

The Cedar Hollow Case File: Deer, Cattle and the Next Dry Year

Investigation question: Twelve years of monitoring records show rain, forage, cattle and deer in one valley. What limits the deer herd, did adding cattle change it, and what should the county do before a dry year that forecasters expect next spring?

Data-driven decision

Groups of 4

1 session

Setup 2 · Activity 46 · Cleanup 2 min

MS-LS2-1 · assesses

MS-LS2-4 · practice

MS-LS1-5 · supports

MS-ETS1-2 · practice

Scientific purpose

Students act as a county wildlife team reading a fictional twelve-year case file for a mule deer range. They calculate how much forage each millimeter of rain grows and how many deer each unit of forage supports, graph deer against forage before and after cattle arrived, and test five rival explanations in a skeptic's round. Then they use two prediction methods to forecast the deer count and fawn mass for a coming dry year under several plans, check each plan against criteria and a budget, and commit to a recommendation. The lab assesses the chapter's main data skill on records that include both population size and the growth of individual animals.

Why this helps students with this chapter

Real wildlife decisions are made from records like these: messy, lagging, and full of more than one thing changing at once. The textbook's two graphs show a tidy pattern and call it cause and effect; this case file makes students earn that claim by naming the mechanism, finding the years that act as natural comparisons, and testing rival explanations one at a time. Two prediction methods that disagree show students that a forecast has a range, and a budget forces them to choose rather than do everything. The decision is honest about uncertainty, which is what makes it science rather than a guess.

Standards connections

MS-LS2-1 (assesses, the whole PE: analyzing records from abundant and scarce years for effects on deer numbers and on individual fawn growth): Students analyze and interpret a simulated twelve-year record of rainfall, forage, deer counts and fawn mass, and use it as evidence that forage availability changes both the size of the population and how large individual fawns grow. The clarification statement's emphasis on cause and effect during abundant and scarce periods is met by the dry-year and wet-year comparisons and the skeptic's round.

MS-LS2-4 (practice, making warranted inferences that adding a biological component (cattle) changed the deer population): Students argue from patterns in the data that a new competitor lowered the deer herd's carrying capacity, and must rule out rainfall, recovery lag, water, predators and counting error. This practices the evidence-based argument the PE requires; Lesson 22 assesses it with real ecosystem changes.

MS-LS1-5 (supports, an environmental factor (food supply) influencing the growth of individual animals): Average fawn mass falls in scarce years and after cattle arrive, which is evidence that food supply affects

individual growth. In the California integrated sequence MS-LS1-5 is a Grade 6 PE, so it is background here, not a target.

MS-ETS1-2 (practice, the plan check only): Groups check plans A to E against two criteria and two constraints in a table, and may design plan E, before recommending one. The plans, criteria and prediction methods are supplied, so this practices the systematic evaluation the PE describes rather than assessing it.

Roles (rotate each session)

- **Data analyst:** Computes the forage-per-rain and deer-per-forage columns and the two averages; every number is read aloud so the others can check it.
- **Grapher:** Plots deer against forage with a different symbol before and after cattle, and draws a trend line by eye through each set.
- **Skeptic:** Leads the skeptic's round: reads each rival explanation and will not let the group move on until it names the years and numbers that support or rule it out.
- **Planner and spokesperson:** Runs the prediction and criteria tables, keeps track of costs, drafts the recommendation from the group's numbers and presents it to the class in one minute.

Materials

Item	Quantity	Per	Note
Printed case file and recording sheet	1	student	
Calculator	1	group	Phone calculators are fine if allowed.
Ruler and two colored pencils (one for the years before cattle, one for after)	1 set	student	
Large copy of the criteria and constraints posted at the front of the room	1	class	
Sticky notes for the class vote on plans (optional)	1 pad	class	

Estimated cost: 2 to 4 per class (estimate) (an estimate; Printing only; calculators, rulers, colored pencils and sticky notes are classroom stock.)

Safety

- Paper, pencil and calculator only; there are no physical hazards. Keep the discussion about the fictional valley rather than about any named local ranch or family.

Teacher preparation and setup

1. Work the computations yourself with the answer key beside you: the twelve indexes, the two averages (35.0 and 27.0) and the planning table. The most common slip is including year 7 in an average.

2. Print the case file. The dataset, skeptic cards, plan menu and planning tables are all on the recording sheet.
3. Post the criteria and constraints where every group can see them: C1, at least 180 deer in the fall count of year 13; C2, average fawn mass at least 24 kg; K1, the plan costs at most \$10,000; K2, the cattle lease cannot be ended for good.
4. Decide how you will run the skeptic's round: within groups, or with each group taking one card and reporting to the class.
5. Some students come from ranching or hunting families. Tell the class the valley is fictional, the cattle are not the villains, and the job is to read the evidence fairly.

Investigation design

Independent variable	In the record: rainfall and the forage it grows, and whether cattle were on the range (0 head in years 1 to 6, 200 head from year 7). In the decision: the number of cattle kept on the range during year 13.
Dependent variable	Deer counted each fall, the deer index (deer per 100 kg/ha of forage), and average fawn mass.
Controlled	The same valley, survey route and counting method every year; Forage measured the same way each spring on the same sample plots; Water available in the creek and springs in every year of the record; The same criteria, constraints and prediction methods for every plan
Trials	Twelve years of records (one value per year); each group evaluates at least four plans with two prediction methods, and the class compares recommendations.
Comparison	Years with no cattle against years with 200 cattle at similar forage (year 3 against year 9 for dry years; years 5 and 6 against years 11 and 12 for wet years), and plans A to E against the criteria and budget.

Student procedure

1. Read the background and the dataset. Answer q1 and q2: find the scarce years and describe how forage relates to rainfall.
2. Fill the work table. For every year, divide forage by rainfall (one decimal is enough) and compute the deer index: $\text{deer} \div \text{forage} \times 100$, which is the number of deer counted for every 100 kg/ha of forage. Round to one decimal.
3. Average the deer index for years 1 to 6 (no cattle) and for years 8 to 12 (200 cattle). Leave year 7 out of both averages. Answer q3 and q4.
4. Graph deer counted against spring forage. Plot years 1 to 6 as dots in one color, years 8 to 12 as crosses in the other color, and year 7 as a triangle. Draw a trend line by eye through each set of points.
5. Skeptic's round. The skeptic reads each card aloud. For each one, the group finds the years and numbers that test it, decides whether the data support it or rule it out, and fills one row of the skeptic table.
6. Read the forecast and the plan menu. Predict the year-13 forage (2 kg/ha for every mm of rain). Fill the planning table with both methods for 0, 100 and 200 cattle kept, and the fawn mass column.

7. Fill the criteria table for plans A to D. If no plan meets every criterion and constraint, design plan E by choosing how many cattle to keep, compute its predictions and cost, and add it to both tables.
8. Decide. Write the recommendation (q5) using numbers from your tables, and present it to the class in one minute. If time runs short, finish the written recommendation as homework.
9. Answer the analysis questions on your own.

Expected observations

- Forage is close to 2.0 kg/ha for every mm of rain in every year (1.93 to 2.06).
- The deer index averages 35.0 for years 1 to 6 and 27.0 for years 8 to 12. On the graph the crosses (years 8 to 12) sit below the dots (years 1 to 6) at similar forage.
- Matched comparisons: year 3 (no cattle, 560 kg/ha) had 230 deer and 25 kg fawns; year 9 (200 cattle, 520 kg/ha) had 160 deer and 23 kg fawns. Years 5 and 6 (no cattle, about 1,000 kg/ha) had 350 and 330 deer and 31 to 32 kg fawns; years 11 and 12 (200 cattle, about 1,000 kg/ha) had 260 deer and 29 to 30 kg fawns.
- Year-13 forage = $2 \times 280 = 560$ kg/ha. Predicted deer, Method 1 / Method 2: 0 cattle 230 / 196; 100 cattle 201 / 174; 200 cattle 172 / 151. Fawn mass 25, 24 and 23 kg.
- Plan A meets C1 and C2 but costs \$12,000; plan B meets C1 only by Method 1; plans C and D fail both criteria. A plan E keeping about 35 to 70 cattle (for example 50 kept: 216 / 185 deer, 24.5 kg, \$9,000) meets every criterion and constraint.

Likely difficulties

- Students divide forage by deer instead of deer by forage, or forget to multiply by 100. Have the data analyst read year 1 aloud ($300 \div 840 \times 100 = 35.7$) before anyone does the rest.
- Groups include year 7 in an average or average the raw deer counts instead of the indexes. Ask what changed partway through year 7.
- Interpolating for 100 or 50 cattle is new to many students. Model the 100-cattle row on the board: halfway between 41.1 and 30.8 is $(41.1 + 30.8) \div 2 = 35.95$.
- Students want to pick plan A because it is best for the deer and ignore the budget. Point to K1 and ask what a real county does when the best plan costs more than it has.
- The skeptic's round can become a debate about ranching. Keep it on the data: each card is tested with named years and numbers, and the verdict comes from the numbers.

Structured debrief

1. Collect the averages from every group (35.0 before cattle, 27.0 after). Ask what the drop means in words: after the cattle arrived, every 100 kg/ha of forage supported about 8 fewer deer. Point to the two clouds of points on the graph: same forage, lower herd.
2. Run the skeptic's round as a class. The strongest rival is usually S2 (recovery lag). Show why the data rule it out: the herd grew 25 and 30 percent in years 10 and 11 but did not grow at all in year 12 in a wet year, so it was leveling off at a lower ceiling, not still climbing. S1 is answered by the matched wet years, S3 by the creek note and fawn mass, S4 by the steady lion counts, S5 by the size of the difference.

- Put the plans on the board with both predictions. Ask which plans every group rejected (C and D) and why. Then ask whether anyone found a plan E that meets every criterion and the budget under both methods (keeping about 35 to 70 cattle). Discuss why plan B, which passes by one method and fails by the other, is risky.
- Ask what the county should measure in April of year 13. Forage plots: if the spring forage comes in well below 560 kg/ha, the forecast was too hopeful and the plan should change before the herd pays for it.
- Close on q12: 200 cattle eat as much as about 1,200 deer, yet the herd dropped by only about 70. The two species overlap only partly in what they eat, which is the textbook's point about using a shared resource in different ways, now with numbers.

Recording sheet: what students fill in

Lab 3 recording sheet: The Cedar Hollow case file

Cedar Hollow is a **fictional** valley of dry foothill rangeland, and every number in this file is a **teaching dataset** built to behave like real rangeland records. Mule deer live there all year. Each spring the county clips and weighs the grasses and leafy plants on sample plots to estimate **spring forage** in kilograms per hectare (kg/ha: the mass of plants grown on a square 100 m on a side). Each fall a team walks the same survey route to count the deer and weighs fawns caught for ear-tagging. Starting in year 7 the county leased the valley to a ranch for **200 cattle**. A creek and two springs held water in every year of the record. Biologists think each fall count is within about 10 percent of the true number.

Cedar Hollow monitoring record, years 1 to 12 (teaching dataset)

Simulated teaching dataset: the numbers are invented to be realistic, not measured.

Year	Rainfall (mm)	Spring forage (kg/ha)	Cattle on the range	Deer counted in fall	Average fawn mass in fall (kg)	Deer found killed by mountain lions
1	420	840	0	300	30	9
2	360	730	0	270	28	11
3	290	560	0	230	25	10
4	480	980	0	290	31	8
5	510	1050	0	350	32	10
6	490	990	0	330	31	12
7	470	950	200	320	29	9
8	400	800	200	255	27	11
9	270	520	200	160	23	10
10	450	900	200	200	30	8
11	520	1060	200	260	30	9

Year	Rainfall (mm)	Spring forage (kg/ha)	Cattle on the range	Deer counted in fall	Average fawn mass in fall (kg)	Deer found killed by mountain lions
12	500	1010	200	260	29	11

Simulated data for a fictional valley, written for this lab. Cattle arrived at the start of year 7.

- Which years were scarce (spring forage under 600 kg/ha)? In those years, what happened to the deer count and to fawn mass compared with the year before?

Answer: Years 3 (560 kg/ha) and 9 (520 kg/ha). In year 3 the herd fell from 270 to 230 and fawn mass fell from 28 to 25 kg. In year 9 the herd fell from 255 to 160 and fawn mass fell from 27 to 23 kg.

Why: These are the only two years with forage under 600 kg/ha. In both, the population and individual growth fell together, which is the PE's two effects.

- Names years 3 and 9
- Gives the drop in deer and fawn mass for each, with numbers

- Describe how spring forage relates to rainfall, and name the mechanism that links them.

Answer: Forage rises and falls with rainfall: every year it is close to 2 kg/ha for each mm of rain (for example $840 \div 420 = 2.0$ in year 1). Mechanism: plants need water to grow, so more rain means more plant mass for the deer to eat.

Why: The ratio is nearly constant (1.93 to 2.06), so the pattern is strong; the mechanism turns the pattern into a cause-and-effect explanation.

- Describes the pattern with the 2 kg/ha per mm relationship or an equivalent example
- States that plants need water to grow

Work table

Year	Cattle	Forage $\div$ rainfall (kg/ha per mm)	Deer index (deer $\div$ forage $\times$ 100)
1	0		
2	0		
3	0		
4	0		
5	0		
6	0		
7	200		
8	200		
9	200		
10	200		
11	200		

Year	Cattle	Forage ÷ rainfall (kg/ha per mm)	Deer index (deer ÷ forage × 100)
12	200		
Average, years 1-6	0		
Average, years 8-12	200		

3. Why should year 7 be left out of both averages?

Answer: Year 7 is a transition year: the cattle arrived at the start of it, but the deer counted that fall were mostly the herd that had built up before. It does not belong to either the no-cattle or the full-cattle pattern.

Why: Populations respond to a change over time; mixing a transition year into either average would blur the comparison.

- States that year 7 is when the change happened
- Explains that its count reflects partly the old conditions

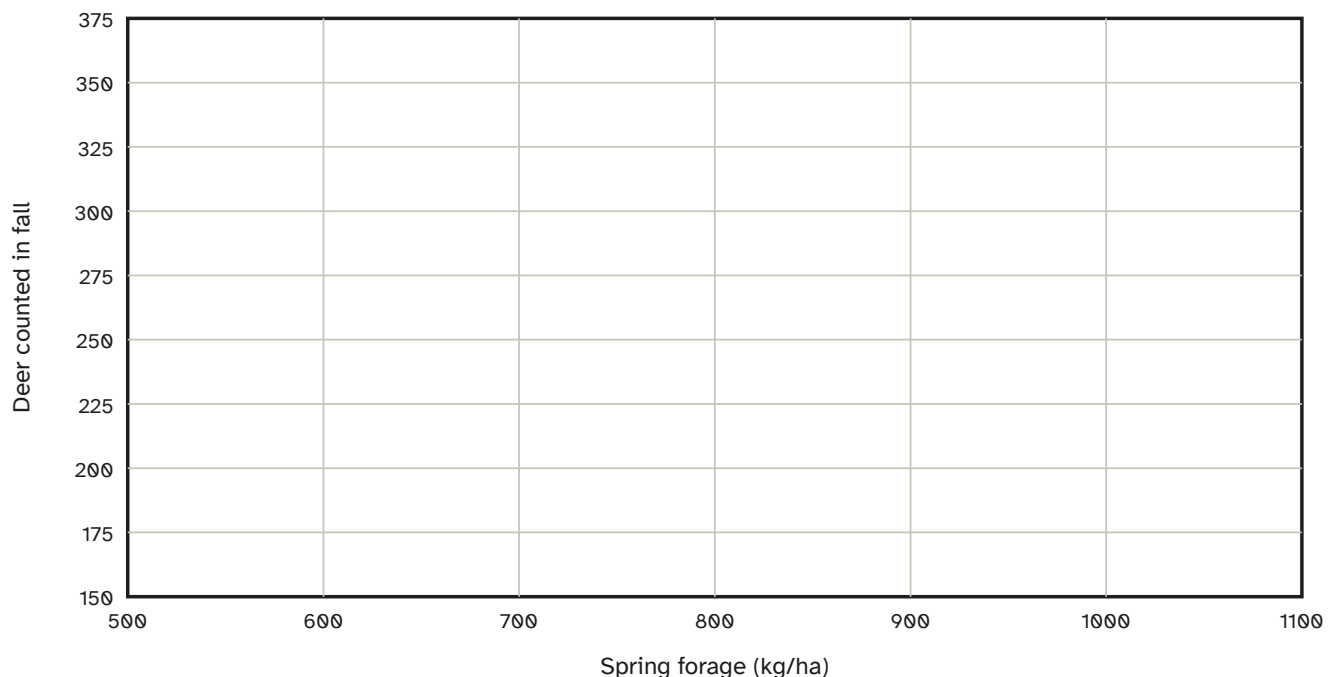
4. What do the two average deer indexes show? Write one sentence that uses both numbers.

Answer: Before cattle the range supported about 35.0 deer for every 100 kg/ha of forage, but with 200 cattle it supported only about 27.0, so the same forage fed about 8 fewer deer per 100 kg/ha, or roughly 23 percent fewer.

Why: Averages: $(35.7 + 37.0 + 41.1 + 29.6 + 33.3 + 33.3) \div 6 = 210.0 \div 6 = 35.0$; $(31.9 + 30.8 + 22.2 + 24.5 + 25.7) \div 5 = 135.1 \div 5 = 27.0$. The index removes the rain effect, so the drop points to something other than weather.

- Uses both averages
- States that the same forage supported fewer deer after the cattle arrived

Deer counted against spring forage (dots: years 1-6; crosses: years 8-12; triangle: y



Skeptic cards: rival explanations for the smaller herd after year 7

1 S1: It was the drought.

Year 9 was very dry. The herd shrank because of the weather, not because of the cattle.

2 S2: The herd is still recovering.

Deer can only grow back as fast as fawns are born. Give the herd a few more wet years and it will be back to 350.

3 S3: The deer are short of water.

Cattle drink a lot. The deer are thirsty, not hungry.

4 S4: Mountain lions.

More lions moved in about the time the cattle arrived, and they are eating the deer.

5 S5: Bad counting.

Counts are never exact. The difference after year 7 is just counting error.

Skeptic's round

Card	Years and numbers you checked	Verdict (supported or ruled out)	Reason
S1			
S2			
S3			
S4			
S5			

The forecast. Forecasters expect year 13 to be dry, with about **280 mm** of rain. The herd at the end of year 12 was 260 deer. **Two ways to predict the year-13 fall count.** Method 1, the closest dry year: use the deer index from the most similar dry year (year 3, index 41.1, with no cattle; year 9, index 30.8, with 200 cattle), because those years started from a herd of similar size. Method 2, the long-run average: use your average index for that cattle level (years 1-6 or years 8-12). Either way, predicted deer = index $\times$ forage $\div$ 100. For 100 cattle, use the index halfway between the 0-cattle and 200-cattle values. For any other number, move from the 0-cattle index toward the 200-cattle index by one quarter of the gap for every 50 cattle kept. Predict fawn mass the same way, from 25 kg (year 3) with no cattle to 23 kg (year 9) with 200. **Criteria:** C1, at least 180 deer in the year-13 fall count. C2, average fawn mass at least 24 kg (in real deer herds heavier fawns are more likely to survive their first winter; this 24 kg cutoff is part of the fictional case). **Constraints:** K1, the plan may cost the county at most \$10,000. K2, the lease cannot be ended for good; cattle can be reduced or removed for year 13 only. The lease pays the county \$60 per head of cattle per year, so every head kept off the range for year 13 costs \$60 in refunds to the rancher.

Plan menu for year 13

Plan	Action in year 13	Cost to the county
A	Keep all cattle off the range for year 13 (0 kept)	\$12,000 in refunds
B	Keep half the cattle off (100 kept)	\$6,000 in refunds
C	Keep all 200 cattle and build two wildlife water tanks	\$9,000
D	No action (200 kept)	\$0
E	Your own plan: choose how many cattle to keep	\$60 for every head kept off

Planning table (year-13 forage = ____ kg/ha)

Cattle kept in year 13	Method 1 index (closest dry year)	Method 1 predicted deer	Method 2 index (long-run average)	Method 2 predicted deer	Predicted fawn mass (kg)
0	41.1				25
100					
200	30.8				23
Plan E: ____					

Criteria and constraints check

Plan	Cost	C1 met by Method 1?	C1 met by Method 2?	C2 met?	K1 met (at most \$10,000)?	Meets everything?
A						
B						
C						
D						
E						

5. Recommendation. Which plan should the county choose? Give the predicted deer count (both methods), fawn mass and cost for your plan, explain why you rejected at least two other plans, and say what the county should measure in spring of year 13 and what result would make it change course.

Answer: Strongest answer: plan E, keeping about 50 cattle (150 kept off) for year 13. Forage 560 kg/ha; Method 1 index $41.1 - (10.3 \div 4) \approx 38.5$ (one quarter-step toward 30.8 for 50 cattle kept), giving $38.5 \times 560 \div 100 \approx 216$ deer; Method 2 index $35.0 - (8.0 \div 4) = 33.0$, giving $33.0 \times 560 \div 100 \approx 185$ deer; fawn mass about 24.5 kg; cost $150 \times \$60 = \$9,000$. It meets C1 by both methods, C2, K1 and K2. Rejected: plan A meets both criteria (230 / 196 deer, 25 kg) but costs \$12,000, over budget; plan B costs \$6,000 but its Method 2 prediction (174) misses C1; plans C and D leave 200 cattle (172 / 151 deer, 23 kg) and fail both criteria, and C spends money on water, which was never short. Monitoring: weigh the spring forage plots in April of year 13; if forage is well below 560 kg/ha (for example under 500), keep the remaining cattle off as well and ask for emergency funds, because the herd would fall below 180.

Why: With K1 limiting refunds to \$10,000, at most 166 head can be kept off (at least 34 kept). C1 by Method 2 needs index $\geq 180 \div 5.6 \approx 32.1$, which requires keeping no more than about 70 cattle. So any plan keeping about 35 to 70 cattle meets everything.

Also acceptable: Full credit for plan B with a clear trigger (for example, remove the other 100 cattle by early summer if spring forage is low) if the student acknowledges that Method 2 predicts 174, below C1. Full credit for plan A only if the student acknowledges it breaks K1 and gives a realistic way to find the extra \$2,000. No credit for plans C or D unless the student shows they fail and argues for them on other grounds.

- Names a plan and gives its predicted deer count by both methods, fawn mass and cost
- Checks C1, C2, K1 and K2 explicitly
- Rejects at least two other plans with numbers
- Names a spring measurement and a trigger for changing the plan

Analysis questions: answer key

6. Use only years 1 to 6, before cattle. Give evidence that forage availability affected (a) the number of deer and (b) how large individual fawns grew. Quote numbers from at least one scarce year and one abundant year.

Answer: (a) Numbers: in the scarce year 3 (560 kg/ha) the herd fell to 230, while in the abundant year 5 (1,050 kg/ha) it reached 350; more forage supported more deer. (b) Individual growth: fawns averaged 25 kg in year 3 but 32 kg in year 5, and 31 kg in years 4 and 6; with more food per deer, each fawn grew larger.

Why: Using only the no-cattle years keeps the comparison about forage alone. The PE's clarification asks for effects on both individual growth and numbers during abundant and scarce periods.

- Uses only years 1 to 6
- Quotes numbers from a scarce and an abundant year for deer counts
- Quotes fawn mass for the same years and links it to food supply

7. Write an argument that adding cattle changed the deer population. State the claim, give two pieces of evidence that compare years with similar forage, explain the reasoning (what the cattle and the deer were competing for), and answer the rival explanation you found strongest.

Answer: Claim: adding 200 cattle lowered the deer herd's carrying capacity. Evidence 1 (dry years): year 3 (no cattle, 560 kg/ha) had 230 deer and 25 kg fawns, while year 9 (cattle, 520 kg/ha) had 160 deer and 23 kg fawns; forage was only about 7 percent lower but the herd was 30 percent smaller. Evidence 2 (wet years): years 5 and 6 (no cattle, about 1,000 kg/ha) had 350 and 330 deer with 31-32 kg fawns, while years 11 and 12 (cattle, about 1,000 kg/ha) had 260 deer with 29-30 kg fawns. Reasoning: cattle and deer both eat spring forage, so every mouthful a cow takes is unavailable to the deer; with less food per deer, fewer fawns survive and grow, and the herd levels off lower. Rival answered (S2, recovery lag): the herd grew by 25 and 30 percent in years 10 and 11 but not at all in year 12, a wet year, so it had stopped climbing at about 260, well below the 330 to 350 of similar years before cattle.

Why: A warranted inference needs comparisons in which rainfall is held about constant, a mechanism, and an answer to the strongest alternative.

Also acceptable: Credit evidence from the deer index averages (35.0 against 27.0) as one of the two pieces, or answering S1, S3, S4 or S5 instead of S2, if the answer uses data.

- A clear claim about cattle and the deer population
- Two pieces of evidence comparing years with similar forage
- Reasoning that names competition for forage
- A rival explanation answered with specific numbers

8. Plan C spends \$9,000 on water tanks. Explain why the evidence in this case file does not support it. At Tomales Point in California, when a fenced tule elk herd fell from about 540 to about 280 between 2012 and 2015, some groups blamed a lack of water, but the Park Service found no evidence that the elk died of thirst. How was the water question settled in each place?

Answer: Cedar Hollow: the case file says the creek and springs held water in every year, including the driest, and both deer counts and fawn mass follow forage, not water, so water was not the limiting resource; tanks would cost \$9,000 and leave the forage problem unchanged (predicted 172 / 151 deer). Tomales Point: the Park Service reported that the elk had water throughout the drought and found no evidence of death by thirst; the elk that died were starving, so forage, not water, was the documented limit there too. In both places a believable rival explanation (thirst) was checked against evidence before money was spent on water.

Why: Students should use evidence, not a hunch, to identify the limiting resource, and see that management depends on which resource is actually short. A fenced herd cannot travel to water, so checking water there was reasonable; the evidence answered it.

Also acceptable: Credit a student who argues that water deserved checking at Tomales Point because the fence stopped the elk from walking to other water, as long as the answer says what the evidence showed.

- Cites the creek and springs note or the forage pattern
- States that water was not limiting at Cedar Hollow
- Names the Tomales Point evidence (water available; no sign that elk died of thirst; the dead elk were starving)

9. Why is it reasonable to use this record to predict a year with 280 mm of rain, but not a year with 150 mm or 700 mm?

Answer: The record covers 270 to 520 mm of rain, and 280 mm is inside that range, so the pattern has actually been observed there. At 150 mm or 700 mm the valley may behave differently (plants could die off entirely, or a different mix of plants could grow), and nothing in the data shows what happens, so a prediction would be a guess.

Why: Predicting outside the measured range (extrapolation) assumes the pattern continues, which the data cannot show.

- States the measured range (270 to 520 mm)
- Explains why predictions outside it are not supported

10. For the same plan, Method 1 predicts more deer than Method 2. Explain why, using what you know about how fast a herd shrinks in its first dry year and how fast it grows back. Which method would you trust more for a one-year forecast, and why?

Answer: Method 1 uses a dry year that started with a herd of about the same size as year 12's. In a first dry year the herd falls only part of the way toward its new ceiling, so the count is still fairly high (the year-3 and year-9 indexes are high). Method 2 averages years that include growing-back years, like year 10, when the herd was below what the forage could support, so its index is lower. Method 1 is better for a one-year forecast from a herd of 260 because it matches the starting situation; Method 2 is closer to where the herd would settle if the dry years continued. A careful manager plans for the lower number.

Why: The difference comes from lag: herds shrink faster than they grow back, but not instantly. Both methods are reasonable; students should explain what each assumes.

Also acceptable: Credit choosing Method 2 if the student argues it is more cautious or uses more years of data.

- Explains the difference using lag or the starting herd size
- Chooses a method with a reason tied to the one-year forecast
- Recognizes that the lower prediction is the safer planning number

11. Fall counts are within about 10 percent of the true number. Calculate the range of true herd sizes that a predicted count of 185 could stand for. How should that uncertainty change the way the county uses your recommendation?

Answer: 10 percent of 185 = 18.5. The true herd could be about $185 - 18.5 = 166.5$ to $185 + 18.5 = 203.5$, roughly 167 to 204 deer. Because part of that range is below 180, a plan whose prediction is only a few deer above 180 might actually miss C1. The county should either choose a plan with a bigger margin or pair the plan with a spring forage check and a trigger to remove more cattle.

Why: A prediction with a margin smaller than the measurement uncertainty cannot be called a sure pass.

- Shows 10 percent of 185 and the range (about 167 to 204)
- Notes that part of the range is below 180
- Uses the uncertainty to argue for a margin or monitoring

12. One cow eats about as much forage in a year as six mule deer. How many deer's worth of forage do 200 cattle eat? Compare that number with the drop in deer between year 6 and year 12. What does the comparison suggest about how much cattle and mule deer eat the same plants?

Answer: $200 \times 6 = 1,200$ deer's worth of forage. The herd fell from 330 (year 6) to 260 (year 12), a drop of 70 deer, at about the same forage. If cattle ate exactly the same plants as deer, 1,200 deer's worth of food would have wiped out the herd. The much smaller drop suggests their diets overlap only partly: cattle eat mostly grasses, while mule deer eat many leafy plants and shrubs, so they compete for only part of the forage. Using a shared resource in different ways reduces competition.

Why: The comparison shows partial niche overlap with numbers, which ties to the lesson's yak and horse example. The six-deer figure is approximate.

- Calculates 1,200
- Calculates the drop of 70 deer from years 6 to 12
- Concludes that the diets overlap only partly and connects it to reduced competition

Individual evidence of learning

Each student submits their own completed work table, graph, skeptic table, planning and criteria tables, the q5 recommendation and answers to q6 to q12. The work table with q1, q4 and q6 is the evidence for analyzing data on resource availability and its effects on the population and on individual fawns; q7 and the skeptic table are the evidence for an argument about a biological change to the ecosystem; q5 with q10 and q11 shows whether the student can use data to make and qualify a prediction.

Assessment criteria

Criterion	Proficient looks like
Calculations	Forage-per-rain values near 2.0, all twelve deer indexes correct to one decimal, averages of 35.0 and 27.0 with year 7 excluded, and correct planning-table predictions.
Interpreting resource data	Uses scarce and abundant years to show that forage changed both deer numbers and fawn mass (q1, q6), with the rain-forage-deer mechanism stated.
Argument about the cattle	Claims that cattle lowered the herd's carrying capacity, supports it with matched-forage comparisons in both dry and wet years, and rules out at least three rival explanations with specific numbers (q7, skeptic table).
Decision	Recommends a plan with both predictions, fawn mass and cost; checks every criterion and constraint; rejects at least two plans with reasons; names a spring measurement and a trigger for changing course (q5).
Handling uncertainty	Explains why the two methods differ, stays inside the measured rainfall range, and uses the counting uncertainty to argue for a margin above 180 or a monitoring trigger (q9 to q11).

Accessibility adaptations

- Give students who need support a work table with years 1 and 8 already computed as worked examples, and a calculator key sequence (deer $\div$ forage $\times$ 100).

- Let a student who struggles with graphing plot only years 3, 5, 9 and 11, which carry the main comparison, and add the rest with a partner.
- Read the background and skeptic cards aloud for students who need reading support, and provide the sentence frame 'The data rule out ___ because in year ___ the ___ was ___.'
- Accept a one-minute recorded spoken recommendation in place of the written q5, as long as it includes the numbers and the trigger.

Low-cost alternative

No printing: project the dataset and have students copy only the columns they need (year, forage, cattle, deer) into notebooks, and run the skeptic's round and the plan vote as a whole class on the board. The calculations and decision are unchanged.

Model limitations

Cedar Hollow is fictional and every number was written for this lab, so it has not been tested against a real herd, and the activity itself has not been physically tested with a class by the authors. The dataset was built so that forage tracks rain closely and the cattle effect is clear; real records are noisier and often have missing years. Both prediction methods assume that next year will behave like the past, that the cattle effect grows in proportion to the number of cattle, and that nothing else changes: a hard winter, a disease outbreak, a change in hunting, or a dry year that is also hot could each push the real count below the prediction. The deer index lumps together everything about forage quality, deer movement and fawn survival into one number. Use the case to practice reading evidence and making a qualified decision, not as a guide to managing any real range.

Teacher notes

Deer indexes, one decimal: 35.7, 37.0, 41.1, 29.6, 33.3, 33.3, 33.7, 31.9, 30.8, 22.2, 24.5, 25.7; averages 35.0 (years 1-6) and 27.0 (years 8-12). Forage ÷ rain: 2.00, 2.03, 1.93, 2.04, 2.06, 2.02, 2.02, 2.00, 1.93, 2.00, 2.04, 2.02. Year-13 forage 560 kg/ha. Planning table, Method 1 index / deer then Method 2 index / deer: 0 kept 41.1 / 230 and 35.0 / 196; 100 kept 35.95 (36.0) / 201 and 31.0 / 174; 200 kept 30.8 / 172 and 27.0 / 151; fawn mass 25, 24, 23 kg. Accept predictions within about 2 deer of these when students round the index first. Plan E keeping 50: 38.5 / 216 and 33.0 / 185, 24.5 kg, \$9,000. Feasible plan E range: keep about 35 to 70 cattle. The six of these twelve years shown on presentation slide 17 match this table.