

GLOBAL
EDITION



Elements of ECOLOGY

NINTH EDITION

Thomas M. Smith • Robert Leo Smith

ALWAYS LEARNING

PEARSON



ELEMENTS OF

Ecology

Ninth Edition
Global Edition

Thomas M. Smith

University of Virginia

Robert Leo Smith

West Virginia University, Emeritus

PEARSON

Boston Columbus Indianapolis New York San Francisco Upper Saddle River
Amsterdam Cape Town Dubai London Madrid Milan Munich Paris Montréal Toronto
Delhi Mexico City São Paulo Sydney Hong Kong Seoul Singapore Taipei Tokyo

Elements of Ecology, Global Edition

Table of Contents

Cover

Title Page

Copyright

Contents

Preface

Chapter 1 The Nature of Ecology

1.1 Ecology Is the Study of the Relationship between Organisms and Their Environment

1.2 Organisms Interact with the Environment in the Context of the Ecosystem

1.3 Ecological Systems Form a Hierarchy

1.4 Ecologists Study Pattern and Process at Many Levels

1.5 Ecologists Investigate Nature Using the Scientific Method

QUANTIFYING ECOLOGY 1.1: Classifying Ecological Data

QUANTIFYING ECOLOGY 1.2: Displaying Ecological Data: Histograms and Scatter Plots

1.6 Models Provide a Basis for Predictions

1.7 Uncertainty Is an Inherent Feature of Science

1.8 Ecology Has Strong Ties to Other Disciplines

1.9 The Individual Is the Basic Unit of Ecology

ECOLOGICAL ISSUES & APPLICATIONS: Ecology Has a Rich History

Summary

Study Questions

Further Readings

Part 1 The Physical Environment

Chapter 2 Climate

2.1 Surface Temperatures Reflect the Difference between Incoming and Outgoing Radiation

Table of Contents

2.2 Intercepted Solar Radiation and Surface Temperatures Vary Seasonally

2.3 Geographic Difference in Surface Net Radiation Result in Global Patterns of Atmospheric Circulation

2.4 Surface Winds and Earth's Rotation Create Ocean Currents

2.5 Temperature Influences the Moisture Content of Air

2.6 Precipitation Has a Distinctive Global Pattern

2.7 Proximity to the Coastline Influences Climate

2.8 Topography Influences Regional and Local Patterns of Climate

2.9 Irregular Variations in Climate Occur at the Regional Scale

2.10 Most Organisms Live in Microclimates

 ECOLOGICAL ISSUES & APPLICATIONS: Rising Atmospheric Concentrations of Greenhouse Gases Are Altering Earth's Climate

Summary

Study Questions

Further Readings

Chapter 3 The Aquatic Environment

3.1 Water Cycles between Earth and the Atmosphere

3.2 Water Has Important Physical Properties

3.3 Light Varies with Depth in Aquatic Environments

3.4 Temperature Varies with Water Depth

3.5 Water Functions as a Solvent

3.6 Oxygen Diffuses from the Atmosphere to the Surface Waters

3.7 Acidity Has a Widespread Influence on Aquatic Environments

3.8 Water Movements Shape Freshwater and Marine Environments

3.9 Tides Dominate the Marine Coastal Environment

3.10 The Transition Zone between Freshwater and Saltwater Environments Presents

Table of Contents

Unique Constraints

ECOLOGICAL ISSUES & APPLICATIONS: Rising Atmospheric Concentrations of CO₂ Are Impacting Ocean Acidity

Summary

Study Questions

Further Readings

Chapter 4 The Terrestrial Environment

4.1 Life on Land Imposes Unique Constraints

4.2 Plant Cover Influences the Vertical Distribution of Light

QUANTIFYING ECOLOGY 4.1: Beer's Law and the Attenuation of Light

4.3 Soil Is the Foundation upon which All Terrestrial Life Depends

4.4 The Formation of Soil Begins with Weathering

4.5 Soil Formation Involves Five Interrelated Factors

4.6 Soils Have Certain Distinguishing Physical Characteristics

4.7 The Soil Body Has Horizontal Layers or Horizons

4.8 Moisture-Holding Capacity Is an Essential Feature of Soils

4.9 Ion Exchange Capacity Is Important to Soil Fertility

4.10 Basic Soil Formation Processes Produce Different Soils

ECOLOGICAL ISSUES & APPLICATIONS: Soil Erosion Is a Threat to Agricultural Sustainability

Summary

Study Questions

Further Readings

Part 2 The Organism and Its Environment

Chapter 5 Adaptation and Natural Selection

5.1 Adaptations Are a Product of Natural Selection

5.2 Genes Are the Units of

Table of Contents

Inheritance

5.3 The Phenotype Is the Physical Expression of the Genotype

5.4 The Expression of Most Phenotypic Traits Is Affected by the Environment

5.5 Genetic Variation Occurs at the Level of the Population

5.6 Adaptation Is a Product of Evolution by Natural Selection

5.7 Several Processes Other than Natural Selection Can Function to Alter Patterns of Genetic Variation within Populations

5.8 Natural Selection Can Result in Genetic Differentiation

 QUANTIFYING ECOLOGY 5.1: Hardy–Weinberg Principle

 FIELD STUDIES: Hopi Hoekstra

5.9 Adaptations Reflect Trade-offs and Constraints

 ECOLOGICAL ISSUES & APPLICATIONS: Genetic Engineering Allows Humans to Manipulate a Species' DNA

Summary

Study Questions

 Further Readings

Chapter 6 Plant Adaptations to the Environment

6.1 Photosynthesis Is the Conversion of Carbon Dioxide into Simple Sugars

6.2 The Light a Plant Receives Affects Its Photosynthetic Activity

6.3 Photosynthesis Involves Exchanges between the Plant and Atmosphere

6.4 Water Moves from the Soil, through the Plant, to the Atmosphere

6.5 The Process of Carbon Uptake Differs for Aquatic and Terrestrial Autotrophs

6.6 Plant Temperatures Reflect Their Energy Balance with the Surrounding Environment

6.7 Constraints Imposed by the Physical Environment Have Resulted in a Wide Array of Plant Adaptations

6.8 Species of Plants Are Adapted to Different Light Environments

 FIELD STUDIES: Kaoru Kitajima

Table of Contents

QUANTIFYING ECOLOGY 6.1: Relative Growth

Rate

6.9 The Link between Water Demand and Temperature Influences Plant

Adaptations

6.10 Plants Exhibit Both Acclimation and Adaptation in Response to Variations in

Environmental

Temperatures

6.11 Plants Exhibit Adaptations to Variations in Nutrient

Availability

6.12 Plant Adaptations to the Environment Reflect a Trade-off between Growth

Rate and

Tolerance

ECOLOGICAL ISSUES & APPLICATIONS: Plants Respond to Increasing Atmospheric

CO₂

Summary

Study Questions

Further Readings

Chapter 7 Animal Adaptations to the Environment

7.1 Size Imposes a Fundamental Constraint on the Evolution of Organisms

7.2 Animals Have Various Ways of Acquiring Energy and Nutrients

7.3 In Responding to Variations in the External Environment, Animals Can Be either Conformers or

Regulators

7.4 Regulation of Internal Conditions Involves Homeostasis and Feedback

FIELD STUDIES: Martin Wikelski

7.5 Animals Require Oxygen to Release Energy Contained in Food

7.6 Animals Maintain a Balance between the Uptake and Loss of Water

7.7 Animals Exchange Energy with Their Surrounding Environment

7.8 Animal Body Temperature Reflects Different Modes of Thermoregulation

7.9 Poikilotherms Regulate Body Temperature Primarily through Behavioral Mechanisms

7.10 Homeotherms Regulate Body Temperature through Metabolic Processes

7.11 Endothermy and Ectothermy Involve Trade-offs

7.12 Heterotherms Take on Characteristics of Ectotherms and Endotherms

Table of Contents

7.13 Some Animals Use Unique Physiological Means for Thermal Balance

7.14 An Animal's Habitat Reflects a Wide Variety of Adaptations to the Environment

 ECOLOGICAL ISSUES & APPLICATIONS: Increasing Global Temperature Is Affecting the Body Size of Animals

Summary

Study Questions

Further Readings

Part 3 Populations

Chapter 8 Properties of Populations

8.1 Organisms May Be Unitary or Modular

8.2 The Distribution of a Population Defines Its Spatial Location

 FIELD STUDIES: Filipe Alberto

8.3 Abundance Reflects Population Density and Distribution

8.4 Determining Density Requires Sampling

8.5 Measures of Population Structure Include Age, Developmental Stage, and Size

8.6 Sex Ratios in Populations May Shift with Age

8.7 Individuals Move within the Population

8.8 Population Distribution and Density Change in Both Time and Space

 ECOLOGICAL ISSUES & APPLICATIONS: Humans Aid in the Dispersal of Many Species, Expanding Their Geographic Range

Summary

Study Questions

Further Readings

Chapter 9 Population Growth

9.1 Population Growth Reflects the Difference between Rates of Birth and Death

9.2 Life Tables Provide a Schedule of Age-Specific Mortality and Survival

 QUANTIFYING ECOLOGY 9.1: Life Expectancy

9.3 Different Types of Life Tables Reflect Different Approaches to Defining Cohorts and Age Structure

Table of Contents

9.4 Life Tables Provide Data for Mortality and Survivorship Curves

9.5 Birthrate Is Age-Specific

9.6 Birthrate and Survivorship Determine Net Reproductive Rate

9.7 Age-Specific Mortality and Birthrates Can Be Used to Project Population Growth

QUANTIFYING ECOLOGY 9.2: Life History Diagrams and Population Projection Matrices

9.8 Stochastic Processes Can Influence Population Dynamics

9.9 A Variety of Factors Can Lead to Population Extinction

ECOLOGICAL ISSUES & APPLICATIONS: The Leading Cause of Current Population Declines and Extinctions Is Habitat Loss

Summary

Study Questions

Further Readings

Chapter 10 Life History

10.1 The Evolution of Life Histories Involves Trade-offs

10.2 Reproduction May Be Sexual or Asexual

10.3 Sexual Reproduction Takes a Variety of Forms

10.4 Reproduction Involves Both Benefits and Costs to Individual Fitness

10.5 Age at Maturity Is Influenced by Patterns of Age-Specific Mortality

10.6 Reproductive Effort Is Governed by Trade-offs between Fecundity and Survival

10.7 There Is a Trade-off between the Number and Size of Offspring

10.8 Species Differ in the Timing of Reproduction

QUANTIFYING ECOLOGY 10.1: Interpreting Trade-offs

10.9 An Individual's Life History Represents the Interaction between Genotype and the Environment

10.10 Mating Systems Describe the Pairing of Males and Females

10.11 Acquisition of a Mate Involves Sexual Selection

Table of Contents

FIELD STUDIES: Alexandra L. Basolo

10.12 Females May Choose Mates Based on Resources

10.13 Patterns of Life History Characteristics Reflect External Selective Forces

ECOLOGICAL ISSUES & APPLICATIONS: The Life History of the Human Population Reflects Technological and Cultural Changes

Summary

Study Questions

Further Readings

Chapter 11 Intraspecific Population Regulation

11.1 The Environment Functions to Limit Population Growth

QUANTIFYING ECOLOGY 11.1: Defining the Carrying Capacity (K)

QUANTIFYING ECOLOGY 11.2: The Logistic Model of Population Growth

11.2 Population Regulation Involves Density Dependence

11.3 Competition Results When Resources Are Limited

11.4 Intraspecific Competition Affects Growth and Development

11.5 Intraspecific Competition Can Influence Mortality Rates

11.6 Intraspecific Competition Can Reduce Reproduction

11.7 High Density Is Stressful to Individuals

FIELD STUDIES: T.Scott Sillett

11.8 Dispersal Can Be Density Dependent

11.9 Social Behavior May Function to Limit Populations

11.10 Territoriality Can Function to Regulate Population Growth

11.11 Plants Preempt Space and Resources

11.12 A Form of Inverse Density Dependence Can Occur in Small Populations

11.13 Density-Independent Factors Can Influence Population Growth

ECOLOGICAL ISSUES & APPLICATIONS: The Conservation of Populations Requires an

Table of Contents

Understanding of Minimum Viable Population Size and Carrying Capacity

Summary

Study Questions

Further Readings

Part 4 Species Interactions

Chapter 12 Species Interactions, Population Dynamics, and Natural Selection

12.1 Species Interactions Can Be Classified Based on Their Reciprocal Effects

12.2 Species Interactions Influence Population

Dynamics

QUANTIFYING ECOLOGY 12.1: Incorporating Competitive Interactions in Models of Population Growth

12.3 Species Interactions Can Function as Agents of Natural Selection

12.4 The Nature of Species Interactions Can Vary across Geographic Landscapes

12.5 Species Interactions Can Be Diffuse

12.6 Species Interactions Influence the Species' Niche

12.7 Species Interactions Can Drive Adaptive Radiation

ECOLOGICAL ISSUES & APPLICATIONS: Urbanization Has Negatively Impacted Most Species while Favoring a Few

Summary

Study Questions

Further Readings

Chapter 13 Interspecific Competition

13.1 Interspecific Competition Involves Two or More Species

13.2 The Combined Dynamics of Two Competing Populations Can Be Examined Using the Lotka–Volterra Model

13.3 There Are Four Possible Outcomes of Interspecific Competition

13.4 Laboratory Experiments Support the Lotka–Volterra Model

13.5 Studies Support the Competitive Exclusion Principle

13.6 Competition Is Influenced by Nonresource

Table of Contents

Factors

13.7 Temporal Variation in the Environment Influences Competitive Interactions

13.8 Competition Occurs for Multiple Resources

13.9 Relative Competitive Abilities Change along Environmental Gradients

QUANTIFYING ECOLOGY 13.1: Competition under Changing Environmental Conditions:
Application of the Lotka-Volterra Model

13.10 Interspecific Competition Influences the Niche of a Species

13.11 Coexistence of Species Often Involves Partitioning Available Resources

13.12 Competition Is a Complex Interaction Involving Biotic and Abiotic Factors

ECOLOGICAL ISSUES & APPLICATIONS: Is Range Expansion of Coyote a Result of
Competitive Release from
Wolves?

Summary

Study Questions

Further Readings

Chapter 14 Predation

14.1 Predation Takes a Variety of Forms

14.2 Mathematical Model Describes the Interaction of Predator and Prey Populations

14.3 Predator-Prey Interaction Results in Population Cycles

14.4 Model Suggests Mutual Population Regulation

14.5 Functional Responses Relate Prey Consumed to Prey Density

QUANTIFYING ECOLOGY 14.1: Type II Functional
Response

14.6 Predators Respond Numerically to Changing Prey Density

14.7 Foraging Involves Decisions about the Allocation of Time and Energy

QUANTIFYING ECOLOGY 14.2: A Simple Model of Optimal
Foraging

14.8 Risk of Predation Can Influence Foraging Behavior

14.9 Coevolution Can Occur between Predator and Prey

14.10 Animal Prey Have Evolved Defenses against

Table of Contents

Predators

14.11 Predators Have Evolved Efficient Hunting

Tactics

14.12 Herbivores Prey on Autotrophs

FIELD STUDIES: Rick A. Relyea

14.13 Plants Have Evolved Characteristics that Deter

Herbivores

14.14 Plants, Herbivores, and Carnivores

Interact

14.15 Predators Influence Prey Dynamics through Lethal and Nonlethal

Effects

ECOLOGICAL ISSUES & APPLICATIONS: Sustainable Harvest of Natural Populations

Requires Being a “Smart

Predator”

Summary

Study Questions

Further Readings

Chapter 15 Parasitism and Mutualism

15.1 Parasites Draw Resources from Host

Organisms

15.2 Hosts Provide Diverse Habitats for

Parasites

15.3 Direct Transmission Can Occur between Host

Organisms

15.4 Transmission between Hosts Can Involve an Intermediate

Vector

15.5 Transmission Can Involve Multiple Hosts and

Stages

15.6 Hosts Respond to Parasitic

Invasions

15.7 Parasites Can Affect Host Survival and

Reproduction

15.8 Parasites May Regulate Host

Populations

15.9 Parasitism Can Evolve into a Mutually Beneficial

Relationship

15.10 Mutualisms Involve Diverse Species

Interactions

15.11 Mutualisms Are Involved in the Transfer of

Nutrients

FIELD STUDIES: John J. Stachowicz

15.12 Some Mutualisms Are Defensive

15.13 Mutualisms Are Often Necessary for

Pollination

15.14 Mutualisms Are Involved in Seed

Table of Contents

Dispersal

15.15 Mutualism Can Influence Population

Dynamics

QUANTIFYING ECOLOGY 15.1: A Model of Mutualistic Interactions

ECOLOGICAL ISSUES & Applications: Land-use Changes Are Resulting in an Expansion of Infectious Diseases Impacting Human Health

Summary

Study Questions

Further Readings

Part 5 Community Ecology

Chapter 16 Community Structure

16.1 Biological Structure of Community Defined by Species

Composition

16.2 Species Diversity Is defined by Species Richness and Evenness

16.3 Dominance Can Be Defined by a Number of Criteria

16.4 Keystone Species Influence Community Structure Disproportionately to Their Numbers

16.5 Food Webs Describe Species

Interactions

16.6 Species within a Community Can Be Classified into Functional Groups

16.7 Communities Have a Characteristic Physical Structure

16.8 Zonation Is Spatial Change in Community Structure

16.9 Defining Boundaries between Communities Is Often Difficult

QUANTIFYING ECOLOGY 16.1: Community Similarity

16.10 Two Contrasting Views of the Community

ECOLOGICAL ISSUES & APPLICATIONS: Restoration Ecology Requires an Understanding of the Processes Influencing the Structure and Dynamics of Communities

Summary

Study Questions

Further Readings

Chapter 17 Factors Influencing the Structure of Communities

17.1 Community Structure Is an Expression of the Species' Ecological Niche

Table of Contents

17.2 Zonation Is a Result of Differences in Species' Tolerance and Interactions along Environmental Gradients

FIELD STUDIES: Sally D. Hacker

17.3 Species Interactions Are Often Diffuse

17.4 Food Webs Illustrate Indirect Interactions

17.5 Food Webs Suggest Controls of Community Structure

17.6 Environmental Heterogeneity Influences Community Diversity

17.7 Resource Availability Can Influence Plant Diversity within a Community

ECOLOGICAL ISSUES & APPLICATIONS: The Reintroduction of a Top Predator to Yellowstone National Park Led to a Complex Trophic Cascade

Summary

Study Questions

Further Readings

Chapter 18 Community Dynamics

18.1 Community Structure Changes through Time

18.2 Primary Succession Occurs on Newly Exposed Substrates

18.3 Secondary Succession Occurs after Disturbances

18.4 The Study of Succession Has a Rich History

18.5 Succession Is Associated with Autogenic Changes in Environmental Conditions

18.6 Species Diversity Changes during Succession

18.7 Succession Involves Heterotrophic Species

18.8 Systematic Changes in Community Structure Are a Result of Allogenic Environmental Change at a Variety of Timescales

18.9 Community Structure Changes over Geologic Time

18.10 The Concept of Community Revisited

ECOLOGICAL ISSUES & APPLICATIONS: Community Dynamics in Eastern North America over the Past Two Centuries Are a Result of Changing Patterns of Land Use

Table of Contents

Summary

Study Questions

Further Readings

Chapter 19 Landscape Dynamics

19.1 A Variety of Processes Gives Rise to Landscape
Patterns

19.2 Landscape Pattern Is Defined by the Spatial Arrangement and Connectivity of
Patches

19.3 Boundaries Are Transition Zones that Offer Diverse Conditions and
Habitats

19.4 Patch Size and Shape Influence Community
Structure

19.5 Landscape Connectivity Permits Movement between
Patches

FIELD STUDIES: Nick A. Haddad

19.6 The Theory of Island Biogeography Applies to Landscape
Patches

19.7 Metapopulation Theory Is a Central Concept in the Study of Landscape
Dynamics

QUANTIFYING ECOLOGY 19.1: Model of Metapopulation
Dynamics

19.8 Local Communities Occupying Patches on the Landscape Define the
Metacommunity

19.9 The Landscape Represents a Shifting Mosaic of Changing
Communities

ECOLOGICAL ISSUES & APPLICATIONS: Corridors Are Playing a Growing Role in
Conservation
Efforts

Summary

Study Questions

Further Readings

Part 6 Ecosystem Ecology

Chapter 20 Ecosystem Energetics

20.1 The Laws of Thermodynamics Govern Energy
Flow

20.2 Energy Fixed in the Process of Photosynthesis Is Primary
Production

20.3 Climate and Nutrient Availability Are the Primary Controls on Net Primary
Productivity in Terrestrial
Ecosystems

20.4 Light and Nutrient Availability Are the Primary Controls on Net Primary
Productivity in Aquatic
Ecosystems

20.5 External Inputs of Organic Carbon Can Be Important to Aquatic

Table of Contents

Ecosystems

20.6 Energy Allocation and Plant Life-Form Influence Primary Production

20.7 Primary Production Varies with Time

20.8 Primary Productivity Limits Secondary Production

20.9 Consumers Vary in Efficiency of Production

20.10 Ecosystems Have Two Major Food Chains

FIELD STUDIES: Brian Silliman

20.11 Energy Flows through Trophic Levels Can Be Quantified

20.12 Consumption Efficiency Determines the Pathway of Energy Flow through the Ecosystem

20.13 Energy Decreases in Each Successive Trophic Level

ECOLOGICAL ISSUES & APPLICATIONS: Humans Appropriate a Disproportionate Amount of Earth's Net Primary Productivity

QUANTIFYING ECOLOGY 20.1: Estimating Net Primary Productivity Using Satellite Data

Summary

Study Questions

Further Readings

Chapter 21 Decomposition and Nutrient Cycling

21.1 Most Essential Nutrients Are Recycled within the Ecosystem

21.2 Decomposition Is a Complex Process Involving a Variety of Organisms

21.3 Studying Decomposition Involves Following the Fate of Dead Organic Matter

QUANTIFYING ECOLOGY 21.1: Estimating the Rate of Decomposition

21.4 Several Factors Influence the Rate of Decomposition

21.5 Nutrients in Organic Matter Are Mineralized During Decomposition

FIELD STUDIES: Edward (Ted) A. G. Schuur

21.6 Decomposition Proceeds as Plant Litter Is Converted into Soil Organic Matter

21.7 Plant Processes Enhance the Decomposition of Soil Organic Matter in the

Table of Contents

Rhizosphere

21.8 Decomposition Occurs in Aquatic Environments

21.9 Key Ecosystem Processes Influence the Rate of Nutrient Cycling

21.10 Nutrient Cycling Differs between Terrestrial and Open-Water Aquatic Ecosystems

21.11 Water Flow Influences Nutrient Cycling in Streams and Rivers

21.12 Land and Marine Environments Influence Nutrient Cycling in Coastal Ecosystems

21.13 Surface Ocean Currents Bring about Vertical Transport of Nutrients

 ECOLOGICAL ISSUES & APPLICATIONS: Agriculture Disrupts the Process of Nutrient Cycling

Summary

Study Questions

Further Readings

Chapter 22 Biogeochemical Cycles

22.1 There Are Two Major Types of Biogeochemical Cycles

22.2 Nutrients Enter the Ecosystem via Inputs

22.3 Outputs Represent a Loss of Nutrients from the Ecosystem

22.4 Biogeochemical Cycles Can Be Viewed from a Global Perspective

22.5 The Carbon Cycle Is Closely Tied to Energy Flow

22.6 Carbon Cycling Varies Daily and Seasonally

22.7 The Global Carbon Cycle Involves Exchanges among the Atmosphere, Oceans, and Land

22.8 The Nitrogen Cycle Begins with Fixing Atmospheric Nitrogen

22.9 The Phosphorus Cycle Has No Atmospheric Pool

22.10 The Sulfur Cycle Is Both Sedimentary and Gaseous

22.11 The Global Sulfur Cycle Is Poorly Understood

22.12 The Oxygen Cycle Is Largely under Biological Control

Table of Contents

22.13 The Various Biogeochemical Cycles Are

Linked

ECOLOGICAL ISSUES & APPLICATIONS: Nitrogen Deposition from Human Activities Can Result in Nitrogen Saturation

Summary

Study Questions

Further Readings

Part 7 Ecological Biogeography

Chapter 23 Terrestrial Ecosystems

23.1 Terrestrial Ecosystems Reflect Adaptations of the Dominant Plant Life-Forms

23.2 Tropical Forests Characterize the Equatorial Zone

QUANTIFYING ECOLOGY 23.1: Climate Diagrams

23.3 Tropical Savannas Are Characteristic of Semiarid Regions with Seasonal Rainfall

23.4 Grassland Ecosystems of the Temperate Zone Vary with Climate and Geography

23.5 Deserts Represent a Diverse Group of Ecosystems

23.6 Mediterranean Climates Support Temperate Shrublands

23.7 Forest Ecosystems Dominate the Wetter Regions of the Temperate Zone

23.8 Conifer Forests Dominate the Cool Temperate and Boreal Zones

23.9 Low Precipitation and Cold Temperatures Define the Arctic Tundra

ECOLOGICAL ISSUES & APPLICATIONS: The Extraction of Resources from Forest Ecosystems Involves an Array of Management Practices

Summary

Study Questions

Further Readings

Chapter 24 Aquatic Ecosystems

24.1 Lakes Have Many Origins

24.2 Lakes Have Well-Defined Physical Characteristics

24.3 The Nature of Life Varies in the Different Zones

24.4 The Character of a Lake Reflects Its Surrounding Landscape

Table of Contents

24.5 Flowing-Water Ecosystems Vary in Structure and Types of Habitats

24.6 Life Is Highly Adapted to Flowing Water

QUANTIFYING ECOLOGY 24.1: Streamflow

24.7 The Flowing-Water Ecosystem Is a Continuum of Changing Environments

24.8 Rivers Flow into the Sea, Forming Estuaries

24.9 Oceans Exhibit Zonation and Stratification

24.10 Pelagic Communities Vary among the Vertical Zones

24.11 Benthos Is a World of Its Own

24.12 Coral Reefs Are Complex Ecosystems Built by Colonies of Coral Animals

24.13 Productivity of the Oceans Is Governed by Light and Nutrients

ECOLOGICAL ISSUES & APPLICATIONS: Inputs of Nutrients to Coastal Waters Result in the Development of "Dead Zones"

Summary

Study Questions

Further Readings

Chapter 25 Coastal and Wetland Ecosystems

25.1 The Intertidal Zone Is the Transition between Terrestrial and Marine Environments

25.2 Rocky Shorelines Have a Distinct Pattern of Zonation

25.3 Sandy and Muddy Shores Are Harsh Environments

25.4 Tides and Salinity Dictate the Structure of Salt Marshes

25.5 Mangroves Replace Salt Marshes in Tropical Regions

25.6 Freshwater Wetlands Are a Diverse Group of Ecosystems

25.7 Hydrology Defines the Structure of Freshwater Wetlands

25.8 Freshwater Wetlands Support a Rich Diversity of Life

ECOLOGICAL ISSUES & APPLICATIONS: Wetland Ecosystems Continue to Decline as a Result of Land Use

Table of Contents

Summary

Study Questions

Further Readings

Chapter 26 Large-Scale Patterns of Biological Diversity

26.1 Earth's Biological Diversity Has Changed through Geologic Time

26.2 Past Extinctions Have Been Clustered in Time

26.3 Regional and Global Patterns of Species Diversity Vary Geographically

26.4 Various Hypotheses Have Been proposed to Explain Latitudinal Gradients of Diversity

26.5 Species Richness Is Related to Available Environmental Energy

26.6 Large-scale Patterns of Species Richness Are Related to Ecosystem Productivity

26.7 Regional Patterns of Species Diversity Are a Function of Processes Operating at Many Scales

ECOLOGICAL ISSUES & APPLICATIONS: Regions of High Species Diversity Are Crucial to Conservation Efforts

Summary

Study Questions

Further Readings

Chapter 27 The Ecology of Climate Change

27.1 Earth's Climate Has Warmed over the Past Century

27.2 Climate Change Has a Direct Influence on the Physiology and Development of Organisms

27.3 Recent Climate Warming Has Altered the Phenology of Plant and Animal Species

27.4 Changes in Climate Have Shifted the Geographic Distribution of Species

27.5 Recent Climate Change Has Altered Species Interactions

27.6 Community Structure and Regional Patterns of Diversity Have Responded to Recent Climate Change

27.7 Climate Change Has Impacted Ecosystem Processes

27.8 Continued Increases in Atmospheric Concentrations of Greenhouse Gases Is

Table of Contents

Predicted to Cause Future Climate Change

27.9 A Variety of Approaches Are Being Used to Predict the Response of Ecological Systems to Future Climate Change

FIELD STUDIES: Erika Zavaleta

27.10 Predicting Future Climate Change Requires an Understanding of the Interactions between the Biosphere and the Other Components of the Earth's System

Summary

Study Questions

Further Readings

References

Glossary

Credits

Index

A
B
C
D
E
F
G
H
I
J
K
L
M
N
O
P
Q
R
S
T
U
V
W

Table of Contents

X

Y

Z