

Fixing Lake Vesipuro: Test a Restoration Plan on Paper

Investigation question: Which combination of cutting nutrient inflow, netting out plankton-eating fish and stocking predatory fish will bring a fictional murky lake back to clear water within four years, within budget, and keep it clear afterward?

Data-driven decision

Groups of 4

2 sessions

Setup 5 · Activity 85 · Cleanup 5 min

MS-ETS1-4 · practice

MS-LS2-4 · practice

MS-LS2-3 · supports

Name _____

Group _____

Date _____

Your role today

- ☐ **Modeler:** Applies the five model rules in order for each year and reads the results aloud.
- ☐ **Checker:** Recomputes every row independently before it is accepted, and flags any step where the rules were applied out of order.
- ☐ **Accountant:** Tracks the cost of each plan year by year, checks every criterion and constraint, and fills the criteria table.
- ☐ **Spokesperson:** Drafts the group's justification from the recorded numbers and presents the decision to the class.

Safety

- Paper and pencil only; no physical hazards. Keep the discussion about the fictional lake, not about any named local water body, unless you have checked the facts.

Procedure

1. Session 1. Read the baseline dataset and answer q1 and q2: describe the lake's problem with numbers, and write the sign chain the food-web model is betting on (fewer roach → more zooplankton → fewer algae → clearer water).
2. Read the rule card together. Practice the rules on the 'no action' plan for one year: N stays 8, R stays 10, Z = 0, A = 8, clarity = 0.8 m. Every group should get these numbers before going on.
3. Choose two plans from the plan menu that fit the budget (at most 9 units over years 1 to 4). Write each plan's actions in the first column of run sheets A and B.
4. Run plan A for years 1 to 5, one year at a time, applying the rules in order: nutrients, roach, zooplankton, algae, clarity, then cost. The checker recomputes each row before the group moves on. Year 5 has no spending; it tests whether the result holds.
5. Run plan B the same way. Plot clarity against year for both plans on the graph in two colors, and draw the 2.0 m criterion line across the graph.

6. Fill the criteria table for plans A and B. Answer q3: which criteria did each plan meet or miss, and by how much?
7. Session 2. Modify one plan to fix its biggest miss. You may add, remove or move an action, as long as the total stays within budget. Write the modified plan C and your reason for the change (q4). Run plan C for years 1 to 5 and plot it in the third color.
8. Decide. Compare all three plans against every criterion and constraint. Choose one, and write the justification (q5): the numbers that show it meets the criteria, why you preferred it over the other plans, and one limitation of the model that could make the real lake behave differently.
9. Present your decision in under two minutes. Listen for groups that chose a different plan and record what they valued more (cost, speed, holding, anglers). Answer the analysis questions individually.

Record your observations

Lab 3 recording sheet: Fixing Lake Vesipuro

Lake Vesipuro is a **fictional** lake, and every number here is a **teaching dataset** built to behave the way the chapter's food-web model predicts. For decades a town piped sewage into the lake. The sewage carried nutrients that fed the algae, and the water turned green and murky. Fish died in late summer when decomposers breaking down dead algae used up the oxygen. Small plankton-eating fish called roach now swarm; big predatory fish are rare. Your team has four years and nine budget units to bring the lake back.

Baseline monitoring data, three years before the project

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

Year	Nutrient inflow score (0-10)	Roach per net-night	Predatory fish per net-night	Zooplankton per liter	Algae cells per drop	Clarity depth (m)	Dawn oxygen, late summer (mg/L)
3 years ago	8	44	2	10	950	0.8	2.3
2 years ago	8	46	1	8	1000	0.7	1.9
Last year	8	41	2	11	900	0.8	2.1

Clarity depth is how deep a white disk can be lowered before it disappears; deeper means clearer. Fish are stressed when oxygen falls below about 4 mg/L. Simulated data for a fictional lake.

1. Describe the lake's problem using at least three variables from the dataset, with their numbers.

2. Write the sign chain the food-web model is betting on when it says 'fewer roach will clear the water'. Start with roach – and end with clarity.

Model rule card: apply the rules in this order, every year — Start: nutrient score $N = 8$, roach index $R = 10$. Each year: (1) **Nutrients N**: if the inflow has been diverted (built this year or earlier), N falls by 1, minimum 4; otherwise N stays. (2) **Roach R**: if roach are netted this year, $R = 3$. Otherwise $R = \text{last year's } R + 2$ (maximum 10). Then, if predatory fish were stocked in an earlier year, subtract 3 (minimum 1). (3) **Zooplankton Z** = $10 - R$. (4) **Algae A** = $N - Z \div 2$. (5) **Clarity (m)** = $(10 - A) \times 0.4$. Then record the cost of this year's actions.

Plan menu and costs

Action	What it does in the model	Cost (units)	Notes
Divert the nutrient inflow (build a pipeline to a treatment plant)	N falls by 1 every year from the build year on, minimum 4	6, once	Slow because nutrients stored in the bottom mud keep feeding algae for years
Net out roach	$R = 3$ in each year it is done	2 per year	Roach breed fast; R regrows by 2 each year it is not done
Stock predatory fish	R falls by 3 each year starting the year after stocking	3, once	Also gives anglers something to catch by year 4 if stocked by year 2
No action	Nothing changes	0	The lake stays at $N = 8$, $R = 10$, clarity 0.8 m

Criteria (what success means): C1, clarity at least 2.0 m in year 4. C2, clarity still at least 2.0 m in year 5 with no new spending. C3, predatory fish stocked by year 2, so anglers have fish by year 4. **Constraints** (limits): K1, total cost over years 1 to 4 at most 9 units. K2, each action can be taken at most once per year.

Run sheet A (plan: _____)

Year	Actions this year	N	R	$Z = 10 - R$	$A = N - Z \div 2$	Clarity = $(10 - A) \times 0.4$	Cost
1							
2							
3							
4							
5 (no spending)	none						0

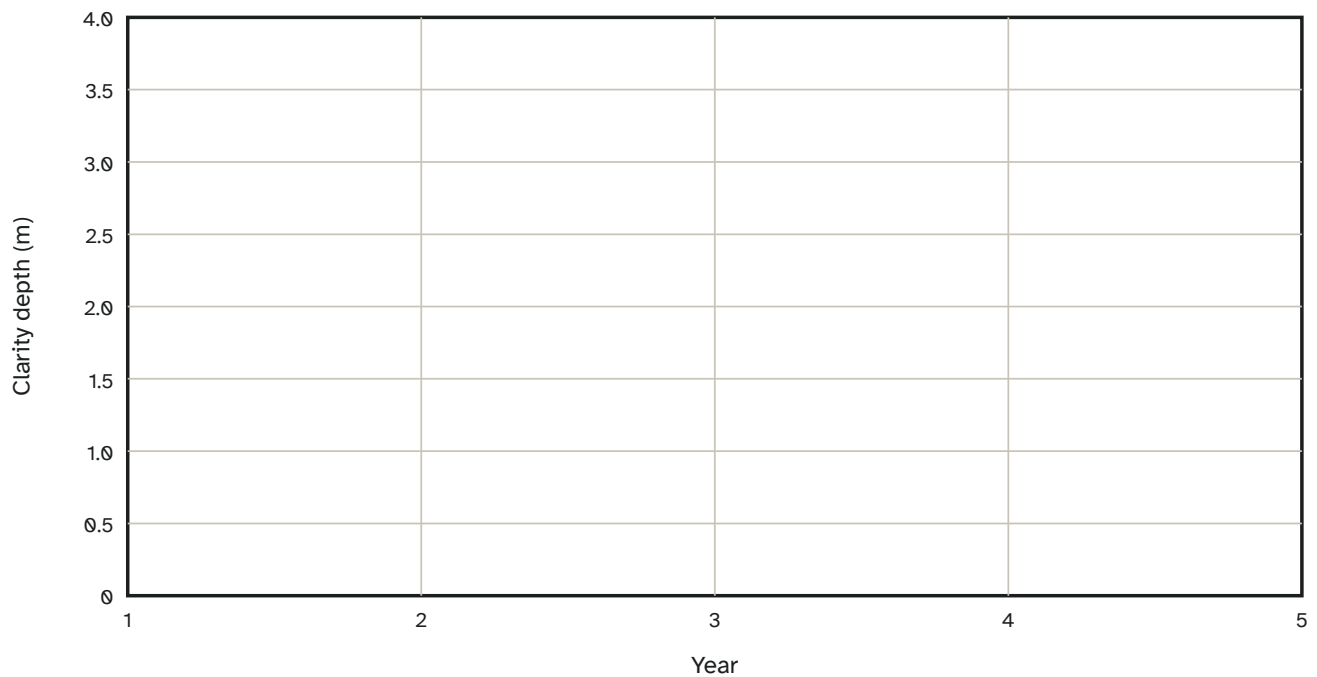
Run sheet B (plan: _____)

Year	Actions this year	N	R	$Z = 10 - R$	$A = N - Z \div 2$	$\text{Clarity} = (10 - A) \times 0.4$	Cost
1							
2							
3							
4							
5 (no spending)	none						0

Run sheet C, the modified plan (plan: _____)

Year	Actions this year	N	R	$Z = 10 - R$	$A = N - Z \div 2$	$\text{Clarity} = (10 - A) \times 0.4$	Cost
1							
2							
3							
4							
5 (no spending)	none						0

Predicted clarity depth by year for plans A, B and C



Criteria and constraints check

Plan	C1: year-4 clarity ≥ 2.0 m?	C2: year-5 clarity ≥ 2.0 m?	C3: predators stocked by year 2?	K1: total cost ≤ 9?	Criteria met (out of 3)
A					
B					
C					

3. For plans A and B, which criteria were met and which were missed? Give the year-4 and year-5 clarity numbers and the total cost for each.

4. What did you change to make plan C, and what miss were you trying to fix? Did the model output show the change worked?

5. Decision and justification. Which plan do you recommend? Give the numbers that show it meets each criterion and the constraint, explain why you preferred it over the others, and name one way the real lake might behave differently from the model.

Analysis questions

6. Run 'divert only' and 'net in year 1 plus stock in year 1' if your group did not already. One works through matter (less nutrient coming in) and the other through the food web (an indirect effect on algae). Compare their year-4 clarity, their cost and which criteria each meets, and explain what each one misses.

7. A plan that nets roach every year for four years reaches 2.2 m every year and then falls to 1.8 m in year 5. Use the rule card to explain why, and explain the real biology the rule stands for.

8. In the model, stocking predators alone takes until year 5 to reach 2.0 m. In the real Finnish lake the textbook describes, scientists stocked predatory fish for several years and also netted out plankton-eating fish. Using your runs, explain why doing both makes sense even though each alone has a weakness.

9. Name two things a real lake has that the model leaves out, and explain how one of them could make a plan that the model says will work fail, or a plan the model rejects succeed.

- 10.** Diverting the inflow lowers algae, and stocking predators also lowers algae, but for different reasons. Explain each using the chapter's ideas: one in terms of matter entering the system and the other in terms of direct and indirect effects.

- 11.** You will only know the real lake is responding by measuring. Name three measurements to make in year 1, say what result would tell you the plan is on track, and what result would make you modify the plan early.
