HOW DOES FOOD PRODUCTION AFFECT ECOSYSTEMS?

Ecosystems, food webs and bioaccumulation

Introduction

This lesson investigates how food production affects ecosystems. Working through two connected biological concepts — food web disruption and the accumulation of toxic materials — students build a scientific explanation for why farming practices have consequences that travel far beyond the field. The lesson is grounded in evidence connecting farmed animal feed crop monoculture to habitat loss, biodiversity decline and ecosystem disruption.

The lesson maps directly onto the KS3 National Curriculum for science, specifically the 'Interactions and Interdependencies' strand', the interdependence of organisms in ecosystems including food webs; and how organisms affect and are affected by their environment, including the accumulation of toxic materials. It can be taught as a standalone lesson within any ecology or ecosystems unit.

The lesson follows an 'I do / We do / You do' structure. The 'I do' establishes the science through teacher-led instruction. The 'We do' gives students a structured investigation – sequencing and analysing data on bioaccumulation – so that the key pattern emerges through their own thinking rather than being handed to them. The 'You do' asks students to construct an independent scientific explanation, with differentiated support built in.

Relevant Links

Bioaccumulation KS3 – BBC Bitesize
Bioaccumulation and eutrophication KS4 – BBC Bitesize
Environment and sustainability – The Vegan Society

LESSON OVERVIEW

Timing
60 minutes

Setting
classroom

National Curriculum Links

KS3 Science: Interactions and interdependencies.
- "The interdependence of organisms in an ecosystem, including food webs"
- "How organisms affect, and are affected by, their environment, including the accumulation of toxic materials"

What you'll need

Slide deck – How does food production affect ecosystems?, Organism Cards, Eutrophication sequencing cards, Writing frame.

Additional resources

Exercise books, pens, envelopes for prepared cards, interactive whiteboard (ideally).whiteboards and pens

Before the lesson

- Print and cut organism cards (laminate if reusing) and place in envelopes – 1 set per pair, 15 per class.
- Print and cut eutrophication sequencing cards and place in an envelope – 1 set per pair. Alternatively, print 1 table for each student requiring the stretch option (note: this is a stretch task, so please judge how many your class requires).
- Print writing frame – 1 per student (note: this is a support sheet, so please judge how many you need for your class).

Learning Objectives

1. Explain how organisms in an ecosystem depend on each other, using food webs as evidence.
2. Describe how agricultural practices can disrupt food webs and reduce biodiversity.
3. Explain how toxic materials accumulate through a food chain and the consequences for organisms.

The Lesson

Timings are a guide – adjust them to suit your class.

Slide 1 – Title Page

Slide 2 – Learning objectives and key terms

• Reveal the learning objectives and key terms – students to record if necessary.

Starter – 8 minutes

Resources: Organism cards (1 set per pair).

Slide 3

The activity

• Students receive a laminated set of organism cards and arrange them into a food web on their desk in pairs.

• The ecosystem is a UK mixed farmland/hedgerow habitat. The card set includes:

- Grass
- Wildflowers
- Hawthorn
- Aphids
- Caterpillars
- Field mice
- Rabbits
- Hedgehogs
- Sparrows
- Sparrowhawks
- Foxes

• Once students are happy with their arrangement, they will copy their food web into their exercise book and draw in the arrows to show feeding relationships. They then answer two questions from the board:

1. What would happen to the sparrowhawk if the rabbit population disappeared?
2. Which organism do all other organisms ultimately depend on, and why?

Potential script

• You've been given a set of cards – each one is a different organism from a UK hedgerow habitat. In pairs, arrange them into a food web on your desk.

• Remember: the arrow always points from the organism being eaten to the organism doing the eating – it shows the direction energy is moving.

• [Class feedback for question 2] Which organism does everything else ultimately depend on? ... Grass and wildflowers – the producers. Without photosynthesis capturing energy from the sun, there's no energy entering the system at all. Every organism in this web traces back to that. Keep hold of this idea in today's lesson.

Task – I do – [15 minutes]

Slides 4-5

Key point 1: What happens to the web when the landscape is changed by humans?

The activity

• These slides are teacher-led instructions focusing on the impact of monoculture farming.

• The teacher will demonstrate a cascade as a result of monoculture farming, by crossing out images on the board. See the script below for more details.

• Students listen, observe and respond to any teacher questioning.

Important point
This is not about blaming farmers; farmers do not choose to damage ecosystems. The way our food system and society are currently set up, demanding cheap food and high quantities of meat and dairy, creates pressures that make intensive farming the norm. Encourage students to ask scientific questions about what our current food system does to living beings and our living world. See the suggested script in bold below.

Potential script

• You've just built a food web – a network of feeding relationships where every organism depends on others to survive. That's what scientists call interdependence.

• What happens to that web when humans change the landscape?

• Imagine the hedgerow habitat on your cards is cleared. The farmer needs more land to grow crops – specifically, crops to feed livestock. So the wildflowers go. The hedgerows go. In their place: a single crop, grown in rows, as far as you can see. Scientists call this a monoculture – one species, covering a large area. [Remove or cross out wildflowers, hedgehog and sparrow from the displayed food web].

- The wildflowers are gone, so the caterpillars that fed on them now have no food source.
[Remove caterpillars].
- The hedgehogs that sheltered in the hedgerow have lost their habitat.
[Remove the hedgehogs].
- The sparrows have fewer insects to eat. Watch what happens to the web.
[Remove the sparrows… Continue removing organisms one by one as their food sources disappear].
- This is what ecologists call a cascade – a disruption at one point ripples through the whole system because of interdependence. And when a habitat loses species like this, we say it has lost biodiversity, the variety of living things in an ecosystem.
- Research found that in the EU, over 60% of cropland grows feed for animals rather than food for people (Greenpeace, 2019, cited in The Vegan Society, n.d.).
- This suggests that our food choices have a huge impact on ecosystems and the environment.
- **It's important to be clear here:** farmers don't choose to damage ecosystems. The way our food system is currently set up – the demand for cheap food, including meat and dairy on a large scale – creates pressures that make intensive farming the norm. This isn't about blaming individual farmers. It's about understanding a system, and asking scientific questions about what that system does to the living world.

Slide 6
Key point 2: What happens to the organisms?

The activity
- Another teacher-led demonstration looking at the impact of pesticides on the living world through bioaccumulation.
- Use the example of DDT and then empower students by informing them of legislation changes which removed this pesticide, improving populations of some birds of prey.
- Students to actively listen.

Potential script
- Growing a monoculture at scale creates a problem: pests. When you have thousands of plants of the same species in one place, insects and other organisms that feed on that plant thrive. So farmers use pesticides.
- But where do those pesticides go? They don't just disappear. Some are absorbed into the roots and leaves of the plants. Some wash into the soil and water. And when an organism eats a plant that contains pesticide residue, that chemical enters their body.
- Many pesticides are non-biodegradable. That means they cannot be broken down by the organism's body. They don't get excreted. They accumulate – they build up in the organism's tissues over time.
- A field mouse eats many plants over its lifetime. Each time, it absorbs a small amount of pesticide. That pesticide stays in its body. Now a sparrowhawk eats many field mice over its lifetime. Each mouse carries that accumulated pesticide. So the sparrowhawk ends up with a far higher concentration of the chemical in its body than any single plant ever contained.
- This process, the build-up of toxic materials through a food chain, is called bioaccumulation. The key word is accumulate: the toxin doesn't pass through, it builds up. And it builds up most severely in the organisms at the top of the food chain – the apex predators.
- A real example of this is from the 1950s and 60s, where a pesticide called DDT was widely used on farmland in the UK and US. It accumulated through food chains into birds of prey – peregrine falcons, sparrowhawks, and ospreys. Concentrations became so high that it affected the birds' ability to produce healthy eggs. Populations collapsed. DDT was eventually banned, and many of those species have since recovered – but it took decades.
- So we have two types of disruption: structural (the food web is damaged when habitat is destroyed) and chemical (toxic materials accumulate through the food chain, affecting organisms furthest from the source most severely). In a moment, you're going to investigate the chemical disruption yourselves.

Task – we do – [17 minutes]
Resources: Eutrophication sequencing cards (optional stretch extension task)

Slide 7
The activity
- Students work in pairs, referring to the slide.

• The slide presents a simple fictional food chain with concentration data at each trophic level. They complete the structured tasks that build up from reading the data to explaining the pattern.

Potential script

• Now it's your turn to investigate it. On the screen you will see a food chain and some data showing pesticide concentrations at each trophic level. Start by plotting the data as a bar chart, then work through the questions. You're working in pairs but each of you need to write your own answers.

Questions to ask

• What pattern are you noticing as you move up the food chain?

• Why does the apex predator end up with the highest concentration, even though it never touched the original source?

• What does non-biodegradable mean for an organism that eats contaminated food every day of its life?

Optional extension / stretch

• For pairs/individuals who complete all five tasks, hand out a set of eutrophication sequencing cards.

• The cards need to be organised into the correct order, or they can number the boxes (see appendix 1 for answers). Then students answer: "Is eutrophication another example of how organisms are affected by their environment? Explain your reasoning using evidence from the cards."

Task – you do – [12 minutes]

Resources: Bioaccumulation data task sheet, writing frame (support sheet, hand out as required).

Slide 8

The activity

• Students work independently to create a written response to the following:

A farmer converts a mixed hedgerow habitat into a monoculture field to grow crops for animal feed. Using your knowledge of food webs and the accumulation of toxic materials, explain two ways this could affect the ecosystem.

• Students can draw on knowledge from the bioaccumulation task sheet (and eutrophication extension task).

Potential script

• You've investigated two ways the ecosystem could be affected. Now is your chance to consolidate your understanding.

• [Towards the end of the task] If you've covered both ways, go back and check: have you explained the mechanism, or just described the outcome? A scientist always explains why.

What to look for

• Naming specific organisms or trophic levels.

• Using the term bioaccumulation correctly.

• Explaining the mechanism – why concentrations increase up the chain.

• Referring to interdependence to explain food web disruption.

Stretch responses may

• Refer to non-biodegradable accurately.

• Make a causal link between the scale of monoculture farming (partially due to livestock farming practices) and the sale of pesticides.

• Reference apex predators and explain why they are disproportionately affected.

• Students who've completed the eutrophication extension may also refer to a third way – nutrient run-off affecting aquatic ecosystems.

Plenary – [8 minutes]

Slide 9

The activity

• Pairs to play a short game of 'convince a sceptic'. The phrase they are arguing against is: 'I don't see what my food has to do with wildlife. That's ridiculous!'.

• They take it in turns; one responding and one actively listening for scientific key terms from the lesson.

• The teacher should choose two or three responses to be shared in front of the class.

• Encourage all students to count how many scientific terms are used correctly while listening.

Potential script

• To finish, there is a challenge for you. Your friend turns to you and says: 'I don't see what my food has to do with wildlife. That's ridiculous! You have 60 seconds to convince them using science. Not opinions or feelings, science.

• Here's the twist: while the scientist is talking, the sceptic is listening for scientific key terms from today's lesson – food web, interdependence, bioaccumulation, non-biodegradable, apex predator, biodiversity. Every time you hear one used correctly, put a finger up. See how many you can count. Then it's your job to tell your partner which terms they used and which ones they missed.

Differentiation

Support

• Organism cards for the starter provide a concrete starting point before any writing takes place.

• The word bank is designed so students can easily cross off terms as they go.

• There is a writing frame to scaffold and support during the I Do task.

• Verbal plenary to assess understanding without further writing.

Stretch

• Task 5 of the bioaccumulation task asks students to predict future outcomes.

• Eutrophication extension task requires analytical thinking; it is also a concept referred to at KS4.

Appendix 1 Eutrophication sequencing cards: correct order

1. Nutrient run-off: Fertilisers and livestock slurry from nearby farmland wash into the river during rainfall. The water becomes enriched with nutrients – especially nitrogen and phosphorus.

2. Algal bloom: The extra nutrients cause algae to multiply rapidly. A thick layer of algae – called an algal bloom – forms on the surface of the water.

3. Light blocked: The algal bloom is so dense that it blocks sunlight from reaching the aquatic plants below the surface. Without light, photosynthesis cannot occur.

4. Aquatic plants die: The aquatic plants die because they cannot photosynthesise. As they die, they begin to decompose on the riverbed.

5. Decomposers multiply: Decomposing bacteria feed on the dead plant material and multiply rapidly. These bacteria use oxygen from the water as they respire.

6. Oxygen depletion: Oxygen levels in the water drop so low that fish and invertebrates can no longer survive. Large numbers of aquatic organisms die.