

Contents

1	Introduction: The Structure of the Book	1
	Quizzes and Problems	4
	References	4
 Part I The Scope of Ecology		
2	The Definition and Scope of Ecology	7
2.1	Historical Overview of the Conception of Ecology	7
2.1.1	Early Views	7
2.1.2	Tansley's Concept of Ecosystem	8
2.1.3	Discussion on the Centrality of the Ecosystem Concept in Ecology	9
2.2	My Definition Proposal of Ecology	12
2.3	The Basic Components of an Ecosystem	14
2.4	Two Ways of Defining Ecosystem According to Study Context ...	19
2.5	Importance of the Abiotic Factor System	21
2.6	Are the Ecosystems the Only Objects of Ecology?	22
	Quizzes and Problems	24
	References	24
3	Biomes	27
3.1	Ecosystem vs Biome	27
3.2	The Forerunners of the Biome Concept	28
3.2.1	The Concept of Association	28
3.2.2	Gradualism sensu Philippi vs Formation sensu Grisebach	29
3.2.3	Life Zones	30
3.3	The Evolution of the Concept of Biome	31
3.3.1	From Clements to Whittaker	31
3.3.2	The Concept of Driver	36
3.3.3	Hierarchy Theory and Formal Definitions of Biome and Biome-Like Categories	36

3.4	Towards a Scientific and Universal Typology of Biome-Likes	38
3.5	Traits and Drivers Taken From Plant Ecology	42
3.6	Description of the Realms [36, Table 3]	45
3.6.1	The Terrestrial Realm	45
3.6.2	The Subterranean Realm	46
3.6.3	The Freshwater Realm	46
3.6.4	The Marine Realm	47
3.6.5	The Atmospheric Realm	48
3.7	Description of the Biomes	49
3.7.1	Within the Terrestrial Realm R_1	49
3.7.2	Within the Subterranean Realm R_2	70
3.7.3	Within the Freshwater Realm R_3	71
3.7.4	Within the Marine Realm R_4	73
3.7.5	Within the Transitional Terrestrial-Freshwater Realm R_{13}	75
3.7.6	Within the Transitional Terrestrial-Marine Realm	75
3.7.7	Within the Transitional Terrestrial-Freshwater-Marine Realm R_{134}	76
3.7.8	Within the Transitional Subterranean-Freshwater Realm R_{23}	77
3.7.9	Within the Transitional Subterranean-Marine Realm	78
3.7.10	Within the Transitional Freshwater-Marine Realm	78
	Quizzes and Problems	79
	References	79
4	The Interactions	83
4.1	Interactions Between the Heterospecific Populations of a Biocoenosis	83
4.2	Interactions in Biocoenoses	84
4.2.1	Trophic Relationships	84
4.2.2	Coevolution	86
4.2.3	Competition	88
4.3	Interactions Between Biocoenosis and Abiotic Factor System	92
4.3.1	Decomposition and Mineralisation	92
4.3.2	Genesis of Biogenic Molecules from Metabolism	94
4.4	Interaction within the Abiotic Factor System	95
	References	96
5	Example of an Ecological System: The Kelp Zone of Central California	99
5.1	Description of an Almost Total Biocoenosis	101
5.1.1	The Primary Producers	101
5.1.2	The Consumers	108
5.1.3	The Process of Decomposition and Mineralisation in the Kelp Zone (KZ)	123

5.2	Description of a Crucial Limited Biocoenosis: Kelps, the Purple Sea Urchin, the Sea Otter	124
	References	125
6	Ecological Models	129
6.1	The Scientific Nature and Methodology of Ecology	129
6.2	The Compartmental Model	130
6.3	Illustration from Our Example	132
6.4	Mathematical Modelling of Compartmental Systems	134
6.5	Complexity of Compartmental Systems	138
6.6	The Biosphere	140
6.7	The Different Disciplines Dealing with Parts of the Entire Ecological System <i>sensu lato</i> (EESSL)	141
6.8	Ecosystem Specificity Explained with Compartmental Models ...	144
	References	145
 Part II History of Ecology		
7	Ecology Before Darwin	149
7.1	The Pathway to Ecology	149
7.2	The Great Scientific Travellers	151
7.3	Linnaeus (1708–1778)	154
7.4	The Predarwinian Forerunners of Ecology	157
7.4.1	Alexander von Humboldt (1769–1859)	157
7.4.2	Augustin de Candolle (1769–1859)	161
7.4.3	Rudolf Amandus Philippi (1808–1904)	162
7.4.4	August Heinrich Rudolf Grisebach	163
7.4.5	The Ecogeographical Rules	163
	References	164
8	The Emergence of Modern Ecology	167
8.1	Darwin and His Direct Followers	167
8.1.1	Charles Darwin (1809–1886)	167
8.1.2	Alfred Russel Wallace (1823–1913)	168
8.1.3	Ernst Haeckel (1832–1919)	169
8.2	Towards a Science Called ... Ecology	170
8.3	The Emergence of Genetics and Its Impact on Ecology	171
8.4	Holistic vs Individualistic Conception of Communities	175
8.4.1	The Holistic School of Thought	175
8.4.2	The Individualistic School of Thought	176
8.5	History of the Understanding of the Inner Composition and Dynamics of an Ecosystem	177
8.6	The Advent of Community Ecology	178
8.7	The Advent of Evolutionary Ecology	179
8.8	Ecology Today	180
	References	182

Part III Structure and Functions of Ecosystems: Three Approaches

9	The Energetical Approach	187
9.1	Thermodynamic Concept of Energy	187
9.1.1	Systems and Their States.....	187
9.1.2	Concept of Work, as Applied to One Point Object.....	189
9.1.3	Elements of Thermodynamics of Irreversible Systems ...	193
9.2	Thermodynamic Equilibrium and the Case of Life, thus of Ecosystems	198
9.2.1	Thermodynamic Equilibrium	198
9.2.2	The Flux of Energy in an Ecosystem	198
9.3	The Originality of the Biological System	201
9.4	From the Primary Source of Energy in Most Ecosystem.....	204
9.4.1	Simplified Description of Photosynthesis	204
9.4.2	The Different Phases and Steps of Photosynthesis.....	205
9.4.3	Assessment of the Primary Energy Intake of the Ecosystems.....	207
9.4.4	Brief Summary of Other Types of Global Energy Intake	215
	Quizzes and Problems	217
	References.....	218
10	The Material Approach-I: The Biogeochemical Cycles	221
10.1	Some Necessary Basics of Chemistry	221
10.1.1	The Basis of Redox Mechanism, and Energy	221
10.1.2	Electrons, Orbitals	222
10.2	Principle of Matter Recycling	225
10.3	The Distal Origin of All the Telluric Chemical Species Used by the Ecosystems	227
10.3.1	The Bedrock	227
10.3.2	The Nature of Bedrock	229
10.3.3	The Three Main Rock Groups of the Earth's Crust	234
10.3.4	Ecological Impact of this Geological Situation	237
10.4	The Cycle of Water (H ₂ O)	238
10.4.1	Generalities on the Water Cycle	238
10.4.2	Infiltration and Percolation.....	241
10.4.3	Evaporation and Evapotranspiration	241
10.4.4	Run-offs and Leaching	242
10.4.5	Summary of the Cycle of Water	243
10.5	The Cycles of Carbon (C).....	244
10.5.1	Generalities on the Carbon Cycles.....	244
10.5.2	Cycle 1 Delivers to All Cells Their Carbon Machinery	245
10.5.3	Cycle 2 Is an Equilibrium of CO ₂ Between Atmosphere and Hydrosphere	246

10.5.4	Cycle 3 Is the Strict Control of Circulating Carbon Dioxide that Accompanies Limestone Sedimentation.....	246
10.5.5	Conclusion: The Supercycle of Carbon	248
10.6	The Cycle of Nitrogen	248
10.6.1	Nitrogen, a Paradoxical Case	248
10.6.2	Presentation of Some Nitrogen-fixers	250
10.6.3	Nitrogen Fixation	251
10.6.4	Nitrification	254
10.6.5	Anammox	255
10.6.6	Ammonification	255
10.6.7	Denitrification.....	255
10.7	The Cycle of Oxygen	256
10.7.1	Specificity of Circulating Oxygen	256
10.7.2	The Oxygen Biogeochemical Cycle of Oxygen.....	258
10.8	The Cycle of Phosphorus	259
10.9	The Cycle of Sulphur	260
	References.....	260
11	The Material Approach-II: The Physical Parameters	263
11.1	The Physical Parameters of the Environment	263
11.2	Temperature	263
11.2.1	Different Adaptive Mechanisms to Temperature.....	263
11.2.2	Temperature Optimisation: Constraints on Metabolism, e.g. on Proteins and, in Particular, on Enzymes	266
11.3	Humidity: The Presence of Water in the Environment	266
11.3.1	Thermic Inertia of Water	267
11.3.2	Link Between Soil and Water	267
11.3.3	Humidity	268
11.4	Relationship Between Temperature and Rainfall Height.....	270
11.5	Light	272
11.5.1	The Action of Light on Plants and Beyond.....	272
11.5.2	Distribution of Light Across Time and Space: Seasonal and Latitudinal Effect.....	274
11.5.3	How Light and Humidity Determine Climate Diversity	276
11.6	Physical Parameters of Aqueous Ecosystem	278
11.6.1	Temperature.....	278
11.6.2	Light.....	281
11.6.3	pH	288
	Quizzes and Problems	290
	References.....	291

12	The Biosociological Approach-I: Species, The Relays of Matter and Energy	295
12.1	Organisms: The Relays of the Energy and Matter Dynamics Through the Ecosystems	295
12.2	The Biosphere Is Multiscale	296
12.3	The Spatiotemporal Scales of Communities (Biocoenoses).....	297
12.4	The Proximal (or Short-term) Processes	298
12.5	Ecological Successions: The Proximal Dynamics Process	300
12.6	Elements of Evolutionary Ecology: The Distal Dynamics Process	303
12.7	The Distal Development of the Biosphere	305
12.7.1	Development of the Biosphere: An Evolving, Spontaneous and Stochastic Process in Permanent Instantaneous Thermodynamic Disequilibrium	305
12.7.2	Biogeographical Events as a Driver to the Distal Processes	308
12.7.3	An Example: The Evolution of the Equids, Revealing the Evolution of the Paleoenvironments	314
12.7.4	Polymorphism	317
12.7.5	The Barriers	318
12.7.6	Insular Speciations.....	320
12.7.7	Continental Speciations	322
12.7.8	Sympatric Speciations	322
12.7.9	Allopatric Speciation	328
12.8	Heterospecific Populations in the Sense of Components of a Community	335
12.8.1	A Difficult Problem Prone to Debate: Where Is the Frontier Between Conspecificity and Heterospecificity?.....	335
	References	336
13	The Biosociological Approach-II: Populations, Communities	343
13.1	Populations	343
13.1.1	Population: A Biological and a Statistical Concept.....	343
13.1.2	Population Norm	346
13.1.3	Population Structure	349
13.1.4	Distribution Area	350
13.1.5	Population Models.....	358
13.1.6	Spatial Organisation of Populations	374
13.2	The Communities	376
13.2.1	The Linear Model.....	376
13.2.2	The Lotka-Volterra Model	379
13.2.3	The Nicholson-Bailey Model	384
13.2.4	Limitation of the Mathematical Models in Ecology	391

13.2.5	Clement's and Gleason's Models of Communities	392
13.3	The Ecological Niche	393
13.3.1	Ecological Characteristics of a Species.....	393
13.3.2	The Hutchinsonian Ecological Niche.....	394
13.4	The Food Web	397
	Quizzes and Problems	397
	References.....	398
14	Epilogue	403
Glossary	.....	405
References	.....	411
Author Index	.....	413
Taxonomic Index	.....	417
Subject Index	.....	425