Functions of an Ecosystem

Main Functions:

1. **Energy Flow** - The transfer of energy through different trophic levels within the ecosystem. It begins with producers and flows through various consumers and decomposers.
2. **Nutrient Cycling (Biogeochemical Cycles)** - The circulation and transformation of nutrients through the living (biotic) and non-living (abiotic) components of the ecosystem. Important cycles include the carbon, nitrogen, and phosphorus cycles.
3. **Ecological Succession** - The process by which the structure of a biological community evolves over time. It involves stages of species colonization and replacement until a stable climax community is reached.

Energy Flow

Trophic Levels:

1. **Producers (Autotrophs)** - Organisms that produce their own food through photosynthesis or chemosynthesis. Examples include green plants and algae.
2. **Primary Consumers (Herbivores)** - Organisms that feed on producers. Examples include cows, rabbits, and caterpillars.
3. **Secondary Consumers (Carnivores)** - Organisms that feed on primary consumers. Examples include snakes and frogs.
4. **Tertiary Consumers** - Organisms that feed on secondary consumers. Examples include eagles and big fish.
5. **Quaternary Consumers (Top Carnivores)** - Apex predators that have no natural predators. Examples include lions and sharks.

Key Points:

- **Unidirectional Flow:** Energy flows in one direction from producers to various levels of consumers and is not recycled.
- **Energy Loss:** At each trophic level, energy is lost as heat due to metabolic processes. This loss limits the number of trophic levels.
- **Efficiency:** Only about 10% of the energy from one trophic level is transferred to the next level, known as the 10% law.

Food Chains and Food Webs

Food Chain:

- A linear sequence of organisms where each organism is eaten by the next one in the chain.
- **Example:** Grass → Grasshopper → Frog → Snake → Hawk

Types of Food Chains:

1. **Grazing Food Chain:**

- Starts with living green plants and moves through herbivores to carnivores.
- **Terrestrial Example:** Grass → Caterpillar → Lizard → Snake
- **Aquatic Example:** Phytoplankton → Zooplankton → Fish → Pelican

2. **Detritus Food Chain:**
   - Begins with dead organic matter and moves through decomposers and detritivores to higher-level predators.
   - **Example:** Dead leaves → Earthworms → Chicken → Hawk

Food Web:

- A complex network of interconnected food chains in an ecosystem.
- **Interconnected Chains:** Provides multiple pathways for energy flow, increasing stability and resilience.
- **Example:** In a grassland, grass can be eaten by rabbits, grasshoppers, goats, or cows, and these herbivores can be prey for multiple predators.

Ecological Pyramids

Types of Pyramids:

1. **Pyramid of Numbers:**
   - Illustrates the number of individual organisms at each trophic level.
   - **Upright Pyramid:** Common in grasslands, where the number of producers (grasses) is very high compared to consumers (grasshoppers, rats, snakes, hawks).
   - **Inverted Pyramid:** Common in forests, where few large producers (trees) support many herbivores (birds) and even more parasites and hyperparasites.

2. **Pyramid of Biomass:**
   - Represents the total biomass (dry weight) of all organisms at each trophic level.
   - **Upright Pyramid:** Common in terrestrial ecosystems where biomass decreases from producers to top carnivores.
   - **Inverted Pyramid:** Seen in aquatic ecosystems where small, rapidly reproducing producers (phytoplankton) support larger consumers (zooplankton, fish).

3. **Pyramid of Energy:**
   - Illustrates the flow of energy through each trophic level.
   - **Always Upright:** Energy decreases at each trophic level due to loss as heat, reflecting the laws of thermodynamics.
   - **Example:** If an ecosystem receives 1000 kcal of solar energy, only 100 kcal is stored in plants, 10 kcal in herbivores, and 1 kcal in carnivores.

Pollutants and Trophic Levels

Processes:

1. **Bioaccumulation:**

- Refers to the accumulation of pollutants in an organism from the environment.
- **Example:** Pesticides accumulating in the tissues of a plant.

2. **Biomagnification:**

- Refers to the increase in concentration of pollutants at each successive trophic level.
- **Example:** Mercury accumulating in fish, with higher concentrations in larger predatory fish.

Nondegradable Pollutants:

- Pollutants that cannot be broken down by living organisms and hence persist in the environment, such as DDT and PCBs.
- These pollutants can cause serious health issues as they accumulate in the food chain.

Biotic Interactions

Types of Interactions:

1. **Mutualism:** Both species benefit.
   - **Example:** Bees pollinating flowers while obtaining nectar.
2. **Commensalism:** One species benefits, the other is unaffected.
   - **Example:** Barnacles on whales, where barnacles get transportation and access to plankton.
3. **Competition:** Both species are harmed by the interaction.
   - **Example:** Two predators competing for the same prey.
4. **Predation:** One species benefits (predator), the other is harmed (prey).
   - **Example:** A lion hunting a zebra.
5. **Parasitism:** One species benefits (parasite), the other is harmed (host).
   - **Example:** Ticks feeding on a deer.
6. **Amensalism:** One species is harmed, the other is unaffected.
   - **Example:** A large tree shading smaller plants.
7. **Neutralism:** Neither species benefits or is harmed.
   - **Example:** Two species coexisting in the same habitat without affecting each other.

Biogeochemical Cycles

Types of Cycles:

1. **Gaseous Cycles:**

   - **Water Cycle (Hydrologic):**
     - Continuous movement of water through evaporation, transpiration, condensation, and precipitation.
     - Important for nutrient transportation and as a solvent for biochemical reactions.
   - **Carbon Cycle:**
     - Involves the movement of carbon through photosynthesis, respiration, decomposition, and combustion.
     - Short-term cycle includes photosynthesis and respiration.
     - Long-term cycle involves carbon storage in fossil fuels and sedimentary rocks.

- **Nitrogen Cycle:**
  - Conversion of atmospheric nitrogen (N_2) into usable forms (ammonia, nitrates) through nitrogen fixation.
  - Nitrogen is essential for the synthesis of amino acids and proteins.

2. **Sedimentary Cycles:**

- **Phosphorus Cycle:**
  - Phosphorus moves from rocks to soil and water bodies through weathering and erosion.
  - Essential for DNA, RNA, and ATP.
- **Sulfur Cycle:**
  - Sulfur moves from rocks and sediments to the atmosphere through weathering, volcanic activity, and decomposition.
  - Essential for amino acids and proteins.

Interconnected Cycles:

- Nutrient cycles interact with each other and are crucial for maintaining ecosystem balance and supporting life.

Ecological Succession

Types of Succession:

1. **Primary Succession:**

- Occurs on newly formed habitats without soil, such as volcanic lava or glacial retreat areas.
- **Pioneer Species:** First organisms to colonize, such as lichens and mosses.
- **Soil Formation:** Pioneer species break down rocks, accumulating organic matter to form soil.
- **Community Development:** Gradual replacement of pioneer species by more complex plant and animal communities until a stable climax community is established.

2. **Secondary Succession:**

- Occurs in areas where a climax community has been disturbed but soil remains, such as after a forest fire or agricultural abandonment.
- **Stages:** Rapid colonization by pioneer species, followed by intermediate species, and finally the return of a stable climax community.

Characteristics:

- **Increased Productivity:** More biomass production as succession progresses.
- **Nutrient Shift:** Movement of nutrients from non-living to living components.
- **Increased Diversity:** More species and niches develop, enhancing ecosystem complexity.
- **Complex Food Webs:** More interactions among species, leading to a stable and resilient ecosystem.

TERRESTRIAL ECOSYSTEMS

3.1 Tundra

Characteristics:

- **Climate:**
  - Extremely cold with temperatures often below freezing.
  - Short growing season (about 50-60 days).
  - Low precipitation, mostly as snow.
- **Soil:**
  - Poorly developed due to permafrost (permanently frozen subsoil).
  - Low in nutrients and organic material.
- **Vegetation:**
  - Dominated by mosses, lichens, sedges, and dwarf shrubs.
  - Plants have shallow root systems due to permafrost.
  - Adaptations include thick cuticles, small leaves, and antifreeze proteins.

Adaptations:

- **Plants:**
  - Arctic willow has a long lifespan (150-300 years).
  - Protected by thick cuticles and epidermal hair to reduce water loss and withstand cold.
- **Animals:**
  - Mammals like caribou and Arctic foxes have large bodies, small ears, and tails to minimize heat loss.
  - Fur and blubber provide insulation.
  - Insects have short life cycles to exploit the brief summer.

3.2 Forest Ecosystem

Types of Forests:

1. **Coniferous Forest (Boreal Forest):**
   - **Climate:**
     - Long, cold winters and short, cool summers.
     - Moderate to high rainfall, often as snow.
   - **Vegetation:**
     - Dominated by coniferous trees such as pines, firs, spruces, and larches.
     - Adaptations include needle-like leaves and antifreeze proteins to survive harsh winters.
   - **Soil:**
     - Acidic, nutrient-poor, and often frozen.
2. **Temperate Forest:**
   - **Climate:**
     - Moderate temperatures with distinct seasons.
     - Sufficient rainfall to support dense forests.
   - **Vegetation:**
     - Deciduous trees (e.g., oaks, maples, beeches) shed leaves in winter.

        - Evergreen trees (e.g., pines) retain leaves year-round.
    - **Soil:**
        - Podzolic, fairly deep, and rich in organic matter.
    - **Importance:**
        - Fire plays a role in regeneration by clearing old vegetation and allowing new growth.

3. **Tropical Rainforest:**

    - **Climate:**
        - Near the equator with high temperatures and humidity.
        - Rainfall exceeds 2000 mm per year.
    - **Vegetation:**
        - Extremely high biodiversity.
        - Layers include emergent trees, canopy, understory, and forest floor.
        - Adaptations include large leaves for photosynthesis, buttress roots for stability, and epiphytes like orchids and bromeliads.
    - **Soil:**
        - Nutrient-poor due to rapid decomposition and leaching.
    - **Locations:**
        - Found in Southeast Asia, Central and South America, Northern Australia, Western Africa, and parts of India.

4. **Temperate Rainforest:**

    - **Climate:**
        - High rainfall with frequent fog, especially important in water balance.
        - Moderate temperatures with seasonal variation.
    - **Vegetation:**
        - High biotic diversity but less than tropical rainforests.
        - Includes large evergreen trees, mosses, ferns, and lichens.

Importance of Forests:

- **Ecological:**
    - Maintain biodiversity.
    - Regulate climate and water cycles.
    - Prevent soil erosion and act as carbon sinks.
- **Economic:**
    - Provide timber, fuel, medicinal plants, and raw materials.
    - Support livelihoods through forest products and ecotourism.

3.4 Deforestation

Causes:

1. **Shifting Cultivation:**
    - Traditional agricultural practice where land is cleared, used for a few years, and then abandoned.
    - Leads to soil degradation and loss of forest cover.
2. **Development Projects:**

    - Infrastructure projects like dams, roads, and urban expansion require land clearance.
    - Result in large-scale deforestation.
3. **Fuel Requirements:**
    - High demand for firewood due to population growth.
    - Leads to unsustainable tree cutting.
4. **Raw Material Requirements:**
    - Wood and other forest products are vital for industries.
    - Overexploitation of resources like timber, rubber, and medicinal plants.
5. **Other Causes:**
    - Overgrazing by livestock.
    - Mining activities.
    - Urbanization and industrial activities.
    - Natural disasters like floods and fires.

Effects:

- **Environmental:**
    - Loss of biodiversity and habitat destruction.
    - Disruption of water cycles and reduction in precipitation.
    - Increased soil erosion and land degradation.
    - Climate change due to loss of carbon sinks.
- **Social:**
    - Displacement of indigenous communities.
    - Loss of livelihoods dependent on forest resources.

3.5 Grassland Ecosystem

Types of Grasslands:

1. **Semi-Arid Zone:**
    - Found in Northern Gujarat, Rajasthan, Western Uttar Pradesh, Delhi, and Punjab.
    - Characterized by hill spurs and sand dunes.
2. **Dry Sub-Humid Zone:**
    - Covers most of peninsular India.
3. **Moist Sub-Humid Zone:**
    - Found in the Ganga alluvial plain in Northern India.
    - Level, low-lying, and poorly drained topography.
4. **Humid Montane Regions:**
    - Includes Assam, Manipur, West Bengal, Uttar Pradesh, Punjab, Himachal Pradesh, and Jammu & Kashmir.
    - Savannas derived from humid forests due to shifting cultivation and grazing.

Economic Importance:

- **Livestock Grazing:**
    - Supports large populations of domesticated animals.
    - Provides fuel, draught power, nutrition, and raw materials.
- **Biodiversity:**

- Maintains populations of wild herbivores.
- Supports various ecosystems and food chains.

Impact of Grazing:

- Overgrazing leads to soil degradation, reduced grass cover, and erosion.
- Changes in microclimate and disruption of biogeochemical cycles.

Role of Fire:

- Maintains grasslands by preventing shrub and tree invasion.
- Increases forage yield under controlled burning conditions.

3.6 Desert Ecosystem

Characteristics:

- **Climate:**
  - Low rainfall (<25 cm annually).
  - Extreme temperature variations between day and night.
- **Vegetation:**
  - Sparse, drought-resistant plants like cacti and shrubs.
  - Adaptations include deep root systems, small leaves, and succulence.

Types of Deserts:

1. **Hot Deserts (e.g., Thar Desert):**
   - High temperatures, low humidity, and scanty rainfall.
   - Plants include deep-rooted shrubs and succulents.
   - Animals adapted to conserve water and avoid heat.
2. **Cold Deserts (e.g., Ladakh, Leh, Kargil):**
   - Extreme cold with low precipitation.
   - Sparse vegetation and specialized fauna like Tibetan antelope and snow leopards.

Adaptations:

- **Plants:**
  - Conserve water through succulence, reduced leaf size, and deep root systems.
  - Germinate, bloom, and reproduce during short rainy seasons.
- **Animals:**
  - Physiological and behavioral adaptations to conserve water.
  - Nocturnal habits to avoid daytime heat.
  - Adaptations like long legs, fast running, and concentrated urine.

3.7 Desertification

Causes:

- **Human Activities:**

    - Overgrazing, deforestation, unsustainable agriculture, and mining.
    - Population pressure and urbanization.

Status in India:

- 69.6% of land is under drylands.
- 32.07% of total land area undergoing land degradation.
- 81.45 million hectares affected by desertification.

Control Measures:

- National Action Programme for combating desertification.
- Integrated Watershed Management Programme.
- National Afforestation Programme.
- Mahatma Gandhi National Rural Employment Guarantee Scheme.
- Soil Conservation in River Catchments and Flood Prone Areas.
- Desert Development Programme.

Afforestation:

- Essential for preventing soil erosion and modifying hostile climates.
- Crucial for meeting local demands for firewood, timber, and fodder.

3.8 Indian State of Forest Report, 2017

Key Findings:

- **Forest Cover:**
    - Total forest and tree cover is 24.39% of the total geographical area.
    - Increase of 8,021 sq km (1%) compared to 2015.
    - Very dense forest (VDF) has increased by 1.36%.
    - Madhya Pradesh has the largest forest cover, followed by Arunachal Pradesh and Chhattisgarh.
- **Percentage Cover:**
    - Mizoram has the highest forest cover percentage (88.93%), followed by Lakshadweep (84.56%).
    - 15 states/UTs have above 33% forest cover.
    - Seven states/UTs have more than 75% forest cover.
    - Eight states have forest cover between 33% and 75%.
- **Global Ranking:**
    - India ranks 10th in forest cover and 8th in net forest area gain.

These highly detailed notes should provide a deep understanding of the chapter, covering all key points and intricate details for your exams. If you need further details on specific topics, feel free to ask!