# Mitigation and Adaptation Studies

## Class 14: Understanding Vulnerabilities: The Earth's Life-Support System

Case Study Input

Contents

- More on Risk, Vulnerability, Resilience, Adaptation
- Vulnerabilities of the Planetary System
- Land Cover Changes
- Global Warming: Earth Energy Imbalance
- Sea Level Rise
- Pollution

# Extinction of Species in the African savanna

Tyler French

# Background Information

- Tropical grassland, warm temperatures year-round

- Central, eastern, southern Africa
- Diverse, iconic fauna
    - Carnivores: hyena, lion, leopard
    - Herbivores: elephant, rhinoceros, hippopotamus

# Vulnerabilities

- Illegal poaching - extremely vulnerable
  - Killed for bones, coats, sport
  - Ex: African elephant (~ 35K each year)
  - Ex: Black rhino (pop. down ~98% since 1960)
- Ecotourism - highly vulnerable
  - Production of roads, infrastructure, lodges
- Habitat loss - very vulnerable
  - Habitat fragmentation, land privatization
  - Often hand-in-hand w/ ecotourism
- Wildfires - vulnerable
  - Climate change, road construction, fire-control/prevention methods
  - Human-caused/influenced

# Stakeholders

- African Wildlife Foundation (AWF)
- National Park reps.
  - Serengeti, Masai Mara, Etosha
- Local African tribes
  - Zulu, Masaai, Tutsi
- Research scientists , conservationists
- Legal trophy hunters
- International tourists

# References


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Risk (in $) = Hazard Probability * Vulnerability * Exposed Assets

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- probability of extreme events is often underestimated:
- bad physics (incorrect description of processes)
- bad assumptions (choice of poorly known parameters)
- bad data (lacking, incomplete, or underappreciated)
- bad luck (low probability events) (Stein, 2011, 2012)

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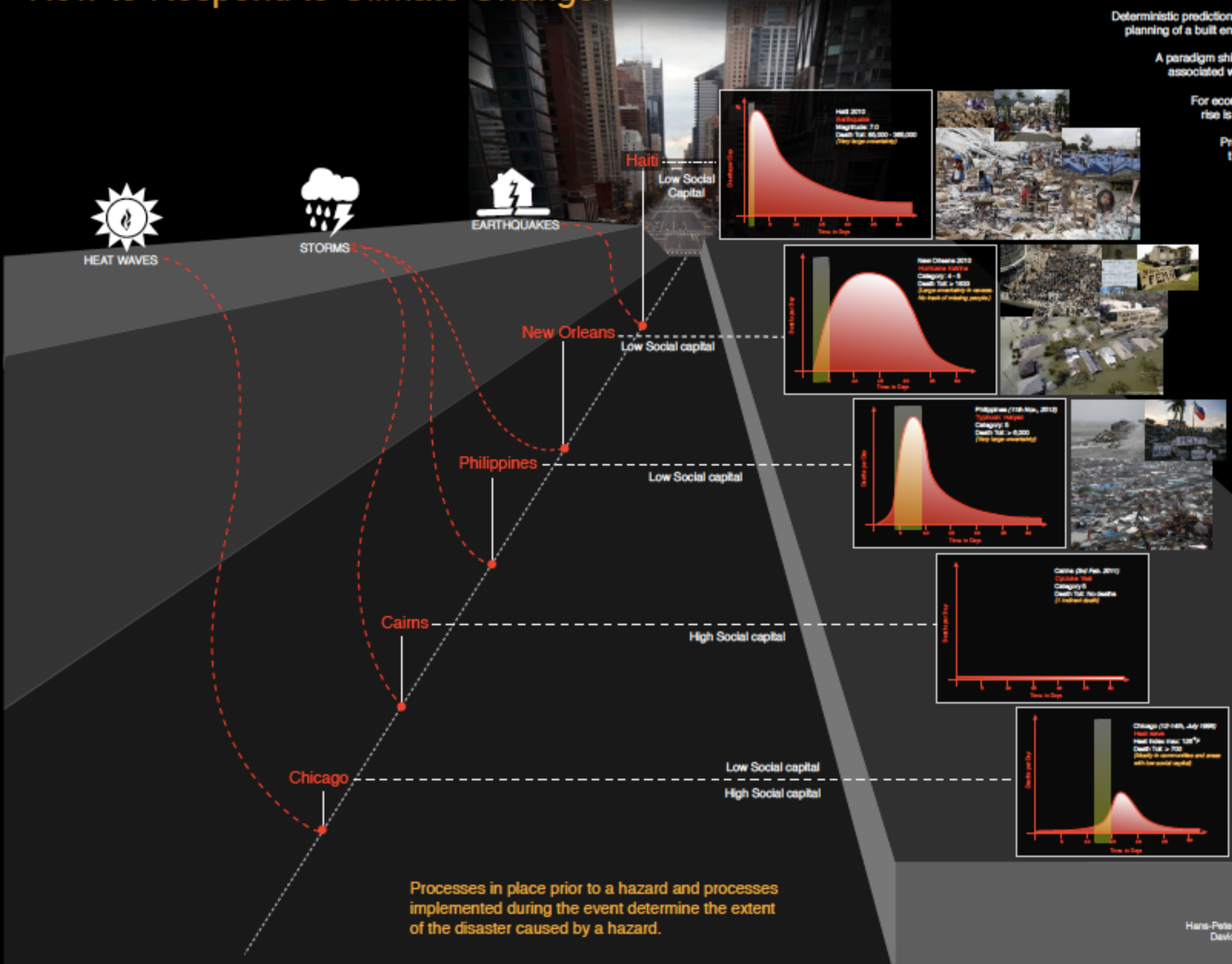
- e.g., earthquakes trigger tsunamis, landslides, fires
- e.g., fires destroy health facilities

# Deterministic or Probabilistic - Robustness or Resilience: How to Respond to Climate Change?




## Natural hazards are not the disaster!

Deterministic predictions of climate change and sea level rise do not provide a basis for feasible planning of a built environment with thresholds that will not be exceeded by extreme events.

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For economic reasons, mitigation of impacts of climate change and sea level rise is limited, and rare surprising events will exceed thresholds.

Processes in place prior to a hazard and processes implemented during the event determine the extent of the disaster caused by hazards that exceed thresholds.

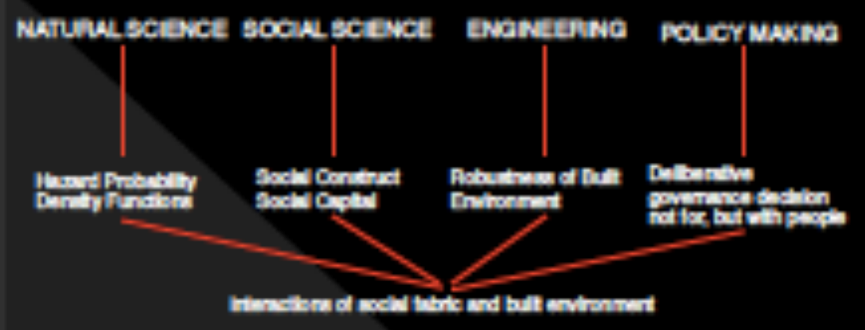
If an event exceeds thresholds of the built environment, the resilience of the social fabric determines the processes and extent of the disaster.

Resilience depends strongly on social capital. 'Social capital' refers to dense social networks with norms and social trust that allow community members to share interests, communicate valuable information, and identify opportunities to collaborate for the benefit of the entire community. Disaster risk reduction requires resilience and an increased social capital.

A best practice is needed that can utilize uncertainties and surprises to increase robustness, strengthen resilience, and reduce fragility of the social system during times when infrastructure fails.

A paradigm shift is needed to a new science-policy interface.

## A Science - Engineering - Policy Paradigm

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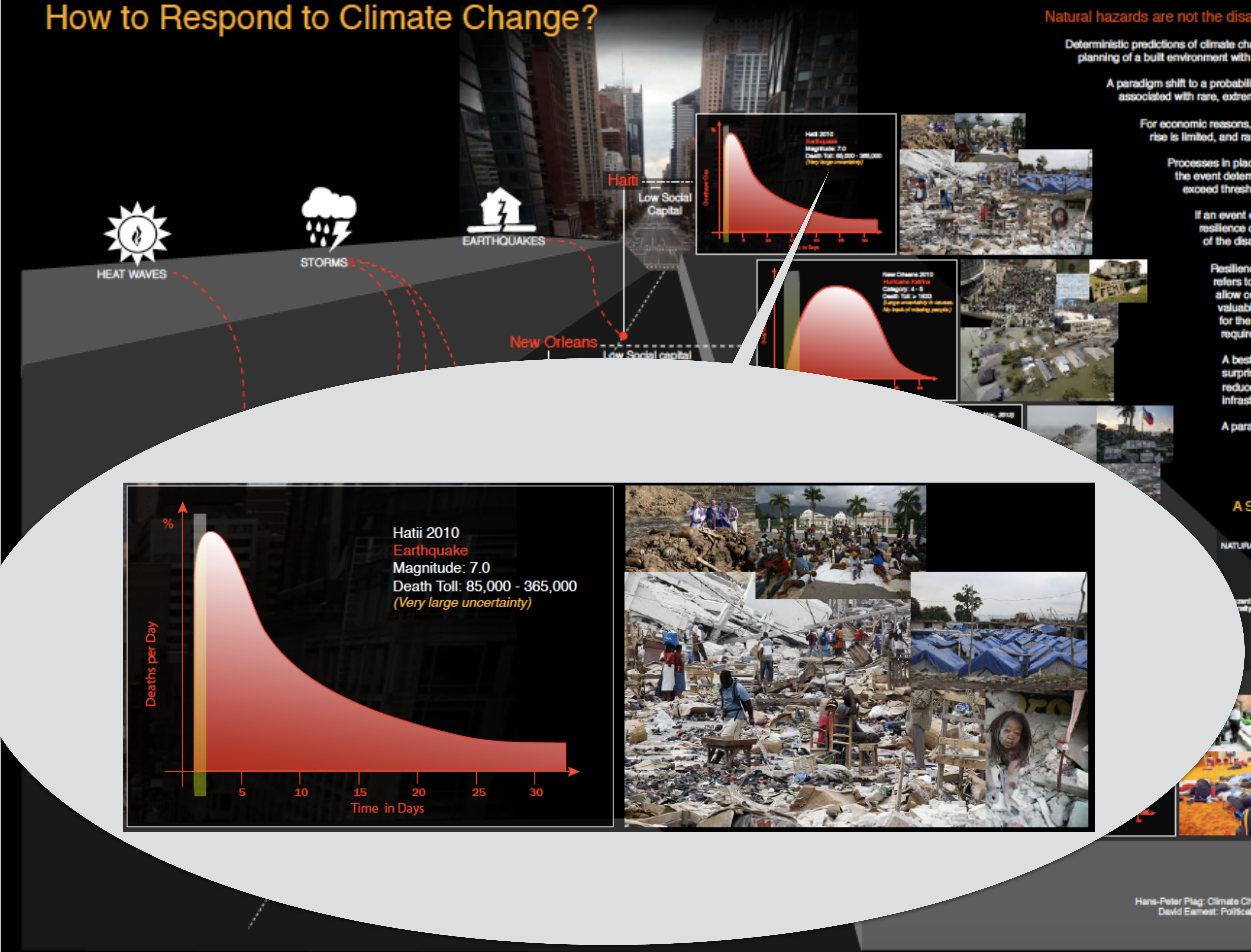


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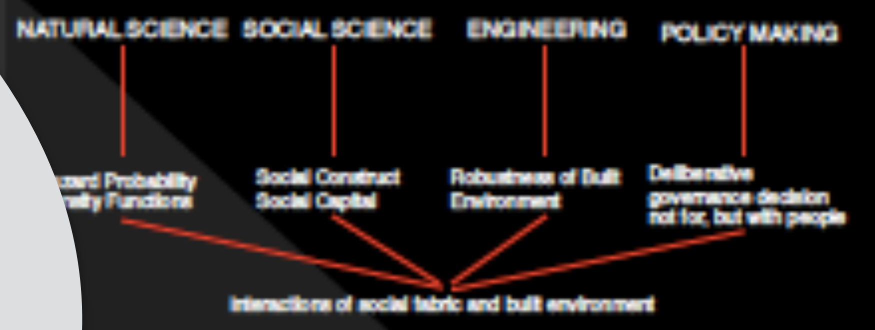



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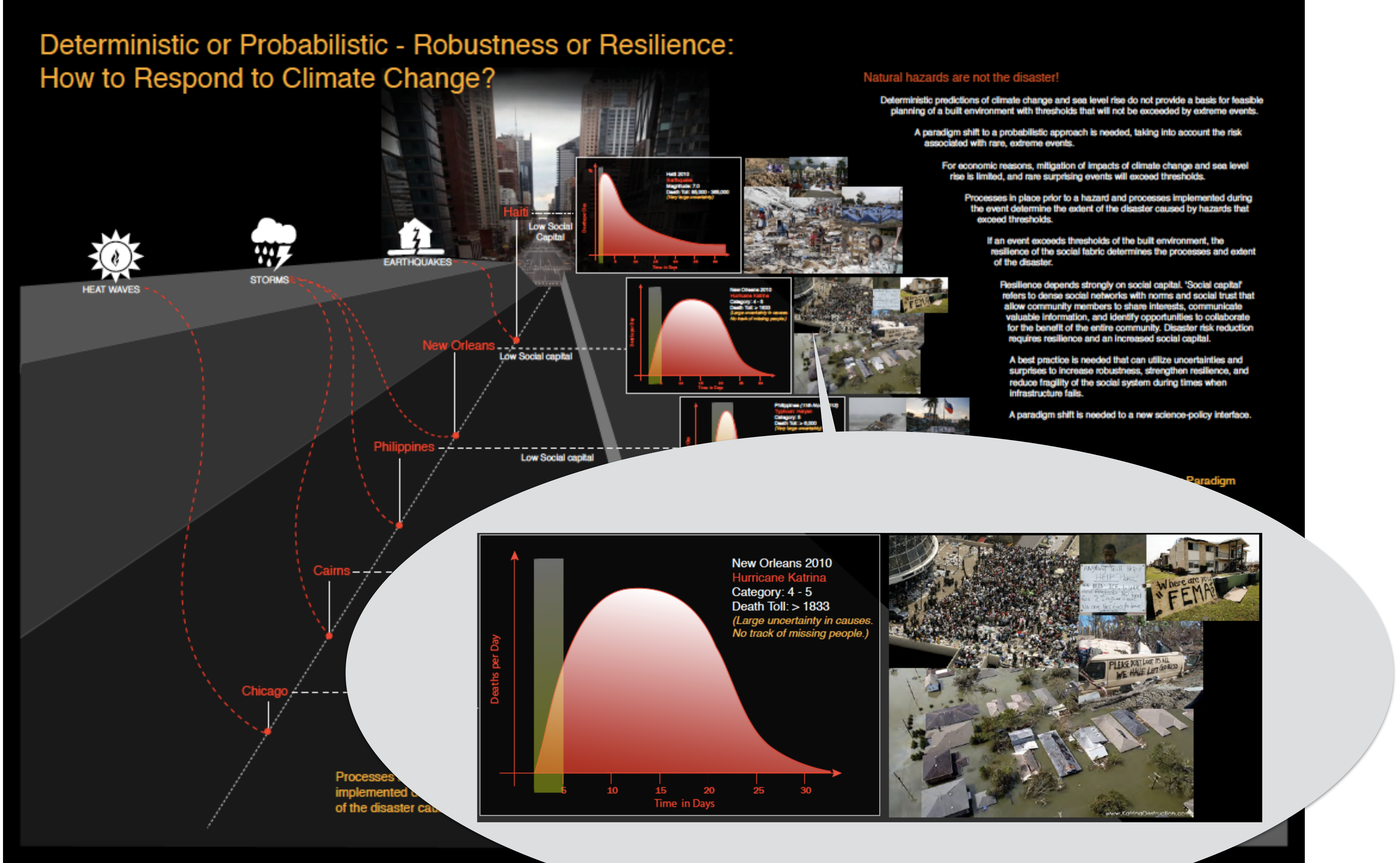
Deterministic or Probabilistic - Robustness or Resilience:
How to Respond to Climate Change?
HEAT WAVES
STORMS
EARTHQUAKES
Haiti
Low Social Capital
New Orleans
Low Social capital
Philippines
Low Social capital
Cairns
Chicago
Processes
implemented
of the disaster ca
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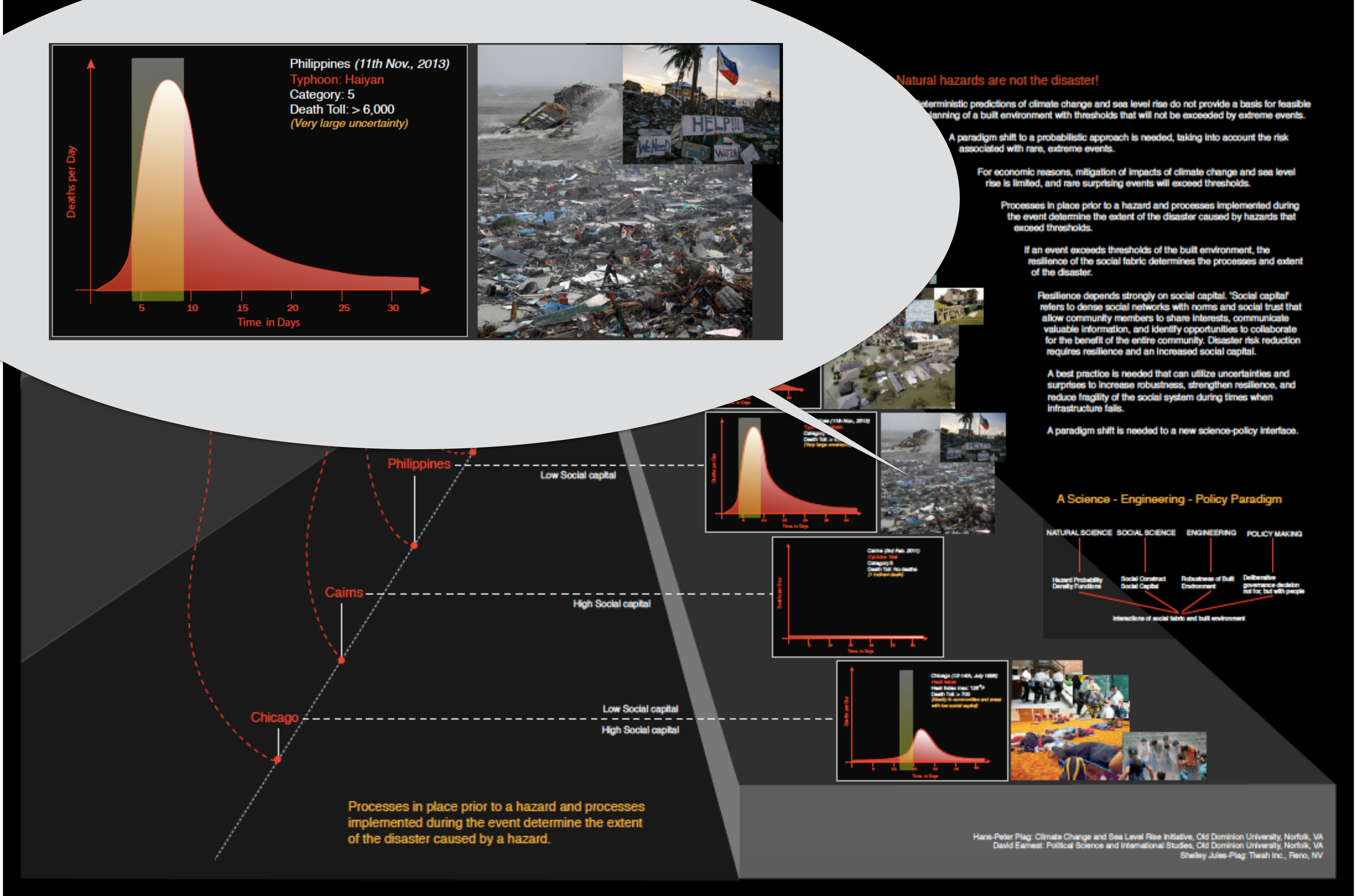
Paradigm
New Orleans 2010
Hurricane Katrina
Category: 4 - 5
Death Toll: > 1833
(Large uncertainty in causes.
No track of missing people.)
Deaths per Day
5
10
15
20
25
30
Time in Days
Where are you FEMA
PLEASE DON'T LOOT IT'S ALL WE HAVE LEFT GOD BLESS
www.KatrinaDestruction.com


Philippines (11th Nov., 2013)
Typhoon: Haiyan
Category: 5
Death Toll: > 6,000
(Very large uncertainty)
Deaths per Day
5
10
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Time in Days
HELP!!!
We Need
FOOD
WATER
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High Social capital
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NATURAL SCIENCE
SOCIAL SCIENCE
ENGINEERING
POLICY MAKING
Hazard Probability Density Functions
Social Construct Social Capital
Robustness of Built Environment
Deliberative governance decision not for, but with people
Interactions of social fabric and built environment
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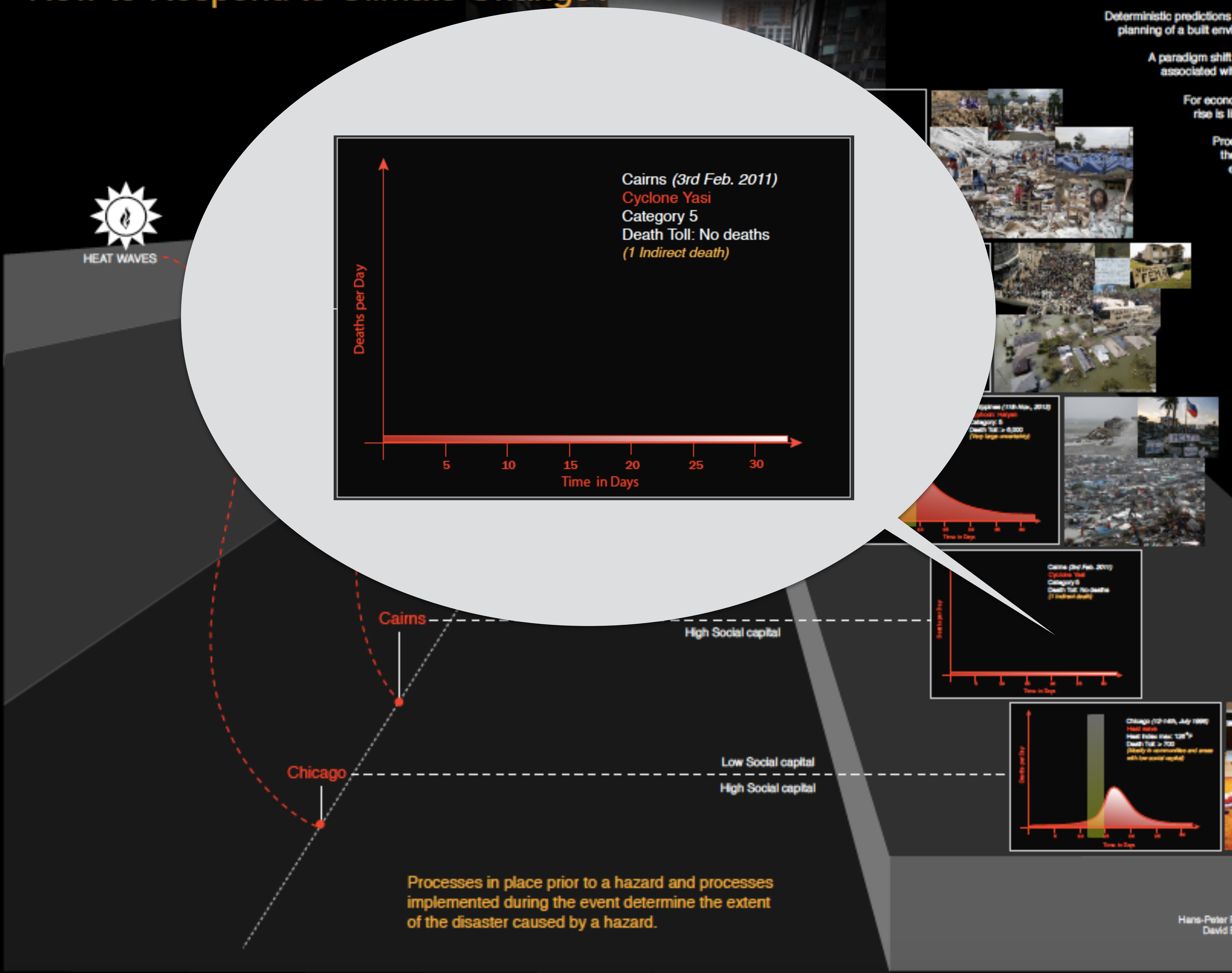


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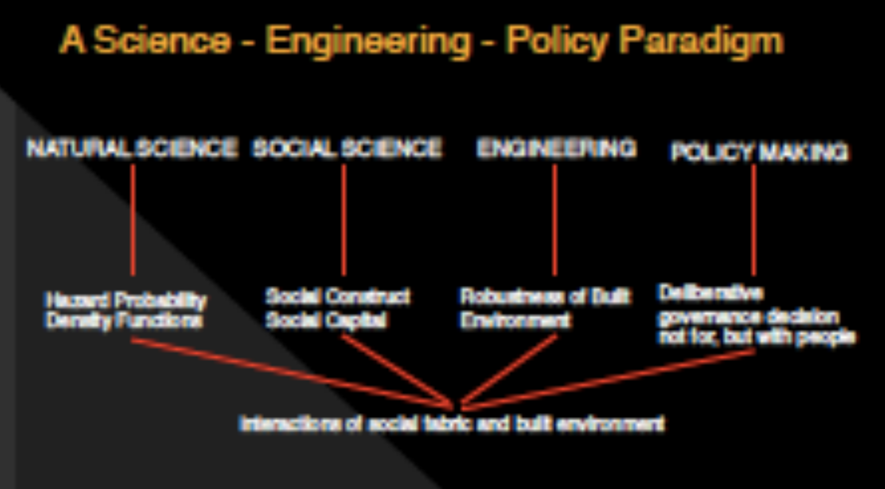



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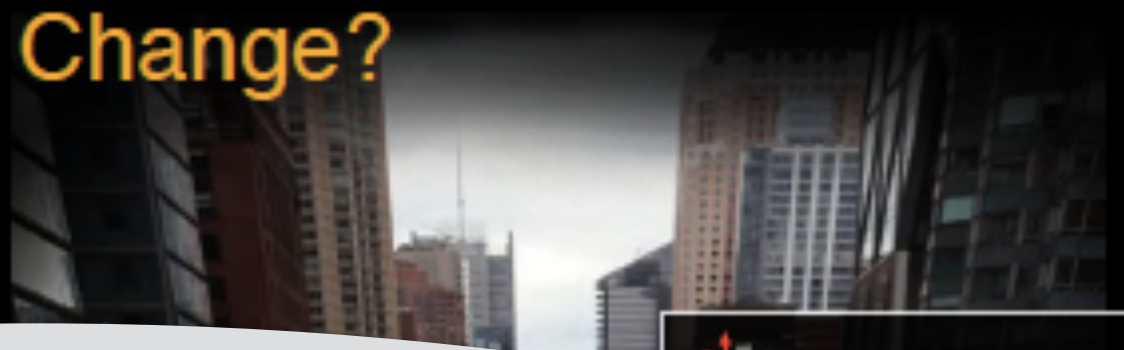

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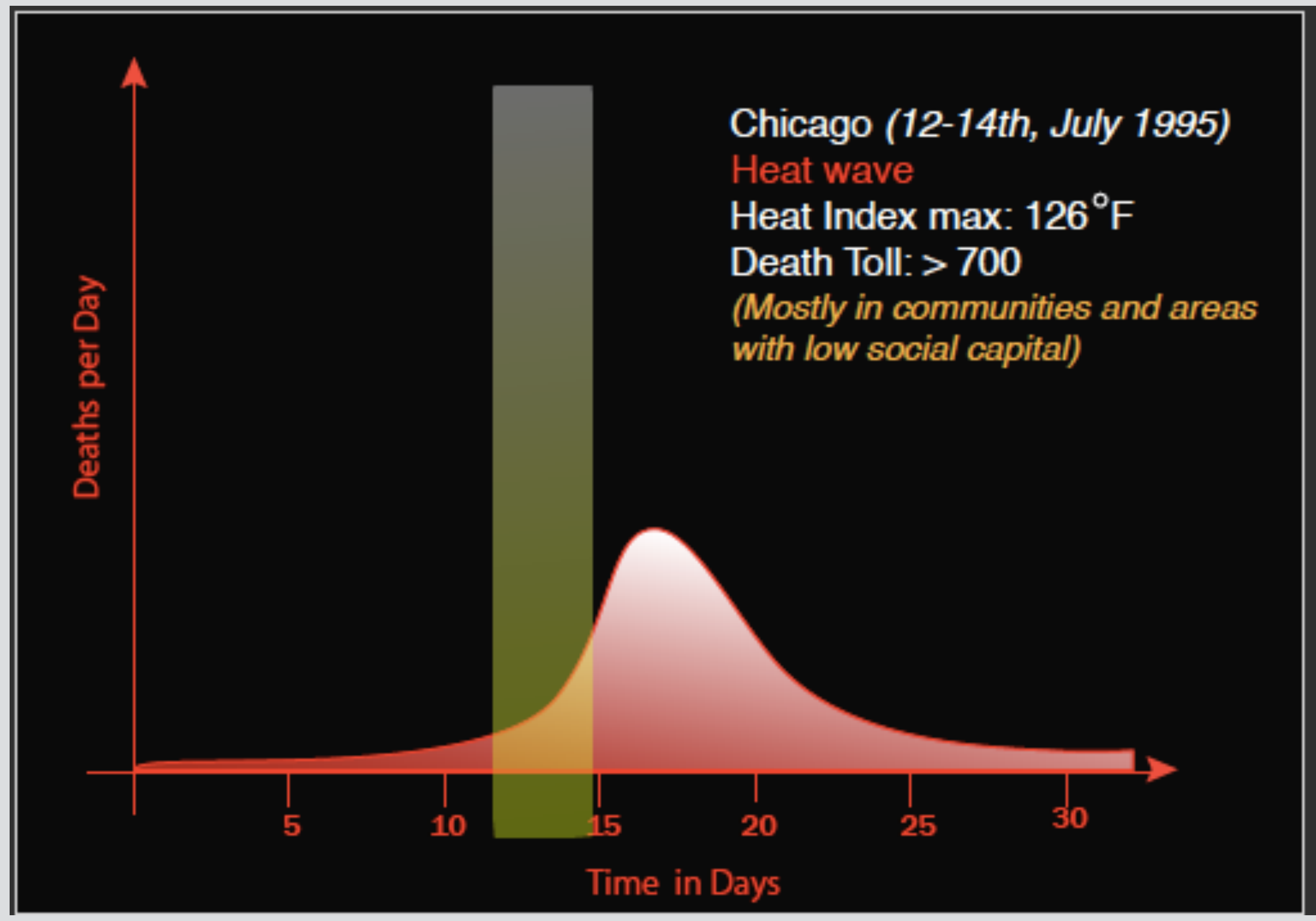


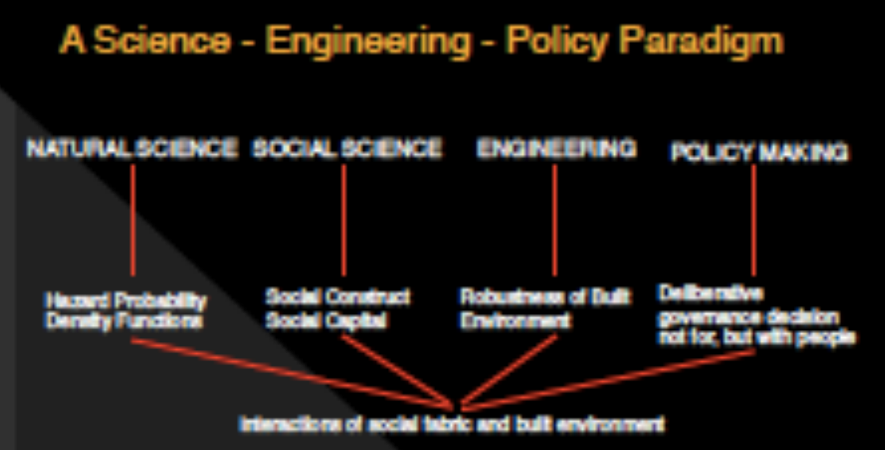


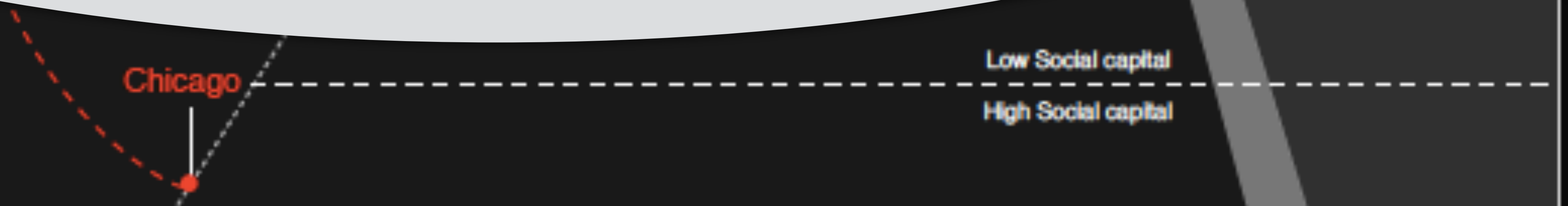


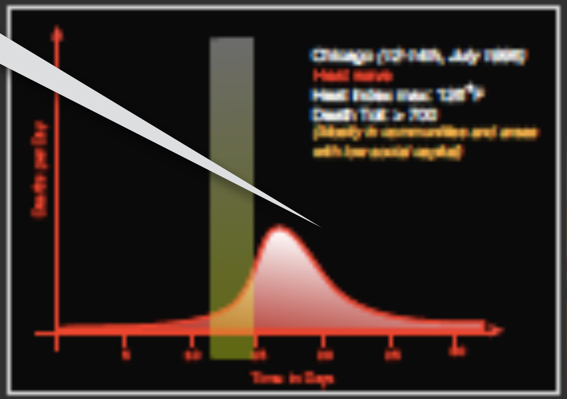

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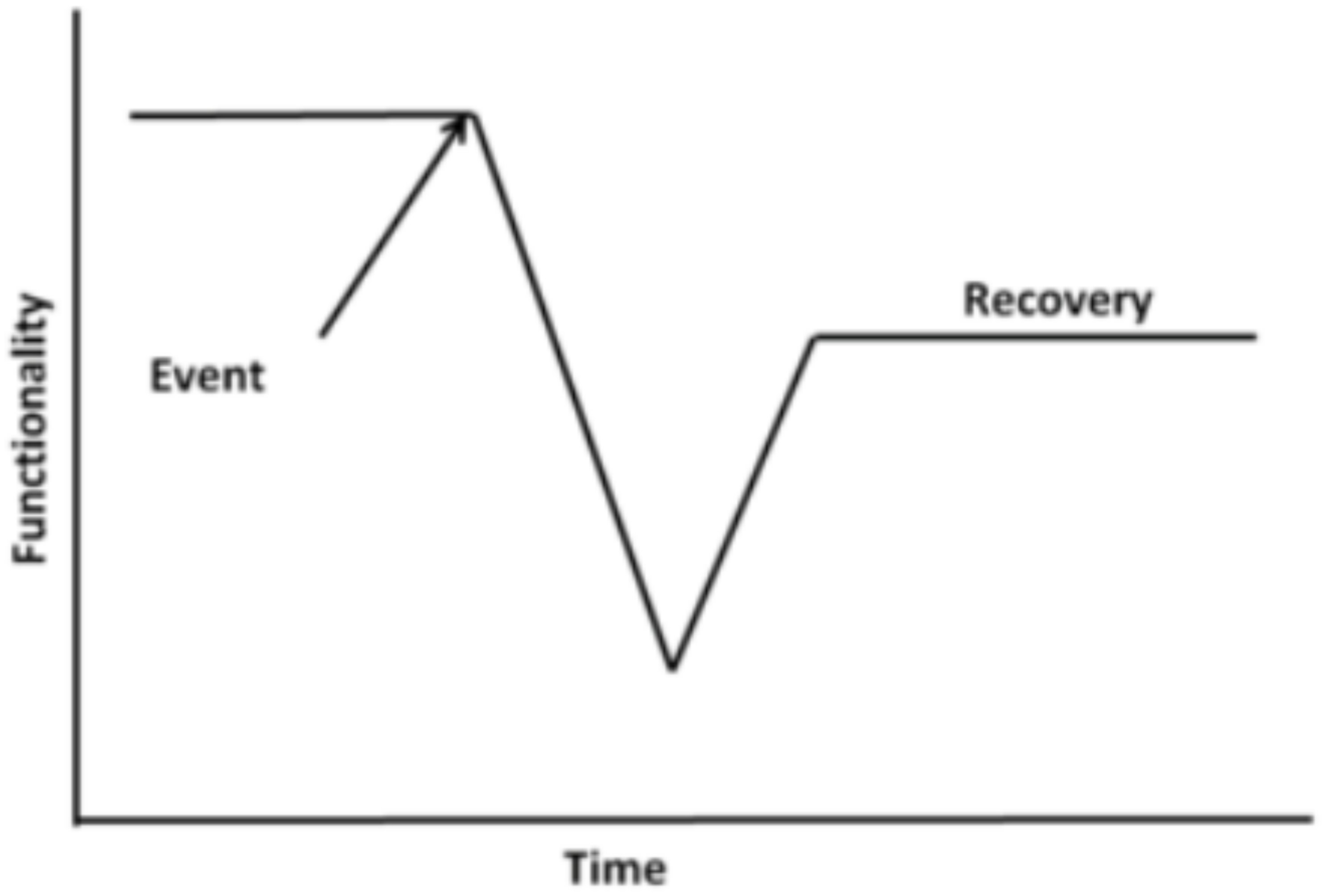
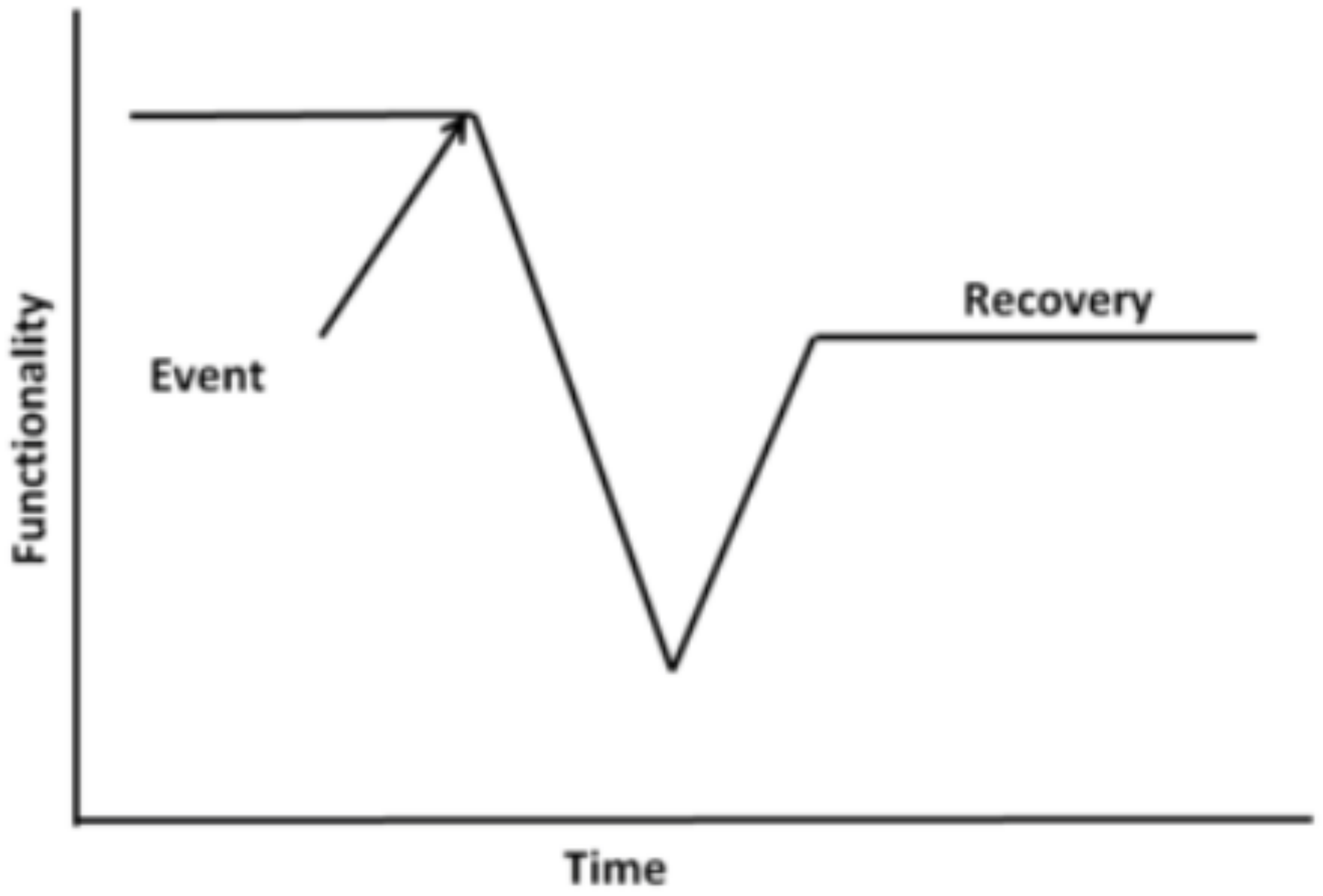


## Resilience

“**Resilience is the act of rebounding or springing back**”
(Oxford English Dictionary, 1973)



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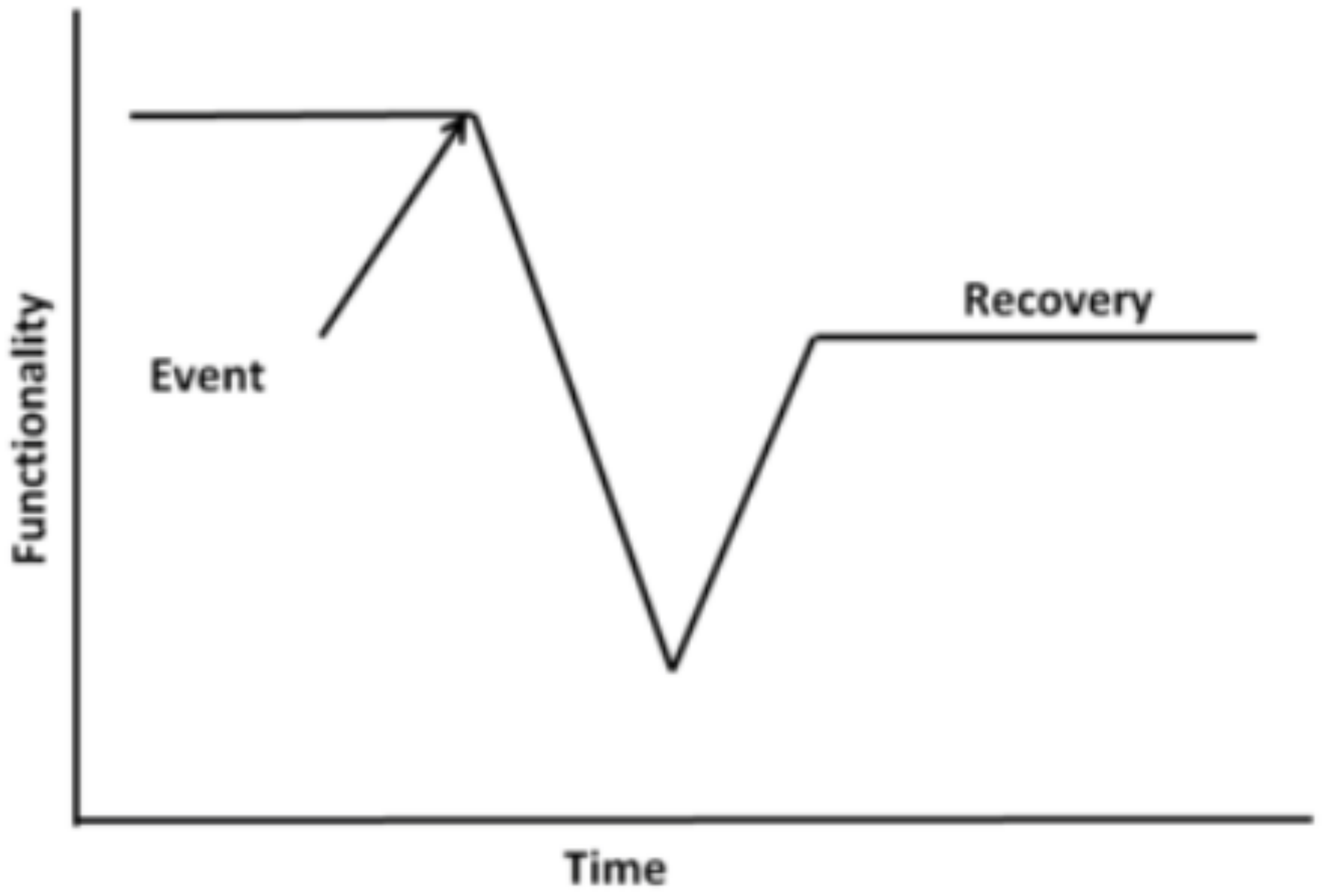
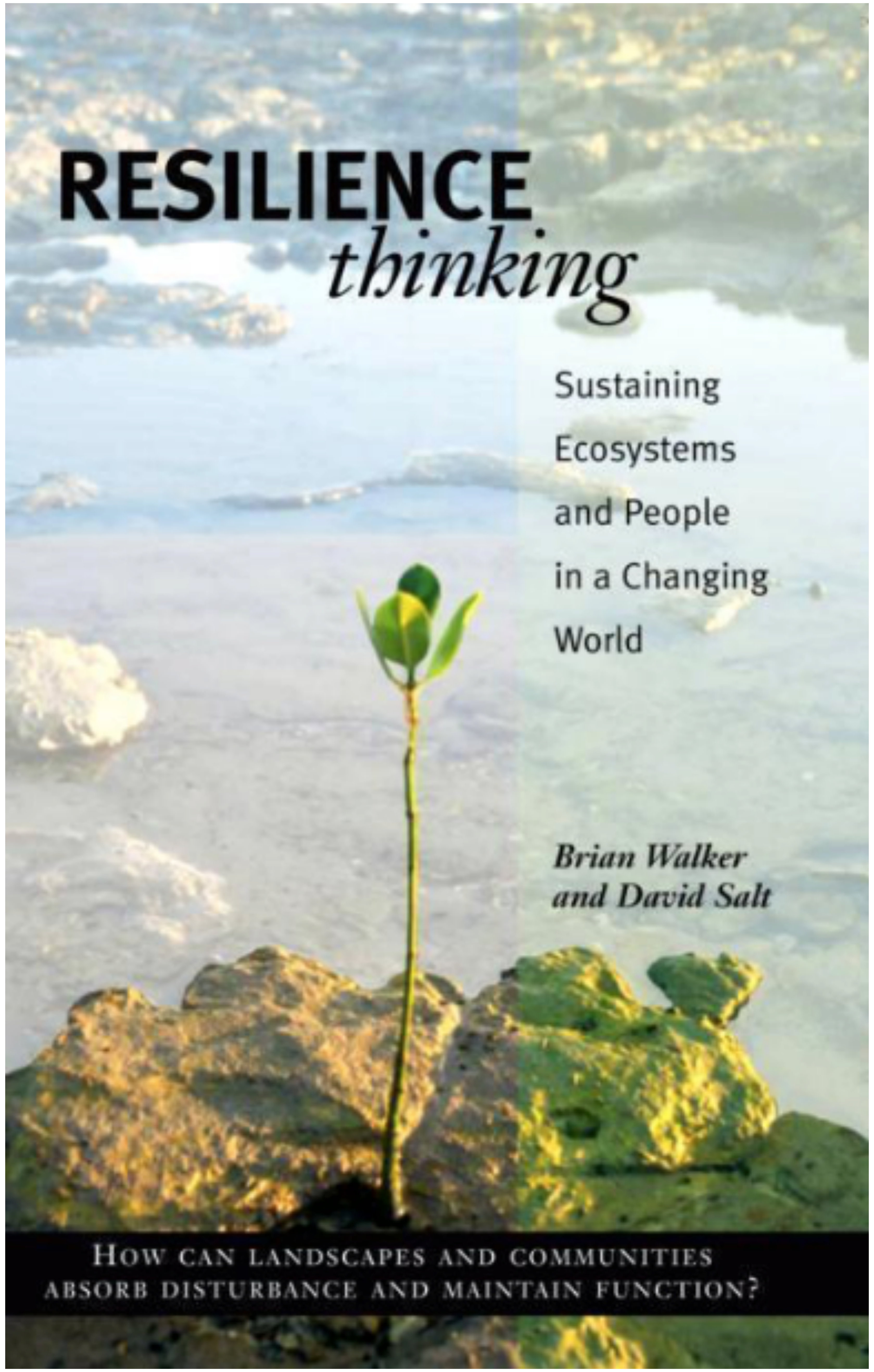
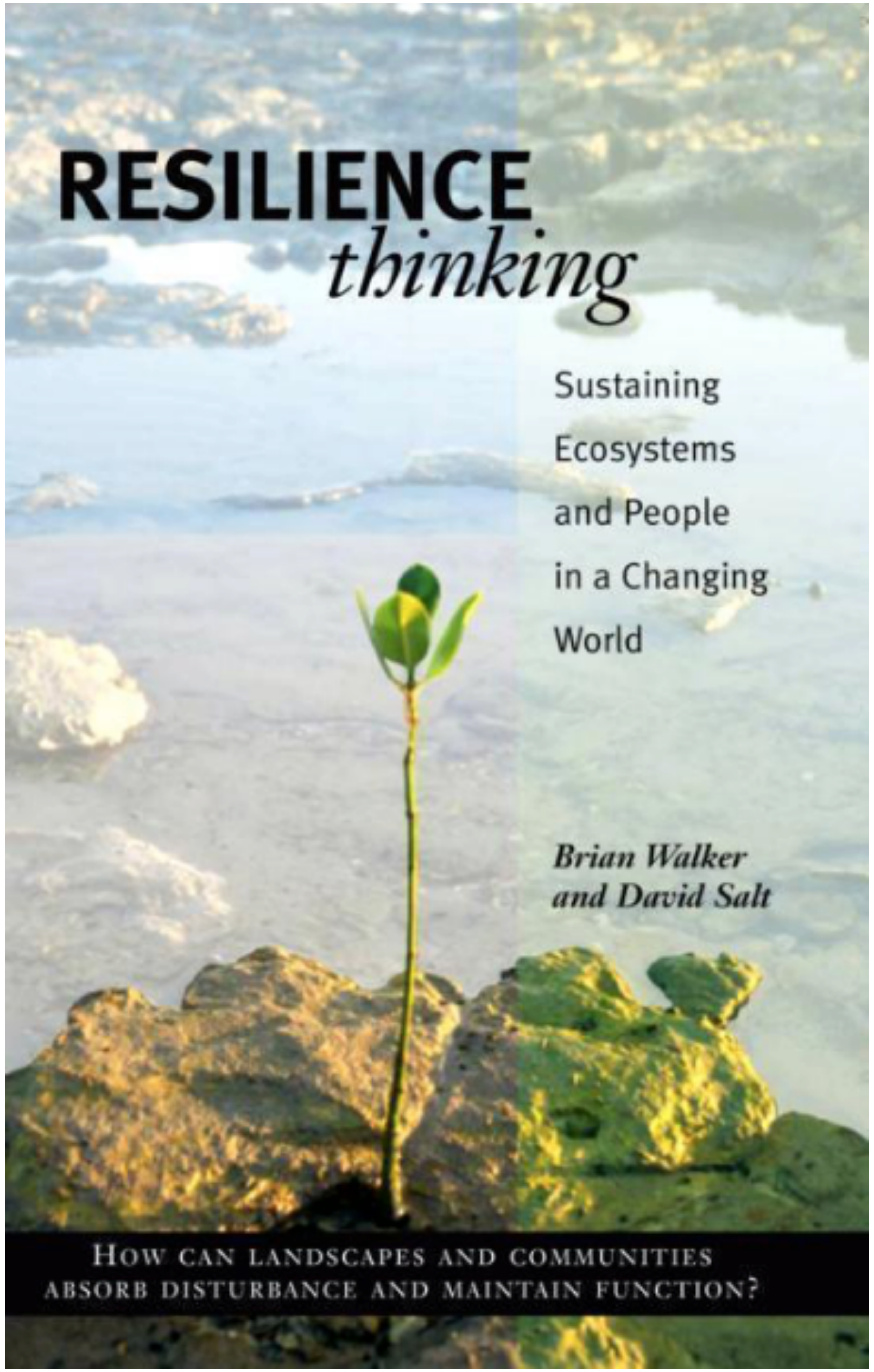



"Resilience is the **capacity of a system to absorb disturbance and still retain its basic function and structure**."

Brian Walker PhD. Resilience Thinking: Sustaining Ecosystems and People in a Changing World (Kindle Locations 64-65). Kindle Edition.



## Adaptive Cycles



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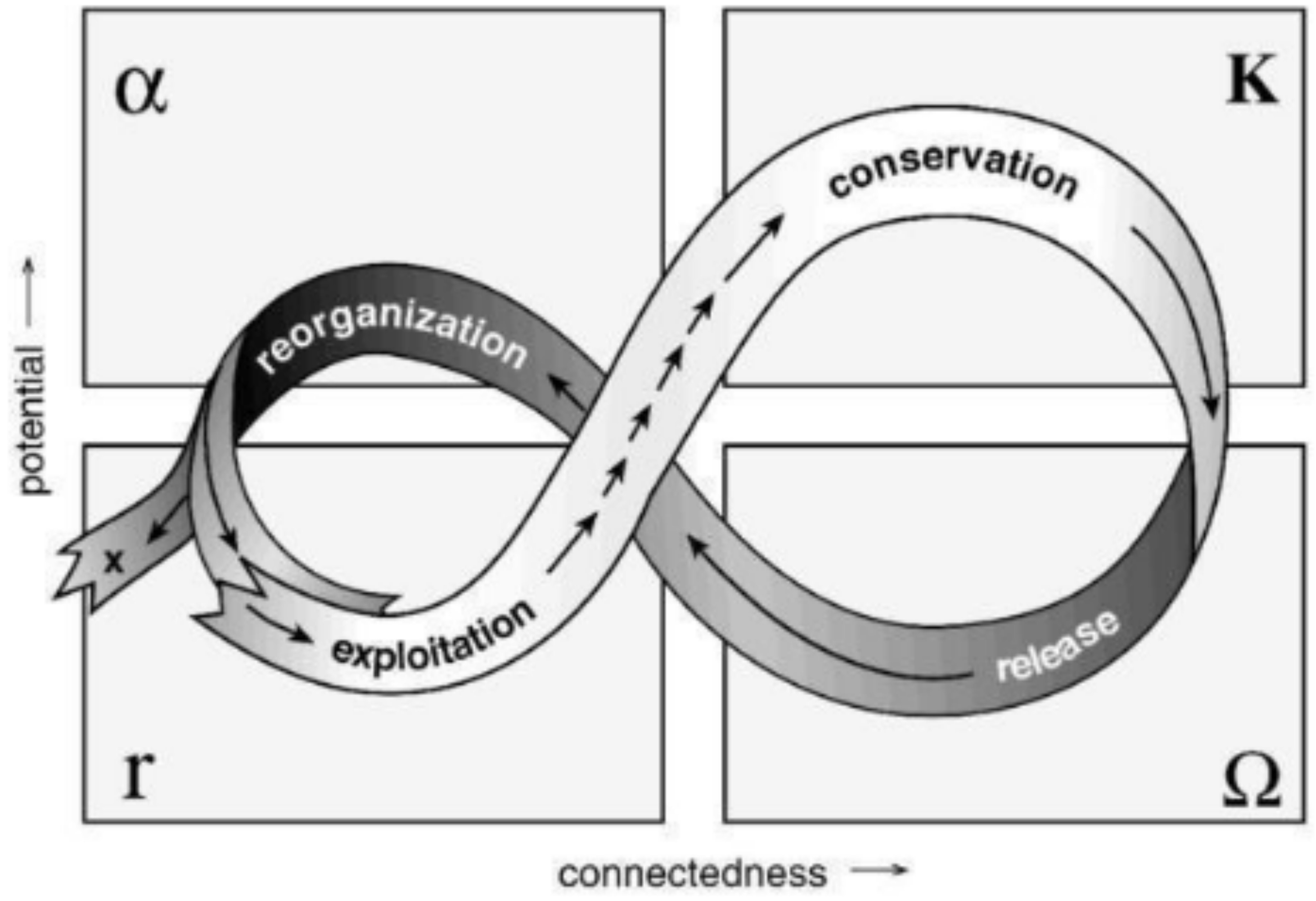
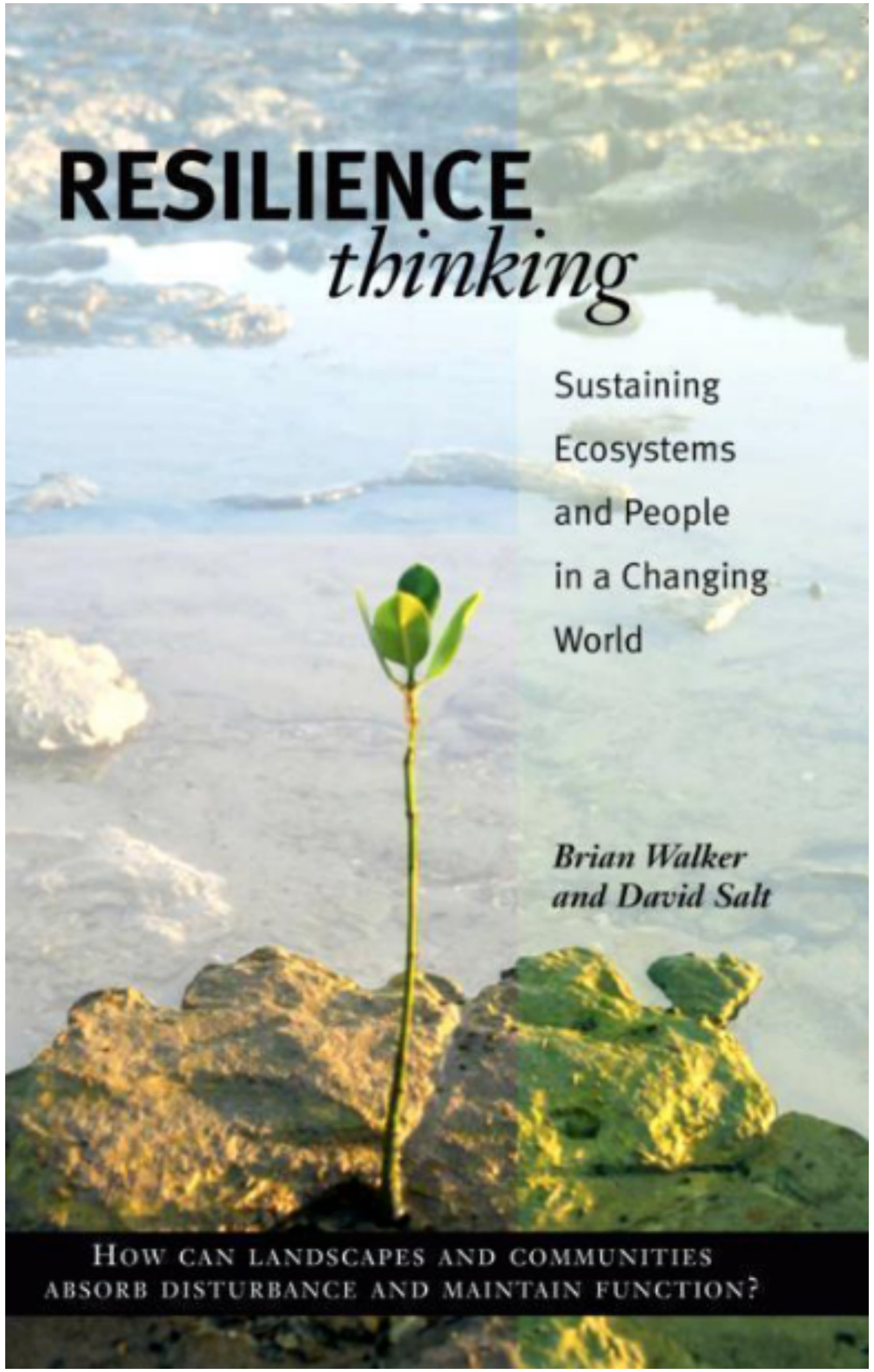



FIGURE 9 The First Version of the Adaptive Cycle

The first versions of the adaptive cycle pictured it as a figure 8 in two dimensions with the axes being connectedness and potential. Potential reflects accumulated growth and storage (biomass that is increasingly inactive like heartwood in trees or leaf litter). The use of the simpler loop, as shown in figure 10, has been adopted because it better reflects the passage from release to reorganization in some systems. However, because the adaptive cycle in the shape of the number 8 (as shown here in figure 9) was the original version it has iconic value, and it is often seen as a symbol of studies on resilience and adaptive cycles. *(From Gunderson and Holling, 2002 )*



# More on Risk, Vulnerability, Resilience, Adaptation

## Adaptive Cycles

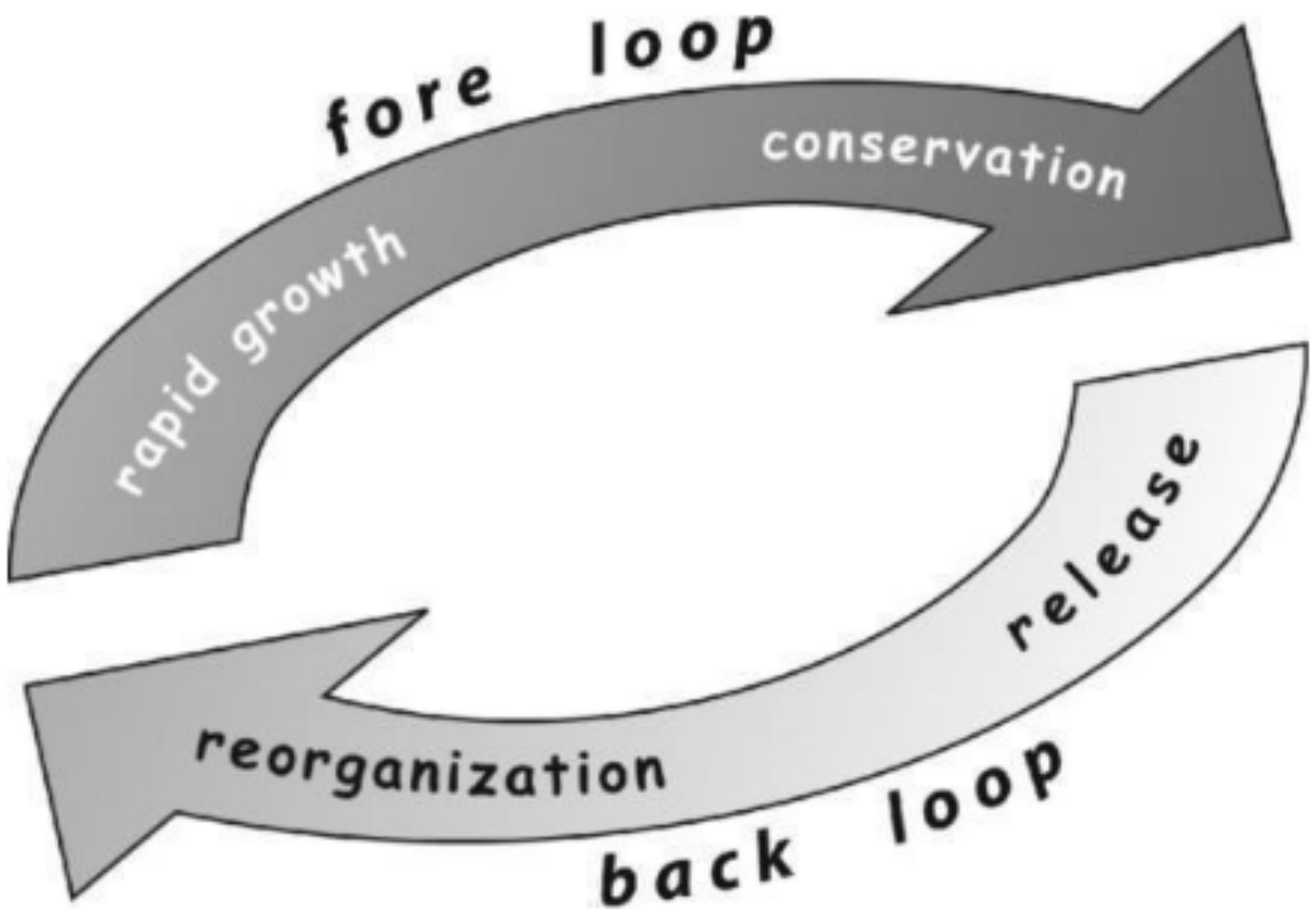
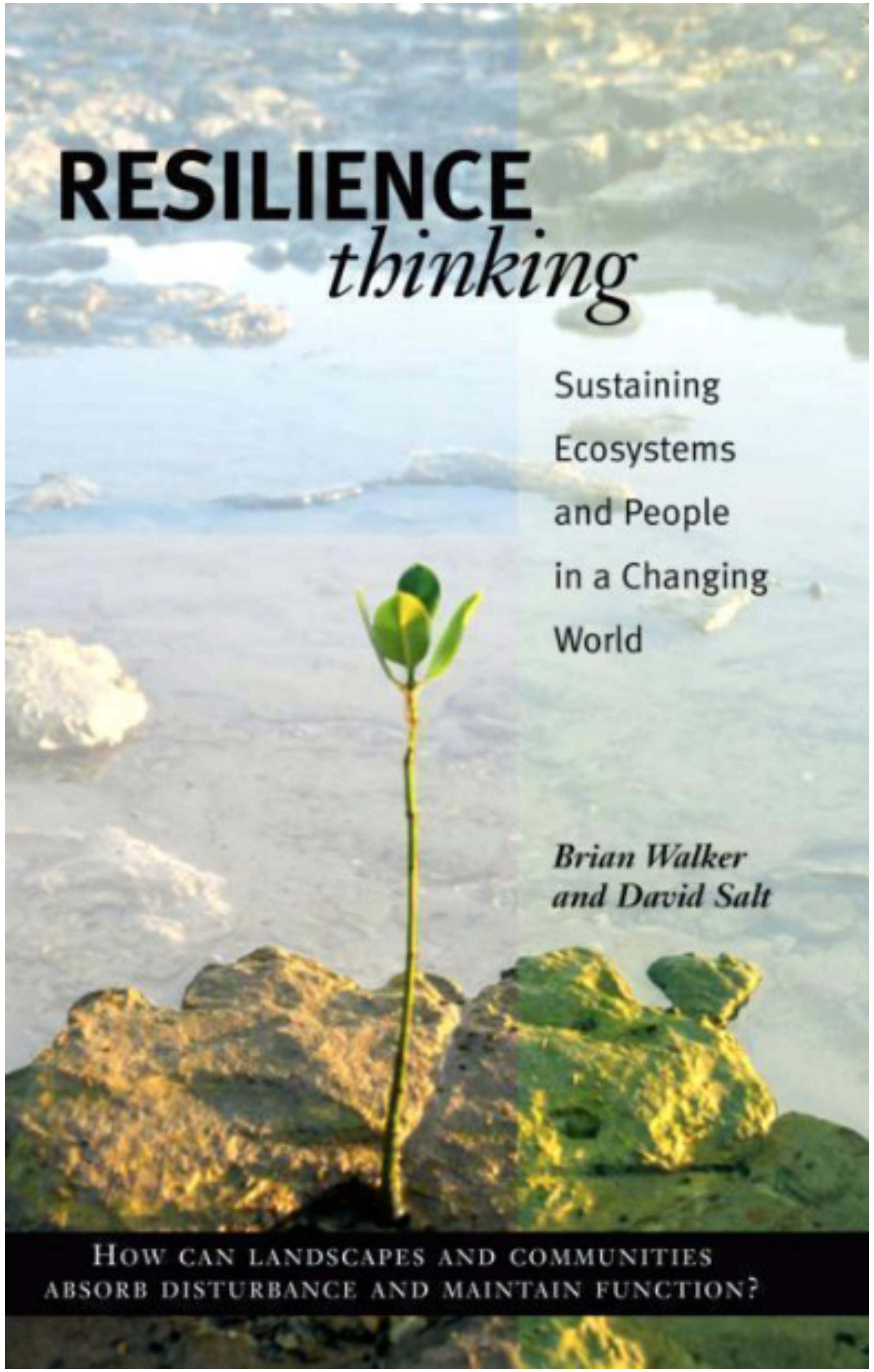



FIGURE 10 A Simple Representation of the Adaptive Cycle

The rapid growth and conservation phases are referred to as the fore loop with relatively predictable dynamics and in which there is a slow accumulation of capital and potential through stability and conservation. The release and reorganization phases are referred to as the back loop, characterized by uncertainty, novelty, and experimentation and during which there is a loss (leakage) of all forms of capital. The back loop is the time of greatest potential for the initiation of either destructive or creative change in the system.



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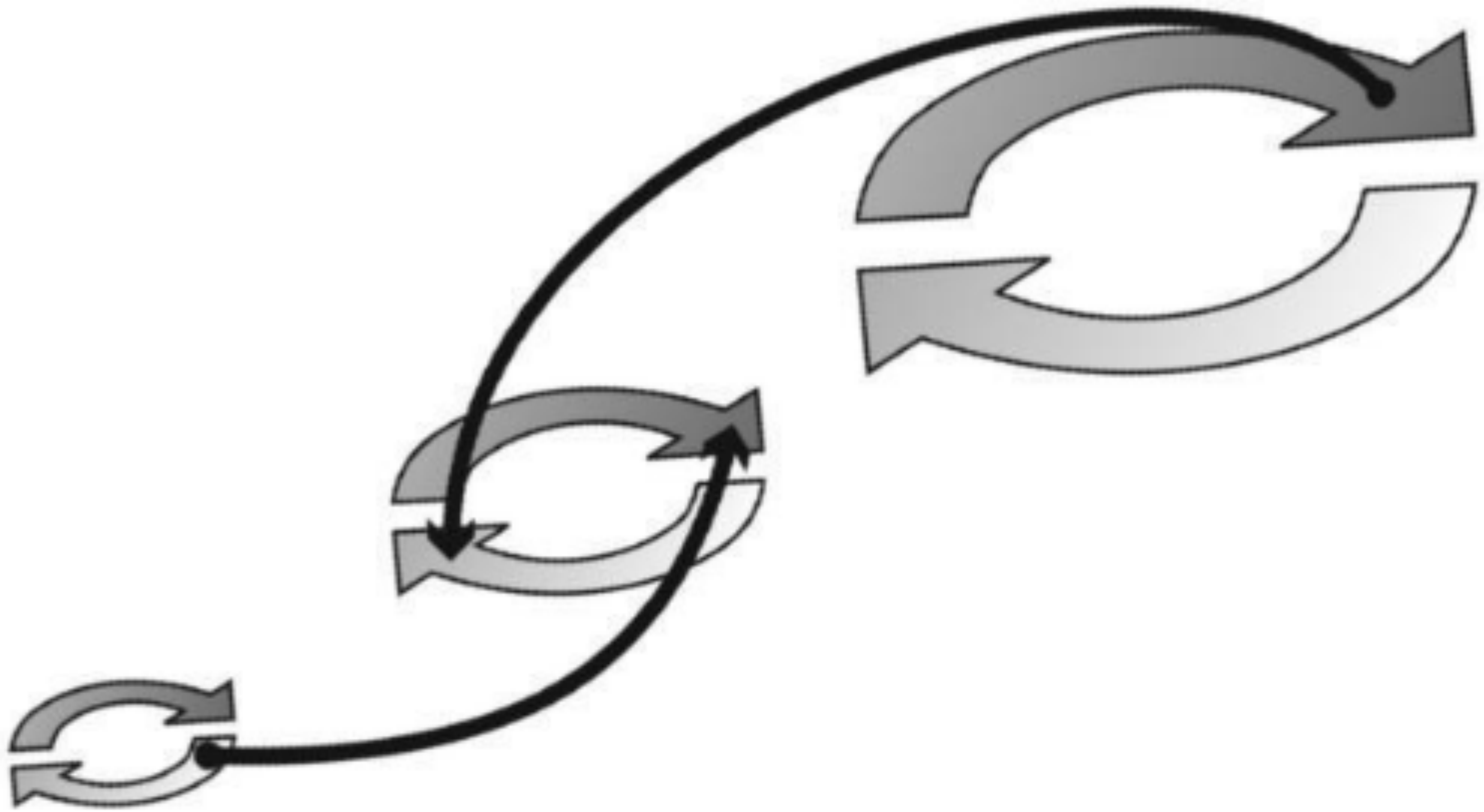
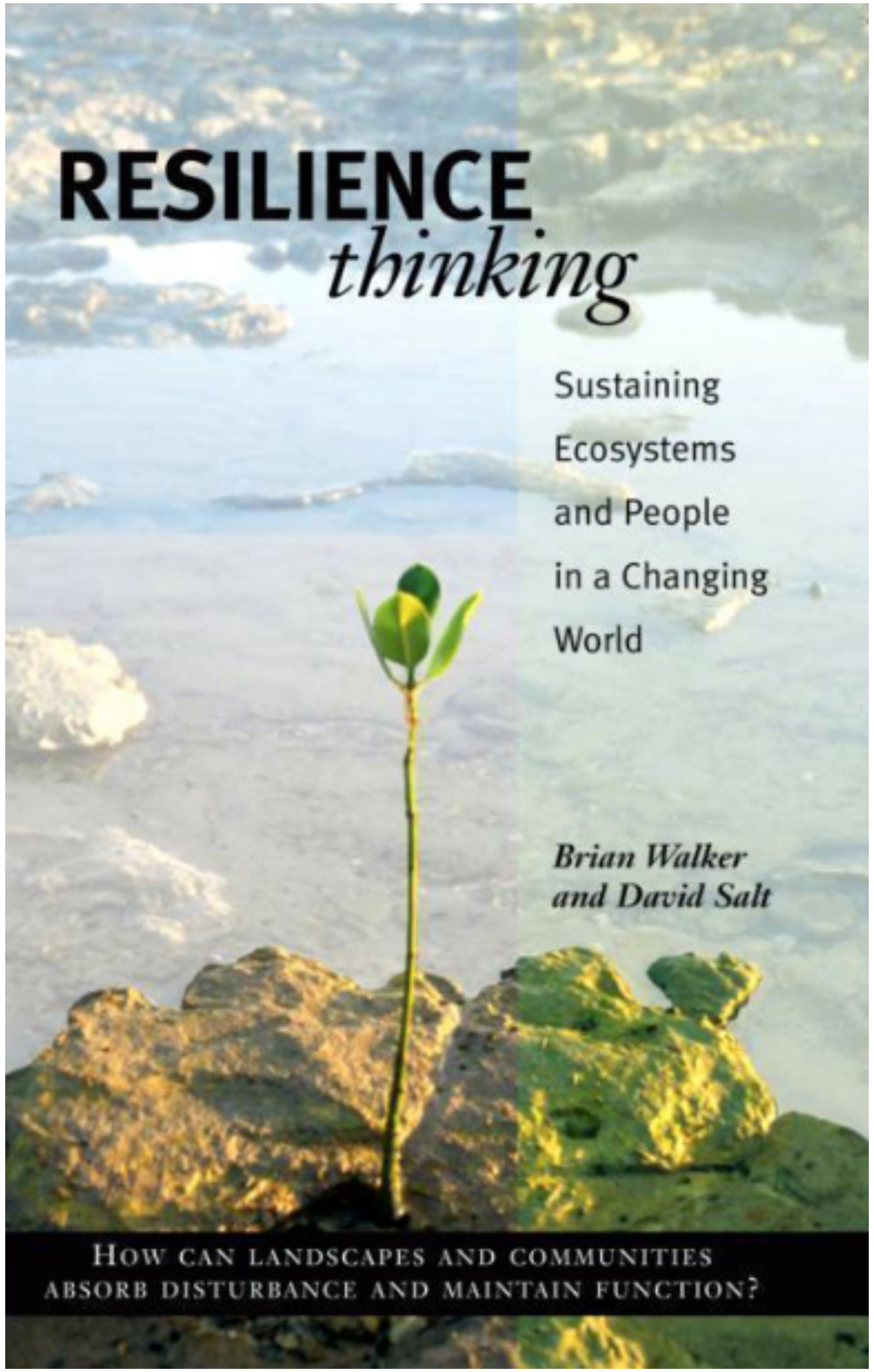
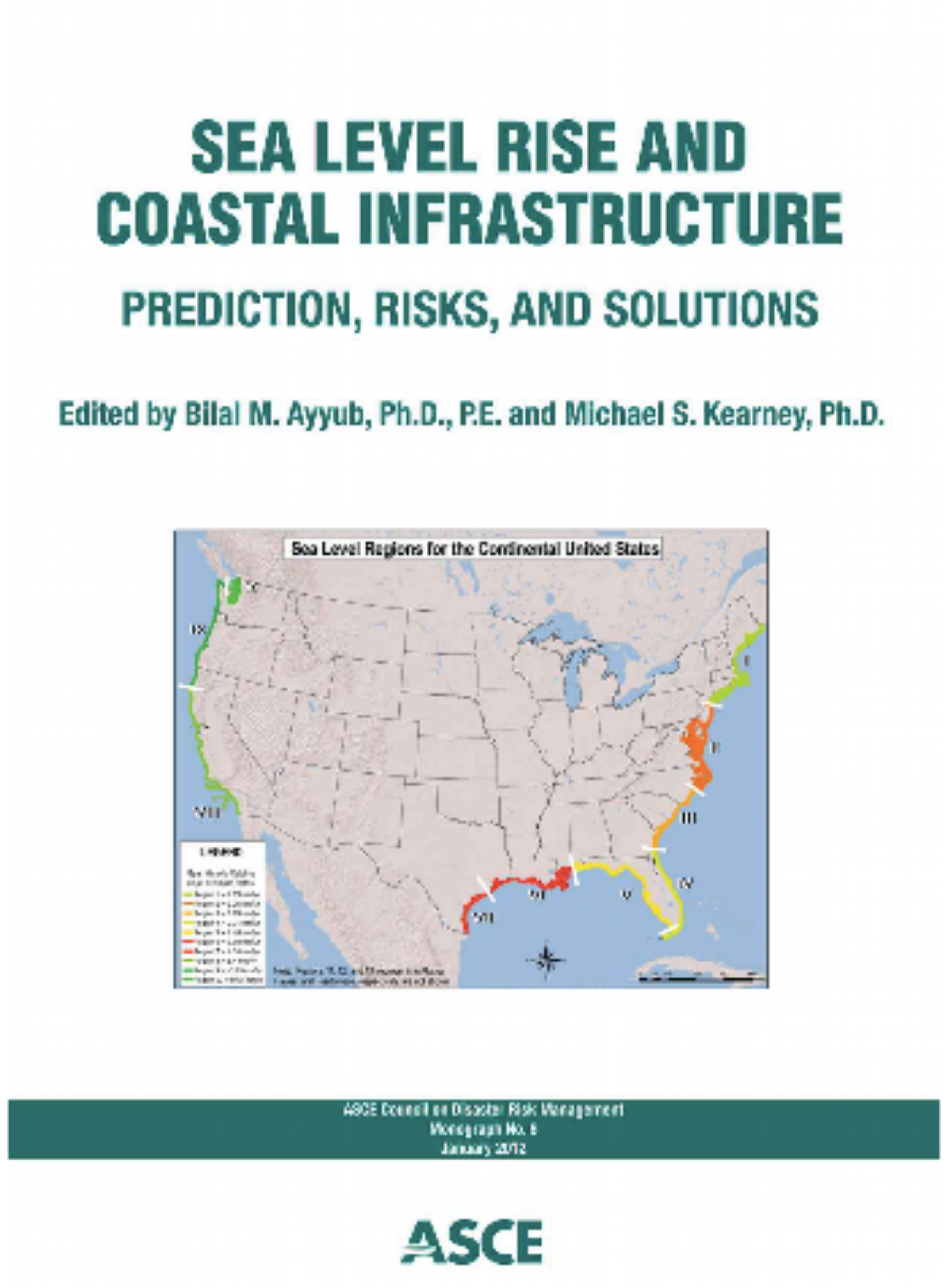


FIGURE 13 Panarchy Refers to Hierarchies of Linked Adaptive Cycles



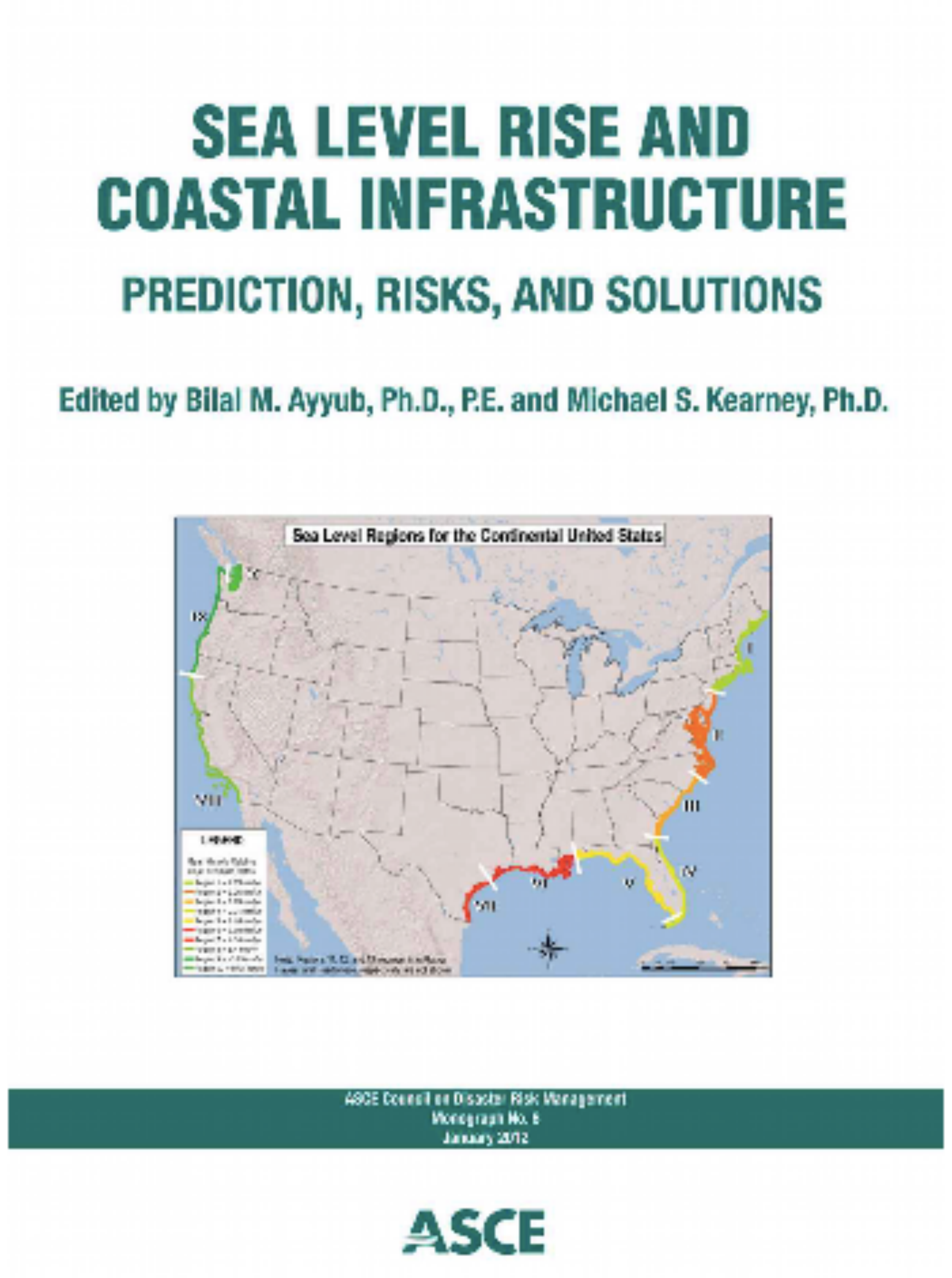
# Resilient and Adaptive Systems



## Resilient and Adaptive Systems

Resilient systems **bend under stress but do not break,** so they are able to weather storms more effectively and recover more quickly. **Adaptive systems are characterized by redundancy, diversity, efficiency, strength, interdependence, adaptability, and collaborativeness** (Godschalk 2003). They are designed so that the failure of one part does not cause the whole system to collapse.

Ayyub, Bilal M.. Sea Level Rise and Coastal Infrastructure: Prediction, Risks, and Solutions (Council on Disaster Risk Management (CDRM) Monograph) (Kindle Locations 2359-2361). American Society of Civil Engineers. Kindle Edition.



# Resilient and Adaptive Systems

# More on Risk, Vulnerability, Resilience, Adaptation

## Resilient and Adaptive Systems

"I want to reserve resilience to refer to the broader capability – how well can a system handle **disruptions and variations that fall outside of the base mechanisms/model for being adaptive** as defined in that system."

Hollnagel in Woods, D. D. Resilience Engineering: Concepts and Precepts (Kindle Locations 487-488). Ashgate Publishing Ltd. Kindle Edition.

However, we would argue that we should extend the definition a little more broadly, in order to **encompass also the ability to avert the disaster or major upset**, using these same characteristics. Resilience then describes also the characteristic of managing the organisation's activities to **anticipate and circumvent threats** to its existence and primary goals. This is shown in particular in an ability to manage severe pressures and conflicts between safety and the primary production or performance goals of the organisation.

Hale & Heijer, in Woods, D. D. Resilience Engineering: Concepts and Precepts (Kindle Locations 728-732). Ashgate Publishing Ltd. Kindle Edition.

# More on Risk, Vulnerability, Resilience, Adaptation

## Content:




# More on Risk, Vulnerability, Resilience, Adaptation

## Resilience

### Content:




http://stockholmresilience.org/download/18.10119fc11455d3c557d6928/1459560241272/SRC+Applying+Resilience+final.pdf

# More on Risk, Vulnerability, Resilience, Adaptation

Principle one

## Maintain diversity and redundancy

In a social-ecological system, components such as species, landscape types, knowledge systems, actors, cultural groups or institutions all provide different options for responding to change and dealing with uncertainty and surprise.

Principle two

## Manage connectivity

Connectivity can be both a good and a bad thing. High levels of connectivity can facilitate recovery after a disturbance but highly connected systems can also spread disturbances faster.

Principle three

## Manage slow variables and feedbacks

Social-ecological systems can often be "configured" in several different ways. In other words, there are many ways in which all the variables in a system can be connected and interact with one and these different ...vide ...ices.

Principle four

## Foster complex adaptive systems thinking

In order for us to continue to benefit from a range of eco- ...tem services, we need to ...stand the complex inter- ...and dynamics that exist ...n actors and ecosystems ...al-ecological system. ...ement based on 'complex ...ive systems thinking' that ...reciates these interactions ...nd the often complex dynamics they create can enhance the resilience of social-ecological systems.

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Connectivity can be both a good and a bad thing. High levels of connectivity can facilitate recovery after a disturbance but highly connected systems can also spread disturbances faster.

In order for us to continue to benefit from a range of eco- system services, we need to understand the complex inter- actions and dynamics that exist between actors and ecosystems in a social-ecological system. Management based on 'complex adaptive systems thinking' that appreciates these interactions and the often complex dynamics they create can enhance the resilience of social-ecological systems.

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http://stockholmresilience.org/download/18.10119fc11455d3c557d6928/1459560241272/SRC+Applying+Resilience+final.pdf

# More on Risk, Vulnerability, Resilience, Adaptation

### Principle five

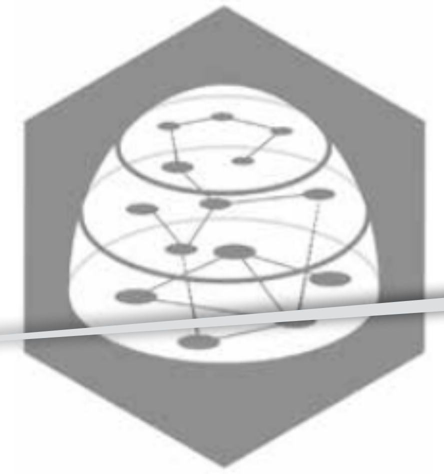
## Encourage learning

Knowledge of a system is always partial and incomplete and social-ecological systems are no exceptions. Efforts to enhance the resilience of social-ecological systems must therefore be supported by continuous learning and experimentation.

### Principle six

## Broaden participation

Participation through active engagement of all relevant stakeholders is considered fundamental to building social-ecological resilience. It helps build the trust and relationships needed to improve legitimacy of knowledge and authority during decision making processes.



### Principle seven

## Promote polycentric governance

Polycentricity, a governance system in which multiple governing bodies interact to make and enforce rules within a specific policy arena or location, is considered to be one of the best ways to achieve collective action in the face of disturbance and change.

Although there are many ways in which collective action can be achieved, polycentricity is considered unique. Classic studies on the sustainable governance of social-ecological systems highlight the importance of so-called "nested institutions" (the norms and rules governing human interactions). These are institutions connected ... set of rules that interact across hierarchies and structures so that problems can be addressed swiftly by the right people at the right time. Nested institutions enable the creation of social engagement rules and

In contrast to more monocentric strategies, polycentric governance is consider... enhance the resilience of ec... in six ways, which coi... with other princi... it provides opp... experimenta... of particip... response d... that can mi... governance.

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# More on Risk, Vulnerability, Resilience, Adaptation

Risk: static, event based loss

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Adaptation: responding to, or preparing for change

Anti-fragile: learning from disturbances and impacts

Danger of implicit adaptation …

## AS THE CLIMATE CHANGES, ARE WE ALL BOILING FROGS?

New research finds that we normalize rising temperatures remarkably quickly.

TOM JACOBS · FEB 26, 2019

A winter storm left cold temperatures, heavy rains, and even snow on the mountains of Baja California State and other parts of northwestern Mexico, pictured here on February 22nd, 2019.

(Photo: Guillermo Arias/AFP/Getty Images)

PNAS Proceedings of the National Academy of Sciences of the United States of America

## Rapidly declining remarkability of temperature anomalies may obscure public perception of climate change

Frances C. Moore, Nick Obradovich, Flavio Lehner, and Patrick Baylis

PNAS published ahead of print February 25, 2019 https://doi.org/10.1073/pnas.1816541116
Add to Cart ($10)

Edited by Edward W. Maibach, George Mason University, Fairfax, VA, and accepted by Editorial Board Member Hans J. Schellnhuber January 14, 2019 (received for review September 25, 2018)

# Class 14: Understanding Vulnerabilities: The Earth's Life-Support System

Contents

- More on Risk, Vulnerability, Resilience, Adaptation
- Vulnerabilities of the Planetary System
- Land Cover Changes
- Global Warming: Earth Energy Imbalance
- Sea Level Rise
- Pollution

# Vulnerabilities of the planetary system

## Thresholds as a Vulnerability

**Thresholds and the adaptive cycle metaphor are both central to resilience thinking**. Adaptive cycles describe how many systems behave over time, and how resilience varies according to the phase where the system lies. **Thresholds represent transitions between alternate regimes**. While the two concepts can sometimes be related in the pattern of a particular system's dynamics, this not always the case. They are different models used for different purposes, and it is not always possible to equate the dynamics of a basin of attraction with the dynamics of an adaptive cycle. Where they do coincide, however, alternate regimes generally represent a new adaptive cycle, indicating that the system has new structures and feedbacks.

Brian Walker PhD. Resilience Thinking: Sustaining Ecosystems and People in a Changing World (Kindle Locations 1168-1170). Kindle Edition.

# Vulnerabilities of the planetary system

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In a system, a **threshold** is a point at which a relatively small change or disturbance causes a rapid change in the system.

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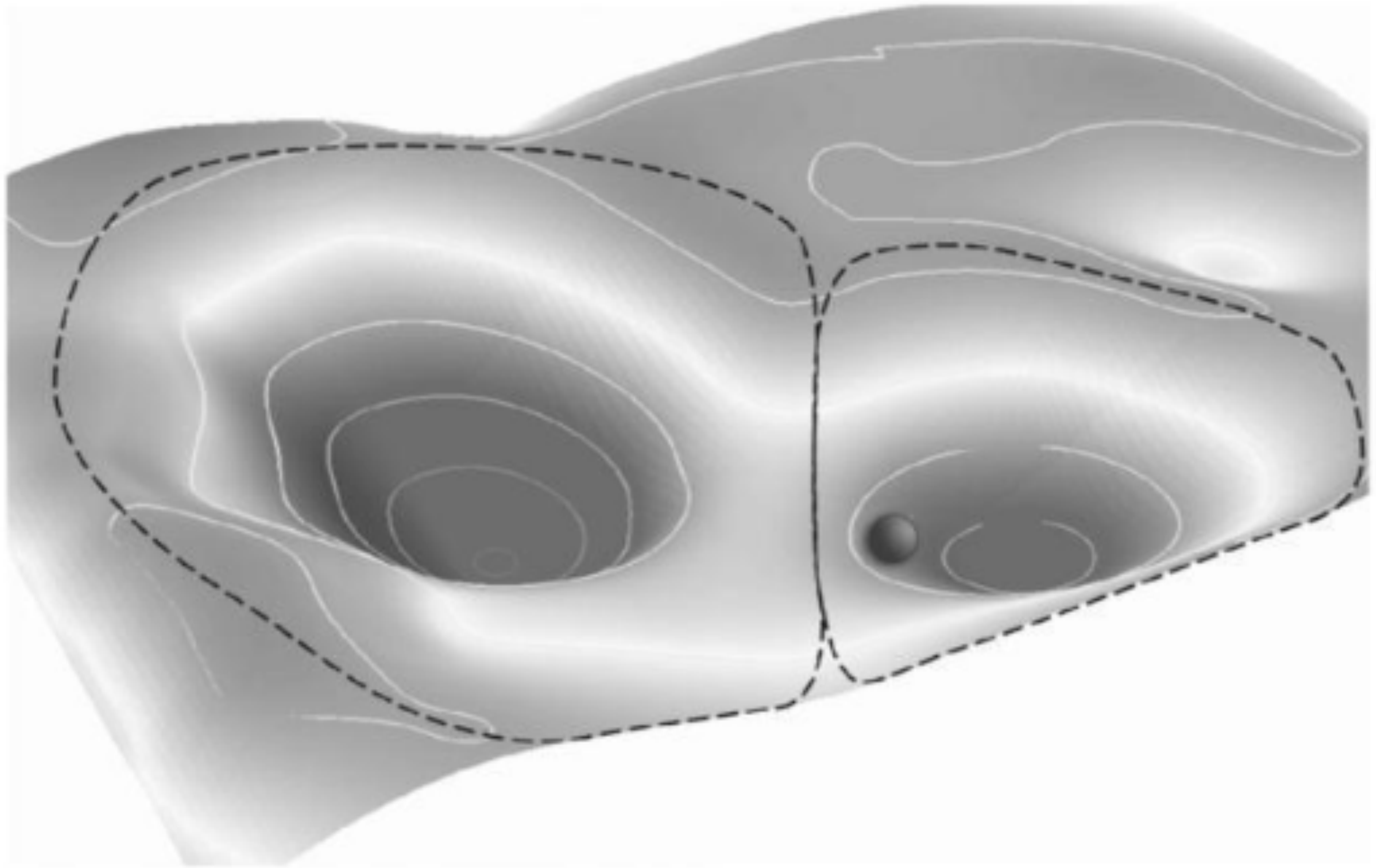

FIGURE 3 The System as a Ball-in-the-Basin Model

The ball is the state of the social-ecological system. The basin in which it is moving is the set of states which have the same kinds of functions and feedbacks, resulting in the ball moving towards the equilibrium. The dotted line is a threshold separating alternate basins. *(From Walker et al , 2004 )*

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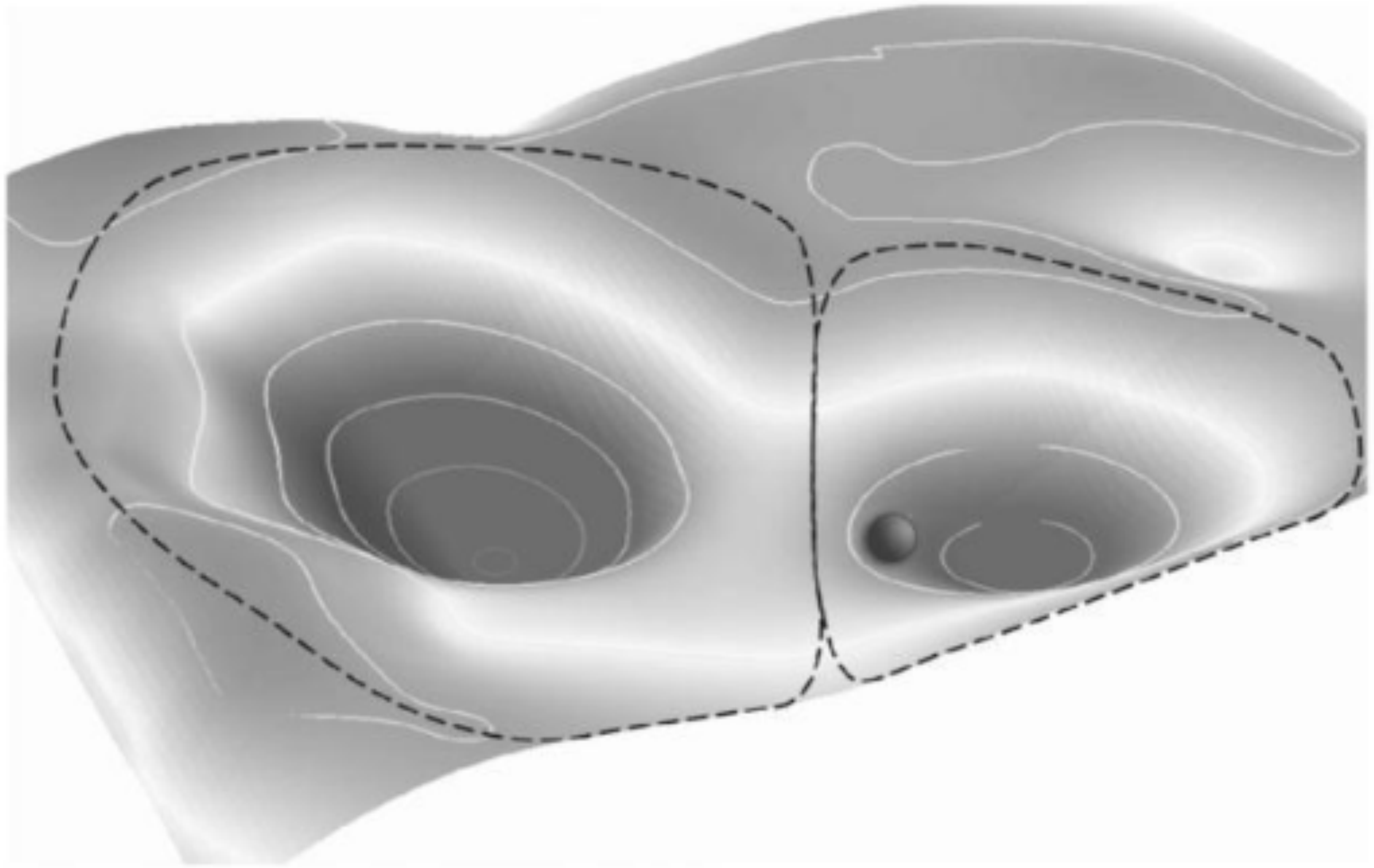

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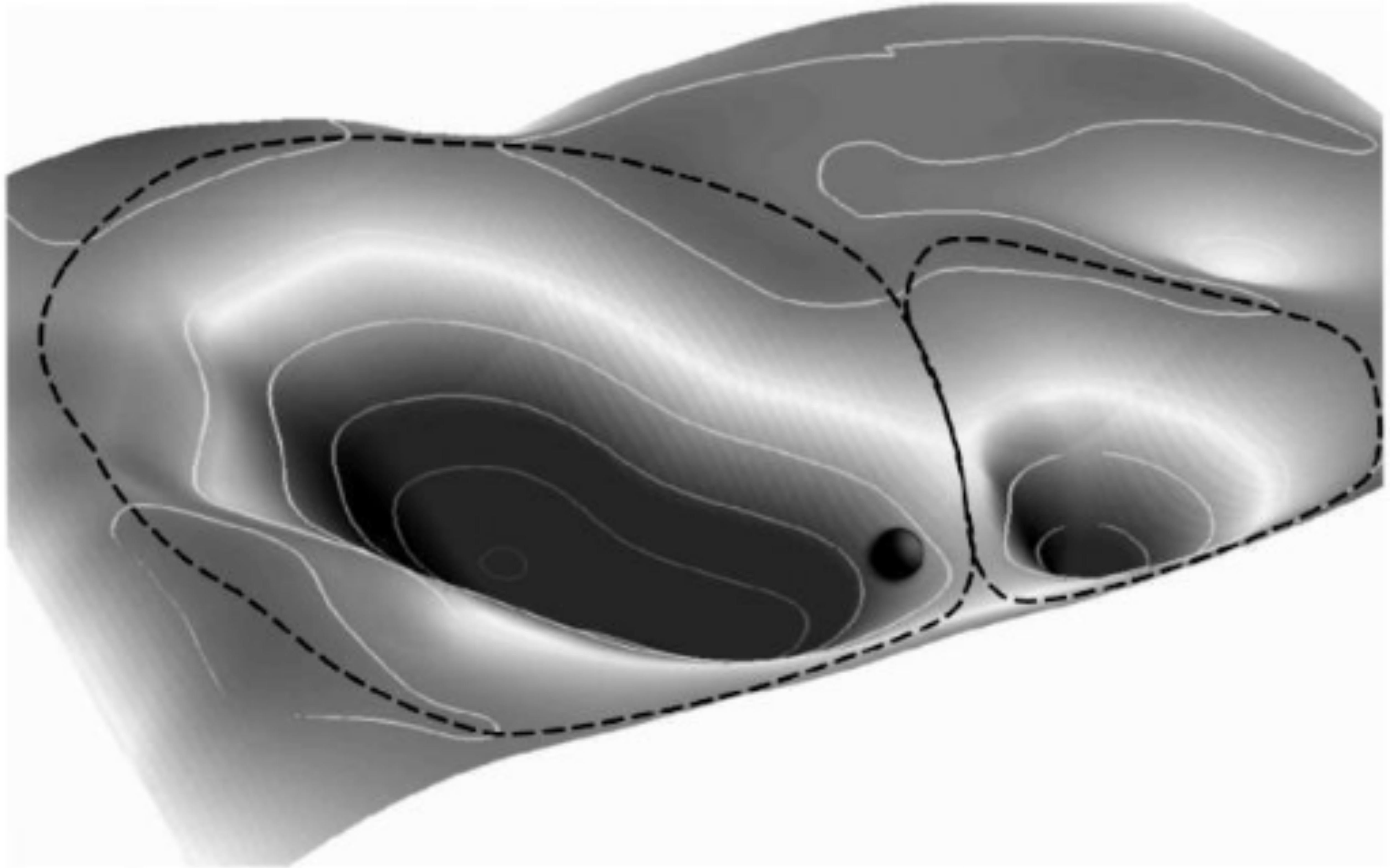
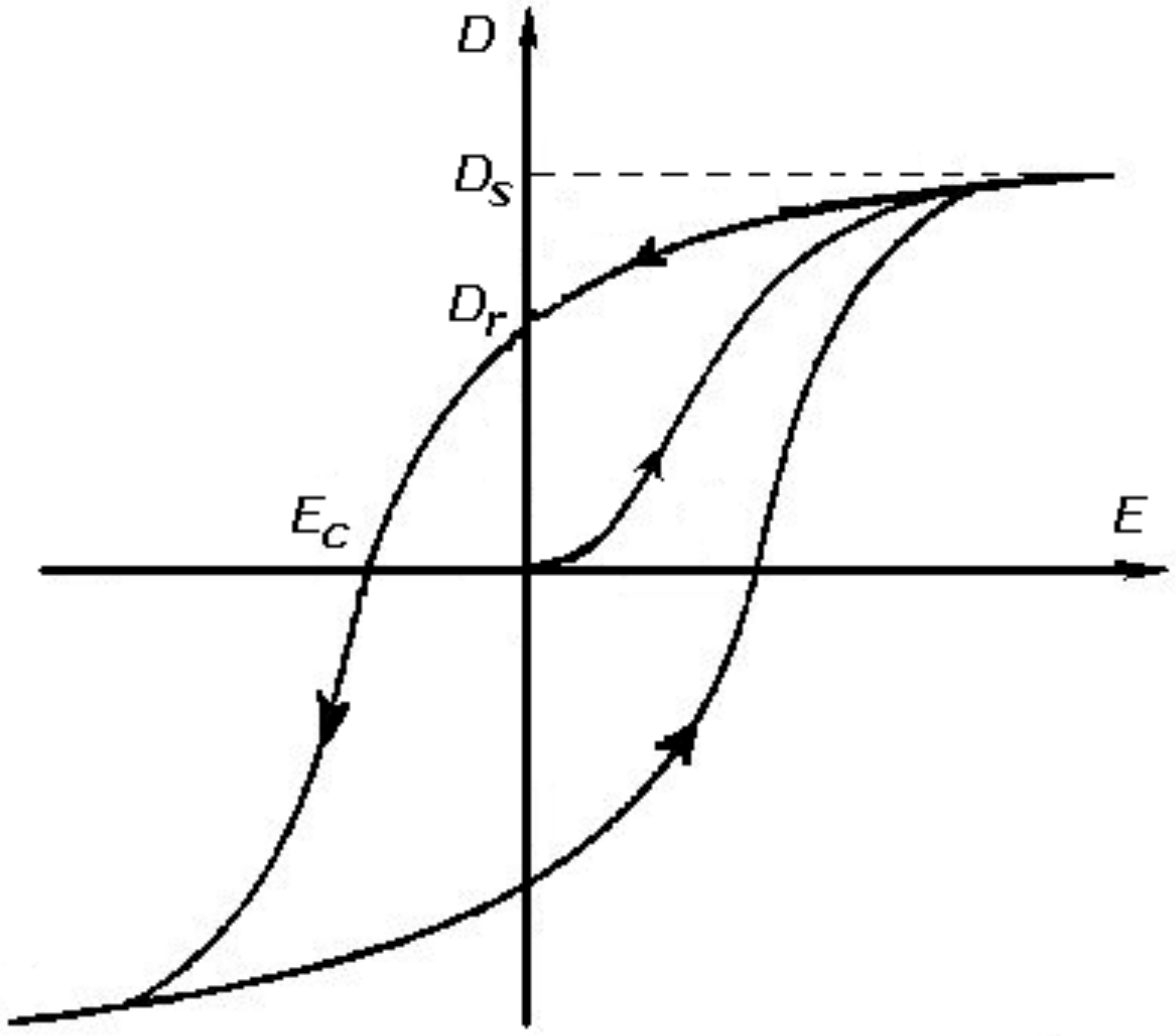


FIGURE 4 The Basin Changes Shape

This this is the same system as in figure 3. The state of the system (position of the ball) has not changed, but as conditions change, so too does the shape of the basin and the behavior of the system. *(From Walker et al , 2004.)*

# Vulnerabilities of the planetary system

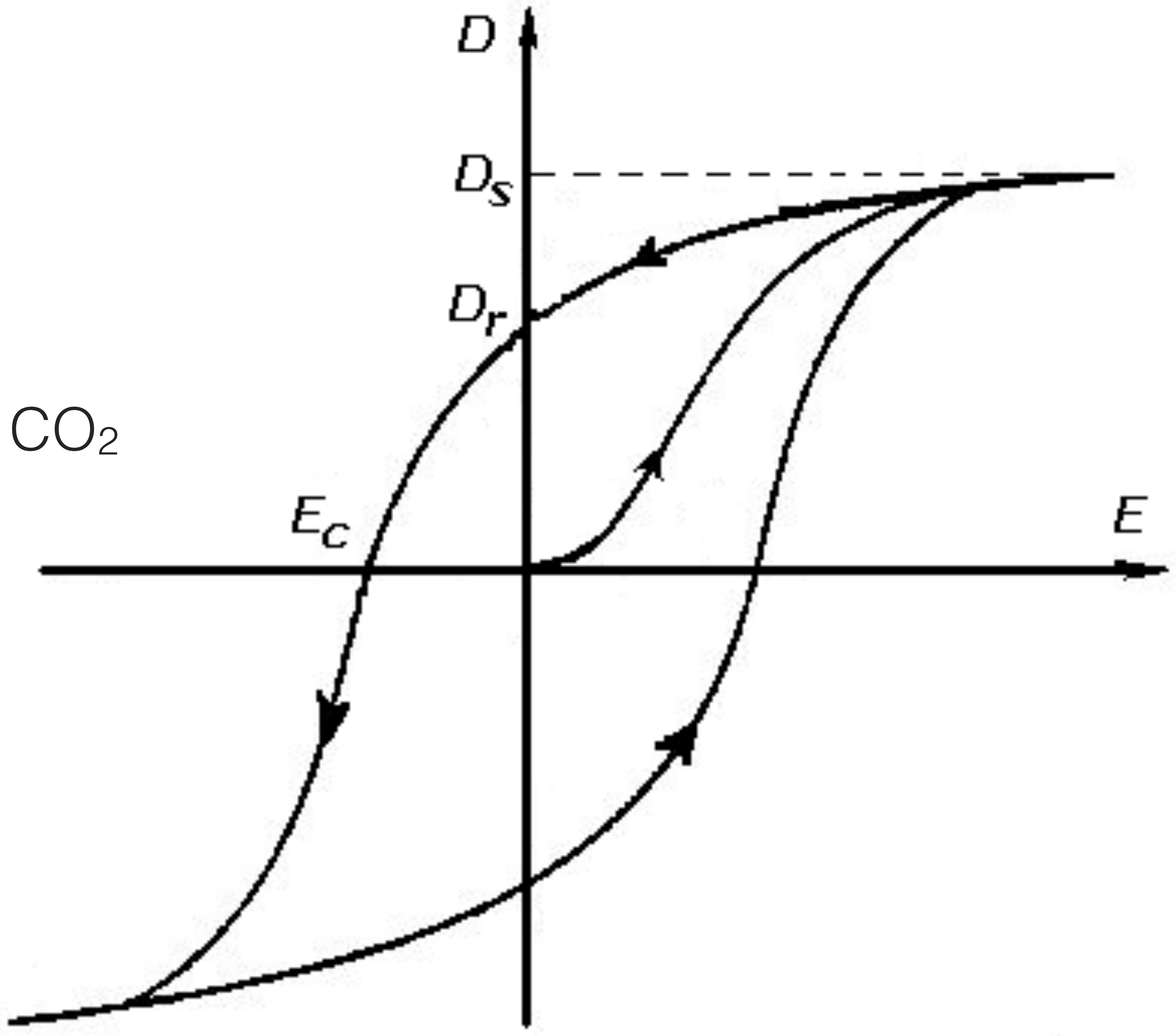


## Thresholds as a Vulnerability

**Hysteresis**: state of the system depends on both the presence and the past history.

Examples:

- post-glacial deformation as function of ice load
- global air temperature as function of atmospheric $CO_2$
- ecosystem as function of disturbances




Electromagnetic Displacement Field *D* as function of the electrical field *E*.

# Vulnerabilities of the planetary system

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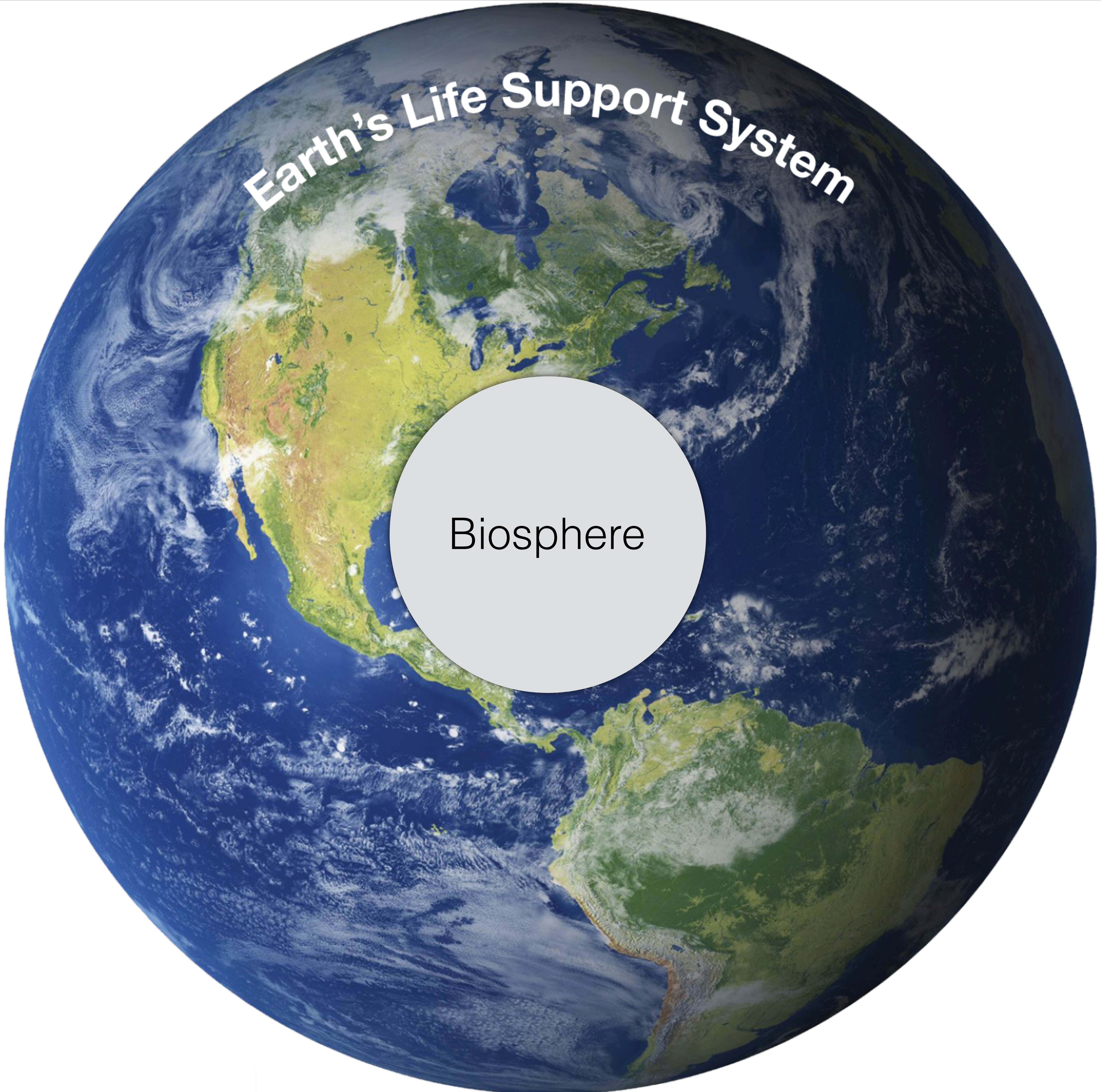

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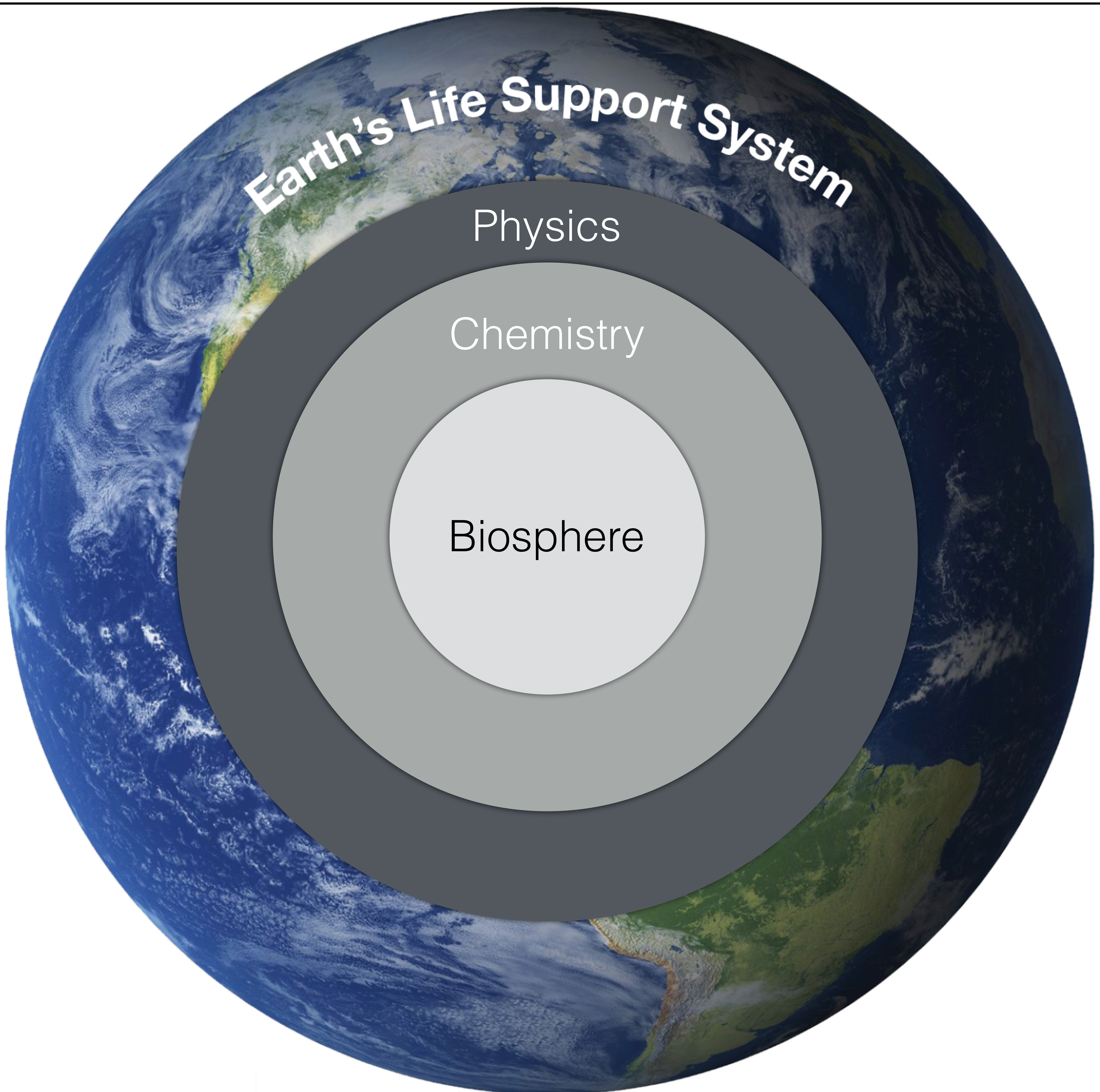

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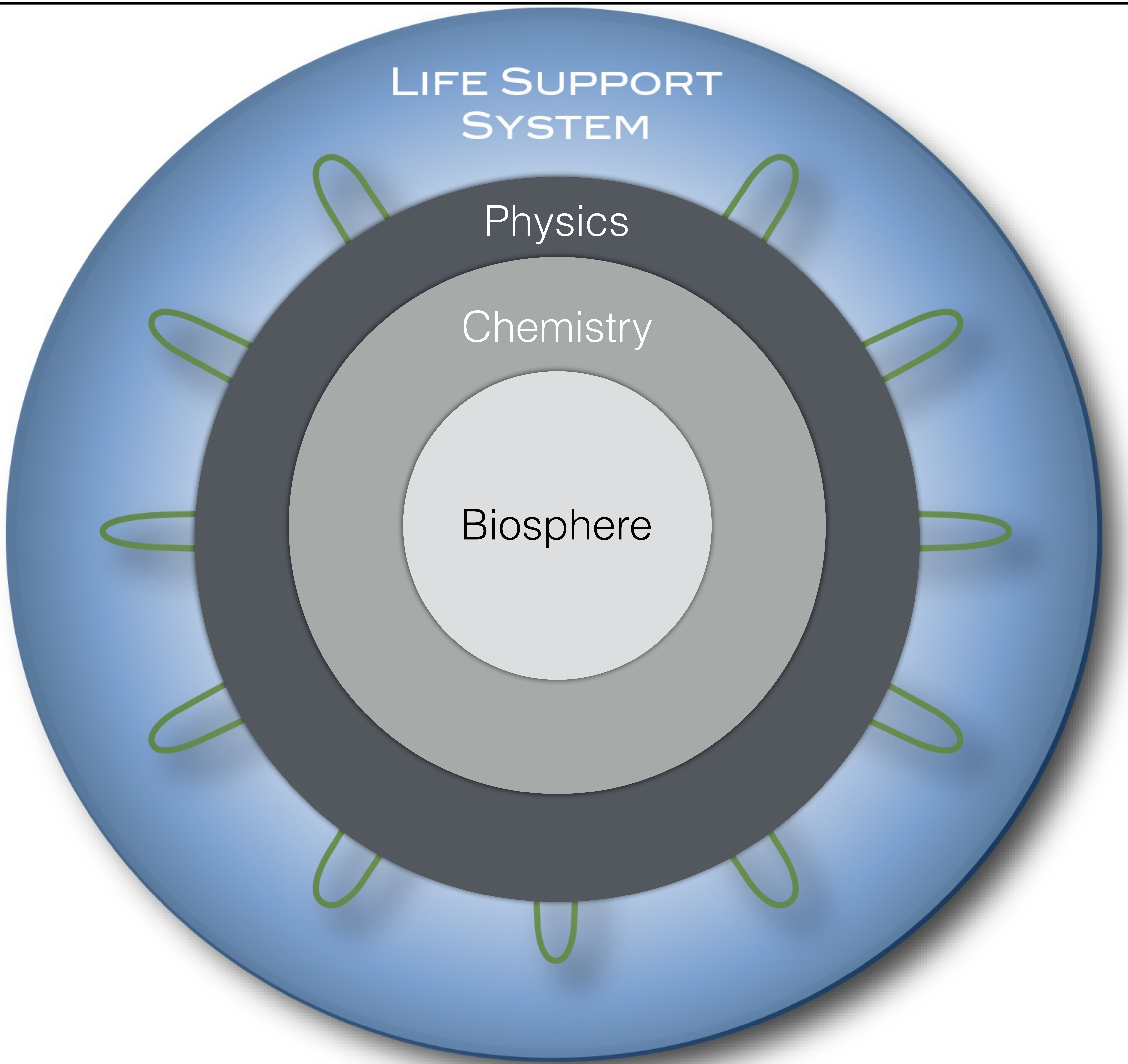
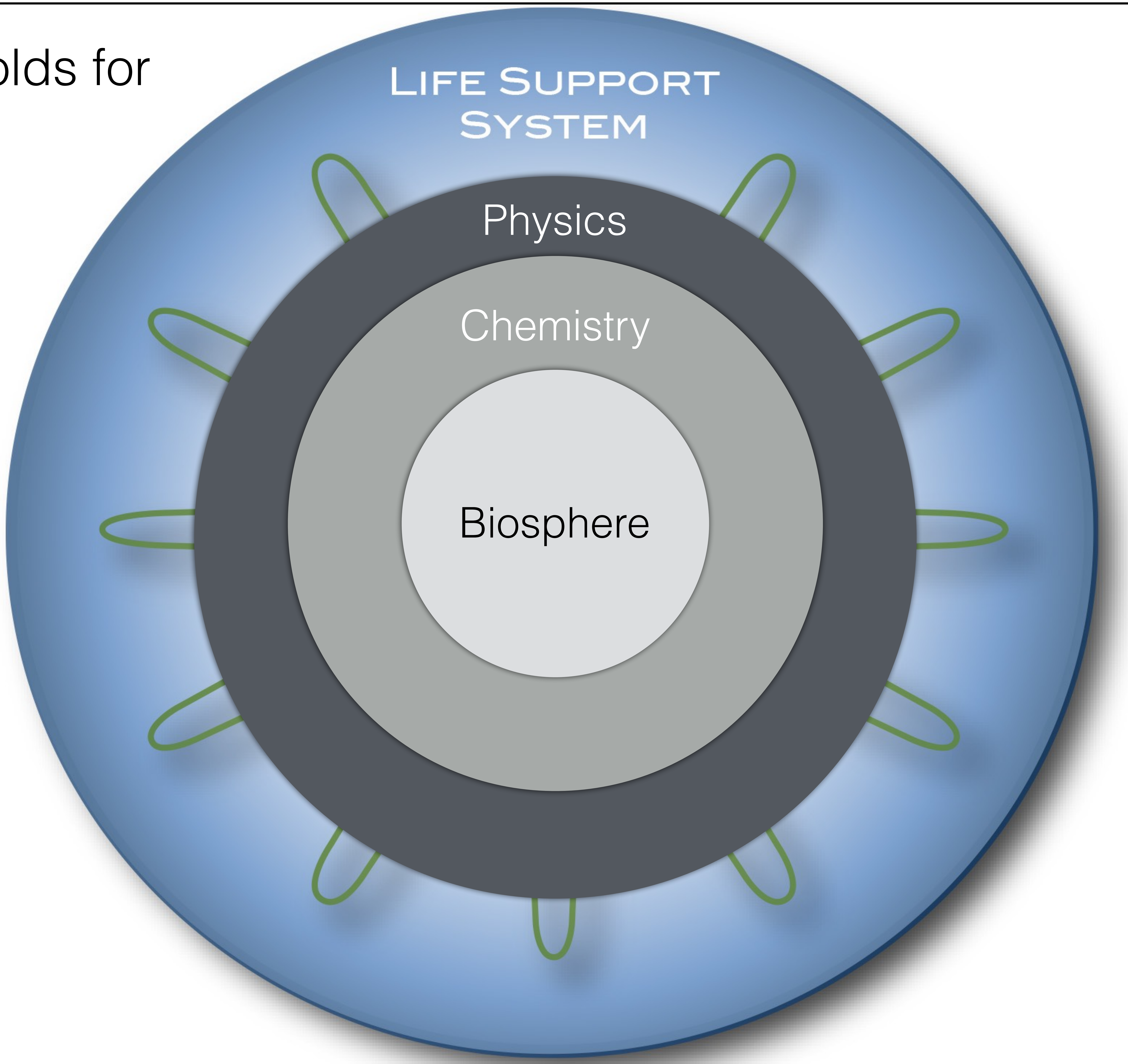


# Vulnerabilities of the planetary system

Potential thresholds for changes in:

- flows
- physics
- chemistry
- biodiversity



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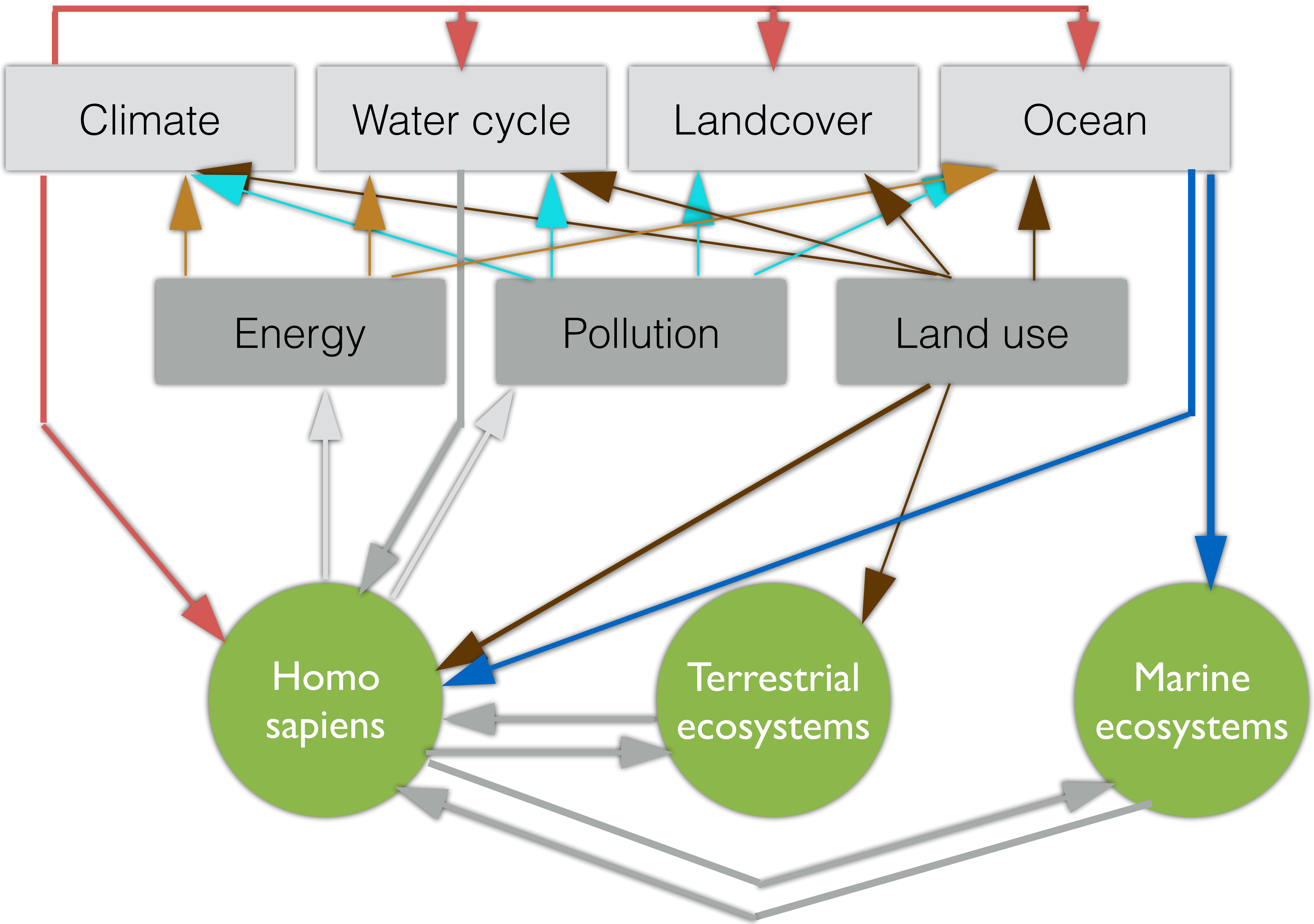

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Can one species push the planetary system across thresholds:

- flows: energy, carbon, water, plastics, concrete, materials, …
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# Direct impacts:

The Mauritius flying fox, a fruit bat endemic to the island of Mauritius, is the target of controversial culls.

PHOTOGRAPH BY JACQUES DE SPEVILLE

**ANIMALS** | WILDLIFE WATCH

## These endangered bats are being killed by the thousands—here's why

Scientists are suing the Mauritius government to halt the culling of flying foxes. So far, 50,000 bats have been slaughtered.

https://www.nationalgeographic.com/animals/2019/03/endangered-bats-killed-in-mauritius/

ELSEVIER

Journal for Nature Conservation

Volume 47, February 2019, Pages 58-64


## Mass-culling of a threatened island flying fox species failed to increase fruit growers' profits and revealed gaps to be addressed for effective conservation

F.B.V. Florens [1], C. Baider [2]

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https://doi.org/10.1016/j.jnc.2018.11.008

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# Vulnerabilities of the planetary system

## Indirect impacts:

### World's only tool-using vulture risks being lost forever

Hailed for its intelligence and majesty, the Egyptian Vulture was admired and worshipped throughout history. But decimated by poisoning, electrocution and illegal trophy hunting, the bird that was once an Ancient Egyptian hieroglyph is now Endangered. Can we save it before it's too late?

The Egyptian Vulture was once nicknamed the 'Pharaoh's Chicken' © BirdLife Europe

http://www.birdlife.org/worldwide/news/world's-only-tool-using-vulture-risks-being-lost-forever

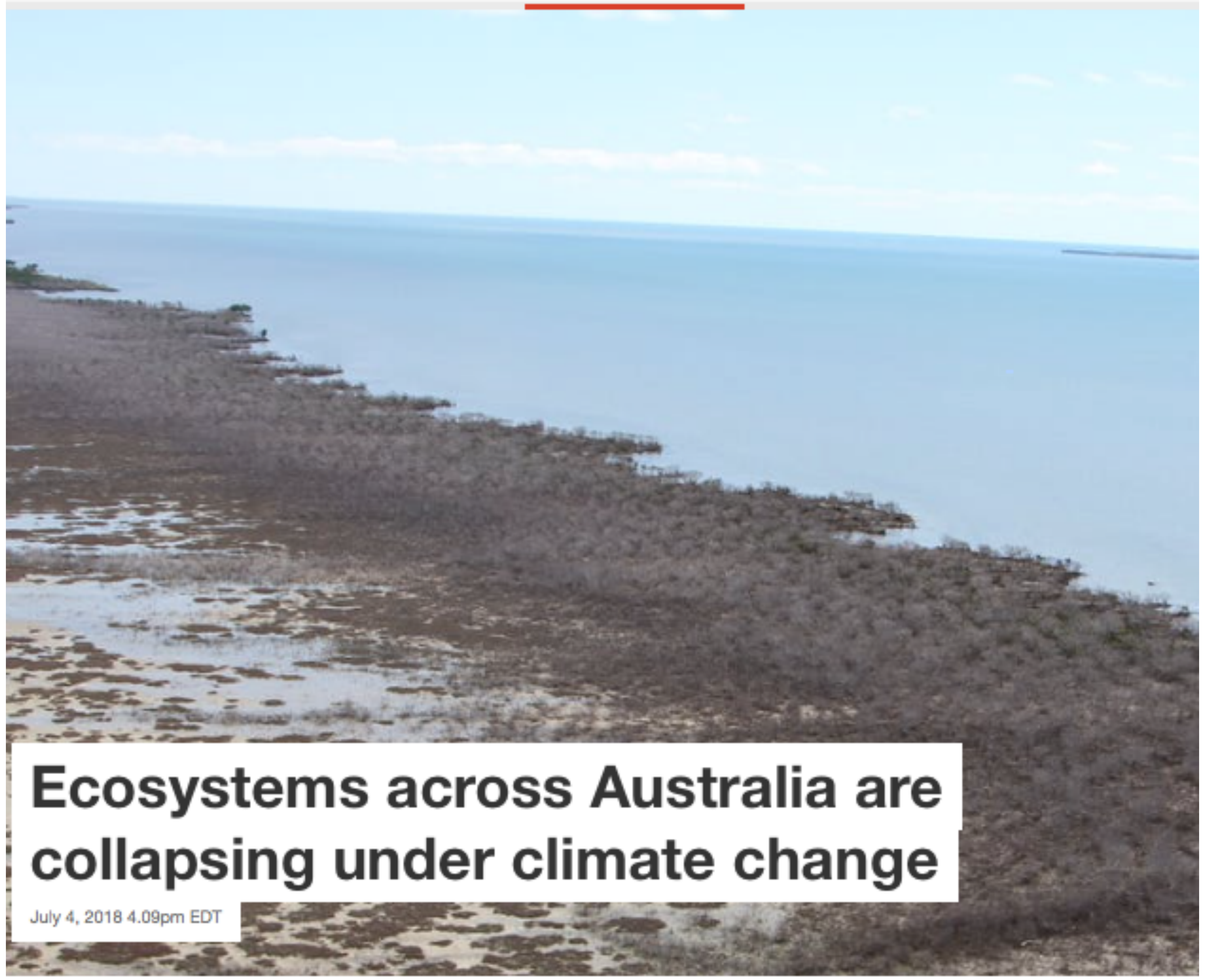
# Vulnerabilities of the planetary system

## Complex Interactions:

**THE CONVERSATION**

Academic rigor, journalistic flair

Arts + Culture | Economy + Business | Education | Environment + Energy | Ethics + Religion | Health + Medicine | Politic



**Ecosystems across Australia are collapsing under climate change**

July 4, 2018 4.09pm EDT

Widespread mangrove dieback in the Gulf of Carpenteria. JAMES COOK UNIVERSITY/AAP

Email
Twitter 1.1k
Facebook 8k

To the chagrin of the tourist industry, the Great Barrier Reef has become a notorious victim of climate change. But it is not the only Australian ecosystem on the brink of collapse.

https://theconversation.com/ecosystems-across-australia-are-collapsing-under-climate-change-99367

nature climate change

PERSPECTIVE

https://doi.org/10.1038/s41558-018-0187-9

Corrected: Author Correction

## Biological responses to the press and pulse of climate trends and extreme events

R. M. B. Harris[1,2*], L. J. Beaumont[3], T. R. Vance[1], C. R. Tozer[1,4], T. A. Remenyi[1], S. E. Perkins-Kirkpatrick[5,6], P. J. Mitchell[7], A. B. Nicotra[8], S. McGregor[6,9], N. R. Andrew[10], M. Letnic[11], M. R. Kearney[12], T. Wernberg[13], L. B. Hutley[14], L. E. Chambers[21], M.-S. Fletcher[15], M. R. Keatley[16], C. A. Woodward[17,18], G. Williamson[19], N. C. Duke[20] and D. M. J. S. Bowman[19]

**The interaction of gradual climate trends and extreme weather events since the turn of the century has triggered complex and, in some cases, catastrophic ecological responses around the world. We illustrate this using Australian examples within a press–pulse framework. Despite the Australian biota being adapted to high natural climate variability, recent combinations of climatic presses and pulses have led to population collapses, loss of relictual communities and shifts into novel ecosystems. These changes have been sudden and unpredictable, and may represent permanent transitions to new ecosystem states without adaptive management interventions. The press–pulse framework helps illuminate biological responses to climate change, grounds debate about suitable management interventions and highlights possible consequences of (non-) intervention.**

# Vulnerabilities of the planetary system

## Loss of biodiversity:

### Insects are dying en masse, endangering ecosystems

**Scott E. Rupp**
Tuesday, February 26, 2019

0 COMMENTS

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If you've noticed a few less bugs buzzing about, that's something to be concerned about, scientists warn. The number of insects in the world appears to be on the decline. Alongside this reduction in the world's bugs, there has never been much real long-term awareness of the decline.

But, warning signs have been around for years about plummeting insect populations worldwide, scientists say. The declining numbers are so much so now that the levels are seen as potentially "catastrophic" and have not been well-understood until now.

http://exclusive.multibriefs.com/content/insects-are-dying-en-masse-endangering-ecosystems/facilities-grounds

### Worldwide decline of the entomofauna: A review of its drivers

Francisco Sánchez-Bayo [a], Kris A.G. Wyckhuys [b, c, d]

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https://doi.org/10.1016/j.biocon.2019.01.020 Get rights and content

#### Highlights

- Over 40% of insect species are threatened with extinction.
- Lepidoptera, Hymenoptera and dung beetles (Coleoptera) are the taxa most affected.
- Four aquatic taxa are imperiled and have already lost a large proportion of species.
- Habitat loss by conversion to intensive agriculture is the main driver of the declines.
- Agro-chemical pollutants, invasive species and climate change are additional causes.

# Vulnerabilities of the planetary system

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## Flows and biodiversity:

## We're Eating the Largest Animals off the Face of the Earth

92 | tweet | 0 | 0 | email | 59

By: Alicia Graef | February 10, 2019
About Alicia | Follow Alicia at @care2

We already know some of the earth's largest animals are facing a range of threats from climate change and pollution to habitat loss, but according to a new study our demand for their meat is now one of the biggest threats to their survival.

https://www.care2.com/causes/were-eating-the-largest-animals-off-the-face-of-the-earth.html

Conservation Letters
Open Access
A journal of the Society for Conservation Biology

LETTER | Open Access

### Are we eating the world's megafauna to extinction?

William J. Ripple, Christopher Wolf, Thomas M. Newsome, Matthew G. Betts, Gerardo Ceballos, Franck Courchamp, Matt W. Hayward, Blaire Van Valkenburgh, Arian D. Wallach, Boris Worm

First published: 06 February 2019 | https://doi.org/10.1111/conl.12627

Find Text Here

Editor: David Lindenmayer

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### Abstract

Many of the world's vertebrates have experienced large population and geographic range declines due to anthropogenic threats that put them at risk of extinction. The largest vertebrates, defined as megafauna, are especially vulnerable. We analyzed how human activities are impacting the conservation status of megafauna within six classes: mammals, ray-finned fish, cartilaginous fish, amphibians, birds, and reptiles. We identified a total of 362 extant megafauna species. We found that 70% of megafauna species with sufficient information are decreasing and 59% are threatened with extinction. Surprisingly, direct harvesting of megafauna for human consumption of meat or body parts is the largest individual threat to each of the classes examined, and a threat for 98% (159/162) of threatened species with threat data available. Therefore, minimizing the direct killing of the world's largest vertebrates is a priority conservation strategy that might save many of these iconic species and the functions and services they provide.

# Invasive species:

## Dogs' becoming major threat' to wildlife

By Navin Singh Khadka
Environment correspondent, BBC World Service

12 February 2019

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PITAM CHATTOPADHYAY

Protected species like blackbuck are attacked by feral and free-ranging dogs

**They may be our "best friends" but dogs have also emerged as a major threat to wildlife.**

Scientists say they have contributed to the extinction of nearly one dozen wild bird and animal species.

### One billion dogs

There are an estimated one billion domestic dogs worldwide and their conditions range from feral and free-ranging to entirely dependent on humans.

There is no definitive figure for feral and free-ranging dogs, but conservationists say their number is definitely rising.

"It's quite a matter of serious concern," Piero Genovesi, head of the invasive species specialist unit at the IUCN conservation body, told the BBC.

"As the human population rises, so will the number of dogs, and this problem could get worse."

https://www.bbc.com/news/science-environment-47062959

# Vulnerabilities of the planetary system

Potential thresholds for changes in:

- flows
- physics
- chemistry
- biodiversity

Can one species push the planetary system across thresholds:

- flows: energy, carbon, water, plastics, concrete, materials, …
- physics: Earth Energy imbalance, global (ocean) warming
- chemistry: ocean chemistry (acidification, deoxidation, …)
- loss of biodiversity

# Vulnerabilities of the planetary system

## Changing flows:

**Guardian concrete week**
Cities

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**Guardian concrete week**

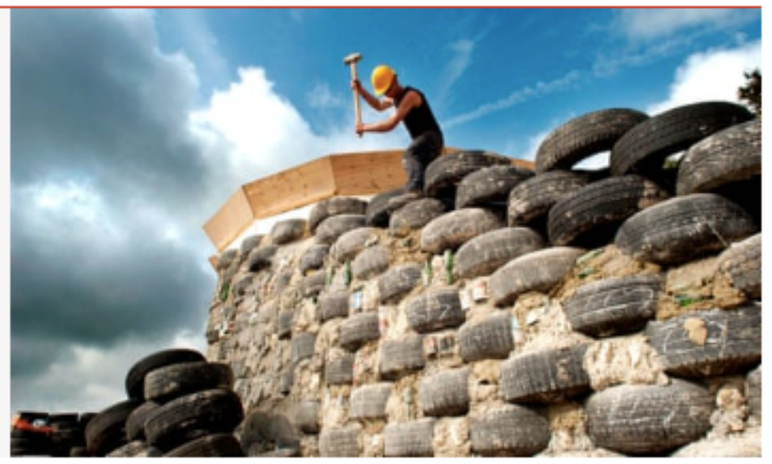
Guardian Cities celebrates the aesthetic and social achievements of concrete, while investigating its innumerable harms, to learn what we can all do today to bring about a less grey world

2 March 2019

**What you can do to reduce the destructive impact of concrete**

From recycling to divesting from cement firms, here are some ways you can lessen the impact of concrete on the planet

3:00 AM 134



1 March 2019

**Yes, concrete is harmful but it also has huge benefits for mankind**

**Letters:** Building on Guardian concrete week, readers debate its advantages and environmental impact
11:25 AM

**'We're wholly disappointed': the industry responds to Guardian concrete week**

10:23 AM

'A powerful argument for radical change': readers respond to Guardian concrete week

8:08 AM

**How science fiction can save us from concrete**

6:15 AM 60

Readers' photos: hideous eyesores or beautiful landmarks? You decide

1:00 AM

28 February 2019

**Hard living: what does concrete do to our bodies?**

**'Delicate sense of terror': what does concrete do to our mental**

**The grey wall of China: inside the world's concrete**

https://www.theguardian.com/cities/series/guardian-concrete-week

## The grey wall of China: inside the world's concrete superpower

▲ Beijing Daxing international airport contains 1.6m cubic metres of concrete. Photograph: Sipa

Advertisement

## 'Delicate sense of terror': what does concrete do to our mental health?

▲ 'Inspired by the artifacts of war': Ernö Goldfinger's 27-storey Balfron Tower in Poplar, east London. Photograph: Justin Tallis/AFP/Getty Images

## Concrete is tipping us into climate catastrophe. It's payback time

*John Vidal*

Cement has transformed the world, but now threatens to wreck the environment. We need to tax it, now

Find the rest of our Guardian concrete week pieces here

▲ The heat and chemical processes involved in making cement (a key component of concrete) mean that each tonne made releases a tonne of CO2. Photograph: Zoonar GmbH/Alamy Stock Photo/Alamy Stock Photo

Tucked away in volume three of the technical data for Britain's £53bn high speed rail project is a table that shows 20m tonnes of concrete will have to be poured to build the requisite 105 miles of track, culverts, bridges and tunnels. It is enough, it has been calculated, to pave over the entire city of Manchester.

# Vulnerabilities of the planetary system

Changing flows:

03.02.19

## We have to fix fashion if we want to survive the climate crisis

The industry churned out 100 billion pieces of clothing for 7 billion people in 2015. The problem is so bad, some brands are burning unsold inventory. The waste has got to stop.

[Source Image: Sashkinw /iStock, Goran Jakus Photography/iStock]

https://www.fastcompany.com/90311509/we-have-to-fix-fashion-if-we-want-to-survive-the-next-century

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# Vulnerabilities of the planetary system

## Physics and chemistry:

Wildlife Energy Pollution

### Our oceans broke heat records in 2018 and the consequences are catastrophic

**Rising temperatures can be charted back to the late 1950s, and the last five years were the five hottest on record**

Bleached coral in Guam. The heating of oceans is causing tremendous problems for sea life. Photograph: David Burdick/AP

Last year was the hottest ever measured, continuing an upward trend that is a direct result of manmade greenhouse gas emissions.

https://www.theguardian.com/environment/climate-consensus-97-per-cent/2019/jan/16/our-oceans-broke-heat-records-in-2018-and-the-consequences-are-catastrophic

OCEANS

### Record-Warm Oceans: How Worried Should We Be?

By Environmental Defense Fund | Feb. 26, 2019 09:45AM EST

A sea turtle swims above a fragile coral reef in Wailea, Maui, Hawaii. *M Swiet Productions / Moment / Getty Images*

https://www.ecowatch.com/oceans-warming-faster-2630061947.html

EARTH

### The Ocean Is Running Out of Breath, Scientists Warn

Widespread and sometimes drastic marine oxygen declines are stressing sensitive species—a trend that will continue with climate change

By Laura Poppick on February 25, 2019

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Oxygen Depletion Smothered Marine Life in Earth's Largest Mass Extinction

9 Ocean Conservation Groups You Don't Know about...but Should

Like Oceans, Freshwater Is Also Acidifying

https://www.scientificamerican.com/article/the-ocean-is-running-out-of-breath-scientists-warn/