

INTERNATIONAL EDITION

Environmental A STUDY OF INTERRELATIONSHIPS Science



seventh edition

Enger  Smith

C O N T E N T S

Preface	xvi
---------	-----



PART ONE Interrelatedness

2

Chapter 1

Environmental Interrelationships	4
The Field of Environmental Science	5
The Interrelated Nature of Environmental Problems	5
• Environmental Close-Up: Science Versus Policy	6
• Global Perspective: Fish, Seals, and Jobs	6
An Ecosystem Approach	7
Regional Environmental Concerns	8
• Environmental Close-Up: The Greater Yellowstone Ecosystem	8
• Environmental Close-Up: Ecosystem Size	9
<i>The Wilderness North</i>	9
<i>The Agricultural Middle</i>	9
<i>The Dry West</i>	11
<i>The Forested West</i>	11
<i>The Great Lakes and Industrial Northeast</i>	12
<i>The Diverse South</i>	13

Chapter 2

Environmental Ethics	16
Views of Nature	17
<i>Environmental Ethics</i>	17
• Environmental Close-Up: What is Ethical?	18
• Environmental Close-Up: Code of Environmental Ethics and Conduct	19
Environmental Attitudes	19
Societal Environmental Ethics	20
• Environmental Close-Up: Naturalist Philosophers	21
• Environmental Close-Up: Environmental Philosophy	22
Corporate Environmental Ethics	22
• Environmental Close-Up: A Corporate Perspective	23
• Global Perspective: General Motors Environmental Principles	24
• Global Perspective: Chico Mendes and Extractive Reserves	26
Environmental Justice	26
Individual Environmental Ethics	27
Global Environmental Ethics	27
• Global Perspective: International Trade in Endangered Species	28

• Issues and Analysis: Antarctica—Resource or Refuge?	30
• Global Perspective: Earth Summit	31
• Global Perspective: The Kyoto Protocol	32



PART TWO

Ecological Principles and Their Application 34

Chapter 3

Interrelated Scientific Principles: Matter, Energy, and Environment	36
Scientific Thinking	37
• Environmental Close-Up: Typical Household Chemicals	38
Limitations of Science	39
The Structure of Matter	39
<i>Atomic Structure</i>	39
<i>Molecules and Mixtures</i>	39
<i>Acids, Bases, and pH</i>	40
<i>Inorganic and Organic Matter</i>	40
<i>Chemical Reactions</i>	40
<i>Chemical Reactions in Living Things</i>	41
Energy Principles	41
<i>States of Matter</i>	41
<i>Kinds of Energy</i>	42
<i>First and Second Laws of Thermodynamics</i>	42
<i>Environmental Implications of Energy Flow</i>	42
• Issues and Analysis: Improvements in Lighting Efficiency	45

Chapter 4

Interactions: Environment and Organisms	47
Ecological Concepts	48
<i>Environment</i>	48
<i>Limiting Factors</i>	48
<i>Habitat and Niche</i>	49
• Environmental Close-Up: Habitat Conservation Plans: Tool or Token?	51
The Role of Natural Selection and Evolution	51
<i>Species Definition</i>	51
<i>The Mechanism of Natural Selection</i>	52
Kinds of Organism Interactions	53
<i>Predation</i>	53
<i>Competition</i>	54
<i>Symbiotic Relationships</i>	54
• Environmental Close-Up: Human Interaction—A Different Look	56

Community and Ecosystem Interactions	56
<i>Major Roles of Organisms</i>	56
<i>Energy Flow Through Ecosystems</i>	57
<i>Food Chains and Food Webs</i>	58
• Environmental Close-Up: Name That Relationship	60
<i>Nutrient Cycles in Ecosystems</i>	60
• Global Perspective: Human Impact on Nutrient Cycles	63
• Environmental Close-Up: Colorado River Restoration	64
• Environmental Close-Up: Organic Contaminants	
in Great Lakes Fish	64
• Issues and Analysis: Reintroducing Wolves to	
Yellowstone	65

Chapter 5

Kinds of Ecosystems and Communities

Succession	68
<i>Primary Succession</i>	69
<i>Secondary Succession</i>	70
Major Types of Climax Communities: Biomes	71
<i>Desert</i>	71
• Environmental Close-Up: The Changing Nature of	
the Climax Concept	75
<i>Grassland</i>	75
• Environmental Close-Up: Grassland Succession	77
<i>Savanna</i>	77
<i>Tropical Rainforest</i>	77
• Global Perspective: Destruction of the Rainforests	78
• Global Perspective: Rainforest Products	79
• Environmental Close-Up: Forest Canopy Studies	79
• Global Perspective: Old-Growth Temperate	
Rainforests of the Pacific Northwest	81
<i>Temperate Deciduous Forest</i>	81
<i>Taiga, Northern Coniferous Forest, or</i>	
<i>Boreal Forest</i>	81
<i>Tundra</i>	82
<i>Altitude and Latitude</i>	82
Major Aquatic Ecosystems	83
<i>Marine Ecosystems</i>	83
<i>Freshwater Ecosystems</i>	85
• Issues and Analysis: Restoring Ecosystems	88

Human Population Growth	99
<i>Humans Are Social Animals</i>	100
<i>Ultimate Size Limitation</i>	100
• Environmental Close-Up: Population Growth of	
Invading Species	101
• Issues and Analysis: Wolves and Moose on Isle	
Royale	102

Chapter 7

Human Population Issues

Current Population Trends	106
Population and Standard of Living	106
The Human Population Issue	107
Causes of Population Growth	107
<i>Biological Reasons for Population Growth</i>	108
<i>Social Reasons for Population Growth</i>	109
• Global Perspective: The Impact of AIDS on	
Populations	110
• Environmental Close-Up: Control of Births	111
• Global Perspective: Governmental Policy and	
Population Control	112
• Global Perspective: Thomas Malthus and His Essay	
on Population	113
<i>Political Factors That Affect Population</i>	
<i>Growth</i>	113
The Demographic Transition Concept	113
The U.S. Population Picture	114
• Global Perspective: The Urbanization of the World's	
Population	115
Hunger, Food Production, and Environmental	
Degradation	116
• Global Perspective: Population and Poverty: A	
Vicious Cycle	118
Anticipated Changes with Continued Population Growth	118
• Global Perspective: Canadian Population Overview	119
• Issues and Analysis: Population Growth in Mexico	119



PART THREE

Energy	122
--------	-----

Chapter 8

Energy and Civilization: Patterns of Consumption

History of Energy Consumption	125
<i>Biological Energy Sources</i>	125
<i>Increased Use of Wood</i>	125
<i>Fossil Fuels and the Industrial Revolution</i>	126
Energy and Economics	127
<i>Economic Growth and Energy Consumption</i>	127
<i>The Role of the Automobile</i>	127
• Global Perspective: Gasoline Prices and	
Government Policy	128

Chapter 6

Population Principles

Population Characteristics	91
<i>Natality and Mortality</i>	92
<i>Sex Ratio and Age Distribution</i>	92
<i>Population Density and Spatial Distribution</i>	93
<i>Summary of Factors that Influence Population</i>	
<i>Growth Rates</i>	94
A Population Growth Curve	94
Carrying Capacity	95
Reproductive Strategies and Population Fluctuations	96
• Global Perspective: Managing Elephant Populations	98

• Global Perspective: Five Ways to Curb Traffic	129
How Energy is Used	129
<i>Residential and Commercial Energy Use</i>	129
<i>Industrial Energy Use</i>	130
<i>Transportation Energy Use</i>	130
• Environmental Close-Up: Why Do Gasoline Prices Vary from Day to Day?	131
Electrical Energy	131
• Environmental Close-Up: Electric Car Development	132
Energy Consumption Trends	132
• Environmental Close-Up: Alternative-Fuel Vehicles	133
• Global Perspective: OPEC	134
• Global Perspective: Energy Development in China	137
• Global Perspective: When Will We Run Out of Oil?	138

Chapter 9

Energy Sources	140
Energy Sources	141
Resources and Reserves	142
Fossil-Fuel Formation	143
<i>Coal Formation</i>	143
<i>Oil and Natural Gas Formation</i>	143
Issues Related to the Use of Fossil Fuels	145
<i>Coal Use Issues</i>	145
<i>Oil Use Issues</i>	147
<i>Natural Gas Use Issues</i>	148
Renewable Sources of Energy Currently Being Used	150
<i>Hydroelectric Power</i>	150
• Global Perspective: Hydroelectric Sites	151
<i>Tidal Power</i>	152
<i>Geothermal Power</i>	152
• Global Perspective: The Three Gorges Dam	153
<i>Wind Power</i>	154
• Global Perspective: Electricity from the Ground Up	155
<i>Solar Energy</i>	156
<i>Biomass Conversion</i>	158
<i>Fuelwood</i>	159
<i>Solid Waste</i>	160
Energy Conservation	161
• Issues and Analysis: The Arctic National Wildlife Refuge and Oil	162

Chapter 10

Nuclear Energy: Benefits and Risks	164
The Nature of Nuclear Energy	165
The History of Nuclear Energy Development	166
Nuclear Reactors	166
Breeder Reactors	168
Nuclear Fusion	170
The Nuclear Fuel Cycle	170
Nuclear Material and Weapons Production	171
Nuclear Power Concerns	172

<i>Reactor Safety: The Effects of Three Mile Island and Chernobyl</i>	172
<i>Exposure to Radiation</i>	174
<i>Thermal Pollution</i>	176
<i>Decommissioning Costs</i>	176

• Global Perspective: The Nuclear Legacy of the Soviet Union	178
<i>Radioactive Waste Disposal</i>	177



PART FOUR

Human Influences on Ecosystems

184

Chapter 11

Human Impact on Resources and Ecosystems	186
The Changing Role of Human Impact	187
Historical Basis of Pollution	187
Renewable and Nonrenewable Resources	187
Costs Associated with Resource Exploitation	188
Mineral Resources	189
<i>Steps in Mineral Exploitation</i>	189
<i>Recycling of Mineral Materials</i>	191
Exploitation and Modification of Terrestrial Ecosystems	191
<i>Agricultural Ecosystems</i>	191
<i>Forest Resources</i>	191
<i>Managing Forest Ecosystems</i>	193
• Environmental Close-Up: The Northern Spotted Owl	194
<i>Management of Rangeland Ecosystems</i>	194
Areas with Minimal Human Impact—Wilderness and Remote Areas	196
Managing Aquatic Ecosystems	197
<i>Managing Marine Ecosystems</i>	197
• Global Perspective: The History of the Bison	198
<i>Managing Freshwater Ecosystems</i>	199
Managing Ecosystems for Wildlife	200
• Environmental Close-Up: Farming, Fish Kills and <i>Pfiesteria piscicida</i>	202
• Environmental Close-Up: Native American Fishing Rights	203
Natural Selection and Extinction	205
Human-Accelerated Extinction	207
Why Worry about Extinction?	209
What Is Being Done to Prevent Extinction?	209
• Environmental Close-Up: The California Condor	210
• Issues and Analysis: Costa Rican Forests Yield Tourists and Medicines	213

Chapter 12

Land-Use Planning	216
The Need for Planning	217
Historical Forces that Shaped Land Use	217
<i>The Importance of Waterways</i>	217

<i>The Rural to Urban Shift</i>	218
The Death of the Central City and The Rise of Suburbia	218
• Global Perspective: Urbanization in the Developing World	219
Some Problems Associated with Unplanned Urban Growth	221
<i>Transportation Problems</i>	221
<i>Loss of Open Space</i>	221
<i>Loss of Farmland</i>	221
<i>Floodplain Problems</i>	221
• Environmental Close-Up: Wetlands Loss in Louisiana	222
<i>Wetlands Misuse</i>	222
<i>Other Land-Use Considerations</i>	223
Land Use Planning: Principles and Challenges	223
<i>Urban Transportation Planning</i>	223
<i>Urban Recreation Planning</i>	224
National and Regional Planning	225
<i>Multiple Land Use</i>	226
<i>The Use of Public Land for Outdoor Recreation</i>	226
• Issues and Analysis: Decision Making in Land-Use Planning: The Malling of America	228

Chapter 13

Soil and Its Uses	230
Geologic Processes	231
Soil and Land	232
Soil Formation	232
Soil Properties	234
Soil Profile	236
Soil Erosion	237
Soil Conservation Practices	239
<i>Contour Farming</i>	240
<i>Strip Farming</i>	241
<i>Terracing</i>	241
<i>Waterways</i>	242
<i>Windbreaks</i>	242
• Global Perspective: World Wide Soil Degredation	243
<i>Conservation Tillage</i>	244
Protecting Soil on Nonfarm Land	247
• Environmental Close-Up: Land Capability Classes	248
• Issues and Analysis: Soil Erosion in Virginia	250

Chapter 14

Agricultural Methods and Pest Management	252
Differing Agricultural Methods	253
Energy Versus Labor	255
The Impact of Fertilizer	255
Pesticides	256
<i>Insecticides</i>	256
• Environmental Close-Up: Regulation of Pesticides	258
<i>Herbicides</i>	258

• Environmental Close-Up: A New Generation of Insecticides	259
<i>Other Agricultural Chemicals</i>	260
<i>Fungicides and Rodenticides</i>	260
• Environmental Close-Up: Politics and the Control of Ethylene Dibromide (EDB)	261
Problems with Pesticide Use	261
<i>Persistence</i>	261
<i>Bioaccumulation and Bioamplification</i>	261
<i>Pesticide Resistance</i>	263
<i>Effect on Nontarget Organisms</i>	263
<i>Human Health Concerns</i>	264
Why Are Pesticides So Widely Used?	264
• Global Perspective: China's Ravenous Appetite	265
• Global Perspective: Contaminated Soils in the Former Soviet Union	266
Alternatives to Conventional Agriculture	266
• Environmental Close-Up: Food Additives	267
Techniques for Protecting Soil and Water Resources	267
Integrated Pest Management	268
• Issues and Analysis: Herring Gulls as Indicators of Contamination in the Great Lakes	271

Chapter 15

Water Management	274
The Water Issue	275
The Hydrologic Cycle	275
Human Influences on the Hydrologic Cycle	277
Kinds of Water Use	278
<i>Domestic Use of Water</i>	278
<i>Agricultural Use of Water</i>	279
<i>Industrial Use of Water</i>	280
<i>In-Stream Use of Water</i>	281
Kinds and Sources of Water Pollution	282
• Environmental Close-Up: Is It Safe to Drink the Water?	283
<i>Municipal Water Pollution</i>	283
<i>Agricultural Water Pollution</i>	285
• Environmental Close-Up: New Optimism for the New River	286
<i>Industrial Water Pollution</i>	287
<i>Thermal Pollution</i>	287
• Global Perspective: The Cleanup of the Holy Ganges	288
• Global Perspective: Comparing Water Use and Pollution in Industrialized and Developing Countries	289
<i>Marine Oil Pollution</i>	290
<i>Groundwater Pollution</i>	290
Water-Use Planning Issues	291
<i>Water Diversion</i>	292
<i>Wastewater Treatment</i>	292

• Environmental Close-Up: Is It Too Late for the Everglades	293
<i>Salinization</i>	295
<i>Groundwater Mining</i>	295
• Global Perspective: Death of a Sea	296
<i>Preserving Scenic Water Areas and Wildlife Habitats</i>	297
• Global Perspective: ECOPARQUE	300
• Issues and Analysis: The California Water Plan	302

PART FIVE

Pollution and Policy	306
----------------------	-----

Chapter 16

Risk and Cost: Elements of Decision Making

Measuring Risk	309
<i>Risk Assessment</i>	309
• Environmental Close-Up: What's In a Number?	311
<i>Risk Management</i>	311
<i>True and Perceived Risks</i>	312
Economics and the Environment	313
<i>Economic Concepts</i>	313
<i>Market-Based Instruments</i>	314
<i>Extended Product Responsibility</i>	316
• Environmental Close-Up: Georgia-Pacific Corporation: Recycled Urban Wood—A Case Study in Extended Product Responsibility	317
<i>Cost-Benefit Analysis</i>	317
<i>Concerns about the Use of Cost-Benefit Analysis</i>	318
<i>Economics and Sustainable Development</i>	319
• Global Perspective: Sustainable Development	320
• Environmental Close-Up: “Green” Advertising Claims—Points to Consider	321
• Global Perspective: Pollution Prevention Pays!	322
<i>External Costs</i>	323
<i>Common Property Resource Problems</i>	324
<i>Economic Decision Making and the Biophysical World</i>	324
<i>Economics, Environment, and Developing Nations</i>	325
• Environmental Close-Up: Placing a Value on Ecosystem Services	326
• Global Perspective: The Tragedy of the Commons	327
<i>Lightening the Load</i>	327
• Issues and Analysis: Shrimp, Turtles, and Turtle Excluder Devices	328

Chapter 17

Air Pollution

The Atmosphere	332
Primary Air Pollutants	333

• Global Perspective: Air Pollution in Mexico City	334
<i>Carbon Monoxide (CO)</i>	334
<i>Hydrocarbons (HC)</i>	335
<i>Particulates</i>	335
<i>Sulfur Dioxide (SO₂)</i>	335
<i>Oxides of Nitrogen (NO and NO₂)</i>	336
Photochemical Smog	336
Other Significant Air Pollutants	337
Control of Air Pollution	337
Acid Deposition	339
• Environmental Close-Up: The 1990 Clean Air Act	340
• Environmental Close-Up: Secondhand Smoke	342
Global Warming and Climate Change	344
<i>Worsening Health Effects</i>	345
<i>Rising Sea Level</i>	345
<i>Disruption of the Water Cycle</i>	345
<i>Changing Forests and Natural Areas</i>	346
<i>Challenges to Agriculture and the Food Supply</i>	346
• Environmental Close-Up: Aesthetic Pollution	349
Ozone Depletion	350
Indoor Air Pollution	350
• Environmental Close-Up: Radon	352
• Environmental Close-Up: Noise Pollution	354
• Issues and Analysis: International Air Pollution	355

Chapter 18

Solid Waste Management and Disposal

Introduction	358
The Disposable Decades	358
The Nature of the Problem	359
Methods of Waste Disposal	361
<i>Landfill</i>	361
• Environmental Close-Up: Resins Used in Consumer Packaging	362
<i>Incineration</i>	364
<i>Source Reduction</i>	365
<i>Recycling</i>	366
• Environmental Close-Up: Container Laws	368
• Environmental Close-Up: What You Can Do To Reduce Waste and Save Money	368
• Environmental Close-Up: Recycling Is Big Business	370
• Environmental Close-Up: Recyclables Market Basket	371
• Issues and Analysis: Corporate Response to Environmental Concerns	372

Chapter 19

Regulating Hazardous Materials

Hazardous and Toxic Materials in Our Environment	375
Hazardous and Toxic Substances—Some Definitions	375

Defining Hazardous Waste	376
Issues Involved in Setting Regulations	376
<i>Identification of Hazardous and Toxic Materials</i>	376
<i>Setting Exposure Limits</i>	376
<i>Acute and Chronic Toxicity</i>	377
<i>Synergism</i>	378
<i>Persistent and Nonpersistent Pollutants</i>	378
Environmental Problems Caused by Hazardous Wastes	378
• Environmental Close-Up: Exposure to Toxins	379
Health Risks Associated with Hazardous Wastes	379
Hazardous-Waste Dumps—A Legacy of Abuse	379
• Environmental Close-Up: Toxic Chemical Releases	380
• Global Perspective: Lead and Mercury Poisoning	381
Managing Hazardous Wastes	383
<i>Pollution Prevention</i>	383
<i>Waste Minimization</i>	383
<i>Recycling of Waste</i>	384
<i>Treatment of Waste</i>	385
<i>Land Disposal</i>	385
Hazardous Waste Management Choices	385
• Issues and Analysis: Love Canal	387
• Global Perspective: Hazardous Wastes and Toxic Materials in China	388

Chapter 20

Environmental Policy and Decision Making	390
New Challenges for a New Century	391
Learning from the Past	392
Thinking about the Future	392
Defining the Future	394
The Development of Environmental Policy in the United States	394
Environmental Policy and Regulation	396

• Environmental Close-Up: The National Environmental Policy Act	398
The Greening of Geopolitics	399
• Environmental Close-Up: Changing the Nature Of Environmental Regulation—The Safe Drinking Water Act	401
• Environmental Close-Up: Environmental Backlash—The Wise Use Movement	402
• Global Perspective: Eco-Terrorism	403
International Environmental Policy	404
• Global Perspective: Environmental Policy and the European Union	405
It All Comes Back to You	405
• Global Perspective: Overview of an International Organization—The International Whaling Commission (IWC)	406
• Global Perspective: Eco-Labels	407

Appendix One:

Critical Thinking	409
-------------------	-----

Appendix Two:

Metric Unit Conversion Tables	410
-------------------------------	-----

Appendix Three:

The Periodic Table of the Elements	412
------------------------------------	-----

Appendix Four:

What <i>You</i> Can Do to Make the World a Better Place In Which to Live	413
--	-----

Appendix Five:

How to Write to Your Elected Officials	414
--	-----

Glossary	415
Credits	423
Index	425