

Contents

Preface

page xiii

Abbreviations and units

xiv

Chapter 1 | The tropical environment

1

1.1 The tropics

1

1.2 Climate in the tropics

1

1.3 Biogeographical regions

11

1.4 Chapter summary

17

Chapter 2 | Hot deserts and environmental factors

18

2.1 The Sahara Desert and arid zones of northern Africa

18

2.2 The Namib Desert

22

2.3 Australian deserts

27

2.4 Environmental factors

31

2.5 Water

31

2.6 Limiting factors

34

2.7 Temperature

37

2.8 Salinity

38

2.9 Soils and nutrients

39

2.10 Environmental factors and plant and animal distributions

43

2.11 Desertification or land degradation?

46

2.12 Chapter summary

48

Chapter 3 | Grasslands and primary production

50

3.1 Grass structure and biology

50

3.2 Neotropical grasslands

53

3.3 Light as an energy source

56

3.4 Carbon dioxide uptake by plants

56

3.5 Photosynthesis

57

3.6 Photorespiration

58

3.7 Photosynthetic strategies

60

3.8 Respiration

61

3.9 Environmental factors and photosynthesis

63

3.10 Primary production

64

3.11 Assessment of grassland primary production

64

3.12 Effects of grazing on grass growth

66

3.13 Seasonal variation in grassland primary production

67

3.14 Primary production rates in terrestrial biomes

68

3.15 Chapter summary

71

Chapter 4 | Savanna and population dynamics

72

4.1 Fire and savanna vegetation

72

4.2	Savannas of the world	75
4.3	The Serengeti	78
4.4	Savanna plants and heterogeneity	80
4.5	Animal population dynamics in the Serengeti	81
4.6	Herbivores and herbivory	84
4.7	Principles of population growth	86
4.8	Factors determining population density	91
4.9	Density-dependent mortality factors	93
4.10	Competition theory and the competitive exclusion principle	99
4.11	Predation	100
4.12	Density-independent mortality factors	109
4.13	Reproductive strategies and population growth	109
4.14	Population age structure and life tables	110
4.15	Key factor analysis	117
4.16	Conservation of African wildlife	119
4.17	Ecosystem dynamics and ecological models	121
4.18	Chapter summary	126
Chapter 5 Lakes, energy flow and biogeochemical cycling		128
5.1	Thermal stratification	128
5.2	Pelagic zone production	143
5.3	Littoral zone producers and primary production	147
5.4	The catchment area concept	152
5.5	Aquatic consumers	154
5.6	The biota of tropical and temperate lakes: a comparison	158
5.7	Food chains and energy flow	159
5.8	Food chain energetics	159
5.9	Trophic levels	160
5.10	Limited length of food chains	163
5.11	Food chain efficiencies	165
5.12	Food web dynamics	166
5.13	Biogeochemical cycles	168
5.14	Quantitative aspects of nutrient supply and cycling	174
5.15	Eutrophication	177
5.16	Aquatic resource management	182
5.17	Chapter summary	184
Chapter 6 Rivers, floodplains and estuaries: the flood-pulse and river continuum concepts		186
6.1	Nile River	188
6.2	Purari River	195
6.3	Amazon River	199
6.4	<i>Ecological concepts</i>	208
6.5	Estuaries	216
6.6	Chapter summary	219

Chapter 7	Wetlands and succession	221
7.1	What are wetlands?	221
7.2	Sudd communities of Lake Naivasha	222
7.3	Rooted emergent swamps of Lake Chilwa	223
7.4	Freshwater herbaceous wetlands: structure and function	225
7.5	Swamp forests	228
7.6	Wetland zonation	229
7.7	Wetland succession	231
7.8	Ecological succession	233
7.9	Community development and assembly	233
7.10	Wetland loss and conservation	234
7.11	Chapter summary	236

Chapter 8	Tropical rain forests and biodiversity	238
8.1	Biogeography of rain forests	239
8.2	Vegetation structure of tropical rain forests	242
8.3	Phenology and reproduction of tropical forest trees	245
8.4	Life-form concept of plants	247
8.5	Rain-forest animals	248
8.6	Convergent evolution	248
8.7	Plant–animal interactions	249
8.8	Co-evolution	253
8.9	Productivity and nutrient cycling in forests	254
8.10	Micro-climates and resource acquisition	256
8.11	Biological diversity	257
8.12	Why are rain forests so diverse?	262
8.13	Latitudinal gradients and species diversity	262
8.14	Gap theory	264
8.15	Patch dynamics	266
8.16	Tropical deciduous forests and ecotones	269
8.17	Low-diversity tropical rain forests	270
8.18	Deforestation and the loss of biodiversity	270
8.19	Rain-forest conservation	273
8.20	Chapter summary	278

Chapter 9	Mountains, zonation and community gradients	280
9.1	Tropical mountains	280
9.2	Zonation on tropical mountains	280
9.3	Vegetation zonation on Mount Wilhelm, Papua New Guinea	281
9.4	Altitude zonation in Venezuela	287
9.5	Plant and animal ecophysiology: examples from Mount Kenya	289
9.6	Mountain zonation	294
9.7	Variation in plant and animal communities	296
9.8	Chapter summary	298

Chapter 10	Mangroves, seagrasses and decomposition	299
10.1	Mangroves of Australia and New Guinea	301
10.2	Ecological adaptations of mangroves	302
10.3	Mangrove animals	306
10.4	Mangrove productivity	309
10.5	Seagrasses	310
10.6	Coastal vegetation and organic matter export	311
10.7	Decomposition	313
10.8	Decomposition rates and environmental factors	315
10.9	Detritus food chains	316
10.10	Decomposition in other tropical systems	317
10.11	Coastal zone management	318
10.12	Chapter summary	318
Chapter 11	Coral reefs and community ecology	320
11.1	Coral reef communities	320
11.2	Coral biology	322
11.3	Coral reefs	329
11.4	Coral reef algae	332
11.5	Coral reef herbivores	332
11.6	Coral reef biogeography and biodiversity	336
11.7	Community ecology	339
11.8	Coral reef management and conservation	344
11.9	Chapter summary	348
Chapter 12	Isolated habitats and biogeography: islands in the sea, air and land	349
12.1	Island ecosystems	349
12.2	Krakatau	349
12.3	Dispersal	352
12.4	Colonisation and community assembly	356
12.5	Island biogeography	358
12.6	Speciation	363
12.7	Extinction	368
12.8	Exotic species on islands	370
12.9	Chapter summary	372
Chapter 13	Cities and human ecology	373
13.1	Jakarta, Indonesia	373
13.2	Evolution of human societies	375
13.3	World population growth	377
13.4	Food production	382
13.5	Industrialisation, natural resource use and pollution	388
13.6	Human population growth: consequences and solutions	391
13.7	Conclusions	395
13.8	Chapter summary	395

Preface

Chapter 14 Global ecology: biodiversity conservation, climate change and sustainable development 397

14.1	Temperate and tropical environments	397
14.2	Biodiversity loss	398
14.3	Biodiversity conservation	399
14.4	Global climate change	404
14.5	Sustainable development	409
14.6	Conclusions	410
14.7	Chapter summary	410

Glossary

References

Index

411

425

442

of interest in tropical ecology fuelled by concern for the impact we are having on tropical ecosystems and the biodiversity they harbour. The rapid growth in both our numbers and our material aspirations has led to the depletion and degradation of the earth's natural resources. This is not a regional issue but one that should concern all humans irrespective of where they live. Ecology, as the science that underpins the conservation, protection and wise use of natural resources, has become more than a sub-discipline of biology. Its study and application require an appreciation of chemistry, physics, geology and physical geography. The conservation of tropical ecosystems also has a human dimension and, therefore, effective management of natural resources also draws from the social sciences of economics, political science, anthropology, human geography and sociology. This book can provide only an introduction to these broader conservation issues.

Ecology is a huge subject, and even limiting it geographically to the tropics leaves far more material and examples than can be covered in a semester-long course or, indeed, in a book to support such a course. I am acutely aware that much has been omitted from this book, and selecting what to include has presented the biggest challenge in writing it. Despite a bias from my life and work in Papua New Guinea and Australia, I have endeavoured to present a regionally balanced account.

Many ecology texts focus on terrestrial environments with inadequate coverage of aquatic systems. I am redressed this imbalance with chapters devoted to lakes, coral reefs, mangroves, rivers and wetlands. Life in water differs markedly from that on land and these differences can be

effectively used to illustrate ecological concepts and provide stark examples of how organisms are adapted to their environment.

I wish to thank the following colleagues for reviewing drafts of chapters: Dr Mary Burgess, United Kingdom; Dr David Dudgeon, University of Hong Kong; Dr Terry Erwin, Smithsonian Institution, Washington; Dr Max Finlayson, Environmental Research Institute of the Supervising Scientist, Australia; Dr Geoffrey Humphreys, University of Macquarie, Australia; Dr David Harper, University of Leicester, United Kingdom; Dr Michael Huber, Australia; Dr Greg Leach, Conservation Commission, Northern Territory, Australia; Dr Lance Hill, University of Papua New Guinea; Dr Geoffrey Hope, Australian National University; Dr Robert Meade, United States Geological Survey, Denver, Colorado; Dr David Mitchell, Charles Sturt University, Australia; Dr Stephen Mulkey, University of Florida, Gainesville, United States; Dr Nicholas Polunin, University of Newcastle-upon-Tyne, United Kingdom; Professor Ghilleen Prance, Kew Gardens, United Kingdom; Dr Robert Ricklefs, University of Missouri, St. Louis, United States; Dr Ian Thornton, La Trobe University, Australia; Dr Peter Woodall, University of Queensland, Australia; and Dr Truman Young, Fordham University, United States. Any errors remaining, however, are my own. I thank Allen Crowden, Marie Murphy, Susan Peck and Gillian Maude at Cambridge University Press for their support and care in guiding the manuscript through the production process.

I acknowledge the Barge Allen Charitable Trust for providing a grant through the International Center for Tropical Ecology at the University of Missouri-St. Louis to cover costs of producing the manuscript and purchasing illustrations.

I also thank my wife, Nancy, for her unfailing love and support. This book is dedicated to our children and the next generation – for they are the custodians of our legacy.

Patrick J. Osborne
International Center for Tropical Ecology
University of Missouri-St. Louis
email: posborne@umsl.edu