DP Biology – D4.2

Stability and change

- What allows ecosystems to remain stable indefinitely?
- Which human changes put ecosystem stability at risk?

SL statements D4.2.1–10. Textbook pp. 798–813. Succession is at HL.
Image: the Amazon rainforest from space. Alexander Gerst, CC BY 2.0.



Objectives for each class

Class	Statements	By the end of the class, you can...
1	D4.2.1–3	Explain what stability is and what it requires, and why Amazon deforestation might reach a tipping point
2	D4.2.4–6	Explain keystone species, and assess the sustainability of harvesting and of farming
3	D4.2.7–8	Explain eutrophication, BOD and biomagnification
4	D4.2.9–10	Describe the effects of plastics in the oceans, and explain how rewilding works

Stability in natural ecosystems

D4.2.1



Tropical forest. V. Argenberg, CC BY 4.0.

- **Stability** is the ability of an ecosystem to continue over long periods
- Some forests and deserts show continuity over many thousands of years
- Some ecosystems may have persisted for millions of years, as in parts of the Daintree rainforest in Australia
- Stability does not mean nothing changes: populations fluctuate within limits

Local example

Switzerland has patches of old forest, which have never been managed for timber. What evidence would show that a forest has been continuous for a long time? Think about tree age, dead wood and fossil pollen.

What stability requires

D4.2.2

Requirement	Why
Supply of energy	Usually sunlight, to replace what is lost as heat
Recycling of nutrients	Elements return to producers; little leaves the ecosystem
Genetic diversity	Some individuals can survive selection pressures
Climate within tolerance	Temperature and rainfall stay within limits

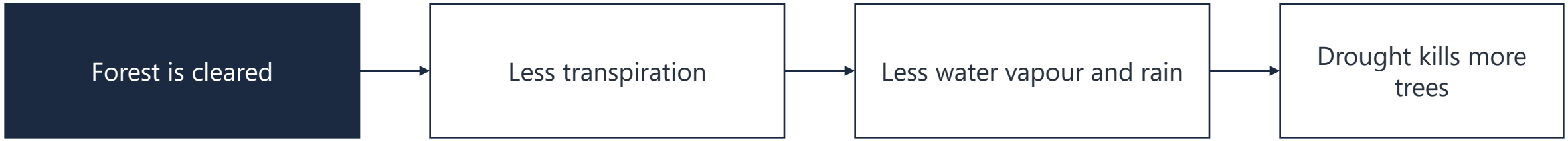
Activity

Look at examples of harvesting timber, poaching a top predator, and soil erosion. For each, say which of these requirements is put at risk, and how.

Tipping points: the Amazon

D4.2.3

- A **tipping point** is a point beyond which a system moves to a new state, and may not recover
- Positive feedback can drive this change



Why the size of the forest matters

A large rainforest makes much of its own rain. Water vapour from transpiration cools the air and drives air flows and rainfall further inland. Clearing large areas breaks this cycle.

Possible outcome

Part of the forest could shift to savanna. Scientists disagree about exactly when this might happen. Use an online forest map to see how tree cover has changed in the Amazon.

Modelling stability: mesocosms

D4.2.1–2

- A **mesocosm** is a small, enclosed model of an ecosystem, in a tank or a sealed vessel
- Sealed glass vessels stop matter entering or leaving, while allowing energy transfer
- They let you test how a variable affects stability

Design questions

Should the container be glass or plastic, clear or opaque? Which organisms would make up a working community? Which trophic levels should be included? How will oxygen and nutrients keep cycling?

Ethics

Animals should not be included if they might suffer. Is it acceptable to include an animal in a sealed vessel? What could you observe in one with only plants and microorganisms?

Keystone species



Beaver dam. Sean Dudley, public domain.

- A **keystone species** has a very large effect on community structure, in proportion to its numbers
- If it is removed, the ecosystem may collapse
- Beavers make dams, creating wetlands used by many species
- Amphipods in Swiss rivers break down leaf litter and feed fish



Example: wolves in Yellowstone

After wolves were returned in 1995, numbers of elk fell and their behaviour changed. Some willow and aspen recovered. Scientists still debate how much is due to wolves. Image: NPS, public domain.

Is harvesting sustainable?

The rule

Harvesting is sustainable if its rate is lower than the rate of replacement.

	Timber in Finland	Atlantic cod
Type	Terrestrial plant	Marine fish
Replacement	Law requires regrowth after logging	Depends on adult fish left to breed
Assessment	Measure growth and felling rates	Fish surveys and catch records
Outcome	Forest area has been maintained	Stocks collapsed, as in Canada in the 1990s



Images: Atlantic cod, public domain. Use the same questions for any harvested species: how fast does it reproduce, and how fast is it removed?

Sustainability of agriculture

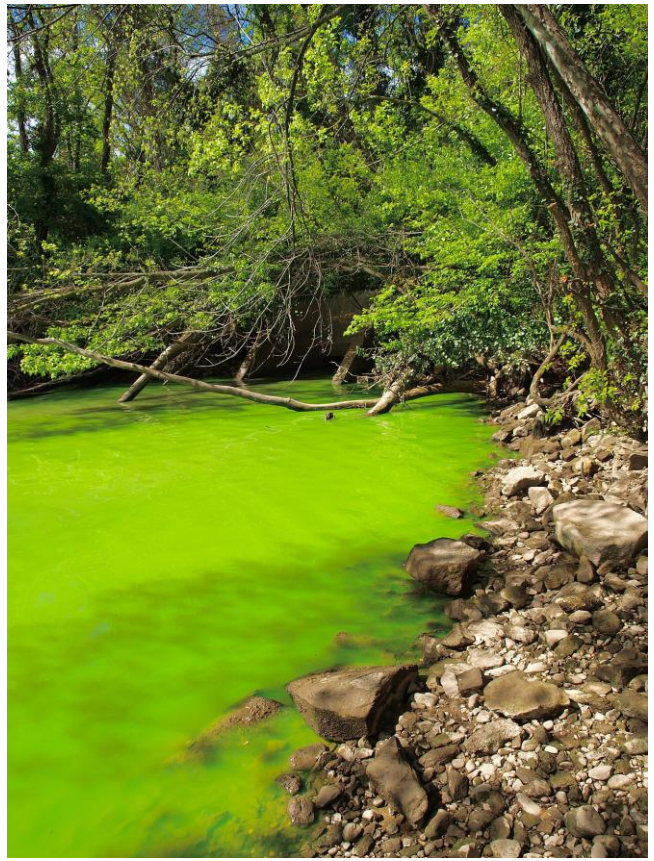
D4.2.6

Factor	Issue
Soil erosion	Ploughing exposes soil, and it is carried away by wind and water
Leaching	Rain washes nutrients from soil into rivers
Fertilizers and inputs	Supply is limited, and making them uses much energy
Pollution	Pesticides and herbicides affect other organisms
Carbon footprint	Machines, transport and glasshouses release carbon dioxide

Discussion

What changes could make a farm more sustainable, and what might each one cost?

Eutrophication



Algal bloom in the Potomac. A. Trubetskoy, CC BY-SA 3.0.

1. Nitrates and phosphates leach from fertilizers into water
2. Algae grow rapidly and block light, forming a bloom
3. Plants below die, as they lack light
4. Bacteria decompose dead matter, using much oxygen
5. Oxygen falls, so fish and other animals die

Biochemical oxygen demand

BOD is the amount of oxygen that microorganisms use to break down organic matter in water. A high BOD shows heavy organic pollution, and it can leave too little oxygen for other organisms.

Biomagnification

D4.2.8

	Bioaccumulation	Biomagnification
Meaning	Toxin builds up in one organism during its life	Concentration rises at each trophic level
Why	It cannot be excreted, often as it is fat soluble	Each consumer eats many prey

Level	DDT / ppm (example values)
Water	0.00005
Plankton	0.04
Small fish	0.5
Fish-eating bird	25

Examples

DDT in birds thinned their eggshells. **Mercury** builds up in large predatory fish, such as shark and swordfish.

Plastics in the oceans

D4.2.9



Albatross chick with plastic. Duncan Wright, public domain.



Microplastics on a beach. Ifremer, CC BY 4.0.

	Macroplastics	Microplastics
Size	Larger than 5 mm	Smaller than 5 mm
Harm	Entangle animals; fill stomachs	Taken in by small animals; pass along food chains

Why they persist

Most plastics do not biodegrade, so they remain in the environment for a very long time.

Examples

Laysan albatrosses feed plastic to their chicks. Sea turtles mistake plastic bags for jellyfish.

Rewilding

D4.2.10

- **Rewilding** restores natural processes, often with little further human input
- Bringing back apex predators and other keystone species
- Reconnecting habitats over large areas
- Reducing human impact, including by removing livestock
- Removing invasive species

Examples

Hinewai Reserve in New Zealand has regenerated native forest with minimal intervention. Rewilding Europe works in the Iberian Highlands and the Danube Delta. The Swiss National Park leaves nature to run its course.

Discussion

Local farmers may oppose the return of wolves. How should conservation goals be weighed against people's livelihoods?

Check that you can explain

1. What stability is and what it requires
2. How the Amazon could reach a tipping point
3. How mesocosms model ecosystems
4. Keystone species, with examples
5. How to assess whether harvesting or farming is sustainable
6. Eutrophication, BOD and biomagnification
7. Effects of plastics, and how rewilding works

Exit activity: 5 minutes

On your own and without notes. Hand this in as you leave.

1. State the condition that makes harvesting of a species sustainable.
2. Outline how leaching of fertilizer can lead to the death of fish.
3. Distinguish between bioaccumulation and biomagnification.

Image credits

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Virgin tropical forest in southern Thailand, Khlong Phanom, Surat Thani.jpg – Vyacheslav Argenberg – CC BY 4.0

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