

Contents



Figures ix

Tables xi

Authors and Contributors xiii

Foreword xv
David B. Wake

Preface xvii
Antecedents xvii
Authorship xviii
Acknowledgments xviii

Chapter 1. Introduction 1
Previous Work 2
Intended Audience 3

**Chapter 2. Amphibian Diversity and
Natural History: An Overview 5**

Roy W. McDiarmid

Introduction 5
Order Gymnophiona (Caecilians) 7
Order Caudata (Salamanders) 7
Order Anura (Frogs) 12
Amphibian Larvae 13

**Chapter 3. Essentials of Standardization
and Quantification 17**

Introduction 17
Study Questions 18
Sampling Considerations 18
Scale 18
Randomization and Bias 19
Replication and Assumptions 19
Reporting Data 20

Chapter 4. Research Design for Quantitative Amphibian Studies 21

Lee-Ann C. Hayek

Introduction 21

Project Design 21

The Research Question 21

Formulating the Research Hypothesis 24

Validity 25

Field Observation and Statistical Design 28

Data Accuracy 28

Measurement Scales and Statistical Analysis 29

Randomness 30

Independence 34

Sample Size 35

Testing Errors 35

Statistical versus Substantive Significance 38

Chapter 5. Keys to a Successful Project: Associated Data and Planning 41

Introduction 41

Climate and Environment, *Martha L. Crump* 42

Basic Weather Data 43

Additional Environmental Data 44

Measuring Weather Variables 45

Automated Data Acquisition, *Charles R. Peterson and Michael E. Dorcas* 47

Data Loggers 47

Environmental Sensors 49

Thermal Environment 53

Recording Frog Calls 54

Recording Radiotelemetry Signals 55

Data Standards, *Roy W. McDiarmid* 57

Geographic Characterization 58

Habitat 58

Sampling Methodology 60

Microhabitat Description, *Robert F. Inger* 60

Characteristics of a Microhabitat

Checklist 61

Basic Descriptors for a Microhabitat

Checklist 63

Field Methods 66

Voucher Specimens, *Robert P. Reynolds, Ronald I. Crombie, and Roy W.*

McDiarmid 66

Field Identifications 67

Sample Size 68

Specimen Data 69

Call Vouchers 70

Selection of a Specimen Repository 70

Permits, *Roy W. McDiarmid, Robert P.*

Reynolds, and Ronald I. Crombie 72

Chapter 6. Standard Techniques for Inventory and Monitoring 75

Selection of Techniques 75

Standard Techniques 76

1. Complete Species Inventories, *Norman J. Scott, Jr.* 78

2. Visual Encounter Surveys, *Martha L. Crump and Norman J. Scott, Jr.* 84

3. Audio Strip Transects, *Barbara L. Zimmerman* 92

4. Quadrat Sampling, *Robert G. Jaeger and Robert F. Inger* 97

5. Transect Sampling, *Robert G. Jaeger* 103

6. Patch Sampling, *Robert G. Jaeger* 107

7. Straight-Line Drift Fences and Pitfall Traps, *Paul Stephen Corn* 109

8. Surveys at Breeding Sites, *Norman J. Scott, Jr., and Bruce D. Woodward* 118

9. Drift Fences Encircling Breeding Sites, *C. Kenneth Dodd, Jr., and David E. Scott* 125

10. Quantitative Sampling of Amphibian Larvae, *H. Bradley Shaffer, Ross A. Alford, Bruce D. Woodward, Stephen J. Richards, Ronald G. Altig, and Claude Gascon* 130

Chapter 7. Supplemental Approaches to Studying Amphibian Biodiversity 143

Introduction 143

Artificial Habitats 143

Sampling with Artificial Pools, <i>Claude Gascon</i>	144
Sampling with Artificial Cover, <i>Gary M. Fellers and Charles A. Drost</i>	146
Acoustic Monitoring at Fixed Sites, <i>A. Stanley Rand and George E. Drewry</i>	150
Target Organisms and Habitats	151
Background	151
Research Design	152
Special Considerations	152
Tracking	152
Thread Bobbins, <i>W. Ronald Heyer</i>	153
Radio Tracking, <i>Stephen J. Richards, Ulrich Sinsch, and Ross A. Alford</i>	155
Tracking with Radioactive Tags, <i>Ray E. Ashton, Jr.</i>	158
Night Driving, <i>H. Bradley Shaffer and J. Eric Juterbock</i>	163
Target Organisms and Habitats	163
Background	164
Research Design	165
Field Methods	165
Personnel and Materials	166
Data Treatment and Interpretation	166
Special Considerations	166
Geographic Information Systems	166
GIS and Remote Sensing Techniques, <i>Lee-Ann C. Hayek and Roy W. McDiarmid</i>	166
Manual GIS Application for Habitat Specialists, <i>J. Eric Juterbock, Samuel S. Sweet, and Roy W. McDiarmid</i>	171
Group Activities and Field Trips, <i>Roy W. McDiarmid and Maureen A. Donnelly</i>	175
Target Organisms and Habitats	175
Background	175
Research Design	176
Personnel and Materials	176
Data Treatment and Interpretation	176
Special Considerations	176
Examples of Group Activities	177

Chapter 8. Estimating Population Size 183

Introduction	183
Mark-Recapture, <i>Maureen A. Donnelly and Craig Guyer</i>	183
Objectives	183
Target Organisms and Habitat	184
Background	184
Research Design and Field Methods	185
Data Analysis and Interpretation	186
Personnel and Materials	186
Population Estimators	186
Capture-Resight	200
Bayesian Approach to Mark-Recapture Data	200
Removal Sampling, <i>Lee-Ann C. Hayek</i>	201
Target Organisms and Habitats	201
Background	201
Research Design and Field Methods	202
Data Analysis and Interpretation	203
Special Considerations	205

Chapter 9. Analysis of Amphibian

Biodiversity Data 207

Lee-Ann C. Hayek

Introduction	207
Species Richness	207
Presence-Absence Data	207
Measures of Association	209
Species Abundance	232
Individual Counts and Proportions	232
Interrelationships of Standard Tests	235
Model-Based Methods	236
Advice about Tests for $R \times C$ Tables	237
Advice about Tests for 2×2 Tables	239
Summary and Recommendations	241
Species Density and Continuously Distributed Data	243
Graphical Representation	243
Descriptive Statistics	244
Species Diversity	244
Inventories and Richness	245
Monitoring, Richness, and Evenness	246

Summary and Recommendations 251

Notes 252

Appendix: Properties of Association Measures 255

Examples for Invariance 255

Examples for Linearity Conditions 255

Range Conditions 261

Chapter 10. Conclusions and Recommendations 271

The Importance of Inventory Data 271

Flexibility and Insight 272

Modification of Techniques 272

Comparisons with Previous Studies 273

Epilogue 273

Appendix 1: Handling Live Amphibians 275

Gary M. Fellers, Charles A. Drost, and W. Ronald Heyer

Philosophy 275

Handling 275

Anesthesia 276

Measurement 276

Appendix 2: Techniques for Marking Amphibians 277

Maureen A. Donnelly, Craig Guyer, J. Eric Juterbock, and Ross A. Alford

Marking Adult Amphibians 277

Pattern mapping 277

Marking and Tagging 278

Marking Larval Amphibians 283

Recommendations 283

Appendix 3: Recording Frog Calls 285

W. Ronald Heyer

Equipment 285

Making the Recording 286

Voucher Specimens 287

Associated Data 287

Appendix 4: Preparing Amphibians as Scientific Specimens 289

Roy W. McDiarmid

Introduction 289

Documentation 289

Specimen Processing 291

Procedures for Killing 291

Preservatives 292

Fixation 293

Eggs and Larvae 294

Special Preparations 295

Packing and Shipping 295

Field Equipment and Supplies 296

Appendix 5: Collecting Tissue for Biochemical Analysis 299

Jeremy F. Jacobs and W. Ronald Heyer

Freezing Tissues in the Field 299

Protocol for Preparing Tissue

Samples 300

Sample Size 300

Appendix 6: Vendors 303

Equipment and Supplies 303

Computer Programs 311

Appendix 7: Table of Random Numbers 313

Lee-Ann C. Hayek

Instructions for Use 313

Example 314

Table of Random Numbers 316

Glossary 325

Literature Cited 329

Index 351

Addresses of Authors and Contributors 361