

Ecological Niches
and Geographic Distributions

A. TOWNSEND PETERSON

JORGE SOBERÓN

RICHARD G. PEARSON

ROBERT P. ANDERSON

ENRIQUE MARTÍNEZ-MEYER

MIGUEL NAKAMURA

MIGUEL BASTOS ARAÚJO

PRINCETON UNIVERSITY PRESS

Princeton and Oxford

Table of Contents

Acknowledgments	ix
1. Introduction	1
Practicalities	2
This Volume	3
PART I	
THEORY	
2. Concepts of Niches	7
Major Themes in Niche Concepts	9
Grinnellian and Eltonian Niches	16
Estimating Grinnellian Niches: Practicalities	19
Summary	21
3. Niches and Geographic Distributions	23
Relations between Environmental and Geographic Spaces	24
The Ecological Equations	26
The BAM Diagram: A Thinking Framework	29
Ecological Niches and Geographic Distributions	31
Estimating Geographic Areas and Ecological Niches	40
Summary	46
PART II	
PRACTICE	
4. Niches and Distributions in Practice: Overview	51
General Principles	52
Steps to Building Niche Models	56
5. Species' Occurrence Data	62
Types of Occurrence Data	62
Occurrence Data Content and Availability	77
Summary	81

6. Environmental Data	82
Species-Environment Relationships	82
Environmental Data for Ecological Niche Modeling	85
Environmental Data in Practice	87
Summary	95
7. Modeling Ecological Niches	97
What Is Being Estimated?	98
Modeling Algorithms	101
Implementation	112
Model Calibration	112
Model Complexity and Overfitting	123
Study Region Extent and Resolution Revisited	125
Model Extrapolation and Transferability	126
Differences among Methods and Selection of “Best” Models	128
Characterizing Ecological Niches	131
Summary	137
8. From Niches to Distributions	138
Potential Distributional Areas	138
Nonequilibrium Distributions	141
Detecting and Processing Nonequilibrium Distributions	143
Summary	149
9. Evaluating Model Performance and Significance	150
Presences, Absences, and Errors	150
Calibration and Evaluation Datasets	153
Overfitting, Performance, Significance, and Evaluation Space	154
Selection of Evaluation Data	156
Evaluation of Performance	162
Assessing Model Significance	167
Future Directions	176
Summary	180

PART III APPLICATIONS

10. Introduction to Applications	185
11. Discovering Biodiversity	189
Discovering Populations	190

Discovering Species Limits	191
Discovering Unknown Species	192
Connection to Theory	192
Practical Considerations	193
Review of Applications	195
Discussion	198
12. Conservation Planning and Climate Change Effects	200
Generalities	200
Connection to Theory	201
Practical Considerations	206
Review of Applications	208
13. Species' Invasions	215
Connection to Theory	216
Practical Considerations	216
Review of Applications	218
Caveats and Limitations	222
Future Directions and Challenges	224
14. The Geography of Disease Transmission	226
Connection to Theory	229
Practical Considerations	229
Review of Applications	230
Caveats and Limitations	235
Future Directions and Challenges	236
15. Linking Niches with Evolutionary Processes	238
Changes in the Available Environment	238
Niche Conservatism	240
Tests of Conservatism	243
Context	250
Learning More about Ecological Niche Evolution	250
Future Directions and Challenges	254
16. Conclusions	256
Appendices	
Appendix A: Glossary of Symbols Used	261
Appendix B: Set Theory for G- and E-Space	266

Glossary	269
Bibliography	281