



## Climate Feedback Loops: Permafrost

### Key Points and Guiding Questions

#### SUMMARY

Permafrost, an icy expanse of frozen ground covering one-quarter of the Northern Hemisphere, is thawing. As it does, microscopic animals are waking up and feeding on the previously frozen carbon stored in plant and animal remains, releasing heat-trapping gases as a byproduct. These gases warm the atmosphere further, melting more permafrost in a dangerous feedback loop. With permafrost containing twice as much carbon as the atmosphere, its thaw could release 150 billion tons of carbon by the end of the century.

Tip # 1: Get familiar with the content.

Tip # 2: Create connections between what viewers say in the discussion and key concepts from the film. Use your knowledge of the presentation to make these connections.

Tip #3: Practice empathy. This content may be hard to understand for some viewers.

## PERMAFROST FEEDBACK LOOPS

- **What is permafrost?** Covering nearly one-quarter of the landmass of the Northern Hemisphere, permafrost is ground that remains frozen for two or more consecutive years. It consists of rock, soil, and sediments bound together by ice under a layer of soil extending from three feet to more than a mile deep. It contains the remains of animals and plants that haven't decomposed because of the frozen state of permafrost, which can last hundreds of thousands of years.
- **Why is it important?** Because the frozen remains of plants and animals contain large amounts of carbon, scientists estimate that the world's permafrost holds 1,500 billion tons of carbon, nearly double the amount currently in the atmosphere. When permafrost thaws, microscopic animals called microbes wake up and feed on the carbon. As a byproduct of digestion, they produce carbon dioxide and methane, releasing these dangerous heat-trapping gases into the atmosphere.
- **Permafrost Feedback Loop** – Fossil fuel emissions → warming climate → permafrost thaws → microbes digest newly-thawed carbon remains → carbon dioxide and methane produced → heat-trapping gases released into atmosphere → more warming.
- **Carbon dioxide or methane?** When microbes digest carbon in oxygen-rich, or aerobic, conditions like soil and lake surfaces, they produce carbon dioxide. In anaerobic environments lacking oxygen, like bogs and muddy lake bottoms, they produce methane. Methane is nearly 30 times more potent at trapping heat than carbon dioxide.
- **Methane Craters** – Sometimes, methane builds up under a thick layer of ice. When the ice melts, the pressure gives way and causes an explosion. In Siberia, such explosions have left huge crater-like holes on the landscape. A year or two later, the craters form lakes that release the previously buried methane into the atmosphere.
- **Lake Microbes** – In the Northern Hemisphere, home to most of the world's lakes, the warming climate is bringing southern plant species northward. This results in new food sources – such as oak tree, maple tree, and cattail litter – for the microbes that live in lake bottoms. Because the conditions are anaerobic, microbes emit methane as a byproduct of digestion. Studies show that 400 times as much methane is released by lake microbes when they digest cattail litter compared to tree litter.

- **Lakes Feedback Loop** – Fossil fuel emissions → warming climate → plant species migrate north → new food sources for lake microbes → more methane is released → more warming.

## Discussion Questions:

### Feedback Loops

What is a positive feedback loop? What is a negative feedback loop?

A positive feedback loop enhances or amplifies the effects of change, producing instability, such as warming creating more warming. A negative feedback loop reduces and or dampens the effect of change, helping maintain balance.

Have you heard of feedback loops before? If so, where?

Can you think of examples of positive and negative feedback loops from your everyday experience?

What is warming the Earth and setting off feedback loops?

Why are feedback loops so important in understanding climate change?

Is it possible to slow, halt, or reverse feedback loops?

### Permafrost

How much of the world's land contains permafrost?

How much carbon is stored in permafrost? How does this compare to what's in the atmosphere?

What happens as the permafrost thaws?

Can you describe the permafrost feedback loop?

When do microbes release carbon dioxide and when do they release methane?

How can permafrost thaw transform the landscape?

Can the permafrost refreeze?

Have you heard of permafrost feedbacks before? If so, how?

## **Methane**

What's causing methane craters? What happens when they form lakes?

What's happening around lakes in the Northern Hemisphere as the climate warms?

What new species are migrating northward?

How are the new varieties of plant species affecting the microbes that live in lake bottoms?

Can you describe the lake feedback loop?

What greenhouse gas are they emitting?

In the next 50 years, how much will methane production increase around lakes?

Have you heard of lake feedbacks before? If so, how?

How do particular images impact your reaction and reception of the messages in the film? What images or facts had the biggest impact on you?

Have you heard anything in the news lately that affirms or contradicts any of the issues presented in this film?

## **General**

Should we focus on reducing emissions of carbon or focus on finding ways to store it? Or both?

Do you think we can continue living the way we have been while also reducing global warming?

How can we manage Earth in ways that help us mitigate climate change? What are some possible positive steps humans can initiate?

*What do you feel motivated to do?* The film ends with a message of the need to act. While feedback loops mean that one problem can cause many more, they also imply that one solution can trigger many others. What are some possible action steps humans can take?

Why is the content of this film important for the world to know?

## Resources:

[Methane Feedbacks to the Global Climate System in a Warmer World](#)

[The Global Carbon Budget and Permafrost Feedback Loops in the Arctic](#)

[How Microbes in Permafrost Could Trigger a Massive Carbon Bomb](#)

[Arctic Bogs Hold Another Global Warming Risk that Could Spiral Out of Control](#)

[Scientists Find New Climate Feedback Loop in Lakes](#)

[Drawdown - Solutions to decrease your carbon footprint](#)

[How You Can Stop Global Warming](#)