



CHAPTER 22 OF 29 · RESOURCES IN ECOSYSTEMS

Changing Ecosystems

Lesson 22: How do ecosystems change, and how do we prove that a change affected the living things there?

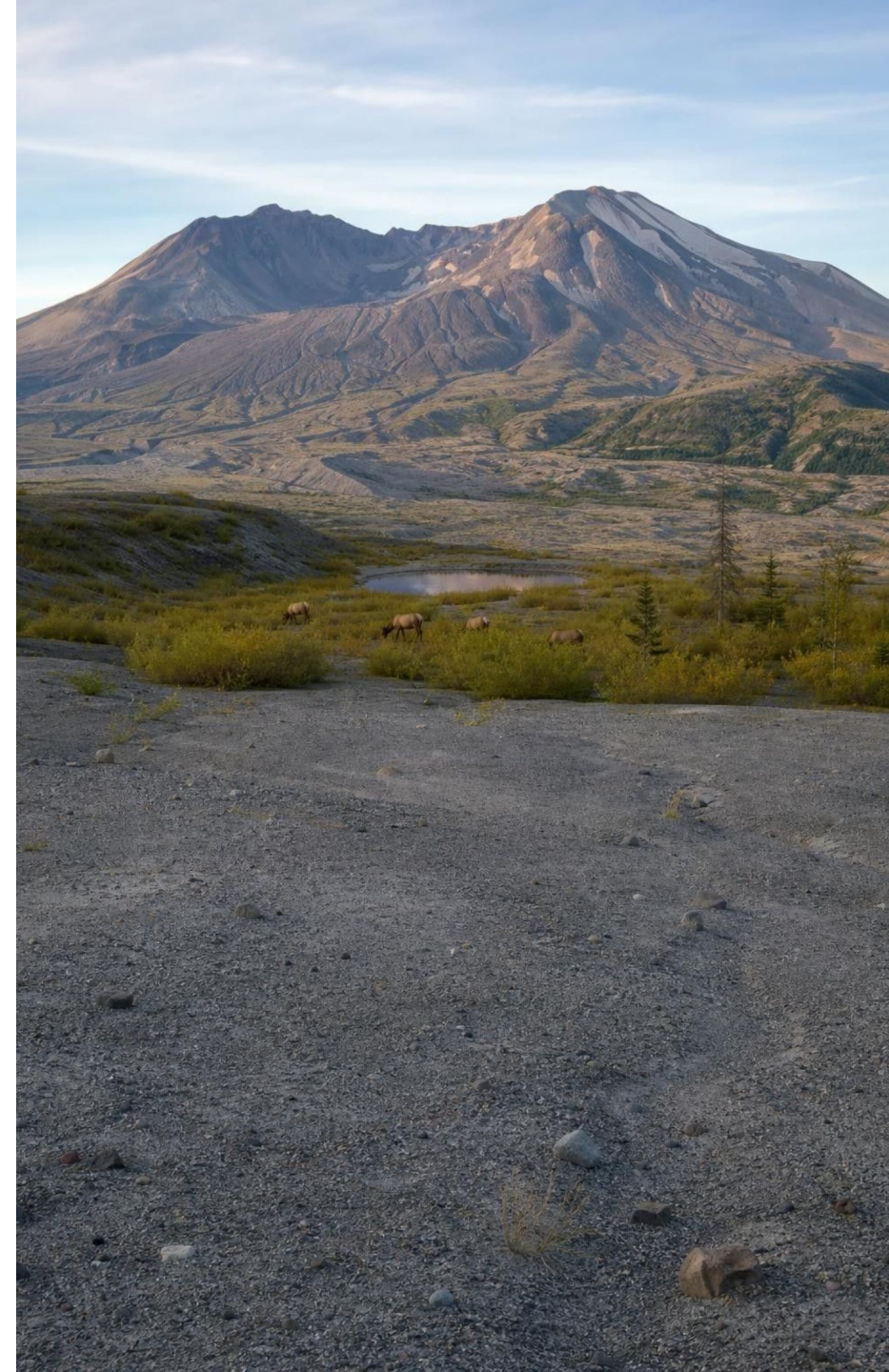
Angela's Wand · Bring Science Alive! 7th Grade Integrated

PHENOMENON

The mountain that blew its top and grew back green

May 18, 1980: the north side of Mount St. Helens collapsed and a sideways blast flattened or scorched forests across about 600 square kilometers. Hot pumice buried the valley to the north under a bare gray plain. Forty years later the same valley has lupine meadows, willow thickets, elk herds and ponds full of frogs. No one planted the plain.

- Notice: compare the 1980 photo with the recent one. What is different? What is the same?
- Wonder: where did the first living things come from?
- Predict: will the valley ever look exactly like it did before 1980?





LEARNING TARGETS

What you will be able to do

- 1 Describe gradual and sudden changes and explain why every ecosystem is a dynamic system.
- 2 Explain how succession rebuilds a community, and tell primary succession from secondary.
- 3 Trace how changing one living or nonliving part shifts other populations, including cascades.
- 4 Build an argument from empirical evidence that a change affected populations.
- 5 Identify criteria and constraints in an engineering plan to restore a damaged ecosystem.

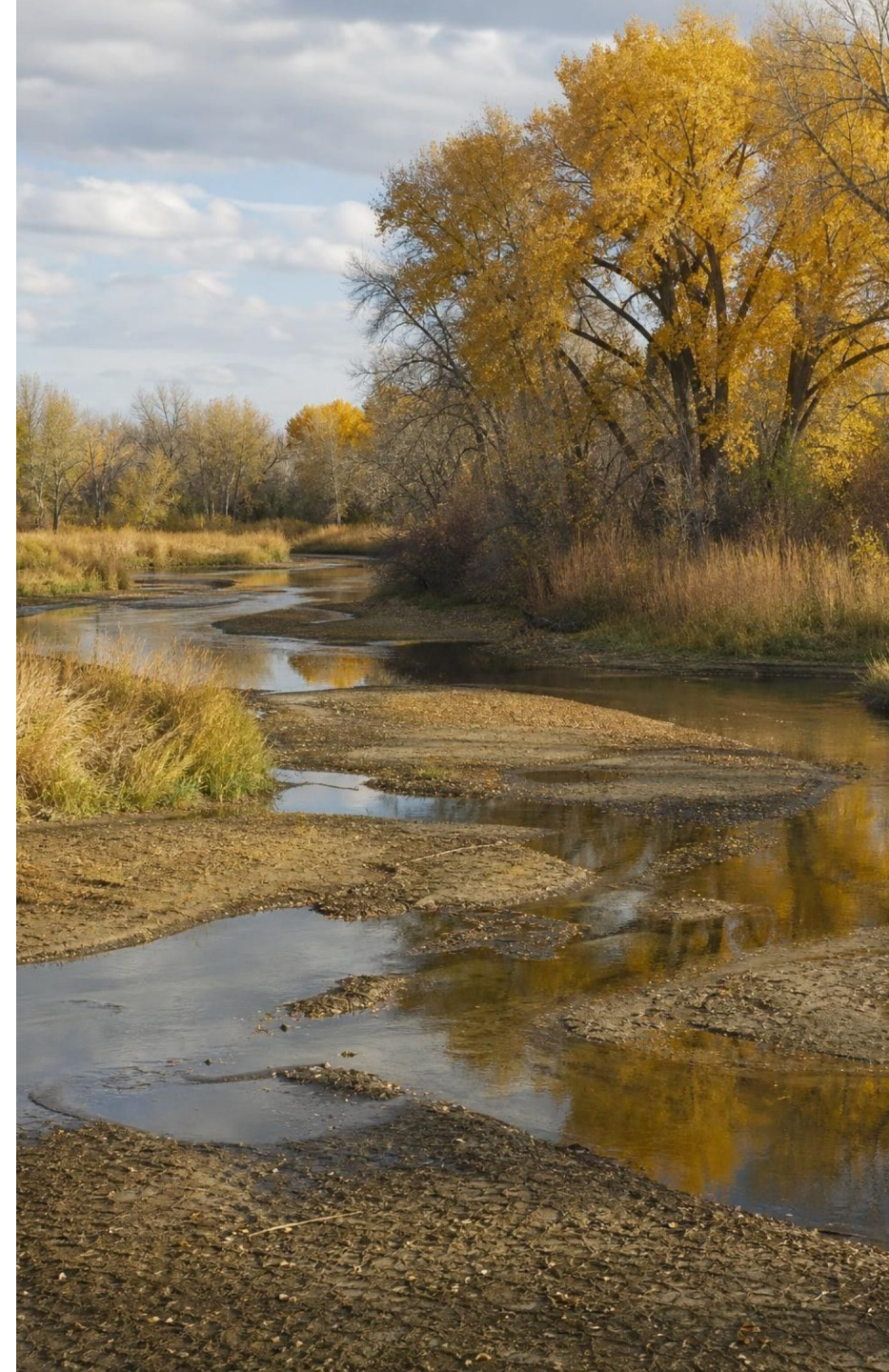
Every ecosystem is a dynamic system

A dynamic system is one whose parts are always changing. In an ecosystem the water level, soil, temperature and the number of every species shift from season to season and year to year. Some changes creep along for centuries. Others happen in an afternoon. Either way, a change in one part can travel to many others.

Nonliving parts change: water, light, soil, temperature, sediment.

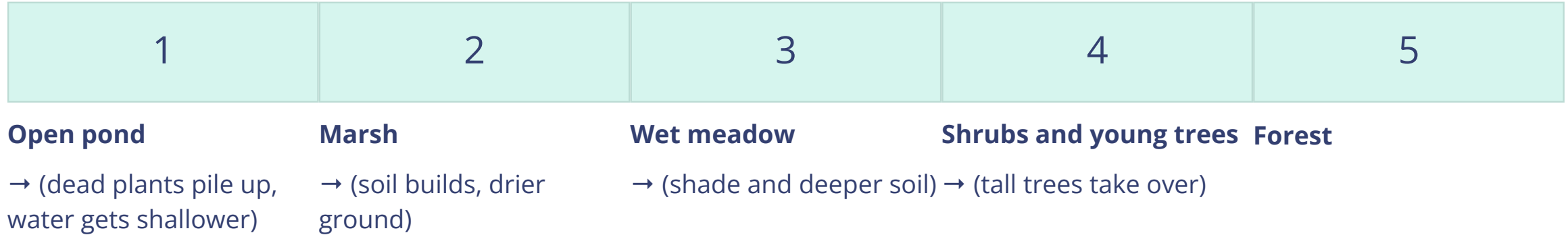
Living parts change: a species arrives, booms, crashes or disappears.

The changes are linked: alter one part and others follow.



Gradual change: a pond becomes a forest

Model: One common path of gradual change



Arrows point forward in time, not to food. The pace varies from decades to thousands of years, and not every pond follows this exact path.

Sudden change: disturbances

A disturbance is an event that removes living things from part of an ecosystem and changes its resources. Some are natural: eruptions, wildfires, floods, hurricanes, landslides, droughts. Some are caused by people: clearing land, oil spills, draining wetlands, bringing in a species that did not live there before.

- Natural: volcano, fire, flood, storm, landslide, drought.
- Human-caused: land clearing, pollution, dams and levees, new species.
- Both kinds reset the ecosystem; what happens next depends on what survived.





CHECK FOR UNDERSTANDING

Quick check: gradual or sudden, natural or human?

- A glacier melts back and leaves bare gravel.
- A bulldozer clears a hillside for new houses.
- A wildfire burns a chaparral slope in one afternoon.
- Cattails slowly fill a pond over many decades.
- A ship releases water carrying mussels from another continent.

For each change, hold up G (gradual) or S (sudden), then N (natural) or H (human-caused). Be ready to defend one.

Succession: how living things rebuild a place

Ecological succession is the gradual replacement of one community by another as living things change the conditions. The first arrivals, called pioneer species, can survive on bare or damaged ground. As they live and die they add organic matter, hold moisture, make shade and shelter, and that lets species with bigger needs move in.

- Pioneers tolerate harsh ground: lichens, mosses, lupine, fireweed.
- Each community changes the soil, shade and shelter for the next.
- Later stages have more species, more soil and bigger plants.



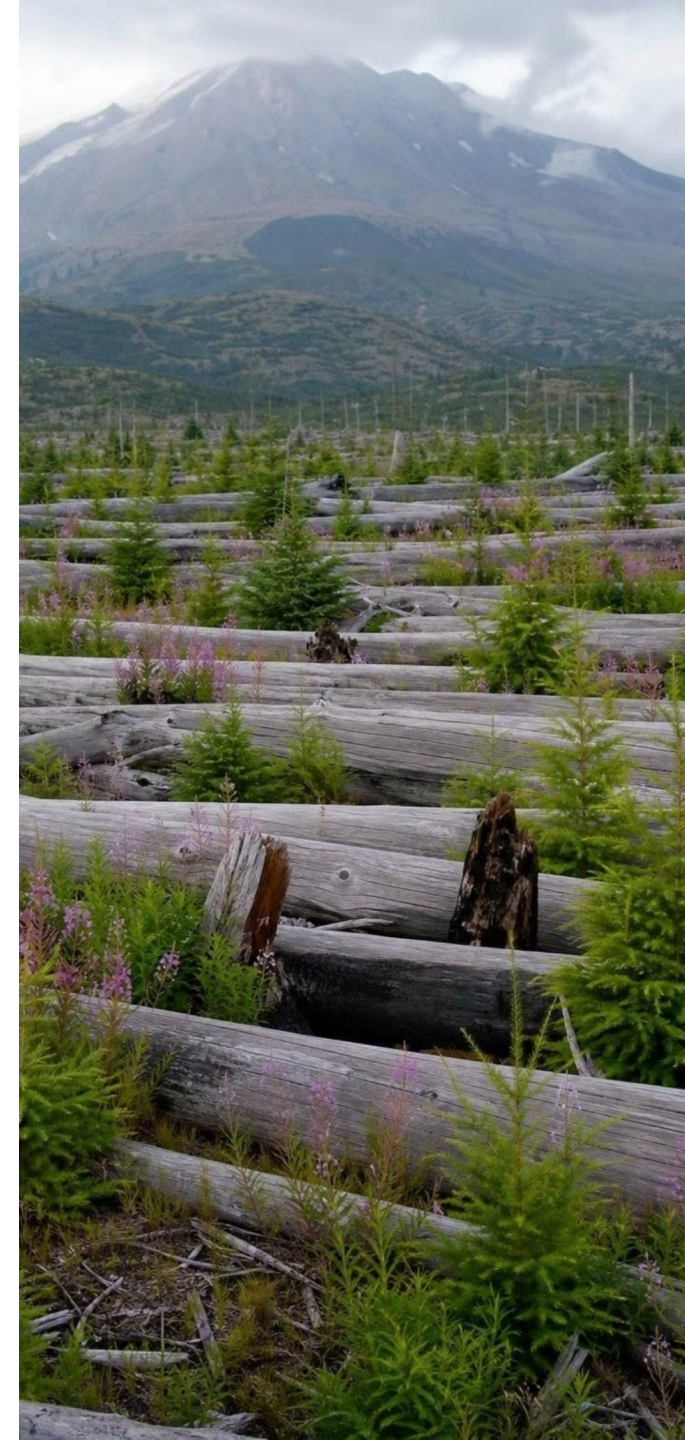
MODEL

Two starting lines: primary and secondary succession

Model: Primary versus secondary succession

Primary succession	Secondary succession
Starts on new ground with no soil: lava, pumice, glacier gravel	Starts where a disturbance left soil behind: fire, blowdown, cleared field
No seeds or roots in place; everything must arrive	Seeds, roots, fungi and burrowing animals often survive
Pioneers must make soil before most plants can grow	Soil already holds water and nutrients
Slow: decades to centuries for a forest	Faster: years to decades for shrubs and young trees
Example: the Mount St. Helens pumice plain	Example: the blown-down forest around the mountain

The difference is the starting material. Soil and survivors make secondary succession much faster.





VOCABULARY IN CONTEXT

Words for a place that is recovering

disturbance: An event that removes living things from part of an ecosystem and changes its resources. *A wildfire, a flood, a landslide, or a field cleared for building.*

pioneer species: A hardy organism that can settle bare or damaged ground first and begins to improve it for others. *Lichens on bare rock; prairie lupine on volcanic pumice.*

biological legacy: Living things or their remains that survive a disturbance in place and give recovery a head start. *Seeds in the soil, roots that resprout, logs, and gophers in burrows after an eruption.*

Four decades on the pumice plain

MODEL

Model: Recovery on the Mount St. Helens pumice plain

- 1 **May 1980: eruption:** Pyroclastic flows bury the valley north of the crater in hot pumice. No soil, no plants.
- 2 **1980-1981: first arrivals:** Spiders and insects drift in on the wind; seeds blow in; survivors emerge at the edges.
- 3 **1981-1982: the first lupine:** Scientists find a single prairie lupine growing on the bare pumice, kilometers from any other plant.
- 4 **Mid-1980s to 1990s: lupine patches:** Lupines enrich the ash with nitrogen; other plants take root inside the patches; elk return.
- 5 **2000s: meadows and thickets:** Willows and alders line the streams; ponds hold frogs and insects; meadows spread.
- 6 **2020s: still early:** Shrubs and young trees in places, but no mature conifer forest yet. Recovery continues.

Dates mark when scientists recorded each change. The pace depended on survivors, arrivals, and chance.





CHECK FOR UNDERSTANDING

Quick check: primary or secondary?

- A fresh lava flow that cooled into black rock last year.
- A chaparral hillside burned in a fast-moving wildfire.
- Gravel exposed by a melting glacier in the Sierra Nevada.
- A cornfield abandoned by a farmer.
- A forest knocked flat by a volcanic blast, soil still in place.

Decide whether each place will recover by primary or secondary succession, and name the clue that told you.



Changing a living part: the prairie dog town

Prairie dogs are ground squirrels that form big colonies, called towns, on the Great Plains. They dig burrow systems, clip the plants around their burrows, and are eaten by many predators. Surveys of many similar grasslands, some with colonies and some without, show a pattern in other populations that repeats from site to site.

Burrows shelter burrowing owls, rabbits, snakes and black-footed ferrets.

Digging mixes the soil and lets water and air in.

Clipping produces fresh regrowth that grazers like bison seek out.

Clipping also holds back shrubs, so shrub-dependent animals lose.

Prairie dogs themselves are the main food of black-footed ferrets.

One species, many threads

Model: How a prairie dog colony reaches other populations

Center: Prairie dog colony

Burrows: shelter: Burrowing owls, rabbits, rattlesnakes and ferrets use them. Gain.

Digging: soil: Water and air get into the soil; nutrients mix. Plants near burrows gain.

Clipping: plants: Fresh regrowth draws bison and pronghorn (gain); shrubs are held back (lose).

Prey: food: Black-footed ferrets, badgers, hawks and eagles eat prairie dogs. Gain.

Shrub users: Birds and insects that need shrubs have fewer of them. Lose.

A keystone species: its effect on the community is far larger than its size or numbers suggest.





VOCABULARY IN CONTEXT

Words for ripples through a community

keystone species: A species whose presence shapes the whole community far more than its numbers suggest. *Prairie dogs on the plains; sea otters in a kelp forest.*

cascading change: A chain of effects in which one population change alters resources for the next, and the next. *Fewer otters, more urchins, less kelp, fewer fish that hide in kelp.*

resilience: An ecosystem's ability to absorb a disturbance and recover its main populations and functions. *A grassland that regrows the same grasses within two years of a fire.*

A wide-angle photograph of a grassland at sunset. The sun is low on the horizon, casting a warm orange glow across the sky and the flat landscape. Several prairie dogs are visible, standing on their hind legs on small mounds of earth. The grass is dark green and appears to be blowing in the wind.

THINK, PAIR, SHARE

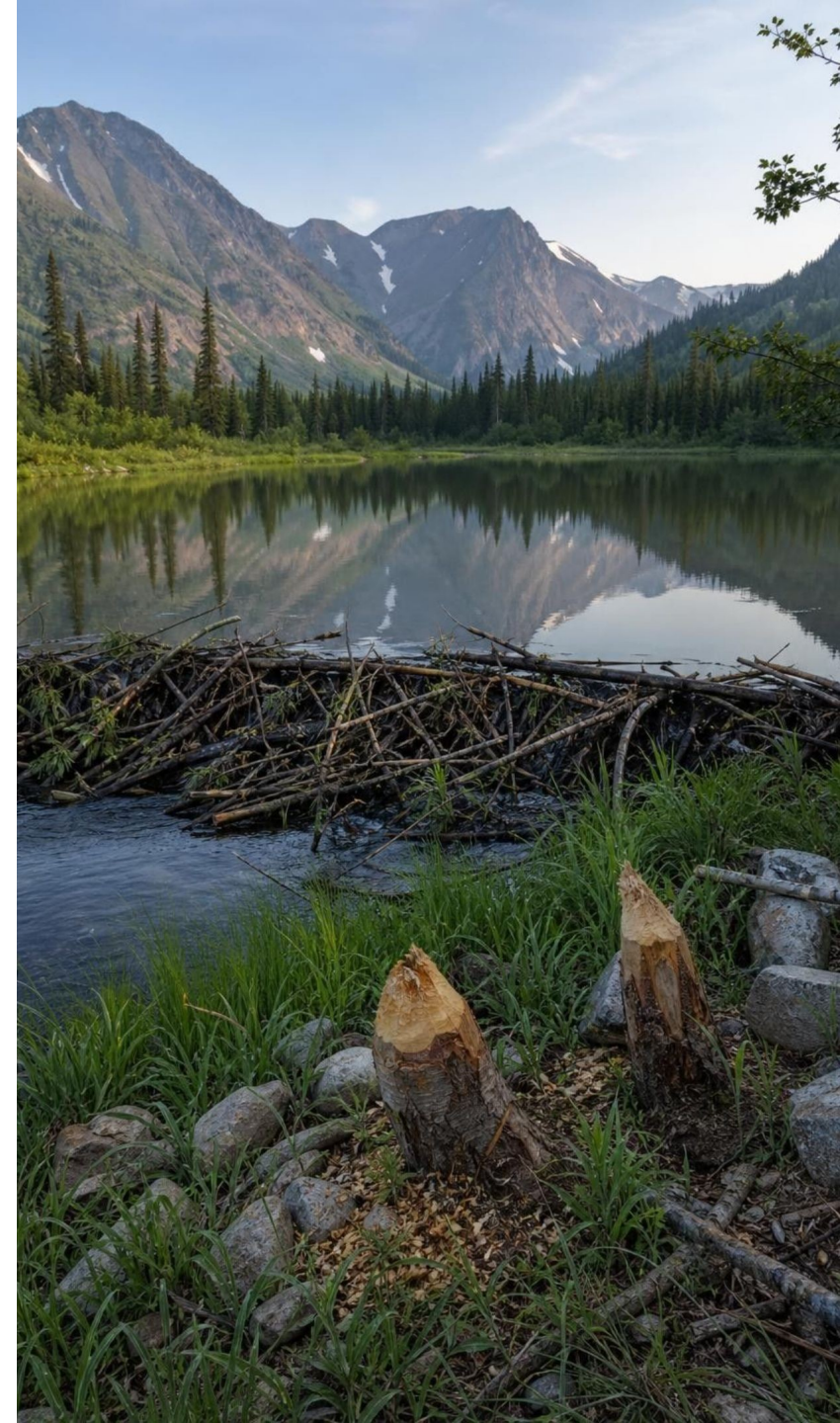
Discuss: are prairie dogs good or bad for a grassland?

A rancher says prairie dogs ruin grassland. A biologist says the grassland depends on them. Can both be looking at real evidence? What would you need to measure to settle it?

Changing a nonliving part: the beaver's pond

A beaver cuts trees and piles them into a dam across a stream. Upstream, fast shallow water becomes a deep, slow pond. Along the bank, the felled trees let sunlight reach the ground. Downstream, water spreads out and soaks the soil. The beaver changed physical parts of the ecosystem: water depth, water speed, light and moisture.

- Deep, slow water: pond plants, fish, frogs and insects move in.
- Fast-water species lose their habitat in the flooded stretch.
- More light on the ground: small plants grow, feeding moose and elk.
- Wetter soil downstream: lush plant communities support more animals.



How one dam travels through the ecosystem

Model: A cascading change from a beaver dam

1

Beaver builds dam

→ (physical change)

2

Stream becomes a deep, slow pond

→ (new habitat and food)

3

Pond plants and insects increase

→ (more prey)

4

Frogs and fish that eat them increase

→ (more prey)

5

Herons and otters that eat those increase



Each arrow means 'leads to more of'. A parallel chain runs the other way for fast-water species.



CHECK FOR UNDERSTANDING

Quick check: which part changed?

- A levee stops a river from spreading sediment onto a marsh.
- Black-footed ferrets return to a valley after decades of absence.
- A beaver dam floods a stream.
- A new fungus kills most of the bats in a cave.
- A drought dries a pond to half its size.

For each event, say whether a living (biological) or nonliving (physical) part changed first, then name one population that would respond.

Task: what does the evidence support?

A coastal marsh was surveyed in 1990 and again in 2020. In between, a levee cut off the river sediment that used to spread over the marsh, and a canal let salty bay water in. Teams counted the same things the same way both years. Study the table, then write one claim the data support, one claim they do not support, and one thing you would still need to know.

What was counted	1990	2020	Change
Marsh cordgrass cover (% of plot)	82	36	down
Periwinkle snails (per square meter)	41	13	down
Young shrimp (per net pull)	58	21	down
Great egrets (per survey walk)	6	7	about the same
Mullet, an open-water fish (per net pull)	14	31	up
Open water (% of plot)	9	48	up

Simulated data for practice.



REAL-WORLD CONNECTION

California connection: the kelp forest that lost its keystones

Along the northern California coast, giant forests of bull kelp shelter fish, abalone and urchins. Sea otters and sunflower sea stars eat purple sea urchins and keep them in check. Starting in 2013 a wasting disease killed most of the sea stars, and a marine heat wave weakened the kelp. Purple urchins multiplied and ate the kelp down to bare rock.

- Keystone predators lost: sea stars died, and otters were already absent north of San Francisco.
- Cascade: fewer predators, far more urchins, more than 90 percent of the bull kelp gone by 2016.
- Ripple: red abalone starved, and the recreational abalone fishery closed in 2018.
- Resilience test: urchin barrens can persist for years even after conditions improve.





What makes an argument strong?

A pattern tells you what changed. A strong argument also tells you why, and shows that the pattern is not a coincidence. Ecologists build that strength in three ways, and the best studies use more than one.

Before and after: the same place, the same counts, repeated over time.

With and without: many similar places that differ mainly in the one change.

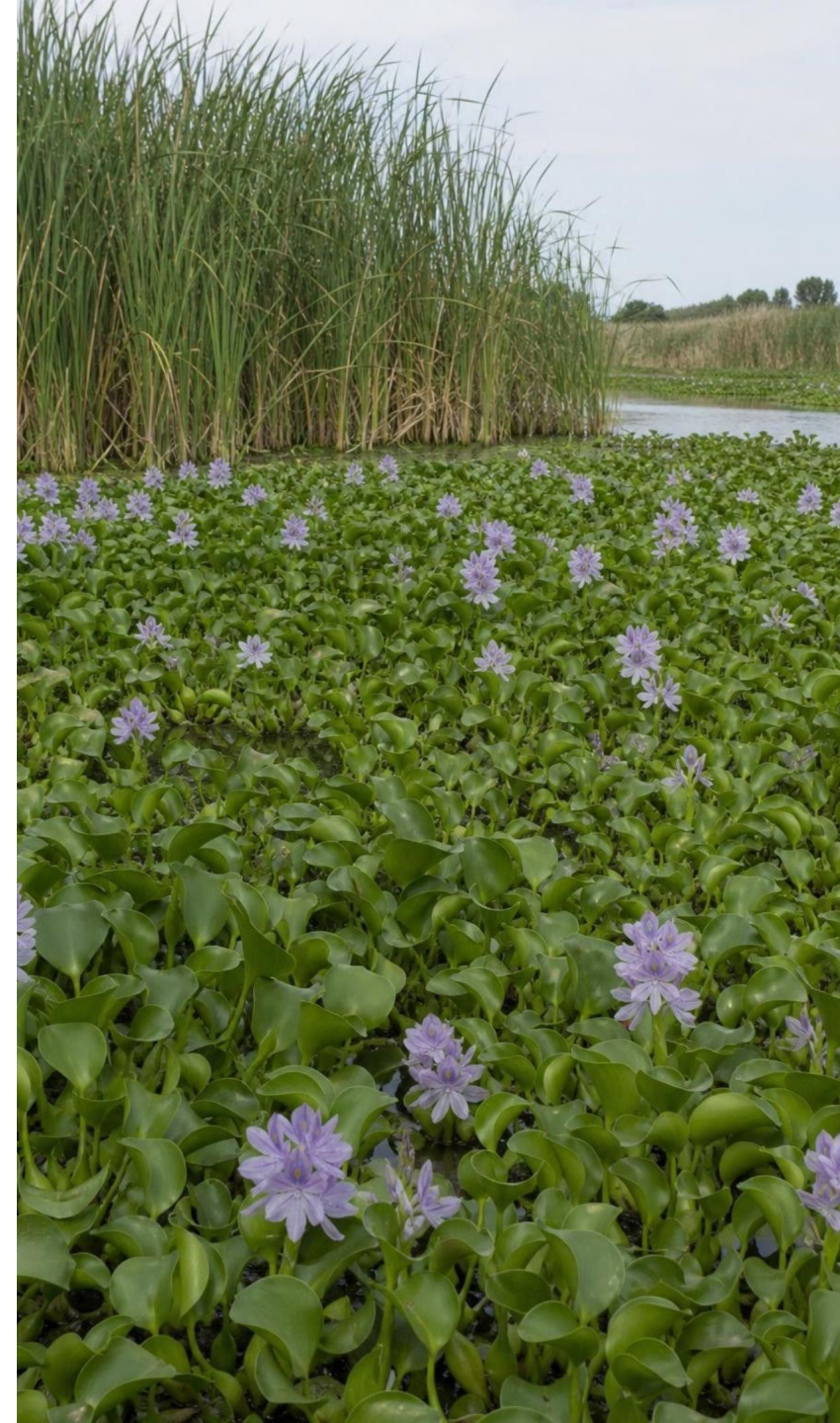
A mechanism: a reason the change should affect that population, which you can test.

Repetition: the pattern shows up at many sites, not just one.

When people move a species: invasive species

People carry living things around the world on purpose and by accident: in ship water, on boots, in garden pots. Most arrivals fail or stay rare. An introduced species becomes invasive when it spreads and harms native populations or the way the ecosystem works, often because the predators and diseases that limited it at home are missing.

- Introduced: moved by people outside its native range.
- Invasive: introduced, spreading, and causing harm.
- California example: water hyacinth mats choke Delta channels and shade native plants.
- A new species is a change to a living part, with cascades like any other.



MODEL

Engineering a comeback: criteria and constraints

Model: Two ways to rebuild a Louisiana wetland

Open channel (Wax Lake Outlet)	Gated diversion in a levee (Caernarvon)
Channel dug in 1941 to ease flooding at Morgan City	Gates built into a levee near New Orleans, 1988-1991
Carries Atchafalaya River water and sediment into a shallow bay	Opened to let river water into the marsh, closed when floods threaten
New delta land keeps forming; plants colonize the sandbars	Main goal: push back salt water; land-building is debated
Works where few people live close by	Works where neighborhoods sit right behind the levee

Same criterion, different constraints, different design. Precision about both is what makes a design fit its place.



A photograph of a small, clear creek flowing over dark, smooth rocks. The water is shallow and reflects the surrounding greenery. On the left, a large tree with long, thin leaves hangs over the water. The right bank is covered in tall, golden-brown grasses. In the background, a dense forest of evergreen trees is visible under a soft, overcast sky.

THINK, PAIR, SHARE

Discuss: what would restoring a creek near us require?

Imagine a channelized, concrete-lined creek near school being restored to a natural streambed. List two criteria for success and two constraints, and say which one would be hardest to satisfy.



MISCONCEPTION CHECK

Is this right?

"A student says: 'The 1980 eruption killed everything on Mount St. Helens, so the new ecosystem had to be built entirely by seeds and animals that arrived from outside.'"

True or false? Explain your reasoning.

Putting it together

🌿 Ecosystems are dynamic systems: change is normal, gradual or sudden, natural or human-caused.

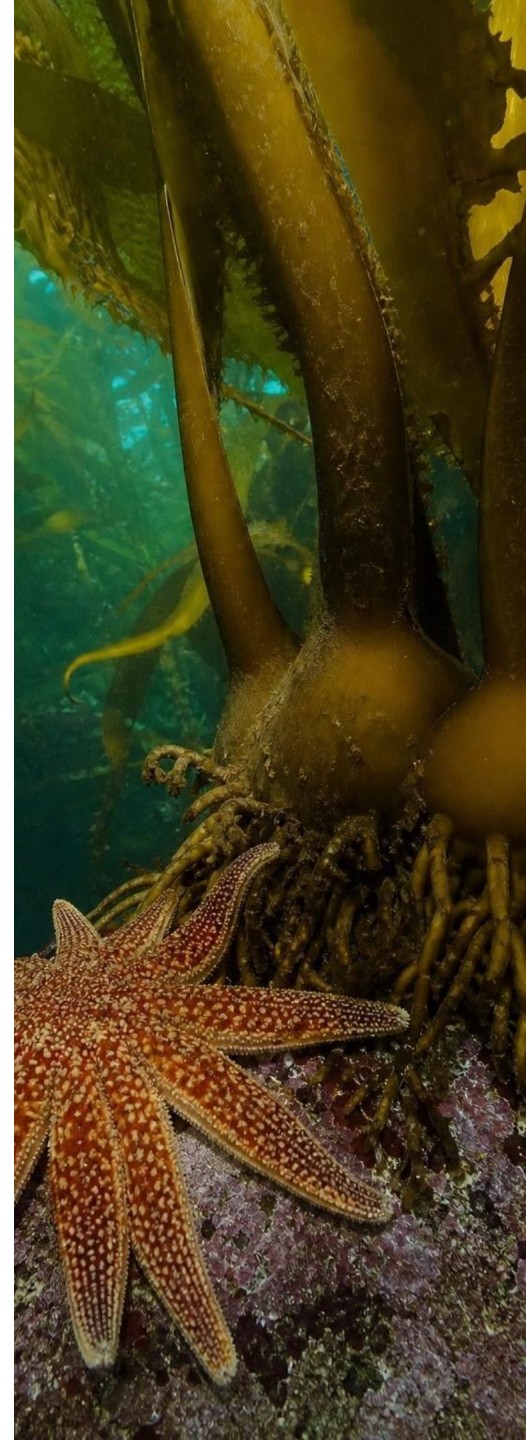
🌿 Succession rebuilds a place as living things improve it; primary starts without soil, secondary with it.

🌿 Survivors (biological legacies) plus new arrivals drive recovery, which may end somewhere new.

🌿 Change one living part (prairie dogs, sea stars) or one physical part (a dam, sediment) and populations shift.

🌿 Keystone species and cascades mean small changes can cause large ones.

🌿 A strong argument uses before-and-after, with-and-without, a mechanism and repetition.





EXIT TICKET

Exit ticket

- A wildfire burns a forest but leaves the soil. Primary or secondary succession? Give the clue.
- Name one living and one nonliving change to an ecosystem, and a population each change would affect.
- A friend shows one before-and-after graph as proof that a dam caused a fish decline. What is missing?