

Ecosystems

Energy flow and chemical cycling are determined by trophic structure. Feeding relationships determine energy flow. Amount of energy in a system, and the major routes (availability) of that energy, largely determines ecosystem function and structure

Energy flow

Trophic levels: members of an ecosystem are placed in a trophic level depending on their source of nutrition.

Autotrophs: support all others (primary producers). Convert energy from sunlight or inorganic molecules into chemical bond energy of organic molecules (eg carbs). Many also absorb inorganic nutrients like nitrates, phosphate, sulfate, calcium, and potassium and convert them to organic forms such as proteins, nucleic acids and other molecules.

Heterotrophs: consumers – primary, secondary and tertiary consumers. Many cross trophic levels. Omnivores

Decomposers: scavengers and detritivores, feed off decaying organisms. Usually fungi or bacteria. Absorb organic molecules into their bodies, and convert nutrients back into an inorganic form. Many soil bacteria reduce the remains of organisms into nitrates, ammonia, sulfates, phosphates and CO₂ and water. They are an important link in the cycle.

Food webs: energy is extracted and converted at each level. Grazing food chains vvs. Detritus food chains: inverts feeding off decaying plant matter (eg. Streams and in the leaf litter). But such linear progressions are not 'true'. More complex food webs are what we see.

Ecological pyramids. Represent trophic levels, and the energy, or # indiv., or biomass present at each level.

individuals. Often first level is largest, but not in a forest. Note that secondary carnivores are almost always less numerous.

Biomass: usually greatest at the bottom level: plants can store organic matter better than heterotrophs.

Energy: 10% transferred at each level. 90% of energy eaten in food by consumers is not stored as body structures (as in trees), but is lost in waste or used in maintaining the animal (eg lost in respiration). All that they do requires energy.

Feeding low on the trophic pyramid is energy efficient (and many poor people do it), but diet is a problem – we need protein for example (kwashiorkor).

Productivity and energy: **Production** is the amount of energy stored by a trophic level (kilocalories/sq meter) eg energy stored in grasshoppers who have been eating grass. Productivity is a rate: eg. Production per 24 hours. **Gross productivity**: amount of energy taken in by photosynthesis or by consuming the bodies of other orgs. **Net**

productivity : amount of energy left after losses due to respiration are taken into account. Amount available to the heterotrophs

Primary productivity is a measure of how much energy an ecosystem has to work with. *Amount of light energy converted to chemical energy by autotrophs.* **Net** primary productivity = gross primary productivity – autotrophic respiration. ****50-90 %** of gross productivity remains as net productivity in producers. Primary productivity can be expressed in units of **energy** per area per unit of time, or as **biomass** or vegetation added to the ecosystem per g per area per time. Dry weight of organic material. Not to be confused with standing crop biomass. Productivity is the rate at which vegetation synthesizes new biomass.

Net community productivity is net primary minus heterotroph respiration. Net community productivity greater than 0 are growing (eg. Disturbance recovery). Less than 0 = stable or mature – reached an equilibrium between energy assimilation and E use. Some of the net productivity (see above) available to heterotrophs is exported from the system, and not available (eg. Wind, water, humans etc.)

Eutrophication: too many nutrients in a system. Leads to oxygen depletion.

Ecosystem and community budgets: oxygen, energy, everything has a budget. How much biomass of fish produced each year in a lake? How much primary productivity?

WHALES: the role of species assemblages and functional groups in ‘processing’ and routing energy in a system. These tie in with species diversity too...Whales in gulf of CA responsible for use of 20% of total energy budget

Energy flows through an ecosystem to be lost as heat, but nutrients *cycle* between organisms and the abiotic components of an ecosystem.

Chemical cycling: Biogeochemical cycles. A combination of geological and chemical processes drives these.

SPONCH, along with others such as iron, cobalt, sodium, chlorine. Elements taken up as molecules or ions. Plants take nitrogen as nitrates, while animals take it up from the bodies of their prey. Some are turned into new molecules, some (like Carbon, oxygen, and hydrogen) are metabolized for their chemical bond energy. But these elements reappear in metabolic wastes, or through decay. **Decomposers** play a key role in this cycling.

Rates of nutrient cycling are often dependant or influenced by rates of decomposition, which are dependant on abiotic factors such as temperature, oxygen availability, and moisture.

Elements accumulate in three major places;

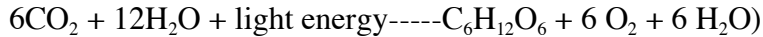
- In the **bodies** of living organisms

- In **exchange pools**: readily available water soluble reserves of a mineral nutrient, such as nitrates in soil water easily taken up by plants
- **Reservoirs**: harder to get to places such as air, bones of animals, shells etc.

Water cycle: most occurs between sea and atmosphere. This is primarily a *physical* cycle, not a *chemical* one.

Carbon cycle:

Photosynthesis and respiration



Link between atmosphere and terrestrial environment. High demand by plants recycles it fast. Atmospheric CO₂ varies by season

Carbon removal – eg build up of organic matter---coal/oil - carbonification

Aquatic environments: Carbon reacts with water and limestone.

Dissolved CO₂ reacts with water to form Carbonic acid: H₂CO₃, which reacts with limestone: CaCO₃, to form Bicarbonate (2 HCO₃⁻) and carbonate (2CO₃²⁻) ions:

Bicarbonates are a CO₂ reservoir

Ocean is an important buffer

Nitrogen cycle:

NO₃⁻ = nitrates (plants can use this)

NH₄⁺ = ammonium (plants can use this)

NO₂⁻ = nitrites (some bacteria can use this)

Animals need organic forms of nitrogen (eg. amino acids)

Nitrogen is a principal constituent in nucleic acids, proteins, chlorophyll, etc. Largest reservoir is the atmosphere. We can't get it. Plants get it in the form of nitrate ions (NO₃⁻) which are produced by soil and water bacteria through **nitrogen fixation** and **ammonification** (atmospheric Nitrogen is converted to an ionic form (NH₄⁺), and **nitrification** (oxidative conversion of ammonium to nitrate). This allows for nitrogen in soil available to plants. Some settles directly into the soil through water or particulate (5-8%).

nitrogen fixation (atmospheric Nitrogen is converted – via bacteria- to an ionic form NH₃ (ammonia) which quickly becomes (NH₄⁺) ammonium in acidic soils. In regions with neutral soil the ammonia (a gas) can be released back to atmosphere, and deposited via rain – one part of the cycle. Performed by prokaryotes-free living and symbiotic (rhizobium) in legumes and other plants.

N_2 ----- NH_3 ammonia gas ----- NH_4^+ ammonium in soils

Decomposers convert organic nitrogen back to ammonium (NH_4^+): **ammonification**.

nitrification (oxidative conversion of ammonium to nitrate). Most ammonium is used by aerobic bacteria in soil. They oxidize ammonium to nitrite (NO_2^-) and then to nitrate (NO_3^-). These can be assimilated by plants.

NH_4^+ ammonium ----- NO_2^- nitrite ----- nitrate NO_3^- which can be assimilated by plants

Some **denitrifying** (anaerobic) bacteria convert nitrate NO_3^- (instead of O_2) into N_2 , which goes back into the atmosphere.

Animals can only assimilate organic nitrogen by eating animals or plants.

Most nitrogen is cycled through decomposition and reassimilation

Phosphorous cycle

Nucleic acids, phospholipids, ATP..., bones and teeth

Sedimentary cycle and animal/plant/soil cycle – can be a long cycle (time)

No atmospheric component. Only one inorganic form (PO_4^{3-}). Plants absorb this

- Weathering of rocks
- Excretion and decomposition
- Humus and soil particles bind phosphates – recycling and availability is localized.
Limiting factor
- In ocean accumulates in sediments and make it back to earth through geologic processes