



CONTENTS

<i>Preface</i>		<i>xiii</i>
1	Introduction	1
1.1	Why Study Ecosystems?	2
1.2	State of the World's Forests	4
1.3	The Study of Nature: Balance and Flux	8
1.4	A Brief Overview of the Book	9
1.5	Summary	9
2	Basic Terminology and Concepts	11
2.1	Some Basic Concepts	12
2.2	The Subdisciplines of Ecology	14
2.3	The Nature of Systems	16
2.4	Summary	19
3	Forests as Part of the Global Ecosystem	21
3.1	A Brief Look at the Global Ecosystem	21
3.2	Ecosystem Services Provided by Forests	30
3.3	Forests and Human Health	39
3.4	Summary	40
4	Major Forest Types and Their Climatic Controls	41
4.1	The Influence of Climate on Forest Type	42
4.2	Latitudinal Gradients in Forest Characteristics	47

4.3	How Will Global Climate Change Affect the Distribution of Forests?	50
4.4	Summary	59
5	Local Variation in Community Type	
	<i>The Landscape Mosaic</i>	60
5.1	A Case History	60
5.2	Topoedaphic Influences on Vegetation Patterns	65
5.3	The Emergent Landscape: Integration of Topography, Soils, and Disturbance	73
5.4	Vegetation Classification	75
5.5	Summary	78
6	Change in Time	
	<i>An Overview</i>	79
6.1	Earth Music	80
6.2	Summary	84
7	Disturbance in Forest Ecosystems	86
7.1	The Complex Nature of Disturbance	86
7.2	Fire	87
7.3	Wind	108
7.4	Tectonic Activity	111
7.5	Flooding	111
7.6	Invasive Species	111
7.7	Summary	117
8	Patterns and Mechanisms of Succession	118
8.1	Historical Notes	118
8.2	Compositional and Structural Change during Succession	120
8.3	Mechanisms of Succession	130
8.4	Ecosystem Changes during Succession	146
8.5	The Emergent Landscape Revisited	155
8.6	Summary	155
9	The Structure of Local Ecosystems	156
9.1	Forest Structure	159
9.2	Habitat and Niche	170
9.3	Food Webs: Pathways of Energy Flow within Ecosystems	172
9.4	Niche Overlap and Diversification	179
9.5	The Tradeoff between Dominance and Diversity	184
9.6	Scales of Diversity	184
9.7	Summary	189
10	How Biodiversity Is Created and Maintained	190
10.1	Forces That Generate and Maintain Diversity within Communities	190
10.2	The Variation of Species Richness among Environments	193
10.3	Relationships between Forest Structure and the Diversity of Animals and Microbes	195
10.4	Forces Producing Diversity in Trees and Other Forest Plants	205
10.5	Summary	215

11	The Biological Web	
	<i>Interactions among Species</i>	216
11.1	The Structure of Relationships within Communities	216
11.2	Interactions between Two Species: Basic Concepts	220
11.3	Mutualisms	221
11.4	Competition	232
11.5	Higher-Order Interactions	234
11.6	Summary	241
12	Size-Density Relationships in Forests over Time and across Space	242
12.1	Self-Thinning: An Orderly Process	242
12.2	Size-Density Relationships in Forests: The Spatial Dimension	245
12.3	Summary	246
13	Genetic and Evolutionary Aspects of Species Interactions	247
13.1	The Role of Biotic Interactions in Evolution	248
13.2	Community and Ecosystem Genetics	251
13.3	The Selection of Cooperation within Groups	253
13.4	Summary	255
14	Soil	
	<i>The Fundamental Resource</i>	256
14.1	What Is Soil?	257
14.2	The Soil Profile	258
14.3	Physical Properties of Soils	260
14.4	Chemical Properties of Soils	269
14.5	Biological Properties of Soils	281
14.6	Soil Development	291
14.7	Soil Classification	297
14.8	Summary	299
15	Primary Productivity	301
15.1	Light Capture and Gas Exchange in Canopies	302
15.2	Respiration by Trees and Ecosystems	306
15.3	Net Primary Productivity	307
15.4	Carbon Allocation in Different Environments	314
15.5	The Limiting Factors of the Environment	317
15.6	Trees Are Not Prisoners of the Environment	328
15.7	Productivity in the Twenty-first Century	329
15.8	Summary	332
16	Forest Nutrition	333
16.1	The Essential Nutrients and Their Physiological Roles	334
16.2	Nutrient Requirements and Limitations	337
16.3	Diagnosing Nutrient Deficiencies	342
16.4	The Concept of Relative Addition Rate	345
16.5	Summary	346
17	Biogeochemical Cycling	
	<i>Nutrient Inputs to and Losses from Local Ecosystems</i>	347
17.1	An Overview of Nutrient Inputs to Local Ecosystems	347
17.2	Atmospheric Inputs	348

17.3	Inputs from Weathering of Primary Minerals	351
17.4	Biological Nitrogen Fixation	353
17.5	Nutrient Losses from Undisturbed Forests	362
17.6	Nutrient Losses from Disturbed Forests	363
17.7	Summary	370
18	Biogeochemical Cycling	
	<i>The Intrasystem Cycle</i>	372
18.1	Overview of the Intrasystem Nutrient Cycle	373
18.2	The Contribution of Nutrient Cycling to Primary Productivity	375
18.3	Detritus	375
18.4	The Intratree Nutrient Cycle	382
18.5	Throughfall and Stem Flow	383
18.6	Decomposition and Nutrient Cycling: Some Basic Concepts	384
18.7	Broad Patterns of Decomposition: The <i>k</i> Value	385
18.8	Factors Controlling the Rate of Decomposition	385
18.9	Effects of Food-Chain Interactions on Decomposition, Immobilization, and Mineralization	392
18.10	Biodiversity Affects Decomposition	395
18.11	A Closer Look at Nitrogen, Phosphorus, and Sulfur Cycles	396
18.12	Plant Uptake	400
18.13	Nutrient Cycling through Succession	406
18.14	Global Change and Nutrient Cycling	408
18.15	Summary	408
19	Herbivores in Forest Ecosystems	409
19.1	Effects of Herbivory on Primary Productivity	411
19.2	Factors Controlling Herbivores	417
19.3	Coevolutionary Balance in Forests	435
19.4	Summary	437
20	Ecosystem Stability I	
	<i>Introduction and Case Studies</i>	438
20.1	Stability of What?	439
20.2	Resistance, Resilience, Robustness	440
20.3	Pollution	440
20.4	Degrading Forests through Mismanagement	445
20.5	Loss of Bioregulation: Breaking the Links between Plants and Soils	451
20.6	Loss of Bioregulation: Breaking the Top-Down Links	460
20.7	Balls, Dancers, and Dances	461
20.8	Summary	463
21	Ecosystem Stability II	
	<i>The Role of Biodiversity</i>	464
21.1	May's Paradox	464
21.2	Intensive Forest Management Simplifies Natural Ecosystems	465
21.3	Does Biodiversity Stabilize Ecosystems? Yes, But ...	465
21.4	Understanding Stabilization Requires Understanding Structure-Function Interactions	467
21.5	Summary	479

22 Ecosystem Stability III	
<i>Conserving Species</i>	480
22.1 Conserving Species Means Protecting Habitat	482
22.2 What Kind of Habitat? A Matter of Balance	484
22.3 Fine Filters, Coarse Filters, and Pluralism	485
22.4 Viable Populations	489
22.5 Landscape Patterns: Fragmentation, Variegation, and Permeation	493
22.6 Summary	502
23 The Future	503
23.1 The Implications of Global Warming	504
23.2 Maintaining Biological Diversity in Managed Forests	506
23.3 Coda: The New and the Renewed	518
23.4 Summary	519

Bibliography 521

Index 595

MUCH HAS HAPPENED IN ECOLOGY and forestry since the book first appeared in 1995. In ecology, new concepts of metacommunities, corridors and niche-ecosystems have extended and affirmed the importance of spatial interactions in ecological dynamics; a new theory of forces that create biodiversity has joined an already crowded field; progress has been made on the perennially contentious issue of the relationship between biodiversity and stability; the importance of positive feedbacks in ecosystem dynamics has entered the mainstream; a synthesis of community and ecosystem evolution has emerged; the view of the world has been revised; long-term data sets have begun to reveal the slowest ecosystem dynamics that play out over decades; the field has deepened into aspects of nature ranging from the molecular to the whole within ecosystems through the structure of ecological communities and interactions that tie the global ecosystem together.

The past decade has been characterized by a convergence of previously separate disciplines, deepening and broadening our understanding of how nature works. By asking questions about the interactions of ecosystems, ecologists have initiated the development of landscape ecology and ecosystem ecology, the disciplines that bridge the gap between the interface between hydrology and ecology, the intersection of a new discipline, earth system science, and the study of the ecology of the biotic and earth sciences.

Overlaying and permeating these developments are the most powerful particular quantitative tools that have been developed in describing ecosystem dynamics, and the most powerful conceptual tools that have