

Six Pressures Jigsaw: Weighing Solutions Three Ways

Learning target: I can work with a team to evaluate six real solutions to human pressures on ecosystems using scientific, economic and social criteria, and explain one solution on my own.

Collaborative investigation

About 55 min

Jigsaw

MS-LS2-5 · practice

MS-ETS1-2 · practice

MS-ESS3-4 · supports

collaboration

reading

discussion

Standards connections

MS-LS2-5 (practice): Teams evaluate six real solutions for how well they protect biodiversity and ecosystem services, weighing the scientific, economic and social considerations named in the PE's clarification statement. The group rating builds the reasoning that W6 and W9 assess individually.

MS-ETS1-2 (practice): The group table applies the same three kinds of criteria and an evidence-strength rating to every solution, a systematic comparison of competing approaches.

MS-ESS3-4 (supports): Several cards link a pressure to growing human populations and resource use. In California this is a Grade 8 performance expectation; the connection is background and is not assessed here.

Purpose: practice · **Time:** about 55 minutes · **Format:** jigsaw

Answers with reasoning

Twelve evidence cards: six pressures and six solutions

1 Card 1 (Set A): Over-exploitation problem, Lake Malawi

As the population along Lake Malawi in southeastern Africa grew, heavy fishing removed many small cichlid fish that eat snails. The snails carry the young stage of the parasite that causes bilharzia, a long-lasting disease. Studies comparing sites found fewer infected children where snail-eating fish were common. Most families depend on the lake for food and income.

2 Card 2 (Set A): Solution, larger-mesh nets

Nets with larger holes still catch big fish, but small snail-eaters slip through and survive. The nets are cheap, can be made from local materials, and let families keep fishing. Tradeoff: fewer fish in each haul at first. Evidence: the fish-and-infection link comes from comparing sites, not from a controlled test, so snails and infections must be tracked after the change.

3 Card 3 (Set A): Pollution problem, plastic in the ocean

Millions of metric tons of plastic reach the ocean every year. Sea turtles mistake floating bags for jellyfish and swallow them, and lost nets and fishing line tangle turtles, seals and seabirds. Most plastic does not rot away; sunlight and waves break it into smaller and smaller pieces, and pieces under 5 millimeters are called microplastics.

4 Card 4 (Set A): Solution, using less plastic

Options include reusable bottles and bags, recycling, less packaging and new materials. California banned most single-use plastic carryout bags at large grocery and drug stores in a 2014 law that voters upheld in 2016. Limits: some alternatives cost shoppers or stores more, only a small share of plastic is recycled, and many plastics labeled 'biodegradable' break down only in industrial compost facilities, not in seawater.

5 Card 5 (Set B): Emerging disease problem, Nipah virus

In Malaysia in 1998 and 1999, a virus new to people spread from pig farms. Fruit bats naturally carry Nipah virus, usually without getting sick. On farms where pigs were kept near fruit trees that bats fed in, pigs ate fruit the bats had bitten or dropped, became infected and passed the virus to farmworkers. More than 100 people died.

6 Card 6 (Set B): Solution, keep bats and farm animals apart

Health agencies advise keeping pigs away from fruit trees where bats feed, covering feed and pig sheds, and wearing gloves and protective clothing when handling sick animals. Limits: moving pens or removing trees costs farmers money and space, workers need training and gear, and the virus stays in the bats. The bats are wild animals that pollinate fruit trees and spread seeds, so killing them would harm forests.

7 Card 7 (Set B): Habitat degradation problem, sun coffee

In parts of Central and South America, forests are cleared to plant coffee in full sun. Black-and-white warblers and other songbirds that nest in North America spend the winter in these forests. Clearing removes the trees they feed and shelter in, along with the flowering plants that support bees and the roots that hold soil on steep slopes.

8 Card 8 (Set B): Solution, shade-grown coffee

Coffee can grow under taller trees that hold soil, shelter birds and support bees. Tradeoff: a shaded farm harvests fewer beans per hectare than a full-sun farm. Some buyers pay a higher price for certified bird-friendly coffee, but not every farm finds such a buyer. Shade farms help many birds, but some forest species still need real forest.

9 Card 9 (Set C): Invasive species problem, Asian carp

Several carp species were brought to the United States from Asia in the 1960s and 1970s to control weeds and algae in fish farms and wastewater ponds. Some escaped during floods into the Mississippi River system. Silver and bighead carp eat huge amounts of plankton, the food that young native fish need, and have few predators here. They are moving upriver toward the Great Lakes.

10 Card 10 (Set C): Solution, electric barriers

Near Chicago, electric barriers in a shipping canal that links the Mississippi River system to Lake Michigan send a pulsing current through the water that turns fish back while boats pass through. Limits: the barriers must run all the time and be maintained, they are costly, and they cannot remove carp already in the rivers. Agencies also net and fish out carp and test river water for carp DNA.

11 Card 11 (Set C): Climate change problem, rising seas

Since 1880 the average height of the world's oceans has gone up about 21 to 24 centimeters, mainly because seawater expands as it warms and melting land ice adds water. Low-lying coastal places such as Miami Beach and parts of San Diego flood more often during storms and very high tides. Marshes and dunes drown or get squeezed between the rising water and roads or seawalls.

12 Card 12 (Set C): Solution, plan with models

Computer models use past and present data to project a range of future sea levels. NOAA projects about 25 to 30 cm (10 to 12 inches) of rise along U.S. coasts between 2020 and 2050. Planners use the range to choose among seawalls, raised roads, restored marshes and dunes that absorb waves, or moving buildings back. Limits: projections further ahead are less certain, seawalls are costly and can wipe out the beach or marsh in front of them, and moving homes is hard on families.

Part A: Expert round

1. Your expert set: _____. For each of your two cases, complete the row.

Answer: Set A: Lake Malawi: more people → heavy fishing → fewer snail-eating fish → more snails → more bilharzia; at risk: snail-eating cichlids, fish for food, natural disease control; limit: fewer fish per haul at first, evidence only from comparisons. Plastic: plastic waste → reaches the ocean → turtles swallow or get tangled → injury and death; plastic breaks into microplastics; at risk: sea turtles, seabirds, seals; limit: alternatives cost more, little plastic is recycled, 'biodegradable' often only in industrial compost. Set B: Nipah: pigs kept near fruit trees → pigs eat bat-bitten fruit → pigs infected → farmworkers infected; at risk: human health, and fruit bats that pollinate and spread seeds; limit: costs farmers space and money, virus stays in bats. Coffee: forest cleared → fewer trees → warblers lose winter habitat, fewer bees, soil erodes; at risk: songbirds, pollination, soil; limit: fewer beans, premium price not guaranteed. Set C: Carp: brought for ponds → escaped in floods → eat plankton → young native fish lose food → native fish decline; at risk: native fish of rivers and the Great Lakes; limit: barriers must run all the time, cost, cannot remove carp already present. Sea level: warming → water expands and land ice melts → seas rise → more flooding, marshes drown; at risk: coastal marshes and dunes, and the flood protection they provide; limit: projections uncertain, seawalls costly and can destroy marsh, moving homes is hard.

Why: The chains and limits come directly from the cards; the expert round checks that each student understands both cases before teaching.

Also acceptable: Accept chains that start at a different point (for example, 'pigs kept near fruit trees') if the steps are in the correct order.

- A chain with at least three arrows for each case
- A correct species or service at risk
- A limit or tradeoff taken from the solution card

Part B: Home group task

1. Each expert teaches both of their cases in about two minutes: the problem, the solution and its limits.
2. For each solution, give a rating of + (helps), 0 (mixed or unclear) or – (hurts) for each kind of criterion, and write the card fact that justifies it.
3. Scientific: does it protect species, biodiversity or an ecosystem service? Economic: what does it cost, and who pays or gains? Social: is it fair, healthy and likely to be accepted?

4. Rate the evidence as strong, medium or weak, and say why (measured results, comparisons only, or projections).
5. Every member must be able to explain the rating of at least two solutions they did not teach.

2. Group answer: rate each solution and write the fact that justifies each rating.

Answer: Model ratings: Larger-mesh nets: scientific + (protects snail-eating fish, lowers snails); economic + or 0 (cheap, fewer fish at first); social + (families keep fishing); evidence medium (comparisons, not a controlled test). Using less plastic: scientific + (fewer turtles harmed); economic 0 (some alternatives cost more); social 0 or + (bag law upheld by voters, habits must change); evidence medium ('biodegradable' claims weak, the harm to turtles well documented). Bats and farm animals apart: scientific + (prevents spillover without killing bats that pollinate and spread seeds); economic 0 or – (costs space and gear); social + (protects workers' health); evidence strong to medium (follows a well-studied outbreak). Shade coffee: scientific + (birds, soil, bees); economic 0 (fewer beans, premium only sometimes); social 0 or + (depends on buyers and farmers' choices); evidence medium (studies show more birds, but income varies). Electric barriers: scientific + (keeps carp from Lake Michigan so far); economic – or 0 (costly, must run all the time); social + (boats keep moving, protects Great Lakes fishing); evidence medium (no proof it will always hold). Sea-level models: scientific + or 0 (depends on which option planners choose: marsh restoration +, seawall –); economic 0 (planning is cheap, the projects are costly); social 0 (moving homes is hard, flooding is worse); evidence strong for past rise, medium for projections.

Why: Ratings can vary; what matters is that each rating is justified by a card fact and that evidence strength reflects the kind of evidence (measured, compared or projected).

Also acceptable: Accept different ratings with a card-based reason. A group that rates electric barriers scientifically 0 because they cannot remove carp already present is reasoning well.

- All six rows completed
- Every rating backed by a card fact
- Evidence strength distinguishes measured results, comparisons and projections

3. Group answer: which two solutions does your group think are most promising for protecting biodiversity and ecosystem services? Explain your ranking using at least two kinds of criteria.

Answer: Example: Larger-mesh nets and keeping bats and farm animals apart. Both protect species that provide services (snail-eating fish that hold back disease; bats that pollinate and spread seeds), both are fairly cheap, and both let people keep their livelihoods. The nets' evidence needs follow-up, so we would also track snails and infections.

Why: Any pair is acceptable if the ranking uses at least two kinds of criteria and the card facts.

Also acceptable: Shade coffee or marsh restoration chosen through the models card are also strong choices.

- Names two solutions
- Uses at least two kinds of criteria
- Uses card evidence

4. Group answer: find one solution that could create a new problem if it were done carelessly, and explain how.

Answer: Examples: a seawall can protect a town but destroy the beach or marsh in front of it; killing bats to stop Nipah would harm pollination and seed spread; a 'biodegradable' plastic that does not break down in seawater could make people litter more; larger-mesh nets could shift fishing pressure to other species.

Why: Unintended consequences come from links in the ecosystem the solution did not consider.

Also acceptable: Accept 'electric barriers could fail during a power outage' as a risk, though it is a failure rather than a new problem.

- Names a specific solution
- Explains a realistic new problem through an ecosystem link or human behavior

Part C: Individual accountability (complete alone)

5. Choose a case you did **not** teach. Explain the problem as a cause-and-effect chain and describe the solution's biggest strength and biggest limit.

Answer: Example (shade coffee, taught by a groupmate): forest is cleared for sun coffee → fewer trees → warblers lose winter habitat, bees decline and soil washes off slopes. Strength: shade coffee keeps many birds, bees and soil while still producing coffee. Limit: fewer beans per hectare, and a higher price is paid only if a buyer is found.

Why: This checks that each student learned from the jigsaw, not only from their own cards.

Also acceptable: Any of the six cases, accurately explained.

- A case the student did not teach
- A correct chain
- One strength and one limit from the card

6. Which kind of criterion (scientific, economic or social) was hardest for your group to rate, and why?

Answer: Example: social criteria were hardest, because the cards say little about whether people will accept a solution, and acceptance can change over time; scientific effects are often measured, and costs can be estimated.

Why: There is no single right answer; the reason must show awareness of what evidence the cards provide.

Also acceptable: Accept 'scientific, because many results take years to show up' with a reason.

- Names one kind of criterion
- Explains why with reference to the evidence available

7. Pick one solution and describe a measurement that would show, a few years from now, whether it is working. Say what result would count as success.

Answer: Examples: Lake Malawi: count snails at the same beaches and test children for bilharzia each year; success = fewer snails and fewer infections than before. Carp barrier: test water above the barrier for carp DNA and net for carp; success = no carp or carp DNA found upstream. Shade coffee: yearly bird surveys and soil-loss measurements; success = at least as many bird species and less soil lost.

Why: A test plan names a measurement, where and when it is taken, and a success value.

Also acceptable: Accept any solution with a measurable outcome.

- A specific measurement
- A result that would count as success

8. Two solutions from the cards both involve a tradeoff between money and nature. Name them, explain each tradeoff, and explain which one you think is the better deal for the ecosystem and the people, with a reason.

Answer: Example: Shade coffee gives up some harvest (money) to keep birds, bees and soil; electric barriers cost money every year to protect Great Lakes fish. I think shade coffee is the better deal because farmers also keep services they use, such as soil and pollination, and can sometimes earn a higher price, while the barrier is a cost that never ends and does not remove carp already present.

Why: Either choice is acceptable with a reason that compares what is gained and given up for both nature and people.

Also acceptable: Other pairs (larger-mesh nets, seawalls versus marsh restoration, plastic alternatives) are acceptable.

- Names two solutions with a money-versus-nature tradeoff
- Explains each tradeoff
- Chooses one with a reason that considers both people and the ecosystem

Scoring rubric

Criterion	4 • Exemplary	3 • Proficient	2 • Developing	1 • Beginning
Expert knowledge (Part A)	Both chains are complete and accurate, the species or service at risk is correct, and the limit comes from the card.	Both cases mostly correct; one chain is missing a step.	One case correct; the other incomplete or inaccurate.	Chains missing or inaccurate.
Group evaluation (q2)	All six solutions rated on all three kinds of criteria, each rating justified by a card fact, and evidence strength explained.	All six rated; a few ratings lack a reason or evidence strength is unexplained.	Several solutions or criteria missing.	Table mostly blank or unjustified.
Ranking and new problems (q3, q4)	Ranking uses two or more kinds of criteria with card evidence; a realistic unintended consequence is explained through an ecosystem link.	Ranking justified with one kind of criterion; a consequence is named but not fully explained.	Ranking given without reasons, or no consequence.	Neither question answered meaningfully.
Individual accountability (Part C)	Explains a case the student did not teach accurately, proposes a measurable test with a success value, and compares two tradeoffs with a reasoned choice.	Three of the four items strong; one weak.	Answers are vague or repeat the student's own expert case.	Part C incomplete.

Teacher notes

Every card is original and fact-checked. Corrections to the textbook built into the cards: Asian carp escaped from fish farms and wastewater ponds during floods rather than being released on purpose (U.S. Fish and Wildlife Service), and federal agencies now often call them invasive carp; plastic fragments into microplastics rather than simply not breaking down, and many 'biodegradable' plastics need industrial composting (NOAA); global sea level has risen about 21-24 cm since 1880, and NOAA projects 25-30 cm along U.S. coasts from 2020 to 2050 (the textbook's figure caption is dated); the Nipah outbreak killed more than 100 people

(CDC). California's carryout bag law is SB 270 (2014), upheld by Proposition 67 in 2016. Ratings in q2 are judgment calls; grade the reasons, not the symbols.

Scaffold offered to students: Teaching your case in four sentences

Use this pattern when you teach your home group: 'The problem is _____. It happens because _____, which leads to _____. The solution is _____, and it helps because _____. Its biggest limit is _____.' When rating, if a card does not give enough information, rate 0 and write 'card does not say' rather than guessing.

Extension: Combine two solutions

Many real problems are tackled with several solutions at once. Choose one pressure and design a combined plan using the card's solution plus one more idea of your own (for example, adding a carp fishing market to the electric barrier). Explain how the second idea covers a limit of the first, and rate your combined plan on the three kinds of criteria.