

Ridgeback Reserve: Design a Drought Plan for a Fenced Elk Herd

Learning target: I can use resource data to find how many elk a fenced reserve can support in wet, average and drought years, identify the limiting resource in each, and design and justify a drought plan that meets criteria and constraints.

Transfer and design

About 50 min

Pairs

MS-LS2-1 · practice

MS-ETS1-2 · practice

engineering design

data analysis

writing

Name _____

Date _____

Period _____

Directions

Work with a partner. Read the real case first, then the problem at Ridgeback Reserve. In Part A, calculate what the reserve can support with no plan. In Part B, test each option by itself. In Part C, design your own plan, check it against every criterion and constraint, and defend it. Show every calculation with units. When you divide to find a number of elk, round down, because the reserve cannot feed part of an elk.

You will need: This worksheet, Pencil, Calculator

A real case: elk behind a fence

At Point Reyes National Seashore, north of San Francisco, a herd of tule elk at Tomales Point lived behind a fence that kept the elk off neighboring ranch land. In the dry years of 2012 to 2015, the National Park Service's counts of that herd fell from about 540 animals to about 280. Park biologists found no evidence that the elk died of thirst; there was not enough good forage inside the fence for that many elk. (Some groups argued that water ran short too, and the Park Service disagreed.) A free-roaming herd can walk to wherever water and food remain. A fenced herd cannot, so it depends entirely on the resources inside the fence.

The problem: Ridgeback Reserve

Ridgeback Reserve is an imaginary coastal reserve with the same problem. Its 300 elk live inside a fence. Elk need two resources the reserve can run short of: **forage** (grasses and other plants they eat) and **summer water**, because most ponds dry up by the end of a dry summer. The managers expect a drought within the next few years and have asked for a plan. The numbers below are planning values for teaching, not measurements from a real reserve.

Ridgeback Reserve: resources in three kinds of year (teaching dataset)

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

Kind of year	Forage grown (kg per hectare)	Ponds that still hold water at the end of summer
Wet	1800	6
Average	1200	3
Drought	700	1

Simulated planning values. Forage grown is the mass of plants elk can eat that grows on each hectare in a year.

Planning values (teaching dataset)

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

Planning value	Amount
Area inside the fence	1,000 hectares
Forage one elk eats in a year	about 1,500 kg
Share of each year's forage that must be left ungrazed (criterion C4)	one half
Elk that one summer pond can water	about 120
Elk in the herd now	300

Simulated values chosen to be reasonable for tule elk on a coastal grassland.

How to find the carrying capacity — Elk need forage **and** water. First find how many elk the usable forage can feed (forage grown $\times$ area $\times$ one half $\div$ 1,500 kg). Then find how many elk the summer water can supply (ponds $\times$ 120, plus any troughs). The carrying capacity is the **smaller** of the two numbers, and the resource that gives the smaller number is the **limiting resource**. Adding more of the other resource does not help.

Criteria and constraints set by the reserve managers — **Criteria** (what a good plan must do): **C1** In a drought year, the reserve's carrying capacity is at least as large as the herd you plan to keep, so the elk do not die off. **C2** The herd stays at 250 elk or more, the managers' goal for a healthy herd. **C3** The plan keeps working in future droughts without large costs every time. **C4** Elk use no more than half of each year's forage, leaving the rest for soil, other plants and other wildlife. **Constraints** (limits you cannot break): a budget of \$60,000 this year; the main fence stays; no more than 60 elk can be moved this year.

Options and estimated costs (teaching dataset)

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

Option	What it does	Estimated cost	Notes
A. Water trough fed by a solar-powered well pump	Waters about 100 more elk through a dry summer	\$12,000 each, one time	Only 4 sites have groundwater, so at most 4 troughs; each lasts 20 years or more
B. Hay brought in during a drought year	Replaces the forage one elk would otherwise lack that year	\$200 per elk, every drought year	Must be bought again in every drought; elk crowd around feeding sites, where disease spreads more easily
C. Move elk to other public lands	Removes elk from the herd	\$600 per elk	Receiving sites can take at most 60 elk this year; capture is stressful for the animals
D. Open a corridor of neighboring park land	Adds 300 hectares of forage and one pond that holds water even in droughts	\$45,000, one time	Deer and hikers already use the corridor; the half-forage rule applies there too

Simulated cost estimates for teaching. You may combine options and use some of them more than once.

Part A: What can the reserve support with no plan?

1. Complete the table for each kind of year. Show the forage calculation for the drought year below the table.

Usable forage (kg)	Elk the forage can feed	Elk the ponds can water	Carrying capacity	Limiting resource
Wet year				
Average year				
Drought year				

2. The herd is 300 elk now. Predict what will happen to the herd in a drought year if the managers do nothing. About how many elk could be lost, and how does that compare with what happened at Tomales Point?

3. The limiting resource is not the same in every kind of year. Explain how that can be true, and why it matters when you choose which option to pay for.

Part B: Test each option by itself (drought year)

4. For each option used alone, find the drought-year numbers. Start from your drought row in q1 and add only what the option provides.

Cost	Elk the forage (plus any hay) can feed	Elk the water can supply	Drought carrying capacity	Lasts for future droughts?
1 trough				
2 troughs				
4 troughs				
Corridor (option D)				
Hay for 70 elk				

5. Your table should show that a third or fourth trough does not raise the drought carrying capacity at all. Explain why, using the term **limiting resource**.

6. Explain why buying hay alone fails criterion C1, and why moving 60 elk alone fails both C1 and C2. Use numbers.

Part C: Design, check and defend your plan

7. Write your plan. List each option you chose and how much of it, the total cost this year, the elk the forage (plus any hay) can feed in a drought, the elk the water can supply in a drought, the drought carrying capacity, and the number of elk you plan to keep.

8. Check your plan against every criterion and constraint. Be honest: 'partly' is an allowed answer if you explain it.

Met? (yes, partly or no)	The number or reason that shows it
C1: drought capacity at least the herd you keep	
C2: at least 250 elk	
C3: keeps working in future droughts	
C4: half the forage left ungrazed	
Budget: \$60,000 or less this year	
No more than 60 elk moved	

9. Defend your plan in a paragraph. Compare it with at least one other plan that also meets C1 and C2, and explain why yours is better. Name one trade-off your plan accepts, and one way your plan could affect another population that shares the reserve or the corridor.

10. Suppose your plan works, and then several average years follow. Calculate the average-year carrying capacity with your plan in place. Predict what the herd will do over those years and what will happen at the next drought. What rule or measurement would you add to your plan to prevent that?

The calculation in four steps

Step 1: forage grown on the whole reserve = kg per hectare $\times$ 1,000 hectares. Step 2: usable forage = half of that. Step 3: elk the forage can feed = usable forage $\div$ 1,500 kg, rounded down. Step 4: elk the water can supply = ponds $\times$ 120 (add 100 for each trough). The carrying capacity is the smaller of the Step 3 and Step 4 numbers. For the drought year, Step 1 is $700 \times 1,000 = 700,000$ kg. For the corridor, repeat Steps 1-3 with 300 hectares and add the result to the reserve's number.

The cheapest plan this year, or over twenty years?

Suppose four droughts happen in the next 20 years. Compare the total 20-year cost of a plan built on the corridor and one trough with a plan built on two troughs and drought hay, assuming the herd is 300 at the start of each drought. Then write a paragraph about whether the cheapest plan this year is the cheapest plan overall, and name one cost that is not measured in dollars (for example, the stress of capture or the spread of disease at hay piles).