

With and Without Beavers: What the Stream Surveys Show

Learning target: I can graph survey data from streams with and without beaver ponds, calculate averages and differences, and use the patterns to make a claim about how a change to a physical component affects populations.

Data and graphing

About 50 min

Pairs

MS-LS2-4 · practice

MS-LS2-1 · supports

data analysis

independent practice

Standards connections

MS-LS2-4 (practice, recognizing patterns in data and making warranted inferences, the emphasis of the clarification statement): Students analyze with-and-without and before-and-after stream data showing that a change to physical components (water depth and speed behind a beaver dam) shifted three populations, and they write a claim the data support. They do not yet build the full written argument with reasoning, which comes in W6, so the role is practice.

MS-LS2-1 (supports): Still, deep water and fast, oxygen-rich water are resources that different populations need. Students use the resource-population link from Lesson 20 to explain why the counts moved in opposite directions.

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

Answers with reasoning

The study

In July 2024, ecologists surveyed eight short sections of mountain stream, called reaches, in the same valley during the same week. Four reaches had an active beaver dam with a pond behind it. The other four were similar reaches nearby with no beavers. All eight were at about the same elevation, ran through the same kind of forest, and were sampled with the same nets in the same way. In each reach the team measured water depth and water speed, then counted three kinds of animals: **tadpoles** of the Pacific chorus frog, which develop in still or very slow water; **stonefly larvae**, insects that cling to rocks and need fast, cold water with plenty of oxygen; and **dragonfly larvae** of kinds that hunt small animals in still water.

Stream survey of eight reaches in one valley, July 2024 (teaching dataset)

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

Reach	Beaver pond?	Water depth (cm)	Water speed (cm/s)	Chorus frog tadpoles	Stonefly larvae	Dragonfly larvae
A	yes	120	5	64	2	18
B	yes	95	8	48	4	14
C	yes	140	3	71	1	22
D	yes	105	6	57	5	16
E	no	30	45	6	38	3
F	no	25	52	2	44	1
G	no	35	40	9	31	4
H	no	30	47	3	39	2

Simulated data for teaching. Tadpoles and dragonfly larvae are counts per 10 sweeps of a dip net; stonefly larvae are counts per kick-net sample. Reaches A to D have a beaver pond; reaches E to H do not.

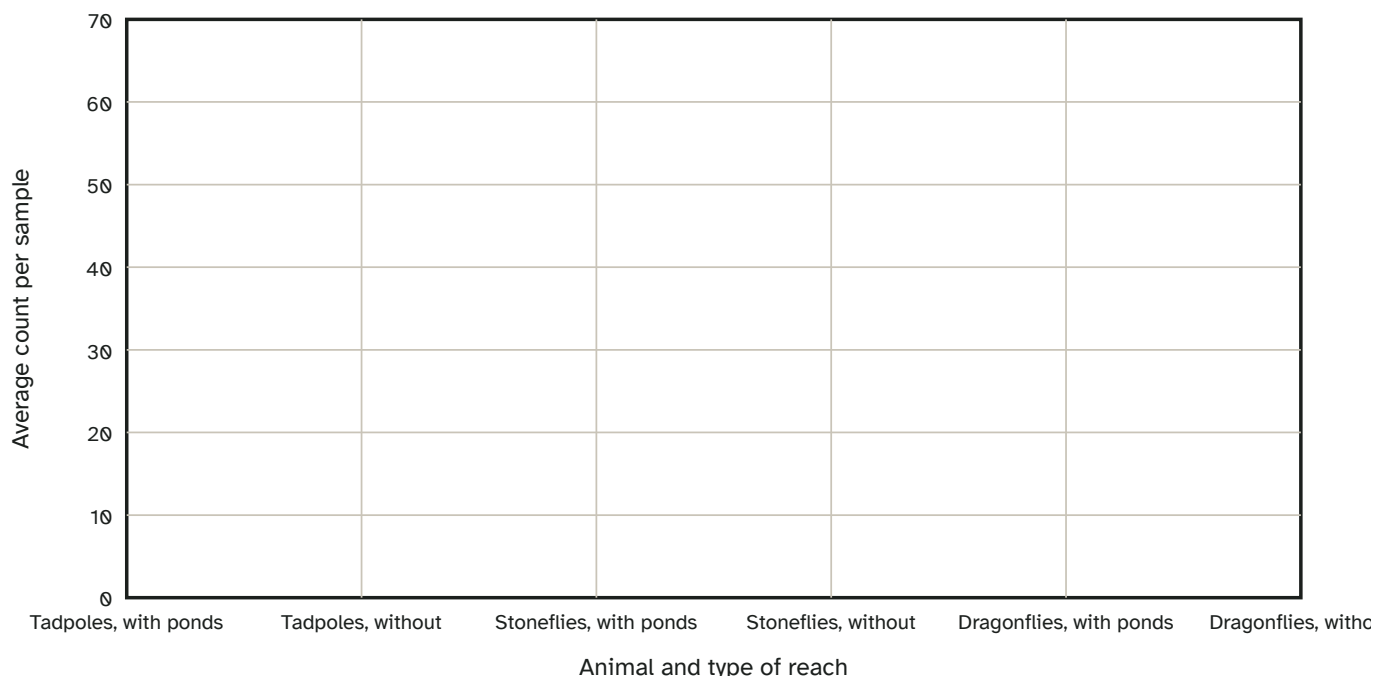
Part A: Compare reaches with and without beaver ponds

1. Calculate the average (mean) of each measurement for the four reaches with beaver ponds (A to D) and the four without (E to H). Write each average to one decimal place. Show one full calculation below the table.

Answer: With beaver ponds: depth $(120 + 95 + 140 + 105) \div 4 = 460 \div 4 = 115.0$ cm; speed $(5 + 8 + 3 + 6) \div 4 = 22 \div 4 = 5.5$ cm/s; tadpoles $(64 + 48 + 71 + 57) \div 4 = 240 \div 4 = 60.0$; stoneflies $(2 + 4 + 1 + 5) \div 4 = 12 \div 4 = 3.0$; dragonflies $(18 + 14 + 22 + 16) \div 4 = 70 \div 4 = 17.5$. Without beavers: depth $(30 + 25 + 35 + 30) \div 4 = 120 \div 4 = 30.0$ cm; speed $(45 + 52 + 40 + 47) \div 4 = 184 \div 4 = 46.0$ cm/s; tadpoles $(6 + 2 + 9 + 3) \div 4 = 20 \div 4 = 5.0$; stoneflies $(38 + 44 + 31 + 39) \div 4 = 152 \div 4 = 38.0$; dragonflies $(3 + 1 + 4 + 2) \div 4 = 10 \div 4 = 2.5$.

Why: Each average is the sum of four reaches divided by 4. The numbers were chosen so every average comes out exact to one decimal place, which makes errors easy to spot.
Also acceptable: Accept 115 and 30 without the decimal. A student who averages all eight reaches together has missed the point of the comparison and should redo the table.

Average animal counts in reaches with and without beaver ponds



2. On average, how many times as many chorus frog tadpoles were found in reaches with beaver ponds as in reaches without? How many times as many dragonfly larvae? Show each division.

Answer: Tadpoles: $60.0 \div 5.0 = 12$ times as many. Dragonfly larvae: $17.5 \div 2.5 = 7$ times as many.

Why: 'Times as many' is the larger average divided by the smaller one.

Also acceptable: Accept '12 to 1' and '7 to 1'. A student who subtracts (55 more tadpoles, 15 more dragonfly larvae) has computed a difference, not a ratio; give partial credit and ask for the division.

3. By what percent were stonefly larvae lower in the reaches with beaver ponds? Use (average without – average with) $\div$ average without $\times 100$, and show your work.

Answer: $(38.0 - 3.0) \div 38.0 \times 100 = 35 \div 38 \times 100 = 92.1$ percent lower.

Why: The percent change is measured against the starting comparison value, which here is the no-beaver average of 38.0.

Also acceptable: Accept 92 percent. Dividing by 3.0 instead of 38.0 (giving about 1,167 percent) is the most common error; point out that a count cannot fall by more than 100 percent.

4. Describe the pattern in your graph in two sentences: which animals were more common where there were beaver ponds, and which were less common?

Answer: Chorus frog tadpoles (60.0 versus 5.0) and dragonfly larvae (17.5 versus 2.5) were much more common in reaches with beaver ponds. Stonefly larvae were much less common there (3.0 versus 38.0).

Why: The graph shows two pairs with tall shaded bars and one pair with a tall open bar; the pattern runs in opposite directions for different animals.

Also acceptable: Accept the pattern described in words if the student refers to bar heights.

- Names tadpoles and dragonfly larvae as more common with ponds
- Names stonefly larvae as less common with ponds
- Uses at least one pair of numbers

5. Use the depth and speed averages to explain the pattern. What did the beaver dams change about the stream, and why would that change help tadpoles and dragonfly larvae but hurt stonefly larvae?

Answer: The dams made the water much deeper (115.0 cm versus 30.0 cm) and much slower (5.5 cm/s versus 46.0 cm/s). Tadpoles develop in still or very slow water, and these dragonfly larvae hunt in still water, so the pond gave them habitat they lack in a fast stream. Stonefly larvae need fast, cold water with plenty of oxygen flowing over rocks; slow, deep pond water gives them less oxygen and covers their rocks with silt, so they lost habitat.

Why: This is the mechanism step: a change to physical components (depth and speed) changes which resources are available, and each population responds to the resource it needs.

Also acceptable: Accept 'warmer water' for the stonefly decline; ponds in sun do warm up, although temperature was not measured here.

- Uses the depth and speed numbers
- Explains why still water helps tadpoles and dragonfly larvae
- Explains why slow water hurts stonefly larvae (oxygen, current, rock surfaces)

6. Counts vary within each group. For example, tadpoles ranged from 48 to 71 in the beaver-pond reaches. For each animal, compare the **lowest** count in one group with the **highest** count in the other. What do you find, and why does surveying four reaches of each kind make the pattern more convincing than surveying one of each?

Answer: Tadpoles: the lowest beaver-pond count (48, reach B) is far above the highest no-beaver count (9, reach G). Dragonfly larvae: the lowest with ponds (14, reach B) is above the highest without (4, reach G). Stonefly larvae: the highest with ponds (5, reach D) is far below the lowest without (31, reach G). The groups never overlap. With four reaches of each kind, the difference cannot be explained by one unusual reach; every single pond reach differs from every single no-beaver reach in the same direction.

Why: Checking for overlap is a simple way to see whether a difference between averages is consistent or driven by one extreme value. Repetition is one of the features of a strong argument from slide 22.

Also acceptable: A student who explains that one reach could be odd for many reasons (a predator, a shady bend) has the key idea.

- Makes the comparison for at least two animals with correct numbers
- States that the groups do not overlap
- Explains why several reaches are better than one

Part B: One reach, before and after

Reach J is in the same valley. Until the autumn of 2020 it was a fast, shallow stretch like reaches E to H. That autumn a beaver family built a dam there. The team had surveyed reach J every July since 2017, so they have four summers of data from before the dam. In 2021, the first summer after the dam, the pond was still filling and the stream bed was still changing.

Reach J surveys, 2017 to 2024 (teaching dataset)

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

July survey	Chorus frog tadpoles (per 10 sweeps)	Stonefly larvae (per kick sample)
2017	4	41
2018	7	36
2019	3	44
2020	5	39
2021	31	18
2022	52	6
2023	58	4
2024	61	3

Simulated data for teaching. Same methods as the survey above. The beaver dam was built in autumn 2020, after the July 2020 survey.

7. Calculate the average tadpole count and the average stonefly count for the four years before the dam (2017 to 2020) and for the three most recent years (2022 to 2024). Leave out 2021, when the pond was still filling. Then give the change in each average.

Answer: Tadpoles before: $(4 + 7 + 3 + 5) \div 4 = 19 \div 4 = 4.75$, about 4.8. Tadpoles after: $(52 + 58 + 61) \div 3 = 171 \div 3 = 57.0$. Change: $57.0 - 4.75 = 52.25$, an increase of about 52.3 per 10 sweeps. Stoneflies before: $(41 + 36 + 44 + 39) \div 4 = 160 \div 4 = 40.0$. Stoneflies after: $(6 + 4 + 3) \div 3 = 13 \div 3 = 4.33$, about 4.3. Change: $40.0 - 4.33 = 35.67$, a decrease of about 35.7 per sample.

Why: The 'after' average uses three years because 2021 is a transition year, and the question tells students to leave it out.

Also acceptable: Accept 52.2 for the tadpole change if the student subtracts the rounded 4.8, and 35.7 or 35.6 for the stonefly change depending on rounding. Ratios (about 12 times as many tadpoles, about one ninth as many stoneflies) are a fine addition.

8. Before the dam, tadpole counts at reach J went up and down from 3 to 7. Why do four years of 'before' data make the comparison more trustworthy than using only the 2020 survey?

Answer: Populations rise and fall from year to year even when nothing special happens. One 'before' year could have been unusually high or low. Four years show the normal range (3 to 7 tadpoles), so we can see that the after-dam counts (52 to 61) are far outside anything that happened naturally before.

Why: A baseline of several years separates a real change from ordinary variation, which is why ecologists value long-term monitoring.

Also acceptable: Accept 'if 2020 had been a bad year, the change would look bigger than it really is'.

- Says counts vary naturally between years
- Explains that several years show the normal range to compare against

9. Part A is a **with-and-without** comparison and Part B is a **before-and-after** record. Give one weakness of each kind of evidence, and explain how the other kind helps cover it. Then name one more set of measurements that would make the case stronger still.

Answer: With-and-without weakness: beavers might choose places that were already different (a flatter valley floor or more groundwater), so the difference could come from the place rather than the dam. The before-and-after record at reach J covers this, because the same place changed right after the dam was built. Before-and-after weakness: something else might have changed in the whole valley around 2021, such as a wet year or warmer summers. The with-and-without survey helps here, because the no-beaver reaches still had few tadpoles (2 to 9) in 2024, so a valley-wide change did not produce tadpole booms without ponds. Stronger still: yearly counts at reaches E to H from 2017 to 2024 alongside reach J, surveys in more valleys, or measurements of oxygen and temperature to test the mechanism.

Why: This item asks students to see that each kind of evidence answers a different 'what else could explain it?' question, which is the reasoning behind combining them.

Also acceptable: Accept 'the with-and-without data come from only one summer' as a weakness of Part A; accept 'reach J is only one stream' as a weakness of Part B.

- One weakness of the with-and-without comparison
- One weakness of the before-and-after record
- How each kind covers the other's weakness
- One sensible additional measurement

10. Write one claim these data support about how a beaver dam affects populations in a stream, and back it with at least three numbers from this sheet. Then explain why the claim **'Beaver dams are good for streams'** is not supported by these data.

Answer: Supported claim: A beaver dam makes a stretch of stream deeper and slower, and in that stretch chorus frog tadpoles and dragonfly larvae increase while stonefly larvae decrease. Numbers: pond reaches averaged 115.0 cm deep and 5.5 cm/s versus 30.0 cm and 46.0 cm/s; tadpoles 60.0 versus 5.0 (12 times as many); stoneflies 3.0 versus 38.0 (92.1 percent lower); at reach J, tadpoles rose from an average of 4.75 to 57.0 and stoneflies fell from 40.0 to 4.3 after the 2020 dam. Not supported: 'good' is a value judgment, not a measurement. The data show winners and losers (stoneflies lost), they cover only the dammed stretches, not the water downstream or the fish, birds and plants of the whole stream, and they come from one valley. A scientist would describe which populations go up and down rather than give the dam a grade.

Why: Full credit separates a claim about measured directions of change from a judgment. This is the same distinction as the prairie dog 'good or bad' discussion on slide 16.

Also acceptable: A student who argues that beaver ponds increase the number of kinds of animals (biodiversity) is making a different claim; ask whether the data measured that (they counted only three kinds).

- A claim that names the physical change and at least two population changes with directions
- At least three accurate numbers
- Explains that 'good' is a judgment and that stoneflies lost
- Notes at least one limit of the data's scope

Teacher notes

Both datasets are simulated. The patterns follow what field studies of beaver ponds commonly report: pond-breeding amphibians and still-water insects increase in impounded reaches, while insects that need fast, oxygen-rich water, such as many stoneflies, decline in those stretches. Real effects vary with stream size, climate and how long the pond has existed, and effects downstream of dams differ again, so keep claims to the dammed reaches. The reach numbers were chosen so that the q1 averages are exact and the groups never overlap; q6 makes students notice that. Common errors: dividing by the smaller value in q3, averaging all eight reaches together in q1, and including 2021 in the q7 'after' average. This sheet uses the same counting-and-comparing logic as Lab 3 and the with-and-without idea on slide 17. Beaver dam analogs in the extension are a real restoration technique used in western streams.

Scaffold offered to students: Three calculations, step by step

Average: add the four values, then divide by 4 (example with made-up numbers: $10 + 12 + 14 + 8 = 44$; $44 \div 4 = 11.0$). 'How many times as many': divide the bigger average by the smaller one ($30 \div 6 = 5$ times). Percent lower: subtract the smaller from the bigger, divide by the bigger, then multiply by 100 ($(20 - 5) \div 20 = 0.75$; $0.75 \times 100 = 75$ percent). Write each step on its own line so you can check it.

Extension: Design a before-after-control-impact study

Ecologists often combine both kinds of evidence in one design called before-after-control-impact: they survey places that will get a change and similar places that will not, both before and after the change. A restoration group plans to install beaver dam analogs (rows of wooden posts with willow branches woven between them, which slow water the way a beaver dam does) in two of reaches E to H next autumn. Design the study: which reaches get structures and which are left alone, what you would measure, in which years, and what pattern of results would convince you the structures caused any change. Sketch the line graph you would expect if they work.