Empowering Youth through Environmental Storytelling

Tipping points:
climate change science

Drought near the Amazon River in Loma Linda, Colombia, 20 October 2024. (AP Photo/Ivan Valencia, File)

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The Empowering Youth through Environmental Storytelling is a collaboration between The Environment and Human Rights Academy (TEHRA), News Decoder and the Young Educators European Association (YEEA).

The purpose of these educational materials is to help young people understand the climate crisis on a systems level through engaging with the topics and foster agency through the skills and techniques of journalism.

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Learning objectives

1. Understand the mechanisms behind tipping points and why they are a crucial part when it comes to the risks of climate change.
2. Communicate the science behind climate change to an every-day audience.

✅ GreenComp alignment:
- Systems thinking

Unit guide

We recommend that you begin your class with the Opening Activity, to have students immediately look at the concept of tipping points through a clear example and to get them talking and thinking.

The Project Instructions can be shown to students before going through the Learn section, to have them understand what their task will be following the text.

Optional Activities are included in case you wish to spend more time on this unit.

Here is the link to the **lesson slides**.

OPENING ACTIVITY

Watch and discuss

Watch this video on the Amazon Rainforest until the 4:13 mark, and write short dot-point answers to the below questions as you go. Take a few minutes afterwards to discuss questions 4-8 with your classmates.

1. How big is the Amazon rainforest compared to India?
2. The Amazon stores up to 200 billion tons of carbon. How many years worth of global carbon emissions is that?
3. What leads to the intense rainfall in a tropical rainforest like the Amazon?
4. What are the main drivers (activities) of deforestation in the Amazon?
5. Why is deforestation changing the Amazon?
6. What are the consequences of fewer trees in the Amazon?
7. How is the game Jenga a metaphor for tipping points like the Amazon?
8. If you were a journalist, what follow up-questions would you like to ask about this topic, so that you could dive deeper into the issue or take another angle? (e.g. which are the tipping points on my continent/in my country?)

Storytelling

Visualising complex topics

One way to help others understand complex scientific concepts is through visuals, including images, charts, and graphs.

As you go through the next section on tipping points, you will hopefully realise that understanding this concept is very important for understanding why climate change is such a big problem – and that visualising it can be very helpful!

So how can you draw or create a visual representation of one way in which your community could potentially be impacted if certain tipping points were crossed?

Your task: create a visual

Create a physical or digital poster or a physical model. You can use drawings, charts, graphs, animations, models, anything!

1) Research and identify one tipping point that could affect the region where you live or come from (e.g., the AMOC for Western Europe)
2) Research what the impacts of crossing that tipping point would mean for your region, and for your local community, and how close we are from crossing it
3) Create a visual individually or in groups to represent your findings

This module will delve into tipping points. Tipping points and their complicated, difficult to predict nature will help highlight the complexity of Earth's systems, and why climate change is a systemic crisis.

1. Earth's system and subsystems

To better understand the Earth's system, scientists have divided it into subsystems. All subsystems have their individual functions but are also connected to the other subsystems and they influence each other.

There are many subsystems within our Planet Earth, depending on the classification we are looking at. Some are large, some are smaller.

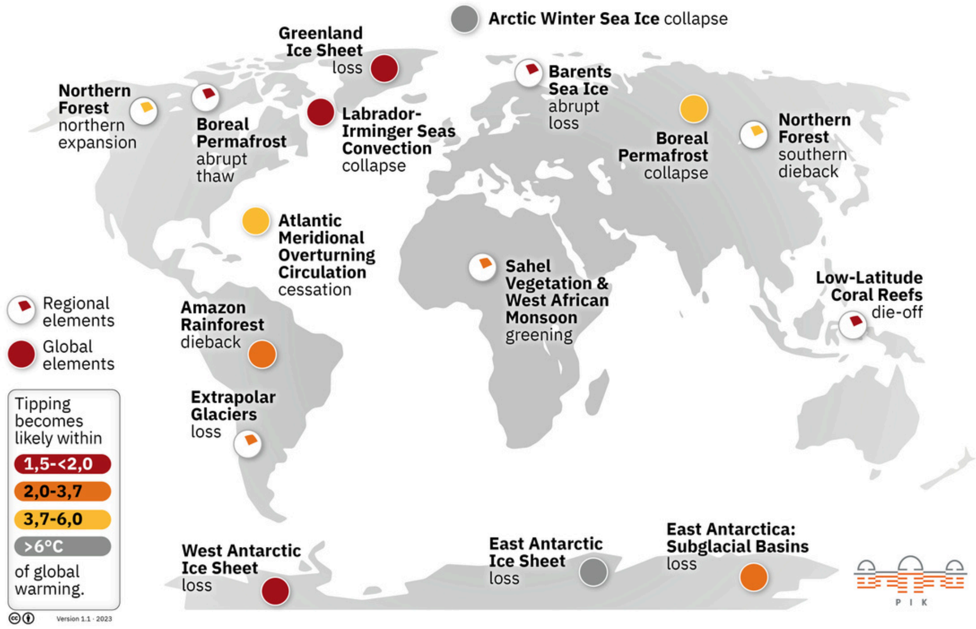
The main, large, Earth subsystems are:

- Atmosphere – the layer of gases surrounding the Earth (e.g. clouds, air, weather).
- Hydrosphere – all the water on Earth (e.g. oceans, rivers, lakes, glaciers).
- Lithosphere (or Geosphere) – the solid part of the Earth (e.g. rocks, mountains, soil).
- Biosphere – all living things (e.g. plants, animals, humans, microorganisms).
- Cryosphere – frozen water parts of the Earth (e.g. glaciers, polar ice caps, sea ice).

Some parts of nature belong mostly to one subsystem, while others involve many.

For example, coral reefs are mainly part of the biosphere because they are full of life, but they also depend on the hydrosphere (ocean water), grow on the lithosphere (seafloor), and are affected by changes in the atmosphere (like warming or pollution).

This shows how connected everything is: when one part changes, it can affect many others.



The geographical distribution of global and regional tipping elements, color-coded according to the best estimate for their temperature thresholds, beyond which the element would likely be 'tipped'. Figure designed at PIK, based on Armstrong McKay et al., Science (2022).[1]

2.What is a tipping point?

2.1 Understanding sudden shifts in Earth's systems

Through the mass burning of fossil fuels and the resulting increase in global average temperatures, we are massively changing how the Earth's system and its subsystems operate.

For example, changes in climate are disrupting the water cycle, leading to shifts in water temperature and availability. These shifts, in turn, affect marine ecosystems, influencing species such as algae and fish, which play vital roles in ocean carbon storage and support global fisheries and coastal communities that depend on them.

Warming of waters create good conditions for algal growth, while the increased intensity of heavy rainfall, also a consequence of climate change, washes nutrients such as nitrogen and phosphorus from agricultural lands and urban run-off into water bodies.

Together, nutrient pollution and warm temperatures, as well as increased concentrations of CO2, create the ideal combination for algal blooms[2][3].

As a consequence of algal blooms, oxygen levels decrease in water bodies, and the algae block sunlight, which has negative and even lethal effects for other flora and fauna in the ecosystem.

Harmful algal blooms can happen both in freshwater and marine ecosystems, and sometimes the algae that bloom are toxic, creating even more problems.

However, these changes are not straightforward or linear. The way a complex system reacts is not predictable due to the many interdependent variables involved. Sudden and dramatic shifts, known scientifically as "non-linear change", can occur when key factors cross a critical threshold.

Due to climate change, Earth's systems can reach a critical ('breaking') point at which the systems will change dramatically in their response, or even completely break down and collapse. This point is called a tipping point.

In simple terms, the rocking of a chair also has a tipping point. Pushing off with your feet leads to an expected, safe amount of rocking. However, pushing too far leads the chair to cross its tipping point and topple over. A small increase in the amount of pushing off can have a radically different effect depending on whether it causes the chair to cross its tipping point or not.

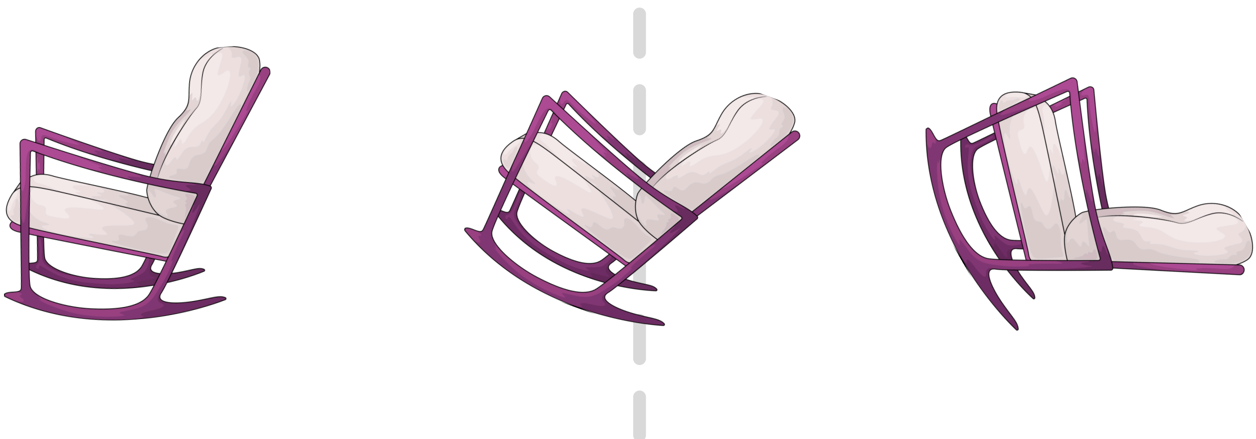


Figure 2: The chair tipping point analogy (inspired by ClimateScience.org)

3. Tipping points and stable states

Once they cross their tipping point, these systems will radically change their functioning.

The process of systems passing tipping points from one state of functioning into another can be visualised as two basins, as shown below.

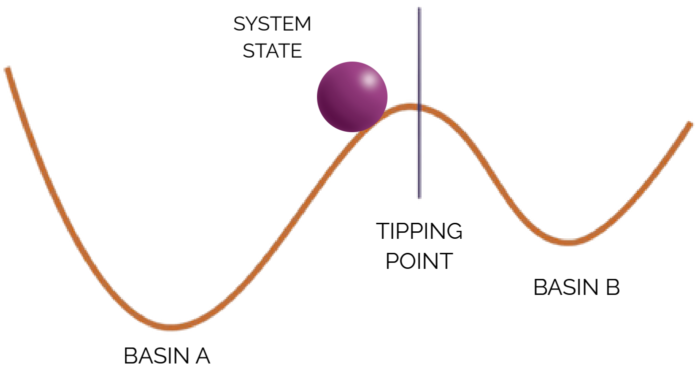


Figure 3: Illustration showing a system shifting between two stable states (basins). Adapted from Bernier (2020): Explainer: What is a tipping point, and why should I care?[4]

The figure above shows two stable states (basins) within which a system (blue dot) can sit. Basin A is our starting point - the way the system operates today as we know it. By changing an external context such as temperature, we push the system to a slightly different state further up 'the hill', but still within its functions of basin A. However, if the system is pushed too far past the tipping point, it will roll into basin B and fundamentally change how the system works.

This illustration shows how hard it is to reverse a tipping point. If we push the system within basin A but stop before the tipping point, it will return to its stable state when the pressure is removed. But if we push it just a bit further and it crosses the tipping point into basin B, it won't come back so easily. A small push won't be enough to return it to basin A — the system has shifted to a new, more stable state.

Tipping points are not only present in nature, but in social systems as well. You may have already come across them in everyday life. For example, how a trend becomes a trend. A few people start wearing say, ripped jeans, then a few more follow, and suddenly everybody around is wearing them!

When significant changes happen in society, such as the rapid improvement of women's rights, it's often because a social tipping point is reached. For a long time, there may be small actions: people speaking out, protests, new laws. Then, something shifts: enough people are on board, public opinion changes, or a major event sparks global attention and suddenly things change quickly. A social tipping point is crossed, and society moves in a new direction.

Can you think of an example of a tipping point that's relevant to your life?

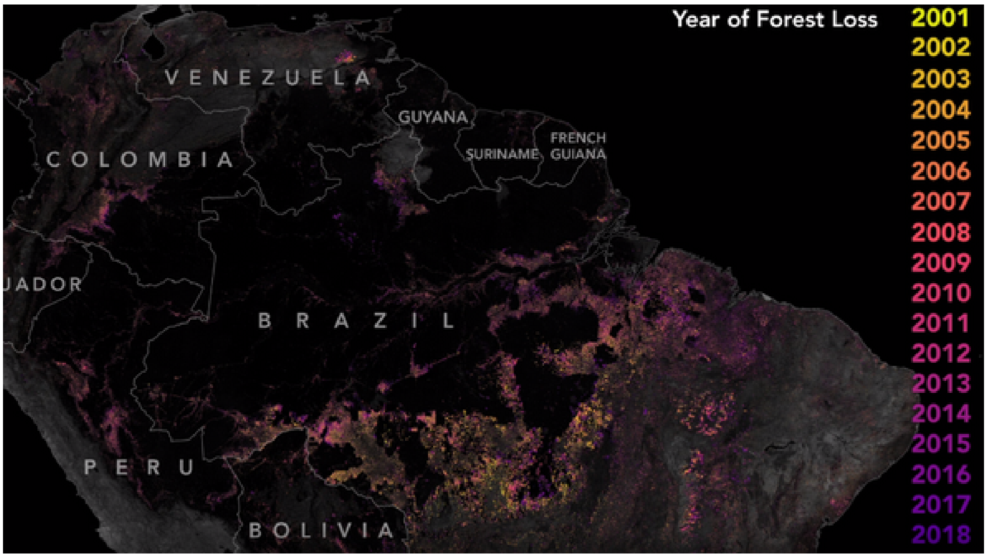


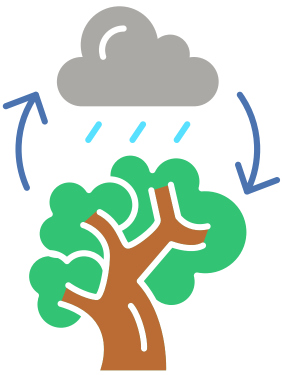
Figure 4: Representation of Amazon rainforest extent (dark area) and the extent of its deforestation (yellow to purple colours) by year. Image created from satellite data by NASA[5]

4. An example of a tipping element and point: the Amazon rainforest

The Amazon rainforest is a nearly 6 million km^2 large ecological haven, harbouring around 40,000 species of plants, 1294 bird species, 378 reptile species, 427 amphibian species, around 3,000 fishes, and 427 mammal species.[6]

As its name indicates, rainforests are highly dependent on large amounts of water. The Amazon rainforest generates much of its own water through a self-sustaining cycle. Leaves lose moisture through evaporation to the air as a natural part of transpiration. This helps cool the surrounding air and contributes to cloud formation, then rainfall, which replaces the lost moisture. This way, the rainforest recycles nearly half of its water usage.[7]

Through extensive deforestation (mainly for agriculture)[8] and increased average temperatures due to global warming, the Amazon rainforest is slowly drying out. This is because with fewer trees, less moisture is released into the air. Less moisture in the air makes the atmosphere warmer, and that warming reduces cloud formation, resulting in less rainfall.



The current state of the Amazon system as a rainforest can be seen in the context of the illustration in Figure 3 as basin A.

Increasing temperature and decreasing forest cover pushes the system ever closer to its tipping point. When this tipping point is reached and the rainforest dries out, it will transform into a savanna ecosystem - basin B.

The functioning of the Amazon ecosystem within this basin B (the savanna) is fundamentally different to its current functioning in basin A (the rainforest).

The latest estimates of when this tipping point would be crossed lie at a warming of around 3.5˚C or at 40% deforestation of the total rainforest area. [9]

However, deforestation amplifies the drying effect of warming and so estimates of a deforestation tipping point with current levels of global warming lie at around 20-25%[10] deforestation of rainforest area. This estimate is rather alarming, as total deforestation was around 18% in 2019 and has only accelerated since.[11]

If the tipping point of the Amazon rainforest is crossed, the rainforest would naturally convert to a much drier savanna landscape within around 100 years. This would lead to the loss of a major carbon sink[12] (meaning it would no longer absorb carbon from the atmosphere), the extinction of thousands of native species, and make the area uninhabitable to the many Indigenous Peoples who live in and depend on the rainforest.

This process has already seemingly started in the southeastern parts of the Amazon rainforest, where deforestation is at its most intense. Historically, Earth's land surfaces absorb around 25% of all CO_2 emissions, with large rainforests such as the Amazon taking in a large proportion of this absorbed CO_2.[13]

However, due to droughts, deforestation and fires, the Amazon rainforest has already turned from being a carbon sink to a source of CO_2.[14] Additionally, across the entire forest, around 8,000 endemic plants and 2,300 animal species are at high risk of extinction.[15]

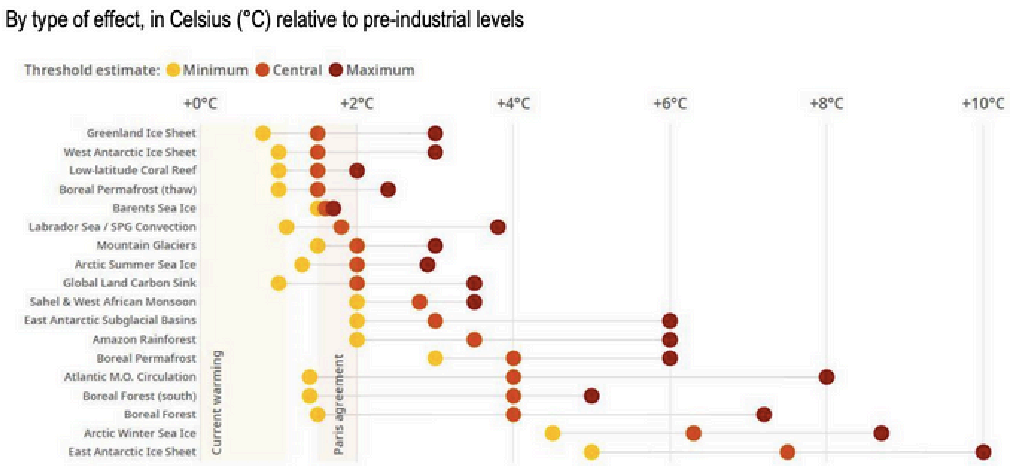
The case of the Amazon rainforest also highlights the difficulty (and often impossibility on human timescales) of reversing the effects of crossing a tipping point.

The Amazon began forming over 55 million years ago, as the uplift of the Andes Mountains shaped its climate and river systems, gradually evolving into one of the most biodiverse ecosystems on Earth. Simply reversing warming in the savanna-like ecosystem (corresponding to basin B), if it was possible, would not be enough to restore the system to a rainforest state (basin A).

Even if favourable conditions returned, it would take hundreds to thousands of years for the rainforest to regrow, a short time compared to the millions of years it took to form. However, even in such a scenario, the loss of Indigenous Peoples' livelihoods and cultural ties to the rainforest, along with the extinction of species, would be irreversable.

5. Other tipping points

To help understand how sensitive each tipping element is to global average temperature increases (and its side-effects), it can be helpful to lay them out, as is done in the figure below.



Source: (McKay et al., 2022[3]) in OECD (2022) *Climate Tipping Points: Insights for Effective Policy Action*, OECD Publishing, Paris, https://doi.org/10.1787/abc5a69e-en.

Figure 5: Various tipping elements and the range of temperature increases within which they are likely to reach their tipping point. From Nusche, Fuster Rabella and Lauterbach (2024)[16]

One of the most striking things about the above figure is how many tipping points could be crossed, even if global warming is limited to no more than 2˚C as outlined by the Paris Agreement.

Much of the Earth's cryosphere, including Greenland and West Antarctic Ice Sheets, Boreal permafrost, mountain glaciers, and Arctic Summer Sea Ice and Barents Sea Ice, as well as tropical coral reefs, the Labrador Sea Circulation, and the global land carbon sink are at risk of crossing their tipping points.

We have already reached the lower estimates of many of these tipping elements' tipping points too - we are already experiencing a global warming of 1.1˚C.[17]

6. Tipping cascades

As seen in Figure 1, many of today's tipping elements are vital parts of the Earth system. Because these components are highly interconnected, the tipping of one element can trigger another element to tip. This chain of knock-on effects is called a tipping cascade, which has far reaching and potentially catastrophic consequences across the Earth's system.

For instance:

- The collapse of the glaciers and ice sheets would lead to several metres of sea level rise, having devastating consequences on coastal communities around the world.

- The collapse of large-scale forest ecosystems, such as the Amazon or Boreal forests, would release significant amounts of carbon into the atmosphere and result in the loss of essential ecosystem services for our everyday lives, including water regulation, air purification, and climate stability.

- The breakdown of global circulation patterns, such as the Atlantic Meridional Overturning Circulation (AMOC), could severely alter regional climate patterns, leading to widespread shifts in rainfall, temperature, and storm activity. [18]

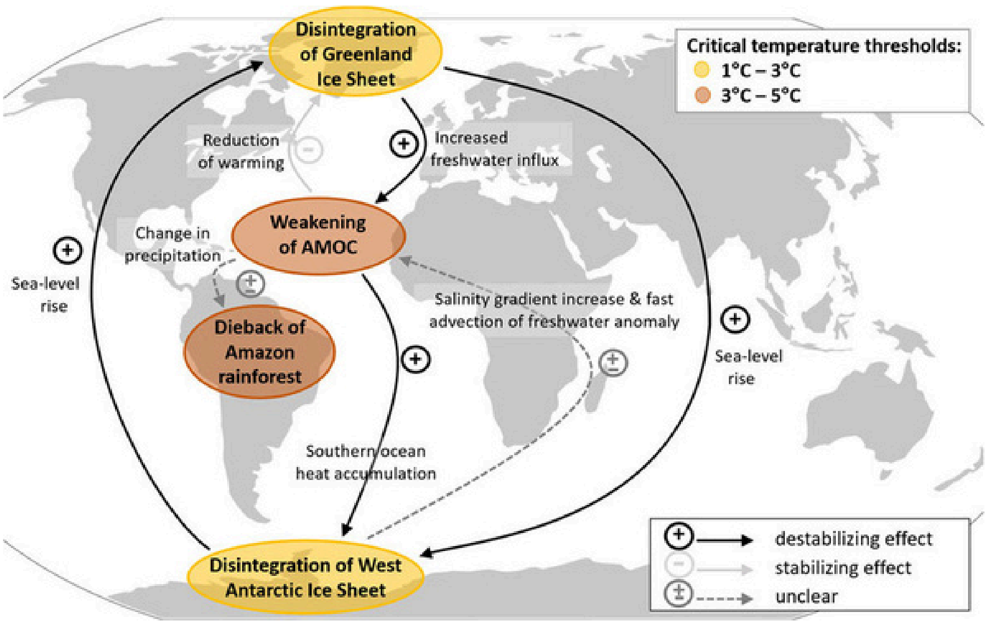


Figure 6: Various tipping elements and the range of temperature increases within which they are likely to reach their tipping point. From Nusche, Fuster Rabella and Lauterbach (2024) [19]

7. Feedback loops

Feedback loops are important to consider when thinking about tipping points and how Earth's systems function and change.

Feedback loops are cause-and-effect cycles where a change in one part of a system leads to further changes.

- A positive feedback loop amplifies the original change, making it stronger.

Example: Melting ice reduces sunlight reflection, because ice is white and reflects sunlight, while dark ocean water absorbs it. So as ice melts, more heat is absorbed, causing even more ice to melt.

- A negative feedback loop balances or reduces the original change, keeping the system stable.

Example: When your body gets too hot, you sweat to cool down and return to a normal temperature.

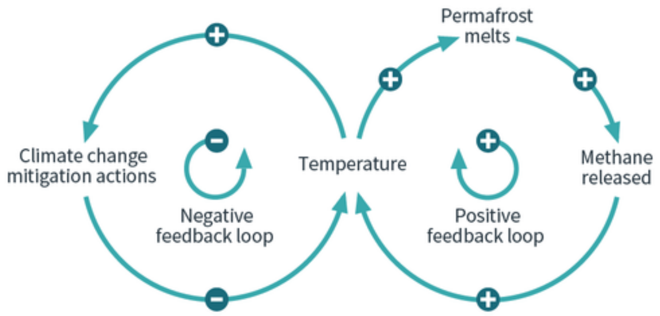
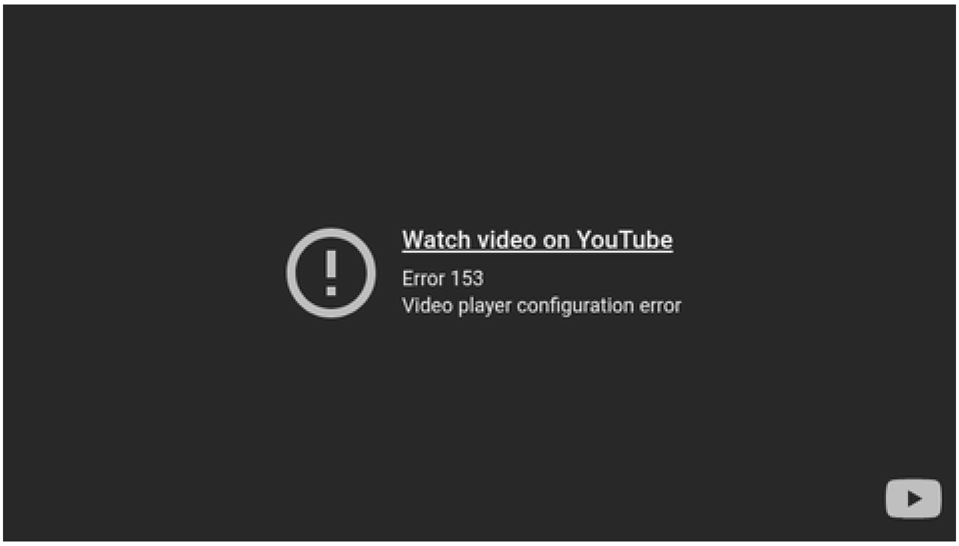


Figure 7: Examples of a positive and negative feedback loop[20]

These loops help explain how systems can either spiral out of control or stay in balance (Figure 7).

Taking steps to reduce greenhouse gas emissions (such as transitioning to renewable energy, reducing energy demand and restoring ecosystems) reduces the amount of global warming that could occur - this is a negative feedback loop.



This TedEd video provides a concise explanation of feedback loops in natural systems.

An example of feedback loop relates to permafrost. Permafrost is ice that has been frozen for a long time - the oldest permafrost has been frozen for around 700,000 years.

The melting of permafrost leads to the release of methane - a greenhouse gas 30 times more effective at trapping additional heat in the atmosphere over a 100-year period than CO_2.

The released methane will amplify global warming through the trapping of additional heat, which will lead to accelerated permafrost melting, which will lead to more methane release, and so on.

This positive feedback between a tipping element and the climate is not unique to permafrost, as many other tipping elements are able to enter positive feedback loops due to global warming and climate change.

Positive feedback loops highlight the dangers of crossing tipping points.

The processes of tipping cascades and feedback loops further highlight the dangers of crossing any tipping point and the importance of keeping global warming to 1.5˚C or 2˚C. Causing a tipping element to tip, can, as seen above, cause multiple other elements to tip too, and amplify global warming.

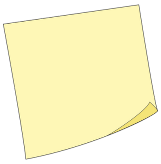
Approaching or going beyond a 2˚C average global warming significantly increases the chances of crossing a tipping element (as seen by the data in Figure 5), which in turn increases the chances of causing a tipping cascade.

Higher levels of warming become exponentially more dangerous due to these cascades and feedbacks.

Tipping Points: from pressure to collapse

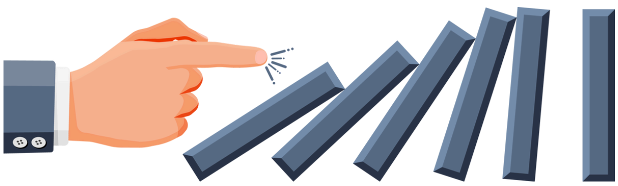
This activity is suitable for older students who have background knowledge in biology.

Concept: Connecting the dots between systems, tipping points and feedback loops:
Type: In groups
Time: 15 minutes



Materials needed:
- Pre-made cards or post-its:
  - Starting conditions (e.g. Healthy coral reef)
  - Pressures/drivers (e.g. Ocean warming, Deforestation, Melting permafrost)
  - Tipping points (e.g. Coral bleaching, Forest dieback)
  - End states (e.g. Algae-dominated coast, Savannah, Methane release)
  - Optional: Labels for subsystems (Biosphere, Atmosphere, etc.)
- Optional: Strings, markers, or tape to create physical links on the board or wall
- Optional: Printed icons or visuals (for sensory engagement)

How It works:
1. Divide students into small groups, each getting one example set.
2. Each group arranges cards in a logical chain:
3. Initial system → Pressures → Tipping point → New state
4. They then connect relevant subsystems to each stage.
5. Each group presents their chain and explains how one small pressure can lead to a big shift.
6. Optionally, have groups move around and try to 'repair' or 'delay' a tipping point by suggesting possible interventions (e.g. reduce CO_2, protect forests, restore wetlands).



Tipping point chains, one per group:

1. Coral reefs

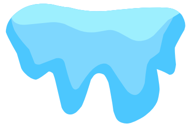
- Initial: Healthy coral reef
- Pressure: Ocean warming, acidification, pollution
- Tipping point: Mass coral bleaching
- New state: Algae-dominated coast, biodiversity loss
- Subsystems: Biosphere, Hydrosphere, Atmosphere
- Interventions: reducing CO_2, reducing pollution, establishing Marine Protected Areas, sustainable fishing practices

2. Amazon rainforest

- Initial: Lush tropical forest
- Pressure: Deforestation, increased droughts and fires brought by climate change
- Tipping Point: Forest dieback
- New State: Dry savannah, carbon release
- Subsystems: Biosphere, Atmosphere, Lithosphere

Interventions: reducing CO_2, protecting and restoring the Amazon Rainforest

3. Melting of ice sheet



- Initial: Stable ice sheet
- Pressure: Global warming, increasing both air and ocean temperatures
- Tipping Point: Ice sheet melting accelerates and permafrost starts to melt
- New State: Methane release from permafrost melt, irreversible sea level rise
- Subsystems: Cryosphere, Atmosphere, Hydrosphere
- Interventions: reducing CO_2 emissions

4. Atlantic Ocean Circulation (AMOC)

- Initial: Strong ocean currents regulating climate
- Pressure: Melting ice adds freshwater
- Tipping Point: Currents weaken or collapse
- New State: Drastic climate changes in Europe and the tropics
- Subsystems: Hydrosphere, Atmosphere, Cryosphere
- Interventions: reducing CO_2 emissions

Wrap-up discussion:

- What did you notice about how many systems are connected?
- Are there any feedback loops?
- How would the systems that one of the groups focused on affect the other?

Storytelling: Come up with a metaphor

Concept: Positive feedback loops
Skills: Applying metaphors to convey complex topics
Type: Individual or in pairs
Time: 10 minutes

Journalists, storytellers, and other communicators use multiple tools in order to help their audience understand the issue. One way a communicator does this is by using metaphors and similes.

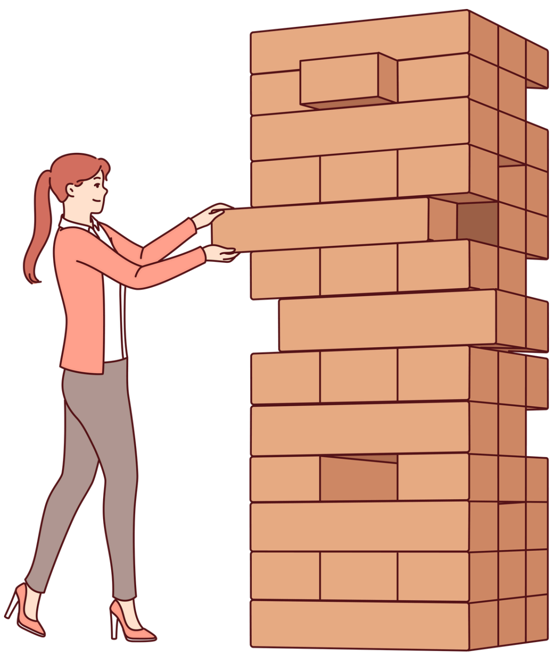
A metaphor is a figure of speech used to represent something else, like “time is a thief”.

A simile compares two things using the word “like” or “as”, for example “the Amazon is like a drying sponge.”

Come up with a metaphor or simile (like the Jenga game and tipping points) for a positive feedback loop.

This is an example to help you along: Two people are in an argument. One person throws an insult, so someone else shouts back. This response is met by an even fiercer reply, and so on. The argument gets worse and worse until it actually becomes violent and out of control. In a short space of time the two people find themselves thinking - how did things get that bad so quick?

A way of describing this could be, “Positive feedback loops are when one part of a system amplifies the reaction of another part of a system, like an escalating argument between two people.”



Endnotes

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8. Science Panel for the Amazon (SPA) (2021): Executive Summary of the Amazon Assessment Report 2021.

9. McKay et al. (2022): Exceeding 1.5°C Global Warming Could Trigger Multiple Climate Tipping Points

10. Lovejoy and Nobre (2008): Amazon Tipping Point

11. Science Panel for the Amazon (SPA) (2021): Executive Summary of the Amazon Assessment Report 2021.

12. A carbon sink is a system that takes in more CO2 than it releases

13. Friedlingstein et al. (2020): Global Carbon Budget 2020

14. Gatti et al. (2021): Amazonia as a carbon source linked to deforestation and climate change.

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16. Nusche, Fuster Rabella and Lauterbach (2024): Rethinking education in the context of climate change: Leverage points for transformative change

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18. For a short but clear breakdown of some of these effects, see for instance Lenton et al. (2020): Climate tipping points - too risky to bet against. Available at: https://www.nature.com/articles/d41586-019-03595-0

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