Ecosystem Ecology

Ecosystem Structure – Trophic Relationships

Trophic relationships determine an ecosystem's routes of energy flow and chemical cycling

Trophic structure refers to the feeding relationships among organisms in an ecosystem

Tropic level refers to how organisms fit in based on their main source of nutrition

Primary producers – autotrophs (plants, algae, many bacteria, phytoplankton)

Primary consumers – heterotrophs that feed on autotrophs (herbivores, zooplankton)

Secondary consumers – heterotrophs that feed on primary consumers (carnivores)

Tertiary consumers – heterotrophs that feed on secondary consumers (carnivores)

Quaternary consumers – heterotrophs that feed on tertiary consumers (carnivores)

Detritivores – bacteria, fungi, and animals that feed on decaying organic matter

Food chain – the pathway along which food is transferred from trophic level to trophic level in an ecosystem

Food web – the feeding relationships in an ecosystem; many consumers are opportunistic feeders

Decomposition interconnects all trophic levels

Energy Flow in Ecosystems

Energy enters an ecosystems, flows within it, and eventually exits from it

The ecosystem's energy budget

Most primary producers use light energy to synthesize energy-rich organic molecules (photosynthesis)

Consumers acquire energy-rich organic molecules through food webs

Both producers and consumers break down energy-rich organic molecules (respiration) for energy to grow, survive, reproduce, etc.

Therefore, the extent of photosynthetic activity sets the energy budget for the entire ecosystem

Of the visible light that reaches photosynthetic organisms, 1% to 2% is converted to chemical energy by photosynthesis

Primary productivity – the amount of light energy converted to chemical energy by autotrophs in a given time period

Gross primary productivity – total primary productivity; everything that is produced in a given time period

Net primary productivity – gross primary productivity minus the energy used by producers in respiration to grow, survive, reproduce, etc. in a given time period

Gross primary productivity results from photosynthesis

Net primary productivity is the difference between the yield of photosynthesis and the consumption of organic fuel in respiration

Primary productivity can be expressed in energy terms – J/m^2/unit time – or as biomass – g/m^2/unit time

Primary productivity is the rate at which organisms synthesize new biomass

Total biomass (dry weight of organic material) of photosynthetic autotrophs present at a given time is standing crop biomass

As energy flows through an ecosystem, much is lost at each tropic level

Secondary productivity – the rate at which consumers convert the chemical energy of the food they eat into their own new biomass

Ecological efficiency and ecological pyramids

Ecological efficiency is the percentage of energy transferred from one trophic level to the next

Pyramid of productivity – graphic depiction of energy transfer in Joules

Pyramid of biomass – graphic depiction of energy transfer in terms of dry weight

Pyramid of numbers – graphic depiction of the number of individuals present in each trophic level

Cycling of Chemical Elements in the Ecosystem

Biogeochemical cycles – the movement of nutrients between the biotic and abiotic components of the ecosystem

Biological and geological processes move nutrients among organic and inorganic compartments

Organic materials available as nutrients – living organisms, detritus

Organic materials not available as nutrients – coal, oil, peat

Inorganic materials available as nutrients – atmosphere, soil, water

Inorganic materials not available as nutrients – minerals in rocks

The water cycle

Evaporation exceeds precipitation over the oceans

There is a net movement of water vapor, carried by winds, from the ocean to the land

Precipitation exceeds evapotranspiration over the land

The excess on land results in the formation of surface and groundwater systems that flow back to the oceans

The carbon cycle

Photosynthesis removes carbon dioxide from the atmosphere and converts it to organic matter

Respiration returns carbon dioxide to the atmosphere

Organic carbon can become unavailable when detritus accumulates more quickly than detritivores can break it down (coal, petroleum)

Burning of fossil fuels returns carbon dioxide to the atmosphere

Concentrations of carbon dioxide in the atmosphere are lowest during the northern hemisphere's summer and highest during the northern hemisphere's winter

A great deal of carbon resides in the oceans in various inorganic forms

The nitrogen cycle

- Nitrogen enters ecosystems via two natural pathways
  - Atmospheric deposition – ammonium and nitrates in the atmosphere are added to soil by being dissolved in rain or contained in dust or other particles that settle
  - Nitrogen fixation – atmospheric nitrogen is reduced to ammonium by nitrogen-fixing bacteria that live in the roots of legume plants or in the soil
- Nitrogen is cycled within the ecosystem
  - Ammonification – decomposition of organic nitrogen (dead organisms, detritus) to ammonium by decomposers (aerobic and anaerobic bacteria and fungi)
  - Nitrification – conversion of ammonium to nitrites and then nitrates by nitrifying bacteria
  - Plant assimilation – conversion of nitrates to organic forms of nitrogen (amino acids, proteins, nucleotides, nucleic acids) by plants
  - Animal assimilation – assimilation of organic forms of nitrogen by eating plants and other animals
- Nitrogen enters the atmosphere by denitrification
  - Denitrification – conversion of nitrates to atmospheric nitrogen by denitrifying bacteria

The phosphorus cycle

The weathering of rocks gradually adds phosphate to soil

Producers incorporate phosphate into organic forms (nucleic acids, ATP, phospholipids)

Consumers obtain organic forms by eating plants and other animals

Decomposition of dead organisms, wastes, and detritus by decomposers cycles phosphate to soil

Phosphate leeches out of soil into surface and groundwater and drains into oceans

Phosphate that reaches oceans accumulates in sediments and is incorporated into rocks

Decomposition rates largely determine the rates of nutrient cycling

This lecture outline was prepared partly from *Biology*, by Campbell and Reece, 2002 (6th edition), and from *Botany – An Introduction to Plant Biology*, by Mauseth, 1998 (2nd edition), and may contain phrases or entire sentences taken verbatim from those sources.