

Owls or Poison? Designing Rodent Control for a California Vineyard

Learning target: I can evaluate competing solutions to a farm pest problem against criteria and constraints, choose a plan that keeps biodiversity and a natural pest-control service, and justify it with evidence.

Transfer and design

About 55 min

Pairs

MS-LS2-5 · assesses

MS-ETS1-2 · assesses

MS-ETS1-1 · practice

engineering design

data analysis

writing

Standards connections

MS-LS2-5 (assesses, evaluating competing design solutions for maintaining biodiversity and an ecosystem service in a new context): Students evaluate competing solutions (poison bait, trapping, barn owl nest boxes, owls with a habitat strip, doing nothing) for controlling vineyard pests while maintaining biodiversity and the pest-control service predators provide, and defend a choice. Costs and results are simulated teaching estimates; the evaluation itself is evidence toward the PE.

MS-ETS1-2 (assesses): Students apply a constraint, compute three-year costs and complete a weighted decision matrix with stated scoring rules before recommending a solution, which is the systematic evaluation this PE describes.

MS-ETS1-1 (practice): q3 asks students to rewrite a vague criterion ('fewer pests') precisely enough to measure; most criteria are supplied, so this is practice.

Purpose: extend · **Time:** about 55 minutes · **Format:** pairs

Answers with reasoning

The problem

Ridgeline Vineyard is a made-up 40-acre wine-grape vineyard in a California valley. Pocket gophers chew grapevine roots underground, and voles gnaw the bark at the base of young vines. Last year rodents killed about 600 vines, and every one had to be replanted. A strip of oak woodland and grassland borders the vineyard on two sides. The owners want a rodent-control plan for the next three years, and they have heard that barn owls might help.

What growers and biologists know — Barn owls hunt at night, mostly for small rodents such as voles, pocket gophers and mice. They do not build nests; they use tree hollows, barns or wooden nest boxes, and many California vineyards and farms put up boxes for them. A pair raising chicks must catch many rodents every night. Owls hunt over open ground, and studies in California vineyards found they often hunt over nearby grassland as well as among the vines. Most rodent baits are anticoagulant poisons: a rodent that eats bait may live for days, and an owl, hawk, fox or bobcat that eats a poisoned rodent can be poisoned too, which is called secondary poisoning. Trapping in gopher tunnels works but takes labor for every animal caught. Owls rarely remove every pest, so growers often combine nest boxes with spot trapping.

Ridgeline Vineyard options and estimates (teaching dataset)

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

Option	What is done	Program cost over 3 years (\$)	Vines lost: year 1, year 2, year 3	Effect on other wildlife	Labor
A Poison bait	Bait stations along every row, refilled monthly	9000	150, 150, 150	Risk of secondary poisoning of owls, hawks, foxes, bobcats and pets	Low
B Trapping crew	A trapper sets traps in gopher tunnels two days a week	24000	220, 200, 180	Little effect	High
C Owl boxes	Ten barn owl boxes on poles, cleaned each winter	6000	300, 220, 180	Supports owls; no poison risk	Low
D Owls, strip and spot trapping	Ten owl boxes, a 2-acre strip of native grasses and flowers, and trapping only where damage appears	15000	250, 170, 120	Supports owls, hawks and pollinators; strip also holds soil	Medium
E Do nothing	Replant whatever dies	0	600, 600, 600	No direct effect	None

Simulated estimates for teaching. Replanting a vine killed by rodents costs \$30 in this scenario. Program cost covers equipment, materials and labor for three years.

Criteria and constraint — **Constraint:** the program cost (not counting replanting) must be no more than \$20,000 over three years. **Criteria and weights:** (1) vine losses by year 3, weight 3; (2) protects biodiversity and natural predators, weight 3; (3) low total three-year cost including replanting, weight 2; (4) low labor, weight 1. **Scoring rules:** Losses in year 3: 3 = under 150, 2 = 150 to 199, 1 = 200 or more. Biodiversity: 3 = supports predators or habitat, 2 = no effect, 1 = puts wildlife at risk. Total cost: 3 = under \$25,000, 2 = \$25,000 to \$35,000, 1 = over \$35,000. Labor: 3 = low or none, 2 = medium, 1 = high.

Part A: Understand the system

1. What ecosystem service would barn owls provide to the vineyard, and which category does it belong to? Explain one way the oak woodland and grassland next to the vineyard help provide it.

Answer: Pest control: owls eat the voles and gophers that kill vines. It is a regulating service because it keeps a pest population in check. The oak woodland and grassland provide hunting ground full of rodents that keep owls well fed, roosting and nesting places such as tree hollows, and habitat for other predators such as hawks, so a population of owls can live next to the vineyard all year.

Why: Natural pest control is a regulating service; it depends on the surrounding habitat that supports the predators.

Also acceptable: Accept 'supporting' for the habitat role if pest control is still named as regulating.

- Names pest control (rodent control)
- Names regulating
- Explains one way the nearby habitat supports the predators

2. Draw or describe a food chain that shows how bait put out for gophers could end up harming an owl or bobcat that never touched the bait. Explain each link.

Answer: Bait → gopher or vole → owl (or bobcat). A rodent eats the bait and carries the poison in its body; because anticoagulants act slowly, it may live for days and become easier to catch. An owl or bobcat that eats the rodent takes in the poison stored in its body. Because each predator eats many rodents, it can build up a harmful dose even though it never touched the bait.

Why: Secondary poisoning travels along feeding links, the same way matter moves in a food chain.

Also acceptable: A drawn chain with labeled arrows earns full credit.

- Correct chain from bait to rodent to predator
- Explains that the poison moves with the matter that is eaten
- Mentions slow action or many rodents eaten

3. The owners first wrote their goal as 'Have fewer pests.' Rewrite it as a criterion precise enough to measure, and say how they would measure it.

Answer: Example: 'Rodents kill fewer than 150 vines per year by year 3, counted each winter by walking every row and recording dead or chewed vines.' Other precise criteria: 'fewer than 2 fresh gopher mounds per acre in a monthly count'.

Why: A precise criterion names a quantity, a target value, a time and a method of measuring.

Also acceptable: Any measurable criterion with a target and a method.

- Names a measurable quantity
- Gives a target number
- Gives a time frame or method of measuring

Part B: Calculate, apply the constraint and score

4. Complete the table. Replanting cost = vines lost $\times$ \$30. Three-year total = replanting cost + program cost.

Answer: A: $150 + 150 + 150 = 450$ vines; $450 \times \$30 = \$13,500$; program \$9,000; total \$22,500. B: $220 + 200 + 180 = 600$; \$18,000; \$24,000; total \$42,000. C: $300 + 220 + 180 = 700$; \$21,000; \$6,000; total \$27,000. D: $250 + 170 + 120 = 540$; \$16,200; \$15,000; total \$31,200. E: 1,800; \$54,000; \$0; total \$54,000.

Why: Including replanting shows that the cheapest program (C) is not the cheapest overall, and that doing nothing is the most expensive choice.

Also acceptable: Allow follow-through credit for a single addition slip.

- Vines lost: 450, 600, 700, 540, 1,800
- Replanting: \$13,500, \$18,000, \$21,000, \$16,200, \$54,000
- Totals: \$22,500, \$42,000, \$27,000, \$31,200, \$54,000

5. Which option fails the constraint and is removed before scoring? Explain.

Answer: Option B, the trapping crew, is removed: its program cost of \$24,000 is more than the \$20,000 limit.

Why: A constraint is a limit, so an option that breaks it is eliminated before scoring.

Also acceptable: None.

6. Use the scoring rules to give each remaining option a score of 1 to 3 on each criterion. Write the score and the weighted points in each cell (for example '2 $\rightarrow$ 6'), then add the weighted total.

Answer: A: losses 150 $\rightarrow$ 2 $\rightarrow$ 6; biodiversity at risk $\rightarrow$ 1 $\rightarrow$ 3; cost \$22,500 $\rightarrow$ 3 $\rightarrow$ 6; labor low $\rightarrow$ 3 $\rightarrow$ 3; total 18. C: losses 180 $\rightarrow$ 2 $\rightarrow$ 6; biodiversity supports $\rightarrow$ 3 $\rightarrow$ 9; cost \$27,000 $\rightarrow$ 2 $\rightarrow$ 4; labor low $\rightarrow$ 3 $\rightarrow$ 3; total 22. D: losses 120 $\rightarrow$ 3 $\rightarrow$ 9; biodiversity supports $\rightarrow$ 3 $\rightarrow$ 9; cost \$31,200 $\rightarrow$ 2 $\rightarrow$ 4; labor medium $\rightarrow$ 2 $\rightarrow$ 2; total 24. E: losses 600 $\rightarrow$ 1 $\rightarrow$ 3; biodiversity no effect $\rightarrow$ 2 $\rightarrow$ 6; cost \$54,000 $\rightarrow$ 1 $\rightarrow$ 2; labor none $\rightarrow$ 3 $\rightarrow$ 3; total 14.

Why: With the stated rules, D ranks first (24), C second (22), A third (18) and E last (14).

Also acceptable: Allow follow-through credit if a q4 total was wrong and the cost score follows from it.

- Scores follow the rules for every cell
- Weights applied correctly
- Totals 18, 22, 24 and 14

Part C: Decide, justify and plan the test

7. Recommend one option to the owners. Justify it with at least two numbers from your tables, explain how your choice maintains biodiversity and the pest-control service, and name one trade-off you are accepting.

Answer: Example: 'We recommend option D. It scored highest (24 points) and has the lowest losses by year 3 (120 vines), and its program cost of \$15,000 fits under the \$20,000 limit. It keeps the pest-control service working by giving barn owls nest boxes and hawks and owls more grassland to hunt over, and it uses no poison, so predators are not at risk of secondary poisoning. The strip also supports pollinators and holds soil. The trade-off: its three-year total (\$31,200) is \$8,700 more than poison (\$22,500), and it needs more labor for spot trapping.'

Why: A strong recommendation uses the matrix and the costs, explains the ecosystem service and biodiversity, and admits a trade-off.

Also acceptable: Option C can earn full credit if justified (lowest program cost, 22 points, strong biodiversity) with its trade-off (higher losses early). Option A earns full credit only if the student explains how to manage the secondary-poisoning risk and accepts the biodiversity cost openly; most such answers reach level 3.

- Clear choice of one option
- At least two numbers from the tables
- Explains how the choice maintains biodiversity and pest control
- Names a real trade-off

8. Plan the test. Name two things the vineyard should measure each year to know whether the plan is working, what result at the end of year 2 would make you change the plan, and what change you would make.

Answer: Measure: (1) number of vines killed or damaged by rodents, counted each winter row by row; (2) number of owl boxes occupied and chicks raised each spring; also useful: fresh gopher mounds per acre each month. Change trigger: if losses at the end of year 2 are still above 200, or fewer than half the boxes are occupied, change the plan: for example, move boxes closer to the grassland edge, add more boxes, or increase spot trapping in the worst blocks.

Why: A test plan needs measurable outcomes, a decision point and a specific modification.

Also acceptable: Accept any reasonable thresholds.

- Two measurable quantities
- A specific year-2 result that triggers a change
- A specific modification tied to the result

9. Option C's losses fall from 300 to 180 over three years, while option A's stay at 150. Use what you know about populations and resources to explain why an owl solution gets better over time while poison works right away but never improves.

Answer: Poison kills rodents as soon as they eat it, so it works from the start, but it must be replaced every month and it never adds anything to the ecosystem; it can even remove predators. Owls must first find and move into the boxes, and their population can grow only as they raise chicks, which takes a breeding season. With plenty of rodents to eat, more owls raise more young each year, so more rodents are caught and losses fall over time. The predator population responds to its food supply, so the service builds up.

Why: Predator populations grow in response to resources (prey) over breeding cycles; a chemical acts at once but does not grow.

Also acceptable: Accept answers that mention owls learning the area or young owls joining the hunt.

- Owls must occupy boxes and reproduce, which takes time
- More owls means more rodents caught
- Poison acts immediately but must be repeated and does not build up a predator population

Scoring rubric

Criterion	4 • Exemplary	3 • Proficient	2 • Developing	1 • Beginning
Use of ecosystem science	Names pest control as a regulating service, explains how nearby habitat supports it, and traces secondary poisoning along a food chain accurately.	Names the service and traces the food chain, with one link unexplained.	Names the service but the food chain or the habitat role is missing or confused.	Science missing or incorrect.
Systematic evaluation	Costs, constraint and every matrix cell are correct and follow the rules; totals 18, 22, 24, 14 (or correct follow-through).	One calculation or scoring slip; constraint applied correctly.	Several slips, or the eliminated option is scored as if allowed.	No systematic comparison.
Recommendation and justification	A clear recommendation supported by at least two numbers, an explanation of how biodiversity and the service are maintained, and an honest trade-off.	A sound recommendation with numbers; the biodiversity link or the trade-off is thin.	A recommendation with a reason that does not use the data.	No recommendation, or one that breaks the constraint.
Test plan and iteration	Two measurable outcomes, a specific year-2 trigger and a specific change; explains why owl results improve over time.	Measurable outcomes and a change, but the trigger or the population explanation is general.	Outcomes named without a trigger or change.	No test plan.

Teacher notes

Ridgeline Vineyard and all numbers are invented. The facts box is accurate: barn owls are cavity nesters that readily use nest boxes, many California vineyards install them for rodent control, research in Napa Valley vineyards found owls often hunted over adjacent uncultivated grassland, and anticoagulant rodenticides cause secondary poisoning of predators such as owls, hawks and bobcats. Avoid claims about exactly how

many rodents an owl family eats; published estimates vary widely. This transfers the chapter's ideas (a service from a predator, like the vultures' cleanup; habitat beyond the farm, like the almond growers' wild bees) to a new case. Extension answer: with biodiversity weighted 5, $A = 6 + 5 + 6 + 3 = 20$, $C = 6 + 15 + 4 + 3 = 28$, $D = 9 + 15 + 4 + 2 = 30$ (D still first); with cost weighted 4, $A = 6 + 3 + 12 + 3 = 24$, $C = 6 + 9 + 8 + 3 = 26$, $D = 9 + 9 + 8 + 2 = 28$ (ranking unchanged, but the gap between A and the owl options narrows). The point is that weights express values, which people choose.

Scaffold offered to students: Order of work and one worked row

Work in this order: constraint first, then costs, then scores. Worked example for option E: vines lost = $600 + 600 + 600 = 1,800$; replanting = $1,800 \times \$30 = \$54,000$; program = $\$0$; total = $\$54,000$.

Scores for E: losses $600 \rightarrow 1 \rightarrow 1 \times 3 = 3$; biodiversity no effect $\rightarrow 2 \rightarrow 2 \times 3 = 6$; cost over $\$35,000 \rightarrow 1 \rightarrow 1 \times 2 = 2$; labor none $\rightarrow 3 \rightarrow 3 \times 1 = 3$; weighted total 14.

Extension: Change the weights

A neighbor who sells wine labeled 'farmed for wildlife' would weight biodiversity 5 instead of 3. Another neighbor, short on money this year, would weight total cost 4 instead of 2. Recalculate the weighted totals for options A, C and D under each neighbor's weights. Does the ranking change? Write a paragraph explaining what this shows about who decides the weights in a decision matrix, and why science can inform the decision but does not make it by itself.