

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