

Reading the Fur Ledger: Peaks, Lags and a Rising Line

Learning target: I can graph predator and prey records, calculate the cycle length and the lag between peaks, judge what the evidence can and cannot show about causes, and compare the pattern with real human population data.

Data and graphing

About 50 min

Individual

MS-ESS3-4 · supports

MS-LS2-1 · supports

MS-LS2-5 · supports

data analysis

independent practice

writing

Standards connections

MS-ESS3-4 (supports): Part C has students compute intervals from real United Nations population estimates and test the claim that growth is speeding up. In California this is a Grade 8 performance expectation; the sheet builds the data skills it relies on but does not assess the argument about Earth's systems.

MS-LS2-1 (supports): Students interpret predator-prey records and a real food-and-predator experiment as evidence for how resource availability and predation affect a population, revisiting an earlier Grade 7 idea.

MS-LS2-5 (supports): Contrasting a self-limiting wild cycle with steady human growth sets up why people must design solutions that keep ecosystems working; no solution is evaluated on this sheet.

Purpose: practice · **Time:** about 50 minutes · **Format:** individual

Answers with reasoning

Part A: The fur ledger

For more than a century, trading posts across northern Canada recorded the snowshoe hare and Canada lynx pelts that trappers brought in. A pelt count tells you how many animals were trapped, which depends on how many animals there were but also on how many trappers were working and what furs were worth.

Pelts traded per year at a group of trading posts (teaching dataset)

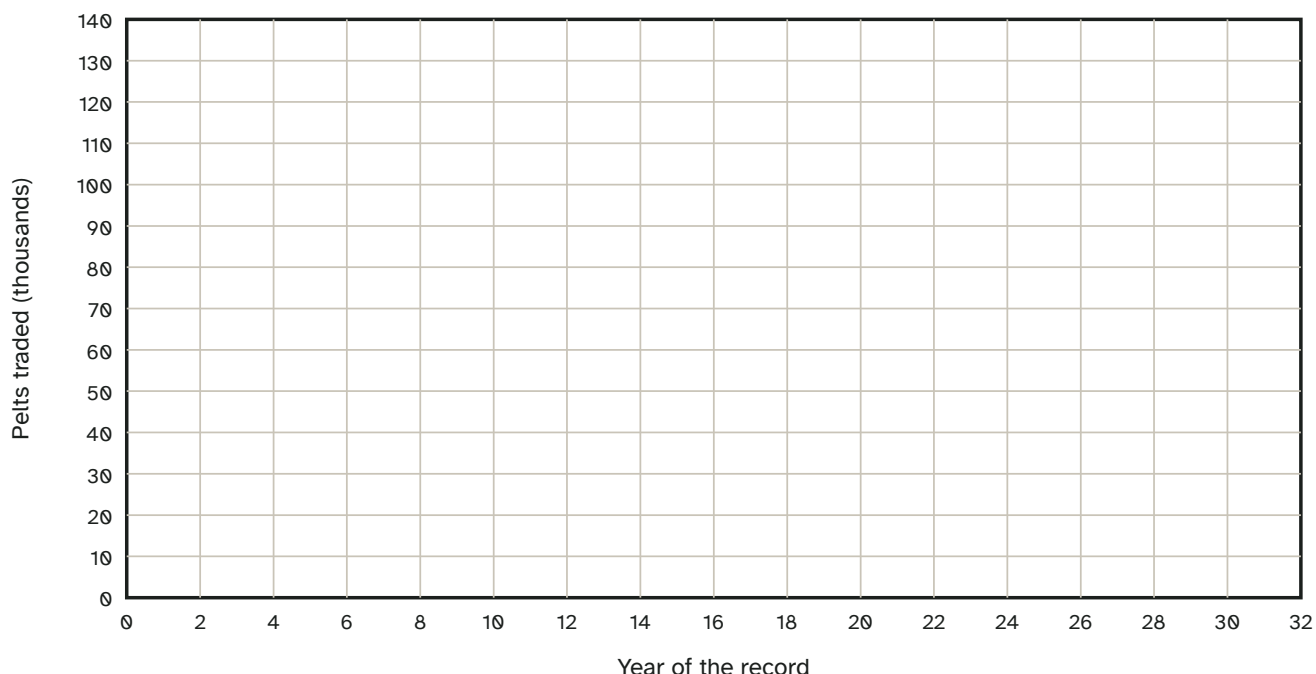
Simulated teaching dataset: the numbers are invented to be realistic, not measured.

Year	Hare pelts (thousands)	Lynx pelts (thousands)
1	20	8
2	45	9
3	90	14
4	120	25
5	80	38
6	30	33

Year	Hare pelts (thousands)	Lynx pelts (thousands)
7	10	18
8	6	8
9	9	4
10	22	3
11	50	5
12	95	11
13	130	22
14	105	34
15	40	41
16	12	26
17	5	12
18	7	5
19	18	3
20	40	4
21	75	8
22	110	15
23	115	27
24	70	36
25	25	39
26	8	24
27	5	10
28	12	5
29	35	4
30	70	7
31	100	12

Simulated data for teaching. The values are invented to copy the real pattern in Hudson's Bay Company records: a cycle of about ten years, with lynx peaks a year or two after hare peaks. Year 1 is the first year of the record.

Hare and lynx pelts traded per year



- From the table, list the three years when hare pelts peaked and the three years when lynx pelts peaked. (A peak is a year higher than the year before and the year after.)

Answer: Hare peaks: years 4 (120), 13 (130) and 23 (115). Lynx peaks: years 5 (38), 15 (41) and 25 (39).

Why: Each listed year is higher than the years on either side of it in the table.

Also acceptable: None; the peaks are unambiguous in the table.

- Calculate the time between the first and second hare peaks and between the second and third. What is the average cycle length?

Answer: $13 - 4 = 9$ years; $23 - 13 = 10$ years. Average = $(9 + 10) \div 2 = 9.5$ years.

Why: The real fur records show a cycle of roughly 9 to 10 years, which this teaching dataset copies.

Also acceptable: Accept 9.5 years or 'about 10 years' with the work shown.

- For each cycle, calculate the lag: lynx peak year minus hare peak year. Then find the average lag to one decimal place.

Answer: Lags: $5 - 4 = 1$ year; $15 - 13 = 2$ years; $25 - 23 = 2$ years. Average = $(1 + 2 + 2) \div 3 = 5 \div 3 \approx 1.7$ years.

Why: In real records the lynx peak usually trails the hare peak by about one to two years, sometimes more.

Also acceptable: Accept 1.67 years.

4. Divide the highest hare count in the record by the lowest hare count that follows it. How many times bigger is the boom than the bust?

Answer: Highest hare count: 130 thousand (year 13). Lowest that follows: 5 thousand (year 17). $130 \div 5 = 26$ times.

Why: Real hare cycles also swing by more than tenfold between peak and low.

Also acceptable: If a student uses the year-27 low of 5 thousand after the year-23 peak of 115 thousand, $115 \div 5 = 23$ times earns credit with work shown.

5. Use births and deaths to explain why lynx numbers keep rising for a year or two after hares have started to crash, and why they then fall.

Answer: When hares are plentiful, lynx find food easily, more kittens survive and fewer adults starve, so the lynx population keeps growing; new lynx are still being born and raised even as hares begin to crash. Once hares are scarce, lynx cannot find enough food, few kittens survive, adults starve or leave, and lynx numbers fall a year or two after the hares.

Why: The lag reflects the time it takes births and deaths to respond to a change in food supply.

Also acceptable: Accept answers that also mention lynx moving away when hares are scarce.

- Links lynx births or survival to hare abundance
- Explains the delay
- Explains the later fall through starvation or low kitten survival

Part B: Testing the causes

Pelt records show a pattern, but they cannot show what causes it. Ecologists have long debated whether hares crash mainly because predators catch up with them, because winter food (twigs and bark) runs out, or both. In the Yukon in the late 1980s and early 1990s, a team led by Charles Krebs changed conditions in separate square-kilometer blocks of forest: they fenced out mammal predators such as lynx and coyotes (owls and hawks could still fly in), added food, or did both, and compared each block with an unchanged block.

Hare numbers during the peak and decline, compared with an unchanged forest block

Treatment	Hares compared with the unchanged block
Unchanged block (control)	1 times
Mammal predators fenced out	about 2 times
Food added	about 3 times
Predators fenced out and food added	about 11 times

Real results, rounded, from Krebs and others, Science, 1995. '2 times' means about twice as many hares per area as the unchanged block.

6. Which explanation do the experiment results support best: predators alone, food alone, or both together? Use the numbers. Explain why an experiment like this gives stronger evidence about causes than the pelt records do.

Answer: Both together. Fencing out predators alone gave about 2 times as many hares and adding food alone gave about 3 times, but doing both gave about 11 times, far more than either alone. So predators and food both matter, and they work together. The experiment is stronger evidence because the scientists changed one factor at a time and compared it with an unchanged block, so they could see the effect of each cause; the pelt records only show that two numbers change together, and trapping effort and prices also affect them.

Why: Krebs and colleagues (1995) concluded that food and predation interact to produce the cycle; 11 is larger than either 2 or 3 and larger than their sum.

Also acceptable: Accept 'predators matter most, but food matters too' if the student uses the numbers and acknowledges the combined result. Note that the debate continues: later Kluane work found that stress from predators also lowers hare reproduction.

- Chooses both together
- Uses the numbers 2, 3 and 11
- Explains why a controlled comparison shows causes better than a pattern

7. Give two reasons a year with many lynx pelts might not be a year with many lynx.

Answer: More trappers may have been working that year; fur prices may have been high, so trappers tried harder; lynx may be easier to trap when they are hungry and moving more; records from some posts may be missing or combined differently.

Why: Pelt counts are an index of trapping, not a census, so they track but do not equal population size.

Also acceptable: Accept 'traps were set in a different area that year'.

- Two distinct reasons related to trapping or record keeping

Part C: The human line

World population milestones and projections

World population	Year
1 billion	about 1804
2 billion	1927
3 billion	1960
4 billion	1974
5 billion	1987
6 billion	1999
7 billion	2011
8 billion	2022
about 8.2 billion	2025 (estimate)
9 billion (projected)	about 2037

World population	Year
about 10.3 billion, the projected peak	mid-2080s

Real estimates and projections from the United Nations (World Population Prospects 2024 and UN Population Fund 2025 estimate). Early dates are least certain; projections may change.

8. Calculate how many years it took to add each billion people.

Answer: 1 → 2: 1927 – 1804 = 123 years. 2 → 3: 1960 – 1927 = 33. 3 → 4: 1974 – 1960 = 14. 4 → 5: 1987 – 1974 = 13. 5 → 6: 1999 – 1987 = 12. 6 → 7: 2011 – 1999 = 12. 7 → 8: 2022 – 2011 = 11. 8 → 9: about 2037 – 2022 = about 15 (projected).

Why: Simple subtraction of milestone years.

Also acceptable: Accept 'about 15' for the projected value.

9. An older textbook says the human population is 'growing at an increasing rate'. Use your answers to q8 to evaluate this claim for the years since 1974. Is the total still rising? Is it rising faster and faster?

Answer: The total is still rising: each billion has been added. But since 1974 each billion has taken about the same time (11 to 13 years), and the next is projected to take about 15. Adding about the same number of people each year to a bigger and bigger population means the percentage growth rate is falling. So growth is not speeding up anymore; it is still large, but slowing in relative terms.

Why: The UN reports that the growth rate peaked in the 1960s and has fallen since; the population is projected to peak around 10.3 billion in the mid-2080s.

Also acceptable: Accept 'the rate was increasing until about the 1970s and has slowed since' with interval evidence.

- States the total is still rising
- Uses the intervals as evidence
- Concludes the claim of ever-faster growth is no longer accurate

10. Compare the hare record with the human record. Why does one cycle while the other has kept rising? Then explain why a human population that is growing more slowly can still put more and more pressure on ecosystems. Use the term **per capita** in your answer.

Answer: Hares are limited by local food and by predators, so a boom brings its own crash. People have no major predator and have expanded food supply with farming, trade, medicine and clean water, so deaths fell and the population kept rising. Even with slower growth, the total keeps getting bigger, and per capita use of energy, water and materials has also risen; total demand is roughly population times per capita use, so pressure on ecosystems can keep climbing unless the technologies people use are designed to cause less harm.

Why: This contrasts self-limiting wild populations with human growth and connects to the population-times-consumption idea of MS-ESS3-4.

Also acceptable: Accept answers noting that some places have shrinking populations but high per capita use.

- Explains why hares cycle (food and predators)
- Explains why people have not cycled
- Uses per capita correctly and links total demand to population and use per person

Teacher notes

Part A is simulated and labeled; it copies the real Hudson's Bay Company pattern (about a ten-year cycle, lynx peaks lagging hare peaks by about one to two years). Part B's numbers are real and rounded from Krebs et al. (1995, Science 269:1112-1115): predator exclosure doubled hare density, food addition tripled it, and both together raised it about elevenfold during the peak and decline. The exclosures kept out mammals but not owls and hawks. Part C uses UN milestone estimates, the UNFPA 2025 estimate (8,232 million) and WPP 2024 projections (9 billion around 2037, peak about 10.3 billion in the mid-2080s). The textbook's statement that population is growing 'at an increasing rate' is dated; q9 lets students correct it from data. The extension refers to Gilpin's 1973 paper 'Do hares eat lynx?'.

Scaffold offered to students: Finding peaks and lags

Run your pencil down the hare column and circle each number that is bigger than both of its neighbors; those are the peaks. Do the same for lynx with a box. Then pair each hare circle with the next lynx box below it and subtract the years. For q8, subtract the earlier year from the later year in each pair of rows.

Extension: Do hares eat lynx?

In 1973 an ecologist wrote a paper with that joking title, because in some stretches of the old fur records the hare peaks seem to come after the lynx peaks, which a simple predator-prey model cannot explain. One reason is that the famous hare series was stitched together from different regions and sources. Write a paragraph explaining how combining records from different places and different collection methods could create a misleading pattern, and propose a rule a scientist should follow before comparing two long-term data series.