Collegedunia NCERT Formula Sheet

Class 12 Biology (12th) — NCERT 2026-27 / Latest Edition

Chapter 13: Biodiversity and Conservation

Quantitative ecology — species-area law, diversity indices, extinction rates, IUCN categories, hotspots and *in situ* / *ex situ* conservation

Also see for this chapter: NCERT Solutions | Revision Notes | Exemplar Solutions

Chapter-Wide Key Quantitative Reference

Parameter	Typical Value / Range	Significance / Source
Global recorded species (IUCN 2004)	> 1.5 million	$\sim 22\%$ of estimated total
Robert May's global estimate	~ 7 million species	Scientifically sound figure
India's share of land area	$2.4\,\%$ of world	But $8.1\,\%$ of global species
India's recorded species	$\sim 45{,}000$ plants; $\sim 90{,}000$ animals	One of 12 mega-diversity nations
Animals among all recorded species	$> 70\,\%$	Insects alone $> 70\,\%$ of animals
Plants among recorded species	$\leq 22\,\%$	Incl. algae, fungi, bryophytes
Z (species-area), small areas	0.1–0.2	Within-region (any taxon)
Z (species-area), continents	0.6–1.2	e.g. frugivorous birds ≈ 1.15
Tropical latitudinal band	23.5° N to 23.5° S	Greatest species richness
IUCN Red List extinctions (2004)	784 species in 500 yr	338 vert. + 359 invert. + 87 plants
Species facing extinction threat	$> 15{,}500$ worldwide	IUCN Red List total
Current vs pre-human extinction rate	$\mathbf{100}$–$\mathbf{1000}\times$ faster	"Sixth Extinction" in progress
Forecast loss (next 100 yr)	$\sim 50\,\%$ of all species	If present trends continue
Biodiversity hotspots (world)	34 $(25 + 9)$	$< 2\,\%$ land; protection cuts loss $\sim 30\,\%$
India's hotspots	3	Western Ghats–Sri Lanka, Indo-Burma, Himalaya
India's protected areas	14 BR, 90 NP, 448 WLS	Biosphere Res., Nat. Parks, Sanctuaries
Amazon O_2 contribution	$\sim 20\,\%$ of atmospheric O_2	"Lungs of the planet"
Plant-derived modern drugs	$> 25\,\%$ of market	$25{,}000$ plants in traditional medicine

1 13.1 Biodiversity — Levels and Patterns

Biodiversity is the sum total of variety at every level of biological organisation. Three NCERT levels: genetic, species and ecological diversity.

Three levels of biodiversity (NCERT)

(i) Genetic diversity: variation within a single species (e.g. *Rauwolfia vomitoria* reserpine potency varies across Himalayan ranges; India has $> 50{,}000$ rice strains, $1{,}000$ mango varieties).

(ii) Species diversity: variation at the species level (Western Ghats $>$ Eastern Ghats for amphibians).

(iii) Ecological diversity: variation at the ecosystem level (India $>$ Norway: deserts, rain forests, mangroves, coral reefs, wetlands, estuaries, alpine meadows).

Latitudinal gradient in diversity

Empirical rule: species richness S decreases as latitude $|\phi|$ increases from equator to poles.

Tropics: $-23.5^\circ \le \phi \le +23.5^\circ$ harbour the most species.

Birds — illustration: Colombia (near equator) ≈ 1400 species; New York (41°N) $= 105$; Greenland (71°N) $= 56$; India > 1200.

Amazon rain forest — **greatest biodiversity on Earth**: $> 40{,}000$ plants, $3{,}000$ fishes, $1{,}300$ birds, 427 mammals, 427 amphibians, 378 reptiles, $> 1{,}25{,}000$ invertebrates.

Species-Area Relationship (Alexander von

Power-law form:

$$S = C \cdot A^{Z}$$

Logarithmic (linear) form:

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

where S = species richness; A = area explored; C = Y-intercept (regression constant); Z = slope of the line (regression coefficient).

Z values:

- Within a region (any taxon — plants in Britain, birds in California, molluscs in NY): $Z = 0.1$–0.2.
- Across very large areas / continents: $Z = 0.6$–1.2 (e.g. frugivorous birds and mammals in tropical forests ≈ 1.15).

On linear axes the plot is a **rectangular hyperbola**; on log–log axes it becomes a **straight line**. A steeper Z across continents means each new biogeographic realm adds many more endemic species than a comparable area within one region.

How to use $S = CA^Z$ in a NEET/JEE-level numerical

Given S_1 at area A_1 and Z, predict S_2 at a new area A_2:

$$\frac{S_2}{S_1} = \left(\frac{A_2}{A_1}\right)^{Z}$$

Worked check: if $Z = 0.2$ and area is doubled, S rises by $2^{0.2} \approx 1.149$ — only $\sim 15\%$ more species. With $Z = 1.0$ (continental), doubling area *doubles* richness.

Why are the tropics so species-rich? (3 NCERT hypotheses)

(a) Tropics were not disturbed by glaciations $\Rightarrow$ longer evolutionary time for speciation.

(b) Less seasonal, more constant and predictable environment $\Rightarrow$ niche specialisation and greater diversity.

(c) More solar energy $\Rightarrow$ higher productivity $\Rightarrow$ greater diversity (indirectly).

2 13.2 Diversity Indices

The textbook narrative speaks of "species richness"; for JEE/NEET and AIIMS, two named indices quantify diversity beyond a simple count.

Species Richness S

Definition: S = total number of different species in a defined community or sample.

Simplest measure — ignores abundances. Underlies the species-area equation $S = CA^Z$ on the left. Two communities can share the same S yet feel very different if one is dominated by a single species.

Shannon–Wiener Diversity Index H'

$$H' = -\sum_{i=1}^{S} p_i \ln p_i$$

where $p_i = n_i/N$ = proportional abundance of the i-th species (n_i = individuals of species i; N = total individuals); S = species richness.

Range: $H' = 0$ when one species accounts for everyone; $H' = \ln S$

when all species are equally abundant (maximum diversity).

Units: *nats* when using **ln**; *bits* when using $\log_2$.

Captures both **richness** (S) and **evenness** (how equally individuals are spread). Higher H' = community has many species *and* no single species dominates.

Simpson's Index D and complement $1-D$

$$D = \sum_{i=1}^{S} p_i^2$$

where p_i = proportional abundance of species i.

Range: $D \in (0, 1]$. $D \to 1$ when one species dominates; $D \to 1/S$ when species are perfectly even.

Diversity form: $\boxed{1-D}$ = Gini–Simpson; rises with diversity.

Probability meaning: D = probability that two individuals picked at random belong to the **same species**; $1-D$ = probability they belong to **different** species.

Simpson is more sensitive to *dominant* species; Shannon is more sensitive to *rare* species. Always report both indices when comparing communities.

Evenness J — the partner index

Pielou's evenness: $J = H'/\ln S$.

$J = 1$ means perfect evenness; $J \to 0$ means one species dominates. Useful when two sites have the same H' but very different S.

Don't confuse D with $1-D$

D (Simpson's index) *decreases* with diversity (it measures dominance). Most ecology textbooks therefore report the **Gini–Simpson** form $1-D$, which *increases* with diversity. Read the question carefully — "Simpson's index of diversity" usually means $1-D$.

3 13.3 Rivet-Popper & Stability

David Tilman's long-term plots: plots with more species show less year-to-year variation in biomass, and higher productivity. Stability = low variation + resilience + resistance to invasions.

Tilman's stability criteria for a community

A **stable community** must satisfy three conditions:

- Year-to-year productivity must not vary too much.
- It must be **resistant** or **resilient** to natural / man-made disturbance.
- It must resist **invasion** by alien species.

Paul Ehrlich's Rivet-Popper Hypothesis

Treat an ecosystem as an aeroplane and each species as a rivet. Popping a few rivets may not crash the plane, but each loss weakens it. **Loss of rivets on the wings** (= key/keystone species that drive major ecosystem functions) is far more dangerous than loss of rivets on seats or windows. Captures the asymmetric value of species in ecosystem function.

4 13.4 Loss & Sixth Extinction

Earth has seen **five** past mass extinctions; the **Sixth Extinction** is in progress and is human-driven. Quantified extinction rate equations follow.

Current vs background extinction

Comparison rule:

$$\frac{R_{\text{curr}}}{R_{\text{bg}}} = 100 \text{ to } 1000$$

where R_{curr} = present-day species extinction rate; R_{bg} = pre-human (geological) background extinction rate.

Forecast (NCERT): if present trends continue, $\sim$ **50 %** of all species may

be wiped out within the next 100 years.

The previous five mass extinctions were geological; the Sixth is **anthropogenic** (habitat loss, over-exploitation, alien invasions, co-extinction).

IUCN Red-List extinction tally (2004)

Group	Extinctions
Vertebrates	338
Invertebrates	359
Plants	87
Total (last 500 yr)	784

Recent extinctions: dodo (Mauritius), quagga (Africa), thylacine (Australia), Steller's sea cow (Russia), three subspecies of tiger (Bali, Javan, Caspian). Last 20 yr: 27 species.

Currently threatened — % of each group

Taxonomic group	% at risk
All bird species	12 %
All mammal species	23 %
All amphibian species	32 %
All gymnosperm species	31 %
Total threatened	$> 15{,}500$

Amphibians are **disproportionately vulnerable** — likely due to permeable skin (pollution sensitivity), water-dependent life cycle, and chytrid fungal disease.

Consequences of biodiversity loss

(a) Decline in plant production.

(b) Lowered resistance to environmental perturbations (e.g. drought).

(c) Increased variability in ecosystem processes (plant productivity, water use, pest and disease cycles).

These three are the ecosystem-service outcomes that justify the conservation argument later in the chapter.

The Evil Quartet — four causes of biodiversity loss

HOAC — **H**abitat loss & fragmentation, **O**ver-exploitation, **A**lien-species invasions, **C**o-extinctions.

Rank: habitat loss is the **single biggest** driver — tropical rain forest cover has fallen from > 14 % to < 6 % of Earth's land surface.

The Evil Quartet — examples to remember

Habitat loss: Amazon ("lungs of the planet") cleared for soya / cattle; 1000 ha rain forest lost while you read one chapter.

Over-exploitation: Steller's sea cow, passenger pigeon; many marine fisheries.

Alien invasions: Nile perch in Lake Victoria $\rightarrow$ extinction of $>$ 200 cichlid species; *Parthenium*, *Lantana*, water hyacinth (*Eichhornia*); African catfish *Clarias gariepinus* in Indian rivers.

Co-extinctions: loss of a host fish $\Rightarrow$ loss of its obligate parasites; loss of one partner in plant–pollinator mutualism $\Rightarrow$ loss of the other.

5 13.5 IUCN Red-List Categories

Although NCERT names only "extinct", "endangered" and "threatened" in the running text, the full IUCN ladder is the standard reference for JEE / NEET / AIIMS.

IUCN Red List — nine categories

Code	Category	Definition (concise)
EX	Extinct	No reasonable doubt last individual has died (e.g. dodo)
EW	Extinct in the Wild	Survives only in captivity / cultivation
CR	Critically Endangered	Extremely high risk of extinction in the wild
EN	Endangered	Very high risk of extinction in the wild
VU	Vulnerable	High risk of extinction in the wild
NT	Near Threatened	Close to qualifying for VU in the near future
LC	Least Concern	Widespread and abundant; lowest risk
DD	Data Deficient	Insufficient info to assess risk
NE	Not Evaluated	Not yet assessed against the criteria

NCERT operational definition of "threatened": *endangered* species are those facing a very high risk of extinction in the wild in the near future $\Rightarrow$ trigger for **ex situ** measures.

IUCN ladder — bottom $\rightarrow$ top

"LC NT VU EN CR EW EX" — Lazy Cats Never Visit Even Crusty Excited Exes.
Risk rises left $\rightarrow$ right. Add **DD** and **NE** as off-ladder admin tags.

CR / EN / VU thresholds (JEE/NEET extension)

Quantitative IUCN criteria (any one suffices):

- **CR:** population decline $\geq 80\%$ over 10 yr / 3 generations, *or* pop. size < 250 mature individuals.
- **EN:** decline $\geq 50\%$, *or* pop. $< 2{,}500$.
- **VU:** decline $\geq 30\%$, *or* pop. $< 10{,}000$.

Not in NCERT — but common in competitive-exam MCQs.

6 13.6 Conservation — Why & How

NCERT groups reasons into three classes: **narrowly utilitarian**, **broadly utilitarian**, and **ethical**.

Three NCERT arguments for conservation

Narrowly utilitarian — direct economic benefits: food, firewood, fibre, industrial products, medicines ($> 25\%$ of all drugs are plant-derived; $25{,}000$ plant species in traditional medicine); **bioprospecting** explores molecular/genetic/species diversity for products.

Broadly utilitarian — ecosystem services: Amazon contributes $\sim 20\%$ of atmospheric O_2 via photosynthesis; pollination by bees, bumblebees, birds and bats; aesthetic and recreational value.

Ethical — every species has **intrinsic value**; moral duty to pass on biological legacy in good order.

In situ (on-site) conservation — protected areas of India

Class of protected area	India count	Scope
Biosphere Reserves	14	Largest, multi-zone, UNESCO-linked
National Parks	90	Strict protection; no human use
Wildlife Sanctuaries	448	Some regulated human activity allowed
Sacred groves	many	Khasi/Jaintia Hills (Meghalaya), Aravallis, W. Ghats (KA/MH), Sarguja–Chanda–Bastar (MP)

Principle: save the whole ecosystem to save its biodiversity at every level — *save the forest to save the tiger*.

Biodiversity Hotspots — Norman Myers & successors

Definition (Myers): a region of (i) very high species richness and (ii) very high **endemism**, but (iii) suffering accelerated habitat loss.

Global count: 34 hotspots (25 originally identified $+9$ added later).

Land coverage: all 34 together $< 2\,\%$ of Earth's land area.

Conservation impact: strict protection of these hotspots alone could reduce ongoing mass extinctions by $\sim 30\,\%$.

India's three hotspots:

- Western Ghats & Sri Lanka
- Indo-Burma
- Himalaya

"Endemism" = species confined to that region and found nowhere else. India's three hotspots overlap our most biodiverse zones; together they hold a disproportionate share of national species diversity.

Ex situ (off-site) conservation

Endangered organisms are removed from their natural habitat and given special protection. NCERT examples:

- Zoological parks, botanical gardens, wildlife safari parks.
- **Cryopreservation** of gametes of threatened species.
- *In vitro* fertilisation of eggs; tissue-culture propagation of plants.
- **Seed banks** for genetic strains of commercially important plants.

Several species now extinct in the wild survive only in zoological parks (= IUCN category **EW**).

International conservation agreements

The Earth Summit (1992) — Convention on Biological Diversity (CBD), Rio de Janeiro: nations to take measures for conservation & sustainable use.

World Summit on Sustainable Development (2002), Johannesburg, South Africa: 190 countries pledged a significant reduction in the rate of biodiversity loss by 2010 at global, regional and local levels.

***In situ* vs *ex situ* — when to use which**

In situ = on-site (whole ecosystem saved): biosphere reserves, NPs, sanctuaries, sacred groves, biodiversity hotspots. Default choice.

Ex situ = off-site: zoo parks, botanical gardens, seed banks, cryopreservation, tissue culture. Used *only* when the species is endangered or already extinct in the wild and on-site protection cannot save it in time.

Bioprospecting — JEE/NEET extension

Bioprospecting = systematic search for new genes, molecules and species (chemicals, drugs, dyes, enzymes) with commercial value. Countries with rich biodiversity (India, Brazil, Indonesia) hold enormous untapped chemical libraries. The CBD (1992) recognises sovereign rights over genetic resources — a country can charge for access.

7 13.7 Worked Numericals — Species-Area Law

The species-area equation is the only equation in this chapter that lends itself to plug-and-chug problems. Two textbook-style numericals are worked out below.

Numerical 1 — predicting S for a larger plot

Given: A within-region taxon obeys $S = CA^{Z}$ with $Z = 0.15$. A 10 ha plot has $S_1 = 40$ species.

Find: expected richness S_2 on a 250 ha plot.

Solution:

$$\frac{S_2}{S_1} = \left(\frac{A_2}{A_1}\right)^{Z} = \left(\frac{250}{10}\right)^{0.15} = 25^{0.15}$$

$$\log_{10}(25^{0.15}) = 0.15 \times 1.398 = 0.2097 \Rightarrow 25^{0.15} \approx 1.62$$

$$\therefore S_2 = 40 \times 1.62 \approx 65 \text{ species.}$$

Within-region Z is small $\Rightarrow$ a $25\times$ jump in area only $\sim 1.6\times$ the species count. Reflects the rectangular-hyperbola saturation in S vs A.

Numerical 2 — extracting Z from data

Given: A continental survey records $S = 200$ species over $A = 10^3$ km^2 and $S = 1{,}600$ species over $A = 10^6$ km^2.

Find: the slope Z on a log–log plot.

Solution:

$$Z = \frac{\log S_2 - \log S_1}{\log A_2 - \log A_1} = \frac{\log 1600 - \log 200}{\log 10^6 - \log 10^3} = \frac{3.204 - 2.301}{6 - 3} = \frac{0.903}{3} \approx 0.30$$

$Z \approx 0.30$ — slightly above the within-region range, well below the continental range. Likely represents a large biogeographic province (e.g. Indian subcontinent for one taxon).

Diagram cue — species-area on log-log

On linear A-vs-S axes, the curve is a **rectangular hyperbola** (rises steeply, then saturates). On $\log A$ vs $\log S$ axes the same curve is a **straight line of slope** Z and intercept $\log C$. Always plot on log-log to extract Z from data.

8 13.8 India — Mega-Diversity Snapshot

Quantitative cheat-sheet for the "India" sub-topic, frequently tested in NEET and AIIMS general-awareness MCQs.

India — diversity headline numbers

Metric	Value / note
World rank	one of 12 **mega-diversity countries**
Share of world land area	2.4 %
Share of global species diversity	8.1 %
Recorded plant species	$\sim$ 45,000
Recorded animal species	$\sim$ 90,000
Bird species	$>$ 1,200
Estimated unrecorded plants	$>$ 1,00,000 (May's 22 % rule)
Estimated unrecorded animals	$>$ 3,00,000
Biodiversity hotspots in India	3 (W. Ghats–SL, Indo-Burma, Himalaya)
Biosphere Reserves	14
National Parks	90
Wildlife Sanctuaries	448

Apply May's 22 %-recorded rule to any country's tally to estimate undiscovered species.

Sacred groves of India — *in situ* folk conservation

Tracts of forest set aside on religious/cultural grounds; total protection to all trees and wildlife. Major regions:

- Khasi and Jaintia Hills (Meghalaya) — last refuges for many rare/threatened plants.
- Aravalli Hills (Rajasthan).
- Western Ghats — Karnataka and Maharashtra.
- Sarguja, Chanda and Bastar areas (Madhya Pradesh).

Mega-diversity countries — context

The 12 "mega-diversity" countries (Mittermeier classification) collectively house $> 70\,\%$ of Earth's species on $< 10\,\%$ of land. India is the only country with **three** hotspots, two mega-deltas (Ganga, Brahmaputra) and tropical-to-alpine altitudinal sweep — all within 32.8×10^5 km^2.

Read the Full Revision Notes

Related Collegedunia Resources

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- Revision Notes
- NCERT Book PDF
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Continue learning:
- Ch 9: Biotechnology - Principles and Processes
- Ch 11: Organisms and Populations
- Class 12 Biology — All Chapters

Quick Reference — Formula & Datum Index

Topic / Equation	Formula or Datum	Key Note
Species-area (power form)	$S = C\,A^{Z}$	Humboldt; rect. hyperbola
Species-area (log form)	$\log S = \log C + Z \log A$	Straight line on log–log
Z value (within region)	0.1–0.2	Any taxon
Z value (continents)	0.6–1.2	e.g. frugivorous birds 1.15
Predict S_2 from S_1	$S_2 = S_1(A_2/A_1)^{Z}$	NEET numerical
Shannon–Wiener index	$H' = -\sum p_i \ln p_i$	Captures richness + evenness
Simpson's dominance	$D = \sum p_i^2$	Higher D = less diverse
Gini–Simpson diversity	$1 - D$	Pr(two picks differ)
Pielou's evenness	$J = H'/\ln S$	$J = 1 \Rightarrow$ perfect evenness
Max Shannon value	$H'_{\text{max}} = \ln S$	All species equal
Extinction-rate ratio	$R_{\text{current}}/R_{\text{background}} = 100$–$1000$	Sixth Extinction
Threatened bird species	$12\,\%$	IUCN
Threatened mammals	$23\,\%$	IUCN
Threatened amphibians	$32\,\%$	IUCN — highest
Threatened gymnosperms	$31\,\%$	IUCN
Total recorded extinctions	784 in last 500 yr	338 V + 359 I + 87 P
Species facing threat	$> 15{,}500$ worldwide	IUCN Red List 2004
Global hotspots	34 $(25 + 9)$	$< 2\,\%$ land area

Topic / Equation	Formula or Datum	Key Note
Hotspot conservation gain	~ 30 % less extinction	With strict protection
India's hotspots	3	W. Ghats–SL, Indo-Burma, Himalaya
India's protected areas	14 BR, 90 NP, 448 WLS	In situ
Amazon O_2 contribution	~ 20 % of atmospheric O_2	"Lungs of the planet"
Global recorded species	> 1.5 million	IUCN 2004
Robert May's estimate	~ 7 million total	Scientifically sound
India species (recorded)	$\sim 45{,}000$ plants; $\sim 90{,}000$ animals	12 mega-diversity nations
India's land vs species share	2.4 % vs 8.1 %	Disproportionate richness
IUCN ladder (low $\rightarrow$ high risk)	LC, NT, VU, EN, CR, EW, EX	Plus DD, NE off-ladder
The Evil Quartet	H habitat, O over-exploit, A alien, C co-extinct	HOAC mnemonic
Earth Summit (CBD)	Rio de Janeiro, 1992	Conservation + sustainable use
Johannesburg Summit	2002, 190 countries	Cut loss-rate by 2010

NCERT 2026-27 syllabus. Numbers per IUCN Red List (2004) as cited in the NCERT chapter.