

A photograph of a white truck with a flatbed trailer, heavily loaded with numerous wooden crates. The truck is parked in an orchard with many trees in the background, some of which are in bloom. The image is dimmed to serve as a background for the text.

Chapter 28: The Importance of Healthy Ecosystems

Chapter 28 of 29 • Humans and Changing Ecosystems

Lesson 28: What do living systems do for people, and what would it cost to replace them?

Angela's Wand • Bring Science Alive! 7th Grade Integrated

The bee trucks of February

Each winter, trucks stacked with beehives roll into California's Central Valley from as far away as Florida, Texas and North Dakota. When the almond trees bloom, usually from mid-February, growers rent millions of honey bee colonies, by one estimate close to every managed colony in the country. A few weeks later the trucks leave. Why pay to haul in tens of billions of bees?

- Notice: what is being moved, how far, and at what time of year?
- Wonder: what does a bee do in an almond blossom that the tree cannot do for itself?
- Predict: what would happen to the harvest in a year when many hives died over the winter?





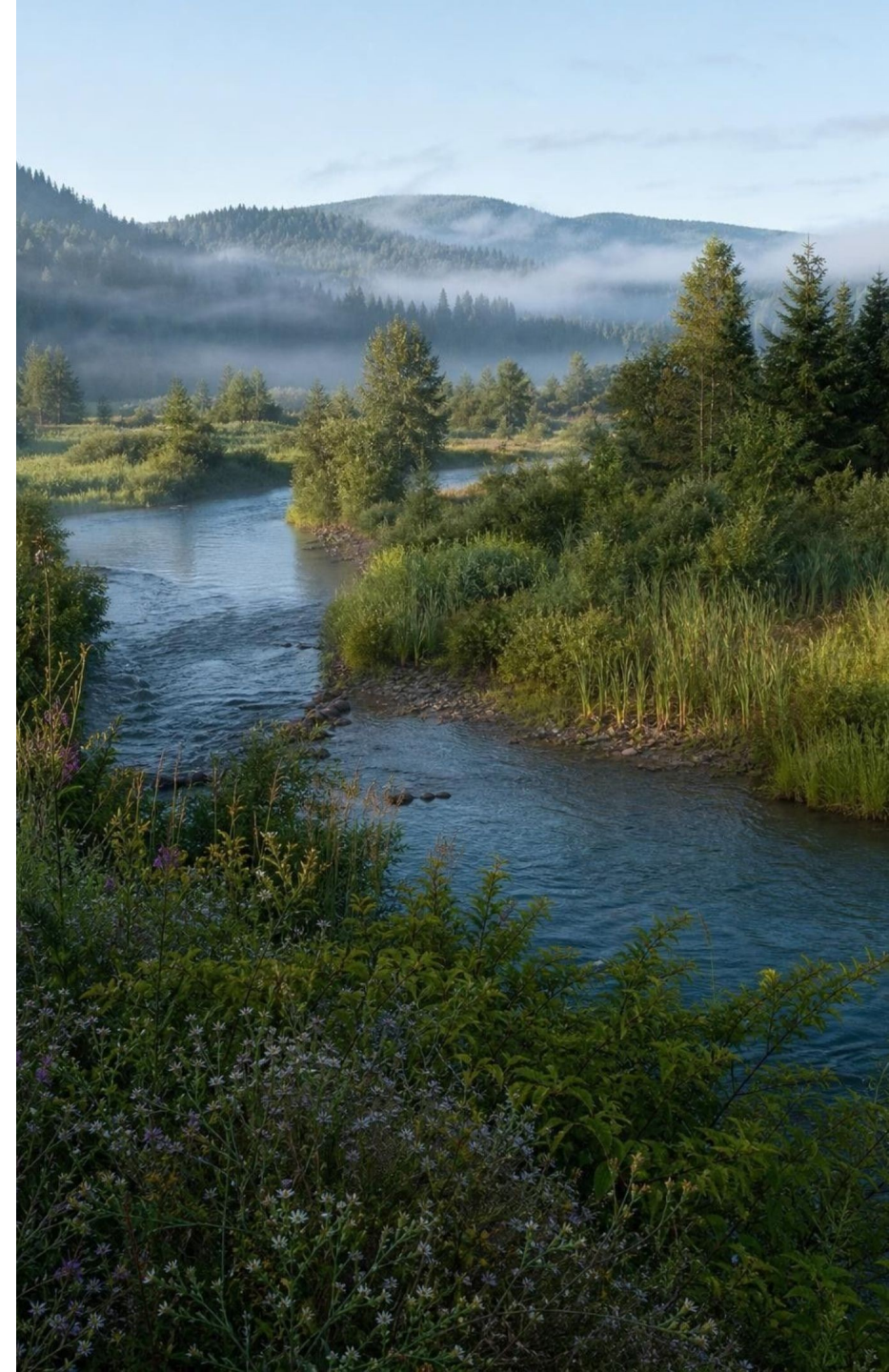
LEARNING TARGETS

What you will be able to do

- 1 Define an ecosystem service and name the living things and processes behind each kind.
- 2 Use model data to explain why almond blossoms need bees to bring pollen from a different variety.
- 3 Trace how one small change, a drug given to cattle, spread through an ecosystem to people.
- 4 Design, test and improve a water filter, and compare it with a forested watershed.
- 5 Weigh protect-or-replace choices using scientific, economic and social criteria.

What counts as an ecosystem service?

- An ecosystem service is a benefit people get from the normal work of an ecosystem.
- The workers are organisms and nonliving parts together: bees, fungi, roots, soil, sand and water.
- Some services supply things we use: food, wood, fresh water, chemicals for medicines.
- Others keep the system running or protect us: pollination, soil building, water filtering, flood buffering.
- Stone and metals are natural resources too, but they form by geology, not by living ecosystems.
- No one sends a bill, so services are easy to overlook until they stop.





Four kinds of work a healthy ecosystem does

Model

Model: Sorting ecosystem services

Center: Healthy ecosystem

Supplies:

Food, wood, fibers, fresh water, chemicals used in medicines

Keeps the system running:

Photosynthesis, decomposition, soil formation, nutrient cycling

Regulates and protects:

Pollination, water filtering, flood and erosion control, pest and disease control, carbon storage

Enriches people's lives:

Recreation, beauty, culture, scientific discovery

One common way to group services, from a 2005 international assessment that lists pollination as regulating. Many services fit more than one group: pollination also keeps plants reproducing and supplies food.



Vocabulary in context

Words for what nature provides

ecosystem service: A benefit people get from the normal work of an ecosystem's living and nonliving parts. *Native bees nesting in an oak woodland pollinate the orchard next door.*

natural resource: A material or energy source from nature that people use; some are grown by ecosystems, some form by geology. *Lumber is grown by a forest; copper ore formed in rock.*

biodiversity: The variety of life in a place: how many kinds of organisms, and how much individuals of each kind differ. *A wild banana forest holds many kinds of bananas with different traits.*

The meadow's quiet work: building soil

- Plants take nutrients such as nitrogen from the soil as they grow, then drop leaves, stems and seeds.
- Animals eat plants and one another, leaving wastes and, eventually, their bodies.
- Fungi and bacteria break down that dead matter and release nutrients back into the soil.
- Over many years this recycling builds dark, crumbly topsoil that holds water and feeds roots.
- Matter cycles; the energy in dead matter is used by decomposers and leaves as heat.
- A farm stays fertile through the same decomposer work in its own soil.





CHECK FOR UNDERSTANDING

Quick check: service, resource, or neither?

- Wild bees nesting in a hedgerow visit the blossoms in the next orchard.
- Copper ore is dug from a mine to make electrical wire.
- A farmer sprays fertilizer on a field.
- Marsh grasses slow storm waves before they reach a road.
- Fungi in a forest floor turn fallen leaves into soil nutrients.

Label each S (an ecosystem service), R (a natural resource but not an ecosystem service), or N (neither: a human action).

Pollination: the first step toward a nut

- Pollen grains from a flower's anthers carry the male cells a plant needs to make seeds.
- Pollination is moving pollen onto a stigma, the sticky tip of the flower's female part.
- A pollen tube then grows down to an ovule; once fertilized, the ovule becomes a seed.
- The almond you eat is a seed; its fuzzy hull and shell are the fruit, a cousin of the peach.
- Most almond varieties reject their own pollen: they need pollen from a different, compatible variety.
- Wheat, rice and corn are wind- or self-pollinated, so not every crop needs bees.





MODEL

From blossom to almond

Model: Cross-pollination in an almond orchard

- 01 Bee feeds at a Nonpareil blossom → (brushes the anthers)
- 02 Pollen sticks to its hairy body → (crosses to the next row)
- 03 Bee flies to a pollinizer-variety tree → (presses into a blossom)
- 04 Nonpareil pollen lands on a stigma → (a tube grows down)
- 05 Pollen tube reaches the ovule → (fertilized ovule develops)
- 06 Seed grows into a nut by late summer

Bees carry pollen both ways, so both compatible varieties can set nuts. Harvest usually runs from about August into October.



VOCABULARY IN CONTEXT

Two pollination words

pollination: Moving pollen from anthers to a stigma, the first step toward seeds and fruit; wind or animals can carry it. *Bees pollinate almond blossoms while gathering nectar and pollen.*

cross-pollination: Pollination with pollen from a different plant; most almond varieties need pollen from a different variety. *A bee carrying pink-variety pollen to a blue-variety blossom cross-pollinates it.*

REAL-WORLD CONNECTION

California connection: renting a pollination service

California grows roughly 80 percent of the world's almonds on about 1.4 million acres of bearing orchards. Growers usually stock about two honey bee colonies per acre for varieties that need cross-pollination, and fewer for newer self-fertile varieties. One 2025 analysis put the 2024 demand near 2.7 million colonies, rented at an average of more than \$200 each.

- Honey bees came from Europe with colonists; the U.S. has about 4,000 native bee species.
- Wild bees visit almond blossoms mostly where orchards border natural habitat or strips of wild plants.
- These numbers change every year; treat them as estimates and always check the year.





THINK, PAIR, SHARE

Discuss: why rent bees, and what could go wrong?

- Think about what a bee needs all year, not just during the few weeks of bloom.
- What happens if winter colony losses are high, or the weather at bloom is cold and rainy?
- Name one solution besides renting more hives.

Before orchards, wild bees pollinated the valley's wildflowers. Why can't wild bees alone pollinate today's huge almond orchards, and what are the risks of depending on one rented species?

CHECK FOR UNDERSTANDING

Quick check: which blossom becomes a nut?

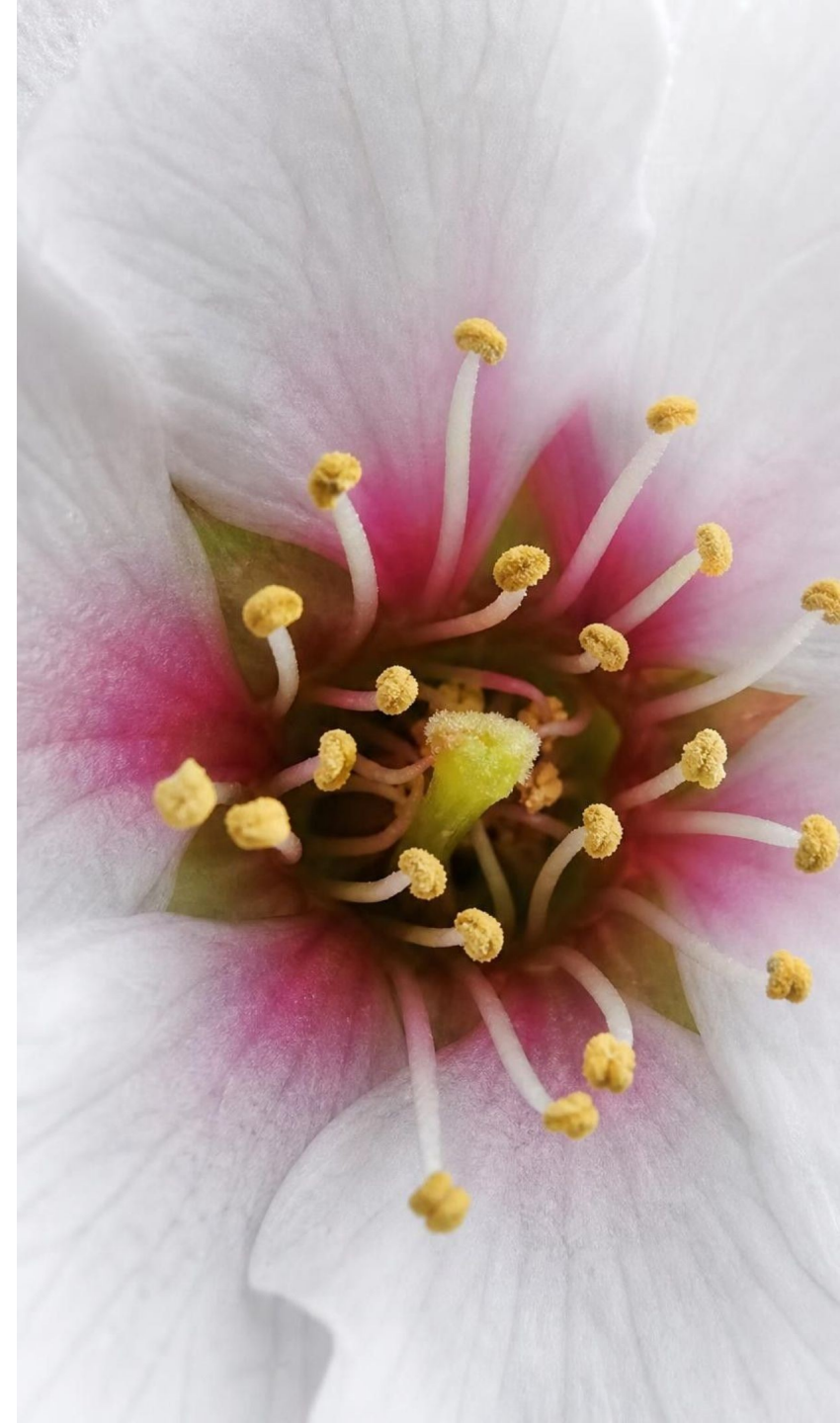
In Lab 1, the main variety (Nonpareil) is blue and the pollinizer is pink. Which blue blossom can set a nut?

A. Its stigma shows only blue chalk

B. Its stigma shows some pink chalk

C. Its petals were brushed many times by the swab

D. Any blossom the bee visited at least once



Biodiversity as insurance: the banana problem

- Most bananas sold in U.S. stores are one variety, Cavendish, grown from shoots of parent plants: close copies.
- Copies share weaknesses, so a disease that kills one plant can sweep through a whole plantation.
- Cavendish took over because it resisted an older strain of Panama disease, a fungal wilt.
- A newer strain, Tropical Race 4, does kill Cavendish and has spread to several continents.
- Wild bananas carry varied traits, so breeders search them for disease resistance.
- Disease resistance: inherited traits that make infection less likely or less harmful.





MODEL

One drug, many links: India's vultures

Model: A chain of effects from cattle to people

- 01 Cattle treated with the painkiller diclofenac → (carcasses go to vultures)
- 02 Vultures eat treated carcasses and die of kidney failure → (drug builds up)
- 03 Vultures fall 97-99.9% (1992-2007) → (fewer scavengers)
- 04 Carcasses left for feral dogs and rats → (more food for dogs)
- 05 More dogs, more bites → (dogs spread rabies)
- 06 More rabies exposures and human deaths

Experiments confirmed the drug-to-vulture links; the links to dogs and people rest on population counts and district comparisons. India banned veterinary diclofenac in 2006, and at least one vulture species' decline has since slowed.



Think, pair, share

Discuss: a pattern, or a cause?

- What else was changing in India between 1992 and 2007?
- How could you compare places that lost their vultures with places that never had many?
- If vultures were the cause, what would you expect to see in each kind of place?

A graph shows vultures falling while feral dogs rose. Does that alone prove the vulture loss caused more dogs and more rabies? What extra evidence would convince you?

CHECK FOR UNDERSTANDING

Quick check: small change, big effect

Which statement best explains how a drug given to cattle ended up affecting human health in India?

- A. The drug made beef unsafe for people to eat.
- B. Losing a scavenger left carcasses for other scavengers that spread disease to people.
- C. Vultures carry rabies, so dying vultures spread it to dogs.
- D. The drug harmed dogs directly and made them aggressive.



Dunes and marshes: living flood barriers

- Dune grasses spread roots and buried stems through sand, holding it in place and trapping more.
- A tall, plant-covered dune is a wall of sand that storm waves must wear down before reaching homes.
- Marsh plants slow moving water and take energy out of waves; mud settles among the stems.
- NOAA reports that about 15 feet of marsh can absorb roughly half of incoming wave energy.
- Paving or building on dunes and marshes removes the buffer, and rising seas add to the risk.
- Flooding is the most common and most costly kind of natural disaster in the United States.





REAL-WORLD CONNECTION

California connection: giving the bay back its marshes

Around South San Francisco Bay, salt companies once walled off thousands of acres of tidal marsh into ponds to make salt. In 2003 about 15,100 acres of those ponds were bought for restoration. The South Bay Salt Pond Restoration Project has been opening levees so tides can rebuild marsh, with three goals: wildlife habitat, places for people to visit, and flood protection for shoreline towns.

- Restored marsh can build upward by trapping sediment, which may help it keep pace with rising seas.
- Flood plans pair restored marsh with levees on the landward side: nature plus structure.
- The project is planned over decades, and its results are monitored as it goes.



MODEL

Two ways to protect a beach town

Model: Seawall versus restored dunes and marsh · *General trade-offs; how well each works depends on the site, the size of storms and the upkeep.*

Concrete seawall

Strong as soon as it is built

High building cost; repairs after big storms

Waves bounce off; the beach in front can narrow

Little habitat for plants or animals

Does not grow as the sea rises

Restored dunes and marsh

Takes several years for plants to establish

Lower building cost; needs replanting and sand after big storms

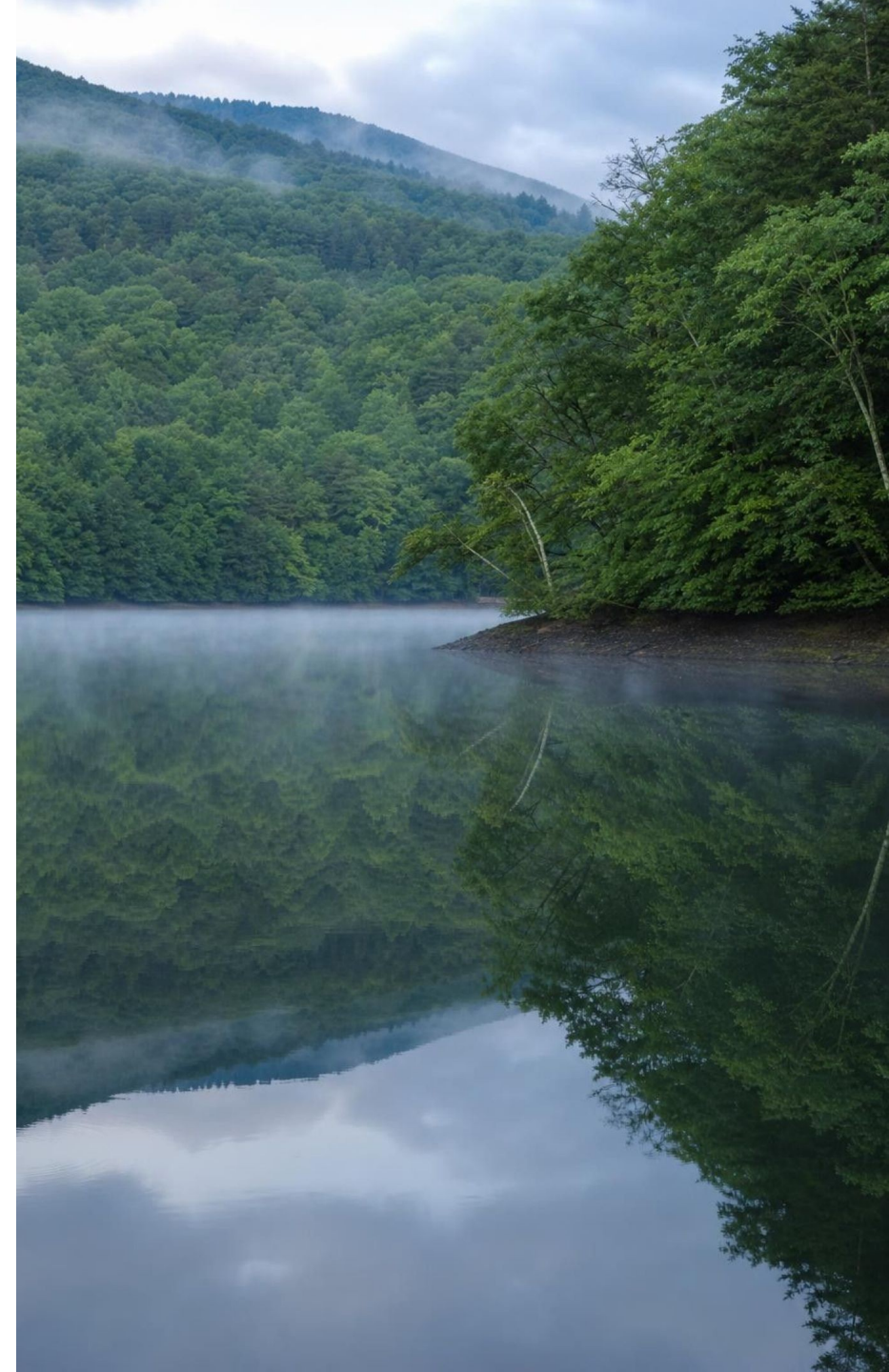
Plants take energy out of waves and trap sand

Habitat for birds, fish and insects; trails for people

Can build up or shift inland if given room

Engineering case: New York City's water

- About nine million people use more than a billion gallons a day from upstate reservoirs.
- Federal rules (1989) said surface water must be filtered unless the source could be kept very clean.
- Criteria: clean, safe water; enough of it; a system that keeps working as the city grows.
- Constraints: affordable for decades, and good for people and the environment upstate.
- Choice: protect the mostly forested Catskill and Delaware watersheds instead of building a giant plant.
- The water is still disinfected and tested; the forests and soils do much of the filtering.





VOCABULARY IN CONTEXT

Words for water and value

watershed: All the land that drains rain and melted snow into the same stream, lake or reservoir. *The Catskill forests are part of the watershed for New York City's reservoirs.*

turbidity: How cloudy water is because of particles floating in it; higher turbidity means murkier water. *Lab 2 rates turbidity by comparing filtered water with reference cups.*

replacement cost: An estimate of a service's worth: what people would pay for a human-made substitute that does the same job. *A filtration plant's cost is the replacement cost of a forest's water cleaning.*

Check for understanding

Quick check: criterion or constraint?

- The filtered water must reach a clarity rating of at least 3.
- The team may spend no more than \$10 in classroom money.
- At least 150 mL must come out within 3 minutes.
- Only sand, gravel, cotton balls and coffee filters may be used.
- All layers must fit in the top half of one bottle.

For the Lab 2 filter challenge, label each C (criterion: what success requires) or K (constraint: a limit you must stay within).



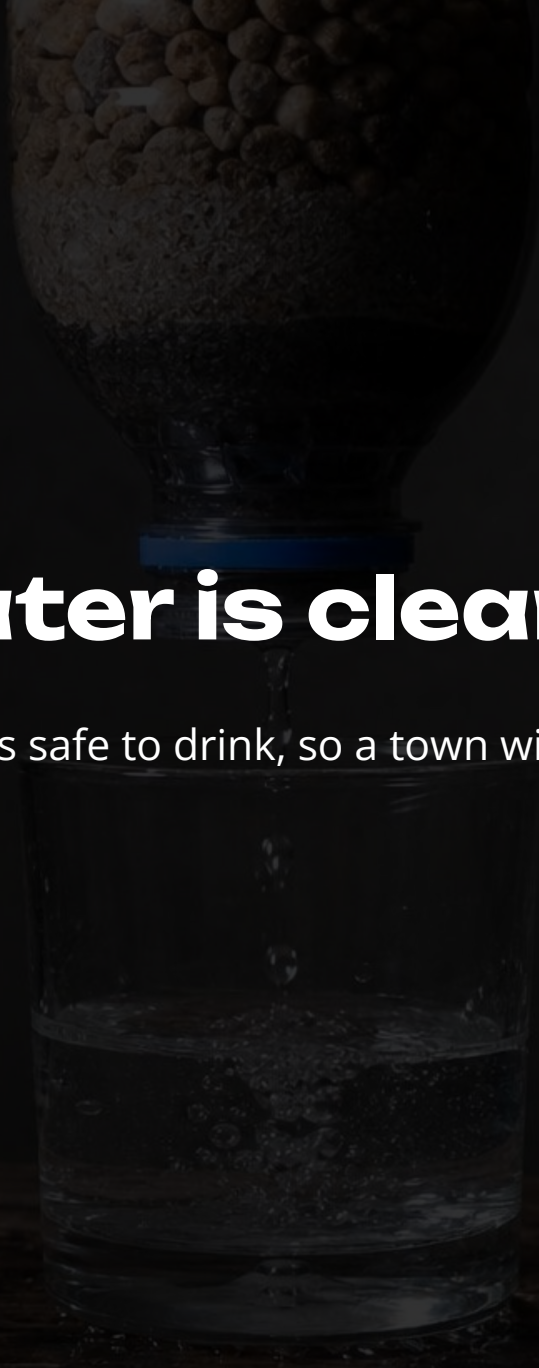


APPLY IT • SIMULATED DATA FOR PRACTICE.

Task: the Valley Orchard pollination plan

A fictional 200-acre almond orchard needs a 10-year pollination plan. Find the 10-year cost of each plan, then decide which you would choose and what you would still want to know.

Plan	Up-front cost	Yearly cost	10-year total	Other effects
A: rent 2 hives per acre (400 hives at \$200)	\$0	\$80,000		Depends on hive supply and price each year
B: plant 2 miles of flowering hedgerow and rent 1.5 hives per acre (300 hives)	\$24,000	\$63,000		Feeds wild bees, birds and pest-eating insects; wild bees help most near the hedgerow
C: rent 2.5 hives per acre (500 hives)	\$0	\$100,000		Extra bees help most in cold, rainy bloom years



MISCONCEPTION CHECK

True or false? Clear water is clean water

"If the water coming out of a Lab 2 filter is crystal clear, it is safe to drink, so a town with a good enough filter does not need a healthy watershed."

True or false? Explain your reasoning.



PUTTING IT TOGETHER

Putting it together

- Ecosystem services come from organisms and nonliving parts doing their everyday work.
- Almond growers rent honey bees because huge one-crop orchards support few wild pollinators.
- Biodiversity is insurance: wild relatives hold traits, such as disease resistance, that crops may need.
- Small changes ripple: a cattle drug, fewer vultures, more dogs, more rabies.
- Substitutes such as rented hives, filters and seawalls can work, but they cost money and do one job.
- Good decisions compare options against precise criteria and constraints, using evidence.

EXIT TICKET

Exit ticket

- Name one ecosystem service near your home and the organisms that provide it.
- Explain why a Nonpareil blossom dusted only with Nonpareil pollen will not become a nut.
- A seawall costs \$28 million to build plus \$0.4 million a year. What is its 30-year cost?
- Give one benefit of a restored dune that the seawall's price tag does not show.

