

The Bead Meadow: Deal the Grass, Count the Deer

Investigation question: If every deer needs a patch of meadow to survive and only lush patches have enough grass to raise a fawn, how large can a herd grow, what sets that limit, and what happens when a drought dries up half of the lush grass?

Collaborative systems modeling

Groups of 4

1 session

Setup 3 · Activity 42 · Cleanup 5 min

MS-LS2-1 · practice

MS-LS2-2 · practice

Scientific purpose

Students run a rule-based model of a deer herd in which beads are deer and playing cards are patches of meadow. Each round is one year: every deer is dealt a patch, deer on lush patches raise a fawn, and deer left without a patch starve. Two pairs run an abundant meadow and a scarce meadow side by side, then put the abundant meadow through three drought years and two wet years. From round-by-round data and a class table, students find that each herd stops at an exact ceiling, work out the rule that predicts that ceiling from the deck, and explain why births and deaths balance there.

Why this helps students with this chapter

A carrying capacity is easy to define and hard to believe in, because students rarely watch a population run out of anything. In the bead meadow nobody hunts the deer, nothing is random once the herd is large, and the herd still stops growing at exactly the same number in every group. That exactness is the point: it lets students trace the ceiling straight back to the resources in the deck and write a rule for it. Running a scarce meadow beside an abundant one, and then a drought, turns 'more resource, larger population' into numbers students produced themselves, and the places where the model fails (instant recovery, no wobble) set up the real data in Lab 2 and Lab 3.

Standards connections

MS-LS2-1 (practice, analyzing population data from periods of abundant and scarce resources (model-generated data)): Students tabulate, graph and compare population data from an abundant meadow, a scarce meadow and a drought, and use them as evidence that resource availability controls how fast and how far a population grows. Because the data come from rules the students apply themselves, this builds the analysis toward the PE; Lab 2 and Lab 3 supply the evidence from real organisms and field records.

MS-LS2-2 (practice, the competition pattern, within one species and (q9 and the extension) between two species): Deer compete for a fixed number of lush patches, and the two-species question asks students to predict what happens when elk share the same deck. This builds the competition pattern that the PE asks students to predict across ecosystems; predator and partner interactions are Lesson 21.

Roles (rotate each session)

- **Meadow A dealer:** Shuffles the Meadow A deck each round, deals one card beside each deer, removes starved deer and adds fawns. Swaps with the recorder after round 6.
- **Meadow A recorder and checker:** Counts red cards, black cards and deer with no card aloud, fills the Meadow A row, and checks that deer at end = deer at start + fawns – starved before the next round begins.
- **Meadow B dealer:** Runs the scarce meadow the same way, and after round 10 runs the optional two-species trial if time allows. Swaps with the recorder after round 5.
- **Meadow B recorder and checker:** Fills the Meadow B table with the same arithmetic check, then reports the group's two levels to the class table.

Materials

Item	Quantity	Per	Note
Pony beads or dried beans of one color (the deer)	about 70	group	Meadow A can hold up to 36 deer and Meadow B up to 26 at the same time, plus a few spares. Large wooden beads or lima beans are easier to handle.
Beads or beans of a second color (elk, for the optional two-species trial)	about 15	group	
Ordinary deck of playing cards (red = lush patch, black = thin patch)	1	group	One deck makes both meadows: Meadow A uses 16 red and 4 black, Meadow B uses 6 red and 14 black. Thirty index cards (16 marked L, 14 marked T on one side only) also work but shuffle less well.
Envelope labeled 'Dried-up patches' (holds the 8 red cards removed during the drought)	1	group	
Sheets of paper labeled 'Meadow A' and 'Meadow B' to use as mats, and a small cup for each meadow's bead supply	2 mats, 2 cups	group	
Recording sheet, two colored pencils and a ruler	1 set	student	
Calculator	1	group	

Estimated cost: 12 to 15 per class of 8 groups (estimate) (an estimate; A 1,000-count bag of pony beads costs about \$5 (a 1 lb bag of dried beans about \$2) and dollar-store playing cards about \$1.25 a deck (about \$10 for eight decks); paper, cups, envelopes and calculators are classroom stock. Everything is reused year to year.)

Safety

- Beads and dried beans are a choking hazard: nothing goes in mouths, noses or ears. Raw dried beans, especially kidney beans, contain a natural toxin and must never be eaten.
- Beads that roll onto the floor are a slip hazard. Keep them on the mats or in the cups and pick up any that fall right away.
- Students with a legume allergy can use plastic beads instead of beans; handling dry beans rarely causes reactions, but there is no reason to take the chance.

Teacher preparation and setup

1. Build two decks per group from one pack of cards and rubber-band each: Meadow A = 16 red + 4 black (20 cards), Meadow B = 6 red + 14 black (20 cards). Keep the leftover cards out of reach so they do not get mixed in.
2. Bag about 70 deer beads and 15 elk beads per group. Count them once; the final step of the procedure counts them back.
3. Run Meadow A yourself for four rounds before class. Each round takes about a minute, and you will see that the herd cannot pass 36, which helps you avoid giving the answer away when groups ask.
4. Draw the class results table on the board (group, Meadow A level, round A first reached it, Meadow B level, round B first reached it, drought level).
5. If you are opening with the whole-class floor version (see differentiation), tape 20 paper patches on the floor, 16 marked lush, and run two rounds with students as deer before handing out beads.

Investigation design

Independent variable	The number of lush patches in the deck (16 in Meadow A, 6 in Meadow B) and, during the drought, the number of patches of any kind (Meadow A drops from 20 cards to 12).
Dependent variable	The number of deer at the end of each round, the level each herd reaches, and the round in which it first reaches that level.
Controlled	Every herd starts with 4 deer; The same rule card in every round and every group; Meadows A and B both have 20 patches; only the share of lush patches differs; One card per deer, dealt from a freshly shuffled deck each round; The arithmetic check before every new round
Trials	One run of each meadow per group; the class table pools about eight runs of each meadow so students can see which results vary by luck and which do not.
Comparison	Meadow A against Meadow B (abundant against scarce lush grass), and Meadow A before, during and after the drought.

Student procedure

1. Before dealing anything, answer q1 and q2 on the recording sheet: sketch the shape you expect Meadow A's graph to have, and predict whether Meadow B will level off higher, lower or at the same number.

2. Split into two pairs. Pair A takes the Meadow A deck (16 red, 4 black) and mat; pair B takes the Meadow B deck (6 red, 14 black) and mat. Each pair puts 4 deer beads in a line on its mat and writes 4 in the 'Deer at start' box for round 1.
3. Run one round using the rule card. Shuffle the deck. Deal one card face up beside each deer, starting at the front of the line, until every deer has a card or the deck runs out. Deer with no card starve: count them and return them to the supply cup. Every deer beside a red card raises one fawn: add a bead at the end of the line. Deer beside a black card survive with no fawn.
4. The recorder counts red cards dealt, black cards dealt and starved deer aloud, fills the row, and checks: deer at end = deer at start + fawns – starved. Only then collect all the cards for the next shuffle. The deer at end become the deer at start of the next round.
5. Pair A runs Meadow A for rounds 1 to 8. Pair B runs Meadow B for rounds 1 to 10. Swap dealer and recorder halfway.
6. Drought in Meadow A. Before round 9, take 8 red cards out of the Meadow A deck and put them in the 'Dried-up patches' envelope. The deck is now 8 red + 4 black. Run rounds 9, 10 and 11 with this smaller deck.
7. Rain returns. Before round 12, put the 8 red cards back into the Meadow A deck (16 red + 4 black again). Run rounds 12 and 13.
8. Graph both meadows on the same axes: deer at end of each round against round number, one color per meadow. Shade rounds 9 to 11 lightly and label them 'drought'. Answer q3 to q5 together.
9. Report your levels and the rounds you first reached them to the class table, then copy the class results onto your sheet.
10. Optional, for a pair that finishes early: run a two-species trial. Start Meadow A again with 4 deer and 4 elk mixed in one line, use the full 16 red + 4 black deck and the same rules, and before each deal mix the line by pouring all the animals into a cup and spilling them back out. Record both species for 8 rounds on scrap paper and bring the numbers to the debrief.
11. Count the beads (about 70 deer, 15 elk) and the cards (52) back into the bag. Answer the analysis questions on your own; finish them for homework if the period ends.

Expected observations

- Meadow A typically grows 4 → 6 to 8 → 11 to 15 → 19 to 27 and first reaches 36 in round 4 or 5 (it cannot get there sooner than round 4). From then on it is exactly 36 every round: 20 deer get patches, 16 starve, 16 fawns are born.
- Meadow B grows more slowly (often 4 → 5 → 7 → 9 → 11 → 14 → 19) and usually first reaches 26 between rounds 6 and 9; in roughly 1 run in 60 it has still not reached 26 by round 10. Once there it stays at exactly 26.
- In drought round 9 Meadow A falls from 36 to exactly 20 (12 survive, 24 starve, 8 fawns) and stays at 20 in rounds 10 and 11 (12 survive, 8 starve, 8 fawns). When the 8 red cards return it jumps back to 36 in a single round.
- In round 1 most Meadow A herds raise 3 or 4 fawns from 4 deer (about 0.75 to 1.0 fawns per deer); at the ceiling the rate is 16 fawns for 36 deer, about 0.44.

- In the optional two-species trial the deer and elk together reach 36, but the deer share drifts widely; after 8 rounds it can be anywhere from about 9 to 27, and occasionally one species disappears.

Likely difficulties

- Dealers keep dealing past the end of the line or forget to stop when the deck runs out. The rule is one card per deer, and the deck running out is exactly what makes deer starve; have the recorder say 'deck empty' aloud.
- Adding fawns before removing starved deer makes the line confusing. Remove starved deer first, then add fawns, then count.
- Groups mix Meadow A and Meadow B cards. Rubber-band the decks and check the counts (20 cards each, plus 8 red in the envelope during the drought) at round 9.
- Some students think the level of 36 is 'the number of beads we had'. Ask them to show you a round in which the deck, not the bead supply, ran out.
- Arithmetic slips propagate into every later round. The check line on the rule card catches most of them; insist on it before each new shuffle.

Structured debrief

1. Put the class table on the board and ask what is the same in every row and what is different. The levels (36, 26 and 20 during the drought) match in every group; the rounds in which groups first reached them do not. Ask why: the early rounds depend on which cards the shuffle happened to give, but once a herd outnumbers the patches every card is dealt, so luck no longer matters. That is a carrying capacity set by resources, not by chance.
2. Have two groups explain their q5 rule. Write it as $\text{level} = \text{patches} + \text{lush patches}$ and ask what each part stands for: the patches set how many deer survive the year, and the lush patches set how many fawns are added to them. Then ask what happens to the rule if a deer on a lush patch could raise two fawns (the level becomes $\text{patches} + 2 \times \text{lush patches}$).
3. Compare the graph with the fenced-meadow graph from slide 9. Both rise steeply and flatten. Ask what the real graph does that the bead graph cannot (it wobbles around the ceiling instead of sitting on it) and which rule would have to change to produce a wobble, for example a coin flip for each fawn.
4. If a pair ran the two-species trial, show their numbers: deer plus elk always level off at 36, but the deer share drifts from round to round. Ask what that means for the deer: a competitor that uses the same resource lowers the deer's ceiling without ever fighting a single deer.
5. Close on q11 and preview Lab 3: the model bounces back in one round, real herds do not. Ask students to watch for the slow recovery in the Cedar Hollow case file.

Recording sheet: what students fill in

Lab 1 recording sheet: The bead meadow

Rule card: one round is one year — Each bead is one deer. Each card is one patch of meadow big enough to feed one deer for a year. A **red card is a lush patch**: enough grass for the deer to survive and raise one fawn. A **black card is a thin patch**: enough to survive, not enough to raise a fawn. (1) Shuffle the deck. (2) Deal one card beside each deer in the line until every deer has a card or the deck runs out. (3) A deer with **no card** finds no patch and **starves**: remove it. (4) A deer beside a **red card** raises a fawn: add one bead. (5) A deer beside a **black card** survives with no fawn. (6) Check: deer at end = deer at start + fawns – starved.

1. Prediction before you deal: sketch in the box the shape you expect Meadow A's graph of deer against rounds to have over rounds 1 to 8, and write one sentence explaining your sketch.

Answer: A sketch that starts low, rises faster and faster for a few rounds, then flattens out at some ceiling, with a sentence such as 'The herd grows quickly at first because there are more patches than deer, then it stops when there are more deer than patches.'

Why: This is a prediction, so any reasoned sketch earns credit. The strongest predictions already link the flattening to the fixed number of cards.

Also acceptable: A steadily rising straight line or a curve that keeps rising earns credit if the reason is stated; revisit it in the debrief.

- A sketch with labeled or clearly implied axes
- A sentence that gives a reason for the shape

2. Meadow B has the same 20 patches as Meadow A, but only 6 of them are lush. Predict whether Meadow B's herd will level off higher, lower or at the same number as Meadow A's, and why.

Answer: Lower. Meadow B has the same number of patches but far fewer lush ones, so fewer fawns are added each round; the herd should grow more slowly and stop at a lower number.

Why: Students should reason from the resource: fewer lush patches means fewer fawns, so less growth. Any prediction with a resource-based reason earns credit.

Also acceptable: 'The same, because both have 20 patches' earns credit as a reasoned prediction; it is a good misconception to test with the data.

- A clear prediction (higher, lower or same)
- A reason that refers to the number of lush patches or fawns

Meadow A: 20 patches, 16 lush (drought in rounds 9 to 11)

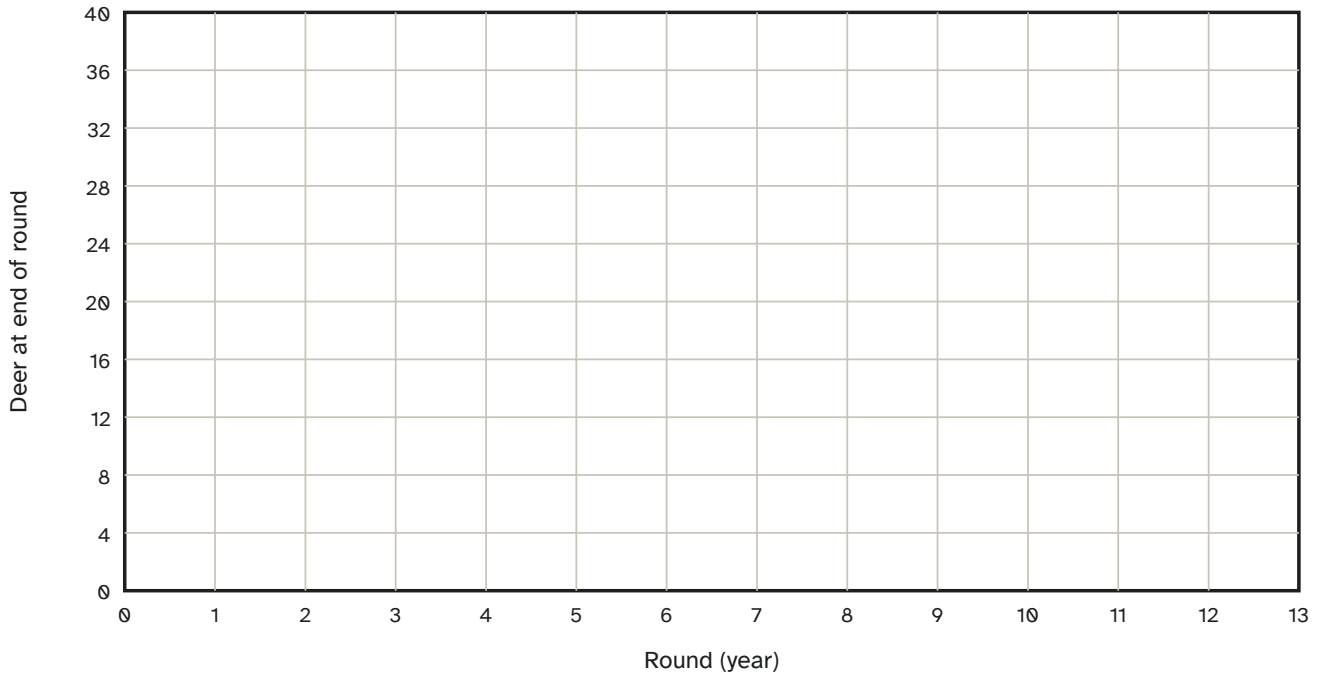
Round	Deck (red + black)	Deer at start	Red cards dealt = fawns	Black cards dealt	Deer with no card = starved	Deer at end
1	16 + 4	4				
2	16 + 4					
3	16 + 4					
4	16 + 4					

Round	Deck (red + black)	Deer at start	Red cards dealt = fawns	Black cards dealt	Deer with no card = starved	Deer at end
5	16 + 4					
6	16 + 4					
7	16 + 4					
8	16 + 4					
9 (drought)	8 + 4					
10 (drought)	8 + 4					
11 (drought)	8 + 4					
12 (rain returns)	16 + 4					
13	16 + 4					

Meadow B: 20 patches, 6 lush

Round	Deck (red + black)	Deer at start	Red cards dealt = fawns	Black cards dealt	Deer with no card = starved	Deer at end
1	6 + 14	4				
2	6 + 14					
3	6 + 14					
4	6 + 14					
5	6 + 14					
6	6 + 14					
7	6 + 14					
8	6 + 14					
9	6 + 14					
10	6 + 14					

Deer at the end of each round in Meadow A and Meadow B



3. At what number did Meadow A level off before the drought, and in which round did it first get there?
Answer the same for Meadow B.

Answer: Meadow A leveled off at 36, usually first reached in round 4 or 5. Meadow B leveled off at 26, usually first reached between rounds 6 and 9. (The round numbers are group-specific; the levels are the same for every group.)

Why: Once deer outnumber the 20 patches, every card is dealt: 20 survive and 16 (A) or 6 (B) fawns are added. Meadow A cannot reach 36 before round 4 because it can at most double each round from 4 ($4 \rightarrow 8 \rightarrow 16 \rightarrow 32$).

Also acceptable: If a Meadow B run had not yet reached 26 by round 10, the student should say so and give the highest value reached.

- Levels of 36 and 26
- Round numbers that match the student's own table

4. Pick one round when Meadow A was at its level (before the drought). How many deer starved that round, and how many fawns were born? What does this tell you about births and deaths when a population is at its carrying capacity?

Answer: At the level, 36 deer start the round, 20 get patches, 16 starve, and 16 fawns are born. Births (16) equal deaths (16), so the herd stays at 36. A population at its carrying capacity has not stopped reproducing; births and deaths balance.

Why: This is the core idea of a carrying capacity, and it corrects the common belief that a flat line means no births.

- Gives 16 starved and 16 fawns (or the equivalent numbers from the student's table)
- States that births balance deaths at the carrying capacity

5. Write a rule that predicts the level from the deck alone: level = _____. Explain why the rule works, then test it on Meadow B and on the drought deck (8 red + 4 black).

Answer: Level = number of cards in the deck + number of red (lush) cards. It works because once there are more deer than cards, every card is dealt: the number of survivors equals the number of cards, and the number of fawns equals the number of red cards, no matter how many deer started. Before that point the herd is below the level and can never jump past it. Test: Meadow A $20 + 16 = 36$; Meadow B $20 + 6 = 26$; drought deck $12 + 8 = 20$, which matches rounds 9 to 11.

Why: Students should derive the rule from the starving and fawn columns at the ceiling. Testing it on two other decks turns a pattern into a rule that predicts.

- States level = patches + lush patches (in any wording)
- Explains that every card is dealt once deer outnumber cards
- Tests the rule on Meadow B and the drought deck with correct sums

Class results

Group	Meadow A level before drought	Round A first reached it	Meadow B level	Round B first reached it	Meadow A level during drought
1					
2					
3					
4					
5					
6					
7					
8					

Analysis questions: answer key

6. Calculate fawns per deer (red cards dealt $\div$ deer at start) for Meadow A in round 1 and in round 6. Show both divisions. How did one deer's chance of raising a fawn change as the herd grew, and why?

Answer: Round 1: for example $3 \div 4 = 0.75$ fawns per deer (most groups get 3 or 4 fawns, so 0.75 or 1.0). Round 6: $16 \div 36 \approx 0.44$ fawns per deer. Each deer's chance of raising a fawn fell. While the herd was smaller than the deck, every deer drew from the full set of patches, 16 of which are lush; once deer outnumbered patches, the same 16 lush patches were shared among 36 deer and 16 deer got no patch at all.

Why: This is competition within a species measured as a rate: the resource is fixed, so the share per individual falls as the population grows. In rounds while the herd is under 20, the expected value stays near $16 \div 20 = 0.8$.

- Both divisions shown with the student's own round-1 numbers and $16 \div 36$
- States that fawns per deer fell
- Explains it with a fixed number of lush patches shared among more deer

7. Use your data and the class table as evidence. How did the amount of lush grass affect (a) how fast the herd grew and (b) how large it finally became? Quote at least three numbers from Meadow A and Meadow B.

Answer: (a) More lush grass meant faster growth: by round 3 Meadow A had about 19 to 27 deer while Meadow B had about 6 to 12, because each round A added far more fawns. (b) More lush grass meant a larger final herd: A leveled at 36 and B at 26, and every group in the class table got the same two numbers. The drought supports the same claim from the other direction: removing 8 lush patches dropped Meadow A from 36 to 20. Resource availability controlled both the rate of growth and the size the population could reach.

Why: This is the MS-LS2-1 reasoning applied to model data: compare abundant and scarce conditions and use numbers as evidence for the effect of the resource on the population.

- Addresses both speed of growth and final size
- Quotes at least three numbers from the student's tables or the class table
- Concludes that the amount of the limiting resource controlled the population

8. Describe what happened to Meadow A in round 9. How many deer starved? Why did the herd not drop to zero, and why did it stay at the same number in rounds 10 and 11? Use the term carrying capacity.

Answer: Round 9 started with 36 deer but only 12 cards: 12 deer got patches, 24 starved, and the 8 on red cards raised 8 fawns, so the herd fell to $12 + 8 = 20$. It did not drop to zero because 12 patches were still there to feed 12 deer and 8 of them were lush. The drought lowered the meadow's carrying capacity from 36 to 20, and the herd fell to the new carrying capacity, not below it. In rounds 10 and 11, 20 deer met the same 12 cards: 12 survived, 8 starved and 8 fawns were born, so the herd stayed at 20.

Why: Students should see that a drought changes the carrying capacity, and the population follows it down to the new level.

- Gives 24 starved and the end count of 20
- Explains that the remaining patches still supported some deer
- Uses carrying capacity to describe the new, lower level
- Explains rounds 10 and 11 as births balancing deaths at 20

9. Suppose 4 elk (a second bead color) join the 4 deer in Meadow A in round 1. Elk follow the same rules and are dealt cards from the same deck. Predict the level for deer and elk together, and roughly how many of those would be deer. Explain your prediction using competition between species.

Answer: Deer and elk together would still level off at 36, because the rules and the deck do not care which species a bead is. On average the deer would get about half of that, roughly 18, but the split would change from round to round with the shuffle. Every patch an elk takes is a patch no deer can use, so each species lowers the other's ceiling. That is competition between species: neither population can be as large as it would be alone.

Why: In the model the two species are identical, so the shared ceiling is 36 and the expected split is even; simulation gives a median of 18 deer after 8 rounds with a wide spread. The point is that a competitor using the same limiting resource reduces the deer population.

Also acceptable: Credit an answer that predicts one species may slowly take over, or that elk would win if they were dealt cards first; both describe real outcomes of competition.

- Predicts a combined level of about 36
- Predicts fewer deer than the 36 they reached alone, with a reasonable estimate
- Explains with both species using the same limited patches

10. Suppose you counted Meadow A right after the starving step, before any fawns were added. What level would the herd show once it reached its ceiling? Why do wildlife biologists always say what time of year a count was made?

Answer: It would show 20, the number of patches, because that is how many deer survive each year before the fawns are added. A count right after the birth season is higher than a count after the hungry season, so a number means little unless you know when it was taken.

Why: The model's level depends on when you count. Real deer counts in fall, after fawns are born, are higher than late-winter counts after the lean season.

- Gives 20 (patches only)
- Explains that the timing of a count changes the number

11. After the rain returned, how many rounds did Meadow A take to get back to its old level? Real deer herds usually need several years to rebuild after a drought. Which rule on the rule card makes the model recover too fast, and how would you change it to be more realistic?

Answer: One round: it went from 20 to 36 in round 12. The fawn rule makes recovery too fast: every deer on a lush patch raises a fawn, including last year's fawns, and nothing happens to the fawns before they are counted. In a real herd only adult females give birth, young deer usually do not breed in their first year, and many fawns die in their first months, so the herd rebuilds over several years. A better rule: a deer raises a fawn only if it is on a red card and wins a coin flip, or fawns born last round cannot breed until the round after next.

Why: Students should connect the unrealistic speed to a specific rule and propose a specific change. This sets up the slow recovery students will see in the Lab 3 case file.

- States that recovery took one round
- Identifies the fawn rule as the cause
- Gives a biological reason real herds are slower
- Proposes a specific rule change

12. Name two ways the bead meadow is different from a real meadow, and for each one explain how it might change the results.

Answer: Any two well-explained differences. Examples: (1) The patches are the same every year, but real deer eat the grass down, so a large herd can make next year's grass worse and push the herd below its old ceiling. (2) There are no predators, disease or hunting, which in a real meadow can hold a herd below its carrying capacity. (3) All deer are identical; in reality old, young, sick or pregnant deer need different amounts of food. (4) Deer cannot move to another meadow, while real deer can wander to find food. (5) The model sits exactly on its ceiling; real herds rise and fall around it because weather and births vary.

Why: Evaluating a model's limits is part of modeling; credit requires an effect on the result, not just a difference.

- Two distinct differences from a real meadow
- For each, a specific effect on the results

Individual evidence of learning

Each student hands in their own copy of both round tables, the shared graph, the class table and written answers to q1 to q12. The q5 rule with its test on Meadow B and the drought deck is the evidence for reasoning about a ceiling set by resources; q6, q7 and q8 are the evidence for interpreting population data from abundant and scarce periods; q9 is the evidence for predicting competition between species.

Assessment criteria

Criterion	Proficient looks like
Data recording	Both tables complete, every row passes the $\text{end} = \text{start} + \text{fawns} - \text{starved}$ check, and the graph shows both meadows with the drought rounds marked.
Finding and explaining the ceiling	States the levels (36, 26, 20), writes the rule $\text{level} = \text{patches} + \text{lush patches}$, explains it (every patch is dealt once deer outnumber patches), and confirms it on two decks.
Using data as evidence about resources	Cites numbers showing that more lush grass meant faster growth and a higher ceiling, and that the drought lowered the ceiling (q7, q8).
Competition reasoning	Explains falling fawns per deer as competition for a fixed number of lush patches (q6) and predicts that a second species sharing the deck lowers the deer's level (q9).
Evaluating the model	Names at least two specific differences from a real meadow, such as instant recovery or no year-to-year wobble, and says how each changes the result (q11, q12).

Accessibility adaptations

- Use large wooden beads or lima beans and jumbo playing cards for students with limited fine-motor control or low vision; the recorder reads every count aloud.
- Give students who need support the Meadow A table with round 1 already completed as a worked example and the check line printed in bold at the top of each table.
- Run the first two rounds as a whole-class floor game with students as deer standing on paper patches, then move to beads, so the rules are seen and felt before they are read.
- Accept a spoken or recorded answer for q7 to q12, and allow the graph to be made by sticking dots on a pre-drawn grid.

Low-cost alternative

Skip the beads and cards entirely: write the numbers 1 to 20 on scrap-paper slips, call 1 to 16 lush, and 'deal' by drawing one slip per deer from a cup without putting any back until the round ends. Tally deer with marks in the table instead of beads. The rules, tables and ceiling are the same.

Model limitations

The bead meadow is a deliberately simple model and has not been physically tested by the authors with a class; the expected numbers come from running the rules on paper and by computer. Its patches are fixed each year, so the deer never eat the grass down and make next year worse, which real overgrazing does. Every deer is identical, there are no males and females, fawns breed in their first year, there are no predators, disease or migration, and the herd can rebuild in a single round, all of which make real populations slower and less tidy. Once a herd outnumbers the patches the model has no chance left in it, so it sits exactly on its ceiling while real populations rise and fall around one. Treat the ceiling rule as a fact about this model, not as a formula for real deer.

Teacher notes

Every group should get the same levels (36, 26 and 20), so any group reporting a different number has a dealing or arithmetic error worth finding together; the round in which the level is first reached varies. The ceiling rule (patches + lush patches) is a property of this model and is counted after fawns are added; a count before fawns gives the number of patches (q10). The textbook does not use the terms carrying capacity or limiting resource; slides 8 to 10 introduce them before this lab. The optional two-species trial needs about 8 extra minutes; skip it if time is short, since q9 can be answered as a prediction.