Ecosystems, productivity and succession

Populations, communities and ecosystems, primary productivity, efficiency of energy transfer, abiotic and biotic factors, niche, sampling a habitat, and succession.

Ecological terms

Term	Meaning
Population	All the organisms of **one species** in a habitat at one time
Community	All the **populations** of different species living in a habitat
Habitat	The place where an organism lives
Ecosystem	A community and its non-living (**abiotic**) environment, and their interactions
Niche	The role of a species in an ecosystem

Energy flow and productivity

Plants capture only a small amount of the light that falls on them (about 1–3%), because some is reflected, some is the wrong wavelength, some passes through, and the rate is often held back by other limiting factors such as carbon dioxide concentration or temperature.

- **Gross primary productivity (GPP)** is the **total** chemical energy (or biomass) fixed by photosynthesis per unit area per unit time (kJ m^{-2} $year^{-1}$).
- **Net primary productivity (NPP)** is the energy **available to the next trophic level**, after some is used in the plant's own **respiration** (R):

$$NPP = GPP - R$$

> **TRY IT**
>
> A crop has a GPP of 90 000 kJ m^{-2} $year^{-1}$ and loses 40% in respiration. Find the NPP.

$R = 0.40 \times 90\,000 = 36\,000$. $NPP = 90\,000 - 36\,000 = 54\,000$ kJ m^{-2} $year^{-1}$.

Efficiency of transfer

$$\text{efficiency} = \frac{\text{energy (or biomass) transferred to the next trophic level}}{\text{energy (or biomass) available at the previous level}} \times 100$$

Efficiency is usually only **about 10%** between trophic levels, because energy is **lost** as:

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- **heat** from respiration,
- **excretion** (urea) and **faeces** (undigested material),
- parts that are **not eaten** (bones, roots, shells),
- uneaten organisms that die (and go to decomposers).

This limits the length of **food chains** (4 or 5 levels) and explains why there is less biomass at higher trophic levels, as shown by **pyramids of biomass** and **energy**.

Distribution and abundance

The number and distribution of organisms are controlled by:

- **Abiotic factors**: light, temperature, water, pH, salinity, oxygen, soil type, wind.
- **Biotic factors**: competition (within and between species), predation, parasitism and disease, availability of food, mutualism.

The **niche** concept accounts for distribution and abundance: an organism is found where its requirements are met and where it can **compete** successfully with other species for that niche.

Core Practical 11: study of a habitat

Quadrats

A **quadrat** (e.g. 0.5 m × 0.5 m square) is used to sample **abundance** (the number of individuals) or **percentage cover**.

- Use **random sampling**: place quadrats at **coordinates from random numbers** on a grid, to avoid bias. A **larger number** of quadrats gives a better estimate.
- **Mean number per quadrat × area of habitat / area of the quadrat** gives an estimate of the population size.

Transects

A **transect** is a line across a habitat, along which quadrats are placed to measure **changes in distribution** where there is a **gradient** (for example, from the sea to dune). A **belt transect** is a strip of continuous or regular quadrats.

Abiotic factors

Measure the factors that might explain the distribution: **light** (light meter), **temperature** (thermometer), **soil moisture** or **pH** (probes), **wind speed**, **salinity**. Take several readings at each location and use the means.

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Correlation: use a **correlation test** (e.g. Spearman's rank) to see whether the distribution of a species is related to an abiotic factor.

Succession

Succession is the change in the species in a community over time.

1. **Colonisation**: **pioneer species** (lichens, mosses, algae) colonise bare ground. They are adapted for harsh conditions, so they have **wind-blown spores**, can fix nitrogen and tolerate extremes.
2. Pioneers die and **decompose**, forming **soil** (humus) with more water and nutrients.
3. Conditions become **less harsh**, so other species (grasses, then herbs, shrubs and trees) can colonise. Each stage **changes the environment** and makes it more suitable for the next species, which out-competes the earlier ones. **Species diversity** increases.
4. The **climax community** is a stable community in balance with the environment, with a high biodiversity and **dominant species** (e.g. oak woodland).

Primary succession starts on bare rock or sand with no soil. **Secondary succession** begins on soil that had a community that was removed (abandoned farmland, after a fire).

> **NOTE**
>
> A climax community is stable because its species are adapted to the conditions, but it is not static. A change in climate or human activity can set succession back (**deflected succession**, e.g. grazing or burning maintaining grassland).

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