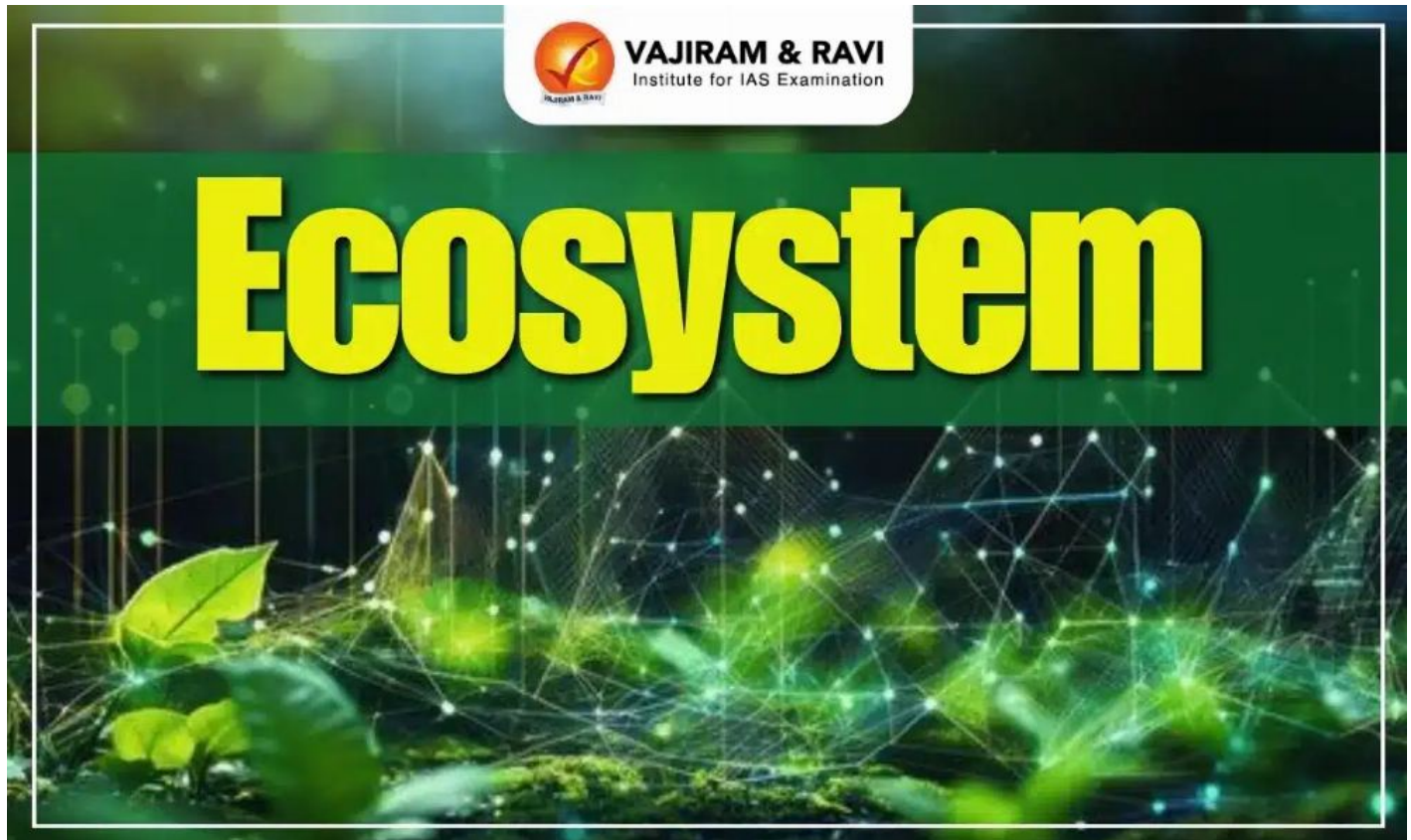


Ecosystem, Meaning, Structure, Functions, Types, UPSC Notes

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Ecosystems, coined by **Arthur Tansley in 1935**, are dynamic systems where living organisms interact with their non-living environment. They vary in composition, species diversity, and non-biological components, involving energy flow and material cycling. It can be as large as the entire Biosphere itself or as small as a log of wood, each hosting the various components of the ecosystem interacting together.

The study of ecosystems focuses on their structure and function. These complex systems face threats that can degrade, fragment, or destroy them, impacting the delicate balance crucial for supporting life. Understanding these threats is vital for preserving biodiversity and the health of the ecosystems globally.

Components of Ecosystem

An ecosystem consists of two main components: biotic and abiotic.

- **Biotic components:** These are the living organisms present in an ecosystem, including:
 - **Producers** (autotrophs): Organisms that produce their food through **photosynthesis** (plants, algae, and certain bacteria) are autotrophs. They form the base of the food chain and are essential for energy

flow in ecosystems.

- **Consumers** (heterotrophs): These are organisms that consume other organisms for food.
 - **Primary consumers (herbivores):** Organisms that feed directly on producers. Examples: deer, rabbits, grasshoppers, etc.
 - **Secondary consumers (carnivores):** Organisms that feed on primary consumers. Examples: snakes, foxes, owls etc.
 - **Tertiary consumers (top predators):** Organisms at the top of the food chain that feed on secondary consumers. Examples: lions, sharks, eagles, humans, etc.
- **Decomposers** (detritivores): Organisms that break down dead organic matter, releasing nutrients back into the ecosystem. Examples: bacteria, fungi, earthworms). They play a crucial role in nutrient cycling.
- **Keystone species:** These are species that play a disproportionately large role in maintaining the structure and functioning of an ecosystem relative to their abundance.
 - Their removal or decline can have cascading effects on the entire ecosystem.
- **Ecological Niche:** A niche is the **functional role or position of a species** within an ecosystem, including its behaviour, activities, and interactions with the biotic and abiotic environment.
 - Each species occupies a unique niche, allowing for coexistence and efficient resource utilisation.
- **Abiotic components:** These are the non-living physical and chemical factors present in an ecosystem, including **Sunlight, Temperature, Water, Soil, Air, Minerals and Nutrients.**

Types of Ecosystem

Ecosystems can be classified based on various factors, such as their physical characteristics, location, and dominant species. Here are some common types of ecosystems:

- **Terrestrial Ecosystems:**
 - Forest Ecosystems (tropical rainforests, temperate forests, boreal forests)
 - Grassland Ecosystems (savannas, prairies, steppes)
 - Desert Ecosystems (hot and cold deserts)
 - Tundra Ecosystems (Arctic tundra, Alpine tundra)
- **Aquatic Ecosystems:**
 - Freshwater Ecosystems (lakes, rivers, ponds, wetlands)
 - Marine Ecosystems (oceans, coral reefs, estuaries, mangroves)
- **Artificial Ecosystems:**
 - Urban Ecosystems (cities, parks, gardens)
 - Agricultural Ecosystems (croplands, pastures, orchards)

Ecotone

Ecotone is a **transition zone between two ecosystems**, varying in width and occurring locally or regionally.

- It hosts species from both adjacent ecosystems and includes examples like **marshlands, mangrove forests, and estuaries.**

- Generally, the biodiversity in an ecotone is higher than the two constituting ecosystems. This is called the **edge effect**.

Functioning of Ecosystem

Ecosystems function through various processes and interactions between their biotic and abiotic components. These processes include the flow of energy and material (nutrients) among the components of the ecosystem, which are essential for maintaining the balance and sustainability of the ecosystem.

Productivity

Ecosystems rely on solar energy, which plants convert into biomass through photosynthesis, a process known as **Primary Production**. The rate of this production is called **Productivity**.

- **Standing crop and Biomass:** Standing crop refers to the mass of living material (organisms) at a specific time within a trophic level.
 - It can be measured either as **biomass** (fresh or dry weight) or as the **number of organisms per unit area**.
 - Measuring biomass in terms of **dry weight** is more accurate because it accounts for variations due to water content.
- **Productivity is categorised into:**
 - **Gross Primary Productivity (GPP):** It is the total organic matter produced by photosynthesis. Plants use a portion of this for respiration.
 - **Net Primary Productivity (NPP):** The remaining organic matter after subtracting respiration from GPP, is available for consumption by heterotrophs (herbivores and decomposers) and is called NPP.
 - **Secondary Productivity:** The rate at which consumers form new organic matter.
- **Factors for high NPP:** Types of plant species, environmental conditions, nutrient availability and photosynthetic capacity influence productivity. Hence, it varies across ecosystems.
 - **Coral Reefs** and **Tropical Rainforests** have high productivity.
- **Total annual NPP of the biosphere:** It is **about 170 billion tons** of organic matter.
 - Despite covering **70% of the Earth**, oceans contribute only **55 billion tons**, with the rest coming from land.

Energy Flow

Energy is the driving force that sustains life in ecosystems. The primary source of energy is the **sun**, and this energy is transferred through the ecosystem via food chains and food webs.

- **Trophic levels:** Organisms in an ecosystem occupy specific positions based on their feeding relationships. These positions are called **trophic levels**.
 - The trophic levels include **Producers** (Autotrophs), **Primary consumers** (Herbivores), **Secondary consumers**, and **Tertiary consumers**.
- **10% Law and Energy transfer:** Approximately **10% of energy** is transferred from one trophic level to the next in a food chain.

- As energy flows through the food chain, some are lost as **heat** during **metabolic processes** and due to **inefficiencies**.
- Consequently, the **number of trophic levels** in an ecosystem is limited by the **available energy**.
- **Energy flows unidirectionally** from the sun to producers and then to consumers.
- This process aligns with the **first law of thermodynamics** (conservation of energy).
- **Food Chains and Webs:** These represent the energy flow in an ecosystem, from producers to the top predators.
 - **A food chain** is a linear sequence of organisms where each organism is consumed by the next at the higher trophic level.
 - **A food web** is a network of interconnected food chains that show more complex interactions.
 - Organisms depend on producers directly or indirectly for their food.
 - **Types of food chains:** Grazing food chain, Detritus food chain, and Parasitic food chain.
- **Ecological Pyramid:** These are **graphical representations** that illustrate the relative amounts of producers, consumers, and energy at different trophic levels in an ecosystem.
 - **Types of Pyramids:** Pyramid of Biomass, Pyramid of Numbers, and Pyramid of Energy.

Nutrient Cycle

Nutrient cycling is the continuous movement and exchange of essential elements (carbon, nitrogen, phosphorus, sulfur, water, etc.) between the biotic and abiotic components of an ecosystem. These cycles are driven by various biological, geological, and chemical processes.

- **Hydrological cycle:** Also known as the **water cycle**, it is the continuous movement of water through different reservoirs on Earth, including the atmosphere, surface water, groundwater, and living organisms.
 - It involves processes such as evaporation, transpiration, condensation, precipitation, and surface runoff.
- **Carbon cycle:** This involves the movement of carbon dioxide between the atmosphere, biosphere (living organisms), hydrosphere (water bodies), and lithosphere (Earth's crust and mantle).
 - The main processes involved are photosynthesis, respiration, decomposition, combustion, and geological processes like **weathering** and **volcanic activity**.
- **Nitrogen cycle:** This is the **continuous transformation** and **transfer of nitrogen** between the atmosphere, biosphere, and lithosphere.
 - Key processes include **nitrogen fixation** (conversion of atmospheric nitrogen into usable forms), **nitrification** (conversion of ammonia to nitrites and nitrates), and **denitrification** (conversion of nitrates back to atmospheric nitrogen).
- **Phosphorus cycle:** Phosphorus is primarily obtained from **rocks and minerals** through weathering processes.
 - It is then taken up by plants, consumed by animals, and returned to the environment through decomposition and excretion.
- **Sulphur cycle:** Sulphur is released into the atmosphere through **volcanic activity** and **industrial processes**, and it is taken up by plants and microorganisms.
- It is then cycled through the ecosystem through processes like decomposition, respiration, and precipitation.

Ecological Succession

Ecological succession is the gradual process by which communities of plant and animal species in an ecosystem are replaced over time, leading to a relatively stable climax community. There are two main types of ecological succession:

- **Primary succession:** This refers to the gradual development of a biotic community in a previously uninhabited and barren habitat, such as a **new rock face** or **sand dunes**.
 - The process is typically slow due to the lack of existing life and organic matter.
- **Secondary succession:** This occurs in areas where a pre-existing biotic community has been **disrupted or destroyed**, like abandoned farmlands or burned forests.
 - As some soil or sediment is already present, this type of succession progresses faster than primary succession.

Ecosystem UPSC PYQs

Question 1: Define the concept of carrying capacity of an ecosystem as relevant to an environment. Explain how understanding this concept is vital while planning for sustainable development of a region. **(UPSC Mains 2019)**

Question 2: Which one of the following is the best description of the term 'ecosystem'? **(UPSC Prelims 2015)**

1. A community of organisms interacting with one another
2. That part of the Earth which is inhabited by living organisms
3. A community of organisms together with the environment in which they live
4. The flora and fauna of a geographical area

Answer: (c)

Question 3: With reference to food chains in ecosystems) consider the following statements: **(UPSC Prelims 2013)**

1. A food chain illustrates the order in which a chain of organisms feed upon each other.
2. Food chains are found within the populations of a species.
3. A food chain illustrates the numbers of each organism which are eaten by others.

Which of the statements given above is/are correct?

1. 1 only
2. 1 and 2 only
3. 1, 2 and 3
4. None

Answer: (a)

Question 4: Which one of the following is the correct sequence of ecosystems in the order of decreasing productivity? **(UPSC Prelims 2013)**

1. Oceans, lakes, grasslands, mangroves
2. Mangroves, oceans, grasslands, lakes
3. Mangroves grasslands, lakes, oceans
4. Oceans, mangroves, takes, grasslands

Answer: (c)

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