

Contents

Preface: why? *xiii*

- 1 The world as it was and the world as it is 1**
 - 1.1 Early ecological history 1
 - 1.2 The more recent past 5
 - 1.3 Characteristics of freshwater organisms 7
 - 1.4 Freshwater biodiversity 8
 - 1.5 A spanner in the works? 11
 - 1.6 Politics and pollution 14
 - 1.7 On the nature of textbooks 15
 - 1.8 Further reading 17

- 2 Early evolution and diversity of freshwater organisms 18**
 - 2.1 Introduction 18
 - 2.2 The freshwater biota 19
 - 2.3 Bacteria 20
 - 2.4 The variety of bacteria 22
 - 2.5 Viruses 24
 - 2.6 Two sorts of cells 25
 - 2.7 The diversity of microbial eukaryotes 27
 - 2.8 Algae 28
 - 2.9 Kingdoms of eukaryotes 30
 - 2.10 Further reading 37

- 3 Diversity continued: multicellular organisms in freshwaters 38**
 - 3.1 Introduction 38
 - 3.2 Osmoregulation 38
 - 3.3 Reproduction, resting stages and aestivation 39
 - 3.4 Getting enough oxygen 41
 - 3.5 Insects 41
 - 3.6 Big animals, air-breathers and swamps 42
 - 3.7 Dispersal among freshwaters 44
 - 3.8 Patterns in freshwater diversity 46
 - 3.9 Fish faunas 49
 - 3.10 The fish of Lake Victoria 51
 - 3.11 Overall diversity in freshwaters 53
 - 3.12 Environmental DNA 56
 - 3.13 Further reading 57

- 4 Water: a remarkable unremarkable substance 58**
 - 4.1 Introduction 58
 - 4.2 The molecular properties of water and their physical consequences 59
 - 4.3 Melting and evaporation 60
 - 4.4 How much water is there and where is it? 61
 - 4.5 Patterns in hydrology 62
 - 4.6 Bodies of water and their temperatures 66
 - 4.7 An overview of mixing patterns 70
 - 4.8 Viscosity of water and fluid dynamics 71
 - 4.9 Diffusion 73
 - 4.10 Further reading 73

- 5 Water as a habitat: some background water chemistry 74**
 - 5.1 Introduction 74
 - 5.2 Polar and covalent compounds 74
 - 5.3 The atmosphere 75
 - 5.4 Carbon dioxide 76
 - 5.5 Major ions 77
 - 5.6 The big picture 81
 - 5.7 Further reading 83

- 6 Key nutrients, trace elements and organic matter 84**
 - 6.1 Introduction 84
 - 6.2 Concepts of limiting substances 85
 - 6.3 Experiments on nutrient limitation 86
 - 6.4 Nutrient supply and need 91
 - 6.5 Phosphorus 91
 - 6.6 Nitrogen 92
 - 6.7 Pristine concentrations 93
 - 6.8 Trace elements and silicon 96
 - 6.9 Organic substances 98
 - 6.10 Substance budgets and movements 101
 - 6.11 Sediment-water relationships 104
 - 6.12 Further reading 106

- 7 Light thrown upon the waters 108**
 - 7.1 Light 108
 - 7.2 Effects of the atmosphere 109
 - 7.3 From above to under the water 110
 - 7.4 Remote sensing 114
 - 7.5 Further reading 116

- 8 Headwater streams and rivers 118**
 - 8.1 Introduction 118
 - 8.2 General models of stream ecosystems 118
 - 8.3 The basics of stream flow 121
 - 8.4 Flow and discharge 122
 - 8.5 Laminar and turbulent flow 122
 - 8.6 Particles carried 124
 - 8.7 The response of stream organisms to shear stress 125

- 8.8 Community composition in streams 126
- 8.9 Algal and plant communities 127
- 8.10 Macroinvertebrates 128
- 8.11 Streams in different climates: the polar and alpine zones 132
- 8.12 Invertebrates of kryal streams 134
- 8.13 Food webs in cold streams 135
- 8.14 Stream systems in the cold-temperate zone 137
- 8.15 Allochthonous sources of energy 139
- 8.16 Stream orders 140
- 8.17 The river continuum concept 141
- 8.18 Indirectly, wolves are stream animals too 142
- 8.19 Scarcity of nutrients 143
- 8.20 Warm-temperate streams 144
- 8.21 Desert streams 147
- 8.22 Tropical streams 148
- 8.23 Further reading 152

- 9 Uses, misuses and restoration of headwater streams and rivers 154**
- 9.1 Traditional use of headwater river systems 154
- 9.2 Deforestation 156
- 9.3 Acidification 157
- 9.4 Eutrophication 162
- 9.5 Commercial afforestation 163
- 9.6 Settlement 164
- 9.7 Engineering impacts 166
- 9.8 Alterations of the fish community and introduced species 168
- 9.9 Sewage and toxic pollution and their treatment 170
- 9.10 Diffuse pollution 174
- 9.11 River monitoring 176
- 9.12 The Water Framework Directive 177
- 9.13 Implementation of the Directive 178
- 9.14 Restoration and rehabilitation ecology 180
- 9.15 Further reading 183

- 10 Rich systems: floodplain rivers 185**
- 10.1 Introduction 185
- 10.2 From an erosive river to a depositional one 187
- 10.3 Submerged plants 188
- 10.4 Growth of submerged plants 190
- 10.5 Methods of measuring the primary productivity of submerged plants 193
- 10.6 Enclosure methods 194
- 10.7 Other methods 195
- 10.8 Submerged plants and the river ecosystem 196
- 10.9 Farther downstream: swamps and floodplains 196
- 10.10 Productivity of swamps and floodplain marshes 198
- 10.11 Swamp soils and the fate of the high primary production 199
- 10.12 Oxygen supply and soil chemistry in swamps 200
- 10.13 Emergent plants and flooded soils 202
- 10.14 Swamp and marsh animals 204
- 10.15 Whitefish and blackfish 205

- 10.16 Latitudinal differences in floodplains 206
- 10.17 Polar floodplains 207
- 10.18 Cold-temperate floodplains 208
- 10.19 Warm-temperate floodplains 209
- 10.20 Tropical floodplains 211
- 10.21 The Sudd 212
- 10.22 Further reading 215

- 11 Floodplains and human affairs 216**
- 11.1 Introduction 216
- 11.2 Floodplain services 218
- 11.3 Floodplain fisheries 220
- 11.4 Floodplain swamps and human diseases 222
- 11.5 Case studies: the Pongola River 226
- 11.6 River and floodplain management and rehabilitation 231
- 11.7 Mitigation: plant bed management in rivers 231
- 11.8 Enhancement 234
- 11.9 Rehabilitation 236
- 11.10 Inter-basin transfers and water needs 238
- 11.11 Further reading 240

- 12 Lakes and other standing waters 242**
- 12.1 Introduction 242
- 12.2 The origins of lake basins 244
- 12.3 Lake structure 248
- 12.4 The importance of the catchment area 254
- 12.5 Lakes as autotrophic or heterotrophic systems 255
- 12.6 The continuum of lakes 258
- 12.7 Lake history 263
- 12.8 Organic remains 267
- 12.9 General problems of interpretation of evidence from sediment cores 269
- 12.10 Two ancient lakes 270
- 12.11 Younger lakes 271
- 12.12 Filling in 276
- 12.13 Summing-up 278
- 12.14 Further reading 278

- 13 The communities of shallow standing waters: mires, shallow lakes and the littoral zone 280**
- 13.1 Introduction 280
- 13.2 What determines the nature of mires and littoral zones? 280
- 13.3 Temperature 281
- 13.4 Nutrients 282
- 13.5 Littoral communities in lakes 286
- 13.6 The structure of littoral communities 288
- 13.7 Periphyton 291
- 13.8 Heterotrophs among the plants 292
- 13.9 Neuston 295
- 13.10 Linkages, risks and insurances among the littoral communities 296
- 13.11 Latitude and littorals 297

- 13.12 The role of the nekton 299
- 13.13 Further reading 301

14 Plankton communities of the pelagic zone 304

- 14.1 Kitchens and toilets 304
- 14.2 Phytoplankton and sinking 306
- 14.3 Photosynthesis and growth of phytoplankton 309
- 14.4 Net production and growth 310
- 14.5 Nutrient uptake and growth rates of phytoplankton 311
- 14.6 Distribution of freshwater phytoplankton 312
- 14.7 Washout 314
- 14.8 Cyanobacterial blooms 314
- 14.9 Heterotrophs in the plankton: viruses and bacteria 319
- 14.10 The microbial pathway 320
- 14.11 Zooplankton 321
- 14.12 Grazing 324
- 14.13 Feeding and grazing rates of zooplankton 328
- 14.14 Competition and predation among grazers 328
- 14.15 Predation on zooplankters by invertebrates 330
- 14.16 Fishes in the open-water community 333
- 14.17 Predation on the zooplankton and fish production 335
- 14.18 Avoidance of vertebrate predation by the zooplankton 338
- 14.19 Piscivores and piscivory 340
- 14.20 Functioning of the open-water community 340
- 14.21 Polar lakes 342
- 14.22 Cold-temperate lakes 343
- 14.23 Warm-temperate lakes 346
- 14.24 Very warm lakes in the tropics 347
- 14.25 Further reading 349

15 The profundal zone and carbon storage 352

- 15.1 The end of the line 352
- 15.2 The importance of oxygen 353
- 15.3 Profundal communities 356
- 15.4 Biology of selected benthic invertebrates 357
- 15.5 What the sediment-living detritivores really eat 359
- 15.6 Influence of the open-water community on the profundal benthos 361
- 15.7 Sediment storage and the global carbon cycle 365
- 15.8 Further reading 370

16 Fisheries in standing waters 371

- 16.1 Some general principles 371
- 16.2 Some basic fish biology 372
- 16.3 Eggs 372
- 16.4 Feeding 374
- 16.5 Breeding 375
- 16.6 Choice of fish for a fishery 379
- 16.7 Measurement of fish production 379
- 16.8 Growth measurement 381
- 16.9 Fish production and commercial fisheries in lakes 383

16.10	Changes in fisheries: a case study	387
16.11	The East African Great Lakes	390
16.12	Fish culture	395
16.13	Stillwater angling	400
16.14	Amenity culture and the aquarium trade	403
16.15	Further reading	405
17	The uses, abuses and restoration of standing waters	406
17.1	Introduction	406
17.2	Services provided by standing waters	408
17.3	Domestic water supply, eutrophication and reservoirs	409
17.4	Eutrophication – nutrient pollution	410
17.5	Dams and reservoirs	415
17.6	Fisheries in new lakes	418
17.7	Effects downstream of the new lake	419
17.8	New tropical lakes and human populations	419
17.9	Man-made tropical lakes, the balance of pros and cons	419
17.10	Amenity and conservation	421
17.11	The alternative states model	424
17.12	Ponds	426
17.13	Restoration approaches for standing waters: symptom treatment	426
17.14	Treatment of proximate causes: nutrient control	428
17.15	Present supplies of phosphorus, their relative contributions and how they are related to the algal crop	430
17.16	Methods available for reducing total phosphorus loads	430
17.17	In-lake methods	434
17.18	Complications for phosphorus control – sediment sources	434
17.19	Nitrogen reduction	435
17.20	Habitat creation	436
17.21	Further reading	438
18	Climate change and the future of freshwaters	440
18.1	Introduction	440
18.2	Climate change	442
18.3	Existing effects of freshwaters	444
18.4	Future effects	449
18.5	Future effects on freshwaters	453
18.6	Switches and feedbacks	457
18.7	Wicked problems	464
18.8	Mitigation of global warming	468
18.9	The remedy of ultimate causes	468
18.10	Rewilding the world	474
18.11	Reforming governments	477
18.12	Further reading	479
	References	483
	Index	515