REVISION GUIDE

What we stand to *lose*

Conservation of biodiversity

There may be more kinds of living thing on Earth now than ever before, and they are disappearing faster than at any time since the dinosaurs. Count biodiversity two ways, follow a moa, a seal and a rainforest to their ends, read the evidence of a crisis, and decide which species to save first.

6 chapters · a dry lab

The interactive guide, with every animation:

biologybybradford.com/guides/ib-biology-a4-2-conservation-of-biodiversity

Contents

01	Counting the variety	3
02	More than ever, for now	5
03	Gone for good	7
04	Losing a whole forest	9
05	Reading the evidence	11
06	Saving what is left	13
	Key terms	17
	Dry lab: Which species first? The EDGE list	18
	Check yourself	19
	Answers	20

By the end you can

- [ ] Describe biodiversity at three levels: ecosystem, species and genetic diversity A4.2.1
- [ ] Compare the number of species alive today with past levels, from fossil evidence A4.2.2
- [ ] Explain the causes of anthropogenic extinction, using the moa, the Caribbean monk seal and a local example A4.2.3
- [ ] Explain the causes of ecosystem loss, using mixed dipterocarp forest and a local example A4.2.4
- [ ] Evaluate the evidence for a biodiversity crisis, and why surveys must be repeated A4.2.5
- [ ] Explain the causes of the current crisis, with human population growth as the overarching one A4.2.6
- [ ] Explain why conservation needs several approaches, in situ and ex situ A4.2.7
- [ ] Explain how the EDGE of Existence programme chooses species to prioritise A4.2.8

Tick each one when you can do it without the book.

01 Counting the *variety*

A4.2.1 BIODIVERSITY AS THE VARIETY OF LIFE IN ALL ITS FORMS, LEVELS AND COMBINATIONS

Biodiversity is the variety of life, and it comes at three levels. **Ecosystem diversity** is the range of habitats and communities in an area: a coast with dunes, salt marsh, woodland and a river has more than one covered in wheat. **Species diversity** is the number of species and how their numbers are shared. **Genetic diversity** is the variety of alleles within a species, which lets a population survive a new disease or a changing climate.

Species diversity has two parts. **Species richness** is how many species there are. **Evenness** is how equally the individuals are shared among them. Compare the two meadows: both hold four species, but in one, almost every plant is the same. Walk through it and you would barely notice the other three.

KEY POINTS

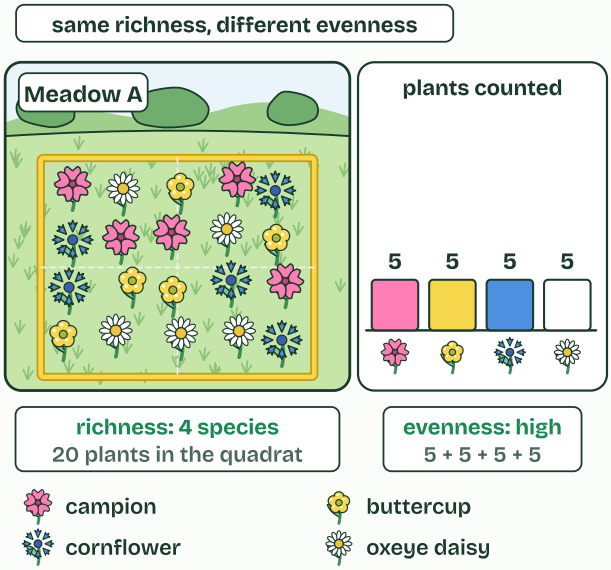
- Three levels: ecosystem, species and genetic diversity.
- Richness: how many species. Evenness: how equally individuals are shared.
- Genetic diversity lets a population adapt to change.

KEY TERMS

biodiversity
The variety of life in all its forms, levels and combinations: the diversity of ecosystems, of species and of the genes within species.

species richness
The number of different species present in an area.

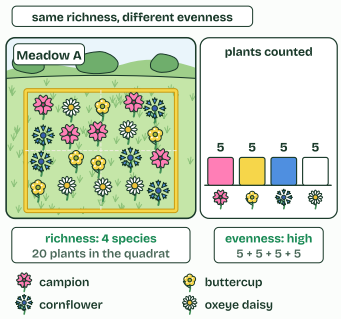
evenness
How evenly the individuals in an area are shared among its species: high when each species has similar numbers, low when one species dominates.



SWITCH IT

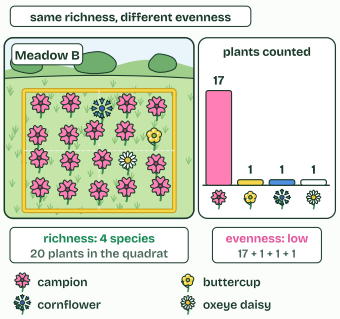
2 SETTINGS

1



Meadow A

2



Meadow B

WATCH OUT

Two places with the same number of species need not be equally diverse. A place where one species makes up nearly all the individuals has low evenness, and so lower diversity.

PREDICT

A cheetah population passed through a bottleneck and now has very little genetic diversity. Why does that put it at risk?

(A) With few alleles, the cheetahs cannot interbreed with other cat species to bring in new genes when they are needed

(B) With few alleles, a new disease that kills one cheetah is likely to kill most of them, as none may carry resistance

(C) With few alleles, each cheetah needs more food and a larger territory, so the population runs out of habitat sooner

Decide before you look. Answer on page 20.

A4.2.2 COMPARISONS BETWEEN CURRENT NUMBER OF SPECIES ON EARTH AND PAST LEVELS OF BIODIVERSITY

02 More than *ever*, for now

Scientists have named and described about 2 million species. Many more have never been found: estimates run from a few million to many more, and one widely quoted study put the number of eukaryote species alone at about 8.7 million. Most of the unknown ones are small: insects, mites, fungi and microbes in soil, in rainforest canopies and on the deep sea floor.

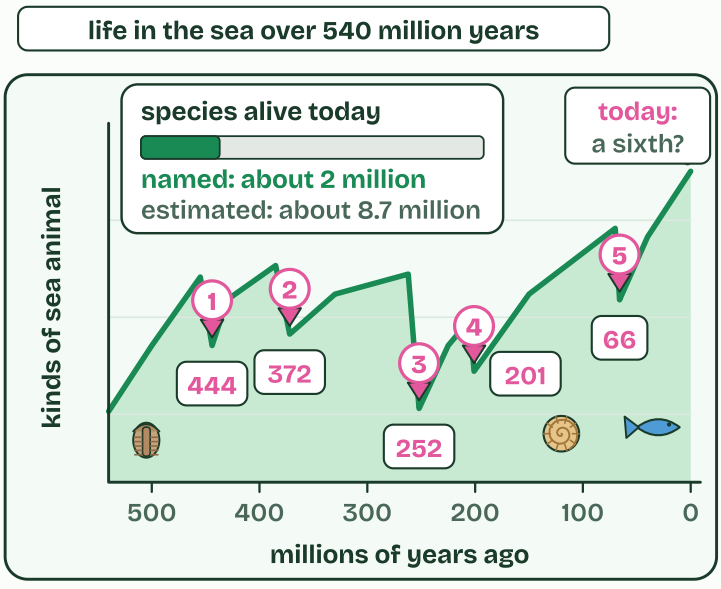
The fossil record shows how this compares with the past. Counting the kinds of sea animal preserved in rocks of each age, the number has risen over 540 million years, so there are probably more species alive now than at any time before. But the rise was broken five times by **mass extinctions**, when most species died out in a geologically short time. The worst, 252 million years ago, ended perhaps nine in ten species in the sea. After each, it took millions of years for diversity to recover.

KEY POINTS

- About 2 million species named; many millions more not yet found.
- Fossils suggest more species alive today than ever before.
- Five mass extinctions: 444, 372, 252, 201 and 66 million years ago.

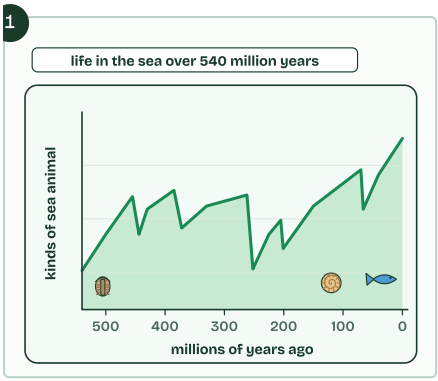
KEY TERMS

mass extinctions
An event in which a large proportion of Earth's species, often more than three quarters, die out in a geologically short time.



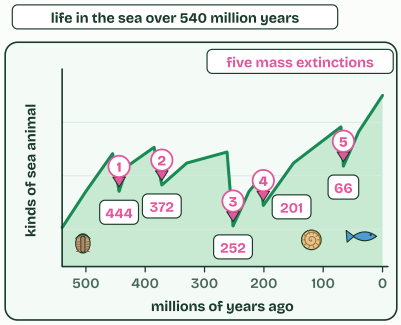
STEP BY STEP
3 STEPS

1



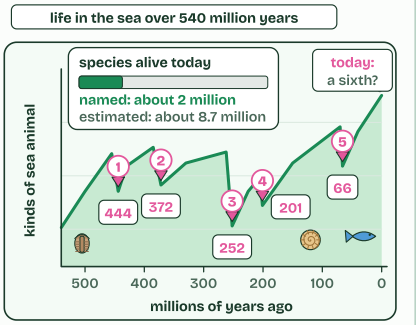
Fossils of sea animals show the number of kinds **rising** over 540 million years, to more than ever today.

2



Five times it crashed: the **mass extinctions**. Each time, recovery took millions of years.

3



About **2 million** species are named today, of perhaps **8.7 million**, and losses are speeding up.

NATURE OF SCIENCE

Classifying is pattern recognition, and the same observations can be sorted in different ways. Some taxonomists, "splitters", name a new species for every population that differs in a consistent way; "lumpers" group them into fewer, more variable species. Giraffes have been counted as one species by some and four by others, from the same data. So a count of species depends partly on who does the counting.

PREDICT

Why are so many of the species not yet described thought to be insects and other small invertebrates?

(A) Small invertebrates evolved only recently, so most of their species have appeared since the last survey was done

(B) Small invertebrates are not counted as species by most taxonomists, so their numbers are left out of the totals

(C) They are small, live in hard places to sample, and look alike, so many have simply never been collected and compared

Decide before you look. Answer on page 20.

03 Gone for *good*

A4.2.3 CAUSES OF ANTHROPOGENIC SPECIES EXTINCTION

The five past mass extinctions had natural causes: huge volcanic eruptions, changes in climate and sea level, and an asteroid. Many biologists now speak of a sixth, and this one is **anthropogenic**: caused by humans. Three short case studies show different ways it happens.

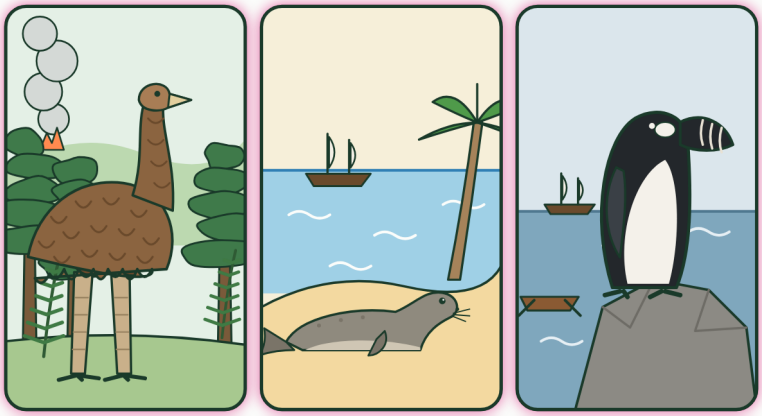
The **North Island giant moa** (*Dinornis novaezealandiae*) was a flightless bird up to about 2 m tall. New Zealand had no land mammals except bats, so moa had no defence against hunters. Within about 150 years of Polynesian settlers arriving, around 1300, every species of moa was gone: hunted, their eggs taken and their forest burned. Moa bred slowly, so even modest hunting outpaced their births. It is one of many losses of **megafauna**, large animals, after people arrived.

The **Caribbean monk seal** (*Neomonachus tropicalis*) basked on beaches and did not flee from people. From the 1500s it was killed for oil and meat, and its food fish were overfished. It was last seen in 1952 and declared extinct in 2008: a marine species lost to overexploitation. The **great auk**, a flightless seabird of the North Atlantic, went the same way in 1844. Find one for your own area.

KEY POINTS

- The sixth mass extinction is anthropogenic: caused by human activity.
- Moa: hunting of slow-breeding megafauna with no fear of humans.
- Monk seal: overexploitation for oil, and overfishing of its food.

tap each one: how did people end it?



giant moa New Zealand	monk seal Caribbean	great auk North Atlantic
gone by about 1450	last seen in 1952	last pair killed 1844

North Island giant moa (Dinornis novaezealandiae): a flightless bird of the forests of New Zealand, the females up to about 2 m tall with the neck raised. Polynesian settlers arrived around 1300 and hunted moa, took their eggs and burned forest. Moa bred slowly and had never met a mammal hunter, so within about 150 years every moa species was gone. Loss of megafauna by overhunting.

Great auk (Pinguinus impennis): a flightless seabird of the North Atlantic that came ashore to breed on a few rocky islands, where it could be rounded up on foot. Sailors killed millions for meat, eggs, oil and feathers, and collectors paid for the last skins and eggs. The last known pair was killed on Eldey, off Iceland, in 1844. A local example for Europe and North America: find one for where you live.

Caribbean monk seal (Neomonachus tropicalis): a seal of the warm Caribbean and Gulf of Mexico that hauled out on beaches and had no fear of people. From the 1500s it was killed for oil from its blubber and for meat, and later the fish of its reefs were overfished. The last confirmed sighting was in 1952; it was declared extinct in 2008. Loss of a marine species by overexploitation.

PREDICT

Large, slow-breeding animals, such as moa, were wiped out far faster than small birds on the same islands. Why?

(A) Each one killed takes years to replace, because few young are born each year, so hunting outstrips births

(B) Large animals need more water each day, so they were first to suffer in the droughts that people brought with them

(C) Large animals carry more parasites, so they caught the diseases brought by settlers sooner than small birds did

Decide before you look. Answer on page 20.

04 Losing a whole *forest*

A4.2.4 CAUSES OF ECOSYSTEM LOSS

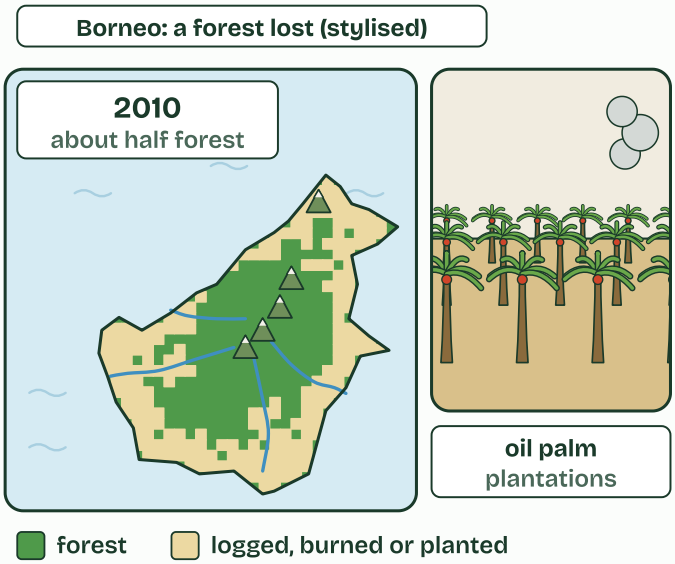
Whole ecosystems are lost too, with every species that depends on them. **Mixed dipterocarp forest** is the lowland rainforest of Southeast Asia, named after the dipterocarps, tall hardwood trees that tower over the canopy. On the island of Borneo it is among the richest forest on Earth, home to orangutans, hornbills and thousands of tree species.

In 1973 about three quarters of Borneo was forested; by about 2010, roughly half. The causes, all human, build on each other. **Logging** took the valuable dipterocarp timber first, starting with lowland forest near the coasts and rivers. Logging roads opened the forest to **clearance** for **oil palm** and other plantations. Dried-out logged forest and drained peat swamps burned in **fires**, most fiercely in El Niño droughts. What grows back is not the same ecosystem.

A second case study should come from near you. One example: the **Aral Sea**, once the fourth largest lake in the world, shrank to a fraction of its size after its rivers were diverted to irrigate cotton, and its fishery and wetlands collapsed.

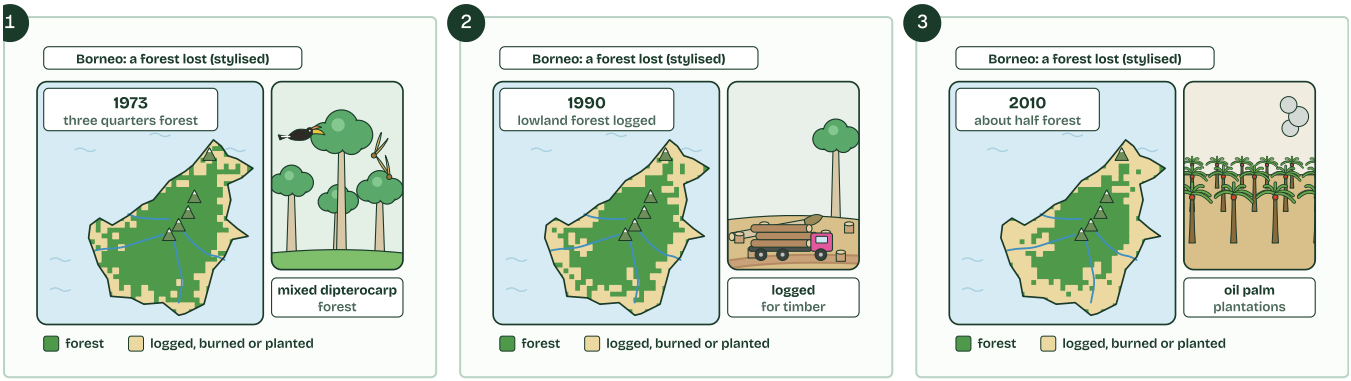
KEY POINTS

- Mixed dipterocarp forest: lowland rainforest of Southeast Asia.
- Causes: logging, clearance for oil palm and farms, fire, peat drainage.
- Losing an ecosystem loses every species that depends on it.



STEP BY STEP

3 STEPS



1973: about three quarters of Borneo is forest, most of it mixed dipterocarp forest.

1990: logging has moved inland from the coasts and rivers.

2010: about half is left; the rest is logged, burned or planted with oil palm.

WATCH OUT

A plantation of oil palms is green from the air, but it is not forest in an ecological sense. One species of tree in rows supports a small fraction of the species of the forest it replaced.

PREDICT

On Borneo, the lowland forest near the coasts went first, and mountain forest in the interior is still mostly standing. Why?

(A) Mountain forest has fewer dipterocarp trees in it, so loggers had no reason to go further than the edge of the lowlands

(B) Lowland forest is easier to reach by river and road, and its flat land suits plantations, so it was cleared first

(C) Mountain forest is protected by law in every part of Borneo, so it cannot be logged or cleared by any company

Decide before you look. Answer on page 20.

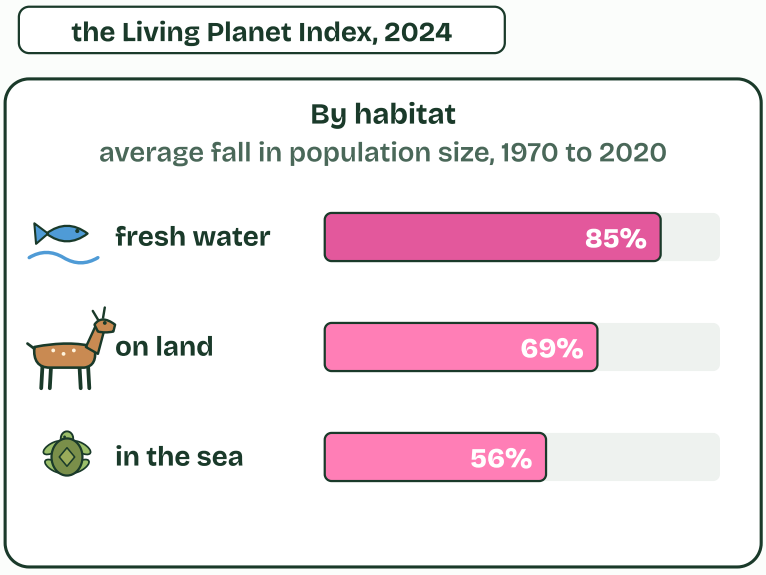
A4.2.5 A4.2.6 EVIDENCE FOR A BIODIVERSITY CRISIS CAUSES OF THE CURRENT BIODIVERSITY CRISIS

05 Reading the *evidence*

How do we know biodiversity is falling? From surveys, repeated. One survey of a habitat gives its richness and evenness at one moment; only the same survey, done the same way years later, shows change. The **Living Planet Index** tracks almost 35,000 populations of vertebrates around the world. Between 1970 and 2020 their average size fell by 73%. The UN's biodiversity panel, the **IPBES**, drew on thousands of studies in 2019 and estimated that about a million species face extinction.

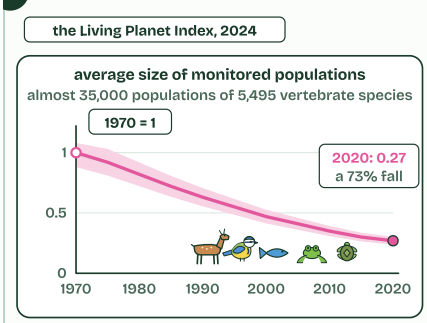
The causes are many, but one lies under all of them: **human population growth**, with each person using more land, water and resources. From it come the specific causes:

Hunting and overexploitation: overfishing, poaching, the wildlife trade.
Urbanisation: cities and roads cover and split habitats.
Deforestation and land clearance for farming: the biggest single cause of habitat loss.
Pollution: pesticides, fertiliser run-off, plastics and carbon dioxide.
Pests, diseases and invasive species spread by global transport, such as the chytrid fungus killing frogs.



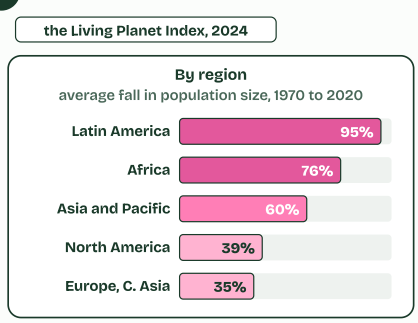
STEP BY STEP 3 STEPS

1



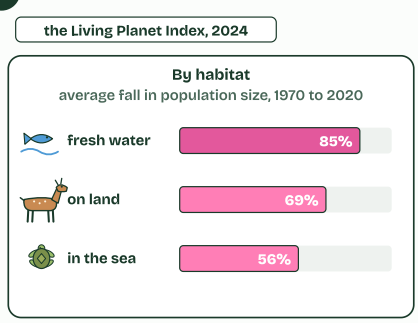
Across almost 35,000 monitored populations of vertebrates, average size fell by **73%** from 1970 to 2020.

2



The fall is steepest in **Latin America and the Caribbean**, where tropical forest is being cleared.

3



By habitat, **fresh water** has lost most: rivers are dammed, drained and polluted.

NATURE OF SCIENCE

Evidence counts when it is published in a peer-reviewed journal, so others can check the method. Citizen scientists, members of the public recording birds, butterflies or plants, add data on a scale no team of scientists could. But their skill varies, and they record where people go, not where a random sample would, so their data need checks for misidentification and bias.

PREDICT

A bird count in a park finds 30 species in 2024. Why is this not, on its own, evidence of a biodiversity crisis?

(A) Thirty species is too high a number to show a crisis, which would only be declared if fewer than ten species were found

(B) One survey shows no change; it needs repeating in the same way over years, to compare richness and evenness through time

(C) Birds fly between parks, so a count of birds can never be used as evidence of anything happening in one place

Decide before you look. Answer on page 20.

A4.2.7 A4.2.8 NEED FOR SEVERAL APPROACHES TO CONSERVATION OF BIODIVERSITY SELECTION OF EVOLUTIONARILY DISTINCT AND GLOBALLY ENDANGERED SPECIES FOR CONSERVATION PRIORITIZATION IN THE EDGE OF EXISTENCE PROGRAMME

06 Saving what is *left*

No single method is enough, and different species need different help.

In situ conservation protects species where they live, in **nature reserves** and national parks. A reserve must be managed: patrols against poaching, removal of invasive species, control of grazing, and corridors to link it to others.
Rewilding restores a degraded ecosystem and lets it run itself again: reintroducing lost species such as beavers, wolves or lynx, blocking drains and letting forest regrow. **Reclamation** brings back land damaged by mining or farming.
Ex situ conservation keeps species away from their habitat: captive breeding in **zoos** and **botanic gardens**, to release later, and **seed and tissue banks** that store dried, frozen seeds or cells as a reserve of genetic diversity.

Money is limited, so which species come first? The **EDGE of Existence** programme, run from the Zoological Society of London, prioritises species that are both **evolutionarily distinct**, with few or no close relatives, and **globally endangered** on the IUCN Red List. Lose one of these and a whole branch of the tree of life goes with it. Rank six species yourself in the Dry lab, then see the EDGE ranking.

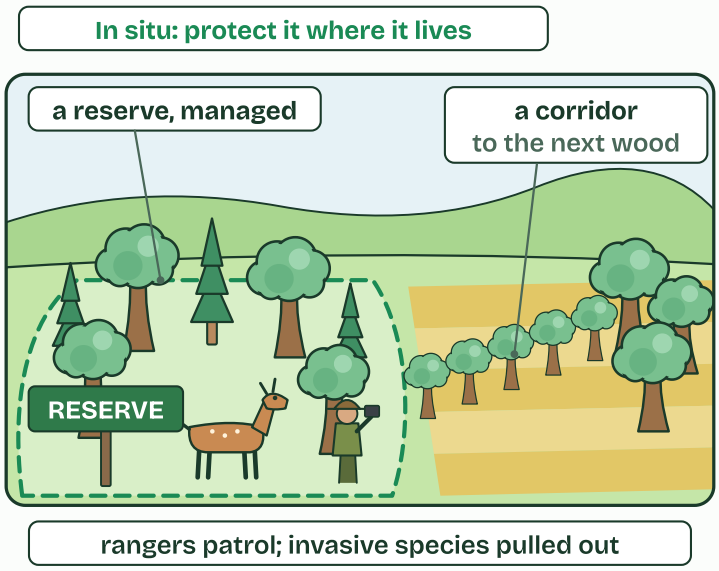
KEY POINTS

- In situ: reserves, managed; rewilding and reclamation.
- Ex situ: zoos, botanic gardens, seed and tissue banks.
- EDGE: Evolutionarily Distinct and Globally Endangered.

KEY TERMS

in situ
Conservation of a species in its own natural habitat, for example in a nature reserve or national park.

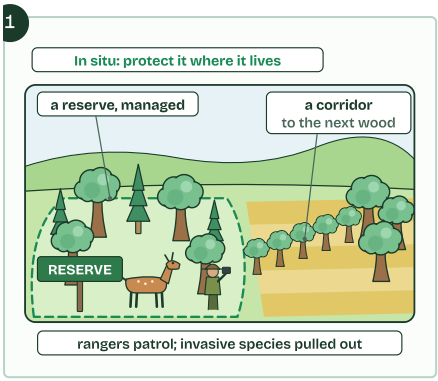
ex situ
Conservation of a species away from its natural habitat, for example in a zoo, botanic garden or seed bank.



SWITCH IT

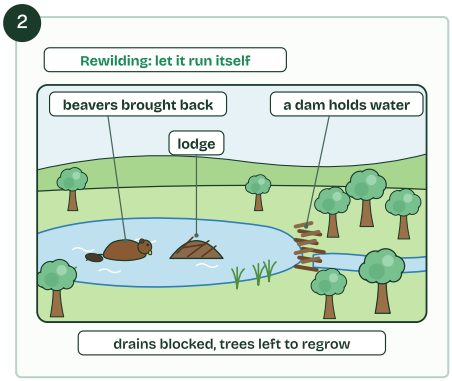
3 SETTINGS

1



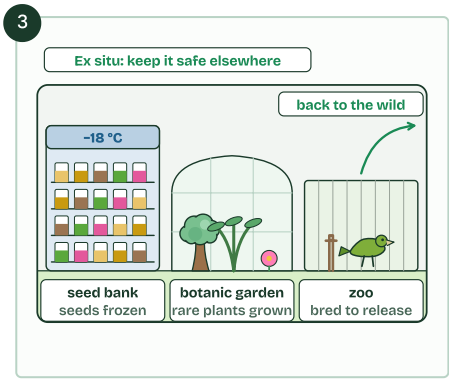
In situ

2



Rewilding

3

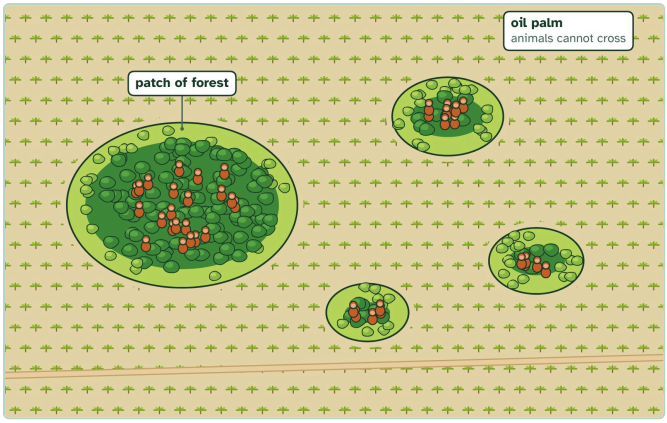


Ex situ

ANIMATION · PATCHES AND CORRIDORS

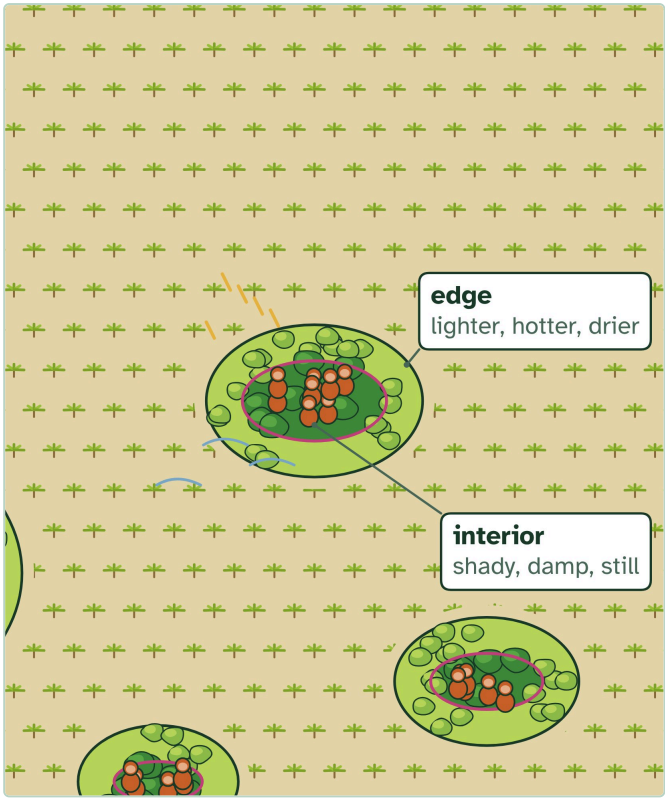
6 MOMENTS

1 FRAGMENTS



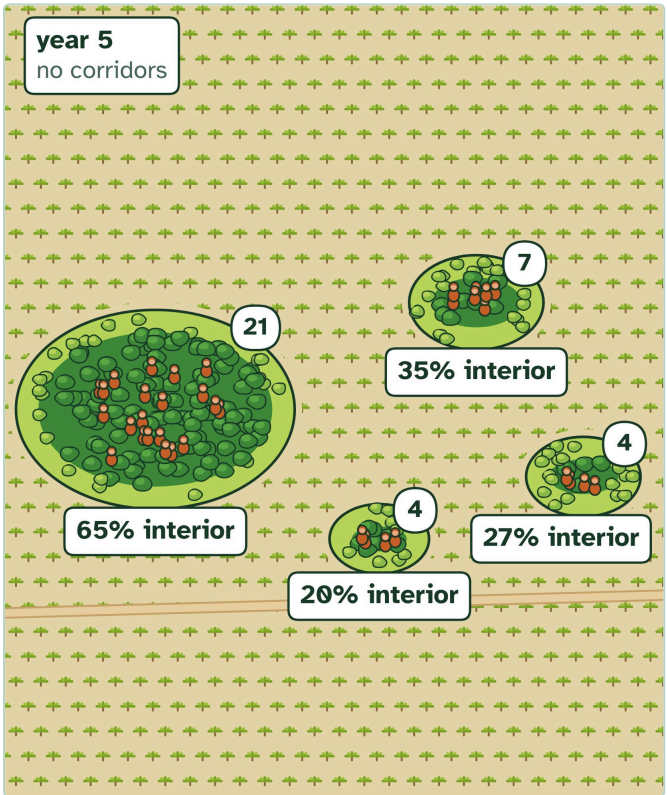
Fragments: one forest has become four patches of forest in a sea of oil palm.

2 EDGES



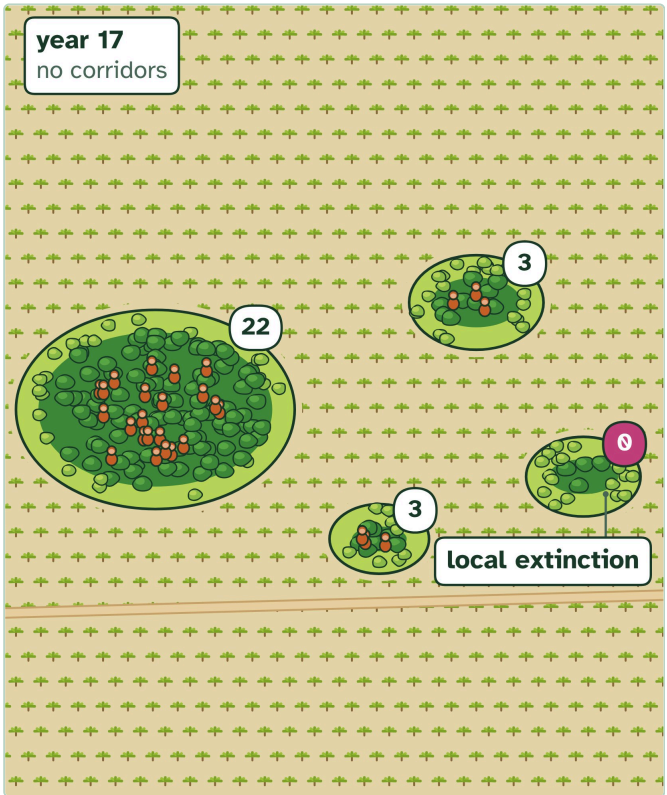
Edges (going deeper): near a patch edge it is lighter, hotter, drier and windier. A small patch is nearly all edge, so species of the deep forest have little room.

3 SMALL POPULATIONS



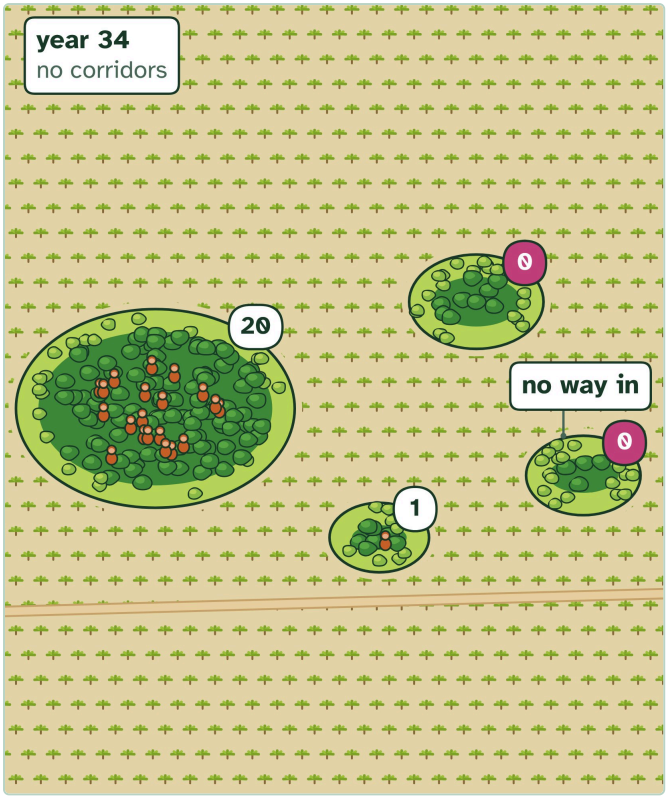
Each patch holds its own **small population**. The years start to run.

4 CORRIDORS



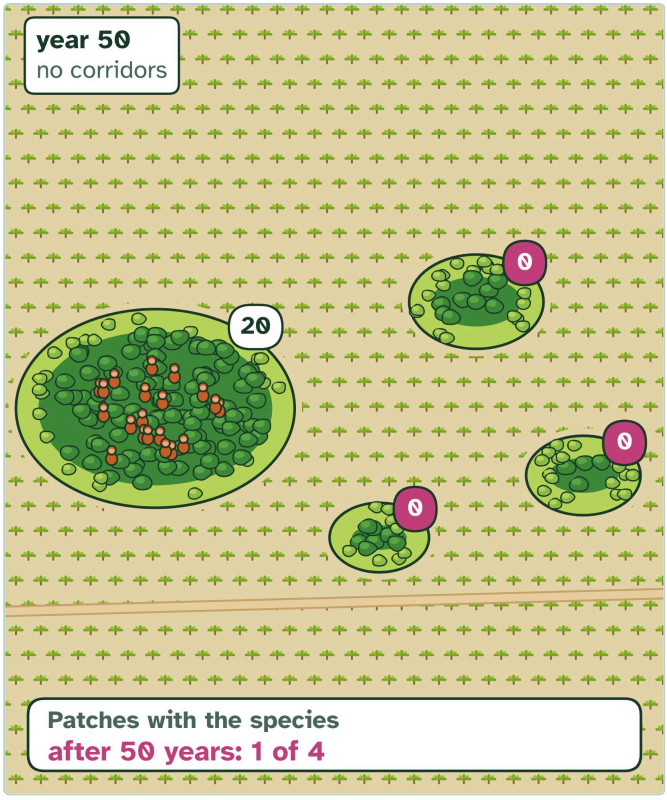
Without corridors, nothing crosses the farmland. A bad year or a disease can wipe out a small population: a **local extinction**.

5 RECOLONISING



An emptied patch stays empty: nothing can get in to **recolonise** it. The few left in each patch inbreed and lose **genetic diversity**.

6 FIFTY YEARS ON



Fifty years on, in this model, only the biggest patch still has the species. Switch Corridors on to compare.

Watch it move, and change it as it runs: biologybybradford.com/guides/ib-biology-a4-2-conservation-of-biodiversity#save

NATURE OF SCIENCE

Choosing which species to save is not only a scientific question. It has ethical, political, economic, social and cultural sides: a species may be sacred to a people, earn money from tourists, or compete with farmers. The science can inform the choice, but it has to be debated.

PREDICT

Why is ex situ conservation alone not enough to save a species such as the orangutan?

(A) Zoos are not allowed to keep orangutans, so they can only be bred in their forest habitat in Borneo and Sumatra

(B) Orangutans held in zoos lose their genetic diversity at once, so their young are all born unable to survive in a forest

(C) Without its forest, a captive-bred orangutan has nowhere to be released, and its role in the ecosystem is lost

Decide before you look. Answer on page 20.

Key terms

Every term this guide defines, A to Z, with the chapter it is in. Cover the right-hand side and test yourself.

biodiversity 01
The variety of life in all its forms, levels and combinations: the diversity of ecosystems, of species and of the genes within species.

evenness 01
How evenly the individuals in an area are shared among its species: high when each species has similar numbers, low when one species dominates.

ex situ 06
Conservation of a species away from its natural habitat, for example in a zoo, botanic garden or seed bank.

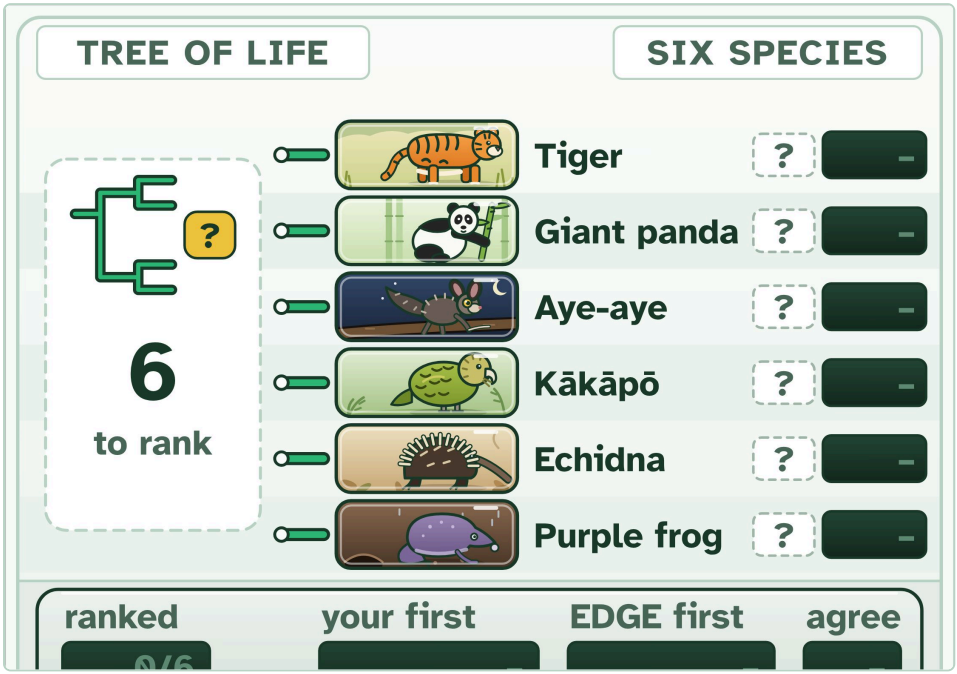
in situ 06
Conservation of a species in its own natural habitat, for example in a nature reserve or national park.

mass extinctions 02
An event in which a large proportion of Earth's species, often more than three quarters, die out in a geologically short time.

species richness 01
The number of different species present in an area.

Dry lab: *Which species first? The EDGE list*

Six threatened species and one budget. Rank them for funding by your own reasons, then see how the EDGE of Existence programme would rank them, and why.



Run it online: change the variables, run the trials, and the table and graph fill in as you go. `biologybybradford.com/guides/ib-biology-a4-2-conservation-of-biodiversity#lab`

Your question

If you could fund the conservation of only some species, which would you choose first? Predict first: will the EDGE score put the tiger and the giant panda near the top or near the bottom?

What you do

Read each species' card and tap them in the order you would fund them. Then show the EDGE scores and compare: each species' evolutionary distinctiveness (ED), its Red List category (GE), its score and its rank.

What to record

Your ranking and your reasons, the EDGE ranking, and where the two disagree. The distinctiveness values are rounded and illustrative; the method is the one the programme began with.

Find out

- **Your ranking.** Read all six cards first. Then tap them in the order you would fund them, and write one reason for your first and last choice.
- **The EDGE ranking.** Show the scores. Which species moved furthest between your list and the EDGE list, and why?
- **The two parts.** On the graph, which species is most distinct, and which most endangered? Which is first, and why does it beat the purple frog?
- **The method.** Work the score for the tiger yourself and check it against the table.

Record

- Your ranking, with a reason for each place.
- The EDGE table: ED, Red List category, score and rank.
- One sentence on what EDGE values, and one thing it leaves out.
- Download the CSV to keep the table.

Your question If you could fund the conservation of only some species, which would you choose first? Predict first: will the EDGE score put the tiger and the giant panda near the top or near the bottom?**What you do**Read each species' card and tap them in the order you would fund them. Then show the EDGE scores and compare: each species' evolutionary distinctiveness (ED), its Red List category (GE), its score and its rank.**What to**

recordYour ranking and your reasons, the EDGE ranking, and where the two disagree. The distinctiveness values are rounded and illustrative; the method is the one the programme began with.

Back to conservation

Use your results to explain why the EDGE of Existence programme puts evolutionarily distinct and globally endangered species first, and why that choice still needs debate.

QUESTIONS ON THE LAB

QUESTION 1

The tiger is endangered, yet it comes last on the EDGE list. Why?

(A) Tigers are not on the IUCN Red List at all, so their global endangerment score counts as zero in the EDGE method

(B) Tigers have close living relatives in the other big cats, so they carry little evolutionary history found nowhere else

(C) Tigers breed well in zoos, so the EDGE programme leaves them out of its scores and puts them at the bottom of the list

Answer on page 20.

QUESTION 2

The purple frog is far more distinct than the kākāpō, yet ranks below it. What does that show about the EDGE score?

(A) The score counts only a species' Red List category; its distinctiveness is shown on the card but not used in the ranking

(B) Frogs are always ranked below birds by the EDGE programme, because birds have a larger effect on their ecosystems

(C) Endangerment weighs heavily: one step up the Red List counts as much as doubling the distinctiveness, and the kākāpō is a step higher

Answer on page 21.

QUESTION 3

A government has money to protect one forest. Why might it not simply choose the forest with the highest-ranked EDGE species?

(A) Cost, chance of success, the other species in each forest and what each means to local people all matter alongside the score

(B) The EDGE score is calculated only for species kept in zoos, so it cannot be used to compare forests or wild populations

(C) The EDGE list changes every year, so no government can use it to plan how to spend money on conservation in advance

Answer on page 21.

Check yourself

The check for this guide is online: a fresh paper of past-paper style questions from the exam bank on A4.2 each time, marked as you go, and saved to your Exam practice progress when you are signed in. Scan the code, or type the link.

biologybybradford.com/exam-maker/sit?topics=A4.2&level=SL&paper=quiz&marks=15&src=ep

Answers

PREDICTIONS IN THE CHAPTERS

01 A cheetah population passed through a bottleneck and now has very little genetic diversity. Why does that put it at risk?

B **With few alleles, a new disease that kills one cheetah is likely to kill most of them, as none may carry resistance**

Genetic diversity is the raw material for natural selection. If every individual has nearly the same alleles, a new disease or change in conditions that harms one harms all of them, and there may be no variants that survive to breed.

02 Why are so many of the species not yet described thought to be insects and other small invertebrates?

C **They are small, live in hard places to sample, and look alike, so many have simply never been collected and compared**

Big animals are easy to see and were named long ago. Tiny ones in rainforest canopies, soil and the deep sea are hard to reach and often differ in features seen only under a microscope or in their DNA, so most are still undescribed.

03 Large, slow-breeding animals, such as moa, were wiped out far faster than small birds on the same islands. Why?

A **Each one killed takes years to replace, because few young are born each year, so hunting outstrips births**

A species survives hunting only if births keep up with deaths. Moa laid one or two eggs at a time and took years to reach breeding age, so even a few killed each year sent their numbers down. They were also large, easy targets with no fear of people.

04 On Borneo, the lowland forest near the coasts went first, and mountain forest in the interior is still mostly standing. Why?

B **Lowland forest is easier to reach by river and road, and its flat land suits plantations, so it was cleared first**

Timber is cheapest to move by river, and flat lowland is easiest to plant. Steep mountain slopes are hard to reach and poor for oil palm, so they have been spared, for now. The lowland forest, the richest, has been lost first.

05 A bird count in a park finds 30 species in 2024. Why is this not, on its own, evidence of a biodiversity crisis?

B **One survey shows no change; it needs repeating in the same way over years, to compare richness and evenness through time**

A crisis is a change: a fall in richness, evenness or population sizes. One survey is a single point. The same survey repeated by the same method over many years, ideally across many habitats, shows the trend.

06 Why is ex situ conservation alone not enough to save a species such as the orangutan?

C **Without its forest, a captive-bred orangutan has nowhere to be released, and its role in the ecosystem is lost**

Captive breeding keeps the species alive, but its purpose is release. If the habitat is gone, there is nowhere to return to, and a species in a zoo no longer disperses seeds or plays any other part in its ecosystem. Ex situ work backs up in situ work, never replaces it.

QUESTIONS ON THE DRY LAB

Q1 The tiger is endangered, yet it comes last on the EDGE list. Why?

B **Tigers have close living relatives in the other big cats, so they carry little evolutionary history found nowhere else**

The tiger is as endangered as the aye-aye or the purple frog, but it split from the lion, leopard and jaguar only a few million years ago. Its evolutionary distinctiveness is low, so its EDGE score is too. That is no reason not to protect it, and it already attracts large funds.

Q2 The purple frog is far more distinct than the kākāpō, yet ranks below it. What does that show about the EDGE score?

C Endangerment weighs heavily: one step up the Red List counts as much as doubling the distinctiveness, and the kākāpō is a step higher

The score adds ln(1 + ED) to GE × ln 2. The frog's extra distinctiveness (50 against 25 million years) adds about 0.67; the kākāpō's extra Red List step (critically endangered against endangered) adds 0.69. So the two score almost the same, with the kākāpō just ahead.

Q3 A government has money to protect one forest. Why might it not simply choose the forest with the highest-ranked EDGE species?

A Cost, chance of success, the other species in each forest and what each means to local people all matter alongside the score

EDGE measures what would be lost from the tree of life. A real choice also weighs how much protection costs, whether it is likely to work, how many other species benefit, and the ethical, economic and cultural views of the people who live there. That is why it needs debate.

How this was made. The course structure, the activities and the teaching choices come from my own classroom, my presentations and my years of teaching IB and AP Biology. I use Claude, an AI, to help write and build the interactive guides, lesson plans, slides and practice questions, and to draw the diagrams and code the interactives. I direct the work and review it against the IB and AP specifications before it goes live.

Written and drawn for Biology by Bradford, biologybybradford.com. Free to print and share with a class.