Ecology

Topic 2 · SL and HL

Fourteen wolves

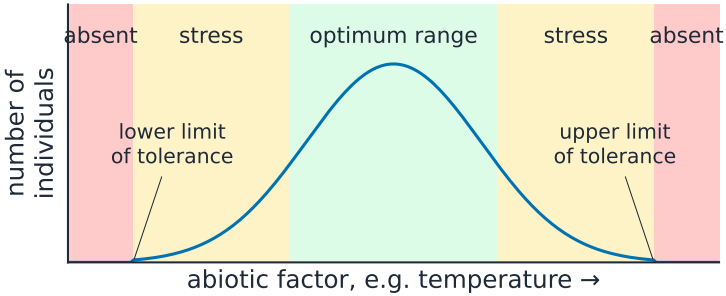
> No **species** lives alone; one change can spread through an **ecosystem**.

- Fourteen wolves returned in 1995; later changes invited food-web hypotheses.
- Water, other predators, hunting, **climate** and sampling also matter.
- Compare mechanisms and alternative explanations, not dates alone.

Population, community, ecosystem

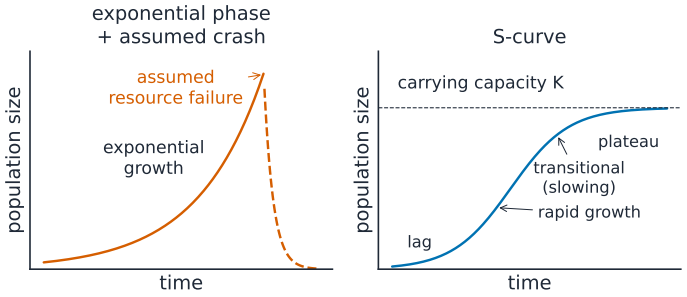
Term	Meaning
Population	One **species**, one area, one time
Community	All the populations in an area
Ecosystem	A community plus its physical environment
Habitat	Where a species normally lives
Niche	Its role, what it eats, when and how it lives

Range of tolerance



- A tolerance curve depends on **species**, life stage and response measured.
- Absence alone need not reveal a physiological limit.

J-curves and S-curves



- An exponential equation contains no automatic crash; the example assumes changed conditions.
- A logistic model slows under density dependence; **carrying capacity** can change.

Interactions between species

One side gains, one loses

Predation, **herbivory**, **parasitism**, disease.

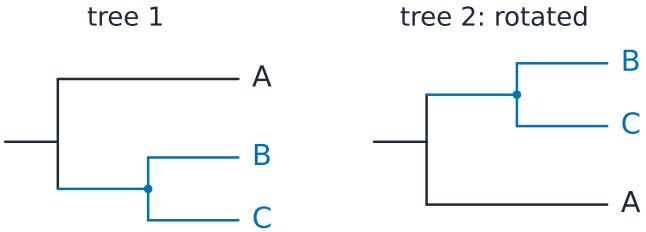
Competition harms both.

Both gain

Mutualism, such as bees and flowers.

Nitrogen-fixing bacteria in bean roots.

AHL: Classify by ancestry



same ancestry: B and C share
a more recent ancestor
invented taxa; branch lengths do not encode time

A **clade** contains an ancestor and all its descendants; node rotation preserves ancestry.

AHL: Fundamental and realised niches

Potential niche

Conditions and resources allowing persistence without specified restrictive interactions.

Abiotic limits still apply.

Realised niche

Actual occurrence and role with interactions and constraints.

Absence alone does not identify its cause.

AHL: Life-history tendencies

r-strategists

Many small offspring, little care.

Insects, weeds, mice.

K-strategists

Greater offspring investment, often later maturity.

Some whales/elephants; long-lived oaks still make many acorns.

Estimating a plant population

1. **Mean per quadrat.** Invented field: 2000 m^2. Ten 0.25 m^2 quadrats hold 46 daisies: mean 4.6 per **quadrat**.
2. **Density.** $4.6 \div 0.25 = 18.4$ per m^2
3. **Scale up.** $18.4 \times 2000 = 36\,800$ plants

Decision

Estimated abundance 36800; sampling variation and bias still need consideration.

The Lincoln index

- 40 beetles marked; later 50 caught, 8 of them marked.
- Assumes full mixing, no lost marks, no births, deaths or migration.

$$N = \frac{M \times C}{R} = \frac{40 \times 50}{8} = 250$$

If marks wear off, R is too small and N too large.

Simpson's reciprocal index

- Site A has 10, 6 and 4 individuals; site B has 18, 1 and 1.
- Same richness, but A is shared more evenly.

$$D = \frac{N(N-1)}{\sum n(n-1)}$$

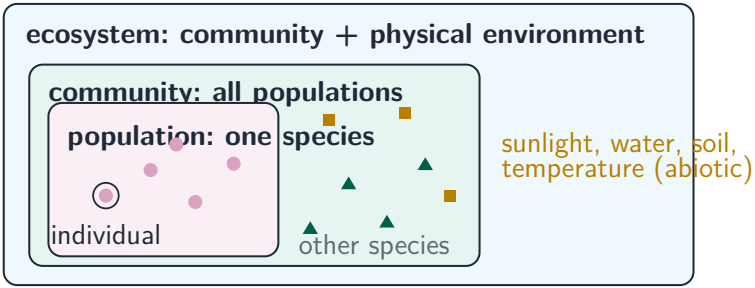
$$D_A = \frac{380}{132} = 2.88$$

$$D_B = \frac{380}{306} = 1.24$$

These invented samples have equal richness and different evenness; compare like sampling.

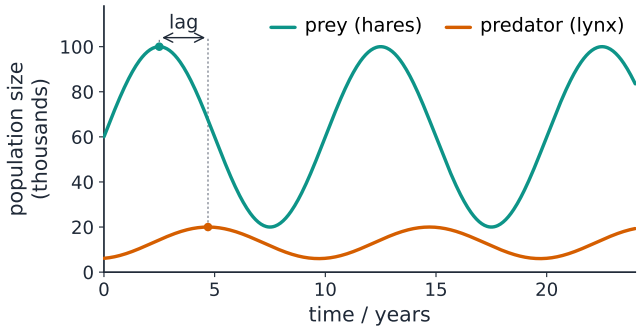
exercises.lol exercises.com.cn

From individual to ecosystem



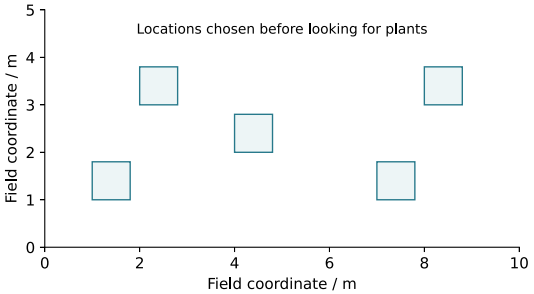
Each level contains the one before

Predator and prey cycles



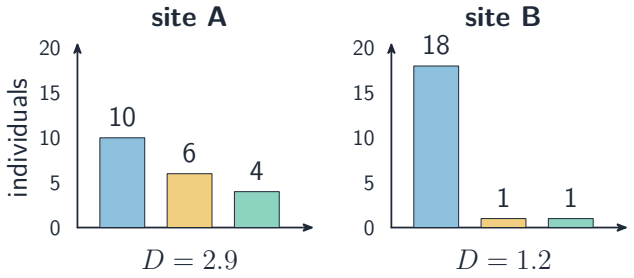
Negative feedback links the two populations

Random quadrats



Random placement avoids choosing the interesting spots

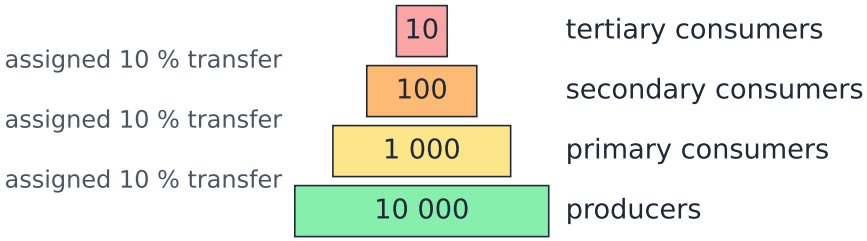
Simpson's index rewards evenness



same richness (3 species),
same $N = 20$;
A is more even, so more diverse

Same **species**, same total: A is more diverse

Why food chains are short



- **Respiration** disperses energy; uneaten matter and wastes also enter detrital pathways.
- The displayed 10% transfers are assigned examples, not a fixed universal rule.

Pyramids

Can be inverted

Numbers, one oak and many caterpillars.

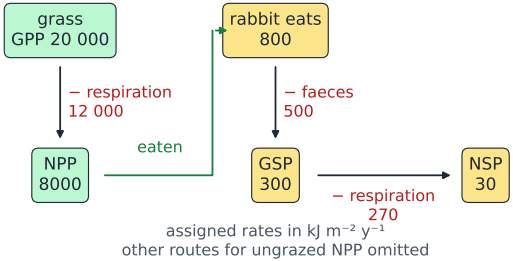
Biomass in the sea, fast-growing algae.

Never inverted

Productivity, energy flow over time.

Each level passes on only part.

AHL: Productivity in a meadow



- NPP = GPP − R; GSP = food eaten − faeces; NSP = GSP − R.
- All values in kJ m^{-2} y^{-1}.

AHL: Working the meadow numbers

1. **NPP.** Invented common rate units: GPP 20000, **producer respiration** 12000; NPP $= 8000$.
2. **GSP.** Rabbits ingest 800 and lose 500 as faeces: GSP $= 300$.
3. **NSP.** Rabbit respiration is 270: NSP $= 300 - 270 = 30$.

Decision

State whose respiration and which denominator an efficiency uses.

AHL: Measuring production

1. **Known.** Invented two-hour bottles: initial 8.0 mg/L; light final 10.0; dark final 7.0.
2. **Net and respiratory.** Light: $(10 - 8)/2 = 1.0$ mg/L/hour. Dark respiratory use: $(8 - 7)/2 = 0.5$.
3. **Gross.** $1.0 + 0.5 = 1.5$ mg/L/hour under the stated model.

Decision

Test assumptions before calling the inferred rate a direct carbon measurement.

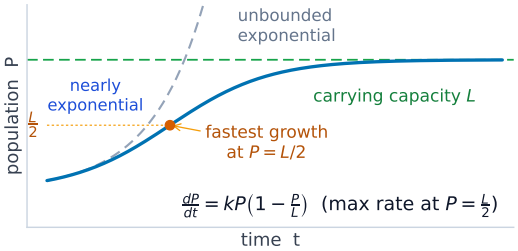
AHL: Model harvest maximum

1. **Given.** Invented logistic $K = 1000$ and $r = 0.4$ per year.
2. **Peak.** Net growth peaks at $N = K/2 = 500$; $rK/4 = 100$ individuals/year.
3. **Limit.** A model maximum is not a guaranteed safe annual catch under changing conditions.

Decision

Use a defensible net production budget and monitoring, not a universal half-K target.

Logistic growth



logistic: $dP/dt = kP(1 - P/L)$ · $P \to L$ as $t \to \infty$

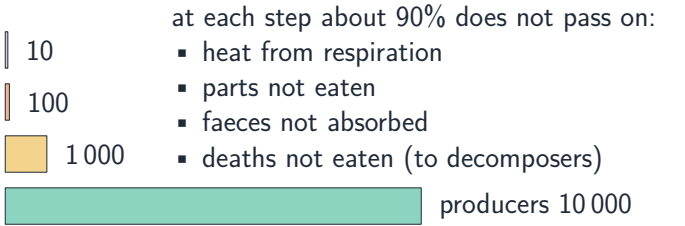
> The **maximum sustainable yield** is taken at $L/2$

Biomagnification

Uptake, elimination and chemical form determine accumulation; not every pollutant is stored in fat.

- Invented gradient: water 0.00005 ppm, bird 25 ppm; ratio 500000 on comparable bases.
- DDE can affect eggshells; methylmercury binds to proteins in fish muscle.

Why only about a tenth passes on



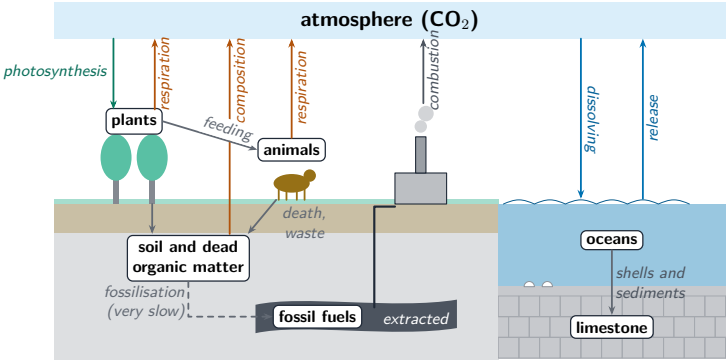
at each step about 90% does not pass on:

- heat from respiration
- parts not eaten
- faeces not absorbed
- deaths not eaten (to decomposers)

illustrative energy units with 10% transfer; widths to scale

So food chains are short

The carbon cycle



storages in boxes, flows on arrows; not to scale

A store is an amount; a net **sink** is defined by the balance of flows over time.

People and the carbon cycle

In the air

A stronger greenhouse effect.

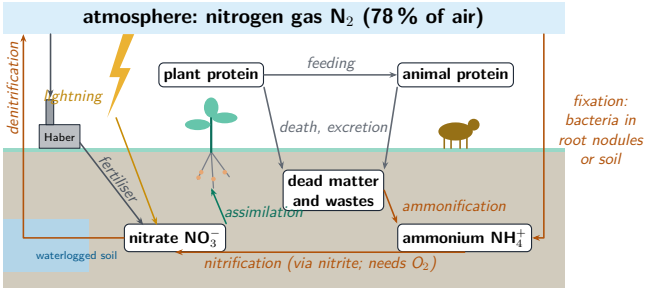
Global warming, Topic 6.

In the oceans

A model pH fall 8.2 $\rightarrow$ 8.1 gives about 26% higher hydrogen-ion activity.

Acidification does not require pH below 7.

AHL: The nitrogen cycle



red: done by bacteria; storages in boxes, flows on arrows; not to scale

Trace the named transformation; fixation, **nitrification** and **denitrification** are different.

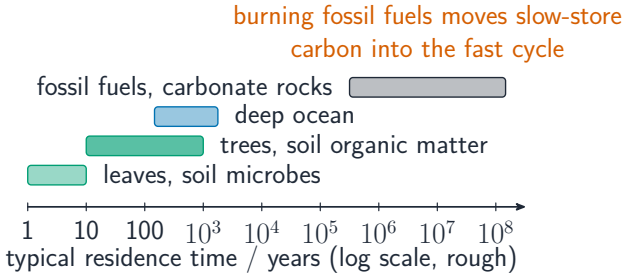
AHL: Check: which bacteria?

Your turn

A field stays waterlogged and oxygen-poor for weeks; nitrate declines. Which nitrogen-cycle process can reduce nitrate toward gaseous nitrogen?

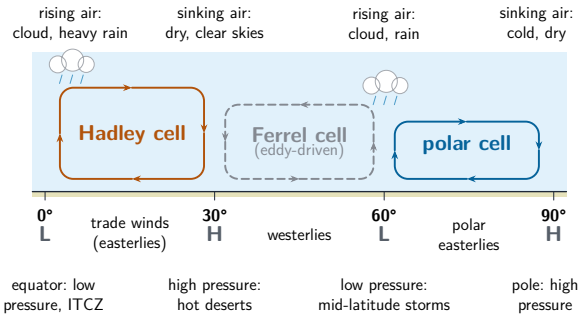
A. Nitrogen fixation
B. Nitrification
C. Denitrification
D. Ammonification

How long carbon stays in each store



Burning fossil fuels moves slow carbon into a fast store

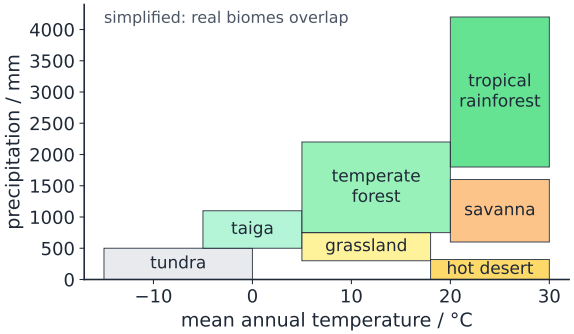
The tricellular model



one hemisphere, idealised zonal mean; heights not to scale

Link rising and sinking air to pressure and surface winds.

Biomes



Climate envelopes describe broad influences, not every local land cover.

Zonation and succession

Primary succession

Starts with no soil.

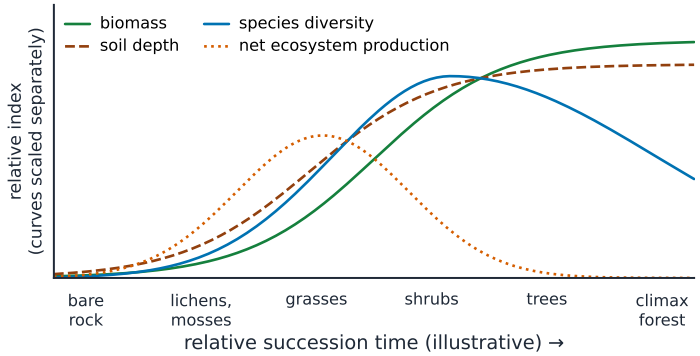
New volcanic rock, sand dunes.

Secondary succession

Soil already present.

After a fire or on an abandoned field.

Changes during succession



Near-zero **ecosystem** carbon accumulation does not mean zero **producer** NPP.

A mature ecosystem can still feed consumers

1. **Given.** GPP 1000; **producer respiration** 600; total **ecosystem** respiration 1000 in matching rate units.
2. **Producer net.** NPP $= 1000 - 600 = 400$.
3. **Ecosystem net.** NEP $= 1000 - 1000 = 0$; NPP remains available to other pathways.

Decision

Near-balanced ecosystem carbon does not imply zero NPP.

Plagioclimax

> Woodland is not an inevitable endpoint everywhere.

- Repeated grazing, cutting or burning can maintain a **plagioclimax**.
- After intervention stops, the direction depends on local conditions.

AHL: Climate mechanisms

ENSO and ocean

El Niño can suppress nutrient-rich upwelling near Peru.

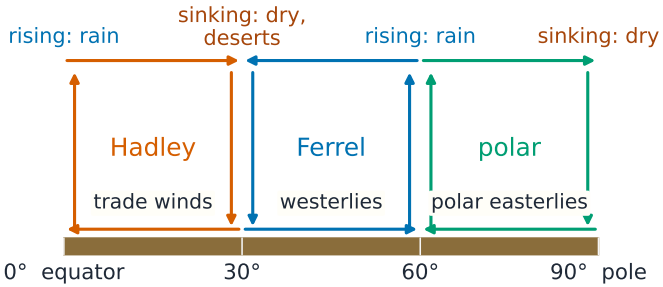
Temperature/salinity influence density; winds and mixing also matter.

Evidence and limits

ENSO is irregular; remote effects vary by place and season.

Warming can intensify rain and strong storms without raising total counts everywhere.

Three cells per hemisphere



The cells set the prevailing winds

Exam tips

> For every cycle flow, name the process and what drives it.

- Name the growth phase and give its reason.
- AHL: Write the **productivity** equation before the numbers.
- Energy is released as heat, never used up.

Check yourself

Try these

60 snails marked; later 45 caught, 9 marked. Estimate the population and state assumptions.

Explain why producer NPP can remain positive in a mature ecosystem with little net carbon accumulation.

Explain how circulation contributes to subtropical dry regions, with a local-condition qualification.