

George W. Cox

Conservation Biology

second edition



concepts

and

applications

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Professor Emeritus - San Diego State University

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Conservation Biology

To Darla

for helping in field studies throughout the world,
and for patience, encouragement and love during
the preparations of this textbook

preface

The Earth is now in a critical period for the survival of its natural ecosystems and their plant and animal members. The continuing growth of human populations, through consumption of resources and discharge of the resulting wastes, is modifying ecosystem processes on a global scale. Global warming, stratospheric ozone depletion, acid deposition, tropical deforestation, desertification, accelerating soil erosion, chemical pollution—these and other large-scale threats are combining to threaten a massive loss of biodiversity. Yet our ultimate well-being depends on health of the global processes that are experiencing these massive changes—the myriad interactions among plants, animals, microorganisms, and their abiotic surroundings that provide us with food, fiber, medicine, pure water, and clean air. The crisis of survival of natural ecosystems and their members is a crisis of survival of the human species.

This global challenge requires our personal involvement. As responsible citizens, we must educate ourselves about the nature of this crisis, and about the choices that must be made in meeting it. An understanding of basic ecology has become a requirement of every educated person.

Each of us is now faced with decisions, on an almost daily basis, about environmental issues relating to the global ecosystem. Should we buy only tuna that were caught by dolphin-safe techniques, eat hamburgers made from beef that was not produced on tropical pastures created by deforestation, or use paper products instead of plastic and styrofoam items that might pollute the oceans? Should we support preservation of old-growth forests in the Pacific Northwest, taxation of sugar to aid the restoration of the Florida Everglades, and removal of exotic species from national and state parks—even the removal of mountain goats from Olympic National Park? Should we oppose efforts to weaken the Endangered Species Act and the Clean Water Act, to reduce populations of wolves and grizzly bears in Alaska in efforts to increase moose and caribou populations for hunters, or to divert more water from the Platte River so that greatly reduced flow reaches the portion of the river in Nebraska where migratory cranes stop in the spring? Should we support measures to reduce power plant emissions that contribute to acid rain, to ban the use of chlorofluorocarbons and other chemicals that damage the stratospheric ozone layer, and to reduce the use of fossil fuels that contribute to the greenhouse

effect and global warming? Should we continue to require shrimp fishermen to use devices that prevent sea turtles from entering their nets, to protect the mountain lion from hunting in California, or to support an international ban on trade in elephant ivory? These, and countless issues like them, demand the collective decision of society.

The goal of this text is to introduce the reader to the nature of biodiversity in its broadest sense, to the threats to its survival that are intensifying daily, and to ecologically sound approaches to conserving biodiversity. The earth's biodiversity is not only the remarkable product of billions of years of evolution. It is our survival system.

Conservation Biology: Concepts and Applications is based on the course "Conservation of Wildlife" that I have taught at San Diego State University since the early 1960s. Its content has evolved considerably over the years, although remaining concentrated on the global ecosystem and its health. This same course was the stimulus for *Readings in Conservation Ecology*, first published in 1969 by Appleton-Century-Crofts. The students in this course (in some cases now the offspring of earlier students!) thus deserve credit for helping to maintain their instructor's interest in conservation ecology, especially over a long period when conservation was placed on the back burner by society at large. My sincere appreciation goes to all those students.

New to This Edition

The first edition of this text, titled *CONSERVATION ECOLOGY: BIOSPHERE AND BIOSURVIVAL*, emphasized the ecosystem concept and its application to conservation issues. This second edition has broadened in coverage, and includes several new chapters. Two topics of growing scientific concern have received full chapter treatment: habitat fragmentation and global climate change. The examination of societal issues has also been broadened and strengthened by inclusion of a chapter on environmental ethics and by the expansion of other chapters to include discussions of public policy relating to conservation of biodiversity and of efforts to achieve sustainability in the relation of human life within the biosphere. A chapter dealing cohesively with ecological principles relevant

to conservation of biodiversity has been placed early in the text, and the nature and origin of biodiversity have received expanded coverage. Because of these changes, I have retitled the text *CONSERVATION BIOLOGY: CONCEPTS AND APPLICATIONS*. Its coverage retains an essential emphasis on ecological aspects of conservation science, but now gives fuller coverage to fields with which ecology interfaces, including biological fields such as systematics and genetics, as well as rapidly growing interdisciplines such as ecological economics and environmental ethics. Thus, this text represents a comprehensive examination of the discipline now generally known as *Conservation Biology*.

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George W. Cox

brief contents

Preface xv

part one

Basic Concepts 1

1. Conservation Biology: Emergence of a Discipline 2
 2. History of Conservation 10
 3. Populations, Communities, and Ecosystems 20
 4. Global Biodiversity 31
 5. Processes of Extinction 41
-

part two

Terrestrial Ecosystems 51

6. Temperate Forests, Woodlands, and Shrublands 52
 7. Grasslands and Tundra 62
 8. Temperate and Tropical Deserts 71
 9. Moist Tropical Forests 82
 10. Tropical Savannas and Woodlands 92
 11. Coastal Ecosystems 103
 12. Islands 113
-

part three

Special Problems of Terrestrial Ecosystems 123

13. Habitat Fragmentation 124
 14. Predator Ecology and Management 132
-

part four

Aquatic Ecosystems 145

15. Lakes, Ponds, and Marshes 146
 16. Rivers and Streams 156
-

17. Oceanic Ecosystems 167

18. Coastal Marine Ecosystems 178
-

part five

Special Problems of Aquatic Ecosystems 189

19. Marine Mammals and Birds 190
-

part six

Special Problems at the Biosphere Level 201

20. Management of Exotic Species 202
 21. Disruption of Migrations 211
 22. Chemical Pollution 222
 23. Global Climate Change 233
-

part seven

Conservation Theory and Practice 245

24. Harvesting Natural Populations 246
 25. Conserving Genetic Diversity 258
 26. Protecting Endangered Species 268
 27. Designing Biodiversity Preserves 279
-

part eight

Conservation and Society 287

28. Conservation Ethics 288
 29. Conservation Economics and Public Policy 296
 30. Sustainable Living in the Biosphere 306
-

Literature Cited 317

Glossary 345

Credits 351

Index 353

contents

Preface xv

part one

Basic Concepts 1

chapter 1

Conservation Biology: Emergence of a Discipline 2

FIELDS WITH WHICH CONSERVATION BIOLOGY INTERFACES 3

CONSERVATION BIOLOGY AND BIODIVERSITY 4

THE BIODIVERSITY CRISIS AND THE ORIGIN OF CONSERVATION BIOLOGY 4

RESPONSIBILITIES OF CONSERVATION BIOLOGY 6

READING 1.1 IS CONSERVATION BIOLOGY A VALUE-LADEN SCIENCE? 7

SUMMARY 9

QUESTIONS FOR DISCUSSION 9

SUGGESTED READING 9

chapter 2

History of Conservation 10

BACKGROUND OF WESTERN CONSERVATION ATTITUDES 11

CONSERVATION: CYCLES OF CRISIS AND ACTIVITY 11

Disappearance of the Eastern Wilderness, 1850–1865 11

Closing of the Western Frontier, 1890–1905 13

The Dust Bowl Era, 1930–1940 14

The Explosion of Population and Environmental Pollution, 1960–1975 15

The Biodiversity Crisis, 1990–???? 16

READING 2.1 EDWARD O. WILSON: BIODIVERSITY AND BIOPHILIA 17

Looking into the Future 18

SUMMARY 18

QUESTIONS FOR DISCUSSION 19

SUGGESTED READING 19

chapter 3

Populations, Communities, and Ecosystems 20

POPULATION CONCEPTS 21

COMMUNITY CONCEPTS 22

THE ECOSYSTEM CONCEPT 23

EQUILIBRIUM AND DISTURBANCE IN ECOSYSTEMS 26

ECOSYSTEMS AND LANDSCAPES 27

THE NECESSITY OF THE ECOSYSTEM APPROACH 27

THE BIOSPHERE AND GLOBAL CHANGE 27

READING 3.1 WILDLIFE ECOSYSTEMS IN EAST AFRICA 28

HUMANS AS MEMBERS OF THE GLOBAL ECOSYSTEM 30

SUMMARY 30

QUESTIONS FOR DISCUSSION 30

SUGGESTED READING 30

chapter 4

Global Biodiversity 31

COMPONENTS OF BIODIVERSITY 32

The Biodiversity Hierarchy 32

Endemism 33

Estimating the Total Number of Species 33

READING 4.1 LAKE BAIKAL 34

RICHNESS OF LIFE ON EARTH 35

MEASURES OF DIVERSITY 37

DETERMINANTS OF BIODIVERSITY 37

PUBLIC PERCEPTION OF THE BIODIVERSITY CRISIS 38

SUMMARY 40

QUESTIONS FOR DISCUSSION 40

SUGGESTED READING 40

chapter 5

Processes of Extinction 41

EXTINCTION AS A NORMAL PROCESS 42

EARLY HUMANS AND EXTINCTIONS 42

RECENT EXTINCTIONS 44

Deterministic Processes and Decline to Extinction 44

Stochastic Processes and Extinction in Small Populations 47

WHAT MAKES SPECIES VULNERABLE TO EXTINCTION?	47
READING 5.1 EXTINCTION OF THE PASSENGER PIGEON	48
GLOBAL RATES OF EXTINCTION	48
SUMMARY	50
QUESTIONS FOR DISCUSSION	50
SUGGESTED READING	50

part two

Terrestrial Ecosystems 51

chapter 6

Temperate Forests, Woodlands, and Shrublands 52

SUCCESSIONAL DYNAMICS	53
Early and Late Successional Species	53
READING 6.1 OLD-GROWTH FORESTS	54
Examples of Early and Late Successional Species	55
HUMAN IMPACTS ON FORESTS, WOODLANDS, AND SHRUBLANDS	56
MANAGING SUCCESSION	57
MANAGING FIRE RELATIONSHIPS	59
GLOBAL CHANGE IMPACTS ON FORESTS, WOODLANDS, AND SHRUBLANDS	60
SUMMARY	60
QUESTIONS FOR DISCUSSION	60
SUGGESTED READING	61

chapter 7

Grasslands and Tundra 62

DISTRIBUTION OF GRASSLANDS AND TUNDRA	63
ECOSYSTEM DYNAMICS IN GRASSLANDS AND TUNDRA	64
HUMAN IMPACTS ON GRASSLAND ECOSYSTEMS	66
HUMAN IMPACTS ON TUNDRA ECOSYSTEMS	67
IMPLICATIONS OF GLOBAL CHANGE FOR GRASSLANDS AND TUNDRA	68
GRASSLAND AND TUNDRA RESTORATION	68
READING 7.1 THE ARCTIC NATIONAL WILDLIFE REFUGE	69
SUMMARY	70
QUESTIONS FOR DISCUSSION	70
SUGGESTED READING	70

chapter 8

Temperate and Tropical Deserts 71

ORIGIN AND DISTRIBUTION OF DESERTS	72
SUBSTRATE STABILITY IN DESERT ECOSYSTEMS	73
HUMAN IMPACTS AND DESERTIFICATION	73

CONSERVATION PROBLEMS IN NORTH AMERICAN DESERTS	76
Overgrazing by Livestock and Feral Ungulates	76
READING 8.1 THE DESERT TORTOISE	77
Physical and Biotic Impacts of Off-Road Vehicles	78
Invasion of Exotic Plants	79
CONSERVATION PROBLEMS IN OTHER WORLD REGIONS	79
GLOBAL CHANGE AND DESERT ECOSYSTEMS	80
DESERT MANAGEMENT PLANS	80
SUMMARY	80
QUESTIONS FOR DISCUSSION	81
SUGGESTED READING	81

chapter 9

Moist Tropical Forests 82

DISTRIBUTION OF MOIST TROPICAL FORESTS	83
CHARACTERISTICS OF MOIST TROPICAL FORESTS	84
READING 9.1 THE LAST FRONTIER: THE TROPICAL FOREST CANOPY	85
TROPICAL DEFORESTATION	87
IMPACTS OF DEFORESTATION	88
DEFORESTATION, CLIMATE CHANGE, AND GLOBAL WARMING	90
CONSERVATION OF TROPICAL FOREST DIVERSITY	90
SUSTAINED FOREST RESOURCE MANAGEMENT EFFORTS	90
SUMMARY	91
QUESTIONS FOR DISCUSSION	91
SUGGESTED READING	91

chapter 10

Tropical Savannas and Woodlands 92

THE SAVANNA AND WOODLAND ENVIRONMENT	93
BASIC TYPES OF SAVANNAS AND WOODLANDS	94
READING 10.1 THE SERENGETI-MARA ECOSYSTEM: A CASE STUDY	95
HUMAN POPULATIONS AND SAVANNA PRESERVES	98
FRAGMENTATION OF SAVANNA WILDLIFE HABITAT	99
POACHING THREATS TO ELEPHANTS AND RHINOCEROSSES	99
RESTORING THE ECOLOGICAL BALANCE IN SAVANNA PRESERVES	101
SUMMARY	102
QUESTIONS FOR DISCUSSION	102
SUGGESTED READING	102

chapter 11

Coastal Ecosystems 103

ECOSYSTEMS OF SANDY COASTLINES	104
PLANT AND ANIMAL LIFE OF SANDY COASTAL ECOSYSTEMS	106
Plant Communities	106

Terrestrial Vertebrates	106
Sea Turtles	107
PROTECTING BARRIER ISLAND ECOSYSTEMS	109
READING 11.1 THE OUTER BANKS: A CASE STUDY	110
OTHER COASTAL ENVIRONMENTS	111
GLOBAL CHANGE AND COASTAL ECOSYSTEMS	111
SUMMARY	112
QUESTIONS FOR DISCUSSION	112
SUGGESTED READING	112

chapter 12 Islands 113

CHARACTERISTICS OF ISLAND BIOTAS	115
HUMAN IMPACTS ON ISLAND ECOSYSTEMS	116
KEYSTONE EXOTICS AND THE STABILITY OF ISLAND ECOSYSTEMS	117
READING 12.1 THE GALÁPAGOS ISLANDS	118
READING 12.2 THE HAWAIIAN ISLANDS	120
SUMMARY	122
QUESTIONS FOR DISCUSSION	122
SUGGESTED READING	122

part three Special Problems of Terrestrial Ecosystems 123

chapter 13

Habitat Fragmentation 124

EFFECTS OF PATCH ISOLATION	125
Island Biogeographic Theory	125
Island Biogeography and Habitat Islands	127
READING 13.1 NEOTROPICAL MIGRANT BIRDS IN MIDWESTERN UNITED STATES FORESTS	128
Metapopulation Dynamics in Fragmented Habitats	128
EDGE EFFECTS IN HABITAT PATCHES	128
EVALUATING THE ADEQUACY OF PRESERVES	129
SUMMARY	130
QUESTIONS FOR DISCUSSION	131
SUGGESTED READING	131

chapter 14

Predator Ecology and Management 132

ECOLOGY AND BEHAVIOR OF PREDATORS	133
PREDATION IN AN ECOSYSTEM CONTEXT	133
Coyote Predation on Mule Deer	134
Grey Wolf Predation on Ungulates	135
PREDATORS AND LIVESTOCK DEPREDATIONS	138
PREDATORS DANGEROUS TO HUMANS	139
REINTRODUCTION OF PREDATORS TO PARKS AND PRESERVES	139

READING 14.1 THE GRIZZLY BEAR: A CASE STUDY	140
READING 14.2 REINTRODUCTION OF THE MEXICAN WOLF	142
SUMMARY	143
QUESTIONS FOR DISCUSSION	143
SUGGESTED READING	143

part four Aquatic Ecosystems 145

chapter 15

Lakes, Ponds, and Marshes 146

DIVERSION AND DRAINAGE	147
WATERSHED MODIFICATION	148
OVEREXPLOITATION AND INTRODUCTION OF EXOTICS	148
EUTROPHICATION	148
READING 15.1 THE ST. LAWRENCE GREAT LAKES: A CASE STUDY	150
RECOVERY OF LAKES FROM EUTROPHICATION	150
READING 15.2 THE EVERGLADES	152
ULTRAOLIGOTROPHIC LAKES: A SPECIAL CASE	152
AFRICAN RIFT VALLEY LAKES	154
LAKE ECOSYSTEMS AND GLOBAL WARMING	154
PROTECTION OF WETLANDS	155
SUMMARY	155
QUESTIONS FOR DISCUSSION	155
SUGGESTED READING	155

chapter 16

Rivers and Streams 156

RIVERS AND THEIR FLOODPLAINS	157
HUMAN IMPACTS ON STREAM ECOSYSTEMS	157
Water Diversion	157
Watershed Modification	157
Overexploitation of Fisheries	158
Pollution	158
Mining Impacts	158
Damming	159
Channelization	160
Combined Impacts: Major North American River Systems	160
READING 16.1 THE COLORADO RIVER: A CASE STUDY	161
MAJOR TROPICAL AND SUBTROPICAL RIVERS	163
STREAM ECOSYSTEMS AND GLOBAL CHANGE	164
CONSERVATION MANAGEMENT OF RIVER ECOSYSTEMS	164
READING 16.2 BRAZIL'S PANTANAL	165

SUMMARY 165
QUESTIONS FOR DISCUSSION 166
SUGGESTED READING 166

chapter 17

Oceanic Ecosystems 167

PRODUCTIVITY OF OCEANIC REGIONS 168
TRENDS IN MARINE FISHERY HARVESTS 170
DROPPING DOWN THE FOOD CHAIN 171
HARVESTING INFLUENCES IN COMPLEX MARINE
ECOSYSTEMS 171
READING 17.1 THE PERUVIAN ANCHOVETA
FISHERY 172
DISCARDED CATCHES OF COMMERCIAL FISHING 174
READING 17.2 THE BERING SEA ECOSYSTEM 175
DRIFT GILL NET FISHERIES 176
OCEANIC ECOSYSTEMS AND GLOBAL CHANGE 176
MANAGING OFFSHORE MARINE FISHERIES 176
SUMMARY 177
QUESTIONS FOR DISCUSSION 177
SUGGESTED READING 177

chapter 18

Coastal Marine Ecosystems 178

ESTUARIES 179
ESTUARINE EUTROPHICATION 181
SHALLOW MARINE WATERS 181
Intertidal and Subtidal Environments 181
READING 18.1 THE SAN FRANCISCO BAY ESTUARY: A
CASE STUDY 182
Kelp Forests 182
CORAL REEF ECOSYSTEMS 184
GLOBAL CHANGE AND COASTAL MARINE
ECOSYSTEMS 187
ESTUARINE AND MARINE PRESERVES 187
SUMMARY 187
QUESTIONS FOR DISCUSSION 187
SUGGESTED READING 188

part five

Special Problems of Aquatic Ecosystems 189

chapter 19

Marine Mammals and Birds 190

WHALES AND WHALING 191
SMALL CETACEANS 193
READING 19.1 ABORIGINAL WHALING 194
PINNIPEDS 195
OTHER MARINE MAMMALS 196

MARINE MAMMALS AND FISHERY CONFLICTS 197
MARINE BIRDS 198
CONSERVATION OF MARINE MAMMALS AND
BIRDS 198
SUMMARY 198
QUESTIONS FOR DISCUSSION 199
SUGGESTED READING 199

part six

Special Problems at the Biosphere Level 201

chapter 20

Management of Exotic Species 202

DETERMINANTS OF SUCCESS 203
Suitability of Habitat and Ecological Niche 203
Adequacy of Introduction Unit 203
Escape from Diseases, Parasites, and Predators 204
Escape from Competitors 204
MECHANISMS OF INTRODUCTION 205
DETERMINANTS OF IMPACT 205
Ecological Distinctiveness 206
READING 20.1 MOUNTAIN GOATS IN OLYMPIC
NATIONAL PARK 207
Potential for Competitive Exclusion 208
Potential for Disease or Disease Transmission 208
Potential for Genetic Swamping 208
DEALING WITH DETRIMENTAL EXOTICS 208
Biological Control 209
CRITERIA FOR DELIBERATE INTRODUCTIONS 210
SUMMARY 210
QUESTIONS FOR DISCUSSION 210
SUGGESTED READING 210

chapter 21

Disruption of Migrations 211

MIGRATORY BIRDS 212
Staging and Stopover Areas 212
Long-Term Trends of Migratory Birds 214
Migrant Birds on their Breeding Grounds 215
Migrants on their Nonbreeding Grounds 215
Hunting of Migratory Birds 216
READING 21.1 HAWK MOUNTAIN SANCTUARY 218
Other Migration Hazards 219
Conservation of Migratory Birds 219
OTHER MIGRATORY ANIMALS 220
MIGRATORY SPECIES AND GLOBAL CHANGE 220
SUMMARY 220
QUESTIONS FOR DISCUSSION 221
SUGGESTED READING 221

chapter 22 Chemical Pollution 222

- PESTICIDES 223
 - Chlorinated Hydrocarbon Pesticides 223
 - Other Pesticides 225
- MARINE OIL POLLUTION 225
- READING 22.1 THE EXXON VALDEZ OIL SPILL 227
- SYNTHETIC ORGANIC POLLUTANTS 228
- HEAVY METALS AND CYANIDE 228
- SELENIUM 229
- RADIOISOTOPES 229
- PLASTICS 230
- INTERACTIONS OF POLLUTANTS 230
- PESTICIDE REGULATION AND ALTERNATIVES 230
- CONTROLLING CHEMICAL POLLUTION 231
- SUMMARY 231
- QUESTIONS FOR DISCUSSION 232
- SUGGESTED READING 232

chapter 23 Global Climate Change 233

- CAUSES OF GLOBAL CHANGE 234
- THE GREENHOUSE EFFECT AND GLOBAL WARMING 235
- STRATOSPHERIC OZONE DEPLETION 236
- TROPOSPHERIC POLLUTION AND ACID DEPOSITION 237
- ECOLOGICAL IMPACTS OF GLOBAL CHANGE 239
 - Global Change and Biodiversity 239
 - Global Change and Ecosystem Function 240
- READING 23.1 FOREST DECLINE 241
- COMBATTING GLOBAL CHANGE 242
- SUMMARY 243
- QUESTIONS FOR DISCUSSION 243
- SUGGESTED READING 244

part seven

Conservation Theory and Practice 245

chapter 24 Harvesting Natural Populations 246

- HARVESTING TERMINOLOGY 247
- EARLY HARVEST MODELS 247
- CARRYING CAPACITY AND POPULATION REGULATION 247
- LOGISTIC HARVESTING MODELS 249
- DYNAMIC POOL MODELS 252
- HARVEST MANAGEMENT IN PRACTICE 253
- SHORTCOMINGS OF POPULATION MODELS 255
- HOW SHOULD FORESTS BE MANAGED? 255

- READING 24.1 ZIMBABWE'S CAMPFIRE PROGRAM 256
- GAME CROPPING AND WILDLIFE CONSERVATION 256
- SUMMARY 257
- QUESTIONS FOR DISCUSSION 257
- SUGGESTED READING 257

chapter 25 Conserving Genetic Diversity 258

- GENES IN POPULATIONS 259
- GENETIC CHANGES IN SMALL POPULATIONS 259
- GENETIC PROBLEMS IN CAPTIVE POPULATIONS 263
- CONSERVING GENETIC VARIABILITY 263
- MANAGING THE GENETICS OF SMALL WILD POPULATIONS 264
- READING 25.1 THE FLORIDA PANTHER 265
- ZOOS, BOTANIC GARDENS, AND GENE BANKS 266
- SUMMARY 266
- QUESTIONS FOR DISCUSSION 267
- SUGGESTED READING 267

chapter 26 Protecting Endangered Species 268

- UNITED STATES GOVERNMENTAL PROGRAMS 269
- INTERNATIONAL ENDANGERED SPECIES LISTINGS 269
- STRENGTHENING ENDANGERED SPECIES LAW 270
- POPULATION VIABILITY ANALYSIS 271
- RECOVERY OF ENDANGERED SPECIES 273
 - Ex Situ Care of Endangered Species 273
 - Captive Propagation for Reintroduction to the Wild 273
- READING 26.1 CAN THE CALIFORNIA CONDOR BE REINTRODUCED TO THE WILD? 274
 - Population Translocation 274
- READING 26.2 RECOVERY OF THE WHOOPING CRANE 276
- SUMMARY 278
- QUESTIONS FOR DISCUSSION 278
- SUGGESTED READING 278

chapter 27 Designing Biodiversity Preserves 279

- SIZE, SHAPE, AND SPACING OF PRESERVES 280
- THE SLOSS CONTROVERSY 280
- SPACING AND INTERCONNECTION OF PRESERVE UNITS 281
- SHORTCOMINGS OF ISLAND BIOGEOGRAPHIC THEORY 281
- BUILDING PRESERVE SYSTEMS 281
- NEW TECHNOLOGIES FOR DESIGN OF PRESERVE SYSTEMS 282
- READING 27.1 THE WILDLANDS PROJECT 284
- SUMMARY 286
- QUESTIONS FOR DISCUSSION 286
- SUGGESTED READING 286

part eight

Conservation and Society 287

chapter 28

Conservation Ethics 288

- BASIC CONCEPTS OF ENVIRONMENTAL ETHICS 289
- A HISTORICAL OVERVIEW OF ENVIRONMENTAL ETHICS 290
- OTHER PARADIGMS OF ENVIRONMENTAL ETHICS IN WESTERN SOCIETY 291
- PROGRESS TOWARD A COMPREHENSIVE ENVIRONMENTAL ETHIC 291
- READING 28.1 DEEP ECOLOGY 292
- DO ASPECTS OF BIODIVERSITY HAVE MORAL STANDING? 292
- HOW SHOULD CONFLICTING ETHICAL DUTIES BE BALANCED? 293
- WHAT ETHICAL DUTIES DO WE HAVE TO FUTURE GENERATIONS? 294
- SUMMARY 295
- QUESTIONS FOR DISCUSSION 295
- SUGGESTED READING 295

chapter 29

Conservation Economics and Public Policy 296

- CONSERVATION ECONOMICS 297
- ECONOMIC VALUES OF ECOLOGICAL RESOURCES 298

- READING 29.1 CONTINGENT VALUATION AND THE EXXON VALDEZ 302
- PUBLIC ENVIRONMENTAL RESOURCE POLICY 303
- SUMMARY 305
- QUESTIONS FOR DISCUSSION 305
- SUGGESTED READING 305

chapter 30

Sustainable Living in the Biosphere 306

- BIODIVERSITY UNDER PROTECTION 307
- INTERNATIONAL CONSERVATION ORGANIZATIONS 307
- THE INTERNATIONAL GEOSPHERE-BIOSPHERE PROGRAM 309
- READING 30.1 THE BIOSPHERE RESERVE SYSTEM 310
- WORLD CONSERVATION STRATEGY 312
- THE HUMAN POPULATION, SUSTAINABILITY, AND BIODIVERSITY 312
- READING 30.2 THE WORLD HERITAGE PROGRAM 314
- SUMMARY 316
- QUESTIONS FOR DISCUSSION 316
- SUGGESTED READING 316
- Literature Cited* 317
- Glossary* 345
- Credits* 351
- Index* 353

p a r t

one

Basic Concepts

Conservation biology is a new science that has drawn together scientists and environmentalists in basic and applied studies of biodiversity. This introductory section examines the nature of this emerging field, and traces the history of conservation activism in North America. Following this, we survey basic principles of ecology, with emphasis on the concept of the ecosystem and its central role in conservation management. Finally, we examine biodiversity in detail and consider the processes of extinction that are leading to a biodiversity crisis.

chapter

1

Conservation Biology: Emergence of a Discipline



Outline

Fields with which Conservation Biology Interfaces	3
Conservation Biology and Biodiversity	4
The Biodiversity Crisis and the Origin of Conservation Biology	4
Responsibilities of Conservation Biology	6
Reading 1.1 Is Conservation Biology a Value-Laden Science?	7
SUMMARY	9
QUESTIONS FOR DISCUSSION	9
SUGGESTED READING	9

Throughout history, times of crisis often have been times of advance in human capabilities. In Western history, crises have fostered advances in science and technology. Crises also have stimulated the formation of new institutions, both governmental and private. In the 1990s, conservation biology has emerged as a vital new branch of science directed at an environmental crisis: the human population stands on the verge of causing the massive extinction of species and loss of ecosystems throughout the biosphere. What is this newly organized branch of science? Can it contribute to the formulation of policies for protection of the earth's biotic heritage and the management of ecological resources such as forests, rangelands, fisheries, and game animals?

Conservation biology is the scientific study of biodiversity and its management for sustainable human welfare. It seeks to understand how the rich variety of plant and animal life around us arose, how it has been maintained by natural processes, and how we can utilize this resource sustainably. It is not content with understanding the patterns of biodiversity and their origin; systematics and evolutionary biology effectively fill this niche. Nor is it concerned only with encouraging the protection of biodiversity: this niche is filled by a variety of activist conservation organizations. Conservation biology is unique in focusing on the interaction of humans with biodiversity, seeking to reveal the aspects of this interaction that are significant to human interests, and striving to answer questions about how these aspects can be managed for sustainable human benefit.

But a crisis does exist, and some authors have contended that conservation biology has the primary role of preventing the loss of biodiversity. Soulé (1985) states that the mission of conservation biology is . . . to provide principles and tools for preserving biological diversity, and Primack (1993) describes it as . . . the new, multidisciplinary science that has developed to deal with the crisis confronting biological diversity. Brussard (1995) recently has affirmed that conservation biology has the specific goal of preserving biodiversity.

In this chapter we shall first describe the relation of conservation biology to the fields of science, humanities, and human affairs with which it interfaces. Next, we shall examine the biodiversity crisis and consider how this crisis has given rise to the conservation biology movement. Finally, we shall define the goals of conservation biology in the study and management of biodiversity.

Conservation Biology is the science of survival for thousands of species, including the American bald eagle.

FIELDS WITH WHICH CONSERVATION BIOLOGY INTERFACES

Conservation biology is engaged in activities that involve the diverse, often conflicting, interests of complex human society. Thus, it must draw knowledge and use methods not only from biology, but also from the physical sciences, engineering, economics, sociology, law, history, and political science. Conservation biology has both basic and applied aspects as well. In the area of basic science, our knowledge of how both natural and human-dominated ecosystems function is still primitive. Thus, a major goal of conservation biology must be to examine these systems in detail and reveal the ways in which biodiversity is important to their function. Ultimately, this knowledge will be of great value to humanity. As an applied science, however, conservation biology functions to obtain data and devise methods to manage ecological systems to achieve goals that society has defined. Through the political process, for example, society may decide that national parks should be managed to minimize the risk of disastrous fires, that pollution of streams and lakes be reduced, that productivity of game or fish populations increase, or that extinction of species be prevented. Conservation biologists then must use their knowledge of ecological processes to develop management procedures to obtain the desired goal.

From the start, conservation biology has emphasized an interdisciplinary approach that draws on many basic and applied disciplines within biology (Brussard 1991) (Fig. 1.1). Perhaps the closest relationships are with ecology, the science concerned with relationships of organisms with each other and with their non-living environment. Some branches of ecology deal with particular groups of organisms; these include plant ecology, animal ecology, and microbial ecology. Others, such as terrestrial ecology, freshwater ecology, and marine ecology, focus on particular environments. Still others, such as organismal, population, community, and ecosystem ecology, are concerned with different levels of organization. Other fields of biology, however, are essential to conservation biology. Captive breeding and reintroduction of animals, for example, require the expertise of ecologists, endocrine physiologists, geneticists, animal behaviorists, wildlife managers, veterinarians, and biopark managers. Conservation biology thus is drawing together scientists from many subfields of biology that have grown apart over the past century.

Moreover, to achieve a defined goal such as the protection and recovery of an endangered species, conservation biologists must work in an even broader, real-world context of societal institutions and laws. They must understand the biology of the species, the ways in which human activities are likely to affect its environment, and how efforts to preserve the species can be carried out under the constraints of laws, available funds, and public opinion. Like a doctor of medicine, a successful conservation biologist must be able to integrate the areas of research, diagnosis, and treatment. The global crises that humanity now confronts, in fact, reflect the lack of effective integration of scientific research, monitoring of environmental change, and corrective management.

Conservation biology thus interacts with many nonbiological fields of the physical sciences, social sciences, and humanities

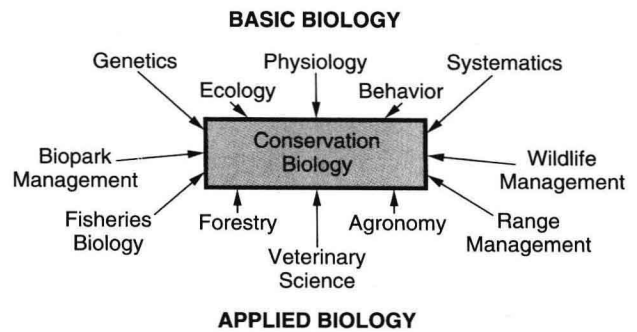


FIGURE 1.1

Conservation biology has close ties to many basic and applied disciplines within biology.

(Fig. 1.2). These fields are as important to sound environmental management as is the core science of conservation biology. An individual conservation project may require collaboration of individuals with expertise in many of these areas. Ecosystem restoration efforts, for example, may require active participation of individuals skilled in biopreserve design, ecological systems modeling, ecological economics, and environmental law, as well as advice from scientists and engineers in plant ecology, agronomy, hydrology, geology, and civil engineering.

An interface field of particular interest is that with the humanities. This is the arena in which society debates the merits of alternative values: environmental ethics, or in its more popular form, environmentalism. **Environmental ethics** examines moral values relating to the natural environment. Leopold (1949), in his essay on the land ethic, stimulated modern interest in environmental ethics when he recommended,

A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise.

Leopold's writings have become a powerful catalyst for the field of environmental ethics, now one of the most active interfaces of science and the humanities (Schrader-Frechette 1981; Rolston 1988).

Environmentalism is the popular expression of environmental ethics. It is a societal movement, in the words of Scheffer (1991),

. . . toward understanding humankind's natural bases of support while continuously applying what is learned toward perpetuating those bases.

In other words, environmentalism is the effort to live in harmony within the global ecosystem. Environmentalism is thus a philosophical conviction that the future of humankind depends on the establishment of a sound relationship between humans and the natural world. This conviction provides the political support for many efforts of conservation biology. Many, if not most, conservation biologists are environmentalists at heart, although to do their job right, they must also be objective scientists. Since environmental policy is the responsibility of all of society, environmental ethics and environmentalism are important