Chapter 13: Biodiversity and Conservation

Comprehensive Study Notes

Class 11/12 Biology - NCERT Based

EXAM SPRINT - Complete Coverage for NEET and Board Examinations

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Introduction

The enormous diversity of life on Earth continues to amaze scientists and common people alike. From over 20,000 species of ants to 300,000 species of beetles, the variety is staggering. This diversity raises fundamental questions about evolution, ecosystem functioning, and human survival.

Key Questions Addressed:

- Why are there so many species?
- Did such diversity exist throughout Earth's history?
- How did diversification occur?
- Why is diversity important to the biosphere?
- How do humans benefit from biodiversity?

13.1 BIODIVERSITY

Definition:

Term popularized by Edward Wilson: Combined diversity at all levels of biological organization, from macromolecules to biomes.

Three Levels of Biodiversity:

1. Genetic Diversity

- **Definition**: Variation within a single species across its distributional range
- **Example**: Rauwolfia vomitoria showing different potency of reserpine in different Himalayan ranges
- **India's Wealth**:
  - 50,000+ genetically different strains of rice
  - 1,000+ varieties of mango

2. Species Diversity

- **Definition**: Diversity at the species level within ecosystems
- **Example**: Western Ghats have greater amphibian species diversity than Eastern Ghats
- **Measurement**: Number of different species in a given area

3. Ecological Diversity

- **Definition**: Diversity at ecosystem level
- **India's Example**: Deserts, rainforests, mangroves, coral reefs, wetlands, estuaries, alpine meadows
- **Comparison**: India has greater ecosystem diversity than Norway

Temporal Perspective:

- **Evolution Time**: Millions of years to accumulate diversity
- **Loss Rate**: Could lose all wealth in <200 years at current rates
- **Conservation Priority**: Vital environmental issue of international concern

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13.1.1 HOW MANY SPECIES ARE THERE?

Global Species Count (IUCN 2004):

- **Described Species**: 1.5 million+ plant and animal species
- **Undiscovered Species**: Unknown number waiting to be found

Estimation Methods:

- **Statistical Comparison**: Temperate vs tropical species richness
- **Extrapolation**: From well-studied insect groups to other taxa
- **Estimates Range**: 20-50 million (extreme) to 7 million (conservative - Robert May)

Current Biodiversity Statistics:

Global Distribution:

- **Animals**: >70% of all recorded species
- **Plants**: 22% (including algae, fungi, bryophytes, gymnosperms, angiosperms)
- **Insects Dominance**: >70% of animal species
- **Ratio**: 7 out of 10 animals are insects
- **Fungi**: More species than fishes, amphibians, reptiles, and mammals combined

Prokaryotic Challenge:

- **Problem**: Conventional taxonomy unsuitable for microbes
- **Unculturable**: Many species cannot be grown in laboratory
- **Potential**: Biochemical/molecular criteria could reveal millions of species

India's Biodiversity Wealth:

Global Significance:

- **Land Area**: Only 2.4% of world's land
- **Species Share**: 8.1% of global species diversity
- **Status**: One of 12 mega-diversity countries

Current Records:

- **Plants**: 45,000 species
- **Animals**: 90,000 species (twice as many as plants)

Undiscovered Potential:

- **May's Estimate**: Only 22% of total species recorded globally
- **India's Projection**:
  - 100,000+ plant species yet to be discovered
  - 300,000+ animal species waiting to be found
- **Challenge**: Species extinction before discovery ("Nature's library burning")

13.1.2 PATTERNS OF BIODIVERSITY

1. Latitudinal Gradients

General Pattern:

Species diversity decreases from equator to poles

Evidence:

- **Tropics** (23.5°N to 23.5°S): Harbor more species than temperate/polar areas
- **Bird Species Examples**:
  - Colombia (near equator): 1,400 species
  - New York (41°N): 105 species
  - Greenland (71°N): 56 species
  - India (tropical latitudes): 1,200+ species

Plant Diversity:

- **Tropical Forest**: Up to 10 times more vascular plant species than temperate forest of equal area
- **Amazon Rainforest**: Greatest biodiversity on Earth
  - 40,000+ plant species
  - 3,000 fish species
  - 1,300 bird species
  - 427 mammal species
  - 427 amphibian species
  - 378 reptile species
  - 125,000+ invertebrates
  - 2 million+ undiscovered insect species (estimated)

Hypotheses for Tropical Richness:

A. Time Hypothesis:

- **Speciation Function**: Generally depends on time
- **Tropical Stability**: Remained undisturbed for millions of years
- **Temperate Disruption**: Frequent glaciations in the past

- **Result**: Long evolutionary time for species diversification

B. Environmental Stability:

- **Tropical Constancy**: Less seasonal, more predictable environment
- **Niche Specialization**: Constant conditions promote specialization
- **Outcome**: Greater species diversity through specialized niches

C. Energy Hypothesis:

- **Solar Energy**: More available in tropics
- **Higher Productivity**: Contributes to ecosystem productivity
- **Indirect Effect**: Higher productivity supports greater diversity

2. Species-Area Relationships

Alexander von Humboldt's Observation:

Species richness increases with area but only up to a limit

Mathematical Relationship:

Rectangular Hyperbola: S = CA^Z

Logarithmic Form: log S = log C + Z log A

Where:

- **S** = Species richness
- **A** = Area
- **Z** = Slope (regression coefficient)
- **C** = Y-intercept

Z-Value Patterns:

- **Small Areas**: Z = 0.1 to 0.2 (regardless of taxonomic group or region)
- **Examples**: Plants in Britain, birds in California, molluscs in New York
- **Large Areas** (continents): Z = 0.6 to 1.2 (steeper slopes)
- **Frugivorous Birds/Mammals**: Tropical forests, Z = 1.15

Significance of Steeper Slopes:

Higher sensitivity to area changes in large-scale ecosystems

13.1.3 IMPORTANCE OF SPECIES DIVERSITY

Ecosystem Functioning Question:

Does species number matter for ecosystem functioning?

Historical Perspective:

Ecologists traditionally believed more species = more stability

Stability Definitions:

- **Productivity Stability**: Minimal year-to-year variation
- **Resistance**: Withstands disturbances
- **Resilience**: Recovers from disturbances
- **Invasion Resistance**: Resistant to alien species

David Tilman's Experiments:

Findings:

- **Biomass Variation**: Plots with more species showed less year-to-year variation
- **Productivity**: Increased diversity contributed to higher productivity
- **Long-term Studies**: Outdoor plot experiments provided evidence

Rivet Popper Hypothesis (Paul Ehrlich):

Analogy:

- **Airplane** = Ecosystem
- **Rivets** = Species
- **Passenger Removing Rivets** = Species extinction

Implications:

- **Initial Effect**: May not affect functioning immediately
- **Cumulative Effect**: System becomes dangerously weak over time
- **Critical Species**: Loss of key species (wing rivets) more serious than others

Message:

Rich biodiversity essential for ecosystem health and human survival

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13.1.4 LOSS OF BIODIVERSITY

Current Extinction Crisis:

Historical Context:

- **Five Previous Mass Extinctions**: Occurred before human arrival
- **Sixth Extinction**: Currently in progress

- **Key Difference**: Current rates 100-1000 times faster than pre-human times

Extinction Statistics:

Recent Losses (IUCN Red List 2004):

- **Total Extinctions** (last 500 years): 784 species
  - 338 vertebrates
  - 359 invertebrates
  - 87 plants

Famous Extinctions:

- **Dodo** (Mauritius)
- **Quagga** (Africa)
- **Thylacine** (Australia)
- **Steller's Sea Cow** (Russia)
- **Tiger Subspecies**: Bali, Javan, Caspian
- **Recent** (last 20 years): 27 species disappeared

Current Threats:

- **Worldwide**: 15,500+ species facing extinction threat
- **Birds**: 12% of all species
- **Mammals**: 23% of all species
- **Amphibians**: 32% of all species (most vulnerable)
- **Gymnosperms**: 31% of all species

Future Projections:

If current trends continue: Nearly 50% of species could be extinct within 100 years

Consequences of Biodiversity Loss:

1. **Decline in plant production**
2. **Lowered resistance** to environmental perturbations
3. **Increased variability** in ecosystem processes

THE EVIL QUARTET - Causes of Biodiversity Loss

1. Habitat Loss and Fragmentation

Most Important Cause of extinctions

Tropical Rainforest Example:

- **Historical Coverage**: >14% of Earth's land surface
- **Current Coverage**: <6% of Earth's land surface
- **Destruction Rate**: 1000 hectares lost while reading this chapter

Amazon Rainforest:

- **Nickname**: "Lungs of the planet"
- **Threats**:
  - Cleared for soya bean cultivation
  - Converted to grasslands for beef cattle
  - Habitat degradation through pollution

Fragmentation Effects:

- **Large Territory Animals**: Mammals and birds badly affected
- **Migratory Species**: Disrupted migration patterns
- **Population Declines**: Small fragments cannot support viable populations

2. Over-exploitation

Definition: When 'need' turns to 'greed'

Historical Examples:

- **Steller's Sea Cow**: Extinct due to over-hunting
- **Passenger Pigeon**: Over-exploited to extinction

Current Threats:

- **Marine Fish**: Many populations over-harvested globally
- **Commercial Species**: Endangered due to unsustainable harvesting

3. Alien Species Invasions

Definition: Introduction of non-native species causing native species decline

Major Examples:

Nile Perch in Lake Victoria:

- **Introduction**: East Africa
- **Result**: Extinction of 200+ cichlid fish species
- **Impact**: Loss of ecologically unique assemblage

Indian Examples:

- **Carrot Grass** (Parthenium): Invasive weed

- **Lantana**: Threatens native vegetation
- **Water Hyacinth** (Eicchornia): Clogs waterways
- **African Catfish** (Clarias gariepinus): Threatens indigenous catfish

4. Co-extinctions

Definition: Extinction of associated species when host species becomes extinct

Examples:

- **Host-Parasite**: Fish extinction leads to parasite extinction
- **Plant-Pollinator**: Co-evolved mutualistic relationships
- **Obligatory Associations**: One species' extinction causes another's

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13.2 BIODIVERSITY CONSERVATION

13.2.1 Why Should We Conserve?

Three Categories of Arguments:

1. Narrowly Utilitarian

Direct Economic Benefits:

- **Food**: Cereals, pulses, fruits
- **Materials**: Firewood, fiber, construction materials
- **Industrial Products**: Tannins, lubricants, dyes, resins, perfumes
- **Medicines**: 25% of current drugs derived from plants
- **Traditional Medicine**: 25,000 plant species used globally
- **Bioprospecting**: Molecular and genetic exploration for economic products

2. Broadly Utilitarian

Ecosystem Services:

- **Oxygen Production**: Amazon produces 20% of atmospheric oxygen
- **Pollination Services**: Bees, bumblebees, birds, bats
- **Economic Value**: Cost of artificial pollination vs natural
- **Intangible Benefits**: Aesthetic pleasures, psychological well-being

Examples:

- **Walking through forests**
- **Spring flowers in bloom**
- **Bird songs in morning**

3. Ethical Arguments

Moral Responsibility:

- **Intrinsic Value**: Every species has value regardless of economic importance
- **Shared Planet**: Moral duty to care for other species
- **Future Generations**: Pass biological legacy in good order
- **Philosophical Perspective**: Spiritual connection to biodiversity

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13.2.2 HOW DO WE CONSERVE BIODIVERSITY?

Two Main Approaches:

A. In Situ Conservation (On Site)

Principle: Protect entire ecosystem to save species

Global Strategy: Biodiversity Hotspots

- **Definition**: Regions with high species richness and high endemism
- **Original**: 25 hotspots identified
- **Current**: 34 hotspots worldwide
- **Coverage**: <2% of Earth's land area
- **Species**: Collectively harbor extremely high number of species
- **Protection Impact**: Could reduce ongoing extinctions by 30%

India's Hotspots:

1. **Western Ghats and Sri Lanka**
2. **Indo-Burma**
3. **Himalaya**

India's Protected Areas:

- **Biosphere Reserves**: 14
- **National Parks**: 90
- **Wildlife Sanctuaries**: 448

Sacred Groves:

Traditional Conservation: Religious and cultural protection

Locations:

- **Meghalaya**: Khasi and Jaintia Hills
- **Rajasthan**: Aravalli Hills
- **Karnataka and Maharashtra**: Western Ghat regions
- **Madhya Pradesh**: Sarguja, Chanda, Bastar areas

Significance: Last refuges for rare and threatened plants

B. Ex Situ Conservation (Off Site)

Definition: Threatened species removed from natural habitat for special care

Traditional Methods:

- **Zoological Parks**: Animal conservation and breeding
- **Botanical Gardens**: Plant conservation and research
- **Wildlife Safari Parks**: Semi-natural conservation

Modern Techniques:

Cryopreservation:

- **Gametes**: Preserved in viable condition for long periods
- **Long-term Storage**: Genetic material banking

Assisted Reproduction:

- **In Vitro Fertilization**: Eggs fertilized outside body
- **Breeding Programs**: Captive breeding for reintroduction

Plant Propagation:

- **Tissue Culture**: Vegetative propagation methods
- **Seed Banks**: Long-term storage of genetic strains
- **Commercial Plants**: Different genetic varieties preserved

Applications:

- **Extinct in Wild**: Species maintained only in captivity
- **Breeding Programs**: Reintroduction to wild
- **Genetic Banking**: Preserve genetic diversity

INTERNATIONAL CONSERVATION EFFORTS

Convention on Biological Diversity (1992):

- **Location**: Rio de Janeiro ("Earth Summit")
- **Objective**: Conservation and sustainable utilization
- **Scope**: Called upon all nations for biodiversity measures

World Summit on Sustainable Development (2002):

- **Location**: Johannesburg, South Africa
- **Participants**: 190 countries
- **Target**: Significant reduction in biodiversity loss by 2010
- **Levels**: Global, regional, and local conservation efforts

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NEET-Specific Important Points

High-Yield Topics:

1. Biodiversity Levels:

- Three types with examples
- Genetic, species, ecosystem diversity
- India's biodiversity statistics

2. Species Distribution Patterns:

- Latitudinal gradient concept
- Species-area relationship
- Mathematical expressions

3. Conservation Methods:

- In situ vs ex situ conservation
- Biodiversity hotspots
- Sacred groves importance

4. Extinction Causes:

- The Evil Quartet
- Human impact assessment
- Conservation urgency

Common NEET Question Patterns:

1. Statistical Questions:

- Biodiversity numbers and percentages
- India's share in global diversity
- Extinction rates and threats

2. Concept Application:

- Conservation strategy selection
- Hotspot identification
- Ecosystem service examples

3. Cause-Effect Relationships:

- Extinction causes and consequences
- Conservation methods and outcomes
- Human activities and biodiversity loss

Memory Aids and Mnemonics

Biodiversity Levels:

"GSE - Genes, Species, Ecosystems"

- **G**enetic diversity
- **S**pecies diversity
- **E**cosystem diversity

Evil Quartet:

"HOAC - Habitat, Over-exploitation, Alien, Co-extinction"

- **H**abitat loss and fragmentation
- **O**ver-exploitation
- **A**lien species invasion
- **C**o-extinctions

Conservation Arguments:

"NuBE - Narrow, Broad, Ethical"

- **N**arrowly utilitarian
- **B**roadly utilitarian
- **E**thical arguments

Tropical Richness Hypotheses:

"TSE - Time, Stability, Energy"

- **T**ime hypothesis (evolutionary time)
- **S**tability hypothesis (environmental constancy)
- **E**nergy hypothesis (solar energy/productivity)

Practice Questions for NEET

Multiple Choice Questions:

1. Which level of biodiversity is represented by different varieties of rice? a) Species diversity b) Genetic diversity c) Ecosystem diversity d) Functional diversity
2. The most important cause of biodiversity loss is: a) Over-exploitation b) Alien species c) Habitat loss d) Co-extinction

3. India's share in global species diversity is: a) 2.4% b) 8.1% c) 12% d) 22%

Short Answer Questions:

1. Explain the species-area relationship with mathematical expression.
2. What are biodiversity hotspots? Name India's three hotspots.
3. Differentiate between in situ and ex situ conservation with examples.

Long Answer Questions:

1. Discuss the patterns of biodiversity distribution with suitable examples.
2. Explain the causes of biodiversity loss (Evil Quartet) with examples.
3. Describe the importance of biodiversity conservation with different arguments.

Summary Table: Biodiversity Overview

Aspect	Details	Examples/Statistics
Global Species	1.5+ million described	7 million estimated total
Composition	70% animals, 22% plants	70% of animals are insects
India's Share	8.1% species, 2.4% land	45K plants, 90K animals
Threats	Evil Quartet causes	784 extinctions in 500 years
Hotspots	34 globally	3 in India
Protection	In situ + Ex situ	552 protected areas in India

Key Equations to Remember

1. **Species-Area Relationship**: $\log S = \log C + Z \log A$

2. **Current Extinction Rate**: 100-1000 times pre-human rates
3. **Hotspot Coverage**: <2% land area, 30% extinction reduction potential
4. **Medicine Source**: 25% drugs from plants, 25,000 medicinal species

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EXAM SPRINT - Master biodiversity through understanding distribution patterns, conservation strategies, and human impacts. Focus on numerical data, conservation methods, and cause-effect relationships for NEET success. Regular practice with application-based questions essential for comprehensive preparation.