
Contents

Chapter 1 Approaches to studying food webs	I
1.1 Introduction	1
1.2 Traditions in ecology	3
1.2.1 The community perspective	5
1.2.2 The ecosystem perspective	7
1.3 Food webs and traditions in ecology	11
1.3.1 Theoretically based food webs	11
1.3.2 Empirically based food webs: architecture	11
1.3.3 Empirically based food webs: information	13
1.3.4 How useful are these descriptions?	15
1.4 Bridging perspectives through energetics	18
1.4.1 Core concepts and elements	18
1.4.2 Comments on our approach to studying food webs	19
1.5 An overview of the parts and chapters	21
1.6 Summary	22

Part I Modeling simple and multispecies communities

Chapter 2 Models of simple and complex systems	27
2.1 Introduction	27
2.2 Model structure and assumptions	27
2.2.1 Dimensions of mass, area, and time	30
2.2.2 Functional responses	30
2.2.3 Energetic efficiency and conversion rates	33
2.2.4 Intraspecific competition and self-limitation	36
2.3 Stability	36
2.3.1 Local stability	37
2.3.2 Qualitative stability	38
2.3.3 Negative diagonal dominance and quasi-diagonal dominance	39
2.3.3.1 Diagonal dominance	39
2.3.3.2 Quasi-diagonal dominance	41

2.3.4	Quasi-diagonal dominance and loops	42
2.3.4.1	Global stability	44
2.4	Simple food chains	44
2.4.1	Primary-producer-based food chains	45
2.4.2	Detritus-based food chains, internal cycling, and donor control	46
2.4.2.1	Models of donor-control dynamics	47
2.4.2.2	The stability of donor control and detritus	48
2.5	The dynamics of primary-producer-based and detritus-based models	50
2.6	Summary and conclusions	51

Chapter 3 Connectedness food webs 54

3.1	Introduction	54
3.2	Soil food webs	54
3.3	The CPER soil food web	55
3.3.1	Food web components	57
3.3.1.1	Basal resources	57
3.3.1.2	Inorganic nitrogen and carbon	59
3.3.1.3	Consumers	59
3.3.2	Aspects of food web structure	61
3.3.2.1	Diversity and food chain length	61
3.3.2.2	Diversity and complexity	64
3.3.2.3	Omnivory	68
3.3.3	Spatial and temporal averaging	70
3.4	Summary and conclusions	71

Chapter 4 Energy flux food webs 72

4.1	Introduction	72
4.2	Biomass and physiological parameters	72
4.3	Feeding rates and mineralization rates	75
4.3.1	Feeding rates, mass balance, and energy budgets	75
4.3.2	Mineralization rates	78
4.4	Energy flux descriptions	79
4.5	Summary and conclusions	92

Chapter 5 Functional webs 94

5.1	Introduction	94
5.2	Interaction strengths	94
5.2.1	Population models	97
5.2.2	The Jacobian matrix	98
5.2.3	Estimating interaction strength from energy flux	99
5.2.4	Stability	102

5.3	A functional food web for the CPER	103
5.3.1	Energy flux and interaction strengths	103
5.3.2	Mortalities from predation	111
5.3.3	Functional groups and food web stability	113
5.4	Summary and conclusions	113

Part II The dynamics and stability of simple and complex communities

Chapter 6 Energetic organization and food web stability 127

6.1	Introduction	127
6.2	Energetic organization and stability	128
6.3	Distribution of interaction strengths: trophic-level-dependent interaction strengths	131
6.3.1	Distribution of biomass and flux rates: the role of energetics	132
6.3.2	Distribution of interaction strengths: the role of trophic interaction loops	135
6.3.3	Food web stability: loops and energetics	137
6.4	Summary and conclusions	140

Chapter 7 Enrichment, trophic structure, and stability 141

7.1	Introduction	141
7.2	Simple primary-producer-based and detritus-based models	143
7.2.1	Feasibility	144
7.2.2	Stability and resilience	146
7.3	Trophic structure and dynamics along a productivity gradient	147
7.3.1	Transitions in trophic structure	149
7.3.2	Transitions in dynamic states	150
7.3.3	Energetic efficiencies	152
7.3.4	Body size and home range	155
7.4	More complex models	157
7.4.1	Attack rates and dynamics	157
7.4.2	Paradox of enrichment	159
7.4.3	Enrichment and donor control	160
7.4.4	Chaos and complex dynamics	161
7.5	Connections to real-world productivity	165
7.6	Summary and conclusions	169

Chapter 8 Modeling compartments 172

8.1	Introduction	172
8.2	Complexity, diversity, compartments, and stability	173

8.3	Defining compartments	176
8.4	Approaches to studying compartments	177
8.4.1	Evidence of compartments—binary data I	178
8.4.2	Evidence of compartments—binary data II	179
8.4.3	Evidence of compartments—carbon and nitrogen flux	180
8.4.4	Evidence of compartments—carbon flux and interaction strengths	184
8.5	The energy channel	187
8.5.1	Time—flux rates and turnover	187
8.5.2	Habitats—spatial arrangement	192
8.5.3	Temporal arrangements and spatial interactions	192
8.5.4	Structural and dynamic properties	195
8.5.5	Quasi-independence of dynamics	196
8.6	Energy channels—structure and stability	200
8.6.1	Coupled pathways and weak links	201
8.6.2	Resistance and resilience	204
8.6.3	Enrichment, predators, and energetic bottlenecks	205
8.6.4	Donor-controlled dynamics	206
8.7	Summary and conclusions	207

Chapter 9 Productivity, dynamic stability, and species richness 208

9.1	Introduction	208
9.2	Trophic structure, dynamics, and productivity	213
9.3	Feasibility revisited	214
9.4	Feasibility and the hump-shaped curve	218
9.4.1	Life history strategies and adaptations	220
9.4.2	Oscillations, instabilities, and population turnover rates	220
9.4.3	Energetic properties of populations	222
9.5	Trophic structure and the diversity of production	224
9.6	A review of hypotheses	226
9.6.1	Time	227
9.6.2	Dynamic stability and disturbance	227
9.6.3	Environmental heterogeneity	227
9.6.4	Area	228
9.7	Summary and conclusions	229

Part III Dynamic food web architectures

Chapter 10 Species-based versus biomass-based food web descriptions 235

10.1	Introduction	235
10.2	Dynamic food webs—playing Jenga	236

10.3	Two case studies	239
10.3.1	Island biogeography	239
10.3.2	Tuesday Lake	243
10.3.3	Summary of the case studies	243
10.4	Stability, disturbance, and transition	244
10.4.1	Stability	245
10.4.2	Agents of change	248
10.5	Summary and conclusions	250

Chapter II Dynamic architectures and stability of complex systems along productivity gradients **252**

11.1	Introduction	252
11.2	Food web structure in a cave ecosystem	253
11.3	Food web structure and stability along the primary succession gradient at the Wadden island of Schiermonnikoog, The Netherlands	260
11.4	Food web structure in a changing Arctic	268
11.5	General framework	280
11.6	Summary and conclusions	282

Chapter I2 Food web dynamics beyond asymptotic behavior **284**

12.1	Introduction	284
12.2	Variability, equilibrium states, and asymptotic stability	285
12.2.1	Variability, steady state, and the calculation of energy flow and nutrient cycling	285
12.2.2	Variability, trophic interaction strengths, and asymptotic stability	287
12.3	Transient dynamics	289
12.4	Spatial systems	296
12.4.1	Spatial networks, structure, and resilience	298
12.4.2	Dynamical implications of space	301
12.5	Asymptotically ambiguous states	303
12.5.1	Permanence	303
12.5.2	Apparent complexity	305
12.6	Reconciling asymptotic stability, spatial structure, and transient dynamics	306
12.7	Summary and conclusions	307

References **310**

Index **329**