



David A. Castillon

Southwest Missouri State University

#### **Book Team**

Editor Jeffrey L. Hahn Developmental Editor Lynne M. Meyers Production Editor Kay J. Brimeyer Art Editor Carla Goldhammer Photo Editor Robin Storm Permissions Editor Karen L. Storlie Visuals Processor Andréa Lopez-Meyer



# WCB Wm. C. Brown Publishers

President G. Franklin Lewis Vice President, Publisher George Wm. Bergquist Vice President, Operations and Production Beverly Kolz National Sales Manager Virginia S. Moffat Group Sales Manager Vincent R. Di Blasi Vice President, Editor in Chief Edward G. Jaffe Marketing Manager John W. Calhoun Advertising Manager Amy Schmitz Managing Editor, Production Colleen A. Yonda Manager of Visuals and Design Faye M. Schilling Production Editorial Manager Julie A. Kennedy Production Editorial Manager Ann Fuerste Publishing Services Manager Karen J. Slaght

#### **WCB Group**

President and Chief Executive Officer Mark C. Falb Chairman of the Board Wm. C. Brown

Cover photograph: © L. Proser/Superstock, Inc.

Copyright © 1992 by Wm. C. Brown Publishers. All rights reserved

Library of Congress Catalog Card Number: 91-70378

ISBN 0-697-11229-2

No part of this publication may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without the prior written permission of the publisher.

Printed in the United States of America by Wm. C. Brown Publishers, 2460 Kerper Boulevard, Dubuque, IA 52001

10 9 8 7 6 5 4 3 2 1

#### Introduction

Conservation of natural resources will have new meaning in the 1990s. Almost every university in North America introduced a course into their curriculum in the 1960s, if they didn't already have one, in response to the environmental movement of that time period. Many books were written to supply these classes with material, although most books carried the pessimistic message of environmental degradation. The pessimism of the 1960s gave way to the programs of the 1970s, which began with the first Earth Day on April 22, 1970. The legislation to affect environmental improvement is in place and, in most cases, is working. The many success stories of the previous three decades have given the environmental movement an optimism it has never had before. It is in keeping with this

optimism that this book is written as we move through the 1990s, The Decade of the Environment, and attempt to continue our successful programs in the Conservation of Natural Resources.

Wm. C. Brown Publishers is committed to improved conservation methods in their publishing business. A discussion of their recycling program is given in chapter 15. This is one of the first books published by WCB on recycled paper.

#### **Purpose**

The purpose of this book is to expose you, the reader, to the ecological processes and problems related to our physical environment, so that conservation of natural resources will have new meaning to you as an inhabitant of North America and Planet Earth. To accomplish this purpose, the book will present material related to the conservation of natural resources so that you will:

Understand the role of the physical variables of geology, topography, soil, water, and air in the natural environment.

Understand the role of solar and internal heat energy as the driving force for all natural systems.

Understand that the living world (biosphere) is a response to the interactions of the lithosphere, hydrosphere, and atmosphere with solar or internal heat energy.

Understand the workings of ecosystems as they relate to the conservation of natural resources.

Understand that the management and conservation of all natural resources depends on working with nature to compliment normal energy flow cycles.

Understand the concept of *sustainability* as it relates to the management of all of our natural resources.

Understand the individual's place in the environment in both geologic and biologic time.

Understand that much work remains to be accomplished in the field of conservation and management of our resources and that your generation will be called on to do the work in the 21st century.

Develop an appreciation of nature by reading excerpts form the works of authors who understand man and nature and write well to express this knowledge.

Develop the love of the land necessary to establish for yourself a land ethic that makes you a part of the land community of Planet Earth.

#### **Audience**

This book is designed to be used in a one-semester (quarter) undergraduate course in Conservation of Natural Resources or Resource Management and Conservation. The vocabulary and level of discussion are appropriate for a freshman-through-junior-level college class with little or no scientific background as a prerequisite. The book could be retained as a valuable reference source after the course is completed.

# Geographic Area

Throughout this book emphasis is given to the conservation of natural resources in North America. The United States, Canada, and Mexico are all included in the discussion of physical variables (Part One). Natural resources management programs of the United States are emphasized in Part Two, but mineral resources of all three countries are discussed. Part Three is devoted to the human resources of the United States. By comparing human population problems of the United States with those of Mexico, the population problems of a developing nation are highlighted. A discussion of global environmental problems, including global sustainability and biodiversity, is included in Part Three.

#### Organization

This book is organized into three major parts. Part One is a brief physical geography of North America with emphasis on lithologic, hydrologic, and atmospheric circulation cycles. Physical variables of rock, soil, topography, weather, climate, air, and water compose the base of a biotic pyramid. The sun provides the energy to convert these physical variables into a biosphere. Important environmental topics in Part One include acid rain, greenhouse warming, ozone depletion, irrigation problems, sunless ecosystems, ocean dumping, groundwater pollution, and wetlands conservation.

Part Two covers the management and conservation of natural resources. An introductory chapter on the "tools of the trade" for a resources manager includes a discussion of remote sensing and geographic information systems. Management chapters include forest, agriculture, rangeland, wildlife, aquatic resources, energy, minerals, and waste. These chapters can be covered in any order.

Part Three on the human resource discusses the population problem, problems of urbanization, and land-use controls. Global sustainability and biodiversity are briefly reviewed to demonstrate the need for conservation management beyond North America. The book ends with a discussion on ethics and individual land ethics.

The three major parts of the book may be presented in any order. Instructors that prefer to set the stage for environmental problems by beginning with the people problems can begin with Part Three. However, it is recommended that chapter 1 be presented first before changing the sequence of the remaining chapters, because it contains many definitions and concepts that are used throughout the book. If physical geography is a prerequisite for the course on conservation of natural resources, most of Part One, with the exception of chapter 1, could be skipped without loss of continuity. Chapter 1 and Part Two provide enough material for a course in Resources Management if appropriate outside readings are assigned.

## **Educational Concepts**

A number of educational concepts have been applied in this book that will help to motivate the not-so-serious student. All examples that highlight important ideas have been included in the content of the text. Therefore, there are no boxed inserts or case studies separated from the text because the not-so-serious students, when pressed for reading time, tend to skip these to get through the assigned reading.

Many photographs and illustrations are included to generate and stimulate interest. A picture is worth a thousand words and is especially helpful in conveying volumes of information in a restricted amount of space.

The not-so-serious student will usually look at the photos and illustrations before he/she reads the text. Photos with captions can generate enough interest to motivate a student to read the corresponding text. If it doesn't, at least they have learned something from the illustrations.

Humor has been added occasionally to break the monotony of a serious subject. Illustrating the humorous side of an issue is an effective way to generate optimism when the outlook for improvement seems somewhat bleak.

Boldface type and italics have been used throughout the book. Boldface is used to emphasize important words or phrases and italics mark words or terms that are defined in the text.

#### **End-of-Chapter Materials**

At the end of each chapter key words and phrases used and/or defined in the chapter are listed. Also, a set of questions and discussion topics are provided for review, study, or discussion. Many of these questions attempt to motivate students to relate their own geographic area and its natural resources or conservation problems to the material in the text. Attempting to solve local problems by a method that has proved successful elsewhere is a good positive management strategy.

A list of references for further study is also given at the end of each chapter. The lists are purposely short, providing five or six choices that will extend discussion or elaborate on important ideas in the text. It should be obvious from these lists that the works of Loren Eiseley and Aldo Leopold are required reading in my classes. Leopold, in his Sand County Almanac, gives conservation its true meaning, and Eiseley relates humans to science and science to humans perhaps better than any other modern author.

# **Acknowledgements**

Many people have contributed in a variety of ways to the writing of this book. The Castillon household routine was dominated by my work on the project. A special thanks to my wife Joanne who sacrificed while I did nothing around the house for three years. Thanks to my children, Cindy, Kim, Linda, Laura, Rick, and Kelly and my granddaughter Shannon for their understanding and support.

Southwest Missouri State University and the Department of Geosciences have supported me throughout this project and I am very grateful for their help and assistance. The secretaries, especially Deana Gibson, have spent many hours typing and retyping the manuscript that

became this book. Doug Hemsath and Mike Klein have been my cartographers throughout this project. A special thanks to them for their work.

Obviously, the content of a book this size is the work of a large scientific community. They have shared their ideas through a vast network of publications and writings that provided me with the inspiration I needed to collect their ideas and information and present it to you in this book. To them I am grateful. I accept the responsibility for any errors that exist in this book and ask that you write to me and let me know of any that you find so that they may be corrected in later printings.

## Reviewers

Miriam Helen Hill
Indiana University Southeast
Clarence M. Head
University of Central Florida
Eric A. Johnson
Illinois State University
John R. Ray
Wright State University
Robert D. Loring
DePauw University

# **Contents**

Preface xi Acknowledgements xv



# Physical and Biological Variables of the Natural Environment

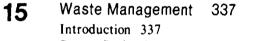
Introduction to the Conservation of Natural
Resources 5
Introduction 5
Brief History of Conservation 7
Natural Resources 11
Inexhaustible Resources 11
Renewable Resources 12

Nonrenewable Resources 12
Potential Resources 13
Time 13
Geologic Time versus Biologic Time 13
Future Time 16
The Biotic Pyramid 16
The Laws of the Biosphere 18
Law of Production 18
Law of Adaptation 18
Law of Fertility 18
Law of Succession 20
Law of Control 20
Summary 21

2	Lithosphere—Geology 25		Gleization 98
_	Introduction 25		Invertization 98
	Composition of the Lithosphere 26		Soil Classification and Soil Geography 98
	Lithology 27		Soil Biota 101
	Endogenic Processes 27		Soil Erosion 102
	Sea Level 29		Irrigation 104
	Lithologic Circulation 31		Wetlands 106
	<u> </u>		Summary 108
	A Sunless Ecosystem 32		<b>,</b>
	Mount St. Helens 32		
	Exogenic Processes 33	6	Biosphere—Biogeography 111
	Continental Glaciation 35	_	Introduction 111
	Topography 37		Energy Flow in the Biosphere 112
	The Biosphere through Geologic Time 38		Chemical Element Cycles of the Earth 113
	Natural Geologic Hazards 39		The Carbon Cycle 114
	Summary 41		The Oxygen Cycle 115
			The Nitrogen Cycle 116
_	Atura andra an Olimata AO		The Sedimentary Cycle 117
3	Atmosphere—Climate 43		Biogeography of North America 117
	Introduction 43		
	Solar Energy 43		Natural Biotic Regions 118
	Atmosphere—Composition and Properties 47		Climate as a Control in Biogeography 119
	Atmospheric Circulation 49		Horizontal and Vertical Zonation of
	Climate 50		Vegetation 123
	The Köppen System 51		Biologic Productivity 130
	Climatic Extremes 54		Ecoregions of North America 131
	Climate Change 56		Tropical 134
	The Greenhouse Effect 57		Tropical Savanna 136
	The Ozone Problem 59	Subtropical 138	
	Summary 61		Hot Continental 140
	Summary of		Warm Continental 142
			Subarctic 144
4	Hydrosphere—Water 63		Tundra 146
•	Introduction 63		Prairie 148
	Changing States of Water 63		Steppe 150
	Hydrologic Cycle 64		Desert 152
	Oceanic Circulation 66		Marine 154
			Mediterranean 156
	Composition of the Hydrosphere 67		
	The Aquatic Environments 68		Summary 158
	Freshwater Environments 69		
	Lakes 69		CONTRACTOR OF THE PARTY OF THE
	Lake Zones 71		Part Two
	The Acid Rain Problem 71		
	Streams 74		
	The Missouri River 74		Natural Resources Management
	Saltwater Environments 77		
	The Ocean Basins 80	_	Internation to Matural Decourage
	Ocean Dumping 83	7	Introduction to Natural Resources
	Groundwater 85		Management 163
	Summary 88		Introduction 163
	<b>54</b>		The Technology of Resource Management 164
			Remote Sensing 164
5	Soil 91		Remote Sensing of the Lithosphere 166
	Introduction 91		Remote Sensing of the Atmosphere 168
	Definition of Soil 93		Remote Sensing of the Hydrosphere 171
	Soil Horizons 93		
	Soil Formation 95'		Remote Sensing of the Biosphere 172
	Podzolization 96		Geographic Information Systems 175
	Laterization 96		Environmental Monitoring 176
	Calcification 96		Resource Management 177
	Calcinication 70		A General Plan for Natural Resource
			Management 177
			Summary 178

8	Forest Management 181	71	Whome Management 231
•	Introduction 181		Introduction 231
	The Forest Resource 181		Legislation to Protect Wildlife 232
	Forest Fires 184		Wildlife Restoration Act 234
	Controlled Burning as a Forest Management		Endangered Species Act 234
	Tool 185		Wildlife Management Techniques 235
	U.S. Forest Service 185		Whooping Crane 236
			Eastern Wild Turkey 238
	Sustained Yield 186		· · · · · · · · · · · · · · · · · · ·
	Even-Aged Management 186		White-Tailed Deer 242
	Uneven-Aged Management 186		Ring-Necked Pheasant 244
	Forest Service 50-Year Plans 188		Modern Medicine in Wildlife Management 246
	Wilderness 190		Summary 247
	National Parks 192		
	Forest Management Practices 194	10	Aquatic Resources Management 249
	A Forest Management Cycle 194	12	
	Timber Stand Improvement for Small		Introduction 249
	Woodlots 195		Aquatic Resources Legislation 250
	Summary 197		State Game Laws to Protect the Fisheries
	Summary 177		Resource 252
			Stream Management 252
9	Agricultural Management 199		Stream Habitat Improvement 253
	Introduction 199		Channelization 256
	Pesticides 201		Stocking Fish as a Management Practice 256
	Alternative Pest Controls 204		Pond Management 261
	Agricultural Chemicals in Groundwater		Fish Farming 263
	Strategy 204		Lake Management 264
	Integrated Pest Management (IPM) 204		Great Lakes 266
	· · · · · · · · · · · · · · · · · · ·		Corps of Engineer Impoundments 268
	Farming Without Chemicals 205		Waterfowl Management 270
	The Food Security Act 209		
	Conservation Reserve Program (CRP) 209		Summary 276
	Conservation Compliance 209		
	Sodbuster 209	13	Energy Management 277
	Swampbuster 209	13	Introduction 277
	Drought of 1988 209		Fossil Fuels 278
	1990 Farm Bill 210		
	Climate as a Control in Agriculture 210		Oil 279 The Neath Stanz Aleston Oil Field 270
	Soil Fertility 211		The North Slope Alaskan Oil Field 279
	Organic Matter ContentpH 211		The Arctic National Wildlife Refuge
	Nitrogen 211		(ANWR) 283
	Phosphorus 211		Exxon Valdez 283
	Potassium 213		American Trader 284
			Natural Gas 286
	Summary 213		Coal 287
			The Surface Mining Control and Reclamation
0	Rangeland Management 215		Act of 1977 289
U	Introduction 215		Nuclear Energy 291
	Brief History of Rangeland Use and Abuse 217		The Shippingport Nuclear Reactor Funeral 295
			Geothermal Energy 297
	Public Lands 218		Solar Energy 298
	Forest Service Rangeland Policy 219		Hydropower 305
	Bureau of Land Management 220		Wind Power 306
	Overgrazing 221		
	Rangeland Biogeography 222		Energy Management 307
	Rangeland Management 226		Summary 309
	Feral Horses and Asses 227		
	Summary 229		

14	Mineral Resources 311
	Introduction 311
	Metallic Minerals 311
	Abundant Metals 312
	Iron 314
	Aluminum 315
	Magnesium 316
	Titanium 317
	Manganese 317
	Scarce Metals 318
	Copper, Lead, Zinc, and Nickel 320
	Gold, Silver, and Platinoids 321
	Management Strategies for Industry 323
	Underground Mining 324
	Nonmetallic Minerals 325
	Building Materials 325
	Stone 325
	Sand and Gravel 326
	Cement 328
	Plaster 328
	Fertilizer and Chemical Minerals 328
	Nitrogen 329
	Phosphorus 329
	Potash (Potassium) 330
	Halite 331
	Sulfur 333
	Summary 334
15	Waste Management 337
10	Introduction 337
	Source Reduction 338
	Waste-to-Energy Plants 340
	Landfills 341



Hazardous Waste Management 342 Household Hazardous Waste 343 Industrial Waste Management 345 Superfund 345 RCRAs Rules 346 Wastewater Treatment 347 Sludge as a Resource 350 Recycling 351 Paper 352 Paper Recycling at WCB Publishers 352 Plastic 352 Summary 355

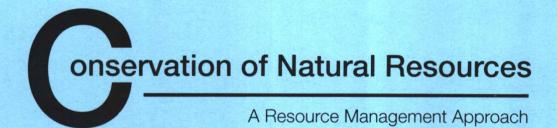


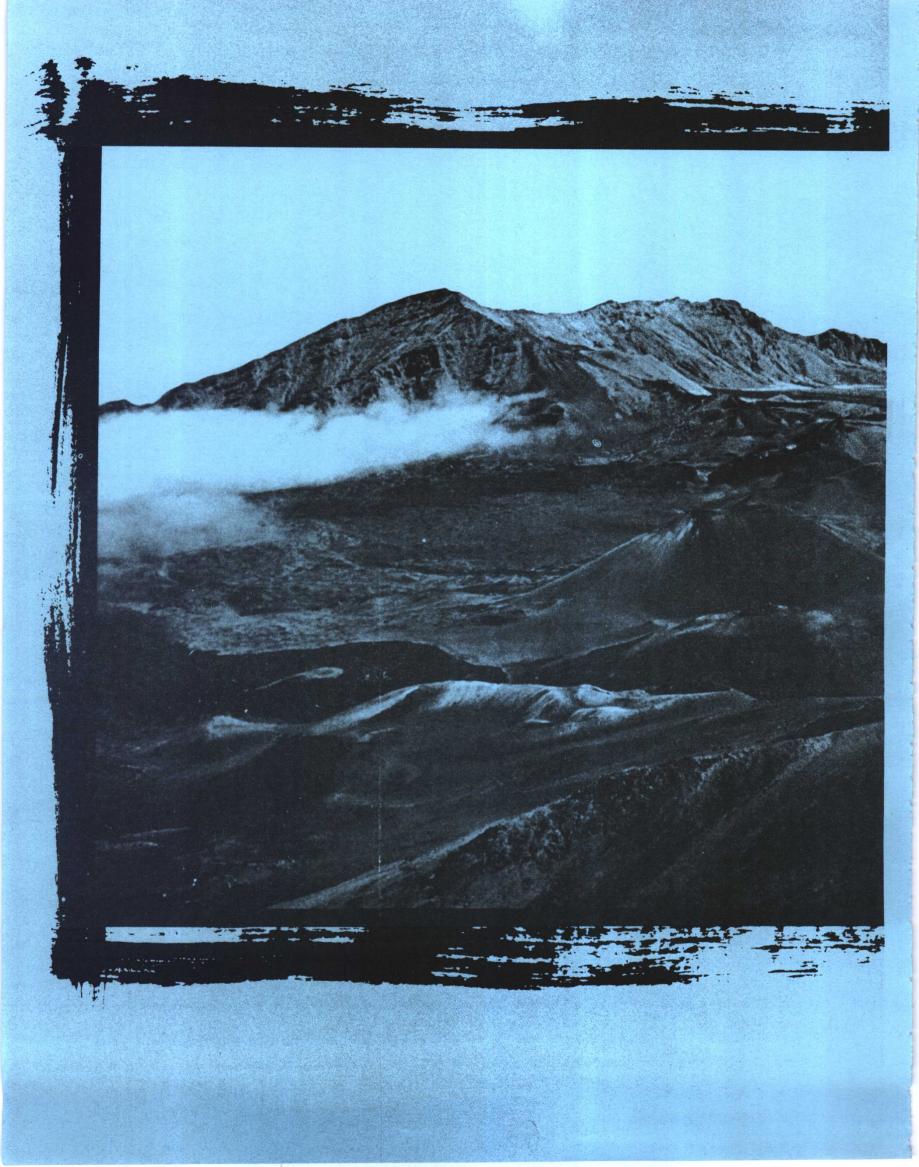
## People—Land Ethics—Global Sustainability

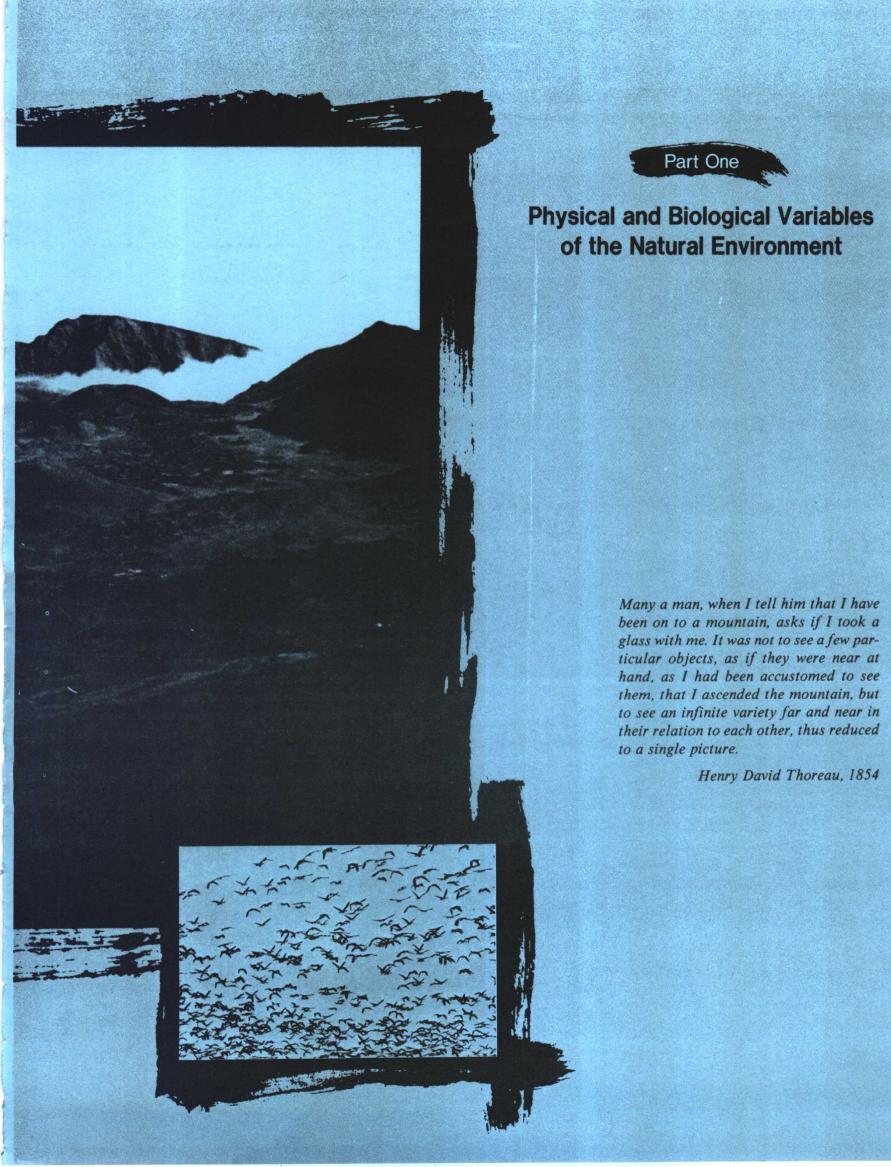
16 The Human Resource 361 Introduction 361 The Peopling of North America 362 Population Dynamics 362 Human Carrying Capacity 364 Dealing with Population Increases 366 Birth Control 366 Family Planning 366 Urbanization of the Human Population 367 Urban Growth 369 ZPG's Urban Stress Test 370 The Environmental Index of the UST 371 Urban Planning 371 Land Controls 374 Sustainability 376 A Global View 378 Biodiversity 380 Ethics 381 Land Ethics 382 Summary 383

## **Appendices**

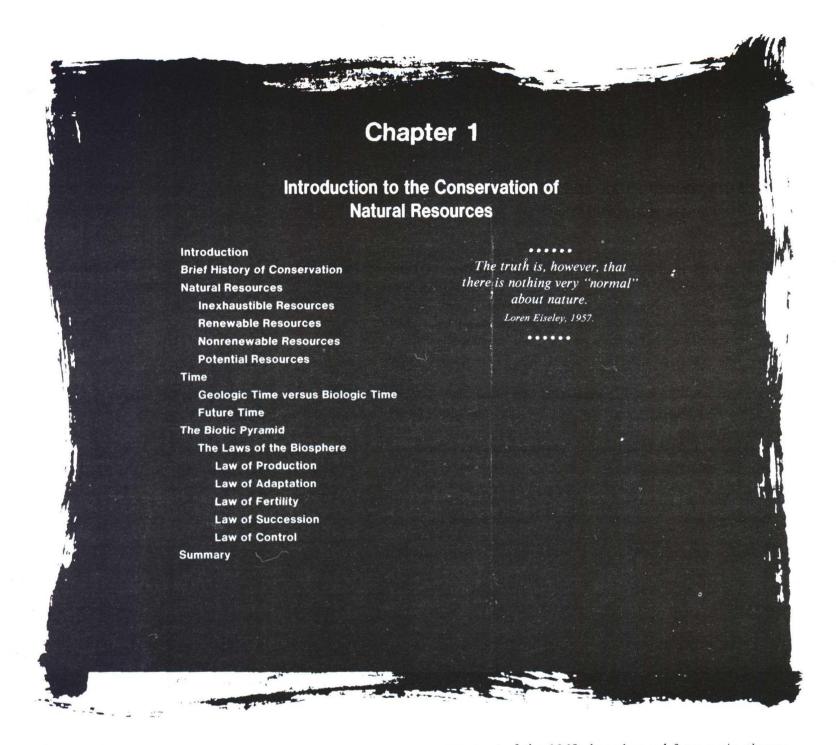
Al Periodic Chart of the Elements 385 A2 Relative Percentages of Elements in the Earth's Spheres 386 B Geologic Time and Formations 387 C Units of Measurement Metric/English Conversions 388 D Köppen Climate Classification Chart 390 E The National Wilderness Preservation System 1964-1989 391 F How to Write Your Elected Officials 403 G List of Environmental Organizations 404 H United States Government Agencies 406 I Environmental Publications 407 J Important United States Environmental Legislation 409 K Environmental Literacy Test with Answers 410 L Basic Geographic Data on Canada, Mexico, and the United States 412 M Acronyms Used in this Text 418 N Threatened and Endangered Species List for the United States 419 Index 424







			•			
	•					
				<i>:</i>		
		•		* *	•	
			4			
			•		÷	
			•			
			•			
		• .				
•						*
				•		
	<b>·</b>					•
•	·					
						************************************
				and the second		
			•			
					e de la companya de	
•						
				•		
·						
•			•			
					•	•
						- 
						•
						· .
	•					renative of
		•				
						•
						<u>ز</u> ر
						Î
4						
						n de la companya de La companya de la co
			•		•	
					, et	
그렇다 하 한경을 맞았다면 물건이 그리다						· 1



#### Introduction

It has been more than two decades since the first Earth Day, April 22, 1970, a day declared by the citizens of the United States to express concern for cleaning up the environment. In fact, so many politicians from both parties jumped at the opportunity to express their concern that Congress was forced to close down for the day. In the Gallup polls, concern over air and water pollution jumped from tenth place in the summer of 1969 to fifth place by the summer of 1970 and was perceived as more important than race, crime, and teenage problems but not as important as the perennial poll leaders, peace (Vietnam) and the pocket book issues, the dollar problems of the federal budget (taxes and expenditures). The environmental

movement of the 1960s has changed from a reactionary statement by the young to an ongoing involvement by the masses. We have changed from a society that did not consider the environmental consequences of our daily actions to one that at least recognizes the environmental ramifications of our developmental projects. The National Environmental Policy Act (NEPA) of 1969 was signed by President Nixon and became law January 1, 1970. This law, for the first time in our history, made environmental concerns a national policy and priority, although we still do not always make the most environmentally sound choice in our development decisions. This act does not require that we do so however, only that we consider the action and alternatives, including the no-action alternative, before a decision can be made to proceed. We have come a long