LIVING IN THE ENVIRONMENT / FIFTH EDITION / G. TYLER MILLER, JR.

LIVING IN THE ENVIRONMENT

An Introduction to Environmental Science

FIFTH EDITION

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Preface: To the Instructor

Goals The purposes of this book are to **(1)** cover environmental concepts and information in an accurate, balanced, and interesting way without the use of mathematics, **(2)** enable the teacher to use the material in a flexible manner for one-semester or full-year courses of varying emphases, and **(3)** introduce students to key scientific concepts that govern how nature works (see Chapters 3 through 6), **(4)** consistently use these concepts throughout the course to evaluate problems and options available in dealing with the use of natural resources, population growth, and pollution and environmental degradation, **(5)** expose students to important and controversial environmental issues that affect individuals, countries, and the world now and in the future, **(6)** provide a long-term historical perspective on environmental degradation along with a realistic but hopeful view of how much has been accomplished since 1965 (when the American public first became aware of many environmental problems) and how much more needs to be done (Chapters 2 and 26), and **(7)** show how most environmental problems are interrelated.

A Well-Tested Product The material in this textbook has been used and class-tested by over 1 million students at over two-thirds of the country's colleges and universities. By a very large margin, it has been the most widely used environmental science textbook in the United States since 1975, when the first edition was published.

Two Different Textbooks Available This fifth edition of *Living in the Environment* is the more comprehensive of two related textbooks designed for different types of introductory courses on environmental concepts and problems. The other book, *Environmental Science: An Introduction*, 2nd (Wadsworth, 1988), is a briefer (395-page) version, designed for shorter courses with less emphasis on environmental economics, politics, and ethics.

Flexibility To provide teaching flexibility, this book is divided into six major parts:

- Humans and Nature: An Overview (two chapters)
- Basic Concepts (four chapters)
- Population (three chapters)
- Resources (nine chapters)
- Pollution (five chapters)
- Environment and Society (three chapters)

Once Parts One and Two have been covered, the remainder of the book may be used in any order that meets the needs of the instructor. Major parts, chapters within these parts, and many sections within chapters can be moved around or omitted to accommodate courses with varying lengths and emphases.

Other Major Features The fifth edition, like earlier editions, **(1)** *consistently uses fundamental concepts* (Chapters 3–6) to illustrate the interrelationships of environmental problems and their possible solutions, **(2)** *provides balanced discussions of the opposing views* on major environmental issues, **(3)** *is based on an extensive review of the professional literature* (from more than 10,000 research sources; key readings for each chapter are listed at the end of the text), **(4)** *has received extensive manuscript review* by 175 experts and instructors—probably more reviewers than any textbook ever published (see List of Reviewers, pp. viii–x)—plus unsolicited suggestions from hundreds of students and teachers who have used this material, and **(5)** *uses Guest Essays to expose the reader to various points of view* (see List of Guest Essayists, p. viii).

Major Changes in the Fifth Edition Despite the overwhelming success of this textbook, the publisher and I feel obligated to improve each edition to meet changing needs indicated by the extensive reviews and

surveys of users. The major changes in this edition include:

1. Material throughout the book has been updated, rewritten, and in many cases condensed to make this an even better textbook.
2. Throughout the text, important and controversial issues and further insights into environmental problems are highlighted in *Spotlights*. *Enrichment studies* at the ends of a number of chapters provide more detailed treatment of selected issues.
3. Because there is now greater agreement among instructors on the major topics to be covered in introductory environmental courses, the format of *Living in the Environment* has been reorganized: The enrichment studies placed in a separate section in previous editions have been incorporated into the main text either as chapters (Chapter 21, Solid Waste and Hazardous Waste, and Chapter 23, The Environment and Human Health), chapter sections, or end-of-chapter enrichment studies (see Detailed Table of Contents). The new organization is designed to make the book flow more smoothly and logically from one topic to another; as in previous editions, enrichment material can easily be omitted or used as the instructor chooses.
4. The treatment of pesticides has been expanded to a full chapter (Chapter 22), and new material (mostly as enrichment studies) has been added on the coastal zone (Chapter 5), environmental risk analysis and risk management (Chapter 6), desertification (Chapter 11), indoor air pollution from radioactive radon gas (Chapter 19), and the Great Lakes (Chapter 20).
5. Seven new guest essays have been added to seven used in earlier editions.
6. Color has been added to charts, maps, and drawings, and the number of illustrations and photographs has been increased dramatically from 201 in the fourth edition to 440 in this edition.
7. Three new study aids have been added: **(a)** *general objectives*, a list of major questions at the beginning of each chapter, **(b)** *chapter summaries*, and **(c)** a *student preface* to acquaint students with the book's overall goals and numerous study aids.

As you and your students deal with the crucial and exciting issues discussed in this book, I hope you will take the time to point out errors and suggest improvements for future editions. Please send such information to me, care of Jack Carey, Science Editor, Wadsworth Publishing Company, 10 Davis Drive, Belmont, CA 94002.

Supplementary Materials Dr. Robert Janiskee at the University of South Carolina has written an excellent instructor's manual for use with this text. It contains sample multiple-choice test questions with answers; suggested projects, field trips, and experiments; and a list of suitable topics for term papers and reports for each chapter. In addition, a series of master sheets for making overhead transparencies of many key diagrams is available from the publisher.

Acknowledgments I wish to thank the many students and teachers who responded so favorably to the first four editions of *Living in the Environment* and offered suggestions for improvement. I am also deeply indebted to the prominent environmentalists and scholars who wrote guest essays and to the reviewers, who pointed out errors and suggested many important improvements. Any errors and deficiencies remaining are mine, not theirs.

It has also been a pleasure to work with a team of talented people who have helped improve this book. I am particularly indebted to production editor Leland Moss, art editor Marty Kongsle, photo researcher Stuart Kenter, designer Julia Scannell, copy editors Noel Deeley (who made many useful suggestions for improvement) and Jennifer Gordon, and to artists Darwen and Vally Hennings, John and Judith Waller, Linda Harris-Sweezey, Raychel Ciemma, Victor Royer, Joan Carol, and Florence Fujimoto. Above all I wish to thank Jack Carey, science editor at Wadsworth, for his encouragement, help, friendship, and superb reviewing system.

G. Tyler Miller, Jr.

Preface: To the Student

Major Goals I have written this book to show you that learning about environmental concepts and issues is **(1)** fun and interesting, **(2)** need not be difficult, **(3)** does not require use of mathematics or complex chemical and biological information, **(4)** is important and relevant to every aspect of your life, and **(5)** can help you make wiser decisions in vital matters that affect you, your loved ones, and society as a whole. This is not just another college course to be passed for credit. It is an introduction to how nature works, how it has been and is being abused, and what we can do to protect and improve it for ourselves, future generations, and other living things. I am convinced that nothing else deserves more of our energy, time, care, and personal involvement.

I have gone to considerable effort to present opposing views on these complex and highly controversial life-and-death issues in a balanced way. My goal is not to tell you what to think but to provide you with ecological concepts and information which you can use to reach your own conclusions. The more I have studied environmental issues, the more I have realized how complex and interrelated they are. I hope this book will stimulate you to begin a life-long involvement in the important and exciting task of learning how nature works and using this information to help make the world a better place to live now and in the future.

How I Became Involved I feel you are entitled to know how I became involved in environmental concerns and to what degree I try to put what I write about into practice in my own life and lifestyle. In 1966, when what we now know as the environmental movement began in the United States, I heard a scientist give a lecture on the problems of overpopulation and environmental abuse. Afterwards I went to him and said, "If even a fraction of what you have said is true, I will feel ethically obligated to give up my present scientific research on the corrosion of metals and devote the rest of my life to these issues. Frankly, I don't want to believe a word you have said, and I'm going into the literature to try to prove what you have said is either untrue or grossly distorted." After six months of study I was convinced of the seriousness of the problems, and since then I have been studying, speaking, teaching, and writing about them. I have also attempted to live my life in an ecologically sound way—with varying degrees of success—by treading as lightly as possible on the earth. Working toward this goal has involved making more compromises and trade-offs than I have liked, but I continue the effort (see p. 596 for a summary of my own progress in attempting to work with nature).

Emphasis on Concepts The purpose of useful learning is not to stuff ourselves full of information but to learn and understand a small number of basic concepts or principles with which we can integrate numerous facts into meaningful patterns. In this book a small number of key scientific concepts (presented in Chapters 3 through 6 and summarized in the Epilogue) are used throughout to evaluate environmental problems and options for dealing with them. Since this is not a murder mystery, I suggest you take the time now to read the Prologue (p. xxii) and the Epilogue (p. 603) to get an overview of our planetary problems and the ideas you will be using to tie together the facts concerning these problems presented in this book.

A Realistic but Hopeful National and Global Outlook Our actions are based primarily on our worldview—our beliefs about how the world works. In this book I offer a realistic but hopeful view of the future based primarily on **(1)** how much has been done since 1965 (frankly, much more than I expected at that time), when the public first became aware of many environmental problems, and **(2)** the fact that an increasing number of ordinary citizens are developing a new worldview—based on the necessity of sustaining the earth—and are acting on this belief system in their personal and political lives by leading rather than following conventional political leaders.

Politics is not just voting—it is also how you lead your life. For example, turning off a light, buying an energy-saving appliance or car, not buying an all-electric house (the most resource-wasting type), or doing anything that saves electricity and other forms of energy

is an important economic action that reduces the need to build more electric power plants and saves you money in a world where electricity and gasoline are expected to become increasingly expensive. At the same time, it is a political action, sending a strong message to other citizens and to those who hope to win our votes.

Much more needs to be done, but there is hope if enough of us care. The key is to *think globally and act locally.* Most environmental problems and their possible solutions are interrelated and must be considered on a local, national, and global scale—as this book does. Pollution, for example, does not respect national boundaries, as was clearly illustrated by the radiation that drifted over much of the world after being released in the 1986 accident at the Chernobyl nuclear power plant in the Soviet Union.

How This Book Is Organized To get a better idea of what you will be learning, I suggest that you take a few minutes to look at the brief table of contents and the detailed table of contents. This book has been designed to be flexible enough for use in courses with different lengths and emphases. After the six chapters in Parts One and Two have been studied, the remainder of the book can be covered in essentially any order, so do not be concerned if your instructor skips around and omits material (I do hope, however, that you will go ahead and read it on your own).

This book is written for you. To help you learn more efficiently and effectively, I have provided a number of learning aids, as outlined below.

General Objectives and Chapter Summaries I believe in the old writing and teaching adage: Tell people where you are going, go there, and then remind them of where they have been. As a result, each chapter begins with a few general questions or learning objectives written in nontechnical language and designed to give you an idea of what you will be learning. After you finish a chapter, you can go back and try to answer these questions to review what you have learned. You will also find a brief summary at the end of each chapter. Reading the summary should not replace reading the entire chapter, because the summary is a review that omits much of the information needed for adequate understanding of the material; it should serve only as a reminder of the main points.

Vocabulary In each chapter you will be introduced to a number of new terms whose meanings you need to know and understand. To help you identify these key terms, each is printed in boldface when it is introduced. The pages where key terms are defined are shown in boldface in the index, and a glossary of all key terms appears at the end of the book.

Visual Aids Great emphasis has been placed on developing a variety of diagrams that illustrate complex ideas in a simple manner. Many carefully selected photos give you a better picture of how topics discussed in this book relate to the real world.

Discussion Topics The questions at the end of each chapter are not designed to test your recall of facts. That is left to your instructor. Instead, these questions are designed to make you think, to apply what you have learned to your personal lifestyle, to take sides on controversial issues, and to back up your conclusions and beliefs.

Further Readings At the end of this book you will find a list of readings, grouped by chapter, which you can use to increase your knowledge of a particular topic and to prepare reports. Most of these works cite other works that can enhance your knowledge.

Save This Book This book will be a useful reference long after you have completed this course because you will have to deal with its vital issues throughout your life. So instead of throwing it away or reselling it for about half what you paid for it, I suggest you keep it in your personal library. Learning is a lifelong process and you should be building a collection of books that will be useful to you now and in the future. You may also purchase the latest updated version of this text (published every three years) directly from Wadsworth Publishing Company, 10 Davis Drive, Belmont, CA 94002.

Help Me Improve This Book Publishing a book is such a complex process that some errors are almost certain to be present. If you find what you believe to be an error, write it down, send it to me, and turn in a copy to your instructor. Hundreds of students have helped me improve this book since it was first published in 1975; please continue this tradition by letting me know what you like and dislike most about the book. Send any errors or suggestions for improvement to Jack Carey, Wadsworth Publishing Company, 10 Davis Drive, Belmont, CA 94002. He will send them on to me. Unfortunately, time does not permit me to answer your letters, but be aware of how much I appreciate learning from you.

And Now Relax and enjoy yourself as you learn about the challenging issues we all face in preserving the earth's life-support system for ourselves, future generations, and the millions of plants and animals we share the planet with and depend upon for our survival.

G. Tyler Miller, Jr.

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Prologue

It is time for the annual State of the Earth report. As you know, we live on a relatively small planet hurtling through space at about 107,200 kilometers (66,600 miles) per hour on a fixed course. Although we can never take on any significant amounts of new supplies, our planetary home has a marvelous set of life-support systems that use solar energy to recycle most of the chemicals needed to provide a reasonable number of us and other life forms with adequate water, air, and food. We also have a large but depletable supply of fossil fuels (oil, coal, and natural gas), metals, and other nonrenewable resources that we have learned to extract from the earth's crust and convert to useful materials.

Let me summarize. There are 5 billion people on earth, living in 166 countries. About 1 billion live in 33 *more developed countries*, most of them enjoying good to luxurious living conditions mostly in the Northern Hemisphere. About 80% of the fossil fuels, metals, and other nonrenewable supplies we get from the earth's crust are used by the affluent people in these countries. Unfortunately, conditions have not improved much this year for many of the 4 billion people in the 133 so-called *less developed countries*, located mostly on the continents of Africa, Asia, and Latin America in the Southern Hemisphere. Many are suffering from hunger, malnutrition, inadequate shelter, and lack of clean water. Although we are feeding more people than ever before, more people starved to death or died from malnutrition-related diseases this year than at any time in human history.

As the gap between rich and poor countries continues to widen, many in the poorer countries wonder whether they will be forced to struggle for survival in "never to be developed countries," and they are beginning to demand a fairer share of the planet's nonrenewable and potentially renewable supplies. As a result, during the coming decades the focus of international political and economic confrontation over the earth's resources will shift increasingly from East–West to North–South.

The most important fact molding our lives today is that over the past hundred years we have "gone around the bend" of four curves shaped like the letter *J*, which represent global increases in population, resource use, pollution of air and water, and environmental degradation of the soil, grasslands, forests, and wildlife populations that form the base of all human economic activity and growth. Although human population growth rates have decreased slightly in recent years, at the current rate our present population of 5 billion will probably grow to about 6.1 billion by the year 2000 and could reach 10.4 billion by the year 2100.

Our global life-support systems are threatened by a combination of *people-overpopulation* in the poorer countries and *consumption-overpopulation* in the rich countries. Each affluent person uses so many resources at a rapid rate that each has an impact on our life-support systems equal to about 25 times that of each poor person. Efforts to conserve and reduce unnecessary waste of our supplies in the rich countries are still grossly inadequate. Pollution control in many of these countries is improving, but there is a long way to go.

Billions of tons of soil, one of our most precious resources, are washed or blown away each year as a result of unwise management for survival in poorer countries and for short-term economic gain in rich countries. Once-productive croplands and grazing lands are being degraded and converted to deserts by overuse and poor management in both rich and poor countries. Tropical forests, containing perhaps one-fifth of all the different kinds of plants and animals on earth, are being chopped down at an alarming rate to provide temporary cropland, grazing land, and firewood for the landless poor and to furnish the rich with choice lumber. If they are not replanted and their rate of removal is not sharply reduced, little will remain of these vital and essentially nonrenewable storehouses of biological diversity by the middle of the next century. In the oceans we ravage one fishery after another. We pollute the seas just as we do many of the world's inland freshwater lakes and rivers and precious deposits of fresh groundwater located beneath the earth's crust.

We are burning up in only a few hundred years the earth's finite supply of fossil fuels, which took hundreds of millions of years to form. This burning

releases so much carbon dioxide gas that some scientists fear it will cause a long-term warming of the earth's atmosphere. Such a change could disrupt food supplies for decades and perhaps centuries, reduce dependable supplies of fresh water, and within a hundred years or so raise average sea levels from the gradual melting of Antarctic glaciers, flooding heavily populated coastal cities.

Some experts say we can avoid such a catastrophe by shifting to nuclear power rather than burning coal to produce most of our electricity. There is growing evidence, however, that nuclear power is an uneconomic source of energy, compared to other energy alternatives. Many also believe that nuclear power is ethically unacceptable at any cost because catastrophic accidents may occur, because future generations must store our nuclear wastes safely for thousands of years by methods that experts still can't agree will work, and because the chances of nuclear war are increased by the spread of "peaceful" nuclear knowledge and materials throughout the world.

An increasing number of experts urge that over the next 50 to 75 years we begin a global effort to reduce unnecessary waste of matter, energy, and biological resources and shift from nonrenewable fossil and nuclear fuels to renewable energy in the form of essentially inexhaustible supplies of sunlight, wind, flowing water (hydropower), and vegetation (biomass). Efforts to bring about this shift have started but, compared to fossil fuels and nuclear energy, are still inadequately supported by governments and taxpayers.

Although the interlocking problems of population growth, resource depletion, pollution, and environmental degradation are serious, the single greatest human and environmental threat to the earth's life-support system is war—especially global nuclear war. It is discouraging that so little progress has been made in reducing the extravagant waste of resources and human talent devoted to the arms race. We live in a world where the number of countries with the knowledge to produce nuclear weapons continues to increase; there is one soldier for every 43 people and one doctor for every 1,030 people; 40% of our research and development expenditures and 60% of our physical scientists and engineers are devoted to developing weapons to improve our ability to kill one another—when we already have enough atomic weapons to kill everyone on earth 67 times; and this year we spent 250 times more on military expenditures than on international cooperation for peace and development.

Some thinkers believe that the human species is already doomed. Others see a glorious future based on using human ingenuity to invent technologies and change social institutions to solve the problems we face. Most experts agree that the situation is serious but not hopeless. They believe that if we begin now, we can learn to control the growth of human population, to reduce unnecessary resource consumption and waste and the resulting pollution and environmental degradation, and to live together peacefully on the beautiful and fragile planet that is our home. Our most important and exciting challenge is to engage in individual and group action to sustain—not further degrade—the earth's support systems for present and future generations of human and other forms of life.

1. Two college students spending the weekend at a Colorado ski resort caught the State of the Earth report on television. "I'm sick of hearing about environmental problems, nuclear war, and nuclear power plants," said John, as he ripped the tab from his third can of beer. "It's already too late. My motto is 'Eat, drink, and have a good time while you can.' What's the world done for me?"

"I don't think it's too late at all," observed Susan. "If we can put astronauts on the moon, we can certainly solve our pollution problems. Sure it's going to cost some money, but I'm willing to pay my share. The whole thing is just a matter of money and technology. By the way, John, during Christmas break let's fly to Switzerland. There are too many people here. We always have to wait in line, and all these hideous new ski lodges and condominiums have spoiled the view. Besides, I want to shop for a new ski outfit."

2. In a tenement room in New York City, Larry angrily switched off the television, even though he usually kept it on to drown out noises around him—particularly the rats scratching. A high school dropout, he's given up looking for work. "This ecology crap is just another way for the rich to keep us from getting a piece of the action. What do I care about pollution when my baby sister was bitten by a rat last night, my little brother is a drug addict, my ma's got emphysema, and we haven't had any heat in this firetrap for months. Tell it to my uncle in Florida who's paralyzed from the waist down from some chemical used on the fruit he was picking. Give me a chance to pollute and then I might worry about it."

3. In Calcutta, Mukh Das, his wife Kamala, and their seven children did not hear the broadcast in the abandoned piece of drainage pipe where they lived. Mukh, age 36, watched his emaciated 34-year-old wife patting animal manure into cakes to be dried and used for fuel to cook the little food they had and to provide some heat. He was glad that 7 of their 12 children were still alive to help now that he and Kamala were in their old age. Five of their children had died as infants from malnutrition and diarrhea caused by contaminated water from the single spigot serving hundreds of other poor people like themselves. Mukh felt a chill, and he hoped the children would soon return from begging and gathering manure and scraps of food. Perhaps

they had been lucky enough to meet a rich American or European tourist today as they did last week.

4. In a Connecticut suburb, Bill and Kathy Farmington and their three children were discussing the broadcast. David, a college senior, turned away in disgust. "Environmentalists don't understand economics and how the world works. Increased economic growth and improved technology will allow us to protect the environment, feed the poor, and allow most people in the world to live longer and become more affluent. When I get my MBA degree from Harvard, I plan to start my own genetic engineering company to develop better crops and drugs and make millions before I'm 28 years old."

"You're the one who doesn't understand what's going on," said Karen, a college sophomore. "The real problem is that poor people have too many children. Why don't you work on family planning in the slums this summer? I did last year, and I even got college credit for it. This is the problem I plan to work on when I get my sociology degree."

Bill Farmington, chief engineer for Monarch Power Company, looked irritated. "I agree with you, David. I'm all for clean air and water, but we can't stop the economic growth our American way of life is built on. Remember last year when we had a lot of misinformed people and ecofreaks trying to stop us from starting up the new nuclear power plant? In spite of all the talk about energy conservation, Americans are going to use more and more energy, and it's my job to make sure our customers have all the electricity they want. David, it's getting hot in here. Would you please turn up the air conditioning?"

Kathy Farmington, a real estate agent, slowly shook her head. "I just don't know. We have to do something about pollution and overpopulation. The problem is, I don't know what to do. One scientist says we shouldn't build nuclear plants, another says we should. One says ban pesticides, and another says that if we do, many people will die from diseases and starvation. How can we know what to do when experts disagree? I recognize that the population problem is bad in Asia, Africa, and South America. Remember how horrid it was to see all of those people begging in the streets when we were in Calcutta on our vacation last summer? I just couldn't wait to leave. I'm glad we don't have an overpopulation problem in the United States. At least your father and I have made enough money to raise and educate the three of you."

As Linda, a college freshman, got up, she was thinking that no one in her family had really understood the speech. "Don't you realize that we are all connected with one another and that our primary goal must be to preserve—not degrade or destroy—the life-support systems that keep us and other species alive? Can't you see that everyone on earth is a unique human being, entitled to a fair share of our basic resources? I'm afraid for all of us, too, but I don't think it's too late if enough of us truly care. When I become a public service lawyer, I plan to devote my life to environmental reform."

Contents in Brief

Detailed Contents