs through open drainage ditches less than 10 feet from their wells.

Similar problems plague parts of Appalachia. "The vital connection between poverty and sickness is bad water," observes a West Virginia health official. "So much of the disease comes from the wells. It starts with the baby. You're basically mixing a formula with sewer water."

West Virginia officials say kidney disease, worms, and parasites are common. Many families have no running water at all, and no money to install pipes or septic systems. Some still haul water from creeks which may be contaminated by mining, industrial, or household waste. In fact, 80 percent of West Virginia's streams and 100 percent of its lakes are impaired, putting it dead last for surface water quality. The state also ranks 39th in households served by wells, 47th in households dependent on septic tanks, 47th in water used for non-drinking purposes, 43d in spending for water quality, and 46th in investment needed for adequate sewage facilities. For too many West Virginians, a drink of cool, clean mountain water goes with the myth of country living, not the reality.

WATER POLLUTION

State	FRESH WATER WITHDRAWALS		TOXIC CHEMICAL RELEASE TO SURFACE WATER						TOXIC CHEMICAL TRANSFERS TO PUBLIC SEWERS					
	Gal. Per Capita	Rank	Total Pounds	Rank	Pounds Per Capita	Rank	Pounds Per Sq. Mile	Rank	Total Pounds	Rank	Pounds Per Capita	Rank	Pounds Per Sq. Mile	Rank
Alabama	2,736	42	6,908,442	42	1.7	44	133.6	38	1,223,368	17	0.3	11	23.7	16
Alaska	421	7	4,274,455	35	8.3	49	7.2	15	1,000	1	0.0	2	0.0	1
Arizona	2,309	35	9,850	5	0.0	3	0.1	5	4,524,493	30	1.3	27	39.7	18
Arkansas	2,925	44	7,446,055	45	3.1	47	140.0	40	1,108,236	16	0.5	12	20.8	15
California	1,518	30	11,017,789	46	0.4	27	69.4	31	48,609,149	47	1.7	34	306.3	35
Colorado	4,949	46	87,843	8	0.0	7	0.8	7	1,879,125	19	0.6	18	18.1	14
Connecticut	409	6	7,305,148	44	2.3	45	1,455.8	49	2,795,903	25	0.9	24	557.2	42
Delaware	225	2	574,167	20	0.9	38	280.9	45	2,271,089	21	3.4	44	1,111.1	46
Florida	642	12	7,198,454	43	0.6	33	122.7	35	16,678,069	40	1.3	28	284.3	34
Georgia	1,122	20	6,509,879	41	1.0	40	110.5	34	8,658,999	35	1.4	29	147.0	31
Hawaii	1,237	23	10,000	6	0.0	6	1.5	9	835,250	12	0.8	20	129.1	28
Idaho	17,928	50	296,220	12	0.3	22	3.5	12	515,514	11	0.5	14	6.2	9
Illinois	1,473	29	14,304,086	48	1.2	41	253.9	44	59,151,864	49	5.1	47	1,049.8	45
Indiana	2,545	38	4,873,432	38	0.9	39	134.7	39	12,067,445	36	2.2	38	333.5	36
Iowa	1,111	19	1,563,824	26	0.6	32	27.8	23	6,262,070	31	2.2	39	111.3	27
Kansas	2,695	41	801,192	23	0.3	23	9.7	17	3,387,911	27	1.4	30	41.2	19
Kentucky	1,234	22	1,697,760	28	0.5	29	42.0	26	2,358,242	22	0.6	19	58.4	21
Louisiana	2,676	39	157,333,611	50	35.6	50	3,294.9	50	3,565,551	28	0.8	22	74.7	23
Maine	730	13	439,516	17	0.4	24	13.2	20	2,733,459	24	2.3	40	82.2	25
Maryland	319	3	3,756,283	33	0.8	37	359.1	47	3,959,217	29	0.9	23	378.5	38
Massachusetts	429	8	699,295	22	0.1	14	84.4	32	16,649,263	39	2.8	43	2,009.8	49
Michigan	1,651	31	1,147,387	25	0.1	15	19.6	22	15,833,193	38	1.7	33	270.5	33
Minnesota	740	14	2,758,505	31	0.6	34	32.7	24	6,557,312	32	1.5	32	77.7	24
Mississippi	1,110	18	1,984,907	29	0.8	35	41.6	25	1,366,669	18	0.5	15	28.7	17
Missouri	1,379	27	4,091,507	34	0.8	36	58.7	30	77,606,284	50	15.1	50	1,113.5	47
Montana	13,333	49	124,874	10	0.2	18	0.8	8	1,312	2	0.0	1	0.0	2
Nebraska	7,481	47	309,468	14	0.2	19	4.0	13	875,885	13	0.5	17	11.3	12
Nevada	3,830	45	250	1	0.0	1	0.0	1	19,505	4	0.0	3	0.2	4
New Hampshire	381	4	484,711	18	0.4	28	52.2	29	504,434	10	0.5	13	54.4	20
New Jersey	383	5	1,003,447	24	0.1	16	128.9	37	53,823,264	48	7.0	49	6,911.9	50
New Mexico	2,690	40	750	2	0.0	2	0.0	2	36,116	5	0.0	5	0.3	5
New York	450	9	2,084,783	30	0.1	13	42.5	27	25,643,490	44	1.4	31	522.2	40
North Carolina	1,294	24	695,661	21	0.1	9	13.2	19	7,493,240	34	1.1	25	142.3	30
North Dakota	1,460	28	3,600	4	0.0	5	0.1	4	52,681	6	0.1	6	0.7	6
Ohio	1,303	25	5,897,407	39	0.5	31	142.7	41	22,193,113	41	2.0	37	537.0	41
Oklahoma	513	10	363,208	15	0.1	12	5.2	14	424,512	9	0.1	7	6.1	8
Oregon	2,529	37	303,696	13	0.1	11	3.1	11	7,067,786	33	2.6	42	72.8	22
Pennsylvania	1,349	26	4,453,168	37	0.4	25	98.3	33	15,437,749	37	1.3	26	340.7	37
Rhode Island	176	1	385,645	16	0.4	26	318.2	46	1,930,025	20	1.9	36	1,592.4	48
South Carolina	1,740	32	1,599,365	27	0.5	30	51.4	28	2,688,403	23	0.8	21	86.4	26
South Dakota	975	15	2,400	3	0.0	4	0.0	3	156,884	8	0.2	10	2.0	7
Tennessee	2,098	34	6,398,920	40	1.3	42	151.8	42	24,623,468	43	5.0	46	584.3	43
Texas	976	16	4,306,731	36	0.3	21	16.1	21	40,459,590	46	2.4	41	151.6	32
[illegible]	2,494	36	255,653	11	0.2	17	3.0	10	900,304	14	0.5	16	10.6	11
Vermont	636	11	113,058	9	0.2	20	11.8	18	72,765	7	0.1	8	7.6	10
Virginia	982	17	19,780,454	49	3.3	48	485.2	48	38,704,548	45	6.5	48	949.4	44
Washington	1,861	33	13,511,390	47	2.9	46	198.3	43	977,544	15	0.2	9	14.3	13
West Virginia	2,893	43	3,122,244	32	1.7	43	128.9	36	3,338,844	26	1.8	35	137.8	29
Wisconsin	1,215	21	535,849	19	0.1	10	9.5	16	22,406,583	42	4.6	45	399.0	39
Wyoming	10,392	48	42,050	7	0.1	8	0.4	6	10,350	3	0.0	4	0.1	3
Total	1,529		312,868,389		1.3		86.5		570,441,070		2.3		157.6	

WATER POLLUTION

State	TOXIC CHEMICAL UNDERGROUND INJECTIONS Total Pounds	Rank	Pounds Per Capita	Rank	Pounds Per Sq. Mile.	Rank	SUMMARY FOR 9 TOXIC INDICATORS Score	Rank	PUBLIC SEWERS IN NON-COMPLIANCE %	Rank	INVESTMENT FOR SEWER NEEDS TO YEAR 2008 Mill. $	$ Per Capita	Rank
Alabama	1,634,717	36	0.40	35	31.62	35	274	31	4	7	781	190	15
Alaska	1,018	26	0.00	30	0.00	21	180	18	5	10	221	422	41
Arizona	0	1	0.00	1	0.00	1	91	9	19	39	979	281	27
Arkansas	7,036,201	39	2.91	41	132.29	39	294	37	20	42	370	154	11
California	946,853	34	0.03	32	5.97	34	320	41	8	18	6,539	231	21
Colorado	0	1	0.00	1	0.00	1	76	7	4	7	196	59	3
Connecticut	0	1	0.00	1	0.00	1	232	26	10	23	1,392	431	42
Delaware	0	1	0.00	1	0.00	1	217	25	29	46	127	192	16
Florida	34,651,596	43	2.80	40	590.68	42	338	43	19	39	6,186	501	45
Georgia	52,800	31	0.01	31	0.90	32	304	39	10	23	1,007	159	13
Hawaii	1,051,509	35	0.96	38	162.50	40	194	22	18	37	413	376	38
Idaho	1,400	28	0.00	29	0.02	27	164	15	4	7	124	124	8
Illinois	7,340,184	40	0.64	37	130.27	38	389	49	14	31	2,958	255	23
Indiana	34,820,650	44	6.25	43	962.30	44	357	45	32	47	1,721	310	33
Iowa	0	1	0.00	1	0.00	1	181	20	6	14	646	228	20
Kansas	90,766,710	48	36.50	48	1,103.18	46	281	35	2	6	720	289	30
Kentucky	30,000,250	42	8.06	44	742.42	43	274	31	7	17	1,457	391	39
Louisiana	423,320,002	49	95.77	50	8,865.15	50	372	48	23	44	1,189	270	25
Maine	0	1	0.00	1	0.00	1	153	11	8	18	341	283	28
Maryland	2	20	0.00	1	0.00	20	248	28	19	39	919	199	18
Massachusetts	4,000	30	0.00	28	0.48	30	287	36	15	32	5,836	991	50
Michigan	5,617,060	37	0.60	36	95.97	37	276	34	39	49	3,321	359	36
Minnesota	0	1	0.00	1	0.00	1	180	18	12	27	1,106	257	24
Mississippi	46,806,563	45	17.82	46	981.50	45	275	32	5	10	548	209	19
Missouri	500	24	0.00	25	0.01	25	321	42	9	22	1,222	238	22
Montana	0	1	0.00	1	0.00	1	44	5	8	18	69	86	5
Nebraska	68,208	32	0.04	33	0.88	31	184	21	5	10	114	71	4
Nevada	0	1	0.00	1	0.00	1	17	1	0	1	165	157	12
New Hampshire	0	1	0.00	1	0.00	1	121	10	0	1	854	787	49
New Jersey	2,750	29	0.00	27	0.35	29	309	40	25	45	3,754	486	44
New Mexico	0	1	0.00	1	0.00	1	24	2	10	23	130	86	6
New York	251	23	0.00	21	0.01	24	253	29	12	27	12,721	710	48
North Carolina	250	21	0.00	22	0.00	23	204	24	8	18	1,799	277	26
North Dakota	0	1	0.00	1	0.00	1	34	3	6	14	34	51	2
Ohio	56,920,293	47	5.24	42	1,377.21	48	367	47	32	47	3,579	330	34
Oklahoma	6,353,464	38	1.95	39	90.82	36	178	17	5	10	476	147	10
Oregon	1	19	0.00	1	0.00	1	153	11	0	1	1,273	460	43
Pennsylvania	750	25	0.00	24	0.02	26	270	30	15	32	1,644	137	9
Rhode Island	0	1	0.00	1	0.00	1	195	23	40	50	408	411	40
South Carolina	0	1	0.00	1	0.00	1	158	13	13	30	684	197	17
South Dakota	0	1	0.00	1	0.00	1	38	4	0	1	87	122	7
Tennessee	49,906,110	46	10.15	45	1,184.18	47	394	50	11	26	1,467	300	32
Texas	490,826,922	50	29.25	47	1,839.63	49	343	44	6	14	4,975	295	31
Utah	0	1	0.00	1	0.00	1	82	8	15	32	583	345	35
Vermont	0	1	0.00	1	0.00	1	75	6	17	35	209	375	37
Virginia	1,373	27	0.00	26	0.03	28	363	46	17	35	957	159	14
Washington	0	1	0.00	1	0.00	1	176	16	21	43	2,685	578	47
West Virginia	97,712	33	0.05	34	4.03	33	301	38	18	37	976	520	46
Wisconsin	250	22	0.00	23	0.00	22	238	27	12	27	1,399	288	29
Wyoming	27,113,559	41	57.57	49	277.21	41	162	14	0	1	18	38	1
U.S. Total	1,315,343,908		5.36		363.48				11		81,379	332	

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WATER POLLUTION

State	Rivers & Streams: Miles	Rivers & Streams: % Impaired	Rivers & Streams: Rank	Lakes & Reservoirs: 1,000 Acres	Lakes & Reservoirs: % Impaired	Lakes & Reservoirs: Rank	Spending on Water Quality & Devel.: $ per Capita	Spending on Water Quality & Devel.: Rank	People Served by Groundwater: %	People Served by Groundwater: Rank	Households Served by Own Wells: %	Households Served by Own Wells: Rank	Households with Septic Tank Only: %	Households with Septic Tank Only: Rank
Alabama	40,600	9.5	5	504	17.5	25	3.24	42	54	28	18.4	29	46.8	44
Alaska	365,000	47.0	34	12,787	46.9	39	14.33	18	69	39	21.0	32	32.0	33
Arizona	6,671	30.5	20	111	14.2	19	4.97	35	65	38	4.0	4	18.8	9
Arkansas	11,508	58.3	42	na			3.78	38	50	23	24.0	38	42.1	40
California	26,970	33.5	26	1,418	47.2	40	25.49	5	46	16	3.9	3	10.5	1
Colorado	14,655	14.0	9	266	1.3	6	5.01	34	15	1	7.2	7	12.8	4
Connecticut	8,400	33.9	27	83	57.1	43	5.02	33	32	4	21.1	33	31.7	32
Delaware	500	40.0	30	na			14.45	17	60	31	22.9	37	25.2	17
Florida	12,659	33.4	25	2,085	67.3	46	20.28	9	90	47	13.4	17	28.1	25
Georgia	20,000	2.8	3	418	1.3	5	1.61	48	48	17	20.1	30	39.7	39
Hawaii	349	24.1	15	na			8.05	24	95	50	0.2	1	18.5	7
Idaho	7,310	17.3	12	363	0.0	1	22.10	6	88	46	24.7	40	36.3	38
Illinois	14,080	55.4	40	247	87.5	49	21.08	8	49	19	10.3	12	15.1	6
Indiana	90,000	32.1	22	105	0.2	2	3.32	41	61	33	26.5	43	34.1	35
Iowa	18,300	99.2	50	81	66.6	45	16.38	14	82	44	21.1	34	25.9	19
Kansas	19,791	42.0	31	175	32.9	34	9.44	20	62	35	12.3	14	20.9	12
Kentucky	18,465	28.6	19	228	16.4	23	6.73	26	41	9	18.3	28	45.7	43
Louisiana	14,180	32.5	23	714	27.3	30	21.89	7	69	40	13.0	15	28.3	27
Maine	31,672	1.2	1	995	3.7	8	3.78	39	57	30	34.9	49	50.0	48
Maryland	9,300	7.2	4	17	15.0	21	8.57	22	28	3	16.3	21	20.4	11
Massachusetts	10,704	56.7	41	na			28.70	3	33	5	6.2	5	26.1	21
Michigan	36,350	2.2	2	841	28.3	32	11.01	19	43	13	27.1	45	28.6	28
Minnesota	91,944	65.0	45	3,411	16.5	24	4.56	36	75	42	25.0	41	25.2	16
Mississippi	15,623	11.3	6	500	3.7	7	1.96	46	93	49	16.7	23	43.5	41
Missouri	19,630	48.3	35	288	0.8	4	8.34	23	34	6	15.6	20	27.7	23
Montana	20,532	37.1	29	756	47.9	41	26.72	4	54	25	25.6	42	36.2	37
Nebraska	10,212	43.0	32	145	3.8	9	4.29	37	82	44	18.2	27	20.3	10
Nevada	na			na			18.68	11	50	22	7.2	6	12.7	3
New Hampshire	14,544	28.6	18	151	12.8	17	15.86	15	60	31	31.7	48	47.7	46
New Jersey	6,450	71.2	48	19	28.0	31	58.29	2	45	15	8.4	8	13.5	5
New Mexico	3,500	50.0	36	127	39.5	37	6.92	25	92	48	14.2	18	26.7	22
New York	70,000	23.7	14	750	39.4	36	5.11	32	35	7	9.8	11	21.3	13
North Carolina	37,378	32.8	24	305	3.9	10	1.91	47	55	29	37.0	50	53.2	49
North Dakota	11,284	30.6	21	626	7.8	13	17.90	13	62	34	21.4	35	27.8	24
Ohio	43,917	68.0	47	117	65.9	44	2.49	45	42	12	17.0	25	23.8	15
Oklahoma	19,791	64.3	44	na			1.58	49	41	10	13.4	16	26.1	20
Oregon	90,000	54.8	39	611	25.9	29	6.30	28	63	37	16.6	22	31.4	30
Pennsylvania	50,000	27.2	17	na			5.54	30	44	14	17.7	26	25.5	18
Rhode Island	724	15.8	10	17	8.7	15	18.04	12	24	2	9.4	10	31.6	31
South Carolina	9,900	25.6	16	525	0.3	3	2.52	44	42	11	26.5	44	46.9	45
South Dakota	9,937	63.0	43	1,598	14.3	20	6.35	27	77	43	21.0	31	29.5	29
Tennessee	19,124	36.6	28	539	16.1	22	5.61	29	49	18	14.9	19	43.6	42
Texas	80,000	13.1	8	1,410	13.1	18	1.05	50	49	20	8.9	9	18.7	8
Utah	na			na			9.01	21	63	36	3.0	2	12.3	2
Vermont	5,162	12.2	7	229	21.7	28	3.72	40	54	25	29.7	47	53.3	50
Virginia	27,240	65.7	46	162	8.5	14	5.30	31	41	8	22.8	36	34.2	36
Washington	40,492	50.3	38	614	21.5	27	14.73	16	50	21	11.8	13	32.3	34
West Virginia	28,361	80.0	49	19	100.0	50	3.11	43	53	24	24.6	39	48.3	47
Wisconsin	na			971	74.4	48	19.78	10	70	41	29.7	46	28.1	26
Wyoming	19,437	17.3	11	427	7.1	12	145.11	1	54	25	16.9	24	21.9	14
U.S. Total	1,522,792	30.4		35,754	25.7		12.47		51		15.1		26.0	

WATER POLLUTION

State	PESTICIDE CONTAMINATED GROUNDWATER %	Rank	SURF.& GROUND WATER POSSIBLY CONTAMINATED %	Rank	WATER SYSTEMS VIOLATING SDWA %	Rank	WATER SYSTEMS SIGNIFICANT NONCOMPLIANCE %	Rank	POPULATION WITH SDWA VIOLATIONS %	Rank	WATER USE FOR DRINKING & COOKING %	Rank	COMPOSITE WATER POLLUTION Score	Rank
Alabama	16.0	35	39.0	34	20.9	27	0.15	4	17.5	41	0.023	37	689	38
Alaska	na		na		78.8	50	78.29	50	48.0	48	0.070	12	647	30
Arizona	28.8	42	47.2	38	62.0	46	24.14	48	59.9	49	0.025	35	575	19
Arkansas	8.5	27	16.3	20	4.0	8	0.00	1	5.8	11	0.020	42	711	41
California	6.6	21	15.2	19	9.4	19	2.25	34	4.6	9	0.035	30	612	27
Colorado	3.4	13	25.8	24	26.2	32	0.93	19	2.3	5	0.012	46	332	2
Connecticut	0.3	5	1.4	6	1.8	4	1.22	24	14.5	34	0.142	6	554	17
Delaware	35.9	45	70.5	48	9.4	20	0.91	17	6.2	15	0.245	2	584	22
Florida	56.5	49	65.0	45	43.1	41	4.18	46	16.2	36	0.091	10	830	50
Georgia	8.3	26	26.0	26	36.5	40	0.64	12	3.7	6	0.056	16	628	29
Hawaii	na		na		23.6	28	1.53	29	6.3	17	0.046	21	553	16
Idaho	22.5	39	27.0	27	35.7	39	1.79	31	17.0	40	0.002	50	598	25
Illinois	24.2	41	63.8	44	6.7	14	3.32	43	8.9	27	0.041	25	800	46
Indiana	38.1	47	66.9	46	4.3	9	1.40	27	2.2	4	0.034	31	815	49
Iowa	56.6	50	75.5	50	25.8	30	3.26	42	16.2	37	0.052	17	666	34
Kansas	36.8	46	70.8	49	26.1	31	1.60	30	12.7	32	0.022	39	731	43
Kentucky	6.7	22	44.9	37	27.1	35	1.06	22	12.5	31	0.048	19	666	34
Louisiana	15.3	33	25.9	25	13.5	22	0.34	7	9.1	28	0.023	37	774	44
Maine	4.0	16	19.0	21	1.7	3	0.00	1	1.2	1	0.112	8	437	8
Maryland	6.9	23	57.3	42	1.8	5	0.84	15	4.3	8	0.196	4	487	12
Massachusetts	0.5	7	1.7	8	4.8	10	0.74	14	20.8	44	0.047	20	579	20
Michigan	14.0	31	69.8	47	3.7	7	0.26	6	1.3	2	0.039	28	652	31
Minnesota	33.1	44	50.9	39	1.0	1	0.00	1	13.1	33	0.069	13	580	21
Mississippi	22.7	40	24.9	23	26.9	34	0.21	5	23.8	46	0.058	15	657	32
Missouri	1.9	11	5.8	11	10.2	21	0.92	18	6.0	13	0.042	24	601	26
Montana	3.7	14	10.4	14	53.2	45	1.40	28	16.0	35	0.005	48	478	11
Nebraska	47.8	48	61.3	43	19.6	25	1.32	25	1.5	3	0.008	47	595	24
Nevada	0.0	1	0.0	1	33.8	38	28.35	49	5.9	12	0.013	45	287	1
New Hampshire	0.0	1	0.0	1	7.6	15	0.88	16	8.0	24	0.073	11	418	5
New Jersey	16.3	36	35.4	32	75.4	49	0.63	11	100.0	50	0.175	5	695	40
New Mexico	0.5	6	0.5	5	29.0	36	2.97	40	7.5	22	0.021	40	428	6
New York	6.9	24	31.4	29	8.8	17	0.48	9	6.1	14	0.099	9	552	15
North Carolina	4.7	18	31.7	30	9.4	18	1.03	21	8.7	26	0.040	27	621	28
North Dakota	6.2	20	12.1	17	26.2	33	3.39	44	20.8	45	0.030	33	410	4
Ohio	18.7	37	56.7	40	8.0	16	0.37	8	4.1	7	0.043	22	791	45
Oklahoma	4.2	17	15.2	18	15.7	24	2.18	33	16.5	38	0.140	7	505	14
Oregon	0.6	8	2.0	9	52.9	44	2.50	36	9.7	29	0.021	40	585	23
Pennsylvania	10.7	29	42.8	36	46.5	43	2.74	38	16.6	39	0.043	22	677	37
Rhode Island	1.0	10	6.5	12	1.6	2	1.16	23	7.7	23	0.390	1	437	8
South Carolina	9.2	28	40.0	35	6.2	13	1.33	26	6.8	18	0.025	36	556	18
South Dakota	15.7	34	22.0	22	25.4	29	3.70	45	20.2	43	0.052	18	445	10
Tennessee	14.9	32	38.3	33	43.2	42	0.55	10	4.6	10	0.028	34	805	47
Texas	5.2	19	11.9	16	20.7	26	2.69	37	11.5	30	0.041	25	670	36
Utah	0.0	1	0.0	1	33.5	37	0.73	13	7.2	19	0.020	42	392	3
Vermont	0.0	1	0.0	1	6.0	12	3.22	41	7.3	21	0.212	3	434	7
Virginia	3.7	15	31.3	28	14.8	23	1.01	20	7.3	20	0.060	14	720	42
Washington	6.9	25	10.8	15	66.6	48	18.68	47	44.5	47	0.031	32	662	33
West Virginia	2.2	12	5.5	10	5.3	11	2.47	35	6.3	16	0.018	44	807	48
Wisconsin	30.1	43	56.8	41	2.4	6	1.85	32	8.5	25	0.036	29	691	39
Wyoming	0.6	9	1.4	7	64.6	47	2.85	39	18.7	42	0.004	49	492	13
U.S. Total	14.9		34.1				3.37		14.5					

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SOURCES FOR WATER POLLUTION INDICATORS

Fresh water withdrawals

Total per-capita consumption in gallons of fresh water from all surface and groundwater sources, including agriculture and industry use but excluding hydroelectric instream pass-through.
Source: "National Water Summary, 1985," Table 23. Published by U.S. Geological Survey, U.S. Department of Interior, 1988.

Toxic chemicals released into surface water

Total pounds, pounds per capita, and pounds per square mile of direct surface water discharges reported by manufacturing facilities using or releasing at least 50,000 pounds of any of 322 chemicals, including 123 carcinogens.
Source: "Toxics in the Community: The 1988 Toxic Release Inventory National Report," September 1990. Published by Office of Toxic Substances, U.S. Environmental Protection Agency, Washington.

Toxic chemicals sent into public sewage systems

Total pounds, pounds per capita, and pounds per square mile of public sewer transfers reported by manufacturing facilities using or releasing at least 50,000 pounds of any of 322 chemicals, including 123 carcinogens.
Source: "Toxics in the Community: The 1988 Toxic Release Inventory National Report," September 1990. Published by Office of Toxic Substances, U.S. Environmental Protection Agency, Washington.

Toxic chemicals injected underground

Total pounds, pounds per capita, and pounds per square mile of underground injections reported by manufacturing facilities using or releasing at least 50,000 pounds of any of 322 chemicals, including 123 carcinogens.
Source: "Toxics in the Community: The 1988 Toxic Release Inventory National Report," September 1990. Published by Office of Toxic Substances, U.S. Environmental Protection Agency, Washington.

Composite toxic water score

Each state's rank for the nine indicators above was totaled to produce a composite score. Lowest score receives best composite rank for toxic chemical releases threatening water quality.

Sewage systems in noncompliance

Percent of publicly-owned wastewater treatment works (POTWs) in significant noncompliance with final effluent limits for secondary treatment or better, and/or with interim effluent limits, and/or with construction schedules.
Source: Office of Water Enforcement and Permits, U.S. Environmental Protection Agency, Washington, for quarter ending June 30, 1988.

Sewage system investment needs

Funds needed for publicly-owned wastewater treatment facilities to meet anticipated demand by 2008, including cost of new, expanded, upgraded, or better managed systems. Total dollars in millions, per-capita dollars, and per-capita ranking.
Source: "1988 Needs Survey Report to Congress: Assessment of Needed Publicly Owned Wastewater Treatment Facilities." Published by Office of Municipal Pollution Control, U.S. Environmental Protection Agency, Washington, February 1989.

Impaired rivers and streams

Total miles of rivers and streams, and percent of total miles that partially or completely fail to meet their designated use for drinking, recreation, or fishing.
Source: "National Water Quality Inventory: 1988 Report to Congress." Published by Office of Water Regulations and Standards, U.S. Environmental Protection Agency, March 1990.

Impaired lakes and reservoirs

Total acres of lakes and reservoirs, and percent of total acres that partially or completely fail to meet their designated use for drinking, recreation, or fishing.
Source: "National Water Quality Inventory: 1988 Report to Congress." Published by Office of Water Regulations and Standards, U.S. Environmental Protection Agency, March 1990.

Funds for water quality and development

Per-capita spending in fiscal 1988 for SWDA and public drinking water programs, water quality protection, and water resource conservation and development. Includes state, federal, and other funds (fines, licences, etc.) that pass through state budgetary process. Excludes funds for coastal water and marine protection.
Source: "Resource Guide to State Environmental Management," second edition, 1991. Published by Council of State Governments, P.O. Box 11910, Lexington, KY 40578; telephone (606) 231-1939.

Population served by groundwater

Percent of population dependent on groundwater for public or self-supplied water systems.
Source: "National Water Summary, 1985," Table 23. Published by U.S. Geological Survey, U.S. Department of Interior, 1988.

Households with wells

Percent of households with their own wells.
Source: "General Housing Characteristics, U.S. Summary, 1980, U.S. Census of Population." Published by Bureau of Census, U.S. Department of Commerce, Washington.

Households with septic tanks only

Percent of households with their own septic tanks or no public sewer service.
Source: "General Housing Characteristics, U.S. Summary, 1980, U.S. Census of Population." Published by Bureau of Census, U.S. Department of Commerce, Washington.

Groundwater potentially contaminated by pesticides

Percent of state's population served by public water supplies in counties potentially contaminated with pesticides or agricultural chemicals.
Source: Elizabeth G. Nielsen and Linda K. Lee, "The Magnitude and Costs of Groundwater Contamination from Agricultural Chemicals." Agricultural Economic Report No. 576, October 1987. Published by the Economic Research Service, U.S. Department of Agriculture, Washington.

Surface and groundwater potentially contaminated

Percent of state's population served by public water supplies in counties potentially contaminated by pesticides or agricultural chemicals.
Source: Elizabeth G. Nielsen and Linda K. Lee, "The Magnitude and Costs of Groundwater Contamination from Agricultural Chemicals." Agricultural Economic Report No. 576, October 1987. Published by the Economic Research Service, U.S. Department of Agriculture, Washington.

Water systems with SDWA violations

Percent of public water systems with one or more violations of the Safe Drinking Water Act during fiscal 1987.
Source: Norman L. Dean, "Danger On Tap: The Government's Failure to Enforce the Federal Safe Drinking Water Act," October 1988. Published by the National Wildlife Federation, 1400 16th Street, NW, Washington, DC 20036; telephone (202) 797-6820.

Water systems in significant noncompliance

Percent of community water systems in significant, chronic violation of the Safe Drinking Water Act during fiscal 1987.
Source: "Danger On Tap: The Government's Failure to Enforce the Federal Safe Drinking Water Act," October 1988. Published by the National Wildlife Federation.

Population with SDWA violations

Percent of population in 1987 served by community water systems with at least one violation of the Safe Drinking Water Act. Each of the nation's 60,000 community water systems serves at least 15 connections or 25 people year-round.
Source: "Danger On Tap: The Government's Failure to Enforce the Federal Safe Drinking Water Act," October 1988. Published by the National Wildlife Federation.

Water use for drinking purposes

Percent of total public and self-supplied withdrawals of water consumed for domestic drinking and cooking purposes. The vast majority of water is consumed by industry, utilities, and agriculture.
Source: "Estimated Use of Water in the United States in 1985," U.S. Geological Survey Circular 1004. Published by U.S. Department of Interior, 1988. Percentages calculated by Chris Nichols in "Drinking Water," Renew America, Washington, 1989.

Composite water quality score

Rankings on 25 indicators were totaled to produce a composite score. Lowest scores receives lowest (best) composite rank for water quality.

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