

Brief Contents

Prologue xix

Part I Principles of Environmental Science 1

- 1 Environmental Science: Meeting the Challenge 2
- 2 New Visions of Life: Evolution of a Living Planet 21
- 3 Principles of Ecology: Ecosystem Structure and Function 44
- 4 Principles of Ecology: Ecosystem Balance and Imbalance 76

Part II Population 103

- 5 Population: Measuring Growth and Its Impact 104
- 6 Population Control: Key to a Sustainable Society 124

Part III Resources 141

- 7 Feeding the World's People: Food and Agriculture 142
- 8 Wildlife and Plants: Preserving Biological Diversity 170
- 9 Rangeland, Forest, and Wilderness: Preserving Renewable Resources 190
- 10 Water Resources: Preserving Our Liquid Assets 210
- 11 Energy: Winning a Dangerous Game 236
- 12 Future Energy: Making the Best Choices 257
- 13 The Earth and Its Mineral Resources 296

Part IV Pollution 313

- 14 Toxic Substances: Principles and Practicalities 314
- 15 Air Pollution: Protecting a Global Commons 337
- 16 Water Pollution: Protecting Another Global Commons 377
- 17 Pesticides: A Double-Edged Sword 401
- 18 Hazardous Wastes: Progress and Pollution 423

Part V Environment and Society 453

- 19 Environmental Ethics: Foundation of a Sustainable Society 454
 - 20 Economics and Environment 468
 - 21 Government and the Environment 491
- Epilogue 514
- Glossary 517
- Text and Photo Credits 531
- Index 535

Detailed Contents

Part I Principles of Environmental Science 1

1 Environmental Science: Meeting the Challenge 2

A Modern Response to the Environmental Crisis 3

What Is Environmental Science? 3

Welcome to a New Kind of Science 3

Outlines of a Crisis 3

Overpopulation: Too Many People 4

Depletion: Eroding the Basis of Life 4

Pollution: Fouling the Land, Water, and Air 5

The Human Failing: A Crisis of Spirit 6

Beyond Despair 8

The Population, Resource, and Pollution Model: A New Perspective 9

Vital Links: Humans and the Environment 9

Studying the Interactions: Cross-Impact Analysis 12

A Glimpse of What Is to Come 12

Building a Sustainable Society 12

Changing Our Ways 13

The Role of Environmental Science 14

Summary 14

Discussion Questions 15

Suggested Readings 15

**Viewpoint: Dedicate the '90s to the Environment/James
Gustave Speth 7**

**Essay 1-1: The Aswan Dam: Ecological Backlash from
Blind Cost-Benefit Analysis 8**

Chapter Supplement 1-1: A Closer Look Science and the Scientific Method 16

2 New Visions of Life: Evolution of a Living Planet 21

Origin of the Earth 22

Formation of the Universe 22

Formation of Galaxies and Stars 23

Formation of the Solar System 23

The Evolution of Life 23

Chemical Evolution of Life's Molecules 24

The First Cells 25

The Process of Evolution 26

Human Evolution 32

Our Biological Roots 32

Human Society and Nature: The Changing Relationship 35

New Visions: A Final View from Outer Space 41

Summary 42

Discussion Questions 43

Suggested Readings 43

Case Study 2-1: The Forgotten People 34

Gallery 1 Understanding the Earth

3 Principles of Ecology: Ecosystem Structure and Function 44

How is the Living World Organized? 45

The Biosphere 45

Biomes 45

Aquatic Life Zones 45
Ecosystems 47
Habitat and Niche 52

How Do Ecosystems Work? 53

Food Chains and Food Webs 54
The Flow of Energy and Matter through Ecosystems 57
Nutrient Cycles 66

Summary 70

Discussion Questions 71

Suggested Readings 71

Case Study 3-1: Benign Neglect in Texas: An Ecological Solution to a Perennial Problem 52

Viewpoint: Ecology of Ecology?/Peter Russell 56

Case Study 3-2: Ecosystem Imbalance in the Great Barrier Reef: Human Impact on a Delicate and Important Ecosystem 60

Chapter Supplement 3-1: A Closer Look The Biomes 72

4 Principles of Ecology: Ecosystem Balance and Imbalance 76

Ecosystem Stability Defined 77

What Keeps Ecosystems Stable? 77

Population Growth and Environmental Resistance 77
Resisting Change 79
Species Diversity and Stability 80

Correcting Imbalance in Ecosystems: Succession 81

Primary Succession 84
Secondary Succession 85

Human Impact on Ecosystems 89

Tampering with Biotic Factors 89
Tampering with Abiotic Factors 91
Simplifying Ecosystems 92

Impact Analysis Model 93

The Impact of Coal Use 93

Why Study Impacts? 95

Assessing the Probability of Impacts 95

Restoration Ecology: Reestablishing the Balance 96

The Birth of a New Science 96
Controversy over Restoration 96
Benefits of Restoration 96

Summary 97

Discussion Questions 97

Suggested Readings 98

Case Study 4-1: Putting a Pest to Work: An Ecological Solution to Water Pollution 81

Point/Counterpoint: Subversive or Realistic?

Ecology is a Subversive Science/William Tucker 82
Ecology is a Neutral Science/Daniel D. Chiras 83

Chapter Supplement 4-1: A Closer Look Nuclear War: Pathway to Environmental Catastrophe 99

Part II Population 103

5 Population: Measuring Growth and Its Impact 104

Dimensions of the Population Crisis 105

Too Many People 105
Reproducing Too Quickly 106

The Population Explosion 107

The Survival Boom 108
A Double-Edged Sword: Expansion of the Earth's Carrying Capacity 108
Exponential Growth 109

Understanding Populations and Population Growth 112

Measuring Population Growth 112
Migration 116
Seeing is Believing: Population Histograms 117

The Future of World Population: Some Projections 120

Summary 122

Discussion Questions 122

Suggested Readings 122

Point/Counterpoint: The Population Debate

The Case for More People/Julian Simon 110
Is More Always Better?/Garrett Hardin 111

Case Study 5-1: Frontierism in San Diego: Seeking the Good Life in Southern California 119

Case Study 5-2: An Eye on the Experts: Sharpening Your Critical Thinking Skills 123

6 Population Control: Key to a Sustainable Society 124

How Do We Control Population Growth? 126

Setting Our Goals 126

Population Control Strategies 126

Developed Countries—What Can They Do? 130

Developing Countries—What Can They Do? 131

Making Strategies Work 131

Psychological Barriers 132

Education Barriers 133

Religious Barriers 134

Overcoming the Obstacles 134

Ethics of Population Control 134

Is Reproduction a Personal Right? 134

Is It Ethical Not to Control Population? 135

The Status of Population Control 135

Encouraging Trends 135

Discouraging Trends 137

Summary 139

Discussion Questions 139

Suggested Readings 140

Viewpoint: Third World Population Growth: Why Should We Worry? 126

Viewpoint: On Immigration, the U.S. Must “Know When to Say When”/Brooke A. Martić 136

Part III Resources 141

7 Feeding the World’s People: Food and Agriculture 142

The Dimensions of Hunger 142

Diseases of Malnutrition 142

Declining Food Supplies 143

Long-Term Challenges 144

Problems Facing World Agriculture 144

Soil Erosion 145

Desertification: Turning Cropland to Desert 145

Depletion of Soil Nutrients 146

High Energy Costs and Diminishing Supplies 147

Water Mismanagement 148

Conversion to Nonagricultural Uses 149

Conversion of Cropland to Fuel Farms: A Future Problem 150

Politics and World Hunger 150

Loss of Genetic Diversity 151

Building a Sustainable Agricultural System 153

Increasing the Amount of Agricultural Land 153

Increasing the Yield of Cropland 155

New Foods and Food Supplements 157

Reducing Pest Damage and Spoilage 158

Increasing Self-Sufficiency 159

Political and Economic Solutions 159

An Integrated Approach 159

Summary 160

Discussion Questions 161

Suggested Readings 161

Case Study 7-1: Stopping the Spread of Desert in China 147

Case Study 7-2: Analyzing the Costs and Benefits of Agricultural Water 160

Chapter Supplement 7-1: A Closer Look Soil and Soil Management 163

Chapter Supplement 7-2: A Closer Look The Promises and Perils of Genetic Engineering 169

Gallery 2 Biomes

8 Wildlife and Plants: Preserving Biological Diversity 170

The Vanishing Species 171

What Causes Extinction? 172

Alteration of Habitat 172

Commercial, Sport, and Subsistence Hunting 173

Introducing Foreign Species 174

Pest and Predator Control 175

Collecting for Zoos, Individuals, and Research 176

Pollution 177

Ecological Factors that Contribute to Extinction 179

Why Save Endangered Species? 181

Aesthetics 181

Ethics 181

Economics 181

Ecosystem Stability 181

Opposing Views 183

How Can We Save Endangered Species? 183

Technical Solutions 183

Legal Solutions 185

Personal Solutions 186

Wildlife Report 187

Summary 188

Discussion Questions 189

Suggested Readings 189

Case Study 8-1: Saving Canada's Troubled Fisheries 175

Viewpoint: Playing God With Nature: Do We Have Any Other Choice?/Norman Myers 182

9 Rangeland, Forest, and Wilderness: Preserving Renewable Resources 190

A Tragedy of the Commons 191

Rangelands and Range Management 192

Rangeland Deterioration 192

Range Management 193

Forests and Forest Management 194

Worldwide Deforestation 194

Forest Conservation in the United States 195

Forest Harvest and Management 196

Prospects for the Future: Building a Sustainable System 198

What Causes Deforestation? 198

Wilderness 205

Preservation: The Wilderness Act 205

Controversy over Wilderness Designation 207

The Wilderness Curse 207

Summary 208

Discussion Questions 208

Suggested Readings 208

Case Study 9-1: Saving the World's Tropical Rainforests 200

Case Study 9-2: Controversy over Fire in Yellowstone National Park 203

10 Water Resources: Preserving Our Liquid Assets 210

The Hydrological Cycle 210

Water Supplies and Usage 212

The Global Picture 212

Water Use in the United States 214

Mismanaging Our Water Resources: Causes and Consequences 214

The Numbers Game: Beyond Drought 214

Overdraft: Depleting Our Liquid Assets 215

Are We Flooding Our Own Homes? 216

Protecting Our Liquid Assets 222

Population Control 222

Technical Solutions: Costs and Benefits 222

Doing Your Share: Personal Solutions 226

Education Solutions 227

Legal Solutions 227

Summary 228

Discussion Questions 229

Suggested Readings 229

Case Study 10-1: Ecological Solutions to Flooding and Water Supply Problems in Woodlands, Texas and Boston, Massachusetts 218

Case Study 10-2: Undoing the Damage to Florida's Kissimmee River 220

Viewpoint: The Third Stage of Environmentalism/ Frederic D. Krupp 225

Chapter Supplement 10-1: A Closer Look Wetlands, Estuaries, Coastlines, and Rivers 230

Gallery 3 Endangered Species

11 Energy: Winning a Dangerous Game 236

The Fossil Fuel Connection: Discovering Our Energy Dependence 237

Energy Use—Then and Now 238

Impacts of Energy Production and Consumption 240

Oil: The End Is Near 246

Natural Gas: A Better Outlook 248

Coal: The Brightest but the Dirtiest? 248

Our Energy Future 252

Hard Paths and Soft Paths 252

Guidelines for Wise Decisions 253

Abandoning the Old 254

Summary 255

Discussion Questions 255

Suggested Readings 256

Case Study 11-1: Controversy over Oil Exploration in the Arctic National Wildlife Refuge 247

Point/Counterpoint: Hard Paths vs. Soft Paths—Opposing Views

If Energy Sources are Thrown Away/A. David Rossin 249

The Best Energy Buys/Amory B. Lovins and L. Hunter Lovins 250

12 Future Energy: Making the Best Choices 257

Establishing a Shopping List 257

Nonrenewable Energy Sources 259

Nuclear Fission 259

Nuclear Fusion 267

Coal 269

Natural Gas 270

Synthetic Fuels 270

Renewable Energy Resources 271

Solar Energy 271

Wind 275

Biomass 277

Hydroelectric Power 278

Geothermal Energy 279

Hydrogen Fuel 280

Conservation 281

Building a Sustainable Energy System 283

Shifting to a Sustainable Transportation System 285

Summary 287

Discussion Questions 288

Suggested Readings 288

Case Study 12-1: The Nuclear Disaster at Chernobyl 262

Case Study 12-2: Cold Fusion: Science on Trial 268

Chapter Supplement 12-1: A Closer Look Radiation Pollution 290

13 The Earth and Its Mineral Resources 296

The Earth and Its Riches 296

A Rocky Beginning 297

The Movements of Continents 297

Mineral Resources and Society 298

Who Consumes the World's Minerals? 299

Growing Interdependence and Global Tensions 299

Will There Be Enough? 300

Meeting Future Needs 300

Can We Expand Our Reserves? 300

Can We Find Substitutes? 306

Can Recycling Stretch Our Supplies? 306

Can Conservation Stretch Our Supplies? 309

Summary 310

Discussion Questions 311

Suggested Readings 311

Case Study 13-1: Antarctica:

Protecting the Last Frontier 303

Point/Counterpoint: Is Outer Space the Answer to Our Population and Resource Problems?

No Escape from the Population Bomb/Daniel Deudney 307

Toward a New World/Ben Bova 308

Part 4

Pollution 313

14 Toxic Substances: Principles and Practicalities 314

Principles of Toxicology 315

Biological Effects of Toxins 315

How Do Toxins Work? 320

Factors Affecting the Toxicity of Chemicals 321

Bioconcentration and Biological Magnification 322

The Roots of Controversy 323

Controlling Toxic Substances 324

Federal Control 324

Market Incentives to Control Toxic Chemicals 325

Determining the Risks 325

Risks and Hazards: Overlapping Boundaries 327

Risk Assessment 327

Risk Management: Decisions about Risk Acceptability 327

The Final Standard: Ethics 330

Summary 331

Discussion Questions 332

Suggested Readings 332

Case Study 14-1: The Dangers of Asbestos 316

**Case Study 14-2: Waterbed Heaters and Power Lines:
A Hazard to Our Health?** 321

Viewpoint: Are We Losing the War Against Cancer?
John C. Bailar, III, and Elaine M. Smith 324

**Chapter Supplement 14-1: A Closer Look Global Lead
Pollution** 334

15 Air Pollution: Protecting a Global Commons 337

Air: The Endangered Global Commons 338

The Trees are Responsible 338

Air Pollutants and Their Sources 338

Primary and Secondary Pollutants 339

Toxic Air Pollutants 339

**The Effects of Climate and Topography on Air
Pollution** 340

Brown-Air and Gray-Air Cities 340

Factors Affecting Pollution Levels 341

Effects of Air Pollution 343

Health Effects 343

Effects on Other Organisms 345

Effects on Materials 345

Global Warming/Global Change 346

Global Energy Balance 346

Upsetting the Balance: The Greenhouse Effect 346

Air Pollution Control 351

Cleaner Air through Better Laws 351

Cleaner Air through Technology 352

Cleaner Air through Conservation: A Framework for Personal
Actions 354

Cost of Air Pollution Control 356

Summary 357

Discussion Questions 357

Suggested Readings 358

**Case Study 15-1: Offsetting Global Warming: Planting a
Seed** 347

**Viewpoint: What's Sacrificed When We Arm/Michael G.
Renner** 355

**Chapter Supplement 15-1: A Closer
Look Stratospheric Ozone Depletion** 359

**Chapter Supplement 15-2: A Closer Look Acid
Deposition: Ending the Assault** 363

**Chapter Supplement 15-3: A Closer Look Indoor Air
Pollution** 372

16 Water Pollution: Protecting Another Global Commons 377

Water and Water Pollution 377

Point and Nonpoint Sources 378

Some Features of Surface Waters 380

Types of Water Pollution 381

Nutrient Pollution and Eutrophication 381

Infectious Agents 385

Toxic Organic Water Pollutants 385

Toxic Inorganic Water Pollutants 386

Sediment 386

Thermal Pollution 387

Groundwater Pollution 387

Ocean Pollution 389

Oil in the Seas 390

Plastic Pollution 392

Medical Wastes and Sewage Sludge 392

Water Pollution Control 392

Legal Controls 392

Control Technologies 394

Personal Solutions 396

Summary 397

Discussion Questions 400

Suggested Readings 400

**Case Study 16-1: The Great Lakes:
Alive but Not Well** 379

Case Study 16-2: The Case of the Dying Seals 389

Viewpoint: Why We Have Failed/Barry Commoner 398

Gallery 4 Resource Misuse

17 Pesticides: A Double-Edged Sword 401

A Historical Overview 402

Development of Chemical Pesticides 402

Exploration, Exploitation, and Reflection 403

Integrated Pest Management 410

Education and Monitoring 410

Environmental Controls 410

Genetic Controls 412

Chemical Controls 413

Cultural Controls 415

Economics, Risk, and Pest Control 416

Herbicides in Peace and War 417

Peacetime Uses: Pros and Cons 417

Controversy Over Wartime Use of 2,4-D and 2,4,5-T 418

Unfinished Business 419

Summary 420

Discussion Questions 421

Suggested Readings 422

Case Study 17-1: Are We Poisoning Our Children with Pesticides? 405

Viewpoint: The Myth of the “Banned” Pesticides/Lewis Regenstein 408

Case Study 17-2: Indonesia Turns to Biological Pest Control 416

18 Hazardous Wastes: Progress and Pollution 423

Hazardous Wastes: Coming to Terms with the Problem 424

Love Canal: The Awakening 424

The Dimensions of a Toxic Nightmare 425

LUST—It’s Not What You Think 431

Attacking Hazardous Wastes on Two Fronts 432

What to Do with Today’s Waste 432

Cleaning Up Past Mistakes 439

Summary 441

Discussion Questions 442

Suggested Readings 442

Point/Counterpoint: Are We Facing An Epidemic of Cancer?

America’s Epidemic of Chemicals and Cancer/Lewis G. Regenstein 428

“America’s Epidemic of Chemicals and Cancer”—Myth or Fact?/David L. Eaton 429

Case Study 18-1: Exporting Toxic Troubles 433

Case Study 18-2: Redefining National Security: Waste From the Nuclear Weapons Industry 438

Chapter Supplement 18-1: A Closer Look Solid Wastes: Solving A Growing Problem 443

Part V Environment and Society 453

19 Environmental Ethics: The Foundation of a Sustainable Society 454

The Frontier Mentality 454

Roots of Our Attitudes toward Nature 456

The Technological Fix 458

A More Personal Look 459

A Low-Synergy Society 460

Sustainable-Earth Ethics 460

Value Judgments and Decision Making 463

Making the Transition 463

Three Approaches 463

Some Attitudinal Changes Are Already Evident 464

Avoiding Pitfalls 464

Summary 465

Discussion Questions 465

Suggested Readings 466

Viewpoint: Why We Should Feel Responsible for Future Generations/Robert Mellert 457

20 Economics and the Environment 467

Economics and the Environment 467

Economic Systems 468

The Law of Supply and Demand 468

Economic Measures: Beyond the GNP 470

Economics and Pollution Control 471

Cost-Benefit Analysis and Pollution Control 472

Who Should Pay for Pollution Control? 473

Harnessing Market Forces to Protect the Environment 475

Environmental Regulations: Do They Impede Business? 476

The Economics of Resource Management 479

Time Reference 480

Opportunity Cost 480

Ethics 481

Differing Perspectives on Growth and the Future 481

The Growth Issue 481

Differing Perspectives on the Future 481

Sustainable Economies 482

The Steady-State Economy 482

Ethical Changes 483

Population Control 483

Global Economic Challenges 483

Challenges for the Developed Countries 483

Challenges for the Less Developed Nations 485

Appropriate Technology and Sustainable Economic Development 486

Making Sustainable Development Work 487

Summary 488

Discussion Questions 489

Suggested Readings 490

**Case Study 20-1: Washington's Historic Timber/Fish/
Wildlife Agreement 474**

**Point/Counterpoint: Environmental Protection:
Job Maker or Job Taker?**

Job Blackmail and the Environment/Richard Grossman and
Richard Kazis 477

The Impact of Environmental Laws on Jobs/Catherine
England 478

**Case Study 20-2: Economic Health: Plugging Up the
Leaks/Finding Hidden Opportunities 484**

**21 Government and the
Environment 491**

Government: An Overview 491

Forms of Government 492

The Role of Government in Environmental Protection 492

Political Decision Making: Who Contributes? 493

Government Officials 494

The Public 495

Special Interest Groups 495

**Some Barriers to Sustainability and Some
Suggestions 498**

Lack of Consensus 498

Crisis Politics 499

Limited Planning Horizons 501

Inadequate Land-Use Planning 502

A Sustainable World Community 503

West Germany's Green Party: An Ecological Approach
to Politics 503

Achieving a Global Society 504

Global Resource Sharing: Is It a Good Idea? 505

Summary 506

Discussion Questions 507

Suggested Readings 507

Case Study 21-1: Two Groups at Work 497

**Chapter Supplement 21-1: A Closer Look A Primer on
Environmental Law 508**

**Epilogue Rethinking the Past/
Remaking the Future 514**

The Third Transition 515

Signs of the Transition 515

**What's Needed: More of the Same Positive
Changes 516**

Glossary 517

Text and Photo Credits 531

Index 534