

INTERNATIONAL EDITION

# Environmental A STUDY OF INTERRELATIONSHIPS Science



seventh edition

Enger  Smith





# ENVIRONMENTAL SCIENCE

A STUDY OF INTERRELATIONSHIPS  
seventh edition

Eldon D. Enger  
*Delta College*

Bradley F. Smith  
*Western Washington University*



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ENVIRONMENTAL SCIENCE: A STUDY OF INTERRELATIONSHIPS,  
SEVENTH EDITION

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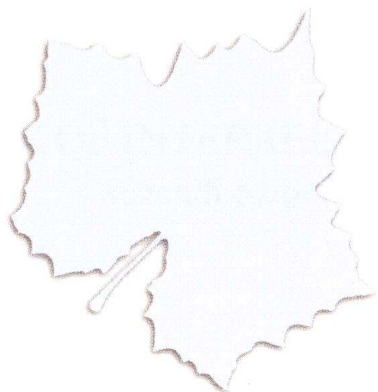
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# ENVIRONMENTAL SCIENCE







To my sons Kyle and Brook Enger with love and respect.



To my children, Morgan and Ian Smith, who have made me very proud.



# Essential Study Partner CD-ROM

A study partner that engages, investigates, and reinforces what you are learning from your textbook. You'll find the **Essential Study Partner** for Enger/Smith's *Environmental Science: A Study of Interrelationships* to be a complete, interactive student study tool featuring animations and learning activities. From quizzes to interactive diagrams, you'll find that there has never been a better study partner to ensure the mastery of core concepts in environmental science.

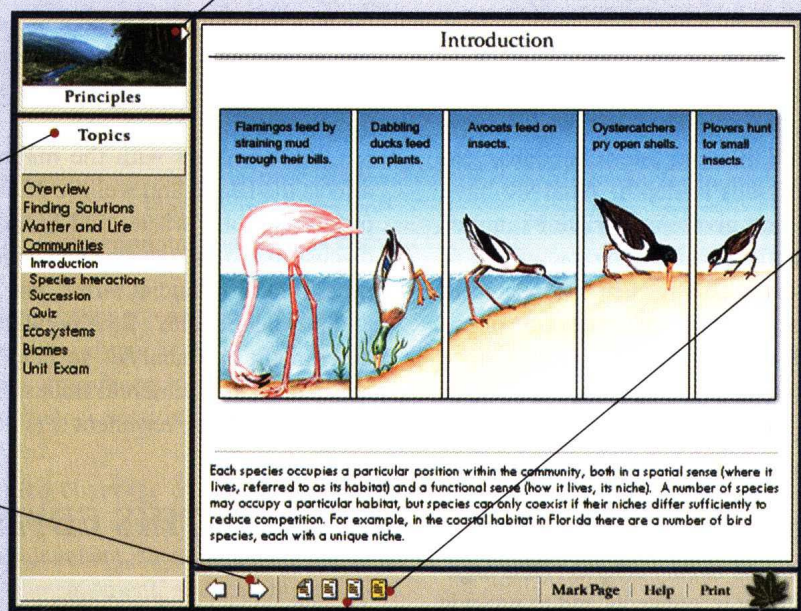
The topic menu contains an interactive list of the available topics. Clicking on any of the listings within this menu will open your selection and will show the specific concepts presented within this topic. Clicking any of the concepts will move you to your selection. You can use the UP and DOWN arrow keys to move through the topics.

Along the bottom of the screen you will find various navigational aids. At the left are arrows that allow you to page forward and backward through text screens or interactive exercise screens. You can also use the LEFT and RIGHT arrows on your keyboard to perform the same function.

The unit pop-up menu is accessible at anytime within the program. Clicking on the current unit will bring up a menu of other units available in the program.

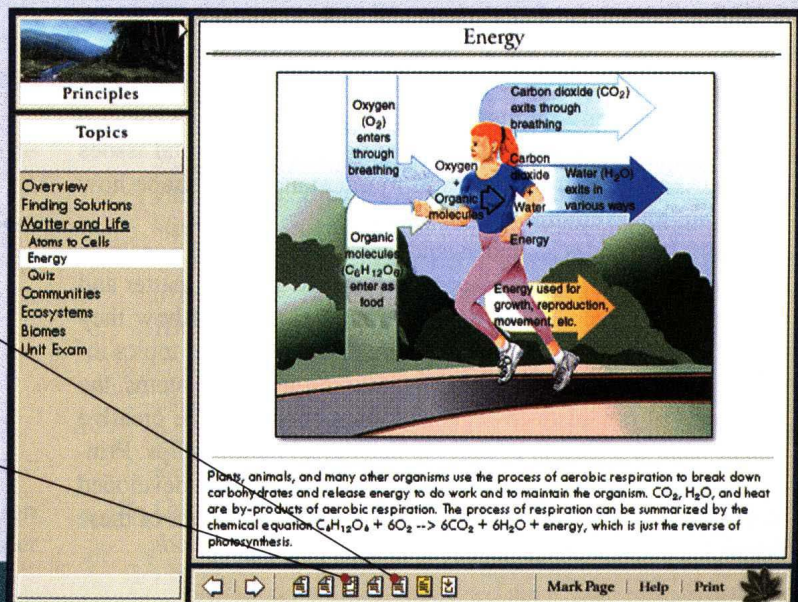
To the right of the arrows is a row of icons that represent the number of screens in a concept. There are three different icons, each representing different functions that a screen in that section will serve. The screen that is currently displayed will highlight yellow and visited ones will be checked.

The film icon represents an animation screen.




The activity icon represents an interactive learning activity.

The page icon represents a page of informational text.







# PREFACE

Environmental science is an interdisciplinary field. Because environmental disharmonies occur as a result of the interaction between humans and the natural world, we must include both when seeking solutions to environmental problems. It is important to have a historical perspective, appreciate economic and political realities, recognize the role of different social experiences and ethical backgrounds, and integrate these with the science that describes the natural world and how we affect it. *Environmental Science: A Study of Interrelationships* incorporates all of these sources of information when discussing any environmental issue. Furthermore, the authors have endeavored to present a balanced view of issues, diligently avoiding personal biases and fashionable philosophies.

*Environmental Science: A Study of Interrelationships* is intended as a text for a one-semester, introductory course for students with a wide variety of career goals. They will find it interesting and informative. The central theme is interrelatedness. No text of this nature can cover all issues in depth. What we have done is to identify major issues and give appropriate examples that illustrate the complex interactions that are characteristic of all environmental problems. There are many facts presented in charts, graphs, and figures that help to illustrate the scope of environmental issues. However, this is not the core of the text, since the facts will change.

## ORGANIZATION AND CONTENT

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This book is divided into five parts and twenty chapters. It is organized to provide an even, logical flow of concepts and to provide clear illustrations of the major environmental issues of today.

**Part 1** establishes the theme of the book in chapter 1 by looking at the kinds of environmental issues typical of different regions of North America. In each region, the specific issues selected involve scientific, social, political, and economic components typical of environmental problems. Chapter 2 focuses on the philosophical base needed to examine environmental issues by discussing various ethical and moral stands that shape how people approach environmental issues.

**Part 2** provides an understanding of the ecological principles that are basic to organism interactions and the flow of matter and energy in ecosystems. The nature of food chains and how they affect the flow of matter and energy are discussed. Other topics included are: the efficiency of energy flow through ecosystems, the intricacies of organism-to-organism interaction, and the creative role of natural selection in shaping ecological relationships. Principles of population structure and organization are also developed in this section, with particular attention to the implications of these principles to growth and impact of human populations.

**Part 3** focuses on energy. A major emphasis is on the historically important, nonrenewable fossil fuels that have stimulated economic success of the developed economies of the world. Renewable sources of energy are discussed, but with the recognition that they currently are a small part of the world energy picture. Weapons production and nuclear power plants use enormous amounts of energy that can be released from the nucleus of the atom. Both of these uses have caused fear among the public related to the dangers of radiation and the adequacy of waste disposal. These issues are discussed in this section.

**Part 4** emphasizes the impact of human activity on natural ecosystems. As human populations grow, and technology changes, the magnitude of human actions becomes more apparent. The natural ecosystems on land and water are modified to meet human needs. The heavy use of pesticides in agriculture is discussed in this section.

**Part 5** deals with the major types of pollution. Pollution affects the health and welfare of humans and other organisms. Air pollution, solid waste, and hazardous and toxic substances are discussed in this section. The cost of pollution cannot always be measured in financial terms, but may be reflected in the mental and physical health of the populace. Government often uses risk assessment and analysis to help set policy regarding pollution and other environmental issues. Separate chapters deal with the ways in which government sets policy and evaluates risk.

## NEW TO THIS EDITION

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1. The text has been edited throughout and rewritten where needed to include the most recent data and ways of thinking about environmental issues.
2. Many new illustrations were developed and many others were modified to improve their ability to convey information.
3. Several chapters have been substantially reorganized. Chapter 11, "Human Impact on Resources and Ecosystems," has been modified to add separate sections on agricultural ecosystems and the discussion on managing aquatic ecosystems was divided into freshwater and marine sections. Chapter 12, "Land-Use Planning," was completely reorganized and updated. Chapter 15, "Water Management," was significantly reorganized and many new and revised illustrations were included. Chapter 20 was completely rewritten with emphasis on environmental policy, personal responsibility for the environment, regulations, and the impact of multinational organizations.
4. Many new topics or boxed readings have been introduced into chapters that did not require major changes in chapter organization.



- Chapter 1 has new material on salmon concerns in the Northwest.
- Chapter 2 has additional material on environmental ethics and three new boxed readings on environmental philosophy, the Kyoto Protocol, and a code of environmental ethics and conduct.
- Chapter 4 has several new boxed readings on habitat conservation plans, ecological roles of humans, human impact on nutrient cycles, and the reintroduction of wolves into Yellowstone.
- Chapter 5 has two new readings on destruction of rainforests and rainforest products.
- Chapter 7 has new boxed readings on the impact of AIDS on populations, and Malthus' essay on population.
- Chapter 8 was updated throughout and has three new boxed readings on daily gasoline price fluctuations, and China's energy policy.
- Chapter 9 has a new boxed reading on the Three Gorges Dam in China and added material on hydroelectric power.
- Chapter 12 features a new boxed reading on the urbanization of the world population, including a chart of cities with the most rapidly growing populations.
- Chapter 13 has a new section on geologic processes—plate tectonics and a new boxed reading on world soil degradation. A new illustration denotes the various components in soil.
- Chapter 14 has increased coverage of sustainable and organic farming practices, world use of fertilizer and pesticides, and new subtitles in sections to make it easier for students to follow the text. A section on protecting soil and water was also added.
- Chapter 16 has expanded coverage of market-based incentives and extended product responsibility. Three new readings on corporate recycling of wood in urban environments, sustainable development, and valuing ecosystem services have been added.
- Chapter 17 has expanded coverage of secondhand smoke and two new boxed readings on global warming and indoor air pollution.
- Chapter 18 has 14 new or significantly modified illustrations.
- Chapter 19 has a new boxed reading on hazardous waste management in China.
- Chapter 20 features new readings on the Wise Use Movement, environment policy in the European Union, and the International Whaling Commission.

## SPECIAL FEATURES AND LEARNING AIDS

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1. Each of the five parts of the text begins with an **introduction** that places the upcoming chapters in context for the reader

by recalling previously discussed material and by describing the organization of the chapters to come. A world map with political boundaries can be found immediately following this preface. We believe that this will help the reader to more fully understand and appreciate global environmental issues.

2. Each chapter begins with a set of learning **objectives**, an **outline**, and a **conceptual diagram**—all of which give the student a broad overview of the interrelated forces that are involved in the material to be discussed. The student is encouraged to refer to these resources while reading and reviewing the chapter.
3. Chapters conclude with an **Issues and Analysis** case study, **summary**, a list of **key terms**, **review questions**, **critical thinking questions**, and a list of topics that correspond to specific Internet links on the accompanying web site. The case studies have been specifically selected to allow the reader to apply the chapter concepts to actual situations. Review questions are related to the chapter objectives, and thus serve to reinforce understanding of basic concepts and principles.
4. To dramatize and clarify text material, each chapter includes a number of **tables**, **charts**, **graphs**, **maps**, **drawings**, or **photographs**. Each illustration has been carefully chosen to provide a pictorial image or an organized format for showing detailed information, which helps the reader comprehend the chapter material.
5. Each chapter also includes **boxed readings**. These provide an in-depth consideration of a specific situation that is relevant to the content, an alternative viewpoint, or a wider world view of the issues discussed in the chapter.
6. The text concludes with several appendixes that deal with the following topics: critical thinking, the metric system, the periodic table of the elements, some thoughts on what you can do to make the world a better place in which to live, and how to write to public officials. In addition there is a complete glossary and index.

## USEFUL ANCILLARIES

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1. An **Instructor's Manual** accompanies the text. It includes chapter outlines, objectives, and key terms; a range of test and discussion questions; suggestions for demonstrations; and suggestions for audiovisual materials and other teaching aids. The Instructor's Manual also provides **additional case studies** for instructors who wish to use additional concrete examples of how the concepts in the chapter can be applied to the real world. It is available on disk only, in either Mac or IBM format.
2. A set of **one hundred transparencies** is also available to users of the text. The transparencies duplicate text figures that clarify essential ecological, political, economic, social, and historical concepts.
3. **Computerized Testing Software** rounds out the supplementary materials. Available for either Windows® or Mac-



Intosh®, this software allows for easy test generation using the questions found in the printed testbank.

4. *Environmental Science Visual Resource Library (VRL)* (0-07-290683-9) © 1999. This dual platform CD-ROM allows the user to search with key words or terms and access hundreds of images to illustrate classroom lectures, with just the click of a mouse. Contains images from three McGraw-Hill textbooks and over 400 additional photographs.
5. *Comprehensive Web Site*. Visit our web site at <http://www.mhhe.com/environmentalscience/> and discover a variety of valuable resources for both instructor and student. Examples include: chapter-by-chapter Internet links (updated regularly) that correspond to the end-of-chapter topics listed in the text, sample syllabi, laboratory exercises, classroom activities, current global environmental events in the news, practice quizzes, career information, and more.

## RELATED TITLES OF INTEREST/ PACKAGING OPPORTUNITIES

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*Annual Editions: Environment 99/00* (0-07-228498-6) © 1999. Editor: John L. Allen, University of Connecticut, Storrs—31 articles that address the current state of Earth and the changes it faces; world population and hunger; present and future energy needs and problems; endangered species; natural resources; and pollution.

*Taking Sides: Clashing Views on Controversial Environmental Issues*, 8th edition (0-07-303184-4) © 1999. Editor: Theodore D. Goldfarb, State University of New York, Stony Brook—18 issues debating general philosophical and political issues; the environment and technology; disposing of wastes; and the environment and the future.

## STUDENT ANCILLARIES

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1. *Environmental Science Essential Study Partner (ESP)* (0-07-303867-9) © 2000. This tutorial CD-ROM contains high-quality 3-D animations, interactive study activities, illustrated overviews of key topics in environmental science, and supplementary quizzes and exams that students will find extremely valuable.
2. *Life Science Living Lexicon* (CD-ROM or paperback print version). (CD = 0-697-37993-0; Print = 0-697-12133-X) © 1996. Author: William Marchuk. A powerful, interactive CD-ROM that contains a complete lexicon of life science terminology. Conveniently assembled on an easy-to-use CD-ROM are components such as a glossary of common biological roots, prefixes, and suffixes; a categorized glossary of common biological terms; and a section describing the classification system.
3. *Field and Laboratory Activities Manual* (0-07-290913-7) © 2000. Authors: Enger and Smith. Newly revised with additional contributors, this laboratory manual features a variety

of exercises on environmental topics. Supporting resources, directions, and interesting activities to accompany the manual may be found on the textbook's web site.

4. *Comprehensive Web Site*. Visit our web site at <http://www.mhhe.com/environmentalscience/> and discover a variety of valuable resources for both instructor and student. Examples include: chapter-by-chapter Internet links (updated regularly) that correspond to the end-of-chapter topics listed in the text, sample syllabi, laboratory exercises, classroom activities, current global environmental events in the news, practice quizzes, career information, and more.

*Sources: Notable Selections in Environmental Studies*, 2nd edition (0-07-303186-0) © 2000. Editor: Theodore D. Goldfarb, State University of New York, Stony Brook. Overviews of environmental issues focus specifically on energy, environmental degradation, population issues and the environment, human health and the environment, and environment and society.

*The Dushkin Student Atlas of Environmental Issues*, 1st edition (0-697-36520-4) © 1997. Editor: John Allen, University of Connecticut, Storrs—covers recent agricultural, industrial, and demographic changes in every world region; 48 full-color maps illustrate global patterns in the physical and human environments; and presents human impact on the air, fresh water and the oceans, the biosphere, and land.

*You Can Make a Difference: Be Environmentally Responsible*, 2nd edition (0-07-292416-0) © 1999. Author: Judy Getis. This book is organized around the three parts of the biosphere: land, water, and air. Each section contains descriptions of the environmental problems associated with that part of the biosphere. In the section on the atmosphere, for example, such problems as acid rain and the greenhouse effect are discussed. Immediately following each discussion or “challenge” are suggested ways that individuals can help solve or alleviate them—i.e., the “response.”

*Environmental Ethics: Divergence and Convergence*, 2nd edition (0-07-006180-7) © 1998. Authors: Botzler and Armstrong. This anthology surveys diverse approaches to environmental ethics by leading writers from a variety of disciplines, and provides a historical survey of thought on our responsibility to the environment. The perspectives are represented by articulate spokespersons and are accompanied by appraisals of their respective strengths and weaknesses. New topics include biodiversity, ecological restoration, environmental justice, and genetic engineering. A new section in the appendix on conflict resolution was requested by students.

*The Age of Environmentalism* (0-07-060841-5) © 1997. Author: J. E. de Steiguer. A scholarly treatment of environmental thought, this work provides information on the changing social and economic factors which gave rise to the modern environmental era, and examines a broad array of academic disciplines—biology, history, theology, philosophy, computer science and economics—which have contributed to modern environmentalism.

*Environmental Problem Solving: A Case Study Approach* (0-07-027686-2) © 1997. Author: Isobel W. Heathcote. This book focuses on real environmental case studies that illustrate an interaction of several disciplines and require analytical techniques to help students gain the “hands-on” experience needed to handle today’s environmental issues.

## ACKNOWLEDGEMENTS

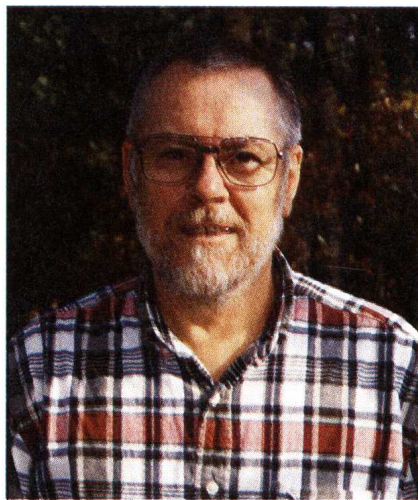
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Liette Vasseur, Saint Mary’s University  
Larry Williams, Benedict College  
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**Eldon D. Enger**

### ELDON D. ENGER

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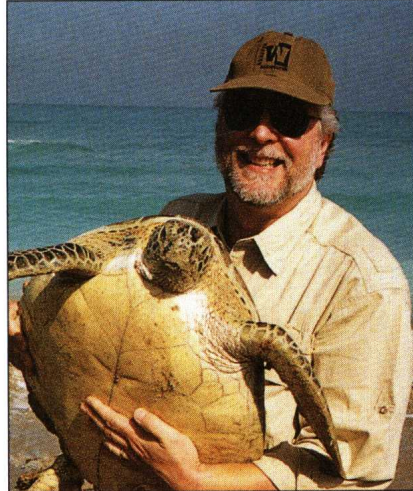
Eldon D. Enger is a professor of biology at Delta College, a community college near Saginaw, Michigan. He received his B.A. and M.S. degrees from the University of Michigan. Professor Enger has over 30 years of teaching experience, during which he has taught biology, zoology, environmental science, and several other courses. He has been very active in curriculum and course development. Recent activities include the development of a learning community course in stream ecology, which involves students in two weekend activities including canoeing and camping, and a plant identification course that incorporates weekend field activities with backpacking and camping. In addition, he was involved in the development of an environmental regulations course and an environmental technician curriculum.

Professor Enger is an advocate for variety in teaching methodology. He feels that if students are provided with varied experiences, they are more likely to learn. In addition to the standard textbook assignments, lectures, and laboratory activities, his classes are likely to include writing assignments, student presentation of lecture material, debates by students on controversial issues, field experiences, individual student projects, and discussions of local examples and relevant current events. Textbooks are very valuable for presenting content, especially if they contain accurate,

informative drawings and visual examples. Lectures are best used to help students see themes and make connections, and laboratory activities provide important hands-on activities.

Professor Enger has been a Fulbright Exchange Teacher to Australia and Scotland, received the Bergstein Award for Teaching Excellence and the Scholarly Achievement Award from Delta College, and participated as a volunteer in an Earthwatch Research Program in Costa Rica, studying the behavior of a bird known as the long-tailed manakin. He has also visited Australia, New Zealand, New Guinea, Fiji, Puerto Rico, Mexico, Canada, Morocco, many areas in Europe, and much of the United States. During these travels he has spent considerable time visiting coral reefs, ocean coasts, mangrove swamps, alpine tundra, prairies, tropical rainforests, cloud forests, deserts, temperate rainforests, coniferous forests, deciduous forests, and many other special ecosystems. This extensive experience provides the background to look at environmental issues from a broad perspective.

Professor Enger is married, has two college-aged sons, and enjoys a variety of outdoor pursuits such as cross-country skiing, hiking, hunting, fishing, camping and gardening. Other interests include reading a wide variety of periodicals, beekeeping, singing in a church choir, and preserving garden produce.



**Bradley F. Smith**

## **BRADLEY F. SMITH**

---

Bradley F. Smith is the Dean of Huxley College of Environmental Studies at Western Washington University in Bellingham, Washington. Prior to assuming the position as Dean in 1994, he served as the first Director of the Office of Environmental Education for the U.S. Environmental Protection Agency in Washington, D.C. from 1991 to 1994. Dean Smith also served as the Acting President of the National Environmental Education and Training Foundation in Washington, D.C. and as a Special Assistant to the EPA Administrator.

Before moving to Washington, D.C., Dean Smith was a professor of political science and environmental studies for fifteen years, and the executive director of an environmental education center and nature refuge for five years.

Dean Smith has considerable international experience. He was a Fulbright Exchange Teacher to England and worked as a research associate for Environment Canada in New Brunswick, Canada. He is a frequent speaker on environmental issues worldwide and serves on the International Scholars Program for the U.S. Information Agency. He also served as a U.S. representative on the Tri-Lateral Commission on environmental education with

Canada and Mexico. In 1995, he was awarded a NATO Fellowship to study the environmental problems associated with the closure of former Soviet military bases in Eastern Europe. Dean Smith is an Adjunct Professor at Far Eastern State University in Vladivostok, Russia and is a member of the Russian Academy of Transport. He also serves as a commissioner for the International Union for the Conservation of Nature (IUCN).

Nationally, Dean Smith serves as a member/advisor for many environmental organizations' boards of directors, advisory councils, and executive committees, including President Clinton's Council for Sustainable Development (Education Task Force).

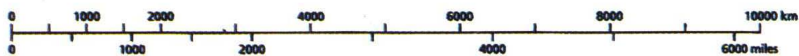
Dean Smith holds B.A. and M.A. degrees in Political Science and Public Administration and a Ph.D. from the School of Natural Resources and Environment at the University of Michigan.

Dean Smith lives with his wife Daria, daughter Morgan, son Ian, and English setter Skye, along Puget Sound south of Bellingham. He is an avid outdoor enthusiast.





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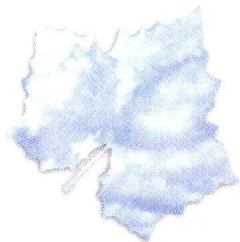






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