



MICRO-CREDENTIAL

LAND MANAGEMENT IN CENTRAL ASIA

4.- Land as a Natural and Ecological Resource

Ecosystem Concept

LM-W04-V24



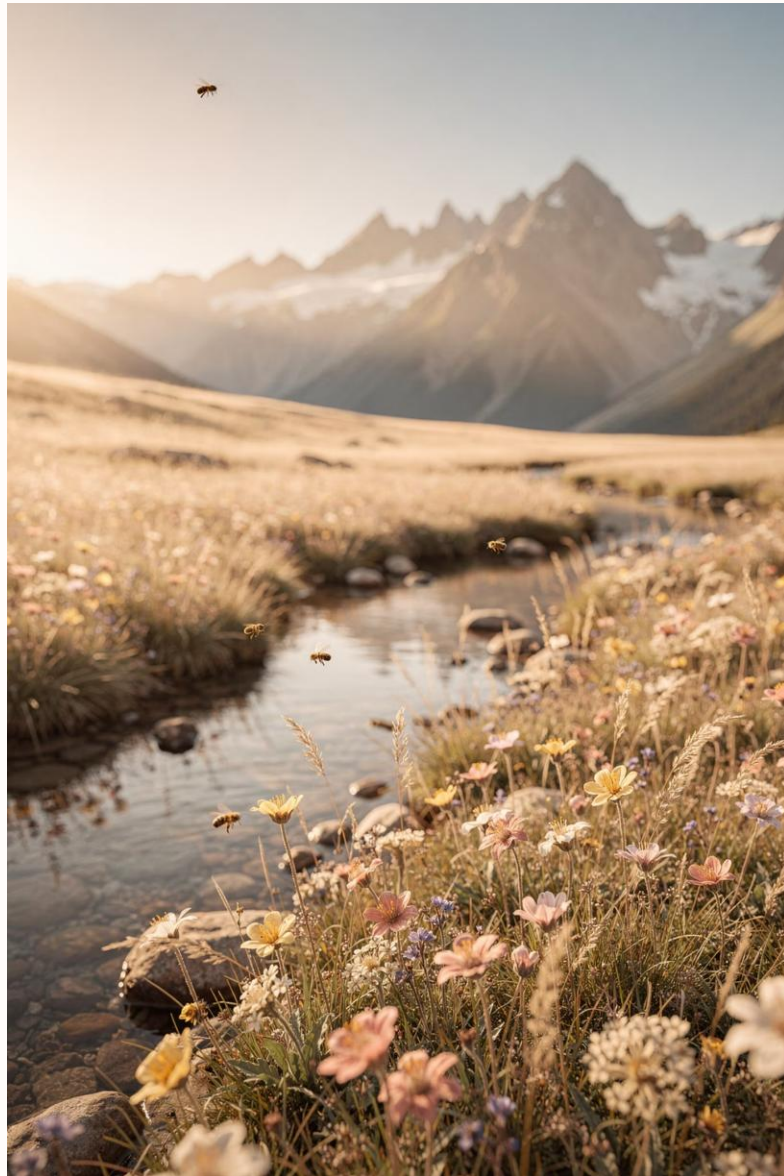
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Foundations of Ecosystem Science

Tracing the origins of how we came to understand the living world as an interconnected system of organisms and their environment.





An ecosystem is a **self-sustaining community** of living organisms interacting dynamically with their physical environment. It encompasses everything from the smallest soil microbe to the tallest canopy tree — and the sunlight, water, and minerals that sustain them all.

The term was first coined by British ecologist **A.G.**

Tansley in 1935, who defined it as the full integration of biotic (living) and abiotic (non-living) factors functioning together as a unified system.

Tansley's insight was revolutionary: he argued that organisms cannot be separated from the environments they inhabit, because both shape each other in continuous feedback loops.

The formal study of ecosystems falls under the broader discipline of **ecology** — a term coined by German zoologist **Ernst Haeckel in 1866**. Derived from the Greek word "*Oikos*," meaning house or habitat, ecology is the scientific investigation of the relationships between organisms and their surrounding environment.

Ecology examines how organisms compete, cooperate, and coexist within shared habitats. It spans multiple scales — from individual organisms and populations to entire biomes — seeking to understand the principles that govern the distribution and abundance of life on Earth.

📄 **Etymology:** *Oikos* (Greek) = house, habitat
Logos (Greek) = study, discourse

Ecology literally means "**the study of the home**" — the home that all living things share.

The Odum Framework

In his landmark 1971 textbook, Eugene Odum described the ecosystem as *"any unit that includes all of the organisms in a given area interacting with the physical environment so that a flow of energy leads to clearly defined trophic structure, biotic diversity, and material cycles."*

Energy Flow

Sunlight drives all biological processes through trophic transfers

Trophic Structure

Organized feeding relationships from producers to top predators

Biotic Diversity

Variety of life forms sustaining ecosystem resilience



A.G. Tansley (1871–1955)

British botanist who first coined the term "**ecosystem**" in 1935, unifying the study of organisms and their physical surroundings into a single, integrated concept.



Eugene Odum (1913–2002)

American ecologist known as the "**father of modern ecology**," whose 1971 textbook established the framework for understanding energy flow, trophic structure, and nutrient cycling within ecosystems.



The Structure of Ecosystems

Exploring the living and non-living components that form the architecture of every ecosystem on Earth.

Two Pillars: Biotic and Abiotic Components

Every ecosystem rests on two fundamental pillars that interact ceaselessly. Understanding this duality is the key to understanding how ecosystems function, persist, and change over time.

Biotic Components

All **living organisms** within an ecosystem — plants, animals, fungi, bacteria, and other microorganisms. These organisms interact through feeding relationships, competition, symbiosis, and reproduction.

Abiotic Components

The **non-living** physical and chemical factors that shape the environment — including soil composition, water availability, sunlight intensity, temperature, humidity, and atmospheric gases.

Neither pillar exists in isolation. Biotic organisms modify their abiotic surroundings (e.g., trees shading soil), while abiotic conditions determine which organisms can survive in a given habitat.

Biotic Components: Producers, Consumers, and Decomposers

Living organisms in an ecosystem are classified by **how they obtain energy**. This functional classification reveals the elegant structure underlying all ecological communities.

Producers (Autotrophs)

Photosynthetic plants, algae, and cyanobacteria that convert sunlight into organic food molecules. They form the **energy foundation** of every ecosystem.

Consumers (Heterotrophs)

Organisms that cannot produce their own food. Includes herbivores, carnivores, and omnivores — all dependent on consuming other organisms for energy.

Decomposers (Saprotrophs)

Fungi, bacteria, and detritivores that break down dead organic matter, releasing nutrients back into the soil and atmosphere for reuse by producers.



Photosynthesis

Autotrophs convert sunlight into chemical energy through photosynthesis — the process that powers virtually all life on Earth. Using chlorophyll, they transform CO_2 and water into glucose and oxygen.



Terrestrial Producers

On land, trees, grasses, shrubs, and mosses serve as primary producers. A single mature oak tree can produce enough oxygen for two people annually.

Consumers form the dynamic heart of ecosystem food webs. Classified by what they eat, they regulate populations, transfer energy, and shape community structure at every trophic level.



Primary Consumers (Herbivores)

Animals that feed directly on producers. Examples include deer grazing on grasses, rabbits eating clover, and caterpillars consuming leaves.



Secondary Consumers (Carnivores)

Predators that feed on herbivores. Foxes hunting rabbits, frogs catching insects, and small hawks preying on rodents are classic examples.



Tertiary Consumers (Top Predators)

Apex predators like lions, eagles, and sharks sit atop the food chain, regulating populations below and maintaining ecological balance.



Decomposers are the **unsung heroes** of every ecosystem. Without them, dead organic matter would accumulate endlessly and nutrients would become permanently locked away, eventually halting all life.

Fungi, bacteria, earthworms, and other detritivores break down dead plants, animals, and waste products into simpler compounds. These nutrients — nitrogen, phosphorus, carbon — are returned to the soil and atmosphere, where producers absorb them to begin the cycle anew.

📖 **Did you know?** A single teaspoon of healthy soil contains more microorganisms than there are people on Earth — many of them decomposers working tirelessly to recycle nutrients.

The non-living elements of an ecosystem set the stage upon which all biological drama unfolds. These physical and chemical factors determine which organisms can survive, reproduce, and thrive in any given habitat.



Climate Factors

Temperature, rainfall, sunlight intensity, humidity, and wind patterns collectively define regional climates and determine the types of ecosystems that can develop.



Soil Properties

Texture, pH level, mineral content, organic matter, and drainage capacity influence which plants can grow and which soil organisms can thrive.



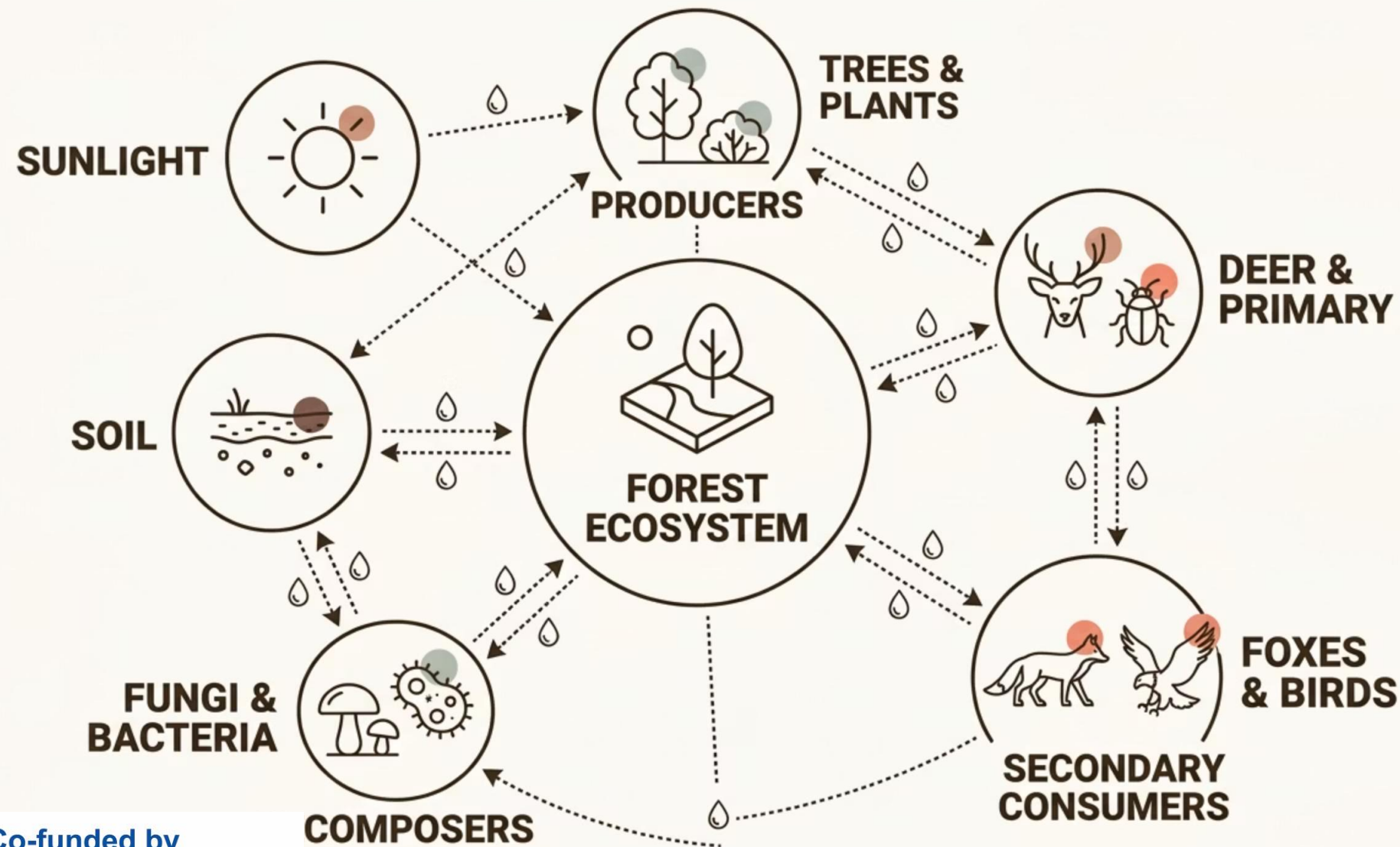
Water Quality & Availability

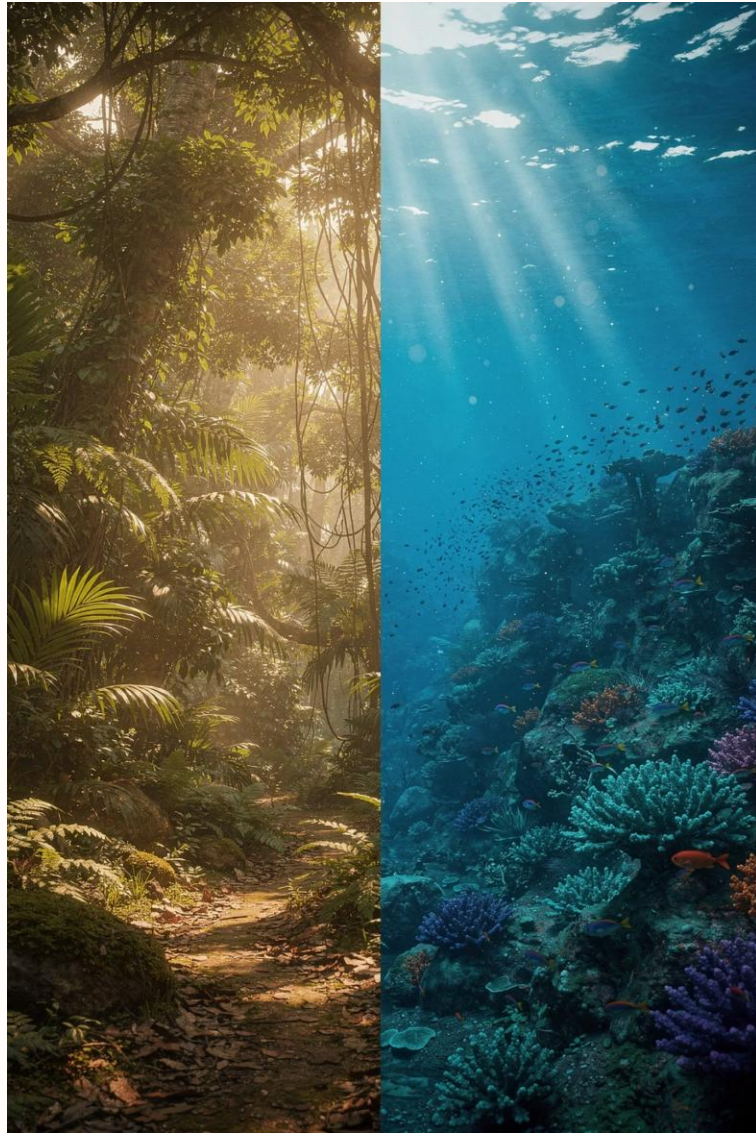
Freshwater availability, salinity, dissolved oxygen, and nutrient concentrations are critical determinants of aquatic and terrestrial ecosystem health.



Topography & Geology

Elevation, slope, rock type, and landform influence microclimates, water flow, and soil formation — creating diverse niches within a single landscape.





CHAPTER 3

Types of Ecosystems

From scorching deserts to frozen tundra, from freshwater ponds to the vast open ocean — ecosystems come in extraordinary variety.

Ecosystems can be broadly categorized by their origin. While natural ecosystems have evolved over millennia through natural processes, artificial ecosystems are created and maintained by human intervention.

Natural Ecosystems

Self-regulating systems shaped by natural forces over thousands of years. Examples include tropical rainforests, coral reefs, deserts, wetlands, and deep ocean trenches. These ecosystems maintain balance through complex species interactions.

Artificial Ecosystems

Human-designed systems that require ongoing management to persist. Examples include botanical gardens, agricultural fields, fish farms, man-made reservoirs, and urban parks. They typically have lower biodiversity and depend on external inputs.

Terrestrial ecosystems are land-based biomes characterized by distinct climates, vegetation types, and wildlife communities. Each biome supports a unique assemblage of species adapted to its particular conditions.



Forests

From tropical rainforests to boreal taiga, forests cover ~31% of Earth's land and house over 80% of terrestrial biodiversity.



Grasslands

Dominated by grasses rather than trees, grasslands support large herbivore populations and are vital for agriculture worldwide.



Deserts

Covering ~33% of Earth's land, deserts host remarkably adapted organisms that survive extreme heat, cold, and water scarcity.

Aquatic ecosystems cover over **70% of Earth's surface** and are divided into freshwater and marine systems. They regulate global climate, produce oxygen, and support an astonishing diversity of life.



Freshwater

Lakes & ponds: Still water bodies supporting fish, amphibians, and aquatic plants.

Rivers & streams: Flowing water ecosystems shaped by current, altitude, and substrate.

Wetlands: Marshes and swamps serving as critical biodiversity hotspots and natural water filters.



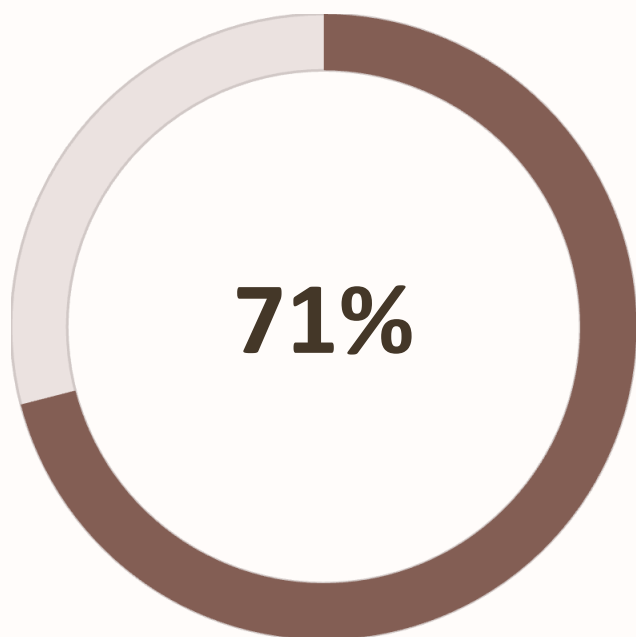
Marine

Oceans: Vast deep-water systems covering most of the planet, home to whales, deep-sea creatures, and plankton.

Coral reefs: "Rainforests of the sea" — the most biodiverse marine ecosystems on Earth.

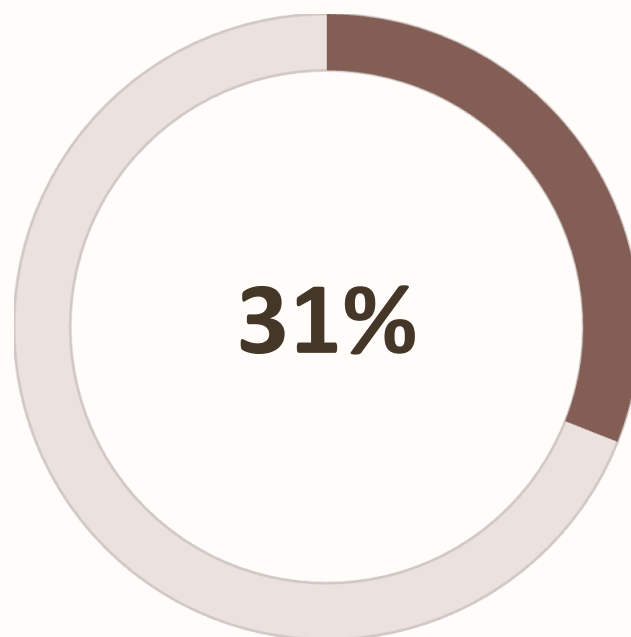
Estuaries: Where rivers meet the sea, creating nutrient-rich nurseries for countless species.

Earth's ecosystems form a mosaic of biomes, each shaped by latitude, altitude, precipitation, and temperature. This global distribution reveals the remarkable diversity of life — and the environmental conditions that sustain it.



Aquatic Coverage

Earth's surface covered by water ecosystems



Forest Coverage

Land area covered by forest ecosystems

CHAPTER 4

Ecosystem Functions and Energy Flow

How ecosystems regulate processes, cycle nutrients, and channel energy through intricate networks of life.

Ecosystems perform critical functions that sustain life at local and global scales. These functions are not isolated processes — they are deeply interconnected, each reinforcing the others in a delicate balance.



Process Regulation

Ecosystems regulate essential ecological processes — from pollination and seed dispersal to water purification and climate moderation — maintaining environmental stability.



Nutrient Cycling

Carbon, nitrogen, phosphorus, and other nutrients cycle continuously between living organisms and the physical environment, ensuring resources are never permanently lost.

Food Chain

A **food chain** is a simplified, linear sequence showing *who eats whom* in an ecosystem. Energy flows in one direction — from producers to consumers — with each link called a trophic level.

Example: Grass → Grasshopper → Frog → Snake → Hawk

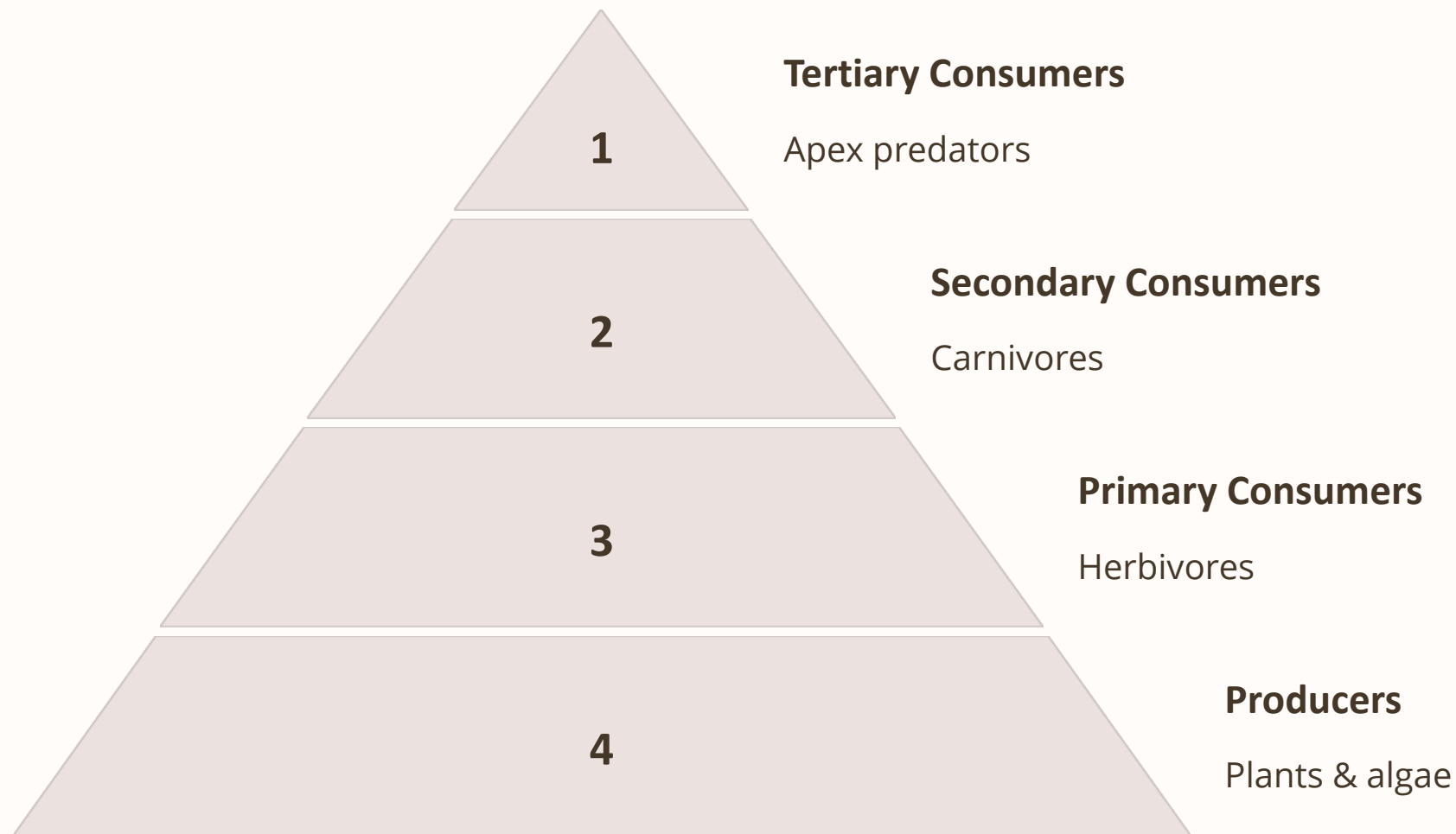
While useful for illustration, food chains rarely capture the full complexity of real ecosystems.

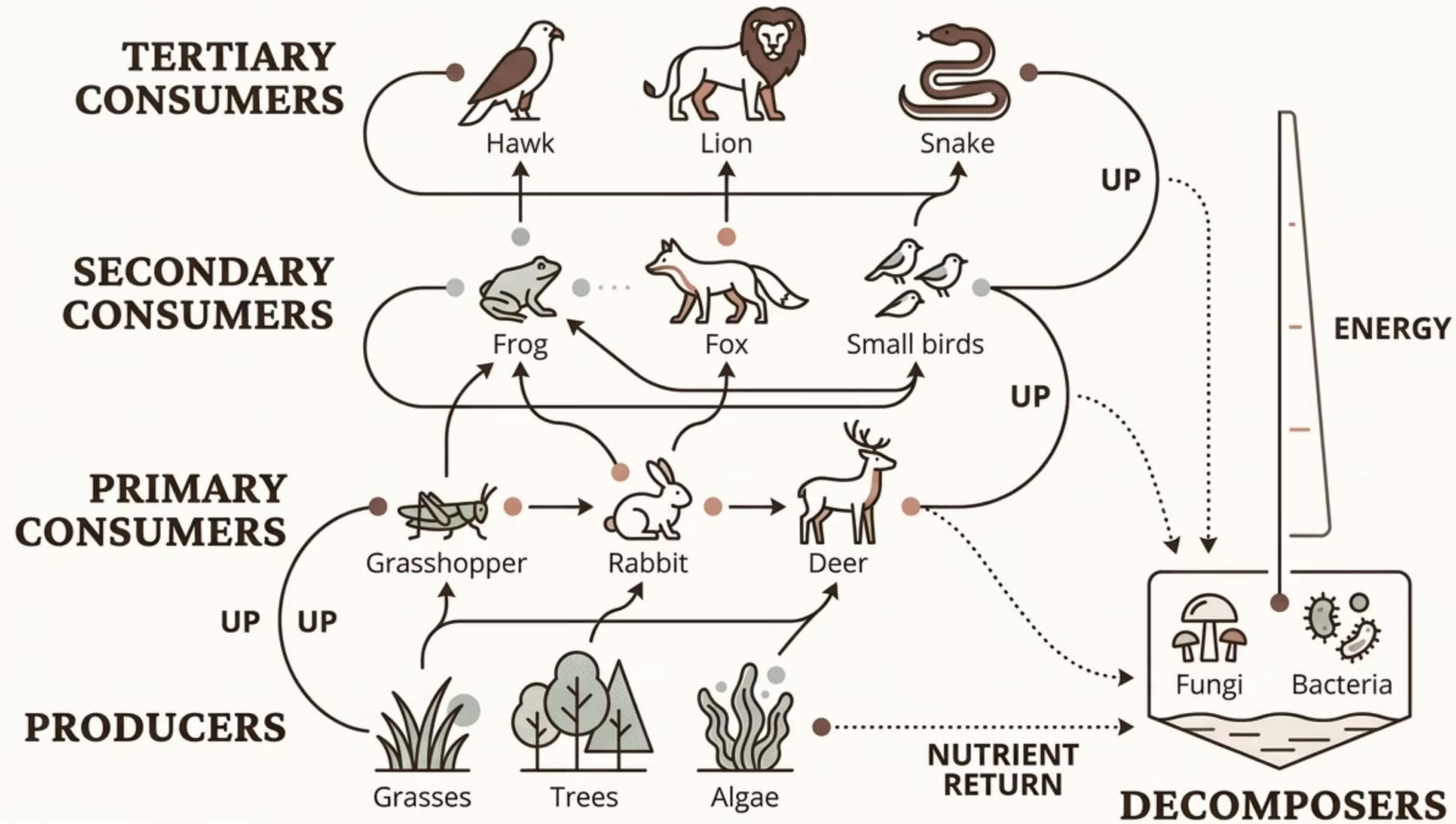
Food Web

A **food web** is a more accurate representation — a complex, interconnected network of multiple food chains within an ecosystem. Most organisms eat and are eaten by multiple species.

Food webs reveal the **true resilience** of ecosystems: if one species declines, others can partially compensate, preventing total collapse.

Energy flows through ecosystems in a structured hierarchy called **trophic levels**. At each level, roughly 90% of energy is lost as heat through metabolic processes — meaning only about 10% is passed to the next level. This is why top predators are always far less numerous than the organisms below them.





Conclusion: Ecosystems as the Web of Life

Ecosystems are the **fundamental fabric of life on Earth** — intricate systems where energy flows, nutrients cycle, and organisms interact in a delicate balance honed over billions of years. From the smallest soil microbe to the largest ocean whale, every species plays an irreplaceable role.

Balance

Ecosystems sustain all life by continuously balancing energy and matter across biotic and abiotic components.

Understanding

Studying ecosystems is vital for informed conservation, sustainable agriculture, and climate resilience strategies.

Action

Protecting and restoring ecosystems is not optional — it is essential for the survival and well-being of future generations.



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