

Contents

Preface xxi Acknowledgments xxv

Part I Building a Foundation 1



Chapter 1: Defining Resilience and Sustainability

- I. CASE STUDY: EASTER ISLAND AND WHAT IS NOT RESILIENT NOR SUSTAINABLE SOCIETY 4
- II. DEFINING "RESILIENCE" AND "SUSTAINABILITY" 6
 - A. Resilience 8
 - 1. Background and Introduction 12
 - 2. Exploring the Subparts of Ecological Resilience 14
 - a. Disturbances 14
 - b. Thresholds 16
 - c. Adaptive cycle 18
 - d. Panarchy 21
 - e. Boundaries 23
 - 3. Critiquing Ecological Resilience 24
 - 4. Summarizing Resilience as a Concept 26
 - B. Sustainability 27
 - 1. Modern Origins of Sustainability 27
 - 2. Two Fundamental Understandings of Sustainability 33
 - a. Intergenerational Equity 33

χij

Contents

- Case Study: Catching Water in a Net, the Population Collapse of the Atlantic Cod 36
- b. Triple Bottom Line 43
 - i. Case Study: *pLAn[ing]* for the Future by Incorporating the TBL 45
- 3. Sustainability and Sustainable Development: Related, But Separate, Concepts 48
- 4. Summary of Sustainability Principles 52

III. OVERLAP AND DIVERGENCE BETWEEN RESILIENCE AND SUSTAINABILITY 54

- A. Core Commonalities and Characteristics: Interdisciplinary Nature, Geographic Variation, and Institutional Arrangements 54
- B. Areas of Further Interaction 55
- C. Areas of Divergence 58
- IV. BUILDING ON DEFINITIONS 61



Chapter 2: Challenges and Root Causes 63

- I. CASE STUDY: THE PEARL CITY 63
- II. CHALLENGES FACING THIS GENERATION 70
 - A. A Product of Our Past 70
 - 1. The Industrial Revolution 70
 - 2. Environment and Society Versus Economic Growth and the Role of Technology 73
 - 3. Environment and Society Versus Economic Growth and the Role of Population 77
 - 4. Summary Forces Affecting the Challenges 82
 - B. Picture of the Present 82
 - 1. Economic Indicators 83
 - 2. Social or Equity Indicators 90
 - 3. Environmental Indicators 98
 - C. A View from the Future 109
- III. SUMMARY OF THE CHALLENGES 112

Part II: Resilience and Sustainability in Context 115

5

Chapter 3: Water 119

I. INTRODUCTION 119

II. SURFACE WATER APPORTIONMENT SYSTEMS 123

- A. The Riparian System 124
- B. The Prior Appropriation System 127
- C. The Hybrid System 132
- D. Global Water 134
- E. Strategy to Facilitate Implementation #1: Addressing Collective Action Challenges 139
 - 1. General Description of Collective Action Challenges 140
 - 2. Specific Description of CAC's Relevance to R&S 142

III. GROUNDWATER SUPPLY ALLOCATION SYSTEMS AND GROUNDWATER PUMPING, MINING, AND MANAGEMENT 146

- A. Groundwater Supply Allocation Systems 149
- B. Groundwater Pumping and Mining 151
- C. Groundwater Management 152

IV. MANAGING WATER QUANTITY AND QUALITY 155

- A. Water Quantity 155
 - 1. Law of Drainage 155
 - 2. Hydrological Alterations 157
 - 3. Liability for Flooding 162
- B. Water Quality 164
 - 1. Safe Drinking Water 164
 - 2. Pollution Surface Water and Groundwater 168
- C. Strategy to Facilitate Implementation #2: Precautionary Principle 172
 - 1. General Description of the Precautionary Principle 173
 - 2. Specific Description of the Precautionary Principle's Relevance to R&S 175
 - Illustration of the Precautionary Principle's Relevance to R&S 177

V. PROPERTY RIGHTS AND HUMAN RIGHTS TO WATER 180

VI. STRATEGY TO FACILITATE IMPLEMENTATION #3: ECOSYSTEM SERVICES MANAGEMENT 184

XIV Contents

- A. General Description of Ecosystem Services Management 184
- B. Specific Description of Ecosystem Services Management's Relevance to R&S 186

VII. WATERSHED MANAGEMENT AND INSTREAM FLOW PROTECTIONS 190

- A. Watershed Management 190
- B. Challenges Involved with Managing Watershed 192
 - 1. Colorado River Watershed 192
 - 2. Jordan River Basin and Collective Action Challenges 194
 - Mississippi River Watershed and Collective Action Challenges 196
 - 4. Instream Flow 202

VIII. MOVING FORWARD 206



- I. INTRODUCTION 209
- II. A BRIEF HISTORY OF AGRICULTURE 210
- III. PRODUCTION AND PRACTICES 216
 - A. Large-Scale Farming 219
 - B. Raising Livestock 224
 - C. Seafood 228

IV. AGRICULTURAL POLLUTION FROM FERTILIZERS AND PESTICIDES 231

- A. Regulating Agricultural Pesticides and Fertilizers 235
- V. REGULATING AGRICULTURAL PRODUCTION AND PRACTICES 237
 - A. Clean Water Act 237
 - B. Clean Air Act 239
 - C. Endangered Species Act 241
 - D. National Environmental Policy Act 242
- VI. FOOD SAFETY 243
- VII. NUTRITION, FOOD JUSTICE, AND LABELING 247
- VIII. CONSERVATION AND PRESERVATION 261
- IX. CONCLUSION 265

ΧV



- I. INTRODUCTION 269
- II. THE TRADITIONAL TOOLS 273
- III. COMPREHENSIVE PLANNING 275
- IV. ZONING 282
- V. SUBDIVISION REGULATION 287
- VI. GROWTH MANAGEMENT 295
 - A. Smart Growth 296
 - B. New Urbanism 301
 - C. Renewable Energy 302
 - D. Green Development 307

VII. URBAN REDEVELOPMENT 313

- A. Financing Redevelopment 313
- B. Community Benefits 317
- C. Revitalization of Vacant Property 321

VIII. HOUSING 325

- A. Exclusionary and Inclusionary Zoning 325
- B. Discrimination and the Fair Housing Act 329
- C. Non-Traditional Living Arrangements and Group Homes 330
- D. Public Housing Assistance 333
- E. Housing Codes and Statutory Housing Requirements 335

IX. LIMITATIONS ON LAND USE REGULATION 337

- A. The Fifth Amendment Takings Clause 338
- B. Other Constitutional Limitations 343
- C. Other Federal and State Limitations on Land Use 349

Chapter 6: Energy Production and Consumption 357

- I. INTRODUCTION 357
- II. STRATEGY TO FACILITATE IMPLEMENTATION #4: SYSTEMS THINKING 361
- III. ENERGY RESOURCES: FOSSIL FUELS 366
 - A. Oil and Natural Gas 366
 - B. Coal 377

XVI Contents

- C. Unconventional Fossil Fuels 381
- D. Resilience, Sustainability and the Use of Fossil Fuels 388

IV. STRATEGY TO FACILITATE IMPLEMENTATION #5: BASELINES AND METRICS 397

- A. General Description of Baselines and Metrics 397
- B. Illustration of Application of Baselines and Metrics to R&S 401

V. ENERGY RESOURCES: NON-FOSSIL FUELS 403

- A. Nuclear Energy 403
 - 1. Nuclear Energy Production 404
 - 2. Resilience, Sustainability, and Nuclear Energy 405
 - a. Nuclear Energy Accidents 405
 - Environmental Impact and Disposal of Nuclear Waste 406
 - 3. Environmental Justice Issues 409
 - 4. Water Impacts 410
 - 5. Minimizing Nuclear Energy Externalities 410
- B. "Renewable" Energy Sources 411
 - 1. Water 419
 - a. Production and Regulation 419
 - b. Resilience and Sustainability 422
 - 2. Wind 427
 - a. Production and Regulation 427
 - b. Resilience and Sustainability 430
 - 3. Biomass 432
 - a. Production and Regulation 432
 - b. Resilience and Sustainability 434
 - 4. Geothermal 436
 - a. Production and Regulation 437
 - b. Resilience and Sustainability 441
 - 5. Solar 442
 - a. Production and Regulation 443
 - b. Resilience and Sustainability 445

VI. THE ELECTRICITY GRID 448



Chapter 7: Natural Resources 453

- I. INTRODUCTION 453
- II. FORESTS, TIMBER, AND WATERSHED PROTECTION 454
 - A. Timber 455
 - B. Deforestation 456

III. MINERAL 460

A. Resilience and Sustainability of Mining 463

IV. RANGELAND 470

A. Resilience and Sustainability of Rangelands 472

V. FISH AND WILDLIFE 475

A. Resilience and Sustainability of Fish Stocks 484

VI. STRATEGY TO FACILITATE IMPLEMENTATION #6: ADAPTIVE GOVERNANCE 488

- A. General description of Adaptive Governance 489
- B. Specific Description of Adaptive Governance's Relevance to R&S 491
- C. Illustration of Adaptive Governance's Application to Resilience and Sustainability 492

VII. PRESERVATION AND RECREATION 499



- I. INTRODUCTION 509
- II. ADDRESSING POLLUTION: CASE STUDY, THE BP OIL SPILL—A TRAGIC EXAMPLE 510

III. ADDRESSING POLLUTION: U.S. ENVIRONMENTAL LAW AND POLLUTION 511

- A. Environmental Impact Statements 511
 - 1. The National Environmental Policy Act 511
 - 2. State Environmental Protection Acts 513
 - 3. Case Study of Resilience and Sustainability 513
- B. Waste Disposal and Cleanup 516
 - 1. Resource Conservation and Recovery Act 516
 - 2. The Comprehensive Environmental Response, Compensation and Liability Act 518
 - 3. Case Study of Resilience and Sustainability 520

IV. STRATEGY TO FACILITATE IMPLEMENTATION #7: LIFE CYCLE SUSTAINABILITY ASSESSMENT 522

- A. General Description of LCSA 522
- B. Specific Description of LCSA's Relevance to R&S 524
- C. Illustration of LCSA's Application to R&S 526
- V. ADDRESSING POLLUTION: U.S. ENVIRONMENTAL LAW AND POLLUTION 531

XVIII Contents

A. Clean Air 531	
1. National Ambient Air Quality Standar	ds 531
2. Acid Rain 532	
3. National Emission Standards for Haza	rdous Air
Pollutants 533	
4 State Implementation Plan 522	

- 4. State Implementation Plan 533
- 5. CAA Regulation of Mobile Sources 534
- 6. CAA Regulation of Stationary Sources 535
- 7. New Source Performance Standards 535
- 8. Attainment Area Controls 536
- 9. Nonattainment Area Controls 537
- 10. Title V and State Permits 539
- 11. Case Study of Resilience and Sustainability 540
- B. Clean Water 544
 - 1. Point Source Regulation 545
 - 2. NPDES Permit for Direct Discharges 545
 - 3. Pretreatment Program for Indirect Discharges 546
 - 4. Nonpoint Source Regulation 547
 - 5. State Water Quality Standards 547
 - 6. Area-Wide Planning and Watersheds 548
 - 7. Oil Pollution Act of 1990 549
 - 8. Case Study of Resilience and Sustainability 550
- C. Oceans and Coastal Management 554
- D. Toxins 560
 - 1. Federal Regulation of Toxins 561
 - a. Toxic Substances Control Act 561
 - b. Federal Insecticide, Fungicide, and Rodenticide Act 561
 - c. Food, Drug, and Cosmetic Act 562
 - d. CAA and CWA 562
 - e. Nanotechnology Impacts 563
 - f. Electronic Waste 565
 - 2. Litigation 566
 - 3. Case Study of Resilience and Sustainability 572

VI. STRATEGY TO FACILITATE IMPLEMENTATION #8: RISK ANALYSIS 574

- A. General Description of Risk Analysis 576
- B. Specific Description of Risk Analysis's Relevance to R&S 577

VII. GLOBAL ENVIRONMENTAL REGULATION 581

- A. Polluter Pays Principle 583
- B. Public Health 585
- C. Population 586

xix



- I. INTRODUCTION 589
 - A. Case Study: The Fukushima Earthquake and Tsunami 594
- II. NATURAL DISASTERS 596
- III. DISASTER PREPAREDNESS, PREVENTION, AND RESPONSE 605
- IV. CONCLUSION 629



Chapter 10: Climate Change 633

- I. SETTING THE FOUNDATION: CLIMATE BASICS, GREENHOUSE GASES, SOURCES, AND SINKS 634
 - A. Greenhouse Gases, Sources, and Sinks 634
 - B. Three Approaches to Addressing Climate Change 641
 - 1. Mitigation 641
 - 2. Adaptation 644
 - 3. Geoengineering 645
- II. CLIMATE CHANGE IMPACTS 649
 - A. Summary of Climate Change Effects 649
 - B. Climate Change, R&S, and Ocean Acidification 653
 - 1. The Ocean System 653
 - 2. Impacts on the Ocean 655
 - 3. Ocean Acidification and Assessing R&S in the Era of Climate Change 660

III. ASSESSING SYSTEM RESILIENCE AND SUSTAINABILITY AND RESPONSES TO CLIMATE CHANGE 662

- A. R&S and Climate Change 663
- B. Strategies to Facilitate Implementation in the Climate Change Context 671
 - Mitigation: Carbon Pricing, Collective Action Challenges, Polluter Pays Principle, and Ecosystem Services Management 672
 - 2. Systems Thinking and Climate Change 677
 - 3. Adaptation: Baselines and Metrics, Adaptive Governance, and Human Health 680