

Contents

Preface

page x

1	Graphs as Structure in the Ecological Context	1
	Introduction	1
	1.1 Graphs as Structure	3
	1.2 Graphs and Ecological Relationships	10
	1.3 Graphs and Locations: Spatial and Temporal	11
	1.4 Networks and Dynamics	17
	1.5 Graphs and Data	18
	1.6 Ecological Hypotheses and Graph Theory	27
	1.7 Statistical Tests and Hypothesis Evaluation	29
	1.8 Concluding Comments	35
2	Shapes of Graphs: Trees to Triangles	37
	Introduction	37
	2.1 Acyclic Graphs	37
	2.2 Digraphs and Directed Acyclic Graphs	41
	2.3 Weighted Directed Trees	45
	2.4 Lattice Graphs	46
	2.5 Triangles	49
	2.6 Smaller Than Triangles: Singletons, Isolated Pairs and Whiskers	50
	2.7 How It Looks	51
	2.8 Concluding Comments	52
3	Species Interaction Networks	54
	Introduction	54
	3.1 Objects	57
	3.2 Properties	60
	3.3 Generative Models	68
	3.4 Comparisons	72
	3.5 Concluding Comments	77

4	Trophic Networks: Structure, Partitioning and Dynamics	79
	Introduction	79
	4.1 Trophic Networks and Derived Graphs	82
	4.2 Trophic Network Characteristics	86
	4.3 Concluding Comments	102
5	Species Associations, Communities and Graphs of Social Structure	105
	Introduction	105
	5.1 Graphs of Social Structure	107
	5.2 Cluster Detection in Graphs and Networks	113
	5.3 Transitivity and Reciprocity	121
	5.4 Balance	122
	5.5 Change	124
	5.6 Key Nodes; Key Edges	126
	5.7 Concluding Comments	127
6	Competition: Hierarchies and Reversals	128
	Introduction	128
	6.1 Concepts for Competition Interaction Graphs	130
	6.2 Measuring Competitive Outcomes	135
	6.3 Choosing Edges and Finding Hierarchies	137
	6.4 Example: <i>Arabidopsis thaliana</i> Ecotypes	141
	6.5 Concluding Comments	144
7	Mutualism, Parasitism and Bipartite Graphs	147
	Introduction	147
	7.1 Internal Structure of Bipartite Graphs	147
	7.2 Applications of Bipartite Graphs	158
	7.3 Concluding Comments	163
8	Temporal or Time-Only Graphs	164
	Introduction	164
	8.1 Properties of Temporal Graphs	170
	8.2 Techniques for Temporal Graphs: Testing Significance	180
	8.3 Applications of Techniques	183
	8.4 Conclusions and Advice	185
9	Spatial Graphs	191
	Introduction	191
	9.1 Properties of Spatial Graphs	193

9.2	Techniques for Spatial Graphs: Testing Significance and Other Assessments	201
9.3	Choice and Applications of Techniques	202
9.4	Concluding Comments	221
10	Spatio-temporal Graphs	222
	Introduction	222
	10.1 Characteristics	226
	10.2 Two Spatio-temporal Properties	228
	10.3 Examples of Ecological Applications	232
	10.4 Concluding Comments	251
11	Graph Structure and System Function: Graphlet Methods	252
	Introduction	252
	11.1 Graphs for Structure and Dynamics in Ecological Systems	257
	11.2 Graph Characteristics and Methods Based on Graphlets	259
	11.3 Concluding Comments	269
12	Synthesis and Future Directions	271
	Introduction	271
	12.1 Comparisons and Matching	271
	12.2 What Next?	276
	12.3 Concluding Comments	285
	<i>Glossary</i>	286
	<i>References</i>	297
	<i>Index</i>	328
	<i>Appendix</i>	333
	<i>Colour plates are found between pages 212 and 213.</i>	