

Unit 2: The Living World: Biodiversity

Unit 2 explains why biodiversity matters and what happens when it is lost. It covers the levels of biodiversity, the services ecosystems provide, island biogeography, ecological tolerance, natural disruptions to ecosystems, adaptations, and ecological succession.

AP Environmental Science

Biodiversity

About 10 minutes to read

How to use this guide

Read it in order the first time because the topics connect. Biodiversity is the starting point, ecosystem services show why it has value, island biogeography explains where species come from and go, tolerance and disruptions explain what threatens them, adaptations explain how they respond, and succession shows how ecosystems rebuild. Exam questions often describe a scenario, like a fragmented forest or an introduced predator, and ask you to predict which species suffer first.

After the first read, use the trap boxes and the comparison table to review the distinctions that exam questions test most often. Finish with the practice questions, then complete the recall check on the last page out loud and note any items you cannot explain yet.

What this unit is worth. The Living World: Biodiversity is about 6 to 8 percent of the AP Environmental Science exam, which has 80 multiple-choice questions and 3 free-response questions. Its real payoff is cumulative. Biodiversity underlies Unit 3 on populations, Unit 5 on land use, and Unit 9 on global change, so the vocabulary here keeps appearing later.

2.1 Introduction to Biodiversity

Biodiversity is the variety of life, and it comes in three levels. **Genetic diversity** is variation within a population. **Species diversity** is the variety of species in an ecosystem. **Habitat diversity** is the variety of ecosystems themselves. **Species richness**, the number of different species in an area, is one way to measure species diversity, but it is only one level of the full picture.

Genetic diversity is what lets a population respond to stress. When disease, climate, or a new predator arrives, a varied population is more likely to contain individuals with traits that survive. A **population bottleneck**, a sharp reduction in population size, strips that variation away. The survivors carry only a fraction of the original genes, and the population stays vulnerable long after its numbers recover, because genetic variation does not come back quickly.

Diverse ecosystems also recover from disruption faster. When one species is lost, others can take over its role, which is why ecosystems with more species are more likely to bounce back. Losing species weakens that resilience.

Habitat loss drives that weakening in a predictable order. **Specialists**, species that depend on narrow conditions or specific resources, disappear first. **Generalists**, which tolerate a wider range, hold on longer but follow as habitat keeps shrinking. Species with large territorial requirements, like top predators, are hit hard too, because they need more intact habitat than most.

Trap. When a question asks which species are lost first after habitat destruction, the answer is specialists. Specialists depend on specific resources, so they are vulnerable. Generalists tolerate more and persist longer.

Trap. A population bottleneck is a crash inside an existing population. Do not confuse it with a founder effect, where a small group starts a new population somewhere else. Both reduce genetic diversity, but a bottleneck is a reduction and a founder effect is a beginning.

2.2 Ecosystem Services

Ecosystems do work that people depend on, and that work is grouped into four categories of **ecosystem services**. **Provisioning** services provide material goods such as food, fresh water, and timber. **Regulating** services control processes such as climate, flooding, pollination, and disease. **Cultural** services provide nonmaterial benefits such as recreation, aesthetic value, and spiritual or scientific uses. **Supporting** services, such as nutrient cycling, soil formation, and primary production, underlie all the others.

Human activity disrupts these services, and the consequences are ecological and economic at once. Clearing a forest for timber removes a provisioning service, but it also removes regulating services like flood control and water purification. The cost shows up downstream, often in places far from the original clearing.

Trap. The four categories have a hierarchy that questions like to test. Supporting services, nutrient cycling and soil formation, are the foundation the other three build on. If a question asks which service is most fundamental, look at the supporting category.

2.3 Island Biogeography

Island biogeography is the study of how species are distributed on islands and how their communities are structured. Its central model, developed by MacArthur and Wilson, treats species richness on an island as a balance between **immigration** and **extinction**. New species arrive from a mainland source while species on the island die out. Larger islands hold more species because extinction rates are lower, and islands closer to the mainland hold more because immigration rates are higher.

Island colonization is the arrival and establishment of new species from elsewhere. The founding populations may then evolve into **island specialists**, species finely tuned to the island's limited food and territory.

That tuning is fragile. Island species often evolve as specialists because island resources are limited, and specialists are vulnerable when **invasive species**, usually generalists, are introduced and outcompete them. An invasive generalist eats a wider range of food and tolerates more conditions, so it wins the competition for the island's limited resources.

Trap. The pattern on islands is the same as on continents. Specialists are the vulnerable group. Invasive species succeed because they are generalists, and generalists outcompete specialists when a new competitor arrives.

2.4 Ecological Tolerance

Every organism and species has a range of conditions it can endure, such as temperature, salinity, flow rate, and sunlight. That range is its **ecological tolerance**. Outside the range, injury or death results. Tolerance applies to individuals and to whole species, and it explains why species live where they do. A species cannot live where a key condition falls outside its tolerance, no matter how favorable everything else is.

Trap. Ecological tolerance is about conditions, not resources. Temperature, salinity, and sunlight are conditions. Food and water are resources. Questions that mix the two are testing whether you know the difference.

2.5 Natural Disruptions to Ecosystems

Not every disruption is human-made. **Natural disruptions** such as volcanic eruptions, earthquakes, floods, and meteor impacts can have environmental consequences as great as, or greater than, many human-made disruptions for a given event. A single eruption can reshape a landscape faster than decades of development.

Earth processes run on very different **time scales**. Some are **periodic**, regularly repeating, like seasonal flooding. Some are **episodic**, occasional events, like hurricanes or eruptions. Some are **random**. Reading a disruption means knowing which kind of time scale you are dealing with.

Over geologic time, Earth's climate has changed many times, and **sea level** has varied significantly as the amount of glacial ice grew and shrank. Species that could not track those changes disappeared.

When a major upheaval transforms a habitat across a large area, species have three options: adapt, migrate, or die. **Wildlife migration**, the regular seasonal movement of animals between breeding and wintering grounds, is one version of that response, driven by food availability, climate, or disruption.

Trap. Natural does not mean gentle. Exam questions contrast natural and human-caused disruptions, and the point is that natural events can be just as destructive. Do not assume the human-caused option is always the worse one.

2.6 Adaptations

Natural selection acts on heritable traits. Individuals with traits that fit their environment leave more offspring, and over generations the population adapts through small genetic changes. **Adaptation** is a change across generations at the population level, not something an individual chooses to do.

When the environment changes, suddenly or gradually, the change can threaten a species' survival. Individuals must alter their behaviors, move to new areas, or perish. Evolution only works when there is genetic variation to select from, which is why the bottleneck discussion in 2.1 matters here. A bottlenecked population has little raw material for adaptation.

Trap. Individuals do not evolve. Populations do. A question that describes an animal adjusting to cold within its own lifetime is describing acclimation, not evolution. Evolution requires heritable change across generations.

2.7 Ecological Succession

After a disturbance, ecosystems rebuild through **succession**. **Primary succession** begins where there is no soil and no previous life, such as bare rock after a lava flow. **Secondary succession** begins where soil remains after a disturbance, such as a forest regrowing after a fire. Secondary succession moves faster because the soil is already there.

Pioneer species are the first colonizers. They tolerate harsh conditions and change the environment, adding organic matter and holding moisture, which lets later species move in.

Two special roles show up in succession questions. A **keystone species** is one whose activities have a particularly significant role in determining community structure, out of proportion to its abundance. Remove it and the community changes shape. An **indicator species** is different. Its presence, abundance, scarcity, or chemical makeup reveals something about the quality of the ecosystem. It is a measuring tool, not a load-bearing beam.

As succession runs in a disturbed ecosystem, **total biomass** and **species richness** generally increase, and **net productivity** shifts over time. Mature ecosystems store more biomass and support more species than the pioneer stage.

Trap. Keystone and indicator species answer different questions. Keystone is about influence on the community. Indicator is about information on ecosystem health. A sea otter holding urchins in check is keystone. A lichen that dies in polluted air is an indicator.

Trap. Primary succession starts with bare rock and no soil. If the question mentions soil remaining after a fire or flood, that is secondary succession, even if the damage looks severe.

Confusions That Cost Points

PAIR	HOW TO KEEP THEM STRAIGHT
Genetic, species, and habitat diversity	Three levels, not three names for one thing. Genetic is variation within a population. Species is variety of species. Habitat is variety of ecosystems.
Species richness vs biodiversity	Richness is a count of different species, one measure of one level. Biodiversity is the full three-level concept.
Specialist vs generalist	Specialists have narrow requirements and are lost first to habitat change. Generalists tolerate more and persist longer. Invasives are usually generalists.
Bottleneck vs founder effect	A bottleneck is a crash inside an existing population. A founder effect is a small group starting a new population elsewhere. Both shrink genetic diversity.
Keystone vs indicator species	Keystone shapes the community through its activities. Indicator reveals ecosystem quality through its presence or absence.
Primary vs secondary succession	Primary starts with no soil and no previous life. Secondary starts with soil after a disturbance and moves faster.
The four ecosystem services	Provisioning gives goods. Regulating controls processes. Cultural gives nonmaterial benefits. Supporting, nutrient cycling and soil formation, underlies the rest.
Natural vs human-caused disruption	Natural events can match or exceed human-made damage for a given occurrence. Do not assume human-caused is always worse.
Adaptation vs acclimation	Adaptation is heritable change across generations in a population. Acclimation is an individual adjusting within its lifetime.

Practice Questions

Original questions written for this guide in the style of the AP exam. Answers and explanations are on the next page, so complete the questions before checking them.

- 1.** Which of the following best describes the three levels of biodiversity?
 - A. Species richness, species evenness, and endemism
 - B. Genetic diversity, species diversity, and habitat diversity
 - C. Population size, carrying capacity, and growth rate
 - D. Producers, consumers, and decomposers

- 2.** A disease kills 95 percent of a frog population. The surviving frogs have very similar genes, and ten generations later the population is still vulnerable to new diseases. This is best explained by
 - A. the founder effect
 - B. a population bottleneck
 - C. natural selection favoring the survivors
 - D. the island biogeography model

- 3.** A volcanic eruption covers an island with lava, destroying all life and soil. The first plants to grow on the cooled rock are lichens. This process is
 - A. secondary succession, and the lichens are pioneer species
 - B. primary succession, and the lichens are keystone species
 - C. primary succession, and the lichens are pioneer species
 - D. secondary succession, and the lichens are indicator species

- 4.** Two islands are the same distance from the mainland. Island X is much larger than Island Y. According to island biogeography, Island X is expected to have
 - A. higher species richness because extinction rates are lower
 - B. higher species richness because immigration rates are higher
 - C. lower species richness because extinction rates are higher
 - D. the same species richness because distance determines immigration

Answer Key

- 1. B.** The three levels are genetic diversity (variation within a population), species diversity (variety of species), and habitat diversity (variety of ecosystems). A lists community-structure measures that are not the three levels. C lists population ecology terms. D lists trophic levels.
- 2. B.** A sharp population crash that strips genetic variation is a bottleneck, and the lasting vulnerability comes from the lost variation. A is wrong because no small group left to found a new population elsewhere. C is wrong because selection is not what keeps the population vulnerable; the loss of genetic variation is. D is about island immigration and extinction balances, which do not apply here.
- 3. C.** All life and soil were destroyed, so succession starts from bare rock: primary succession. The lichens are the first colonizers that tolerate harsh conditions and modify the environment, which is the definition of pioneer species. A and D wrongly say secondary, which requires soil to remain. B correctly says primary but mislabels the lichens as keystone species; they are not shaping community structure through disproportionate activity.
- 4. A.** At the same distance from the mainland, immigration rates are similar on both islands, so the difference is extinction. Larger islands have lower extinction rates, which raises the equilibrium species richness. B confuses the distance effect with the area effect. C gets the area effect backward. D ignores that area acts through extinction rates.

One-Page Recall Check

- Name the three levels of biodiversity and give an example of each.
- Explain why a population bottleneck leaves a population vulnerable long after its numbers recover.
- Explain why ecosystems with more species recover from disruption faster.
- State the order in which species are lost to habitat loss and explain why specialists go first.
- Define species richness and explain how it differs from biodiversity.
- List the four categories of ecosystem services with one example of each.
- Explain how human activity can disrupt regulating and supporting services at the same time.
- State the island biogeography equilibrium model and the effects of island size and distance.
- Explain why island specialists are vulnerable to invasive generalists.
- Define ecological tolerance and explain why it involves conditions rather than resources.
- Explain how a natural disruption can be as destructive as a human-made one.
- Distinguish periodic, episodic, and random Earth processes with an example of each.
- Explain the link between glacial ice and sea-level change over geologic time.
- State the three options species face when a major upheaval transforms their habitat.
- Explain why evolution acts on populations rather than individuals.
- Distinguish primary and secondary succession and explain which moves faster and why.
- Define keystone species, indicator species, and pioneer species, and give an example of each.
- Describe how total biomass, species richness, and net productivity change during succession.

Where to go next. Turn every missed item above into flashcards and drill them spaced out over several days rather than in one sitting. In Rycal, open the AP Environmental Science deck. The deck covers the terms in this guide, and its practice questions target the same traps named here. If you have a test date, add it in the Test Planner. You can also start your next review with a Brain Dump, then check what you missed against this guide.

Key terms for this unit

Levels of biodiversity, Genetic diversity and population bottleneck, Species diversity and ecosystem recovery, Habitat loss and species loss, Species richness, Ecosystem services (four categories), Human disruption of ecosystem services, Island biogeography, Island colonization, Island specialists and invasive generalists, Ecological tolerance, Natural disruptions vs. human disruptions, Time scales of Earth processes, Climate and sea-level change over geologic time, Environmental upheaval and habitat change, Wildlife migration, Natural selection and adaptation, Responses to environmental change, Primary and secondary succession, Keystone species, Indicator species, Pioneer species, Succession and ecosystem characteristics.

About this guide. Written for Rycal and aligned to the College Board AP Environmental Science course framework, Unit 2. All questions and explanations are original Rycal writing. Rycal is independent and is not affiliated with or endorsed by the College Board.