

Fixing Talia's Field Report: Counting, Calculating and Naming Biodiversity

Learning target: I can find and explain the errors in a student's biodiversity report, correct a diversity index calculation, and rewrite each mistaken statement so it is scientifically accurate.

Error analysis

About 40 min

Individual

MS-LS2-4 · practice

MS-LS2-5 · supports

writing

independent practice

Standards connections

MS-LS2-4 (practice): Statement 7 asks students to explain how a physical change (a freeway) affects a population's genetic diversity, and the corrections require using data rather than impressions, both part of arguing that ecosystem changes affect populations.

MS-LS2-5 (supports): Statement 8 is a flawed design for maintaining biodiversity; diagnosing it prepares students to judge real design solutions against what biodiversity actually includes.

Purpose: practice · **Time:** about 40 minutes · **Format:** individual

Answers with reasoning

Talia's data — School lawn: about 3,000 plants of 2 species (two kinds of lawn grass). Creek banks: about 200 plants of 23 species. Creek plot 1 (50 plants): 10 of each of 5 species. Creek plot 2 (50 plants): 42 of one species and 2 each of 4 other species.

Talia's field report

1. Biodiversity means how many living things there are. The school lawn has more biodiversity than the creek, because we counted about 3,000 plants on the lawn and only about 200 along the creek.
2. Creek plot 1 and creek plot 2 each have 5 plant species, so they have the same species richness.
3. Since their species richness is the same, plots 1 and 2 must be equally diverse.
4. I calculated Simpson's index for plot 1. Each proportion is $10 \div 50 = 0.2$, and $0.2 + 0.2 + 0.2 + 0.2 + 0.2 = 1.0$, so the index is $1 - 1.0 = 0$. Plot 1 has no diversity at all.
5. Sea otters went extinct in Washington State around 1910. Then people brought otters from Alaska in 1969 and 1970, so an extinct species came back.
6. Tomatoes are not native to California, so the tomatoes in our school garden are an invasive species and should be pulled out.
7. A freeway cannot change the mountain lions' genes. Genes are inside the lions and the freeway is outside them. The only way a freeway hurts lions is when a car hits one.
8. To bring back biodiversity at the creek, we should plant 500 trees of one fast-growing kind, because more trees always means more biodiversity.

9. Iceplant spreading over a coastal dune is an example of an invasive species lowering species diversity.

Part A: Diagnose

1. Complete the table for all nine statements. If a statement is partly right, mark it 'incorrect' and name only the part that is wrong.

Answer: 1 incorrect: confuses the number of individuals with the variety of kinds. 2 correct. 3 incorrect: ignores evenness; same richness does not mean the same diversity. 4 incorrect: forgot to square the proportions. 5 incorrect: extirpated, not extinct. 6 incorrect: non-native is not the same as invasive. 7 incorrect: ignores gene flow; isolation lowers genetic diversity. 8 incorrect: more of one species is not more variety; one kind of tree adds little diversity. 9 correct.

Why: Statements 2 and 9 are accurate; the other seven each contain one central error named in the table.

Also acceptable: Accept equivalent wording, such as 'abundance is not diversity' for statement 1.

- All nine correct or incorrect judgments
- Each incorrect statement's error named in a few accurate words

Part B: Explain and rewrite

2. Statement 1: What does biodiversity measure, if not the number of living things? Use Talia's data to rewrite the statement correctly.

Answer: Biodiversity measures the variety of life: how many different kinds (and how evenly they are shared), along with variety in genes and ecosystems. Rewrite: 'The creek has much more biodiversity than the school lawn, because the creek banks have 23 plant species and the lawn has only 2, even though the lawn has more plants.'

Why: Abundance (3,000 versus 200) is a different measurement from richness (2 versus 23).

Also acceptable: None.

- Defines biodiversity as variety, not number
- Uses 23 versus 2 species
- Rewrite reaches the opposite conclusion correctly

3. Statement 3: Calculate Simpson's index of diversity for **both** creek plots (1 – the sum of the squared proportions). Show each step. Then rewrite the statement so it is accurate.

Answer: Plot 1: each proportion $10 \div 50 = 0.2$; squared 0.04 ; sum $5 \times 0.04 = 0.20$; index $1 - 0.20 = 0.80$. Plot 2: $42 \div 50 = 0.84$, squared 0.7056 ; $2 \div 50 = 0.04$, squared 0.0016 , four times = 0.0064 ; sum $0.7056 + 0.0064 = 0.7120$; index $1 - 0.7120 = 0.288$. Rewrite: 'Plots 1 and 2 have the same species richness, but plot 1 is much more diverse (index 0.80) than plot 2 (index 0.29), because plot 2 is dominated by one species.'

Why: Simpson's index includes evenness; one species making up 84 percent of plot 2 lowers its index.

Also acceptable: Accept 0.29 for plot 2.

- Plot 1 index 0.80 with steps
- Plot 2 index 0.288 with steps
- Rewrite mentions evenness or dominance

4. Statement 4: Find the step Talia skipped and redo her calculation for plot 1 correctly. Then explain why her method would give an index of 0 for **every** site.

Answer: Talia skipped squaring the proportions. Correct: $0.2 \times 0.2 = 0.04$ for each species; $0.04 + 0.04 + 0.04 + 0.04 = 0.20$; index = $1 - 0.20 = 0.80$. Her method always gives 0 because the proportions at any site always add up to 1 (they are the parts of one whole), so $1 - 1 = 0$ no matter what the site is like.

Why: Recognizing that proportions sum to 1 is a built-in check that exposes the error.

Also acceptable: None.

- Identifies the missing squaring step
- Correct recalculation giving 0.80
- Explains that proportions always sum to 1

5. Statement 5: Which term should Talia have used? Explain the difference and rewrite the statement.

Answer: Extirpated. Extinction means a species is gone everywhere and cannot return; extirpation means it is gone from one place but survives elsewhere. Rewrite: 'Sea otters were extirpated from Washington State around 1910, but they survived in Alaska and California, so in 1969 and 1970 people moved otters from Alaska to Washington and a population grew again.'

Why: The species never stopped existing, which is why it could be moved back.

Also acceptable: None.

- Names extirpation
- Explains the difference from extinction
- Rewrite says where otters survived

6. Statement 6: Explain what a species must do to count as invasive, and rewrite the statement. Then name one piece of evidence you would need before calling a garden plant invasive.

Answer: A species is invasive only if people moved it outside its native range **and** it spreads and causes harm to native species, ecosystems, the economy or health. Rewrite: 'Tomatoes are not native to California, but they are not invasive, because they grow where we plant them and do not spread into wild places or harm native species.' Evidence needed: observations that the plant is spreading on its own into wild areas and crowding out native species, or a listing by an invasive plant organization such as the California Invasive Plant Council.

Why: Being non-native is necessary but not sufficient for being invasive.

Also acceptable: Accept 'it is found growing wild far from gardens and replacing native plants' as evidence.

- States both conditions: non-native and spreads causing harm
- Correct rewrite
- Names valid evidence of spread or harm

7. Statement 7: Explain how a freeway can lower the genetic diversity of mountain lions even if no lion is ever hit. Rewrite the statement.

Answer: Genes pass from parents to offspring, so a population's gene variety depends on which animals mate. A freeway that lions rarely cross keeps lions from other areas from moving in and mating, so the lions inside breed with relatives. Over generations the population carries less variety in its genes, and signs of inbreeding, such as kinked tails, have appeared in Santa Monica Mountains lions. Rewrite: 'A freeway can lower mountain lions' genetic diversity by stopping lions from moving between populations, so the lions inside mate with relatives; cars hitting lions is a second harm.'

Why: The freeway does not change genes directly; it changes who mates with whom (gene flow).

Also acceptable: Accept 'it blocks gene flow' if the student explains what gene flow means.

- Explains reduced movement and mating between populations
- Connects to breeding with relatives and loss of gene variety
- Correct rewrite that keeps road deaths as a second effect

8. Statement 8: Explain two things wrong with Talia's plan, using what biodiversity includes. Rewrite it as a better plan in one or two sentences.

Answer: Problems: (1) planting one kind of tree adds only one species, so species diversity barely rises, and a single dominant species lowers evenness; (2) a fast-growing kind may be non-native and could even become invasive, and it would not provide the variety of food and shelter that native wildlife need; planting 500 trees from the same source also adds little genetic diversity. Better plan: 'Plant a mix of several native creek plants, such as willows, cottonwoods, sycamores and shrubs, from local seed sources, and remove invasive plants, then measure richness and a diversity index each year.'

Why: More of one thing is not more variety; restoration should add native variety at the species and genetic levels.

Also acceptable: Accept any rewrite that plants several native species and includes a way to measure success.

- Explains that one species adds little diversity
- Names a second problem (non-native risk, little habitat variety or low genetic variety)
- Rewrite proposes a mix of native species

9. Statements 2 and 9 are correct. For each, explain **why** it is correct, adding one detail Talia could include to make it stronger.

Answer: Statement 2 is correct because species richness counts only the number of species, and each plot has 5; Talia could add that the plots differ in evenness, which richness does not show. Statement 9 is correct because highway iceplant was brought by people from South Africa, spreads in thick mats and crowds out native dune plants; Talia could add a number, such as fewer native species or a lower diversity index where iceplant covers the dune.

Why: Students should justify correct statements, not just accept them.

Also acceptable: Accept any accurate added detail.

- Explains why statement 2 is correct
- Explains why statement 9 is correct
- Adds one strengthening detail to each

Part C: The rule behind the mistakes

10. Statements 1, 3 and 8 come from the same confusion. Name it, and write a two-sentence rule Talia could tape inside her notebook that would have prevented all three mistakes.

Answer: The shared confusion is treating **amount** (how many individuals, or how many of one kind) as if it were **variety** (how many kinds, and how evenly they are shared). Rule: 'Biodiversity is about variety, not amount: count the kinds and check how evenly the individuals are shared among them. More plants, or more of one kind, does not mean more biodiversity.'

Why: Statement 1 counts plants, statement 3 ignores evenness and statement 8 adds more of one kind; all treat quantity as variety.

Also acceptable: Accept 'abundance versus diversity' as the name of the confusion.

- Names the confusion between amount and variety
- Rule is two sentences
- Rule would prevent all three mistakes (mentions kinds and evenness)

Teacher notes

Calculations were checked: plot 1 index 0.80, plot 2 index 0.288. The facts in the statements are real: Washington's last recorded sea otter was killed around 1910, and 59 otters were moved from Amchitka Island, Alaska, in 1969 and 1970 (NOAA Olympic Coast National Marine Sanctuary); tomatoes were domesticated from wild plants of western South America and are not invasive in California; National Park Service researchers report low genetic diversity and kinked tails in Santa Monica Mountains mountain lions; highway iceplant is rated highly invasive by the California Invasive Plant Council. Statement 8 is a common real-world error: planting large numbers of one fast-growing species, sometimes non-native, in the name of restoration. Students who say statement 9 is incorrect because 'iceplant adds a species' are raising a real subtlety; agree that richness can go up, and point out that the native community loses species and evenness. This sheet targets three of the chapter's misconceptions: biodiversity is just a species count, more of anything is healthier, and extirpation equals extinction.

Scaffold offered to students: Questions to ask of each statement

For each statement ask: Is it counting **individuals** or **kinds**? Does it say how **evenly** the individuals are shared? Does the species still live **somewhere else** (extirpation) or **nowhere** (extinction)? Has the species **spread and caused harm**, or is it only non-native? For the calculation in statement 4, check: do the proportions add up to 1 before you square them? They always should.

Extension: Write a tricky statement of your own

Write two new statements Talia might have included: one that sounds wrong but is actually correct, and one that sounds right but contains a hidden error about genetic, species or ecosystem diversity. Trade with a partner, diagnose each other's statements, and explain which one fooled you and why. A good tricky statement uses a real number or a real California example.