

Ecosystem

An ecosystem = a functional unit of nature where living organisms interact among themselves & with the ~~non living~~ surrounding physical environment. (coined by A.G. Tansley, 1935)

Types

- (a) Terrestrial - forest, grassland, desert
- (b) Aquatic* - pond, lake, river, ocean, wetland, estuary

(c) Man-made - crop field, aquarium pond ecosystem (aquatic)

Components

1. Abiotic - sunlight, temp, water, soil, air, minerals, pH *
2. Biotic - Producers (P), Consumers (C), Decomposers (D)

Structure vs Function

Structure : species composition + stratification (vertical layers).

Function : productivity, decomposition, energy flow & nutrient cycling.

Productivity

Rate of biomass production per unit area per unit time. Units : $g / m^2 / yr$ or $kcal / m^2 / yr$.

Primary Productivity

Rate at which producers (green plants) fix solar energy by photosynthesis.

$GPP = \text{total organic matter produced}$

\leftarrow Gross PP

$NPP = GPP - R$

$\leftarrow R = \text{respiration loss}$

$NPP = \text{~~food~~ biomass available to consumers (herbivores + decomposers)}$.

Secondary Productivity

Rate of formation of new organic matter by consumers (heterotrophs).

Global NPP

Total annual NPP of biosphere = 170 bn tons (dry organic matter). Oceans contribute 55 bn tons, rest is land.

Decomposition

Break-down of complex organic matter (detritus) into inorganic substances (CO_2 , H_2O , nutrients) by decomposers.

Detritus = dead leaves, bark, faecal matter.

Steps

1. Fragmentation - detritivores (earth-worm) break detritus into small bits
2. Leaching - water-soluble inorganics go down & get precipitated as unavailable salts
3. Catabolism - bacterial/fungal enzymes degrade detritus \rightarrow simpler compounds
4. Humification - ~~simple~~ accumulation of dark, amorphous, colloidal HUMUS ; highly resistant, reservoir of nutrients
5. Mineralisation - humus \rightarrow release of inorganic nutrients (NH_4^+ , NO_3^- , PO_4)

Factors

Faster : warm + moist + O_2 rich + detritus rich in N & water-soluble sugars.

Slower : cold/anaerobic + lignin- & chitin-rich detritus (hard to break).

Energy Flow

Sun = ultimate source. Of incident solar radiation, $< 50\%$ is PAR (Photosynthetically Active Radiation). Plants capture only 2 - 10% of PAR.

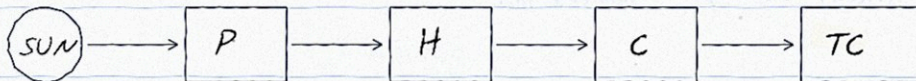
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Trophic Levels

- T1 Producers (green plants, algae)
- T2 Primary consumers (herbivores)
- T3 Secondary consumers (carnivores)
- T4 Tertiary consumers (top carnivore)

Decomposers act at every level.

P = producer H = herbivore C = carnivore



10% Law (Lindeman)

Only 10% of energy at one trophic level is transferred to the next. Rest is lost as ~~light~~ heat (respiration*) & metabolic work.

$$E(T_{n+1}) = 10\% \text{ of } E(T_n) \begin{matrix} \leftarrow \text{energy} \\ \leftarrow \text{decreases} \end{matrix}$$

\Rightarrow food chains rarely exceed 4 - 5 links.

Food Chains & Pyramids

Food Chains

(a) Grazing food chain (GFC) -

starts with living producer

grass \rightarrow goat \rightarrow man

(b) Detritus food chain (DFC) -

starts with dead organic matter

detritus \rightarrow earthworm \rightarrow bird

GFC & DFC are interconnected = food web.

Ecological Pyramids

Graphic representation of trophic structure

ure - base = producers, apex = top carn.

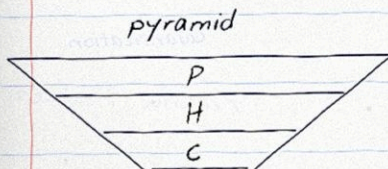
Types :

1. Pyramid of number

2. Pyramid of biomass

3. Pyramid of energy

(always upright)



Inverted Pyramids

Number : inverted in big tree \rightarrow insect \rightarrow

parasite ; few trees support many bugs.

Biomass : ocean - small standing crop of

phytoplankton supports larger fish.

Pyramid Limits + Carbon Cycle

Limitations of Pyramids

- * Assume simple food chain ; food webs ignored.
- * Saprophytes (decomposers) not given a place though vital to ecosystem.
- * A species may occupy more than 1 trophic level (e.g. sparrow - seeds & insects).

Biogeochemical Cycles

Movement of nutrients between biotic & abiotic components. ~~Two~~ Two types -
 Gaseous (C, N - reservoir : atmosphere)
 Sedimentary (P, S - reservoir : crust).

Carbon Cycle

71% of C is dissolved in oceans \rightarrow major regulator of atmospheric CO₂. Atmospheric CO₂ is only 1% of global C pool.

Major flux pathways :

(i) Photosynthesis : CO₂ \rightarrow organic C

(ii) Respiration : organic C \rightarrow CO₂

(iii) Decomposition releases C back

(iv) Fossil-fuel burning + deforestation

\rightarrow extra CO₂ \rightarrow global warming.

Phosphorus Cycle + Services

* Phosphorus Cycle

Sedimentary cycle - reservoir : rocks
(as phosphate).

Steps :

1. Weathering of rocks releases phosphate ions (PO_4^{3-}) into soil/water.
2. Plants absorb soluble phosphates.
3. Herbivores \rightarrow carnivores get P from plants ; excretion & death return P.
4. ~~Bacteria~~ Microbes solubilise organic P \rightarrow back to soil.

Differences vs C cycle

- * No respiratory release (no gaseous P).
- * Atmospheric inputs are negligible.
- * Much slower turnover than C.

Ecosystem Services

Products & processes nature gives us :

- * purification of air & water
- * mitigates droughts & floods
- * cycles nutrients ; pollinates crops
- * generates fertile soils ; aesthetic value

Constanza (1997) : 33 trillion US\$ / yr

Quick Recall *

Key Formulas

$$NPP = GPP - R$$

<- net productivity

$$E \text{ next level} = 10\% \text{ of } E \text{ previous}$$

<- Lindeman

Must Remember

- * Tansley coined 'ecosystem' (1935)
- * Global NPP = 170 bn tons / yr
- * Ocean PP = 55 bn tons / yr
- * PAR = 50% of incoming solar radiation
- * Plants fix 2 - 10% of PAR *
- * Pyramid of energy : ~~invert~~ always upright
- * Decomposition needs O₂ ; humus = colloid
- * C - gaseous cycle ; P - sedimentary cycle
- * DFC dominates in terrestrial ecosystems

Pyramid Type Summary

Number : may be upright OR inverted

Biomass : upright on land ; inverted in
ocean

Energy : ALWAYS upright (10% law)