# Contents in Brief

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preface</td>
<td></td>
<td>xxi</td>
</tr>
<tr>
<td>1</td>
<td>Visions of the Future</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Valuing the Environment: Concepts</td>
<td>14</td>
</tr>
<tr>
<td>3</td>
<td>Valuing the Environment: Methods</td>
<td>34</td>
</tr>
<tr>
<td>4</td>
<td>Property Rights, Externalities, and Environmental Problems</td>
<td>65</td>
</tr>
<tr>
<td>5</td>
<td>Dynamic Efficiency and Sustainable Development</td>
<td>92</td>
</tr>
<tr>
<td>6</td>
<td>The Population Problem</td>
<td>108</td>
</tr>
<tr>
<td>7</td>
<td>The Allocation of Depletable and Renewable Resources: An Overview</td>
<td>134</td>
</tr>
<tr>
<td>8</td>
<td>Energy: The Transition from Depletable to Renewable Resources</td>
<td>156</td>
</tr>
<tr>
<td>9</td>
<td>Recyclable Resources: Minerals, Paper, Bottles, and E-Waste</td>
<td>192</td>
</tr>
<tr>
<td>10</td>
<td>Replenishable but Depletable Resources: Water</td>
<td>215</td>
</tr>
<tr>
<td>11</td>
<td>Land</td>
<td>243</td>
</tr>
<tr>
<td>12</td>
<td>Reproducible Private-Property Resources: Agriculture</td>
<td>267</td>
</tr>
<tr>
<td>13</td>
<td>Storable, Renewable Resources: Forests</td>
<td>296</td>
</tr>
<tr>
<td>14</td>
<td>Common-Pool Resources: Fisheries and Other Commercially Valuable Species</td>
<td>322</td>
</tr>
<tr>
<td>15</td>
<td>Economics of Pollution Control: An Overview</td>
<td>356</td>
</tr>
<tr>
<td>16</td>
<td>Stationary-Source Local Air Pollution</td>
<td>390</td>
</tr>
<tr>
<td>17</td>
<td>Regional and Global Air Pollutants: Acid Rain and Atmospheric Modification</td>
<td>413</td>
</tr>
<tr>
<td>18</td>
<td>Mobile-Source Air Pollution</td>
<td>438</td>
</tr>
<tr>
<td>19</td>
<td>Water Pollution</td>
<td>463</td>
</tr>
<tr>
<td>20</td>
<td>Toxic Substances</td>
<td>495</td>
</tr>
<tr>
<td>21</td>
<td>Environmental Justice</td>
<td>523</td>
</tr>
<tr>
<td>22</td>
<td>Development, Poverty, and the Environment</td>
<td>549</td>
</tr>
<tr>
<td>23</td>
<td>The Quest for Sustainable Development</td>
<td>577</td>
</tr>
<tr>
<td>24</td>
<td>Visions of the Future Revisited</td>
<td>603</td>
</tr>
</tbody>
</table>

*Problem Set Answers*

Glossary 622

Name Index 634

Subject Index 640
## 4 Property Rights, Externalities, and Environmental Problems

**Introduction**

**Property Rights**
- Property Rights and Efficient Market Allocations
- Efficient Property Right Structures
  - **EXAMPLE 4.1 Pollution in Transition Economies**
  - Producer's Surplus, Scarcity Rent, and Long-Run Competitive Equilibrium

**Externalities as a Source of Market Failure**
- The Concept Introduced
- Types of Externalities
  - **EXAMPLE 4.2 Shrimp Farming Externalities in Thailand**

**Improperly Designed Property Rights Systems**
- Other Property Rights Regimes

**Public Goods**
- **EXAMPLE 4.3 Public Goods Privately Provided: The Nature Conservancy**

**Imperfect Market Structures**
- **DEBATE 4.1 How Should OPEC Price Its Oil?**

**Government Failure**
- The Pursuit of Efficiency
  - Private Resolution Through Negotiation
  - The Courts: Property Rules and Liability Rules
  - Legislative and Executive Regulation
- An Efficient Role for Government

**Summary**

**Discussion Questions**

**Problems**

**Further Reading**

## 5 Dynamic Efficiency and Sustainable Development

**Introduction**

**A Two-Period Model**

**Defining Intertemporal Fairness**

**Are Efficient Allocations Fair?**

**Applying the Sustainability Criterion**
- **EXAMPLE 5.1 The Alaska Permanent Fund**
- **EXAMPLE 5.2 Nauru: Weak Sustainability in the Extreme**

**Implications for Environmental Policy**

**Summary**

**Discussion Questions**

**Problems**

**Further Reading**

**Appendix:** The Mathematics of the Two-Period Model
<table>
<thead>
<tr>
<th>Contents</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil: The Cartel Problem</td>
<td>162</td>
</tr>
<tr>
<td>Price Elasticity of Demand</td>
<td>163</td>
</tr>
<tr>
<td>Income Elasticity of Demand</td>
<td>164</td>
</tr>
<tr>
<td>Non-OPEC Suppliers</td>
<td>164</td>
</tr>
<tr>
<td>Compatibility of Member Interests</td>
<td>165</td>
</tr>
<tr>
<td>Fossil Fuels: National Security and Climate Considerations</td>
<td>167</td>
</tr>
<tr>
<td>The Climate Dimension</td>
<td>167</td>
</tr>
<tr>
<td>The National Security Dimension</td>
<td>168</td>
</tr>
<tr>
<td><strong>DEBATE 8.1 How Should the United States Deal with the Vulnerability of Its Imported Oil?</strong></td>
<td>170</td>
</tr>
<tr>
<td><strong>EXAMPLE 8.2 Strategic Petroleum Reserve</strong></td>
<td>172</td>
</tr>
<tr>
<td>The Other Depletable Sources: Unconventional Oil, Coal, and Nuclear</td>
<td>173</td>
</tr>
<tr>
<td>Unconventional Oil Sources</td>
<td>174</td>
</tr>
<tr>
<td>Coal</td>
<td>174</td>
</tr>
<tr>
<td>Uranium</td>
<td>174</td>
</tr>
<tr>
<td>Electricity</td>
<td>178</td>
</tr>
<tr>
<td><strong>EXAMPLE 8.3 Electricity Deregulation in California: What Happened?</strong></td>
<td>180</td>
</tr>
<tr>
<td><strong>EXAMPLE 8.4 Tradable Energy Certificates: The Texas Experience</strong></td>
<td>182</td>
</tr>
<tr>
<td>Energy Efficiency</td>
<td>182</td>
</tr>
<tr>
<td>Transitioning to Renewables</td>
<td>183</td>
</tr>
<tr>
<td>Hydroelectric Power</td>
<td>183</td>
</tr>
<tr>
<td>Wind</td>
<td>184</td>
</tr>
<tr>
<td>Photovoltaics</td>
<td>184</td>
</tr>
<tr>
<td>Active and Passive Solar Energy</td>
<td>184</td>
</tr>
<tr>
<td><strong>DEBATE 8.2 Dueling Externalities: Should the U.S. Promote Wind Power?</strong></td>
<td>185</td>
</tr>
<tr>
<td>Ocean Tidal Power</td>
<td>185</td>
</tr>
<tr>
<td>Biomass Fuels</td>
<td>186</td>
</tr>
<tr>
<td>Geothermal Energy</td>
<td>187</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>187</td>
</tr>
<tr>
<td><strong>Summary</strong></td>
<td>189</td>
</tr>
<tr>
<td><strong>Discussion Questions</strong></td>
<td>190</td>
</tr>
<tr>
<td><strong>Problems</strong></td>
<td>190</td>
</tr>
<tr>
<td><strong>Further Reading</strong></td>
<td>191</td>
</tr>
</tbody>
</table>

**Recyclable Resources: Minerals, Paper, Bottles, and E-Waste**

<table>
<thead>
<tr>
<th>Introduction</th>
<th>192</th>
</tr>
</thead>
<tbody>
<tr>
<td>An Efficient Allocation of Recyclable Resources</td>
<td>192</td>
</tr>
<tr>
<td>Extraction and Disposal Cost</td>
<td>192</td>
</tr>
<tr>
<td>Recycling: A Closer Look</td>
<td>194</td>
</tr>
<tr>
<td>Recycling and Ore Depletion</td>
<td>195</td>
</tr>
<tr>
<td><strong>EXAMPLE 9.1 Lead Recycling</strong></td>
<td>196</td>
</tr>
<tr>
<td>Factors Mitigating Resource Scarcity</td>
<td>196</td>
</tr>
<tr>
<td>Exploration and Discovery</td>
<td>196</td>
</tr>
<tr>
<td>Technological Progress</td>
<td>197</td>
</tr>
</tbody>
</table>
Replenishable but Depletable Resources: Water 215

Introduction
The Potential for Water Scarcity
The Efficient Allocation of Scarce Water
Surface Water
Groundwater
The Current Allocation System
Riparian and Prior Appropriation Doctrines
Sources of Inefficiency
DEBATE 10.1 What Is the Value of Water?
Potential Remedies
EXAMPLE 10.1 Using Economic Principles to Conserve Water in California
EXAMPLE 10.2 Water Transfers in Colorado: What Makes a Market for Water Work?
EXAMPLE 10.3 Protecting Instream Uses Through Acquiring Water Rights
EXAMPLE 10.4 Water Pricing in Canada
DEBATE 10.2 Should Water Systems Be Privatized?
GIS and Water Resources
Summary 240 • Discussion Questions 241 • Problems 241 • Further Reading 241

Land 243

Introduction
The Economics of Land Allocation
Land Use
Land Use Conversion
Efficient Allocations 323
  The Biological Dimension 323
  Static Efficient Sustainable Yield 325
  Dynamic Efficient Sustainable Yield 327
Appropriability and Market Solutions 329
  EXAMPLE 14.1 Open-Access Harvesting of the Minke Whale 332
Public Policy Toward Fisheries 332
  Aquaculture 332
  EXAMPLE 14.2 Harbor Gangs of Maine 333
  Raising the Real Cost of Fishing 334
  DEBATE 14.1 Aquaculture: Does Privatization Cause More Problems than It Solves? 336
Taxes 339
  Individual Transferable Quotas (ITQs) 340
  EXAMPLE 14.3 The Relative Effectiveness of Transferable Quotas and Traditional Size and Effort Restrictions in the Atlantic Sea Scallop Fishery 344
Subsidies and Buybacks 345
  Marine Protected Areas and Marine Reserves 345
  The 200-Mile Limit 347
  The Economics of Enforcement 347
  Preventing Poaching 348
  EXAMPLE 14.4 Local Approaches to Wildlife Protection: Zimbabwe 349
Summary 350 • Discussion Questions 351 • Problems 351 • Further Reading 352
Appendix: The Harvesting Decision: Fisheries 353

15 Economics of Pollution Control: An Overview 356
Introduction 356
  A Pollutant Taxonomy 356
Defining the Efficient Allocation of Pollution 358
  Stock Pollutants 358
  Fund Pollutants 359
Market Allocation of Pollution 362
Efficient Policy Responses 363
  EXAMPLE 15.1 Environmental Taxation in China 364
Cost-Effective Policies for Uniformly Mixed Fund Pollutants 365
  Defining a Cost-Effective Allocation 365
  Cost-Effective Pollution Control Policies 366
Cost-Effective Policies for Nonuniformly Mixed Surface Pollutants 371
  EXAMPLE 15.2 Emissions Trading in Action: The NOx Budget Program 372
  DEBATE 15.1 Should Developing Countries Rely on Market-Based Instruments to Control Pollution? 373
Stationary-Source Local Air Pollution 390

Introduction 390
Conventional Pollutants 391
The Command-and-Control Policy Framework 391

DEBATE 16.1 Should the New Source Review Program Be Changed? 394
The Efficiency of the Command-and-Control Approach 395

DEBATE 16.2 The Particulate and Smog Ambient Standards Controversy 396
Cost-Effectiveness of the Command-and-Control Approach 397

EXAMPLE 16.1 Controlling SO₂ Emissions by Command-and-Control in Germany 400
Air Quality 400

Innovative Approaches 402
The Offset Program 402
The Effectiveness of This Early Application 403
Smog Trading 404
Emission Charges 405
Hazardous Pollutants 407

EXAMPLE 16.2 Technology Diffusion in the Chlorine Manufacturing Sector 410

Summary 409 • Discussion Questions 411 • Problems 411 • Further Reading 412

Regional and Global Air Pollutants: Acid Rain and Atmospheric Modification 413

Introduction 413
Regional Pollutants 413
Acid Rain 414

EXAMPLE 17.1 Adirondack Acidification 415
EXAMPLE 17.2 The Sulfur Allowance Program 418
EXAMPLE 17.3 Why and How Do Environmentalists Buy Pollution? 419
## Mobile-Source Air Pollution

### Introduction
- The Economics of Mobile-Source Pollution
- Implicit Subsidies
- Externalities
- Consequences

### Policy Toward Mobile Sources
- History
- Structure of the U.S. Approach
- CAFE Standards

#### DEBATE 18.1
- *CAFE Standards or Fuel Taxes?*
- Alternative Fuels and Vehicles

#### EXAMPLE 18.1
- *Project XL—The Quest for Effective, Flexible Regulation*

### An Economic and Political Assessment
- Technology Forcing and Sanctions
- Differentiated Regulation
- Uniformity of Control
- The Deterioration of New-Car Emission Rates
- Lead Phaseout Program

#### EXAMPLE 18.3
- *Getting the Lead Out: the Lead Phaseout Program*

### Possible Reforms
- Fuel Taxes
- Congestion Pricing

#### EXAMPLE 18.4
- *Innovative Mobile-Source Pollution Control Strategies: Singapore*

- Private Toll Roads
- Parking Cash-Outs
- Feebates
- Pay-As-You-Drive (PAYD) Insurance
- Accelerated Retirement Strategies

#### EXAMPLE 18.5
- *Modifying Car Insurance as an Environmental Strategy*

#### EXAMPLE 18.6
- *Counterproductive Policy Design*

### Summary

Discussion Questions

Problem

Further Reading
19 Water Pollution 463

Introduction 463
Nature of Water Pollution Problems 464
Types of Waste-Receiving Water 464
Sources of Contamination 464
Types of Pollutants 466

Traditional Water Pollution Control Policy 470
Early Legislation 470
Subsequent Legislation 471
The Safe Drinking Water Act 473
Ocean Pollution 473
Citizen Suits 474

Efficiency and Cost-Effectiveness 475
Ambient Standards and the Zero-Discharge Goal 475
National Effluent Standards 476

EXAMPLE 19.1 Effluent Trading for Nitrogen in Long Island Sound 481
Municipal Waste Treatment Subsidies 482
Pretreatment Standards 483
Nonpoint Source Pollution 483

EXAMPLE 19.2 Cost-Effective Pretreatment Standards 483

Atmospheric Deposition of Pollution 485

DEBATE 19.1 Toxics in Fish Tissue: Do Fish Consumption Advisories Change Behavior? 486
The European Experience 487
Developing Country Experience 488
Oil Spills 488

EXAMPLE 19.3 Economic Incentives for Water Pollution Control: The Case of Colombia 489
Citizen Suits 491
An Overall Assessment 491

Summary 493 • Discussion Questions 493 • Problem 494 • Further Reading 494

20 Toxic Substances 495

Introduction 495
Nature of Toxic Substance Pollution 496
Health Effects 496
Policy Issues 497

Market Allocations and Toxic Substances 499
Occupational Hazards 499

EXAMPLE 20.1 Susceptible Populations in the Hazardous Workplace 502
Product Safety 502
Third Parties 503
Environmental Justice 523

Introduction 523

The Incidence of Hazardous Waste Siting Decisions 524

History 524

Recent Research and the Emerging Role of Analysis Using GIS 525

The Economics of Site Location 526

The Policy Response 527

EXAMPLE 21.1 Which Came First—The Toxic Facility or the Minority Neighborhood? 528

DEBATE 21.1 Does Offering Compensation for Accepting an Environmental Risk Always Increase the Willingness to Accept the Risk? 531

The Incidence of Pollution Control Costs: Individual Industries 531

A Competitive Industry 532

Monopoly 534

DEBATE 21.2 Jobs Versus the Environment: Which Side Is Right? 537

The Generation of Pollutants 537

The Incidence on Households 538

Air Pollution 538

Water Pollution 542

Noise Pollution 543

Floods 544

Socioeconomic Status and Health 544

Implications for Policy 544

EXAMPLE 21.2 Distributional Impacts of RECLAIM 545

Summary 546 • Discussion Questions 547 • Problem 548 • Further Reading 548
22 Development, Poverty, and the Environment 549

Introduction 549

The Growth Process 550
  Nature of the Process 550
  Potential Sources of Reduced Growth 551
  Limits on Technological Progress 553
  The Natural Resource Curse

EXAMPLE 22.1 The “Natural Resource Curse” Hypothesis 554

Environmental Policy 554


Energy 556

Outlook for the Near Future 557
  Population Impacts 558
  The Information Economy 558

The Growth-Development Relationship 559
  Conventional Measures 559
  Alternative Measures 562

Growth and Poverty: The Industrialized Nations 565
  The Effects on Income Inequality 566
  Poverty in the Less Industrialized Nations 566
  Appropriateness of the Traditional Model 567
  Barriers to Development

EXAMPLE 22.3 Trading Water for Beehives and Barbed Wired in Bolivia 570

EXAMPLE 22.4 Debt-for-Nature Revisited: The Nature Conservancy, the Tropical Forest Conservation Act, and Costa Rica 573

Summary 573 • Discussion Questions 575 • Problem 575 • Further Reading 575

23 The Quest for Sustainable Development 577

Introduction 577

Sustainability of Development 578
  Market Allocations 580
  Efficiency and Sustainability

EXAMPLE 23.1 Resource Depletion and Economic Sustainability: Malaysia 582

Trade and the Environment 584

EXAMPLE 23.2 Has NAFTA Improved the Environment in Mexico? 588

Trade Rules Under GATT and the WTO 590

DEBATE 23.1 Should an Importing Country Be Able to Use Trade Restrictions to Influence Harmful Fishing Practices in an Exporting Nation? 591

Managing the Transition 591
  Opportunities for Cooperation 592
24 Visions of the Future Revisited

Addressing the Issues

Conceptualizing the Problem 603

Institutional Responses 605

EXAMPLE 24.1 Private Incentives for Sustainable Development:
Can Adopting Sustainable Practices Be Profitable? 606

Sustainable Development 609

EXAMPLE 24.2 Public/Private Partnerships: The Kalundborg Experience 611

A Concluding Comment 613

Discussion Questions 614

Problem Set Answers 615

Glossary 622

Name Index 634

Subject Index 640