

Contents

Introduction	xi
Nathalie PEYRARD, Stéphane ROBIN and Olivier GIMENEZ	
Chapter 1. Trajectory Reconstruction and Behavior Identification Using Geolocation Data	1
Marie-Pierre ETIENNE and Pierre GLOAGUEN	
1.1. Introduction	1
1.1.1. Reconstructing a real trajectory from imperfect observations	1
1.1.2. Identifying different behaviors in movement	3
1.2. Hierarchical models of movement	3
1.2.1. Trajectory reconstruction model	3
1.2.2. Activity reconstruction model	6
1.3. Case study: masked booby, <i>Sula dactylatra</i> (originals)	14
1.3.1. Data	14
1.3.2. Projection	15
1.3.3. Data smoothing	15
1.3.4. Identification of different activities through movement	16
1.3.5. Results	17
1.4. References	23
Chapter 2. Detection of Eco-Evolutionary Processes in the Wild: Evolutionary Trade-Offs Between Life History Traits	27
Valentin JOURNÉ, Sarah CUBAYNES, Julien PAPAÏX and Mathieu BUORO	
2.1. Context	27
2.2. The correlative approach to detecting evolutionary trade-offs in natural settings: problems	28

2.2.1. Mechanistic and statistical modeling as a means of accessing hidden variables	29
2.3. Case study	31
2.3.1. Costs of maturing and migration for survival: a theoretical approach	31
2.3.2. Growth/reproduction trade-off in trees	37
2.4. References	44
Chapter 3. Studying Species Demography and Distribution in Natural Conditions: Hidden Markov Models	47
Olivier GIMENEZ, Julie LOUVRIER, Valentin LAURET and Nina SANTOSTASI	
3.1. Introduction	47
3.2. Overview of HMMs	48
3.3. HMM and demography	50
3.3.1. General overview	50
3.3.2. Case study: estimating the prevalence of dog-wolf hybrids with uncertain individual identification	54
3.4. HMM and species distribution	55
3.4.1. General case	55
3.4.2. Case study: estimating the distribution of a wolf population with species identification errors and heterogeneous detection	57
3.5. Discussion	60
3.6. Acknowledgments	62
3.7. References	62
Chapter 4. Inferring Mechanistic Models in Spatial Ecology Using a Mechanistic-Statistical Approach	69
Julien PAPAÏX, Samuel SOUBEYRAND, Olivier BONNEFON, Emily WALKER, Julie LOUVRIER, Etienne KLEIN and Lionel ROQUES	
4.1. Introduction	69
4.2. Dynamic systems in ecology	70
4.2.1. Temporal models	70
4.2.2. Spatio-temporal models without reproduction	74
4.2.3. Spatio-temporal models with reproduction	76
4.2.4. Numerical solution	77
4.3. Estimation	77
4.3.1. Estimation principle	77
4.3.2. Parameter estimation	78
4.3.3. Estimation of latent processes	80
4.3.4. Mechanistic-statistical models	82

4.4. Examples	83
4.4.1. The COVID-19 epidemic in France	83
4.4.2. Wolf (<i>Canis lupus</i>) colonization in southeastern France	86
4.4.3. Estimating dates and locations of the introduction of invasive strains of watermelon mosaic virus	90
4.5. References	94

Chapter 5. Using Coupled Hidden Markov Chains to Estimate Colonization and Seed Bank Survival in a Metapopulation of Annual Plants 97

Pierre-Olivier CHEPTOU, Stéphane CORDEAU, Sebastian LE COZ and Nathalie PEYRARD

5.1. Introduction	97
5.2. Metapopulation model for plants: introduction of a dormant state	99
5.2.1. Dependency structure in the model	99
5.2.2. Distributions defining the model	100
5.2.3. Parameterizing the model	101
5.2.4. Linking the parameters of the model with the ecological parameters of the dynamics of an annual plant	103
5.2.5. Estimation	104
5.2.6. Model selection	105
5.3. Dynamics of weed species in cultivated parcels	105
5.3.1. Dormancy and weed management in agroecosystems	105
5.3.2. Description of the data set	106
5.3.3. Comparison with an HMM with independent patches	108
5.3.4. Influence of crops on weed dynamics	109
5.4. Discussion and conclusion	110
5.5. Acknowledgments	113
5.6. References	113

Chapter 6. Using Latent Block Models to Detect Structure in Ecological Networks 117

Julie AUBERT, Pierre BARBILLON, Sophie DONNET and Vincent MIELE

6.1. Introduction	117
6.2. Formalism	119
6.3. Probabilistic mixture models for networks	120
6.3.1. SBMs for unipartite networks	121
6.3.2. Stochastic block model for bipartite networks	122
6.4. Statistical inference	124
6.4.1. Estimation of parameters and clustering	125
6.4.2. Model selection	126

6.5. Application	127
6.5.1. Food web	127
6.5.2. A bipartite plant–pollinator network	129
6.6. Conclusion	130
6.7. References	132

Chapter 7. Latent Factor Models: A Tool for Dimension Reduction in Joint Species Distribution Models 135

Daria BYSTROVA, Giovanni POGGIATO, Julyan ARBEL and Wilfried THULLER

7.1. Introduction	135
7.2. Joint species distribution models	138
7.3. Dimension reduction with latent factors	139
7.4. Inference	140
7.5. Ecological interpretation of latent factors	141
7.6. On the interpretation of JSDMs	142
7.7. Case study	142
7.7.1. Introduction of the dataset	142
7.7.2. R package used	144
7.7.3. Implementation and convergence diagnosis	144
7.7.4. Results and discussion	144
7.8. Conclusion	152
7.9. References	153

Chapter 8. The Poisson Log-Normal Model: A Generic Framework for Analyzing Joint Abundance Distributions 157

Julien CHIQUET, Marie-Josée CROS, Mahendra MARIADASSOU, Nathalie PEYRARD and Stéphane ROBIN

8.1. Introduction	157
8.2. The Poisson log-normal model	159
8.2.1. The model	159
8.2.2. Inference method	162
8.2.3. Dimension reduction	164
8.2.4. Inferring networks of interaction	165
8.3. Data analysis: marine species	167
8.3.1. Description of the data	167
8.3.2. Effects due to site and date	168
8.3.3. Dimension reduction	170
8.3.4. Inferring ecological interactions	171
8.4. Discussion	176
8.5. Acknowledgments	177
8.6. References	177

Chapter 9. Supervised Component-Based Generalized Linear Regression: Method and Extensions	181
Frédéric MORTIER, Jocelyn CHAUVET, Catherine TROTTIER, Guillaume CORNU and Xavier BRY	
9.1. Introduction	181
9.2. Models and methods	184
9.2.1. Supervised component-based generalized linear regression	184
9.2.2. Thematic supervised component-based generalized linear regression (THEME-SCGLR)	187
9.2.3. Mixed SCGLR	189
9.3. Case study: predicting the abundance of 15 common tree species in the forests of Central Africa	191
9.3.1. The SCGLR method: a direct approach	191
9.3.2. THEME-SCGLR: improved characterization of predictive components	194
9.3.3. Mixed-SCGLR: taking account of the concession effect	196
9.4. Discussion	200
9.5. References	201
Chapter 10. Structural Equation Models for the Study of Ecosystems and Socio-Ecosystems	203
Fabien LAROCHE, Jérémy FROIDEVAUX, Laurent LARRIEU and Michel GOULARD	
10.1. Introduction	203
10.1.1. Ecological background	203
10.1.2. Methodological problem	204
10.1.3. Case study: biodiversity in a managed forest	205
10.2. Structural equation model	206
10.2.1. Hypotheses and general structure of an SEM	206
10.2.2. Likelihood and estimation in an SEM	209
10.2.3. Fit quality and nested SEM tests	211
10.3. Case study: biodiversity in managed forests	213
10.3.1. Preliminary steps	213
10.3.2. Evaluating the measurement model alone	213
10.3.3. Evaluating the relational model	214
10.3.4. Significance of parameters in the relational model	219
10.3.5. Findings	221

10.4. Discussion	223
10.4.1. A confirmatory approach	223
10.4.2. Gaussian framework	224
10.4.3. Centered-reduced observed variables	224
10.4.4. Structural constraints	225
10.4.5. Use of resampling	225
10.5. Acknowledgments	226
10.6. References	226
List of Authors	229
Index	233