Are We Building Environmental Literacy?

A Report by the
Independent Commission on
Environmental Education

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Independent Commission on Environmental Education

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Executive Summary

Are We Building Environmental Literacy? A Report by the Independent Commission on Environmental Education details the outcome of a content evaluation of some of the most widely used and highly recommended environmental education teaching resources used in K-12 classrooms around the nation. Environmental education has become popular over the last two decades, but too little attention has been given by experts to the actual content of classroom materials to allow teachers, parents, professional educators, and others to judge its direction or its quality. The Independent Commission on Environmental Education, a group of ten specialists in the areas most often covered in the field, performed this evaluation.

The Commission concluded that *environmental education is important and should be taught in America's schools.* The Commission presents its findings and recommendations in the hope that they will contribute to ongoing efforts to improve the standards and quality of what our students learn about nature and their own impact on the environment.

Children have always had an immediate interest in the trees, bugs, and birds outside their classroom. Teachers have traditionally used the outdoors as a way to make science come alive and to bring together a variety of disciplines, such as math and social studies. Teachers report that environmental education captures their students' attention more readily than many other topics. Given the widespread concern over academic achievement in America's schools, especially in science and math, environmental education holds great promise for boosting the quality of learning in our classrooms.

As this field has gained prominence in American education, it has also become controversial. Of special concern to the Commission are complaints that environmental education materials are often factually inaccurate, superficial, or designed to persuade rather than to inform. Although these criticisms have frequently been more anecdotal than systematic, they point to potentially serious flaws in a critical part of our children's education.

In order to assess the content of environmental education materials, the Commission selected resources that are widely used or recommended by authoritative sources. The Commission also reviewed materials from a range of sources, including those produced by government agencies and industry.

Several results from the Commission's work should be highlighted:

The Commission's review found no relationship between the quality and accuracy of environmental education materials and the type of organization that produced the materials. Advocacy groups, among others, have published good teaching resources. These groups have also published materials they claim are educational, but are so technically flawed that they have no place in a classroom.

The Commission stresses its faith in a teacher's ability to make the best of even bad material. Good materials with solid content are important; good teachers are essential. However, it is expecting too much of teachers to ask them to sort through and correct badly flawed materials.

One of the most troubling aspects of this study is the discovery of how superficial the science is in high school environmental science textbooks. These texts are often little more than catalogs of environmental facts and issues.

Traditionally, environmental education has been as concerned with promoting "responsible environmental behavior" as it has been with teaching children about the environment. However, there is no consensus among parents or the community at large on what constitutes environmentally responsible behavior or to what extent schools should encourage students to take action on behalf of an environmental cause. The field should place its emphasis on building environmental knowledge, not on promoting a particular kind of behavior.

The Commission is concerned that basic aspects of environmental decisonmaking, such as quantitative methodology, economics, and risk analysis, are largely ignored in the upper-level environmental education materials it reviewed.

Environmental Scientists and Environmental Educators: Strengthening the Link

Environmental scientists have a responsibility to put environmental education on a foundation of solid science, while environmental educators have a responsibility to put that science in a real world setting. In this regard, environmental educators are dealing in the realm of usable science—the best available scientific information applied to the understanding and resolution of real world environmental problems. Just as policy makers must make environmental management decisions with less than perfect information, so environmental educators must address their subject with acknowledged uncertainties about economic implications and scientific information. Environmental educators are obligated to seek and employ the most accurate, most complete information available. Environmental scientists are obligated to help environmental educators gain, understand, and apply that information effectively in their teaching.

Findings

The Commission has issued ten findings. Each finding is presented in the report with considerable elaboration and detail.

- Study of the environment is an important subject for grades K-12.
- Teachers are the key to successful environmental education, but the materials often fail to give them the support they need.
- Environmental education should not be confused with environmental science, but materials that are not based on the best available science do not promote environmental literacy.
- Environmental education materials often do not provide a framework for progressive building of knowledge.
- Environmental education has become needlessly controversial.
- Environmental education materials often fail to prepare students to deal with controversial environmental issues.
- Environmental education materials often fail to help students understand tradeoffs in addressing environmental problems.
- Factual errors are common in many environmental education materials and textbooks.
- Many high school environmental science textbooks have serious flaws. Some provide superfical coverage of science. Others mix science with advocacy.
- There is no relationship between the quality of the material and the authoritative recommendations that accompany the publications.

Recommendations

Based on its evaluation, the Commission has issued nine recommendations it believes must be implemented if environmental education is to gain the stature it deserves.

- Environmental educators should place primary emphasis on the acquistion of knowledge.
- Students in the lower elementary grades should begin the study of science with the study of the natural world.
- Schools should consider teaching environmental education as an upper-level multidisciplinary capstone course integrating what students have learned in science, social science, and other upper-level courses.
- Professional scientific and educational organizations such as the AAAS and NSTA should recommend educational materials only after a detailed, substantive review by experts has found them to be accurate.

- Publishers must reevaluate their peer review process for environmental science textbooks and environmental educational materials.
- Textbook adoption committees and educational professionals responsible for selection of materials at the state and local levels should ask scientists, economists, and other experts, in addition to parents and teachers, to review materials for accuracy.
- Environmental education materials at all levels should provide more substantive content in natural science and social science than they now provide.
- Teachers need substantive preparation in science, economics, and mathematics to teach environmental education.
- An independent review process conducted by experts from the areas covered in environmental education should be established to perform ongoing evaluations of curricula in this field.

When these recommendations are implemented, environmental education will gain greater acceptance, will be less controversial, and will make a greater contribution to American education.

Studies of the field show that students do not lack concern for the environment, they lack knowledge. All of us, not just environmental educators, must help children build the knowledge they will need to confront a host of ecological challenges. The environmental problems of the day will change over time, but the environmental literacy gained in schools will last a lifetime.

Introduction

The Independent Commission on Environmental Education was formed to evaluate the content of the most widely used or most often recommended environmental education teaching materials found in America's classrooms from grades kindergarten through twelve. Teaching about the environment in elementary and secondary schools has become popular over the past two decades, but not enough attention has been given to the substantive content of the materials to allow teachers, parents, professional educators, and others to judge their overall quality. The Commission undertook an assessment of teaching materials; its findings are set out in this report.

"Most children have a bug period, I never grew out of mine."
Biologist E.O. Wilson, from his autobiography, *Naturalist*

The Commission believes that environmental education can make, and in many cases is making, an important contribution to primary and secondary education. Because the natural world offers a rich addition to classroom study and children have an immediate interest in trees, insects, rivers, clouds, and animals, environmental studies may hold students' attention to a greater degree than other topics. The environment also presents an opportunity for multidisciplinary education that permits students to apply learning from science, social science, mathematics, history, and other subjects. Moreover, engendering a stewardship ethic in our children is clearly an appropriate goal for American education. For these reasons, environmental education, including that aspect tied to teaching young people science, is a legitimate area of investigation for anyone who cares both about education and the future protection and sustainable use of our natural resources.

As environmental education gains ground in America's schools, serious arguments are being raised about the quality of the field, arguments that are sometimes voiced by those most responsible for the growth of the field and who are most interested in seeing it prosper.[1] Additionally, observers outside the mainstream of the environmental

"Captain Planet." The Internet makes a wealth of information on the environment available to students who have access to it. Students have ample opportunities to learn about the natural world.

Yet surveys indicate that greater opportunity has not necessarily translated into knowledge. A 1992 Roper poll tested teens' knowledge on issues such as air and water pollution, solid waste, and conservation. Roper had previously administered a similar quiz to adults; the report noted, "Our expectations, frankly, were that teens would do better [than the adults] in this exercise, but these expectations proved to be optimistic." Teens, in fact, scored slightly lower than adults on the quiz, even on topics frequently covered in environmental education curricula, such as waste management, acid rain, pollution, and biodiversity.[8]

A 1990-1991 study of over three thousand students in thirty secondary schools in New York State identified a similar lack of knowledge. Students surveyed had a mean score of fifty-two percent. Students who reported studying environmental science tended to score lower on the knowledge test than those who had not.[9]

A national survey of high school students' environmental knowledge (based on responses to environment-related questions designed for National Assessment of Education Progress testing in science and mathematics) found that, although a majority of students could identify sources of environmental problems (e.g., fossil fuels, smokestacks emitting sulfur dioxide), relatively few could identify the consequences. For example, only 43.5 percent of the high school seniors in the sample could identify three potential consequences of the global warming. The study concludes, "Most high school seniors possess an elementary comprehension of environmental problems and lack the necessary understanding to go beyond the common recognition of an issue and use their knowledge to grasp the consequences of environmental problems or offer solutions for those problems."[10]

Remarking on the lack of environmental literacy of students, Larry Gigliotti, Department of Natural Resources, Cornell University, asks in the *Journal of Environmental Education*, "Environmental Education: What Went Wrong? What Can Be Done?"[11] He notes that, "Environmental education has produced ecologically concerned citizens who, armed with ecological myths, are willing to fight against environmental misdeeds of others but lack the knowledge and conviction of their own role in the environmental problems."[12] Despite twenty-five years of experience with environmental education in the classroom, students are still "woefully lacking in knowledge about environmental concepts," Gigliotti concludes.

Environmental education has become controversial.

According to Richard Wilke, director of the National Environmental Education Advancement Project (NEEAP) and Associate Dean and Professor of Environmental Education in the

College of Natural Resources, University of Wisconsin-Stevens Point, "criticism of environmental education materials and activities is accelerating...."[13] A number of articles reporting on the controversy surrounding environmental education have appeared in papers across the country in the last year. The *Los Angeles Times*, for example, reported that Arizona state representative Rusty Bowers began campaigning against environmental education when his son learned in ecology class that "coyotes didn't kill sheep."[14] *U.S. News and World Report* described a battle in the Escambia County, Florida, school district over removal of a popular environmental science textbook because of complaints of its anti-industry bias.[15] A recently published book, *Facts not Fear: A Parent's Guide to Teaching Children About the Environment*, written by Michael Sanera of the Claremont Institute and Jane Shaw of the Political Economy Research Center, presents an extensive critique of how the environment is taught in schools today.[16]

Wilke contends that many of these criticisms are unjustified, exaggerated or politically motivated. Still, the field is clearly in the center of controversy. In Arizona, for example, a grassroots coalition of parents helped persuade the legislature to overturn the requirement that environmental education be taught in grades K-12 and to cut funding for these programs.[17] Similar efforts to cut funding for environmental education programs have been launched in North Carolina, Florida, and Wisconsin.[18]

Some industry groups also have been vocal about environmental education. The aerosol industry, for example, has been trying unsuccessfully to correct the commonly-reported error that aerosols contain CFCs.[19] CFCs were banned from use in aerosols in the U.S. in 1978. In Texas, a major controversy erupted over adoption of an environmental science textbook by Addison-Wesley Publishing Company.[20] Farmers objected to what they argued was bias in the text's description of agriculture's contribution to environmental problems, such as soil erosion and pesticide use. Representatives from the Texas Farm Bureau, the Texas Department of Agriculture, the Texas and Southwestern Cattle Raisers Association, and the Texas Cattle Feeders testified against the adoption of the Addison-Wesley text and several other textbooks during public hearings.[21] The textbooks were ultimately adopted by the Texas State Board of Education.

Some educators also acknowledge that there are problems with environmental education materials. In an article in the environmental magazine *E*, educator Michael Weilbacher criticizes the tendency to evoke apocalyptic visions of the future and to enlist children in political activism: "Children should not be worriers or warriors," Weilbacher argues.[22] The president of the NAAEE, Bora Simmons, who is Associate Professor of Outdoor Teacher Education at Northern Illinois University, addressed the problem of public perceptions of environmental education in her column in the association's newsletter. Simmons reported that, "In the last

few months I've had discipline-based educators tell me, in both public and private forums, that environmental education was irrelevant, redundant, not working, and 'fluff.'"[23] She argues that environmental educators must work to "build bridges with the traditional disciplines."[24]

To address these concerns, NAAEE is developing guidelines for the field and is reviewing materials. This is an important step. However, because environmental education is multidisciplinary, evaluation requires the participation of a broad range of expert reviewers. Adequate understanding of any one environmental issue typically requires applying concepts from several disciplines. It is an impossible task for elementary and secondary level teachers to evaluate these materials for scientific content without adequate guidance from specialists.

Goals of the Commission

In view of the importance of educating the future generation, the Commission undertook this study with two goals: First, to evaluate the most often recommended or most widely used environmental education materials in grades K-12 primarily for scientific and economic content; and second, to recommend, if necessary, steps that should be taken to improve the content of environmental education materials.

The Commission brings to this task a considerable amount of expertise in the key areas in this field: acid rain, biodiversity, climate change, energy, forestry, population, health, waste management, economics, and risk analysis. The Commission's evaluation was focused on the substantive content of educational resources, i.e., the accuracy and completeness of the presentation of the underlying scientific and economic principles.

The Commission has several members with experience in elementary and secondary education, and all its members have considerable experience in post-secondary education, but evaluation of the pedagogical quality of the materials is not the Commission's primary goal. An analysis of this aspect of environmental education may be justified and could prove useful, but it falls beyond the scope of this study.

Materials Reviewed

Selecting a representative sample of environmental education materials was a challenge: First, because the quantity of materials is enormous, and second, because there is no firm consensus even among environmental education professionals themselves about what should properly be considered "environmental education." As noted above, resources for those interested in teaching about the environment are produced or sponsored by environmental groups, industries, trade associations, commercial publishers, state and local education and government agencies.

To select a representative sample of materials from these diverse sources, the Commission looked for materials that were widely used

or recommended or suggested as suitable for classroom use by an established science or education organization. For example, *Environmental Education: Teacher Resource Handbook*, published by Kraus International in cooperation with the National Science Teachers Association (NSTA), suggests environmental education materials and resources for teachers. The Environmental Protection Agency has funded development of a set of manuals to promote environmental education, entitled the *EE Toolbox*, that includes suggestions for teaching materials. The American Association for the Advancement of Science (AAAS) publishes a magazine, *Science Books and Films*, that reviews teaching materials. The California Department of Education has developed six compendia of environmental education curricula materials that identify quality materials. The Commission selected a sample of materials from these and other sources (a list of materials can be found in Appendix A).

Each Commission member reviewed a sample of educational materials, selected according to the member's area of expertise, and submitted written evaluations of each piece. The Commission also held a series of meetings to discuss its findings, and, although the Commission could not conduct a comprehensive survey of educators, it heard from teachers, environmental educators, publishers, and curriculum developers. The Commission also heard from representatives of NAAEE, the AAAS, and the NSTA about their efforts to improve science and environmental education.

How Environmental Topics are Covered

Following is the Commission's analysis of how specific environmental topics were treated in the materials under review.

Acid Rain

Acid precipitation is a common topic in environmental education materials. One text, *Environmental Science: How the World Works and Your Place in It*, published in 1995 by J.M. LeBel, makes a serious attempt to cover the chemistry of acid rain and includes a discussion of the NAPAP report.[25] This text, however, is an exception. In most of the materials reviewed by the Commission the discussions of acid rain are badly out of date. Although this may be due to the recent reevaluation in scientific thinking about this topic, some of the dated coverage appears to reflect inertia on the part of the publishers and authors.

The Commission found that the science of acid rain, when discussed at all, was frequently covered in a simplistic manner. *Acid Rain*, a 1990 Great Explorations in Math and Science (GEMS) publication from the Lawrence Hall of Science, presents information that is dated, but might have accurately reflected the commonly-held scientific view at the time of publication. A high school textbook, *Environmental Science*, published in 1996 by Holt, Rinehart, and Winston, contains very little natural science in its acid rain section, but focuses on the question of acid rain impact in some detail (pp. 161-164). However, the discussion of impacts is now very much out of date. In other material, for example, *Going Green*, published by Puffin Books, acid rain is used to advance an argument for energy conservation with no reference at all to technical issues (p. 14).

Changes in thinking about the acid rain issue began with the NAPAP report, which found the impacts of acid rain in the U.S. to be much more modest than had been hypothesized. This study found that, although acid rain did cause the acidification of some lakes in the northeastern U.S. and Canada, the negative effects are limited to relatively few lakes that lack adequate natural buffering capacity. Furthermore, the study found no evidence that acid rain had a seriously deleterious effect on U.S. or Canadian forests.[26] Other work has suggested that the "die back" that some forests experience is likely due to factors other than acid rain.

Additionally, the negative effects that acid rain was thought to be having on the forests of Europe have not been realized.[27] In fact, the forest resources of Europe experienced their most rapid recorded growth during the decade of the 1980s, growing at a rate about thirty-five percent higher than in earlier decades. This increased growth has occurred throughout Europe, including the regions thought to have been adversely impacted by acid rain.[28]

Although the Commission recognizes that materials become dated, most of the discussions in the texts reviewed treated the damages presumed to be associated with acid rain as scientific fact. However, even at the time these materials were published, these damages were largely hypothetical, and further scientific investigation revealed that most of them were not in fact occurring. As in other topic areas reviewed by the Commission, scientific theorizing on this issue was often presented as settled fact, although scientists were (and still are) engaged in speculation and investigation.

Ecology and Biodiversity

The Commission examined materials dealing with both ecology—the interactions of species with one another and with their physical environment—and biodiversity. Ecology and biodiversity constitute a substantial portion of environmental education and cover a wealth of phenomena and processes. The Commission found that materials on ecology and biodiversity included some of the best it reviewed.

Biological Science: An Ecological Approach, published by Kendall/Hunt, presents college-level ecology at the high school level. *Eco-Inquiry*, developed by the Institute of Ecosystem Studies and published in 1994 by Kendall/Hunt, takes a few fundamental ecological problems and renders them understandable and interesting to young students. It gets students to do work that is truly scientific and helps them to learn about the methods underlying the work. *McGraw-Hill Science*, a 1995 textbook for eighth-grade students, includes a section on ecology that demonstrates how ecological concepts can be used effectively to teach students about science and to interest students in what scientists do.

However, the Commission was concerned with certain problem areas. For example, rates of species extinction were often stated with confidence, while the uncertainties surrounding the current state of scientific knowledge with respect to species extinction in general were sometimes poorly presented or ignored altogether (e.g., Prentice Hall's *Ecology: Earth's Living Resources*, p. 101). *Environmental Science*, published by Holt, Rinehart, and Winston, provides a dated estimate of the number of species (p. 254). The most commonly accepted figure, not counting microorganisms, is around 10 million, not between 10 and 100 million.[29] The same text explains only the role of habitat destruction in species extinctions, when other causes, such as introduced species and harvest, should be covered as well. *Naturescope: Endangered Species: Wild and Rare*, a 1987 National Wildlife

Is There a Balance of Nature?

The concept of a "balance of nature" goes back at least to the ancient Greeks. It crops up later in many cultures, and appears to stem primarily from a psychological need to see order in the world and to believe that a Creator would not create an unbalanced world (Egerton 1973, Simberloff 1980). For the Greeks, as well as in some modern versions of this idea such as the Gaia hypothesis, the balance of nature is endogenous, involving homeostasis and self-regulation. However, in many older versions, it is exogenous, with God periodically intervening to keep nature in balance. To the extent that modern biologists, beginning in the seventeenth century, were interested in a balance of nature, their focus was on the ways in which various natural phenomena, such as predation and disease, acted to help maintain equilibrium in the natural world.

Beginning with Alfred Russell Wallace in the nineteenth century, and continuing with the forceful works of such twentieth century ecologists as Charles Elton, Paul Ehrlich, and Charles Birch, the validity of the concept of the balance of nature was brought into question by virtue of the fact that it seemed unfalsifiable. The concept was demonstrated to be so elastic that any observations from nature could somehow be fit into it. Thus, most practicing ecologists simply stopped thinking about a balance of nature. Further, for about the last twenty years, there has been increasing interest in the ideas that nature is non-equilibrial and that population regulation of many species is at most episodic. These notions have drawn the attention of ecologists still further from the concept of the balance of nature.

However, probably for a variety of reasons, it is still a popular idea in the public mind, so that various figures of speech associated with it (e.g., Mother Nature) appear frequently in popular writing and occasionally even in scientific writings. The Gaia hypothesis seems to resonate so well in the public mind. However, it has found few scientific adherents.

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Simberloff, D., "A succession of paradigms in ecology: essentialism to materialism and probabilism" *Synthese* 43 (1980): 3-39.

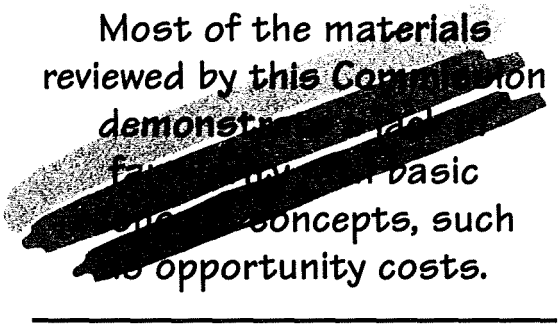
Federation publication, states without qualification that there are 30,000,000 plant and animal species, and that they are being lost at a rate approaching 40,000 species annually (p. 3), although there is considerably more uncertainty about these numbers than the text suggests. LeBel's *Environmental Science: How the World Works and Your Place in It* repeats the long-discredited Kaibab deer "population explosion" story (Caughley 1970),[30] and its treatment of the relationship between diversity and stability is dated and very uncritical (p. 4, 12).

One fundamental problem is the presentation in many materials of the idea of a "balance of nature." The "balance of nature" concept is used as an organizing theme for many of the texts. Students are not told that the balance of nature is viewed as an imperfect metaphor by the great majority of professional ecologists and that the related Gaia hypothesis is taken seriously by very few (see sidebar: Is There a Balance of Nature?). Especially in upper-level texts,

presentations should reflect current concerns, such as the relationship between diversity and various ecosystem properties and functions — stability, nutrient cycling, productivity, and the like.

Economic Analysis

Public policy discussions of environmental issues inevitably include a consideration of the relative costs and benefits of proposed solutions. The coverage of economic impacts in many of these materials fails to prepare students to participate knowledgeably in these debates.



For example, a number of materials (such as *Think Earth,* and *Going Green)* promote recycling without explaining that it is not cost-effective to recycle all materials, that returns for recycled materials vary greatly with time and market conditions, and that there are by-products of the recycling process that also need to be safely disposed. Discussions of alternative energy sources often overestimate the current or near-term economic viability of some of the technologies, or fail to account for other costs (see, for example, *Living Lightly in the City).* Only a few authors writing about wind turbines note the current shortcomings with this potentially important renewable energy source, such as problems with premature blade failure, noise, and threat to birds. Discussion of these factors would help students understand the comparative advantages and disadvantages of alternative sources of energy. Without some discussion of the costs, benefits, and tradeoffs of various policies and technologies, students will gain little understanding of the complexities of the issues involved.

Most of the materials reviewed by this Commission demonstrate a lack of familiarity with basic economic concepts, such as opportunity costs. *The Teacher's Guide to World Resources,* for example, asserts that the Exxon *Valdez* oil spill increased the GNP of the U.S. because of the enormous resources that were spent to clean up the oil.[31] However, even disregarding the loss of oil not available for sale on the market, the massive clean-up operation necessary diverted considerable resources from other uses, such as development of new technology or the production of goods and services that could have made a larger contribution to GNP.

One high school textbook, Prentice Hall's *Environmental Science: The Way the World Works,* does attempt to introduce students to the concept of diminishing returns. The text explains that the cost-effectiveness of pollution controls tends to diminish as pollutants are reduced to low levels. The text states, "Demanding upwards of 90 percent [pollution]

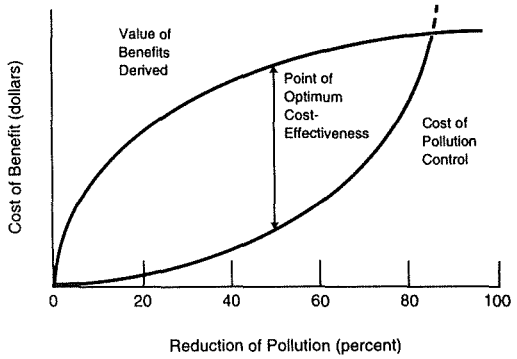
control may involve astronomical costs" (p. 349). The text, however, rejects the usefulness of this analysis, and suggests that it is a "sophisticated method of protecting economic self-interests at the expense of environmental quality and society at large" (p. 349). The text does not ask students to also consider that paying the "astronomical costs" for reducing pollutants to zero means that those funds would likely be unavailable for other environmentally and socially beneficial purposes. See sidebar for an example of a cost/benefit analysis of pollution controls.

Environmental topics provide a valuable opportunity to explain basic economics, particularly for middle- and secondary-level students; and in fact, several materials use energy or environmental issues as a theme for a basic economics unit. Florida's Center for Economic Education, for example, has published *Energy and Economics* to teach economics in Florida high schools. Students study principles of supply and demand, and the costs and benefits of various energy sources. *Eco-Detectives*, a curriculum published by the Political Economy Research Center, asks students to use economic reasoning to think about environmental issues. Exercises such as, "Why are there so few whales and so many chickens?," introduce students to the role of different impacts of private or collective ownership in the exploitation and conservation of resources.

Some of the materials reviewed by the Commission present private property and a market economy as impediments to certain types of environmental protection. *Living Lightly*, for example, tells students that "not all outlooks for the future are negative. We could view our situation of dwindling resources, degrading ecosystems, burgeoning population and the growing human awareness of the need for change as an opportunity to restructure our economy" (p. 187). *Environmental Science: Working With the Earth*, published by Wadsworth Publishing Company, calls for "making a transition to a sustainable earth economy" (p. 176). *Earth Matters* presents, as an alternative to the existing economic system, an "ethical economics" that shuns economic growth and "includes a more equitable distribution of wealth which improves global quality of life for all...." (p. 141).

These materials, however, in calling for an end to economic growth and global reform of economic systems, do not explain the mechanisms by which governments might be persuaded to pursue policies to alter or discourage consumption or economic growth patterns.

Example of a Cost / Benefit Analysis of Pollution Reduction



As the above graph illustrates, optimum cost-effectiveness of pollution controls are achieved at less than 100 percent reduction levels. Costs rise slowly for low levels of benefits but become very large as complete mitigation is approached.

They also do not help students understand that economic growth is critical to helping developing countries turn from questions of survival to issues of quality of life and improving public health. Evidence seems to indicate that it is only after a country reaches a certain level of economic and technological development that it begins to devote resources to reducing emissions from industrial processes and to developing cleaner and more efficient technologies.[32]

Energy and Natural Resources

The use of fossil fuels and the recovery of metals from ores are often implicated as sources of especially intractable environmental problems in the materials reviewed by the Commission. The central themes of most of the K-12 presentations are that there is rapid depletion of fossil fuels and other natural resources coupled with near-term and long-term detrimental effects on the natural environment. The very large differences between available reserves using current technologies and potentially available resources using improved technologies are rarely explained, thereby creating false impressions of the rates of depletion of various fuel supplies. The *CLASS Project*, a joint project of the National Wildlife Federation and the California Department of Education, states that, "Experts believe that by the year 2000, most of the world's oil may be depleted" (p. 39). The Commission is unaware of any expert who agrees with this prediction. The Globe-Fearon text *Impacts of Technology* contains the statement that supplies of oil will grow scarce in the early 2000s" (p. 29). *Environmental Science: Working with the Earth*, published by Wadsworth, states that, "At the current rate of consumption, known world oil reserves will last for 42 years" (p. 519). This statement may reflect proper arithmetic but leaves a false impression since it involves treatment of reserves as a fixed, time- and technology-independent number.

The textbook, *Global Science: Energy, Resources, and Environment*, by Kendall/Hunt, includes a discussion of the difference between oil reserves and resources (including formulas that are of doubtful validity for estimating reserves) and also some mention of technologies for extracting oil from different types of fields (pp. 306-313). The known resources for the production of fossil fuels (including oil, natural gas, coal, tar sands, oil shale) are so vast that depletion must be measured in terms of centuries and not decades.[33] The resources that will ultimately be used will be determined by direct costs with externalized environmental charges and the availability and costs of alternative energy sources and new technologies.

Finding additional fossil-fuel supplies is not generally stated to be a desirable goal in the environmental education texts examined by this Commission because of the environmental impacts of fossil-fuel utilization. For example, *Living Lightly* for grades four to six contains the following paragraph:

> Approximately half of the oil consumed in the United States is used to power automobiles. This consumption takes its toll on people and the environment in many ways. Oil spills degrade coastal ecosystems killing wildlife and destroying fisheries. Burning fuel pollutes the air and contributes to acid rain. Our dependence on foreign oil can also lead to loss of lives and outpouring of billions of dollars in defense (p. 119).

This collection of partially true statements requires considerable clarification in order to establish a proper perspective for the young reader. Students should consider, for example, that urban population centers require transportation systems and that fossil-fuel-based systems are in some ways more benign than the horse-drawn carriages which preceded them. Oil spills are unacceptable; every effort should be taken to avoid them by requiring diligence, the best available technology, and by making the responsible party pay for damages. Pollutants from burning fuel in internal combustion and diesel engines have been lessened in the last decade by stringent emission regulations. Publishers and curriculum writers should not be reluctant to include information that reflects positively on accomplishments and improvements in environmental designs.

A complete presentation on energy use and its impact requires information about the historical relation between standard of living and energy use, while noting that increased conversion efficiency in recent years has temporarily interrupted the historically very tight coupling between energy use and personal income. It should be noted, however, that per capita electricity use and per capita income have always remained closely linked, even during the period when energy efficiencies in conversion systems were greatly improved.

Living Lightly on the Planet for grades four to six explains that "living lightly" means making greater use of solar energy. Data that sound impressive are presented without being placed in context. The student is informed, for example, that there are "more than 1 million active solar systems and 250,000 passive solar homes" in the United States (p. 183). But at what cost? Why are there not more? What do we do with the active systems and what are the implications for the future? Solar technologies for passive space heating and for the production of hot water are indeed a success story for many parts of the world. But students need further information to understand the costs and benefits of solar energy.

In discussing future energy supplies, it is appropriate to emphasize the desirability of developing economically viable renewable technologies such as energy recovery from biomass, wind-energy systems, solar photovoltaic systems, solar thermal energy-conversion systems, etc. Students should also learn that this has been a goal since the early 1970s, but has met with only limited success to date because these technologies are not yet cost-competitive with fossil-fuel technologies. Energy and natural resources are complex topics and comprise an important

component of environmental science. Even upper-level courses in environmental science can provide only an introduction to this complex field. See Appendix B for an example of the kinds of topics that would be covered in a comprehensive course on energy resources and technology.

Forests

Forests, rain forests, and the animals that live there, are the subjects of many exercises and activities, especially for younger children. A pervasive theme in many of the materials reviewed by the Commission is that forests all over the world are in danger. One of the most popular children's books used as a supplemental text, *The Great Kapok Tree*, contains this sentence, "He does not think of his own children, who tomorrow must live in a world without trees."

Coverage of forestry issues varies considerably in accuracy among the materials reviewed. Estimated rates of deforestation, for example, differ widely from one text to another. *Nature in Danger* cites a figure (p. 15) more than twice that of the most reliable statistic available from the U.N.'s Food and Agriculture Organization (FAO). As another example, few materials note that fragmentation of forest areas may be a greater threat to biodiversity in some areas than actual deforestation because of its effect on habitats.[34]

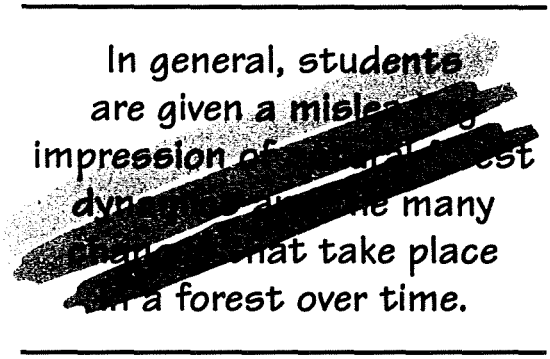
Discussions of temperate forests often do not note the remarkable recovery that has occurred in the United States and Europe in recent decades. Abandonment of fields no longer used for agriculture has permitted large tracts of land, particularly in the Eastern United States, to revert to forests. Most commercial logging in the United States occurs in tree plantations or second-growth forests and almost all old-growth stands are now under protection in national parks or protected by policies not to harvest old-growth remaining in public forests. Similar recovery of temperate forests has occurred in most western nations. Globally, the FAO estimates that there has been a net increase in temperate forests from 1980 to 1990.[35]

Causes for deforestation are often poorly identified. *Living Lightly on the Planet*, for example, tells students, "Rich nations around the world enter the lumbering business in the rain forest and lay waste to vast areas" (p. 22). Unlike much of the commercial logging in the temperate forest, tropical commercial logging almost never involves the clear-cutting of the forest. The usual approach to tropical logging is to select only the few trees that are desired by commercial markets, thereby leaving large numbers of live trees in the forest after the harvest. Clearing land for agriculture, not commercial logging, is the major cause for deforestation in many developing countries. In many such countries, insecure tenure to land or government subsidies for forest conversion have also helped accelerate the rate of forest clearing.

In general, students are given a misleading impression of natural forest dynamics and the many changes that take place in a forest over time. Even old-growth forests undergo natural

changes through the decades; for instance, fire, insects, climate fluctuations, and disease affect forest succession in addition to human activity. One book that effectively introduces students to forest dynamics is *The Great Yellowstone Fire*, published by Little Brown for the Sierra Club. The book presents the catastrophic 1988 fire in the Yellowstone Forest as a great "natural" experiment, to show the regeneration that occurs in forests after destruction by fire.

One of the better presentations of forestry issues among the materials reviewed is offered by *Project Learning Tree*. *Project Learning Tree*, which is sponsored by the American Forest Foundation, uses the forest and trees as a focus for activities and lessons. One lesson, for example, asks students to study three designated plots of land for an extended period of time to observe and compare changes that occur in plant growth, density, and types of species (pp. 306-309).



Global Warming

Climate change is a good example of a scientific issue that provides an opportunity to combine science instruction with a discussion of policy implications drawn from what scientists have learned. The materials under review frequently give less attention to improving students' understanding of the science of climate processes than to the politics of mitigating global warming by the reduction of fossil fuel use. Whether or not we experience serious human-induced climate change, the issue of global warming will be with us for some time to come. It merits more serious consideration than it now receives.

There were several common problems with the materials reviewed. First, basic scientific facts about climate, such as for example, the role of water vapor in the greenhouse effect, are not explained. Second, the greenhouse effect is repeatedly confused with global warming.[36] Third, scenarios of what might happen if global temperatures increased as a consequence of human action edge toward the catastrophic without sufficient explanation that such predictions are derived from computer models, observations, and paleo studies that are continually being refined as scientists develop new data and methods and factor in additional variables.

Science Plus, a general science text for middle school published by Holt, Rinehart, and Winston, never mentions that the naturally occurring greenhouse effect is primarily the consequence of water vapor, but it does note other gases such as methane, carbon dioxide, and chlorofluorocarbons (pp. 408-409). Despite its 1993 publication date, the text notes that CFCs

come from aerosol sprays and does not mention its other uses. *Environmental Science: How the World Works and Your Place in It,* from J.M. Lebel, contains good coverage of weather, including the role of solar energy and water vapor, and provides a good introduction to the next section on climate change (pp. 91-116). However, climate change is presented as primarily a policy question; little natural science is included in the discussion.

Addison-Wesley's *Environmental Science Ecology and Human Impact* includes a chapter on global warming that contains surprisingly misleading information. For example, the text notes that, "The most important natural greenhouse gas is carbon dioxide. Methane, oxides of sulfur and nitrogen, ozone, CFCs and water vapor are also greenhouse gases" (p. 366). The text also continually refers to "greenhouse gas pollution," although greenhouse gases are not pollutants any more than food could be considered a poison. The scientific explanation in this section is undermined by the text's failure to present students with the basic facts about how the greenhouse effect operates.

Environmental Science: The Way the World Works, published by Prentice Hall, devotes most of its chapter on climate change to a discussion of the policies designed to avert climate change rather than to explaining the science that underlies this concern (pp. 336-341). With the exception of carbon dioxide, there is no mention of what gases cause the greenhouse effect, no mention of computer modeling and no mention of the interesting uncertainties scientists face in trying to understand climate processes.

Global Warming High School Science Activities from the Climate Protection Institute also fails to give an accurate picture of the greenhouse effect. Overall, however, the book attempts to interest students in doing science at the same time it leans toward the theory of catastrophic human-induced global warming. Used in the proper context and with other sources, this text could be quite effective in the classroom for teaching natural science.

A clearer and more substantive description of the greenhouse effect than the above appears in Holt, Rinehart, and Winston's *Environmental Science.* The role of various greenhouse gases is discussed properly, and there is a useful case study on climate modeling.

Although several of the texts discussed above apparently focus more on the policy aspects of climate change rather than on the science of climate change, authors do not address the important issues of the costs and benefits involved in reducing the use of fossil fuels. LeBel's environmental science text, for example, lists measures that should be taken to reduce carbon emissions, ranging from using mass transportation, to recycling, to planting trees (p. 115). However, students will not understand the scope of the issue unless they also consider the economic costs that will be incurred in transforming a transportation system that relies on fossil fuels for approximately ninety percent of its energy, or that any efforts to reduce greenhouse gas emissions in the industrialized

countries will be overtaken in the next few decades by greenhouse gas emissions arising from rapidly industrializing nations, especially in Southeast Asia.

Global warming is also discussed at the lower grade levels as well. The author of *Think Earth* does a particularly poor job of explaining this issue. Its edition for fifth-grade students presents climate change in the context of pollution, without attempting to use the greenhouse effect to introduce students to natural climate processes or even a simple lesson on weather. Adding these factors should make the issue more interesting and educational.

Global Warming and the Greenhouse Effect, a Lawrence Hall of Science publication for grades seven to ten, contains solid and interesting science along with educational activities. The text includes this refreshing suggestion to the teacher: "Point out that scientists and others studying the greenhouse effect do not know all of the answers.... This is one reason why it is such an interesting subject to study; we are learning right along with the scientists!" (p. 13).

Population

The field of "population studies" encompasses an array of separate and distinct disciplines, ranging from biology and biochemistry (e.g., human fertility and its contraceptive regulation) to applied mathematics (analytical demographic techniques) to economics (study of the relationship between population change and economic development) to sociology and history (study of patterns of fertility decline in Europe and elsewhere over the past two centuries). Because population studies bring together elements of the natural sciences and elements of the social sciences, it presents special challenges to the environmental educator. Whereas relationships examined in the physical sciences are typically universal and immutable (e.g., the conservation of energy), relationships in the social sciences depend critically upon human behavior, which can differ fundamentally in separate settings and over time. If the distinction between natural science and social science components within population studies is not effectively outlined and explained, there is the risk that students will come away applying inappropriate scientific paradigms to modern population questions.

Population issues are covered most extensively in materials produced by advocacy groups such as Zero Population Growth (ZPG), but they are also addressed in many other environmental education materials and particularly in environmental science and biology textbooks.

In some of these texts, "overpopulation" is asserted as a major cause of environmental problems. Addison-Wesley's environmental science textbook, for example, begins its discussion of the topic with the statement that: "Scientists argue that overpopulation threatens the continued existence of humans on earth" (p. 204). In fact, however, "overpopulation" is not a scientific concept utilized in either demography or population studies. In the peer-reviewed scientific literature on population,

"overpopulation" is a term almost never used, owing to its ambiguity.

Holt's environmental science textbook begins with the statement that "almost all environmental problems trace their origins back to two root causes," the "population crisis" and the "consumption crisis" (p. 11). While this assertion avoids the usage of the term "overpopulation," it is nearly as misleading as the statement from the Addison-Wesley textbook.

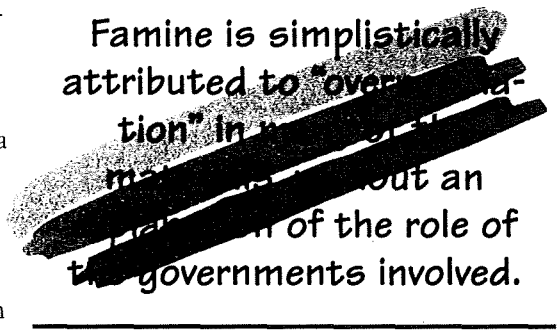
In the texts under review, global population growth trends are consistently depicted in an ominous light, and the uncertainties demographers face in trying to project future population trends are seldom acknowledged. Only a few materials under review mention that the population growth rate is declining throughout the world, even in developing countries, with the exception of sub-Saharan Africa. A number of texts, such as LeBel's environmental science textbook (p. 253), have students calculate the "doubling time" of population as a math exercise. This exercise, though, assumes that population will grow at a constant rate for decades or generations. In historical experience, this has almost never happened. In actual practice, demographers must constantly revise their estimates for future population growth, since demographic techniques offer no reliable method for long-range forecasts of future births. Over the past two centuries, a very general relationship between economic change and population change has been observed: as a country or region's economy improves, fertility levels eventually tend to decline. In Europe, North America, and parts of the Caribbean and high-income East Asia, fertility levels today (if maintained indefinitely) are lower than would be necessary for long-term net population replacement.

While population growth has presented unparalleled pressures on natural resources, discussions of the issues often neglect to mention the reasons for the phenomenon of modern global population increase. Population is growing around the world because of worldwide improvements in health, not because of fertility trends. Between 1950 and 1990, fertility levels declined in almost every region of the world. With the exception of a few current problem areas in the former Soviet Union and sub-Saharan Africa, longevity is increasing and infant mortality is decreasing. Global life expectancy has more than doubled since 1900, and the infant mortality rate has declined by over fifty percent between the early 1950s and the early 1990s. One textbook, Holt's *Environmental Science*, provides an easily understandable explanation of the demographic transition that occurs as health care improves and the birth rate gradually declines (pp. 338-341). The World Resources Institute also provides an impressive curriculum, including databases and overheads, that helps students understand population dynamics.

Some materials present population numbers as fact, without attribution, or discussion of uncertainties, such as the difficulty of estimating trends in war-torn or unstable countries that do not keep accurate records of births and deaths.

Some numbers presented as fact are simply incorrect. For example, Zero Population Growth's *Earth Matters* states that the "approximate number of deaths from the current global famine is 5,000,000 to 20,000,000" (p. 21) and that "20 million Americans do not have enough food to sustain a normal active life" (p. 85). These numbers are much higher than reliable evidence would suggest. Moreover, the implication that hunger is simply correlated to high fertility levels or rapid population growth is incorrect.

Famine is simplistically attributed to "overpopulation" in many of the materials, without an explanation of the role of the governments involved. The recent famines in Africa have been caused or exacerbated not simply by adverse weather or crop failure, but by actions taken by regimes, where food has been used as a weapon, and wars have disrupted agriculture and food distribution. The most severe famines in this century, those in China and the Soviet Union, followed efforts at mass collectivization of agriculture by governments that were cruelly indifferent to the consequences of the programs they promoted. Holt's *Environmental Science* textbook is one of few that at least hints at the more complex causes of famine in Ethiopia (p. 228). Since the goal of environmental education is to help students understand how human actions affect the environment, it would seem particularly appropriate to help them understand the political context of modern famines.



For most of the materials under review, the correlation between poverty and population is not adequately explained, nor the possible non-demographic determinants of differences in economic performance among nations and regions. If "population pressure" were the prime determinant of poverty, one might deduce that Hong Kong would be less developed than Pakistan, since it is far more densely populated; in fact, the reverse is true. As demographic and economic research has demonstrated, the relationship between population change and economic development is subtle and highly complex. Fertility levels and population growth rates are just a few of the many factors affecting income levels and economic growth prospects in any locale, and may seldom be the most important ones (See sidebar: What Happens When Population Grows? We Aren't Sure.).

Poverty, on the other hand, is responsible for many environmental problems faced by undeveloped nations. Deforestation in many underdeveloped countries continues because people have access to no other fuel than wood. Insecure property rights in many nations have led to careless land management, deforestation, and soil erosion.

What Happens When Population Grows? We Aren't Sure.

From *Population Growth and Economic Development: Policy Questions*, National Research Council, Washington, D.C, National Academy Press, 1986.

One important finding of the report is that the evidence regarding the consequences of a change in the rate of population growth is extremely varied, some arguments coming from theory and some from empirical studies. Furthermore, those studies differ widely in quality and scope. Drawing firm conclusions about the overall impact of slower population growth is difficult because the research completed to date is frequently based on limited samples and inadequate data as well as on partial and occasionally inappropriate conceptual models and statistical techniques. The scientific literature contains few adequate studies of the effects of slower population growth in developed countries and fewer still on the effects in developing countries. Consequently, there is much less certainty than we would like about the specific quantifiable effects of different rates of population growth on human capital formation, on physical capital formation in firms, on technical progress and its diffusion, and on the numerous other questions that are addressed in the following chapters.

One text, Globe Fearon's, *Environmental Science: Changing Populations*, provides a thoughtful introduction to current scientific and economic thinking on population change. The text correctly informs the student, for example, of the problems that beset attempts at long-term population forecasts. It also presents the complexity of factors that may influence parents in developing areas to prefer large numbers of children. A number of activities require students to consider the tradeoffs, feedbacks, and interactions involved in both environmental policies and economic development or population change.

Risk Analysis

Some see risk analysis as a useful and much-needed tool. Others see it as a way to justify premeditated murder in the name of profit.

Miller, *Environmental Science*, Wadsworth Publishing Co., 1995, p. 207.

A highly technological nation such as ours requires civic and educational leaders whose understanding of science and technology is sufficient to make decisions based on valid information and rational analysis.

Quoted in *Risk Comparison*, Addison-Wesley, 1990, p. iv.

Environmental science is an applied science, in which information from the natural and physical sciences is used to manage risks to human health and the environment. Risk analysis is the process by which scientific information is distilled so that it becomes useful for making decisions. Difficult decisions, such as how to protect endangered species or what to do about abandoned hazardous waste sites, capture the interest of students. Some knowledge of risk analysis is essential to prepare students to participate as policy makers and informed citizens in public decisionmaking.

Few of the materials reviewed convey key concepts that would help students understand the nature of risk. For example, central to risk analysis is the dose-response (or exposure-effect) relationship. This relationship holds whether studying the effects of chemicals on human health, habitats, or species diversity. The key insight of this relationship is that the likelihood of harm, or the severity of harm, increases with increasing exposure. Very small exposures to substances may have no effect at all, but as the exposure reaches gets high enough levels, virtually any substance or activity can produce adverse effects.

Instead of introducing students to this critical concept, the materials under review focus on enumerating hazards without any discussion of the likelihood or size of the danger. For example, the Prentice Hall environmental science text presents a table of the known health effects, including mutagenicity, teratogenicity and carcinogenicity, of synthetic organic chemicals (Table 11-1, page 276). For each chemical the box under a health threat is checked if it is associated with exposure to that chemical. The table contains no information about the dose (or exposure) that might be necessary to achieve this harm. Students are not told, for example, that aspirin would have checks in many of the health hazard boxes.

Throughout many of the teaching materials considerable attention is paid to the harm that chemicals can cause, with little appreciation for the exposure necessary to elicit the effect. *Going Green*, for examples, notes that, "Even something as healthy as an apple can make you sick if it contains pesticide residues" (p. 32). This focus on hazard, to the exclusion of the actual risk, is misleading.

It is a pervasive failing of these materials that they do not engage students in performing quantitative analyses of evidence or relative risks. Discussions of pesticides, for example, rarely consider the relative costs and effects of alternatives to using pesticides. A few well-known cases such as DDT are used to predict that other (or all) man-made compounds, even where the risk is not yet known or is not indicated by epidemiological evidence, are dangerous. The Prentice Hall environmental science textbook, for example, asserts that many fruits and vegetables contain levels of pesticide residues that "'pose an increased risk of cancer, neurobiological damage and other health problems to children."[37] This assertion is a prime example of focusing on a potential hazard and ignoring the size of the risk. In fact, a recent

National Research Council report found that toxic chemicals that occur naturally in foods may pose a greater health threat than pesticide residues, and that the greatest threat to human health is a poor diet.[38]

The Wadsworth environmental science textbook is one of the few that includes comparative risk information, listing high risk health problems, such as indoor air pollution, and pollutants in water (Table 8-1, page 205). However, students are never told that these risks are small compared to the health risks from smoking or car accidents.

Risk Comparison, published by Addison-Wesley and developed by the Chemical Education for Public Understanding Program, Lawrence Hall of Science, University of California, Berkeley, provides an intelligent and understandable introduction to risk. Students are introduced to the nature of risks through exercises that ask them to consider risks they take in their lives, such as vaccinations. Some exercises, however, understate the role of uncertainty in assessing relative risk, and some exercises rely more on students' perceptions to assess relative risks than on actual data indicating probability of harm.

Waste Management

The Commission notes the extensive use of waste-management issues, especially of the 3Rs (reduce, reuse, recycle), for teaching good civic and responsible environmental behavior at all grade levels. For example, the Indiana Department of Education provides a document for the public schools entitled *Completing the Cycle* as an integrated unit in environmental education and relies on lessons in recycling to teach children responsible actions aimed at material and energy conservation. California has adopted a recycling curriculum, *Closing the Loop*, for instruction on the conservation ethic.

The Commission applauds efforts to teach stewardship and responsibility on environmental issues, particularly at the elementary levels; however, nearly all of the materials reviewed were deficient in substantive content. Unless an especially well trained and dedicated teacher is involved, we see a lost opportunity for instruction that engages the interests of young children for effective learning on a large set of topics ranging from physical science to quantitative reasoning. An especially poor example, complete with a Garbage Gremlin, is the K-6 teacher's guide, *Let's Reduce and Recycle*, produced at the EPA, which is replete with trivial details and essentially devoid of serious content. Unfortunately, in the attempt to make waste management understandable to young children, some materials (e.g., *Think Earth* and *Completing the Cycle)* tend to leave students with the misperception that the 3Rs are easy to implement, that recycling is always cost-effective, and that together they provide a panacea for ridding the planet of unwanted contamination.

Most of the resources reviewed are designed to teach children how to handle garbage and separate what the authors perceive to be recyclable material. There is usually no

meaningful comment on the economic value of engaging in separation and recycling, even at the fifth- or sixth-grade level. More importantly, there is no information about health problems that may be created by handling any types of residues, no urging to wear protective gloves when separating glass bottles from decayed food wastes, no warnings about high pathogen concentrations in the air near compost heaps, no statement that manual materials separation may require not only wearing gloves but also face masks, and no factual information about the history of manual garbage separation that has led to its termination in some European countries.

Instructional materials are readily obtainable from companies engaged in waste management. This type of source material is supplied by industries apparently to correct misperceptions about their environmental stewardship. For example, a teacher's guide from the Aseptic Packaging Council, entitled *Waste Wise*, includes exercises to demonstrate that paper remains the largest source of wastes in landfills (and not plastic or aseptic drink boxes). These materials may well be accurate with regard to scientific and technical data and therefore a useful supplement in classroom teaching. Information on price fluctuations of recycled paper, plastics, colorless glass, aluminum, and other metals is readily available from a variety of sources and could serve as useful instructional material for learning the economics of recycling.

Little needs to be said here about waste-management technologies, which are properly discussed only at the upper-grade levels. Source separation followed by landfilling or incineration are the procedures used. Landfills as potential disease vectors and as sources of methane (an especially potent greenhouse gas per unit of gas) constitute one side of the ledger. Municipal waste incineration with energy recovery meeting EPA limits on emissions described by the use of the maximum achievable control technology (MACT) are an important part of the story. Discussions of environmental equity in facility siting may be used to teach economics and political science. Risk assessments associated with emissions of controlled levels of metals, particulates, congeners of dioxins and furans, etc., constitute challenging topics which should be covered properly at an advanced class level (generally beyond the twelfth-grade) or described in qualitative terms. Appendix B includes an example of the topics that would be covered in a comprehensive unit on waste management.

The Commission notes, however, that texts for all grade levels often miss opportunities to introduce the complexities needed if students are to have more than a shallow understanding of this topic. The 3Rs are an appropriate starting point, perhaps, but to stay at that level too long is a bar to educating students about the difficult issues faced by professionals in the waste management field.

Findings

Study of the environment is an important subject for grades K-12.

The Commission is impressed with ways in which study of the environment can be used to engage and inspire students. The materials under review often use the outdoors as the source for activities and lessons that appear to offer opportunities to teach not only traditional nature studies, but also basic mathematics, social science, science and other subjects.

The Commissioners are aware that introducing environmental education into the curriculum can reduce the time available for teaching basic subjects. The Commission believes, however, that teaching about the environment, if based on rigorous standards, can be an enhancement to, rather than a diversion from, the basics.

Teachers are the key to successful environmental education, but the materials often fail to give them the support they need.

Whether or not students really learn about the environment generally depends more on the teacher than on the classroom materials. Many of the criticisms noted by the Commission may be overcome by a teacher who is aware of problem areas in the texts and can correct them as he or she presents the lesson. A teacher can even use errors to make an important point to the students. The critical role of skilled teachers should not be underestimated.

The complexity of environmental issues, however, makes it unlikely that most teachers would have the expertise to know when, for example, materials include outdated or erroneous information. It is asking too much of even the most energetic teacher to do the kind of research necessary to understand the science, economics, and risk assessments behind environmental issues. It is crucial, therefore, that teacher's guides and textbooks be submitted to experts in the appropriate sciences before they are published to ensure that the materials teachers use are accurate, comprehensive, and understandable.

Teacher's guides and textbooks should include substantial lists of reference sources to help them (and their students) do further research into the topics covered. Moreover, many environmental issues are controversial; indeed, a number of "critical thinking" exercises appear at the ends of chapters or units about environmental topics asking students to do

further research on a topic or to take a position and defend it. For these, reference sources from a variety of viewpoints should be included. Without additional background or data, teachers and students will have to rely on what is frequently a superficial or incomplete presentation of a topic, and they will be unable to investigate the topic with any depth or understanding.

> Many of the criticisms noted by the Commission may be overcome by a teacher who is aware of problem areas in the texts and can correct them as he or she presents the lesson.

Environmental education should not be confused with environmental science, but materials that are not based on the best available science do not promote environmental literacy.

Environmental *science* is an applied science that draws on disciplines such as chemistry, physics, biology, geology, mathematics, and economics. Environmental education, by contrast, is often practiced and defined as citizenship education, aimed at developing awareness and concern about environmental problems.[39]

Teaching good citizenship to students is appropriate. For example, children should learn not to litter and to minimize practices that needlessly consume resources. Students of all ages should have an understanding of the impact of human interaction with the environment.

Students in the upper-grade levels should begin to focus on the *science* upon which environmental education is based. For older students, study of the environment in science classes should reflect scientific methods of investigation and evaluation of evidence. In short, it should be no less rigorous than the study of chemistry, biology, or physics. Discussions of environmental issues would be much richer if students first have a solid introduction to the science and economics to help them understand a problem and proposed solutions. Environmental literacy, particularly for high school students, should include a basic understanding of what is known about the environment.

Environmental education materials often do not provide a framework for progressive building of knowledge.

Many of the most commonly used environmental education programs, such as *Project WILD* and *Naturescope*, are designed to provide multidisciplinary activities that may be incorporated or "infused" into the curriculum in grades K-6 or K-8. Some individual activities are suggested as most appropriate for younger children, while others are indicated as most appropriate for students in upper grades. Usually, the teacher's guides indicate the subject for which the activity is most appropriate, such as science, social studies, or language arts. However, most activities are categorized as science activities.

Although there is debate about whether environmental education should be taught as a separate course or unit, or whether it should be "infused" or integrated into existing curricula, there is generally a commitment among professionals in the field that environmental education should be integrated.[40] According to Bora Simmons, "The rationale for infusing environmental education is compelling: by incorporating environmental education throughout the total curriculum at every grade level, a more comprehensive treatment of environmental concerns can be accomplished."[41] There are also practical reasons: if environmental education is incorporated into an existing curriculum, it does not have to be added as a separate subject to an already crowded schedule.

From kindergarten through eighth grade, students generally are not taught about the environment in a structured way; instead, environmental topics are usually added as supplemental activities to an existing curriculum. Other subjects, such as writing, science, or mathematics, by contrast, are usually taught in a sequence. For example, in physical science, the National Science Education Standards expect that, by the fourth grade, students understand the properties of objects and materials and begin to study light, heat, electricity, and magnetism; in grades five through eight they learn about motions, forces, and transformation of energy. When they are in high school they are prepared to study chemical reactions, structure of atoms, conservation of energy, and interactions of energy and matter.[42] The AAAS's project for science literacy, Project 2061, similarly sets out benchmarks for each grade level.[43]

Because it is often infused across the curriculum, environmental education is not designed to provide a framework for sequential study of applicable topics that will prepare students for a rigorous environmental science course in high school.[44] Some educators have criticized this aspect of the field. Steven Van Matre, Chairman of the Institute for Earth Education, and author of several environmental education teacher's guides, argues that environmental education has "lost a clear sense of direction." He notes:

> Poke your head into most any school today and see how much real environmental education you find going on there. I don't mean a couple of activities (inside or out) led by one or two valiant teachers, I mean focused sequential, instructional programs as a regular, integral part of the whole curriculum.[45]

Study of the environment, such as environmental education, should motivate students to seek further study of environmental science in high school. Most environmental education materials do not provide such motivation.

Environmental education has become needlessly controversial.

The Commission is aware that environmental education is not the only aspect of American education that is the subject of criticism.

Previous commissions have studied biology textbooks,[46] history textbooks,[47] education for teachers,[48] among other educational elements, and found them all in need of reform.

Environmental education is controversial, however, and perhaps inevitably so, in part because there are often opposing views on environmental questions. Everyone wants a clean and healthy environment; how best to achieve this goal is the subject of continuing debate.

There are other reasons for controversy as well. According to many environmental educators, the "primary goal of environmental education is to encourage people to engage in more pro-environmental behaviors."[49] One environmental educator, Louis Iozzi, chairman of the Department of Education, Cook College, Rutgers University, notes that:

> Whereas knowing how to improve environmental quality is important, possessing such knowledge certainly does not ensure that one will be motivated to take action. Moreover, one may not necessarily use such knowledge to select the environmentally "sound" or responsible choice from among the many possible alternatives.[50]

Environmental education in grades K-12 has become controversial in part because it has been defined to include encouraging "responsible environmental behavior." There is, however, no clear consensus among parents, teachers, or within the community as a whole as to what constitutes the environmentally "sound" choice or to what extent schools should encourage students to take actions on behalf of an environmental cause. The EPA-funded *EE Toolbox* recognizes this problem when it suggests that the "environmental education community's identification of skills and values related to behavior change as an integral component of environmental literacy puts it at odds with traditional educational practice."[51] The State Education and Environment Roundtable, a Pew Foundation-funded group of state educators, concludes in a 1995 report that, "The predominant thrust of environmental education appears to have gone from its historical 'educational' perspective to a role in political advocacy...."[52]

Harold R. Hungerford, one of the founders of the environmental education field, and Trudi L. Volk, Professor of Curriculum and Instruction, Southern Illinois University, define an environmentally responsible citizen as one who has:

> (1) an awareness and sensitivity to the total environment and its allied problems [and/or issues], (2) a basic understanding of the environment and its allied problems [and/or issues], (3) feelings of concern for the environment and motivation for actively participating in environmental improvement and protection, (4) skills for identifying and solving environmental problems [and/or issues], and (5) active involvement at all levels in working toward resolution of environmental problems [and/or issues].[53]

If developing environmentally responsible behavior is the primary goal of this field, a

Environmental Science and Environmental Education: What is the Difference?

Environmental science is a multidisciplinary subject that applies concepts from physics, chemistry, biology, and the earth sciences. To a lesser extent, environmental science also draws from the social sciences, such as sociology, political science, history, psychology, and (most commonly) economics.

Environmental education is broader than environmental science. It is generally defined to include environmental knowledge from the natural and social sciences, but also calls for developing awareness of and concern about environmental issues. Environmental education includes an "action" dimension; it asks that students learn, and be encouraged, to "do something" about environmental issues. But the "do something" is not well defined. Environmental education materials should not be designed to direct students toward any particular action to resolve environmental issues. Environmental education, if successful, will provide the tools with which responsible decisions can be made.

successful environmental education curriculum will result in students who are motivated to be advocates for the environment.[54] However, traditional educational strategies are not sufficient to provide this motivation.[55] According to Hines, Hungerford, and Tomera:

> In situations in which individuals do not possess those personality characteristics which would lead to the development of a desire to help alleviate environmental problems, these individuals may be enticed into behaving responsibly toward the environment by the application of behavioral intervention strategies.[56]

As noted, there is some debate within the field about the role of behavior modification in environmental education. One critic, Australian science and environmental educator Ian Robottom, argues that the tendency of environmental educators to emphasize behavior modification contradicts one of education's primary aims—the development of independent critical thinking.[57] Clifford Knapp, in an article in the NAAEE's newsletter, addressed this question:

> The field of EE seems mired in a period of serious internal turmoil. At the same time, we are under fire from critics who believe we are teaching the wrong worldview. The crux of the problem lies in an inherent contradiction between how we define the field and what we say the teacher's role should be when teaching about the environment.[58]

These different views about the purpose of environmental education are reflected in the materials reviewed by the Commission. Some materials are clearly designed to promote certain kinds of environmentally responsible

behavior, from recycling, joining environmental organizations, to sending letters to Congress supporting amendments to the Clean Air Act, while others provide straightforward introductions to environmental topics.

For children in lower elementary grades (K-3), environmental education materials often emphasize personal responsibility, such as not to litter, not to waste water, and to turn off the lights when they leave a room. The *Think Earth* unit for preschool children, for example, is centered around a video and pictures of a happy Earth who smiles when children recycle and sneezes when they do not.

Promoting good personal behavior as a civic responsibility is to be applauded; but promoting a particular kind of environmental activism is not.

For upper elementary and middle school students, there are some materials, such as *Eco-Inquiry, Ten Minute Field Trips,* and the *Ecology Discovery Activities Kit,* that offer a straightforward introduction to ecology, with minimal discussion of environmental issues or actions. Other popular materials, such as *Project Learning Tree, Project WET, Project WILD* and *Aquatic Project Wild,* combine study of the natural world with discussions of environmental issues and suggestions for activities that will "instill the confidence and commitment to take responsible action on behalf of the environment."[59]

But other widely used teacher's guides, books, and textbooks aggressively promote change in behavior and solicit advocacy from students. *Living Lightly in the City*, which is recommended by the *EE Toolbox* and the NSTA, asks fourth- and fifth-grade students to write state legislators requesting their support for tax incentives for those who build solar collectors or wind generators (p. 185). *Think Earth* asks students to fill out a questionnaire with their parents in which they are to check activities that either "I do this now" or "I'll plan to do this." Activities range from "I use only the paper towels, tissues, and napkins I really need," to "I volunteer to help environmental groups take care of the Earth."

Supplementary guides are frequently recommended by environmental education professionals that provide additional pressure to adopt a "greener" lifestyle. *Going Green*, for example, which is recommended by Prentice Hall's middle school science textbook and NSTA's teacher resource handbook, suggests a number of ways children can become "green consumers," ranging from not eating meat, eating organically grown vegetables, and avoiding fast-food restaurants.

While the Commission recognizes that the role of the school system is, in part, to promote good behavior toward fellow humans and towards nature, it does not believe that it is the role of the school system to promote a particular point of view or encourage political

advocacy by the students. Promoting good personal behavior as a civic responsibility is to be applauded; but promoting a particular kind of environmental activism is not. If materials developed for use in K-12 schools focus on developing knowledge and understanding of options and tradeoffs, environmental education at all grade levels will be more effective and less controversial than is currently the case.

Environmental education materials often fail to prepare students to deal with controversial environmental issues.

In a study of the state of biology education in the U.S., the National Research Council examined courses that integrate science and society issues, such as environmental education. The NRC noted that, because these courses do not follow a study of basic sciences but rather replace science courses, they fail to provide sufficient grounding in fundamental scientific concepts. The report concludes,

> We see danger in formats that confuse scientific knowledge with political, economic, and moral judgment. The contribution of science to the solution of societal problems can be understood only when there is considerable understanding of science itself.[9]

The NRC study points to an area of concern noted by the Commission. As discussed at some length above, environmental education is often criticized for encouraging advocacy in the classroom, and in fact, some of the materials reviewed by the Commission tend to advocate a particular viewpoint. The Commission, however, does not suggest that teachers avoid bringing controversial topics into the classroom. We believe that, at the appropriate grade level, environmental courses should challenge students to think critically about controversial environmental issues. However, the materials under review too often fail to provide enough information to arm students with the knowledge they need to understand and discuss environmental controversies thoughtfully.

Few of the environmental science high school textbooks reviewed by this Commission offer enough rigorous science to allow students to make responsible environmental choices. For example, Wadsworth's *Environmental Science* offers "critical thinking" questions at the end of each chapter. Some of the questions are good, but the student will be at a loss to answer them on the basis of data provided in the text. On the other hand, Prentice Hall's *Environmental Science: The Way the World Works* is more heavily weighted toward discussions of environmental issues than toward coverage of the natural science that would help students understand the issues. The text concludes each chapter with a list of suggestions, entitled, "What You Can Do," rather than asking the students to think critically about what they have learned. One teacher's guide, *Critical Issues in Today's World*, published by Sopris West, provides an excellent model for identifying information needed for environmental decisionmaking, complete with initial directions on how to locate and use that information.

Using the Tools of Quantitative Analysis

Students will be better prepared to participate in public policy discussions of environmental questions if they have an understanding of the tools of quantitative analysis. Many secondary level materials do not introduce students to basic statistical tools for analyzing quantitative evidence, although quantitative evidence is often used to make a point. An introduction to basic concepts such as probability, significance tests, random sampling, risk assessment, and correlation is essential. The American Association for the Advancement of Science's *Benchmarks for Scientific Literacy* suggests that all students understand these basic statistical concepts.

One of the most common misuses of statistics in public policy debates (and in materials reviewed by the Commission) is to confuse correlation with causation. Correlation is an observed relationship between two phenomena; for example, A changes at the same time that B changes. This correlation alone, though, does not mean that either phenomenon is caused by the other: A could cause B to change; B could cause A to change; something else, C, could cause them both to change; or they could all have changed at the same time by chance.

At the heart of the global warming debate is the possible correlation between the amount of CO_2 in the atmosphere and global climate change. Has the increase in CO_2 in the atmosphere affected global temperatures? Are observed variations in global average surface temperature a result of natural climate variability? A number of authors simply assert that there is a correlation between CO_2 and global temperature without explaining the uncertainties. Without further information, students will have a hard time understanding one of the most interesting and possibly most important debates of our time.

Helmut Sies took a humorous approach to this problem in *Nature* with a graph and data that clearly indicate a very high correlation between the number of babies born in Germany during the period 1965-1980 and the number of pairs of brooding storks during that same period. Do storks bring babies?

Some familiarity with quantitative methods is also required to help students analyze environmental problems (see sidebar: Using the Tools of Quantitative Analysis). Unfortunately the authors of many of these texts miss opportunities to use environmental topics to introduce students to quantitative analysis. *Global Warming: Social Studies Activities*, from the Climate Protection Institute, for example, asks students to conduct a survey about transportation use (p. 16). There are no instructions, though, about how to select a representative sample, or about the significance of the results in relation to the entire sample, so that students can learn how to assess the validity of data.

If environmental education is to succeed in creating a generation of well-informed citizens, it must prepare students to make responsible environmental decisions. It cannot do this without presenting the science involved, with due attention to comparative risks, and economic and social tradeoffs.

Environmental education materials often fail to help students understand tradeoffs in addressing environmental problems.

Environmental problems often are not easy to mitigate and solutions are often expensive. A key lesson from the last quarter century of environmental risk management is that tradeoffs are everywhere. Tradeoffs arise when an action taken to reduce a risk actually creates risks of its own. A clear example is provided by the decision of sanitation engineers in Peru to substantially reduce the amount of chlorine used in disinfecting drinking water. The engineers' goal was to reduce the potential cancer risk posed by disinfection by-products, such as chloroform, that form when natural organic materials in water react with chlorine. The new level of chlorine was too low to kill the microbes in the water adequately, leading to a cholera outbreak in 1991 that eventually killed thousands.

Many environmental teaching materials fail to convey the tradeoff of one risk for another that pervade environmental management efforts. Instead, in descriptions of actions to reduce environmental damage, textbooks often suggest that the solution is obvious and that people are simply not taking action. This has the unfortunate result of making adults look either inept or irresponsible because they refuse to take the actions necessary to save the environment or to protect public health. Instead, most environmental management questions are rife with difficult scientific issues, uncertainties, competing

"Can" and "May" Can be Overused

The Commission notes imprecision in many materials, particularly in those that are more concerned with warning students about environmental threats than in educating them about the environment. Teachers should be wary of texts that continually employ words such as "can" and "may" to describe a contemporary environmental issue, but fail to provide any substantial information on "why" or "how." For example, here is how *Nature in Danger,* uses these imprecise terms to highlight the threat from pollution:

> People create waste in many forms. It *may* be solid garbage or sewage from homes, poison gases from industry smokestacks, or dangerous chemicals poured into nearby waterways. Most of these wastes end up in the local environment. Pollution *can* destroy entire habitats, or it *may* simply kill certain members of a food chain. Over time whole ecosystems *can* be damaged by such pollution.
>
> *Nature in Danger*, p. 11 [italics added].

Pollution can or may do all of these things, or it can or may do none of them. The lesson provides no context, nor does it even introduce the idea that different substances have varying impacts on the environment. The imprecise language shifts the burden to teachers to discover a way to use this lesson for educational purposes.

social values, and ubiquitous tradeoffs.

For example, LeBel's environmental science textbook titles its chapter about alternatives to pesticides, "Integrated Pest Management—A Better Way to Control Pests" (p. 287). The discussion on agricultural pesticide use suggests that biological controls, such as predator species for pests, are a ready solution to the problem of "toxic" pesticides. However, the presentation does not discuss the risks of using biological controls. Predator species may control pests in some circumstances, but if the predator is not effective (and only a small fraction is effective) a farmer may suffer significant crop losses. Another potential risk may occur from introducing a predator species that becomes a pest in its own right and damages other wildlife in the area, such as has been the cases with the small Indian mongoose, which has caused the extinction of some reptiles in the West Indies.

Balanced against these risks should be a sound assessment of the risks of pesticide use. Many pesticides (especially herbicides) are less acutely toxic than table salt. The evidence for long-term human health risks from pesticides is drawn entirely from high-dose studies on mice and rats, and there is considerable controversy concerning the applicability of such data to human populations.[61] While the risk to human health may be minimal, the risks to the ecosystem from pesticide use must also be considered. Rather than implying that there are easy answers, teaching materials should present students with the difficult tradeoffs that farmers face.

Virtually every environmental issue presents an opportunity to engage students in analyzing tradeoffs. If the tradeoffs are not considered, students will be left with simplistic and misleading perceptions of issues. For example, high per capita energy use in affluent nations permits a higher standard of living in terms of health, comfort, and leisure. Where should sacrifices be made if we want to reduce our level of energy use? As noted above, topics such as recycling or alternative sources of energy are best understood if students have some understanding of the costs and benefits involved.

A few teaching materials do a very good job of introducing students to the tradeoffs inherent in environmental decisions. *Plastics in Our Lives,* from the Chemical Education for Public Understanding Program at the University of California, Berkeley, has students consider alternative ways to carry groceries: paper bags, plastic bags, and mesh or cloth bags. Students learn about the different energy requirements for making each type of bag, how each is recycled and the durability and capacity of the bags. They create a matrix of the scientific evidence and then discuss which factors might be important and deserve greater weight in a decision. From this simple exercise students learn that few decisions are straightforward, that quantitative scientific information is necessary, and that social values are key to good decisions.

Factual errors are common in many environmental education materials and textbooks.

In its review of environmental education materials and textbooks, including resources by Federal agencies and those recommended by

professional education and science groups, the Commission found in a number of the materials either errors, failure to point out the uncertainties inherent in the interpretation of complex physical data, misleading presentations of data, or errors of omission.

The Commission was troubled by the number of factual errors in both environmental education materials and in textbooks including resources prepared or recommended by Federal agencies and those recommended by professional education and scientific groups. These errors seem to stem from insufficient review by professional scientists.

One of the best books on the issue of forests, The Great Yellowstone Fire, is published by Little/Brown Company for the Sierra Club, an environmental group.

Authors of most of the educational materials that this Commission reviewed are not scientists or economists. Environmental science, upon which environmental education is based, draws upon several different scientific disciplines, and theories about environmental phenomena are continually being revised as new data become available. It is understandable that authors who are not scientists will have difficulty understanding the complex science behind phenomena they are discussing and staying current with new thinking in the field. However, factual errors should be corrected in the review process.

Even some commercial textbooks that list scientific reviewers or consultants on their editorial page contain erroneous or dated information that "jumps off the page" to a knowledgeable reader. Either these reviewers provided only a cursory review, or non-technical editing after the scientific review resulted in the misleading or imprecise presentations. For example, Prentice Hall's middle school text, *Ecology: Earth's Natural Resources,* cites a figure for oil production in the U.S. that is incorrect by a factor of 10 (p. 19). Possibly the authors meant total energy *use* in barrels of oil equivalent rather than *oil production.*

LeBel's *Environmental Science: The Way the World Works* provides a substantive discussion of many environmental topics. It is flawed, however, by inclusion of much dated information, such as the presentation of the relationship between biological diversity and stability.[62] One Commission member noted that this text is a "perfect example of a situation where Ph.D.-level researchers could have proofed this book and removed the problems without damaging the many good features."

Teachers will perhaps take into account that advocacy or industry groups may be inclined to select evidence that is most persuasive for their point of view, and therefore, they should make sure that students also have access to other information as well. Selective presentation of evidence for the purpose of persuasion is, however, intolerable in textbooks labeled as science textbooks.

The Commission did not find any correlation between the type of publisher and the quality or accuracy of the materials. One of the best books on the issue of forests, *The Great Yellowstone Fire*, is published by Little Brown for the Sierra Club, an environmental group. The World Resources Institute, another environmental group, provides some excellent materials for teachers that are generally accurate in their presentation of population issues.

The Commission found many excellent materials during its review process, some of which nonetheless contained errors that could have easily been corrected through a substantive review process. The multidisciplinary nature of environmental educational materials makes it critical that a broad panel of experts be solicited as reviewers. A biologist, for example, may not be familiar with developments in the field of alternative energy sources, and an energy expert may not be conversant with the latest theories about species extinction. Environmental science textbooks, in particular, should be reviewed by experts in all of the areas covered in the text.

Many high school environmental science textbooks have serious flaws. Some provide superficial coverage of science. Others mix science with advocacy.

As school districts around the country have begun to add environmental science courses to the high school curriculum, publishers have responded to the growing market. Of the twenty-two states that adopt textbooks at the state level, thirteen have adopted environmental science textbooks.

Some of the high school environmental science textbooks reviewed by the Commission appear to aim more at persuasion than instruction. Others provide an introduction to environmental issues, without attempting to help students understand the scientific or economic underpinnings of the issue.

One of the most troubling examples of the tendency to mix advocacy with science is *Environmental Science: Working with the Earth*, written by G. Tyler Miller and published by Wadsworth. This text is recommended by the EPA-funded *EE Toolbox*, and has been adopted by Texas and a number of other states. The textbook begins with a discussion of the "crisis of unsustainability" faced by the earth and calls for an "Earth-wisdom worldview." To define "Earth-wisdom," the text quotes David Foreman, founder of EarthFirst!, "When a chain saw slices into the heartwood of a two-thousand year-old Coast Redwood, it's slicing into my guts... Madmen and madwomen are wrecking this beautiful, blue-green, living Earth" (p. 36).

This introduction sets the tone for the remainder of the text. Throughout, the author cites the published literature selectively and without proper references in order to justify his personal recommendations.[63] Although entitled an "environmental science" text, the author announces his intention to "provide a readable and accurate introduction to environmental science *without the use of mathematics or complex scientific information*" [emphasis added] (p. v).

Respecting the Scientific Process

Environmental education is broader than environmental science. It is applied science and applied economics, motivated by public spirit. Commissioners found several problems in the way science is treated in the materials studied.

Science is frequently presented as omniscient. Time after time texts seem to imply that science is prepared and able to eliminate most risks or has settled on the answer to environmental problems. Since the materials so often ignore the scientific uncertainties concerning such issues as species extinctions, students are led to the conclusion that all that is needed to avert environmental threats is to consult a qualified scientific expert. Scientists know, however, that they do not have all the answers and that, indeed, even in areas where they are quite assured that they understand the technical aspects of an environmental concern, science alone does not provide a certain remedy.

Missing from many materials is any description of the *process* of science: observation, analysis, hypothesis, prediction, and test of prediction (which then is incorporated into the body of science, or abandoned, depending on the results). There is little hint that at the heart of science is the acknowledgement of the capacity for error. Many middle- and secondary-level textbooks present science merely as a set of facts. How the facts are arrived at, the relative importance of the facts, and to what extent they are indeed facts and not theories, scenarios, or hypotheses, are often ignored.

Where environmental education draws on science, the science is often not carefully portrayed. For example, activities in some materials are presented as scientific experiments although they are designed more to illustrate a point than for scientific inquiry. For example, *Science Insights*, a middle school science text, concludes a brief discussion of acid rain, illustrated by a photograph of a dying forest, with the simple caption: "Experiment in which two sets of seeds are watered, one set with normal water and one set with water mixed with vinegar." There are no instructions about testing the pH of the "normal water" prior to the test, or even whether the water should be tap water, distilled water, or rain water. Nothing in the text indicates that students will learn that rain water is naturally slightly acidic; no explanation is given for the pH scale or how it is derived.

Living Lightly includes an interesting exercise that asks fourth to sixth graders to assume the role of extraterrestrial archaeologists from the future who are studying "planets where we believe life once existed." The teacher is instructed to visit the site ahead of time and, "if lots in your area do not have sufficient artifacts... you may want to add some before students arrive for the activity."

If students are to come to respect the scientific process, they must be exposed to far better experiments than these.

Indeed, the author misses every opportunity to reinforce, apply, and motivate the study of science. Where the text touches upon scientific discussions, it stops short of teaching and presents mere glossaries of terms or taxonomies of species. For example, in mentioning radioactivity the text fails to make the connection between half-life and decay rate, a connection vital to consideration of nuclear wastes.

Other environmental science texts frequently combine superficial discussions of environmental science with lists of suggested political and social responses. The Addison-Wesley text, *Environmental Science: Ecology and Human Impact,* for example, recommends that students send funds to environmental groups and become green consumers (with the help of *Going Green*, which it recommends).

Although other environmental science textbooks reviewed by the Commission are less overtly partisan than the Wadsworth textbook, many share one defect: They simply do not teach environmental *science.*[64] Several environmental science textbooks, such as those published by Addison-Wesley and Holt, Rinehart, and Winston, provide a colorful, graphic-laden but simplistic catalog of facts and theories about the environment. Kendall/Hunt's *Global Science: Energy, Resources, Environment* is an exception; it pays reasonable attention to the actual science in environmental science. Another Kendall/Hunt text, *Biological Science: An Ecological Approach,* provides a substantive introduction to the science of ecology.

Environmental science, particularly at the high school level, will not be taken seriously as a field of study until it becomes a rigorous, scientific endeavor. Study of the environment can be an exciting way to engage students in hands-on scientific investigation of a topic that is interesting and relevant. For this, teachers need the support of substantive and challenging high school environmental science textbooks. Today, teachers have almost nowhere to turn for such a text.

Bora Simmons, president of the NAAEE, notes, "Where examples of poor EE practice are found, we must be proactive to address the specific situations."

There is no relationship between the quality of the material and the authoritative recommendations that accompany the publications.

Educators should be aware that recommendations by even the most respected professional organizations are no guarantee of the accuracy or quality of the environmental education materials. The NSTA's environmental education resource handbook suggests *Going Green,* which contains a number of misleading statements, such as that acid rain "poisons fish" (p. 14) and begins with a picture of the Statue of Liberty under water (p. 9). The EPA-funded manual for environmental education,

EE Toolbox, recommends the problematic Wadsworth environmental science textbook, as well as *Earth Matters*, the ZPG publication that was considered to be one of the most flawed materials reviewed by some members of the Commission.

These professional organizations have access to considerably more authoritative scientific expertise than does the average teacher, and their publications carry weight when teachers are trying to sort through the enormous number of materials that are on the market. Professional organizations such as NSTA and government agencies such as the EPA should take their obligation to foster quality education seriously by ensuring that publications they sponsor or produce recommend only those educational materials that are accurate.

The NAAEE recognizes that there are problems with accuracy and objectivity in some materials and texts.[65] Bora Simmons, president of the NAAEE, notes, "Where examples of poor EE practice are found, we must be proactive to address the specific situations."[66] To that end, NAAEE has been working for the last two years to develop standards for environmental education materials and, when the standards are approved, will use them to evaluate texts and materials. The Commission applauds this effort as a needed step in a positive direction.

Recommendations

Environmental educators should place primary emphasis on the acquisition of knowledge.

To participate as knowledgeable citizens, students need a sound education that helps them distinguish between science and opinion and that enables them to assess evidence offered in support of public policies. Environmental education should prepare the next generation to take part in shaping environmental policies.

The field, however, is full of texts and teacher's guides that involve students, even in lower grades, in environmental "decisionmaking" and environmental activities before they have sufficient background in science and economics to understand the issues on which they are recommending action. Students should begin with a study of the environment before they are asked to take actions to save it.

> Eight-year-olds should not be asked to become warriors or worriers. Children have much more important work to do: Watch ants. Grow flowers. Dance between the raindrops. This is sacred work, and childhood needs to be preserved just as much as rain forests and wetlands."
>
> Michael Weilbacher, *E* (December 1994)

Students in the lower elementary grades should begin the study of science with the study of the natural world.

A number of excellent materials introduce students in the early grades to the world around them and help them to develop the skills they will need in later grades as they begin a substantive and quantitative study of science. Skills such as observing, classifying, and making logical inferences are easily taught using the outdoors as the laboratory. Natural and human habitats can be used to observe nature and natural processes as well as human interactions with the natural and human-built environments. Taking care of plants or small animals in the classroom is another popular approach to introducing young students to relationships and natural cycles. Young children have an immense curiosity that leads them naturally to scientific inquiries; questions children ask about the world are the beginnings of scientific learning.

While teaching good citizenship skills, such as conserving water or energy and properly disposing of trash, is useful and appropriate, it should complement, not supplant, nature study for young children.

Schools should consider teaching environmental education as an upper-level multidisciplinary capstone course integrating what students have learned in science, social studies, and other upper-level courses.

Environmental decisionmaking exercises are an integral part of many environmental education curricula, even those for young children. Students are often asked to offer opinions about environmental questions before they have the intellectual tools to help them understand the issues. In considering the question of science-technology-society courses similar to environmental education, the National Research Council (NRC) finds that, "they typically replace basic science courses, and that results in both a dilution of fundamental knowledge of basic sciences and a lack of the scientific breadth needed to study interdisciplinary topics more than superficially."[97]

The Commission agrees with NRC's proposal that courses such as environmental education that integrate science and social issues be taught as an upper-level capstone course. Such a course would permit students to apply what they have already learned in biology, chemistry, and physics courses, with input from social studies, economics, and political science courses for an in-depth and thoughtful investigation of an environmental issue. The Commission recognizes that such a course is an ideal, and that it may be difficult to add such a course to the curriculum. Success of this course assumes that students will have received adequate preparation by studying environmental topics and environmental science in grades kindergarten through twelve. Because of the interest that many students have in the environment, an upper-level capstone course could provide them with an opportunity for a thoughtful, in-depth study of environmental issues, and possibly motivate them for further study in college.

Publishers should also make sure that qualified experts review textbooks after they have been edited.

Professional scientific and educational organizations such as the AAAS and NSTA should recommend educational materials only after a detailed, substantive review by experts has found them to be accurate.

It is an impossible task for teachers with a full class load to evaluate the vast array of environmental education materials. Moreover, judging the quality of these materials requires scientific expertise in complex and multidisciplinary fields. Teachers, quite properly, rely on publications produced by respected professional organizations such as the NSTA and the EPA for suggestions for materials to use in the classroom.

Any professional organization or government agency that suggests, recommends, or lists available teaching resources must recognize

that in so doing, the prestige of the organization is transferred to and stands behind those resources. If authoritative voices in the field do not now have a substantive expert review process in place, they should establish one before recommending or suggesting educational materials.

Publishers must reevaluate their peer review process for environmental science textbooks and environmental educational materials.

High school environmental science textbooks integrate a number of scientific disciplines. Scientific reviewers from all relevant disciplines should participate in the review of such textbooks to help ensure their accuracy, and publishers should take their reviews seriously. Publishers of supplemental environmental education materials that cover a range of environmental topics must also solicit reviewers who have expertise in the areas covered. In view of the importance of providing a quality education for the next generation, professional scientists, particularly research scientists, have a duty to become more involved as reviewers of resources for the K-12 classroom than they are now.

Publishers should also make sure that qualified experts review textbooks *after* they have been edited. The salutary attempt by publishers to make science textbooks accessible to a broad audience of students can result in explanations of natural phenomena that are misleading or erroneous. Good science writing can be both clear *and* precise.

Publishers of education materials should not underestimate the ability of children to be challenged and to learn.

Textbook adoption committees and professionals responsible for selection of materials at the state and local level should ask scientists, economists, and other experts, in addition to parents and teachers, to review educational materials for accuracy.

States that adopt textbooks for use in their schools usually convene committees to review available textbooks including environmental science textbooks for middle and high school courses. Most often, committee members are teachers in the field, and sometimes parents are as well, but rarely are qualified scientific experts asked to participate. Every state has a research university, and many communities have universities and colleges to which they can turn for assistance. Professional research scientists should work with state and local education committees and officials to review educational materials for scientific accuracy. Scientists can also play an ongoing role in improving science education in the schools by recommending current materials in environmental science, answering questions from teachers and students, and visiting classrooms.

Environmental education materials at all levels should provide more substantive content in natural science and social science than they now provide.

Environmental education programs that are designed for children in grades K-8, or even K-12, should consider developing more substantive materials than they currently provide. Activities that are classified as science activities for fifth through eighth grades should be consistent with the criteria for scientific inquiry as set out in the National Science Education Standards, and should motivate students to acquire a deeper understanding of the science.[58] Publishers of education materials should not underestimate the ability of children to be challenged and to learn.

Environmental science textbooks for high school courses should be revised to introduce students to environmental science in the same way that biology or chemistry textbooks introduce high school students to the study of those sciences. These textbooks should provide a rigorous, substantive introduction to environmental science rather than, as many now do, simply a catalog of environmental facts and issues.

> Teachers will not be able to provide students with a substantive, rigorous, experiment-based environmental science class if they do not have the background necessary to do so.

Teachers need substantive preparation in science, economics, and mathematics to teach environmental education.

Commission members are not experts in educational reform or teacher preparation. However, several recent studies have pointed to the need for improvements in science education for teachers. The National Commission of Teaching and America's Future reported that many science teachers do not have adequate preparation for the classroom. Thirty-seven percent of science teachers do not have a major in science; for schools with a high percentage of minority students, the numbers are worse — fifty-eight percent of science teachers do not have a major in their field.[59]

The National Research Council also noted weaknesses in science education for America's teachers. Elementary teachers, in particular, are expected to be generalists; most of their coursework consists of pedagogy classes. Often their only science course is one that has been designed for them, such as "biology for elementary education majors." Even secondary level science teachers have little opportunity to engage in actual scientific inquiry; most academic departments offer introductory science

in large lecture courses with little or no opportunity for scientific research and hands-on laboratory work. The NRC states that, "A high school curriculum that treats science as a *process* for knowing about the world can be successful only if teachers have a deep understanding of that process themselves."[7]

Teachers will not be able to provide students with a substantive, rigorous, experiment-based environmental science class if they do not have the background necessary to do so.

Publishers of several popular programs, such as *Project Learning Tree*, *Project WILD*, and *Project WET*, provide training to show teachers how to present the activities included in their teacher's guides. This is an important effort that helps to improve teaching at the elementary level. However, few secondary level teachers attend these training sessions.[8] Further educational opportunities for high school science teachers are needed to help them prepare for teaching environmental science and upper-level ecology courses.

An independent review process conducted by experts from the areas covered in environmental education should be established to perform ongoing content evaluations of curriculum in this field.

A variety of groups have executed and continue to perform evaluations of environmental education teaching materials. The California Department of Education has published six compendia of reviews of environmental education materials. The Textbook League, a California-based group of scientists and science writers, publishes a newsletter with reviews of science textbooks (including environmental science textbooks). The NAAEE is currently conducting a review of materials according to the standards it is developing. However, there is no continuing effort by a panel of experts from various fields, such as that brought together in this Commission, to review the substantive content (as opposed to the pedagogical approaches) of environmental materials reaching the nation's K-12 classrooms.

Currently, teachers have nowhere to go to help them judge the content of environmental education materials. Teachers cannot possibly master the details of this multidisciplinary field; they need access to current, and subject-specific reviews of materials they might consider using in their classroom. These evaluations should be readily available to them on the Internet and should be consulted by state and local education officials responsible for selecting and approving materials for schools.

Conclusion

When these recommendations are implemented, environmental education will be stronger, less controversial, and will make a greater contribution to American education. All of us, not just environmental educators, have a role to play in ensuring that children become knowledgeable stewards of our natural resources. In effect, this report represents a call from a group of professional scientists, economists, and educators to our colleagues asking them to join us in improving the content of materials that reach America's classroom.

Children will inherit many challenges in the decades to come. We must help them build the knowledge and skills they need to confront those challenges. Too often environmental education materials and environmental science textbooks used in schools today focus more on developing awareness of and concern for environmental problems than on building knowledge. Yet studies of environmental education clearly show that students do not lack concern, they lack understanding. The environmental problems of the day will change over time, but the environmental literacy gained in schools will last a lifetime.

Endnotes

[1] See, *e.g.*, Hungerford, H., "Response to a President's Message," *Environmental Communicator* 26 (July/August 1996): 14. Hungerford notes that, "Unfortunately, environmental educators, for one reason or another, tend to stop short of good science in their instructional planning and delivery."

[2] See, *e.g.*, Schmidt, K., "Green Education Under Fire," *Science* (13 December 1996): 1828-1830; Adler, J., "Little Green Lies: The Environmental Miseducation of America's Children," *Policy Review* (Summer 1992): 18-26. Poore, P., "Enviro Education: Is it Science, Civics—or Propaganda?" *Garbage* (May 1993): 26-31.

[3] Riechman, D., "Critics Say Students Urged to Become Eco-Activists," *Bennington Banner* (16 November 1996); Holt, T., "Growing Up Green: Are Schools Turning our Kids into Eco-Activists?" *Reason* (October 1991): 36-41.

[4] A tradition of popular reporting of environmental-scientific issues was initiated in 1864 by George Perkins Marsh's "Man and Nature" and was continued by, among many others, John Muir's 1912 "The Yosemite," Paul Sears's 1935 "Deserts on the March," Stuart Chase's 1936 "Rich Land Poor Land," William Vogt's 1948 "The Road to Survival," and Aldo Leopold's 1948 *Sand County Almanac*. In addition to Carson's book, the Club of Rome's *The Limits to Growth* and Paul Erlich's *Population Bomb* were influential in generating popular concern in the late 1960s and early 1970s.

[5] Knapp, C., "A Response to Bora Simmons's Recent President's Message," *Environmental Communicator* (November/December 1996): 12.

[6] Adopted at the 1977 United Nations Intergovernmental Conference on Environmental Education in Tbilisi, Georgia (former USSR).

[7] According to a 1994 Roper-Starch poll conducted for the National Environmental Education and Training Foundation, seventy percent of students polled reported learning most about the environment from television, particularly nature programs.

[8] *Teen America's Environmental GPA* (November 1992), quiz administered by Roper Organization for S.C. Johnson & Son, Inc. The quiz was designed to test environmental *knowledge* with questions for which there were known factual answers, not *attitudes* about problems. The report notes that, in retrospect, the test was probably a tough one, and that "coming up with questions for which science had discovered proven answers was itself a difficult process...." (p. ii).

[9] Hausbeck, K.W., Milbrath, L.W. and Enright, S.M., "Environmental Knowledge, Awareness and Concern among Eleventh-Grade Students: New York State," *Journal of Environmental Education* 24, 1 (1992): 27-34.

[10] Gambro, J. and Switzky, H., "A National Survey of High School Students' Environmental Knowledge," *Journal of Environmental Education* 27, 3 (1996): 28-33, 31. According to the NAAEE newsletter, the recent Third International Mathematics and Science Study (TIMSS) indicates that American students score higher on environment-related questions than students in the other nations tested. From Hollweg, K., "Good News for Environmental Educators in TIMSS Study," *Environmental Communicator* 27 (January/February 1997): 9.

[11] Gigliotti, L., "Environmental Education: What Went Wrong? What Can Be Done?" *Journal of Environmental Education* 22, 1 (1990): 9-12.

[12] *Ibid.*, 9.

[13] "EE Criticism in the Media: What They Say and Where," *The Environmental Education Advocate* (Fall 1996): 3.

[14] "Battle Over Environment Moves to Classroom," *Los Angeles Times* (13 November 1995): A1, A20.

[15] "Dangerous Waters: Why Environmental Education is Under Attack in the Nation's Schools," *U.S. News and World Report* (10 June 1996).

[16] Sanera, M. and Shaw, J., *Facts Not Fear: A Parent's Guide to Teaching Children About the Environment* (Washington: Regnery Publishing Co., 1996).

[17] "Is EE Dead in Arizona? Some Say Yes, Others an Emphatic No!" Unpublished remarks by John Parrish, Arizona Advisory Council on EE, presented at the North American Association for Environmental Education Conference, Burlingame, CA, November 1-5, 1996.

[18] "Rising to the Challenge: States Battle EE Backlash," *The Environmental Education Advocate* (Summer 1995). Available at http://www.uwsp.edu/acad/cnr/neeap/neeap.htm.

[19] "'Green' Teens Have a Lot to Learn about Aerosols," *The Washington Times* (28 September 1993): A18.

[20] "Perry Campaign Against Textbook Revives Debate on Influence," *The Dallas Morning News* (19 November 1995): 45A, 47A.

[21] Flanakin, D., *Sound Science or Psuedo Science: The Future of Environmental Education in Texas* (Cypress: *Environmental Insider,* 1996): 51.

[22] Weibacher, M., "Eight for the Earth," *E* (December 1994): 28.

[23] "President's Message," *Environmental Communicator* (May/June 1996): 2-3. Simmons was NAAEE president for the 1995-1996 term.

[24] *Ibid.*, 3.

[25] See *The Causes and Effects of Acidic Deposition, Vol. IV, Effects of Acidic Deposition*, National Acid Precipitation Assessment Program (NAPAP, 1990).

[26] *Ibid.*

[27] See, *e.g.*, Kandler, O., "The Air Pollution/Forest Decline Connection: The 'Waldsterben' Theory Refuted," *Unisylva* 44, 173 (1993); or Skelly, J. and Innes, J., "Waldsterben in the Forest of Central Europe and Eastern North America: Fantasy or Reality?" *Plant Disease* 78, 11 (November 1994): 1021-1032.

[28] See Kuusela, K., *Forest Resources in Europe* (Cambridge: Cambridge University Press, 1994).

[29] Dobson, A.P., *Conservation and Biodiversity* (New York: Scientific American Library, 1996); also, Reaka-Kudla, M., Wilson, D., and Wilson, E. O., eds., *Biodiversity II: Understanding and Protecting our Biological Resources* (Washington: Joseph Henry Press, 1997).

[30] Caughley, G., "Eruption of Ungulate Populations, with Emphasis on Himalayan thar in New Zealand," *Ecology* 51 (1970): 53-72.

[31] "Sustainable Development," *The Teacher's Guide to World Resources* (Baltimore: World Resources Institute, 1994): 4.

[32] See, *e.g.*, Grossman, G. and Krueger, A., "Economic Growth and the Environment," *Quarterly Journal of Economics* 110 (1995): 353-378. The authors conclude that, "We find no evidence that environmental quality deteriorates steadily with economic growth. Rather, for most indicators, economic growth brings an initial phase of deterioration followed by a subsequent phase of improvement. The turning points for the different pollutants vary, but in most cases they come before a country reaches a per capita income of $8,000."

[33] Penner, S.S. and Icerman, L., *Energy, Volume I: Demands, Resources, Impact, Technology, and Policy* (Reading: Addison-Wesley Publishing Co., 1981).

[34] Deforestation frequently leaves fragments of tree stands that are not contiguous, which may disrupt the habitat of certain species, particularly if the remaining fragments are insufficiently large to maintain a population. See, *e.g*, Simberloff, D., "Species Area and Fragmentation Effects on Old-Growth Forests: Prospects for Longleaf Pine Communities," *Proceedings of the Tall Timbers Fire Ecology Conference*, No. 18 (Tallahassee: Tall Timbers Research Station, 1993).

[35] United Nations Economic Commission for Europe (UN-ECE)/Food and Agriculture Organization of the United Nations (FAO), *The Forest Resources of the Temperate Zone: Main Findings of the UN-ECE/FAO 1990 Forest Resource Assessment* (New York: United Nations, 1992): 46-47.

[36] *Living Lightly in the City* for grades four to six, for example, in its glossary of terms defines the greenhouse effect as "same as global warming," a statement that requires some qualification if students are to understand the difference.

[37] p. 366, citing a 1989 Natural Resources Defense Council study.

[38] National Research Council, *Carcinogens and Anticarcinogens in the Human Diet: A Comparison of Naturally Occurring and Synthetic Substances* (Washington: National Academy Press, 1996).

[39] As noted above, the Tbilisi Declaration that is still the accepted definition for the field defines environmental education as "a process of developing a world population that is aware of and concerned about the total environment and its associated problems...."

[40] See, *e.g.*, Simmons, B., "More Infusion Confusion: A Look at Environmental Education Curriculum Materials," *Journal of Environmental Education* 20, 4 (1989): 15-18. See also, Iozzi, L., "What Research Says to the Educator," *Journal of Environmental Education* 20, 4 (1989): 6-13. Iozzi states that, "Most scholars in environmental education promote a holistic approach to dealing with environmental issues, whereas only a few advocate that this subject should be added as a separate course of study to an already crowded curriculum."

[41] Simmons, 16.

[42] National Research Council, *National Science Education Standards* (November 1994).

[43] American Association for the Advancement of Science, *Benchmarks for Scientific Literacy* (New York: Oxford University Press, 1993).

[44] NAAEE is currently drafting guidelines for environmental education programs which include guidelines for knowledge of environmental concepts, in addition to the affective outcomes, sense of personal responsibility, skills for resolving issues, investigation and analysis skills.

[45] Van Matre, S., "Environmental Education: Mission Gone Astray" (excerpts from a speech), Institute for Earth Education, 1984. Reprinted in "EE Reference Collection," *EE Toolbox* (Ann Arbor: National Consortium for Environmental Education and Training, 1994): 218.

[46] National Research Council, *Fulfilling the Promise: Biology Education in the Nation's Schools* (Washington: National Academy Press, 1990): 88.

[47] Bradley Commission on History in Schools, *Building the History Curriculum: Guidelines for Teaching History in Schools* (1988). Available through the National Council for History Education, Westlake, Ohio.

[48] National Commission on Teaching and America's Future, *What Matters Most: Teaching for America's Future* (September 1996).

[49] Leeming, F., Dwyer, W., Porter, B., and Cobern, M., "Outcome Research in Environmental Education: A Critical Review," *Journal of Environmental Education* 24, 4 (1993): 8. This article presents an analysis of environmental education research since 1974.

[50] Iozzi, L., "What Research Says to the Educator: Part One, Environmental Education and the Affective Domain," *Journal of Environmental Education* 20, 3 (1989): 3-9, 4.

[51] "Defining Environmental Education," *EE Toolbox* (Ann Arbor: National Consortium for Environmental Education and Training, 1994): 3.

[52] State Education and Environment Roundtable, "The Educational Efficacy of Environmental Education," (21 November 1995): available from http://millennianet.com/round/Pages/RESEARCH/Educeff/rescomm.html.

[53] Hungerford, H.R. and Volk, T.L., "Changing Learner Behavior through Environmental Education," *Journal of Environmental Education* 21, 2 (1990): 8-21, 9.

[54] *Ibid.*

[55] The traditional thinking, according to Hungerford and Volk, is that "we can change behavior by making human beings more knowledgeable about the environment and its associated issues."

[56] Hines, J., Hungerford, H., and Tomera, A.N., "Analysis and Synthesis of Research on Responsible Environmental Behavior: A Meta-Analysis," *Journal of Environmental Education* 18, 2 (1987): 8-21, 7. According to Hines, Hungerford, and Tomera, behavioral intervention strategies include environmental problem-solving skills, values, discussions and action-taking skills.

[57] See, *e.g.*, Robottom, I. and Hart, P., "Behaviorist EE Research: Environmentalism as Individualism," *Journal of Environmental Education* 26, 2 (1995): 5-9.

[58] Knapp, 21. The question of the difficulty of separating environmental advocacy from environmental education is sometimes referred to as the "two hats" problem, from a 1977 article by John Hug, environmental education specialist, Ohio Department of Education, that is reprinted in many collections of articles about environmental education, including, most recently, the *EE Toolbox*. Hug notes that although most environmental educators are environmentalists, as educators they must "scrupulously strive to get all the facts, examine and illuminate all the viewpoints, and keep from letting their own particular postition (as an environmentalist) from mixing with their educator role." "Two Hats," *EE Toolbox*, 217. Reprinted from *A Report on the North American Regional Seminar on Environmental Education: A Confrontation with the Issues: Environmental Education for the Real World* (Columbus: SMEAC Information Center, 1977).

[59] *Project Learning Tree* (Washington: American Forest Foundation, 1995): vi.

[60] National Research Council, *Fulfilling the Promise: Biology Education in the Nation's Schools* (Washington: National Academy Press, 1990): 57.

[61] See n. 37.

[62] The text also, in attempting to help students understand the climate implications of even a few degrees of temperature change, states that, "Earth's average surface temperature is only about 1.8 F degrees warmer than the Little Ice Age. Then New York City was buried under 1000 feet of ice." The Little Ice Age ended in the early 1800s; the area now known as New York City has been populated at least since the early 1600s.

[63] Other reviewers of this text have also noted this mixture of advocacy with science. *The Textbook Letter*, a California-based newsletter founded by several scientists and journalists to review science textbooks, noted in its review that, "The [Wadsworth] book is so insistent in promoting its world-view that it could serve as a model for education-with-indoctrination." From Rodel, M. *The Textbook Letter* 3 (January/February 1993): 6.

[64] The concern about the quality of environmental science textbooks is shared by at least some teachers. A study of secondary environmental education courses in Illinois quoted several teachers who agreed that, "There's no good environmental science text." From Singletary, T., "Case Studies of Selected High School Environmental Education Classes," *Journal of Environmental Education* 23, 4 (1992): 35-40, 48.

[65] "EE Criticism: Challenge and Opportunity," *Environmental Education Advocate* (Fall 1996): 3.

[66] *Ibid.*, 3.

[67] National Research Council, *Fulfilling the Promise*, 88.

[68] National Research Council, *National Science Education Standards*, 99.

[69] *What Matters Most: Teaching for America's Future*, 15-16.

[70] National Research Council, *Fulfilling the Promise*, 57.

[71] National Consortium for Environmental Education and Training, *National Survey of EE Teacher Inservice Education* (February 1994): 6.

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Appendices

Materials Reviewed by Title

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As an example of the complexity of environmental topics, consider the scope of a thorough course on energy and waste management:

Definitions of terms and units, with clear explanations of the differences between energy and power, resources and reserves, energy sources and energy carriers, energy sources and energy-conversion systems, renewables and other supplies.

The relation between *per capita* use and economic well-being; international comparisons of energy use and income.

Energy conservation and its effect on energy use per unit of income; historical and international perspectives; technical and non-technical measures for reducing energy consumption.

Worldwide growth in electricity consumption and its relation to economic well-being.

Energy sources; fossil fuels, nuclear energy (fission, breeder and fusion reactors), renewables (biomass, wind energy, solar thermal and photovoltaic systems, hydroelectric sources, others), geothermal energy, other potential energy supplies.

Magnitudes of energy sources; how long will they last?

Costs, including environmental impacts of energy use.

Laws and methods for mitigating the environmental impacts of energy use; health effects of controlled emissions from energy-conversion systems using fossil fuels.

Possible long-term environmental impacts of uncontrolled emissions; the greenhouse effect and persistent greenhouse gases (water vapor, carbon dioxide, methane, others).

The relation between atmospheric constituents and global climate: what do we know and what is speculation or incomplete science?

Developing technologies for cost-effective removal of CO_2 emission from fossil-fuel burners.

Worldwide use of nuclear fission reactors.

Safety issues relating to nuclear reactors; disposal of radioactive wastes.

Design and construction of passively safe nuclear reactors.

Energy-conversion systems and their efficiencies (internal combustion and diesel engines, furnaces and boilers for power generation, fuel cells, others).

Energy-storage systems (pumped-water and compressed-air storage, batteries, inertial storage systems, others).

Definitions of symbols and terms, units and measurements; descriptions of wastes in chemical and physical terms.

Historical perspectives on waste production and management in the U.S. and elsewhere.

Types of wastes produced.

Amounts of wastes produced.

Integrated as opposed to heirarchical (the 3Rs) waste management.

Optimization in complex system management with proper consideration of costs.

The purposes of waste management, including health-impact minimization, cost minimization, resource conservation.

Waste reduction and associated costs.

Technologies for waste management.

International comparison of waste-management procedures.

Green manufacturing and its costs; what is known and what remains to be learned.

Incidental benefits derived from waste-management techniques (e.g., energy recovery from renewable biomass in waste incineration).

Environmental and health effects in resource recovery, composting, incineration, green manufacturing.

The Commission does not expect a high school environmental science course to incorporate this level of detail. A rigorous upper-level course on environmental issues, though, should attempt to introduce students to the complexities of these topics and seek to motivate them to further study in college.