

Contents

Cover Photograph Description	v
Foreword	vii
Preface	ix
Acknowledgements	xiii
About The Author	xv
Second and First Edition Reviewers	xxix
1 The History and Distinctions of Conservation Biology	1
1.1. Perspectives and Questions for an Inquiry into Conservation Biology	2
1.2. The Origins of Conservation	3
1.2.1. Conservation in Historical Context	3
1.2.2. Cultural Foundations of Conservation	4
1.2.3. Conservation as Expression of Privilege	6
1.2.4. Conservation as Right Relationship with Nature – The Arcadian Vision	6
1.2.5. Conservation as Knowledge – The Invitation to Study and Appreciate Nature	7
1.2.6. Conservation to Save Species – Origins of the First Conservation Organizations	8
1.2.7. Conservation as Preservation of Landscape – The Washburn Expedition Goes to Yellowstone	9
1.3. Intellectual Foundations and History of Conservation in the United States	11
1.3.1. Conservation as Moral Mission – John Muir and Theodore Roosevelt	11
1.3.2. “Scientific Conservation” Through Sustained Yield – Moral Mission Gives Way to Utilitarian Purpose	12
1.3.2.1. The Federal Government Empowers Conservation as Science and Democratic Ideal	12
1.3.2.2. German Influences in Conservation – Forest Monocultures and Maximum Yields	14
1.3.2.3. The Rise of the Resource Conservation Ethic	15
1.3.2.4. Aldo Leopold and the Formation of the “Wilderness Ideal” in Conservation	16
1.4. The Emergence of Global Conservation – Shared Interests Lead to Cooperation	17
1.4.1. Multilateral Treaties – The Beginnings of International Conservation Efforts	17
1.4.1.1. Conservation Driven by Shared Commercial Interests	17
1.4.1.2. International Protection of Migratory Species	18
1.4.2. Forums for International Conservation – The United Nations and the International Union for the Conservation of Nature	19
1.5. Conservation in the Developing World: New Expressions of Resource Management, National Parks and Nature Preserves	20
1.6. Return to Start: What is the Place of Conservation Biology in the World Conservation Effort?	22
1.6.1. The Emergence of Conservation Biology from the Applied Sciences	22
1.6.2. Conceptually Distinctive Characteristics of Conservation Biology	24
1.7. Synthesis	25
References	26

2 Values and Ethics in Conservation	29
2.1. What Does Science Have to Do with Value?	30
2.1.1. Avoiding the Absurd – Being Self-Aware of Values in Conservation Decisions	30
2.1.2. Recognizing Management Actions as Value Judgments	30
2.1.3. Values and Ethics – Definitions and Initial Assessments	31
2.2. The Problem of Categories: How Do We Classify Different Kinds of Conservation Values?	33
2.2.1. An Overview of Value Categories	33
2.2.2. Instrumental Values	33
2.2.2.1. General Considerations	33
2.2.2.2. Determining Attitudes with Sociological Surveys	34
2.2.2.3. Tools of Economic Valuation: Cost–Benefit Analysis and Contingency Valuation	35
2.2.2.4. Contingent Valuation Analysis	36
2.2.2.5. Criticisms of Contingent Valuation Analysis	37
2.3. The Problem of Moral Value: Assigning Intrinsic Values in Conservation	39
2.3.1. Where Does Intrinsic Value Reside?	39
2.3.2. Ecocentrism as a Basis for the Intrinsic Value	40
2.3.3. Intrinsic Value in the Judeo-Christian Tradition	42
2.3.4. Other Western Religious Traditions – Islam	44
2.3.5. Eastern Religious Traditions and Conservation – Hinduism and Buddhism	44
2.3.5.1. Hinduism	44
2.3.5.2. Buddhism	45
2.3.6. Practical Implications – Faith-Based Organizations in Conservation	46
2.3.6.1. “Goal Rational” Versus “Value Rational” Conservation	46
2.3.6.2. Jewish and Christian FBOs	46
2.3.6.3. FBOs in Islam	47
2.3.6.4. Conservation Activism in Hinduism	47
2.3.6.5. Conservation FBOs in Buddhism	48
2.3.6.6. Future Roles and Contributions of FBOs in Global Conservation	48
2.4. The Problem of Practice: Do Conservation Values Require Conservation Virtues?	49
2.4.1. The Problem of Plastic Trees	49
2.4.2. From Values to Virtues: Virtue-Based Ethics in Conservation	50
2.4.3. What are Appropriate Conservation Virtues?	50
2.5. Orphaned Orangutans: Ethical Applications in Conservation	51
2.6. Synthesis	53
References	53
3 The Legal Foundations of Conservation Biology	57
3.1. Conservation Law and Policy	58
3.1.1. Context and Definition	58
3.1.2. Historical Origins of Conservation Law	59
3.2. Environmental and Conservation Law in Individual Nations: Modern Examples from the United States, South Africa, and Australia	59
3.2.1. General Considerations	59
3.2.2. Common Characteristics of Effective National Conservation Law	60
3.2.3. The US National Environmental Policy Act (NEPA)	61
3.2.3.1. NEPA’s History and Content	61
3.2.3.2. NEPA and US Federal Lands	62
3.2.3.3. Preparation of an Environmental Impact Statement	62
3.2.3.4. Shortcomings of the National Environmental Policy Act	63
3.2.4. The US Endangered Species Act	64
3.2.4.1. Historical Origins and Content	64
3.2.4.2. The Endangered Species Act and Landowner Conflicts: The Case of the Red-Cockaded Woodpecker	66

3.2.4.3. San Bruno Mountain and the Evolution of Habitat Conservation Planning	67
3.2.4.4. Criticisms of the Endangered Species Act	68
3.2.5. Water as an Inalienable Reserve – South Africa and Australia Establish Radical Categories for Conservation Law	69
3.3. International Conservation Law: Concept and Development	71
3.3.1. General Considerations	71
3.3.2. A Forum for Cooperation and Legal Foundation – The United Nations and Its Environmental Programs	71
3.3.2.1. Background and Context	71
3.3.2.2. Stockholm: The Beginnings of Modern International Conservation Law	71
3.3.2.3. Protection of Endangered Species: The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)	72
3.3.2.4. Rio 1992 – Combining Conservation and Economics in International Agreements	74
3.4. The Process: Creating and Enforcing International Conservation Law	75
3.5. The Problem of Interdependence: How Does One Nation Promote Global Conservation without Negative Effects on Other Nations?	77
3.5.1. The Nature of International Legal Interdependence	77
3.5.2. Case History I: Tuna and Dolphins	78
3.5.3. Case History II: Shrimp and Sea Turtles	79
3.5.4. Outcomes and Future Prospects	80
3.6. Synthesis	80
References	81
 4 Biodiversity: Concept, Measurement, and Challenge	83
4.1. Biodiversity and Conservation Biology	84
4.2. The Problem of Concept and Quantity: How Do We Know What Biodiversity is and How Do We Measure it?	84
4.2.1. A Conceptual Definition of Biodiversity	84
4.2.2. Biodiversity and the Definition of Species	86
4.2.3. Contemporary Issues of the Species Concept	86
4.2.4. Implications of the Species Concept in Conservation	87
4.2.5. Measuring Biodiversity	89
4.2.5.1. What Biodiversity Measurements Tell Us	89
4.2.5.2. Alpha Diversity	89
4.2.5.3. Beta Diversity	90
4.2.5.4. Gamma Diversity	92
4.2.6. Application and Integration of Diversity Measures to Address Issues in Conservation: A Case Study from Eastern Amazonia	93
4.2.7. Problems of Diversity Indices and Alternative Measures	93
4.3. The Problem of Process and Pattern: What Explains Variation in Local Biodiversity?	95
4.3.1. Niche Assembly Theories of Biodiversity	95
4.3.2. The Unified Neutral Theory of Biodiversity	96
4.4. The Problem of Dispersion: Where is Biodiversity Located?	99
4.4.1. Global Patterns of Biodiversity	99
4.4.2. Biodiversity Indices: Can We Find “Hotspots” with Incomplete Information?	100
4.5. The Problem of Quantity: How Much Biodiversity is There?	101
4.5.1. General Considerations	101
4.5.2. Biodiversity and Rarity	101
4.5.2.1. The Problem of Rarity	101
4.5.2.2. Habitat Generalists Versus Habitat Specialists	102
4.5.2.3. Large Populations Versus Small Populations	102
4.5.2.4. Widespread Distribution Versus Restricted Distribution	103
4.5.3. The Problem of Endemism	103
4.5.3.1. Endemism in the Extreme – A Case History	103

4.5.3.2. Endemism, Biodiversity, and Rarity	104
4.5.3.3. Endemism and Island Species	106
4.6. The Problem of Application: How Do We Manage Biodiversity?	107
4.6.1. The Problem with “Hotspots”	107
4.6.2. Identifying Areas of Conservation Value Using Remotely Sensed Data	107
4.6.3. Tracking Biodiversity Using Indicator Species	107
4.6.3.1. Biodiversity Indicators: Using “Surrogate” Species as Biodiversity Indices	107
4.6.3.2. Taxon-Based Biodiversity Indicators	108
4.6.3.3. Structure- and Function-Based Biodiversity Indicators	109
4.6.3.4. Bison as an Example of a Function-Based Keystone Species	110
4.6.3.5. Ecological Redundancy and Function-Based Biodiversity Indicators	110
4.7. The Problem of Conservation: How Do We Identify and Prioritize Areas to Preserve Biodiversity?	111
4.7.1. Current Global Prioritization Strategies	111
4.7.2. Management Approaches to Biodiversity at Landscape Levels	112
4.7.2.1. Gathering Appropriate Background Data	112
4.7.2.2. Maintaining Ecological and Evolutionary Processes Promoting Biodiversity	113
4.7.2.3. Regional Biodiversity Management – Defining Functional Conservation Areas	113
4.7.3. Building Biodiversity Conservation into Existing Management Plans – The New South Wales Environmental Services Scheme	114
4.8. Synthesis	117
References	117
5 Biodiversity Conservation and Climate Change	121
5.1. Climate and Climate Change	121
5.1.1. Why Does Climate Change Threaten Biodiversity?	121
5.1.2. What Is “Climate” and What Is “Climate Change”?	123
5.1.3. Should Contemporary Global Warming Be Called “Climate Change?”	124
5.1.4. The Implications of Rapidly Rising CO ₂	125
5.1.5. Why We Call It “Climate” Change – Non-temperature Variations in Climate in a Warming World	127
5.2. The Global Fingerprint of Climate Change on Biodiversity	128
5.2.1. Extinction Patterns in Edith’s Checkerspot Butterfly	128
5.2.2. Finding the Global Fingerprint of Climate Change	128
5.2.3. Can Climate Change Cause Extinction of Local Populations?	129
5.2.3.1. Climate Change and Pikas	129
5.2.3.2. Climate Change and Desert Bighorn Sheep	130
5.3. Climate Change in Ecosystems – Species Loss and System Degradation.	131
5.3.1. Climate Change at Ecosystem Levels: Biome Boundaries and Elevational Shifts.	131
5.3.2. Life Zone Changes in Tropical Forests.	132
5.3.3. Elevational Shifts in Tropical Cloud Forests: The Case of the Golden Toad	132
5.4. Climate-Mediated Mechanisms of Ecosystem Change	133
5.4.1. Climate Influences on a Keystone Species: The Case of the Whitebark Pine	133
5.4.2. Climate Influences on Ecosystem Processes: Invasive Species in a Warmer World.	136
5.4.3. Climate Influences on Ecosystem Structure	137
5.4.3.1. The Future of Coral in Warmer Oceans	137
5.4.3.2. Loss of Polar Sea Ice: Implications for Polar Biodiversity.	138
5.5. Conservation Planning and Climate Change: Creating Climate-Integrated Conservation Strategies	140
5.5.1. The Bioclimate Envelope: Modeling Climate Effects on Individual Species.	140
5.5.2. Climate Change-Integrated Strategies for Conservation.	142
5.5.3. Modeling Efforts to Predict Future Responses to Ongoing Climate Change	145
5.5.4. Errors of Application: Use and Misuse of Endangerment Criteria to Model Climate Change Effects on Biodiversity	146
5.6. Policy Initiatives for Climate Change and Conservation.	148
5.7. Synthesis	150
References	150

6 Genetic Diversity – Understanding Conservation at Genetic Levels	153
6.1. Genetics and Conservation: An Essential Integration	153
6.2. Conservation Genetics and Conservation Biology	154
6.3. Measuring Genetic Diversity in Populations	157
6.3.1. Foundational Measures of Genetic Diversity	157
6.3.2. The Loss of Genetic Diversity over Time: Bottlenecks and Genetic Drift	157
6.3.3. Genetic Drift and Effective Population Size	160
6.3.4. Bottlenecks, Small Populations and Rare Alleles	161
6.4. The Problem of Inbreeding	162
6.4.1. What Do We Mean by “Inbreeding” and How Would We Measure It?	162
6.4.2. The Problem of Inbreeding Depression	163
6.4.3. Measures of Inbreeding	164
6.5. Inbreeding and Outbreeding in Population Subunits: Estimation of Gene Flow and Metapopulation Genetics	165
6.5.1. Historical Development of Gene Flow Theory	165
6.5.2. Current Models of Gene Flow: Predictions and Implications	166
6.5.3. Models of Recolonization: Propagule Pools and Migrant Pools	168
6.6. Can Inbreeding Cause Extinction?	170
6.6.1. Laboratory Experiments and Models	170
6.6.2. Field Studies of Inbreeding	171
6.6.3. Inbreeding was a Cause of Extinction in Butterfly Populations	172
6.6.4. Inbreeding Effects – Environmental and Demographic Variability	173
6.7. Hybridization and Introgression	174
6.7.1. Hybridization and Introgression in Animals: The Case of the Red Wolf	174
6.7.2. Importing Genetic Diversity: Genetic Restoration of Inbred Populations	175
6.7.3. Hybridization in Plants – Conservation Threat or Conservation Asset?	177
6.7.4. Introgression from Genetically Modified Organisms	179
6.8. Outbreeding Depression	180
6.9. Synthesis	181
References	181
7 Genetic Management – Managing Genetic Diversity for Conservation Goals	185
7.1. Conservation Genetics: From Theory to Application	186
7.2. Genetic Techniques: Solving the Problem of Assessing Genetic Status and Change	186
7.2.1. General Considerations	186
7.2.2. Allozyme Electrophoresis: Genetic Variation at Molecular Levels	186
7.2.3. The Polymerase Chain Reaction: A Non-invasive Method for Genotyping Endangered Species	188
7.2.4. Random Amplified Polymorphic DNA (RAPD) Analysis	189
7.2.5. DNA Fingerprinting: The Use of Satellite Markers	189
7.2.5.1. Minisatellites and Microsatellites – What Are Satellite Markers?	189
7.2.5.2. Measuring Genetic Diversity with Minisatellites and Microsatellites	190
7.2.6. Mitochondrial DNA	191
7.2.7. Restriction Fragment Length Polymorphism (RFLP): A Technique for Assessment of Genetic Variation Among Individuals	193
7.3. Captive Breeding: Managing Genetics of Captive Populations	194
7.3.1. Using Genetic Techniques to Recover Genetic Diversity and Population Size in Captive Populations: The Historical Background	194
7.3.2. Solving the Fundamental Problem: Minimizing Adaptation to Captivity	194
7.3.3. Captive Breeding Today	195
7.3.4. Conservation Implications of Captive Breeding – The Example of the Okapi	196
7.3.4.1. The Significance of the Captive Okapi Population	196
7.3.4.2. Pedigree Analysis and Kinship	196
7.3.4.3. Population Mean Kinship	198
7.3.4.4. Relationship of Inbreeding to Kinship	198
7.3.4.5. How Can a Captive Population Manager Retain Gene Diversity?	199

7.3.5. Captive Breeding Strategies	200
7.3.5.1. Random Mating and Avoidance of Inbreeding Strategies.	200
7.3.5.2. Mean Kinship Breeding Strategies	201
7.3.6. Making Sound Judgments in Captive Breeding Strategies: An Overview	202
7.4. The Problem of Application: How Do We Use Genetic Information and Techniques in Conservation?	202
7.4.1. General Considerations.	202
7.4.2. Genetics Can Clarify Relatedness, Taxonomy, and Phylogeny	202
7.4.3. Genetics Can Define Management Units of Fragmented or Widespread Populations	204
7.4.4. Genetic Techniques Can Determine Rates of Gene Flow Among Populations	205
7.4.5. Genetic Techniques Can Estimate the Time Since Past Population Bottlenecks	205
7.4.6. Genetic Techniques Can Determine Patterns of Reproductive Ecology.	206
7.4.7. Genetic Forensics: Genetic Techniques Can Determine if Conservation Laws and Treaties are Being Obeyed	206
7.4.8. An Exemplary Case History: Exposing Exploitation of Protected Stocks and Species Through Genetic Forensics	207
7.5. Building Genetic Insights into Conservation Management	208
7.5.1. Advanced Technologies, Limited Applications: The Current State of Genetic Considerations in Field Conservation	208
7.5.2. Genetic Conservation Reserves: Genetics as a Basis for Reserve Design	208
7.6. Synthesis	209
References	210
8 The Conservation of Populations: Concept, Theory, and Analysis	213
8.1. Defining Populations	213
8.2. Basic Population Processes and Small Populations.	214
8.2.1. Population Demography	214
8.2.2. Stochastic Perturbations	216
8.2.2.1. Deterministic Versus Stochastic Factors	216
8.2.2.2. Genetic and Environmental Stochasticity	216
8.2.2.3. Demographic Stochasticity	217
8.2.2.4. Natural Catastrophes	218
8.3. Populations and Metapopulations: Complexities of Population Subdivision and Fragmentation	218
8.3.1. Origins of Metapopulation Theory	218
8.3.2. The Definition and Development of Metapopulation Concepts	219
8.3.3. A Metapopulation Case History: The Florida Scrub Jay	222
8.3.4. Managing Metapopulation Interactions: Implications of a Theoretical Model	222
8.4. Population Viability Analysis	224
8.4.1. Conceptual Foundations	224
8.4.2. Uses of PVA Models.	226
8.4.3. A Stage-Based Deterministic Model – The Western Prairie Fringed Orchid.	227
8.4.3.1. General Considerations.	227
8.4.3.2. Stage-Based Deterministic Models.	229
8.4.3.3. Constructing the Model and Matrices.	229
8.4.4. The Concept and Use of Elasticity in PVA Analysis	231
8.4.5. Stochastic Models.	231
8.4.6. The Arizona Cliffrose: PVA Analysis of an Endangered Species	232
8.5. Making Management Decisions for Small Populations.	235
8.5.1. PVA and the Analysis of Risk.	235
8.5.2. The Problem of PVA Application: How Do We Use and Interpret Population Viability Analyses?	237
8.5.3. Can PVAs Predict the Future? Test Cases and General Trends	237
8.5.4. A Final Review: What Are We to Think of PVA?	239
8.6. Synthesis	239

Appendix: Calculation of Columns in a Cohort Life Table.....	240
References	240
9 Population Management and Restoration	243
9.1. Minimum Viable Populations and Recovery Strategies for Threatened Species.....	243
9.1.1. General Considerations.....	243
9.1.2. The Use of PVA to Identify Threats and Recovery Strategies in <i>In Situ</i> Populations: The Case of the Little Bustard.....	244
9.1.3. The Case History of Viper's Grass: When Large Populations Are Not Enough	245
9.1.4. The Lord Howe Island Woodhen: A Case Study in Managing Multiple Threats to a Small and Declining Population	248
9.1.5. Trend Analysis and Factor Resolution: Systematic Approaches for Identifying Causes of Population Decline and Strategies for Restoration.....	250
9.1.6. The Gray Wolf: A Case History of Natural Population Restoration.....	253
9.2. Invasive Species: Threats to Native Biodiversity.....	255
9.2.1. General Considerations.....	255
9.2.2. Characteristics of Successful Invading Species	258
9.2.3. Invasive Species Alter Native Habitats	259
9.3. Managing Invasive Species: Prediction, Response, and Restoration.....	263
9.3.1. The Problem of Prediction: Can We Construct Models of Invasive Patterns to Understand the Invasive Process?.....	263
9.3.2. The Problem of Practical Response: How Do We Prevent or Control Invasions?	265
9.3.2.1. General Considerations.....	265
9.3.2.2. Step One: Preventing Entry of Invasive Species	267
9.3.2.3. Step Two: Controlling Initial Infestations of Invasive Species.....	269
9.3.2.4. Step Three: Controlling Negative Effects of Invasive Species on Native Populations	270
9.3.3. The Problem of Restoration: Can Native Populations Eradicated by Invaders Be Restored? The Case of the White-Clawed Crayfish	270
9.4. Practical Steps in Making Management Decisions for Populations: A Conceptual Framework	273
9.5. Synthesis	275
References.....	275
10 The Conservation of Habitat and Landscape.....	279
10.1. The Definition, Concept, and Importance of Habitat.....	280
10.1.1. What is Habitat?	280
10.1.2. How Do We Measure Habitat Use?	280
10.1.2.1. An Example in Moose: Habitat Choices of a Habitat Generalist	280
10.1.2.2. Measuring Habitat Selection and Preference	282
10.2. Heterogeneity, Landscape Gradients and Patch Dynamics	282
10.2.1. Habitat Heterogeneity, Gradients, and Patchiness	282
10.2.2. Habitats and Landscapes: Understanding Scales of Space and Time.....	283
10.2.3. How Do We Predict Habitat Change?.....	284
10.2.3.1. Predicting Habitat Transitions Using a Markov Model	284
10.2.3.2. Habitat Transition in Conservation – Managing the Successional Process	285
10.3. Problems of Habitat Loss, Isolation, and Fragmentation.....	286
10.3.1. Neutral Landscape Models and the Isolation of Effects.....	286
10.3.2. Percolation Theory: Defining the Critical Threshold of Fragmentation.....	287
10.3.3. Can Percolation Theory Explain the Real World? Models and Field Studies	289
10.3.3.1. Habitat-Population Models Support the Predictions of Percolation Theory.....	289
10.3.3.2. The Spotted Owl: Population Predictions and Conservation Planning.....	290
10.3.4. Field and Experimental Studies of Habitat Fragmentation.....	292
10.3.5. Habitat Loss and Fragmentation: Experimental Isolation of Separate Effects.....	293

10.4. Life on the Edge – Edge Effects Lead to Habitat Degradation	295
10.4.1. Understanding the Effects of Edge: First Principles	295
10.4.2. Edge Influence: Understanding Processes and Effects	296
10.4.3. Environmental Characteristics of Edges	297
10.5. Managing Habitat Connectivity: The Role of Corridors in Habitat Conservation	299
10.5.1. The Theoretical Basis of Habitat Corridors	299
10.5.2. Experimental Studies of Corridors	299
10.5.3. Potential Disadvantages of Corridors	301
10.6. Planning for Reserve Design	302
10.6.1. Algorithms of Reserve Design	302
10.6.2. GAP Analysis and Reserve Design	303
10.6.3. Reserve Design and Habitat Suitability	303
10.6.4. Determining Appropriate Reserve Size	304
10.7. Habitat Management on Non-Reserve Lands: Multiple Use and Conservation	306
10.7.1. Mitigating Human Effects on Non-reserve Lands: The Case of the Line Creek Elk	306
10.7.2. Managing Non-reserve Lands for Habitat Conservation: The Multiple-Use Module	307
10.8. Synthesis	309
References	309
 11 The Conservation of Aquatic Systems	 313
11.1. Conservation Challenges of Aquatic Habitats	313
11.1.1. Overcoming the Terrestrial Bias	313
11.1.2. Conservation Challenges of Freshwater Habitats	314
11.2. Management of Freshwater Habitats for Conservation	315
11.2.1. Managing Chemical and Physical Inputs to Aquatic Systems	315
11.2.2. Managing Freshwater Systems Through Riparian Zones	317
11.2.3. Organizing Information About Freshwater Ecosystems for Conservation – The Problem of Classification and Prioritization	319
11.2.3.1. Coarse-Filter Approaches for Regional Representation – The Nature Conservancy’s Nested Classification System of Aquatic Habitats	319
11.2.3.2. Setting Priorities for Conservation in Freshwater Aquatic Habitats – Incorporating Threat and Urgency in Conservation Planning	321
11.2.3.3. A Fine-Filter Approach to Conservation – Species Conservation Value in the Iberian Peninsula	322
11.3. Wetlands – Unique Challenges in Habitat Conservation	324
11.3.1. What Are Wetlands?	324
11.3.2. Managing Wetlands for Conservation – Management and Legislation	325
11.4. Marine Habitats and Biodiversity	326
11.4.1. A History of Overexploitation	326
11.4.2. Causes of Marine Habitat Degradation	328
11.4.3. Threats to Coral Reef Ecosystems	333
11.4.4. Rehabilitation Techniques for Coral Reefs	335
11.5. Conservation of Marine Habitat and Biodiversity – Managing the Marine Reserve	336
11.5.1. Management Context, Goals and Strategies in Marine Reserves	336
11.5.2. Tourist-Recreation Marine Reserves: The Bonaire Marine Park	338
11.5.3. Protection at Ecosystem Levels: Australia’s Great Barrier Reef Marine Park	338
11.5.4. The “Co-Management” Model – Shared Authority Between Local Citizens and Government Agencies	339
11.5.5. Marine Protected Areas and Commercial Fisheries	341
11.5.6. Mariculture – The Case History of the Giant Clam	343
11.5.7. Multiple and Conflicting Jurisdictions Over Marine Resources	345
11.6. Synthesis	346
References	346

12 Ecosystem Management	349
12.1. The Concept of Ecosystem Management	349
12.1.1. What is Ecosystem Management?	349
12.1.2. The Historical Roots of Ecosystem Management	350
12.1.3. Development of the Ecosystem Management Paradigm	351
12.2. How Do We Choose What to do? Changing the Decision-Making Process in Ecosystem Management	354
12.2.1. The Role of Adaptive Management	354
12.2.2. Evaluating Ecosystem Management as a Performance-Based System	355
12.2.2.1. Theoretical Constructs for Performance-Based Evaluation	355
12.2.2.2. The Black-Legged Kittiwake and the Swamp Wallaby	357
12.2.3. Stakeholder Participation in Ecosystem Management	359
12.3. The Scientific Basis of Ecosystem Management	359
12.3.1. The Problem of Location – Where is the Ecosystem?	359
12.3.2. The Problem of Information – What Data Should Be Collected and Interpreted for Ecosystem Management?	361
12.3.2.1. General Considerations	361
12.3.2.2. Regularly Collected Data	361
12.3.2.3. Ecosystem Management and Geographic Information Systems – How Technology Enables Management Purpose and Strategy	362
12.3.2.4. Archived Data and Historical “Experiments”	364
12.3.2.5. Data from Long-Term Natural Repositories	365
12.4. Implementing Management Decisions – What are the Tools of Ecosystem Management?	366
12.4.1. Ecosystem Modeling	366
12.4.2. Fire	367
12.4.3. Water Flow	368
12.4.4. Herbivory and Herbivores	369
12.4.5. Predation and Predators	371
12.4.6. Managing Ecosystem Components, Structure, and Function	372
12.5. What does Ecosystem Management Accomplish? The Fruits of Ecosystem Management Initiatives	373
12.5.1. Top-Down Approaches – Ecosystem Management Through Government Agency Initiative	373
12.5.2. Initiative from the Bottom-Up – Emerging Coalitions Driven by Environmental Concern	374
12.6. Why Ecosystem Management Matters – The Case of the Spotted Owl	376
12.7. Synthesis	378
References	379
13 Conservation Economics	383
13.1. Identifying and Protecting the Values of Biodiversity	384
13.1.1. The Value of Ecosystem Goods and Services	384
13.1.2. Stock-Flow Resources and Fund-Service Resources	385
13.1.3. Non-excludable and Non-rival Goods	387
13.2. Market-Based Solutions to Conservation Conflicts	388
13.2.1. The Role of Property Rights in Conservation	388
13.2.2. Biodiversity Conservation Through Market Incentive and Local Control	389
13.2.3. Government-Market Coordination – Conservation and Paddlefish Caviar	390
13.2.4. Integration of Conservation Assets in Private Property Value	392
13.2.4.1. Zoning Laws and Conservation Easements	392
13.2.4.2. Hedonic Valuation Models for Private Property	393
13.2.5. Can Property Rights Enhance Conservation in Wildlife Refuges? The Case Histories of Rainey and Baker Wildlife Sanctuaries	394
13.2.6. User Fees on Public and Private Lands – Pricing the Value of Conservation	395
13.2.7. The Travel Cost Method – Estimating the Value of a Costa Rican National Park	396

13.3. Ecological Economics	398
13.3.1. General Considerations	398
13.3.2. Characteristics of Ecological Economics	399
13.3.3. Methods for Valuing Environmental Goods and Services	401
13.3.3.1. General Strategies	401
13.3.3.2. Government Regulation	402
13.3.3.3. Taxation and Subsidies	403
13.3.3.4. Environmental Property Rights	404
13.3.3.5. Insurance Against Environmental Damage	404
13.3.3.6. Empowering Stakeholder Interests	404
13.4. Protecting and Valuing Biodiversity in the Economy: Current Conditions	405
13.4.1. The Convention on Biological Diversity	405
13.4.2. Integrated Conservation and Development Projects as Government Strategies to Encourage Just Protection of National and Indigenous Biodiversity	406
13.4.2.1. General Considerations	406
13.4.2.2. Serengeti National Park and Wildlife Harvests for Local Communities	407
13.4.2.3. Ecotourism as an Integration of Conservation and Development	408
13.4.3. The Broader Debate: Integrated Development or Direct Conservation Payments?	409
13.5. Synthesis	411
References	412
14 On Becoming a Conservation Biologist: The Things Textbooks Never Tell You	415
14.1. People as Agents of Conservation	416
14.2. Conservation Biology as Vocation	416
14.2.1. Articulating Your Personal Mission in Conservation	416
14.2.2. Pursuing Your Mission Through Education	416
14.2.3. Making the Transition from Student to Colleague	418
14.2.3.1. The Hidden Hurdle of Higher Education: Attaining the Status of a Colleague	418
14.2.3.2. The Role of Vocational Experience	419
14.2.3.3. Putting Principles into Practice – Two Examples of Student-to-Colleague Transitions	420
14.2.3.4. Common Threads in Different Cases – Successful Transitions from Conservation Students to Conservation Professionals	422
14.3. Reaching a Wider Audience	422
14.3.1. Building a Professional Network of Contacts and References	422
14.3.2. Conservation as a Social Process: Involvement in Professional Societies	425
14.3.3. Integrating Education and Experience into Social Conservation Outreach	425
14.4. Graduate Education in Conservation Biology	426
14.4.1. Independent Evaluation for Graduate School – The Graduate Record Exam	426
14.4.2. Choosing a Program	427
14.4.3. Choosing a Project, Graduate Professor, and Mentor	428
14.4.4. Hidden Hurdles: The Problem of Traditional Approaches	428
14.4.5. Taking Interdisciplinary Study Seriously – Program Level Innovation in the University of Florida's Tropical Conservation and Development Program	430
14.4.6. Shifting the Scale: Innovative Approaches to Graduate Education in the Classroom	431
14.4.6.1. Legal Ecology 101: Integrating Conservation Management and Law	431
14.4.6.2. Relational Skills in Conservation: Handling Humans, Learning Leadership	432
14.4.6.3. Creating Your Own Path to Innovative Professional Development	434
14.5. Choosing a Vocational Setting	434
14.5.1. Should I Take This Job?	434
14.5.2. How Can I Excel?	436
14.5.3. Nurturing Professional Relationships	436

14.6. Becoming an Effective Advocate for Conservation..... 436

 14.6.1. Professional Expressions of Advocacy..... 436

 14.6.2. An Alternative View of Advocacy 437

 14.6.3. Examining Outcomes: Implications of Alternative Views of Advocacy 438

 14.6.4. Avoiding Conflicts of Interest in Advocacy 439

14.7. Synthesis..... 440

References..... 440

Glossary 443

Index..... 459