Collegedunia NCERT Solutions

Step-by-step solutions, alternate methods & exam tips for Class 12 Biology

Chapter 13: Biodiversity and Conservation

About this Chapter

Biodiversity is the total variety of life on earth at the genetic, species and ecosystem levels. This chapter takes you through global and Indian patterns of species richness, the **species-area relationship**, the rivet-popper view of why diversity matters, the four big drivers of biodiversity loss (the **Evil Quartet**) and the in-situ / ex-situ strategies (hotspots, national parks, sacred groves, seed banks, cryopreservation) used to conserve it. The solutions below answer every Exercise question of the 2026-27 NCERT (Latest Edition, Coloured PDF) for Class 12 Biology Chapter 13 with step-by-step reasoning and exam-ready notes.

Topics covered: Levels of biodiversity • Patterns (latitudinal, species-area) • Importance of diversity • The Evil Quartet • Hotspots & in-situ conservation • Ex-situ conservation

Quick Formula Sheet

Species-area relationship (arithmetic scale):

$S = CA^Z$

Same relation on log scale (linear form):

$\log S = \log C + Z \log A$

Typical slope Z:

0.1–0.2 for small areas; 0.6–1.2 for continents

Also see for this chapter: Revision Notes | Formula Sheet | Exemplar Solutions

Exercise: NCERT Biology Class 12 Chapter 13 Biodiversity and Conservation

Q 13.1 **Name the three important components of biodiversity.**

SOLUTION

Concept used. Biodiversity is a term popularised by the sociobiologist Edward Wilson to describe the combined diversity at all levels of biological organisation. NCERT recognises three hierarchical components (or levels) at which this diversity is measured: genetic diversity (variation in alleles within a species), species diversity (variation in species within a region) and ecological diversity (variation in habitats and ecosystems within a landscape). All three together describe how "rich" nature is in a given place.

Step 1. **Genetic diversity.** A single species may show large variation in its genes across its range. The medicinal plant *Rauwolfia vomitoria* in different Himalayan ranges varies in the potency and concentration of its active chemical (reserpine). India has more than 50,000 genetically different strains of rice and 1,000 varieties of mango, all because of genetic diversity within these species.

Step 2. **Species diversity.** This refers to the number and evenness of different species in a region. For example, the Western Ghats have a much higher amphibian species diversity than the Eastern Ghats.

Step 3. **Ecological (ecosystem) diversity.** At the ecosystem scale, India, with deserts, rain forests, mangroves, coral reefs, wetlands, estuaries and alpine meadows, has far greater ecosystem diversity than a Scandinavian country like Norway.

> **Final Answer:** The three components of biodiversity are genetic diversity, species diversity and ecological (ecosystem) diversity.

☞ Exam Tip

NEET/CUET frame this as "levels at which biodiversity is studied". Always answer in the same order NCERT gives: **genetic** → **species** → **ecosystem** (small scale to large scale).

EXPERT'S SOLUTION *: Aanya Iyer, M.Sc Botany, Delhi University*

Concept used. A clean way to remember the three components is to scale outward in biological organisation: from the molecules inside one organism (genes) to the organisms themselves (species) to the ecosystems they live in. NCERT explicitly lists these as the three that "matter most" for conservation planning, because each is protected by a different toolkit (seed banks for genes, captive breeding for species, protected areas for ecosystems).

Step 1. **Genetic level (within a species).** Inside one species, individuals carry different alleles. This shows up as different strains, varieties or breeds: 50,000 rice strains and 1,000 mango varieties in India, or the variation in reserpine content across *Rauwolfia* populations of the Himalaya. Genetic diversity is the raw material on which natural selection acts.

Step 2. **Species level (within a community).** This is the most familiar layer: how many species coexist in a region and how evenly individuals are spread among them. Western Ghats have more amphibian species than Eastern Ghats; the Amazon has more bird species than any temperate forest. Both number (*richness*) and evenness contribute.

Step 3. **Ecosystem level (within a landscape).** A country or biome that has many distinct ecosystems, mangroves, coral reefs, deserts, alpine meadows, etc., has higher ecological diversity. India is a mega-diversity country partly because its land carries an unusually large variety of habitats.

Why this matters. Conservation only succeeds if all three levels are protected together. Saving a tiger (species level) is pointless if the forest it lives in (ecosystem level) is fragmented, and the population it breeds with (genetic level) is too small to avoid inbreeding.

> **Final Answer:** Biodiversity has three components, genetic diversity, species diversity and ecological (ecosystem) diversity, ordered from the smallest (gene) to the largest (ecosystem) scale.

Q 13.2 How do ecologists estimate the total number of species present in the world?

SOLUTION

Concept used. The total number of species on Earth is unknown because most species are tiny, microbial or live in poorly explored habitats (tropical canopies, deep oceans, soil). Ecologists therefore **extrapolate**: they take a group whose species count is *well known* in temperate regions, measure how many more species of the same group occur in the tropics, and apply that ratio to the poorly studied groups. The most influential of these estimates was made by Robert May, who concluded that the global species total is about 7 million.

Step 1. Start with the recorded baseline. According to IUCN (2004), the total number of plant and animal species described so far is slightly more than 1.5 million. This number is reasonably complete for some groups (birds, mammals, flowering plants) and very incomplete for others (insects, fungi, microbes).

Step 2. Pick a reference group with an almost-complete inventory in temperate countries, for example insects in Europe. Count how many species of this group are known per unit area there.

Step 3. Measure the same ratio for the same group in a tropical region where the inventory is also good (say, insects on Barro Colorado Island, Panama). This gives a *temperate-to-tropical species ratio*, typically $1:2$ to $1:5$ depending on the taxon.

Step 4. Apply this ratio to other taxonomic groups whose tropical inventories are very incomplete (microbes, soil fauna, canopy insects). Extrapolating in this way, Robert May arrived at the "conservative and scientifically sound" estimate of about ~ 7 million species on Earth. Extreme estimates range from 20 to 50 million.

> **Final Answer:** Ecologists estimate the global species total by counting species in well-surveyed groups and extrapolating, via a temperate-to-tropical richness ratio, to the many poorly known groups; Robert May's extrapolation gives ~ 7 million species.

✗ Common Mistake

Do not say "7 million species have been discovered." Only about 1.5 million species have actually been *recorded*. The ~ 7 million figure is May's *estimate* of how many exist (including undiscovered ones).

EXPERT'S SOLUTION *: Pranav Sharma, M.Sc Zoology, Banaras Hindu University*

Concept used. The method is a classic **ratio extrapolation**, the same logic a wildlife biologist uses to estimate a tiger population from a tagged-recapture sample. "Known here, unknown there, use the ratio to guess the unknown."

Step 1. **Pick a well-studied indicator group.** Insects in temperate Europe and North America have been catalogued for more than a century, so their species list is nearly complete.

Step 2. **Measure their tropical inflation factor.** The same kind of survey done in well-explored tropical pockets (the Smithsonian's Barro Colorado plots, for instance) shows roughly 2–5 times as many insect species per equivalent sampling effort. This is the *tropical-to-temperate ratio*.

Step 3. **Apply the ratio to under-studied taxa globally.** Multiply the temperate species count of, say, fungi or soil nematodes by the same factor to project a likely tropical total. Add up across all taxa.

Step 4. **Compare estimates.** The same logic gives wildly different numbers depending on which indicator group is used, which is why estimates range from 20 to 50 million. May used several indicator groups and triangulated to a conservative ~ 7 million.

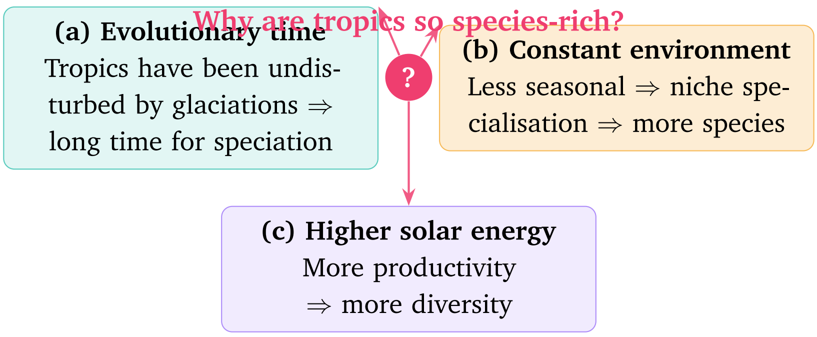
Why this matters. Knowing the order of magnitude (millions, not thousands) is what drives the urgency of conservation: even at ~ 7 million, current extinction rates (100–1000 times the background) wipe out species faster than we can name them.

> **Final Answer:** Ecologists infer the global species total by extrapolating from temperate-tropical richness ratios of well-studied indicator groups; the standard May estimate is ~ 7 million species.

Q 13.3 **Give three hypotheses for explaining why tropics show greatest levels of species richness.**

SOLUTION

Concept used. Tropics (latitudes $23.5°$ N to $23.5°$ S) consistently harbour many more species than temperate or polar zones. Ecologists and evolutionary biologists have proposed several non-exclusive hypotheses to explain this. NCERT highlights three: (a) more evolutionary time for speciation, (b) constant and predictable tropical environment that promotes niche specialisation, and (c) higher solar energy input that drives greater productivity.



Step 1. **Hypothesis (a): More evolutionary time.** Speciation takes time. Temperate regions have been disturbed by repeated glaciations during the Pleistocene that wiped out local biotas. Tropical latitudes, by contrast, have remained relatively undisturbed for millions of years, giving species a long, uninterrupted period to diversify.

Step 2. **Hypothesis (b): Constant, predictable environment favours niche specialisation.** Tropical climates are less seasonal, with low year-round variation in temperature and rainfall. Constant conditions allow species to evolve narrow, finely tuned ecological niches (specialised diet, microhabitat, breeding window). Many narrow niches pack into the same space, raising species richness. Temperate species must be generalists to survive winter, so fewer can coexist.

Step 3. **Hypothesis (c): More solar energy → higher productivity.** The tropics receive more incident solar radiation per square metre per year than higher latitudes. This translates to greater **primary productivity**, which in turn supports more individuals, more biomass and, indirectly, more species at higher trophic levels.

Final Answer: The three NCERT hypotheses for tropical species richness are: (a) more evolutionary time, (b) constant, predictable environment that favours niche specialisation, and (c) higher solar energy and primary productivity.

EXPERT'S SOLUTION *: Karan Reddy, Ph.D Molecular Biology, NCBS Bangalore*

Strategic angle. Treat the three hypotheses as answers to three different questions: a *when* (time), a *how* (niche packing) and a *how much* (energy). They are independent mechanisms that all push in the same direction, which is exactly why the tropics dominate so emphatically.

Step 1. **The "when" hypothesis, evolutionary time.** Speciation is roughly proportional to time multiplied by habitat stability. Temperate biotas were repeatedly wiped out and re-colonised during ice ages of the last ~ 2.6 million years. Tropical lineages, sheltered from these advances, kept accumulating species the whole time, so the running total is far larger.

Step 2. **The "how" hypothesis, niche specialisation.** Imagine fitting many keys (species) into a lock-board (set of niches). In a stable tropical climate the lock-board can be carved into many thin slots: a hummingbird specialised on one flower shape, a frugivorous bat specialised on one fruit season. In seasonal temperate climates the slots must be wide enough for the same key to fit summer and winter conditions, so fewer fit at once.

Step 3. **The "how much" hypothesis, solar energy and productivity.** The tropics receive close to twice the annual solar irradiance of polar latitudes. More photons $\rightarrow$ more photosynthesis $\rightarrow$ more plant biomass $\rightarrow$ longer food chains $\rightarrow$ more species at every trophic level. Tilman's plot experiments showed that productivity itself correlates with diversity, supporting this link.

Why this matters. The three hypotheses also explain why losing tropical forest is so dangerous: cutting a hectare in the Amazon does not just remove trees, it erases millions of years of accumulated speciation, dismantles fine niche structures, and shuts off a high-productivity engine. Note that the three hypotheses are *not* mutually exclusive: they reinforce each other. A constant climate (b) provides the platform on which long evolutionary time (a) can act, and higher productivity (c) provides the energy budget that sustains the many specialised niches (b) creates. Modern biogeographers usually treat the three together as a single "tropical advantage" rather than as competing alternatives.

> **Final Answer:** Three NCERT hypotheses: (a) tropics had more uninterrupted evolutionary time, (b) their constant environment promoted niche specialisation, and (c) higher solar energy fuels higher productivity and hence diversity.

Q 13.4 **What is the significance of the slope of regression in a species–area relationship?**

SOLUTION

Concept used. Alexander von Humboldt observed that within a region, **species richness** S increases with sampled area A, but only up to a limit, following a **rectangular hyperbola**:

$$S = C\,A^Z.$$

Taking $\log_{10}$ on both sides gives a straight line:

$$\log S = \log C + Z\,\log A.$$

Here S is species richness, A is area, C is the Y-intercept (a constant) and Z is the **slope of regression** (the regression coefficient on a log-log plot). The *significance of* Z is therefore that it tells us *how fast* species richness increases with area, which depends on the spatial scale studied.

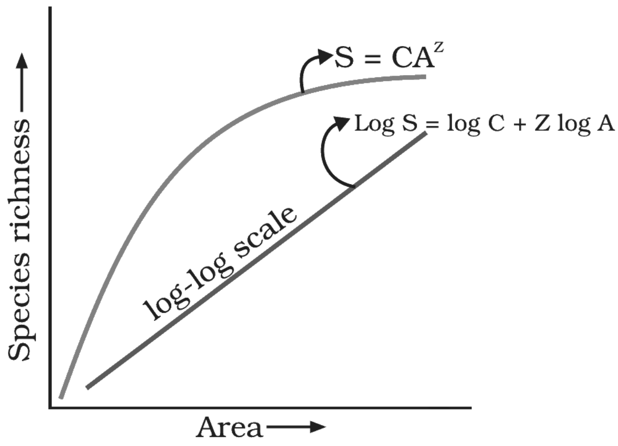


Figure 13.2 Showing species area relationship. Note that on log scale the relationship becomes linear

Fig. 13.2, NCERT Class 12 Biology, Chapter 13. Species-area relationship: rectangular hyperbola on the arithmetic scale, straight line on the log-log scale.

Step 1. **What Z measures.** On a log-log plot, Z is literally the rise-over-run of the regression line: it is the *fractional* increase in species richness per fractional increase in area. A bigger Z means each additional unit of area brings many more new species.

Step 2. **Z for small areas (within a region).** Across a wide range of taxa, plants in Britain, birds in California, molluscs in New York State, the slope Z lies in a remarkably narrow range of 0.1 to 0.2, regardless of the group or the region. This means at small scales, doubling the area adds relatively few new species, mostly because nearby patches share the same species pool.

Step 3. **Z for very large areas (entire continents).** When the spatial scale is enlarged to continents, Z becomes much steeper, typically 0.6 to 1.2. For example, for frugivorous (fruit-eating) birds and mammals in the tropical forests of different continents, $Z = 1.15$. Each new region added brings whole new endemic faunas.

Step 4. **Interpretation of a steeper slope.** A steeper slope means species richness increases *rapidly* with area. This is because large areas span more habitats, more climate zones and more biogeographic regions, each with its own endemic species pool.

> **Final Answer:** The slope Z tells us how rapidly species richness rises with area: $Z \approx 0.1$–0.2 for small areas within a region, and $Z \approx 0.6$–1.2 for entire continents; a steeper slope means each unit increase in area brings many more new species.

♥ Why Z matters for conservation

The flip side of the species-area curve is the *species-area-lost* curve. If a steep slope ($Z = 1$) tells us species pile up fast with area, it also tells us they collapse fast when area is cut. Tropical-rain-forest fragmentation is so devastating precisely because its Z is closer to the continental end.

EXPERT'S SOLUTION *: Sneha Banerjee, Ph.D Pure Mathematics, IISc Bangalore*

Picture-first. On the arithmetic axes, $S = CA^Z$ is a rectangular hyperbola, the curve flattens as area grows. Taking logarithms unwraps the curve into a straight line whose slope *is* the exponent Z. So studying Z is just studying the exponent of the power law, but on a log-log plot it becomes the *slope you can measure with a ruler*.

Step 1. **Derive the log-log line.** Start from $S = CA^Z$. Take $\log_{10}$ on both sides:

$$\log S = \log(CA^Z) = \log C + \log A^Z = \log C + Z\ \log A.$$

This is the equation of a straight line in $(\log A, \log S)$ coordinates with

Y-intercept $\log C$ and slope Z.

Step 2. Read Z off a plot. Pick any two points $(\log A_1, \log S_1)$ and $(\log A_2, \log S_2)$ on the regression line. Then

$$Z = \frac{\log S_2 - \log S_1}{\log A_2 - \log A_1}.$$

Numerically, a Z of 0.15 means doubling the area ($\Delta \log A = \log 2 \approx 0.30$) raises richness by a factor $10^{0.15\times0.30} \approx 10^{0.045} \approx 1.11$, i.e. only 11% more species.

Step 3. Why small-area Z is small. Inside a single biogeographic region, neighbouring patches share most of their species, so adding area mostly adds individuals, not new species. Hence $Z = 0.1$–0.2.

Step 4. Why continental Z is large. Crossing an entire continent crosses climatic and biogeographic boundaries, each new zone holds its own endemic species pool. So Z jumps to 0.6–1.2. For tropical-forest frugivorous birds and mammals across continents, $Z = 1.15$, which is close to proportional growth ($S \propto A$).

Step 5. Apply the slope to conservation. If a tropical forest with $Z \approx 0.3$ loses 50% of its area, the projected loss of species is

$$\Delta S/S_0 = 1 - (A/A_0)^Z = 1 - 0.5^{0.3} \approx 1 - 0.812 \approx 0.19,$$

i.e. about 19% of species are lost. The same 50% loss in a system with $Z = 1.0$ would lose $\sim 50\%$ of its species.

Why this matters. Z converts a question about *area loss* into a question about *species loss*. Conservation biology takes that single number very seriously when designing reserve sizes.

> **Final Answer:** Z is the slope of $\log S$ vs $\log A$, telling us how fast richness grows with area: small (0.1–0.2) inside a region, steep (0.6–1.2) across continents.

Read the Full Class 12 Biology Ch 13 Revision Notes →

Q 13.5 What are the major causes of species losses in a geographical region?

SOLUTION

Concept used. The accelerated extinctions the world is facing today, 100 to 1000 times the natural background rate, are largely caused by human activity. NCERT groups these drivers under a single nickname coined by ecologists, the **Evil Quartet**: four causes that together explain almost every modern species loss.

Step 1. **Habitat loss and fragmentation.** The single biggest driver. Tropical rain forests once covered $> 14\%$ of Earth's land surface but cover less than 6% now. The Amazon rain-forest (called the "lungs of the planet") is cleared for soya bean cultivation and beef-cattle pasture. When habitats are not destroyed outright they are **fragmented**: split into small disconnected patches. Mammals and birds that need large territories, and migratory species, cannot survive in small fragments.

Step 2. **Over-exploitation.** When human "need" turns into "greed", natural resources are harvested faster than they regenerate. Many recent extinctions are due to over-exploitation: Steller's sea cow, the passenger pigeon, and currently many marine fish populations that are over-harvested.

Step 3. **Alien species invasions.** Species introduced (by accident or by design) into a new region can become invasive and displace native species. The Nile perch introduced into Lake Victoria in east Africa caused the extinction of more than 200 species of cichlid fish endemic to the lake. Invasive weeds like *Parthenium* (carrot grass), *Lantana* and *Eichhornia* (water hyacinth) damage Indian ecosystems. Illegal introduction of the African catfish *Clarias gariepinus* threatens native catfishes.

Step 4. **Co-extinctions.** When a species goes extinct, the species obligately associated with it also vanish. A host-specific parasite dies with its host fish. Plants and their obligate pollinators (an orchid and its single pollinator wasp, for example) die together: extinction of one partner forces extinction of the other.

> **Final Answer:** The four major ("Evil Quartet") causes of species loss are: (i) habitat loss and fragmentation, (ii) over-exploitation, (iii) alien species invasions, and (iv) co-extinctions.

✗ Common Mistake

Do not list "pollution" as a separate fifth cause for this NCERT question. Pollution is mentioned in the chapter as a form of *habitat degradation*, which sits inside cause (i) habitat loss and fragmentation.

EXPERT'S SOLUTION *: Vivaan Nair, M.Sc Biotechnology, AIIMS Delhi*

Strategic angle. The Evil Quartet is best remembered as a ranking of seriousness, with habitat loss firmly at the top, plus three accelerators that finish off what habitat loss starts.

Step 1. **(i) Habitat loss and fragmentation, the prime driver.** It does two things at once: it shrinks total carrying capacity (fewer individuals can live there), and it cuts the remaining population into small, genetically isolated pieces. The Amazon (so big it produces $\sim 20\%$ of atmospheric O_2) is being cleared at a hectare-per-second scale for soya bean and beef cattle. By the time a student finishes reading this chapter, NCERT says, 1000 hectares of rain forest are gone.

Step 2. **(ii) Over-exploitation.** The passenger pigeon was the most abundant bird in North America in 1800; mass shooting drove it to extinction by 1914. Indian examples include over-fishing of hilsa and silver pomfret.

Step 3. **(iii) Alien species invasions.** An introduced species often has no natural predators in the new place, so its population explodes. The African Nile perch wiped out > 200 cichlid species in Lake Victoria. In India *Lantana*, *Parthenium* and water hyacinth out-compete native vegetation; the African catfish is displacing indigenous catfish in our rivers.

Step 4. **(iv) Co-extinctions.** Ecological partners share their fate. Lose a fig species and you lose its species-specific pollinator wasp; lose a host fish and you lose its specific parasites; lose a flagship insect and you lose the species that fed on it. This is the *cascade* that makes biodiversity loss feed on itself.

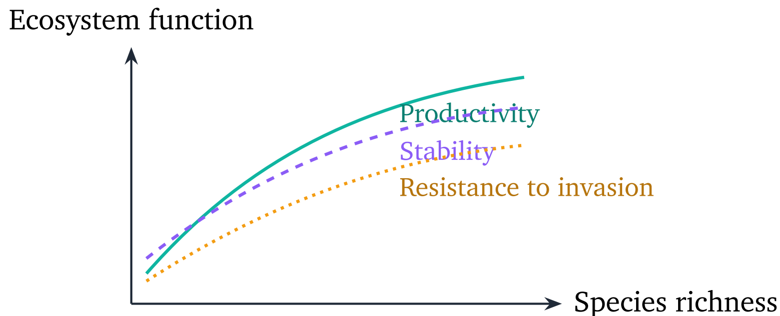
Why this matters. For every conservation plan, ask: "Which of the four am I addressing?" If you protect a forest (tackles habitat loss) but allow illegal hunting (over-exploitation) or release *Lantana* into the same forest (alien invasion), you have addressed only one of four edges of the threat.

> **Final Answer:** Habitat loss and fragmentation, over-exploitation, alien species invasions and co-extinctions, the "Evil Quartet" identified by NCERT.

Q 13.6 How is biodiversity important for ecosystem functioning?

SOLUTION

Concept used. An **ecosystem** is a network of interactions between living (biotic) and non-living (abiotic) components. The biotic component is biodiversity. The classic question is whether ecosystem properties such as productivity, stability and resistance to invasion depend on the *number* of species. Two pieces of evidence, David Tilman's outdoor plot experiments, and Paul Ehrlich's **rivet popper hypothesis**, both say yes.



Tilman-style plot experiments: more species ⇒ higher and steadier ecosystem function

Step 1. **Stability: communities with more species are steadier.** A stable community shows low year-to-year variation in productivity, recovers quickly from disturbances (resilience) and resists alien invasions. Tilman's long-term outdoor plot experiments showed that plots with more species had significantly *less* year-to-year variation in total biomass.

Step 2. **Productivity: more species $\rightarrow$ more biomass.** In the same experiments, plots with higher species richness produced more biomass per season. Different species use slightly different resources (light, water, nutrients), so a diverse community taps the resource pool more completely.

Step 3. **Resistance to invasion.** A community whose niches are all occupied by native species leaves little open "space" for an invader. Species-poor communities are easier to invade.

Step 4. **The rivet popper analogy.** Paul Ehrlich compared an ecosystem to an aeroplane and species to the rivets that hold it together. Removing a few rivets (extinctions) does not cause immediate failure, but eventually the plane (ecosystem) becomes dangerously weak. Some rivets are especially critical: a wing rivet (**keystone species**) matters far more than a seat rivet. Hence *which* species are lost matters as well as *how many*.

Step 5. **Ecosystem services.** Healthy biodiversity also drives services we all depend on: pollination ($> 25\%$ of crop yield), pest control, climate moderation, flood control, soil formation and the production of $\sim 20\%$ of atmospheric O_2 by the Amazon alone.

Final Answer: Biodiversity raises the productivity, year-to-year stability and invasion resistance of an ecosystem; the rivet-popper analogy shows that losing species (especially keystone species) weakens ecosystem functioning even if it does not collapse immediately.

EXPERT'S SOLUTION : *Diya Pillai, M.Sc Microbiology, JNU*

Structural observation. Ecosystem "functioning" is shorthand for three measurable things: how much biomass is produced, how much that production fluctuates, and how well the system fends off invaders. All three improve with diversity.

Step 1. Productivity (the engine). A diverse plant community contains species with slightly different rooting depths, photosynthetic pathways (C_3 vs C_4) and growing seasons. Their combined effect is *complementary resource use*: the community captures more sunlight, water and nutrients than a monoculture could. Tilman's grassland experiments measured this directly: doubling species count roughly raised biomass by $\sim 1.5\times$.

Step 2. Stability (the shock absorber). If one species fails in a bad year (drought, disease), others in a diverse community compensate. This is the *insurance effect*. Tilman's plots with 16 species varied $\sim 70\%$ less in biomass year-to-year than monocultures.

Step 3. Resistance to invasion (the fence). Saturated niches leave no foothold for invaders. Hawaiian forests with reduced native plant diversity are now overrun by guava and *Miconia*; high-diversity Indian sacred groves are not.

Step 4. The rivet-popper analogy made quantitative. Suppose an ecosystem has n species, each contributing f_i to function F. Removing a random species reduces F by the mean $\langle f \rangle = F/n$, small if n is large. But if a *keystone* species is removed, f_i can be much larger than the mean and a single loss collapses F sharply, exactly Ehrlich's wing-rivet warning.

Step 5. Ecosystem services. Translate the above into services humans depend on: $\sim 20\%$ of global O_2 production from the Amazon, pollination of $\sim 75\%$ of food crops by wild pollinators, flood and soil-erosion control by forests, climate moderation by mangroves and coral reefs. Each service rides on the diversity that produces it.

Why this matters. If we treat species as "optional", the ecosystem looks fine until it suddenly does not. The cost of losing diversity is paid silently as resilience, until the day a drought, a pest outbreak or a flood arrives.

> **Final Answer:** Biodiversity boosts ecosystem productivity, stabilises it against year-to-year variation, and protects it from invasions, while the rivet-popper analogy warns that some species are keystone rivets we cannot afford to lose.

Q 13.7 What are sacred groves? What is their role in conservation?

SOLUTION

Concept used. **Sacred groves** are patches of forest that local communities have traditionally protected for religious or cultural reasons. No tree may be cut and no wildlife harmed within a sacred grove. They are an example of **in-situ conservation** that predates modern wildlife law by centuries, and in many cases they are the last surviving refuges for rare and endemic species in otherwise degraded landscapes.

Step 1. **Definition.** Sacred groves are tracts of forest set aside by local communities, with all the trees and wildlife within venerated and given total protection. Cutting wood, hunting and even removing fallen branches is taboo.

Step 2. **Where they occur in India.** Khasi and Jaintia Hills in Meghalaya, the Aravalli Hills of Rajasthan, the Western Ghat regions of Karnataka and Maharashtra, and the Sarguja, Chanda and Bastar areas of Madhya Pradesh, all have well-documented sacred groves.

Step 3. **Their role in conservation, ecological.** In Meghalaya the sacred groves are the last refuges for a large number of rare and threatened plants. They preserve climax vegetation that has long since vanished from surrounding land.

Step 4. **Their role in conservation, genetic.** Because no selective logging or selective hunting is allowed, the wild gene pool of trees, herbs, fungi and animals is preserved intact. Sacred groves serve as natural seed banks for endangered species.

Step 5. **Their role in conservation, social.** They embed conservation in everyday religious life, making protection self-policing and durable, much harder to "cheat" than a government-managed sanctuary alone.

> **Final Answer:** Sacred groves are forest patches protected by local communities on religious grounds; they conserve climax vegetation, act as last refuges for rare and threatened species (notably in Meghalaya), preserve wild gene pools and embed conservation in cultural tradition.

♥ A blueprint for community conservation

Sacred groves predate the Wildlife Protection Act (1972) by centuries and out-perform many official sanctuaries on species density. They show that the most effective long-term conservation is the kind a community owns.

EXPERT'S SOLUTION *: Riya Kapoor, M.Sc Botany, Delhi University*

Structural observation. Think of a sacred grove as *in-situ conservation with a cultural enforcement mechanism*. That second word is what makes them so much more durable than purely legal sanctuaries.

Step 1. **What they are.** Patches (often 0.01 to ~ 10 hectares) of largely undisturbed forest, traditionally protected by a community for religious reasons. The protection is total: no felling, no hunting, no harvest of non-timber forest products in the strict groves.

Step 2. **Where they survive.** The chapter names Khasi and Jaintia Hills (Meghalaya), Aravallis (Rajasthan), Western Ghats (Karnataka and Maharashtra) and Sarguja-Chanda-Bastar (Madhya Pradesh). Different community names exist: *kavu* (Kerala), *devarakadu* (Karnataka), *sarna* (Jharkhand).

Step 3. **Their ecological role.** They preserve climax vegetation that has elsewhere been cleared, sustain endemic and rare species (Meghalayan sacred groves are the last refuges for many rare plants), conserve the wild gene pool and even moderate local microclimate.

Step 4. **Their conservation role at landscape scale.** They function as stepping stones connecting larger protected areas (national parks, reserves), allowing seed dispersal and animal movement across an otherwise fragmented landscape, exactly the antidote to fragmentation listed as the first "Evil" cause of species loss.

Step 5. **Their cultural role.** Religious sanctity makes them "self-enforcing reserves": community members punish offenders socially, so enforcement does not need Forest-Department staff. This is why their integrity has survived for centuries.

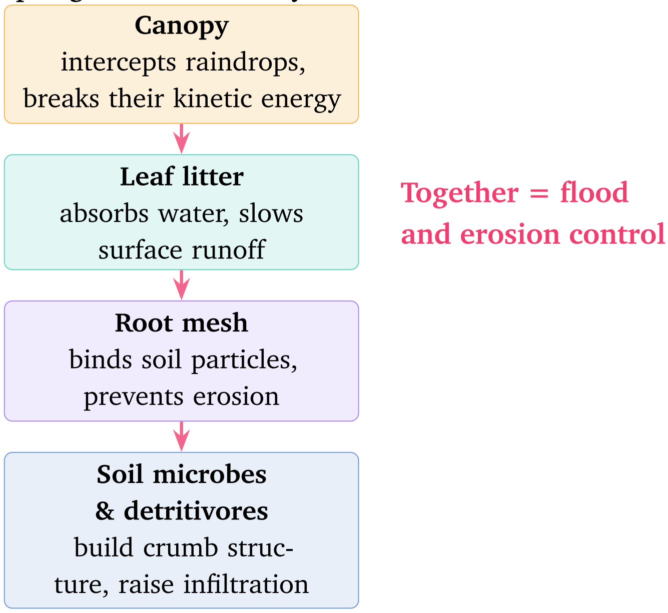
Why this matters. If India's $\sim 100{,}000+$ documented sacred groves were formally linked into the protected-area network, they would significantly expand effective conservation cover at very low public cost, because the community is already doing the work.

> **Final Answer:** Sacred groves are community-protected forest patches that conserve climax vegetation, act as refuges for rare and endemic species, preserve wild gene pools and serve as ecological stepping stones across fragmented landscapes.

Q 13.8 **Among the ecosystem services are control of floods and soil erosion. How is this achieved by the biotic components of the ecosystem?**

SOLUTION

Concept used. Ecosystem services are the free benefits humans receive from ecosystems, two of which are flood control (slowing the runoff of rain into rivers) and soil erosion control (preventing topsoil from being washed or blown away). Both are delivered by the biotic components: trees, shrubs, grasses, leaf litter and soil microbes work together as a sponge-and-anchor system.



Step 1. **Canopy interception.** Forest tree canopies catch and slow falling raindrops. Without the canopy, heavy raindrops hit bare soil with high kinetic energy and dislodge particles, the starting point of soil erosion.

Step 2. **Leaf litter as a sponge.** The layer of fallen leaves on the forest floor absorbs rainwater and releases it slowly, so water seeps into the soil instead of rushing off the surface. This delayed release flattens flood peaks downstream.

Step 3. **Roots that bind soil.** Trees, shrubs and grasses send roots in a dense mesh through the topsoil. This root mesh physically holds soil particles together so wind and water cannot wash them away. A grassland or forest soil has many times the binding strength of bare cropland soil.

Step 4. **Detritivores and microbes that build soil structure.** Earthworms, termites, bacteria and fungi tunnel through the soil, leaving channels that increase infiltration capacity. They also build the soil crumb structure that holds water without becoming impervious.

Step 5. **Combined effect on flood and erosion control.** Together these biotic layers turn a forest into a giant sponge: water enters the ground slowly, recharges groundwater, feeds streams over weeks rather than hours, and the soil itself stays in place. The classic illustration is what happens when a hillside is deforested: rainfall the next monsoon becomes a flash flood and the topsoil washes into the valley.

Final Answer: Tree canopies break the impact of raindrops, leaf litter absorbs and slowly releases water, plant roots physically bind soil particles together, and soil microbes and detritivores build crumb structure that boosts infiltration, jointly preventing floods downstream and erosion upstream.

EXPERT'S SOLUTION *: Aditya Joshi, Ph.D Molecular Biology, NCBS Bangalore*

Picture-first. Think of the forest as a stacked filter: canopy on top, litter middle, roots and soil microbes at the bottom. Each layer does one job in the flood-and-erosion story.

Step 1. Top filter, canopy. A mature tree canopy can intercept ~ 10–40% of incoming rainfall, depending on intensity. Intercepted water evaporates straight back to the atmosphere or trickles down the trunk gently. Either way, raindrops never hit the soil at full speed, so their erosive kinetic energy is dissipated by the leaves.

Step 2. Middle filter, litter mat. The carpet of dead leaves and twigs is highly porous. It absorbs water like a sponge and releases it slowly into the topsoil. The same litter also shades the soil surface, keeping it cooler and slowing evaporation.

Step 3. Lower filter, root network. Roots act as ropes woven through the soil. They hold particles together against the shear stress of surface flow, and they create vertical channels along which infiltrating water can move deep into the ground.

Step 4. Soil biota, the renovator. Earthworms, termites and burrowing arthropods open macropores; bacteria and fungi cement particles into stable crumbs. A soil with intact biota can absorb 5–10 times the rainfall of a compacted, biota-poor soil before runoff begins.

Step 5. What flood control looks like quantitatively. A forested catchment routinely transmits a heavy storm to the river over 24–48 hours, capping the peak flow at a modest level. Strip the forest, and the same storm reaches the river in 1–2 hours as a flash flood. The conversion of slow seepage to fast runoff is exactly what biodiversity prevents.

Why this matters. Floods in Uttarakhand, Kerala and Assam have all been intensified by upper-catchment deforestation, an ecosystem-services failure with a measurable cost in lives and property. Conserving biotic cover is cheaper engineering than building embankments.

Final Answer: The canopy breaks raindrop impact, leaf litter soaks up runoff, roots bind soil and soil biota build crumb structure, together they make the forest a slow-release sponge that prevents both flooding and erosion.

Q 13.9 **The species diversity of plants (22 per cent) is much less than that of animals (72 per cent). What could be the explanations to how animals achieved greater diversification?**

SOLUTION

Concept used. Of all the species recorded on Earth, animals make up $> 70\%$ (insects alone account for $> 70\%$ of animals), while plants (including algae, fungi, bryophytes, gymnosperms and angiosperms) make up only $\sim 22\%$. The reason is not that plants *cannot* diversify, but that animals have several biological features, motility, complex nervous systems, varied feeding modes, short generation times in many groups, and tight coevolution with plants, that let them slice the same habitat into many more niches.

Step 1. **Motility opens up new niches.** Animals can move from place to place to find food, mates, breeding sites and refuges. Each new behaviour (climbing, swimming, flying, burrowing) opens a new way of life and hence a new opportunity for speciation. Plants are largely sedentary, so the niches available to them are fewer.

Step 2. **Nervous system and complex behaviour.** Animals have a nervous system that lets them respond rapidly to the environment, learn, hunt cooperatively, court elaborately, defend territories. Behavioural specialisation creates **behavioural niches** (different song dialects, different feeding techniques) that can act as the first step of speciation. Plants lack nervous systems and so lack this avenue.

Step 3. **Varied modes of feeding and broad food spectrum.** Animals have evolved into carnivores, herbivores, omnivores, detritivores, parasites, blood-feeders, filter-feeders and many more guilds. Each feeding strategy partitions the community further. Plants are almost all photoautotrophs with the same basic mode (capture sunlight, fix carbon), so partitioning is much coarser.

Step 4. **Short generation times in many animal groups.** Insects, the most species-rich group of all, often complete a generation in weeks. Short generations let natural selection act over many cycles in a short calendar time, speeding up speciation.

Step 5. **Coevolution with plants and other animals.** Insects coevolved with flowering plants (each often pollinated by only one or a few insect species), parasites coevolved with their hosts, predators with their prey. Every plant species thus supports many animal species (pollinators, herbivores, seed dispersers, gall makers, parasites of all of these), multiplying animal diversity.

Step 6. **Adaptive radiations have been more frequent in animals.** Whenever a new habitat opens (a new island, a new continent, a new river), animal lineages radiate quickly: Darwin's finches in the Galápagos, cichlid fish in the African

Great Lakes, marsupials in Australia. Plant radiations exist but are slower.

> **Final Answer:** Animals diversified more than plants because they are motile, possess nervous systems and complex behaviour, occupy many feeding guilds, often have short generation times, and coevolve tightly with plants and with each other, especially through repeated adaptive radiations of insects.

☞ **Exam Tip**

A frequent NEET/CUET trap: the question is *not* about why plants have "failed". Plants are diverse in their own right (over 3,50,000 species). The right framing is that animal biology opens *additional* axes of specialisation (movement, behaviour, food-choice) that plants do not have.

EXPERT'S SOLUTION : *Tara Verma, M.Sc Zoology, Banaras Hindu University*

Strategic angle. The cleanest way to think about this is "niche dimensions". Plants partition niches mainly along light, water and nutrient gradients, ~ 3 axes. Animals partition niches along all of those *plus* mobility, behaviour, diet, host specificity and developmental mode, ~ 8 axes. With more axes, many more independent niches fit into the same habitat, and each new niche is potentially a new species.

Step 1. **Motility (axis 1).** The ability to move expands the accessible environment by orders of magnitude. A single forest patch supports terrestrial, arboreal, fossorial (burrowing) and aerial animal guilds; plants are restricted to whatever soil they germinate on.

Step 2. **Nervous system and behaviour (axis 2).** Behavioural innovation is fast (much faster than morphological change), and behaviour itself becomes a reproductive isolating mechanism: birds that sing slightly different songs do not interbreed, and this is the first step of speciation.

Step 3. **Heterotrophic diet (axis 3).** Carnivory, herbivory, parasitism, scavenging, filter-feeding, blood feeding are each separate guilds. Within herbivory alone there are leaf-eaters, seed-eaters, root-feeders, nectar-feeders, sap-suckers, etc.

Step 4. **Coevolution with plants (axis 4).** Flowering plants radiated ~ 130 million years ago and dragged a vast coevolved fauna with them: pollinators, seed dispersers, herbivores and the parasites and predators of those animals. The result: each plant species typically supports several animal species, multiplying their diversity.

Step 5. **Short generations and large populations.** Many animal groups (especially insects) have generation times of weeks and population sizes in millions per hectare. Both quantities speed up evolution: more selection events per year, more chance for novel mutations to fix.

Step 6. **Adaptive radiations.** Repeated bursts of speciation when a new ecological opportunity opens, Darwin's finches, African Great Lake cichlids, Australian marsupials, have compounded animal diversity in ways plants rarely match.

Why this matters. The numerical answer "72% vs 22%" is not because plants are "simple"; it is because animals exploit more independent niche axes. If you remember the axes, you can extrapolate the same logic to any future question about why one taxon is more diverse than another (e.g. why fungi are more diverse than gymnosperms).

> **Final Answer:** Animals diversified more than plants because they exploit additional niche axes, motility, behaviour, varied diets, host specificity, plus rapid generation times and frequent adaptive radiations (especially in insects), which allow many more independent niches to coexist in the same habitat.

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Q 13.10 **Can you think of a situation where we deliberately want to make a species extinct? How would you justify it?**

SOLUTION

Concept used. Conservation policy nearly always tries to *prevent* extinction. The only species we deliberately try to eradicate are those whose presence directly threatens human life or livelihoods, and which can in principle be wiped out without a significant ecological cost. Two such groups are **disease-causing pathogens** that depend obligately on humans (e.g. the smallpox virus), and **disease vectors** (e.g. certain mosquito species responsible for malaria, dengue, chikungunya). The justification is medical, ethical and ecological at once.

Step 1. **A historical example, smallpox virus (*Variola*).** The WHO's global vaccination programme eradicated the smallpox virus from the wild by 1980. It existed only as a human pathogen and had no role in any ecosystem; eradication ended a disease that killed ~ 300 million people in the 20^{th} century alone. The only remaining stocks are sealed in two laboratories.

Step 2. **An ongoing example, polio and Guinea worm.** The same logic drives current eradication campaigns for the polio virus (*Poliovirus*) and the Guinea worm (*Dracunculus medinensis*). These are pathogens of humans only; eliminating them eliminates immense suffering without ecological cost.

Step 3. Disease vectors, the mosquito case. Three mosquito species (*Anopheles gambiae* for malaria, *Aedes aegypti* for dengue/Zika/chikungunya, *Culex quinquefasciatus* for filariasis) cause millions of human deaths each year. Modern gene-drive technology is being actively researched to make targeted populations extinct. Ecologists have analysed the food-web role of these species and concluded that other mosquito species would fill any vacated niche, so the ecosystem cost is low.

Step 4. Pest examples. Locust swarms (*Schistocerca gregaria*) and invasive crop pests (*Helicoverpa armigera* in some contexts) are also candidates, although most strategies focus on *control* rather than eradication.

Step 5. Justification, four-part. (i) *Medical*: huge reduction in human suffering and mortality. (ii) *Ethical*: the moral weight of preventing avoidable human deaths outweighs the intrinsic value of a virus or vector species that benefits no other species. (iii) *Ecological*: the target species (especially obligate human pathogens) has no non-replaceable role in any ecosystem, so its removal does not cause cascading extinctions. (iv) *Economic*: massive savings in health-care expenditure that can be redirected to other conservation and development priorities.

> **Final Answer:** Yes, for organisms such as the smallpox virus, polio virus, Guinea worm and certain disease-spreading mosquitoes we may justifiably aim for deliberate extinction, because the medical and humanitarian benefit is enormous and these species have no irreplaceable ecological role.

✗ Common Mistake

Do not propose eradicating “all mosquitoes” or “all snakes”. Eradication is justifiable only for a *specific* disease-causing or disease-vector species, never for a whole functional group whose removal would unbalance entire ecosystems.

EXPERT’S SOLUTION *: Ishaan Desai, M.Sc Biotechnology, AIIMS Delhi*

Strategic angle. The question is testing whether you can balance two ethical positions: “every species has intrinsic value” (NCERT’s ethical argument for conservation) versus “human life and freedom from disease matter”. The right balance picks targets that score very high on the second axis and very low on the first.

Step 1. Set the criteria. A species can be a candidate for deliberate extinction only if all four are true: (i) it causes severe, reproducible harm to humans; (ii) it has no obvious keystone role in any ecosystem; (iii) a practical eradication technique exists; (iv) eradication is reversible in the limited sense that gene libraries / live cultures of the species can be preserved in BSL-4 labs against a future scientific need.

Step 2. **Apply the criteria, smallpox virus passes all four.** Smallpox killed ~ 300 million people in the 20^{th} century; it lived only in human hosts; vaccination eradicated it from the wild by 1980; lab stocks are kept in two facilities. Outcome: justified eradication.

Step 3. **Polio and Guinea worm, in progress.** The same four criteria are met. Vaccination and water-filtration campaigns are eradicating both species; only a handful of cases per year remain.

Step 4. **Disease-vector mosquitoes, debated but defensible.** *An. gambiae*, *A. aegypti* and *C. quinquefasciatus* cause $\sim 600{,}000$ malaria deaths and millions of dengue infections per year. Ecological modelling suggests other mosquito species would replace their pollination and food-web roles. CRISPR gene-drive techniques now make targeted eradication technically feasible.

Step 5. **Boundary cases that fail the test.** "All mosquitoes worldwide" fails criterion (ii), they are food for fish, bats, birds; removing all of them would cascade. Sharks, wolves, snakes, "scary" species that occasionally harm humans, all fail criterion (i) at the population level (they do not cause large-scale human harm) and criterion (ii) (they are keystone predators).

Step 6. **Ethical justification.** Conservation ethics rest on the principle of *intrinsic value plus ecological role*. A virus that exists only to make humans sick scores zero on ecological role, so the moral weight tilts firmly to human welfare.

Why this matters. The case-by-case framing matters more than the conclusion: every conservation decision in real life is a trade-off between species' intrinsic value, ecosystem services and human welfare. Eradication of *Variola* is the clearest example of when human welfare wins.

> **Final Answer:** Yes, for human-only pathogens (smallpox, polio, Guinea worm) and a few targeted disease-vector mosquito species, deliberate extinction is justified because the medical benefit is enormous and the ecological cost is negligible; the same justification does not extend to whole functional groups such as "all mosquitoes" or "all snakes".

Key Takeaways

- Biodiversity is measured at three levels: **genetic**, **species** and **ecosystem (ecological)**;

India is one of 12 mega-diversity nations.

- Tropical regions are species-rich because of (a) long uninterrupted evolutionary time, (b) constant climate favouring niche specialisation, and (c) higher solar energy $\rightarrow$ higher productivity.
- The species-area relationship $S = CA^Z$ has slope $Z = 0.1$–0.2 within a region and $Z = 0.6$–1.2 across continents; Z also predicts species loss from habitat loss.
- The **Evil Quartet** of species loss is habitat loss/fragmentation, over-exploitation, alien species invasions and co-extinctions.
- Biodiversity boosts ecosystem productivity, stability and invasion resistance (Tilman's plots), and supports services such as $\sim 20\%$ of atmospheric O_2 (Amazon), pollination, flood and erosion control.
- **Sacred groves**, **biosphere reserves** (14), **national parks** (90) and **wildlife sanctuaries** (> 450) constitute India's in-situ conservation network; ex-situ methods include zoos, botanical gardens, seed banks and cryopreservation of gametes.
- Of the 34 global **biodiversity hotspots**, **three** (Western Ghats–Sri Lanka, Indo-Burma, Himalaya) cover India's exceptionally rich biodiversity.
- Deliberate extinction is ethically justifiable only for disease-causing pathogens with no ecological role (smallpox, polio, Guinea worm) and a few targeted disease-vector mosquito species.

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