LIVING IN THE ENVIRONMENT

SEVENTH EDITION

G. TYLER MILLER, JR.

The Annenberg/CPB Project

Selected to accompany the Annenberg/CPB Project's Television Course, *Race to Save the Planet*, airing on public broadcasting

SEVENTH EDITION

An Introduction to Environmental Science

Living in the Environment

G. TYLER MILLER, JR.

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COVER PHOTOGRAPH: Short-tailed weasel (ermine) in winter, Grand Teton National Park, Wyoming, © 1985 Tom Mangelsen. The ermine, which helps control rodent population, was selected as the cover image for this book not only because of its striking beauty but also because it is a part of Earth's vital biodiversity, which we are severely reducing. The ermine symbolizes the ecological and ethical issues we face every day. As you look into the eyes of this animal, ask yourself: Would you kill this animal or have it killed to make a fur coat?

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Psychobiology: The Neuron and Behavior, Hoyenga and Hoyenga
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PREFACE

TO THE INSTRUCTOR

GOALS This book is designed for introductory courses in environmental science. The basic goal of environmental science is to learn how everything is interconnected, and this book summarizes what I have learned after spending 26 years trying to understand how the various parts of the earth are connected. My goals for the book are to

- provide an introduction to environmental science in an accurate, balanced, and interesting way without the use of mathematics or complex scientific information
- help your students discover that dealing with environmental and resource issues is fun, interesting, and important to their lives
- allow you to use the material in a flexible way, depending on course length and what you believe are the important topics
- introduce students to the key concepts and principles that govern how nature works and apply those concepts and principles to possible solutions to environmental and resource problems
- show how environmental and resource problems are interrelated and to emphasize that they must be understood and responded to in an integrated way, locally, regionally, nationally, and globally
- give a realistic but hopeful view of how much has been done and what remains to be done in sustaining the earth for us and other species
- indicate what individuals can do in their personal lives to help sustain rather than degrade Earth's life-support systems

A WELL-TESTED BOOK The material in this textbook has been used and class-tested by more than 2 million students at over two-thirds of the country's colleges and universities. It has been the most widely used environmental science textbook in the United States and throughout the world since 1975, when the first edition was published. In 1990 it was selected by *The Ecologist* as one of the 20 best environmental books published between 1970 and 1990—the only textbook to make the list. Also in 1990 it and its briefer version, *Environmental Science*, were selected as the official textbooks to accompany the Annenberg/CPB Project television series, *Race to Save the Planet*, broadcast on PBS.

THREE DIFFERENT TEXTBOOKS AVAILABLE This book is one of a series of three textbooks designed for different introductory courses on environmental science and resource conservation.

- This book, *Living in the Environment* (7th ed., Wadsworth, 1992, 706 pages, 514 illustrations), gives broad and fairly detailed discussions of environmental and resource issues.
- *Resource Conservation and Management* (Wadsworth, 1990, 546 pages, 406 illustrations) has a different organization. It provides less detailed discussions of ecological concepts, population, and pollution than does *Living in the Environment*, but offers expanded coverage of renewable resources, including seven separate chapters on the following resources and their management: food, fishery, rangeland, forest (two chapters), and wildlife (two chapters).
- *Environmental Science: Sustaining the Earth* (3rd ed., Wadsworth, 1991, 465 pages, 479 illustrations) is the briefest book and is designed especially for a one-semester course. It has a different organization from *Living in the Environment* and *Resource Conservation and Management* and combines some of the features of those two books.

MAJOR CHANGES IN THIS EDITION *This new edition is a comprehensive revision*. Major changes include

- Updating and revising material throughout the book.
- Improving readability by reducing sentence and paragraph length, omitting unnecessary details, and writing in a more personal style.
- Adding three new chapters: "Geologic Processes: The Dynamic Earth" (Chapter 7), "Deforestation and Loss of Biodiversity" (Chapter 10), and "Climate Change, Ozone Depletion, and Nuclear War" (Chapter 11). Chapters 10 and 11 make up a new part (Part 4) titled "Ultimate Global Problems."

- Adding 42 new *Spotlights*, 20 new *Case Studies*, 10 new *Pro/Con* discussions of controversial issues, 7 new *Guest Essays*, and 25 *Individuals Matter* boxes (summaries of what individuals can do to help sustain the earth).
- Expanding coverage of many topics, including pollution prevention, waste reduction, loss of biodiversity, population dynamics, urban problems, climate, global warming, depletion of the ozone layer, tropical deforestation, deforestation in the United States and Canada (the old-growth controversy), sustainable forestry, hazardous waste, and global poverty.
- Adding many new topics, including vanishing amphibians, coral reefs, mangrove swamps, coevolution, loss of biodiversity in Madagascar, Japan's global environmental impact, the Aral Sea disaster, junk bonds and deforestation, declining populations of American songbirds, environmental effects of the Persian Gulf war, deep-well disposal, the solar envelope house, and environmental careers.
- Increasing the number of chapters from 24 to 26 and the length of the basic text by 85 pages, mostly to accommodate the new chapters and topics and new Guest Essays plus the 95 additional figures and photos. Those wanting a shorter textbook can use *Environmental Science, 3rd ed.*, or *Resource Conservation and Management*.
- Adding four-color diagrams and color photographs. These 514 illustrations (95 more than in the 6th edition) make this the most graphically exciting and teachable edition of this book.
- Increasing the number of maps from 42 to 56 to give students a better geographic perspective. A new feature is a series of "Where is . . . ?" maps that show students where areas being discussed are located.
- Adding one or more experiments, individual projects, or group projects to the Discussion Topics at the end of most chapters. These items are marked with an asterisk (*).

See the pages that follow for a more detailed summary of major changes for each chapter.

KEY FEATURES

- *Concept centered approach:* Uses basic principles and concepts to help students understand environmental and resource problems and possible solutions to these problems in an integrated manner. This approach gives students a way to tie together and evaluate the tremendous amount of information in an incredibly complex field that uses information and ideas from almost every discipline. I have introduced only the concepts and principles necessary to understand material in this book and have tried to present them simply but accurately. Key principles are summarized inside the front cover.
- *Global, national, and local treatment of issues and solutions*.
- *Flexibility:* The book is divided into seven major parts (see Brief Contents). After covering all or most of Parts 1 and 2, the rest of the book can be used in almost any order. In addition, most chapters and many sections within these chapters can be moved around or omitted to accommodate courses with different lengths and emphases.
- *Readability:* Students often complain that textbooks are difficult and boring. I have tried to overcome this problem (I hope) by writing in a clear, interesting, and informal way and by relating the information in the book to the real world and to the students' own lives.
- *Comprehensive review of the professional literature:* More than 10,000 research sources have been used; key readings are listed for each chapter at the end of the book.
- *Extensive manuscript review by more than 200 experts and teachers:* Several experts reviewed each chapter, and teachers of environmental science courses reviewed most or all of the manuscript to help make the material accurate and up to date.
- *Guest Essays* (18) to provide more information and expose readers to various points of view.
- *Pro/Con* boxes (28) to present opposing views on controversial environmental and resource issues.
- *Case Studies* (59) to apply concepts and to give in-depth information about key issues.
- *Spotlights* (74) to highlight and offer further insights into environmental and resource problems.
- *Individuals Matter* boxes (25) to give individuals examples of what they can do to help sustain the earth.
- *Four-color diagrams* (287) to illustrate complex ideas simply; carefully selected *color photographs* (227) to show how the book's topics relate to the real world.
- *Maps* (56) to give student a geographic perspective.
- *Summary of key principles* inside the front cover.
- *General questions and issues* summarized at the beginning of each chapter.
- *Numerous cross references* to show how environmental and resource concepts, problems, and solutions are interrelated.
- *Key terms* shown in **boldface type**.
- *Glossary* of all key terms.

- *Discussion Topics* at the end of each chapter, with emphasis on encouraging students to think critically about and apply what they have learned.
- *Experiments, individual projects, and group projects* at the end of most chapters in the Discussion Topics sections. These items are marked with an asterisk (*).
- *Measurements* expressed in metric units, followed with their English equivalents in parentheses.

HELP ME IMPROVE THIS BOOK To minimize errors the manuscript has been reviewed by many teachers and experts, but some errors inevitably creep in during the complex process of publishing a book. If you find any, please write them down and send them to me. Most errors can be corrected in subsequent printings of this edition, rather than waiting for a new edition.

Let me know how you think this book can be improved and encourage your students to evaluate the book and send me their suggestions. Send any errors you find and your suggestions to Jack Carey, Science Editor, Wadsworth Publishing Company, 10 Davis Drive, Belmont, CA 94002. He will forward them to me.

SUPPLEMENTARY MATERIALS David Cotter at Georgia College has written an excellent instructor's manual and test items booklet for use with this text. It contains sample multiple-choice test questions with answers, suggested projects, field trips, experiments, and a list of topics suitable for term papers and reports for each chapter. Master sheets for making overhead transparencies of most key diagrams are also available to adopters.

ANNENBERG/CPB TELEVISION COURSE This textbook is being offered as part of the Annenberg/CPB Project television series *Race to Save the Planet*, broadcast on PBS.

Race to Save the Planet is a ten-part public television series and a college-level television course that examines the major environmental questions facing the world today, ranging from population growth to soil erosion, from the destruction of forests to climate changes induced by human activity. The series takes into account the wide spectrum of opinion about what constitutes an environmental problem, as well as the controversies about appropriate remedial measures. It analyzes problems and emphasizes the successful search for solutions. The course develops a number of key themes that cut across a broad range of environmental issues, including sustainability, the interconnection of the economy and the ecosystem, short-term versus long-term gains, and the tradeoffs involved in balancing problems and solutions.

In addition to my books (*Environmental Science* and *Living in the Environment*) and the video programs, the course includes a study guide and faculty guide available from Wadsworth Publishing Company that integrate the telecourse and my texts. The television program was developed as part of the Annenberg/CPB Collection.

For further information about available television course licenses, duplication licenses, and off-air taping licenses contact: PBS Adult Learning Service, 1320 Braddock Place, Alexandria, VA 22314-1698, 1-800-ALS-ALS-8.

For information about purchasing videocassettes and print materials, contact the Annenberg/CPB Collection, P.O. Box 2284, South Burlington, VT 05407-2284, 1-800-LEARNER.

ACKNOWLEDGMENTS I wish to thank the many students and teachers who responded so favorably to the six editions of *Living in the Environment*, the three editions of *Environmental Science*, and the first edition of *Resource Conservation and Management* and offered many helpful suggestions for improvement.

I am also deeply indebted to the many reviewers who pointed out errors and suggested important improvements to this and earlier editions, and to those who wrote guest essays for this edition. I am especially indebted to Kenneth J. Van Dellen, Macomb Community College, for his detailed and very helpful review of the entire manuscript and for serving as the primary author of Chapter 7, "Geologic Processes: The Dynamic Earth." Any errors and deficiencies left are mine.

The members of Wadsworth's talented production team have also made important contributions. My thanks also go to Wadsworth's dedicated sales staff.

Special thanks to Jack Carey, Science Editor at Wadsworth, for his encouragement, help, friendship, and superb reviewing system. It helps immensely to work with the best and most experienced editor in college textbook publishing.

Finally, I wish to thank Peggy Sue O'Neal, my earthmate, spouse, and best friend, for her love and support of me and the earth. I dedicate this book to her and to the earth that sustains us all.

G. Tyler Miller, Jr.

SOME CHANGES IN THE SEVENTH EDITION

PART ONE

Humans and Nature: An Overview

Chapter 1 Population, Resources, Environmental Degradation, and Pollution

8 color photos; 2 new diagrams; 3 new Spotlights on Don't Squander Your Capital, How Fast Is the Human Population Growing?, and The Importance of Biological Diversity and the Biodiversity-Reduction Crisis; expanded discussion of pollution prevention; most chapters also contain one or more Individuals Matter, boxes that offer examples of what individuals can do to help sustain the earth

Chapter 2 Brief History of Resource Use, Resource Conservation, and Environmental Protection

7 color photos; 2 new Guest Essays by Peter Montague and Jessica Tuchman Mathews

PART TWO

Scientific Principles and Concepts

Chapter 3 Matter and Energy Resources: Types and Concepts

2 color photos; 2 new diagrams; expanded discussion of the nature of science and technology (Section 3-1)

Chapter 4 Ecosystems: What Are They and How Do They Work?

16 color photos; 5 new diagrams; 2 new Spotlights on Survival Strategies of Plants and Vanishing Amphibians; discussion of the distinction between eukaryotic and prokaryotic cells; introduction of five-kingdom classification of Earth's organisms; expanded discussions of abiotic factors in ecosystems and generalist and specialist species; discussion of native, alien, indicator, and keystone species; discussion of fundamental niche, realized niche, and resource partitioning

Chapter 5 Climate, Terrestrial Life, and Aquatic Life

26 color photos; 1 new diagram; new Case Study on The Importance of Coral Reefs; expanded discussion of climate; discussion of the importance of mangrove swamps

Chapter 6 Changes in Populations, Communities, and Ecosystems

5 color photos; 1 improved diagram; 2 new Spotlights on Nature's Secrets for Sustainable Living and Tall-Grass Prairie Restoration; new table on changes affecting ecosystems; expanded discussion of population dynamics; discussion of r-strategists and K-strategists; discussion of coevolution

Chapter 7 Geologic Processes: The Dynamic Earth

New chapter written by guest author Kenneth J. Van Dellen; includes 14 color photos and 15 diagrams and illustrations; Spotlight on Banded Iron Formation and the History of Life and the Atmosphere; and Case Study on The 1980 Eruption of Mt. St. Helens

PART THREE

The Human Population

Chapter 8 Population Dynamics and Population Regulation

Combination of Chapters 7 and 8 in the sixth edition; 4 color photos; 2 new diagrams; 1 improved diagram; 2 new Spotlights on Future Methods of Birth Control and Breastfeeding; 2 new Case Studies on Population Regulation in Indonesia and Population Regulation in Thailand; 1 new Pro/Con on Is Population Growth Good or Bad?

Chapter 9 Population Distribution: Urbanization, Urban Problems, and Urban Land Use

Expanded treatment of urban problems and urban land use; 10 color photos; 3 new diagrams; 2 new Spotlights on Organizing for Survival and a Better Life and High-Speed Regional Train Systems; 1 new Case Study on Tapiola, Finland

PART FOUR

Ultimate Global Problems

New part

Chapter 10 Deforestation and Loss of Biodiversity

New chapter with greatly expanded discussion of tropical deforestation and deforestation in the United States and Canada (old-growth controversy); includes 18 color photos; 6 diagrams; 3 Spotlights on Sustainable Use of Tropical Forests, Survival Through Cooperation, and The Spotted Owl and the Pacific Yew; 4 Case Studies on Japan's Growing Environmental Impact, Sustainable Development and a Debt-for-Nature Swap in Bolivia,

Ecological Protection and Restoration in Costa Rica, and Greed, Junk Bonds, and Redwood Trees; Pro/Con on How Much of the Amazon Basin Should Be Developed?

Chapter 11 Climate Change, Ozone Depletion, and Nuclear War
New chapter with detailed discussion of the chapter's three main topics; 4 color photos; 10 diagrams; 3 Spotlights on The Nature of Scientific Evidence, The Good News, and The Cancer You Are Most Likely to Get; new Guest Essay by Stephen H. Schneider

PART FIVE
Resources and Resource Management

Chapter 12 Soil Resources
10 color photos; 2 new diagrams

Chapter 13 Water Resources
7 color photos; 3 new diagrams; discussion of the unique physical properties of water (Section 13-1); 1 new Spotlight on Escalating Water Crises in the Middle East; 1 new Case Study on The Aral Sea Ecological Disaster

Chapter 14 Food Resources
7 color photos; 1 new diagram; 4 new Spotlights on Nutritional-Deficiency Diseases, Food Additives, Loss of Genetic Variability, and Drift Net Fishing; 1 new Pro/Con on Should Government Farm Subsidies Be Eliminated?

Chapter 15 Land Resources: Forests, Rangelands, Parks, and Wilderness
9 color photos; 1 new diagram; 2 new Pro/Cons on Responsible Forestry: Monocultures or Mixed Cultures? and How Much Timber Should Be Cut From National Forests?; expanded discussion of sustainable forestry; discussion of national trails system

Chapter 16 Wild Plant and Animal Resources
24 color photos; 1 new diagram; 2 new Spotlights on Declining Populations of North American Songbirds and Poaching in the United States: The New Killing Fields; new Case Study on The Water Hyacinth

Chapter 17 Perpetual and Renewable Energy Resources
12 color photos; 2 new diagrams; 2 new Spotlights on Why Don't We Have Fuel-Efficient Cars? and The Solar Envelope House

Chapter 18 Nonrenewable Energy Resources
5 color photos; new Spotlight on Natural Gas as a Vehicle Fuel; 2 new Case Studies on The Search for a Radioactive Waste Depository and Osage, Iowa: Local Economic Development by Improving Energy Efficiency

Chapter 19 Nonrenewable Mineral Resources and Solid Waste
10 color photos; 4 new diagrams; expanded discussion of solid waste and waste reduction; 5 new Spotlights on Mining with Microbes, What It Means to Live in a Throwaway Society, Comparison of Incineration in Japan and the United States, Mega-Landfills, and The Diaper Dilemma; 2 new Case Studies on Recycling Aluminum and What Should We Do About Plastics?; new Pro/Con on Should Mineral Development Be Allowed in Antarctica?

PART SIX
Pollution

Chapter 20 Risk, Human Health, and Hazardous Waste
5 color photos; 1 new diagram; expanded discussion of hazardous waste and pollution prevention; 4 new Spotlights on Are Chemicals Good or Bad?, Working Can Be Hazardous to Your Health, Implications of Exponential Growth in Synthetic Organic Chemicals, Waste Reduction and Pollution Prevention Pay; 3 new Case Studies on Sexually Transmitted Diseases, Smoking, and Should States Be Allowed to Have Stronger Hazardous-Waste Management Laws Than the Federal Government?; new Pro/Con on Is Deep-Well Disposal of Hazardous Waste a Good Idea?; 2 new Guest Essays by Vincent T. Covello and Lois Marie Gibbs

Chapter 21 Air Pollution
6 color photos; 1 improved diagram; new Spotlight on The Clean Air Act of 1990

Chapter 22 Water Pollution
3 color photos; 2 new Spotlights on Environmental Tragedy in the Persian Gulf and Is Drinking Bottled Water the Answer?; 2 new Case Studies on Groundwater Contamination in Woburn, Massachusetts, and Working with Nature to Purify Sewage

Chapter 23 Pesticides and Pest Control
9 color photos; new Spotlight on Agent Orange Controversy; new Pro/Con on Should Food Be Irradiated?

PART SEVEN
Environment and Society

Chapter 24 Economics and Environment
1 color photo; 1 new diagram; 2 new Spotlights on The Case for Zero Discharge and Assuming Chemicals Are Guilty Until Proven Innocent and Using Free Trade as an Excuse to Restrict Environmental Protection and Sustainable Use of Resources

Chapter 25 Politics and Environment
2 color photos; discussion of strategies of polluters and resource depleters; new Spotlight on Environmental Careers; new Guest Essay by Claudine Schneider

Chapter 26 Worldviews, Ethics, and Environment
1 color photo; discussion of bioregions; new Guest Essay by Hugh Kaufman and Lynn Moorer

GUEST AUTHOR AND GUEST ESSAYISTS

Kenneth J. Van Dellen, Professor of Geology and Environmental Science, Macomb Community College, is the primary author of Chapter 7.

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PREFACE

TO THE STUDENT

WHY STUDY ENVIRONMENTAL AND RESOURCE ISSUES? The course you are taking is an introduction to how nature works, how the environment has been and is being used and abused, and what you can do to protect and improve it for yourself and others, for future generations, and for other living things. I am convinced that nothing else deserves more of your energy, time, concern, and personal involvement.

Studying environmental and resource problems is different from studying most courses like chemistry, biology, economics, or psychology. Why? Because environmental science is an *interdisciplinary* study. It involves combining ideas and information from physical sciences, such as biology, chemistry, and geology, and social sciences, such as economics, politics, and ethics, to form a general idea of how the world works and what our role in the world should be.

WHAT IS THE PURPOSE OF LEARNING? *You may be surprised to learn that the purpose of education is to learn as little as you can.* The goal of education is to learn how to sift through mountains of information and ideas to find the small number that are really useful and worth knowing.

This book is full of facts and numbers, but remember three things: First, they are merely stepping stones to ideas, concepts, and connections. Facts by themselves are useless and confusing. Second, most statistics and facts are human beings with the tears wiped off and living things whose lives we are threatening. Third, this book is about how everything is connected to everything else. Learning about how various parts of the earth are interconnected and thus influence one another directly or indirectly is the primary goal of environmental science. This book is a summary of what I have learned about such connections during the past 26 years.

Inside the front cover of this book you will find a list of key principles that summarizes what I have learned so far about how the world works and what my role in it should be. In effect, it is a two-page summary of the key ideas in this book. I use these principles to evaluate other ideas and to make decisions about what to buy or not to buy and how to live my life with increased joy. These ideas are the result of more than 40 years of reading books and articles, tens of thousands of conversations with others, letters from students like you, and direct observations of nature.

Learning is a neverending, wonderful adventure, so I am constantly striving to improve this list by modifying or removing some ideas and adding new ones. As you draw up your own list, please send me any ideas you have and suggest modifications to my list. We are all in this together, and we need all the help we can get.

HOW I BECAME INVOLVED 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. Afterward 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 environmental issues. Frankly, I don't want to believe a word you have said and change my life around, 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 these problems. Since then I have been studying, teaching, and writing about them. I have also attempted to live my life in an environmentally sound way — with varying degrees of success — by treading as lightly as possible on the earth (see pp. 470–473 for a summary of my own progress in attempting to work with nature).

READABILITY Students often complain that textbooks are difficult and boring. I have tried to overcome this problem by writing in a clear, interesting, and informal way. My goal is to communicate with you, not confuse you. Let me know how to do this better.

I also relate the information in the book to the real world and to your own lives, in the main text and in the special *Spotlights, Case Studies, Pro/Con* discussions of issues, and *Individuals Matter* boxes (which suggest things you can do to help sustain the earth) sprinkled throughout the book.

A REALISTIC BUT HOPEFUL LOCAL, NATIONAL, AND GLOBAL OUTLOOK In this book I offer a realistic but hopeful view of the future. Much has been done since the mid-1960s, when many people first be-

came aware of the resource and environmental problems we face. But much more needs to be done to protect the earth, which keeps us and other forms of life healthy and alive. The 1960s, 1970s, and 1980s were merely a dress rehearsal for the much more urgent and difficult work we must do in the 1990s and beyond. This book suggests ways that you can help sustain the earth.

You will also learn that most environmental and resource problems and their possible solutions are interrelated. Treating them in isolation is a recipe for disaster. I point out many of these connections and give cross references to page numbers relating ideas discussed in various parts of the book. Environmental and resource problems must also be considered on a local, national, and global scale—as this book does.

HOW THE BOOK IS ORGANIZED Take a look at the Brief Contents on the next page to get an overview of the seven major parts of this book and the major topics covered in each part. Before studying each chapter, I suggest you look over the major headings listed in the Detailed Contents that follows. This gives you a road map of where you will be going. I have designed the book so that it can be used in courses with different lengths, emphases, and ordering of topics, so don't be concerned if your instructor skips around and omits material.

GENERAL QUESTIONS AND ISSUES, VOCABULARY, AND DISCUSSION TOPICS Each chapter begins with a few general questions about what you will be learning. After you finish a chapter, you can go back and try to answer these questions as a general review of what you have learned.

Each chapter will introduce new terms, whose meanings you need to know and understand. When a term is introduced and defined, it is printed in **boldface** type. There is also a glossary of all key terms at the end of the book.

Each chapter ends with a set of discussion questions designed to encourage you to think critically and apply what you have learned to your own life. They also ask you to take sides on controversial issues and to back up your conclusions and beliefs.

I have not provided questions that test your recall of facts. This important, but mechanical, task is left to you and your instructor. You should know how to learn definitions and facts on your own. It is done the old-fashioned way—by reading, marking key passages, making notes and summaries, and writing and studying flash cards.

VISUAL AIDS To make this book graphically exciting, I have developed a number of four-color diagrams to illustrate concepts and complex ideas simply. I have also used a number of carefully selected color photos to give you a better picture of how the book's key topics relate to the real world.

FURTHER READINGS If you become especially interested in some of the topics in this book, a list of suggested readings for the material in each chapter is given in the back of the book. In Appendix 1 you will find a list of publications to help keep up to date on the book's material and a list of some key environmental organizations.

INTERACT WITH THE BOOK When I read something, I interact with it. I mark sentences and paragraphs with a highlighter or pen. I put an asterisk in the margin next to something I think is important and double asterisks next to something that I think is really important. I write comments in the margins, such as *Beautiful, Confusing, Bull, Wrong,* and so on.

I fold down the top corner of pages with highlighted passages and the top and bottom corners of especially important pages. This way, I can flip through a book and quickly review the key passages. I hope you will interact in such ways with this book. You will learn more and have more fun. I hope you will often disagree with what I have written, take the time to think about or write down why, and send your thoughts to me.

SAVE THIS BOOK After you finish this course, you may be tempted to discard this book or resell it to the bookstore. But learning is a lifelong process, and you will have to deal with the vital issues discussed here for the rest of your life. Therefore, I hope you will keep this book in your personal library for future use. Or at least pass it on free to someone whom you want to learn about sustaining the earth.

HELP ME IMPROVE THE BOOK Writing and publishing a book is such an incredibly complex process that this or any other book is likely to have some typographical and factual errors. If you find what you believe to be an error, write it down and send it to me.

I would also appreciate learning from you what you like and dislike about the book. This information helps me make the book better in future editions. Some of the things you will read here were suggested by students like you.

Send any errors you find and any suggestions for improvement to Jack Carey, Science Editor, Wadsworth Publishing Company, 10 Davis Drive, Belmont, CA 94002. He will send them on to me. Your input helps me, students who take this course in the future, and the earth.

AND NOW Relax and enjoy yourself as you learn more about the exciting and challenging issues we all face in sustaining the earth for us and for other forms of life.

G. Tyler Miller, Jr.

BRIEF CONTENTS

DETAILED CONTENTS