Contents

Preface xi Acknowledgments xiii

Part 1 Introduction 1

Chapter 1 Ecology and how to do it 3

- 1.1 What is ecology? 4
- Scales, diversity of approaches, and rigor 7
 - Questions of scale 7

The diversity of ecological evidence **10** Statistics and scientific rigor **12**

1.3 Ecology in practice 15

Successions on old fields in Minnesota: a study in time and space **15** Hubbard Brook: a long-term commitment to study at the ecosystem scale **18**

Canada's Experimental Lakes Area: decades of exploring the consequences of human activities on lakes **20**

An introduction of an exotic fish species to New Zealand: investigation on multiple biotic scales **21**

Why Asian vultures were heading for extinction: The value of a modeling study 24 Summary 26

Review questions 27

Chapter 2 Ecology's evolutionary backdrop 28

- 2.1 Evolution by natural selection 29
- 2.2 Evolution within species 32
 Geographical variation within species 32
 Variation within a species with man-made selection pressures 37

Evolution and coevolution 39

2.3 The ecology of speciation 39

What do we mean by a 'species'? **39** Allopatric speciation **40** Sympatric speciation? **44**

2.4 The effects of climatic change on the evolution and distribution of species 46

2.5 Continental drift, parallel and convergent evolution 49 dollars

2.6 Conclusion 52 Summary 52 Review Questions 53

Part 2 Conditions and Resources 55

Chapter 3 Physical conditions and the availability of

resources 57

- 3.1 Environmental conditions 58 What do we mean by 'harsh,' 'benign,' and 'extreme'? 58 Effects of conditions 59 Conditions as stimuli 61 The effects of conditions on interactions between organisms 63 Responses by sedentary organisms 64 Animal responses to environmental temperature 64 Microorganisms in extreme environments 68 3.2 Resources for photosynthetic organisms 68 Solar radiation 69 Water 72 Nutrients 75 Carbon dioxide 75 3.3 Heterotrophs and their resources 80
- Nutritional needs and provisions **80** Defense **83**
- 3.4 Effects of intraspecific competition for resources 86

3.5 Conditions, resources, and the ecological niche 88

Summary 89

Review questions 89

Chapter 4 Climate and the world's biomes 91

 4.1 The world's climate 92
 Redistribution of heat through atmospheric movement 93
 Ocean currents and the redistribution of heat 95

- 4.2 Terrestrial biomes 95 Biomes and convergent evolution 99 Tropical rain forest 99 Savanna 104 Temperate grasslands 105 Desert 105 Temperate forest 106 Boreal forest (taiga) 106 Tundra 107 The future distribution of terrestrial biomes 108 4.3 Aquatic ecosystems on the continents 108 Streams and rivers 108
 - Lakes and ponds 112 Wetlands 113
- 4.4 Ocean biomes 113 The deep ocean 114 Subtropical gyres 115 Coastal upwelling systems 116 Broad continental shelves 117 Nearshore coastal marine ecosystems 117 Summary 119 Review guestions 120

Part 3 Individuals and Populations 121

Chapter 5

Birth, death, and movement 123

- 5.1 Populations, individuals, births and deaths 124 What is an individual? 126 Counting individuals, births, and deaths 126 5.2 Life cycles 128 Life cycles and reproduction 128 Annual life cycles 129 Longer life cycles 130 5.3 Monitoring birth and death: life tables and fecundity schedules 133 Cohort life tables 134 Life tables for populations with overlapping generations 137 A classification of survivorship curves 138 5.4 Dispersal and migration 138 Dispersal determining abundance 140 The role of migration 142 5.5 The impact of intraspecific competition on populations 142 Patterns of population growth 143 5.6 Life history patterns 147 Summary 152 **Review Questions** 152 Chapter 6 Interspecific competition 154
- Ecological effects of interspecific 6.1 competition 155 Competition amongst phytoplankton for phosphorus 155 Coexistence and exclusion of competing salmonid fishes 156 Some general observations 157 Coexistence of competing diatoms 158 Coexistence of competing birds 159 Competition between unrelated species 159 The competitive exclusion principle 160 Environmental heterogeneity 165 6.2 Evolutionary effects of interspecific competition 169 Character displacement and ecological release in the Indian mongoose 169 Character displacement in Canadian

sticklebacks 170

Evolution in action: selection on microorganisms 170

- 6.3 Interspecific competition and community structure 172
 - Limiting resources and the regulation of diversity in phytoplankton communities **172**
 - Niche complementarity amongst anemone fish in Papua New Guinea **172**
 - Species separated in space or in time 174
 - Spatial separation in trees and tree-root fungi **175**
 - Temporal separation in mantids and tundra plants **175**
- 6.4 How significant is interspecific competition in practice? **176**
 - The prevalence of current competition 177 Competition or mere chance? 180 Summary 183
 - Review questions 184

Chapter 7 Predation, grazing, and disease 185

- 7.1 What do we mean by predation? 186
- 7.2 Prey fitness and abundance 187
- 7.3 The subtleties of predation 189
 Interactions with other factors 190
 Compensation and defense by individual prey 191
 - From individual prey to prey populations **192**
- 7.4 Predator behavior: foraging and transmission 195
 Foraging behavior 197
- 7.5 Population dynamics of predation 199 Underlying dynamics of predator-prey interactions: a tendency to cycle 199 Predator-prey cycles in practice 203 Disease dynamics and cycles 204 Crowding 207 Predators and prey in patches 209
 7.6 Predation and community structure 211 Summary 214 Review questions 215

Chapter 8 Molecular and evolutionary ecology 216

- 8.1 Molecular ecology: differentiation within and between species 217
 Differentiation within species: albatrosses 221
 Differentiation between species: the red wolf—species or hybrid? 223
 8.2 Coevolutionary arms races 226
- Coevolution 226 Insect-plant arms races 226 Coevolution of parasites and their hosts 229 8.3 Mutualistic interactions 232 Mutualistic protectors 232
- Mutualistic protectors 232 Farming crops or livestock 233 The dispersal of seeds and pollen 235 Mutualistic gut inhabitants 236 Mycorrhizas 236 Fixation of atmospheric nitrogen in mutualistic plants 237 Summary 240 Review questions 240

Part 4 Communities and Ecosystems 243

Chapter 9 From populations to communities 245

- 9.1 Multiple determinants of the dynamics of populations 246
 Fluctuation or stability? 247
 Determination and regulation of abundance 248
 Using k-value analysis 250
 9.2 Dispersal, patches, and metapopulation dynamics 255
- 9.3 Temporal patterns in community composition 259 Founder-controlled and dominance-controlled communities 259 Community succession 262
- 9.4 Food webs 269

Indirect and direct effects **269** Population and community stability and food web structure **274**

Summary 280

Review questions 281

Chapter 10 Patterns in species richness 282

- 10.1 Quantifying species richness and diversity 283
- 10.2 Spatially varying factors influencing species richness 285

Productivity and resource richness 286 Energy 288

- Predation intensity 292
- Spatial heterogeneity 294

Environmental harshness 295

10.3 Temporally varying factors influencing species richness
 296
 Climatic variation and its absence
 296
 Disturbance
 296

Environmental age: evolutionary time 297

- 10.4 Habitat area and remoteness: Island biogeography 298
- 10.5 Gradients of species richness 303

 Latitudinal gradients 303
 Gradients with altitude and depth 304
 Gradients during community succession 306
 Summary 307
 Review questions 308

Chapter 11 The flux of energy and matter through ecosystems 309

- 11.1 The role of energy in ecology 310
- 11.2 Geographic patterns in primary productivity 311
- 11.3 Factors limiting terrestrial primary productivity 312
- 11.4 Factors limiting aquatic primary productivity 318
- 11.5 The fate of primary productivity: grazing 325
- 11.6 The process of decomposition 330

- 11.7 The flux of matter through ecosystems 332
- 11.8 Nutrient budgets and cycling at the ecosystem scale 334
 Summary 338
 Review questions 339

Part 5 Applied Issues in Ecology 341

Chapter 12 Global biogeochemical cycles and their alteration by humans 343

- 12.1 What is biogeochemistry? 344
- The global carbon dioxide cycle 345 12.2 Understanding the carbon dioxide sinks 349 Effects of ocean acidification 351 Will the terrestrial carbon dioxide sink change in the future? 351 Can we reduce carbon dioxide emissions? 354 The global methane cycle 354 12.3 The natural sources of methane 356 Anthropogenic sources of methane 357 Methane and the global climate system 357 How do we reduce methane emissions? 360 The nitrogen cycle at global 12.4 and regional scales 361 Human acceleration of the nitrogen cycle 362 The ecological and human-health costs of nitrogen 364 Regional variation in nitrogen pollution 365 How can we reduce nitrogen pollution? 367

Summary 368

Review questions 368

Chapter 13 Conservation ecology 370

- 13.1 The need for conservation 371
- 13.2 Small populations 375
 The classification of risk 375
 Demographic risks associated with small populations 375

- Genetic problems in small populations **376** Habitat reduction **378**
- 13.3 Threats to biodiversity 378

 Overexploitation 378
 Habitat disruption 379
 Global environmental change 382
 Introduced and invasive species 383
 Infectious disease 386
 Combinations of risks and extinction vortices 386
 Chains of extinctions? 386

 13.4 Conservation in practice 389
- Population viability analysis **390** Protected areas **393** Selecting conservation areas **397** Collections of areas **400**
- 13.5Ecosystem services401Summary404Review questions404

Chapter 14 The ecology of human population growth, disease, and food supply 406

- 14.1 Human use of ecological resources 407
- 14.2 The human population problem 408Population growth up to the present 408Predicting the future 410

Two future inevitabilities 411

A global carrying capacity? 414

- 14.3 Ecology and human health 414
 Loss of the ozone layer 414
 Extreme events 415
 Changing global patterns of infection 416
 Emerging infectious diseases 418
 14.4 Synthetic fertilizer and the intensification
- of agriculture **418 14.5** Monocultures, pests, and pesticides in
- agriculture **421** Chemical approaches to pest control **422**

Biological control 426

- 14.6 Global land use and other constraints on continued intensification of agriculture 428
- 14.7 Food from fisheries and aquaculture 434
 Summary 439
 Review questions 440

References R-1 Index I-1

Glossary G-1

(available online only: www.wiley.com/ college/begon)

In the read for consertation codegy 33
 In the read for consertation 371^{mm}
 Small gapulation 376
 In distribution 376
 Dimographic rists associated 0