The Ultimate AP® Environmental Science Unit 1 Cheat Sheet

1.1 Introduction to Ecosystems

Levels of Organization

Individual → **population** (1 sp., 1 area) → **community** (all spp.) → **ecosystem** (community + abiotic) → **biosphere**.
Biotic = living (plants, animals, microbes). **Abiotic** = nonliving (sunlight, water, temp, soil, pH, salinity).

Species Interactions

Type	Effect	Example
Predation	+ / –	Lynx eats hare
Herbivory	+ / –	Deer eat shrubs
Parasitism	+ / –	Tick on deer
Mutualism	+ / +	Bees & flowers
Commensalism	+ / 0	Barnacle–whale
Competition	– / –	Lions & hyenas

Symbiosis = close, long-term bond between 2 spp.: mutualism, commensalism, or parasitism.
Predator–prey cycle: prey ↑ → predators ↑ (lag) → prey ↓ → predators ↓. Predators keep prey below carrying capacity.
Mutualism examples: coral & algae; **mycorrhizae** (fungi help roots absorb water/nutrients ↔ get sugar); *Rhizobium* & legumes (N fixed for plant ↔ bacteria get sugar).

Competition & Niches

Niche = a sp.'s role: food, habitat, timing. **Fundamental** = could use; **realized** = actually uses b/c of competition.
Competitive exclusion: 2 spp. can't share the exact same niche long-term → 1 is pushed out or shifts.
Resource partitioning ↓ competition: **temporal** (hawk by day, owl by night), **spatial** (warblers feed at different tree heights), **morphological** (beak sizes).

⚠ Parasites usually harm but DON'T kill the host (a dead host = no food). Predators kill + eat prey.

✓ FRQ: name the interaction AND describe each species' effect (+, –, 0) to earn the point; cite the example.

1.2 Terrestrial Biomes

What Sets a Biome

Biome = region w/ similar climate & plant/animal communities. Set mainly by avg **temperature** & **precipitation** (shown on a **climatograph**), not by location.
Latitude & **elevation** shift climate: climbing a mountain ≈ moving toward the poles (cooler, shorter season).

Biome	Climate	Key Trait
Trop. rainforest	Hot, very wet	Top biodiversity
Temp. deciduous	4 seasons	Fertile soil
Temp. grassland	Dry, hot/cold	Deep rich soil
Savanna	Wet/dry seas.	Grass, few trees
Desert	<25 cm rain/yr	Succulents
Taiga (boreal)	Cold, snowy	Conifers
Tundra	Very cold, dry	Permafrost
Chaparral	Dry summer	Fire-adapted

Soil & Nutrients

Rainforest soil = thin & nutrient-poor: fast decomposition + heavy rain **leaches** nutrients; most nutrients stored in plants → cleared land loses fertility within a few years.
Grassland soil = deepest, most fertile (thick roots, slow decay) → best farmland. **Taiga** soil = acidic, poor.

Adaptations & Change

Adaptations match climate: waxy leaves & deep roots (desert), needles shed snow (taiga), fire-resistant seeds & thick bark (chaparral, grassland, savanna).
Climate change shifts biomes poleward & upslope; spp. that can't move, disperse or adapt fast enough decline.

⚠ Biomes are defined by climate, not location. Two deserts on different continents = same biome.

✓ Climatograph MCQ: read BOTH lines: temp curve + precipitation bars → then match the biome.

1.3 Aquatic Biomes

What Sets an Aquatic Biome

Key factors: salinity, depth, flow, temperature, dissolved O_2 (DO), nutrients, & light (↓ w/ **turbidity** = cloudiness).

Biome	Salinity	Key Fact
River/stream	Fresh	High DO (mixing)
Lake/pond	Fresh	Light zones
Wetland	Fresh/mixed	Filter, flood ctrl
Estuary	Brackish	Nursery, high NPP
Coral reef	Salt	Mutualism, warm
Open ocean	Salt	Low nutrients

Freshwater

Lake zones: **littoral** (shallow edge, plants), **limnetic** (open, sunlit), **profundal** (deep, dark), **benthic** (bottom).
Wetlands (marsh, swamp, bog): saturated soil; filter pollutants, absorb floods, recharge groundwater, store C.
Rivers: fast, cold, turbulent water → high DO; slow, warm water → low DO (warm water holds less O_2).

Marine

Estuary = river meets ocean; nutrients from runoff → very high productivity. **Mangroves** & salt marshes buffer storms.
Coral reefs: warm, shallow, clear; coral + **zooxanthellae** = mutualism. Heat → algae leave → **bleaching**.
Intertidal zone: between high & low tide; organisms resist wave action, drying out & salinity swings.
Open ocean: **photic zone** (light, photosynthesis) vs. **aphotic** (dark). Phytoplankton make ~half of Earth's O_2.
Upwelling brings cold, nutrient-rich deep water up → high productivity & fisheries (e.g., off Peru).

⚠ Most productive aquatic biomes = estuaries, wetlands & reefs, NOT the open ocean (too few nutrients).

✓ Ecosystem services: wetlands & mangroves = flood control + water filtering. Use them as FRQ examples.

1.4 Carbon Cycle & 1.7 Water Cycle

Carbon Cycle

Reservoirs: sedimentary rock & fossil fuels (largest, slow), ocean (largest active), soil, biomass, atmosphere.

Process	Moves C
Photosynthesis	Air → plants (sink)
Respiration	Organisms → air
Decomposition	Dead matter → air, soil
Combustion	Fuels/wood → air
Ocean uptake	Air → ocean
Sedimentation	Shells → limestone

Photosynthesis: $6CO_2 + 6H_2O + \text{light} \rightarrow C_6H_{12}O_6 + 6O_2$.
Respiration = reverse (releases energy).
Fast cycle (photosynthesis ↔ respiration, days–yrs) vs. **slow** (burial → fossil fuels over millions of yrs).
Carbon sinks: forests, ocean, peat bogs, permafrost. Thawing permafrost & deforestation → **sources**.
Human impact: burning fossil fuels moves C from long-term storage → air faster than sinks absorb → CO_2 ↑ → warming; ocean absorbs CO_2 → **ocean acidification**.

Water Cycle

Reservoirs: ocean ~97%; freshwater ~3%, mostly in ice caps & glaciers; **groundwater** = largest liquid freshwater store.
Processes: evaporation, **transpiration** (plants), condensation, precipitation, **runoff**, **infiltration** → aquifers. Driven by solar energy (up) + gravity (down).
Human impact: pavement ↑ runoff, ↓ infiltration; deforestation ↓ transpiration → less local rain.
Aquifer = porous rock/sediment holding groundwater; recharged slowly by infiltration; overpumping drains it.

⚠ Source vs. sink: a SINK stores more C than it releases (forests, ocean); a SOURCE releases more (burning fuel).

✓ Sun drives evaporation & transpiration; gravity drives precipitation, runoff & infiltration into aquifers.

1.5 Nitrogen & 1.6 Phosphorus Cycles

Nitrogen Cycle

Reservoir: atmosphere (N_2 ~78%), but most organisms can't use N_2 directly → it must be **fixed** first.

Step	What Happens
Fixation	$N_2 \rightarrow NH_3/NH_4^+$ (bacteria)
Nitrification	$NH_4^+ \rightarrow NO_2^- \rightarrow NO_3^-$
Assimilation	Plants take up N
Ammonification	Decay → NH_3
Denitrification	$NO_3^- \rightarrow N_2$ gas

Fixation by bacteria (e.g., ***Rhizobium*** in legume root nodules = mutualism) & lightning. **Denitrification**: anaerobic bacteria in waterlogged soil & wetlands turn NO_3^- back into N_2 gas.
Human impact: Haber-Bosch fertilizer + burning fuel (NO_x) → excess N → runoff → **eutrophication**; N_2O from fertilized soil = potent greenhouse gas & ozone depleter.
Nitrate (NO_3^-) dissolves easily → **leaches** into groundwater → drinking-water risk (blue baby syndrome).

Phosphorus Cycle

No gas phase → slowest cycle. Reservoir = sedimentary rock & ocean sediment; P moves mostly in water.
Steps: **weathering** of rock releases phosphate (PO_4^{3-}) → soil/water → plants → animals → decomposition → ocean sediment → **uplift** (geologic) → rock again (very slow).
Limiting nutrient: P is often in short supply, esp. in freshwater → adding P triggers rapid algae growth.
Human P sources: mined phosphate rock (fertilizer), detergents, sewage, animal waste, eroded soil.

Eutrophication Chain

Excess N/P (fertilizer, sewage, detergents) → **algal bloom** → algae die → decomposers use up DO → **hypoxia** → fish die (**dead zone**, e.g., Gulf of Mexico each summer).

⚠ Don't mix up nitrification (NH_4^+ → nitrate, aerobic) & denitrification (nitrate → N_2 back to air, anaerobic).

✓ Only N has an atmospheric reservoir; P cycle has none.

1.8 Primary Productivity

GPP vs. NPP

GPP (gross primary productivity) = total rate of photosynthesis by producers in an area.
NPP (net) = **GPP − R** (R = energy producers use for respiration). NPP = energy left for growth & for consumers.
Units: kcal/m²/yr or g/m²/yr. Always carry units in FRQ math.
Biomass = mass of living matter in an area; NPP builds new biomass each year (in g/m²/yr or kg/m²/yr).
Example: GPP = 20,000 kcal/m²/yr, R = 12,000 kcal/m²/yr → NPP = 20,000 − 12,000 = 8,000 kcal/m²/yr.

Where NPP Is High & Low

High NPP	Low NPP
Tropical rainforest	Desert
Estuaries, wetlands	Tundra
Coral reefs	Open ocean (per m²)

Limits: light, water, temperature & nutrients. Warm + wet + nutrient-rich = high NPP; cold or dry = low.
Open ocean: low NPP per area but huge area → large total.
Most → least: rainforest, estuary > grassland > desert.

Measuring & Light

Light/dark bottle: Δ DO in light bottle = NPP; DO drop in dark bottle = R; so **GPP = NPP + R** (DO gain + DO loss).
In water: red light absorbed near surface; blue penetrates deepest → algae at depth use blue wavelengths.
Efficiency: producers capture only ~1% of the sunlight that reaches them; the rest reflects or heats.
Succession link: young ecosystems grow fast → high NPP vs. biomass; mature forests store more but grow slower.

⚠ NPP is always < GPP. A question giving NPP & R wants you to ADD them to get GPP, not subtract.

⚠ Lost units = lost points. Write kcal/m²/yr on every step.

1.9 Trophic Levels & 1.10 10% Rule

Trophic Levels

Producers (autotrophs: plants, algae) → **primary consumers** (herbivores) → **secondary** → **tertiary** (top carnivores).
Decomposers (bacteria, fungi) break down dead matter → return nutrients. **Detritivores** (worms, millipedes) eat detritus.
Matter cycles; **energy flows** one way (sun → producers → consumers → lost as heat, never recycled).
Autotroph = makes own food (photosynthesis, or **chemosynthesis** at vents). **Heterotroph** = eats others.

Laws of Thermodynamics

1st law: energy isn't created or destroyed, only converted (sunlight → chemical energy stored in sugar).
2nd law: each energy conversion loses some energy as **heat** → less usable energy at each higher trophic level.

10% Rule

Level	Energy (kcal)
Producers	10,000
Primary cons.	1,000
Secondary cons.	100
Tertiary cons.	10

~10% passes up each level; ~90% lost to cellular respiration (heat), uneaten parts (bones, roots) & waste.
Shortcut: multiply by 0.1 for each level you move up (2 levels = × 0.01; 3 levels = × 0.001). Divide by 0.1 going down.
Effects: few top predators; food chains rarely >4–5 levels; eating lower on the chain feeds more people per acre.
Example: 1,000,000 kcal in grass → hawk (3rd-level consumer) gets ~1,000 kcal (× 0.1 three times).

⚠ Pyramids of numbers or biomass CAN be inverted (1 tree, many insects). Energy pyramids never are.

✓ Show the × 0.1 steps in calculations: graders want the setup + units, not just the final answer.

1.11 Food Webs & FRQ Moves

Food Chains & Webs

Food chain = 1 feeding path. **Food web** = linked chains → more realistic; more links = more stable.
Arrows point from the eaten → the eater, showing the direction that energy & matter flow through the web.
Omnivores feed at more than 1 trophic level (e.g., bear eats berries & fish; humans eat both plants & meat).
Food web stability: more spp. & links (biodiversity) = backup food sources → recovers faster from disturbance.

Predicting Changes

Remove a sp.: its prey ↑, its predators ↓, competitors may ↑. Effects ripple up & down = **trophic cascade**.
Example: wolves return to Yellowstone → elk ↓ → willows & aspens recover → beavers ↑ → wetlands ↑.
Keystone species = sp. w/ outsized effect on community (e.g., sea otters eat urchins → kelp forests survive).

FRQ Verb	Do This
Identify	Name it (no detail)
Describe	Give key traits
Explain	How/why + cause
Calculate	Setup, units, answer
Justify	Evidence for claim

Design an Investigation (Q1)

Hypothesis (if/then), **independent variable** (what you change), **dependent variable** (what you measure), **control group**, **constants**, repeated trials (≥3) for reliability.
Data Qs: describe the trend w/ specific numbers + units, cite the data directly, then explain the cause.

⚠ Arrow direction trap: "grass → rabbit" means energy moves INTO the rabbit, not the reverse.

✓ Use specific spp. & numbers from the prompt; vague, general answers usually earn 0 points on FRQs.