

Build the Web, Then Break It: A Model of an Oak Woodland

Investigation question: How do matter and energy move among the living and nonliving parts of an oak woodland, and what ripples through the web when one population suddenly changes?

Collaborative systems modeling

Groups of 4

2 sessions

Setup 5 · Activity 80 · Cleanup 10 min

MS-LS2-3 · assesses

MS-LS2-4 · practice

Scientific purpose

Students assemble a card-and-yarn model of a California oak woodland that includes producers, consumers at several levels, decomposers, the air and soil, sunlight and the heat that leaves. They define the system boundary, trace matter around the loop and energy through it, then disturb one population and predict the direct and indirect effects link by link. The model is the evidence for the matter-cycling and energy-flow target, and the disturbance test is practice at predicting population change.

Why this helps students with this chapter

A printed food web is someone else's model; students read it passively and often read the arrows backward. Building the web themselves, card by card and string by string, forces every arrow decision into the open, and adding the air, the soil, the sun and the heat makes the nonliving parts of the ecosystem visible instead of implied. Breaking the web afterward turns direct and indirect effects from definitions into predictions the group has to defend.

Standards connections

MS-LS2-3 (assesses, developing a model of matter cycling and energy flow that includes nonliving components and a stated boundary): Students build a model with living parts, nonliving pools (air and soil), an energy input (sunlight) and an energy output (heat), connect every organism to decomposers, and write what is inside and outside the system. That is the model this PE asks for, without any chemical reactions.

MS-LS2-4 (practice, predicting effects of a change to a biological component): Groups remove or boost one population and reason through direct and indirect effects with sign chains, which builds the cause-and-effect reasoning the PE's arguments require; the evidence here is the model, not field data.

Roles (rotate each session)

- **Web builder:** Sorts the cards by role, lays them out with producers at the bottom and top predators at the top, and keeps the layout readable as yarn is added.
- **Arrow caller:** Reads each card's 'what it eats' line aloud and names every arrow that must be strung, always from the food to the eater.
- **Recorder:** Fills in the card inventory, the boundary statement and the disturbance table; writes the sign chains exactly as the group agrees them.

- **Checker and presenter:** Walks the finished web checking every arrow points at the eater and every organism connects to the decomposers, then presents the group's disturbance chain to the class.

Materials

Item	Quantity	Per	Note
Woodland card set (19 cards from the recording sheet) printed on cardstock and cut apart	1 set	group	Laminate if you want to reuse them; sticky notes then go on the lamination.
Yarn in three colors (for example green for feeding arrows, brown for arrows to decomposers, yellow for matter and energy exchanges with the nonliving cards)	about 10 m of each	group	
Masking tape	1 roll	group	
Poster paper or a cleared desk area at least 60 by 90 cm	1	group	
Sticky notes in two colors (one for +, one for –)	1 small pad of each	group	
Scissors	1 pair	group	
Marker	1	group	
Disturbance cards A to D (cut from the prep list)	1 set	class	Each group draws one; with more than four groups, two groups share a scenario and compare.
Recording sheet	1	student	

Estimated cost: 8 to 12 per class (an estimate; Three skeins of yarn (about \$3 each), ten sheets of cardstock, masking tape and sticky notes; poster paper and scissors are classroom stock. The card set is reusable for years if laminated.)

Safety

- Scissors: cut away from fingers and keep them closed on the desk when not in use.
- Yarn is a tangling and tripping hazard; keep it on the desk or poster, never around a neck or wrist, including in the human-web variant.
- Masking tape only; it lifts cleanly. No hazards beyond ordinary classroom materials.

Teacher preparation and setup

1. Print the 19-card set from the recording sheet, one set per group, and cut the cards apart. Label the back of each set with a group number so sets do not mix.
2. Pre-cut yarn into roughly 30 cm lengths, about 25 green, 20 brown and 15 yellow per group, so stringing does not stall on cutting.

3. Write the four disturbance cards on index cards: A. A disease kills about four fifths of the California ground squirrels. B. A wet spring triples the grasshopper population. C. Rat poison set out near a ranch kills most deer mice and ground squirrels; animals that eat poisoned rodents can be poisoned too. D. Trappers remove nearly all the coyotes from the valley.
4. Build one web yourself first so you know the three arrow rules cold: feeding arrows from food to eater, a brown arrow from every organism card to the decomposer card, and yellow arrows for sunlight into producers, air and soil into producers, carbon dioxide from every living card back to air and soil, nutrients from decomposers to air and soil, and heat from every living card to the surroundings.
5. Post the arrow rules and the phrase 'the arrow points to the eater' where every group can see them.

Investigation design

Independent variable	Which population is disturbed, and in which direction (removed or boosted), set by the disturbance card.
Dependent variable	The predicted direction of change (up, down or uncertain) for every other population in the model.
Controlled	The same 19-card set and the same arrow rules for every group; Feeding arrows based only on the 'eats' lines on the cards; A change is traced one link at a time with its sign written down; Each group reasons at least two links beyond the disturbed card
Trials	One disturbance per group; the class compares groups that drew the same card and groups that drew different cards.
Comparison	Groups with the same disturbance compare predictions card by card; disagreements point to an arrow one group strung differently.

Student procedure

1. Session 1. Sort the 19 cards into four piles: producers, consumers, decomposers, and nonliving. Each card says what it eats or what it is; use that, not your memory, and talk through any card the group disagrees about.
2. Lay the cards out on the poster with the three producers along the bottom, the animals that eat producers in a row above them, animals that eat animals above that, and the decomposer and millipede cards off to one side. Put the sunlight, air and soil, and surroundings cards around the edge. Tape each card down lightly.
3. String the feeding arrows in green. The arrow caller reads each consumer card's 'eats' line, and for every food named you tape one green length from the food card to the eater card, with a small paper arrowhead or a marker arrow at the eater end. Say the rule each time: the arrow points to the eater.
4. String the brown arrows: one from every organism card, producers included, to the decomposer card, because every organism sheds wastes and eventually dies. Add a brown arrow from the millipede to the decomposers too, since its droppings and remains feed bacteria and fungi.
5. String the yellow arrows for the nonliving parts: sunlight to each producer; air and soil to each producer (carbon dioxide, water and nutrients taken in); decomposers to air and soil (carbon dioxide and nutrients

- released); one arrow from the producer row and one from the consumer rows back to air and soil (carbon dioxide breathed out); and one arrow from each row of living cards to the surroundings card for heat.
6. Fill in the card inventory table: role, arrows in and arrows out for every card. Then write the boundary statement: what is inside your model, what is outside it, and exactly what crosses the boundary in each direction.
 7. Find and write two food chains, number their trophic levels, and name the top predators in your model. Sketch the finished web with its three arrow colors on the recording sheet. Leave the web taped down for session 2 if you can.
 8. Session 2. Draw one disturbance card. Write the disturbance at the top of the disturbance table. Put a – sticky note on the population that drops (or a + on one that rises).
 9. Follow the arrows one link at a time. For each neighboring population, decide whether it rises or falls and place a + or – sticky note on it. Write the row: population, direct or indirect, up or down, and the chain of reasoning in words ('fewer squirrels means less food for hawks, so hawks fall').
 10. Keep going to at least two links beyond the first (at least two indirect effects). When two arrows give opposite predictions for the same card, write both and mark the card '?'. That is a real limit of the model, not a mistake.
 11. Present your chain to the class in under two minutes, showing the sticky notes. Listen for whether other groups' webs predicted the same directions for the same disturbance.
 12. Answer the analysis questions individually. Untape the cards, coil the yarn by color and return the set.

Expected observations

- Producers end up with no green arrows in and many green arrows out; needlegrass and the valley oak have the most, five each. Hawks and mountain lions have green arrows in and none out, so they are the model's top predators.
- Every organism card, including the three producers and the millipede, ends with a brown arrow to the decomposers, and the decomposer card has a yellow arrow out to the air and soil but no arrow to any organism.
- Disturbance predictions agree across groups at the first link (direct effects) and begin to differ or get marked '?' two or three links out, especially for omnivores like the deer mouse and the coyote that have arrows pulling in opposite directions.
- The boundary statements list sunlight as crossing inward and heat as crossing outward; strong groups also note that carbon dioxide can cross in and out because the air pool extends beyond the woodland.

Likely difficulties

- Arrows strung backward, from eater to food. The checker role exists for this; have the checker say 'points to the eater' at every arrow in the final walk.
- Groups forget the brown arrow from producers to decomposers, because 'plants do not die' feels true. Ask what happens to fallen leaves.
- The yellow arrows multiply and the web becomes a tangle. Allow one yellow arrow per row of cards for carbon dioxide and heat rather than one per card; the table still records that every living card contributes.

- Students stop the disturbance after one link. Require at least two indirect rows in the table before the group presents.
- Omnivores (deer mouse, coyote, woodpecker) confuse the level numbering. Say that a level belongs to the chain being traced, so the same card can be level 2 in one chain and level 3 in another.

Structured debrief

1. Put two groups' webs side by side and ask the class to find one arrow they strung differently. Trace what that single difference does to their disturbance predictions. The point: a prediction is only as good as the arrows, and real ecologists spend years getting the arrows right.
2. Ask every group that drew card A (squirrel disease) to report the predicted direction for hawks, coyotes, gopher snakes, acorns and deer mice. Hawks and coyotes drop (direct), snakes drop a little (they eat young squirrels), acorns and grass seeds rise (indirect), deer mice may rise because more seeds are left and because hawks and coyotes, with fewer squirrels to eat, may switch to mice, which pushes the other way. The '?' is honest; a model with no numbers cannot settle it.
3. Walk the carbon atom around the loop as a class, then ask whether any atom ever leaves the model for good. No; the air and soil card is a pool, not an exit. Then ask whether energy ever leaves for good. Yes, as heat, every day. Write 'matter cycles, energy flows' above the webs.
4. Close on disturbance C: poison moving up a food chain is real; California has documented anticoagulant rat poison in hawks, owls, bobcats and mountain lions that ate poisoned rodents. The web shows exactly which arrows carry it. Ask what a rancher could do instead (owl boxes, removing food sources, snap traps) and which arrows those options use.

Recording sheet: what students fill in

Lab 1 recording sheet: Build the web, then break it

Cut the 19 cards apart. Each card tells you what the organism eats or, for the nonliving cards, what it supplies or receives. Build every arrow from what the cards say. Remember the rule: **the arrow points to the eater**.

Oak woodland card set (one set per group)

1 Card 1: Valley oak

Producer. Builds sugar and tissue from carbon dioxide, water and sunlight. Makes leaves and acorns. Eaten by: mule deer (leaves, acorns), ground squirrel (acorns), deer mouse (acorns), acorn woodpecker (acorns), coyote (fallen acorns in autumn).

2 Card 2: Purple needlegrass (bunchgrass)

Producer. Builds sugar and tissue from carbon dioxide, water and sunlight. Eaten by: grasshopper (blades), mule deer (blades), jackrabbit (blades), ground squirrel (blades and seeds), deer mouse (seeds).

3 Card 3: Lupine (wildflower)

Producer. Builds sugar and tissue from carbon dioxide, water and sunlight. Eaten by: grasshopper (leaves), jackrabbit (leaves), ground squirrel (seeds), deer mouse (seeds).

4 Card 4: Grasshopper

Consumer. Eats: needlegrass blades and lupine leaves. Eaten by: western fence lizard, deer mouse, acorn woodpecker.

5 Card 5: California ground squirrel

Consumer. Eats: acorns, needlegrass blades and seeds, lupine seeds. Eaten by: gopher snake (young squirrels), coyote, red-tailed hawk.

6 Card 6: Mule deer

Consumer. Eats: needlegrass, oak leaves and acorns. Eaten by: mountain lion.

7 Card 7: Deer mouse

Consumer. Eats: grass and lupine seeds, acorns, and insects such as grasshoppers. Eaten by: gopher snake, coyote, red-tailed hawk.

8 Card 8: Black-tailed jackrabbit

Consumer. Eats: needlegrass and lupine. Eaten by: coyote, red-tailed hawk.

9 Card 9: Acorn woodpecker

Consumer. Eats: acorns and insects such as grasshoppers. Eaten by: red-tailed hawk (occasionally).

10 Card 10: Western fence lizard

Consumer. Eats: grasshoppers and other insects, and small millipedes. Eaten by: gopher snake, red-tailed hawk.

11 Card 11: Gopher snake

Consumer. Eats: deer mice, young ground squirrels, fence lizards. Eaten by: red-tailed hawk, coyote.

12 Card 12: Coyote

Consumer. Eats: ground squirrels, deer mice, jackrabbits, gopher snakes, and in autumn fallen acorns and fruit. Eaten by: mountain lion (occasionally).

13 Card 13: Red-tailed hawk

Consumer. Eats: ground squirrels, deer mice, jackrabbits, gopher snakes, fence lizards, occasionally woodpeckers. Eaten by: nothing else in this card set.

14 Card 14: Mountain lion

Consumer. Eats: mule deer mainly, occasionally coyotes. Eaten by: nothing else in this card set.

15 Card 15: Soil bacteria and fungi

Decomposers. Feed on the wastes and dead remains of every organism in this set, including other decomposers. Release carbon dioxide (from their respiration) and mineral nutrients into the air and soil.

16 Card 16: Millipede

Detritivore, an animal that chews dead leaves and wood. Eats: fallen oak leaves, dead grass. Its droppings and remains are fed on by bacteria and fungi. Eaten by: western fence lizard (small ones only).

17 Card 17: Sunlight

Nonliving energy source from outside the ecosystem. Not matter. Captured only by producers. Supplies: energy to cards 1, 2 and 3.

18 Card 18: Air and soil

Nonliving pool of matter: carbon dioxide and water in the air, water and mineral nutrients in the soil. Supplies: raw materials to producers. Receives: carbon dioxide breathed out by every living card, and nutrients released by decomposers.

19 Card 19: Surroundings (heat exit)

Nonliving. Receives the heat that every living card releases as it uses energy to live. No arrow ever leaves this card: no organism can capture spread-out heat to make food.

Card inventory

Card	Role (producer, consumer, decomposer, detritivore, nonliving)	Green arrows in	Green arrows out	Connected to decomposers? (yes/no)
1 Valley oak				
2 Needlegrass				
3 Lupine				
4 Grasshopper				
5 Ground squirrel				
6 Mule deer				
7 Deer mouse				
8 Jackrabbit				
9 Acorn woodpecker				
10 Fence lizard				
11 Gopher snake				
12 Coyote				
13 Red-tailed hawk				
14 Mountain lion				
15 Bacteria and fungi				
16 Millipede				

1. Write two different food chains from your web that both start at needlegrass. Number the trophic level of every organism in each chain.

Answer: Any two correct chains from the cards, for example: needlegrass (1) → grasshopper (2) → fence lizard (3) → gopher snake (4) → red-tailed hawk (5); and needlegrass (1) → ground squirrel (2) → coyote (3) → mountain lion (4).

Why: A chain follows green arrows from a producer to a card with no green arrow out. Levels count from the producer as 1.

Also acceptable: Accept chains ending at the hawk or the mountain lion; a chain may also end at the coyote if the student notes the mountain lion arrow is 'occasional' and explains the choice.

- Both chains start at needlegrass and follow actual card arrows
- Levels numbered correctly from 1
- The two chains differ in at least one organism

2. Which cards are top predators in this model? Name one real animal you could add to the set that would change that answer, and say which arrow it would add.

Answer: The red-tailed hawk and the mountain lion are the top predators in this model (no green arrow leaves them). Adding a great horned owl, which takes young hawks, would add an arrow hawk → owl and the hawk would no longer be a top predator; adding a grizzly bear (historically present) or a human hunter would do the same for the mountain lion.

Why: Top predator is relative to the model. The student must name a real animal and the arrow it adds.

- Names both hawk and mountain lion
- Names a plausible added animal and the specific arrow it adds

3. Boundary statement. Inside my model: _____. Outside my model: _____. Crossing the boundary inward: _____. Crossing the boundary outward: _____.

Answer: Inside: the 16 living cards plus the air and soil of the woodland. Outside: the sun and the wider surroundings (and the rest of the atmosphere). Crossing inward: sunlight energy; also carbon dioxide and water from the wider air. Crossing outward: heat from every living card; also carbon dioxide that drifts away, and animals or seeds that leave.

Why: MS-LS2-3's clarification asks for defining the boundaries of the system. The key distinction is that energy crosses in as light and out as heat, while matter mostly stays and cycles.

Also acceptable: Accept placing air and soil 'on the boundary' if the student explains that the air pool extends beyond the woodland.

- Places the sun outside and the organisms inside
- Names light as the inward energy crossing
- Names heat as the outward crossing
- Mentions that matter mostly stays inside and cycles

-  Sketch your finished web. Show every card as a box, producers at the bottom. Draw the feeding arrows as solid lines with arrowheads at the eater, the arrows to decomposers as dashed lines, and the arrows to and from sunlight, air and soil, and the surroundings as dotted lines. Label the sunlight arrow 'energy in' and the surroundings arrows 'heat out'.

Answer: A sketch with producers at the bottom, solid feeding arrows pointing at eaters matching the card diets, dashed arrows from every organism to the decomposer box, dotted arrows from sunlight to producers (labeled 'energy in'), between air/soil and producers and decomposers, and from living boxes to the surroundings (labeled 'heat out').

Why: This sketch is the individual model for MS-LS2-3. Check arrow direction first, then the decomposer connections, then the nonliving exchanges.

- All feeding arrows point to the eater
- Every organism has a dashed arrow to decomposers
- No arrow from decomposers to producers
- Sunlight in and heat out are drawn and labeled
- Air and soil exchange with producers and decomposers

Session 2: break the web

Disturbance effects (write your disturbance card letter and text in the first row)

Population	Direct or indirect?	Up, down or ?	Chain of reasoning (one link at a time)
Disturbance:			

4. Pick the longest chain of reasoning in your table. Rewrite it as a sign chain, for example 'squirrels –, hawks –, mice +, grasshoppers –', and explain why the sign flips at some links and not at others.

Answer: Example for card D (coyotes removed): coyotes –, jackrabbits +, needlegrass –, grasshoppers –, fence lizards –. The sign flips at a predator link (fewer coyotes means more jackrabbits; more jackrabbits means less grass) and stays the same at a food link (less grass means fewer grasshoppers; fewer grasshoppers means fewer lizards).

Why: Students should see the pattern: crossing an 'is eaten by' link reverses the sign for the prey; crossing a 'feeds on' link in the forward direction keeps it.

Also acceptable: Any disturbance card; for card B (grasshoppers +): lizards +, woodpeckers +, mice +, grass –, jackrabbits – (less grass), with the same flip rule explained.

- Sign chain of at least four populations
- Signs correct for the chosen disturbance
- Explains the flip at predator links versus no flip at food links

5. Which card did your group mark '?' or argue about, and what were the two competing predictions?

Answer: Group-specific. Common: the deer mouse under card A (more seeds left means mice rise, but hawks and coyotes with fewer squirrels may eat more mice, so mice fall); the coyote under card B (more grasshoppers feeds more mice, so coyotes rise, but less grass means fewer jackrabbits, so coyotes fall).

Why: Conflicts arise where two arrows into a card carry opposite signs. Naming both predictions is the point.

- Names a specific card
- States both competing predictions with their chains

Analysis questions: answer key

6. Every organism card has a brown arrow to the decomposers, but no arrow runs from the decomposers back to the producers. Explain both facts.

Answer: Every organism sheds wastes and eventually dies, and bacteria and fungi feed on all of it, so matter from every card flows to the decomposers. No arrow returns to producers because producers do not eat decomposers. Decomposers release carbon dioxide and mineral nutrients into the air and soil, and producers absorb those raw materials from the environment. The return path runs through the air and soil card, not directly.

Why: This separates 'makes nutrients available' from 'is eaten by'. The yellow arrows decomposers → air and soil → producers are the correct route.

- Explains the brown arrows: all organisms produce wastes and remains
- States producers do not consume decomposers
- Names the route through the air and soil pool

7. Trace one carbon atom around your model, naming at least four cards it passes through and the arrow it uses for each move. Start and end at the air and soil card.

Answer: Example: a carbon atom in carbon dioxide in the air and soil card is taken in by needlegrass (yellow arrow) and built into a blade; the blade is eaten by a grasshopper (green arrow) and becomes grasshopper muscle; a fence lizard eats the grasshopper (green arrow); the lizard dies and bacteria and fungi feed on its body (brown arrow); the decomposers respire and release the carbon as carbon dioxide back to the air and soil (yellow arrow).

Why: Any correct loop with at least four cards and named arrows earns credit. Students may also use a shortcut: the lizard itself breathes the carbon out as carbon dioxide (yellow arrow), skipping the decomposers; that is also correct.

- Starts and ends at air and soil
- Passes through at least four cards
- Names the arrow type for each move
- Carbon returns as carbon dioxide, not as 'nutrients' alone

8. Sunlight has arrows going into producers, and heat arrows go out to the surroundings, but no arrow ever comes back from the surroundings. What does your model say about how energy moves, compared with how matter moves?

Answer: Energy enters the model once, as sunlight into producers, and leaves at every living card as heat into the surroundings, which nothing can capture. So energy flows through the model in one direction. Matter, in contrast, moves out of the air and soil into producers, through consumers and decomposers, and back to the air and soil, so it goes around a loop and is reused. The model needs a steady supply of sunlight but never needs new atoms.

Why: This is the chapter's central contrast. The surroundings card with no outgoing arrow is the visual cue.

- Energy in as light, out as heat
- States that heat is not recaptured
- Contrasts with the matter loop
- Concludes that sunlight must keep arriving

9. A group in another class built the same web but left out the air and soil card and the surroundings card. Name two questions about the woodland that their model cannot answer and yours can.

Answer: Without the air and soil card their model cannot explain where producers get the matter to grow, or where the carbon in a dead mouse ends up after decomposers finish with it. Without the surroundings card it cannot explain why the ecosystem needs new sunlight every day, or where the energy in 3,600 kg of feed went when the steer gained only 360 kg.

Why: The nonliving pools are what make the model a model of matter cycling and energy flow rather than just a who-eats-whom chart.

Also acceptable: Accept 'why plants cannot live on decomposers alone' or 'why the web would stop without the sun'.

- One question about where matter comes from or returns to
- One question about where energy goes

10. Your model predicts the direction of change after a disturbance. Give two things it cannot predict, and explain what the model would need in order to predict them.

Answer: It cannot predict how much a population changes (it has no numbers for population sizes, diets or how much each predator eats) or how fast (it has no timing, seasons or breeding rates). It also cannot predict behavior changes, such as a hawk switching to mice when squirrels are scarce. To predict those it would need population counts, diet proportions, reproduction rates and time steps, which is what the numeric lake model in Lab 3 adds in a simple form.

Why: Model limits are part of the modeling practice. Full credit needs two limits and what each would require.

- Names two distinct limits (size, timing, behavior, missing species)
- Says what data or features would be needed for each

11. Disturbance C: rat poison is set out for mice and ground squirrels. Using the arrows in your web, explain how poison meant for rodents can end up inside a red-tailed hawk, and name one more animal in the set at risk the same way.

Answer: A poisoned mouse or squirrel is slow and easy to catch, and the green arrows mouse → hawk and squirrel → hawk carry the poison along with the matter: the hawk eats the rodent and the poison enters the hawk. Over several meals it builds up. The same arrows put the coyote, the gopher snake (mouse → snake) and, through coyote → mountain lion, even the mountain lion at risk.

Why: Matter that moves along a feeding arrow includes whatever is in the prey's body. This is a real California issue with anticoagulant rodenticides.

- Uses specific arrows from the web
- Explains that poison travels with the eaten matter
- Names a second animal at risk with its arrow

Individual evidence of learning

Each student submits their own card inventory, boundary statement, two food chains, web sketch, disturbance table and written answers to q1 through q11. The sketch with its three arrow types and the boundary statement are the primary evidence for MS-LS2-3; the disturbance table and q4 are the evidence for direct and indirect effect reasoning.

Assessment criteria

Criterion	Proficient looks like
Model structure	Every feeding arrow points to the eater, every organism connects to the decomposers, producers have no feeding arrows in, and the sketch shows sunlight in, air and soil exchanging with producers and decomposers, and heat out.
System boundary	States what is inside and outside the model and names energy (light) crossing in, heat crossing out, and carbon dioxide able to cross both ways.
Matter cycling and energy flow	Traces a carbon atom around the loop through at least four cards (q7) and explains that energy leaves as heat and does not return (q8).
Disturbance reasoning	Records at least two direct and two indirect effects with correct signs and a written chain for each, and marks genuine conflicts with '?' rather than guessing.
Model limits	Names at least two things the model cannot predict (size of change, timing, behavior switches) and what data would be needed (q10).

Accessibility adaptations

- Provide a partly built web (producers and the grasshopper, squirrel and deer already connected) for groups that need a head start, and large-print cards with a raised tape strip on producers for students with low vision.
- Let a student who cannot easily handle yarn take the arrow caller or checker role and direct a partner's hands; accept a labeled photo of the web in place of the sketch.

- Offer the sentence frames 'More ___ means fewer ___ because ___ eats ___' and 'That means more ___ even though ___ never touches ___' for the disturbance table and q4.
- Run the human-web variant for students who need movement: each student holds one card, yarn passes from food to eater across the room, and the disturbed student sits down so everyone holding a slack string can raise a hand.

Low-cost alternative

Skip the printed cards and have students write the 19 card names on index cards from the list on the board, using pencil lines on butcher paper instead of yarn (solid for feeding, dashed for decomposers, dotted for nonliving). The same tables and questions apply.

Model limitations

The card set is a tiny slice of a real woodland: it leaves out most insects, birds, plants and soil animals, so 'top predator' and the number of arrows are properties of the model, not of the ecosystem. The model shows direction of change only; it has no numbers, no timing, no seasons and no behavior changes such as a predator switching prey, which is why some predictions must be marked '?'. Diet lines on the cards are simplified from typical diets of these California species. This activity has not been physically tested by the authors; the two-session timing is an estimate.

Teacher notes

Check arrow direction before anything else; a web with reversed arrows makes every later answer wrong for the wrong reason. For q3, a boundary statement that puts the sun outside and names light in and heat out is the heart of MS-LS2-3. Keep one well-built web taped up for slides 10 and 17; walking a carbon atom around real yarn beats any diagram. For disturbance C, the hawk poisoning is documented in California; keep the discussion on the web's arrows rather than on brand names of poisons.