Systems Thinking and Climate Change

Developing the Next Generation of Female Environmentalists

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What Is A System?

- “A system is a set of things—people, cells, molecules, or whatever—interconnected in such a way that they produce their own pattern of behavior over time.” (Meadows, 2008, 2)

- Examples:
  - the human body
  - a flower
  - a forest
  - a cricket team
  - a university
- Not a system:
  - sand scattered on the side of a road

Systems Thinking

- “Systems thinking is a way of helping a person to view systems from a broad perspective that includes seeing overall structures, patterns and cycles in systems, rather than seeing only specific events in the system.” (“Field Guide to Consulting and Organizational Development”)

Why Systems Thinking?

Systems thinking as a pathway to global warming beliefs and attitudes through an ecological worldview

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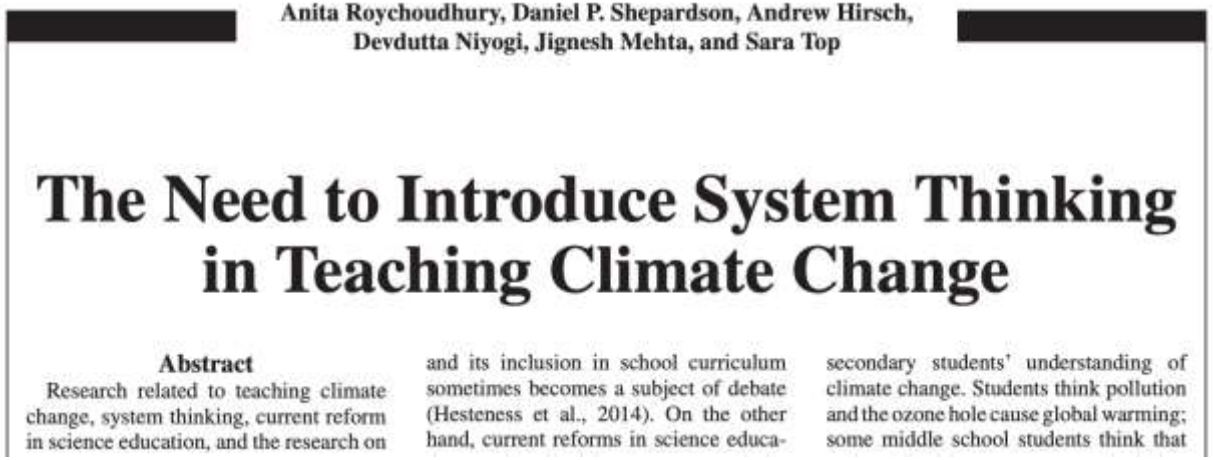
Edited by Arild Underdal, University of Oslo, Oslo, Norway, and approved March 8, 2019 (received for review November 26, 2018)

Significance

Systems thinking is recognized as vital to understanding climate science and addressing climate change. Understanding how systems thinking influences the public's beliefs and attitudes about climate change has important implications for climate change education and communication. Our findings indicate that across the political spectrum, systems thinking may facilitate an ecological ethic or value system that humans should preserve and protect the natural world rather than exploit it. This, in turn, may strengthen proclimate views and understanding of climate change (e.g., that global warming is happening, is human-caused, etc.). The findings contribute to systems thinking theory and indicate the importance of promoting systems thinking to support proclimate science beliefs, attitudes, and behaviors across political lines.

Source: Proceedings of the National Academy of Sciences

Why Systems Thinking?



Anita Roychoudhury, Daniel P. Shepardson, Andrew Hirsch, Devdutta Niyogi, Jignesh Mehta, and Sara Top

The Need to Introduce System Thinking in Teaching Climate Change

Abstract

Research related to teaching climate change, system thinking, current reform in science education, and the research on

and its inclusion in school curriculum sometimes becomes a subject of debate (Hesteness et al., 2014). On the other hand, current reforms in science educa-

secondary students' understanding of climate change. Students think pollution and the ozone hole cause global warming; some middle school students think that

Source: Science Educator

"Statistical analysis of student responses on the pre- and post-test showed a significant ($p<.0001$) gain in knowledge but more importantly, qualitative analysis of student responses showed that they learned that our climate is changing but had constructed a linear connection between variables such as surface temperature and drought. The students did not develop a connected body of knowledge or an understanding of climate as a system. Future research needs to focus on curriculum development, effective system pedagogy, assessment, and teacher development in the context of climate change as an interlinked system."

Why Systems Thinking?

- To address complex environmental problems, we need to approach them holistically, not just one piece at a time!

Systems Thinking Origins

- System Dynamics – founded at MIT Sloan in 1956 by Professor Jay W. Forrester.
  - “This discipline combines the theory, methods, and philosophy needed to analyze the behavior of systems — not only in management, but also in such other fields as environmental change, politics, economic behavior, medicine, and engineering.” (MITSloan.edu)
  - Wrote “World Dynamics” (1971) discussing natural resources, development, and population growth

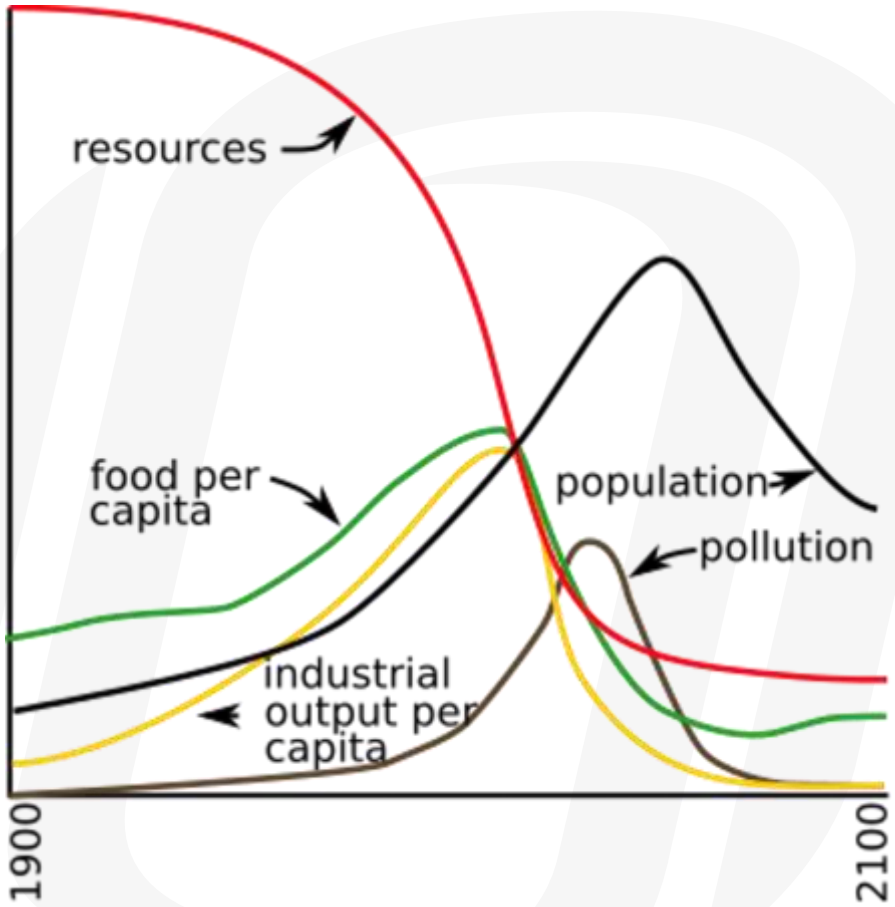
Systems Thinking Origins

- Donella Meadows
  - A student of Forrester's at the "System Dynamics" lab
  - Ph.D. in biophysics from Harvard University
  - Pew Scholar in Conservation and Environment (1991) and a MacArthur Fellow (1994)
  - Taught in the Environmental Studies Program of Dartmouth College

> *"We humans are smart enough to have created complex systems and amazing productivity; surely we are also smart enough to make sure that everyone shares our bounty, and surely we are smart enough to sustainably steward the natural world upon which we all depend."* (donellameadows.org)

Systems Thinking Origins

- “Limits to Growth” (1972) which explored exponential economic and population growth with finite resources
    - Used World3 computer model to examine interrelationships among world population, pollution, industrial production, agricultural production, and resource depletion

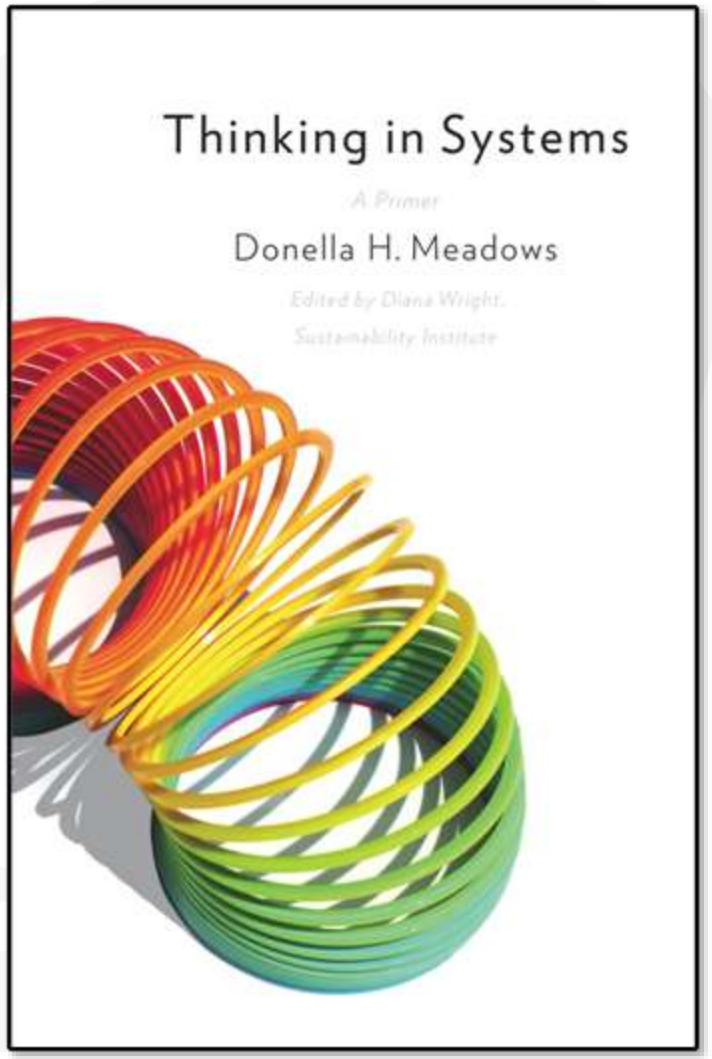


A figure from ‘The Limits to Growth,’ with consumption continuing at the 1970 rate. Depletion of nonrenewable resources leads to a collapse of industrial production, with growth stopping before 2100. YaguraStation/Wikipedia, CC BY-SA

Link

Systems Thinking Origins

- “Thinking in Systems: A Primer” (2008)
  - Used in my Intro to Sustainability course




CONFLICT
STOP
PUTIN


POVERTY


POLLUTION


CLIMATE
CHANGE


WATER
SCARCITY


HEALTH

Solutions Are Interconnected As Well!

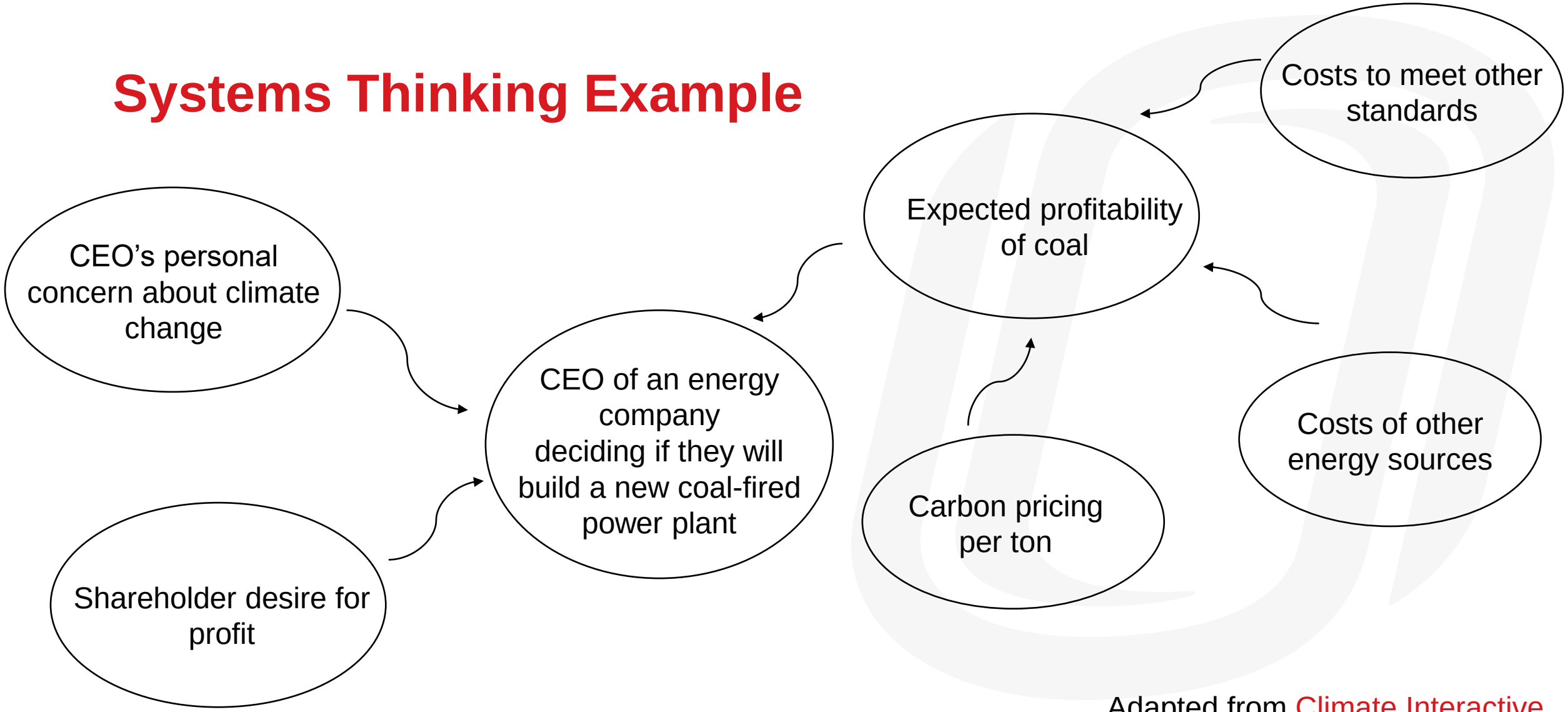
Ugandan university lecturer and cycling enthusiast Amanda Ngabirano on her bicycle

[Amanda Ngabirano]

"We cannot fix one problem in isolation because they are all connected"

- Margaret Robinson (*Sustainability Principles and Practice*, 2014, pg. 5)

Systems Thinking Example



Adapted from Climate Interactive

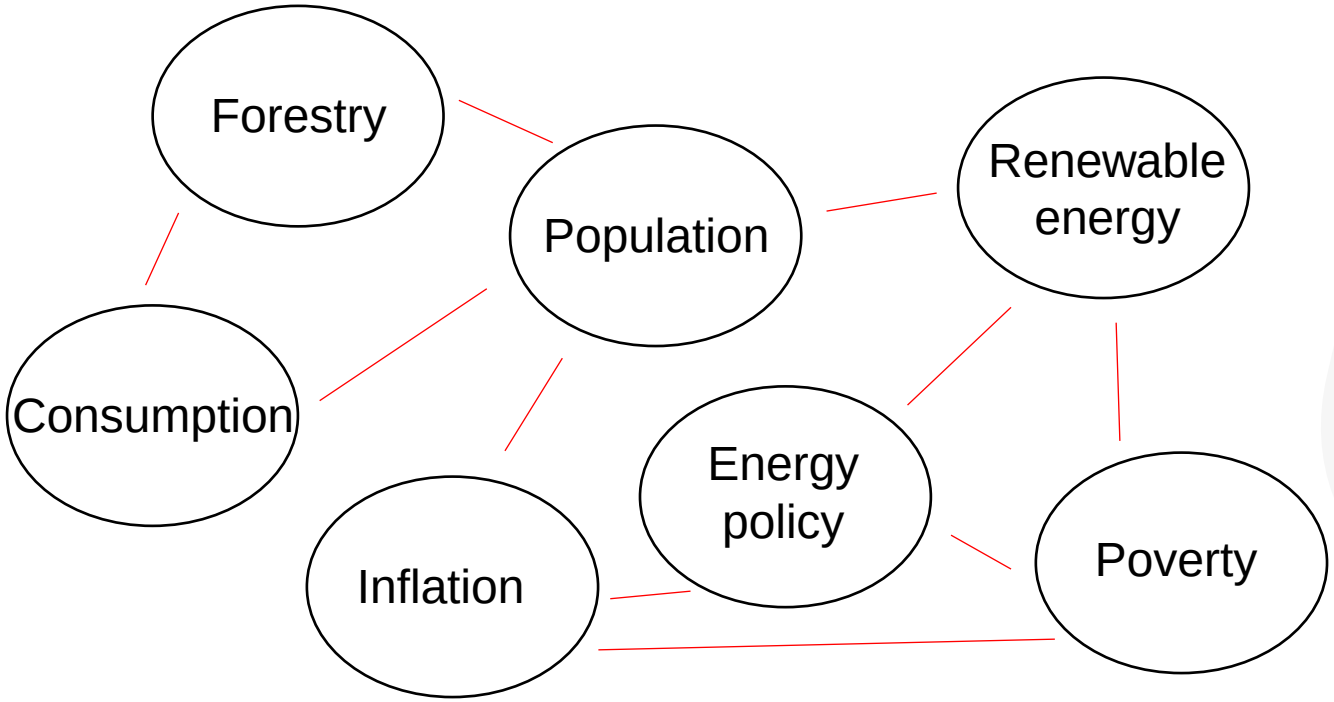
Systems Thinking Example

- Would a new decision-maker placed in the same system make a different decision?

- How to effect change:
  - Ask how the system can be changed
  - Change the taxes, policies, regulations, and incentives that influence decision makers
  - In general, focus more on the system than the players
  - But also lead by example, use the power of persuasion, and demand action
  - Systems rarely change on their own, so it takes commitment!

Climate Change Strategy

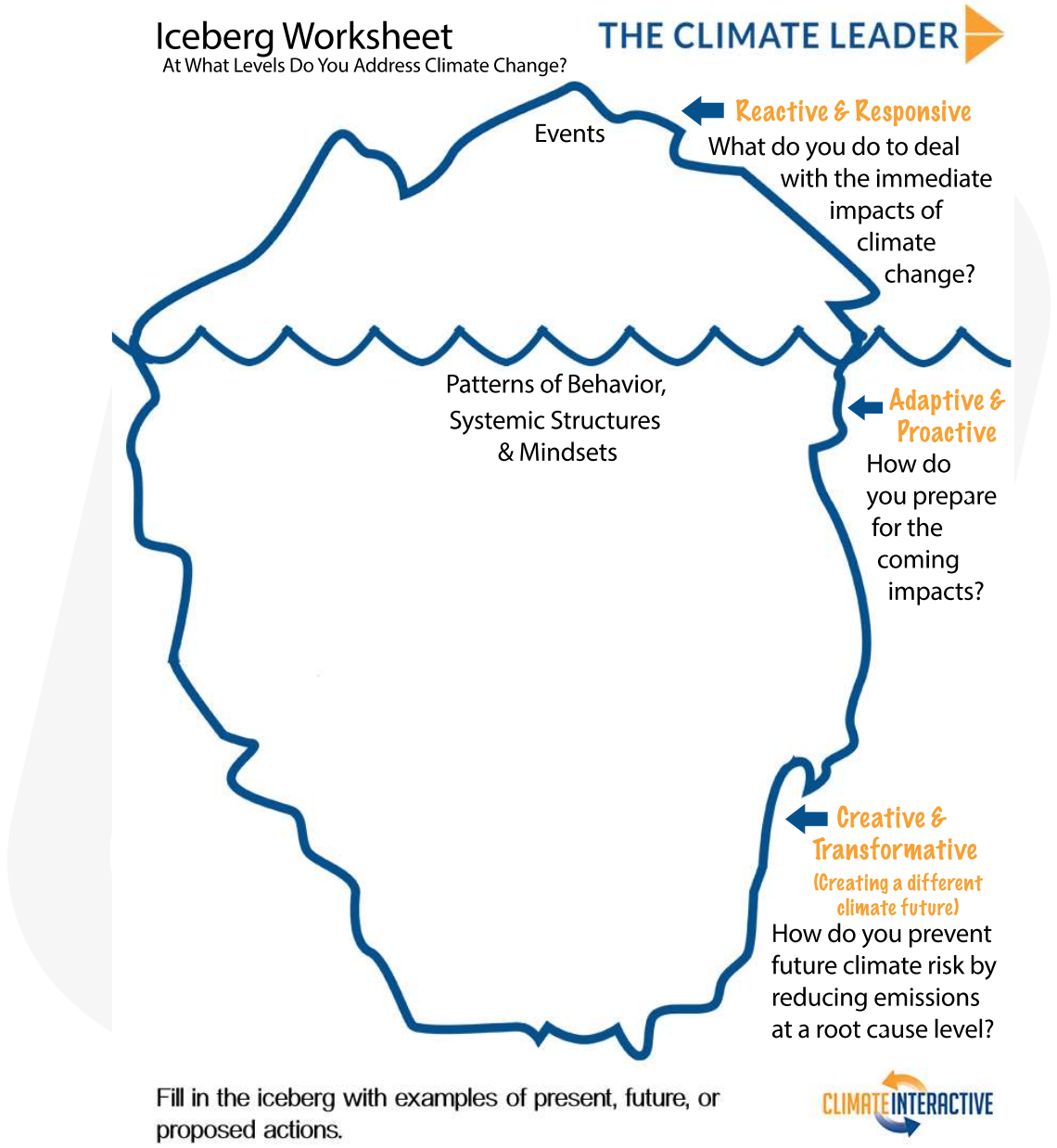
- Addressing the whole system



- Design interventions that appreciate the whole system (rather than just the parts)

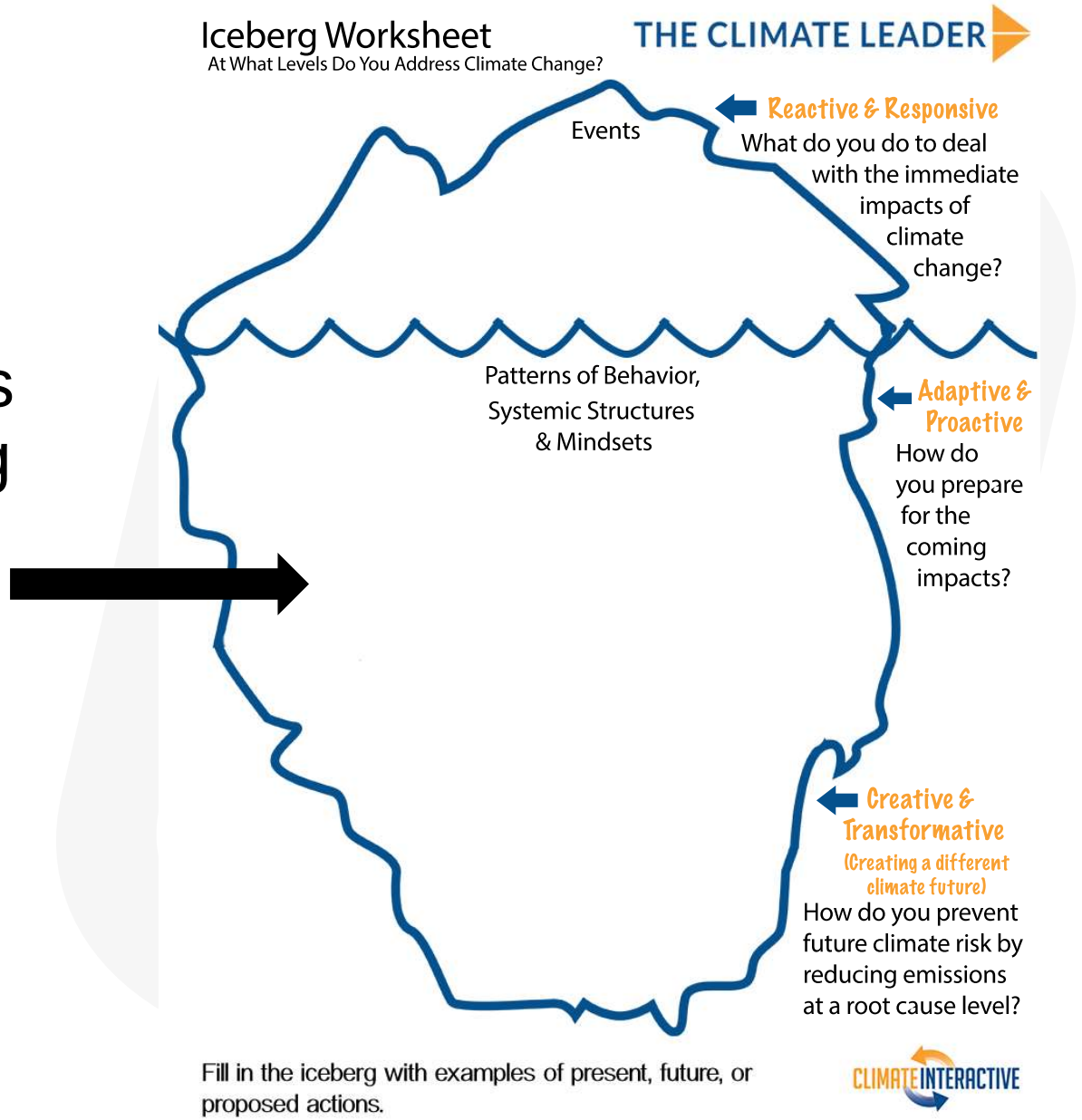
Iceberg Thinking

- What we see is above the water, and that's where we tend to focus our attention
  - When we see events, we react and respond
  - When we ONLY focus on events, we aren't affecting what is driving the long-term behavior of the system
- Look below the water level!



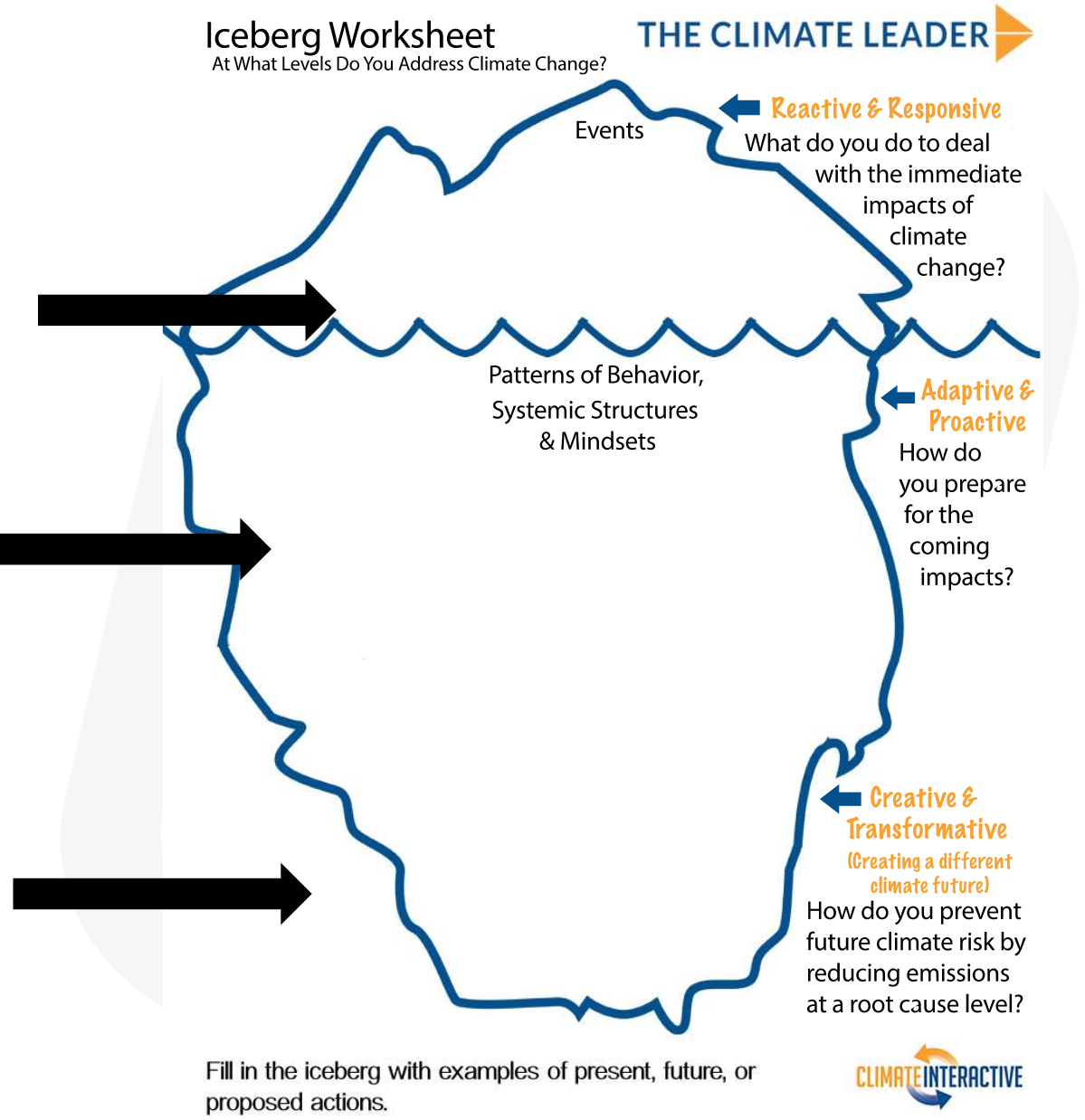
Iceberg Thinking

- What are the systemic structures and mindsets that are the driving forces of patterns and behavior?
  - “my voice matters in the world”
  - “we must use fossil fuels to power economic development”
- What are the feedback loops? (more on this later)



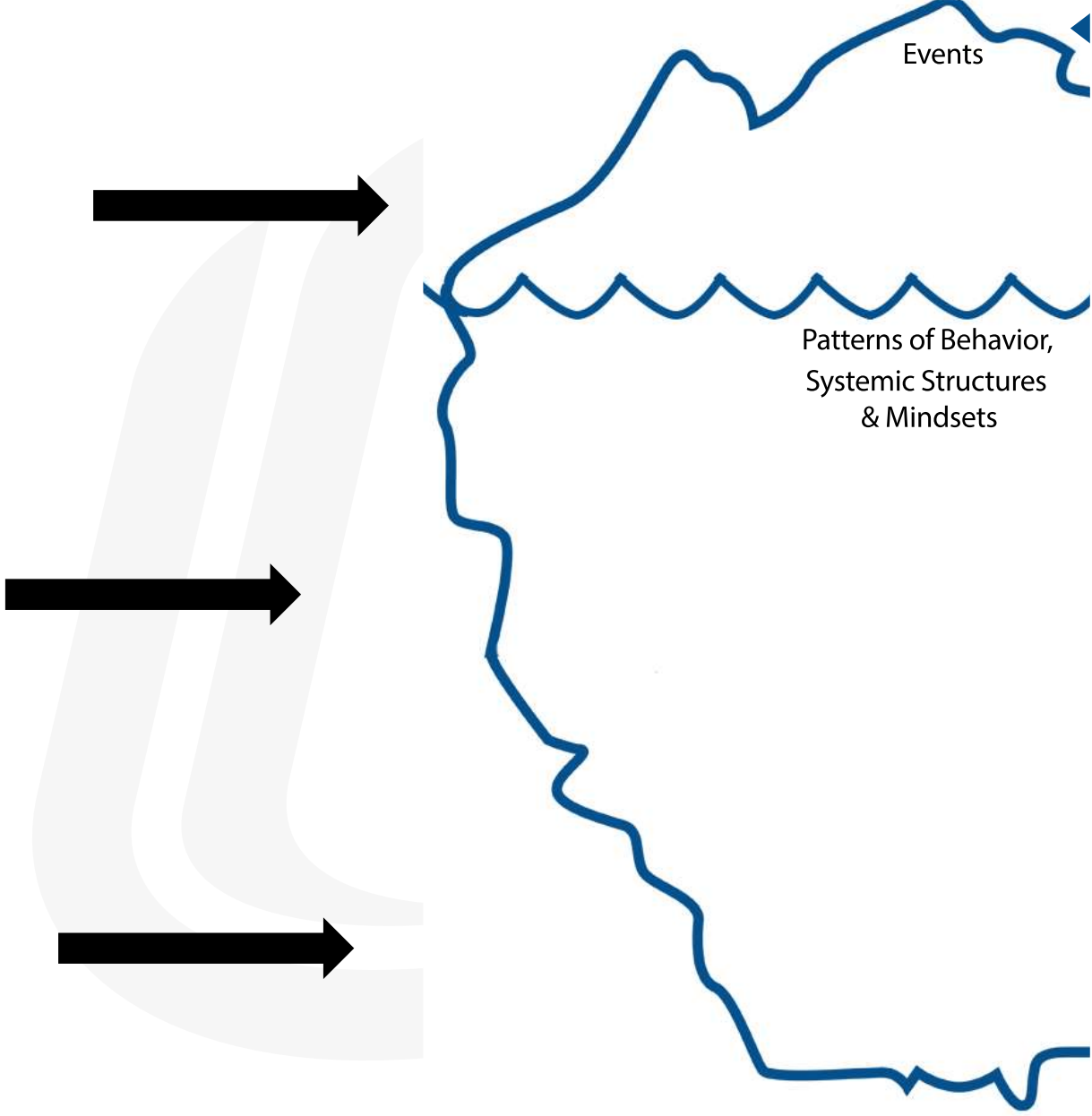
Iceberg Thinking

- Providing emergency housing after a hurricane or a flood
- Preparing for impacts that are coming
  - Adaptation, building in resiliency (i.e. weather-ready cities)
- Mitigation
  - Building renewable energy, protecting forests



Discuss!

- What do you do to deal with the immediate impacts of climate change?
- How do you prepare for the coming impact?
- How do you prevent future climate risk by reducing emissions at a root level cause?

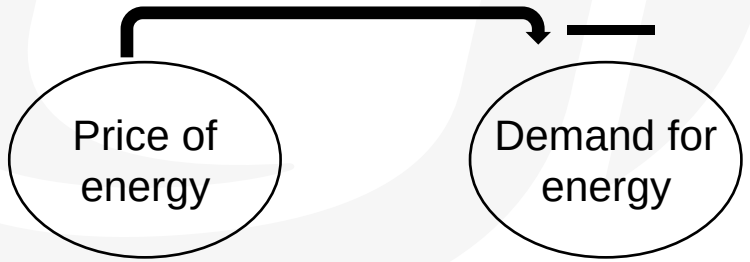


Causal Diagrams

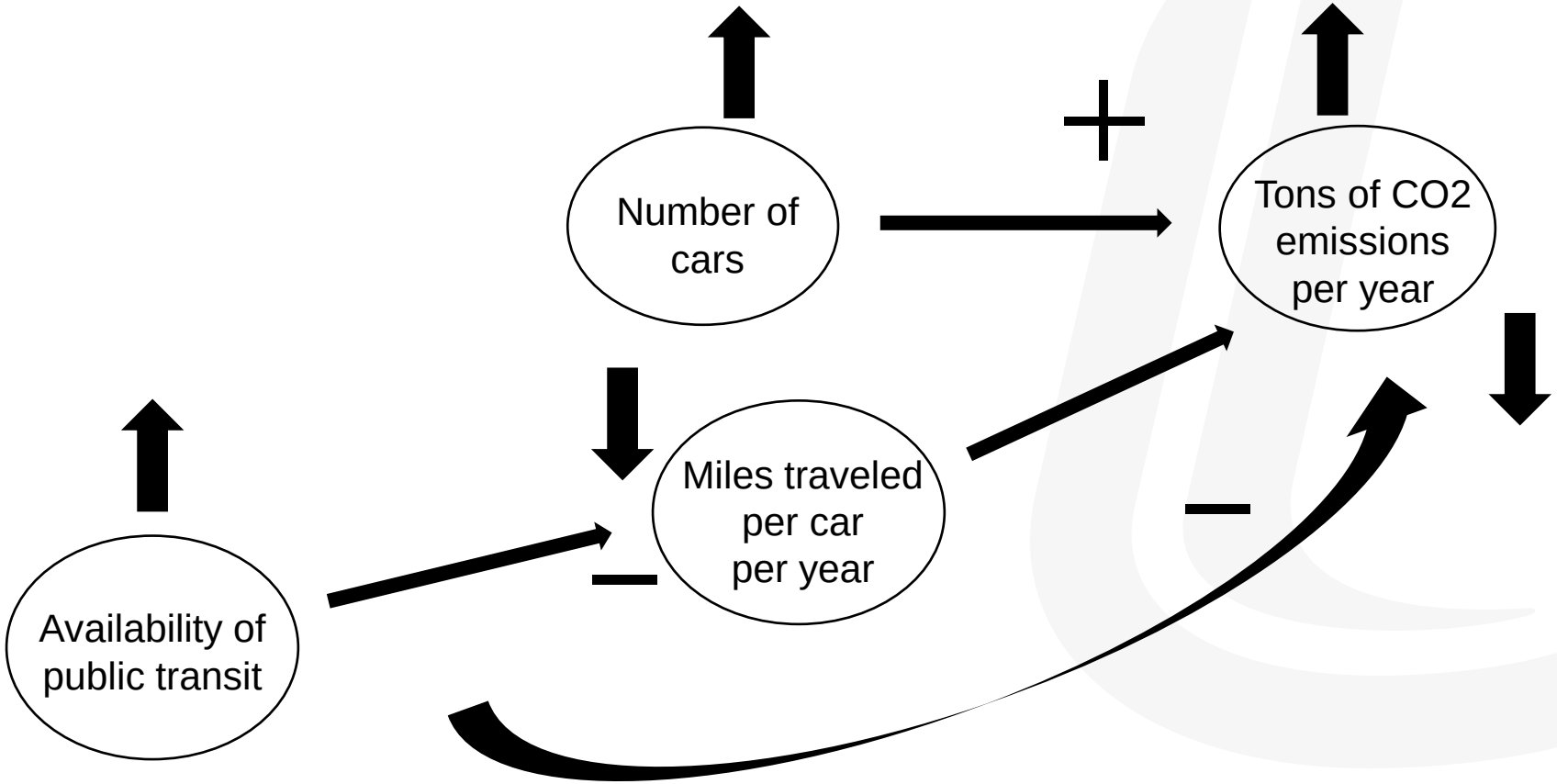
- If you're working on climate change, you're working on systems change!

- Causal diagrams illustrate how the connections in systems give rise to that system's behavior

- Help you to:
  - clarify where to invest your time and energy
  - motivate people to act towards a goal
  - discover new allies

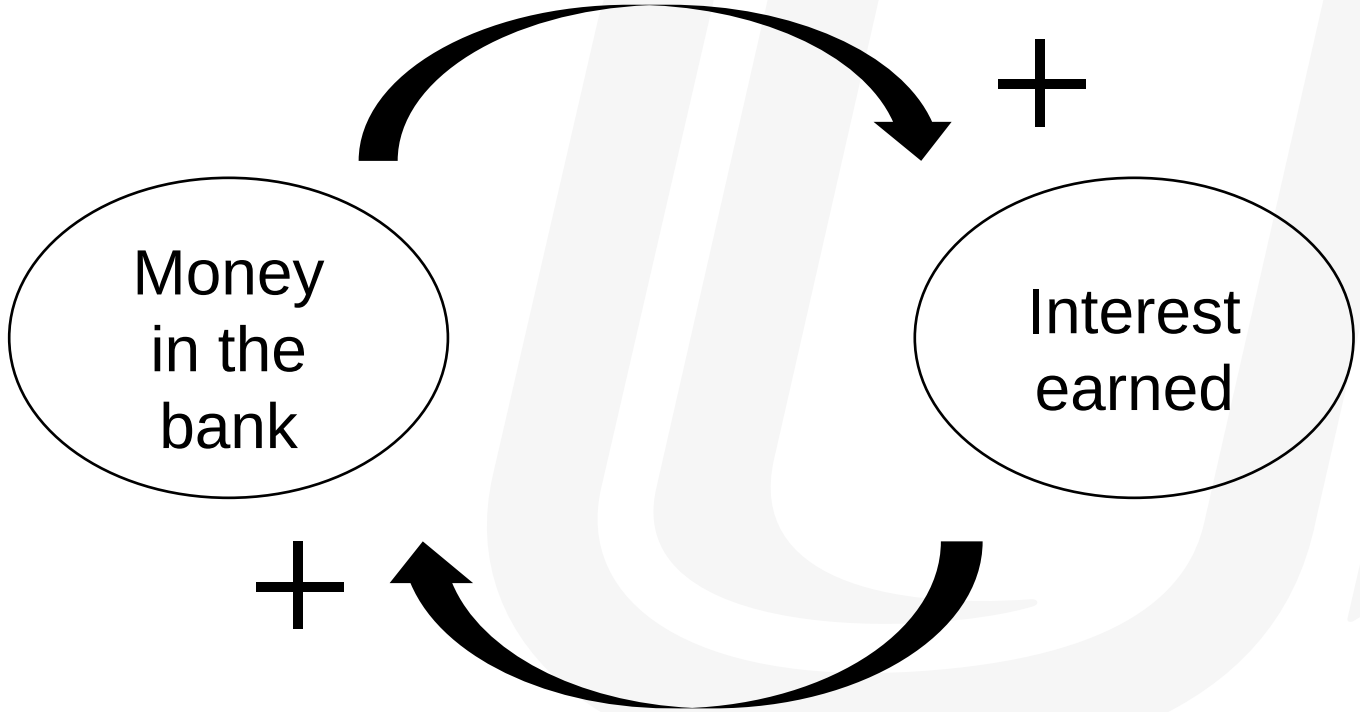


Causal Diagrams



Reinforcing Feedback Loops

- Reinforcing feedback is also known as positive feedback or exponential change



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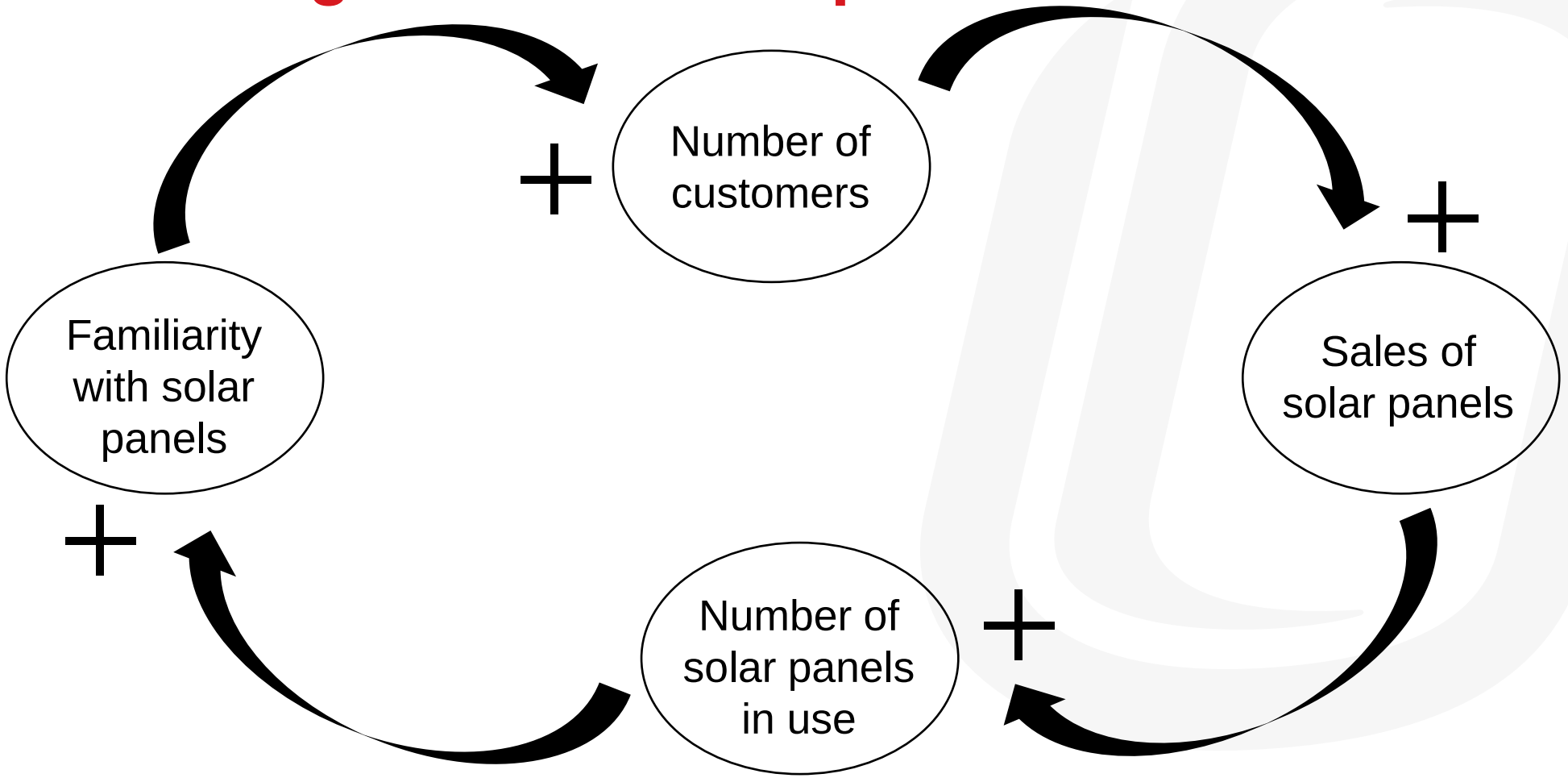

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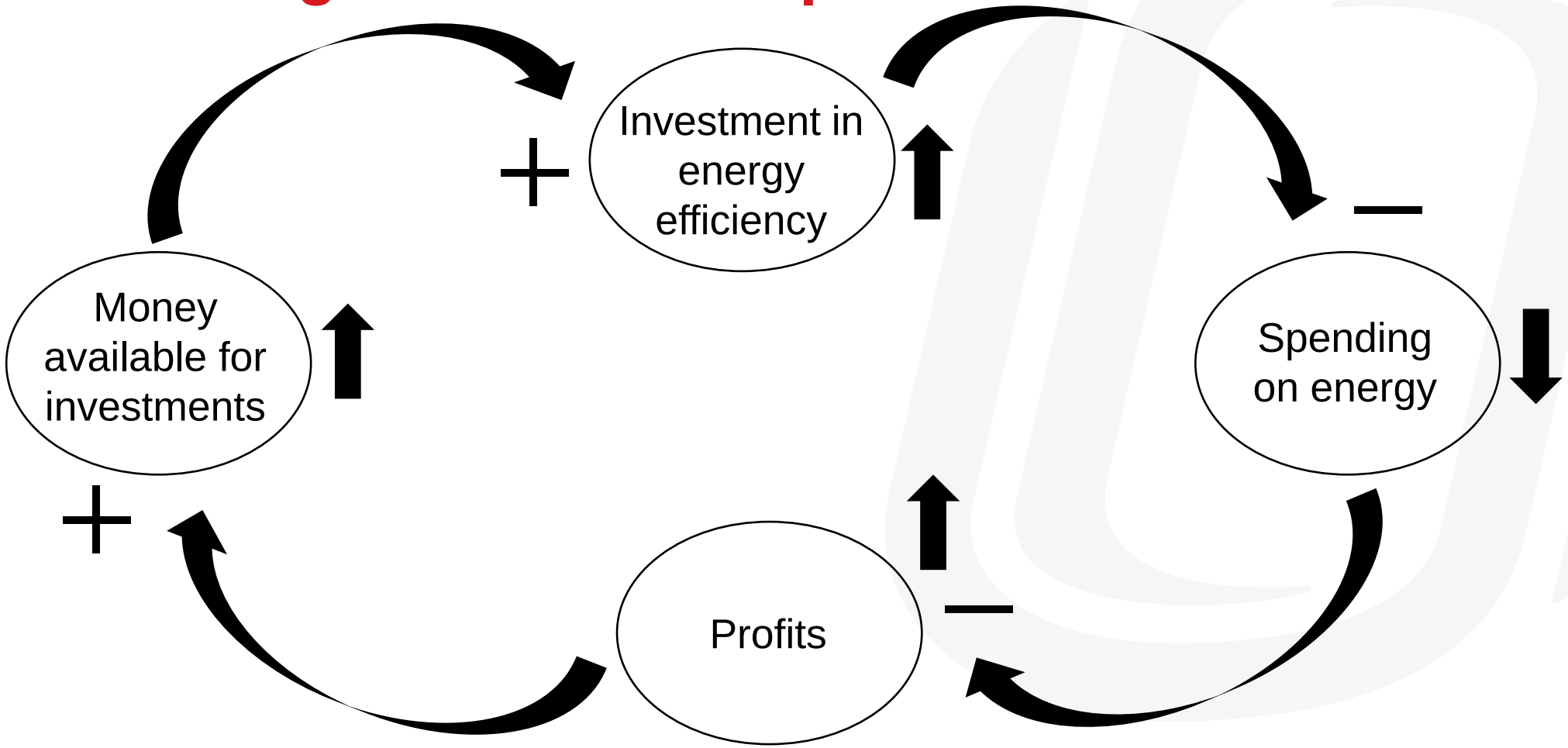

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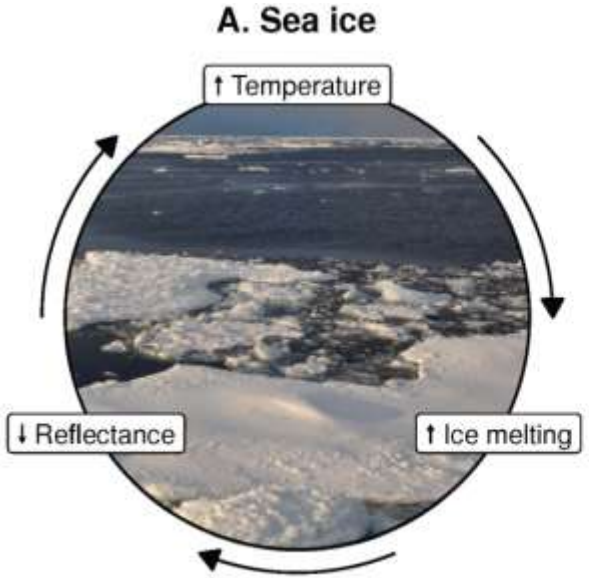
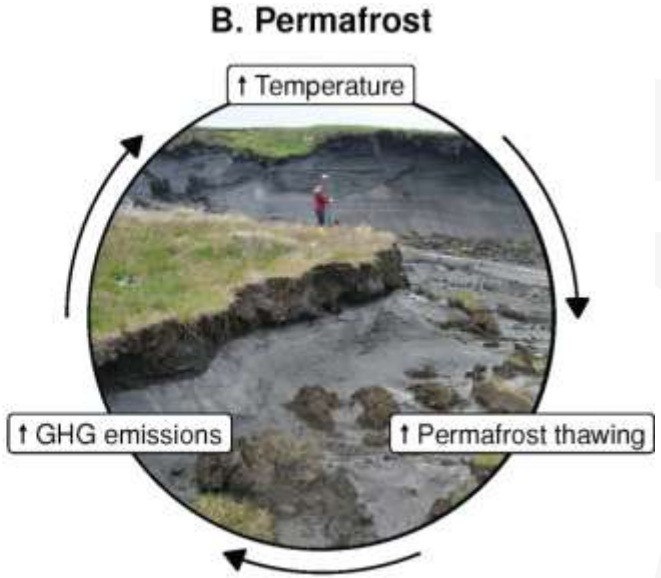
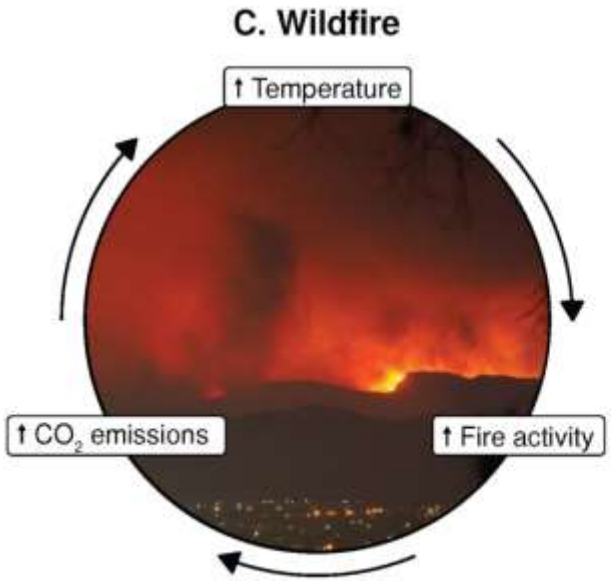






Feeback loop descriptions

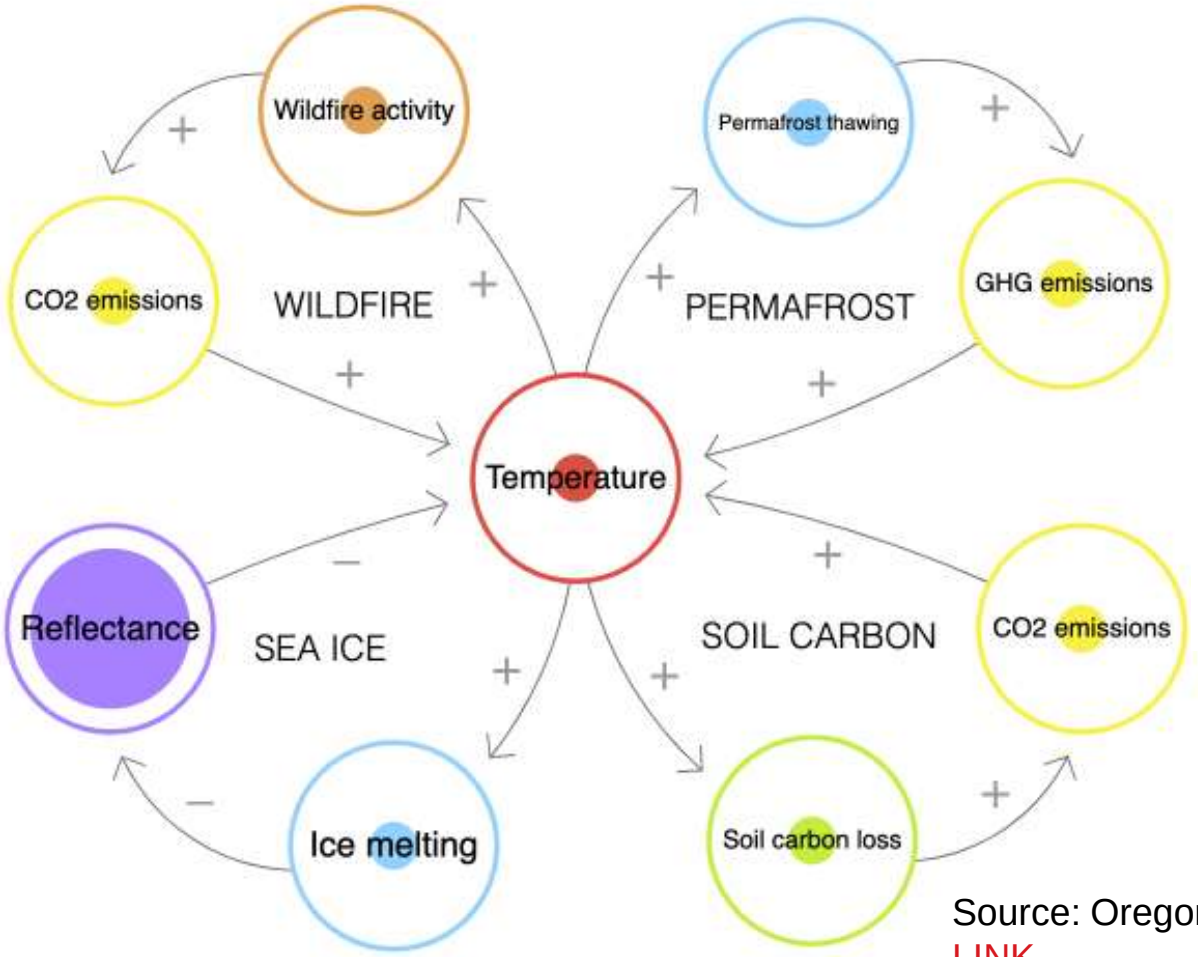
A. Arctic warming leads to melting sea ice, which leads to further warming because water **has lower albedo (reflectance) than ice**

B. Increasing temperatures lead to permafrost thawing, which produces CO_2 and methane emissions, which in turn leads to further increasing temperatures

C. Rising temperatures lead to increasing fire frequency or severity causing increasing CO_2 emissions, loss of sequestration, and changes in albedo, which causing more warming

Photo credits: (A) Patrick Kelley, CC BY 2.0; (B) Boris Radosavljevic , CC BY 2.0; (C) Nick-D, CC BY-SA 4.0.

Reinforcing Feedback Loops



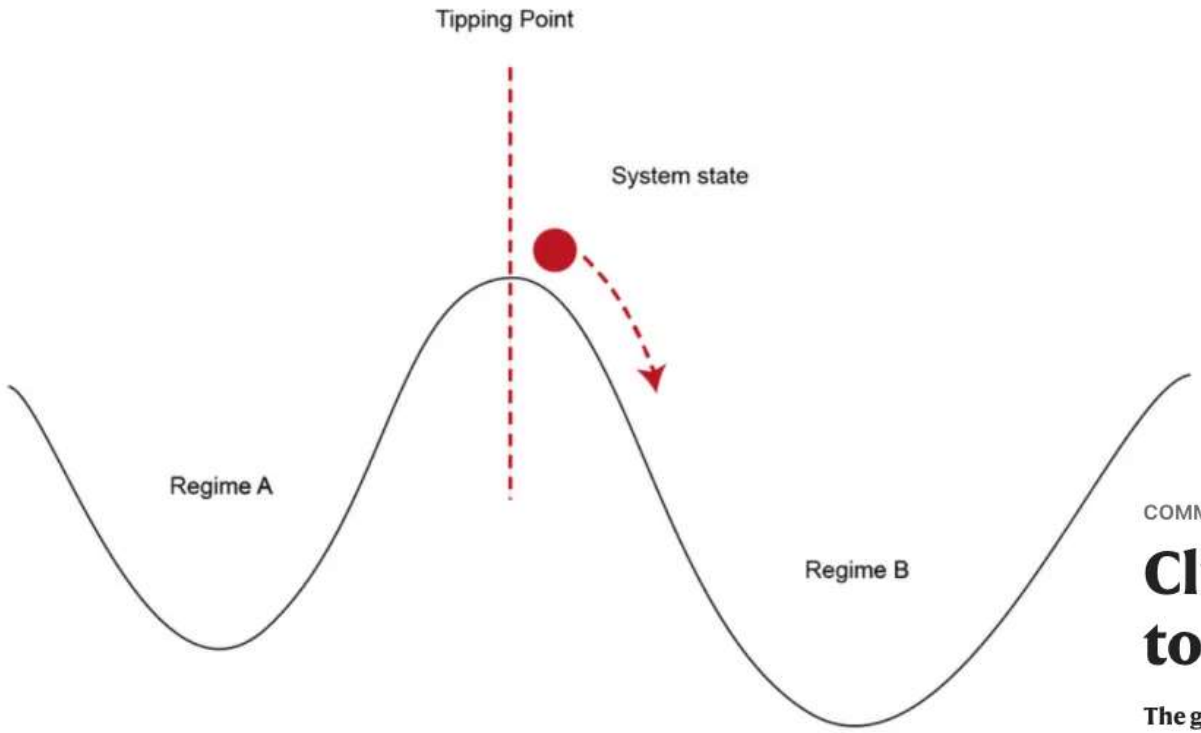
Nearly 30 dangerous feedback loops could permanently shift the Earth's climate, scientists say

By Laura Paddison, CNN
Published 11:00 AM EST, Fri February 17, 2023

LINK

Source: Oregon State University
LINK

Tipping Points



Creative Commons Rauter et al.
LINK

- Occurs when a reinforcing feedback loop crosses a point of no return
- Ex: Rising sea levels
  - Represents a new normal
  - No matter what actions are taken today, these changes are baked into the system and not easily reversed

COMMENT | 27 November 2019 | Correction 09 April 2020

Climate tipping points – too risky to bet against

The growing threat of abrupt and irreversible climate changes must compel political and economic action on emissions.

Timothy M. Lenton, Johan Rockström, Owen Gaffney, Stefan Rahmstorf, Katherine Richardson, Will Steffen & Hans Joachim Schellnhuber

nature.com

“The Power of Multisolving for People and Climate”

Questions & Discussion