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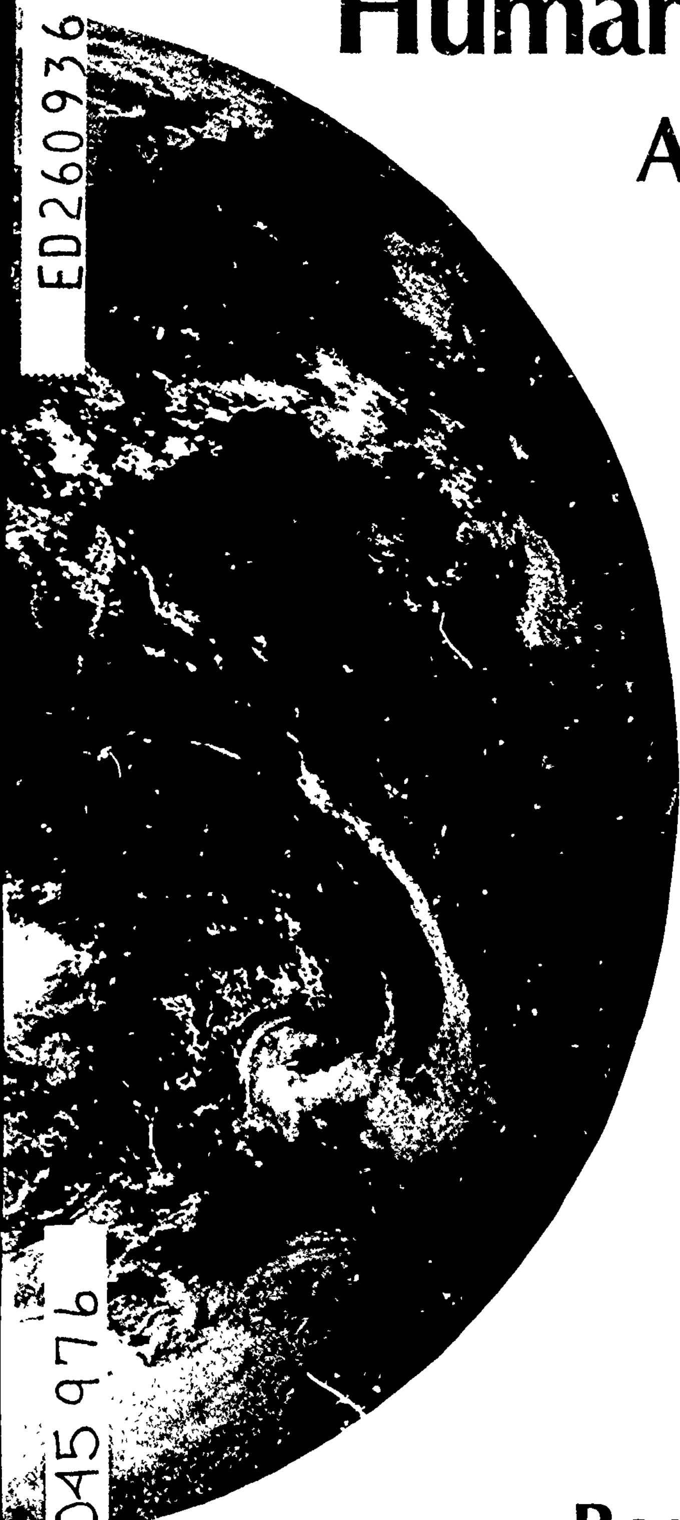
ABSTRACT

This monograph provides a framework for biology teachers who are rethinking and redesigning their programs. The major focus is on the human ecology perspective in biology programs. The first chapter attempts to define and clarify human ecology through historical review. The second chapter provides support, based on a survey of citizens (scientists, engineers, general public, and students), for including human ecology in biology education. Policies for programs and practices are outlined in the third chapter. A conceptual framework for a human ecological perspective in biology education is included. The framework provides (in table format) a list of topics with related concepts and teaching examples. The fourth and fifth chapters are both the major portion and the most practical components of the monograph. An exclusive review of curriculum materials is provided in the fourth chapter. These materials, from 16 publishers, include such programs as "The Human Sciences Program," "Energy, Resources, and Environment," and "Health Activities Project (HAP)." Each curriculum review includes the following: (1) program director/publisher; (2) program objectives and a description; (3) methods of instruction; (4) specific subjects, grade, age, and ability levels; (5) materials offered; (6) program implementation; and (7) teacher preparation. The fifth chapter consists of seven teaching/learning activities focusing on population growth, age structure of population, air quality and automobiles, thermal pollution, vegetations and soils, supply and demand of resources, and a tragedy of the commons (communal pasture). Each activity includes background information, objectives/concepts fostered, and recommended instructional strategies. (JN)

Human Ecology: A Perspective For Biology Education



Monograph Series II

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Human Ecology:
A Perspective for Biology Education

Monograph Series II

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Preface

Reports have been written and recommendations have been made for the reform of American education. The last decades of this century promise to be a period of substantial change in education. While there have been suggestions that ultimately influence every aspect of the educational system, they have been broad—more time on task, improved programs, effective instruction, and the goal of excellence. In the midst of the rhetoric there is a need for some concrete suggestions. *Human Ecology. A Perspective for Biology Education* is a concrete contribution for biology teachers who are rethinking and redesigning their programs.

There are many perspectives that might be taken in the development of new biology education programs. Human ecology is one. It is, I believe, a very crucial perspective congruent with long standing aims of education and especially important at this time in history. This monograph moves from awareness to action relative to a human ecology perspective in biology programs.

The first chapter attempts to define and clarify human ecology through historical review. The second chapter provides support, based on a survey of citizens, for including human ecology in biology education. Policies for programs and practices are outlined in the third chapter The final chapters are both the major portion and the most practical components of the book. One chapter is an exclusive review of curriculum materials and the other is a set of activities for biology teachers.

Human Ecology. A Perspective for Biology Education grew out of interest in the September 1984 issue of the *American Biology Teacher* The theme for this issue was human ecology, and it is recommended as a complement to this monograph.

I wish to acknowledge Carleton College's Science, Technology and Public Policy Program, the Alfred P. Sloan Foundation, and the National Association of Biology Teachers for support of this project. There are several individuals who deserve special recognition for their work on various aspects of this publication. Nancy Gustafson, Eric Johnson, Vicki Miller, Cyndy Rosso and all the students in courses on "Science, Technology and Public Education."

Rodger W. Bybee
October, 1984

A Personal Perspective

This essay is a personal perspective of human ecology. I have tried to answer three basic questions—What is human ecology? Is human ecology important? And, assuming that it is important, why is it important at this time in history?

Early Perspectives in Human Ecology

Charles Darwin (1809-1882) and evolutionary biology provided the intellectual origins of human ecology. The appearance of *On the Origin of Species* (1859) established the relationship between organisms and environments in their natural selection of traits that enhance the organisms' ability to survive and reproduce. Humans are included in this ongoing biological dynamic. Also, during the late 1800s the German biologist, Ernst Haeckel (1834-1919), first identified ecology as a separate field of study in his 1869 text, *General Morphology of Organisms*. I suggest that Darwin's theory and the emergence of ecology as a field of study in the late 19th and early 20th century established the initial perspectives for human ecology. While the biologists were developing the basic concepts of ecology they usually implicitly included humans but without explicitly developing a human ecology. Biologists, bound by their discipline, have been slow to recognize humans in their study (except perhaps in genetics, anatomy, and physiology). The primary contribution of biology was the intellectual birth of ecology and the early development and synthesis of a conceptual foundation (Young 1974).

The early developers of human ecology as a discipline were primarily sociologists. Robert F. Park, Ernest Burgess, and Roderick McKenzie are usually recognized as the founding fathers of human ecology. Park and Burgess first used the term "human ecology" in their 1921 book, *Introduction to the Science of Sociology*. These men drew heavily on the work of biologists such as C.R. Darwin, F.F. Clements and C.S. Elton. It may be instructive to briefly review some early writings in human ecology. For readers interested in more comprehensive collections of writings in human ecology, I refer you to George Theodorson's *Studies in Human Ecology* (1961) and Gerald Young's *Origins of Human Ecology* (1983).

In a 1936 article entitled "Human Ecology," Robert Park elaborated the classical position of human ecology. Park's work had a biological base with sociological applications. I quote Park's summary statement.

> Human ecology is an attempt to apply to the interrelations of human beings a type of analysis previously applied to the interrelations of plants and animals. The term symbiosis described a type of social relationship that is biotic rather than cultural. This biotic social order comes into existence and is maintained by competition. In plant and animal societies competition is unrestricted by an institutional or moral order. Human society is a consequence and effect of this limitation of the symbiotic social order by the cultural. Different social sciences are concerned with the forms which this limitation of the natural or ecological social order assumes on (1) the economic, (2) the political, and (3) the moral level (p. 1)

The summary reveals Park's biological and sociological orientation. The central organizing concept is competition, a restatement of Darwin's idea of "the struggle for existence." For Park, human society was organized on two levels, the biotic, based on competitive cooperation, and the cultural, based on communication and consensus. The biotic level influenced human adjustments and spatial distributions of populations. Human ecology studied the processes that maintained and changed the biotic balance and social equilibrium.

R.D. McKenzie broadened the scope of human ecology to be even more distinctly sociological. For McKenzie, human ecology was concerned with the spatial grouping and sustenance relations of humans occupying a geographical area. The interaction of humans around space and sustenance resulted in sociological changes in the population, such as mobility, employment, segregation, and dispersion. I quote a summary from one of McKenzie's early articles on "The Scope of Human Ecology."

> Human ecology concerns the process of spatial grouping of interacting human beings of interrelated human institutions. Ecological distribution is the resultant of competing forces and changes in distribution are measurable by the rate of mobility, of change of residence, of employment or of any utility. Many factors of general or local significance affect ecological organization and may be classed as geographical, economic, cultural and technical and political (p. 141)

McKenzie continues with a discussion of special forms of groups and institutions and the reasons for their formation. One should note the distinctly sociological tone of the definition and the lack of any suggested problems for study.

Other social science disciplines also adopted the ecological perspective. For example, early papers with a human ecological perspective were published in geography (Barrows 1923, Thornthwaite 1940), anthropology (Sayce 1938), and psychology (Lewin 1944). More recently the social science literature has included the human ecological perspective in economics (Boulding 1950, 1966), political science (Pfaltzgraft 1968, Rodman 1980), cultural anthropology (Orlove 1980) and environmental psychology (Craik 1973).

Three points emerge from this historical review One, early development of human ecology was primarily in the social sciences Two, there was a conspicuous absence of biological ecologists contributing to the emerging study of human ecology And third, while the social scientists were using the term human ecology, there was a great deal of conflict over academic territory and little study of significant problems.

By the late 1930s human ecology was being criticized. Milla Alihan's 1938 book, *Social Ecology A Critical Approach*, was central to the reassessment She criticized the sociologists' use of the term environment as too elastic, the over extension of biological concepts to social situation, too much accretion of social concepts with ecological concepts, and the inappropriate use of competition as the central process in human relationships She also had difficulty with an apparent incomplete understanding of uniquely human qualities, such as purpose and desire, and the role these may play on interactions with the environment.

I was particularly impressed with a 1944 criticism by Amos H. Hawley entitled "Ecology and Human Ecology." Hawley lists the "aberrant intellectual tendencies" which have dominated human ecology.

> The most dominant of these may be described as (1) the failure to maintain a close working relationship between human ecology and general or bioecology, (2) an undue preoccupation with the concept competition, and (3) the persistence in definitions of the subject of a misplaced emphasis on "spatial relations " (p 399)

Hawley then elaborated on these deficiencies, a task we need not pursue here. Later in the article Hawley makes a particularly insightful statement. He is discussing the matter of definitions of a discipline when he suggests the following

> Probably few will deny, however, the problem with which study is to be concerned must not only be significant but must also be a problem that is not already preempted by other disciplines It is no easier to defend a needless duplication of effort than it is a preoccupation with irrelevant issues Unless human ecology has a problem of its own, then, it is nothing and may well be forgotten (p. 402)

I think Hawley's 1944 assessment was correct And, indeed, it was not until the 1960s when population, resource, and environmental problems became dominant and not preempted by other disciplines that human ecology became an important area of study I shall return to this point Hawley later describes human ecology.

> In simplest terms, human ecology is the descriptive study of the adjustment of human populations to the conditions of their respective physical environments (p 404)

I conclude this discussion with a final quotation in which Hawley describes problems of human ecological study In the following quotation, Hawley points out how problems of human ecology are basically population problems, and broadly how the population adjusts to resource shortages and other physical changes in the environment. Hawley continues to describe human ecological problems.

> This (population adjustment to resources and environment) resolves itself into a number of related problems, such as (1) the succession of changes by which an aggregate passes from a mere polyp-like formation into a community of interdependencies, (2) the ways in which the developing community is affected by the size, composition, and rate of growth or decline of the population; (3) the significance of migration for both the development of the community and the maintenance of communal structure, together with the factors which make for change in the existing equilibrium and the ways in which such change occurs (p 405)

Amos Hawley's discussion of population, resource and environment interactions anticipated very well the 1960s, when human ecology became an important field of study.

Contemporary Perspectives in Human Ecology

There have always been some individuals who understood the relevance of ecology and its relation to the human condition. But it was not until the 1960s that ecology became a science with personal meaning for the general population. Why did this occur? My contention is that population, environment, and resource problems became important enough to demand attention. These were human ecological problems, and they were thrust into social prominence not by academics arguing the discipline but by individuals describing the problems. In the next paragraphs I review some of the people and works that brought human ecology to the forefront as a relevant science.

If one person and publication were used to identify the recent significance of human ecology, it would have to be Rachel Carson's *Silent Spring*, published in 1962. *Silent Spring* was a book that immediately drew national attention. Simply, clearly, and forcefully written, it carried the message that the use of chemicals, particularly chlorinated hydrocarbons, had grave consequences. Chapters provide the scientific background and examples of chemical effects on soil, on plants, to birds and fish, and on humans. In the opening paragraph of *Silent Spring*, Rachel Carson provides the human ecology context.

> The history of life on earth has been a history of interaction between living things and their surround-

ings To a large extent, the physical form and the habits of the earth's vegetation and its animal life have been molded by the environment Considering the whole span of earthly time, the opposite effect, in which life actually modifies its surroundings, has been relatively slight Only within the moment of time represented by the present century has one species—man—acquired significant power to alter the nature of his world (p 16)

The message of *Silent Spring* was hotly debated But time has provided support for most of Rachel Carson's arguments. More importantly, environmental problems came to the public's attention, and a human ecological perspective was presented

The Population Bomb, written in 1968 by Paul Ehrlich, is another significant book in the recent development of human ecology. Ehrlich's book, also powerfully written, demonstrated how population growth was related to numerous other problems such as food shortages, environmental degradation, and economic growth Ehrlich summarizes the population problem.

> In summary, the world's population will continue to grow as long as the birth rate exceeds the death rate, it's as simple as that. When it stops growing or starts to shrink, it will mean that either the birth rate has gone down or the death rate has gone up or a combination of the two. (p 16-17)

He continues by making the point that we must find ways to implement the "birth rate solution," or the traditional "death rate solutions," such as pestilence, famine, and war may prevail. This book was one of the first of several that Paul Ehrlich has written. He and his wife, Anne Ehrlich, who is a biologist, have written other books, such as *The End of Affluence* (1974) and *Extinction* (1981) that present global problems in a human ecological perspective

Garrett Hardin's 1968 essay, "The Tragedy of the Commons," is a classic statement in human ecology This article continues to be insightful and informative about the relationship among populations, the physical environment, and cultural issues related to carrying capacity. He argues using an analogy to a New England town commons, summarizing.

> The tragedy of the commons develops in this way Picture a pasture open to all It is to be expected that each herdsman will try to keep as many cattle as possible on the commons Such an arrangement may work reasonably satisfactorily for centuries because tribal wars, poaching, and disease keep the numbers of both man and beast well below the carrying capacity of the land Finally, however, comes the day of reckoning, that is, the day when the long desired goal of social stability becomes a reality At this point, the inherent logic of the commons remorselessly generates tragedy (p. 1245)

The tragedy occurs because herdsmen ask—What is the utility to me of adding one more animal?—a question of personal gain, not social responsibility or environmental accountability Of course, the herdsman adds an animal. He will receive all the profit from the extra animal, but the effect of overgrazing will be shared by all herdsmen. Hardin also confronts the difficult problem of avoiding the tragedy. He concludes that "mutual coercion mutually agreed upon by the majority of the people affected" is the only reasonable solution. This position clearly is not a strictly biological one Hardin is suggesting changes in things such as taxes to avoid exceeding the carrying capacity of air, land, and water

The list of significant contributors to human ecology has to include Barry Commoner As early as 1963 he published *Science and Survival* as warning of environmental problems. Probably his most notable contribution was *The Closing Circle* published in 1971 Where Ehrlich focused on population and Hardin on carrying capacity, Commoner directed his attention to the environmental crisis In a chapter on "Man in the Ecosphere" he confronts the interrelationship of humans and the environment.

> Environmental deterioration is caused by human action and exerts painful effects on the human condition The environmental crisis is therefore not only an ecological problem, but also a social one This adds to the intrinsic complexity of the ecosphere the further complications of human activities the number of people supported by the earth's natural system, the sciences that tell us what we know about nature, the technology that converts this knowledge to practical action, the resultant industrial and agricultural production that extracts new wealth from the earth's skin, the economic systems that govern the distribution and uses of wealth, the social, cultural, and political processes that shape all the rest (pp 109-110)

Here is the holistic understanding required of human ecology. While it is not easy, it is essential Barry Commoner's other works include *The Poverty of Power* (1976) and *The Politics of Energy* (1979)

Ten years after *Silent Spring*, a Club of Rome report entitled *The Limits to Growth* (1972) was published I quote the conclusions of the study

> If the present growth trends in world population, industrialization, pollution, food production and resource depletion continue unchanged, the limits to growth on this planet will be reached sometime within the next one hundred years. The most probable result will be a rather sudden and uncontrollable decline in both population and industrial capacity
>
> It is possible to alter these growth trends and to establish a condition of ecological and economic stability that is sustainable far into the future The state of global equilibrium could be designed so that the basic material needs of each person on earth are satisfied and each person has an equal opportunity to realize his individual human potential. (p 29)

The Limits to Growth was innovative in its approach, using computer modeling, and far reaching in its conclusions. A great debate around various as pects of the study immediately emerged. While the criteria found faults with aspects of the study, the symbolic value of the title and the fundamental findings of the study remain significant in the development of human ecology.

The Global 2000 Report to the President: Entering the Twenty-First Century (Barney 1980) was published eight years after *The Limits to Growth*, during the administration of Jimmy Carter. *The Global 2000 Report* was a massive undertaking by several United States government agencies to assess probable changes in the world's population, natural resources, and environment through the end of the century. President Carter's intention was to use the result in long-term planning and policy development. Some of the findings from this study include:

- —Rapid growth in world population will hardly have altered by 2000. The world's population will grow from 4 billion in 1975 to 6.35 billion in 2000, an increase of more than 50 percent.
- —The large existing gap between the rich and poor nations will continue to widen.
- —World food production is projected to increase 90 percent between 1970 and 2000. Most of the increase will go to countries with an already high per capita food consumption.
- —Arable land will increase only 4 percent by 2000, so increased output will be from higher yields.
- —World oil production will approach geological estimates of maximum production capacity in the 1990s.
- —Potential problems surround the world's finite fuel resources—coal, oil, gas, oil shale, tar sands, and uranium—since they are unevenly distributed, pose difficult economic and environmental problems and vary greatly in their amenability to exploitation and use.
- —The quarter of the world's population in industrial countries will continue to use three fourths of the world's mineral production.
- —Regional water shortages will become severe by the year 2000.
- —There will be significant losses of world forests due to use for forest products and fuelwood.
- —Agricultural soils will deteriorate due to erosion, loss of organic matter, desertification, salinization, alkalinization, and waterlogging.
- —Atmospheric changes due to carbon dioxide and ozone-depleting chemicals could alter the world's climate and upper atmosphere by the year 2050.
- —Extinctions of plant and animal species will increase by the year 2000.

The Global 2000 Report generally confirmed what many had been saying for years. There is an urgent need to recognize the earth's carrying capacity while maintaining a decent quality of life for humanity. There are still many global challenges. One concluding statement summarizes well the human ecological view.

> Vigorous, determined new initiatives are needed if worsening poverty and human suffering, environmental degradation, and international tensions and conflicts are to be prevented. There are no quick fixes. The only solutions to the problems of population, resources and environment are complex and long-term. These problems are inextricably linked to some of the most perplexing and persistent problems in the world - poverty, injustice, and social conflict. (p. 4)

I have referred to *The Global 2000 Report* at some length because the conclusions generally support the positions of others, such as the authors and publications reviewed here. One must also note with some concern that the Reagan Administration has paid little attention to the essential message of *The Global 2000 Report*.

This review would be incomplete without reference to the work of Lester Brown and the Worldwatch Institute. One of Lester Brown's first important works was *The Twenty-Ninth Day*, published in 1978. The book begins with the dimensions and consequences of ecological stress. Brown then expertly presents the biological and social means of accommodating human needs and numbers to the earth's resources. I believe Lester Brown's most significant *conceptual* contribution is in his 1981 book, *Building A Sustainable Society*. The concept of sustainable society is an idea and a vision that other authors had but did not articulate. Brown has discussed sustainability in a recent book entitled *State of the World* (1984), the first in a series of yearly reviews of progress toward a sustainable society.

> Sustainability is an ecological concept with economic implications. It recognizes that economic growth and human well-being depend on the natural resources base that supports all living systems. Technology has greatly expanded the earth's human carrying capacity, most obviously with advances in agriculture. But while the human ingenuity embodied in advancing technology can raise the natural limits on human economic activity, it cannot entirely remove them. (p. 1)

Brown continues with a definition of sustainable society.

> A sustainable society is one that shapes its economic and social systems so that natural resources and life support systems are maintained. (p. 2)

Observations and Reflections on Human Ecology

I developed this essay as a personal exploration of three questions. What is human ecology? Is human ecology important? And, assuming it is important, why is it important at this time in history? Actually, these questions are related to a larger and more important question concerning biology education—What is the place of human ecology as a perspective in biology education?

What is human ecology? As I wrote the essay, I included various defintions offered by different authors to develop a general conception of human ecology. Very broadly, human ecology considers the interrelationship of human beings and their environments. One observation was that authors tended to slant their definition of human ecology toward their discipline. I concluded that human ecology should not be set apart from the general discipline of ecology. This point was also recently made by Edward Kormandy (1984).

The noted ecologist Eugene Odum has suggested that ecology may emerge as a new integrative discipline. He summarizes,

> The new ecology, then, is not an interdiscipline, but a new integrative discipline that deals with the supraindividual levels of organization, an arena that is little touched by other disciplines as currently bounded—that is, by disciplines with boundaries established and strongly reinforced by professional societies and departments or curriculums of universities. Among academic subjects, ecology stands out as being one of the few dedicated to holism (p. 1291)

Odum stresses the ecosystem level of study and uses a holistic methodology. Humans are as much a part of the integrative approach as other organisms. In fact, Odum (1975) points out that the new ecology links the natural and social sciences. This position, the integrative link between natural and social sciences, seems to me an excellent way to think of ecology, and it clearly includes human aspects of ecology without positing human ecology as a new or unique discipline. The term human ecology suggests that both the human sciences and the natural sciences are important in the study of local to global problems.

Is human ecology important? The reading and thought that went into this essay only served to confirm what I suspected. *Yes, human ecology is important.* At this time in history it is more than important; it is vital that citizens have a fundamental understanding of human ecology. If one thinks for a moment about any of the major global problems, they are almost without exception human and ecological.

Why is human ecology important at this time in history? For millennia humans lived in a benign relationship with their environment. Their numbers and technologies had little effect on the air, land, and water. In the 20th century this changed. The many problems of population, environment, and resources are warnings that we are reaching the limits to growth on planet Earth. Since the problems are so closely interconnected with the growth and development of populations and the natural environment, the emergence of human ecology seems like a natural outgrowth of the present global situation if we are to begin understanding and subsequently solving the problems. Indeed, necessity as the mother of invention seems a good, brief answer to the question—Why is human ecology important now?

There is a second reason that human ecology has become important, especially in the last quarter century. There were people like Rachel Carson, Paul and Anne Ehrlich, Garrett Hardin, Barry Commoner and Lester Brown who had the courage to step out of strict discipline boundaries and address problems that threatened the human future.

Conclusion

I now turn to the question of human ecology as a perspective in biology education. The first, and perhaps most important, conclusion is that human ecology does indeed have a place in biology education. All of the reasons reviewed for human ecology's importance justify including human ecology as a part of the biological education of future citizens.

Throughout the essay, several points have arisen that begin forming the educational framework for human ecology. The human ecological perspective in biology education would include:

—study of significant problems such as population growth, environmental degradation, and resource use
—using an ecosystem level of study
—balancing holistic and reductive methods of study
—using an integrative approach that presents human ecological study as the linkage between natural and social sciences

Human ecology is too important to be left out of biology education. The courage demonstrated by individuals who developed the field of human ecology now has to be shown by biology educators. As biology educators we can and must do something, even if it is a small step toward including human ecology in biology education.

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Rodger W. Bybee

A Survey of Global Problems and Public Education

Does human ecology have a place in public education? Specifically, to what degree does the public identify human ecological problems as important aspects of study for students in K-12 science programs? To the first question I would respond *yes*. And to the second I would say that the public does think the study of human ecology related problems is important and would support such programs, with an increasing emphasis from elementary through high school. While these are *my* responses, I thought it may be best to find out how the public would respond.

In fall 1983, students and colleagues in the Science, Technology and Public Policy Program* at Carleton College designed and conducted a survey of citizens on the content and emphasis of public education programs. The survey was directed toward specific global problems related to science and technology and their place in school programs. This chapter reports the results for all respondents 18 years of age and older. My purpose is to clarify the place of human ecology topics in biology education through answers to general questions posed by science teachers. These questions concern priorities, importance, support, and emphasis relative to teaching about global problems related to population, resources, and environment.

The Survey

The project aimed to identify and rate important global problems and to establish a linkage of these issues to education. Twelve broad categories of problems were used in the survey (See Table 1) The first survey item had respondents rank the 12 problems from most to least important Following the initial ranking we asked how people thought the global problems would change by the year 2000, how much they knew about the problems, and what are their typical sources of information concerning the global problems.

The next series of questions was directed toward teaching about the global problems Specifically, we wanted to know about the importance of studying the problems at different levels of education, how much schools were already teaching about the problems, the support for including global problems in school programs, how much emphasis should be given to these issues at different grade levels, how the issues should be taught, and who should take the courses in which global problems were presented.

The survey was conducted during late 1983 and early 1984. Several different groups were included in the survey. scientists and engineers, general public, and students. One hundred (100) scientists were surveyed, including 84 men and 16 women of ages ranging from 20 to 81, with the majority between the ages of 30 and 50. Ninety-seven percent had completed graduate work. The remaining 3 percent were engineers who had not completed work beyond their initial undergraduate education The sample included 24 engineers and 76 scientists Of the total sample, the majority (62) were in higher education Fifty-five percent of respondents were from the Midwest with 13 percent, 16 percent and 8 percent from the East, West and South respectively The remaining 3 percent were from other countries (See Bybee 1984).

One hundred and three adults from the general public were surveyed, 49 were men and 54 were women. The ages ranged from 20 to 90, with the majority between 24 and 30. However, 22 respondents were over 60. Most (45.6 percent) had completed some college, with 37.6 percent having done some work beyond their undergraduate degree. Just over 16 percent had completed only high school. The majority, 77 percent, were from the Midwest with 2 percent, 15 percent and 3 percent from the East, West and South respectively. Most of the general public surveyed were in business or professional occupations (53 percent), and clerical or sales positions (15 percent). The remaining respondents were in the nonlabor force (mostly retired). In general, the population represented a bias toward middle class, the Midwest, and above average education.

Two hundred college students were surveyed on five different college and university campuses. The sample of college students represents a typical student population relative to age (18-23), sex (103 women and 97 men) and distribution of majors. Both public and private schools were represented.

There were 48 high school students included in the survey. These students were selected from a larger sample of pre-college students included as a part of the study. The basis of selection for this review was age In all cases the survey was administered directly, either as an interview or part of a class. The number of nonrespondents was negligible.

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Which Global Problems are Most Important?

Individuals ranked 12 global problems from most important to least important Table 1 presents the final rankings and the mean scores for each item.

War technology, air quality, world hunger, water resources, and population growth are the top five concerns Notice that survival and basic human needs are the value systems underlying the ranking Most citizens agree that war technology, particularly nuclear war, threatens human survival on earth. Recent scientific reports also support these perceptions (Turco et al. 1983, Ehrlich et al 1983) The next three items—air, food, and water—are essentials to long-term human existence.

Population growth was ranked fifth. But there were differences in rankings by different groups. Scientists ranked population growth first, other groups ranked the item much lower. While there was agreement between scientists and other groups on most items, population growth represented the greatest disagreement There are a couple of important points to be made about this disparity One is that population growth has received very little media coverage This seems to be a plausible account for the low ranking by groups other than scientists and engineers The second point is probably more important for biology educators. The high ranking by scientists and engineers reveals their understanding of population growth as fundamental to many other global problems This evaluation has important educational implications; namely, that understanding the dynamic causes and consequences of population growth should be central to biology programs including human ecology topics.

For the items ranked from 6 to 12 there are, I believe, understandable explanations. Those ranked highest—hazardous substances and energy snortages—have been covered by the media and have an immediacy for the public. Other problems such as land use, extinction of plants and animals and mineral resources have not been in the news or topics of special programs. Likewise, they are not perceived by tne average person as having any immediate relationship to his or her life or living. As you will see in the next table, all citizens perceive human health and disease as improving by the year 2000. Advances in medical technology do receive significant media coverage. This may explain the low ranking. Finally, I suggest that nuclear reactors received a low ranking because they are perceived as a greatly diminished issue for one of two reasons. There have been no new reactors ordered since 1976, and almost 90 reactor orders have been cancelled (Brown 1984). Conversely, the public may think that all problems have been eliminated in the nuclear energy industry, and they, along with the present administration, support development in this area—thus, a lower ranking With either explanation nuclear reactors are not perceived as significant problems.

TABLE 1. Citizens Ranking of Twelve Science Related Global Problems (N = 451)

Problem	*Rank*	*Mean*
WAR TECHNOLOGY (nerve gas, nuclear developments, nuclear arms threat)	1	4.94
AIR QUALITY AND ATMOSPHERE (acid rain, CO_2, depletion of ozone, global warming)	2	4.95
WORLD HUNGER AND FOOD RESOURCES (food production, agriculture, cropland conservation)	3	5 23
WATER RESOURCES (waste disposal, estuaries, supply, distribution, ground water contamination, fertilizer contamination)	4	5 88
POPULATION GROWTH (world population, immigration, carrying capacity, foresight capability)	5	6 01
HAZARDOUS SUBSTANCES (waste dumps, toxic chemicals, lead paints)	6	6.21
ENERGY SHORTAGES (synthetic fuels, solar power, fossil fuels, conservation, oil production)	7	6.34
LAND USE (soil erosion, reclamation, urban development, wildlife habitat loss, deforestation, desertification)	8	6 49
HUMAN HEALTH AND DISEASE (infectious and noninfectious disease, stress, diet and nutrition, exercise, mental health)	9	7.45
NUCLEAR REACTORS (nuclear waste management, breeder reactors, cost of construction, safety)	10	7 92
EXTINCTION OF PLANTS AND ANIMALS (reducing genetic diversity)	11	8 07
MINERAL RESOURCES (non fuel minerals, metallic and non-metallic minerals, mining, technology, low-grade deposits, recycling, reuse)	12	9.06

I would note that the rankings of problems in this survey are somewhat paralleled by those reported by George Gallup Jr. in *Forecast 2000* (1984). He too included "the voice of the people," expert opinion, and youth. The Gallup report included a broader range of topics than the survey reported here. I was mainly interested in human ecology or science and technology related problems. Still, here are the problems reported by Gallup: Wars, Terrorism and the Nuclear Threat, Overpopulation, Economic Pressure, Technological Progress, Environmental Emergencies, Crime, Family, Health and Politics. The parallel between the science and technology related items of the two surveys provides some support for the items and rankings of the survey reported here.

Virtually all respondents revealed difficulty in ranking the twelve problems. In part, this may have been a methodological problem related to the number of items. I think, however, methodology was secondary. Individuals consistently indicated the difficulty was due to the importance and interrelated nature of the problems. Awareness of the complexity and interrelatedness of the global problems, particularly by nonscientists, is an important observation not recorded on the survey. It also suggests another important theme for educational programs—the interrelated and interdependent nature of human and natural systems. Based on these observations, I would suggest human ecology as an important unifying conceptual organization for biology education.

How Will Global Problems Change By 2000?

Will the global problems get better or worse by the year 2000? Respondents were asked to indicate changes toward "much better," "better," "about the same," "worse," "much worse," and "don't know." Table 2 summarizes the results. Over 50 percent of the respondents thought war technology, air quality, water resources, population growth, hazardous substances, energy shortages, and extinction of plants and animals would be worse or much worse by the year 2000. The parallel to the initial ranking of problems is quite consistent. The only exception within the top five is world hunger and food resources, almost half (48.9 percent) of the respondents thought it would be worse by the year 2000.

When one realizes that the next highest ranking on all items, except the one which a majority thought would improve, was "about the same," there is certainly some cause for concern. In all, citizens do not have a very optimistic view of the future if this ranking represents their true opinions.

Human health and disease stands out as the one area where a majority (62.8 percent) of respondents thought there would be improvement. As mentioned earlier I would attribute this high rating to media coverage of recent advances and new technologies in the health professions. Clearly, the majority of people surveyed think that most global problems will get worse, not better, by the year 2000. The task of education is central to understanding the nature and dynamics of these global problems. Education can contribute to the actual improvement of global problems, and it can contribute to correcting any misperceptions of science and technology as they are related to the global problems. Biology educators must act on the essential message of Paul Ehrlich's aphorism that "pessimism has no survival value." To understand global problems and learn about ways and means of reducing the problems could be a powerful antidote to the prevailing public pessimism.

TABLE 2. Citizens' Indication of Change for Global Problems by Year 2000 (N = 451)

Global Problems (Listed in Rank Order from Most to Least Important)	*Better (Includes Much Better and Better)* %	*About the Same* %	*Worse (Includes Worse and Much Worse)* %	*Don't Know* %
WAR TECHNOLOGY	17 7	18 4	54 8	9.1
AIR QUALITY AND ATMOSPHERE	19 3	21 9	56 0	2.8
WORLD HUNGER AND FOOD RESOURCES	16 8	30 6	48 9	3.7
WATER RESOURCES	12 2	25 5	57 4	4.9
POPULATION GROWTH	16 6	24 5	54.0	4.9
LAND USE	19.3	38.7	36 4	5.6
HAZARDOUS SUBSTANCES	17.7	27.4	51.6	3.2
ENERGY SHORTAGES	17 8	27 9	51 3	3.0
HUMAN HEALTH AND DISEASE	62 8	26.0	9 0	2.2
NUCLEAR REACTORS	29.3	31 9	30 7	8 1
EXTINCTION OF PLANTS AND ANIMALS	8 8	33 0	52 8	5.4
MINERAL RESOURCES	9.8	34.8	48 1	7.3

TABLE 3. Citizens' Indication of Their Knowledge about Global Problems (N = 451)

Global Problems (Listed in Rank Order from Most to Least Important)	*Quite A Lot* %	*Some* %	*Very Little Or Nothing* %
WAR TECHNOLOGY	20.9	50.4	28.7
AIR QUALITY AND ATMOSPHERE	16.5	60.3	23.2
WORLD HUNGER AND FOOD RESOURCES	18.9	59.7	21.4
WATER RESOURCES	15.7	51.8	32.5
POPULATION GROWTH	24.9	54.0	21.1
HAZARDOUS SUBSTANCES	16.4	52.7	30.9
ENERGY SHORTAGES	21.9	67.4	10.7
LAND USE	15.2	47.3	37.5
HUMAN HEALTH AND DISEASE	24.7	51.2	24.1
NUCLEAR REACTORS	19.9	48.5	31.6
EXTINCTION OF PLANTS AND ANIMALS	14.6	45.1	40.3
MINERAL RESOURCES	7.2	38.9	53.9

What Do Citizens Know About Global Problems?

Respondents were asked to indicate whether they knew "quite a lot," "some," "very little," or "nothing at all" about the global problems. Citizens indicated knowing most about population growth, human health and disease, and war technology. Population growth ranked very high probably due to the high ranking by scientists and engineers. This question provides a general estimation of how much people think they know, but it does not help much to know that people generally know "some" about global problems. Perhaps a more fundamental question is—What about the quality of their knowledge?

The survey included a question designed to evaluate the sources, and subsequently quality, of knowledge about the problems. The results of the question displayed in Table 4 should be of interest to science teachers. The public gains information about science related global problems by reading—in newspapers, weekly magazines, and books. Television is the second most important source of information. For pre-college students, television was ranked number one, but second were teachers and schools. There was a qualitative difference between the scientists' and other citizens' sources of information. There is a greater depth and breadth of information in sources listed highest by scientists. For example, scientists and engineers ranked professional journals and books above newspapers and weekly magazines. They also ranked personal experience among the top five. Also, as science educators we simply must recognize that individuals learn about topics such as global problems from the media. Inclusion of teachers/schools in the top five is a result of including students in the survey. A similar ranking for only scientists and the general public did not include teachers/schools. Finally, if it is necessary to educate citizens in systematic examination and critical analysis of human ecological issues such as these, then school programs, and particularly biology classes, would be a good time and place for such education. Recognition, inclusion and evaluation of various media as sources of information during pre-college education could contribute to a continued, lifelong science education.

TABLE 4. Citizens' Sources of Information Concerning Global Problems (N = 451)

Rank	*Source of Information*
1	NEWSPAPERS
2	TELEVISION
3	WEEKLY MAGAZINES
4	BOOKS
5	TEACHERS/SCHOOLS

Global Problems and Public Education

A connection between global problems and education is developed in this section. Questions on the survey included the importance of studying global problems and support for teaching about global problems.

On the question of how important the study of global problems is at different educational levels there was a consensus supporting its inclusion at all educational levels. The importance of studying global problems at different levels increased across grade levels. For the elementary level, 64.5 percent thought it important. At middle/junior high school, 87.7 percent rated it important. At the high school level, 78.2 percent thought study of global problems very important, while another 19.6 percent thought it fairly important.

Respondents were asked to indicate how much

TABLE 5. Citizens' Indication of Importance of Studying Global Problems at Educational Levels (N = 451)

Level	Very Important %	Fairly Important %	Not Too Important %	Don't Know %
ELEMENTARY SCHOOL	28.6	35.9	33.9	1.6
MIDDLE SCHOOL/JUNIOR HIGH SCHOOL	42.5	45.2	11 1	1.2
HIGH SCHOOL	78.2	19 6	2.0	2
COLLEGE	82.4	14.7	2.7	2

their local schools actually teach about global problems. The dominant response for elementary school was very little or nothing (45.3 percent). At the middle/junior high school about 1/3 indicted some (32.8 percent) and another 1/3 indicated very little or nothing (33.0 percent). For high school, the prominent response was some (46.6 percent). In general there is an increase from very little to some across the K-12 continuum.

This question had another revealing and important response for teachers. Notice that significant numbers of individuals indicated that they don t know how much their schools are teaching about local problems. I suspect the results would have been similar for any topic except "the basics." More importantly, the results shown in Table 6 are inflated by inclusion of high school students and college students in the survey. As part of the data analysis, I ran the statistics for this item with only scientists and the general public. The number indicating "don't know" was above 50 percent for all pre-college levels. Based on these data, one can reasonably conclude that citizens generally do not know what is being taught in science programs. There is an implied public relations mission for science teachers and school administrations.

While it appears there is support for teaching about global problems in public education, we asked an even more probing question. The question was posed as support for a tax increase for textbooks and curriculum materials to teach about global problems. Even though this is still a "free ride" question and it was recognized that taxes are not increased for specific school programs, the question did reveal public support for education in global problems.

A remarkable 79.6 percent indicated they would vote to increase taxes for textbooks and curriculum materials. The majority (41 6 percent) would favor a yearly tax increase up to $20, the response being even higher (52.1 percent) among only the scientists and general public. I think it is understandable that high school and college students would not contribute as much of their money, but still the support for the issue and their agreement to contribute some money is clear.

In review, citizens do think it is important to study global problems in education, the schools are apparently teaching very little about global problems, and citizens clearly support the inclusion of topics such as these in school programs. We also found that citizens generally do not know what is being taught about science topics like global problems. This implies a need for communication and public relations between school personnel and citizens.

Teaching about Global Problems

Information was gathered about some fairly concrete aspects of science teaching relative to global problems. How much time should be devoted to global problems? Who should take classes which include global problems? How should the classes be taught?

Table 8 displays results of the survey question on how much time should be spent on global problems At the elementary level over half (57.6 percent) indicated that 10 percent or less time should be spent on the study of global problems In actual time per week this percent is quite small. At the K-3 level the

TABLE 6. Citizens Indication of How Much Their Local Schools are Teaching About Global Problems (N = 451)

Level	Quite A Lot	Some	Very Little or Nothing	Don't Know
ELEMENTARY SCHOOL	1.4	17.8	45.3	35.5
MIDDLE SCHOOL/JUNIOR HIGH SCHOOL	3.2	32.8	33.0	31.5
HIGH SCHOOL	8.4	46.6	19.1	25.2
COLLEGE	30.6	41.2	6.6	21 6

TABLE 7 Citizens' Indication of Their Willingness to Vote an Increase in Taxes to Support Education in Global Problems (N=451)

	%	$5.00 %	$10.00 %	$15.00 %	$20.00 %
PERCENT FAVORING YEARLY TAX INCREASE	79.6	8.0	18.3	11.7	41.6
PERCENT OPPOSED TO A TAX INCREASE	9 8				
PERCENT INDICATING THEY DID NOT KNOW	10.5				

average time per week on science is less than 100 minutes (in 1978, Weiss reported 95 minutes per week), so the recommended emphasis at this grade level is about 10 minutes per week. In grades 4-6 the average number of minutes per week is 175 (Weiss 1978), so the recommended time spent on global problems is about 18 minutes per week. Especially if inclusion of global problems were combined with social studies lessons, the recommended emphasis would be easily achievable. At the middle/junior high school the recommended amount of time is around 20 percent. This translates to the equivalent of one class period per week or about 10 minutes per day for 50-minute classes. The amount of time for high school classes is slightly more. A review of Table 8 indicates about 25 percent of instructional time is the minimum recommendation for high schools. So slightly more than one class a week or 15 minutes per day is recommended for 60-minute classes.

The question was asked, 'Who should take courses in which the global problems are presented?'' A clear majority (70.3 percent) said the courses should be required of all students, while about a quarter (25 7 percent) indicated they should be electives Only three percent indicated college bound students should take the courses, and only one percent thought students planning to major in science and engineering should be required to take the courses.

Many global problems are related to current political, economic, and social policies. Such situations present the problem posed in one of the survey questions—"How do you suggest the scientific and social aspects of these problems be presented?'' Unfortunately, the response gives little direction for educators. Just over 40 percent (41.2 percent) indicated that science and social studies should be taught separately. Just over 45 percent (45.7 percent) recommended incorporating the science and social studies into one course. The difference was not significant. Another 13.1 percent did not know how the courses should be taught. On this item the survey results are of little help. Perhaps this is as it should be since the practicality and specificity of different instructional approaches should be a function of professional judgment by school personnel.

Summary and Discussion

Results of this survey provide support for a human ecology approach in education. In addition, the article presents information concerning the views of citizens on topics and issues of specific interest to science teachers. This study was intended as a preliminary survey, and other similar studies are recommended Based on the present data we can state the following:

—Global problems can be prioritized for study. Based on citizens ranking the most to least important topics for study are listed below It should be noted, however, that respondents consistently indicated that *all* problems listed were important.

—war technology
—air quality and atmosphere
—world hunger and food resources
—water resources
—population growth

TABLE 8. Citizens' Indication of How Much Schools Should be Teaching About Global Problems (N = 451)

Level	*0-5%*	*6-10%*	*11-15%*	*16-20%*	*21-25%*	*26-30%*	*31% or more*
	Reported as Percent Indicating Minimum Instructional Time in a Science or Social Studies Class						
ELEMENTARY SCHOOL	26.9	30.7	17 4	12.6	8.0	3.0	1.4
MIDDLE SCHOOL/ JUNIOR HIGH SCHOOL	4.3	18.8	22.0	24.5	17.2	9.8	3.4
HIGH SCHOOL	1.3	7.3	12.6	20.6	22.9	22.0	13.3

- —hazardous substances
- —energy shortages
- —land use
- —human health and disease
- —nuclear reactors
- —extinction of plants and animals
- —mineral resources

—Citizens indicate these problems will be worse or about the same by the year 2000. The exception to this statement is human health and disease, which they thought would be better.

—Citizens indicate they know "some" about these problems. These sources of information are newspapers, television, weekly magazines, books and teachers.

—Citizens indicate that global problems should be studied at all educational levels. There is, however, indication of increasing importance across grades K-12.

—From K-12 there are increasing amounts of instruction concerning global problems. However, the indication varies from very little or nothing to some at higher grade levels.

—Citizens said they do not know what is being taught about global problems in local schools.

—Citizens do support teaching about global problems in schools.

—Recommendations for the minimum amount of instructional time devoted to global problems in science and technology education programs increases from 10 percent in elementary school, 20 percent in middle/junior high school to 25 percent in high school.

—Citizens indicate that courses which include global problems should be required of all students.

There is widespread interest in and support for teaching about science and technology related global problems. Many important decisions are still left for science teachers and school personnel, but the connection between human ecology and biology education has been made and it is time to begin strengthening the connection through curriculum programs and instructional practices in the schools.

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Rodger W. Bybee

Policies for Biology Education

My purpose in this chapter is to establish a framework for a human ecological perspective in biology education. Earlier discussions in this monograph and elsewhere serve as background for these policies (See, e.g., Bybee 1979; Bybee et al. 1981; Bybee 1982, 1983, 1984). Here my aim is to provide brief guidelines, recommendations, a conceptual framework, and resources for biology teachers who are redesigning their programs.

Educational Goals of Human Ecology

Biology education programs and teaching should include appropriate objectives to meet the general aim of:

(1) fulfilling basic human needs and facilitating personal development;
(2) maintaining and improving the physical and human environment;
(3) conserving and efficiently using natural resources; and
(4) developing community at the local, regional, national, and global levels.

This aim includes the fundamental relationship of individuals to the environment and to each other in communities. Additionally, the goal can be applied concretely to students. That is, as a result of biology education they should be able to fulfill *their* basic needs, maintain and improve *their* environment, conserve and use *their* resources wisely, and contribute to *their* community. More abstractly, this goal provides an orientation for the knowledge, skills, and understandings as they relate to the broader picture of humanity.

On a slightly more specific level, a human ecological perspective should contribute to a functional scientific literacy of students in the following ways:

(1) through the use of the knowledge, values and skills of ecological science and technology in their *personal* lives;
(2) through an understanding of ecological science and technology related to *social issues;*
(3) through an understanding and appreciation for ecological science and technology as a *human endeavor* with both limits and possibilities for improving the quality of life,
(4) through an introduction, in the context of human ecological problems, to the ways they can *participate in the democratic process*

Emphasis on Human Ecology

Human ecology should be included at all grade levels, kindergarten through college Developmental characteristics of students provide a guide for the amount of time and orientation on human ecological issues Here are my recommendations for the minimum amount of instructional time:

—Elementary School	*10% of the time spent on science instruction.* According to national averages of 100 minutes per week at the K-3 level and 180 minutes at 4-6 level, this means 10 to 18 minutes per week across the K-6 continuum. Emphasis should be toward the child as a *curious naturalist.*
—Middle School	*20% of the time in life science.* This equates to one seven-week unit, one class a week or 10 minutes a day (50-minute classes). Emphasis should be toward the student as an *inquiring adolescent.*
—High School	*25% of the time in biology class.* Again, this is about one nine-week unit, one class a week or 15 minutes a day (60-minute classes). Emphasis should be toward the student as a *concerned citizen.*

Courses, units or lessons with an emphasis on human ecology should be required of *all* students. Neither are these advanced placement, accelerated, or second level programs, nor are these programs exclusively for slow learners, low track, or vocational students.

Curriculum Perspective for Human Ecology

The orientation of curriculum and instruction with a human ecological perspective would include the following approaches:

Problem Centered. The program should include important problems of a human ecological nature.

Based on my earlier work, I would suggest the following problems (listed here in alphabetical order)

- AIR QUALITY AND ATMOSPHERE (acid rain, CO_2, depletion of ozone, global warming)
- ENERGY SHORTAGES (synthetic fuels, solar power, fossil fuels, conservation, oil production)
- EXTINCTION OF PLANTS AND ANIMALS (reducing genetic diversity)
- HAZARDOUS SUBSTANCES (waste dumps, toxic chemicals, lead paints)
- HUMAN HEALTH AND DISEASE (infectious and noninfectious disease, stress, diet and nutrition, exercise, mental health)
- LAND USE (soil erosion, reclamation, urban development, wildlife habitat loss, deforestation, desertification)
- MINERAL RESOURCES (nonfuel minerals, metallic and nonmetallic minerals, mining, technology, low grade deposits, recycling, reuse)
- NUCLEAR REACTORS (nuclear waste management, breeder reactors, cost of construction, safety)
- POPULATION GROWTH (world population, immigration, carrying capacity, foresight capability)
- WAR TECHNOLOGY (nerve gas, nuclear developments, nuclear arms threat)
- WATER RESOURCES (waste disposal, estuaries, supply, distribution, ground water contamination, fertilizer contamination)
- WORLD HUNGER AND FOOD RESOURCES (food production, agriculture, cropland conservation)

Integrative Approach Human ecology would be presented as a link between the natural, social and health sciences. Rather than a multidiscipline or interdisciplinary approach, the program would integrate any discipline appropriate to understanding and resolving global problems.

Holistic Approach. Holistic methods develop the ability to recognize various interacting parts of a system (subsystems) and understand the behavior of the whole system. Ecological science has shown there is a synergy of system, that the whole system characteristics are greater than the sum of the parts A holistic perspective is an important complement to the reductive methods usually presented in science programs.

Broad Perspectives of Space and Time. Biology education should enlarge the students' perspectives of space and time. Across the grades a human ecological emphasis should extend the students' perspective of time from past to present to the future The future orientation will vary with the developmental level of students, so across the elementary grades perspectives may be extended from today to tomorrow, this week to next week, this year to next year, and the next 5-10 years. At the middle junior high school level, the students' lifetime could be extended to their children's lifetime and to future generations. Similarly, students' perspectives of space can be expanded from self, family, and neighborhood in the elementary years and to state, region, and nation in middle junior high school At the high school level students should develop a global perspective for the future of humanity

Human Inquiry Biology education has traditionally held the development of, and ability to use, the methods of scientific investigation as an important goal. An orientation toward human ecology would extend this traditional goal to include decision making. For example, there would be problem identification, observation, collection, analysis and evaluation of data, and a decision made about the problem. Environmental impacts and technology assessments are examples of this idea. Of course, students at precollege levels would not complete such detailed reviews, but they could develop the idea that the activity of scientific inquiry can lead to action While the early part of the inquiry includes scientific processes such as observing, measuring, describing, inferring, designing investigations, forming hypotheses, and synthesizing knowledge, the latter part of the inquiry would include human processes such as decision making, ethical discussions based on cost, risk, and benefits to present and future generations and environments.

Developmental Perspective The actual structure and teaching of human ecology should reflect an understanding and appreciation of the students' developmental level. I have tried to show this in the various policies outlined so far Obviously, a global perspective is too large for elementary students, but local problems related to larger problems are not too large This policy applies to the next section on a conceptual framework Recognition must be given to the level of students' development in all dimensions (cognitive, motor, emotional, social, physical) in the teaching of human ecology After all, this is an application of human ecology to the study of human ecology!

Conceptual Framework for Understanding Human Ecology

In this section I have outlined some key concepts for human ecology programs Anyone who has done this realizes the enormity and difficulty of the task. Trying to include concepts and examples for K 12 and the spectrum of natural, health, and social sciences only makes the task more difficult. In the end, however, I elected to make the framework as broad and general as possible I make no claim that this is a complete list of concepts, but I do believe it is a good beginning for any biology teacher implementing a human ecology approach

Several points are worthy of note concerning the outline in Table 1. As I worked on the concepts, a logic tc the sequence developed First, I think that understanding the general concept of systems can provide students at any level with a world view and vocabulary that is essential for human ecological study Second, since I believe that one should understand basic scientific concepts as they are applied to various problems, the structure generally emphasizes basic scientific concepts. Third, human ecology is viewed as an applied dimension of ecology, so ecosystems are the primary level of investigation and humans serve as the primary examples. Several human dimensions are presented early. I decided this was the best way to set the human context for ecological study.

Without question there are other concepts or a different organization that could be suggested. With the understanding and background established by this basic conceptual framework, students should be able to pursue further inquiry into local issues and global problems related to science and technology.

TABLE 1. A Conceptual Framework for a Human Ecological Perspective in Biology Education

Outline and Topics		*Teaching Examples for Human Ecology*
	CONCEPTS	
Introduction to Systems		
System	A group of related objects that form a whole Elements of a system often are interrelated, interdependent and interactive A system also is a collection of material isolated for the purpose of study	• Human body • Car • Person • Earth
Subsystem	A system that is entirely within another system	• Person in family • Class in school • Circulatory system • Engines of cars
Interaction	The ways systems act on one another. There is usually evidence of the interaction Characteristics of systems are a function of the ways components interact	• Students talking • Family life patterns • School system • Athletic games
Characteristics of Systems		
Boundaries	That which encloses a system's component parts Boundaries help to identify the system from the environment and to differentiate the system from other systems Boundaries vary along a continuum from being *open* (permeable) to being *closed* (impermeable) Boundaries are regions of great activity for systems	• Family • Class, club, "our group" • "Closed discussions" • Cell wall • Town/Community • State/Nation • Planet Earth
Components	Parts of the system existing within the boundaries which interact with one another in a mutually interdependent manner.	• Members of family • Parts of a cell • Administration, teachers, custodians, students, etc., in school
Flow of Resources	The movement of matter, energy, information, or other resources among the system components, between systems and between the system and its environment The latter depends on the permeability of the system's boundaries	• Food in family • Community • Movement of material through all membranes
Feedback	Signals sent back to a self-regulating system. Feedback may be positive which tends to amplify differences, or negative which tends to nullify errors and establish equilibrium.	• Grades on schoolwork • Thermostat • Automobile odometer and speed limit • Body's response to heat (sweating) and cold (shivering)
Open System	A system in which matter, energy, information, etc., can flow between the system and other systems and/or the environment	• Living organisms • Humans as biological beings

TABLE 1 Continued

Outline and Topics		Teaching Examples for Human Ecology
Closed System	A system in which some things do *not* flow between the system and other systems and or the environment Energy but not matter or information may flow between a system and the environment or other systems	• Earth • Need for recycling matter in closed systems • Humans who are not literate • Humans who have "closed minds" on certain topics
Diversity	The complexity of a physical, biological, or human system. Diversity can result in stability.	• Cell vs. human • Pond vs. hydrosphere • Bicycle vs. car
System of Organization		
Levels of Organization	All matter can be viewed as organized in identifiable patterns, as a hierarchy of organization from subatomic particles to galaxies.	• Atoms, molecules • Cells, tissue, organs, organ systems • Earth, planets, stars, galaxies
Organism	A single living thing	• A person • A deer • An elephant
Population	A group or collection of organisms of the same species.	• All humans • All deer • All elephants
Community	Populations of plants, animals, and humans living and interacting in an identifiable locality.	• People, plants and animals in your town, state, nation
Ecosystem	A biotic community interacting with its abiotic (physical and chemical) environment. This is also known as an ecological system. Ecosystem is the basic level of study in ecology (and human ecology).	• School yard • Pond • The planet • Ocean
Atmosphere	The realm of air surrounding the earth.	• Air local to global levels
Hydrosphere	The realm of water (including vapor in air) on earth.	• Water, local to global levels
Lithosphere	The realm of rock and soil on the earth's crust	• Rocks, local to global levels
Ecosphere	The total of all ecosystems and their interactions on earth This is the largest unit of life on earth. It is sometimes referred to as the biosphere.	• Life support systems of earth—oxygen/carbon cycles, H_2O cycle
Ethosphere	The systems that maintain and change the human cultural ethos (dispositions, attitudes, beliefs, values)	• Interrelated systems created by humans—libraries, schools, laws
Change in Systems		
Immediate	The direct, undelayed change in a system.	• Beginning of school day • Balloon exploding
Delayed or Displaced	When new material is inserted a change in systems is sometimes not immediately apparent. Systems change slowly to the accumulation of new material.	• DDT in organisms • Development of automobile and life style • Pollution • Smoking and cancer • Acid rain and pond ecosystem
Cycles	Systems that change in a regular sequence in time and/or space	• Seasons • Lifetime of organisms • Water cycle • Rock cycle • Life cycles of plants, animals, humans (or subcultures)
Linear Growth	A growth rate that changes by a constant amount over a time interval	• Addition (or subtraction) of years, miles, people, money, etc. Adding the number 2 is an example. $2+2=4+2=6+2=8+2=10$

TABLE 1 Continued

Outline and Topics		Teaching Examples for Human Ecology
Exponential Growth	A geometric growth rate. The growth occurs by an increasing rate at a constant percentage for identifiable periods of time.	• Multiplication (or division) of years, miles, people, money, etc. • Continually multiplying by the number 2 is an example $2 \times 2 = 4 \times 2 = 8 \times 2 = 16 \times 2 = 3?$
Limits	Built-in bounds that constrain the behavior of systems Systems show resiliences and accommodation—within their limits. At limits, a system is less capable of sustaining itself or restoring itself to normal functioning. Systems can change within limits and still maintain the structure and function. When the limits to change are exceeded the system is destroyed.	• Rules in classroom, school • Human physical structure • Body temperature range between 89°-107° • Pollution of pond
Basic Scientific Concepts		
Matter	Anything that has mass and occupies space.	• Rock • Piece of coal • Wood
Energy	The ability to do work or bring about change in matter There are two types of energy *Kinetic energy* is the result of movement of matter. Mass and velocity of matter determine the kinetic energy of matter. *Potential energy* is energy due to the position, condition, or composition of matter. Potential energy is "stored."	• Food/Digestion • Falling rock • Burning coal • Sun burning wood • Electrical • Nuclear • Car (gasoline) • Battery
Conservation of Matter	Matter is neither created nor destroyed in common physical and chemical changes. Matter is simply changed from one form to another.	• Burning coal • Eating peanuts • Burning wood or gasoline • We don't consume matter • We don't throw waste and garbage "away" • Recycling matter is possible
Conservation of Energy	Energy is neither created nor destroyed. It is only changed from one form to another. For example, the energy *lost* by a system is equal to the energy *gained* by the environment. All systems, living and nonliving, are subject to this law. This is also known as the first law of thermodynamics.	• Falling ball • Burning coal • Eating • Burning wood • It takes energy to get energy—oil, coal, etc.
Degradation of Energy	Considered as a whole, any system and its surroundings will tend toward an increase in disorder or randomness For example, in conversions of energy to work, some energy is dispersed to less useful forms. This is also known as the second law of thermodynamics.	• Burning coal • Eating • High to low quality (concentration) of material for energy • Conversion of energy in car engine • Conversion of solar energy in photosynthesis, eating plants and converting chemical energy to mechanical energy • Recycling energy is not possible
Equilibrium	Components of a system acting with one another in ways that maintain a balance of the system. This is sometimes referred to as dynamic equilibrium.	• Natural cycles of water • CO_2 and O_2 exchange between plants and animals • Seasons • Changing positions of players on sports teams • Ideal balance of executive, legislative, and judicial branches of government

TABLE 1. Continued

Outline and Topics		*Teaching Examples for Human Ecology*
Structure of Ecosystems		
Abiotic	The nonliving parts of an ecosystem. This includes an energy source (sun), physical factors, e.g., wind, moisture, heat, and chemical factors, e.g., carbon dioxide, nitrogen.	• Energy, soil, wind, heat
Biotic	The living parts of an ecosystem. This includes food *producers* and food *consumers*, (including *decomposers*)	• Plants → animals → human → micro-organisms
Limiting Factors	An organism has a certain degree of tolerance to variations in physical and chemical factors. Too much or too little of a factor can limit or destroy growth and distribution.	• Climate and soil limits for organisms • Chemical factors—availability of CO_2, O_2, etc. • Human range • Growth of plants and nitrogen • Range of animals on earth
Function of Ecosystems		
Energy Flow	The transfer of energy through an ecosystem. This includes the conversion and loss of energy at different levels of the ecosystem.	• Students' energy sources • Flow of matter and energy in person (breathing, eating, drinking) • Ecosystems as closed require recycling of matter • SSTs • Fertilizer • Fluorocarbons
Food Chain	The series of energy transfers in the form of food between trophic levels of an ecosystem. This occurs when organisms eat or decompose each other. There is a grazing food chain and a decomposer food chain.	• Plant → animal → human → decomposers • Produces herbivores (primary consumers) carnivores (secondary consumers) decomposers • Apply second law of thermodynamics to food chains
Biogeochemical Cycles	The process by which carbon, oxygen, phosphorus, nitrogen, and water move through the ecosphere.	• Carbon • Oxygen • Nitrogen • Phosphorus • Hydrogen • Sulfur • Water • Problems of synthetic chemicals
Succession	Change in the structure and function of an ecosystem.	• Vacant lot • Coral reef • Tropical forest • Community development • Changes in Planet Earth
Steady State	The state of an *open system* where flow of energy and cycling (recycling) of chemicals within the system maintains a balanced system.	• Mature ecosystems • Earth • Sustainable society • Simplification of ecosystems by eliminating or introducing species
Synergy	The interaction of system components in which the total effect is greater than or less than the sum of individual effects.	• Some causes of cancer (particulates and chemicals such as SO_2)
Biological Magnification	The increase in concentration of certain substances, at successively higher trophic levels in the food chain.	• DDT in food chain • Hazardous substances in soils, organisms, humans

TABLE 1. Continued

Outline and Topics		*Teaching Examples for Human Ecology*
Carrying Capacity	The maximum population an ecosystem can support indefinitely under a certain set of environmental conditions	• Tragedy of commons • Limits to growth for Earth
Adaptations in Human Systems		
Human Adaptation	Changes due to interactions with the environment and other people so humans can improve their condition. Changes in thinking, valuing, and behaving are attributes of human adaptations Critical problem solving, assessments of cost risk benefit, and, finally, decision-making underlie human adaptation. All of this is done in response to cultural or environmental modifications.	• Clothing, buildings • New rules, policies, standards, or laws • Changes in behavior in different situations, e.g., school, home
Economic Adaptation	Market and prices adjust the demand to the supply. Adaptation comes from changes in price, and price variance is a function of whether goods and services are available and needed.	• Increasing price for scarce material • Price increases are negative feedback resulting in using less and substituting
Political Adaptation	Policies, standards, and laws are enacted to provide broad frameworks of individual and organizational behaviors and decisions. As perceptions of problems and issues change, the political system adapts.	• School rules, policies • Local laws concerning driving, drinking • Legislation about environmental problems • EPA standards • FDA standards
Social Adaptation	Social institutions such as family, school, peer group, church, media, and work develop individual beliefs, attitudes, and values that influence decisions and shape human behavior. Collectively, social adaptations can occur through changes in world views, consciousness, or ways of perceiving the world.	• Family rules • Codes of dress, behavior • Religious values • Work ethic • American dream
Technological Adaptation	The application of existing knowledge to solving problems. New inventions and techniques contribute to changing boundaries, flow or resources, components, and feedback relative to systems.	• Medical technologies for life support systems • Computers • TV and information • Appropriate (soft) technology • High technology
Biological Adaptation	Living systems have processes for adjustment in response to environmental changes. Evolution is the long-term adaptation by populations to environmental change.	• Sweating and shivering • Mutation • Extinction • Use of fossil fuels • Use of DDT and survival of some organisms, elimination of others, and deleterious effects on others
Sustainable Society	A group of people at local, national, or global level that share the same biological and cultural systems. A sustainable society has adapted its economic and social systems so that natural resources and ecosystems are maintained.	

Investigating Global Problems and Human Ecology

Table 2 lists the 12 global problems related to human ecology Additionally, these are listed as a background resource for the teacher and a reference to curriculum materials, which are reviewed in the next chapter, and to lessons in the final chapter of this book. In some cases the curriculum programs cover a number of different topics. I have tried to identify the major topics related to the global problems listed. Please note that some of the curriculum programs and activities provide a broad background or synthesis of topics so they are not listed with the specific problems.

The teacher interested in teaching from a human

TABLE 2. Specific Resource Bibliography

Global Problems Related to Human Ecology	*Background Resources*	*Curriculum Materials*
AIR QUALITY AND ATMOSPHERE	Committee Report. *Atmosphere Biosphere Interactions*. Washington, D.C.: National Academy Press, 1981. *The American Biology Teacher* April/May, 1983.	Acid Precipitation Awareness (see *ABT*, April/May, 1983) *Investigating Your Environment* (BSCS) *The Class Project* (NWF) *Global 2000 Countdown* (ZPG) *Project Wild* "Air Quality and Automobiles" *Investigating Our Ecosystem*
ENERGY SHORTAGES	Miller, T. *Energy and Environment*. 2nd, Belmont, California: Wadsworth, 1980. Barbour, I. et al. *Energy and American Values*. New York: Praeger, 1982.	*Energy & Society* (BSCS) *Energy Resources & Environment* *The Class Project* (NWF) Global 2000 Countdown (ZPG)
EXTINCTION OF PLANTS AND ANIMALS	Ehrlich, P. & Ehrlich, A. *Extinction* New York: Random House, 1981.	*Genes & Surroundings* (BSCS) *The Class Project* (NWP) *Global 2000 Countdown* (ZPG) *Project Wild*
HAZARDOUS SUBSTANCES	Brown, M. *Laying Waste The Poisoning of America by Toxic Wastes*. New York: Pantheon, 1979 Purcell, A. *The Waste Watchers: A Citizens Handbook for Conserving Energy and Resources*. New York: Anchor Press, 1980.	*The Class Project* (NWF)
HUMAN HEALTH AND DISEASE	Eckholm, E. *The Picture of Health. Environmental Sources of Disease*. New York: W.W. Norton, 1977. Eisendud, Merril. *Environment Technology and Health: Human Ecology in Historical Perspective*. New York: NYU Press, 1979. Carter, M. *Dynamics of Health and Disease*. New York: Appleton-Century-Croft, 1972.	*Human Sciences Program* (BSCS) *Health Activities Project* (HAP) *Basic Genetics. A Human Approach* (BSCS)
LAND USE	Eckholm, E. *Losing Ground*. New York: W.W. Norton, 1976. Ward, B. *The Home of Man* New York: W.W. Norton, 1976.	*Land Use* (BSCS) *Investigating Your Environment* (BSCS) *The Class Project* (NWF) *Global 2000 Countdown* (ZPG) *Project Learning Tree* *Outdoor Biology Instructor Strategies* "Vegetation and Soil" (this volume) *Investigating Our Ecosystem*
MINERAL RESOURCES	Abelson, P. & Hammond, A. *Materials. Renewable and Non-Renewable Resources*. Washington, D.C.: AAAS, 1976. Barnet, R. *The Lean Years: Politics in An Age of Scarcity*. New York: Simon & Schuster, 1980.	*Energy Resources & Environment* *Global 2000 Countdown* (ZPG) *Project Learning Tree* *Project Wild*
NUCLEAR REACTORS	Inglis, D. *Nuclear Energy. Its Physics and Social Challenge*. Reading, Mass.: Addison-Wesley, 1973. Hayes, D. *Nuclear Power: The Fifth Horseman* Washington: World Watch Institute, 1976. Hoyle, F & Houle, G. *Commonsense in Nuclear Energy* San Francisco: W H. Freeman, 1980	*Global 2000 Countdown* (ZPG) "Thermal Pollution" (this volume) *Investigating Our Ecosystem*

TABLE 2 Continued

Global Problems Related to Human Ecology	Background Resources	Curriculum Materials
POPULATION GROWTH	Salk, Jonas & Salk, Jonathan *World Population and Human Values* New York: Harper & Row, 1981 Reining, I & Tinker, I. (Ed.). *Population Dynamics, Ethics and Policy* Washington, D.C AAAS, 1975	*Energy Resources and Environment* *Investigating Your Environment* (BSCS) *Global 2000 Countdown* (ZPG) *ZPG Education Materials* "Population Growth" (this volume) "Age Structure of Populations" (this volume)
WAR TECHNOLOGY	Ehrlich, P , Sagan, C., Kennedy, D. and Roberts, W *The Cold and the Dark* New York W W. Norton, 1984. Schell, J. *The Fate of Earth*. New York: Alfred A. Knopf, 1982.	
WATER RESOURCES	Hunt, C. and Garrels, R. *Water The Webb of Life* New York W.W. Norton, 1972. McCaull, J. and Crossland, J. *Water Pollution*. New York: Harcourt, Brace, Jovanovich, 1974.	*Investigating Your Environment* (BSCS) *The Class Project* (NWF) *Global 2000 Countdown* (ZPG) *Project Learning Tree* *Project Wild* *Investigating Our Ecosystem*
WORLD HUNGER AND FOOD RESOURCES	Lappe, Frances and Collins, Joseph. *Food First* Boston Houghton Mifflin, 1977. Scientific American. *Food and Agriculture*. San Francisco: W.H. Freeman, 1976.	*Global 2000 Countdown* (ZPG)

ecological perspective will also need several general resources These are provided in Table 3

Conclusion

Contemporary problems require a new social perspective if they are to be resolved. Human ecology is the perspective that seems to be appropriate. To the degree this assertion is true, education programs, particularly biology education, should reflect the human ecological perspective. In this chapter I have outlined policies that wil. provide a framework for those biology teachers wishing to teach using a human ecology perspective. The next chapters review curriculum programs and provide some introductory activities dealing with population, resources, and environment.

TABLE 3. General Resource Bibliography

Gerald O Barney. *The Global 2000 Report to the President*. Vol. I, Washington, D.C.: U.S. Government Printing Office, 1980.

Lester Brown. *Building A Sustainable Society*. New York: W W. Norton, 1981.

Lester Brown, et al. *State of the World 1984* New York. W W. Norton, 1984.

Rodger W Bybee (Ed) *The American Biology Teacher*, 46(6), September, 1984. This is a theme issue on human ecology.

Erik Eckholm. *Down to Earth*. New York. W.W. Norton, 1982.

Paul Ehrlich, et al *Ecoscience* San Francisco, CA W.H. Freeman, 1977

Eugene Odum *Ecology One Link Between the Natural and the Social Sciences* New York Holt, Rinehart and Winston, 1975

G. Tyler Miller. *Living in the Environment* Belmont, CA. Wadsworth Publishing Company, 1982

References

Bybee, R. (1979). Science education for an ecological society. *The American Biology Teacher*, 41(3).

Bybee, R., Hurd, P., Kahle, J. & Yager, R. (1981). Human ecology. An approach to the science laboratory. *The American Biology Teacher*, 43(6).

Bybee, R. (1982). Citizenship and science education. *The American Biology Teacher*, 44(6).

Bybee, R. (1983). Human ecology: Acid rain and public policy. *The American Biology Teacher*, 45(4).

Bybee, R. (1984). Global problems and science education policy In Bybee, R., Carlson, J. & McCormack, A. (Eds.). *Redesigning science and technology education*, 1984 NSTA Yearbook. Washington, D.C.: National Science Teachers Association.

Rodger W. Bybee

Curriculum Review

This review answers the biology teacher's question, What can I use to teach about human ecology? As it turns out, this question is appropriate, but nevertheless difficult to answer. Biology teachers who ask this question have a unique set of criteria by which to judge their answer. There is not one balanced, thorough, or complete human ecology program. There are materials that can be used in varying degrees and in different ways. Biology teachers will have to decide exactly what they need, how much they wish to implement a human ecology program, and also which concepts, instructional approaches, and curriculum designs they will use These are decisions that *they* will have to make.

Each program reviewed represents one aspect or a portion of the human ecology theme. All programs are available commercially Finally, each program was evaluated as excellent, given the focus and orientation of the materials. Any weaknesses were negligible and often associated with factors beyond the control of curriculum developers and publishers

Authors of the reviews were participants in the Science, Technology and Public Policy program at Carleton College, Northfield, MN 55057 Reviews were developed as part of a course entitled "Science, Technology and Public Education" taught by Rodger Bybee. The following individuals contributed reviews: Kevin Najafi, Mike O'Connell, Teri Mau, Liz Gronen, Mark Hibbs, Karen Brakke, Mary McMillan, Andrew Smith, Kate MacMillen, Jane Woodwell, Ben McLuckie, James White and Stuart Grubb.

The Human Sciences Program

Program Director/Publisher: Biological Sciences Curriculum Study, The Colorado College, Colorado Springs, CO 80903. National Science Programs, P.O. Box 41, 908 W. Wilson St., Batavia, IL 60510.

Program Support: Funding: The National Science Foundation.

Program Objectives:

1. Overall Program Purpose: Through a modular, activity centered, personalized, interdisciplinary and flexible approach, to tailor science curriculum materials more closely than other such materials to the developmental characteristics of the emerging adolescent.

2. Specific Objectives. The program is designed to provide the means to help students enhance their:

a) curiosity about and motivation to explore the natural and social worlds around them,

b) appreciation of the scientific method of gaining knowledge about the natural and social environment, and understanding of these worlds,

c) science process skills and logical thinking, as well as basic skills of reading and following written instructions, communicating orally and in writing, and gathering, displaying, and interpreting quantitative da a,

d) creative thinking and decision making skills, including responsibility for their own learning and classroom resource management,

e) knowledge and acceptance of themselves their bodies, minds, feelings, aptitudes, interests, and values;

f) knowledge and acceptance of and empathy for others. other students, teachers, parents, and those older and younger than themselves,

g) self-esteem, derived through success in the program, in addition to general affective and cognitive development.

Description of Program: The life, physical, earth, and behavioral sciences serve as the sources for, instead of the structure of, the curriculum. Students choose and perform activities which draw from at least two of the aforementioned disciplines. Stu-

QUICK REFERENCE GUIDE

Reviews for the following programs are included:

TITLE	PAGE
• *The Human Sciences Program*	29
• *Energy, Resources and Environment*	30
• *Health Activities Project (HAP)*	31
• *Investigating Your Environment*	32
• *Energy and Society*	33
• *Genes and Surroundings*	33
• *Basic Genetics. A Human Approach*	34
• *The Conservation Learning Activities for Science and Social Studies Project*	35
• *Science and Society Teaching Units*	36
• *Global 2370 Countdown Kit*	37
• *Project Learning Tree*	37
• *Project Wild*	38
• *Outdoor Biology Instructional Strategies (OBIS)*	38
• *Zero Population Growth. Population Education Program*	39
• *Investigating Our Ecosystem*	40
• *Investigating the Human Environment: Land Use*	41

dents learn to observe, describe, record and organize data, compare, interpret, and infer, while practicing the three R's. Rather than a purely conceptual orientation, this program stresses hands-on experience with phenomena In this context, students learn other personal skills, such as physical construction and manipulation, decision making, creative thinking, aesthetic appreciation, and making value judgments. The teacher is more facilitator than lecturer.

Methods of Instruction: Students perform activities either individually, in small groups, in large groups, or as a class. Completion of a particular activity may require work either in the classroom, somewhere else on school grounds, or elsewhere in the community. Methods include discussion, lecture, presentation, use of audiovisual equipment or cassette recorders, construction projects, plus work with various plants and animals.

Specific Subjects, Grade, Age and Ability Levels: This program is composed of 15 six to nine week modules designed for 10- to 14-year-olds. Each module contains 30 to 50 activities, which take from one to three hours apiece (some require a small amount of time each day for several weeks), and modules are grouped into three levels according to difficulty. Because students choose their own activities, some of which are harder than others, many ability levels are accommodated within a single age group or classroom.

Materials Produced:

1 Modules—level *1* is easiest and level *3* is hardest.
   a) Level *1*. Learning, Sense . . . or Nonsense?, Motion, Surroundings, Growing, Behavior
   b) Level 2: Perception, Rules, Survival, Reproduction, What Fits Where?
   c) Level 3· Knowing, Invention, Change, Feeling Fit.
2. Accessories.
   a) *Teaching Human Sciences*, orientation manual, paper.
   b) Extra Teacher's Guides, one per module, paper.
   c) H.S.P. Cart, to display and house printed materials and accessories for one complete module.
   d) H.S.P. Display Rack, to display printed materials for twenty-five activities.
   e) Detailed construction drawings for H.S.P Cart, to be made in school shop or by a local tradesman.

Materials Purchasable. There are four purchase options. individual activities, clusters of activities (related problem areas), complete modules, and accessories

Program Implementation: The flexibility of this program allows teachers to experiment with specific activities or clusters of activities before, or rather than, whole modules. It is necessary to procure the appropriate curriculum components, have standard material and equipment found in most schools or homes, and handle administrative and parental arrangements for out of classroom activity.

Teacher Preparation: The teacher, or interdisciplinary team of teachers, should possess general knowledge of the scientific disciplines previously mentioned, and make use of the helpful Teacher's Guide that accompanies each module. In addition, it may be advantageous to devise a system of formal evaluation The orientation manual is a good embarking point for preparation.

Financial Requirements: Besides the necessary curriculum materials, there are a number of consumable paper forms that must be copied in sufficient quantities, and there are additional materials not provided with a given module (each module Teacher's Guide contains a list of these items) that are required for completion of the activities. Arrangements should be made with the school or community library to house the supplementary literature suggested in the Teacher's Guide. Modules requiring out of class activity mav incur transporation costs.

Energy, Resources and Environment

Program Director/Publisher: John W. Christensen, Teacher of Resources Sciences, Cherry Creek High School, Englewood, CO. Kendall-Hunt Publishing Company, Dubuque, IA.

Program Funding and Support: Colorado section of the American Institute of Mining, Metallurgical and Petroleum Engineers; United States Department of Energy; The Colorado Institute on Population Problems; (Harvard) Project Physics, Inc.

Program Objectives:

1 Overall Program Purpose· To introduce human ecology through study of energy, resources, and environment.

2 Specific Objectives· The materials are designed to:

   a) give the student a fundamental knowledge of the engineering, economic, and environmental aspects of resources and energy.
   b) show how these principles relate to global issues.
   c) enable students to use this knowledge to decide which problems are the most vital and formulate ideas about the solution of these ideas.
   d) demonstrate basic scientific principles and their relationships through laboratory activities.

Description of Program: The curriculum consists of a textbook and accompanying lab manual. Students read chapters in the textbook and are given questions at the end of each chapter The questions are comprehensive and encourage students to reflect on the material presented.

The program begins with basic concepts of the earth and biosphere as well as energy and resources Succeeding chapters incorporate these principles into study of specific world problems. The text also contains appendices on conversion factors, scientific notation and International System units The lab manual presents 33 activities including classroom exercises, individual student activities, and demonstrations. The activities correspond to sections of the text.

Methods of Instruction: This program is fairly standard in its format of readings, questions, and laboratory activities. However, there remains much opportunity for class discussions, as well as flexibility for an individual instructor's knowledge and teaching style.

Specific Subjects, Grade and Ability Levels:
This science course presents scientific principles in relation to social studies concepts concerning complicated world problems. The text is ideal for a nine-week schedule, with an excess of lab activities for such a period Laboratory activities could be selected according to student or instructor preference Materials are designed for high school students with average or above average abilities

Materials Produced and Purchasable:
1. *Energy Resources and Environment*, student and teacher editions (paper).
2. *Energy, Resources and Environment*, lab manual (spiral bound).

Program Implementation: In addition to the text and lab manual, the instructor will need standard laboratory equipment available in most schools, and some materials which can be brought from home. One activity requires transportation to and from the study site.

Teacher Preparation: The instructor should have knowledge of basic geological, chemical, economic, and ecological principles. In addition, familiarity with global issues is important. Knowledge of laboratory technique is also essential.

Financial Requirements. A well equipped but basic classroom laboratory is vital to the program.

Health Activities Project (HAP)

Program Director/Publisher: Lawrence Hall of Science, University of California, Berkeley, CA Hubbard, P O Box 104, Northbrook, IL 60062

Program Support: Funding Agency: Robert Wood Johnson Foundation through the Association of Science Technology Centers.

Program Objectives:
1. Overall Program Purpose To create a positive attitude toward health by providing students with a sense of control over their own bodies and imparting specific understanding about their potential for change
2. Specific Objectives Through *HAP*, students learn:
   a) how the body works and changes,
   b) how the body can be controlled to increase performance, improve skills, and develop strength;
   c) how one can make decisions that result in a healthier, higher quality of life;
   d) how technological devices are used to evaluate health;
   e) how to look at the preventative aspects of health.

Description of Program: *HAP* consists of 64 student-centered activities grouped into 13 modules and covers important areas of health, safety, and nutrition. Students become involved with their own health and safety through discovery activities. They perform tests as well as collect, analyze, and compare data with other students. By investigating their own bodies, the students learn firsthand how their bodies function. Most importantly, the students discover that they can make changes in the way their bodies perform and their overall health.

Methods of Instruction: *HAP* uses hands-on investigations as opposed in style to the passive instruction of many health education programs The teacher introduces the activity, demonstrates any special procedures and equipment, and presents the student with the activity. From then, the teacher has the opportunity to work with individuals or groups. The majority of time is allotted for active and productive student activity.

Specific Subjects, Grade, Age, and Ability Levels:
HAP is a modular curriculum program designed for fourth through eighth grade students that supplements current health, science, and physical education programs, or can be the entire program. Each module represents approximately six to eight weeks of classroom activity.

Materials Produced:
1. Modules: Each module contains teacher materials, charts, and the apparatus and supplies necessary to conduct the activities

a) Breathing Fitness h) Flexibility and Strength
b) Skin Temperature i) Personal Health Decisions
c) Sight and Sound
d) Heart Fitness j) Consumer Health Decisions
e) Action/Reaction
f) Balance in Movement k) Nutrition/Dental Health
g) Growth Trends l) Your Heart in Action
m) Environmental Health and Safety

2. Teacher Materials. The Teacher's Guide is intended to be a source book and reference for teachers using the *HAP* activities and equipment. The guide includes an overview of the program, the *HAP* philosophy, helpful teaching strategies, ways to manage and maintain *HAP* equipment, grade level sequencing, articulation scheme with other commercially available health curricula, and a history of *HAP*.
3. Charts and Labeling Supplies. Large, durable, reusable, plastic charts with special "write on-wipe off" surfaces to record class activities results.
4. Apparatus and Games. Specially designed apparatus such as grip testers, breath control devices, limber gauges, etc., are included in most modules. The apparatus is simple, functional, yet has a degree of sophistication and a reliability factor that students and teachers respect.

Program Implementation: The teacher will need to have the aforementioned materials.

Teacher Preparation: The instructor should possess a general knowledge of health, safety, and nutrition. Each module comes with an activity folio written concisely so that teachers can quickly introduce the activity. All topics represent an assumed awareness level for adults so additional training is avoided. However, workshops are held which provide inservice and preservice teacher training for the entire *HAP* program.

Financial Requirements. The only financial requirement is the purchase of the modules. Each one contains sufficient materials for a class of 27 students. For the most part, the *HAP* materials are nonconsumable. Therefore, a 27 student kit of any *HAP* module can be shared by more than one class and rotated with other modules, thus reducing the cost per student.

Investigating Your Environment

Program Director/Publisher: Biological Sciences Curriculum Study, The Colorado College, Colorado Springs, CO 80903/Addison-Wesley Publishing Company, Menlo Park, CA/Reading, MA.

Program Support: United States Office of Education, Department of Health, Education and Welfare, and the National Institute of Education.

Program Objectives:
1. Overall purpose. To provide the students with an opportunity to investigate important questions about their environment.
2. Specific objectives: The materials will help students:
a) familiarize themselves with and discuss goals, responsibilities about investigating their environment,
b) identify those things which they believe to be valuable and essential for a meaningful and desired lifestyle,
c) use their list of "valued things" to identify potential questions for an environmental studies project;
d) choose a question for investigation,
e) plan projects and then conduct research,
f) analyze and interpret data;
g) choose an audience to which they present results;
h) evaluate their personal experience of conducting an independent investigation.

Description of Program: *Investigating Your Environment* is an instructional module which requires students to choose an aspect of the environment which is important to them and to formulate and to complete an investigation relative to their topic. Human problems, populations, water and air quality, noise, and land use are examples of research topics.

Methods of Instruction: Teacher acts as a "fellow investigator" and facilitator. Discussion sessions, problem identification, survey methods, field work, and laboratory investigations all form part of instruction.

Specific Subjects, Grade and Ability Levels: This module emphasizes "learning how to learn," inquiry, and personal experience in making decisions. The level of sophistication of an investigation is a function of the student's background, interest, and cognitive development. The materials are appropriate for a wide spectrum of students, ranging from 9th grade to college.

The module requires a minimum of six weeks, an optimum of nine. It could be adapted for a 12-week semester. The module is adaptable to situations such as individual investigation projects, mini courses, and summer programs.

Materials Produced and Purchasable.
1. *Investigating Your Environment* (Student handbook).
2. *Investigating Your Environment* (Teachers handbook).

Project Implementations. Little is needed beyond the student workbook. Few special facilities or materials are required beyond those found in most science classrooms. The biggest problem for teachers will be an adjustment in teaching style.

Teacher Preparation: The teacher's role is different from that of the typical program. The teacher acts as a facilitator and fellow investigator For the module to be successful, it requires a thorough understanding of goals and objectives of the curriculum and an ability to work closely with and to understand a variety of students who have different interests and cognitive abilities.

Financial Requirements: The cost is minimal as there are few financial requirements beyond purchase of the books.

Energy and Society: Investigations in Decision Making

Program Director/Publisher: Biological Sciences Curriculum Study, Colorado College, Colorado Springs, CO.Hubbard, P.O. Box 104, Northbrook, IL 60062.

Program Support: Funding Agency: U.S. Office of Education, Department of Health, Education, and Welfare.

Program Objectives:

1. Overall Program Purpose: To develop skills in self-direction, questioning, problem solving, and decision making, while the student examines contemporary energy questions.
2. Specific Objectives. The program is designed to.
   a) reflect the interdisciplinary nature of energy questions, and promote an understanding of the complexity of energy problems and the trade-offs associated with various solutions.
   b) encourage the development of skills and abilities needed to separate relevant from irrelevant information, recognize bias in interpretations of information, and judge the validity of data;
   c) develop the understanding and use of problem solving models and techniques, and foster development of skills in data gathering;
   d) encourage autonomous and competent decision making, balanced with an understanding of the interdependence of living things in both environmental and social contexts,
   e) recognize and capitalize on the diversity of student backgrounds, interests, talents, experiences, and abilities in classroom-related activities, and
   f) promote development in both cognitive and affective realms of activity.

Description of Program: In their study of energy problems, students are encouraged by the activities to become active in inquiry and the use of problem solving skills Students observe, estimate, predict, hypothesize, question, design tools, collect, organize, interpret, and analyze data Students learn to recognize multiple alternative conclusions and to check the validity and reliability of conclusions. The student is also encouraged to recognize and respond to questions where values must be chosen on principles arising from sources other than science and where decisions must be made and based on these value criteria.

Methods of Instruction: Discussion sessions, independent investigations, and varied activities including a simulation game, and an activity in which the student traces direct and indirect use energy.

Specific Subjects, Grade, Age and Ability Levels: This program is a nine-week instructional module designed for high school, college, or adult students. The program could be used as a supplement to either a science or social studies course

Materials Produced:

1. *Energy and Society. Investigations in Decision Making*, Student Edition (paper).
2 *Energy and Society: Investigations in Decision Making*, Teacher's Edition (paper)
3. Man and the Biosphere. Energy Uses and Reserves, set of Daylight Blackboard Projection Slides.
4 Energy: Back to the Source, film loop (silent, Super 8mm).
5. Alternative Energy Sources card set.
6. Energy Management Game.

Program Implementation: The teacher will need to have the aforementioned materials, standard material and equipment available in most schools or homes, and will need to have made the necessary arrangements with parents and the administration, to facilitate student access to school and community resources.

Teacher Preparation: An understanding of the scientific principles pertaining to energy is essential. The teacher should also possess general knowledge of energy issues and related disciplines.

Financial Requirements: In addition to the curriculum components previously mentioned, a classroom library composed of good reference materials is essential to the success of many activities, especially the independent investigations While many materials may be obtained from the school or public library, several books are recommended and would require additional funds.

Genes and Surroundings

Project Director/Publisher: The Center for Education in the Human and Medical Genetics Study, The Colorado College, Colorado Springs, CO 80903/Kendall-Hunt Publishing Company, Dubuque, IA 52001.

Project Support: Health Services Administration, Public Health Service, U.S. Department of Health and Human Services.

Project Objectives:
1. Overall Program Purpose. To provide information about human genetics that is absent or inadequate in existing curriculums for emerging adolescents.
2 Specific Objectives This program will enable students to:
   a) apply their knowledge of genetics to personal and societal aspects of their lives and the world.
   b) understand the interdisciplinary nature of genetics and many activities that relate genetics to the environment.

Description of Project: *Genes and Surroundings* includes 25 activities, each of which stresses at least one of the five following themes. individuality, continuity, variability in relation to others, variability in time, and adaptation Some activities provide case histories as illustrations; in others, students have the opportunity to examine and measure characteristics of themselves and others The activities require only the published materials or equipment, which are commonly found in the science classroom.

Methods of Instruction: Each lesson consists of a main activity in which the students participate either in teams or individually Discussion questions with each lesson stimulate thought and relate genetics to the world of the student. A class discussion follows each activity and students are asked to take a short self quiz at the completion of each lesson. The program has activities for students to do on their own.

Specific Subject, Grade, Age and Ability Levels: *Genes and Surroundings* is designed for middle school or junor high students (11-14-year-olds). It should be taught either as part of a science or a social studies class. Most of the lessons are designed to occupy one class period. The curriculum may be presented in its entirety or certain sections may be taught alone. Activities are designed for average-ability students, and "Going Further" sections are intended for advanced students.

Materials Produced:
1. *Genes and Surroundings*, student edition (paper, 147 pages).
2. *Genes and Surroundings*, teacher edition (paper, 107 pages).

Project Implementation: The project requires the above mentioned materials and equipment commonly found in the classroom. Parental permission slips must be distributed for out-of-classroom activities Tearsheets of some of the activities, provided in the teacher's manual, will have to be photocopied and distributed.

Teacher Preparation: Familiarity with the basic principles of genetics and how heredity interacts with the environment are important.

Financial Requirements: Other than the manuals themselves, only a few materials must be specially purchased for the activities. Most materials can be used repeatedly.

Basic Genetics: A Human Approach

Program Director/Publisher: The Center for Education in the Human and Medical Genetics, A Continuing Program of the Biological Sciences Curriculum Study. (BSCS)/The Colorado College, Colorado Springs, CO 80903/Kendall-Hunt Publishing Company, Dubuque, IA 52001.

Program Support: National Science Foundation—Program for Development in Science Education, and the Cystic Fibrosis Foundation, Rockville, MD.

Program Objectives:
1 Overall Program Purpose. To develop students' awareness of how genetic conditions may affect them as individuals and as members of society.
2. Specific Objectives. The materials are designed to:
   a) replace traditional genetics units, and include moral and ethical questions in a study of basic human genetics;
   b) strengthen the links between facts and their applications, by providing concrete and relevant examples to the students;
   c) facilitate an understanding of mathematical probability, and encourage the ability to analyze situations in which probability and statistics are used;
   d) increase a student's familiarity with technical terms which are used frequently;
   e) encourage students to express their own opinions, and recognize the possible implications of many commonly-held attitudes.

Description of Program:
The students begin by reading a case study about cystic fibrosis which is presented in a magazine format Topics to be studied are highlighted and explained in boxed-in sections of text (e.g., probability, pedigree charts) This format helps to prevent students from skipping over new words and unfamiliar contexts. The unit is designed to be very flexible, so that after the first section, students and

teachers may select parts of the text as they wish Although concepts between sections are linked, they need not be studied sequentially. Emphasis upon human genetics is maintained throughout the book. The authors have covered the usual genetic theory, but placing it in a human context may help to make it more meaningful for the students.

Methods of Instruction: The primary method is discussion, supplemented by a simulation game, worksheets, crossword puzzles, questions, a pedigree chart, and calculations of probability. The teacher's edition includes guidelines for discussion, outlines for particular lessons, and instructions for planning the unit as a whole. Flexibility in this course is certainly possible because certain concepts are treated in several different sections of the book. One could, however, use the entire book without any lesson becoming repetitive.

Specific Subjects, Grade, Age, and Ability Levels: This book was designed to be used by ninth and tenth graders in an introductory biology course It is a replacement for traditional chapters on genetics, not merely a supplement. It would also be interesting for students in second-year biology courses, because some of the later "articles" are more challenging. Book reviews and reference lists will also make this a good starting place for juniors and seniors who may want to do independent projects and reading.

Materials Produced:
1. *Basic Genetics: A Human Approach* (student edition).
2. *Basic Genetics A Human Approach* (teacher's edition).

Program Implementation. This program contains interesting information on cystic fibrosis which could supplement any general biology course. Although the program was designed to replace the genetics curriculum in already existing classes, it could serve equally well as a separate genetics course, a source of one- and two-day activities, or as part of a health education class.

Teacher Preparation: Background information on the topics is provided in the teacher's edition, as are reference lists and addresses of many organizations which provide supplies for basic genetics labs and additional information.

Financial Requirements: Because the texts are paper-bound and there is only one volume in the unit, expense should be minimal. Purchase of pedigree charts, some reference books, and blood-typing kits is recommended. This program would still be of value even if some of the additional resources could not be purchased.

The Conservation Learning Activities for Science and Social Studies Project. (The Class Project)

Publisher: National Wildlife Federation, 1412 Sixteenth St., N.W., Washington, DC 20036.

Program Support: National Science Foundation

Program Objectives:
1. Overall Program Purpose: To help students develop an environmental ethic and to help them use their acquired skills and concepts in taking thoughtful, positive action to protect and enhance the natural environment.
2. Specific Objectives: The materials are designed to:
   a) help students achieve understanding of environmental concepts and skills;
   b) help students develop and practice the skills of observing, measuring, data collecting, classifying, hypothesizing, predicting, making value judgments, communicating, and problem solving;
   c) aid in the development and use of student skills in investigating and solving environmental problems;
   d) involve students in community action projects,
   e) give students experience in observation, classification, data collection, record-keeping, prediction, communication, and decision-making.

Description of Program: There are nine sections in The Class Project. The first section is an introduction and overview. Then there are six content sections which are: Energy Use; Environmental Issues; Forest/Watershed Management, Hazardous Substances, Wetlands, and Wildlife Habitat There is a unique section entitled, "You Can Make It Happen" This section describes class projects that have been completed by other teachers. The addresses and phone numbers of the teachers are listed, and they have agreed to act as consultants The last section, entitled "Digging Deeper/Glossary," is a resource bibliography.

Each content area begins with an introduction that provides background information. Then there are four or five activities. Content and process objectives are provided for each activity. Among the suggestions for each content area is a list of community action projects. These can become a classroom's community action project, which is an important goal of The Class Project.

The Class Project activities are designed to be used as supplementary to an existing program There is not a prescribed order for the content areas or the activities within the areas.

Methods of Instruction: A variety of approaches are used Methods of instruction used in The Class Project include surveys, experiments, simulations, discussions, debates, field trips, and library research.

Specific Subject, Grade, Age and Ability Levels: The subjects are interdisciplinary including biology, earth science, chemistry, and physics There are also parts that include social studies They may be used in either science or social studies classes The materials are designed for use in grades 6 through 9, though they could be easily adapted to higher grades.

The Class Project materials will work with a wide range of ability levels.

Materials Produced:

1 The Class Project binder (containing Activities and Poster Packet).

Program Implementation: Workshops are provided by the National Wildlife Federation. Materials are provided through a grant from the National Science Foundation Names and addresses of teachers who have used The Class Project are provided in the reference section Nothing more than standard science facilities and equipment are required

Teacher Preparation: The materials do not require specialized background. Science teachers should feel comfortable with the content areas. There may be some adjustment to new instructional methods such as simulation activities, and incorporating social studies concepts. Background information is provided with each activity.

Financial Requirements: The first 10,000 sets of materials will be distributed free through National Wildlife Federation workshops.

Science and Society Teaching Units

Program Director/Publisher: Douglas A. Roberts, The University of Calgary/The Ontario Institute for Studies in Education, 252 Bloor St W., Toronto, Ontario, M55 1V6.

Program Support: The Ontario Institute for Studies in Education.

Program Objectives:

1. Overall Program Purpose. To provide materials with a curriculum emphasis on science and society.
2. Specific Objectives. The materials are designed to:

a) introduce an understanding of the relationship between scientific knowledge and the decision making processes used by society in dealing with practical affairs;

b) teach students that they can use science in certain aspects of their lives;

c) enable students to discuss the social consequences of a few of the decisions they might make in the future regarding energy consumption, environment, and other problems related to science and society.

Description of Program. In completing one of these units, students will learn that they can understand various complex problems such as energy use, pollution, and variables influencing the growth and development of plants. Students will learn to take social as well as environmental values into consideration before making a decision on problems that will affect their lives in the future. Furthermore, it shows the students the importance these decisions may have on their quality of life.

Methods of Instruction: Discussion sessions, simple, but effective laboratory experiments, role-playing.

Specific Subjects, Grade, Age and Ability Levels: Each of these units is designed to take approximately twenty 40-minute periods to complete. Although the modules are designed for middle and junior high school students, they would also be effective for use with advanced elementary school students. These units would be most effective when taught as supplements to an existing science course. With some work they could be used as a total curriculum.

Materials Produced:

1. *Force and Energy: A Teacher's Manual for General Level Program Development*, Grade 8.
2. *Separation of Substances A Teacher's Manual for General Level Program Development*, Grade 9.
3 *Green Plants. A Teacher's Manual for General Level Program Development*, Grade 9.
4. *Heat. A Teacher's Manual for General Level Program Development*, Grade 9.

Program Implementation. Some of the units require extra equipment The Heat and Force and Energy units require little, if any, extra material besides the teacher's general knowledge of the subject material. The Green Plants unit requires "basic" gardening supplies plus a small amount of chemistry equipment. The required materials are generally within those found in the average science classroom. Advanced planning is advised to assure that the plant growing segment of the program runs smoothly The Separation of Substances unit requires that the students have access to a fully equipped chemistry laboratory. The teacher may also wish to have on hand reference materials on water purification and water quality.

Teacher Preparation: The teacher should be familiar with the subject matter of the unit before starting the class. However, the units require little unusual knowledge. Excellent resources are listed for updating one's background.

Financial Requirements. Besides the materials mentioned for each of the units, no additional materials are required.

Global 2000 Countdown Kit

Program Director/Publisher: Zero Population Growth, 1346 Connecticut Ave N.W., Suite 603, Washington, DC 20036

Program Support: Not specified

Program Objectives:

1. Overall Program Purpose To demonstrate the interrelationships and interdependence among population, resource, and environmental concerns
2. Specific Objectives. the materials are designed to
   a) help students understand ecology on a world scale.
   b) take a global approach to decision-making.
   c) prepare themselves to be socially and scientifically informed, politically effective citizens.

Description of Program: The *Global 2000 Countdown Kit* consists of 14 units (after the 14 issues addressed by the *Global 2000 Report*) designed to be used individually or in sequence. Each unit includes: a brief introduction to the major findings on that issue as published in the Global 2000 Report, a main activity incorporating the views of different sectors of the public or different cultures in making decisions and discussing their possible consequences, suggestions for ways to become involved in the local community's actions in that area or to increase community awareness, and finally, a list of related printed and audio/visual material available with addresses of their publishing companies.

Methods of Instruction: The program uses a variety of methods, including research papers; simulations; board and classroom games (one of which is student created); calculations, charting and graphing, debates; mapping; experiments; home investigations; and always a culminating class discussion.

Specific Subjects, Age and Ability Levels: The *Global 2000 Countdown Kit* addresses 14 subjects: population; income; food; fisheries; forests; water; nonfuel minerals; energy; species extinctions; and the impacts of agriculture, water resources, forest losses, world's atmosphere and climate, and of nuclear energy It is a teaching supplement applicable to both science and social studies courses taught from the 8th through 12th grade levels. Its basic information and activities can easily be simplified or expanded to apply to both younger and older age ranges

Materials Produced and Purchasable:

1. *The Global 2000 Countdown Kit*

Project Implementation: Each activity can be implemented almost immediately with a 10-minute review by the teacher. Occasionally, ordinary school materials such as rulers, yarn, scissors, photocopying accessibility, a die, etc. are needed.

Teacher Preparation: The Kit is designed to allow students to use it with minimum teacher supervision Each introduction gives necessary information to students and teachers alike; teachers may wish to research certain topics further to be able to answer probing questions. *The Global 2000 Report* would be a valuable resource for this.

Financial Evaluation: The Kit itself is inexpensive—$15, prices of related materials are not listed, but addresses of the companies that would have the prices are Ordinary school materials and library access should fall within the school's budget.

Project Learning Tree

Program Director/Publisher: American Forest Institute, Inc.

Program Support: Western Regional Environmental Education Council and American Forest Institute, 1619 Massachusetts Ave N.W., Washington, DC 20036.

Program Objectives:

1 Overall Program Purpose. For the student to develop an awareness, concern, knowledge, and skill with respect to his or her environment

2 Specific Objectives:
   a) for the student to explore the interrelationships between living and nonliving things;
   b) to involve the student in engaging his or her primary senses;
   c) to display the diversity of natural resources in the immediate environment;
   d) to display how human life is dependent upon the existence of renewable and nonrenewable resources;
   e) to help the student develop skills in evaluating information and in making thoughtful decisions.

Description of Program: This program is interdisciplinary and emphasizes student interaction with the natural and social environment. The outdoors, particularly trees, are used in various activities to exercise the student's senses and to encourage a self-examination of emotions along with the development of personal attitudes. The program aims to increase environmental awareness with respect to both aesthetic values and concern for resources.

The lessons, therefore, are based on activity and discussion which require the student to go out into the environment and observe, use his or her senses, describe, analyze, and conclude. Hence, the student gains personal experience with the environment Each lesson lists principles, concepts and skills gained so the teacher can easily skim through and choose an appropriate activity.

Methods of Instruction: Laboratory investigation, outdoor observations, and inquiry.

Specific Subjects, Grade, Age, and Ability Levels: The program is interdisciplinary. Activities range from grades K-12, and if a specific subject, grade, or ability level is required, it is stated before each activity.

Materials Produced:
1. Two textbooks with activities for grades K-7 and 7-12.

Materials Purchasable:
1. Two paperback textbooks.

Program Implementation. No outside reading or workshops necessary. Books contain background information. Materials for activities are simple and easily obtained from the outdoors or schoolroom environment.

Teacher Preparation: Some activities require previous preparation but preparation is fast and simple as activities are geared towards personal observation and conclusion.

Financial Requirement: Teacher's activity guide is the only book necessary Students do not need individual books.

Project Wild
Earth is Home For Us All

Program Director/Publisher: Dr. Cheryl Charles, Project Wild. Salina Star Route, Boulder, CO 80302. Western Regional Environmental Education Council.

Program Support: Western Association of Fish and Wildlife Agencies; Western Regional Environmental Education Council.

Program Objectives:
1. Overall Program Purpose. To develop awareness, knowledge, skills, and commitment that produces informed decisions, responsible behavior, and constructive actions towards wildlife and the environment
2. Specific objectives: Project Wild helps students learn:
   a) an awareness that humans and wildlife have some things in common;
   b) that wildlife is a valuable resource;
   c) the dynamic processes in ecological systems and their importance for wildlife.
   d) about wildlife conservation and what it requires of humans;
   e) the past and present effects of cultural and social interaction with wildlife;
   f) consequences and alternatives to current wildlife issues and trends;
   g) responsible human actions towards wildlife and their systems.

Description of Program: The curriculum unit consists of activities designed for integration into existing courses of study, or the entire program can be used as the basis for a course of study. Activities are arranged in a thematic order to assist the students in their development from awareness and appreciation to responsible actions concerning wildlife.

Each activity includes: a statement of the instructional objective; background information for the instructor; a list of materials needed, procedures, subjects from which concepts are drawn; skills, duration, and other information Also included are specific suggestions for extending the curriculum as a whole.

The appendices include a useful glossary of terms, an outline of the curriculum's conceptual framework, and cross-references by subject area, skills, and topics for use in creating instructional units

Methods of Instruction: The teacher takes full responsibility in presenting, leading, and concluding the activity. The activities for the most part are an active experience for students (observing, coloring, pasting, etc.) followed by a teacher directed classroom discussion.

Specific Subjects, Grade, Age, and Ability Level: The unit is most suited for the average elementary student and can easily be integrated into most school subjects, especially science, social studies, language arts, mathematics, and art.

A unit geared for grades 7-12 is also available and uses the same format and curriculum framework.

Materials Purchasable:
1 *Project Wild Elementary (K-6) Guide*
2. *Project Wild Secondary (7-12) Guide*

Teacher Preparation: The teacher needs to collect the materials for the activity and have a working knowledge of the background information and procedure given in the unit guide

Financial Requirements: The project guide and miscellaneous supplies that are commonly stocked in the school.

Outdoor Biology Instructional Strategies
OBIS

Program Developer/Publisher: Outdoor Biology Instructional Project, Lawrence Hall of Science, University of California, Berkeley, CA Delta Education, Box M, Nashua, NH 03061.

Program Support: National Science Foundation Grant No. SED72-05823.

Program Objectives:

1. Overall Program Purpose. To provide a base set of experiences in the knowledge of outdoor biology and to foster a positive outlook on science and learning in general.
2. Specific Objectives:
   a) by better understanding the biological world, children can better understand the interrelated, complex world they live in;
   b) in realizing dependence and interrelation with the biological world, children can make intelligent decisions on environmental issues;
   c) to make learning more enjoyable;
   d) to encourage discovery by the student through exploration and experience.

Description of Program: This program is based on a theory that experience and exploration are valid and preferable educating forces to other forms of learning. Therefore all of the lessons in *OBIS* have students playing an active role in investigating the environment. As a result, the students' input determines the outcome and success of the lesson.

The program is made up of 27 independent modules covering a gamut of topics Within each module is from five to ten folios (lesson plans). In each folio there is:

1) Overview. A one sentence overview describing what the students do and what the students will get from the activity;
2) Background: Information for the instructor in order to run the activity;
3) Challenge: A sentence setting forth the assignment for the students;
4) Materials: A list of equipment that an instructor will need to get ready for the activity,
5) Preparation. This lists any preparation needed by the instructor, the type of site needed and the best group size This section also gives an estimation of time required;
6) Action: A procedure list for carrying out the activity;
7) What Do You Think? A set of questions to spawn discussion and give added insight into the Action;
8) Branching Out: Additional ideas for other activities and actions which are related to the topic at hand.

Methods of Instruction: Go through the action. This may involve an exploration of a specific habitat, playing a game, performing an experiment, or building a creature (which simulates what one finds in the natural world on the topic of the folio). Discussion should be generated. All actions involve an outdoor setting.

Specific Subjects, Grade, Age and Ability Level. *OBIS* is designed for students ten to 15 years of age. Any outdoors education program could adopt *OBIS* as a supplement or total curriculum In addition to groups such as scouts, nature centers, families, and schools will find *OBIS* useful.

Materials Produced: OBIS Modules:

OBIS Sampler	Games and Simulations
Adaptations	Human Impact
Animal Behavior	Lawns and Fields
Aquatic Animal Behavior	Neighborhood Woods
Backyard	Nighttime
Bio-crafts	Outdoor Study Techniques
Breakwaters and Bays	Pavement and Parks
Campsite	Ponds and Lakes
Child's Play	Schoolyard
Desert	Seashore
Forest	Streams and Rivers
For Eight- to Eleven-year-olds	Trail
For Large Groups	Wintertime
For Small Groups and Families	

Materials Purchasable:

1. The modules above and most of the equipment listed in the materials list can be purchased through *OBIS*, Delta Publishing, Nashua, NH.
2. The remainder of the materials needed could be purchased inexpensively in local stores or acquired from home.

Program Implementation: The leader of an activity will need the materials listed in the material list gathered and a site appropriate to the activity picked out and cleared for use. The time necessary for each folio varies from 40 to 60 minutes.

Teacher Preparation: No other preparation needed other than gathering materials.

Financial Requirements: Along with the cost of the modules used, there may be additional costs for materials used in the activities. This will vary with modules used.

Zero Population Growth Population Education Program

Program Director-Publisher. Zero Population Growth, 1346 Connecticut Ave., N.W , Washington, DC.

Program Support: The *ZPG* population education project began in 1975 with funding from the U S Office of Environmental Education and private foundations.

Program Objectives:

1. The overall program purposes of *ZPG* are: to educate teachers and students about the dynamics of population growth.

2. Specific objectives the student materials are designed to:

a) introduce population growth and associated problems;

b) study depleted natural resources

c) evaluate the impacts of population on land, water, and air;

d) study species extinction;

e) examine human social problems.

Program Description: ZPG's Population Education Program will help educators and, ultimately, students understand the relationships between population growth and a wide range of scientific and social issues. The Population Education Program provides training and classroom materials for teachers of grades K-12 who are interested in introducing population studies to their classrooms.

Methods of Instruction: Activities simulating real world problems sometimes prefaced by short text and followed by discussion.

Materials Produced:

1. *Elementary Population Activities Kit.* $15.00.
2. *Global 2000 Countdown Kit.* $15.00.
3. *Population Education Resource Kit.* $4.00.
4. *Population Education Leaders Kit.* $5.00.
5. *ZPG Population Education Program: Description and Evaluation.* $5.00.

Materials Purchasable: From Population Education Resources, Zero Population Growth, 1346 Connecticut Ave., N.W., Washington, DC 20036.

Specific Subjects, Grade, and Ability Levels: Elementary Population Activities Kit is designed to teach all students in grades K-6 about basic population dynamics and environmental concepts *Global 2000 Countdown Kit* is designed to teach all students in secondary classrooms about 14 multidisciplinary topics dealing with the earth's population, environment, and resources.

Teacher Preparation: ZPG sponsors workshops ranging from one hour to several days. These are usually presented at major teacher's meetings including the National Association of Biology Teachers and National Science Teacher's Association annual conventions. Careful examination and study of the Population Education Resources Kit will probably be sufficient introduction to teach the program

Financial Requirements: Besides the original investment for students' kits, the lesson plans generally require no extra equipment. A few lessons may use common items found in science classrooms or easily purchased materials.

Investigating Our Ecosystem

Program Director/Publisher: The materials were authored by Irma Greisel and Peter Jensch, Houghton Mifflin Company/Boston, MA.

Program Objectives:

1) Overall Program Purpose: To introduce students to the complex interactions of humans and ecosystems.

2) Specific Objectives: The program is designed to:

a) provide relevant and useful science experiences for students who do not wish to pursue one of the conventional science courses in senior high school.

b) introduce students who are not scientifically oriented to the scientific method, and its use in the identification and solution of environmental problems.

c) provide a course of study in which scientific and technical concepts are realistically integrated with social and economic concerns.

d) develop in students an "environmental conscience," and to equip students with the means to translate their concern into practical action.

e) enable students to generalize from local conditions to global problems by identifying and investigating local fauna, flora, and other environmental factors.

f) enable students to identify the natural ecosystem and to assess the effects of human demands on the total ecosystem.

g) permit students to evaluate environmental deterioration and to formulate practical solutions for environmental problems.

Characteristics of this Program: The program fosters the student's curiosity about the environment. Because it is intended for nonscience-oriented students, it deals with qualitative ideas and a minimum of specialized vocabulary.

Specific Subjects, Grade, Age, and Ability Levels: *Investigating Our Ecosystem* is designed for students in grades 10-12 who have little or no science background. However, those who have had other high school science courses may use the program.

The program is designed as a 32-week course based on 10 chapters of one to six weeks each. Except for the first three introductory chapters, any of the chapters may be deleted or others may be added to adjust for time limitations. Study includes: the ecosystem, human ecosystem, field survey, water, soil, the earth's crust, nuclear energy, interrelationships, and environmental conscience.

Materials Produced:

1) *Investigating Our Ecosystem,* Student Edition, Houghton Mifflin Company/Boston, MA $4.75

2) *Investigating Our Ecosystem,* Teacher's Manual, Houghton Mifflin Company/Boston, MA $5.25

Program Implementation: There are three areas

which are frequently visited for collecting lab samples and therefore should be near the classroom:
1) A pond or other body of water.
2) A small area relatively unchanged by humans.
3) An area of high human impact, such as a busy street corner in a city.

Teacher Preparation: The teacher needs no special training unique to this course but should have basic knowledge of biology (in particular ecology), chemistry, and physics. Laboratory experiments require handling of chemicals and maintaining small biological specimens.

Financial Requirements: This program requires only basic science supplies, instruments, and equipment. Each student or small group of students must be equipped with items such as beakers, test tubes, thermometers, and ring stands. A supply of about 50 simple chemical compounds is required. Most of these use less than 200g of the substance for a year. A list of materials, supplies, and equipment necessary for the program is listed in the Teacher's Manual.

Investigating the Human Environment: Land Use

Project Director/Publisher: Biological Sciences Curriculum Study, The Colorado College, Colorado Springs, CO 80903, Kendall-Hunt Publishing Company, Dubuque, IA 52001.

Program Support: United States Office of Education, Department of Health, Education and Welfare.

Program Objectives:
1) Overall Program Purpose: To introduce the student to the complexity of decision making, bringing about an understanding of the issues and considerations involved.
2) Specific Objectives: The students will:
   a) receive an introduction to the science of politics and public opinion. They will learn how facts may be separated from value statements and learn to recognize biases and their origin as well as determine the pros and cons of a case.
   b) obtain a brief introduction to biological communities, studying population and growth rate and the principle of carrying capacity.
   c) learn the basics of economics, studying concepts of supply and demand, productivity, and budget planning.
   d) investigate ecosystems, learning the concepts of food webs and organism-environment relations.
   e) obtain exposure to situations in which integrations of the economics, sociology, political science, biology and geology they have learned are utilized to solve a particular problem through case studies.
   f) write a research report/Environmental Impact Statement at the end of the program, testing their comprehension of the above exercises and allowing them practical experience in research gathering and report writing.

Description of Program: The program is not a comprehensive study in any *one* traditional field of science; rather, the instruction provided for all disciplines is kept at an introductory level. The emphasis for this program lies in the integration of the several disciplines for the purpose of decision-making relative to land use. Topics include: public opinion, looking at land use, factors influencing land use, independent investigation.

Methods of Instruction: Students participate in small group discussions and debates, reference and record searches, data table/graph reading and construction, map reading and possible construction, some data collection/observation at home and within the local community.

Specific Subjects, Grade, Age, and Ability Levels: Little science background is necessary, yet, strong analytical skills are required. The program is best for grades 8 10, the material usable either as supplemental study in a political science/social studies class or a one-term (10-15 week) elective study.

Materials Produced:
1. *Investigating the Human Environment. Land Use*—Student Manual.
2. *Investigating the Human Environment: Land Use*—Teacher's Manual.

Teacher Preparation: Appendix A of the manual supplies titles of contacts necessary for student inquiries, yet addresses of specific offices in the community or state must be located by student or teacher. Other appendices supply library research information and guidelines for report writing. If desired, the teacher could supplement science overviews in the text with additional lessons.

Financial Requirements: There is little required beyond purchase of books and standard classroom supplies, facilities, and equipment

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Activities for Science Teachers

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This chapter represents the most practical aspects of a human ecological perspective. We have developed seven activities that serve as examples and first activities for science teachers who wish to include human ecology in their programs. While we tried to include lessons for grades 7-12, some activities are conceptually and methodologically difficult. Science teachers will have to review the activities and decide on the appropriateness of the lessons for their students. Activities are organized to introduce concepts of population, environment, and resources in the context of human ecological problems.

The activities are:

1) Population Growth
2) Age Structure of Populations
3) Air Quality and Automobiles
4) Thermal Pollution
5) Vegetations and Soil
6) The Supply and Demand of Resources: A Simulation
7) The Tragedy of the Commons: An Invitation to Inquiry in Human Ecology

Each activity begins with an overview, followed by scientific background and societal implications. Major concepts, objectives, and vocabulary are next. Then there are materials needed and suggested procedures. Finally, there are questions, discussions, and extensions for the activity.

Activity 1: Population Growth

Overview

In this activity students investigate exponential and arithmetic growth with the use of calculators. The activity introduces concepts basic to the dynamics of population growth.

Science Background and Societal Implications

Exponential growth is an increase by a constant percentage for identifiable intervals of time. The increase over a certain time interval is directly related to the amount with which the interval started. An exponential curve has been described as a J curve. In the same way that the letter "J" starts low on the bottom and then suddenly becomes vertical at the bend, an exponential growth starts slowly but quickly turns toward infinity. It should be noted that when one is doubling, the increase in one doubling is greater than total previous increases.

Investment of money is a simple and good example of exponential growth. If you could double your money in one week, then, starting with two dollars, you will have four dollars after one week. But in the next week, the four dollar investment will become eight dollars, and so on.

Here is an illustration:

week	*total*
1	1*2=2
2	*2=4
3	*2=8
4	*2=16
5	*2=32
6	*2=64
7	*2=128

total after 7 weeks: $128.00

Arithmetic is an increase by a constant amount over a time interval. Allowance is an example. Let a person be given two dollars a week allowance. If that person puts the money away on the day of receipt, then the amount will increase by a constant amount (two dollars) for a certain time interval (one week).

Here is an illustration:

week		1	2
increase		2+2=4	+2=
week		3	4
increase	6	+2=8	+2=
week		5	6
increase	10	+2=12	+2=
week		7	
increase	14	+2=16	

Many natural phenomena conform to exponential and arithmetic growth. A major social issue confronting the world today is the fact that population growth is exponential. And the increase in population is the origin of many human ecological problems ranging from depletion of finite resources to use (and misuse) of land, air, and water. Additionally, human health and disease are directly related to population growth.

Concepts

—Exponential growth is an increase in number proportional to a number already present.
—Present human birth rate in many countries is an example of exponential growth.
—Various factors affect the rate of increase, such as death rate or medical technology, but the only variable which changes is the number of generations needed to reach a large population.

Objectives

At the completion of this activity, students should be able to:

—recognize an arithmetic growth curve and describe its properties.

—recognize an exponential growth curve and describe its properties.

—relate the growth curve to human birth rate and the effects that different factors have on the curve.

—extend their knowledge to a realization of the implications that an exponentially increasing population has on the earth.

—analyze examples of natural growth and determine if they follow an exponential or arithmetic growth curve.

Vocabulary

arithmetic curve	rate of increase
exponential curve	birth rate
growth	death rate

Materials

The materials needed for this activity are:

—a straight edge ruler
—a pencil
—standard graph paper
—calculators

Procedures

Part I

1. Divide the class into six groups of five students each (number the groups). Distribute calculators to each group.
2. Begin by having everyone in the class (or if you have only one calculator per group, then one person in each group) punch the number "1" into their calculators.
3. Have group one punch in "+1=" and have them record their findings in a chart. Then repeat "+1=" and recording for five trials.

For example:

trial	1 2 3 4 5
findings	2 3 4 5 6

4. Have each group do the same five trials using

"+5=," "+8=," "*2=," "*3=," "*4="

5. Have each graph their findings either on graph paper or on a chalk board, the trial number being the x-axis and the data findings being the y-axis.

Part II

1. Tell the class that a graph of birth rate over successive generations is going to be made, starting with the class as the total population of generation I. Have them consider for a moment, and then record how many children they wish to have in their family. Add the total number of children, and call this Generation II. Record this number on the chalkboard.
2. Have the students repeat step 1, but this time have them estimate how many offspring each of their own children will have (i.e. the class' grandchildren). Call this Generation III. Again, record the total on the board. Repeat this procedure at least two more times, until five generations have been estimated. These will be the total theoretical descendants from this one class.
3. Have each student graph the results, with the horizontal axis as the number of generations, and the vertical axis as the number of children per generation. At this point, you should make sure that the students realize that this is an exponential curve because birth increase is proportional to the population already present.
4. Emphasize that what has been created is an *actual* birth rate increase as estimated by the class. This becomes a very large number when the point is made that there are many more people who will have children than simply this class.
5. In the next section of the activity, tell the students to think about the birth rate curve as it relates to population increase. Ask them if they think it is an accurate graph of the population, and if not, what are some of the things not taken into consideration by the graph. Some of these are: death rate, medical technology, immigration, and war. Ask the students what effects they think each of these would have on their curve. To illustrate an example of medical technology or death rate, have half the class make another graph, this time with a 10 percent death rate per generation subtracted from the numbers already estimated. The other half should construct a graph with a 15 percent "health care for sick babies" increase per generation. Each generation on the new graphs should be 10 percent less or 15 percent more. What is important for the students to realize in comparing the graphs is that the same number of births will always be reached; the only factor which changes is the number of generations it takes to reach that total.

Extension

Now that the class has a notion of the escalating effects of birth rate, it is possible to consider some of the implications on the earth. Some effects to consider are:

1) *Finite resources*. What happens to the world oil supply when all these children begin driving cars? 2) *Food production*. How can we produce enough food to feed all the new children when we have such a limited area to do it in? 3) *Disease, health and overcrowding*. What about the spread of a disease

through a large crowded population? Or the effects of a large population on available living space? The class should discuss these and other questions

Evaluation

Have the class group some of these common growths

1) The amount of water in a dish for every drip from the leaky faucet.
2) The spreading of a rumor (if A tells two friends and they tell two friends, and so on, and so on).
3) The time of day for every minute that goes by.
4) If for every quarter you lend to a friend he gives you back thirty cnets.
5) The amount of interest you get in a five percent interest bank account for every year that goes by.
6) Population growth.

Activity 2: Age Structure and Population

Overview

Students investigate the topic of age structure, one of the four major factors in human population dynamics. After an introduction to the four major types of age structure diagrams, students compare the graphs of three different countries and examine the changes in the graph of a single country over a period of time.

Science Background and Societal Implications

The number of persons in a certain population at each age level is the age structure, or age distribution, of the population. An important force in population growth is the number of women in childbearing age (15 to 44), especially those in the prime reproductive years (20 to 29). There is a latent momentum to sustain population growth that exists in a population with a relatively large percentage of persons below age 29, and particularly below age 15. That is, even when, on the average, women bear fewer children, the number of births can still increase in a population if there is an increasing number of women capable of bearing children. In 1977, about 36 percent of the people on earth were below age 15 Unless death rates rise sharply, the present world age structure foretells continued population growth for 50 to 100 years. *The Global 2000 Report to the President* predicts an increase in world population from 4.1 billion people in 1975 to 6.35 billion in 2000, a 55 percent increase.

Jumps in population growth, such as the U.S. "baby boom," tend to affect the future growth and structure of society for 20 to 40 years, as the population bulge passes through a whole generation. Thus, although American couples in the recent past have opted for smaller families, the greater number of women able to bear children will likely result in a consistent increase in births throughout the 1970s and 1980s.

The basic age structure diagram for the world, a certain country or region, includes the percentages of the total population in three age categories: preproductive (ages 0 to 14), reproductive (15-29), and post productive (45 to 75) (See Figure 1).

The distinctive shape of the age structure graph indicates whether a population will increase, decrease, or remain about the same in number. A rapidly expanding population characteristically has a very broad base, which means a relatively high percentage of persons in the reproductive category and a still higher proportion in the preproductive years soon to replace them during the next 15 years. The shape of a stable population approaching a zero growth rate (net death rate equals net birth rate) is closer in shape to a rectangle than a pyramid. Generations as well as age groups are of roughly equal size in a stable age structure. Therefore, there are about as many persons of age 10 as there are of age 20, 40, or 60. A declining population, finally, is characterized by a small base.

People of ages 20 to 65, the work force, must support children and retired people in addition to themselves. The "dependency load" is the ratio of old and young dependents (the top and base of the graph) to the work force. Because about 43 million babies, or approximately one-sixth of the present U.S. population, were born between 1947 and 1957, a problem of the 1960s was that a relatively small work force had a large dependency load. Extrapolating present U.S. trends, this problem will likely reoccur by 2030, when a relatively small work force born in the 1960s, 70s, and 80s will shoulder a large dependency load of retired people. The dependency load should decrease, in comparison, during the period from 1975 to 2005, as the baby boom generation moves through the work force.

While the 1980s and early 1970s in the U.S. marked the youth generation, the years 1975 to 2005 will be the period of young adults. Assuming no increase in death rates, older persons should arrive at their highest proportion of the population in U.S. history from 2000 to 2030 or so Hence the term "aging population." In sum, a bulge or indentation in the age structure graph of a population represents a potentially potent force for social, political, and economic changes during a span of some 70 years.

Concepts

—The shape of the age structure diagram suggests whether a given population might grow, contract, or stay the same.

—The dependency load of a population is the ratio of the

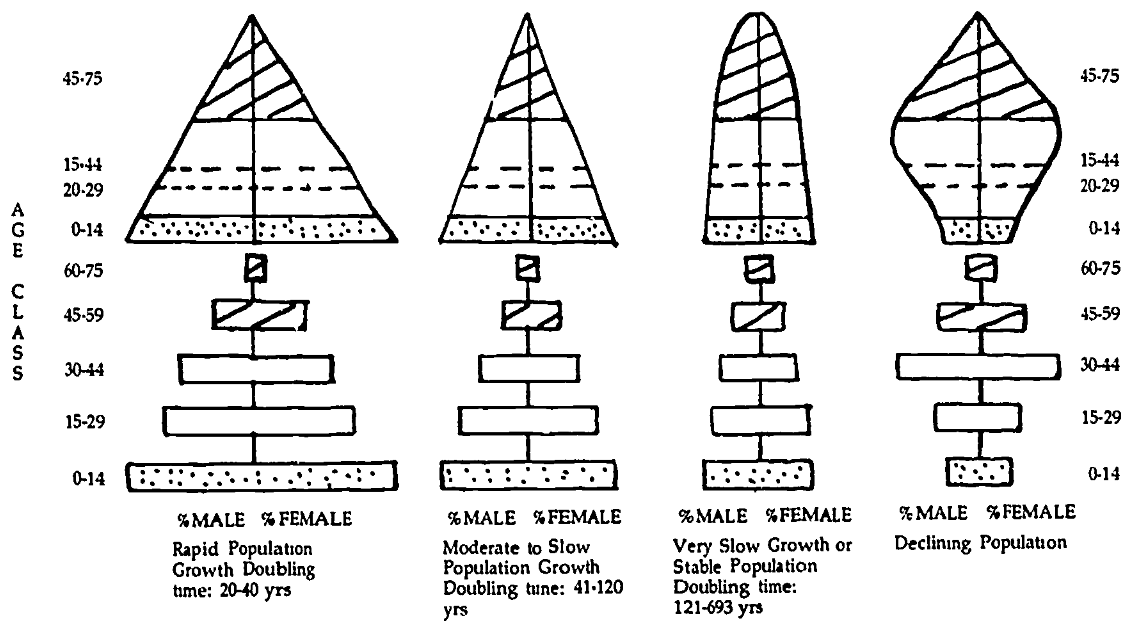


FIGURE 1. Four main types of age structure diagrams for human populations represent preproductive years (0-14). represent reproductive years (15-44). represent postproductive years (45-75). Dotted lines denote prime reproductive years (20-29) (Adapted from Miller, G. Tyler, Jr., *Living in the Environment*. Second edition, 1979, page 112.)

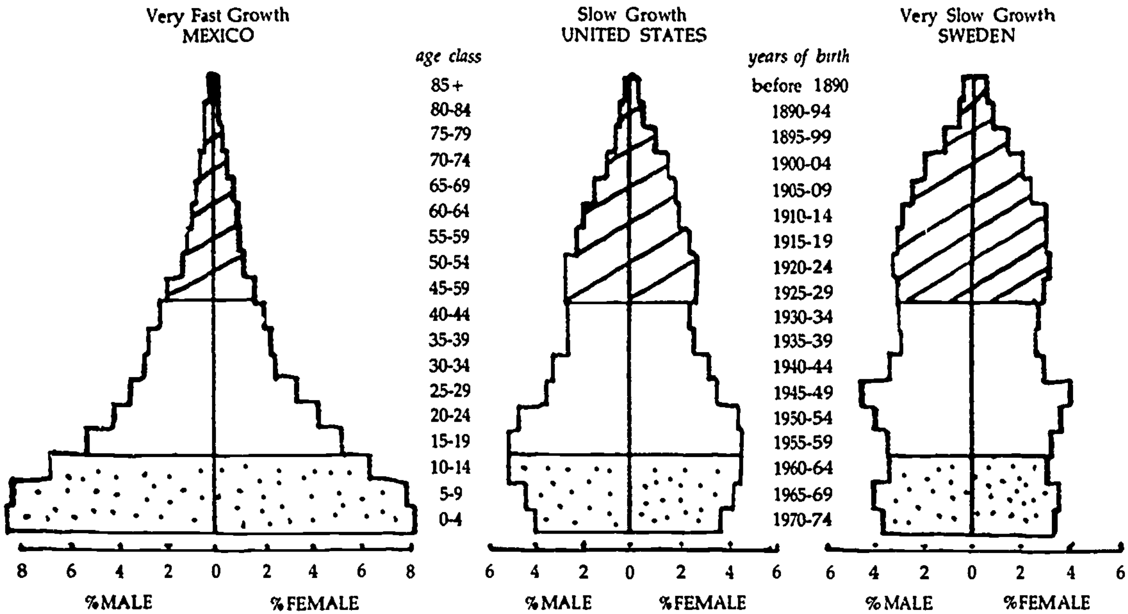


FIGURE 7 Age structure diagrams for Mexico, the United States, and Sweden. (Source. adapted from Miller, page 113.)

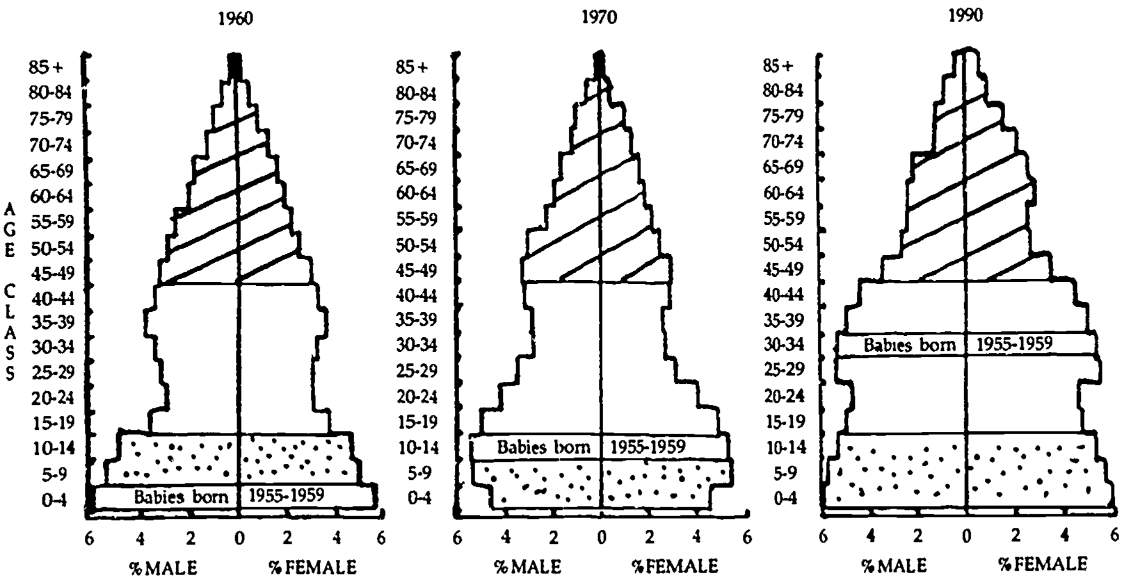


FIGURE 3. The age structure of the U.S. population in 1960, 1970, and 1990 (projected) Follow the gradual upward movement of the population bulge of the babies born in 1955 to 1959. (Source: adapted from Miller, page 114.)

young and old dependents to the size of the work force.

Objectives

At the completion of this activity the student should be able to:

—Define age structure and dependency load.
—Identify the four main kinds of age structure diagrams for human populations.
—Interpret an age structure graph.
—Compare different population diagrams.
—Describe the basic effects of a bulge or indentation in an age structure graph on the dependency load of a nation.

Materials

—Transparencies and transparency projector.
—Chalkboard
—Consumable paper in sufficient quantities.

Vocabulary

Age structure, or distribution
Preproductive
Reproductive
Dependency load
Baby boom
Postproductive

Procedures

1. Preparation for the lesson
   (a) Reproduce on a transparency Figure 1 and make four paper handouts corresponding to the four graph types therein.
   (b) Reproduce four copies of Figure 2 below, giving one copy to each group.
   (c) Reproduce on a transparency Figure 3 below.
2. In the classroom.
   (a) Introduce the activity by asking the student to answer the following questions, then discuss them briefly.
      1—Do you think world population is growing, declining, or staying the same? (Ans.: Growing)
      2—Do you think the U.S. population is growing, declining, or staying the same? (Ans.: Growing)
      3—For a population to increase in number, do you think it is more important to have more older people than younger people, or more younger people than older people? (Ans.: More younger people)
   (b) Utilizing a chalkboard illustration of a simple pyramidical structure graph, define for the students the terms age structure, dependency load, preproductive, reproductive and postproductive. Hint at the importance of the shape of the diagram and clearly explain the axes. Compare the relative sizes of the pre-, re-, and postproductive age groups in the four graphs. Take time to let the students become acquainted with and ask questions about this unusual graphic form.
   (c) Divide the students into four equal groups with a one to one sex ratio in each group if possible. Then, distribute one set of handouts to each group, so that each group has just one of the four diagrams in Figure 1. After a few minutes to examine their graph, the groups should in turn report to the class whether the population might expand, decline, or stay the same. Write these conclusions on the chalkboard. Then, do the same in reference to the relative sizes of the dependency load. Next, using the transparency so that all students can see all four diagrams, evaluate their conclusions, emphasizing the importance of the percentage of people below age 29, especially below 15, to population growth.
   (d) Hand out the sheet with the more complex diagrams of Figure 2, and allow a few minutes for the students to digest the diagrams. Using the transparency of Figure 2, discuss with the students how the concepts just learned apply to real world situations. Before comparing the three diagrams, explain the axes, and the way the age class percentages sum to 100 percent. Mexico is an example of rapid population growth, the U.S. is slowly growing, while Sweden is growing very slowly and is approaching ZPG. As of 1977, Mexico's population of 66.9 million was growing at a rate of 3.4 percent per year, with a doubling time of 20 years, and will continue in this regard due to its very broad base. The U.S. had 218 million people in 1977, growing at .6 percent yearly, for a doubling time of 116 years. Sweden, with only 8.3 million, was growing at a .1 percent yearly rate, doubling itself in 693 years.
   (e) Finally, using the transparency of Figure 3, demonstrate the slow movement of a given age

class up through the various age levels. Explain what is meant by the "baby boom," then show how the bulge, once it reaches the 30-34 age class, has helped instigate another such bulge. Compare the dependency loads in each case, and how it decreases while the baby boom adults move through the work force. Explain that the population might rise even when the average number of children per family decreases, simply because there is an increasing number of fertile women.

Extension

Divide the students into groups of three to four. Ask that each group provide a list of direct or indirect effects on the age structure of a population, and what these effects might have on the age distributions. Direct effects include changing death, birth, or fertility (average number of children born yearly per woman aged 15 to 44) rates, or change in the average age of first marriage. Indirect effects, which work through the direct effects, include war, famine, disease, sanitation, nutrition, and medicine. Alternatively, this might be a homework exercise.

Evaluation

Ask or give a quiz containing a few factual questions about the age structure diagrams. For example, how much greater is the 30-34 age group projected for the U.S. in 1990 than that of 1970? Also, encourage students to reveal any dissenting opinions in procedures 2. (d) and 2. (e). Finally, ask that students define orally the vocabulary terms listed above

Resources/References

Christensen, J.W. (1981). *Energy, Resources and Environment* Dubuque, IA Kendall/Hunt. Chapter 4.

Council on Environmental Quality and the Department of State. *The Global 2000 Report to the President*. Volume 1, p 9

Miller, G T , Jr (1979) *Living in the Environment*. 2nd edition. Belmont, CA: Wadsworth. Chapter 7.

Activity 3: Air Quality and Automobiles

Overview

Students are introduced to the effects of automobile exhaust on air quality. Students collect, analyze, and describe particles in automobile emissions. They test and compare pH levels for the atmosphere and automobile emissions.

Scientific Background and Societal Implications:

It is generally assumed that the world possesses an unlimited supply of air. Unfortunately, this is not the case. The atmosphere is a gaseous envelope, consisting of several layers, that surrounds the earth. Five to seven miles above the earth's surface is the troposphere. This layer contains 95 percent of the earth's air. The stratosphere extends above the troposphere to about 30 miles above the earth. From there, the mesosphere exists until 53 miles above earth. After that, the remaining air in the atmosphere is referred to as the thermosphere. Any pollutants added to the atmosphere mix with each other or with the natural components and often result in chemical reactions. The formation of acid rain is an example. Eventually, most of these pollutants and the chemicals that they form are returned to the land or water through precipitation or fallout. While all such pollutants may not have a negative effect on ecosystems, certainly many do, especially when one also considers the typical rate of deposition and the ability of ecosystems to absorb and degrade the material through natural processes.

Periodic alterations in the composition of the atmosphere are normal. However, pollutants added to the atmosphere as a result of human activity can drastically change the atmospheric composition. An altered world climate (through increased CO_2 in the atmosphere) and detrimental effects on life (including human) would result.

The automobile is the major source of air pollution. Many types of pollutants are found in automobile exhaust. The major ones are carbon monoxide (CO), hydrocarbons, nitrogen oxides (NO_x), particulate matter, and sulfur oxides (SO_x). Of these, carbon monoxide is the number one air pollutant. It is produced by the incomplete burning of carbon-containing substances.

There are two categories of air pollution: visible and invisible Because some exhaust gases are invisible doesn't mean they are harmless. For example, carbon monoxide is dangerous because it is an invisible, tasteless, and odorless gas. The effects of carbon monoxide on humans are: reduced oxygen carrying capacity of blood; impaired judgment; aggravation of heart and respiratory diseases; headaches and fatigue at moderate concentrations; and death by asphyxiation at prolonged high concentrations.

Concepts:

- Automobile exhaust pollutes the atmosphere.
- Emissions affect various forms of life.
- Ways exist to improve air quality through technology and life style changes.

Objectives:

At the completion of this activity the students should be able to:

- Describe the various products of automobile exhaust.
- Explain the various effects of

pollutants on our environment.

—Identify solutions to the car pollution problem.

Materials:

Every group of students should have each one of the following materials:

—clean, white handkerchief
—rubber band
—clean, glass slides
—magnifying lens or microscope
—litmus paper

Vocabulary:

carbon monoxide
hydrocarbons
nitrogen oxide
particulate matter
sulfur oxide
emissions (exhaust)

Procedures:

1. Introduce the activity by showing the class contrasting pictures of air quality found in magazines (heavily polluted city vs. clean one). Explain to the students that they will be studying the products found in automobile exhaust. In order to visually observe the products, it is necessary to collect some emissions. Have the students do this as an experiment. Talk about the varying characteristics of cars and assign each individual student or group of students to measure a representative sample. Distribute handkerchief and rubber band to each with instructions that they are to be used to cover the exhaust pipe of a car. Tell them to put this over the pipe opening, warning them to keep their face away from exhaust fumes and not to touch the pipe of an already idling car. Leave it on for five minutes while the car is running. Remove fixture and place in a bag to bring back to school the next day. Have the students record the model, engine size, year, and type of fuel used. Also explain that a comparison will be made between the pH level of the atmosphere and of the emissions. Place a strip of pH paper outside on a flat surface for 24 hours to accumulate dust particles. In the laboratory moisten with a few drops of recently boiled distilled water.

2. Have students make observations about the density of particles on their handkerchief. Scrape off the particles onto different slides. Have the students examine the particles under a magnifying lens or a microscope. Describe the color, size, and shape of the particles.

3. Allow the students individually to determine the pH of the exhaust gases. Rinse exposed portions of handkerchiefs with 10 ml. of distilled water. Place a few drops of this rinse on a strip of pH paper. Make a comparison between the atmospheric value and that for each car.

4. Lead a discussion on the problem of air pollution.

—What accounts for the difference, if there is any, in the pH levels?

—Recognizing that we are only measuring a few cars for a short period of time, what are the implications when all the cars in the world are accounted for?

—Why are measured particle levels different for different cars?

—Point out environmental implications for living beings (acid rain, health consequences) as well as the detrimental aesthetic effects (accumulated filth).

—Explain also the ethical choices involved in forcing changes.

—Now ask students to think of methods for controlling emissions from automobiles.

Possible responses:

Input approaches

1. Reduce automobile use. How?
   a) place taxes on gasoline, engine size, and car weight.
   b) banning cars in downtown areas.
   c) modifying life-styles and the design of cities to require less automobile use.
2. Develop mass transit (railroad, subway, bus) which moves large groups of people and paratransit (carpools) which moves small groups of people. Who should pay for this? Federal, state, local taxes?
3. Develop less polluting and more energy efficient engines.
4. Use a cleaner fuel for the internal combustion engine. i.e. natural gas, batteries. Note: gasohol may or may not be cleaner. Its development is in response to the energy crisis not atmospheric pollution.
5. Improve fuel efficiency. This can be accomplished by reducing the size, weight, wind resistance, and power of cars and by improving the energy efficiency of transmissions, air conditioning and other accessories.
6. Modify the internal combustion engine to control emissions and improve gas mileage. Such modifications include carburetor adjustments, fuel injection, and diesel and stratified-charge engines.

Output Approaches

1. Control emissions from the internal combustion engine more strictly, i.e. afterburners and catalytic converters.
2. Treat urban air with

chemicals in order to reduce the formation of smog.

Discuss the feasibility of each. Then ask the students:

What actually has been done? Discuss emission standards in particular. Then ask:

Did it make a difference based on observations?

Extension

Have the students consider the long term effect of pollution cycle and implications for living organisms (including humans).

Evaluation

Comparing all the different data of each student, have the students write a statement explaining the differences in emissions from various cars and the desired policies to follow.

Resources/References:

Biological Sciences Curriculum Study (1975). *Investigating Your Environment* Palo Alto, CA: Addison-Wesley Publishing Company.
Greisel, I. and Jensch, P. (1976). *Investigating Our Ecosystem* Boston. Houghton Mifflin Company.
Miller, G.T., Jr. (1979). *Living in the Environment*. (2nd ed.) Belmont, CA. Wadsworth.

Activity 4: Thermal Pollution

Overview

The students are told a story of drastic changes in a lake ecosystem. The students identify possible causes for the changes. The activity ends with the teacher explaining thermal pollution as one possible cause.

Science Background and Societal Implications

Though it is clear that temperature rises in a water environment can change associated plant and animal communities, controversy arises around the consequences of the changes. There are both beneficial and detrimental effects of a rise in water temperature in rivers, lakes, and ocean coast lines.

Possible effects resulting from warming waters are:

Detrimental

a) Initial death of aquatic life that cannot adapt to rapid changes in temperature. This can happen when a power plant first opens and again when it closes for repairs.
b) Many aquatic species are less resistant to disease and other forms of pollution in warm waters.
c) Less oxygen remains dissolved in warm water.
d) Aquatic life in general needs more oxygen to live in warm water.
e) A lowering of species diversity due to the lack of heat sensitive species.
f) A change in type of species present. (Example: increase in blue-green algae).
g) Due to a lowering in key species, the food chain may be disrupted.
h) A change in time of lake turnover.

Beneficial

i) In some areas a bolstering of fishing and aquatic agriculture industry. This may result due to introductions of warmer water species to the area. (Example: catfish, carp, lobsters, oysters, shrimp.)
j) Decrease in winter ice cover.
k) Increase potential for recreational uses.
l) Increase use for irrigation.
m) Possible use for heating buildings and industrial processes.

Electrical power plants, run on fossil fuels or nuclear reactions, release large quantities of excess heat. A typical cooling method involves piping cold water from rivers, lakes, or oceans to the heated portions of the plant. This warmed water is often released back into its natural source. The effects of the hot water depends on the amount of heat added and the quantity or flow of the natural body of water.

It was estimated by Murray and Reeves in 1977 that close to 38 percent of all water used in the United States was for cooling electric power plants. The National Water Commission reported in 1973 that it takes 1.23 billion gallons of cooling water per day to operate a 1,000 megawatt nuclear power plant. Most predict that the demand for electricity will increase by the turn of the century. If present trends persist, then, a proportional amount of cool water will be needed.

Many alternatives to the thermal dumping have been presented. Many suggest using the heated water to heat homes and offices. To do this it would be necessary to place the power plants in very close proximity of dense population regions. In this way transportation of the heat would be minimal in heat loss and cost. But this would put the public in close proximity to additional air pollution and possible radioactive leakage. A commonly used alternative is large cooling reservoirs, either in the form of large towers, lakes or canals.

Concepts

—Changes in the temperature of water can change ecosystems.
—Thermal changes may have both negative and positive effects on a community.
—There are costs, risks and benefits related to the location and operation of power plants.

Objectives:

After completing this activity students should be able to:

—Describe causes of thermal pollution

—Describe beneficial and detrimental effects of thermal pollution on ecosystems.
—Use inductive skills to analyze a change in environment.

Vocabulary

Thermal Pollution
Nuclear reactor

Materials

Chalkboard

Procedures

1. Introduce the students to the day's activity—a story. Ask the students to make a list of all changes that take place in the story.
2. Read or tell the story to the students. (If you are a good story teller then telling the story is far preferable to reading it.)

My name is James D. White. I left my home ten years ago to search for fame and fortune and to get an education in college. My home town was built along a lake. I remembered fondly how I used to fish in the lake. The old men that fished always laughed at me as they came running to help me with my line, for they always feared that the fish would pull my pole and me with it right into the lake. I was always very glad that they helped for I feared that if I did fall in that I would freeze right up like an ice cube and never be able to get out. I loved fishing in that lake over any other lake because I could often see all the way to the rocky bed as the fish nibbled on my line.

I returned to my home town last fall for the first time to find many changes. Many new industries, a new power plant, new stores and many more people had come to the town. The town even built a large public swimming area beside the lake which I thought was crazy remembering how cold the water was.

I decided that I would go fishing while I was there. But I first had to get a state fishing license. I walked to where I remembered my favorite small bait shop was but when I got there I found that it had closed down. I asked some people about it, they said it closed about eight years ago. They claimed that there was no demand for a bait shop, and that it was losing too much money. I thought this was crazy. It had been the best shop in town, every fisherman went there. But the people I talked to said that all the bait shops in town closed, and that nobody in their right mind fishes in that river anymore. I thought at this point that they were really stupid, for I remembered clearly how great the fishing was in the lake.

I went to the city hall, bought my fishing license, and went out to the lake To my dismay, instead of finding the lake sparkling clear I found it dark and algae filled. I casted and waited in expectation. After a few minutes without luck I moved to a new spot Cast after cast, hour after hour went by without a single nibble.

Finally I moved out on a little jetty of stones to cast from. Though I was very careful I slipped on what turned out to be some kind of green slime. As I started to fall I had flashbacks of how cold the water was when I was a child. But crashed into the chest-deep water, I found that it wasn't cold at all. In fact it was very comfortable as lakes go.

As I headed back to town to change my clothes, I thought of all the changes that my home town had gone through. I wondered what happened that made these changes.

3. On a chalkboard make a list of what the students wrote as changes that occurred. Examples:

a) new industries, new stores
b) new power plant
c) more people
d) public swimming area
e) bait shop closed, fishing turned bad
f) blue-green algae rather than clear water
g) water warmed

4. Go through the list of changes and ask the students to classify the changes as "beneficial," "undesirable," or both.

Example:
BENEFICIAL - swimming
UNDESIRABLE - algae and slime, bad fishing
BOTH - new industries, power plant, more people, water warmed

5. Turn to the first two categories and ask the class what changes in the community could produce this effect.

Example:

The students may say that due to the increase in population of the area, a recreation facility became necessary. Then you could add that wouldn't the warming of the water also have an effect since it would have been impractical to have a swimming area due to the water temperature previously? Then ask where the warming might come from.

Each change leads to pollution of some sort from the new industries or power plant, in particular, the warmng from the thermal pollution of the power plant.

6. Explain that great amounts of heat are byproducts of power plants, and that thermal dumping is a common method of disposal.

Extension

Ask the students if they can think of any other beneficial or detrimental effects of thermal dumping in other situations. Go through some ideas listed in the background material. Use the *Reader's Guide to Periodical Literature* to find current information on uses for thermal wastes.

Evaluation

Have students complete a half-page paper assignment on ways to dispose of or use the heat without dumping it into waterways.

Resources/References:

Andrews, W. A. (1972) *Environmental Pollution* Englewood Cliffs, New Jersey Prentice-Hall.
Cairns, J. Jr. (1971). "Thermal Pollution. A

Cause for Concern. *Journal of the Water Pollution Control Federation*, 43 55-66
Cairns, J Jr. (1970) "Ecological Management Problems Caused by Heated Waste Water Discharge into the Aquatic Environment." *Water Resources Bulletin*, 6·868-878.
Coutant, C.C (1970). "Thermal Pollution· Biological Effects." *Journal of the Water Pollution Control Federation* 42 1025-1027
Miller, G T Jr. (1979) *Living in the Environment* Belmont Wadsworth Publishing Company.

Activity 5: Vegetation and Soil

Overview

Students predict, observe and discuss laboratory results. Over a period of days, they weight two different soil samples, and plot the results on graphs. For each student, one container has bare soil and one has soil covered with litter. Discussion questions focus on the importance of vegetation to soils.

Scientific Background and Societal Implications

Vegetation shades soil and holds moisture and nutrients in a network of roots. When vegetation prevents a soil from becoming dried out, it inhibits wind erosion because moist soil particles adhere to each other. When clay-rich soil is dried out by the sun, it becomes even more difficult for new plants to take root because a hard crust forms at the surface. This hard crust can be softened by rain, but the bare soil is more likely to erode. Raindrops falling on bare soil can loosen particles whereas soils with vegetation and litter (dead leaves, twigs or stems) slows the speed of falling rain and protects soil from water erosion.

Soil loss has both environmental and economic consequences. Because vegetation can fertilize and stabilize soil, it is important that students understand the fundamental connection between plants and soils. If students grasp this idea, they may gain a greater appreciation of the need for soil conservation practices, both on farms and in urban areas.

Concepts

—Litter from vegetation slows the rate of evaporation from a soil.
—The amount of water lost to evaporation can be measured by systematically weighing samples before and after water has been added.
—Soil is a resource which needs to be preserved.

Objectives

At the completion of this activity a student should be able to.

—weigh samples quickly and accurately, and record the data on a bar graph;
—explain the role of vegetation in maintaining soil moisture;
—discuss several causes for variations in the rate of evaporation (e.g., various types or depths of litter).

Materials

—Two 250 ml. beakers for each student
—Grease pencil or marking pen
—Local soil (a clay-rich type is best—it holds water—in water-tight containers to be used when soil is returned to the collection site)
—Stirring rods or wooden sticks
—Water
—Graduated cylinders
—Balances
—Graph paper
—Various types of vegetation-based litter—leaves of trees, twigs, grasses

Vocabulary

water content	bar graph
water erosion	saturation
evaporation rate	soil

Procedures

Before class—determine how many milliliters are needed to saturate 200 g of the local soil. Use this amount in Step 3 of the student procedure.

Before beginning the laboratory activity, the teacher can present students with an idea exploration:

1 What do the students already know about vegetation? (Types, places it grows)
2. How might different types of vegetation affect the soil differently? (e.g., soils under grasslands are often very fertile, but soils are less fertile under forests, because more nutrients are stored within the trees themselves.)
3. If we simulate vegetation by shading soil, what other var-

FIGURE 1—SHADED AND UNSHADED SOILS

Beaker #1 — shaded	Beaker #2 — unshaded
Weight of empty beaker:	
#1 ______	#2 ______
Weight of beaker and dry soil:	
#1 ______	#2 ______
Volume of water in graduated cylinder:	
______	______
Weight of beaker + water + soil·	
Day 1 ______	Day 1 ______
Day 2 ______	Day 2 ______
Day 3 ______	Day 3 ______
Day 4 ______	Day 4 ______
Day 5 ______	Day 5 ______

iables are we leaving out? (No roots)

4. Decomposing plant material, whether leaves in forests or stems and leaves in prairies, aids in protecting soils from wind and water erosion.

Preparation of Soil Samples:

1. Have each student weigh two empty beakers, record the weights, label one beaker "shaded" and the other "unshaded" and write his or her name on each beaker.
2. Ask each student to add 200 g. of soil to each beaker. Before measuring, students should try to approximate.
3. Have each student add enough water *just* to saturate the soil in each beaker.
4. Form groups of 4. Choose one type of litter and within each group decide which student will test these litter depths. 1 cm., 2 cm., 3 cm., 4 cm.
5. Identify the bare soil container for each student as the control, each littered container as the experimental one.
6. Have students weigh and record control and experimental containers.
7. Place containers in a window exposed to the drying effects of the sun.
8. Weigh both containers daily.

Preparation of Graph:

Prepare an overhead or draw on the board:

1 A sample of what should be recorded in the student's lab notebook, like the one in Figure 1.

2 A sample of a bar graph, with beaker + soil + water weight on the vertical scale and day 1, day 2 . . . on the horizontal scale. Students should prepare two graphs, one with the data for shaded soil, and one for the unshaded. Ask students to use the same scale, so that they can compare their graphs more easily. Leave weekend days numbered but without measurements.

Post-Laboratory Questions:

1. Does litter reduce soil drying? Which type seems most effective?
2. Before measuring after a weekend, mark on each graph where you expect the new data to appear. Test your hypothesis with measurements.
3. What places around us have no vegetation? (parking lots, streets, fields during winter)
4. Which ones have vegetation during some part of the year? (farms)
5. At what time of year might erosion and drying be worst? (during dry months, when there is no vegetation, wind erosion may be the worst)
6. What are some of the reasons that vegetation is cut?
7. If we were to use vegetation more effectively and not cut as much, how might that affect the soil?
8. If soils need to be quite dry (and sandy, for wind erosion to have much of an effect, then how might vegetation be important?
9. Litter in home gardens is called mulch. How might a vegetable garden benefit from straw or leaf mulches?

Extension

Students may experiment with different types of soils, e.g. very sandy or clay-rich ones, to see which ones can absorb more water, beginning with equal weights of soil.

The teacher may show photographs of areas where severe wind erosion has taken place, e.g. the Dust Bowl of the 1930's, or areas which are becoming deserts today. Desertification may also be an appropriate paper topic, especially as it applies to agricultural land.

Resources/References

Brown, Lester. (1981). *Building A Sustainable Society*. New York W W Norton & Company. (See Chapter 1)

Soil Conservation Service, U S Department of Agriculture

Activity 6: The Supply and Demand of Resources

Overview

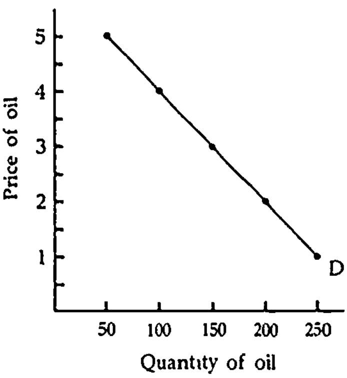
Students are introduced to the concept of supply and demand through a simulation about resource allocation. Students play the role of regulatory commission members in charge of the allocation of a specific nonrenewable resource—soil—and the role of representatives of societies that require oil to survive and to develop. Students learn that resources are finite and, consequently, societies must share them. Resource constraints are part of the reason why various populations, far from being independent, are interdependent.

Scientific Background and Societal Implications:

The amount of a commodity, e.g., oil, that individuals (countries) wish to purchase is called the *quantity demanded*. This quantity is determined by the commodity's own price, the prices of related commodities, average income, personal tastes, income distribution and the size of the population. The fundamental law of demand states that the lower the price of a commodity, the larger the quantity that will be demanded. The relationship between quantity demanded and price is represented graphically by a downward sloping demand curve that shows how much will be demanded at each market price (See Figure 1).

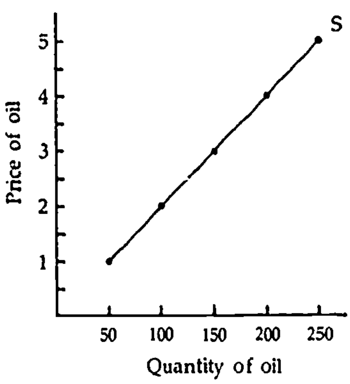
The amount of a commodity that firms (countries) wish to sell is called the *quantity supplied*. This

Figure 1 — Demand



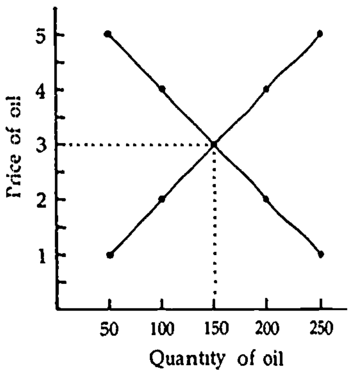
quantity depends on the commodity's own price, the prices of other commodities, the costs of production factors, the goals of the firm, and the state of technology. In the case of a finite resource the supply is fixed. The basic law of supply states that the higher the price of the commodity, the larger the quantity that will be supplied. The relationship between quantity supplied and price is represented graphically by an upward sloping supply curve (See Figure 2). In this simulation of a natural resource, the supply curve will be vertical, illustrating fixed supply at any price.

Figure 2 — Supply



The *equilibrium price* is the one at which the quantity demanded equals the quantity supplied (See Figure 3). At any price below the equilibrium there will be excess demand. Graphically, equilibrium occurs where demand and supply curves intersect.

Figure 3 — Equilibrium



Price is assumed to rise when there is a shortage and to fall when there is a surplus. Thus the actual market price will be pushed toward the equilibrium price, and when it is reached, there will be neither a shortage nor surplus.

Natural resources are commodities. Actually, the commodity is the "reserves" or the total amount of a given resource in known sites that is profitably extractable at present prices and technology. For nonrenewable resources, such as metals and minerals, which may be used up or at least depleted until further recovery is technologically and/or financially unfeasible, the term reserves connotes limitation. All nations face resource constraints; none can boat of self-sufficency. Subsequently, countries, far from being independent in their consumption of many renewable as well as nonrenewable resources, are made more interdependent by the natural limitations imposed on them. If one country, with sufficient power, sees fit to consume a relatively high proportion of available oil, for example, others may be unable to develop as they wish, or, at the extreme, to survive in their present state.

How should a resource be distributed? On what criteria should this decision be based? Who should decide? One solution to these policy-related problems of ethics is to let the marketplace allocate, eventually reaching an equilibrium between supply and demand. If the free market distribution is for some reason considered unequitable, however, an alternative is to oversee the allocation of the resource via a regulatory commission. This commission works toward the goal of an optimal allocation in not only an economic sense, but also in a social sense, taking into account justice as well as economic power.

Concepts:

- —Resource constraints add to the interdependence of nations.
- —The demand of a resource is greater than its supply.
- —Resource allocation is an ethical, and thus political, problem.

Objectives:

After this activity students should be able to:

- —Describe the relationship between the supply of and demand for a resource.
- —Discuss some factors that influence resource allocation.
- —Distinguish between the amount of a resource needed for the nation's survival, and the amount necessary for development.

Materials:

- —40 3" × 5" notecards with the words "25 units of oil" printed on them.
- —Eight different handouts as described below.

Vocabulary

Supply	Reserves
Demand	Interdependence
Resource	Equilibrium

Procedures:

Prior to class:

1. Prepare four different paper handouts in the following manner. On the first, for Group 1, print, "You are the chosen representatives of a country that needs 100 units of oil resources to survive, and 500 additional units to develop your economy to a more advanced state. There are 1,000 available units to be allocated amongst various countries by a commission. You are to petition the commission on behalf of your country." Do the same for the remaining groups but with these figures. For Group 2, use 0 units for survival (perhaps indicate that they burn wood for fuel) and 400 units to develop. Group 3 needs 400 units to survive and 100 more to develop. Group 4 needs 200 units to survive but none to develop. Do not inform the students of the entire total demanded.

   Total survival units required: 700

   Total development units needed: 1000

   Total oil units available for allocation: 1000

2. Print or type four different notecards with the following:

   Group 1: "Your country is overpopulated and rapidly growing. You have no pollution."

   Group 2: "Your country has moderate population growth and overpopulation but no pollution."

   Group 3: "Your country has stable population and moderate pollution."

   Group 4: "Your country has stable population but is polluting heavily. Pollution levels are hazardous to health."

In class:

1. After briefly introducing the topic of the day's activity (simulation game on resource policy), divide the class into five groups. Designate one as the regulatory commission, with the other four as different countries. Distribute the different handouts to the four groups, asking that each group's handout remain confidential. State that your role will not be as the teacher but rather as an economic consultant to the regulatory commission and this means periodic reports to better inform the commission on various problems.

2. Announce the first report of the consultant. As the commission members are entrusted with the notecards, tell them that they are to decide how to allocate 1,000 units of oil amongst these four countries. Tell them to distribute the notecards with a brief explanation of their reasons. (They will probably give 10 notecards to each group). In order for the consultant to gather data for research ask the commission members to request pertinent information the country might have on oil demand.

3. After careful consideration of how the initial allocation meets their demands (needs and wants), have each group, in turn, present to the commission the information on their handout. The other groups as well as the commission should record the demands of their neighbors.

4. Let the commission reconsider its initial distribution and make an oral report suggesting changes to the group. Implement their decisions by redistributing the notecards.

5. Announce the consultant's second appointment with the commission. Ask the commission why they reallocated as they did especially if one group does not have enough survival units. Then the consultant should explain that the main problem is how to allocate the 300 nonsurvival units. Point out the underlying problem of "demand" greater than "supply" and that ethical problems result, i.e. who gets to develop. Tell the commission that it has come to the attention of the analyst through scientific investigation that the countries involved have one of two problems. Hand out to each group their respective cards on pollution and population providing the commission with the information at the same time. The consultant should advise the commission to reevaluate its secondary findings and carry out a reallocation of oil, taking advantage of the opportunity to alleviate the population and pollution problems.

6. In a confidential meeting with the commission, the advisor suggests, for instance, that Group 4 might be asked to clean up their pollution if they want all of the necessary survival units. Also, Group 1 might be awarded their share only if population growth is controlled through policies. The key is to realize the increased complexity associated with reallocating the oil. Let the commission reconvene.

7. After the commission has announced their new reallocation decisions and reasons, let the groups take turns responding to the new policies of the commission.

8. The teacher, in the role of consultant, summarizes the events. Point out that countries do not consume resources without having some effect on other countries, i.e. nonrenewable resources are finite and must be shared. Define interdependence in the context of the activity done and describe how resource constraints make countries more interdependent. Ask the groups why this might be true? The reason is that the progression from groups 1 to 4 constitutes a transition from less to more advanced societies.

That is why Group 1 needs so much to develop and Group 4 none. Explain the fact that some coutries, like Group 3 and 4, might have more buying power than others. Note that this buying power often works against the commission's aim to allocate oil in an equitable manner.

9. On the blackboard, represent graphically, using the resource units for the X-axis, how supply was fixed in this case. Then, on a separate graph, show how the demand would look if price was included. Combine the two graphs into one, stressing the intersection as an equilibrium point. Show how excess demand in this case necessitated the commission to ration supply, since price was implicitly held constant.

Extension:

As a homework exercise, ask each group, including the commission, to prepare a written summary of its actions and how the allocations changed during the course of the activity. Include any suggestions as to a better final distribution.

Evaluation:

To make sure that the groups are paying attention to each other, ask specific group members at various times if they can describe the present situation of another group. Conversely, ask what are the possible consequences of not getting all the desired development units (distribution is not necessarily an all or nothing process). Also, in step 9 pick out specific points on the demand/supply graphs and ask what they represent.

Resources/References:

Lipsey & Steiner. (1981). *Economics.* (6th ed.) New York: Harper and Row Publishers, 190-192.

Miller, G.T. Jr. (1979). *Living in the Environment.* (2nd ed.) Belmont, CA: Wadsworth. Chapters 12, 14 and 19.

Activity 7:
A Tragedy of the Commons: An Invitation to Inquiry in Human Ecology

Overview

Through an invitation to inquiry, students are presented concepts from the tragedy of the commons. Being applicable to current local, national and global situations, the entire activity provides a good interdisciplinary introduction to human ecology.

Scientific Backgrounds and Societal Implications:

This activity is based on Garret Hardin's classic article *The Tragedy of the Commons* (Hardin 1968). The following quotation from this work summarizes the essential material of this lesson.

> The tragedy of the commons develops in this way. Picture a pasture open to all. It is to be expected that each herdsman will try to keep as many cattle as possible on the commons. Such an arrangement may work reasonably satisfactorily for centuries because tribal wars, poaching, and disease keep the numbers of both man and beast well below the carrying capacity of the land. Finally, however, comes the day of reckoning, that is, the day when the long desired goal of social stability becomes a reality. At this point, the inherent logic of the commons remorselessly generates tragedy.
>
> As a rational being, each herdsman seeks to maximize his gain. Explicitly or implicitly, more or less consciously, he asks, "What is the utility to me of adding one more animal to my herd?" This utility has one negative and one positive component.
>
> 1) The positive component is a function of the increment of one animal. Since the herdsman receives all the proceeds from the sale of the additional animal, the positive utility is nearly +1.
>
> 2) The negative component is a function of the additional overgrazing created by one more animal. Since, however, the effects of overgrazing are shared by all the herdsmen, the negative utility for any particular decision-making herdsman is only a fraction of −1.
>
> Adding together the component partial utilities, the rational herdsman concludes that the only sensible course for him to pursue is to add another animal to his herd. And another; and another. But this is the conclusion reached by each and every rational herdsman sharing a commons. Therein is the tragedy. Each man is locked into a system that compels him to increase his herd without limit—in a world that is limited. Ruin is the destination toward which all men rush, each pursuing his own best interest in a society that believes in the freedom of the commons. Freedom in a commons brings ruin to all. (Hardin 1968, p. 1243-44)

Notice the assumption within the body of this synopsis which points to a tragic conclusion. Hardin assumes uniform, rational, profit maximizing behavior by each individual. All herdsmen seek to keep as many cattle as possible in order to maximize their personal gain. This is considered rational behavior.

There are many scientific concepts included in the tragedy. Commons is defined as a natural resource which has no acknowledged ownership. This may be pasturelands, woodlands, the ocean, space, water, or the air. In this case, the commons refers to an open pasture. Another important topic concerns carrying capacity. The maximum population size that a given ecosystem can support *indefinitely* under a given set of environmental conditions is called the ecosystem's carrying capacity. Here the ecosystem refers to the commons and the population is represented by the cattle.

The limiting factors that tend to regulate the maximum allowable size of a population (carrying capacity) are collectively called the population's environmental resistance. If the cattle continually remove more palatable vegetation in a year than the commons can regenerate, either unpalatable weeds take over or all vegetation slowly disappears, leaving severely eroded land that can become barren In either case, overgrazing causes the carrying capacity of the commons—the amount of grazing that can be supported on a sustained basis—to decrease.

Externalities, effects on parties not directly involved in the production or use of a commodity, and the associated problems are also important. When one herdsman raises one too many cows, he affects every other herdsman's herd Yet this effect—a cost to someone else—does not play a role in the herdsman's private calculation of the cost of raising that cow. He accrues the entire gain from the additional cow while all the herdsmen bear a fraction of the overgrazing cost With these conditions, it becomes desirable for every herdsman to raise as many cattle as possible.

We exist in a finite world with limited land and resources. A finite world can support only a finite population Eventually population growth must equal zero. If this doesn't occur, the demand for resources exceeds the supply and a deterioration in living conditions, quality of life, results Quality of life, like beauty, is in the eye of the beholder, meaning many different things to different people Consider the case of bank-robbing The robber acts as if the bank was a commons. From his viewpoint, his quality of life increases; however that of all the customers decreases.

Additional issues from this quotation arise later. One important concept to understand is that this problem does not have a technical solution (supply), but rather concerns values (demand). In order to remedy the situation, social stability (sustainability) must be given higher priority than personal freedom in land use The commons can remain as such only with low density of the cattle population.

These concepts can be applied to real world conditions. Consider the case of human population. The projected world population is estimated to be 6.35 billion in the year 2000 A decision might be made as to whether the personal freedom to decide our family size should be left to each family unit or regulated through government policies. Even if the birth rate is stable in a country, as in the U.S , immigration, if greater than emmigration, causes the population to increase. Legal and illegal immigrants total about one million people per year and comprise a large fraction of the total employment in the U.S.

Pollution, even if population is stable, can generate the tragedy but in a reverse way. Instead of depleting the commons, negative wastes are added. It is cheaper to pollute the free resource rather than purify the discharges. As long as everyone behaves in this manner, destruction of the common results.

There are two types of solutions to the problem. increase supply or decrease demand. Reducing demand will require a reassessment of values and, namely, the subordination of personal freedom to social necessity. In other words, the commons can no longer exist as such.

Various alternatives exist to increase supply. The most obvious answer is to increase the size of the commons. Understand that in order to do so, other uses of land are foregone, i.e. parks, farmland. Assuming that the herdsmen continue to act rationally, in a few years the cattle population once again meets environmental resistance. The soil and carrying capacity are again exceeded. Now the town is faced with the same problem.

Another possible solution is to try to get more palatable vegetation out of the territory provided. This response is similar to the "Green Revolution." But, suppose that hybrid grasses increase production. In a short time period the herdsmen will reach the carrying capacity limit by adding more cattle to the extra grass. They are back where they started. The problem has been merely postponed, not solved. In addition, genetic diversity is reduced, meaning that exchanging all different varieties of grass for a more productive strain increases vulnerability to plant disease and climate extremes. Even with good weather, these strains tend to require much more water and fertilizer which is costly.

Another solution might be hybrid cattle. The same number of cattle exist but provide more food than previously. Again the problem of a reduction in genetic diversity arises. As the bigger cows use more food it is the same as adding more cows.

Several options pertaining to reducing demand are available. One has to do with educating the herdsmen about the consequences of overpopulating the commons. This can be accomplished through the media, schools, or a town meeting. The goal is to persuade the herdsmen to act differently, changing their values. Merely appealing to the herdsmens' consciences will not remedy the problem. Those that do comply end up paying for those who don't, losing sales. The noncomplying herdsmen are not paying the full cost of their continual overgrazing, shifting part of the cost to the socially conscious citizens.

Laws could be enacted controlling the cattle population. This is the solution Hardin suggested, "mutual coercion, mutually agreed upon." Coercion is more powerful than an appeal to conscience and would force the citizens to take responsibility for their actions. If they refuse to obey the law, they are punished. At this juncture, the commons cease to be free to all. The land could be divided up and parceled out as private property or a cattle limit may be specified.

The optimal solution is to tax the individual herdsman. A specific tax per cow above a certain number, increasing in cost the more cattle added, would shift the cost on to the shoulders of that herdsman. This maintains personal freedom, the herdsmen can decide what is best for them, but it tends to favor those with money. The tax should be set up so that the carrying capacity is almost exceeded, the tax on another cow would be higher than the profit it might generate.

Concepts

—Exceeding land's carrying capacity results in the tragedy of the commons.

—To avert crisis and possible ruin, social and/or technical solutions are needed.

—The relationship between individual freedom and social stability must be balanced in any sustainable solution.

Objectives:

After this activity students should be able to:

—Describe the problem of carrying capacity in the commons in terms of supply and demand.

—Define carrying capacity and environmental resistance.

—Explain how the problem of carrying capacity requires social, not technical, solutions.

—Propose and justify possible solutions to the commons problem.

—Apply the problem of carrying capacity in the commons to the real world.

Materials:

chalkboard
film

Vocabulary:

supply
demand
commons
carrying capacity
population density
environmental resistence
externality
quality of life
hybrid
tragedy

Procedures:

1. Provide the students with essential preliminary information through the following story:

Imagine a designated area of prairie land adjacent to a colonial town where the townspeople allow cattle to graze. This area was called a commons. The commons was of a fixed size, about as big as several city blocks, and was used freely by anyone. Gradually, herdsmen, the townmembers who worked in the commons, added more and more cattle to the commons. For a time everything was fine. Adding more cattle brought extra money to the herdsmen because they sold more beef and dairy products. There seemed to be no problems, only profit, by adding more cattle.

But, after a while the townspeople started to observe changes in the cattle and in the commons. They found out that less milk and meat was being produced per cow and collectively than previously. They noticed many more hoof prints on the soil, and a greater amount of dung than before. Moreover, they saw that the grass didn't appear as tall, full-grown, and lush as before. In fact, some of the edible vegetation was being replaced by indigestible weeds. Also, in some areas of the commons, but by no means everywhere, vegetation was slowly disappearing. They observed that land erosion had started to occur, leaving behind some barren soil patches. The cattle didn't weigh as much as before either.

2. *At this point stop the story line to ask the students some questions.*

What is happening in the commons?
Is something wrong?
If so, what are the problems?

Note that the remarks about footprints and manure were included to challenge the students to sift through the information they were given. List on the chalkboard the suggestions made by the students. Possible responses included:

1. The cattle were losing weight because they weren't getting enough food.
2. Less milk and meat is evidence of not enough food.
3. Too many cattle eating at once caused a reduction of lush pasture.
4. Too many cattle were eating the good vegetation faster than it could grow back.
5. Overgrazing was causing weed replacement and soil erosion.

Confirm the correct responses as being plausible.

3. If available, show the film on the *Tragedy of the Commons.* Afterwards, compare the answers in this film to those listed on the board.

4. Continue the story again by telling the students that the townspeople decided to form a group to suggest some ways to reduce the problem of the commons. They feel that unless they act, the situation will get only worse and there may be a crisis.

5. *Stop and ask the students:*

If you were a member of that group, what are the options that should be considered?
What could be changed?

List student suggestions on the chalkboard next to the previous list.

1. Make the commons bigger—enclose another parcel of land to increase its area.
2. Grow better grass to sufficiently feed the cattle.
3. Limit the number of cattle.

6. Incorporate the students' ideas into the story. Start with

the solution to increase the land area. Say that the committee decided to try that first so they annexed enough land to make the commons 50% larger. But after a few years the same problem cropped up. This was because the herdsmen took advantage of the extra land to add more cattle and make more money.

Address the suggestion to use better grass. Suppose the committee decides to try this solution next. They planted a type of grass that grows higher, is more compact, and has better nutritional value. The herdsmen, adhering to the principle of freedom in the commons, added more cattle to eat the mo·e plentiful grass. Within a few years, the same problem arose again.

The final alternative was to limit the number of cattle. Attempts to leave the commons as a free area were not working. They concluded that, instead of trying to change the land, they would change the people's behavior. The committee realized they needed to act in social and political arenas.

7. *Stop here and pose the question:*

How could the committee limit the herdsmen's use of the commons? To answer this question, divide the students into groups of 4 or 5, giving them 15 minutes or so to do two things: discuss possible answers to the question and choose one of them to report to the class, including the pros and cons of their choice. Visit each group to facilitate the quality of life discussion. Reconvene the class, and list the various suggestions on the chalkboard. Possible group responses incl\u de:

1. Informally persuade both the herdsmen and townspeople that the cattle population must be maintained below carrying capacity.
2. Prohibit by force from having too many cattle.
3. Charge the herdsmen money if they add too many cattle.

This first answer implies public education Develop with the group this line of thought· Education may occur on several levels—schools, media (town gazette), public lectures, town meetings, or peer pressure.

> Which measures should be taken?
> Is it enough to educate the young, future herdsman?
> Should there be a comprehensive effort?

Indicate the possible problems with this approach. Those who are conscientious may find their reduced cattle numbers refilled by those who are more immune to guilt, causing the same problem to exist all over again. This time, however, the ones who are conscientious are paying the price for those who aren't, in both lost sales and soil erosion.

The second answer is to enact a law. Again, develop the solution of the group with them, recognizing that the law may take various forms: a specified limit on the number of cattle; the division of the commons into private property, or limit on the number of cattle divided equally between the total number of herdsmen. The point is that penalties result for those who break the law in the form of a fine, prison sentence, or revoking of cattle grazing privileges. In the case of private property, personal injury would fall on the culprit, without direct harm to others since the lot is fenced in.

The final response is to tax herdsmen for use of the commons. This method doesn't prohibit, it just gives biased options. Perhaps the tax will be per additional cattle over a certain limit, with possibly a higher tax as more cattle are added. The tax may be high enough so that adding another head would cost more than it would sell for. Herdsmen are still able to add cattle, but they pay the price for exceeding their limit. Conclude the exploratory part of this activity by emphasizing that at last the committee had found a viable and rather permanent solution. The goal, however, is to get all townspeople to understand and desire a limit on cattle so that lawbreakers and tax evaders are minimized.

8. *Stop at this point.*

Shift the explanation of the tragedy of the commons from an intuitive, qualitative approach to one based on scientific concepts. Now present two ways to view the problem. First, start by defining carrying capacity and describe how the problem of overgrazing, caused by overpopulation, meant that the carrying capacity was exceeded. Stress that sustainability is a major objective for the commons. Explain how the cattle population met environmental resistance by defining the term. Use the first list put on the board to relate these concepts to the story. Define what supply and demand refer to in the context of this activity. Add that the committee was necessary to bring the two in equilibrium. This was accomplished by decreasing demand because increasing supply created a vicious circle. increased supply always led to increased demand. Looking at the second list on the board, explain why each supply side solution was a technical solution. Yet, the problem at hand was not permanently soluable by technology.

Now refer to the third board list, talking about each suggestion in turn. Explain that the solution had to be made by limiting demand which means a value change. Explain how the herdsmen received all the sales but paid only a fraction of the cost to the environment until public sanctions were taken.

Elaborate on the conflict of values; add the subordination of individual liberty to use the commons to social necessity, well being, and stability. There exists a loss but also a big social gain. Give the bank robber example to clarify this concept. Propose that some freedoms may not be desirable. Introduce the quality of life concept in relation to the story and the example just given.

9. Challenge the students with this question:

> Is there any way in which the commons could have been left as it was—free to all?
>
> What had to be true for this to occur?
>
> After a few minutes, define population density and explain how a low population density averts the tragedy.

10. Finish the activity with the important point that the above discussion applies to the real world. Describe the analogy between the cattle and humans, and the commons and the earth. Show how the concepts learned can apply to the global commons for the case of pollution, human population, etc. Concerning human population, the issue is: the freedom to breed versus birth control policies. Furthermore, taxes, education, laws, and technology are all solutions to real world problems.

Extension:

Introduce a new variable into the analysis: pollution Describe how this might generate the tragedy even if population is stable. Explain the effect of excessive pollution, caused by population, on the carrying capacity. Do this in the context of the real world so that current problems are discussed. Optional: Note the weakness of the private property solution in this context and the resulting externalities.

Introduce another variable to the analysis immigration to the U.S.

Ask the students What do you propose to do?

Evaluation:

In order to evaluate the students' understanding of the ideas brought out in the story of *The Tragedy of the Commons*, ask the following question as a written homework exercise or quiz.

> The seas and ocean may be considered a commons just like land. Fishermen trying to catch tuna thought so. Unfortunately, as time has passed, the numbers of fishermen have increased yet they have less and less tuna to catch even though technological solutions have been sought to increase the tuna supply. What is happening here? Why?

Resources/References

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