

Forecast Desk Jigsaw: How Much Warning Does Each Hazard Give?

Learning target: I can use evidence cards to compare how far ahead different hazards can be forecast, explain why some come with hours or days of warning and others with almost none, and match mitigation to the warning time.

Collaborative investigation

About 55 min

Jigsaw

MS-ESS3-2 · practice

collaboration

discussion

reading

Name _____

Date _____

Period _____

Directions

Your teacher will put you in a home group of three and give each member one expert set of four cards: Slopes (cards 1 to 4), Ocean (cards 5 to 8) or Rivers (cards 9 to 12). First meet with the other experts on your set, read your cards together and answer q1. Then return to your home group, teach your cards, and build the warning ladder together. Finish Part C alone; it is how your teacher checks that everyone understood every set.

You will need: One set of the twelve cards per home group, cut apart, This worksheet, Seven sticky notes per group, Pencil

Twelve evidence cards from California's hazard forecasters

1 Card 1 (Slopes): Maps of where slopes fail

The California Geological Survey combines maps of slope steepness, rock type and the scars of old landslides to show which areas are most likely to have landslides. The maps are made years before any event. Counties use them to decide where building is allowed and which roads to reinforce, but no map can tell anyone the day a slope will fail.

2 Card 2 (Slopes): Burn scars and rain thresholds

After a wildfire, USGS scientists estimate how likely debris flows are in each burned canyon and how intense the rain must be to set them off, often a burst lasting only about 15 minutes. When weather forecasts call for rain that intense, forecasters can issue watches and warnings hours to a day or two ahead, and counties can order evacuations before the storm arrives.

3 Card 3 (Slopes): A creeping slope speeds up

The Portuguese Bend landslide in Rancho Palos Verdes, Los Angeles County, has crept downhill for decades. GPS stations showed parts of it moving many times faster after the very wet winters of 2022-23 and 2023-24, cracking homes and roads. Monitoring like this shows a slope changing days to months ahead, but it cannot say exactly when, or whether, a slope will suddenly give way.

4 Card 4 (Slopes): Slides set off by shaking

The 1994 Northridge earthquake set off more than 11,000 landslides across the hills and mountains north of Los Angeles as the ground shook. No one can forecast the date of an earthquake, so slides set off by shaking come with no warning beyond the shaking itself. Protection has to be planned in advance: knowing which steep slopes would fail in strong shaking and keeping roads and homes away from them.

5 Card 5 (Ocean): Seismic networks

Seismometers around the world detect a large undersea earthquake within minutes and estimate its location and size. Tsunami warning centers, including the National Tsunami Warning Center in Palmer, Alaska, which serves California, send their first alerts based on that information alone. At that moment they do not yet know for sure whether a tsunami formed or how big it is.

6 Card 6 (Ocean): DART buoys

Pressure sensors on the deep seafloor feel the extra weight of water as a tsunami passes and send the readings by sound to a buoy, then by satellite to the warning center. These readings confirm whether a tsunami formed and how large it is, so forecasters can update arrival times and expected wave heights for each coast, or cancel an alert that was not needed.

7 Card 7 (Ocean): A distant source

In 1964 an earthquake in Alaska sent waves to Crescent City about four hours later. The fourth wave was the largest, and 11 people died in the town. In 2011 an earthquake off Japan sent waves that reached Crescent City about 10 hours later. That time, warnings had cleared the waterfront hours ahead; the harbor was wrecked, but the town lost no one.

8 Card 8 (Ocean): A source next door

The Cascadia Subduction Zone runs offshore from Cape Mendocino in Northern California to Vancouver Island in Canada. Its last great earthquake, in January 1700, sent a tsunami all the way to Japan. A similar earthquake today could send waves onto parts of the North Coast within minutes. California's tsunami hazard maps, evacuation-route signs and school drills treat strong shaking that lasts a long time as the warning itself.

9 Card 9 (Rivers): River forecasts

The National Weather Service's California Nevada River Forecast Center combines rain and snow forecasts with streamgauge readings to forecast how high rivers will rise, often several days ahead on large rivers. Those forecasts give time to release water from reservoirs, close roads, move livestock and evacuate low areas.

10 Card 10 (Rivers): Atmospheric rivers

Most of California's largest floods come from atmospheric rivers: long, narrow bands of water vapor that flow in from the Pacific and can drop days of heavy rain. Satellites and weather models often spot one several days before it reaches land. In 2023 a series of them flooded towns including Planada in Merced County and Pajaro in Monterey County, where a river levee broke.

11 Card 11 (Rivers): Flash floods

In steep canyons, desert washes and heavily paved neighborhoods, a short, intense downpour can turn a dry channel into a deep, fast torrent within minutes. Such storms are small and hard to pin down exactly, so flash flood warnings may come less than an hour ahead, and the rain may fall miles upstream of the place that floods.

12 Card 12 (Rivers): Flood maps

FEMA flood maps shade the areas with a 1 percent chance of flooding in any year, often called the 100-year floodplain. The maps are made years ahead from river records and the shape of the land. They guide where to build, how high to raise buildings and who must buy flood insurance, but they do not say when the next flood will come.

Part A: Expert round (with the others who have your set)

1. For each of your four cards, write: the hazard, the first signal or data that forecasters can use, and how far ahead that signal comes (seconds, minutes, hours, days, or 'where but not when'). Agree on one sentence you will use to teach each card.

Part B: Home group task

1. Each expert teaches their four cards in about three minutes. Listeners write one note per card.

2. Together, complete the warning ladder in q2. Every row must cite at least one card number.

3. Copy each hazard onto a sticky note and place it on the timeline in Figure 1 under its warning time.

4. Discuss q3 and q4 and write one group answer for each. Every member must be able to explain at least two rows of the ladder.
2. Group answer: complete the warning ladder. Cite card numbers in every row.

First data signal (card)	Warning time	A mitigation that fits that warning time
Landslides set off by an earthquake		
Debris flow below a burn scar		
Creeping landslide speeding up		
Tsunami from a distant earthquake (Alaska, Japan)		
Tsunami from a Cascadia earthquake		
River flood from an atmospheric river		
Flash flood in a canyon		

How much warning? From none to years



Figure 1. A warning-time scale. Place each hazard from the ladder under the warning time forecasters can usually give. Maps made years ahead tell where a hazard is likely, not when.

- Group answer: Which hazards on your ladder have a signal that comes **before** the event starts, and which can be forecast only **after** the trigger has already happened? What do the hazards with the most warning have in common?

- Group answer: For the two hazards with the least warning, explain why mitigation must be built or practiced before anything happens. Give one example of such mitigation for each, from the cards.

Part C: Individual accountability (complete alone)

- Why can California get hours of warning for a tsunami from Alaska or Japan but only minutes for one from a Cascadia earthquake? Use evidence from two cards.

- A neighbor says, 'Debris flows are like earthquakes: nobody can warn us.' Use cards 2 and 4 to explain what is wrong with that comparison.

7. Cards 1 and 12 both describe maps made years ahead. What can such a map do that a warning cannot, and what can a warning do that the map cannot?

8. Choose one hazard from the ladder that was **not** on your expert set. Write a forecast statement for it (a chance or a time window, not an exact date), then describe a mitigation plan that matches its warning time. Cite two cards.

Card-reading frame

For each card, underline three things in different ways: the hazard (circle it), the tool or data (underline it), and any time word such as minutes, hours, days, years or 'no warning' (box it). Then fill in this frame: 'For ___, forecasters watch ___, which gives about ___ of warning, so the best protection is ___.' Use the frame to teach your home group.

When the warnings stack up

A strong earthquake on the North Coast happens during a week of atmospheric-river storms, on hills burned the summer before. Using at least four cards, describe the chain of hazards that could follow over the next minutes, hours and days, and design a short emergency-planning checklist for the county that covers each time scale. Explain which item on your checklist would save the most lives and why.