

Beads, Cards and Cycles: A Fox-and-Vole Simulation

Investigation question: If foxes can only survive by catching voles, and voles can only breed if they are not caught, what pattern do the two populations make over twenty rounds, and which one changes first?

Collaborative systems modeling

Groups of 4

1 session

Setup 5 · Activity 40 · Cleanup 5 min

MS-LS2-2 · practice

MS-LS2-1 · supports

Name _____

Group _____

Date _____

Your role today

- ☐ **Scatterer:** Counts out the voles for the round, drops them onto the meadow from about 20 cm so they spread randomly, and nudges any that land outside the square back inside the edge.
- ☐ **Hunter:** Tosses each fox card from about 20 cm so it lands flat on the meadow, counts the voles it touches, and removes them to the burrow cup before tossing the next fox.
- ☐ **Bookkeeper:** Applies the fox and vole rules at the end of each round (who starves, who reproduces, the sixty-vole cap, immigration) and announces next round's starting numbers.
- ☐ **Recorder and grapher:** Writes every count in the data table, checks the bookkeeper's arithmetic, and plots both populations on the graph as the rounds go by.

Safety

- Beads and beans are a choking hazard for small children and pets; keep them away from mouths and count them back into the burrow cup at the end so none leave the room.
- Beads on a hard floor are a slip hazard; stop and pick up any that escape the tray before continuing.
- Toss cards onto the meadow only, never at a person, and keep the drop height to about 20 cm so beads do not bounce out.
- No chemicals, heat or sharp tools are used; scissors are used only during teacher prep.

Procedure

1. Set up the meadow in its tray. Put 6 voles on the meadow and 1 fox card in the hunter's hand. Put the rest in the burrow cup and the den cup. Write '6 voles, 1 fox' in the row for round 1.
2. Scatterer: stand at the X corner, collect the voles, hold your hand about 20 cm above the middle of the meadow, and drop them so they spread across it. Move any vole that lands outside the square, or rolls against the tray wall, back onto the meadow a few centimeters in from the edge.
3. Hunter: toss the first fox card from about 20 cm so it lands flat somewhere on the meadow. If it lands partly off the square, toss it again. Count every vole the card touches or covers; those voles are caught. Move them to the burrow cup. Repeat for every fox card, one at a time.

4. Bookkeeper: decide each fox's fate from what it caught. Caught 0, 1 or 2: the fox starves; put its card in the den cup. Caught 3, 4 or 5: the fox survives. Caught 6 or more: the fox survives and raises one pup; take one extra card from the den cup for next round.
5. Bookkeeper: count the voles still on the meadow. Each survivor has a litter, so double the number by adding the same number of voles from the burrow cup. The meadow can feed only 60 voles; if doubling would give more than 60, use 60.
6. Immigration: if no voles are left after step 5, 3 voles move in from a neighboring meadow. If no foxes are left after step 4, 1 fox moves in. Record the number of voles and foxes that will start the next round.
7. Recorder: fill in the row for the round (voles and foxes at the start, total voles caught, fox fates, voles after breeding, foxes for next round), then plot the two starting counts for the round on the graph. Use one color for voles and another for foxes.
8. Repeat steps 2 to 7 until you have completed 20 rounds. Rotate roles every five rounds so everyone scatters, hunts and keeps the books.
9. Connect the vole points with one line and the fox points with another. Mark the first vole peak with a V and the first fox peak with an F. If the voles sit at the 60 cap for several rounds, the peak is that whole flat top: put the V on the last round at 60, just before the voles start to fall.
10. Answer the recording-sheet questions, return every bead and card to the cups, and count them: 70 beads and 12 cards.

Record your observations

Lab 1 recording sheet: Beads, cards and cycles

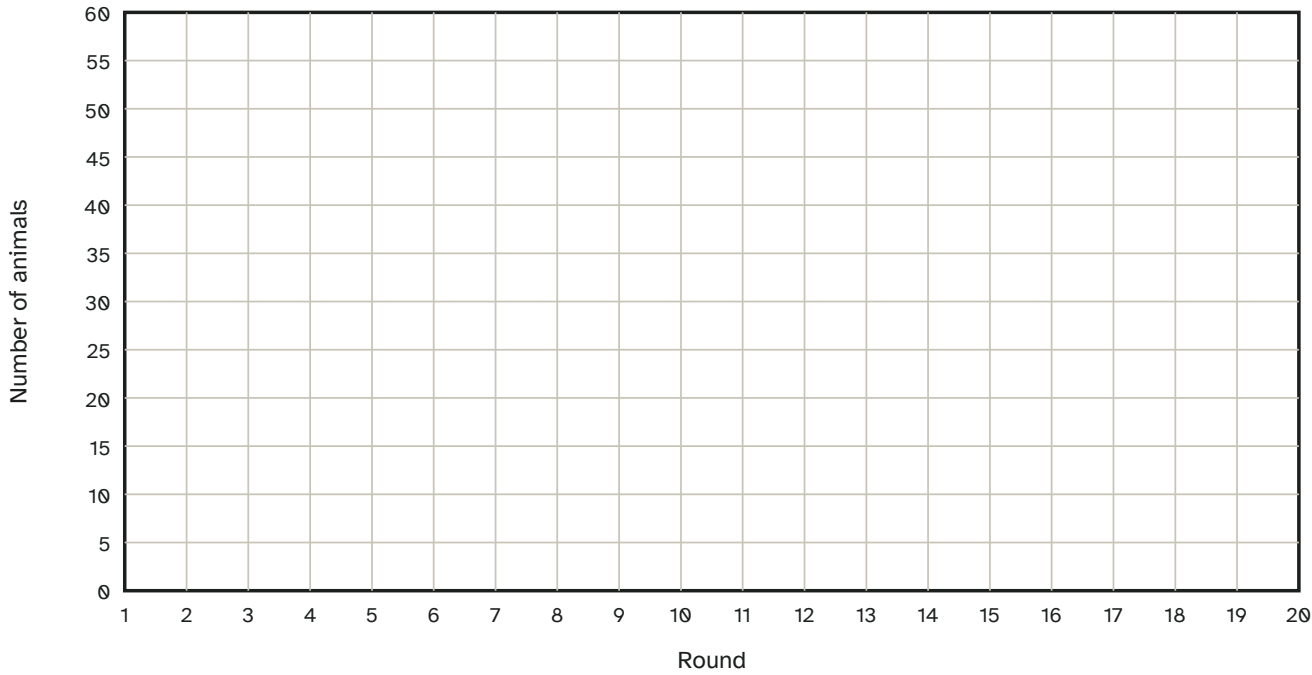
The rules in short — A fox that catches 0-2 voles starves. A fox that catches 3-5 survives. A fox that catches 6 or more survives and adds one pup. Surviving voles double, up to a limit of 60. If voles hit zero, 3 move in; if foxes hit zero, 1 moves in.

Round-by-round data (counts are at the start of each round)

Round	Voles at start	Foxes at start	Total voles caught	Fox fates (S = survived, X = starved, P = pup added)	Voles after doubling (max 60)	Foxes for next round
1	6	1				
2						
3						
4						
5						
6						
7						

Round	Voles at start	Foxes at start	Total voles caught	Fox fates (S = survived, X = starved, P = pup added)	Voles after doubling (max 60)	Foxes for next round
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						

Voles and foxes at the start of each round



1. In which round did the voles first peak (the last round at the top, if they stayed at 60 for a while), and in which round did the foxes first peak? How many rounds apart are they?

2. Look at the rounds right after the fox peak. What happened to the voles, and then what happened to the foxes? Use numbers from your table.

Analysis questions

3. Round 9 in one group began with 24 voles and 2 foxes. The first fox card caught 7 voles and the second caught 4. Using the rules, how many voles and how many foxes begin round 10? Show each step.

4. Which rule in the model causes the fox line to rise after the vole line, instead of at the same time? Explain how that rule stands in for something that happens to real predators.

5. Describe the overall shape of your two lines across the twenty rounds. Did the pattern repeat? Were the second peaks the same height as the first? Explain why a repeat with different heights still counts as the pattern.

6. Compare your graph to the textbook's account of wolves and moose on Isle Royale. Name one way the model matches it and one way the island is more complicated than the model.

7. Suppose you renamed the beads 'sea urchins' and the cards 'sea otters' and ran the same rules. Predict the graph. Then explain why ecologists expect the same pattern in a kelp forest, a desert and a meadow even though the species are different.

8. List two rules in the model that are not like real life, and for each one say how it might change the shape of the graph compared with real population data.

9. Round 14 began with 60 voles and 7 foxes. The seven fox cards caught 9, 8, 6, 5, 3, 2 and 1 voles. How many voles and foxes begin round 15? Show your work.
