# Environmental Economics

# **An Introduction**

Seventh Edition

# Barry C. Field

Department of Resource Economics University of Massachusetts Amherst

# Martha K. Field

Department of Business and Information Technology Greenfield Community College



# About the Authors

**Barry C. Field** is Professor Emeritus of Resource Economics at the University of Massachusetts Amherst. Previously he taught at the University of Miami and The George Washington University. He received his B.S. and M.S. degrees from Cornell University and his Ph.D. from the University of California at Berkeley.

At the University of Massachusetts he has devoted many years to teaching environmental economics to students at all levels and has worked to develop an undergraduate major in environmental and resource economics.

**Martha K. Field** is Professor of Economics at Greenfield Community College, where she has taught environmental economics for many years. She has taughtattheUniversity ofMassachusetts,MountHolyokeCollege,WestfieldState College, HolyokeCommunityCollege, and theConsumerCooperative at Gomel, Belarus. She received a B.S. and M.S. from the University of Massachusetts and holds a Ph.D. from the University of Connecticut.

They reside in Leverett, Massachusetts.

# Contents in Brief

#### SECTION ONE Introduction 1

- 1 What Is Environmental Economics? 2
- **2** The Economy and the Environment 20

# SECTION TWO

#### Analytical Tools 39

- **3** Benefits and Costs, Supply and Demand 40
- **4** Markets, Externalities, and Public Goods 60
- **5** The Economics of Environmental Quality 79

#### **SECTION THREE** Environmental Analysis 105

- **6** Frameworks of Analysis 106
- **7** Benefit–Cost Analysis: Benefits 130
- 8 Benefit–Cost Analysis: Costs 154

# SECTION FOUR Environmental Policy

#### Analysis 173

- **9** Criteria for Evaluating Environmental Policies 174
- **10** Decentralized Policies: Liability Laws, Property Rights, Voluntary Action 185
- **11** Command-and-Control Strategies: The Case of Standards 202

- **12** Incentive-Based Strategies: Emission Charges and Subsidies 221
- 13 Incentive-Based Strategies: Market Trading Systems 245

#### **SECTION FIVE** Environmental Policy in the United States 263

- 14 Federal Water Pollution– Control Policy 264
- **15** Federal Air Pollution–Control Policy 291
- **16** Federal Policy on Toxic and Hazardous Substances 316
- **17** State and Local Environmental Issues 345

# SECTION SIX

#### Global

#### Environmental Issues 363

- **18** The Global Environment 364
- **19** International Environmental Agreements 384
- 20 Globalization 404
- **21** Economic Development and the Environment 419

# APPENDIX

Abbreviations and Acronyms Used in the Book 441

# NAME INDEX 445

SUBJECT INDEX 448

# Contents

#### Preface xvii

#### SECTION ONE INTRODUCTION 1

#### Chapter 1 What Is Environmental Economics? 2

Economic Analysis 3 The Importance of Incentives 4 Incentives: A Household Example 5 Incentives and Global Warming 7 The Design of Environmental Policy 8 Macroeconomic Questions: Environment and Growth 9 Benefit–Cost Analysis 13 Valuing the Environment 13 Environment and Development 15 International Issues 15 Globalization and the Environment 17 Economics and Politics 18 Summary 19

#### Chapter 2 The Economy and the Environment 20

Natural Resource Economics 21 The Fundamental Balance 23 The Environment as an Economic and Social Asset 27 Basic Terminology 30 Emissions, Ambient Quality, and Damages 31 Types of Pollutants 33 *Cumulative Versus Noncumulative Pollutants 33 Local Versus Regional and Global Pollutants 34*  Point-Source Versus Nonpoint-Source Pollutants 35 Continuous Versus Episodic Emissions 35 Environmental Damages Not Related to Emissions 37 Summary 37 Questions for Further Discussion 37

#### SECTION TWO ANALYTICAL TOOLS 39

#### Chapter 3 Benefits and Costs, Supply and Demand 40

Willingness to Pay 40 Demand 43 Aggregate Demand/Willingness to Pay 45 Benefits 46 Cost 48 Opportunity Cost 49 Private and Social Costs 49 Cost Curves 50 The Shapes of Cost Curves 50 Technology 54 The Equimarginal Principle 55 Marginal Cost and Supply 56 Summary 58 Questions for Further Discussion 58

#### Chapter 4 Markets, Externalities, and Public Goods 60

Economic Efficiency 61 Efficiency and Equity 63 Markets 63 Markets and Social Efficiency 65 External Costs 66 *Open-Access Resources* 70 External Benefits 73 *Public Goods* 73 Summary 77 Questions for Further Discussion 77

#### Chapter 5 The Economics of Environmental Quality 79

Pollution Control—A General Model 80 Pollution Damages 80 Damage Functions 82 Marginal Damage Functions 84 Damages and Uncertainty 86 Damages and Time 87 Abatement Costs 87 Abatement Cost Functions 88 Aggregate Marginal Abatement Costs 93 The Socially Efficient Level of Emissions 95 Changes in the Efficient Level of Emissions 97 Enforcement Costs 99 The Equimarginal Principle Applied to Emission Reductions 100 Summary 102 Questions for Further Discussion 103

#### SECTION THREE ENVIRONMENTAL ANALYSIS 105

#### Chapter 6 Frameworks of Analysis 106

Impact Analysis 106 Environmental Impact Analysis 106 Economic Impact Analysis 107 Regulatory Impact Analysis 107 Cost-Effectiveness Analysis 108 Damage Assessment 109 Green GDP 110 Benefit–Cost Analysis 111 The Basic Framework 113 Scope of the Program 116 Discounting 117 Choice of Discount Rate 119 Discounting and Future Generations 120 Distributional Issues 122 Risk Analysis 124 Risk Assessment 125 Risk Valuation 125 Risk Management 127 Summary 127 Questions for Further Discussion 128

#### Chapter 7 Benefit–Cost Analysis: Benefits 130

The Damage Function: Physical Aspects 131 Measuring Damage Costs Directly 132 Health Costs 132 The Effects of Pollution on Production Costs 133 Materials Damage 135 Problems with Direct Damage Approaches 136 Willingness to Pay: Estimating Methods 137 Willingness to Pay: Revealed Preference Methods 138 The Value of Human Health as Expressed in Averting Costs 138 The Value of Human Life as Expressed in Wage Rates 139 Valuing Children's Health 141 The Value of Environmental Quality as Expressed in House Prices 141 The Value of Environmental Quality and Intercity Wage Differentials 143

The Value of Environmental Quality as Expressed in Travel Costs 143 Willingness to Pay: Stated Preference Methods 144 Valuing an Environmental Amenity 145 Valuing Health Outcomes 147 Problems of CV Analysis 149 Problems in Benefit Estimation 150 Discounting 150 Willingness to Pay Versus Willingness to Accept 151 Nonuse Values 152 Summary 152 Questions for Further Discussion 153

#### Chapter 8 Benefit–Cost Analysis: Costs 154

The Cost Perspective: General Issues 154 The With/Without Principle 155 A Word on Social Costs 156 The Distribution of Costs 156 Concepts of Cost 157 Opportunity Costs 157 Environmental Costs 158 Enforcement Costs 158 Costs of Single Facilities 159 Costs of a Local Regulation 161 Costs of Regulating an Industry 162 An Example 162 Sources of Cost Data 163 Misrepresentation of Costs 164 Actual Versus Minimum Pollution-Control Costs 164 The Effect of Output Adjustments on Costs 165 Long-Run Technical Change and Pollution-Control Costs 167 Costs at the National Level 167 Future Costs and Technological Change 170

Summary 171 Questions for Further Discussion 171

#### SECTION FOUR ENVIRONMENTAL POLICY ANALYSIS 173

#### Chapter 9 Criteria for Evaluating Environmental Policies 174

Efficiency 174 Cost-Effectiveness 175 Fairness 177 The Idea of "Social" 178 Environmental Justice 178 Enforceability 178 Flexibility 180 Incentives for Technological Innovations 181 Materials Balance Issues 182 Moral Considerations 182 Government Failure 183 Summary 184 Questions for Further Discussion 184

#### Chapter 10 Decentralized Policies: Liability Laws, Property Rights, Voluntary Action 185

Liability Laws 185 The Principle 186 Common Law 187 Statutory Law 189 Property Rights 191 The Principle 192 Rules and Conditions 193 Problems with Property Rights to Internalize Externalities 194 Transactions Costs 194 Public Goods 194 Absence of Markets 195 Markets for Green Goods 196

Voluntary Action 197 Moral Suasion 197 Informal Community Pressure 199 Summary 200 Questions for Further Discussion 201

#### Chapter 11 Command-and-Control Strategies: The Case of Standards 202

Types of Standards203Ambient Standards203Emission Standards204Technology Standards205Standards Used in Combination207

The Economics of Standards207Setting the Level of the Standard207Uniformity of Standards208Standards and the EquimarginalPrinciple209

Standards and Incentives 212 Political-Economic Aspects of Standards 214

The Economics of Enforcement 215 Enforcing Emission Standards 216 Enforcing Technology Standards 218 The Enforcing Agency 218 Summary 219 Questions for Further Discussion 219

#### Chapter 12 Incentive-Based Strategies: Emission Charges and Subsidies 221

Emission Charges or Taxes 223 The Economics of an Emission Tax 223 The Level of the Charge 226 Emission Charges and Cost-Effectiveness 227 Emission Taxes and Nonuniform Emissions 230 Emissions Charges and Uncertainty 233 Emission Charges and Tax Revenues 234 Emission Charges and the Incentives to Innovate 235 Emission Charges and Enforcement Costs 237 Other Types of Charges 237 On Carbon Taxes 238 Distributional Impacts of Emission Charges 238 Abatement Subsidies 240 Deposit-Refund Systems 241 Summary 243 Questions for Further Discussion 244

#### Chapter 13 Incentive-Based Strategies: Market Trading Systems 245

General Principles 245 Cap-and-Trade 246 The Initial Rights Allocation 249 Establishing Trading Rules 251 Reducing the Number of Permits 252 Nonuniform Emissions 253 CAPs and Problems of Competition 254 CAPs and Enforcement 255 CAPs and the Incentive for R&D 255 CAPs and Uncertainty 257 Offset Trading 257 Emission Rate Trading 258 Summary 260 Questions for Further Discussion 261

#### SECTION FIVE ENVIRONMENTAL POLICY IN THE UNITED STATES 263

Chapter 14 Federal Water Pollution– Control Policy 264 Types of Water Pollutants 265 Federal Policy: A Brief History 267 Technology-Based Effluent Standards 269 Efficiency and Cost-Effectiveness of TBESs 272 Experience with TBESs 273 TBESs and Incentives 274 TBESs and Enforcement 275 The Municipal Wastewater Treatment Plant Subsidy Program 276 The Safe Drinking Water Act (SDWA) 279 Coastal Water Pollution 280 **Recent Policy Innovations** in Water-Pollution Control 282 Nonpoint-Source Water Pollution Control 282 Total Maximum Daily Load (TMDL) Program 283 Emission Trading in Water Pollution Control 286 Summary 289 Questions for Further Discussion 290

#### Chapter 15 Federal Air Pollution— Control Policy 291

Federal Air Pollution–Control Laws: A Brief Sketch 294 National Ambient Air Quality Standards 297 Stationary-Source Control 300 Technology-Based Effluent Standards 300 Differentiated Control 300 Cost-Effectiveness of the TBES Approach 302 New Directions in Stationary-Source Control: Emission Trading 303 The CAP Program for Reducing SO<sub>2</sub> Emissions 304

The Role of the EPA 304 Interstate Air Pollution 305 Controlling Greenhouse Gas Emissions 306 Mobile-Source Air-Pollution Control 307 New-Car Emission Standards 308 Direct Controls in the 1990 Clean Air Act 309 Clean Cars 310 Mobile-Source Standards and Climate Change 311 Economic Issues 312 Summary 314 Questions for Further Discussion 315

#### Chapter 16 Federal Policy on Toxic and Hazardous Substances 316

Economic Issues in Laws Governing Chemicals in Production and Consumer Products 318 The "Balancing" Issue 318 Differentiated Control: "Old" Versus "New" 321 On Testing Chemicals and the Burden of Proof 322 Uniform Standards 323 On Technological Change in Chemicals 324 Globalization and Chemicals 326 The Economics of Pest Resistance 327 Economic Issues in Federal Policy on Toxics in Water and Air Emissions 327 Instrument Choice 329 Hazardous Waste Reduction 330 The Management of Hazardous Wastes 333 Economic Issues in Handling Current Hazardous Waste 335 Incentive-Based Possibilities 336 Environmental Justice 337 Radioactive Wastes 338

Economic Issues in Handling Legacy Hazardous-Waste Sites 339 Financing Hazardous-Waste-Site Cleanups 340 How Clean Is Clean? 341 Brownfields 341 Natural Resource Damages 342 Cleaning Up After the Cold War 343 Summary 344 Questions for Further Discussion 344

#### Chapter 17 State and Local Environmental Issues 345

Environmental Federalism 346 Constitutional Issues 346 Efficiency Issues 347 Race to the Bottom? 348 Policy Innovations at the State Level 349 Municipal Solid Waste 349 The Nature of the Problem 350 Technical Options for Reducing MSW 350 Current Policy 351 The Economics of Recycling 352 Producer Use of Recycled Material 354 Consumer Recycling Decisions 356 Producer Take-Back Programs 357 Local Environmental Regulations 358 The Increasing Role of the States 359 Summary 360 Questions for Further Discussion 361

SECTION SIX GLOBAL ENVIRONMENTAL ISSUES 363

Chapter 18 The Global Environment 364 Global Climate Change 364 The Physical Problem 364 Human and Ecosystem Impacts 366 Scientific Uncertainties and Human Choice 367 Technical Responses to the Greenhouse Effect 368 Reducing Domestic GHG Emissions 369 Incentive-Based Approaches for Reducing Greenhouse Gas Emissions 371 International Efforts in Global Warming 372 The Kyoto Protocol 373 A New Global Greenhouse Climate Agreement 375 Estimating the Social Cost of Carbon 378 Biological Diversity 379 Summary 382 Questions for Further Discussion 383

#### Chapter 19 International Environmental Agreements 384

General Issues 385 The Economics of International Agreements 390 Bilateral Agreements 390 Multilateral Agreements 392 The Distribution of Costs 394 Bargaining Issues 394 Cost-Effectiveness in Multinational Agreements 395 A Multilateral Success Story: The Montreal Protocol 396 The Physical Problem 396 International Response 397 The Economics of CFC Controls 399 Summary 402 Questions for Further Discussion 402

#### Chapter 20 Globalization 404

Dimensions of Globalization 404 On Sorting Out Cause and Effect 406 Trade and the Environment 406 *Free Trade Versus Environmental Trade Restrictions* 407 Globalization and a "Race to the Bottom" 410 The Pollution-Haven Issue 411 Trade and Carbon 412 Regional Trade Agreements 413 *Environmental Trade Restrictions* 415 Summary 418 Questions for Further Discussion 418

#### **Chapter 21** Economic Development and the Environment 419

Environmental Degradation in Developing Economies 420 Economic Growth and the Environment 422 *A Static View 422 Sustainability 423 Long-Run Relationships 424* 

Environmental Policy Choices 426 in Developing Countries Benefit–Cost Analysis 426 Reducing Environmental Disincentives 429 Institutional Policy: Property Rights 429 Population Policy as Environmental Policy 431 Instrument Choice in Developing Countries 432 The Role of the Developed Countries 434 Technology Transfer 434 Environmental Values in International Development Banks 438 Summary 439 Questions for Further Discussion 439

### APPENDIX

Abbreviations and Acronyms Used in the Book 441

#### NAME INDEX 445

SUBJECT INDEX 448