

Contents

Preface ix

I

INTRODUCTION

1. Introduction to Ecosystem Science 3
KATHLEEN C. WEATHERS, DAVID L. STRAYER,
AND GENE E. LIKENS
- What Is an Ecosystem? 3
- What Are the Properties of Ecosystems? 8
- Why Do Scientists Study Ecosystems? 11
- How Do Ecosystem Scientists Learn about
Ecosystems? 12
- From There to Here: A Short History of the
Ecosystem Concept in Theory and Practice 19
- References 22

II

ECOLOGICAL ENERGETICS

2. Primary Production: The Foundation
of Ecosystems 27
MICHAEL L. PACE AND GARY M. LOVETT
- Introduction 27
- Components of Primary Production 28
- Measuring Primary Production 33
- Regulation of Primary Production 36
- Rates and Patterns of Primary Production 42
- Fates of Primary Production 46
- A Tale of Scale 48
- Summary 49
- References 50
- References for Table 2.1 51

3. Secondary Production and Consumer Energetics 53

DAVID L. STRAYER

- Introduction 53
- Consumer Energetics 53
- Secondary Production 58
- Definition of Secondary Production 58
- Methods to Estimate Secondary Production 59
- Controls and Prediction of Secondary
Production 61
- Production of an Individual Species of
Consumer 62
- Production of a Guild of Consumers 64
- Production of the Entire Community of
Consumers 66
- Conclusion 69
- References 72

4. Organic Matter Decomposition 75

STUART E.G. FINDLAY

- Introduction 75
- Decomposition of Plant-Derived Particulate
Matter 78
- Organisms Responsible for Decomposition 81
- Controls on Decomposition 84
- Interactions with Other Element Cycles 90
- Summary 91
- References 92

III

BIOGEOCHEMISTRY

5. Element Cycling 97

KATHLEEN C. WEATHERS AND HOLLY A. EWING

- What Is an Element Cycle? 98
- The Importance of Chemical Properties 101
- Move, Stick, and Change: A Simple Framework for
Elemental Cycling 104

What Kinds of Questions Are Associated with Element Cycles?	107
Some Characteristics Important for Understanding an Element's Role in Ecosystems	107
References	108

6. The Carbon Cycle 109

JONATHAN J. COLE

Why Study the Carbon Cycle?	109
Biogeochemistry of Carbon	109
The Carbon Atom and Its Chemistry	110
The Present-Day Global Carbon Cycle and the Greenhouse Effect	116
The Holocene Preindustrial Global Carbon Budget	119
The Carbon Cycle in Selected Ecosystems	123
Concluding Remarks	132
References	132

7. The Nitrogen Cycle 137

PETER M. GROFFMAN AND EMMA J. ROSI-MARSHALL

Introduction	137
The Global Picture	137
Nitrogen Cycle Processes	140
Nitrogen Cycling in Terrestrial Ecosystems	148
Nitrogen Cycling in Aquatic Ecosystems	152
Nitrogen Balances: The Enigma of Missing Nitrogen	156
References	157

8. The Phosphorus Cycle 159

ELENA M. BENNETT AND MEAGAN E. SCHIPANSKI

Introduction	159
Background	159
The Importance of Phosphorus in Terrestrial Ecosystems	160
The Importance of Phosphorus in Agricultural Ecosystems	161
The Importance of Phosphorus in Aquatic Ecosystems	161
The Global Phosphorus Cycle	163
Human Alteration of the Global Phosphorus Cycle	165
The Phosphorus Cycle at the Watershed Scale	171
The Phosphorus Cycle at the Local Scale	172
Managing Human Interaction with the Phosphorus Cycle	176

Summary	177
References	177

IV

SYNTHESIS

9. Revisiting the Ecosystem Concept: Important Features That Promote Generality and Understanding 181

MICHAEL L. PACE

Introduction	181
Budgets and Boundaries	182
Inclusiveness and Flexibility	187
Generality and Prediction	189
References	190

10. Ecosystems in a Heterogeneous World 191

STEWART T.A. PICKETT AND MARY L. CADENASSO

Introduction	191
The Nature of Heterogeneity	192
Toward a Framework for Space and Time Heterogeneity	201
Internal and External Heterogeneity	205
First Principles for Assessing Heterogeneity	208
Conclusions: Ecosystems in Time and Space	209
References	211

11. Controls on Ecosystem Structure and Function 215

KATHLEEN C. WEATHERS, HOLLY A. EWING,
CLIVE G. JONES, AND DAVID L. STRAYER

What Do We Mean by "Control"?	215
Why Do We Care about Controls on Ecosystems?	216
How Are Ecosystems Controlled?	216
Complications	228
References	230

V

CASE STUDIES

12. From Global Environmental Change
to Sustainability Science: Ecosystem
Studies in the Yaqui Valley,
Mexico 233

PAMELA A. MATSON

The Yaqui Valley Case Study 234
Lessons from the Yaqui Valley Ecosystems
Study 239
References 240

13. Ecology of Lyme Disease 243

RICHARD S. OSTFELD

Discovery 243
It's the Deer 244
References 250

14. Understanding Ecosystem
Effects of Dams 253

EMILY H. STANLEY

References 257

15. Acid Rain 259

GENE E. LIKENS

References 264

16. Streams and Their Valleys 265

JUDY L. MEYER

References 275

VI

FRONTIERS

17. Frontiers in Ecosystem Science 279

HEATHER A. BECHTOLD, JORGE DURÁN, DAVID L.
STRAYER, KATHLEEN C. WEATHERS, ANGELICA P.
ALVARADO, NEIL D. BETTEZ, MICHELLE A. HERSH,
ROBERT C. JOHNSON, ERIC G. KEELING, JENNIFER L.
MORSE, ANDREA M. PREVITALI, AND ALEXANDRA
RODRÍGUEZ

Introduction 279
Pressures and Pace of Environmental Change 280
Conceptual Advances 284
Technological Advances 288
The Changing Culture of Science 291
Conclusion 294
References 294

**Appendix: A Primer on Biologically
Mediated Redox Reactions in
Ecosystems 297**

STUART E.G. FINDLAY AND DAVID L. STRAYER

Glossary 303

Index 307