



# Can the Economy in Modern Society Work Without Polluting the Environment with Our Growing Waste?

Hans-Peter Plag  
Old Dominion University  
Norfolk, VA, USA

# Can the Economy in Modern Society Work Without Polluting the Environment with Our Growing Waste?

Prologue:

Our perception depends on the distance we have ...

Hans-Peter Plag  
Old Dominion University  
Norfolk, VA, USA

**What is the Purpose of Economy in the Planetary Life-Support System?**



# What is the Purpose of Economy in the Planetary Life-Support System?



# What is the Purpose of Economy in the Planetary Life-Support System?

Physiology of the Planetary Life-Support System: Homeostasis



# What is the Purpose of Economy in the Planetary Life-Support System?

Physiology of the Planetary Life-Support System: Homeostasis

Life-Support System for very many species forming a complex web of life



# What is the Purpose of Economy in the Planetary Life-Support System?

Physiology of the Planetary Life-Support System: Homeostasis

Life-Support System for very many species forming a complex web of life

Global Essential Variable: Energy Imbalance: Incoming Energy minus Outgoing Energy



# What is the Purpose of Economy in the Planetary Life-Support System?

Physiology of the Planetary Life-Support System: Homeostasis

Life-Support System for very many species forming a complex web of life

Global Essential Variable: Energy Imbalance: Incoming Energy minus Outgoing Energy

“Healthy Life-Support System”:

Earth’s Energy Imbalance (EEI) due to photosynthesis on the order of  $10^{-10}$  to  $10^{-9}$



# What is the Purpose of Economy in the Planetary Life-Support System?

Physiology of the Planetary Life-Support System: Homeostasis

Life-Support System for very many species forming a complex web of life

Global Essential Variable: Energy Imbalance: Incoming Energy minus Outgoing Energy

“Healthy Life-Support System”:

Earth’s Energy Imbalance (EEI) due to photosynthesis on the order of  $10^{-10}$  to  $10^{-9}$



Imbalance today: 300-320 TW, i.e., on the order of  $3 \times 10^{-3}$

(e.g., Stephens et al., 2012; Trenberth et al., 2014, Cheng et al., 2016)



# What is the Purpose of Economy in the Planetary Life-Support System?

Physiology of the Planetary Life-Support System: Homeostasis

Life-Support System for very many species forming a complex web of life

Global Essential Variable: Energy Imbalance: Incoming Energy minus Outgoing Energy

“Healthy Life-Support System”:

Earth’s Energy Imbalance (EEI) due to photosynthesis on the order of  $10^{-10}$  to  $10^{-9}$



Imbalance today: 300-320 TW, i.e., on the order of  $3 \times 10^{-3}$

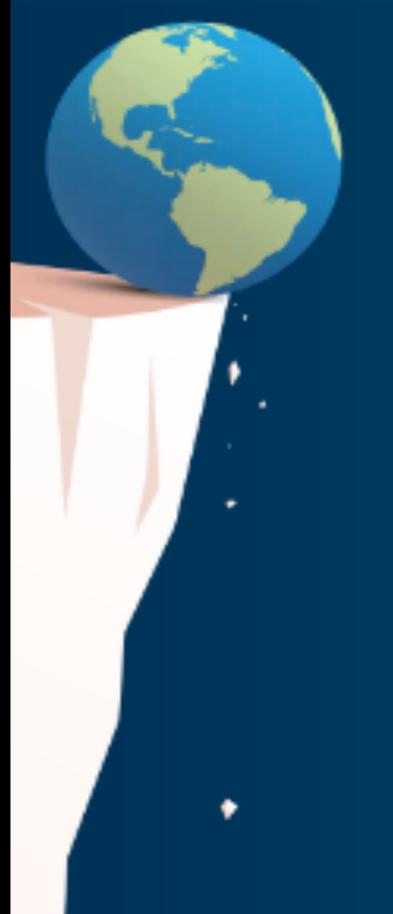
(e.g., Stephens et al., 2012; Trenberth et al., 2014, Cheng et al., 2016)

Why did the Earth’s energy imbalance increased so dramatically?

# Some Humans ask Questions

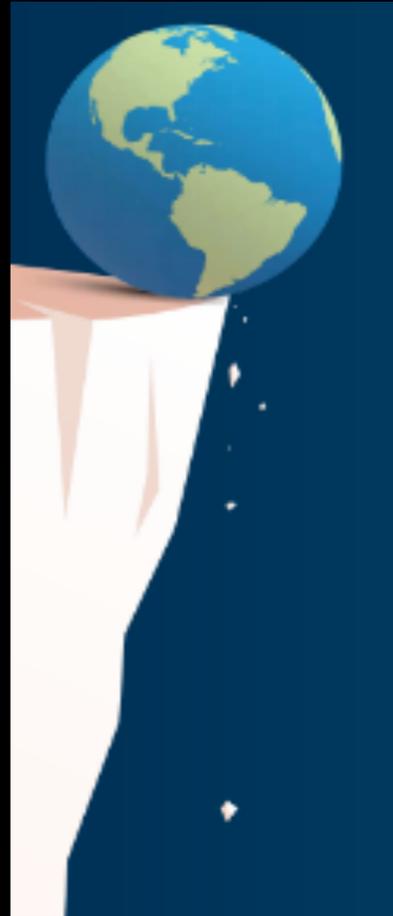
# Some Humans ask Questions

Is Earth on the edge?



# Some Humans ask Questions

Is Earth on the edge?

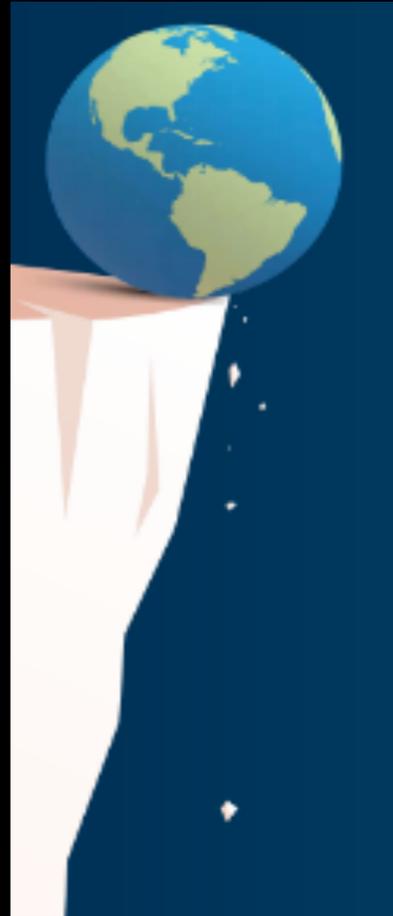


Is humanity as a global species on the edge?



# Some Humans ask Questions

Is Earth on the edge?



Is humanity as a global species on the edge?



# Some Humans ask Questions

Is Earth on the edge?

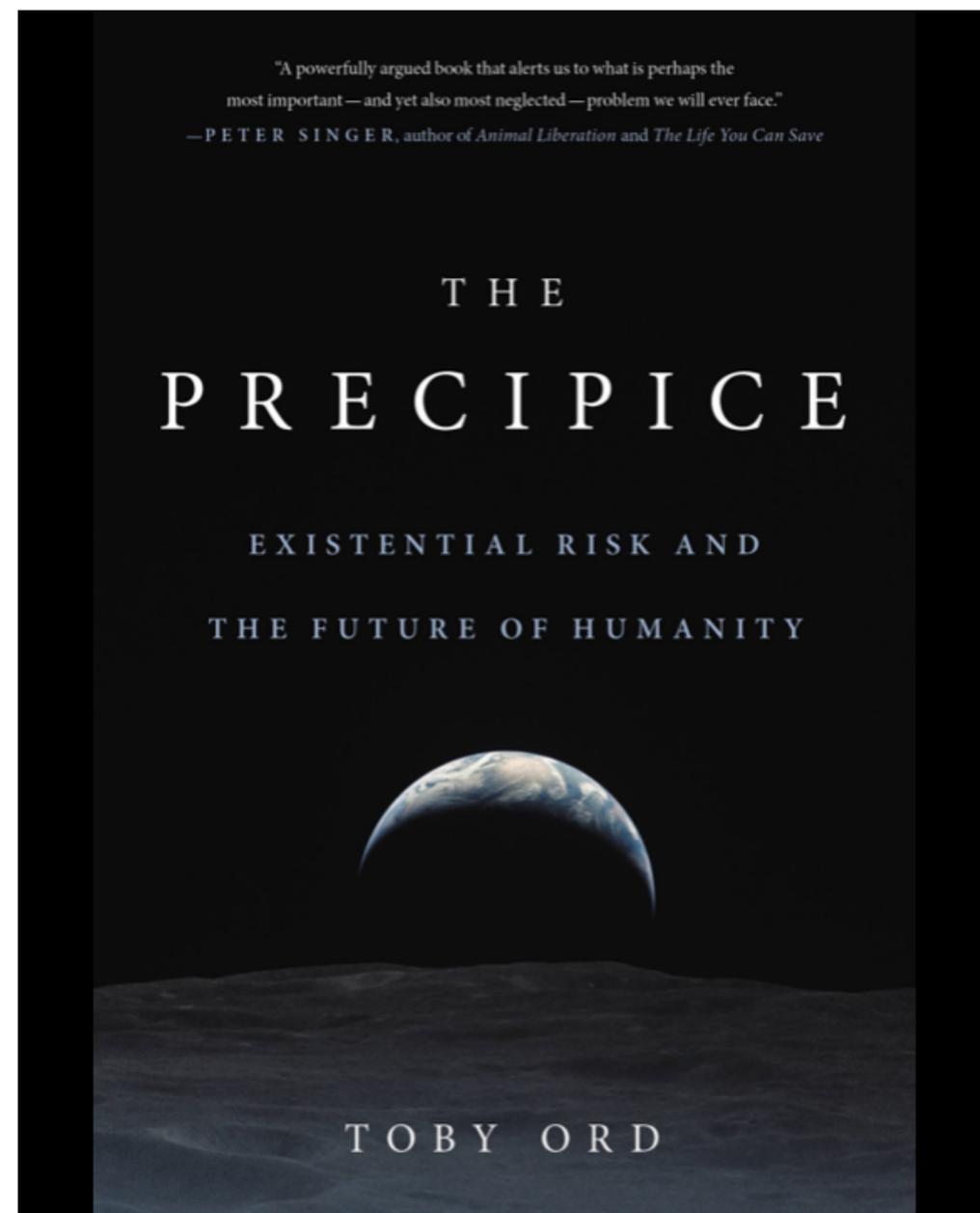


Is humanity as a global species on the edge?



Toby Ord:  
The Precipice





### 3. Natural Risks

Asteroids & Comets

Supervolcanic Eruptions

Stellar Explosions

Other Natural Risks

The Total Natural Risk

### 4. Anthropogenic Risks

Nuclear Weapons

Climate Change

Environmental Damage

### 5. Future Risks

Pandemics

Unaligned Artificial Intelligence

Dystopian Scenarios

Other Risks

## PART THREE: THE PATH FORWARD

### 6. The Risk Landscape

Quantifying the Risks

Combining and Comparing Risks

Risk Factors

Which Risks?

### 7. Safeguarding Humanity

Grand Strategy for Humanity

Risks Without Precedent

International Coordination

Technological Progress

Research on Existential Risk

What You Can Do

### 8. Our Potential

Duration

Scale

Quality

Choices

## PART THREE: THE PATH FORWARD

### 6. The Risk Landscape

Quantifying the Risks

Combining and Comparing Risks

Risk Factors

Which Risks?

### 7. Safeguarding Humanity

Grand Strategy for Humanity

Risks Without Precedent

International Coordination

Technological Progress

Research on Existential Risk

What You Can Do

### 8. Our Potential

Duration

Scale

Quality

Choices

### 3. Natural Risks

Asteroids & Comets

Supervolcanic Eruptions

Stellar Explosions

Other Natural Risks

The Total Natural Risk

### 4. Anthropogenic Risks

Nuclear Weapons

Climate Change

Environmental Damage

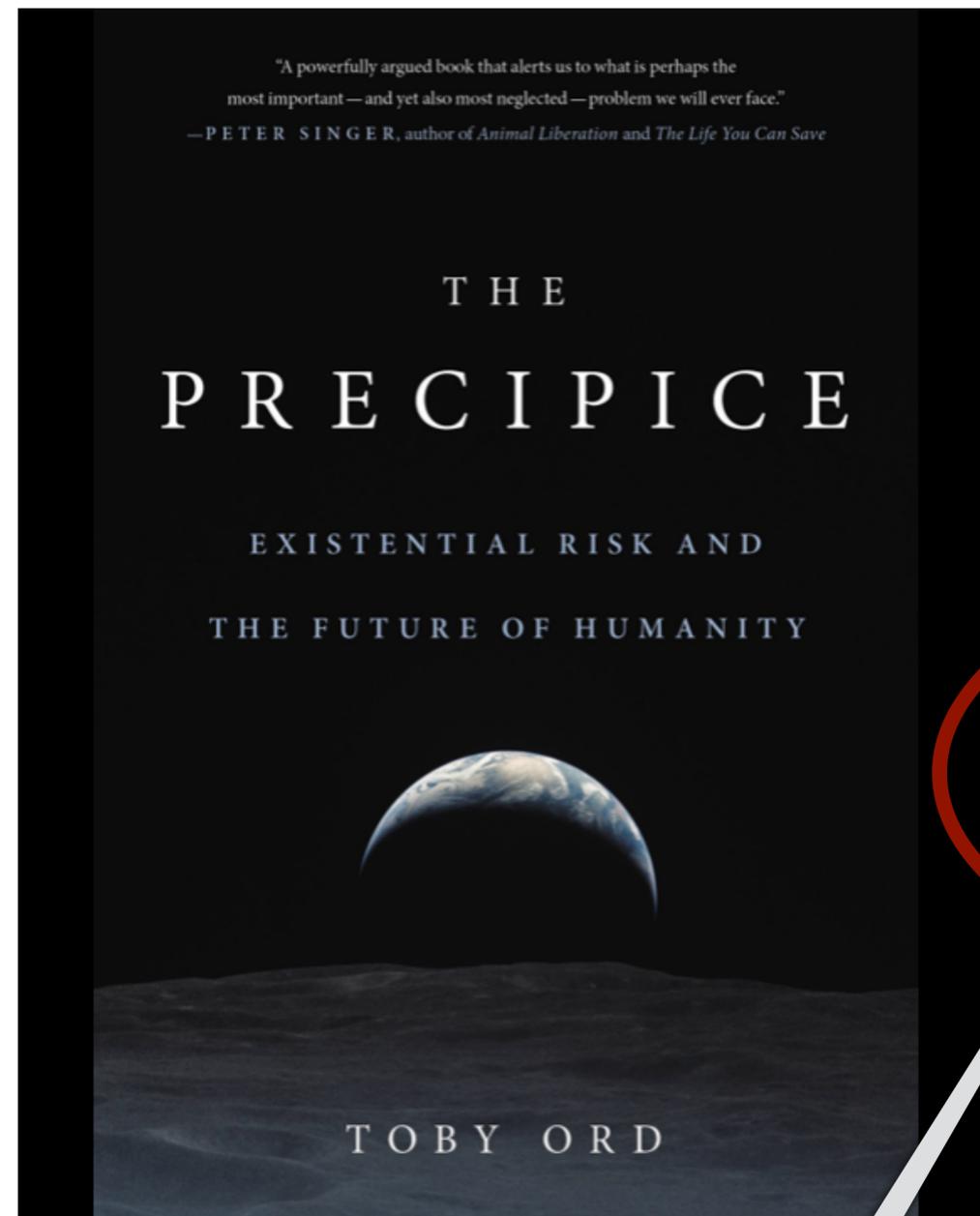
### 5. Future Risks

Pandemics

Unaligned Artificial Intelligence

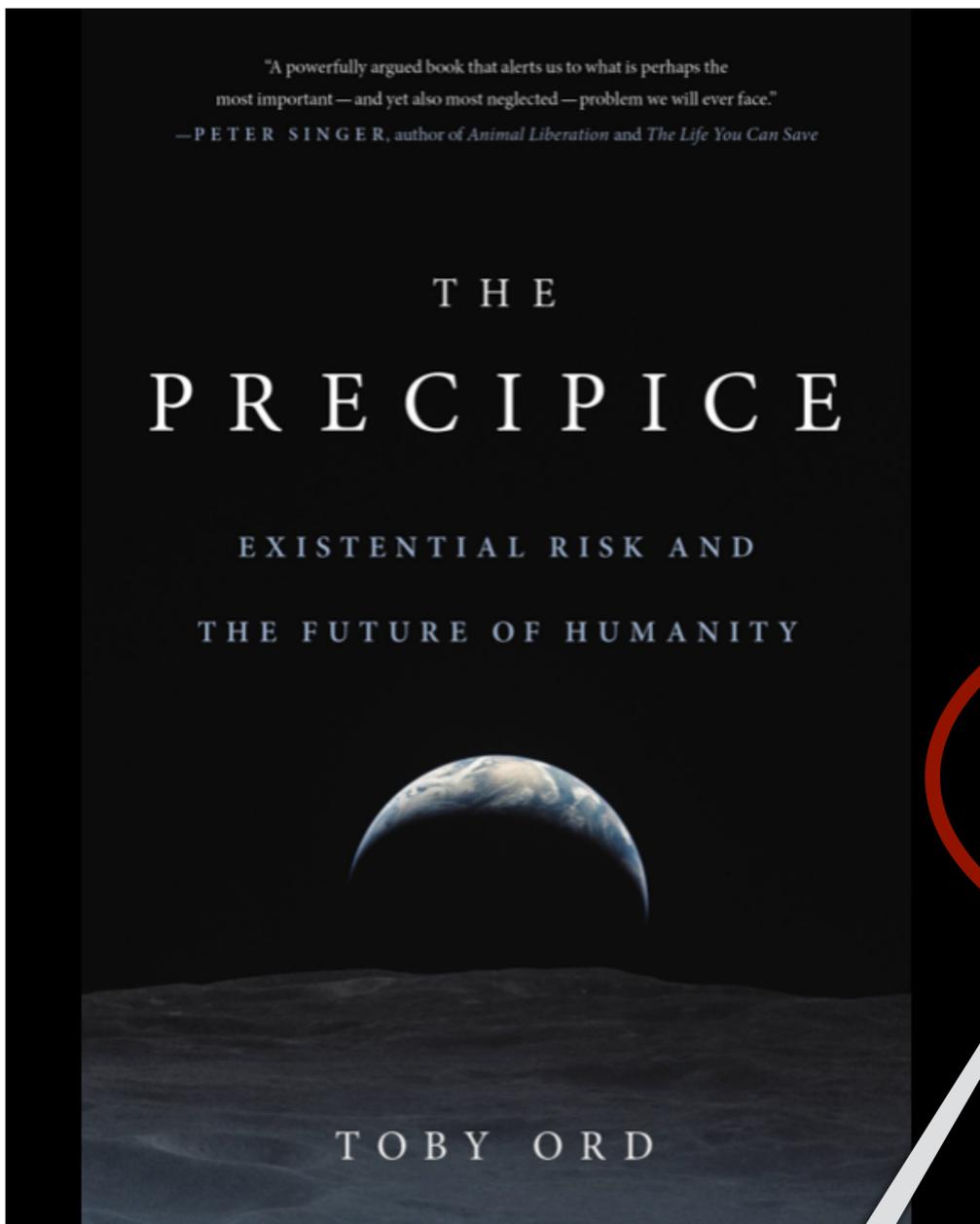
Utopian Scenarios

Risks



The human race's prospects of survival were considerably better when we were defenceless against tigers than they are today, when we have become defenceless against ourselves.

—Arnold Toynbee



### 3. Natural Risks

Asteroids & Comets

Supervolcanic Eruptions

Stellar Explosions

Other Natural Risks

The Total Natural Risk

### 4. Anthropogenic Risks

Nuclear Weapons

Climate Change

Environmental Damage

### 5. Future Risks

Pandemics

Unaligned Artificial Intelligence

Utopian Scenarios

## PART THREE: THE PATH FORWARD

### 6. The Risk Landscape

Quantifying the Risks

Combining and Comparing Risks

Risk Factors

Which Risks?

### 7. Safeguarding Humanity

Grand Strategy for Humanity

Risks Without Precedent

International Coordination

Technological Progress

Research on Existential Risk

What You Can Do

8. C

## GRAND STRATEGY FOR HUMANITY

1. Reaching Existential Security
2. The Long Reflection
3. Achieving Our Potential

The human race's prospects of survival were considerably better when we were defenceless against tigers than they are today, when we have become defenceless against ourselves.

—Arnold Toynbee

# Can the Economy in Modern Society Work Without Polluting the Environment with Our Growing Waste?

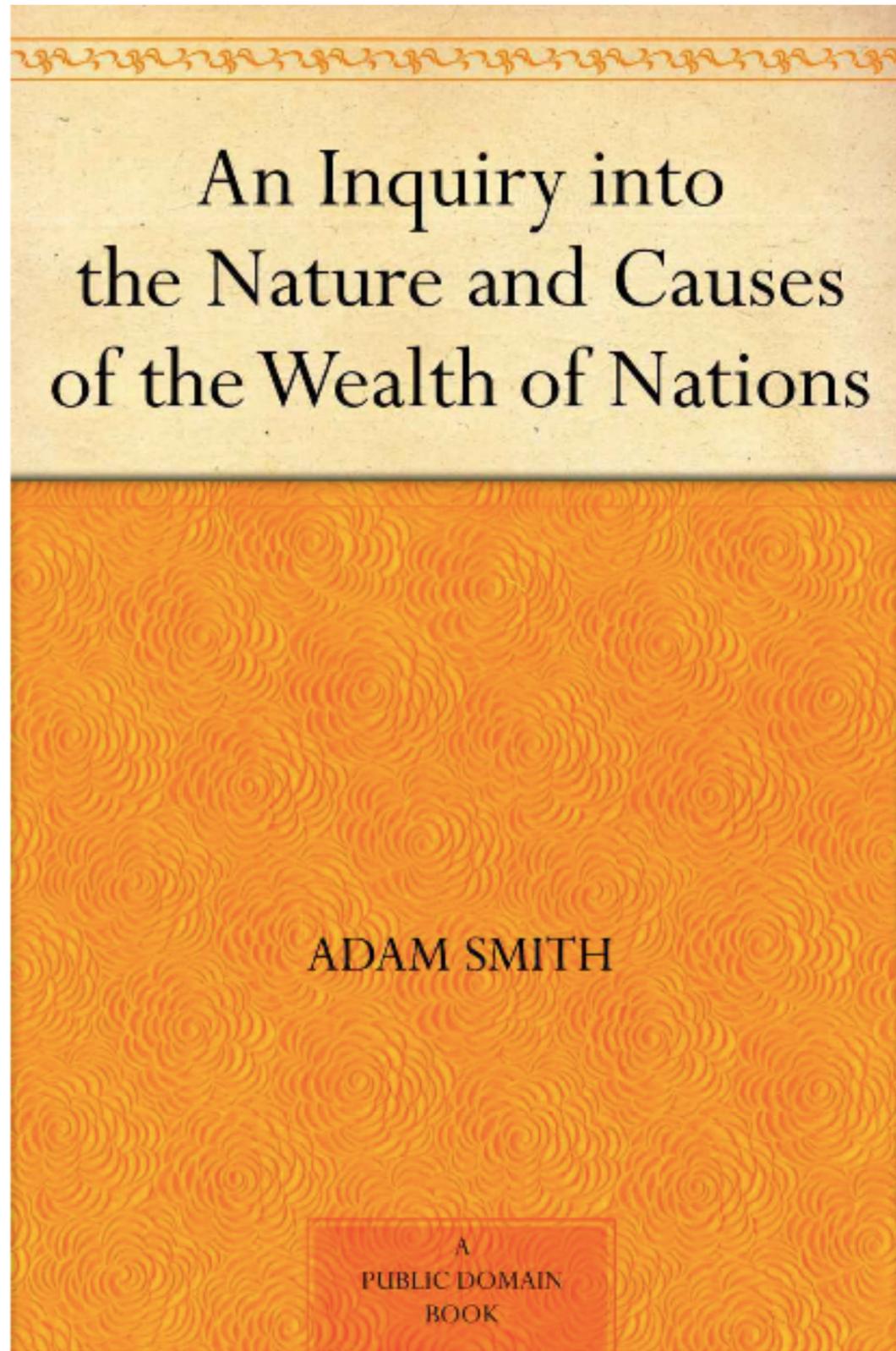
- The Purpose of Economy
- The Syndrome of Modern Global Change
- The Diagnosis: Creating Human Wealth without Regard for Natural Wealth
- The Prognosis: Running out of Resources while Polluting the Environment
- The Therapy: Changing the Official Purpose of Economy

Hans-Peter Plag  
Old Dominion University  
Norfolk, VA, USA

# Can the Economy in Modern Society Work Without Polluting the Environment with Our Growing Waste?

- The Purpose of Economy
- The Syndrome of Modern Global Change
- The Diagnosis: Creating Human Wealth without Regard for Natural Wealth
- The Prognosis: Running out of Resources while Polluting the Environment
- The Therapy: Changing the Official Purpose of Economy

Hans-Peter Plag  
Old Dominion University  
Norfolk, VA, USA



- Purpose of economy is to increase human wealth;
- Earth and its natural wealth is basically infinite.

*Smith (1776)*

*Published in 1776*

## Role of Mainstream “Official” Economic Model

For almost a century, the **consumption of products has been the dominant paradigm and mindset.**

John Maynard Keynes (*“The General Theory of Employment, Interest and Money”*, 1936): *“I should support at the same time all sorts of policies for increasing the propensity to consume. For it is unlikely that full employment can be maintained, whatever we may do about investment, with the existing propensity to consume.”*

Victor Lebow (1955): *“Our enormously productive economy ... demands that we make consumption our way of life, that we convert the buying and use of goods into rituals, that we **seek our spiritual satisfaction, our ego satisfaction, in consumption ... we need things consumed, burned up, replaced and discarded at an ever-accelerating rate.**”*

## Role of Mainstream “Official” Economic Model

For almost a century, the **consumption of products has been the dominant paradigm and mindset.**

John Maynard Keynes (*“The General Theory of Employment, Interest and Money”*, 1936): *“I should support at the same time all sorts of policies for increasing the propensity to consume. For it is unlikely that full employment can be maintained, whatever we may do about investment, with the existing propensity to consume.”*

Victor Lebow (1955): *“Our enormously productive economy ... demands that we make consumption our way of life, that we convert the buying and use of goods into rituals, that we **seek our spiritual satisfaction, our ego satisfaction, in consumption ... we need things consumed, burned up, replaced and discarded at an ever-accelerating rate.**”*

In 1970, Milton Friedman argued that businesses’ sole purpose is to generate profit for shareholders.

This led to globalization ...

## Moral consequences of economic growth:

“Benjamin M. Friedman ’66, Jf ’71, Ph.D. ’71, Maier professor of political economy, now fills in this gap:

he makes a powerful argument that—politically and sociologically—modern society is a bicycle, with **economic growth** being the forward momentum that **keeps the wheels spinning**.

As long as the wheels of a bicycle are spinning rapidly, it is a very stable vehicle indeed.

But, he argues, **when the wheels stop**—even as the result of economic *stagnation*, rather than a downturn or a depression—**political democracy, individual liberty, and social tolerance are then greatly at risk** even in countries where the absolute level of material prosperity remains high.”

*DeLong (2006)*

- Purpose of economy is to increase human wealth;
- Earth and its natural wealth is basically infinite.

*Smith (1776)*

# OUR COMMON FUTURE

THE WORLD COMMISSION  
ON ENVIRONMENT  
AND DEVELOPMENT

*Published in 1987*

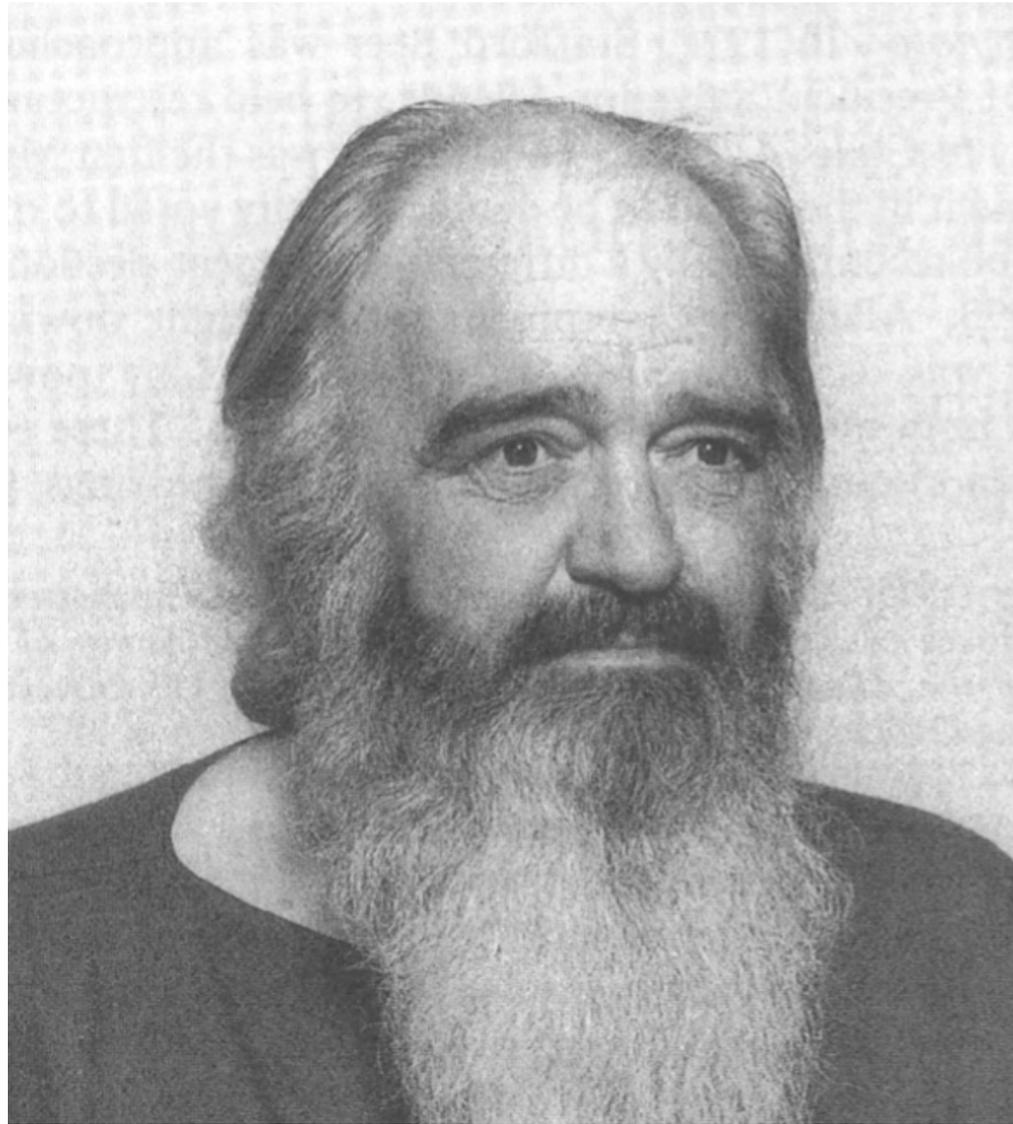
- Purpose of economy is to increase human wealth;
- Earth and its natural wealth is basically infinite.

*Smith (1776)*

"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs".

*WCED (1987)*

## Purpose of a System



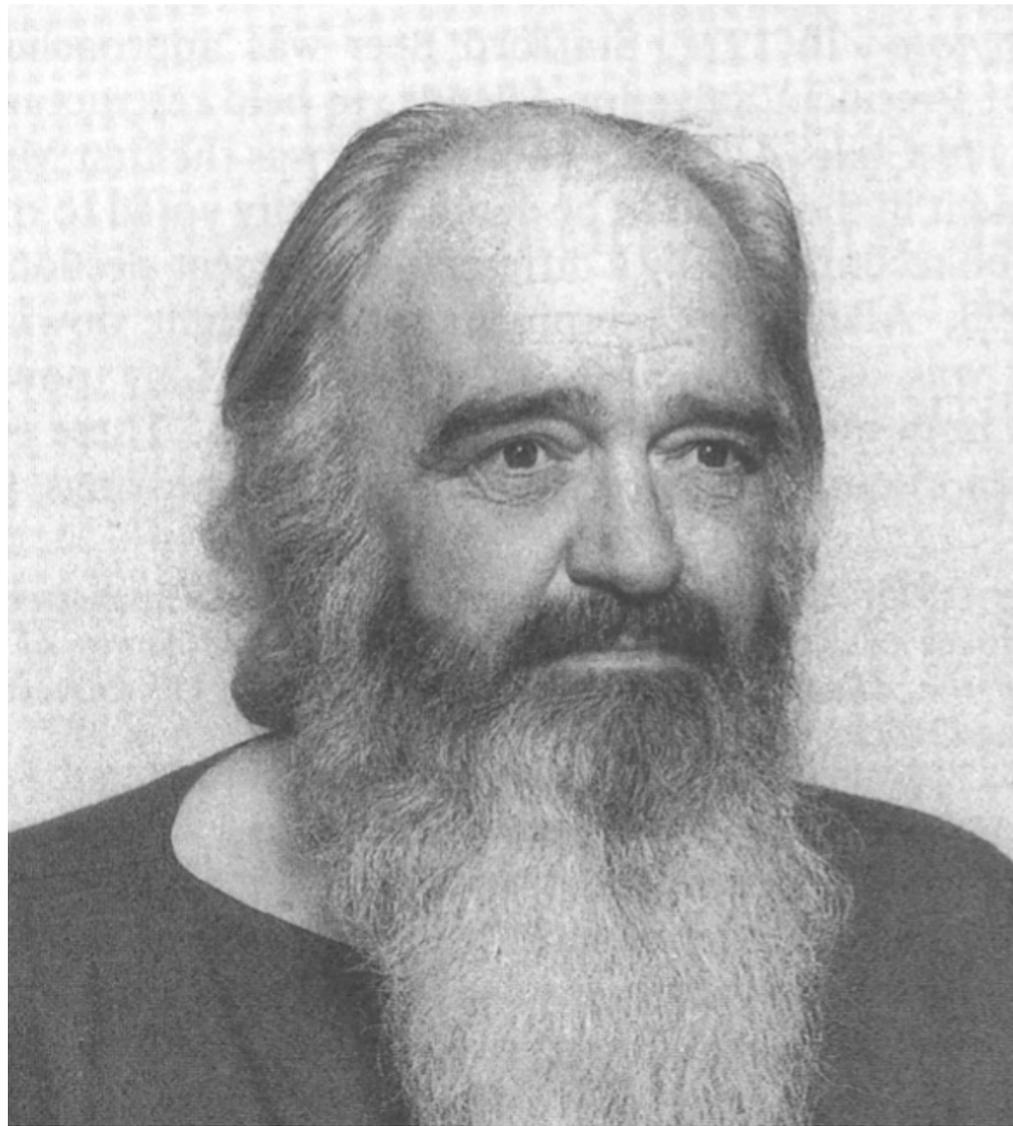
**Stafford Beer**

**1926 - 2002**

Among others:

President of the World Organization of Systems and Cybernetics

## Purpose of a System



The Purpose of a System Is What It Does - POSIWID

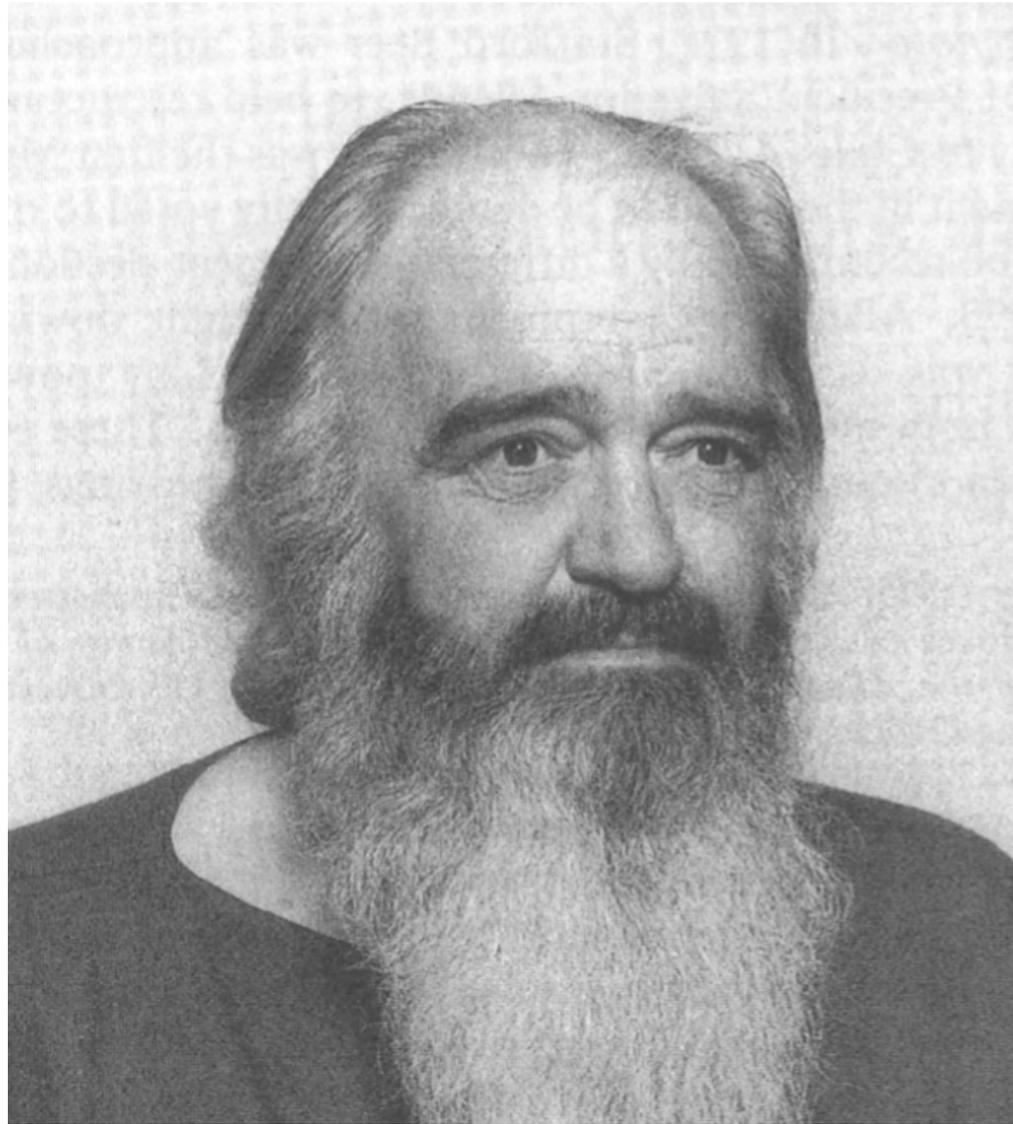
**Stafford Beer**

**1926 - 2002**

Among others:

President of the World Organization of Systems and Cybernetics

## Purpose of a System



**Stafford Beer**

**1926 - 2002**

Among others:

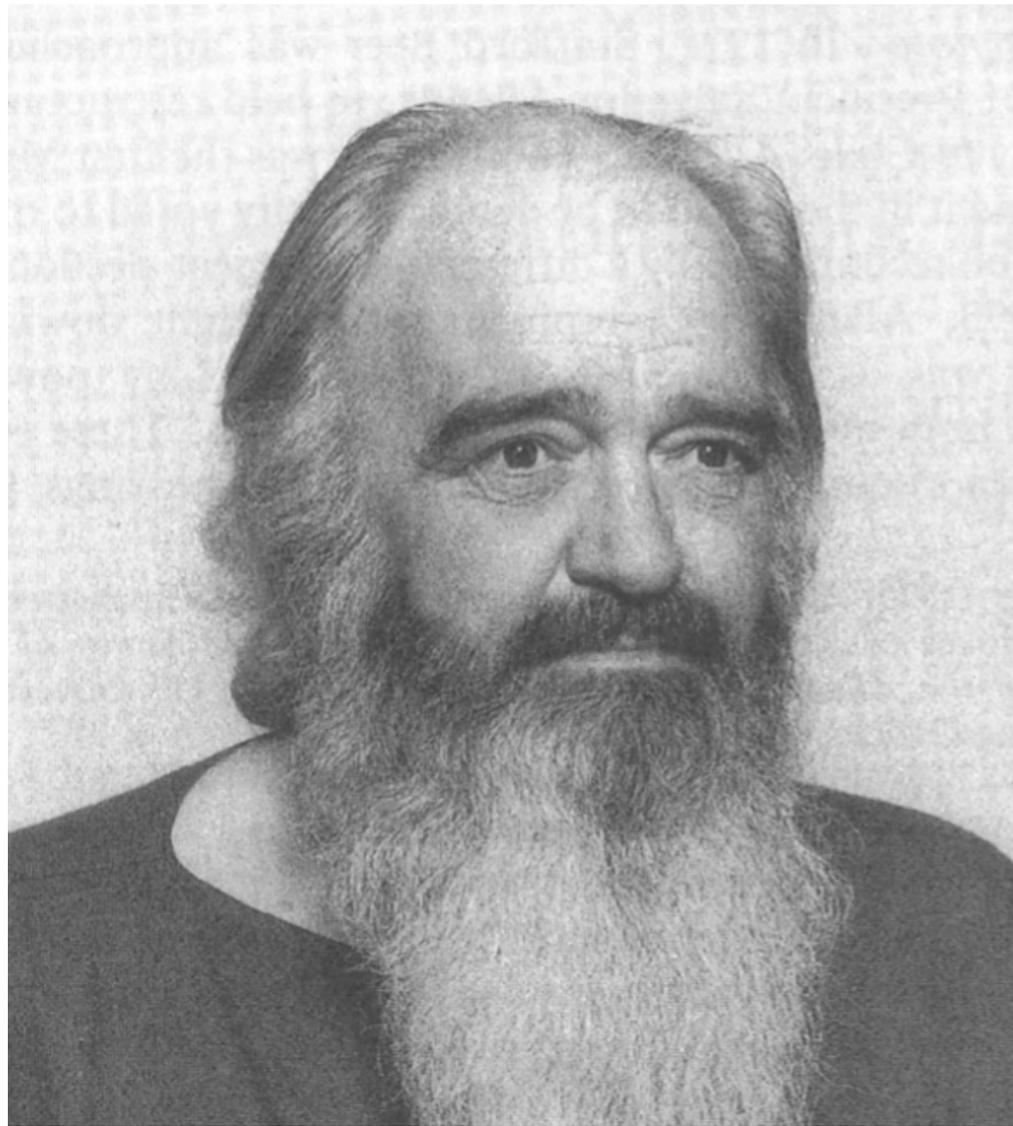
President of the World Organization of Systems and Cybernetics

## The Purpose of a System Is What It Does - POSIWID

This is the *de facto* purpose.

Humans often attribute an “official” purpose to a system that is not aligned to the *de facto* purpose.

## Purpose of a System



**Stafford Beer**  
1926 - 2002

Among others:  
President of the World Organization of Systems and  
Cybernetics

## The Purpose of a System Is What It Does - POSIWID

This is the *de facto* purpose.

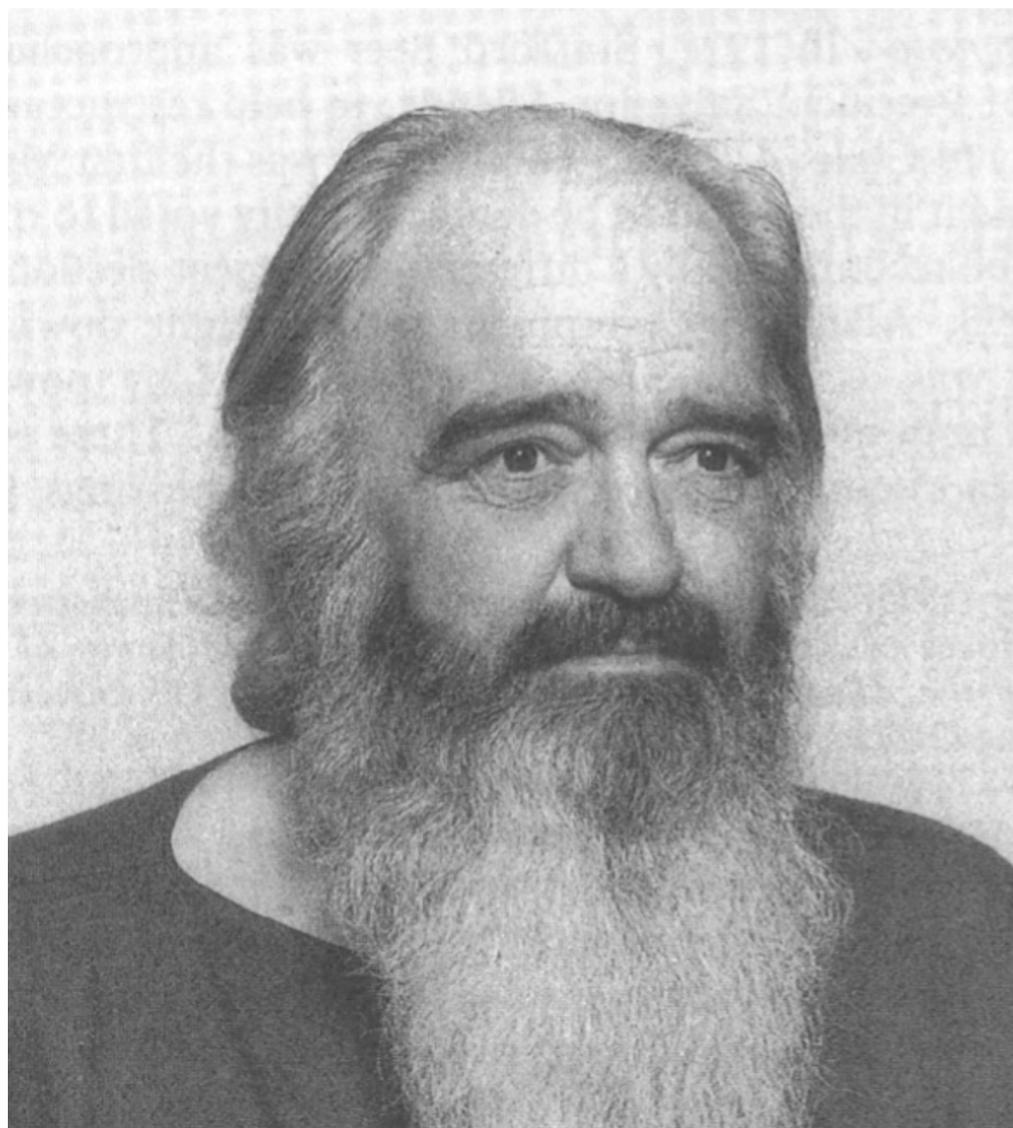
Humans often attribute an “official” purpose to a system that is not aligned to the *de facto* purpose.

### **Beer (2001):**

“According to the cybernetician the purpose of a system is what it does. This is a basic dictum.

It stands for bald fact, which makes a better starting point in seeking understanding than the familiar attributions of good intention, prejudices about expectations, moral judgment or sheer ignorance of circumstances.”

## Purpose of a System



**Stafford Beer**  
1926 - 2002

Among others:  
President of the World Organization of Systems and Cybernetics

### The Purpose of a System Is What It Does - POSIWID

This is the *de facto* purpose.

Humans often attribute an “official” purpose to a system that is not aligned to the *de facto* purpose.

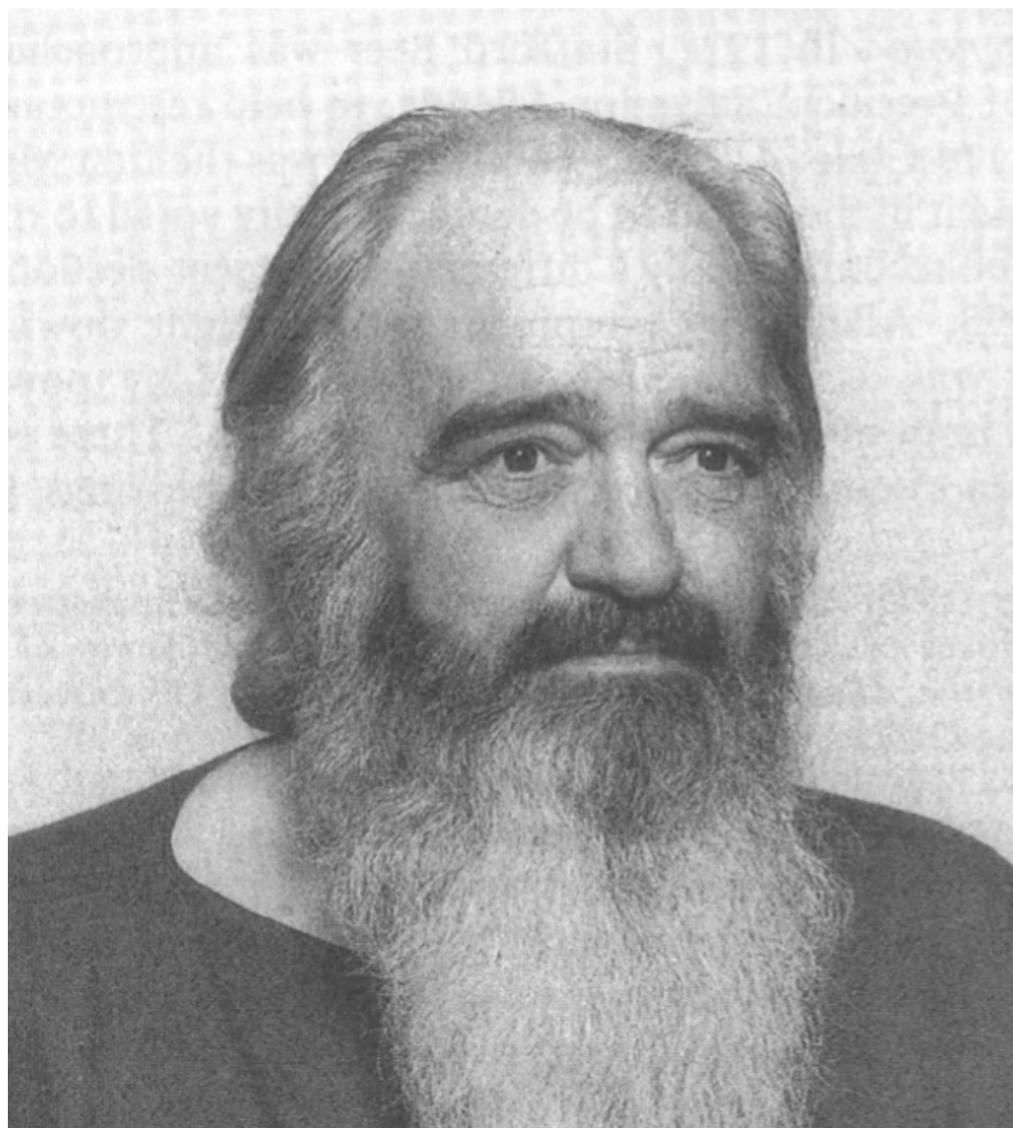
#### **Beer (2001):**

“According to the cybernetician the purpose of a system is what it does. This is a basic dictum.

It stands for bald fact, which makes a better starting point in seeking understanding than the familiar attributions of good intention, prejudices about expectations, moral judgment or sheer ignorance of circumstances.”

#### **Questions to ask:**

What does economy?



**Stafford Beer**  
1926 - 2002

Among others:  
President of the World Organization of Systems and Cybernetics

### The Purpose of a System Is What It Does - POSIWID

This is the *de facto* purpose.

Humans often attribute an “official” purpose to a system that is not aligned to the *de facto* purpose.

#### **Beer (2001):**

“According to the cybernetician the purpose of a system is what it does. This is a basic dictum.

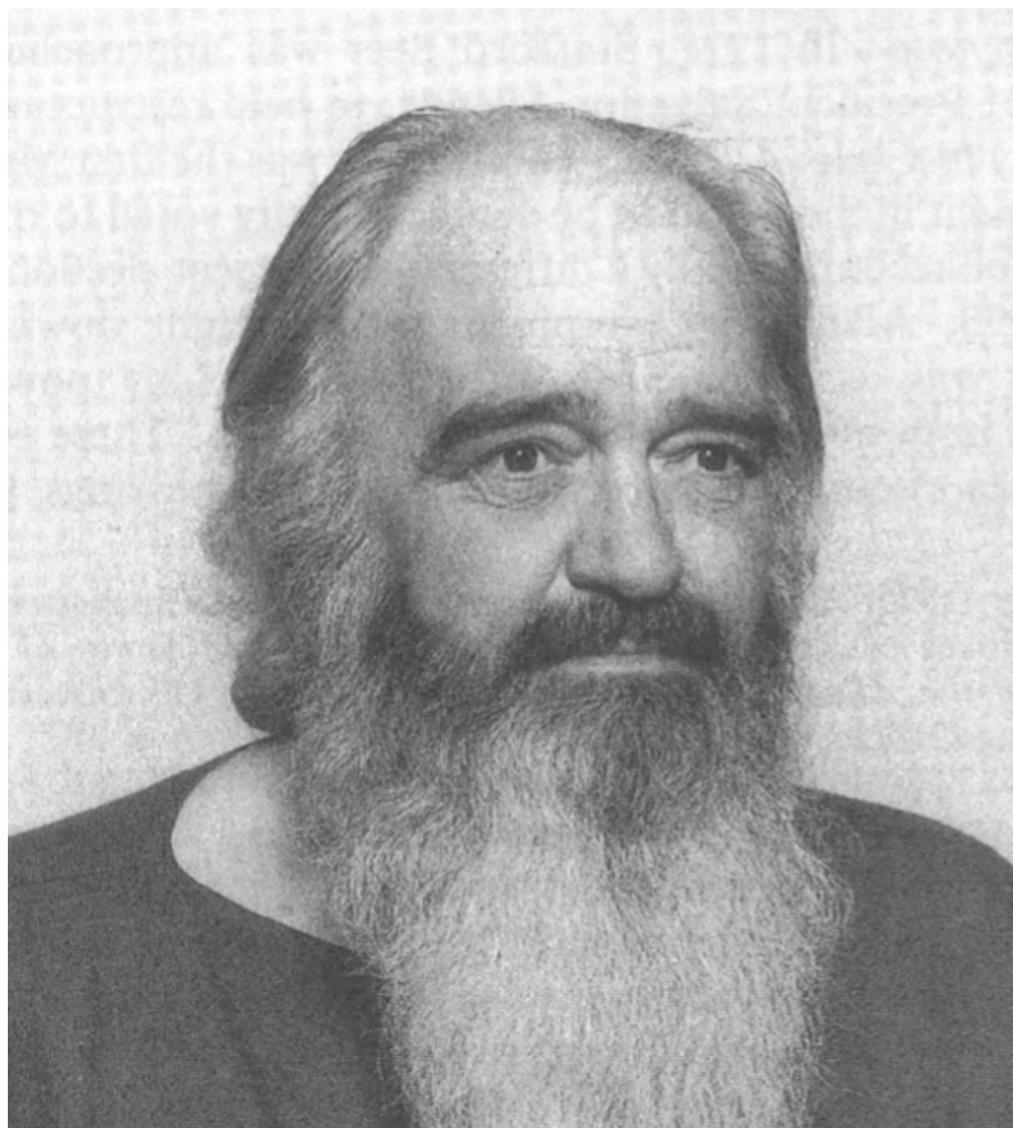
It stands for bald fact, which makes a better starting point in seeking understanding than the familiar attributions of good intention, prejudices about expectations, moral judgment or sheer ignorance of circumstances.”

#### **Questions to ask:**

What does economy?

What did economy throughout human history?

## Purpose of a System



**Stafford Beer**  
1926 - 2002

Among others:  
President of the World Organization of Systems and Cybernetics

### The Purpose of a System Is What It Does - POSIWID

This is the *de facto* purpose.

Humans often attribute an “official” purpose to a system that is not aligned to the *de facto* purpose.

#### **Beer (2001):**

“According to the cybernetician the purpose of a system is what it does. This is a basic dictum.

It stands for bald fact, which makes a better starting point in seeking understanding than the familiar attributions of good intention, prejudices about expectations, moral judgment or sheer ignorance of circumstances.”

#### **Questions to ask:**

What does economy?

What did economy throughout human history?

What does economy for non-human animals?

**Environment**  
(Earth's) Life-Support System

**Community**

## Environment

(Earth's) Life-Support System

### Community

Meeting the needs:

- food+water
- habitat
- safety
- health

**Environment**  
(Earth's) Life-Support System

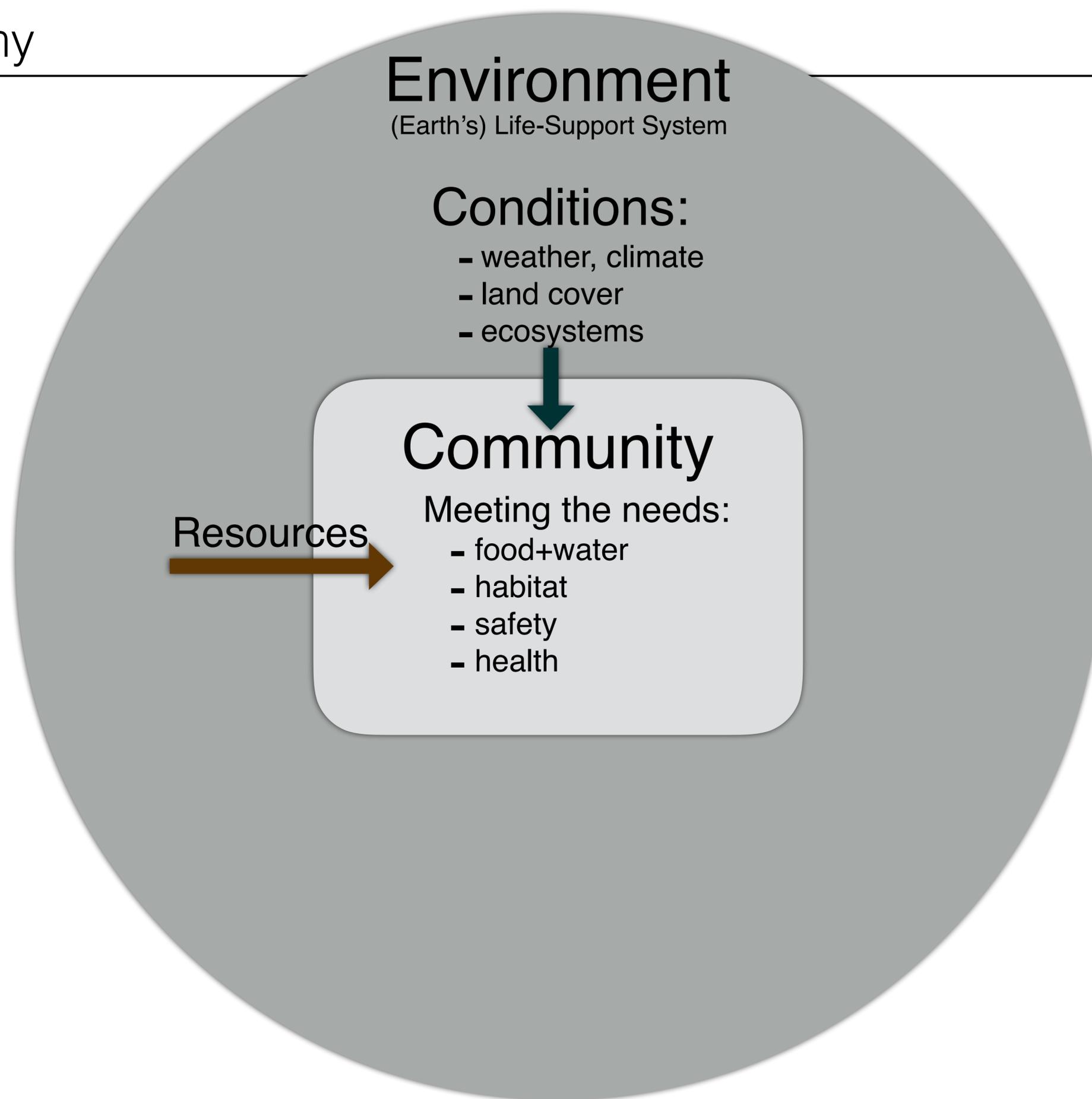
Resources

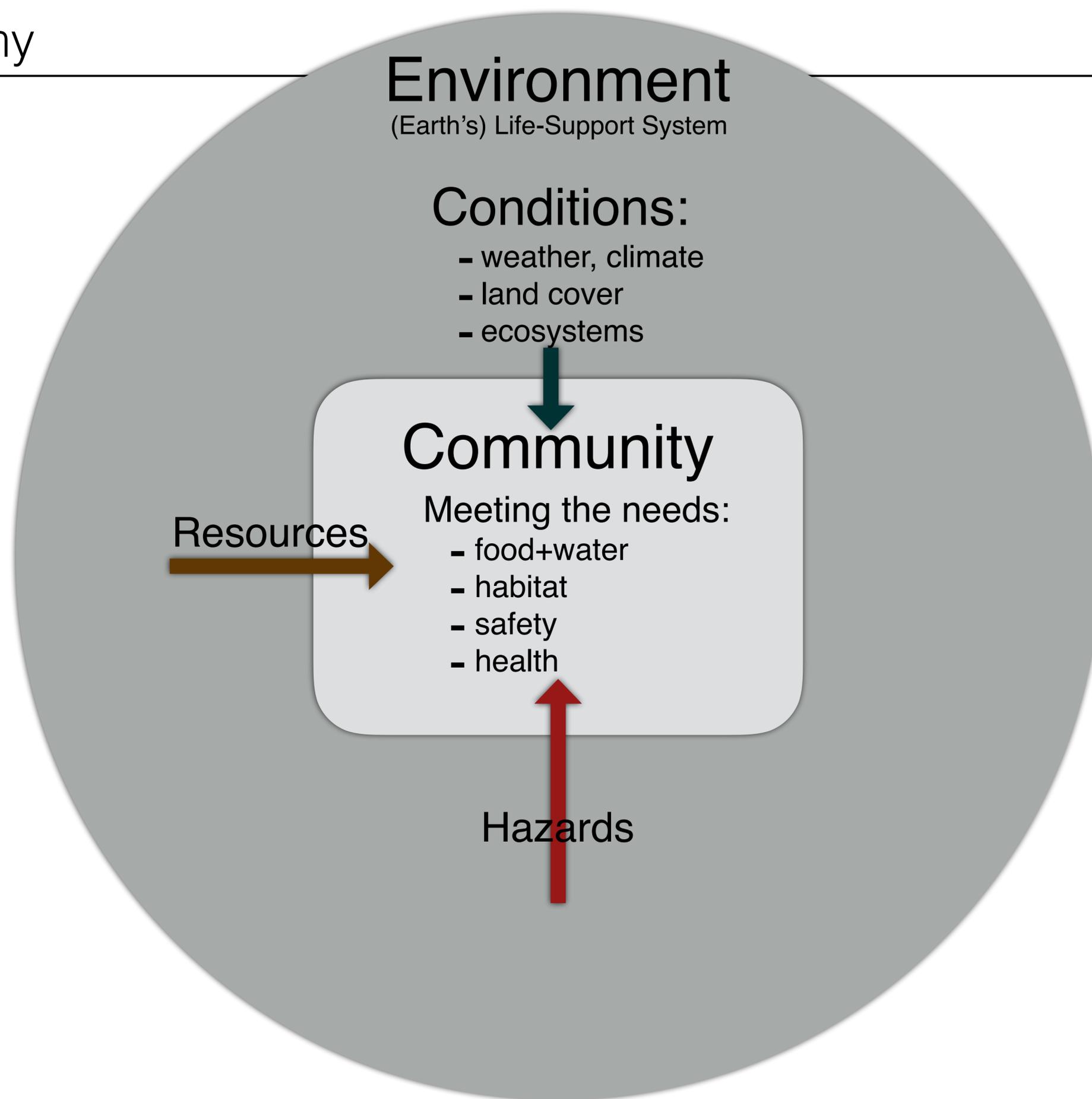


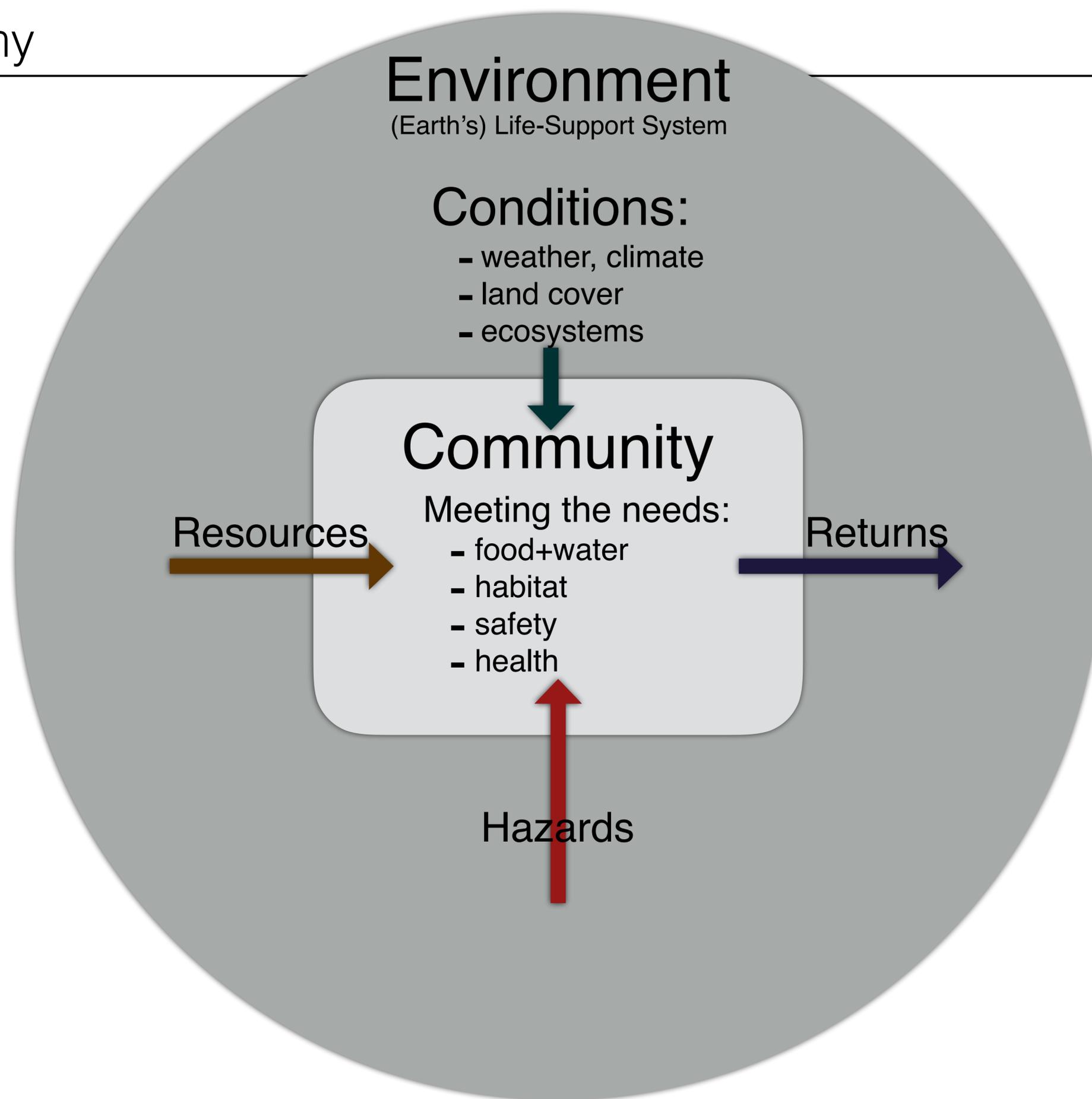
**Community**

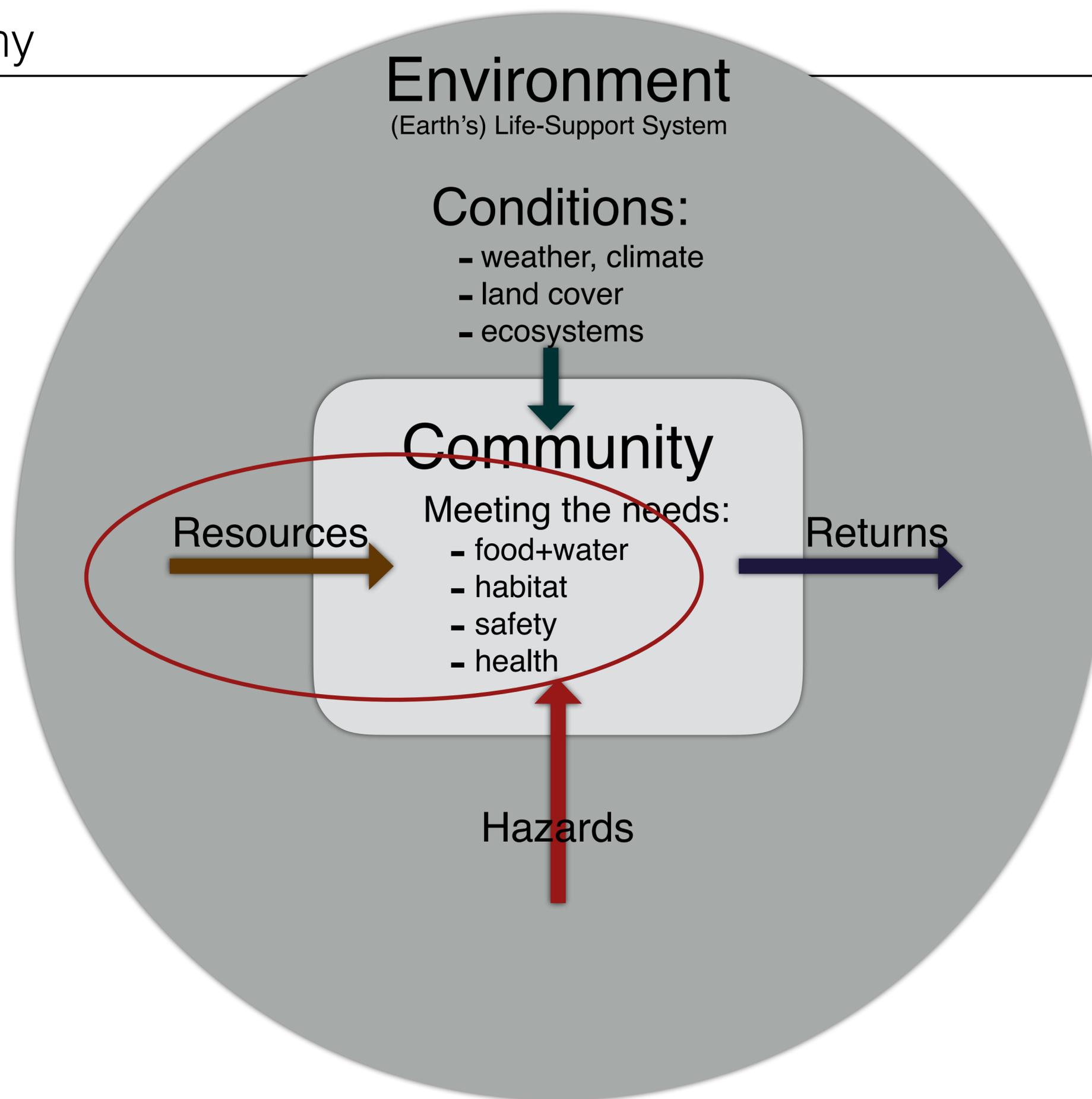
Meeting the needs:

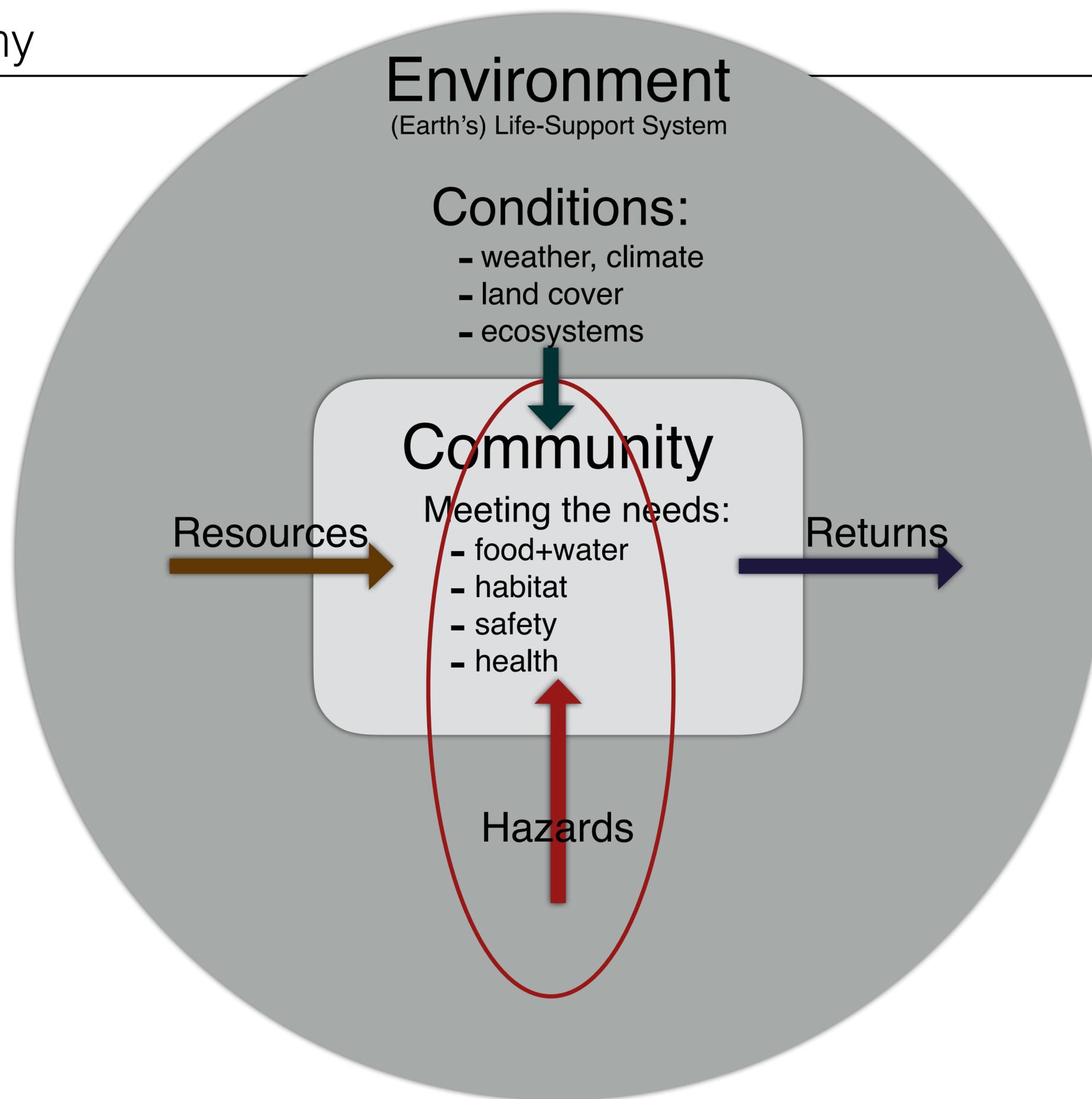
- food+water
- habitat
- safety
- health

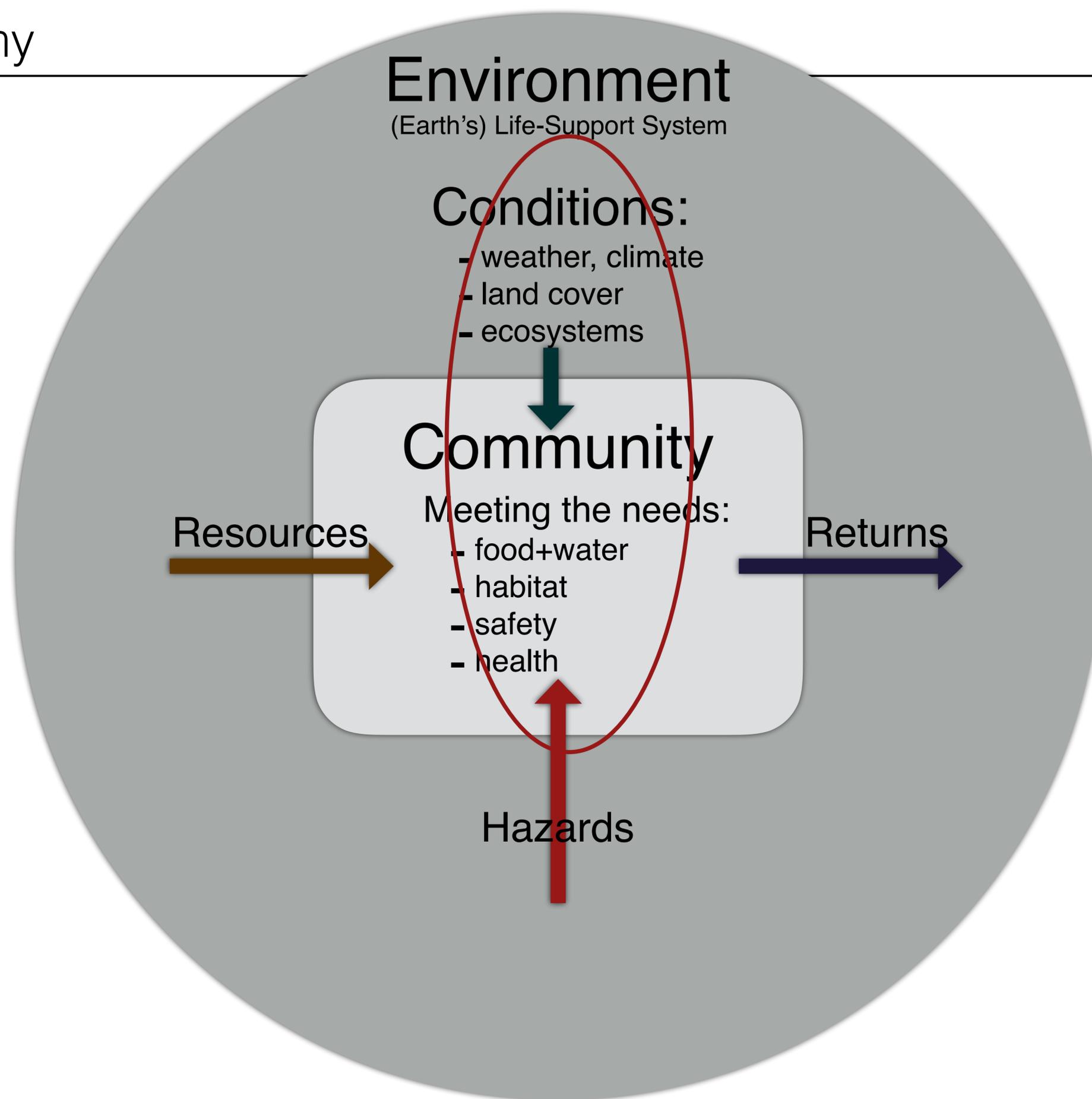


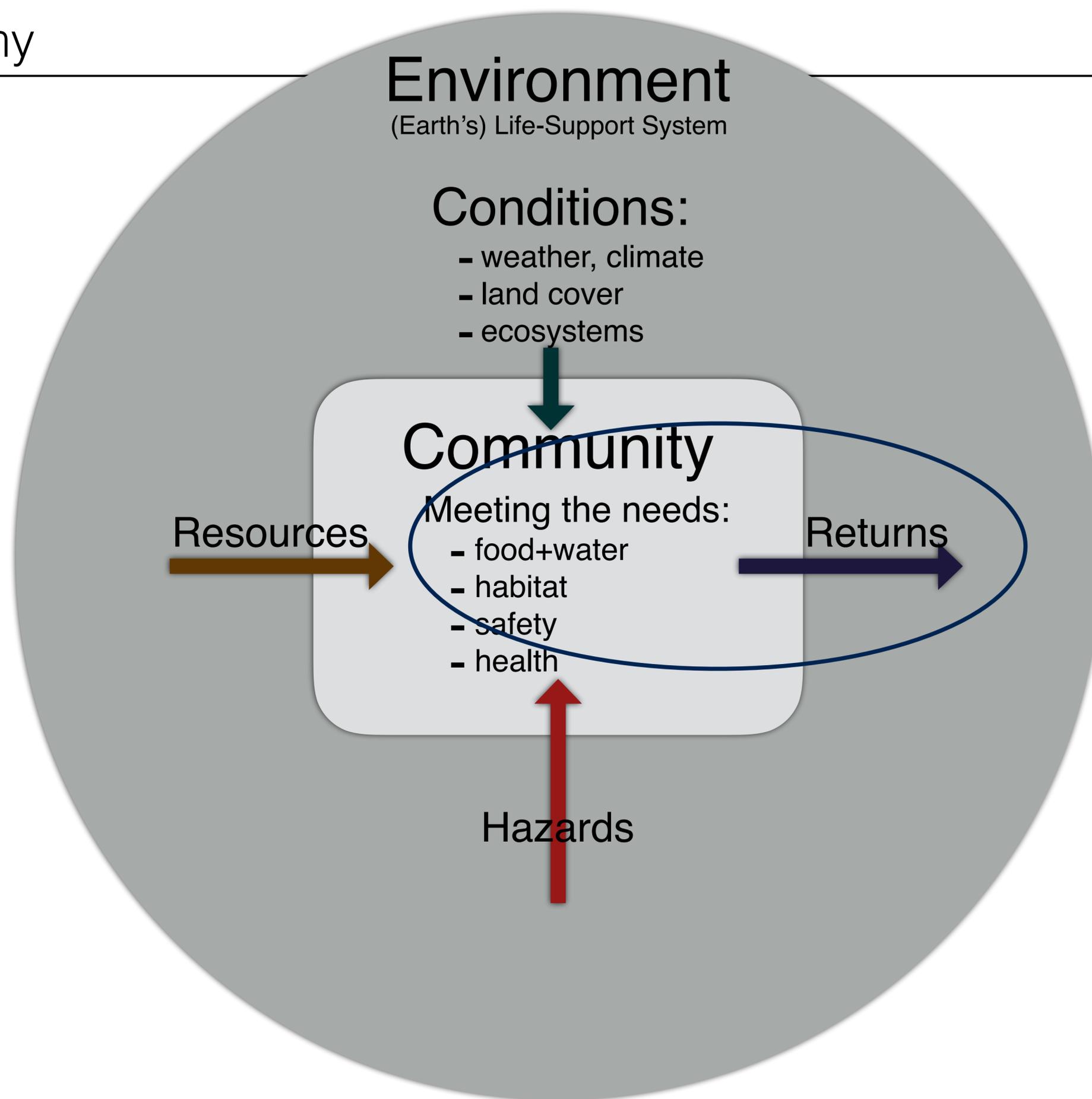


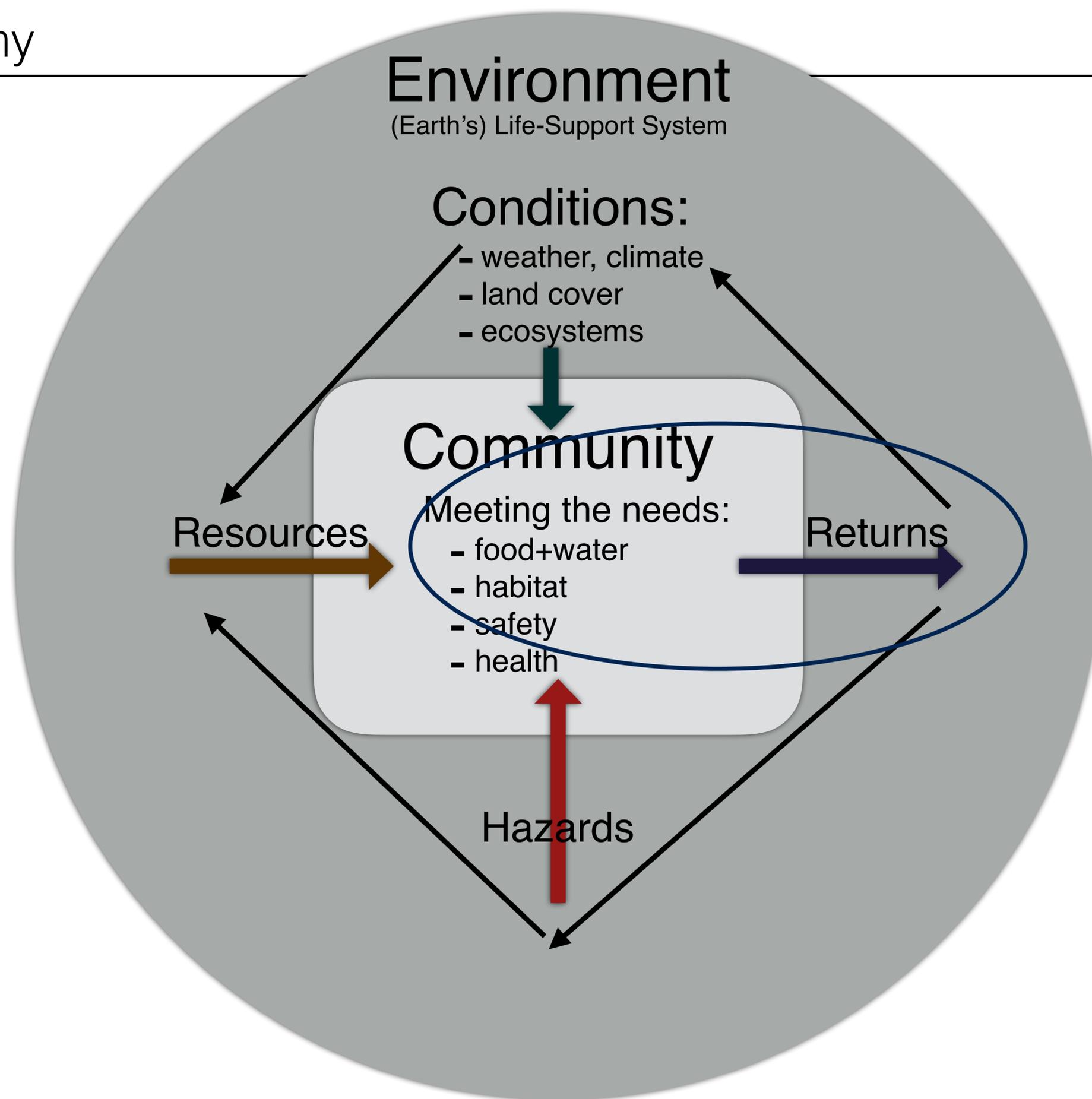


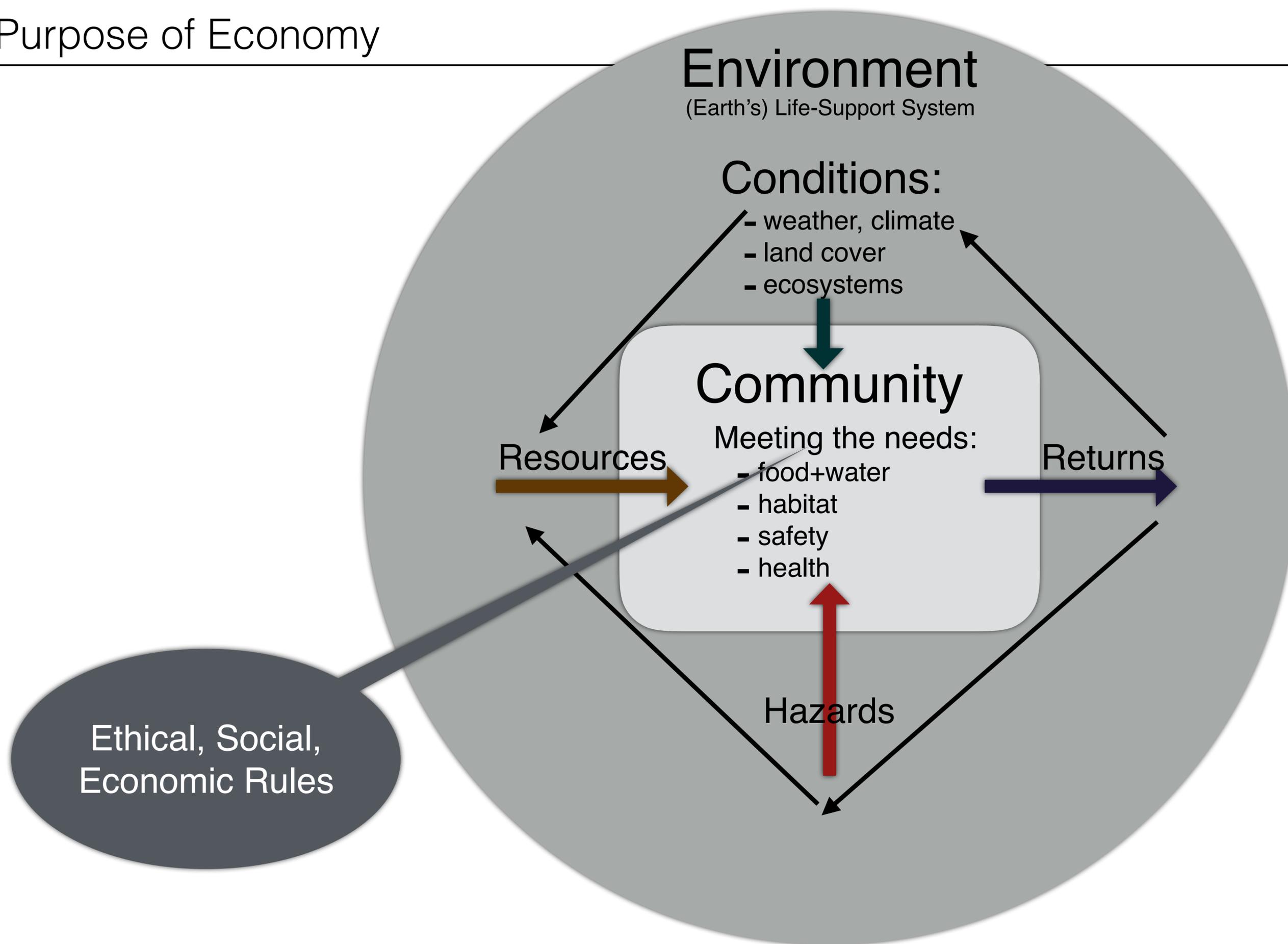


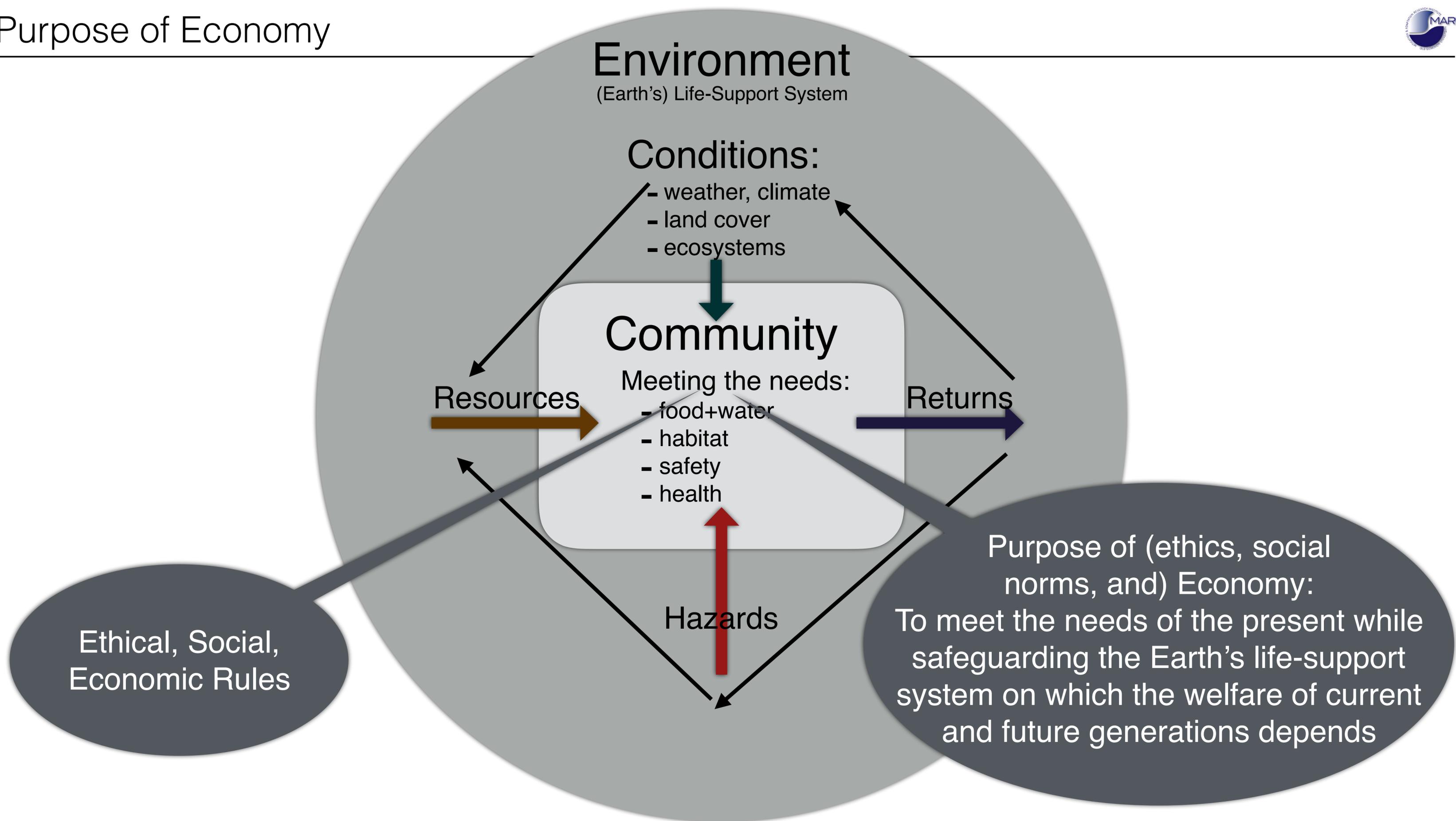








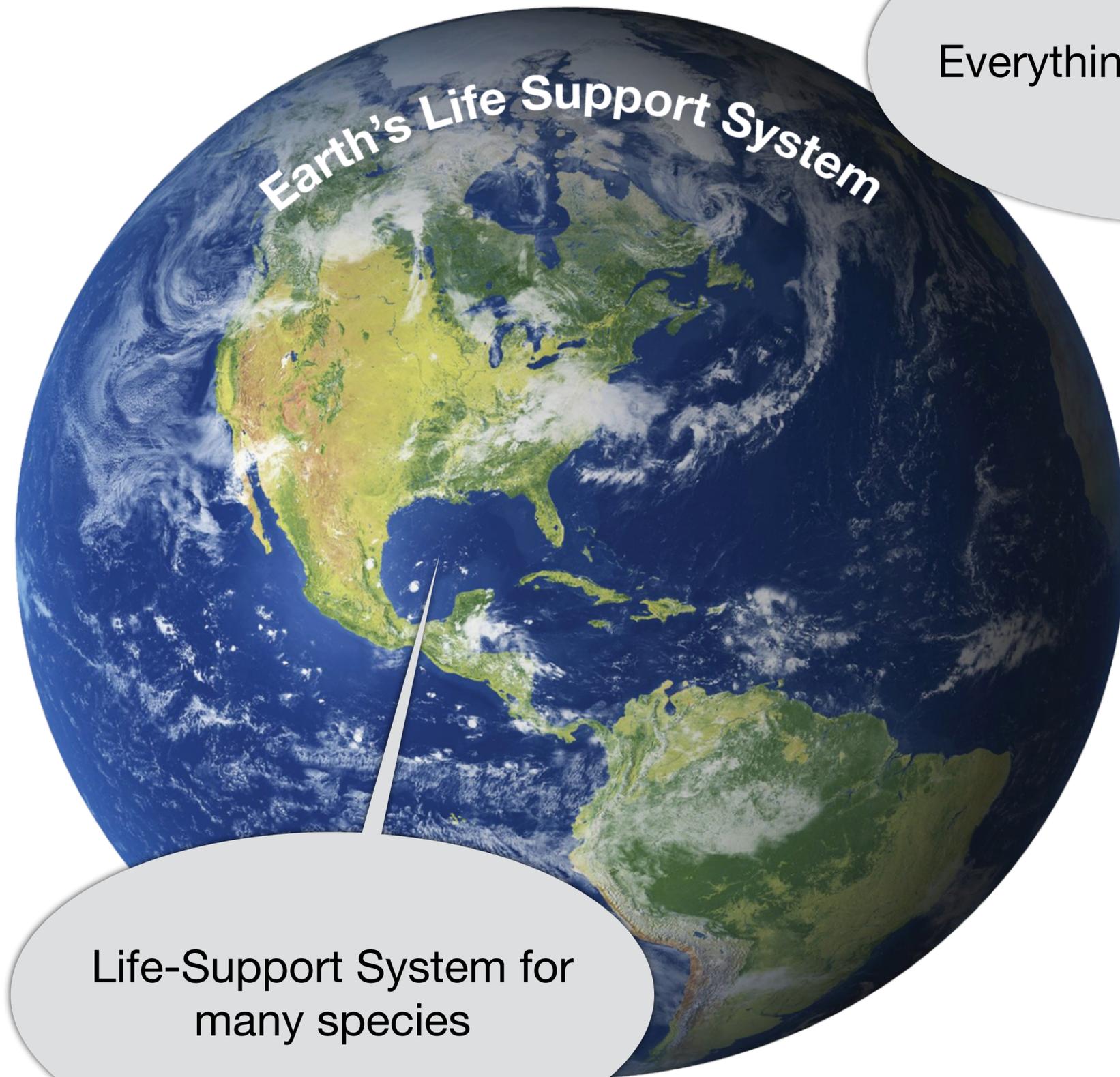






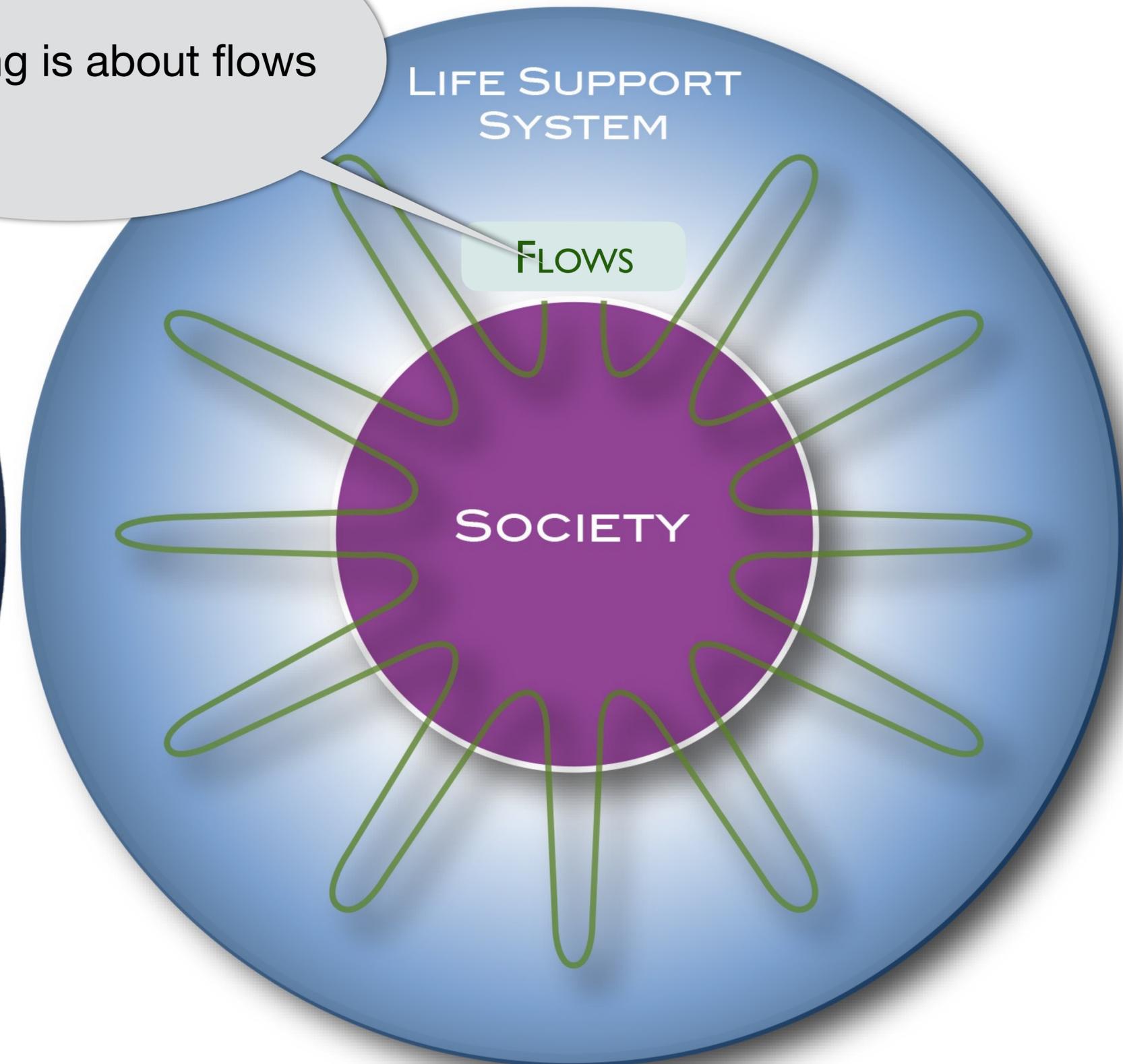


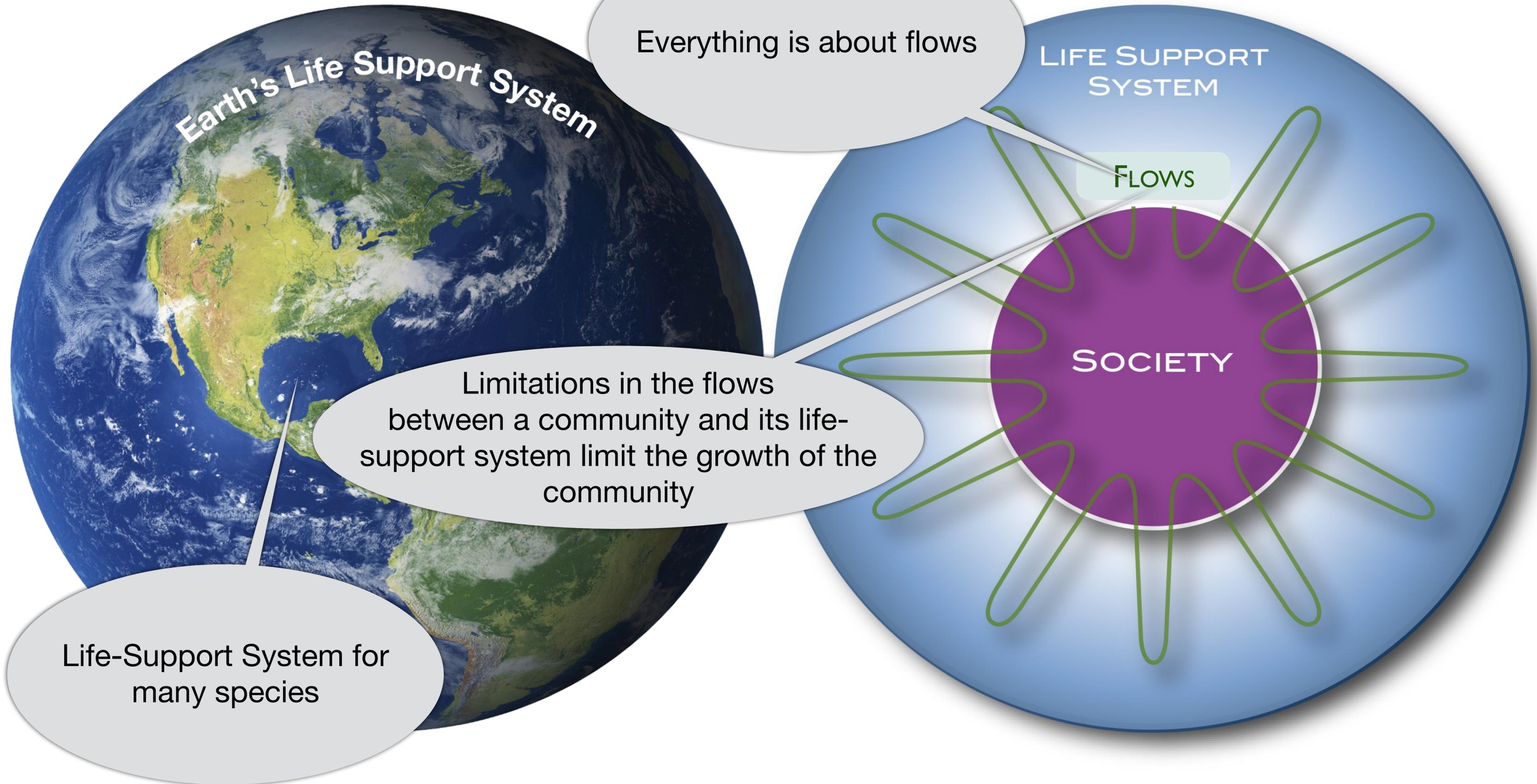
Life-Support System for  
many species

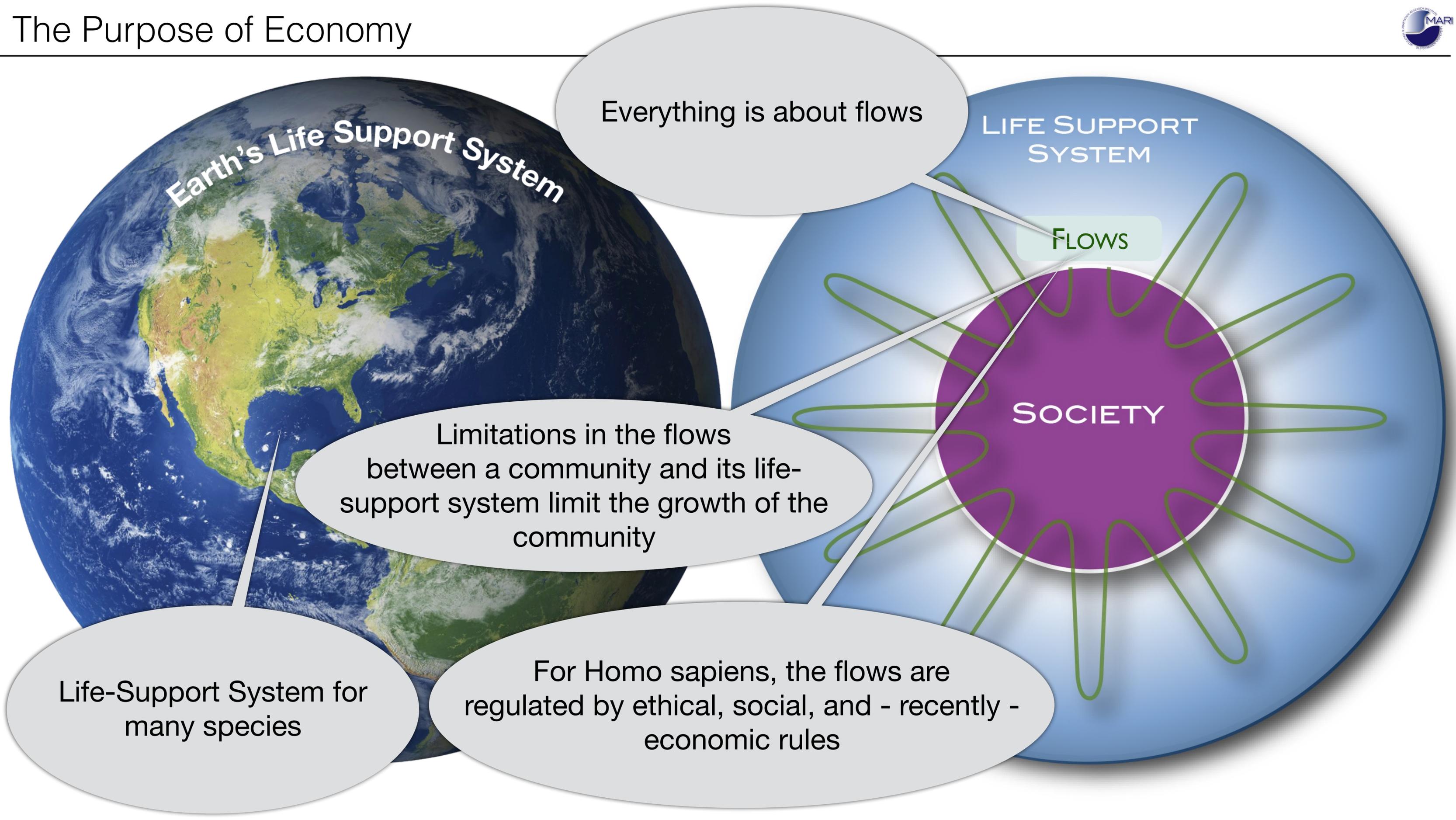


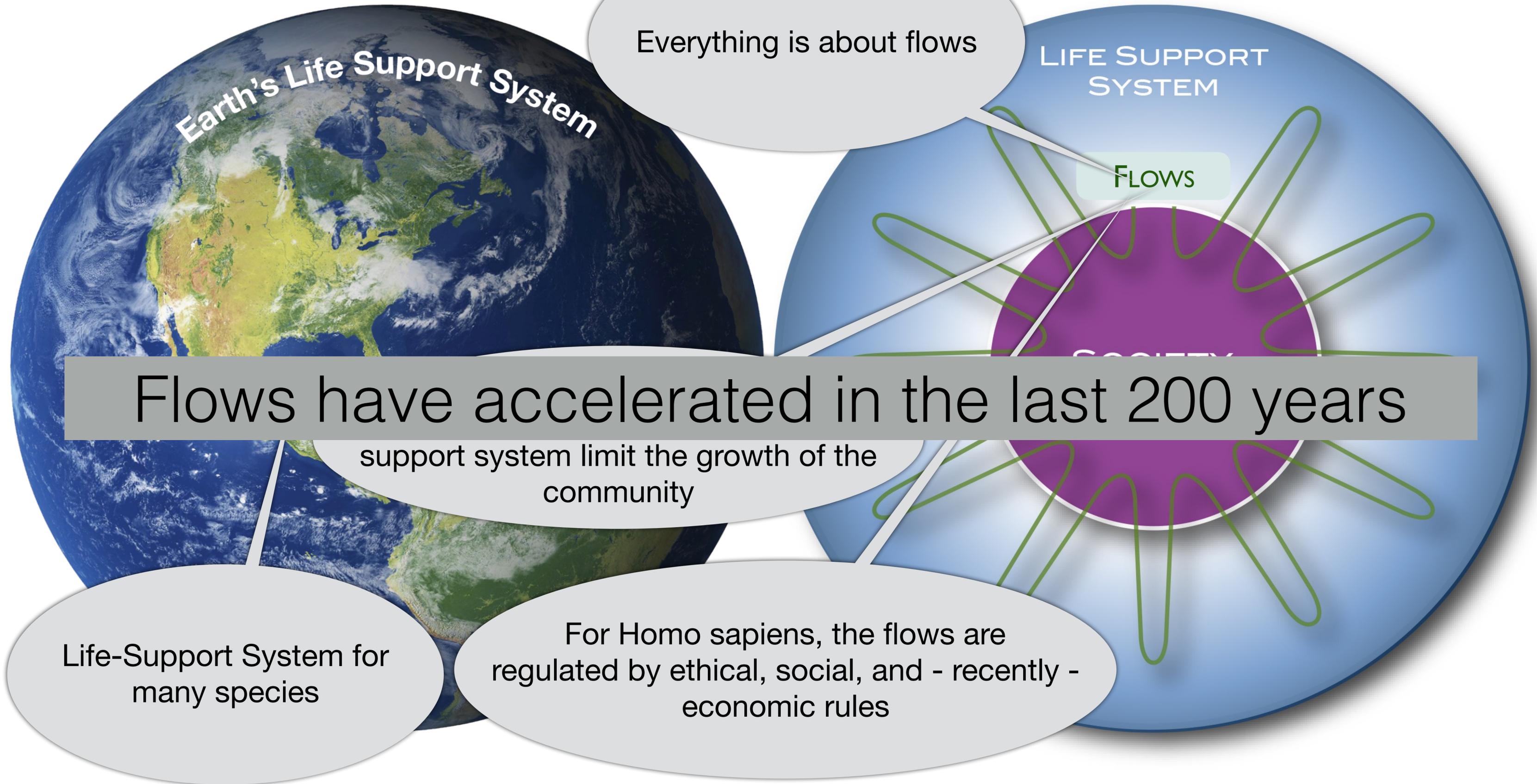
Everything is about flows

Life-Support System for many species









## Purpose of Economy

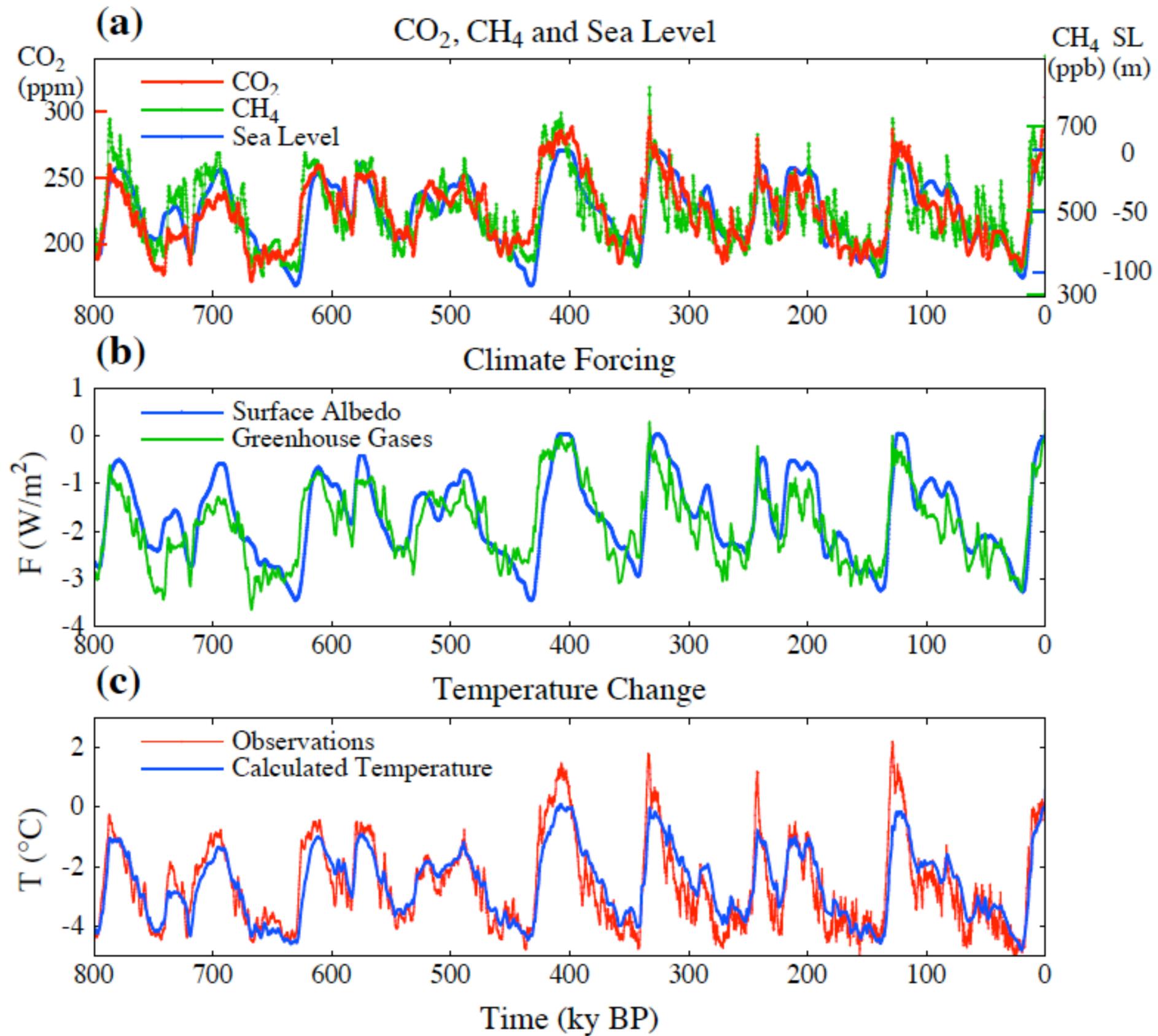
The *de facto* purpose of economy is to meet the needs of the present while safeguarding the Earth's life-support system, on which the welfare of all current and future generation depends.

The current “official” purpose of economy is to create human wealth, and this official purpose is in conflict with the *de facto* purpose.

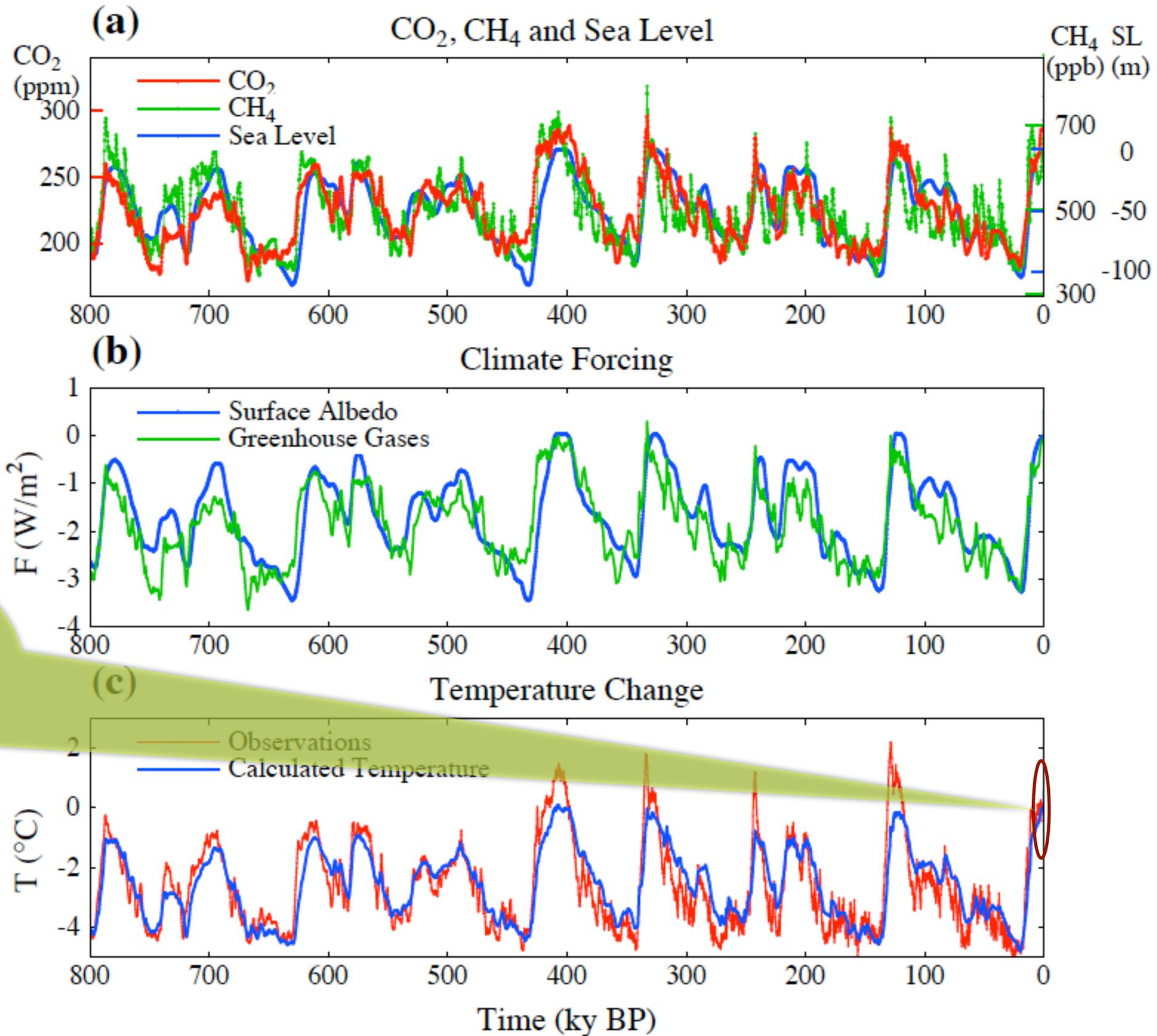
# Can the Economy in Modern Society Work Without Polluting the Environment with Our Growing Waste?

- The Purpose of Economy
- The Syndrome of Modern Global Change
- The Diagnosis: Creating Human Wealth without Regard for Natural Wealth
- The Prognosis: Running out of Resources while Polluting the Environment
- The Therapy: Changing the Official Purpose of Economy

Hans-Peter Plag  
Old Dominion University  
Norfolk, VA, USA



# Syndrome of Modern Global Change



Holocene

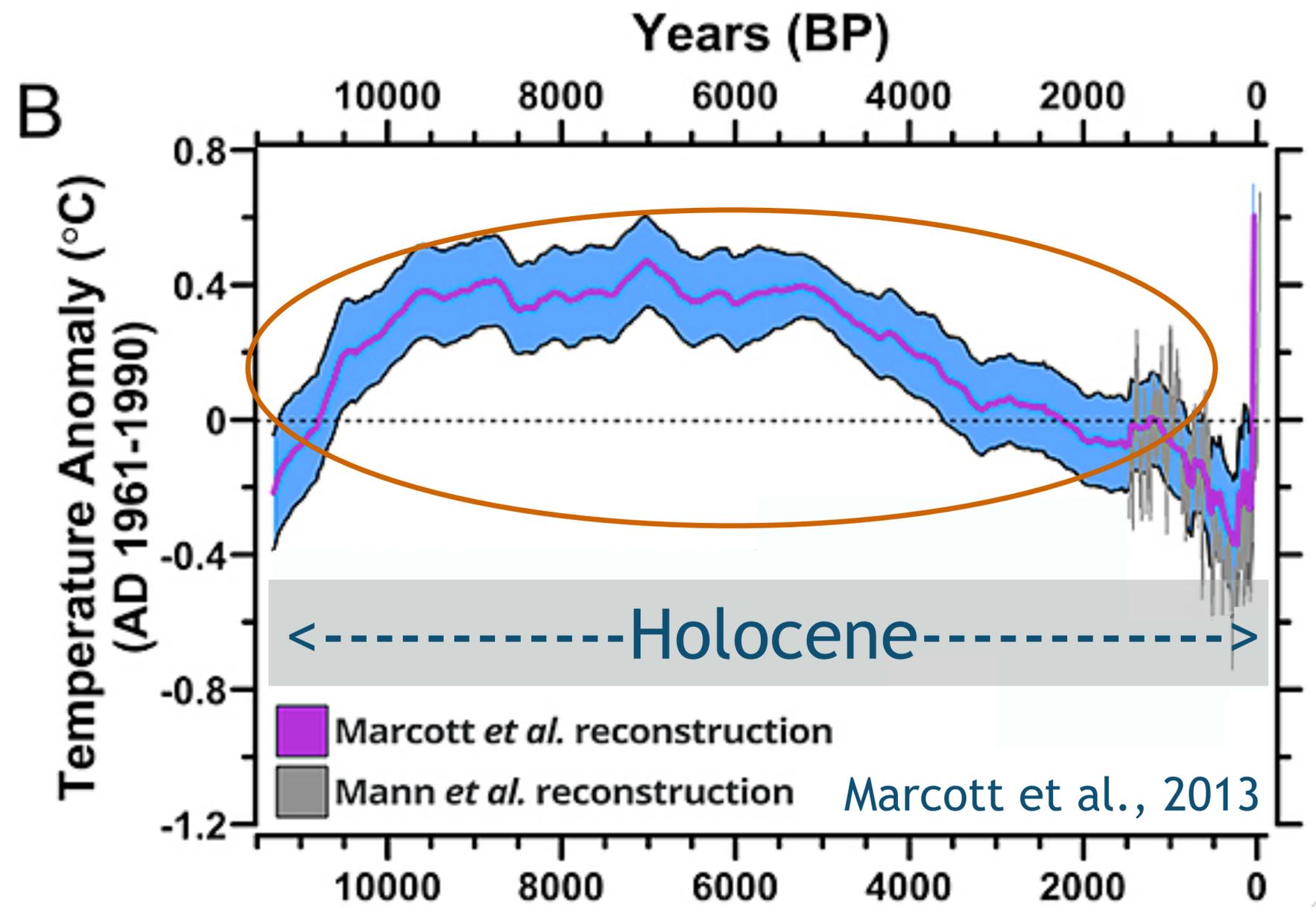
---

Normalcy Bias: Climate variations are small and sea level is stable — a result of the Holocene

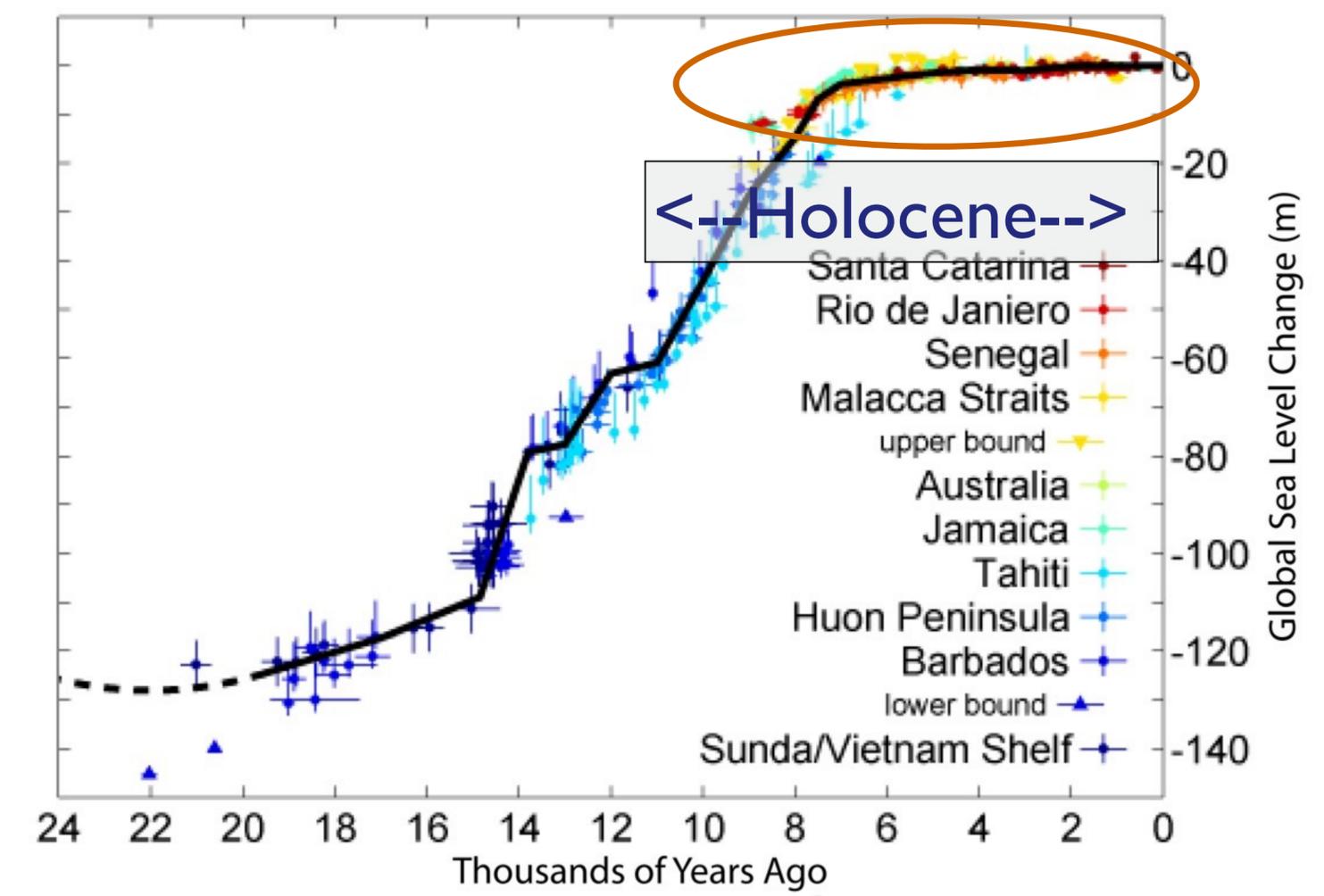
# Syndrom of Modern Global Change

Normalcy Bias: Climate variations are small and sea level is stable — a result of the Holocene

## Global Temperature Changes



## Global Sea Level Changes

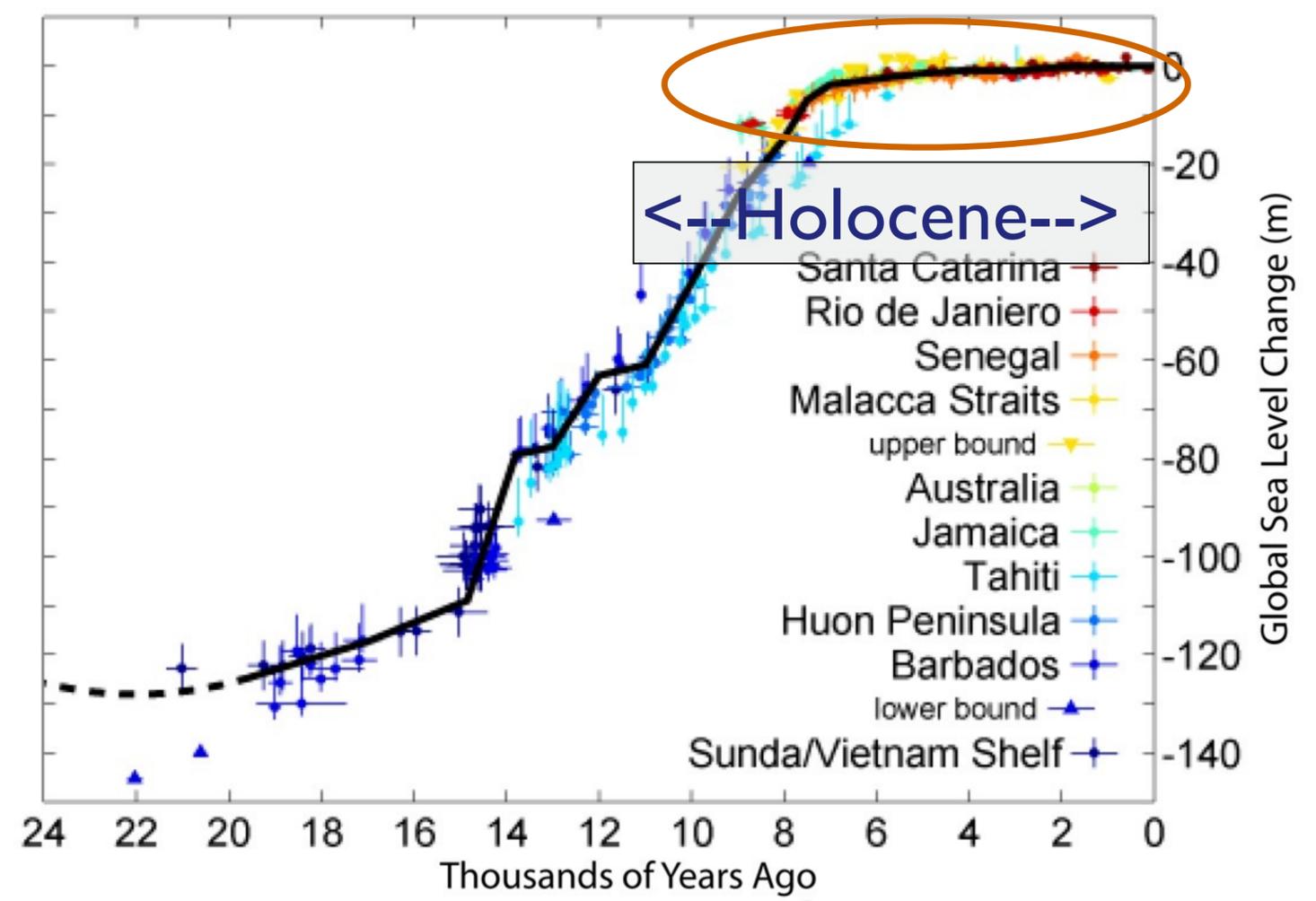
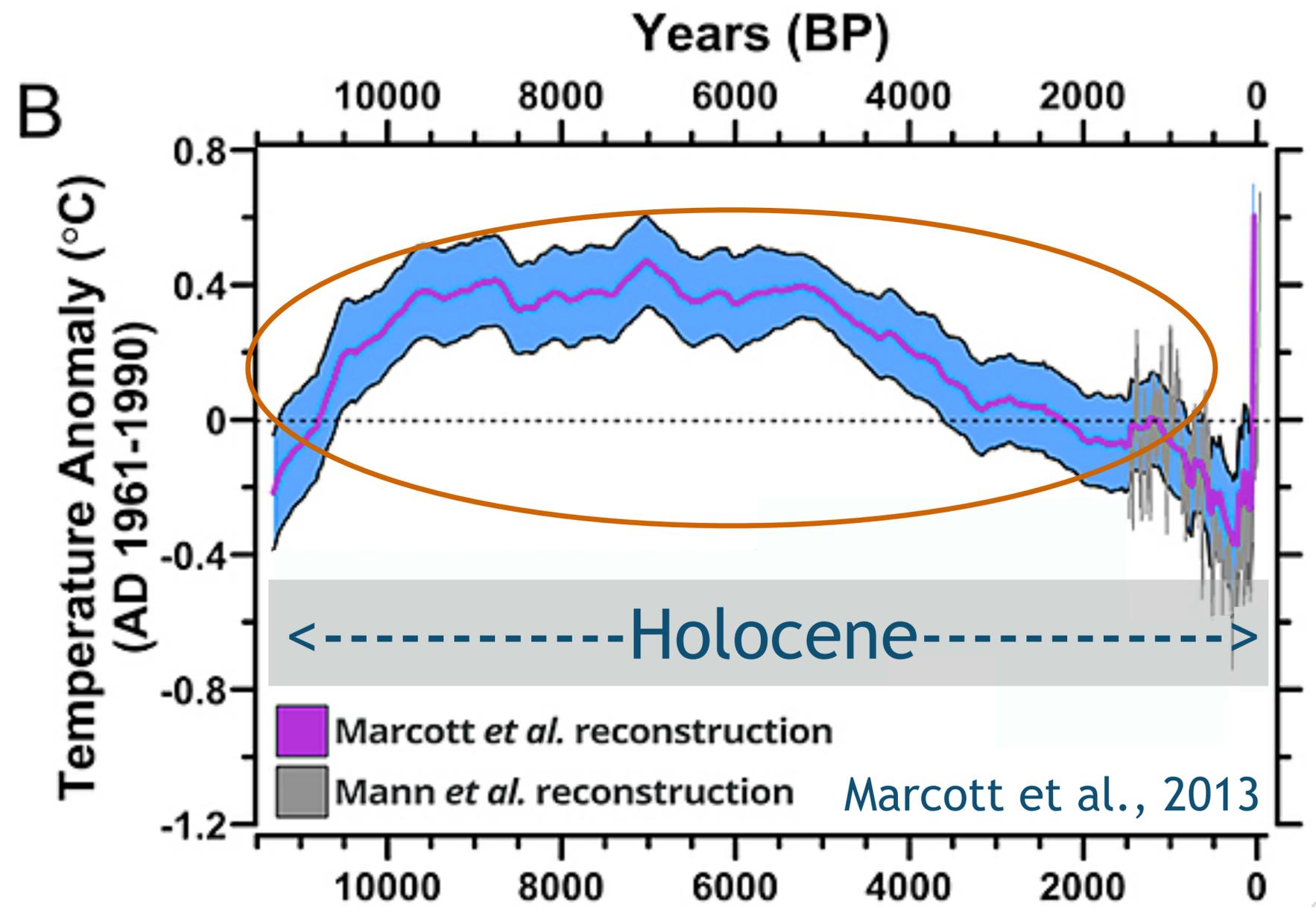


# Syndrome of Modern Global Change

Normalcy Bias: Climate variations are small and sea level is stable — a result of the Holocene

## Global Temperature Changes

## Global Sea Level Changes

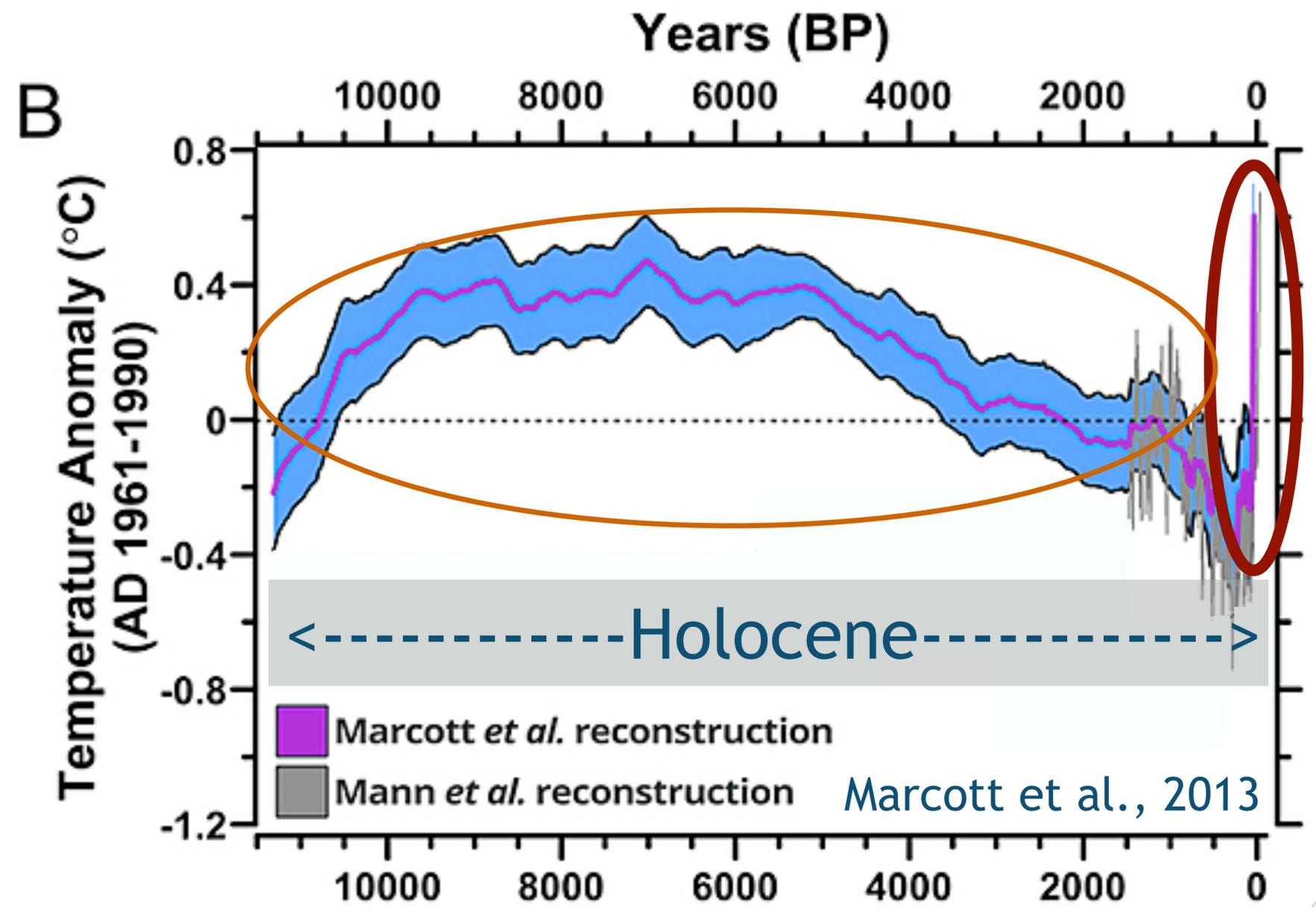


With stable climate and sea level, the Holocene was a safe operating space for humanity.

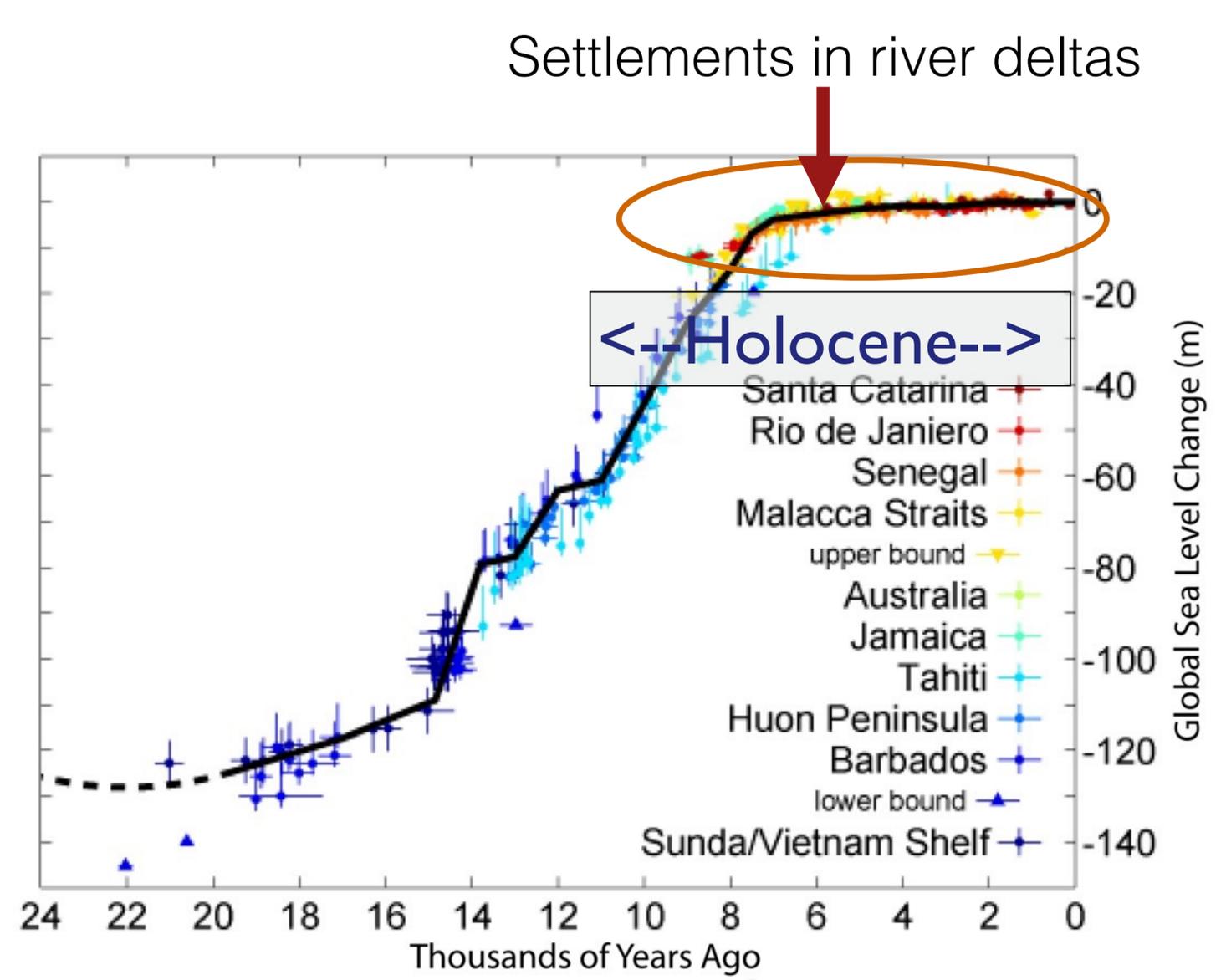
# Syndrome of Modern Global Change

Normalcy Bias: Climate variations are small and sea level is stable — a result of the Holocene

## Global Temperature Changes



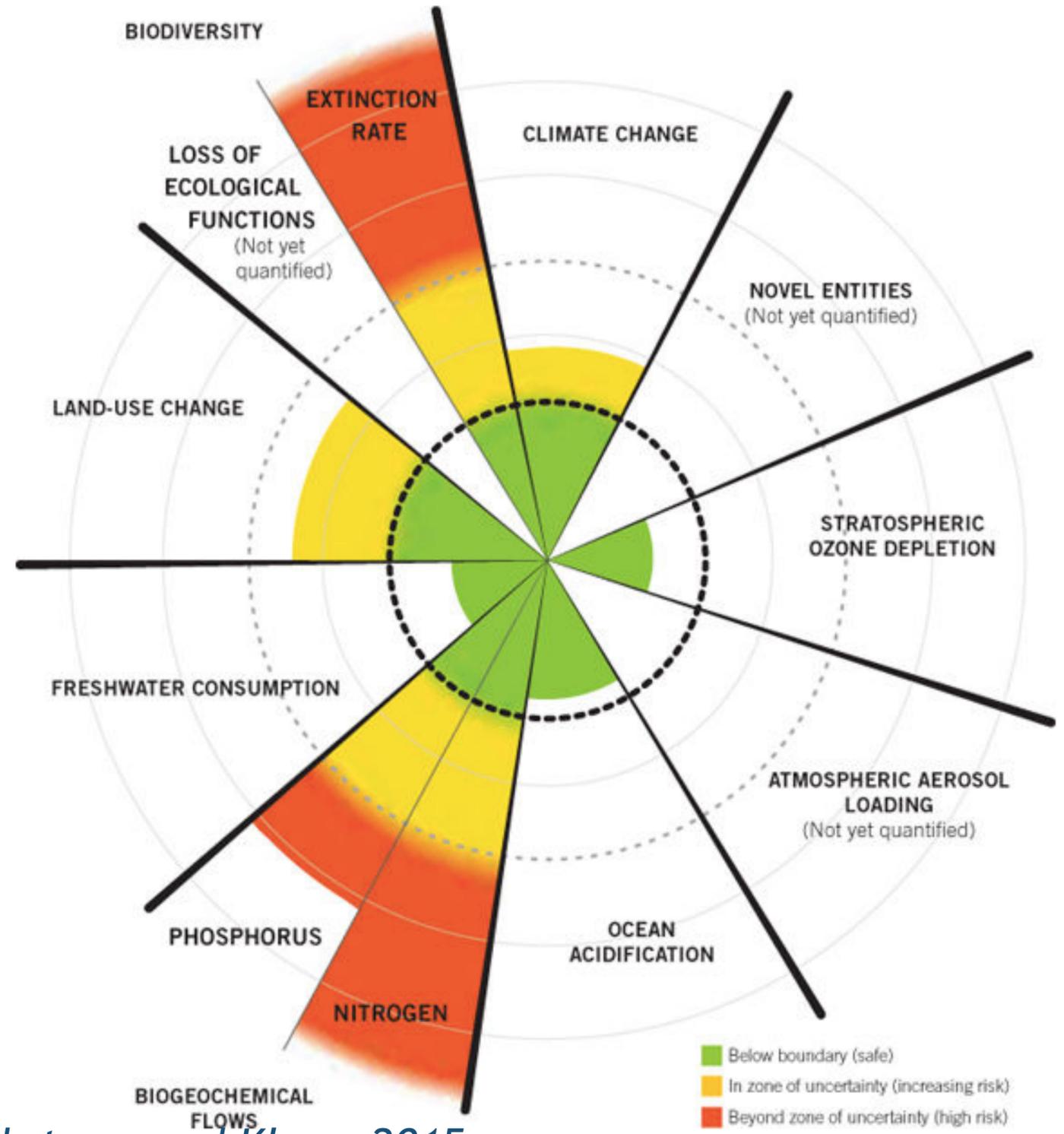
## Global Sea Level Changes



With stable climate and sea level, the Holocene was a safe operating space for humanity.

# Syndrom of Modern Global Change

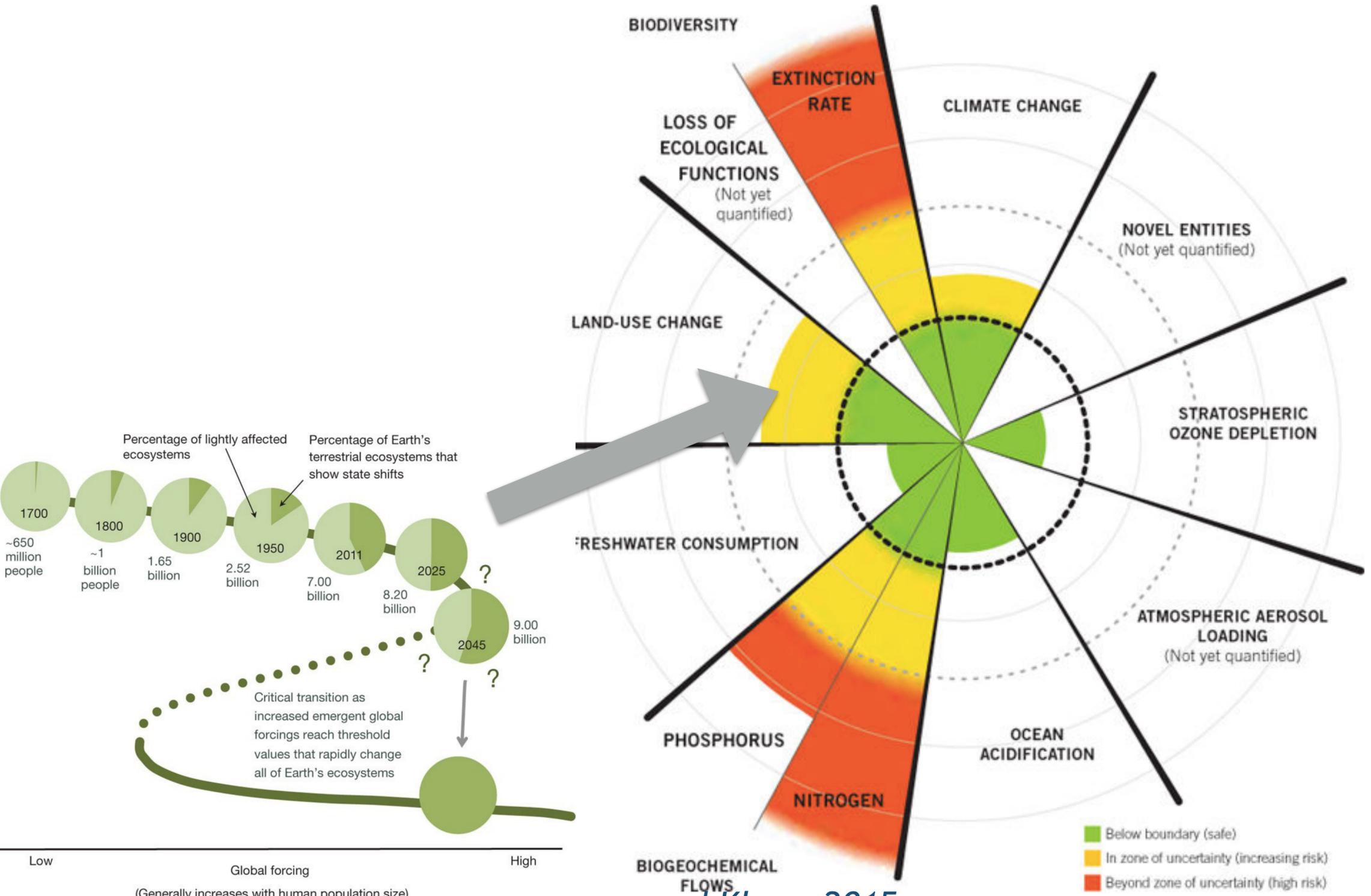
The Holocene was a “safe operating space for humanity”



*Rockstrom and Klum, 2015*

# Syndrom of Modern Global Change

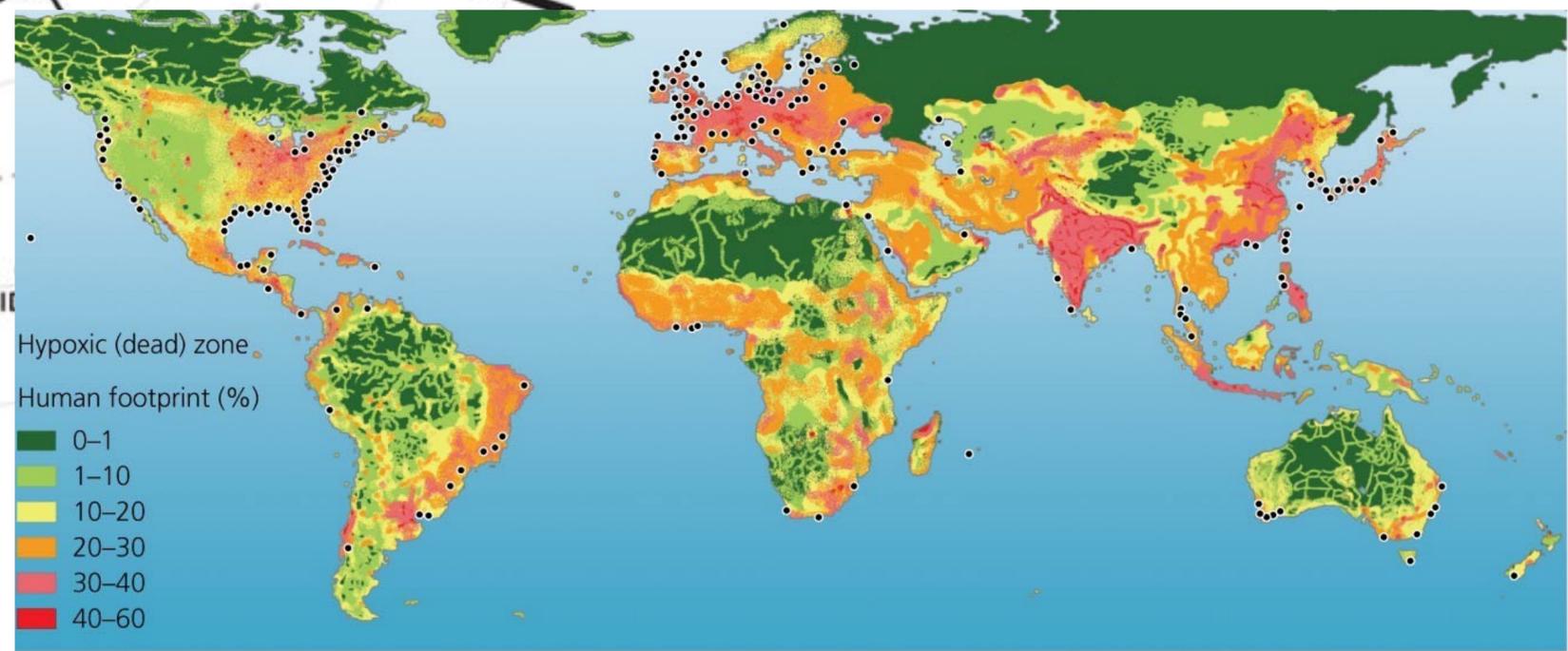
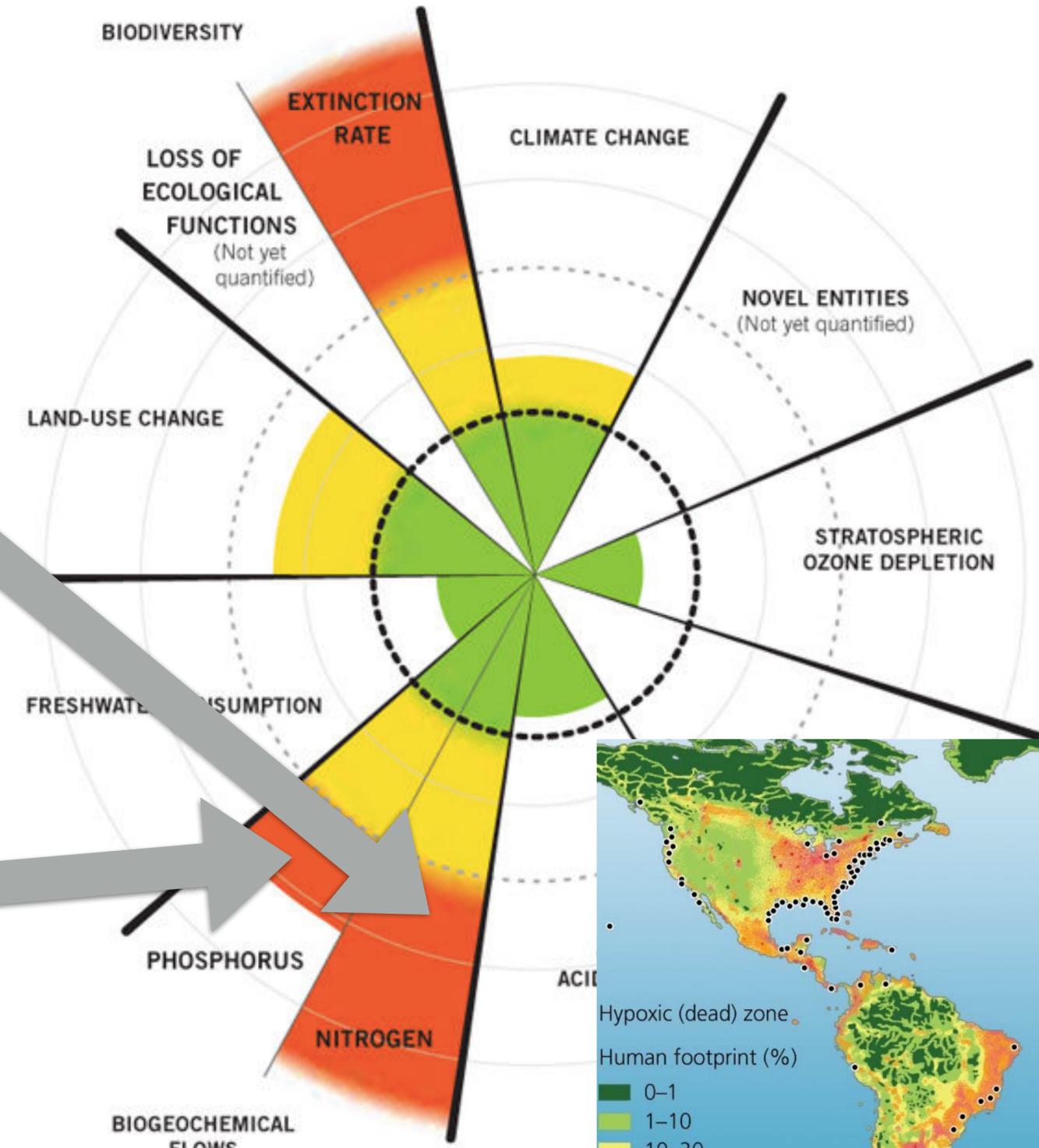
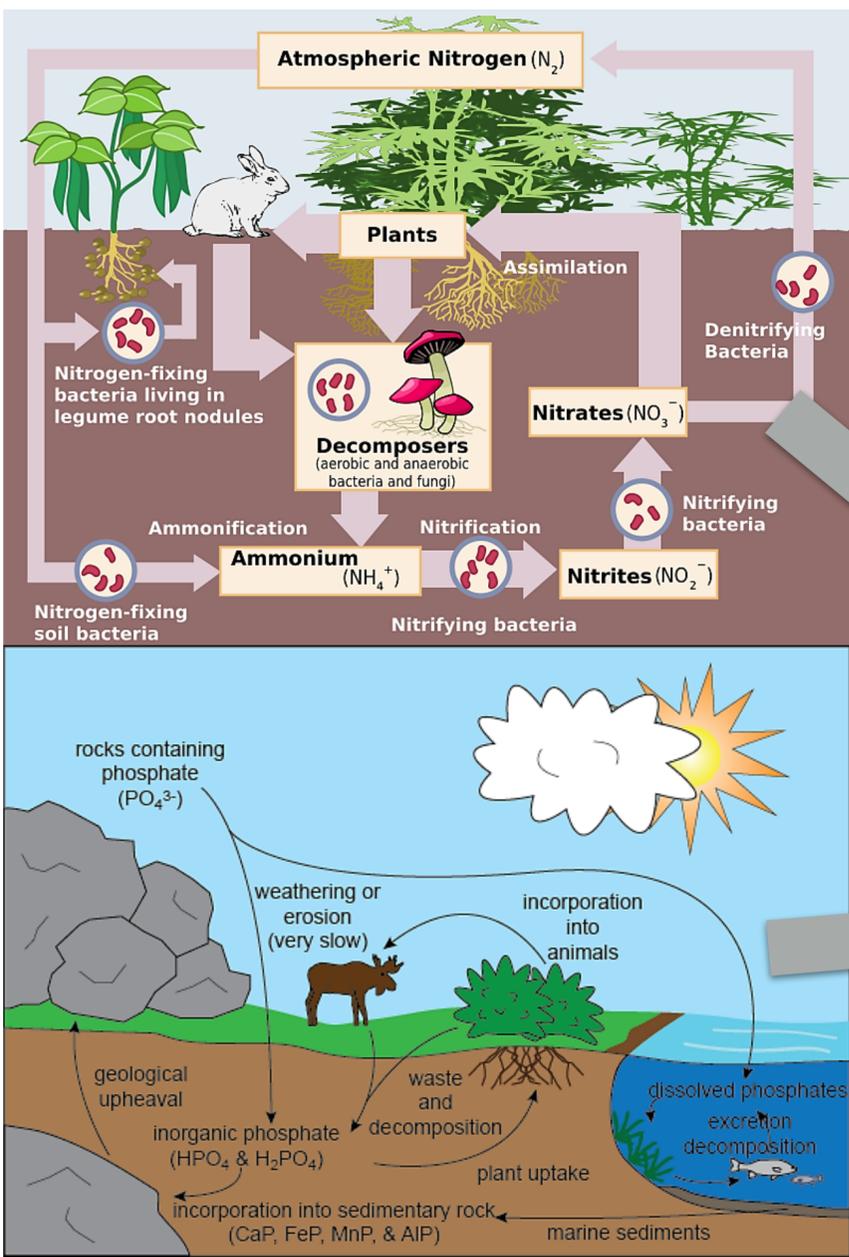
The Holocene was a "safe operating space for humanity"



Rockstrom and Klum, 2015

# Syndrom of Modern Global Change

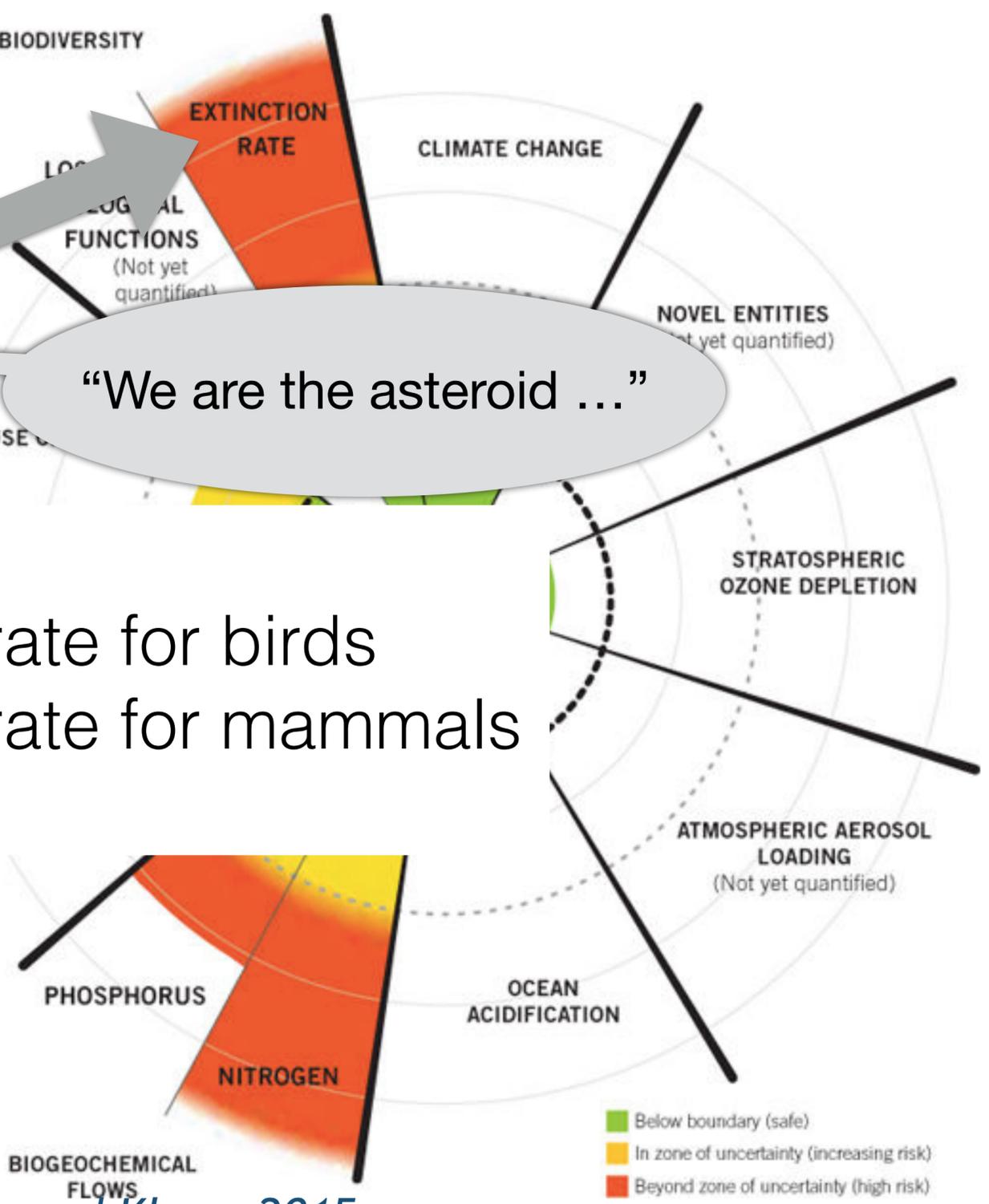
The Holocene was a "safe operating space for humanity"



Rockstrom and Klum, 2015

# Syndrom of Modern Global Change

The Holocene was a “safe operating space for humanity”



“We are the asteroid ...”

Current extinction rates:

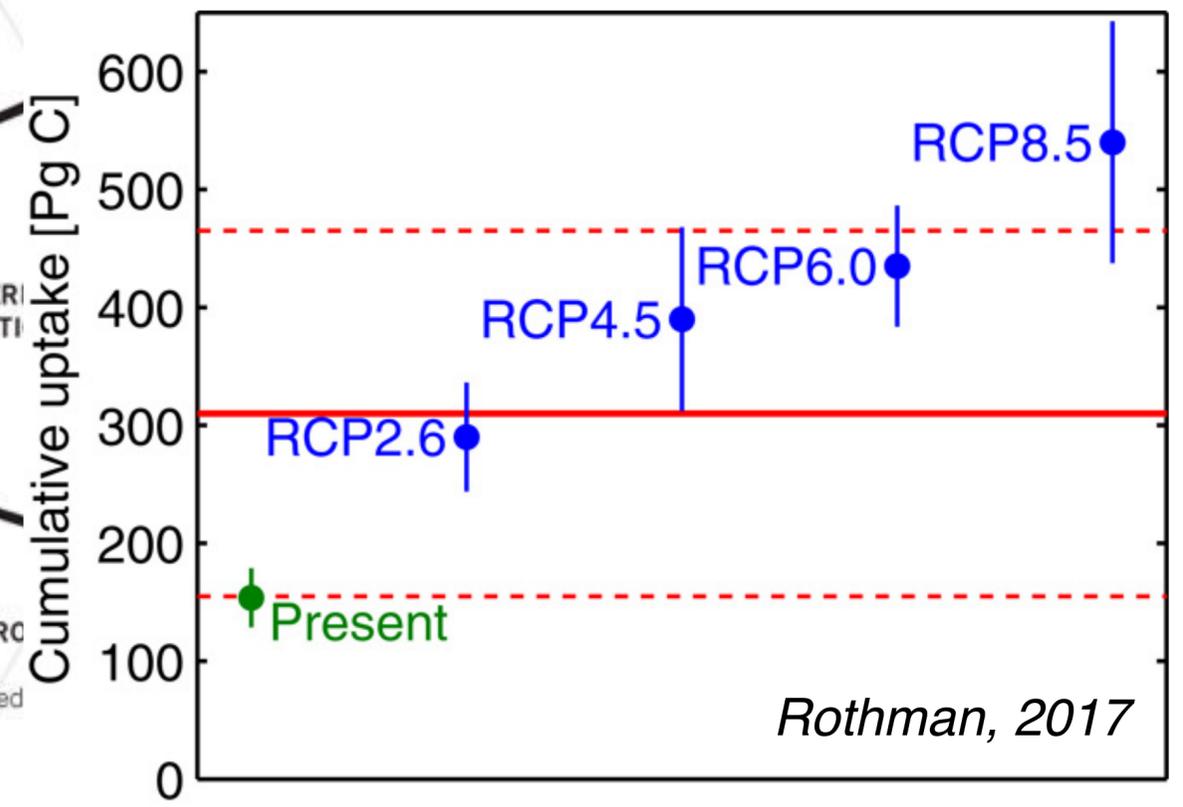
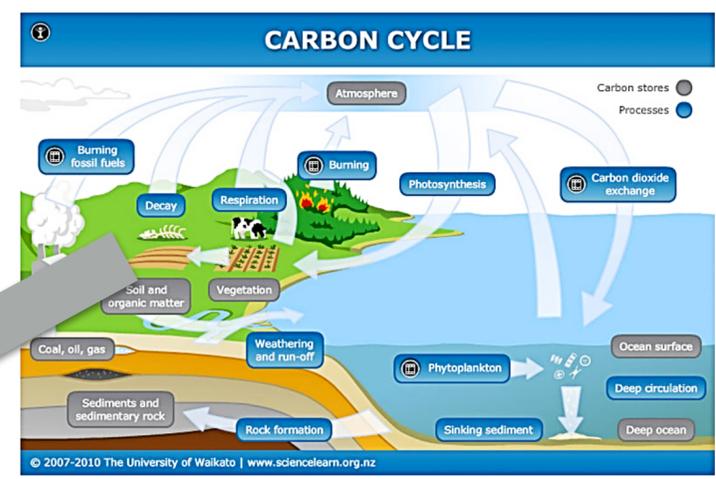
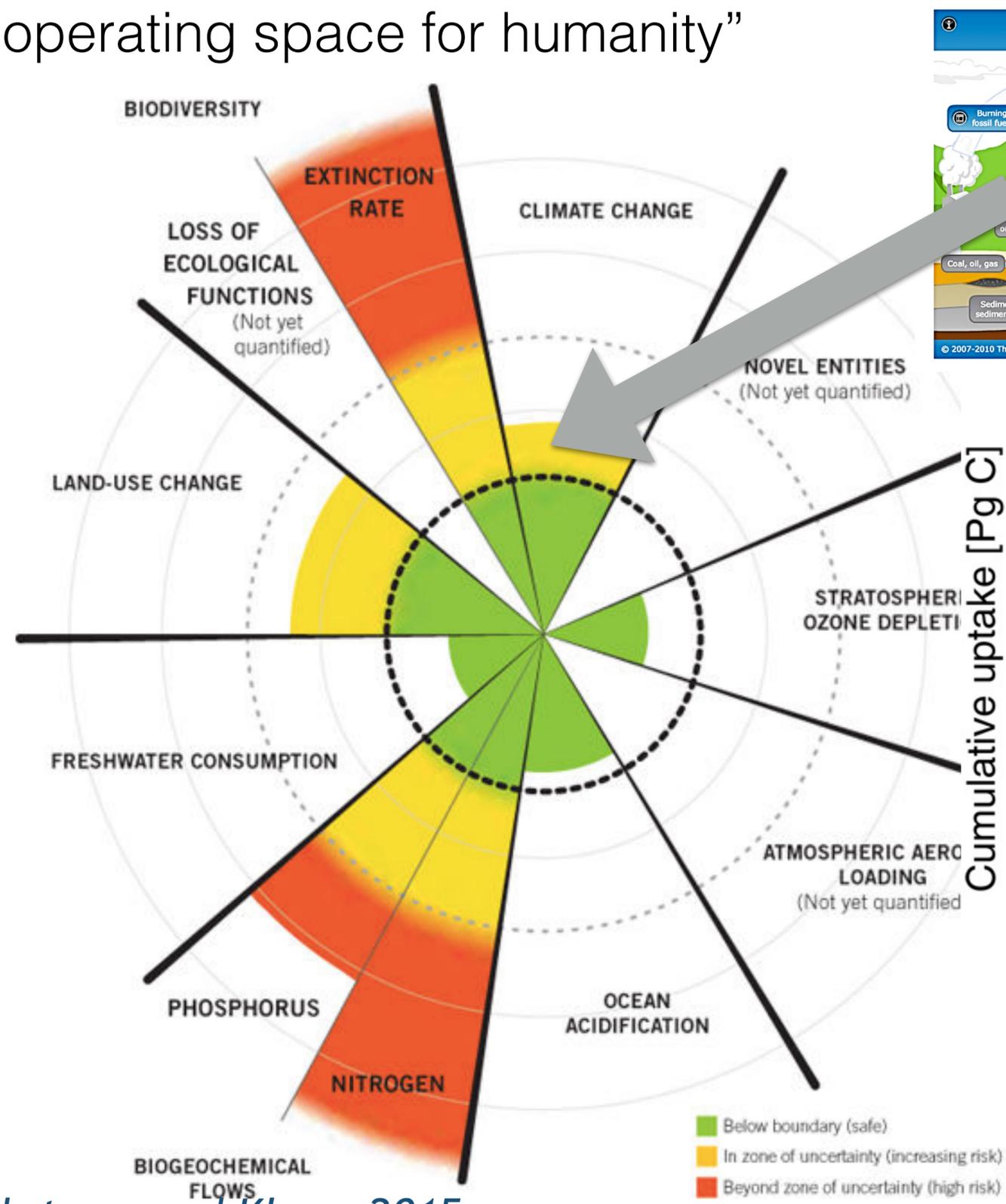
300 times background rate for birds

80,000 times background rate for mammals

*Rockstrom and Klum, 2015*

# Syndrom of Modern Global Change

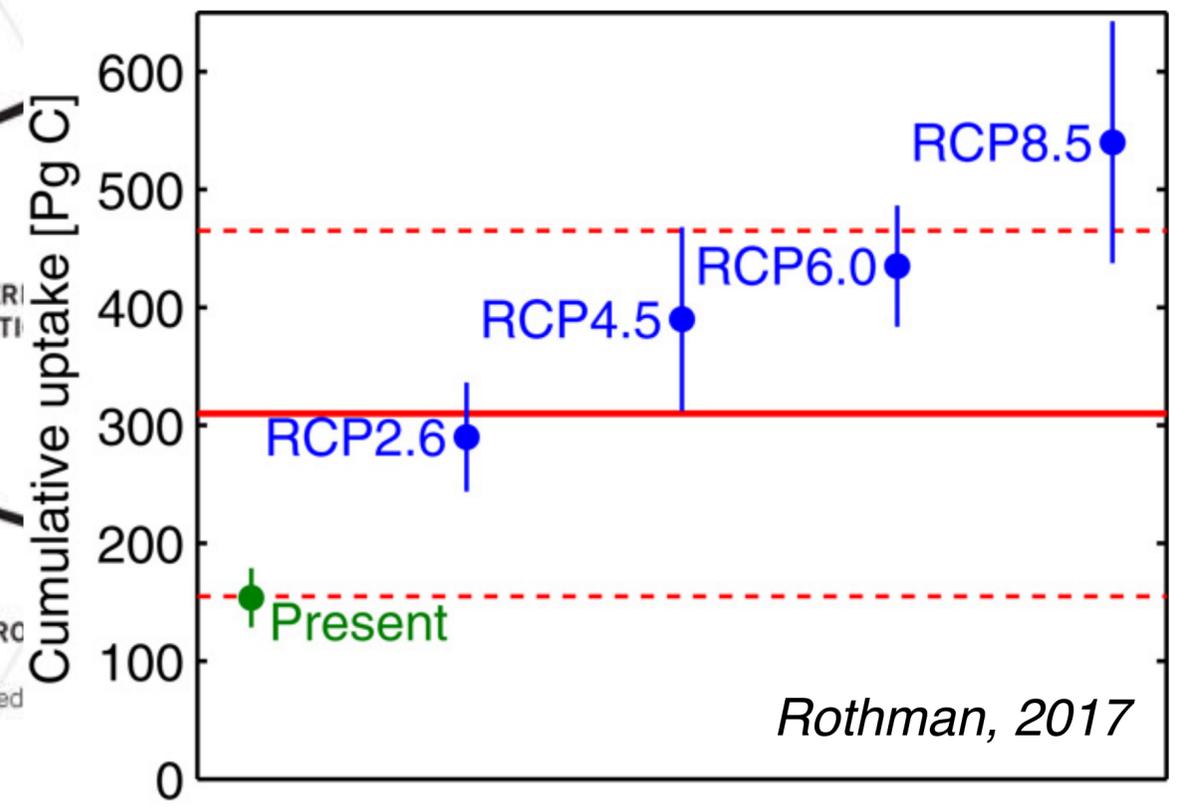
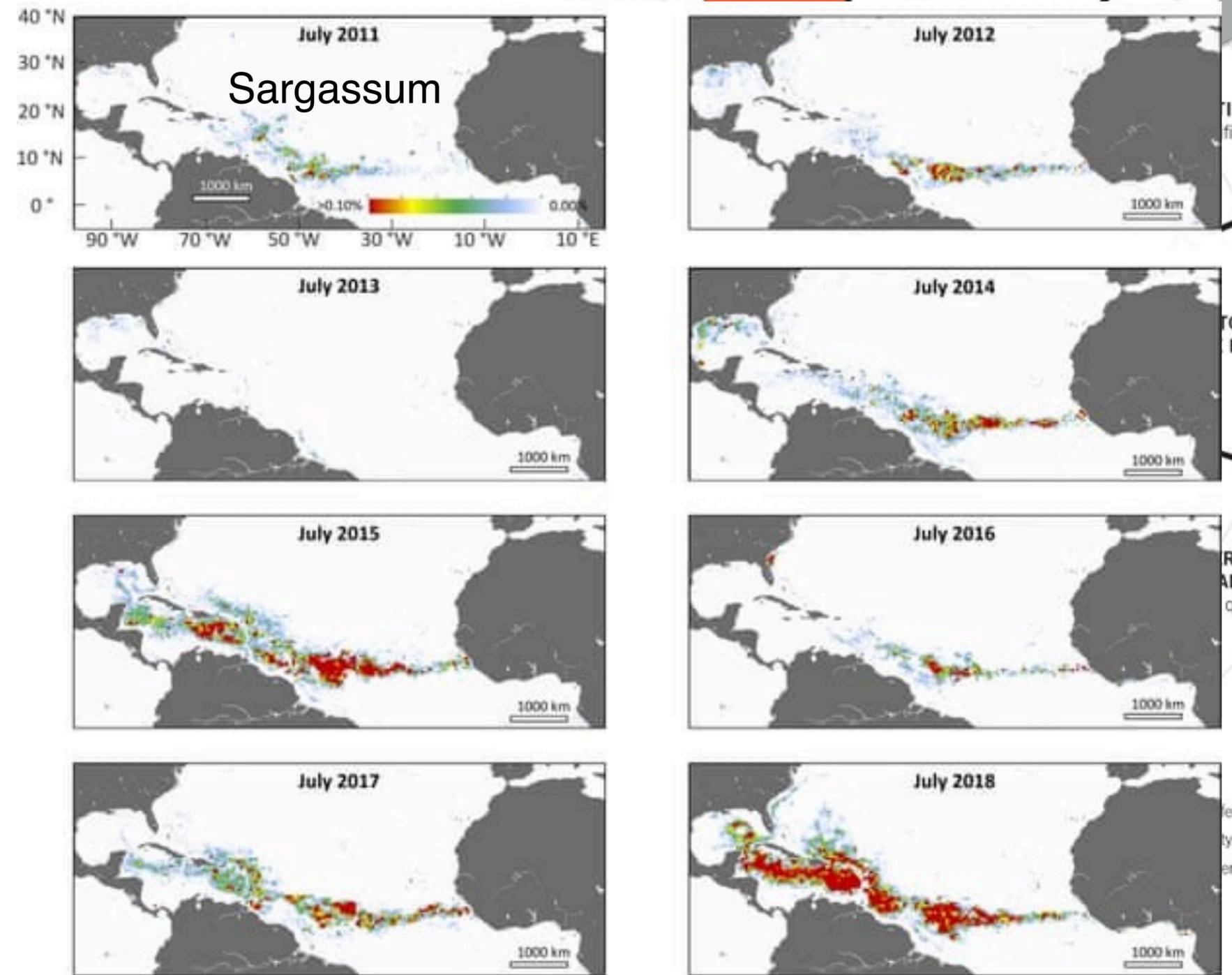
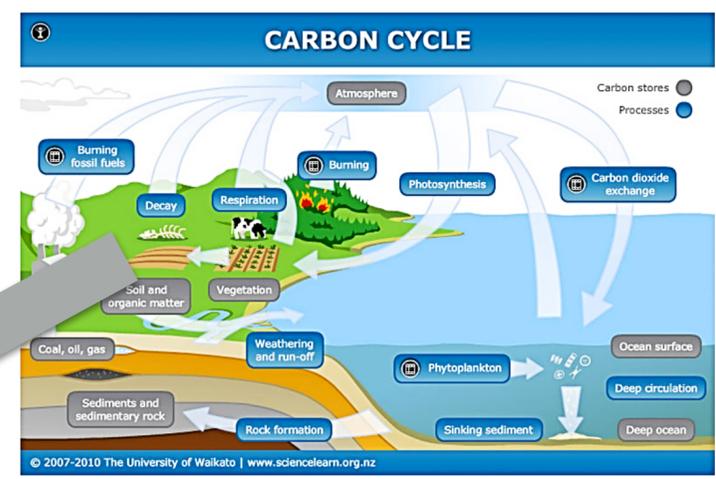
The Holocene was a "safe operating space for humanity"



Rockstrom and Klum, 2015

# Syndrome of Modern Global Change

The Holocene was a “safe operating space for humanity”



ATMOSPHERIC AEROSOL DEPLETION quantified

certainty (high risk)

# Syndrome of Modern Global Change

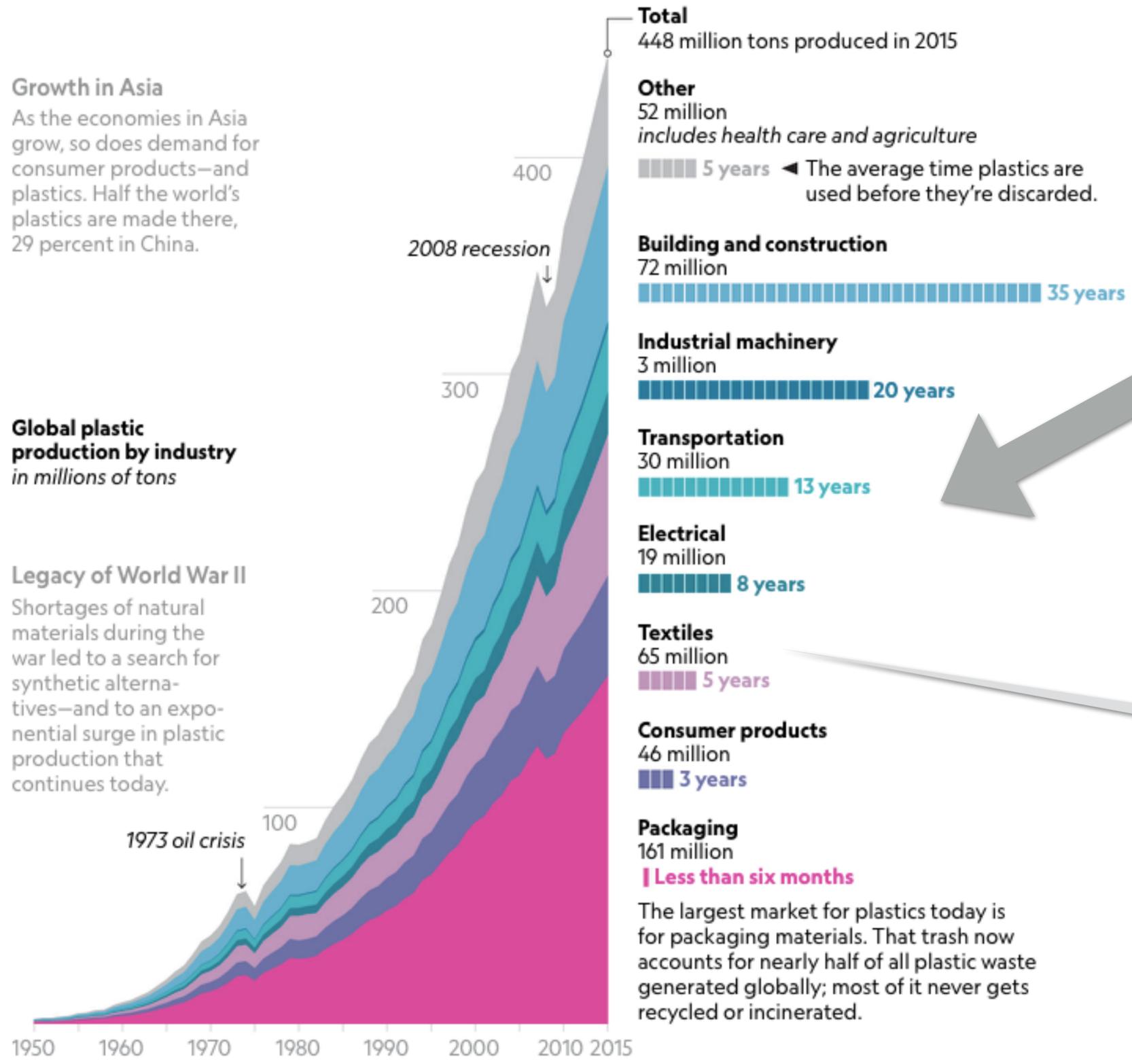
The Holocene was a “safe operating space for humanity”

**Growth in Asia**  
As the economies in Asia grow, so does demand for consumer products—and plastics. Half the world’s plastics are made there, 29 percent in China.

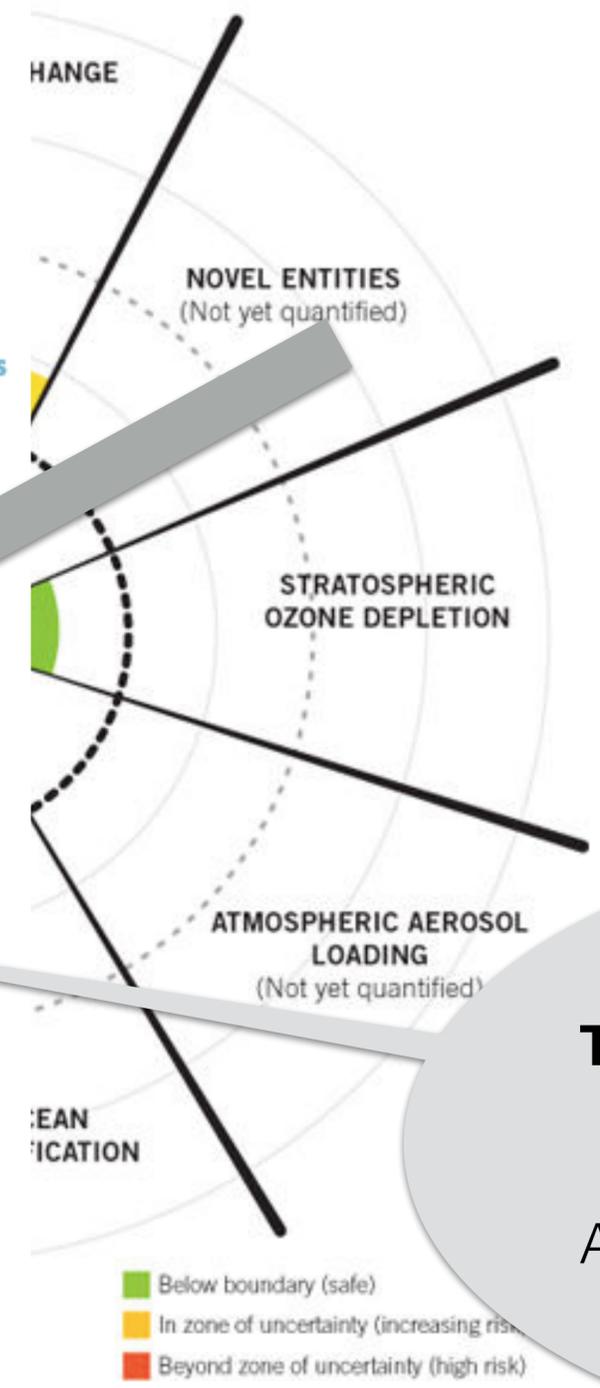
**Global plastic production by industry in millions of tons**

**Legacy of World War II**  
Shortages of natural materials during the war led to a search for synthetic alternatives—and to an exponential surge in plastic production that continues today.

**1973 oil crisis**



The largest market for plastics today is for packaging materials. That trash now accounts for nearly half of all plastic waste generated globally; most of it never gets recycled or incinerated.



**The urgent challenge of plastics**  
448 Million tons in 2015  
Average use time: 5 years  
Average lifetime: 1000-5000 years

## Homo sapiens and Earth

### Human environment

300 million tons of humans and  
700 million tons of domesticated animals

400 million domesticated dogs  
600 million domesticated cats  
1.5 billion cows  
20 billion chicken

81% of Earth's surface changed  
significantly by humans

Earth's Energy Imbalance increased by  
roughly 10,000,000 times above pre-human  
values

### Non-Human environment

100 million tons of wild animals (more than 2 kg)

200,000 wolfs  
40,000 lions  
900,000 African buffalo  
50 million penguins

5% of Earth surface still untouched

Modern climate change is a symptom in the syndrome of Modern Global Change, not the cause.

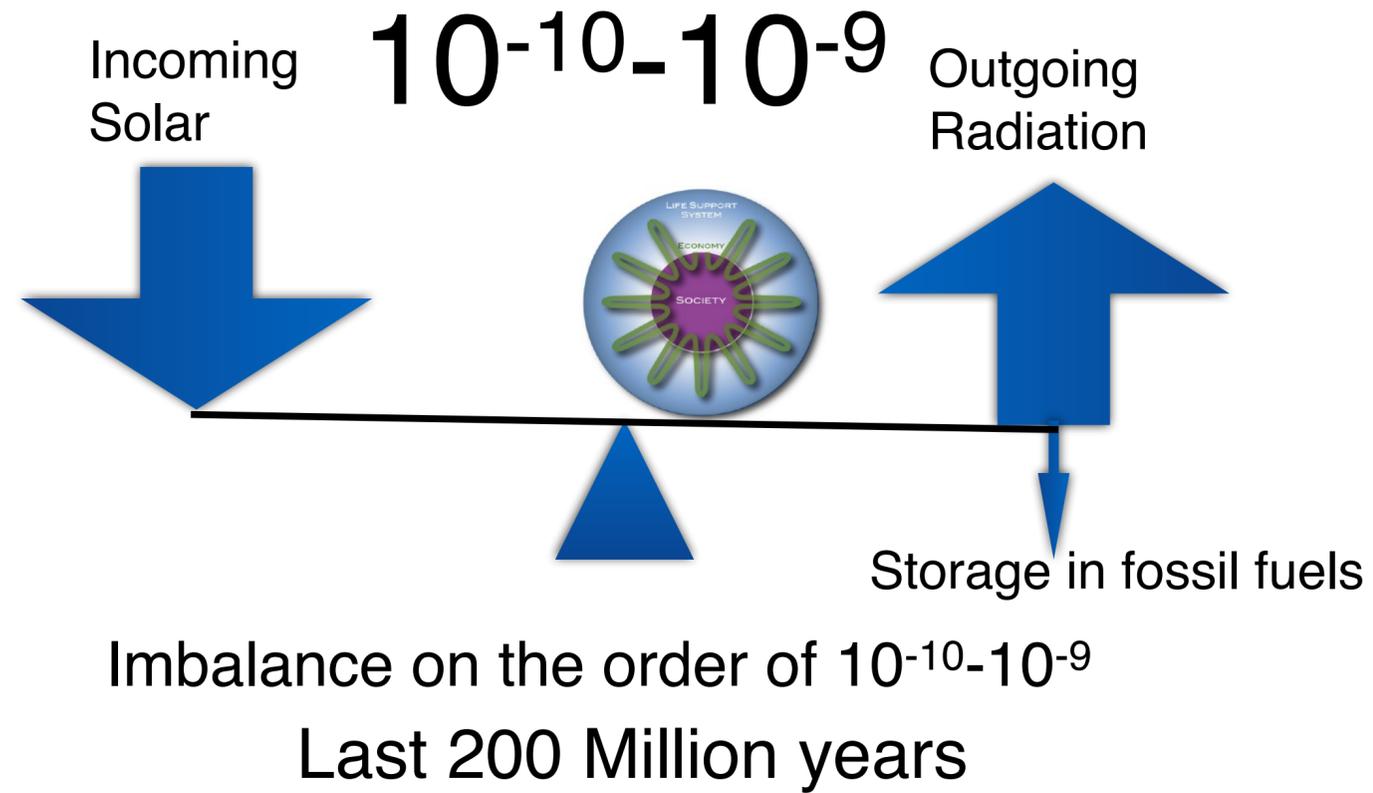
Modern climate change is a symptom in the syndrome of Modern Global Change, not the cause.

However, modern climate change is increasingly causing cascading changes, thus extending the syndrome of modern global change

## Earth's Energy Imbalance

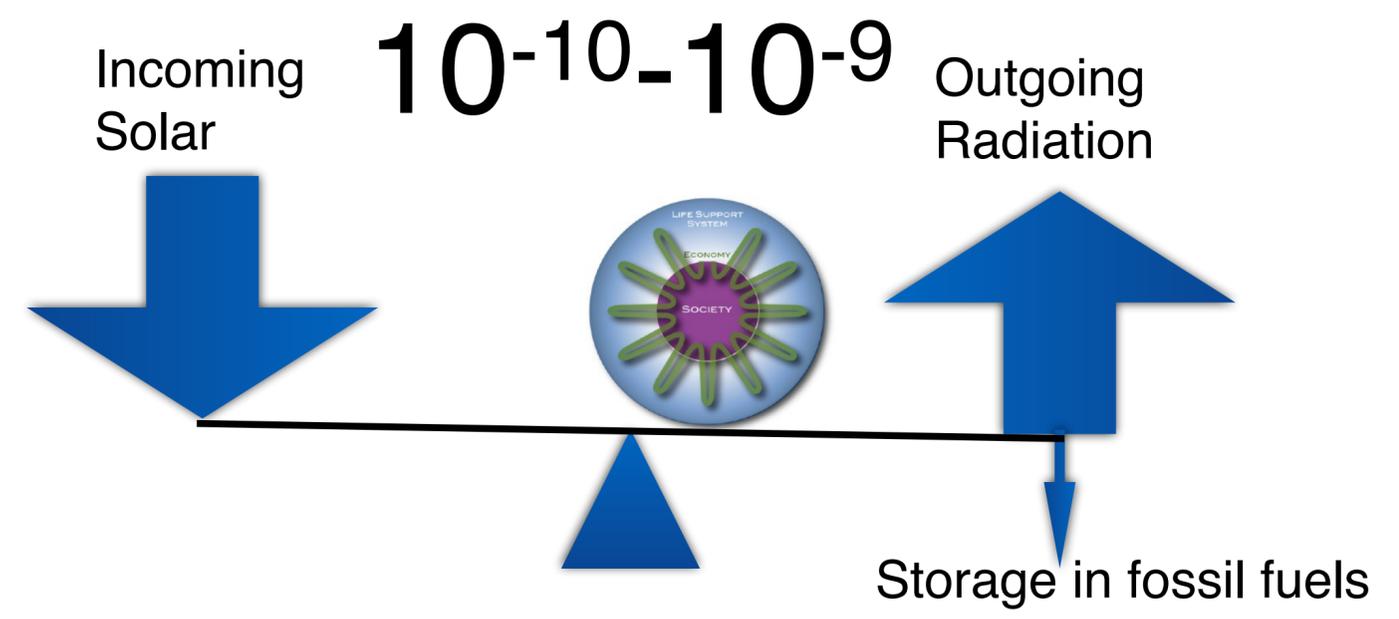
# Syndromes of Modern Global Change

## Earth's Energy Imbalance



# Syndromes of Modern Global Change

## Earth's Energy Imbalance

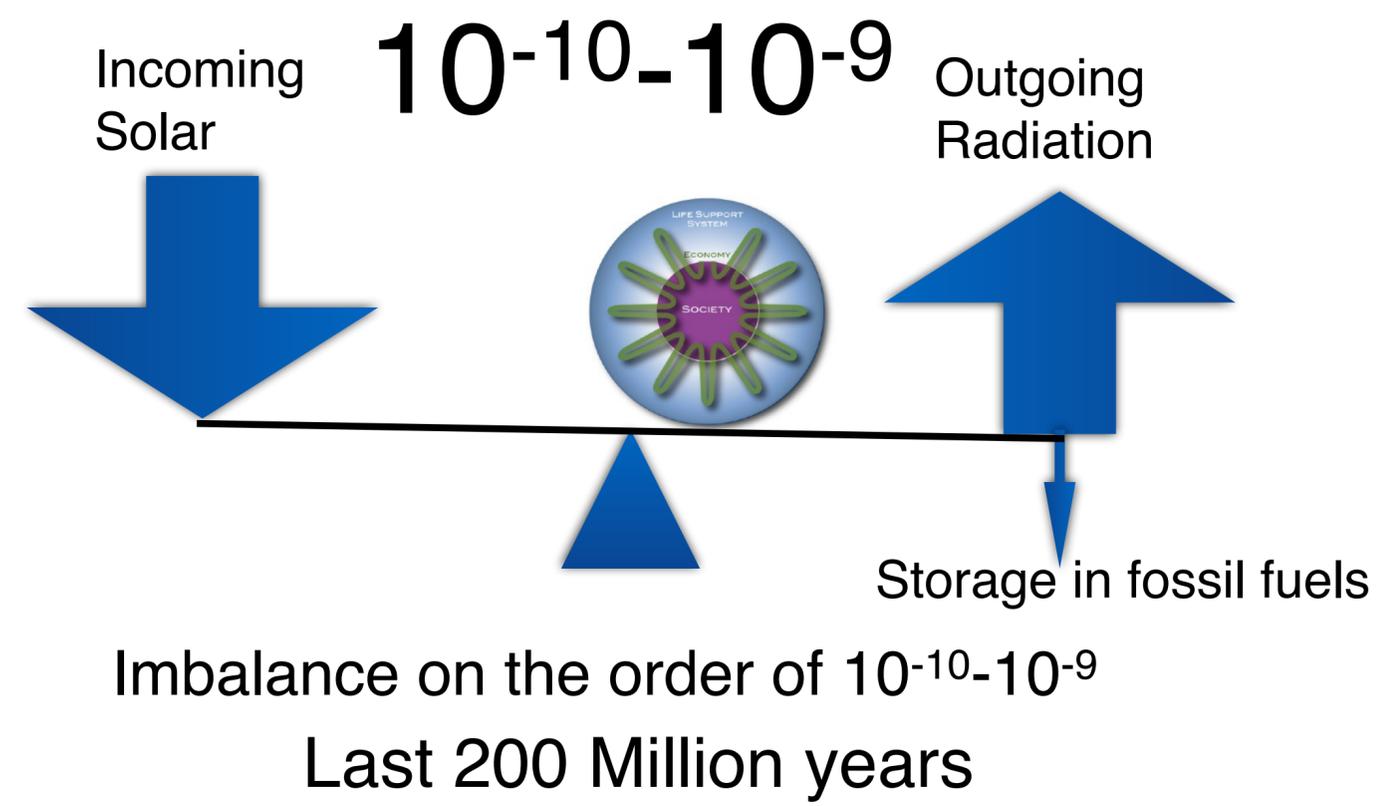


Imbalance on the order of  $10^{-10}-10^{-9}$   
Last 200 Million years

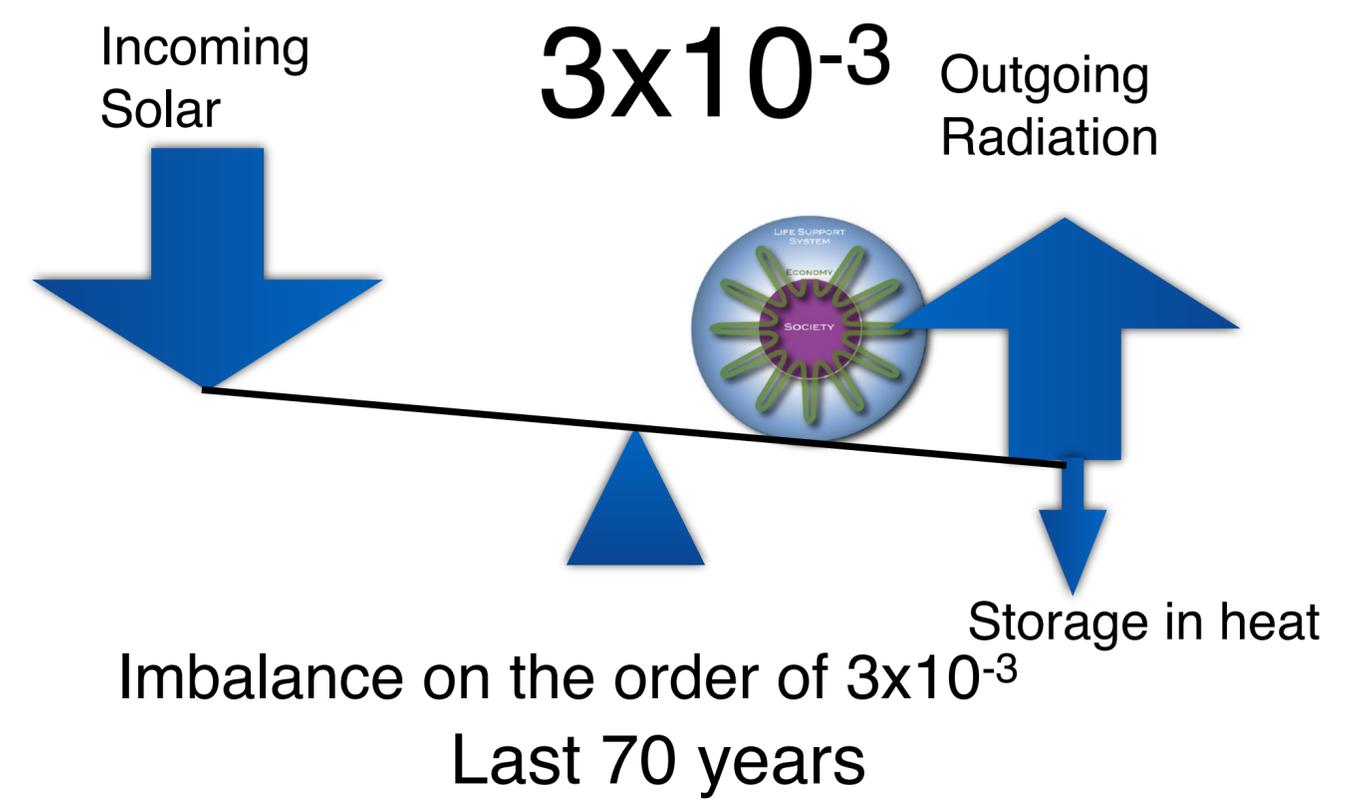
Total energy storage in 200 Myrs:  
Order 100-1000 ZetaJoules

# Syndrom of Modern Global Change

## Earth's Energy Imbalance



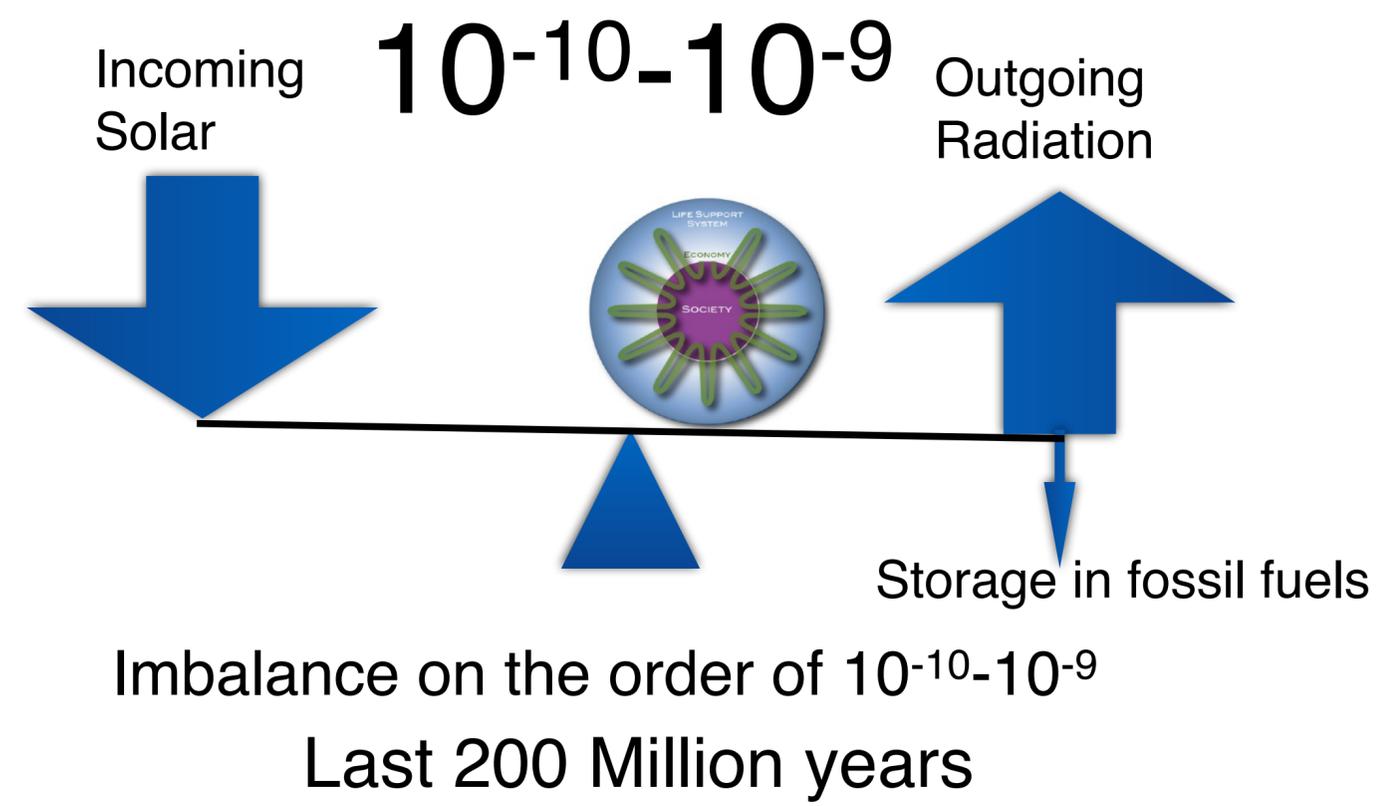
Total energy storage in 200 Myrs:  
Order 100-1000 ZetaJoules



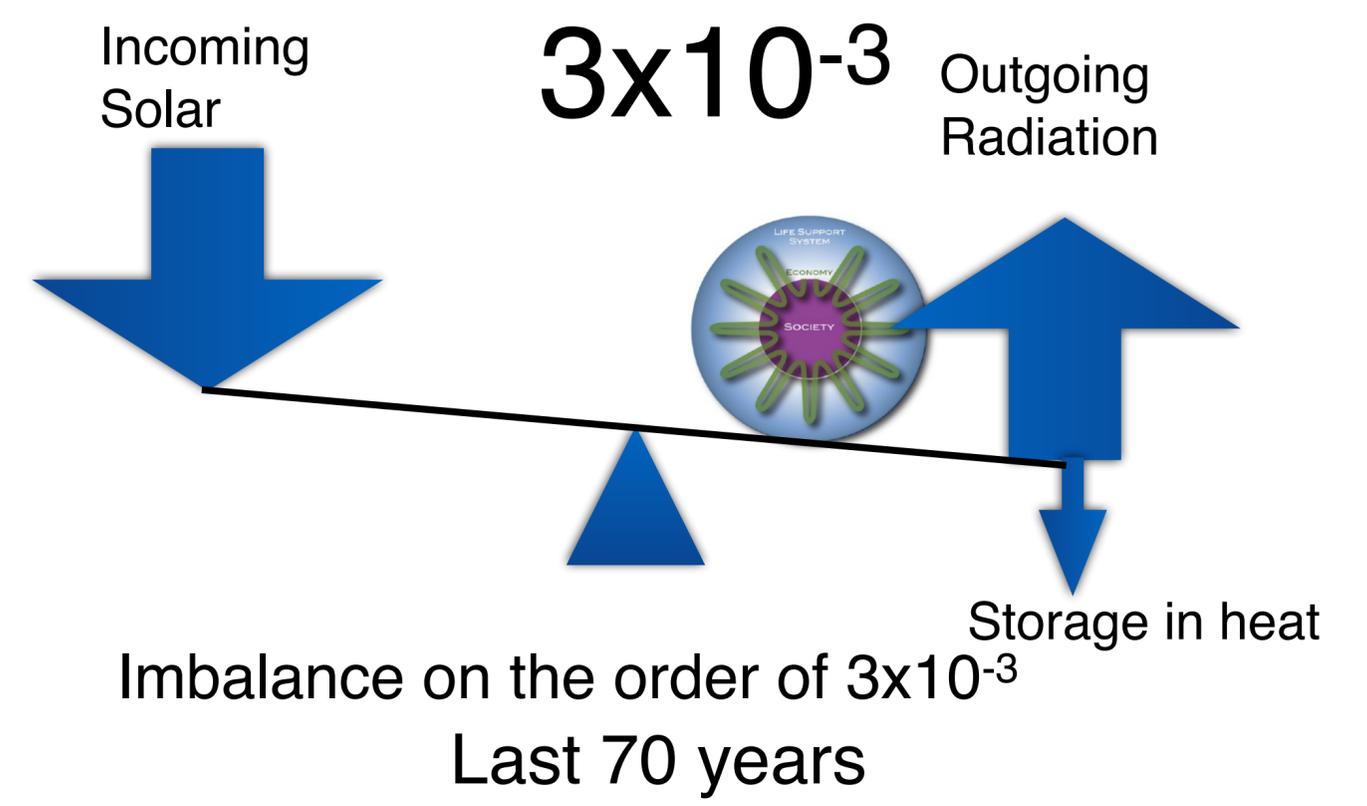
Total energy storage per century:  
Order 1000 ZetaJoules

## Earth's Energy Imbalance

**The Earth's Energy Imbalance increased by a factor of  $10^6$  to  $10^7$ !**



Total energy storage in 200 Myrs:  
Order 100-1000 ZetaJoules



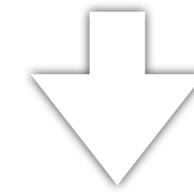
Total energy storage per century:  
Order 1000 ZetaJoules

## Earth's Energy Imbalance

- Long-term due to photosynthesis: 10-100 MegaWatt
- Today: 300-320 TeraWatt

The Earth system is storing far more heat (energy) than what the rising air temperature indicates.

$10^{-10}$  to  $10^{-9}$



$10^{-3}$

# Syndrom of Modern Global Change

## Earth's Energy Imbalance

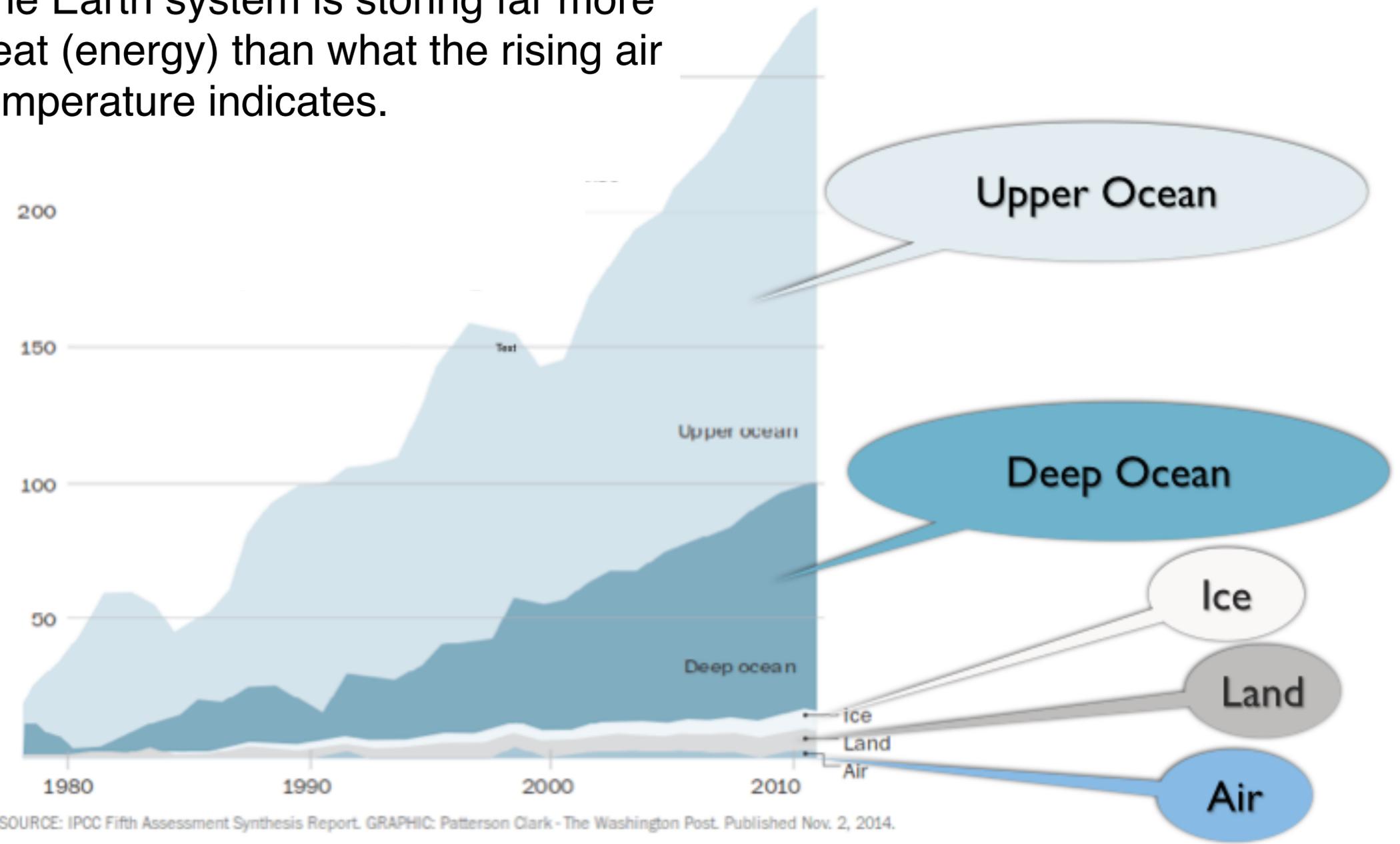
- Long-term due to photosynthesis: 10-100 MegaWatt
- Today: 300-320 TeraWatt

$10^{-10}$  to  $10^{-9}$

↓

$10^{-3}$

The Earth system is storing far more heat (energy) than what the rising air temperature indicates.



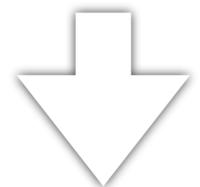
SOURCE: IPCC Fifth Assessment Synthesis Report. GRAPHIC: Patterson Clark - The Washington Post. Published Nov. 2, 2014.

# Syndrome of Modern Global Change

## Earth's Energy Imbalance

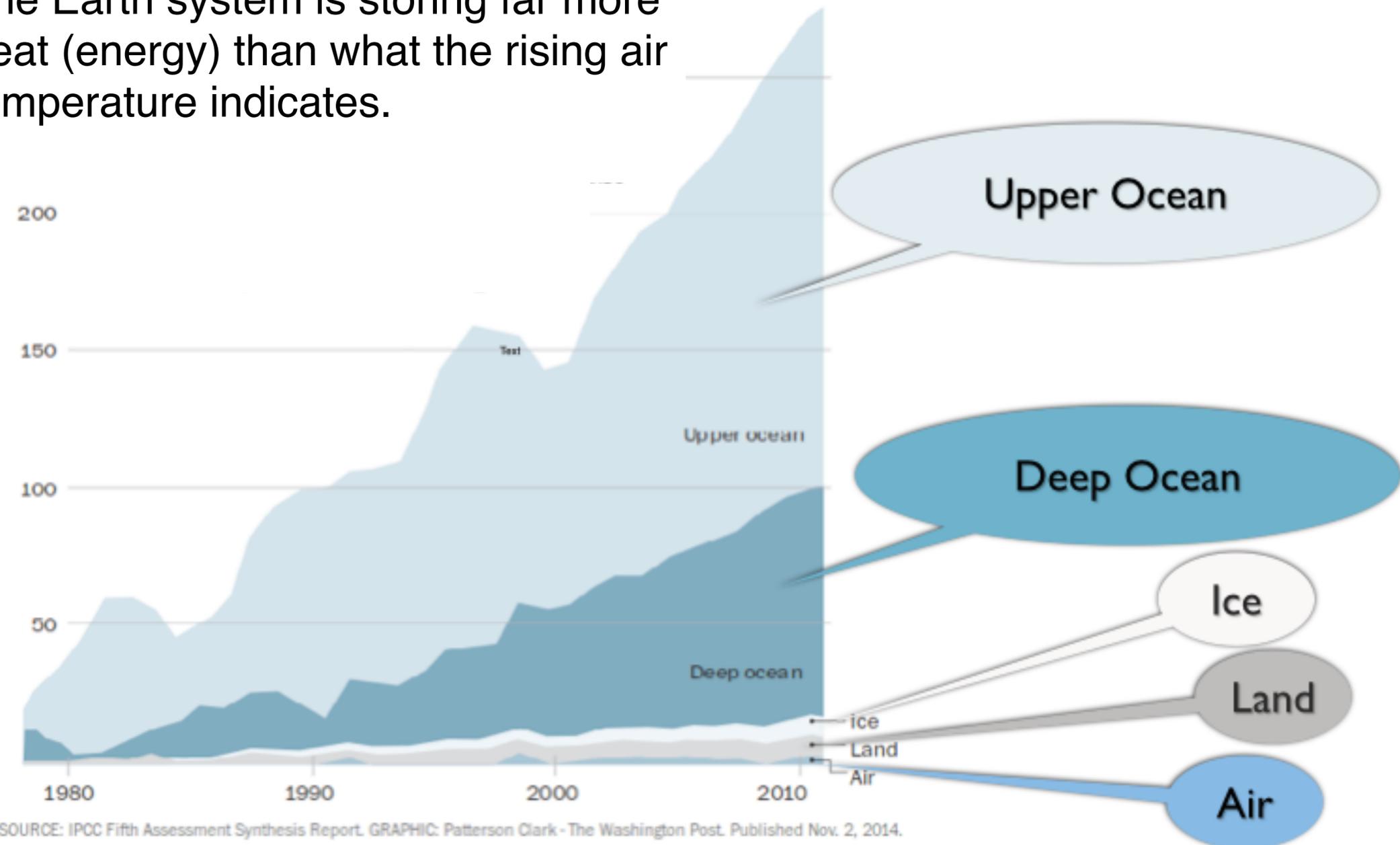
- Long-term due to photosynthesis: 10-100 MegaWatt
- Today: 300-320 TeraWatt

$10^{-10}$  to  $10^{-9}$



$10^{-3}$

The Earth system is storing far more heat (energy) than what the rising air temperature indicates.

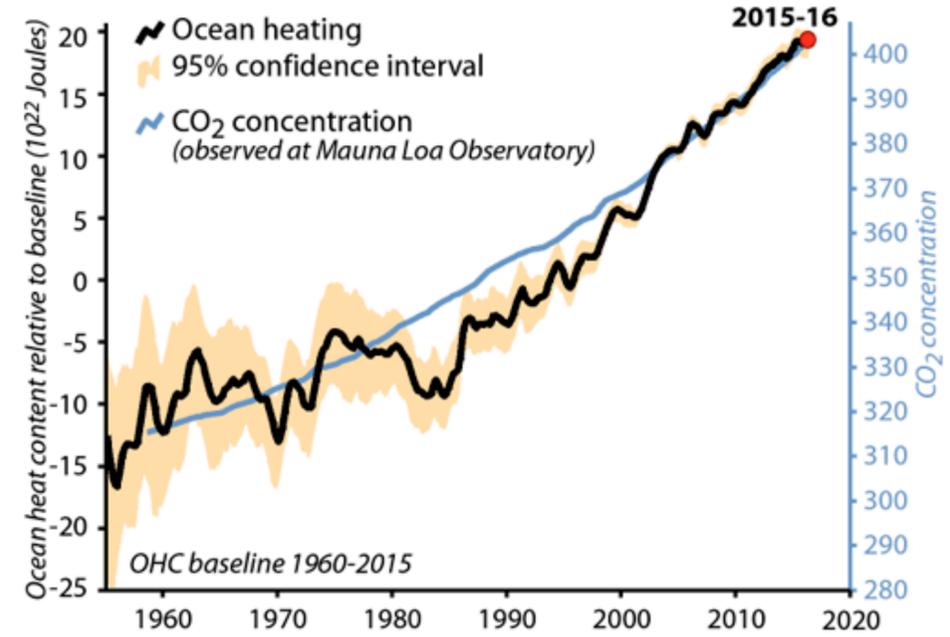


SOURCE: IPCC Fifth Assessment Synthesis Report. GRAPHIC: Patterson Clark - The Washington Post. Published Nov. 2, 2014.

### Oceans Storing More Heat as CO<sub>2</sub> Builds Up

The oceans have absorbed 90 percent of the extra heat trapped by increasing greenhouse gases. During 2015-2016, the amount of heat stored in the upper 2,000 meters of the oceans reached its highest point on record.

**OCEAN HEAT CONTENT AND ATMOSPHERIC CO<sub>2</sub> CONCENTRATIONS**  
At 0-2,000 meter depth, 12-month running means, 1958-2016



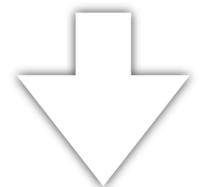
SOURCES: Taking the Pulse of the Planet by Lijing Cheng et al., 2017 (ocean heat content data); NOAA (CO<sub>2</sub> data)

# Syndrom of Modern Global Change

## Earth's Energy Imbalance

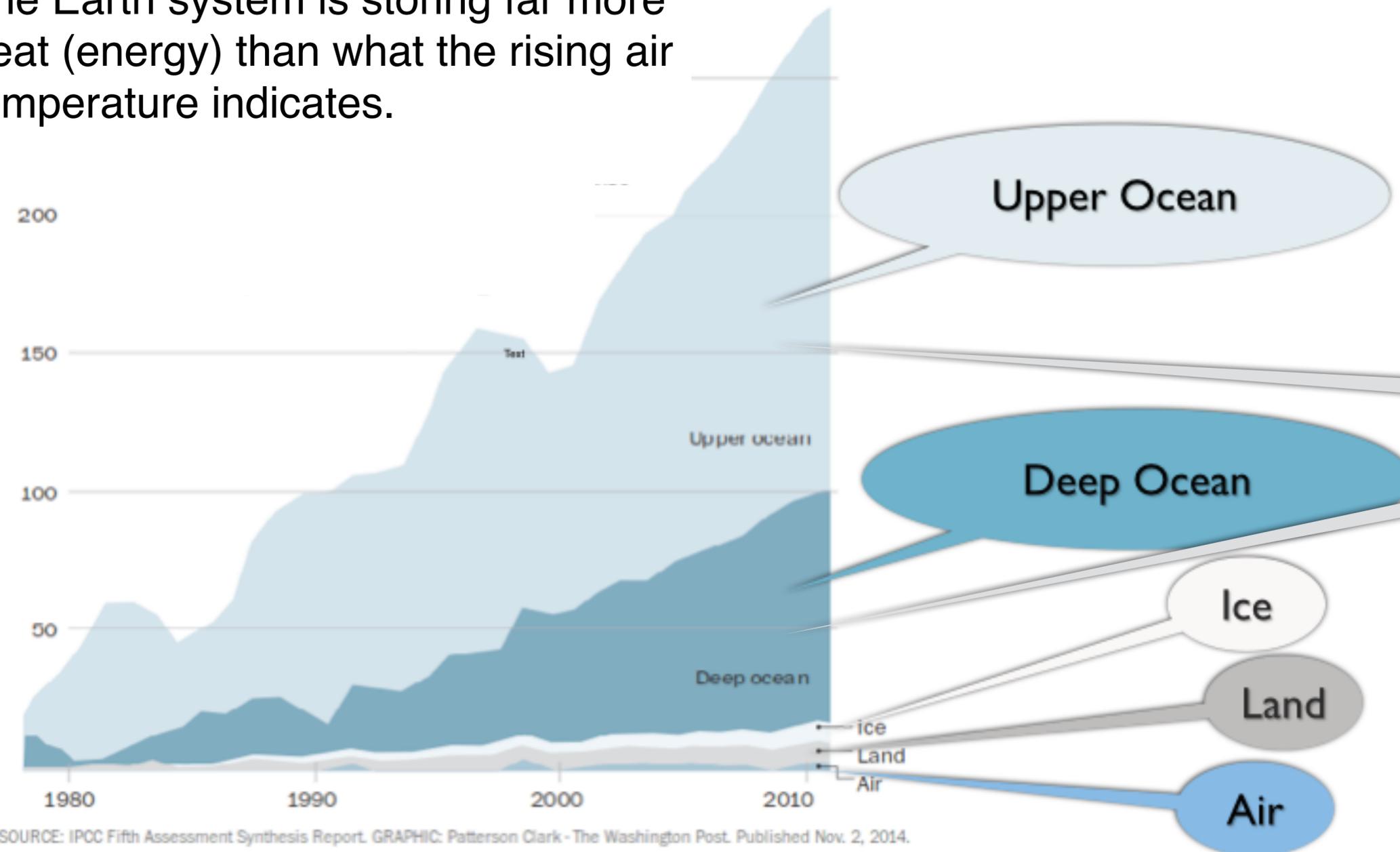
- Long-term due to photosynthesis: 10-100 MegaWatt
- Today: 300-320 TeraWatt

$10^{-10}$  to  $10^{-9}$

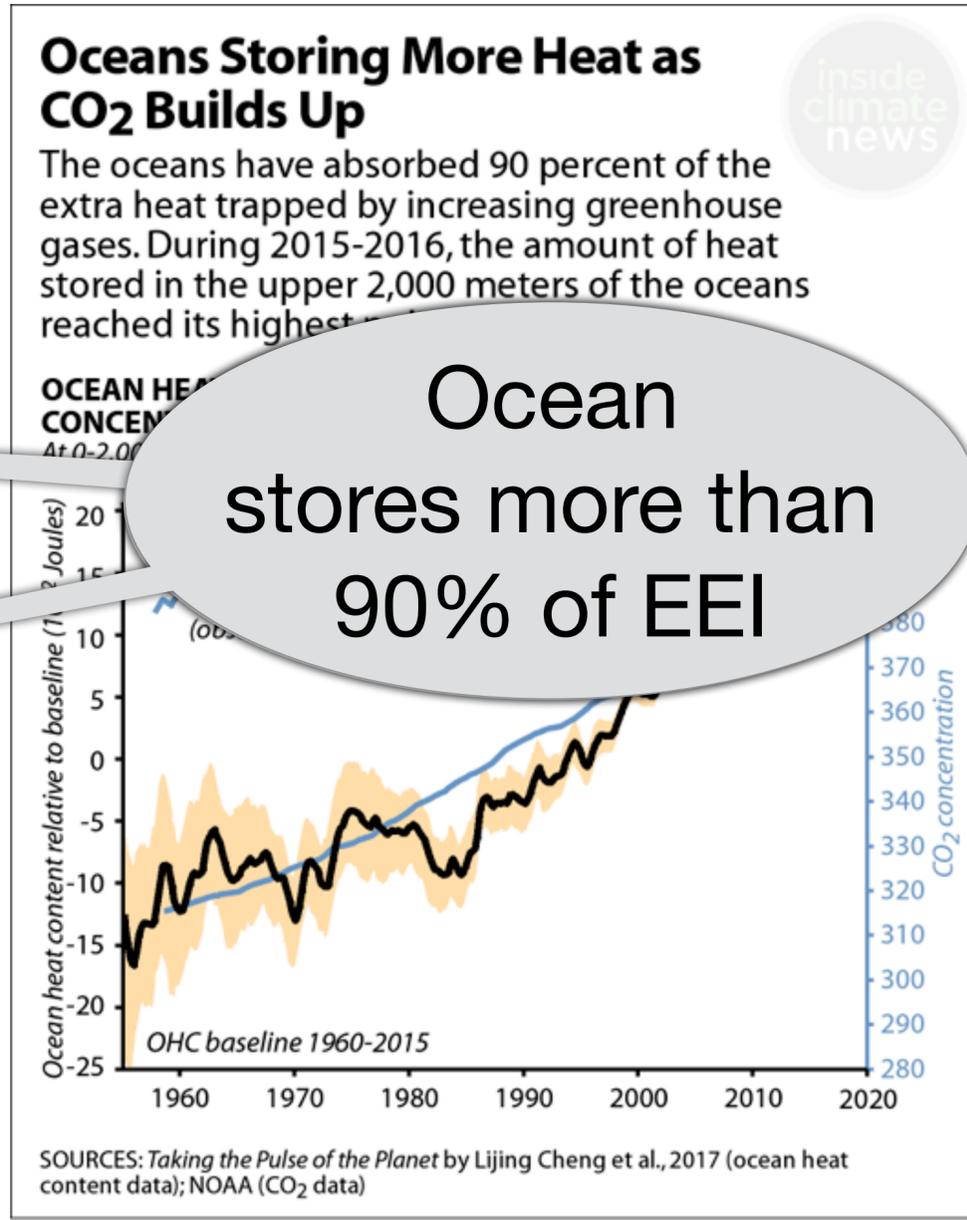


$10^{-3}$

The Earth system is storing far more heat (energy) than what the rising air temperature indicates.



SOURCE: IPCC Fifth Assessment Synthesis Report. GRAPHIC: Patterson Clark - The Washington Post. Published Nov. 2, 2014.



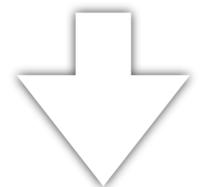
SOURCES: Taking the Pulse of the Planet by Lijing Cheng et al., 2017 (ocean heat content data); NOAA (CO<sub>2</sub> data)

# Syndrom of Modern Global Change

## Earth's Energy Imbalance

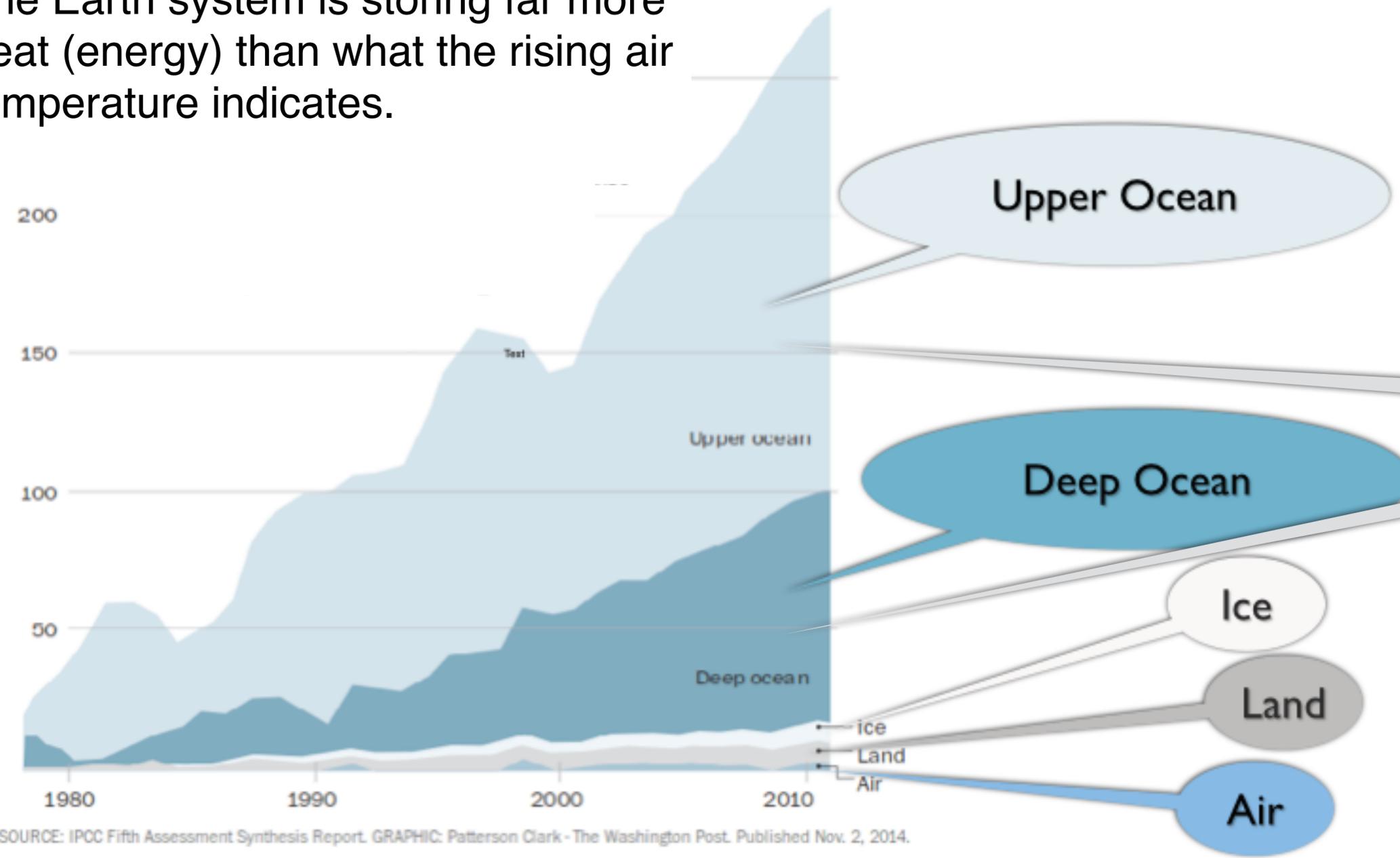
- Long-term due to photosynthesis: 10-100 MegaWatt
- Today: 300-320 TeraWatt

$10^{-10}$  to  $10^{-9}$



$10^{-3}$

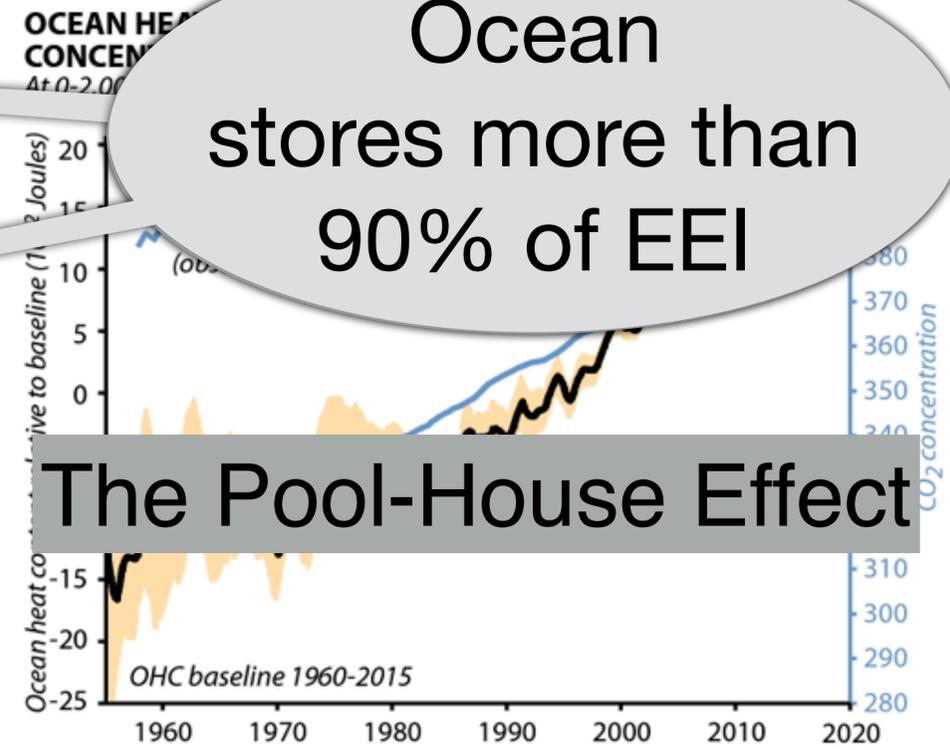
The Earth system is storing far more heat (energy) than what the rising air temperature indicates.



SOURCE: IPCC Fifth Assessment Synthesis Report. GRAPHIC: Patterson Clark - The Washington Post. Published Nov. 2, 2014.

### Oceans Storing More Heat as CO<sub>2</sub> Builds Up

The oceans have absorbed 90 percent of the extra heat trapped by increasing greenhouse gases. During 2015-2016, the amount of heat stored in the upper 2,000 meters of the oceans reached its highest...



SOURCES: Taking the Pulse of the Planet by Lijing Cheng et al., 2017 (ocean heat content data); NOAA (CO<sub>2</sub> data)

# Syndrom of Modern Global Change

## Earth's Energy Imbalance

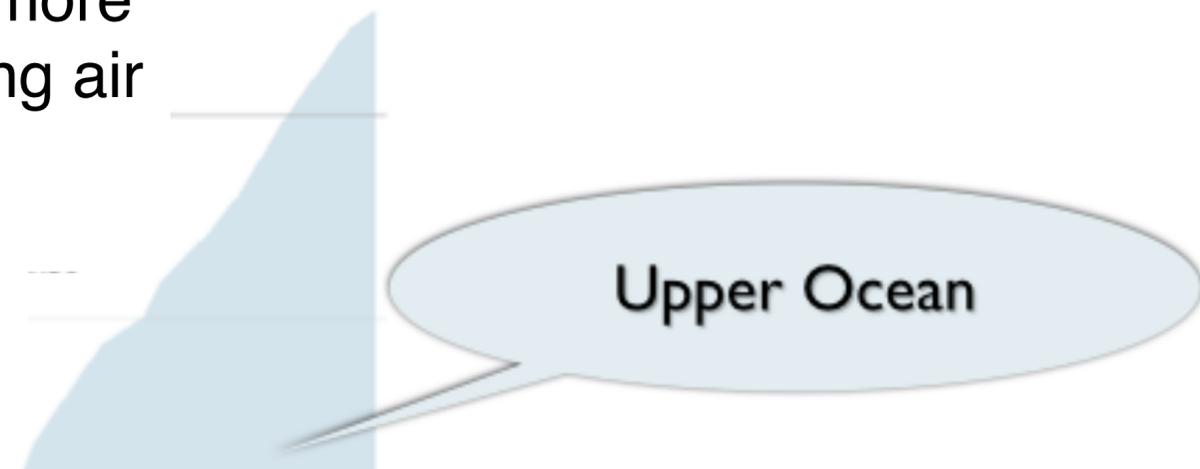
- Long-term due to photosynthesis: 10-100 MegaWatt
- Today: 300-320 TeraWatt

$10^{-10}$  to  $10^{-9}$

↓

$10^{-3}$

The Earth system is storing far more heat (energy) than what the rising air temperature indicates.

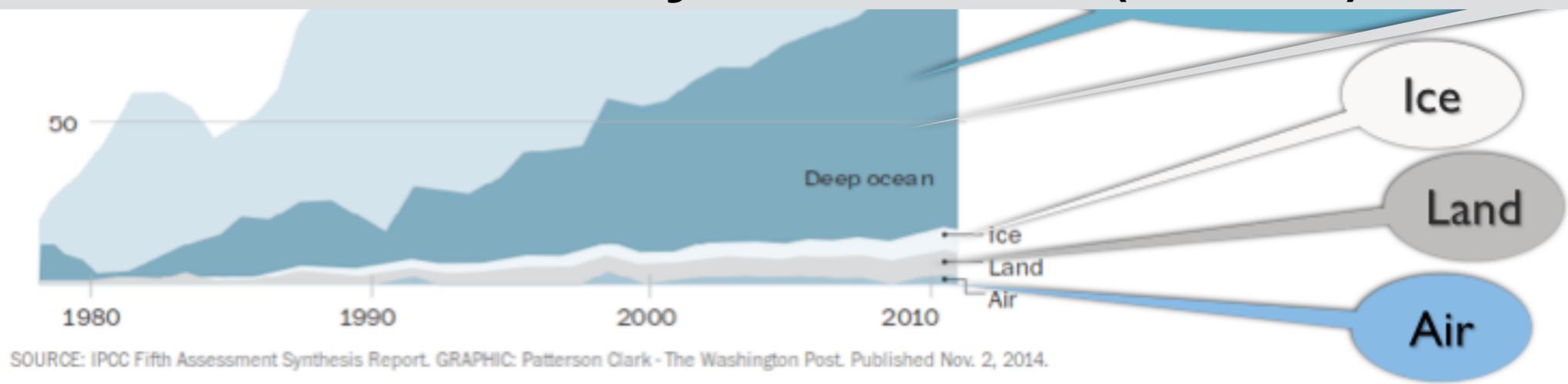


**Oceans Storing More Heat as CO<sub>2</sub> Builds Up**

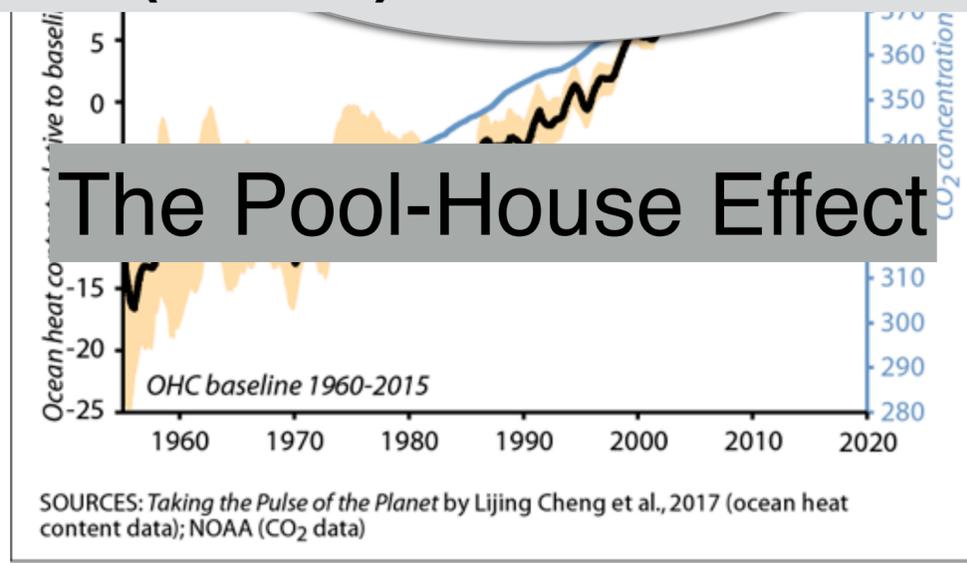
The oceans have absorbed 90 percent of the extra heat trapped by increasing greenhouse gases. During 2015-2016, the amount of heat stored in the upper 2,000 meters of the oceans reached its highest...

*inside climate news*

Without Ocean, the global mean air temperature would already be 55°C (135F), not 18°C (64F)



SOURCE: IPCC Fifth Assessment Synthesis Report. GRAPHIC: Patterson Clark - The Washington Post. Published Nov. 2, 2014.



SOURCES: Taking the Pulse of the Planet by Lijing Cheng et al., 2017 (ocean heat content data); NOAA (CO<sub>2</sub> data)

# Syndrome of Modern Global Change

## Extreme weather-related disasters



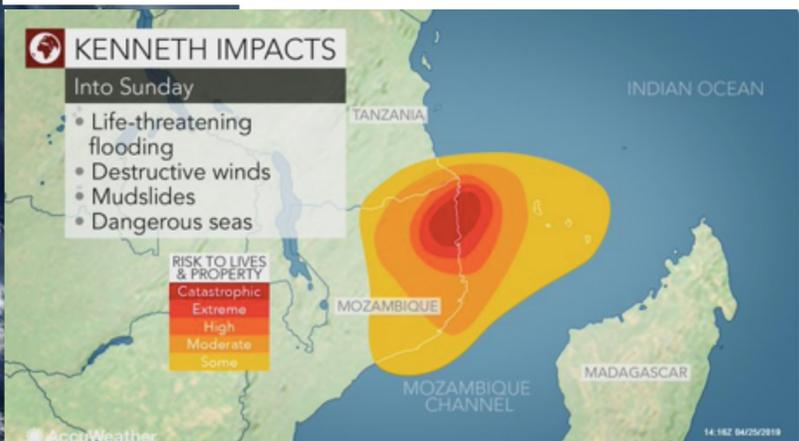
Hurricane Dorian  
September 1, 2019



Cyclone Idai,  
March 15, 2019



Cyclone Kenneth,  
April 22, 2019



## Extreme weather-related disasters



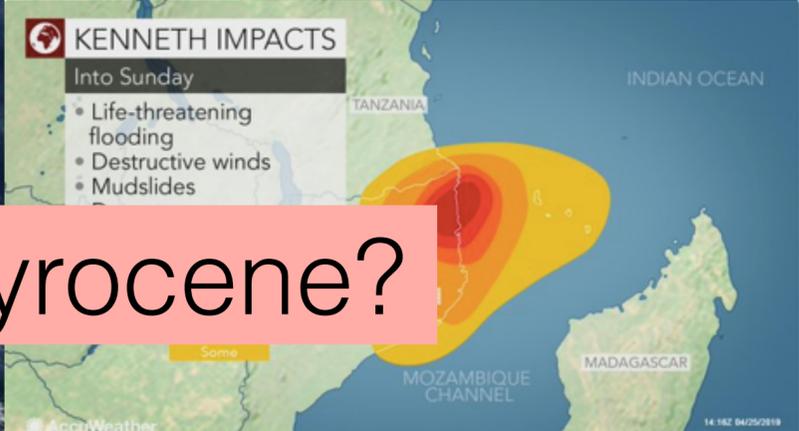
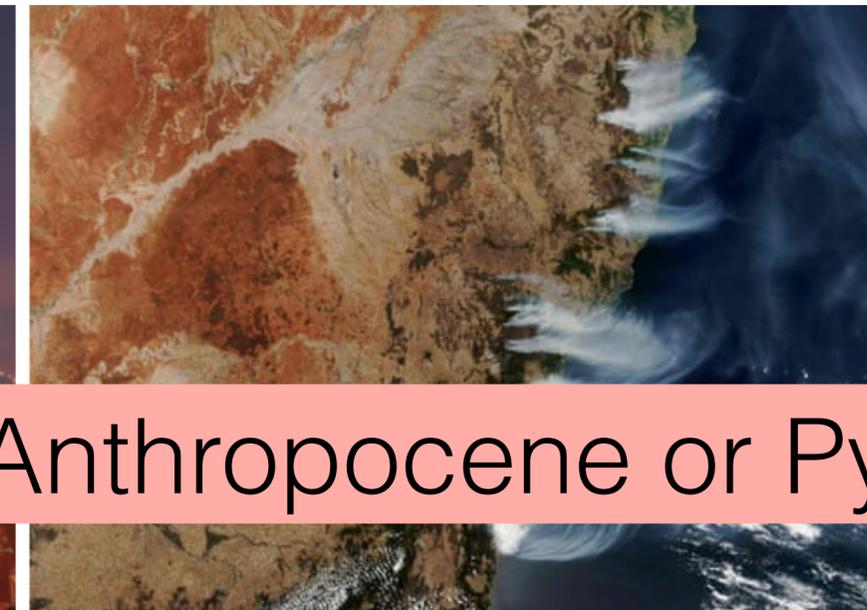
Hurricane Dorian  
September 1, 2019



Cyclone Idai,  
March 15, 2019



Cyclone Kenneth,  
April 22, 2019



Anthropocene or Pyrocene?

## Increase in Wildfires

**Australia bushfires live / NSW and Victoria survey damage as fires merge to form new 'megablaze'**



**Anxious wait**  
Strong southerly drives fires through border towns

**News Corp**  
Employee lashes climate 'misinformation'

**Scott**  
PM re

**Environmental investigations Bushfires**  
**'Silent death': Australia's bushfires push countless species to extinction**

Millions of animals have been killed in the fires but the impact on flora and fauna is more grim even than individual deaths



▲ The habitat of the endangered southern brown bandicoot has been obliterated by fire on Kangaroo Island. It's one of many Australian species whose survival has been further threatened by this summer's bushfires. Photograph: Simon Cherriman/WWF Australia

**Environmental investigations Greenhouse gas emissions**  
**Australia's bushfires have emitted 250m tonnes of CO2, almost half of country's annual emissions**

**Exclusive: forest regrowth can reabsorb emissions from fires but scientists fear natural carbon 'sinks' have been compromised**



▲ The NSW fires emitted about 195m tonnes of CO2 since 1 August, with Queensland's bushfires adding 55m tonnes, almost half of Australia's annual emissions. Photograph: Lauren Dauphin/Nasa Earth Observatory/AFP via Getty

## Increase in Wildfires

**Australia bushfires live / NSW and Victoria survey damage as fires merge to form new 'megablaze'**



**Anxious wait**  
Strong southerly drives fires through border towns

**News Corp**  
Employee lashes climate 'misinformation'

**Scott**  
PM re

**Environmental investigations Bushfires**  
**'Silent death': Australia's bushfires push countless species to extinction**

Millions of animals have been killed in the fires but the impact on flora and fauna is more grim even than individual deaths



▲ The habitat of the endangered southern brown bandicoot has been obliterated by fire on Kangaroo Island. It's one of many Australian species whose survival has been further threatened by this summer's bushfires. Photograph: Simon Cherriman/WWF Australia

**Environmental investigations Greenhouse gas emissions**  
**Australia's bushfires have emitted 250m tonnes of CO2, almost half of country's annual emissions**

**Exclusive: forest regrowth can reabsorb emissions from fires but scientists fear natural carbon 'sinks' have been compromised**

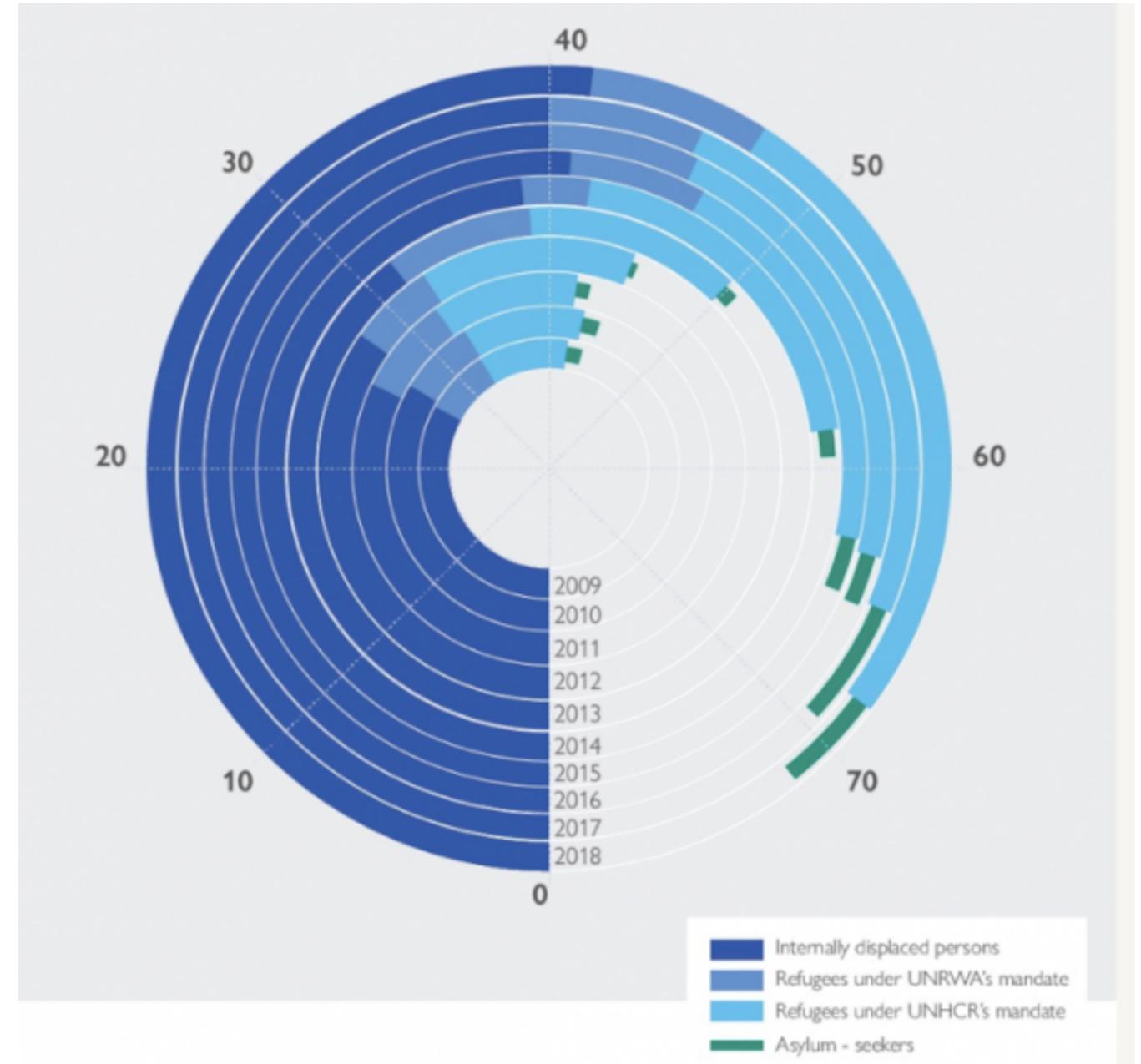
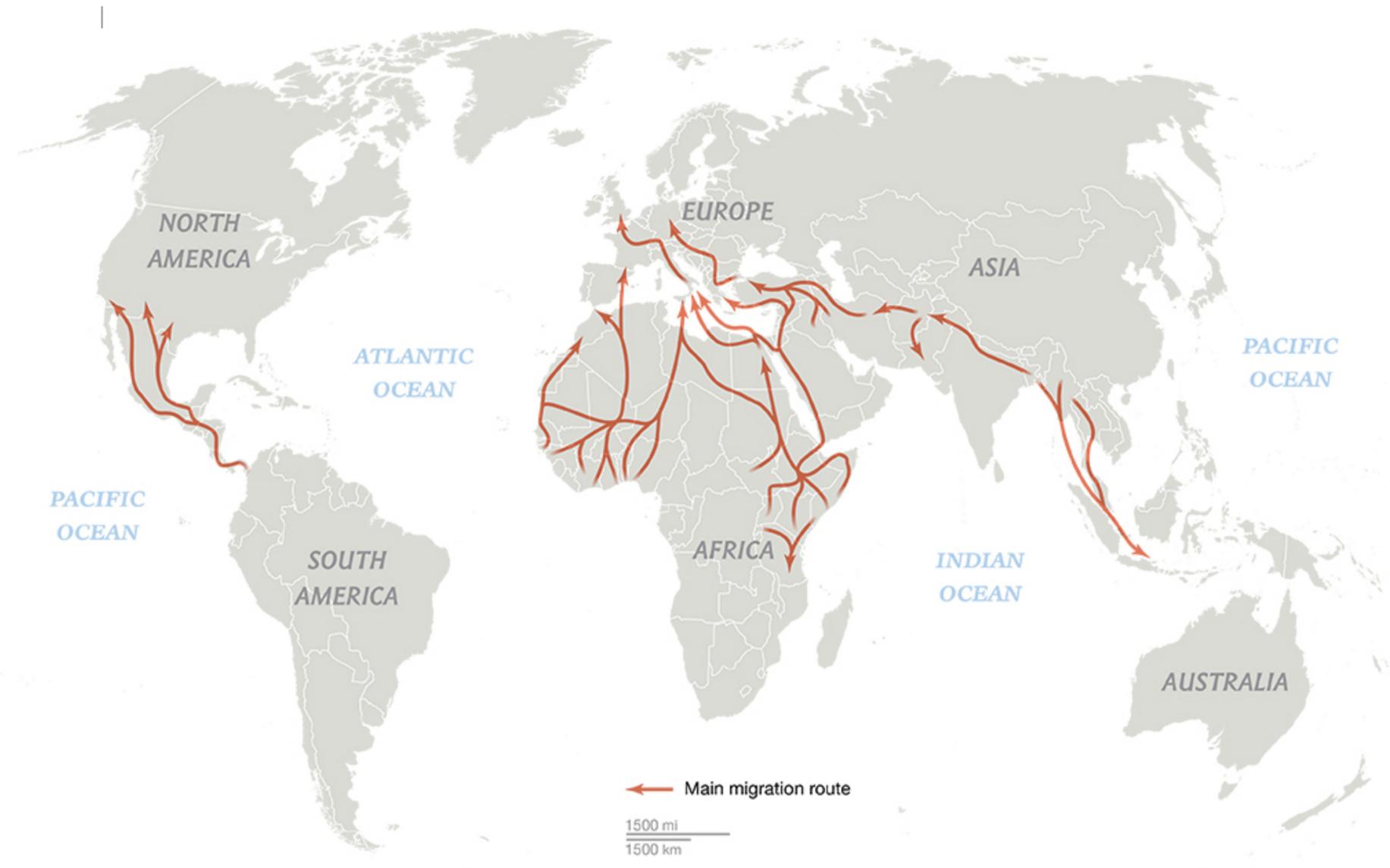


▲ The NSW fires emitted about 195m tonnes of CO2 since 1 August, with Queensland's bushfires adding 55m tonnes, almost half of Australia's annual emissions. Photograph: Lauren Dauphin/Nasa Earth Observatory/AFP via Getty

Anthropocene or Pyrocene?

# Syndrome of Modern Global Change

## Migration Causing Massive Harm



Source: UNHCR, 2019. Global Trends: Forced Displacement in 2018





# HUMANITY'S JOURNEY

The Evolution of Key Environmental Factors

10,000 YRS

AIR TEMPERATURE

0.01 °C / century

CO<sub>2</sub>

0.2 ppm / century

SEA LEVEL

0.05 m / century

POPULATION

16 M / century

ENERGY CONSUMPTION

0.01 TW / century

GINI COEFFICIENT

0.003 / century

10,000 BC

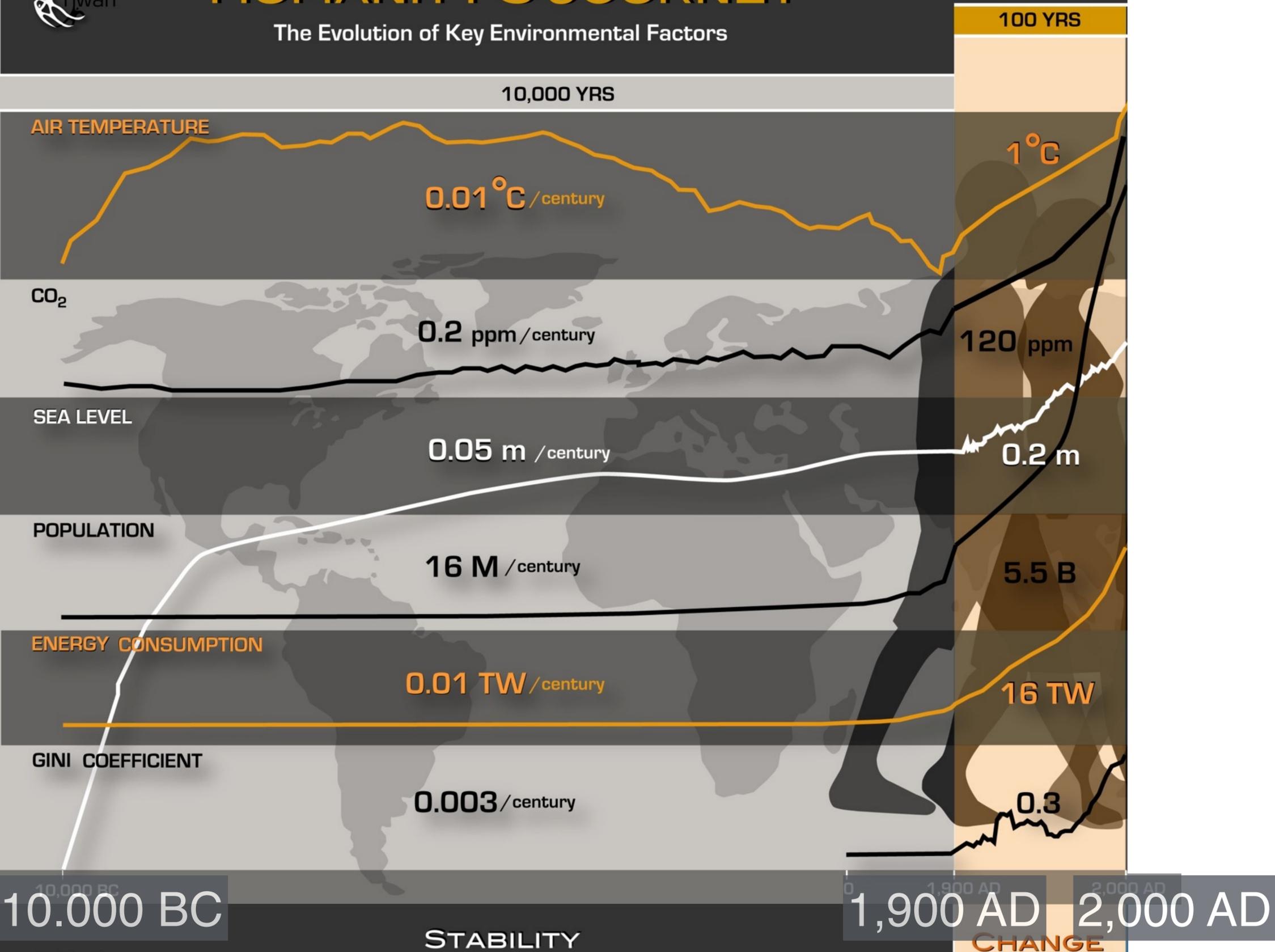
1,900 AD

STABILITY



# HUMANITY'S JOURNEY

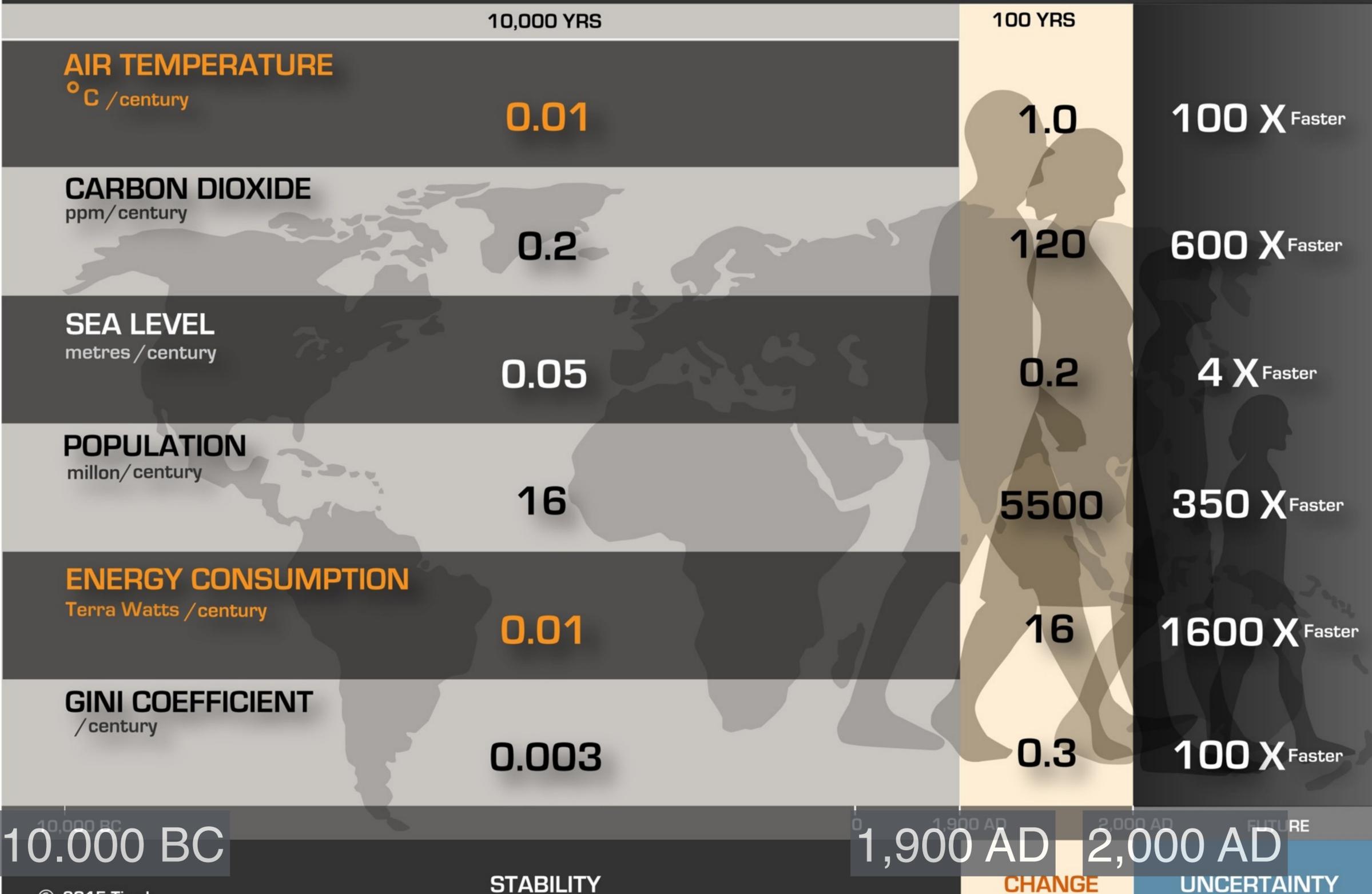
The Evolution of Key Environmental Factors





# HUMANITY'S JOURNEY

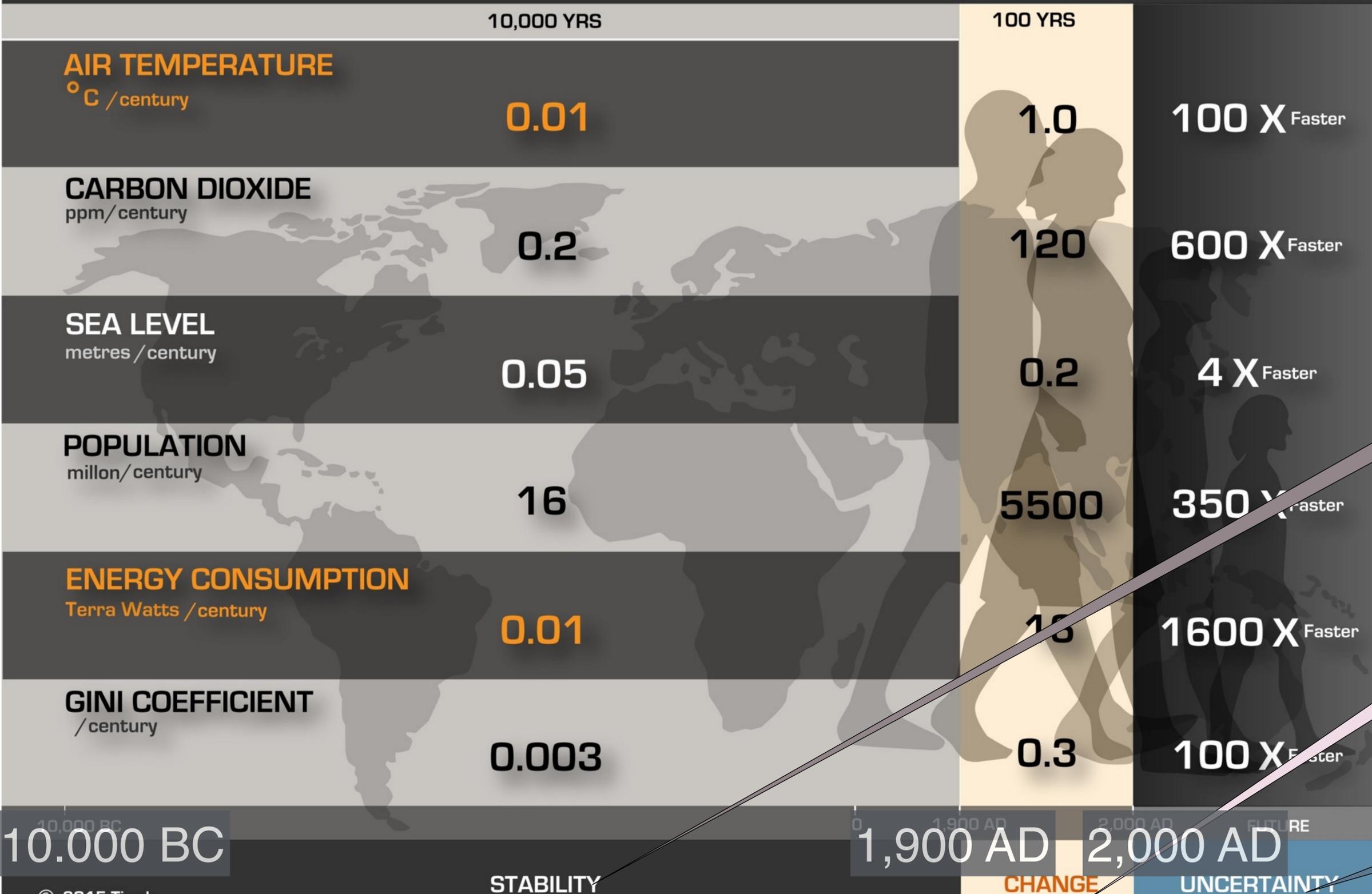
The Evolution of Key Environmental Factors





# HUMANITY'S JOURNEY

The Evolution of Key Environmental Factors



Holocene:  
Stability

20th and  
21st Century:  
Change, imbalance

Future:  
Uncertainty

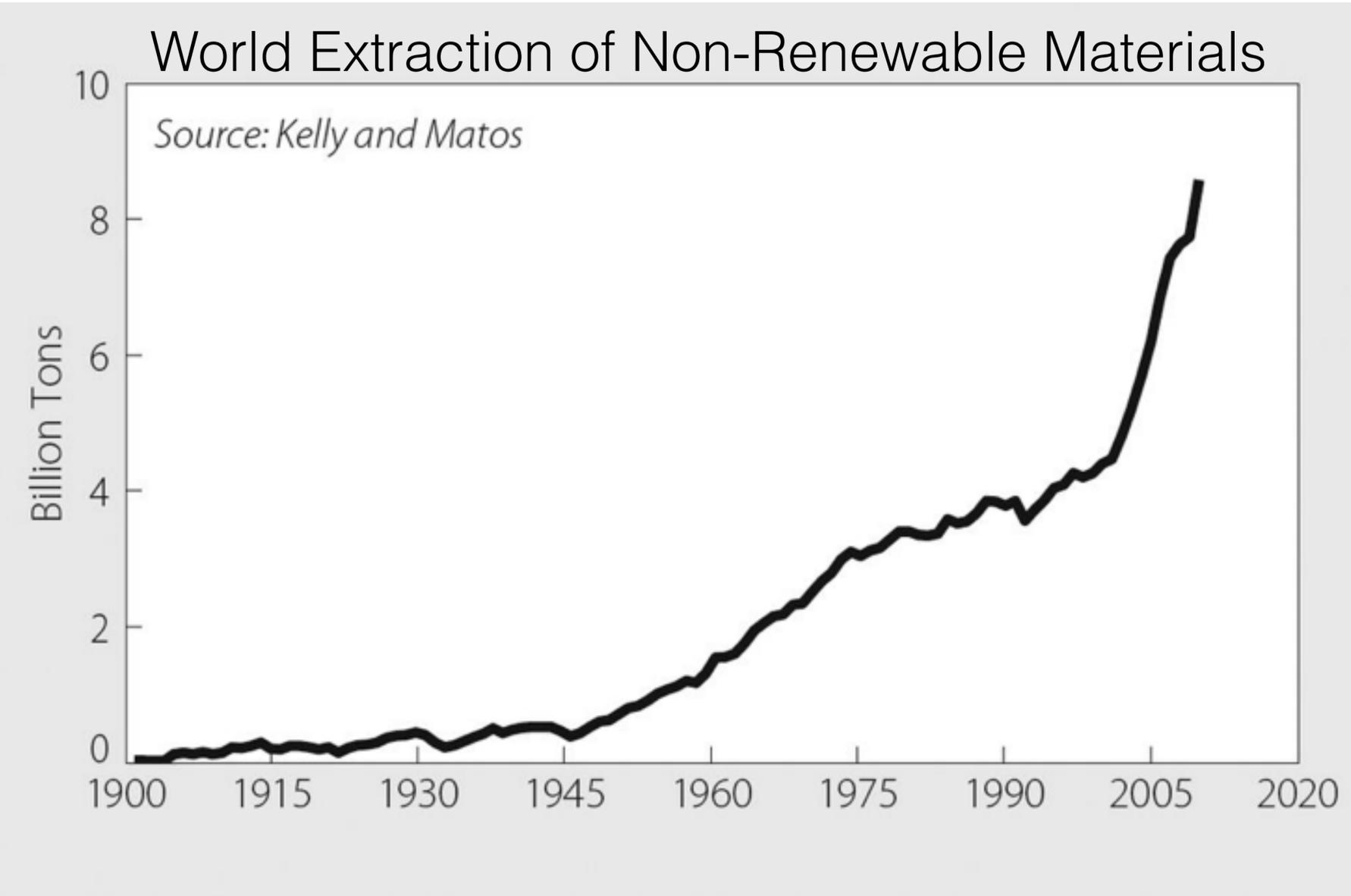
# Syndrome of Modern Global Change

---

Our economy depends on increasing flows:

# Syndrome of Modern Global Change

Our economy depends on increasing flows:

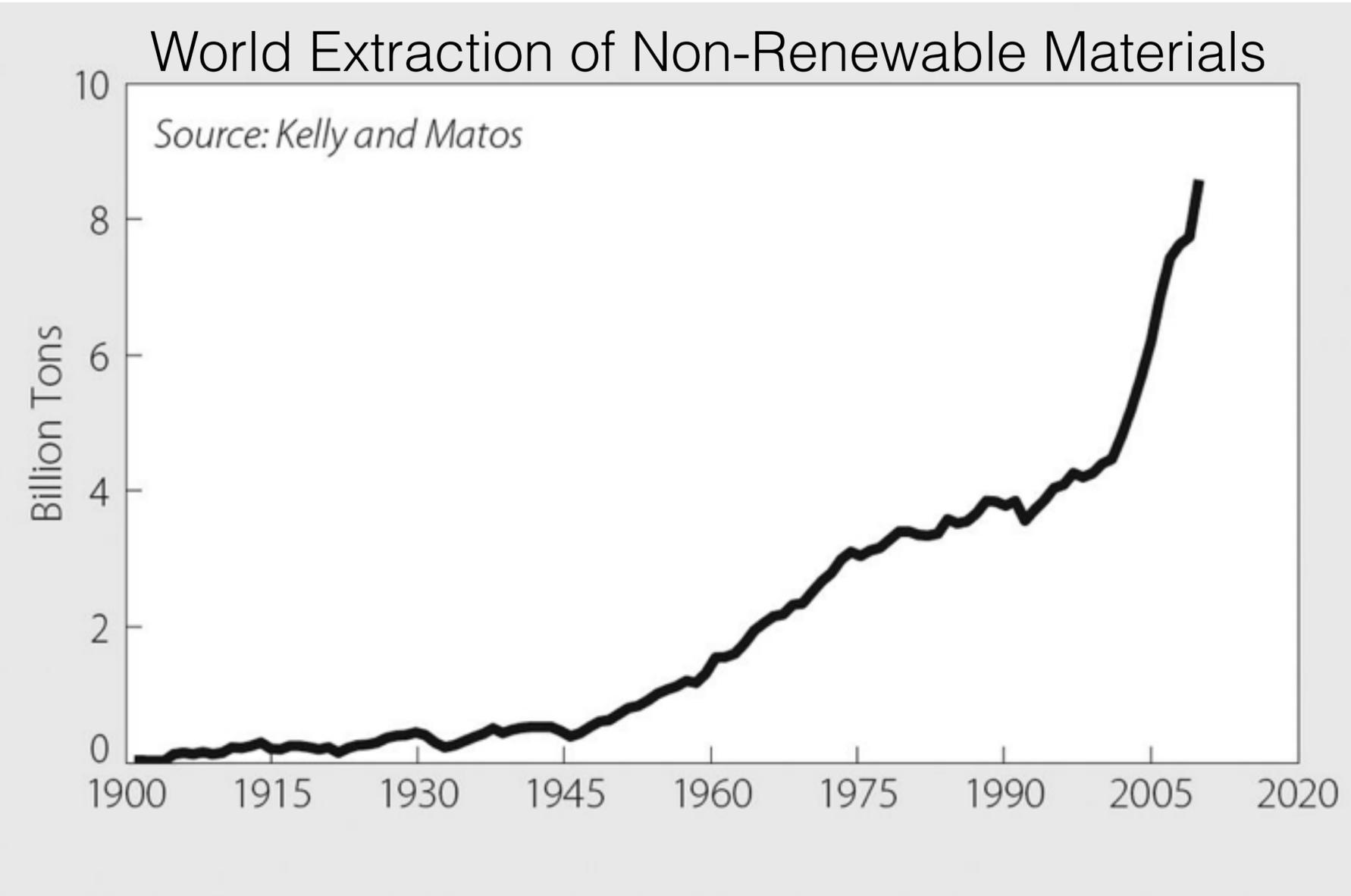


# Syndrome of Modern Global Change

Our economy depends on increasing flows:

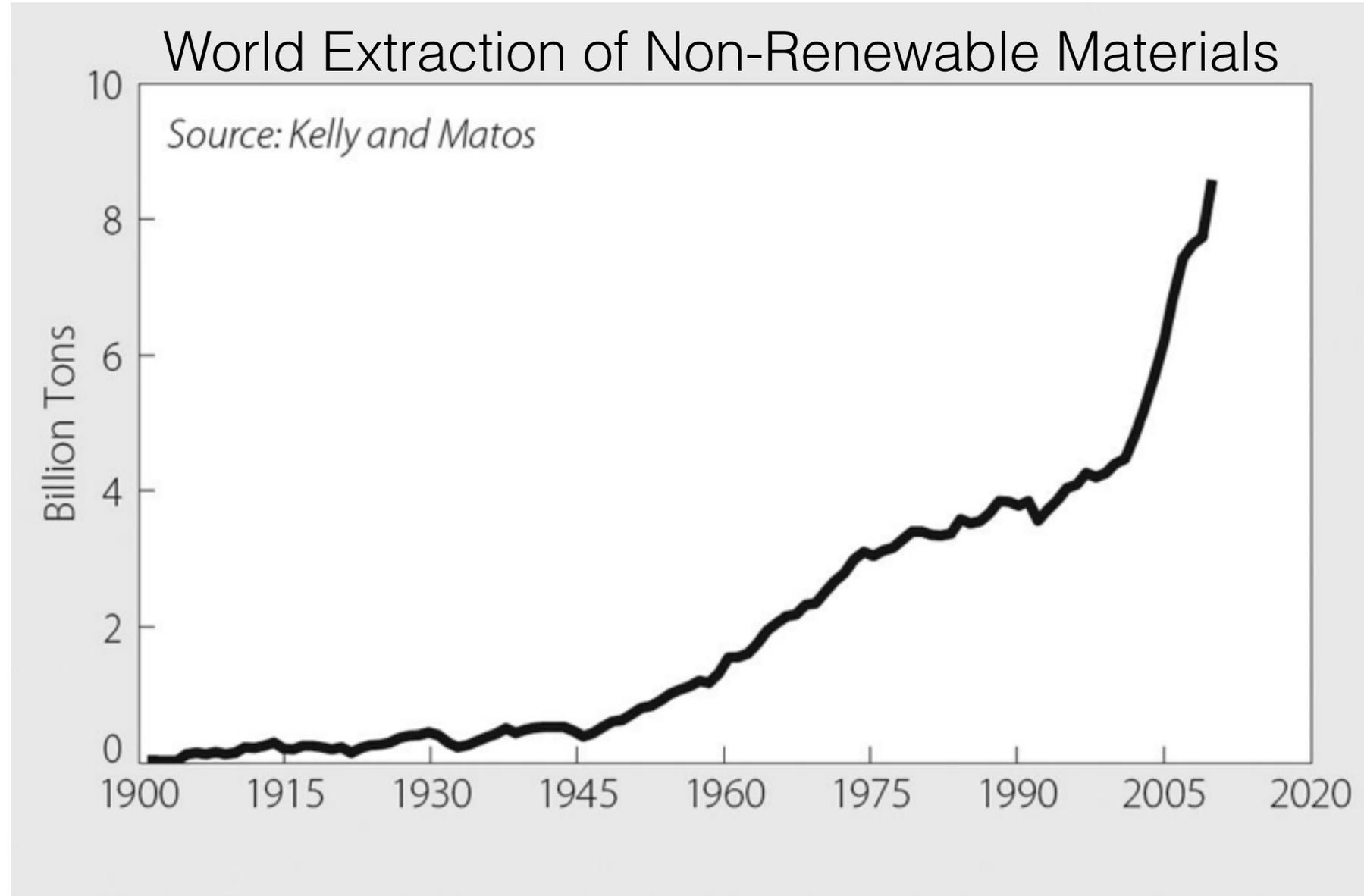
In 2008, people around the world used 68 billion tons of materials, including metals and minerals, fossil fuels, and biomass. That is an average of 10 tons per person— or 27 kilograms each and every day. That same year, humanity used the biocapacity of 1.5 planets, consuming far beyond what the Earth can sustainably provide.

*Assadourian, 2013*



# Syndrome of Modern Global Change

Our economy depends on increasing flows:



In 2008, people around the world used 68 billion tons of materials, including metals and minerals, fossil fuels, and biomass. That is an average of 10 tons per person—or 27 kilograms each and every day. That same year, humanity used the biocapacity of 1.5 planets, consuming far beyond what the Earth can sustainably provide.

*Assadourian, 2013*

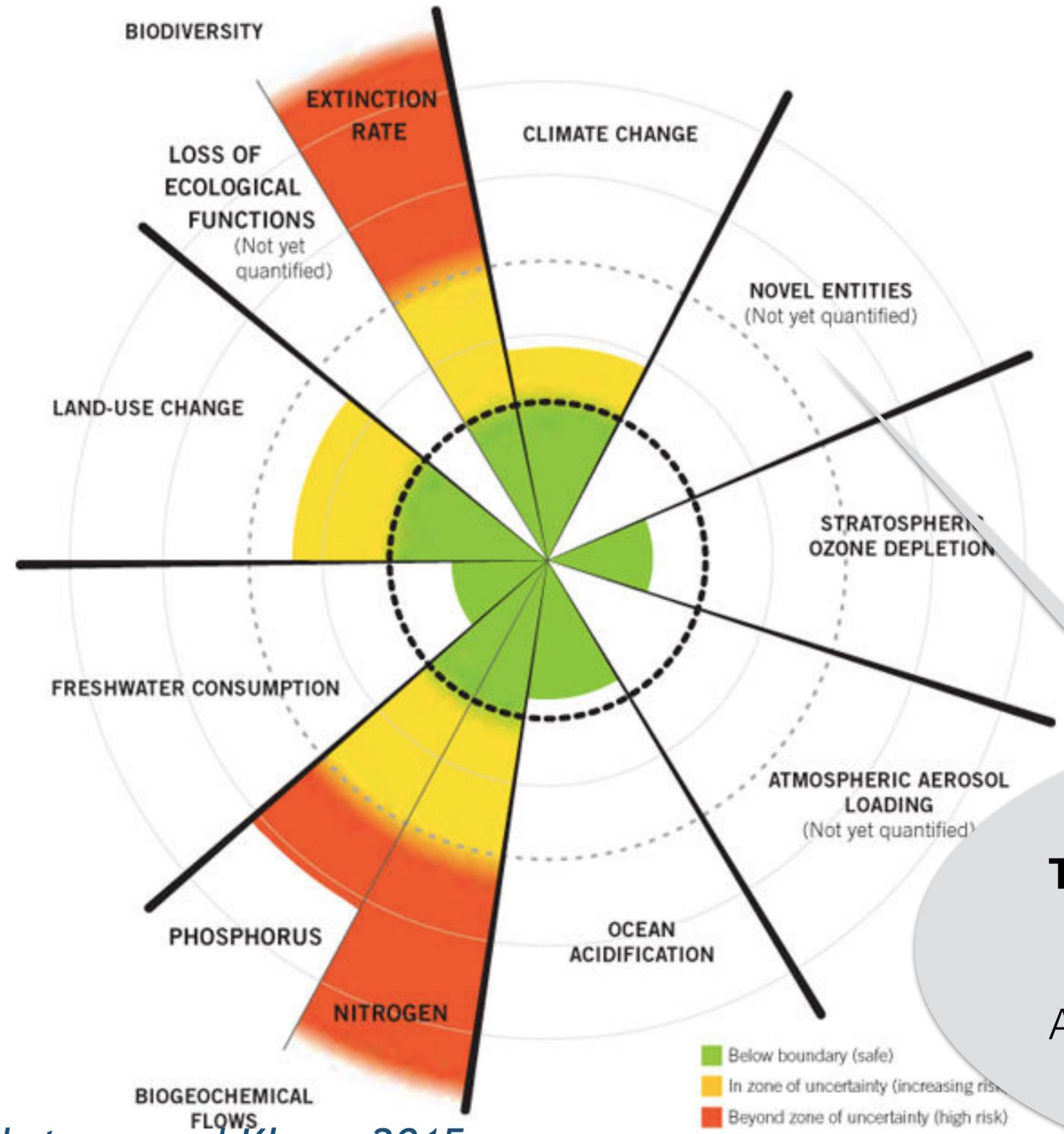
The urban population in the developing world will double by 2030. The implications are staggering. One is that we have 20 years to build as much urban housing as was built in the past 6,000.

*Reinhard Goethert, School of Architecture and Planning, MIT, 2010.*



# Syndrom of Modern Global Change

The Holocene was a “safe operating space for humanity”



**The urgent challenge of plastics**  
448 Million tons in 2015  
Average use time: 5 years  
Average lifetime: 1000-5000 years

*Rockstrom and Klum, 2015*

# Syndrome of Mod

## A LIFETIME OF PLASTIC

The first plastics made from fossil fuels are just over a century old. They came into widespread use after World War II and are found today in everything from cars to medical devices to food packaging. Their useful lifetime varies. Once disposed of, they break down into smaller fragments that linger for centuries.

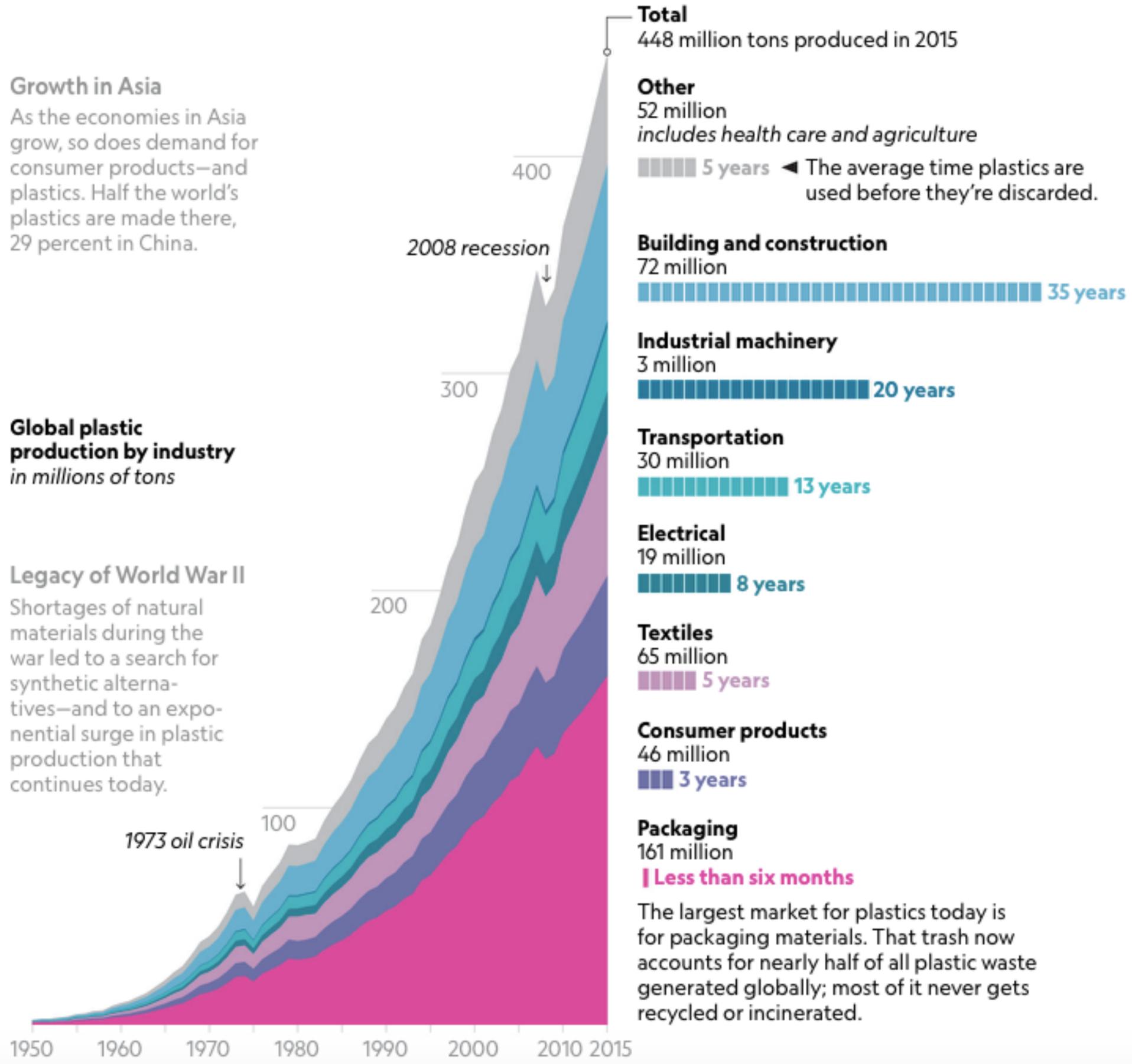
### Growth in Asia

As the economies in Asia grow, so does demand for consumer products—and plastics. Half the world's plastics are made there, 29 percent in China.

### Global plastic production by industry in millions of tons

### Legacy of World War II

Shortages of natural materials during the war led to a search for synthetic alternatives—and to an exponential surge in plastic production that continues today.

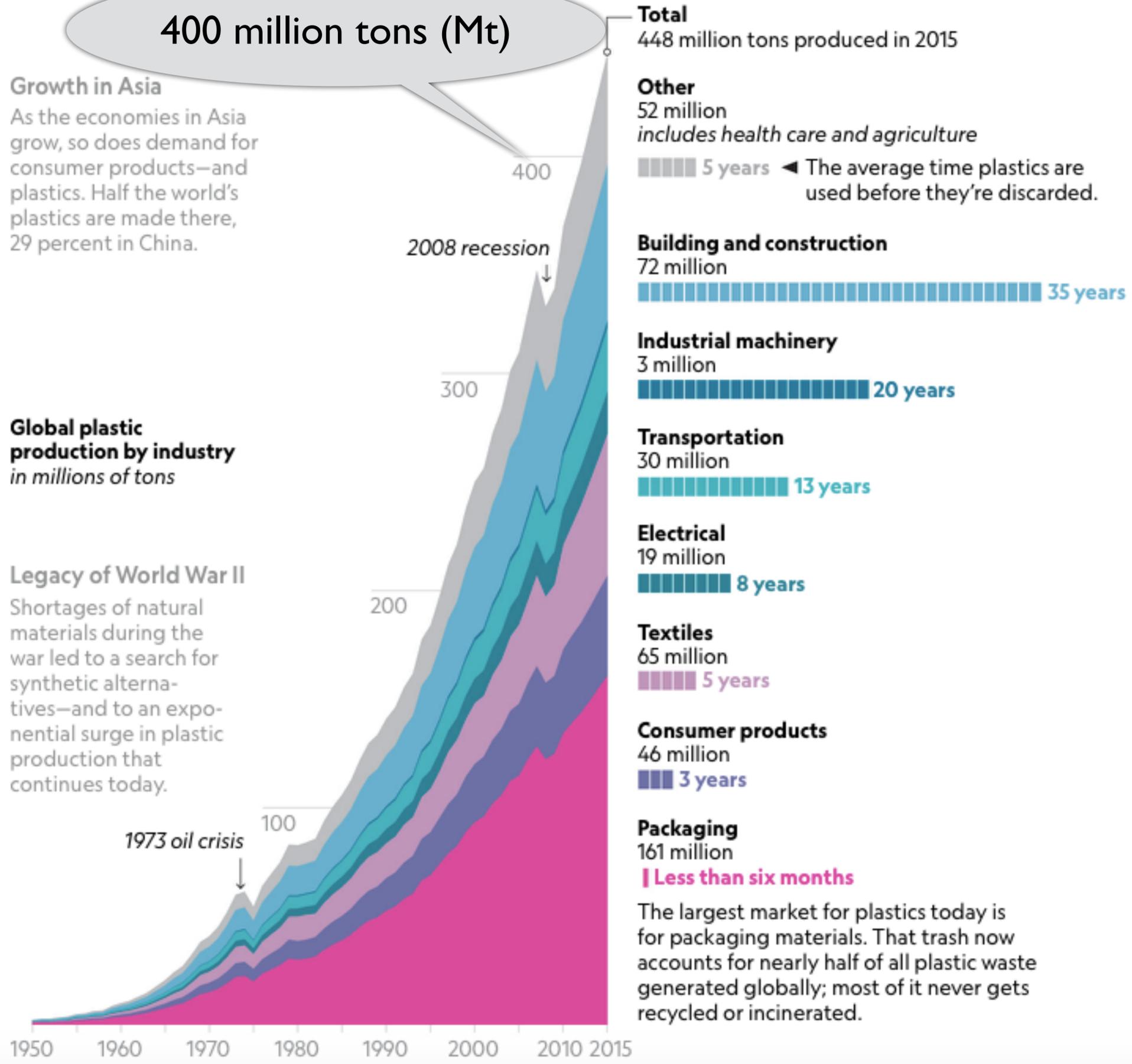


JASON TREAT AND RYAN WILLIAMS, NGM STAFF  
SOURCE: ROLAND GEYER, UNIVERSITY OF CALIFORNIA, SANTA BARBARA

# Syndrome of Mod

## A LIFETIME OF PLASTIC

The first plastics made from fossil fuels are just over a century old. They came into widespread use after World War II and are found today in everything from cars to medical devices to food packaging. Their useful lifetime varies. Once disposed of, they break down into smaller fragments that linger for centuries.

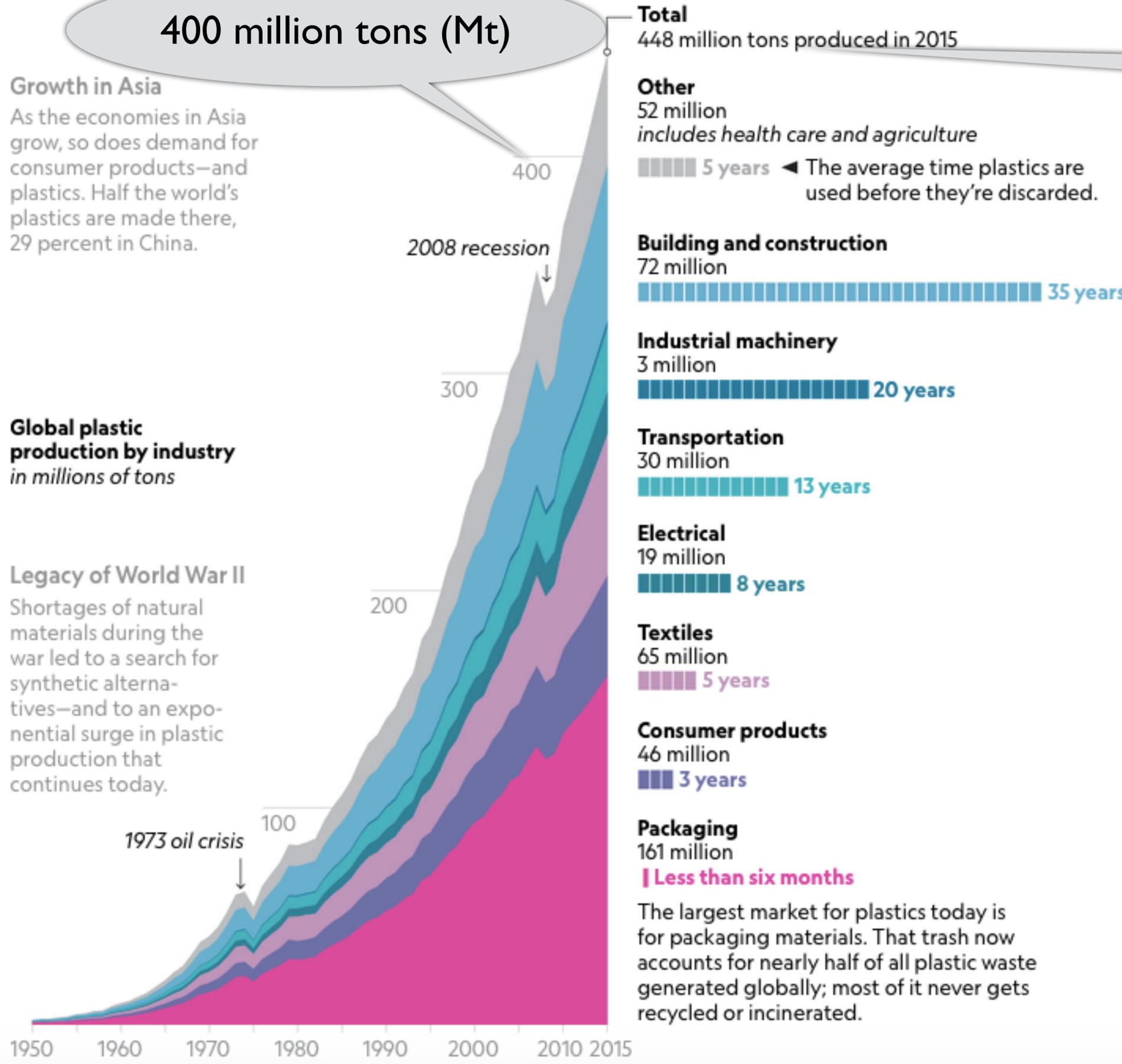


JASON TREAT AND RYAN WILLIAMS, NGM STAFF  
SOURCE: ROLAND GEYER, UNIVERSITY OF CALIFORNIA, SANTA BARBARA

# Syndrome of Mod

## A LIFETIME OF PLASTIC

The first plastics made from fossil fuels are just over a century old. They came into widespread use after World War II and are found today in everything from cars to medical devices to food packaging. Their useful lifetime varies. Once disposed of, they break down into smaller fragments that linger for centuries.

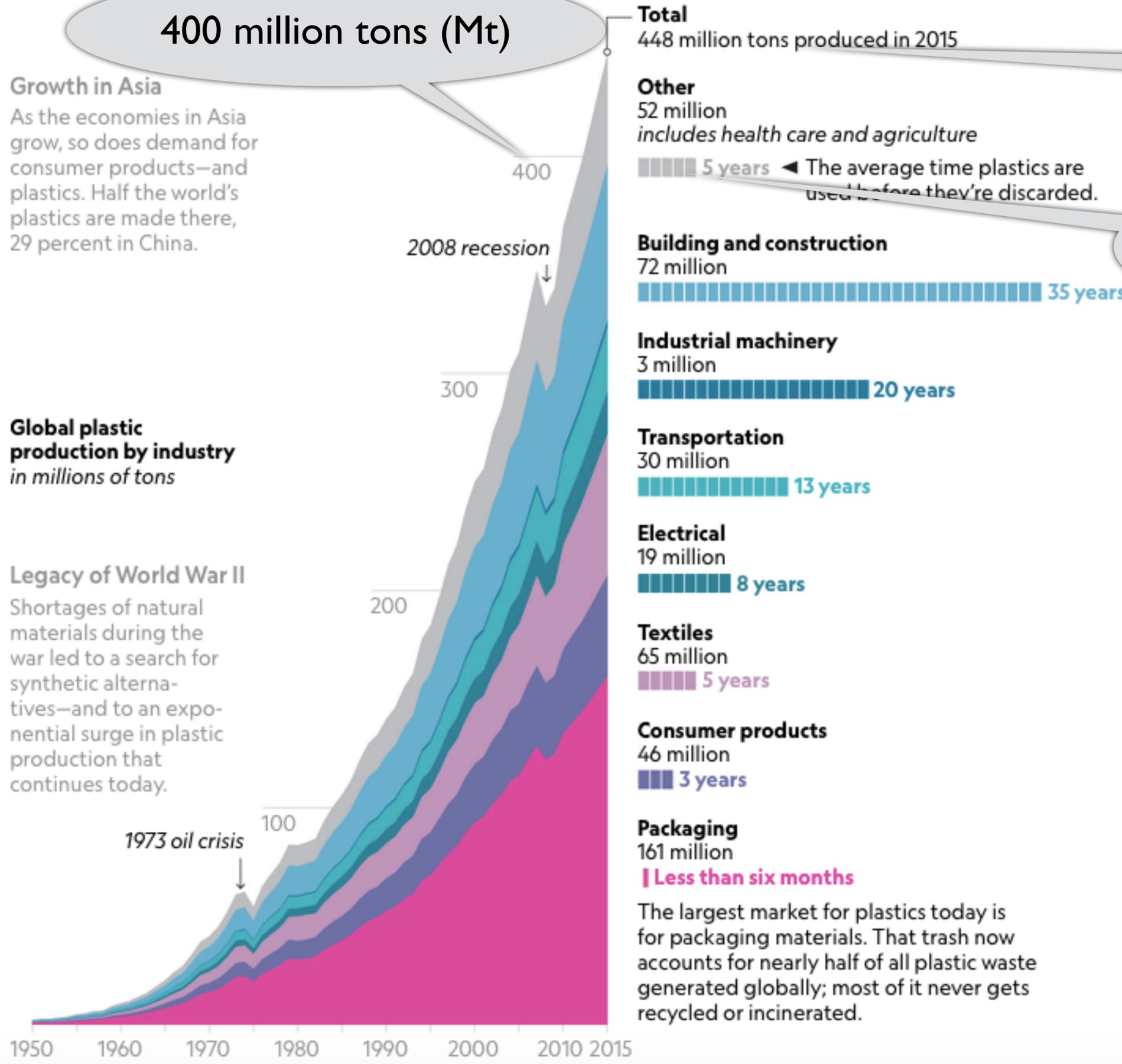


JASON TREAT AND RYAN WILLIAMS, NGM STAFF  
SOURCE: ROLAND GEYER, UNIVERSITY OF CALIFORNIA, SANTA BARBARA

# Syndrome of Mod

## A LIFETIME OF PLASTIC

The first plastics made from fossil fuels are just over a century old. They came into widespread use after World War II and are found today in everything from cars to medical devices to food packaging. Their useful lifetime varies. Once disposed of, they break down into smaller fragments that linger for centuries.



**448 Mt in 2015**

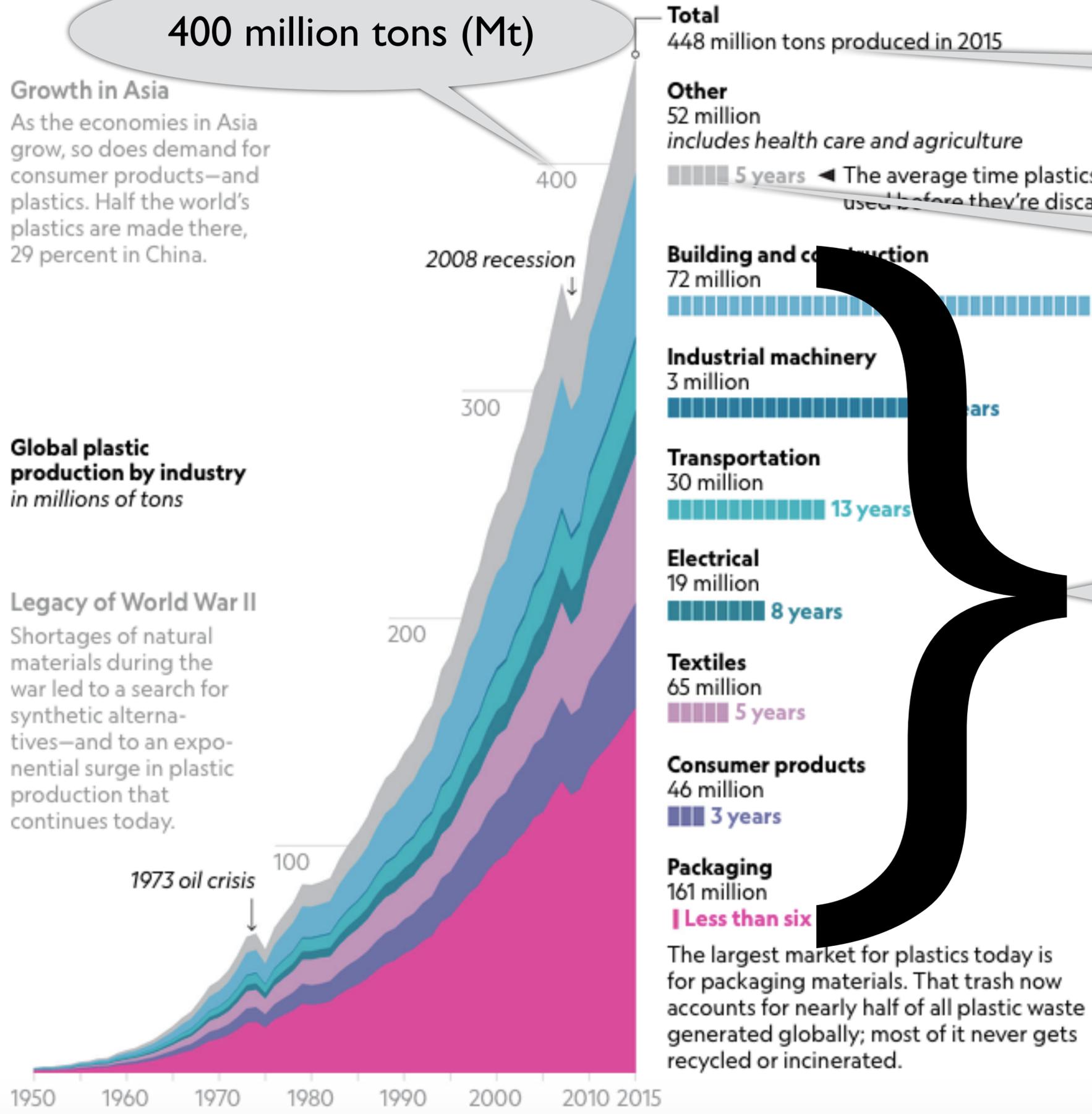
**Average usetime: 5 years**

JASON TREAT AND RYAN WILLIAMS, NGM STAFF  
SOURCE: ROLAND GEYER, UNIVERSITY OF CALIFORNIA, SANTA BARBARA

# Syndrom of Mod

## A LIFETIME OF PLASTIC

The first plastics made from fossil fuels are just over a century old. They came into widespread use after World War II and are found today in everything from cars to medical devices to food packaging. Their useful lifetime varies. Once disposed of, they break down into smaller fragments that linger for centuries.



448 Mt in 2015

Average usetime: 5 years

Build.+Const.:	72 Mt, 35 yrs
Industrial mach.:	3 Mt, 20 yrs
Transportation:	30 Mt, 13 yrs
Electrical:	19 Mt, 8 yrs
Textiles:	65 Mt, 5 yrs
Consum. prod.:	46 Mt, 3 yrs
Packaging:	161 Mt, <0.5 yrs

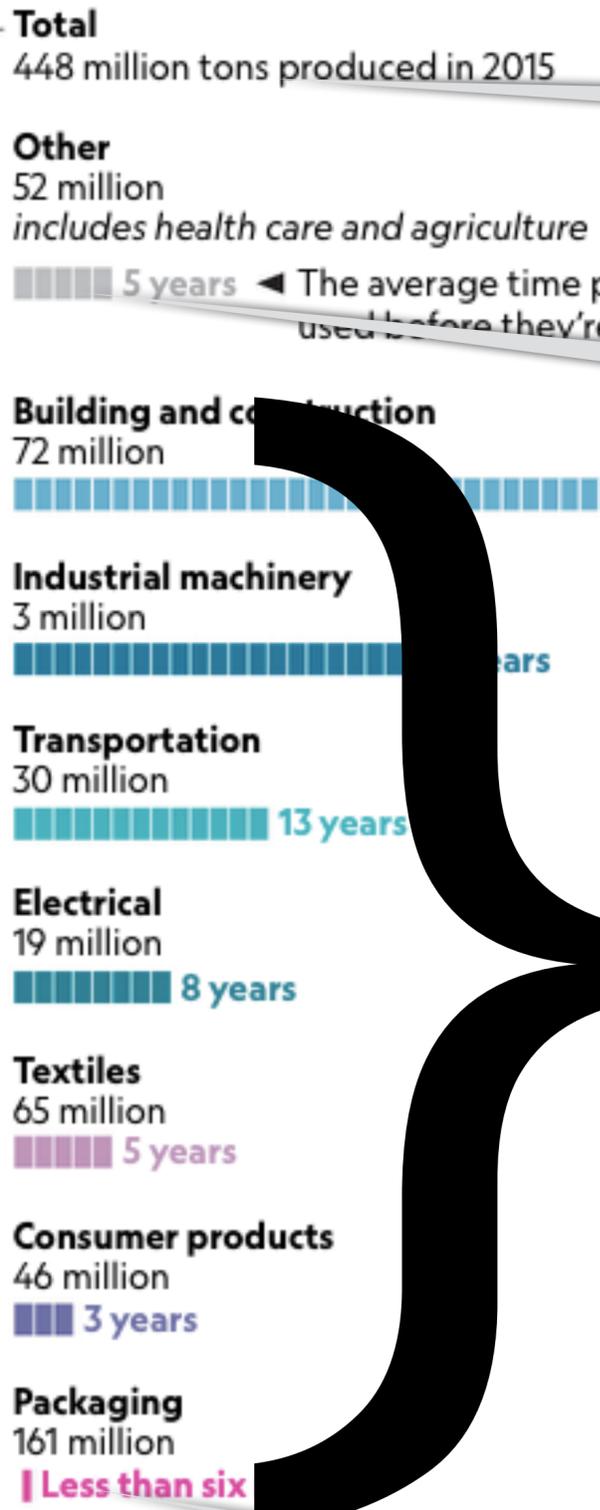
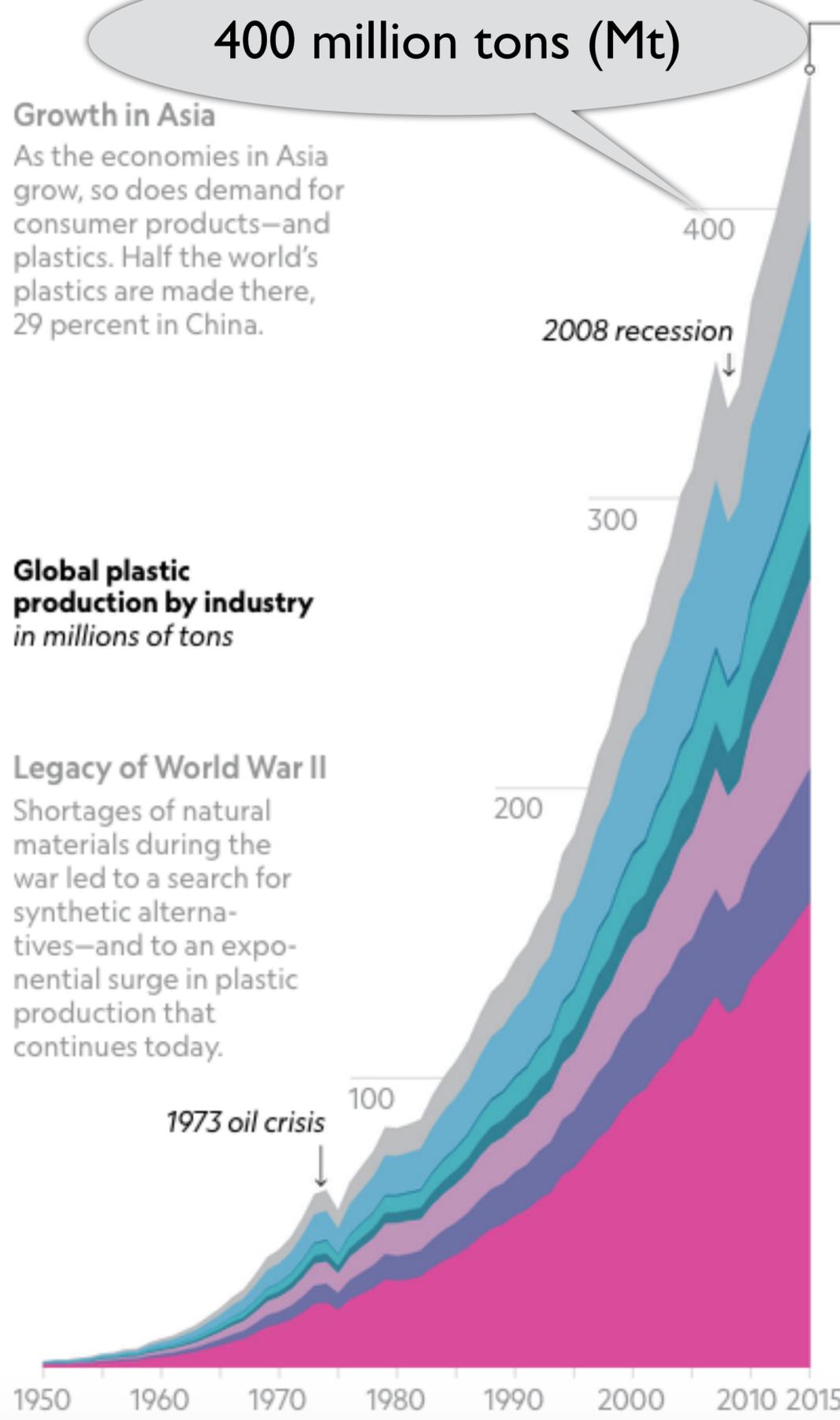
The largest market for plastics today is for packaging materials. That trash now accounts for nearly half of all plastic waste generated globally; most of it never gets recycled or incinerated.

JASON TREAT AND RYAN WILLIAMS, NGM STAFF  
SOURCE: ROLAND GEYER, UNIVERSITY OF CALIFORNIA, SANTA BARBARA

# Syndrome of Mod

## A LIFETIME OF PLASTIC

The first plastics made from fossil fuels are just over a century old. They came into widespread use after World War II and are found today in everything from cars to medical devices to food packaging. Their useful lifetime varies. Once disposed of, they break down into smaller fragments that linger for centuries.



**448 Mt in 2015**

**Average usetime: 5 years**

Build.+Const.:	72 Mt, 35 yrs
Industrial mach.:	3 Mt, 20 yrs
Transportation:	30 Mt, 13 yrs
Electrical:	19 Mt, 8 yrs
Textiles:	65 Mt, 5 yrs
Consum. prod.:	46 Mt, 3 yrs
Packaging:	161 Mt, <0.5 yrs

**161Mt < 6 months**

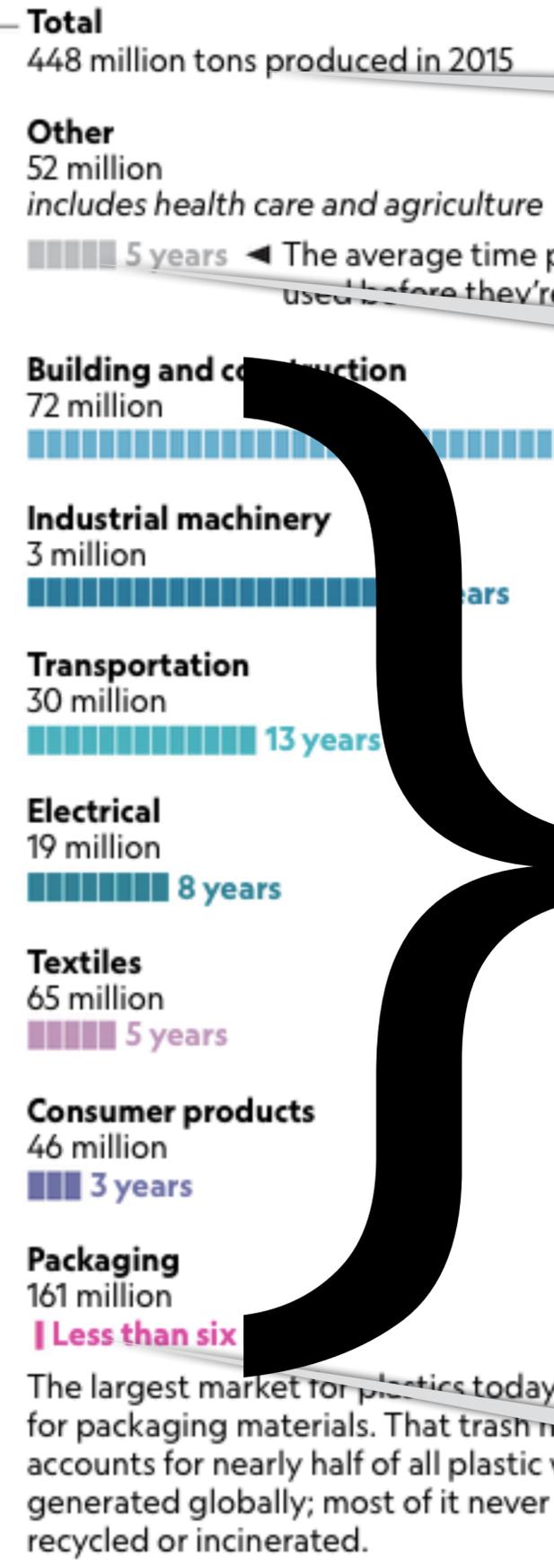
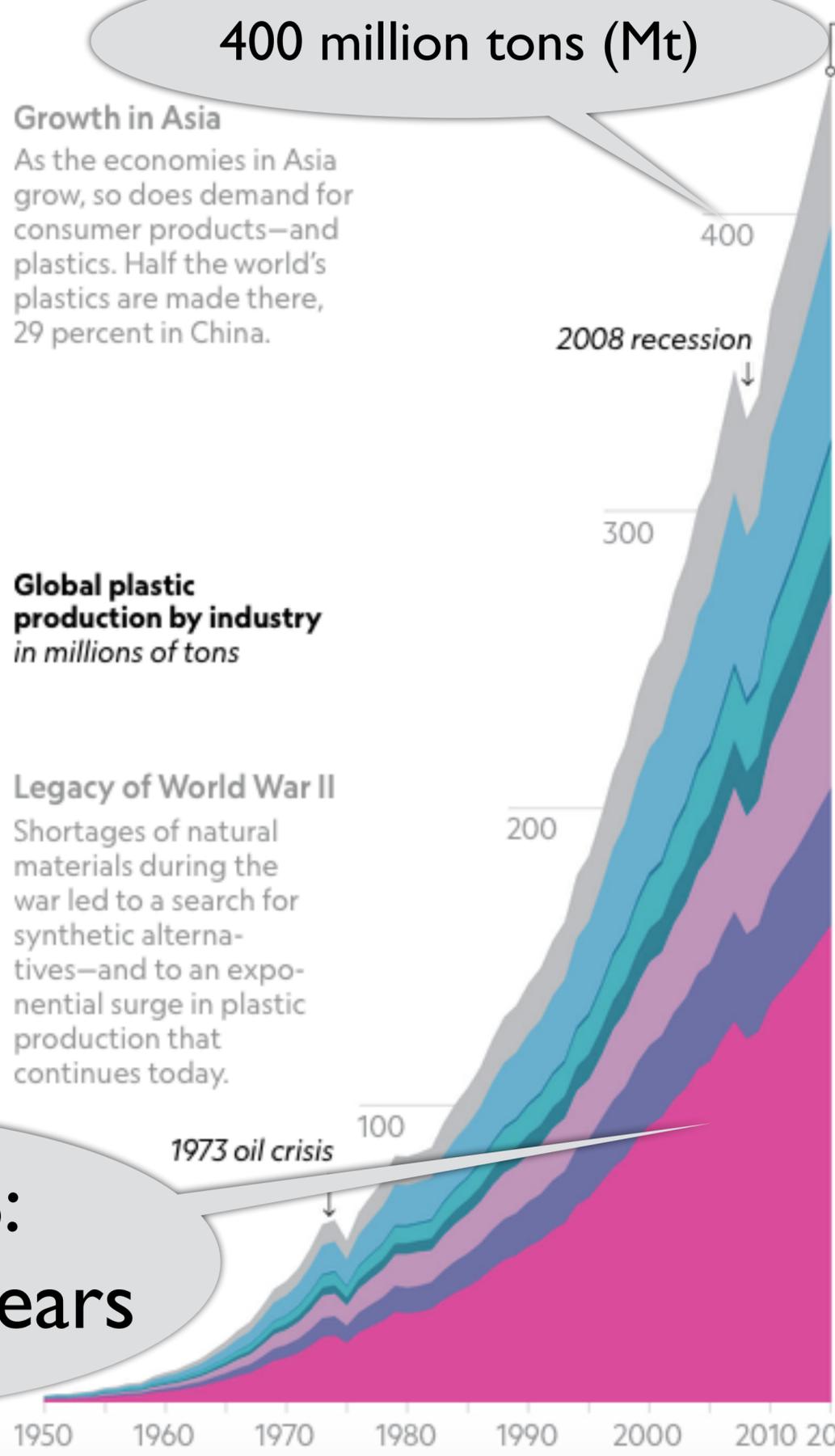
The largest market for plastics today is for packaging materials. That trash now accounts for nearly half of all plastic waste generated globally; most of it never gets recycled or incinerated.

JASON TREAT AND RYAN WILLIAMS, NGM STAFF  
SOURCE: ROLAND GEYER, UNIVERSITY OF CALIFORNIA, SANTA BARBARA

# Syndrome of Mod

## A LIFETIME OF PLASTIC

The first plastics made from fossil fuels are just over a century old. They came into widespread use after World War II and are found today in everything from cars to medical devices to food packaging. Their useful lifetime varies. Once disposed of, they break down into smaller fragments that linger for centuries.



**448 Mt in 2015**

**Average usetime: 5 years**

Build.+Const.:	72 Mt, 35 yrs
Industrial mach.:	3 Mt, 20 yrs
Transportation:	30 Mt, 13 yrs
Electrical:	19 Mt, 8 yrs
Textiles:	65 Mt, 5 yrs
Consum. prod.:	46 Mt, 3 yrs
Packaging:	161 Mt, <0.5 yrs

**LIFETIMES:  
100 to 5000 years**

**161Mt < 6 months**

JASON TREAT AND RYAN WILLIAMS, NGM STAFF  
SOURCE: ROLAND GEYER, UNIVERSITY OF CALIFORNIA, SANTA BARBARA

# Syndrome of Mod

## A LIFETIME OF PLASTIC

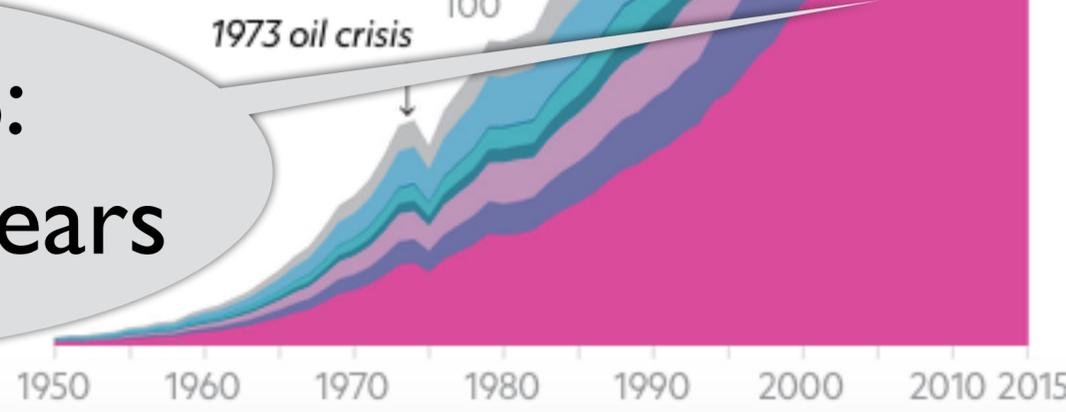
The first plastics made from fossil fuels are just over a century old. They came into widespread use after World War II and are found today in everything from cars to medical devices to food packaging. Their useful lifetime varies. Once disposed of, they break down into smaller fragments that linger for centuries.

### Growth in Asia

As the economies in Asia grow, so does demand for consumer products—and plastics. Half the world's plastics are made there, 29 percent in China.

### Global plastic production by industry in millions of tons

**Legacy of World War II**  
Shortages of natural materials during the war led to a search for synthetic alternatives—and to an exponential surge in plastic production that continues today.



400 million tons (Mt)

**Total**  
448 million tons produced in 2015

448 Mt in 2015

**Other**  
52 million  
includes health care and agriculture

5 years ← The average time plastics are used before they're discarded.

Average usetime:  
5 years

**Building and construction**  
72 million  
35 years

Production contributes as much CO<sub>2</sub> emission as 40 million cars

**Transportation**  
30 million  
13 years

Build.+Const.:	72 Mt, 35 yrs
Industrial mach.:	3 Mt, 20 yrs
Transportation:	30 Mt, 13 yrs
Electrical:	19 Mt, 8 yrs
Textiles:	65 Mt, 5 yrs
Consum. prod.:	46 Mt, 3 yrs
Packaging:	161 Mt, <0.5 yrs

**Electrical**  
19 million  
8 years

**Textiles**  
65 million  
5 years

**Consumer products**  
46 million  
3 years

**Packaging**  
161 million  
Less than six

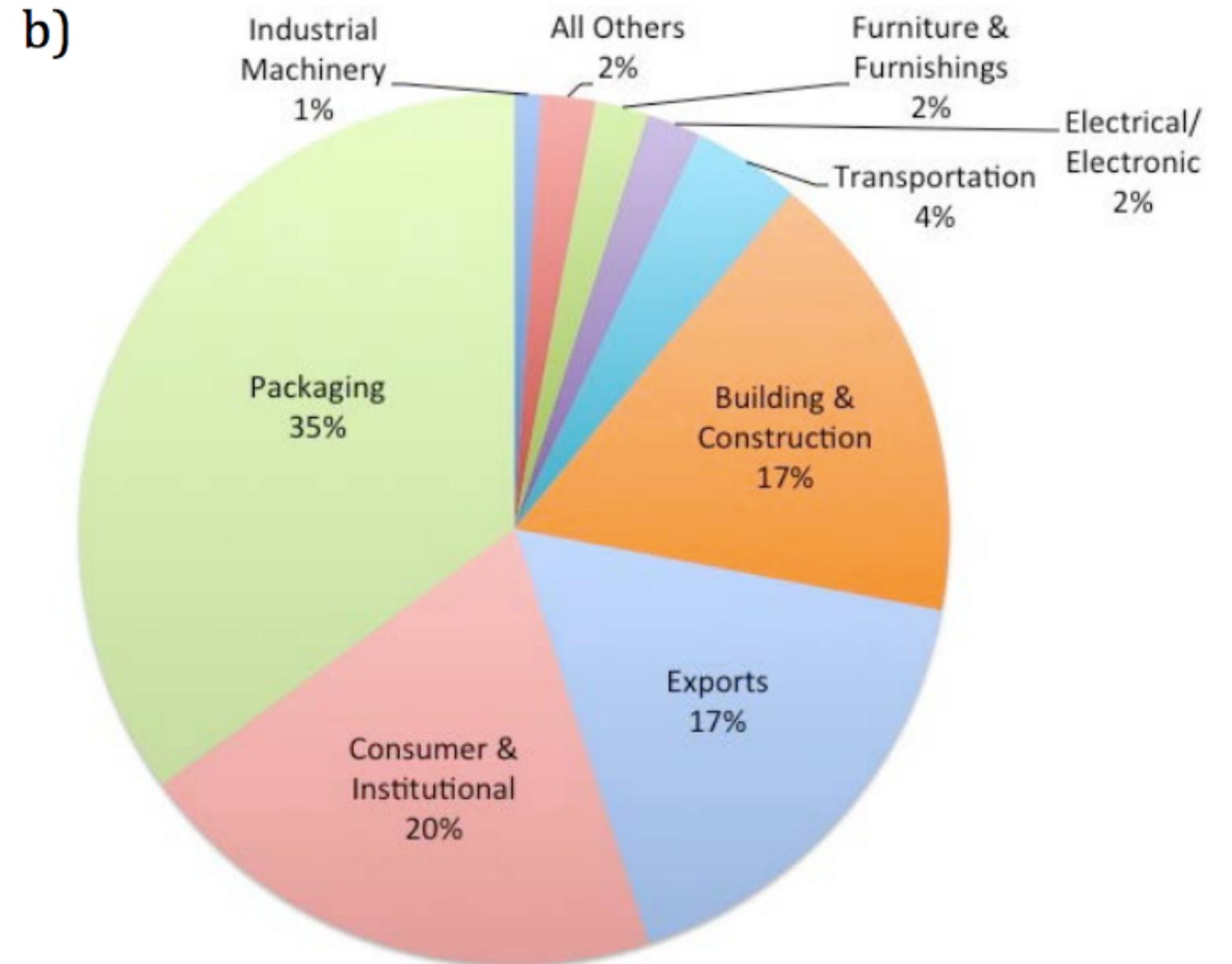
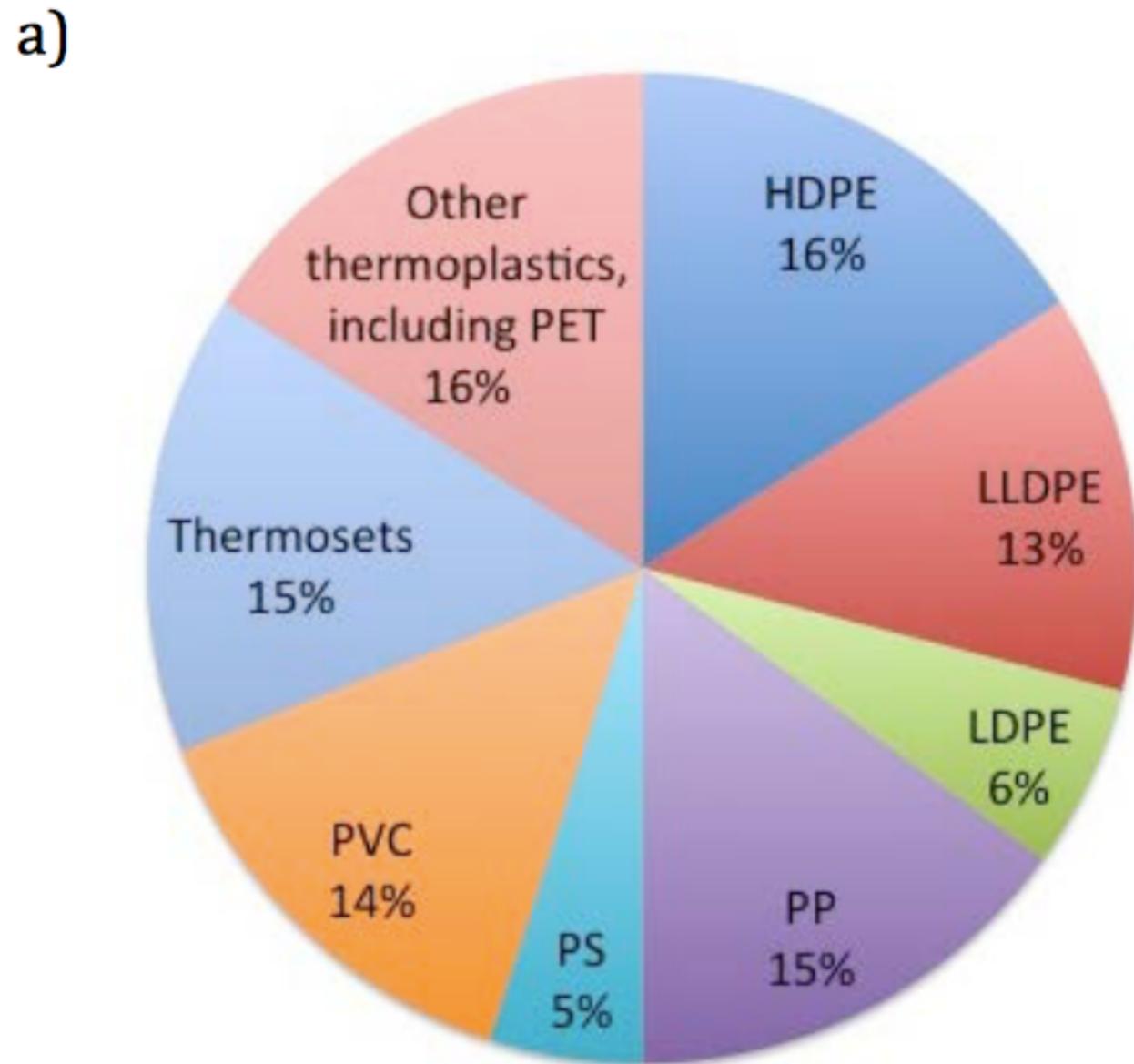
The largest market for plastics today is for packaging materials. That trash now accounts for nearly half of all plastic waste generated globally; most of it never gets recycled or incinerated.

161Mt < 6 months

LIFETIMES:  
100 to 5000 years

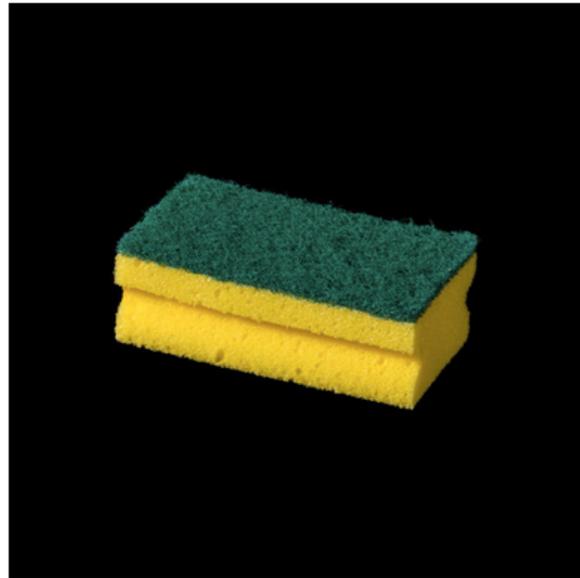
JASON TREAT AND RYAN WILLIAMS, NGM STAFF  
SOURCE: ROLAND GEYER, UNIVERSITY OF CALIFORNIA, SANTA BARBARA

# What we Know: Plastic is produced a lot



Supplemental Figure 1. (a) Percent distribution of U.S. production of plastic resins in 2014. HDPE = High Density Polyethylene; LLDPE = Linear Low Density Polyethylene; LDPE = Low Density Polyethylene; PP = Polypropylene; PS = Polystyrene; PVC = Polyvinyl Chloride; PET = Polyethylene Terephthalate. (b) Percent distribution of U.S. resin sales and captive use of thermoplastics (all materials shown in top panel except thermosets) according to major markets in 2014. Source: American Chemistry Council (2015). From

# What we Know: Plastic is used by everybody for everything



**POLYURETHANE (PU)**



**POLYCARBONATE (PC)**



**POLYSTYRENE (PS)**



**POLYETHYLENE (PE)**



**POLYPROPYLENE (PP)**



**POLYVINYL CHLORIDE**



**POLYETHYLENE TEREPHTHALATE (PET)**

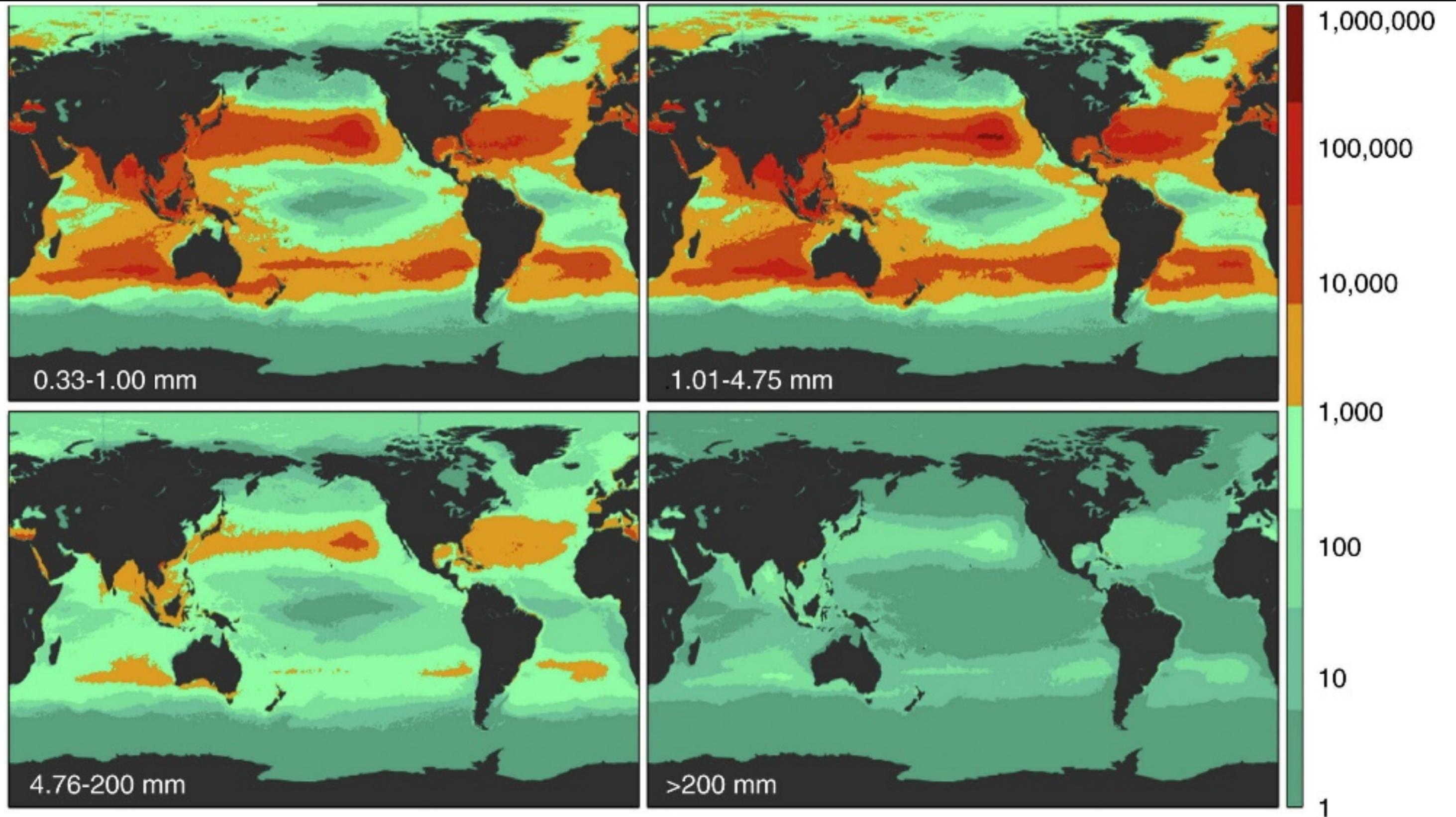


**BIODEGRADABLE PLASTICS**

# What we Know: Plastic is used by everybody for everything



# What we Know: Plastic is found everywhere



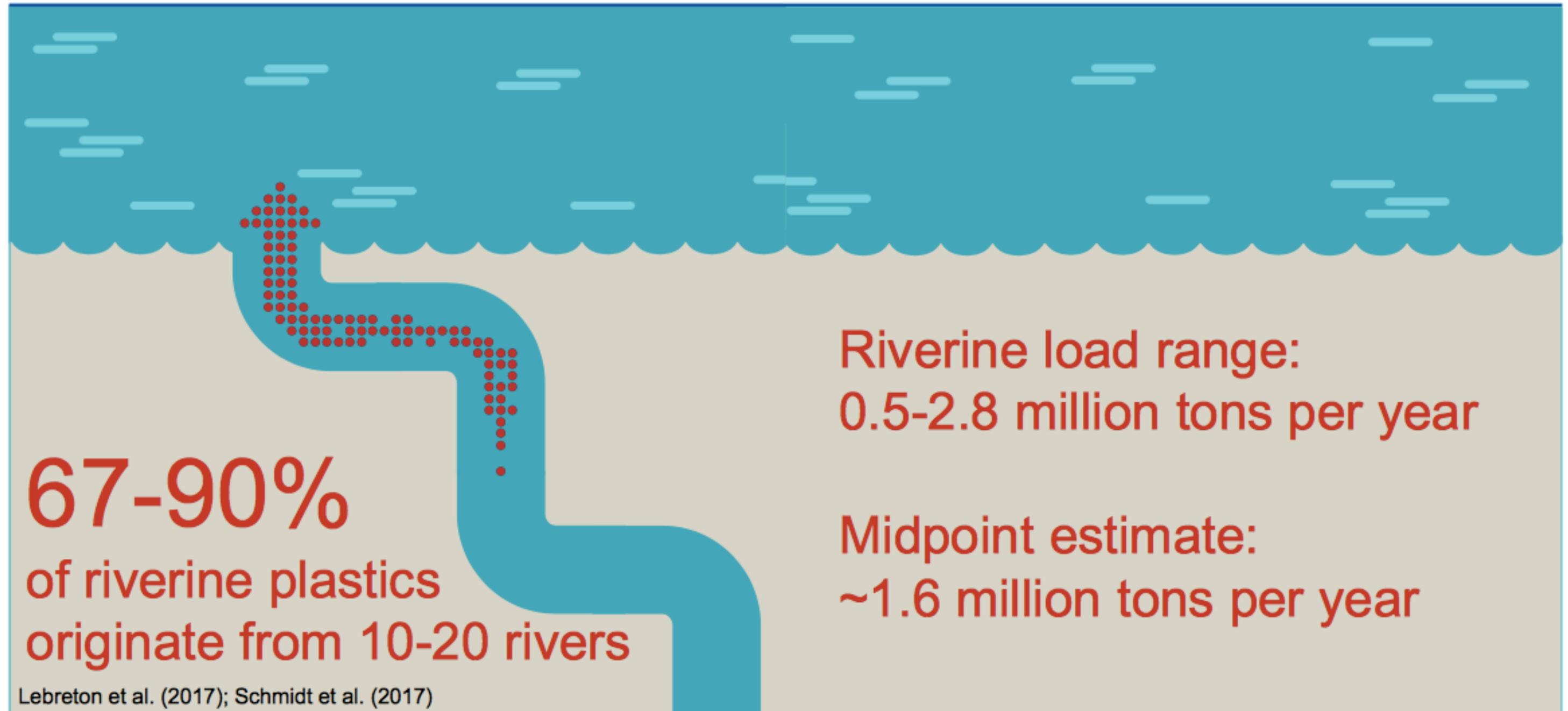
## 'Everywhere we looked': trillions of microplastics found in San Francisco bay

**Most comprehensive study to date finds plastic in sediment collected from bay and tributaries and digestive tracts of fish**



▲ A plastic bottle floating in the ocean in the San Francisco bay. An estimated 7tn pieces of microplastics flow into the San Francisco bay via stormwater drains. Photograph: Sebastian Kennerknecht/Alamy

## Rivers as a source for marine litter



# What we Know: Plastic is found everywhere

## The pathway by which plastic enters the world's oceans

Our World  
in Data

Estimates of global plastics entering the oceans from land-based sources in 2010 based on the pathway from primary production through to marine plastic inputs.

**Global primary plastic production:  
270 million tonnes per year**

**Global plastic waste:  
275 million tonnes per year**

It can exceed primary production in a given year since it can incorporate production from previous years.

**Coastal plastic waste:  
99.5 million tonnes per**

This is the total of plastic waste generated by all populations within 50 kilometres of a coastline (therefore at risk of entering the ocean).

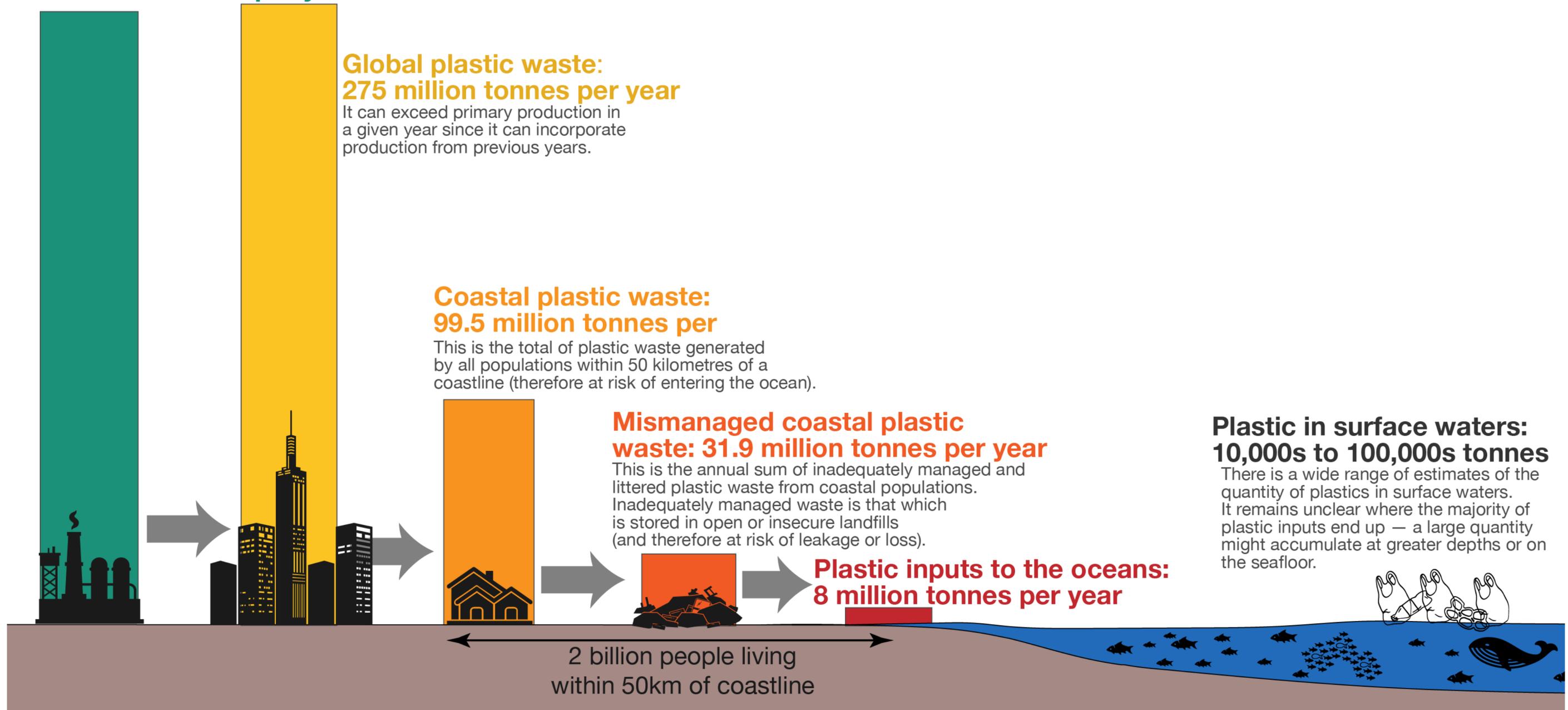
**Mismanaged coastal plastic waste:  
31.9 million tonnes per year**

This is the annual sum of inadequately managed and littered plastic waste from coastal populations. Inadequately managed waste is that which is stored in open or insecure landfills (and therefore at risk of leakage or loss).

**Plastic inputs to the oceans:  
8 million tonnes per year**

**Plastic in surface waters:  
10,000s to 100,000s tonnes**

There is a wide range of estimates of the quantity of plastics in surface waters. It remains unclear where the majority of plastic inputs end up — a large quantity might accumulate at greater depths or on the seafloor.



Source: based on Jambeck et al. (2015) and Eriksen et al. (2014). Icon graphics from Noun Project.

Data is based on global estimates from Jambeck et al. (2015) based on plastic waste generation rates, coastal population sizes, and waste management practices by country

This is a visualization from [OurWorldinData.org](http://OurWorldinData.org), where you will find data and research on how the world is changing.

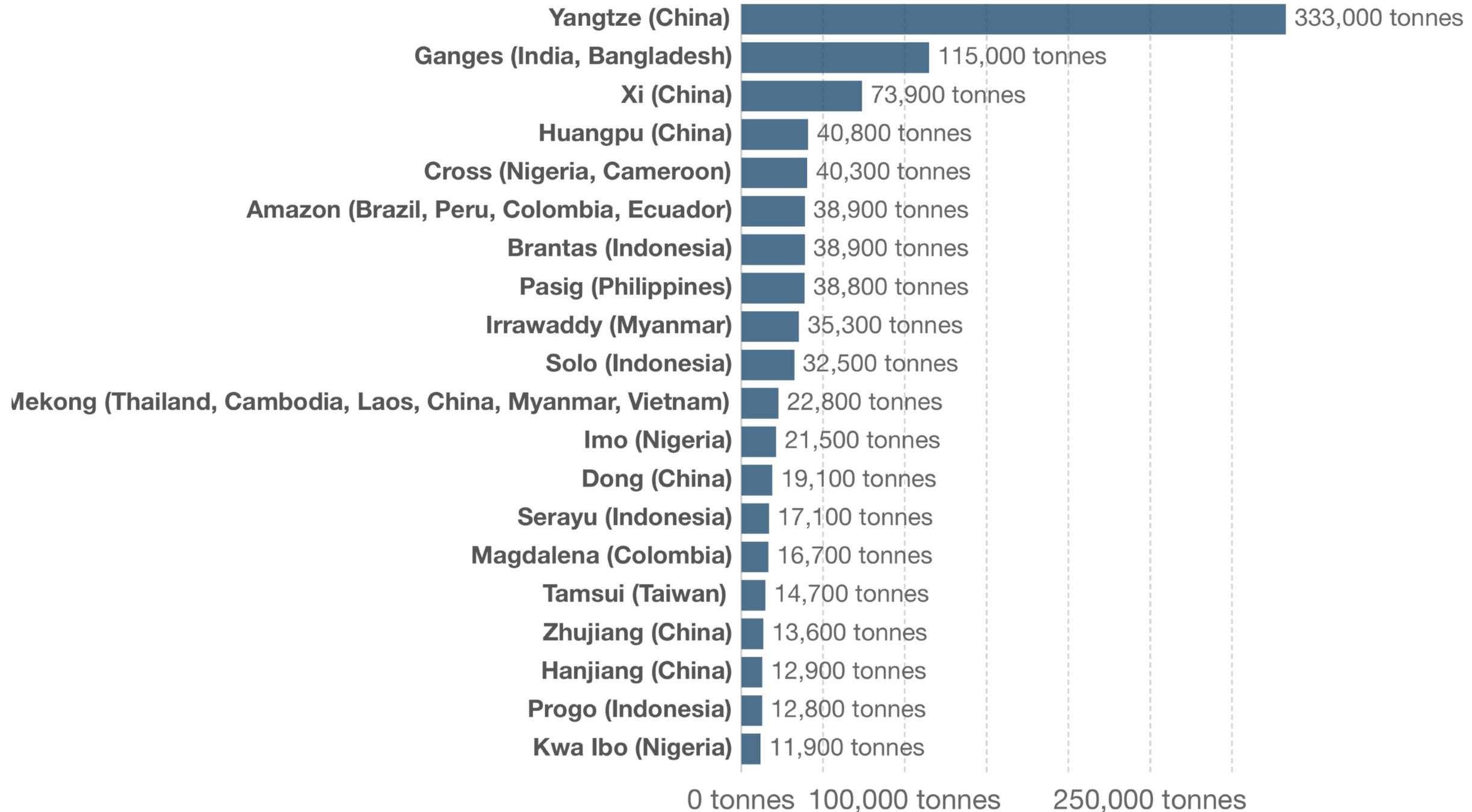
Licensed under [CC-BY-SA](https://creativecommons.org/licenses/by-sa/4.0/) by the authors.

# What we Know: Plastic is found everywhere

## Plastic ocean input from top 20 rivers, 2015

Our World  
in Data

Plastic input to the ocean from the top 20 polluting rivers across the world. Shown is the given river, its location, and estimated annual input of plastic to the oceans in tonnes.



# What we Know: Plastic is found everywhere



U.S. Department of the Interior  
U.S. Geological Survey

Open-File Report 2019-1048

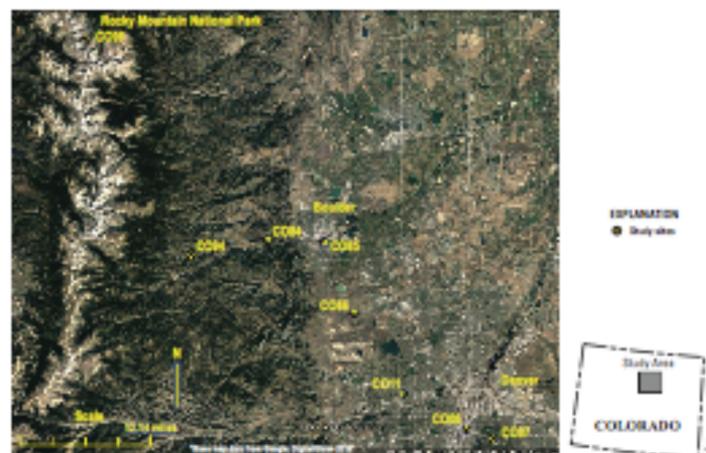
## It is Raining Plastic.

By Gregory Wetherbee,<sup>1</sup> Austin Baldwin,<sup>2</sup> James Ranville<sup>3</sup>

<sup>1</sup>USGS, Hydrologic Networks Branch, Denver, Colorado; <sup>2</sup>USGS, Water Science Center, Boise, Idaho; <sup>3</sup>Colorado School of Mines, Golden, Colorado

### Overview

Atmospheric wet deposition samples were collected using the National Atmospheric Deposition Program/National Trends Network (NADP/NTN) at eight sites (see map) in the Colorado Front Range. Plastics were identified in more than 90 percent of the samples. The plastic materials were mostly fibers that were only visible with magnification, approximately 20–40 times (X). Fibers were present in a variety of colors; the most frequently observed color was blue followed by red>silver>purple>green>yellow>other colors. Plastic particles such as beads and shards were also observed with magnification. More plastic fibers were observed in samples from urban sites than from remote, mountainous sites. However, frequent observation of plastic fibers in washout samples from the remote site CO98 at Loch Vale in Rocky Mountain National Park (elevation 3,159 meters) suggests that wet deposition of plastic is ubiquitous and not just an urban condition.



### Sampling Network

The Network for Urban Atmospheric Nitrogen Chemistry (NUANC) is an NTN subnetwork of five sites in the Denver and Boulder, Colorado urban corridor. An additional urban site (CO84) is located outside Boulder, Colorado. Rural and remote montane NTN sites are nearby and form a southeast-trending transect of NTN sites with the NUANC.

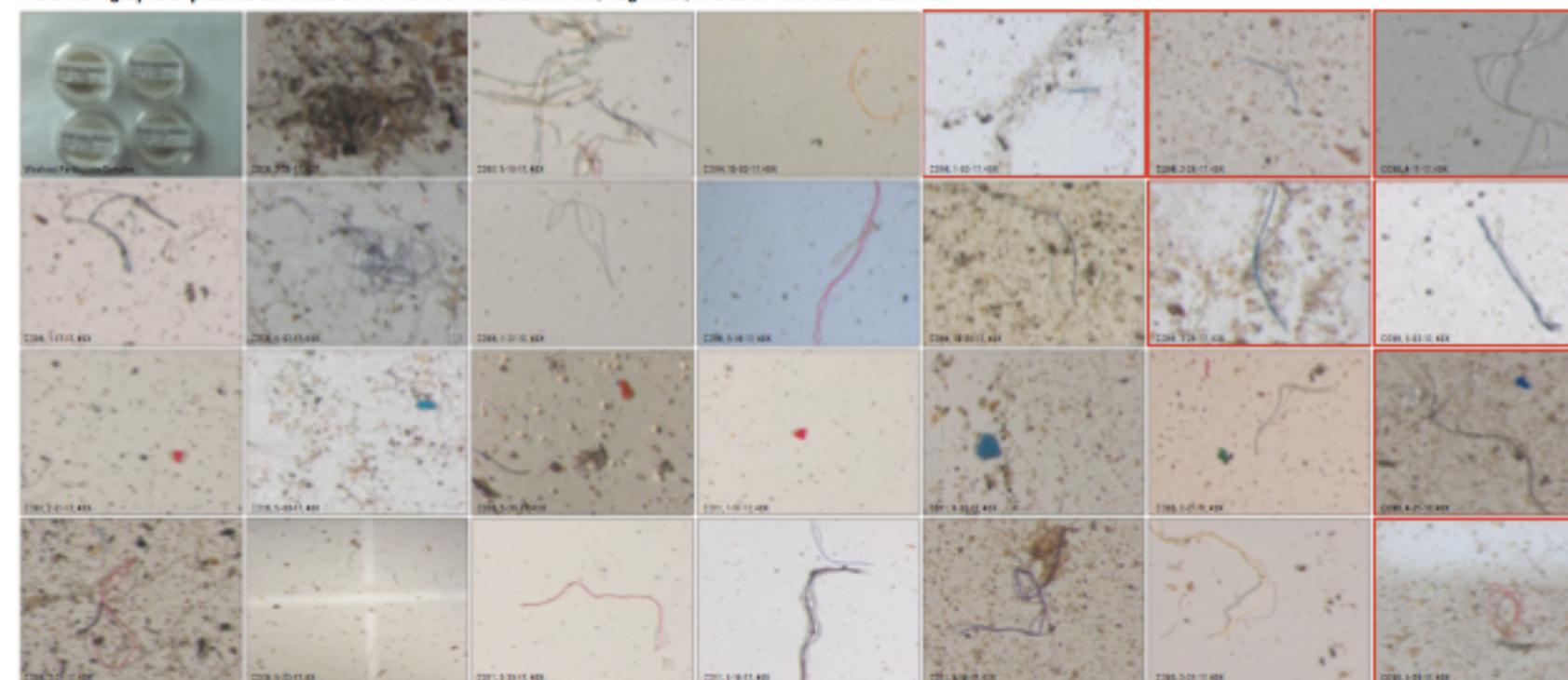
### Methods

NUANC samples were collected in plastic bag-lined buckets. Sites CO84, CO94, and CO98 used standard, unlined NTN buckets. The entire volumes of each sample submitted to the NADP Central Analytical Laboratory were filtered (0.45 micrometer, polyethersulfone) to obtain particulates assumed to be washed from the atmosphere (washout). The filters were dried, weighed, and manually analyzed with a binocular microscope fitted with a digital camera (see photomicrographs). Four deionized water rinses of the sampling system were analyzed as blanks. This study was not designed for collecting and analyzing samples for plastic particles. The results are unanticipated and opportune.

### Results

General types of particles were classified in the observations (see table). Air mass back-trajectory analysis for site CO98 samples was completed using the HYSPLIT model for 24 hours prior to each sample collection at 500-, 750-, and 1,000-meter altitudes. (National Oceanic and Atmospheric Administration,

Photomicrographs of plastics collected at the NUANC NTN subnetwork, Sugarloaf, and Loch Vale sites in Colorado



(Explanation of labels: CO06, site identification; 2-28-17, month-day-year; 40X, magnification; Red outline indicates Loch Vale samples.)

Data for washout particles collected at site CO98, Loch Vale, Rocky Mountain National Park.

(Bold values indicate easterly air mass back trajectories)

Site identifier	Weekly sample collection date (month/day/year)	Sample volume (mL/bucket)	Estimated solids concentration (µg/L)	Identified materials								Notes	Back trajectory (degrees from north)
				Mineral	Soil	Plant	Insects	Micro-plastic	Amorphous carbon				
No plastic positively identified													
CO98	1/24/17	337.0	11.4	Yes	Yes	Yes	Possibly	Possibly	Yes			227	
CO98	2/14/17	566.4	1.1	Yes	Yes	Yes	Possibly	Possibly	Yes	Egg-shaped particle might be plastic		235	
CO98	3/28/17	1,417.3	1.9	Yes	Yes	Yes	No	Possibly	Possibly	Possible blue fiber		159	
CO98	4/8/17	1,837.3	0.1	Yes	Yes	Yes	No	No	Possibly			169	
CO98	5/16/17	881.7	4.5	Yes	Yes	Yes	Possibly	Possibly	Yes	Possible black plastic fiber		62	
CO98	5/23/17	2,856.3	1.0	Yes	Yes	Yes	Yes	No	Yes			62	
CO98	7/18/17	320.9	3.8	Yes	Yes	Yes	Yes	No	Yes			251	
CO98	7/23/17	1,322.5	0.7	Yes	Yes	Yes	Yes	Possibly	Yes			252	
CO98	8/1/17	1,897.1	0.2	Yes	Yes	Yes	Yes	Possibly	Yes			213	
CO98	8/8/17	2,766.3	0.6	Yes	Yes	Yes	Yes	Possibly	Yes			176	
CO98	12/19/17	446.2	<2.2	Yes	No	Yes	No	No	Yes			260	
Plastic identified													
CO98	1/3/2017	530.3	7.5	Yes	Yes	Yes	Yes	Yes	Yes	Blue fiber		225	
CO98	2/28/2017	1,381.2	2.3	Yes	Yes	Yes	No	Yes	Yes	Blue fiber		216	
CO98	4/13/2017	918.7	6.1	Yes	Yes	Yes	Yes	Yes	Yes	Blue, green fibers, 2-3		240	
CO98	4/23/2017	1,352.8	3.1	Yes	Yes	Yes	No	Yes	Yes	Blue chunk		261	
CO98	5/2/2017	1,533.7	0.1	Yes	Yes	Yes	Possibly	Yes	Yes	Blue fibers times 3		265	
CO98	5/9/2017	857.1	5.3	Yes	Yes	Yes	No	Yes	Yes	Red fiber		265	
CO98	5/20/2017	2,095.2	1.0	Yes	Yes	Yes	Possibly	Yes	Yes	Blue fiber		265	
CO98	6/9/2017	557.9	1.7	Yes	Yes	Yes	No	Yes	Yes	White, blue plastic		254	
CO98	6/15/2017	2,981.0	0.1	Yes	Yes	Yes	Yes	Yes	Yes	Plastic fiber		275	
CO98	8/29/2017	516.4	3.3	Yes	Yes	Yes	Yes	Yes	Yes	Plastic fiber		266	

<https://ready.arl.noaa.gov/HYSPLIT.php>) Urban areas are southeast (approximately 140°) of site CO98, but plastic deposition was more positively identified for westerly storms than easterly storms. In the four blank samples, there was one small translucent fiber observed that might have been plastic. Translucent and white materials, which are the colors of the sampling apparatus, were disregarded in the analyses.

### Discussion

The mass of plastic in even the most concentrated samples was not large enough to weigh or reliably estimate. Developing a routine capability to calculate plastic wet-deposition loads is not possible with current (2019) technology. Methods for more accurate estimation of plastic loads are needed.

Better quality control to limit cross contamination and methods for estimation of percent recovery of the plastic materials from NADP samples are needed. Retaining NADP filters for subsequent analysis would make a washout deposition network possible with very little added expense.

How these plastic materials are accumulating and being assimilated in the environment and biota is unclear. Moreover, the potential effects of these materials on biota is not understood.

### Conclusions

It is raining plastic. Better methods for sampling, identification, and quantification of plastic deposition along with assessment of potential ecological effects are needed.

Any use of trade, product, or firm names in this publication is for descriptive purposes only and does not imply endorsement by the U.S. Government.  
This Open-File Report was prepared as a contribution to the public domain and is not subject to copyright. It is available in the public domain and may be reproduced, stored, transmitted, or otherwise used for any purpose without restriction, provided the original source is properly acknowledged.  
For sale by U.S. Geological Survey, Information Services, Box 2098, Federal Center, Denver, CO 80225, 1-888-486-4866.  
Figure 1 available at <https://doi.org/10.26309/20191048>  
Suggested citation: Wetherbee, G., Baldwin, A., Ranville, J., 2019, It is raining plastic: U.S. Geological Survey Open-File Report 2019-1048, available at <https://pubs.usgs.gov/of/2019/1048/>

# What we Know: Plastic is found everywhere



U.S. Department of the Interior  
U.S. Geological Survey

## It's raining plastic: microscopic fibers fall from the sky in Rocky Mountains

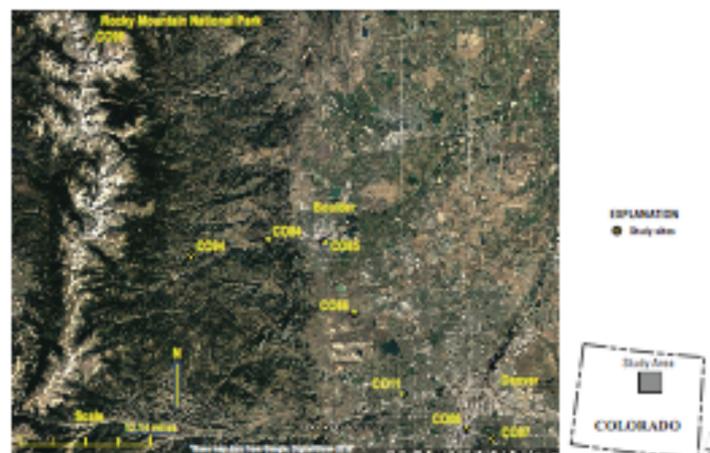
### It is Raining Plastic.

By Gregory Wetherbee,<sup>1</sup> Austin Baldwin,<sup>2</sup> James Ranville<sup>3</sup>

<sup>1</sup>USGS, Hydrologic Networks Branch, Denver, Colorado; <sup>2</sup>USGS, Water Science Center, Boise, Idaho; <sup>3</sup>Colorado School of Mines, Golden, Colorado

#### Overview

Atmospheric wet deposition samples were collected using the National Atmospheric Deposition Program/National Trends Network (NADP/NTN) at eight sites (see map) in the Colorado Front Range. Plastics were identified in more than 90 percent of the samples. The plastic materials were mostly fibers that were only visible with magnification, approximately 20–40 times (X). Fibers were present in a variety of colors; the most frequently observed color was blue followed by red>silver>purple>green> yellow>other colors. Plastic particles such as beads and shards were also observed with magnification. More plastic fibers were observed in samples from urban sites than from remote, mountainous sites. However, frequent observation of plastic fibers in washout samples from the remote site CO98 at Loch Vale in Rocky Mountain National Park (elevation 3,159 meters) suggests that wet deposition of plastic is ubiquitous and not just an urban condition.



#### Sampling Network

The Network for Urban Atmospheric Nitrogen Chemistry (NUANC) is an NTN subnetwork of five sites in the Denver and Boulder, Colorado urban corridor. An additional urban site (CO84) is located outside Boulder, Colorado. Rural and remote montane NTN sites are nearby and form a southeast-trending transect of NTN sites with the NUANC.

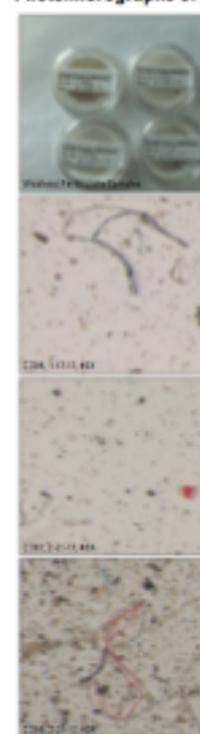
#### Methods

NUANC samples were collected in plastic bag-lined buckets. Sites CO84, CO94, and CO98 used standard, unlined NTN buckets. The entire volumes of each sample submitted to the NADP Central Analytical Laboratory were filtered (0.45 micrometer, polyethersulfone) to obtain particulates assumed to be washed from the atmosphere (washout). The filters were dried, weighed, and manually analyzed with a binocular microscope fitted with a digital camera (see photomicrographs). Four deionized water rinses of the sampling system were analyzed as blanks. This study was not designed for collecting and analyzing samples for plastic particles. The results are unanticipated and opportune.

#### Results

General types of particles were classified in the observations (see table). Air mass back-trajectory analysis for site CO98 samples was completed using the HYSPLIT model for 24 hours prior to each sample collection at 500-, 750-, and 1,000-meter altitudes. (National Oceanic and Atmospheric Administration,

#### Photomicrographs of



(Explanation of labels: CO)

Data for washout particles coll  
(Bold values indicate exactly air dry)

Site Identification	Weekly sample collection date (month/day/year)	Wet Deposition (mg/m <sup>2</sup> )										
CO98	1/24/17											
CO98	2/14/17											
CO98	3/28/17											
CO98	4/8/17											
CO98	5/16/17											
CO98	5/23/17											
CO98	7/18/17											
CO98	7/25/17											
CO98	8/1/17											
CO98	8/8/17											
CO98	12/19/17											
CO98	1/3/2017											
CO98	2/28/2017											
CO98	4/13/2017	918.7	6.1	Yes	Yes	Yes	Yes	Yes	Yes	Blue, green fibers, 2-5	240	
CO98	4/23/2017	1,352.8	3.1	Yes	Yes	Yes	No	Yes	Yes	Blue chunk	261	
CO98	5/2/2017	1,533.7	0.1	Yes	Yes	Yes	Possibly	Yes	Yes	Blue fibers times 3	265	
CO98	5/9/2017	857.1	5.3	Yes	Yes	Yes	No	Yes	Yes	Red fiber	265	
CO98	5/20/2017	2,095.2	1.0	Yes	Yes	Yes	Possibly	Yes	Yes	Blue fiber	265	
CO98	6/8/2017	357.9	1.7	Yes	Yes	Yes	No	Yes	Yes	White, blue plastic	254	
CO98	6/15/2017	2,961.0	0.1	Yes	Yes	Yes	Yes	Yes	Yes	Plastic fiber	275	
CO98	8/29/2017	516.4	3.3	Yes	Yes	Yes	Yes	Yes	Yes	Plastic fiber	266	



▲ Trail markers on the trail near Colorado's highest peak, Mount Elbert, in the Rocky Mountains.

Photograph: Alamy

<https://www.theguardian.com/us-news/2019/aug/12/raining-plastic-colorado-usgs-microplastics>

### Discovery raises new questions about the amount of plastic waste permeating the air, water, and soil virtually everywhere on Earth

READ THE ORIGINAL BY SCOTT MANNING/AMERICA'S

#### Conclusions

It is raining plastic. Better methods for sampling, identification, and quantification of plastic deposition along with assessment of potential ecological effects are needed.

Any use of trade names, or their omission in this publication is for descriptive purposes only and does not imply endorsement by the U.S. Department of the Interior.

This Open-File Report was prepared on a computer using the digital data files, 8.5 x 11 inch format, and paper may change size due to differences in conditions, therefore, the size and position may vary from the printed version of this Open-File Report.

For sale by U.S. Geological Survey, Information Services, Box 2098, Federal Center, Denver, CO 80202, 1-800-485-6000.

Report title available at <https://pubs.usgs.gov/of/2019/1048/>

Suggested citation: Wetherbee, G., Baldwin, A., Ranville, J., 2019. It is raining plastic: U.S. Geological Survey Open-File Report 2019-1048. 1 sheet, available at <https://pubs.usgs.gov/of/2019/1048/>

# What we Know: Plastic is not handled well



## 'Plastic recycling is a myth': what really happens to your rubbish?

▲ Everything you own will one day become property of the £250bn global waste industry. Composite: Guardian Design Team

You sort your recycling, leave it to be collected - and then what? From councils burning the lot to foreign landfill sites overflowing with British rubbish, [Oliver Franklin-Wallis](#) reports on a global waste crisis



United States of Plastic

## Americans' plastic recycling is dumped in landfills, investigation shows

Pearl Pai holds a bag of sorted recyclables that she was unable to posit at her local recycling center. Photograph: Hardy Wilson/The Guardian

Consumers' efforts to be eco-friendly go to waste as many communities find themselves with nowhere to send their refuse

<https://www.theguardian.com/environment/2019/aug/17/plastic-recycling-myth-what-really-happens-your-rubbish>

<https://www.theguardian.com/us-news/2019/jun/21/us-plastic-recycling-landfills>

# What we Know: Plastic is not handled well



## 'Plastic recycling is a myth': what really happens to your rubbish?

▲ Everything you own will one day become property of the £250bn global waste industry. Composite: Guardian Design Team

You sort your recycling, leave it to be collected - and then what? From councils burning the lot to foreign landfill sites overflowing with British rubbish, [Oliver Franklin-Wallis](#) reports on a global waste crisis



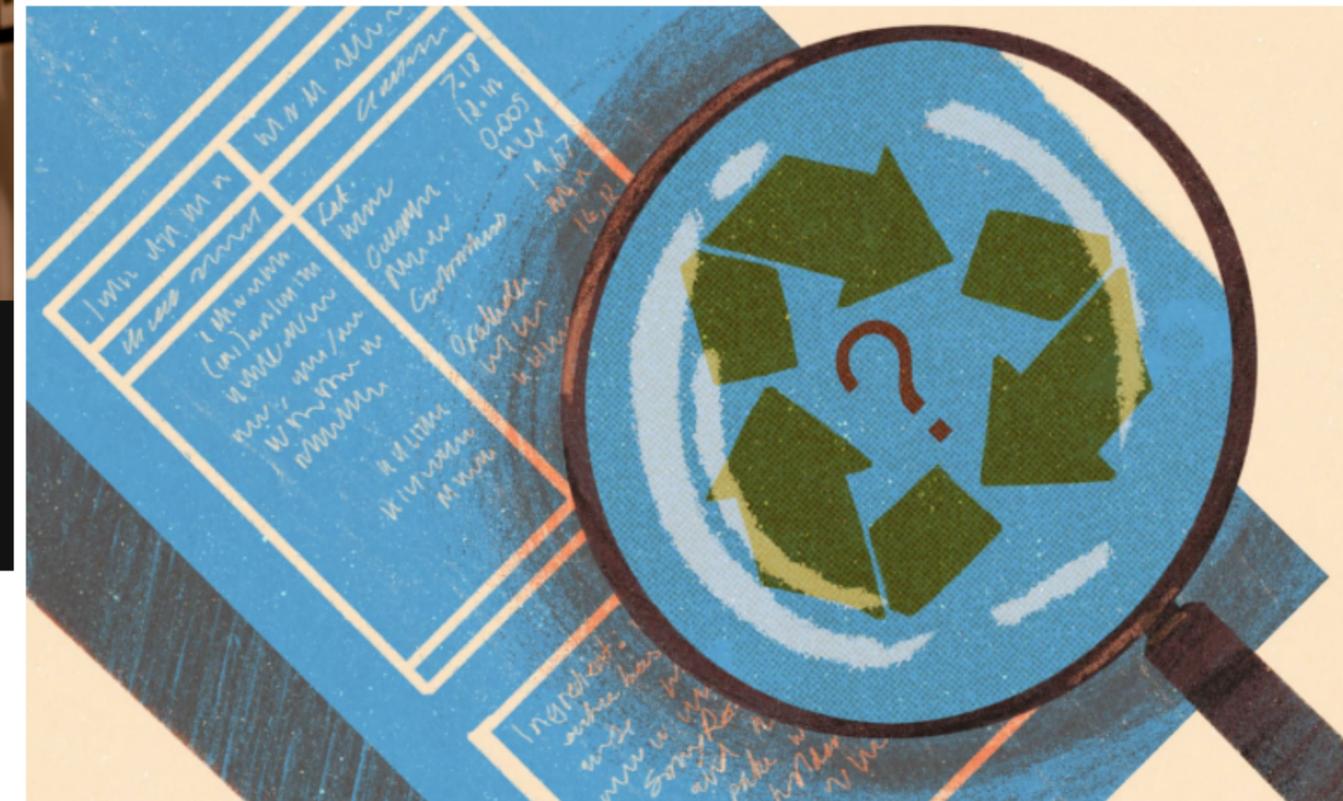
United States of Plastic

## Americans' plastic recycling is dumped in landfills, investigation shows

Pearl Pai holds a bag of sorted recyclables that she was unable to posit at her local recycling center. Photograph: Hardy Wilson/The Guardian

Consumers' efforts to be eco-friendly go to waste as many communities find themselves with nowhere to send their refuse

## How you're recycling plastic wrong, from coffee cups to toothpaste



▲ Illustration: Sonny Ross/The Guardian

If you don't clean your recycling, it can harm more than it helps. And that icon with the arrows is virtually meaningless

Advertisement

<https://www.theguardian.com/environment/2019/aug/17/plastic-recycling-myth-what-really-happens-your-rubbish>

<https://www.theguardian.com/us-news/2019/jun/21/us-plastic-recycling-landfills>

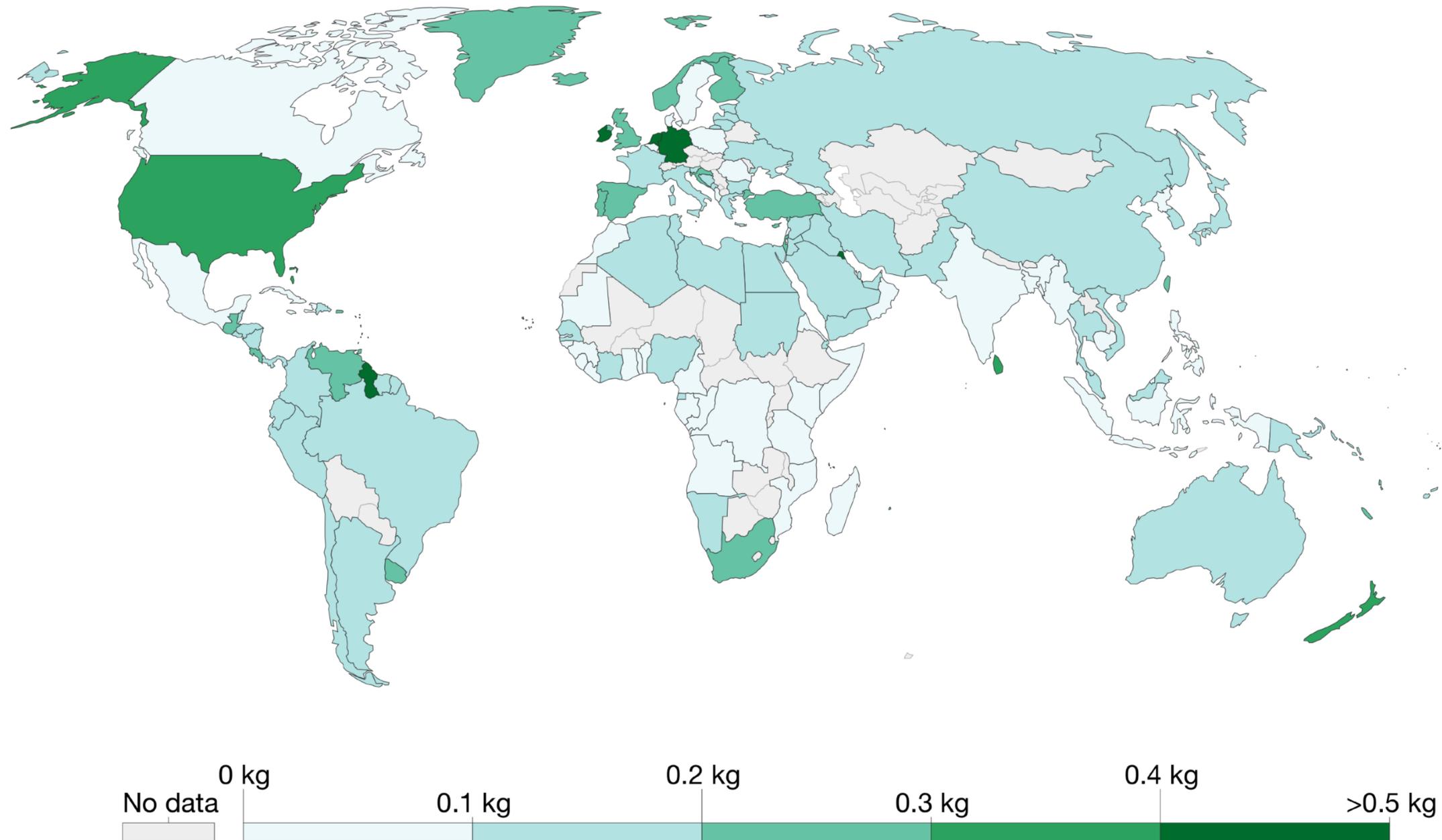
<https://www.theguardian.com/environment/2019/jun/17/recycling-plastic-wrong-guide>

# What we Know: Plastic is not handled well

## Plastic waste generation per person, 2010

Daily plastic waste generation per person, measured in kilograms per person per day. This measures the overall per capita plastic waste generation rate prior to waste management, recycling or incineration. It does not therefore directly indicate the risk of pollution to waterways or marine environments.

Our World  
in Data



“Solutions” that create new problems:



- In 1993, Patagonia became the first outdoor gear company to use recycled PET bottles to make some of its fleece garments.
- This environmentally conscious firm proudly states that this was “a positive step towards a more sustainable system—one that uses fewer resources, discards less and better protects people’s health.”
- Since then, some 92 million PET bottles have been transformed into articles of clothing.
- However, for many firms that produce fleece pullovers and jackets, recent discoveries about microfibers in wastewater present a challenge to take a further innovative step to protect the environment.

# What we Know: impacting the present as well as future of many billions of people



## Dead whale found with 115 plastic cups, 2 flip-flops in its stomach

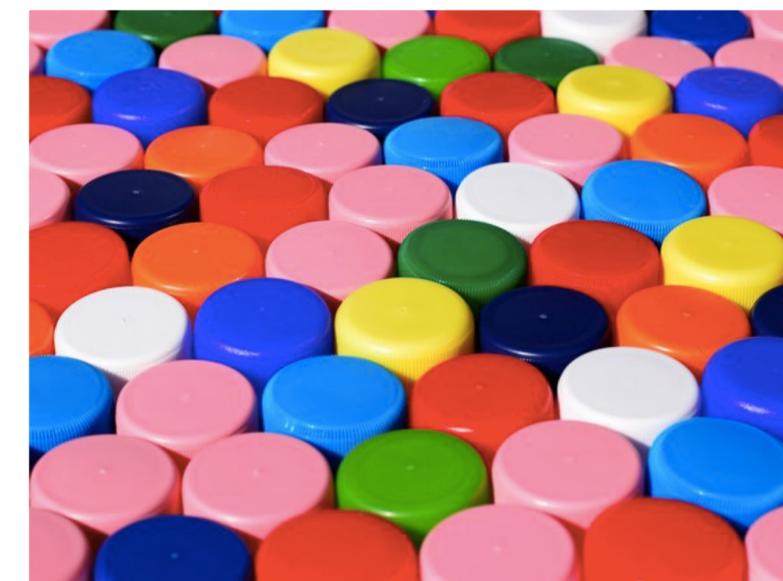


Detritus also included more than 1,000 other plastic pieces, including plastic bags, bottles

The Associated Press · Posted: Nov 20, 2018 9:03 AM ET | Last Updated: November 20



ROBBIE GONZALEZ SCIENCE 10.22.18 06:00 PM  
**YOUR POOP IS PROBABLY FULL OF PLASTIC**



SEA TURTLES

## Green Turtles Are Mistaking Plastic for the Sea Grass They Normally Eat

By  Jordan Davidson | Aug. 09, 2019 01:18PM EST

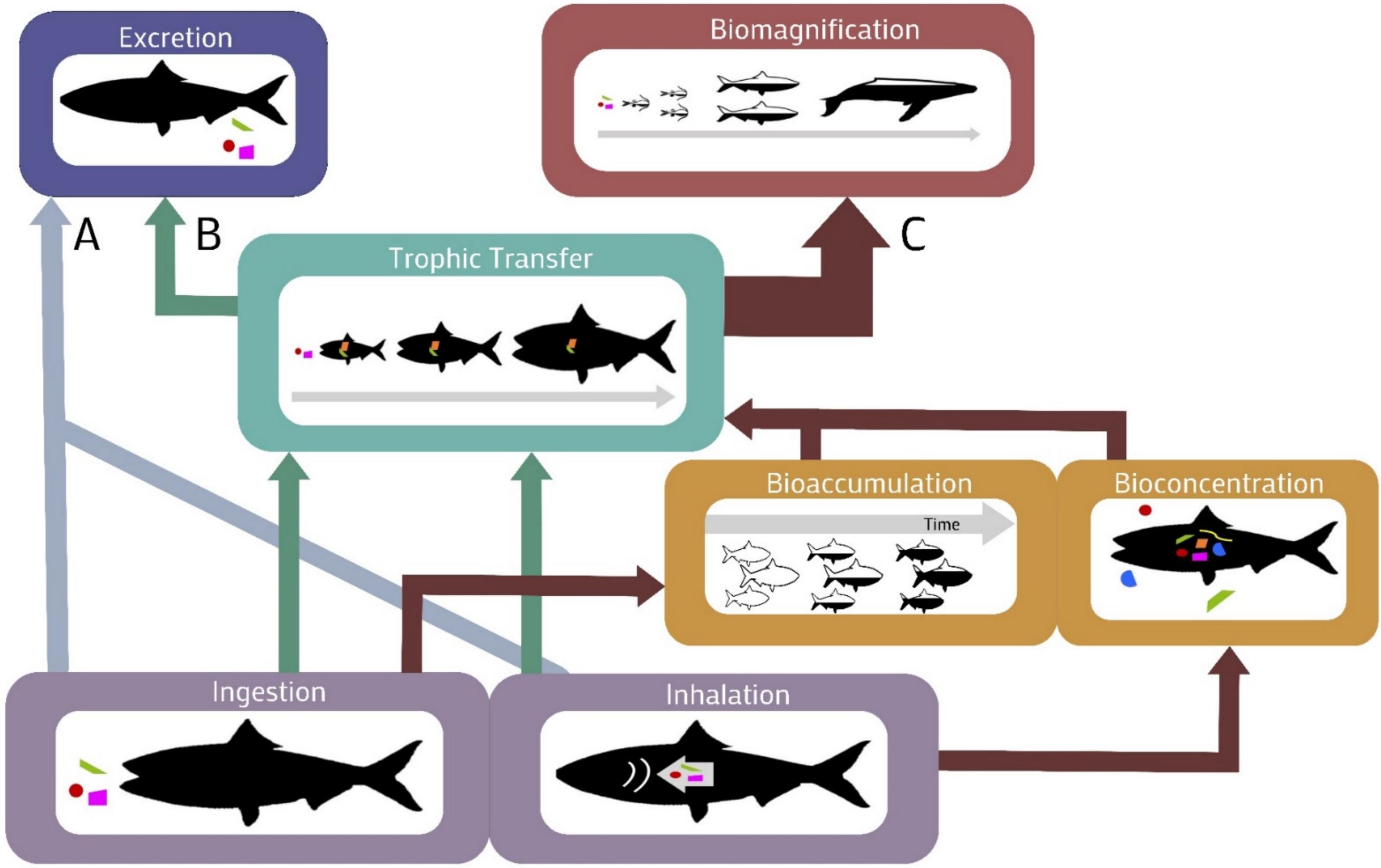
ANIMALS

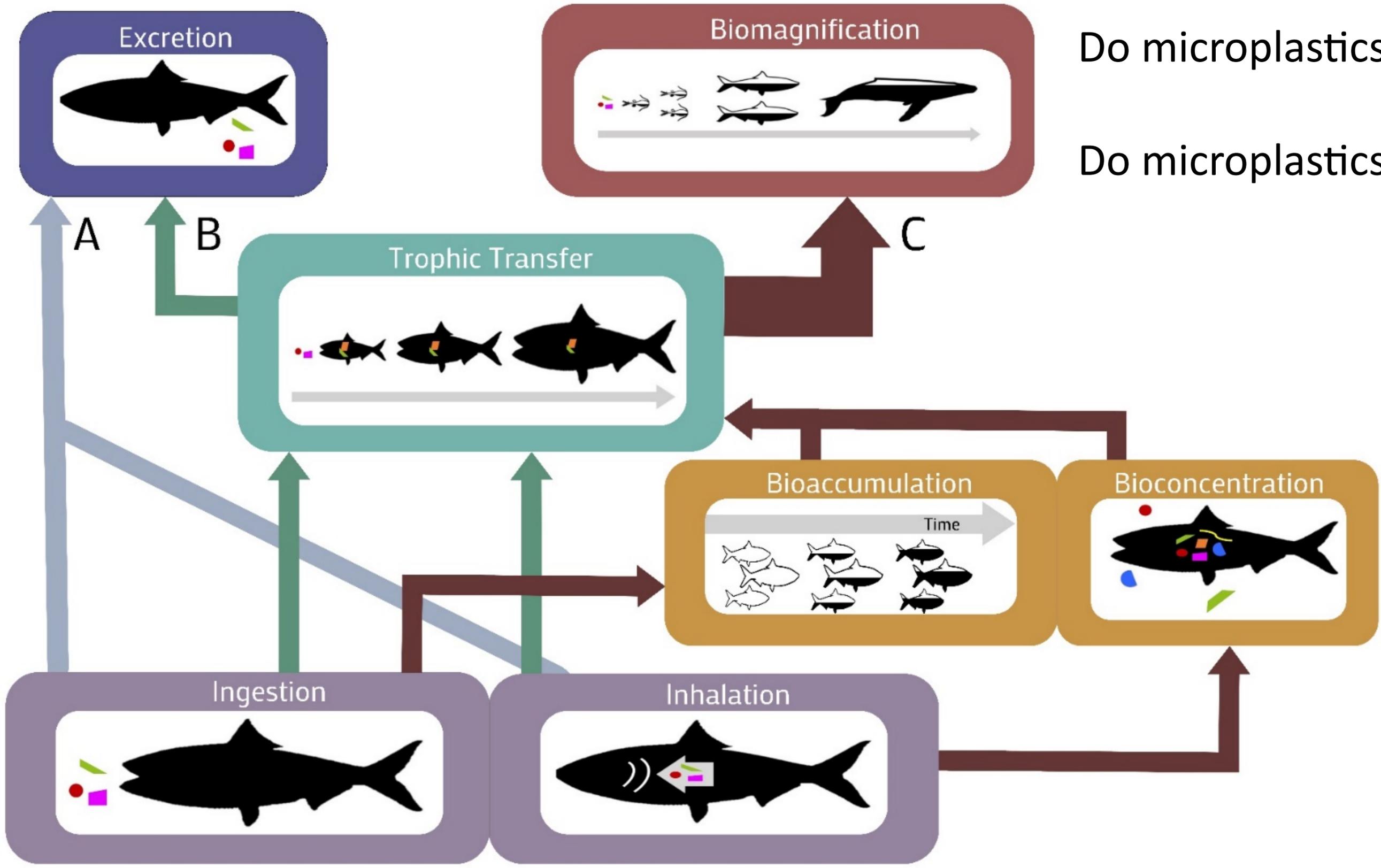


*The green sea turtle (Chelonia mydas) on Hikkaduwa coral reef, Sri Lanka. danilovi / E+ / Getty Images*

Endangered green turtles are having a problem. They're mistaking plastic pollution for the seaweed they survive on, according to [new research](#) from the University of Exeter in the UK and the Society for the Protection of Turtles in Cyprus, as [Newsweek](#) reported.

# What we Know: impacting the present as well as future of many billions of people





Do microplastics bioaccumulate?

Do microplastics biomagnify?

*Provenger (2018)*

🕒 SEPTEMBER 25, 2017

## Brain damage in fish affected by plastic nanoparticles

by Lund University



A school of sardines in Italy. Credit: Wikimedia / Alessandro Duci

Calculations have shown that 10 per cent of all plastic produced around the world ultimately ends up in the oceans. As a result, a large majority of global marine debris is in fact plastic waste. Human production of plastics is a well-known environmental concern, but few studies have studied the effects of tiny plastic particles, known as nanoplastic particles.

## SCIENTIFIC REPORTS

Article | [Open Access](#) | Published: 13 September 2017

## Brain damage and behavioural disorders in fish induced by plastic nanoparticles delivered through the food chain

Karin Mattsson, Elyse V. Johnson, Anders Malmendal, Sara Linse, Lars-Anders Hansson & Tommy Cedervall

*Scientific Reports* **7**, Article number: 11452 (2017) | [Cite this article](#)

**8360** Accesses | **58** Citations | **484** Altmetric | [Metrics](#)

### Abstract

The tremendous increases in production of plastic materials has led to an accumulation of plastic pollution worldwide. Many studies have addressed the physical effects of large-sized plastics on organisms, whereas few have focused on plastic nanoparticles, despite their distinct chemical, physical and mechanical properties. Hence our

# Key Points

---

## Purpose of Economy

The *de facto* purpose of economy is to meet the needs of the present while safeguarding the Earth's life-support system, on which the welfare of all current and future generation depends.

The current “official” purpose of economy is to create human wealth, and this official purpose is in conflict with the *de facto* purpose.

## Syndrome of Modern Global Change

The Holocene was a “safe operating space for humanity” allowing the emergence of a dominant species

During the last few hundred years, humanity has made large and rapid planetary changes, accelerated existing and introduced new flows in the planetary physiology.

The system is outside the “normal range” and in the dynamic transition into the Post-Holocene.

# Can the Economy in Modern Society Work Without Polluting the Environment with Our Growing Waste?

- The Purpose of Economy
- The Syndrome of Modern Global Change
- The Diagnosis: Creating Human Wealth without Regard for Natural Wealth
- The Prognosis: Running out of Resources while Polluting the Environment
- The Therapy: Changing the Official Purpose of Economy



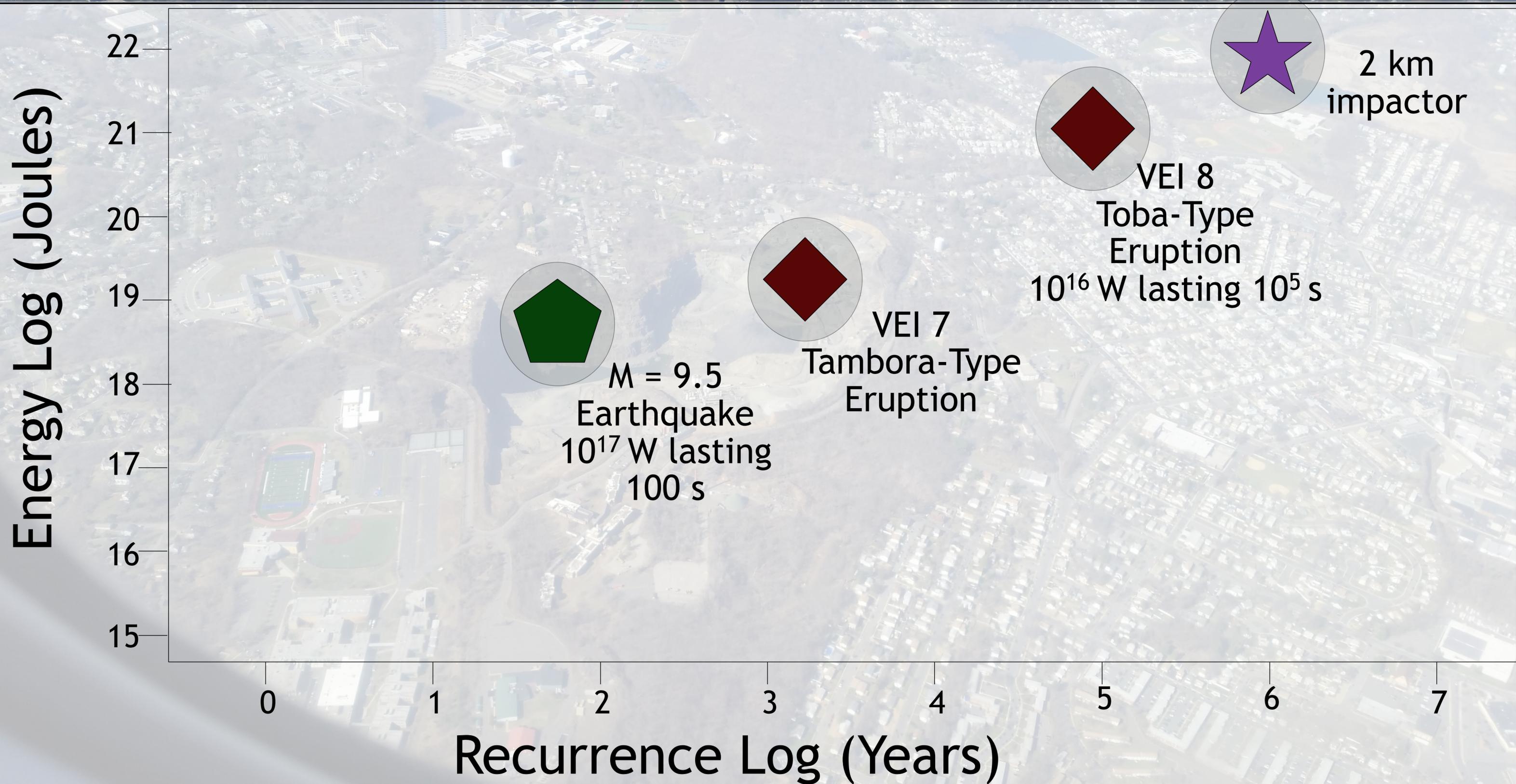
Hans-Peter Plag  
Old Dominion University  
Norfolk, VA, USA



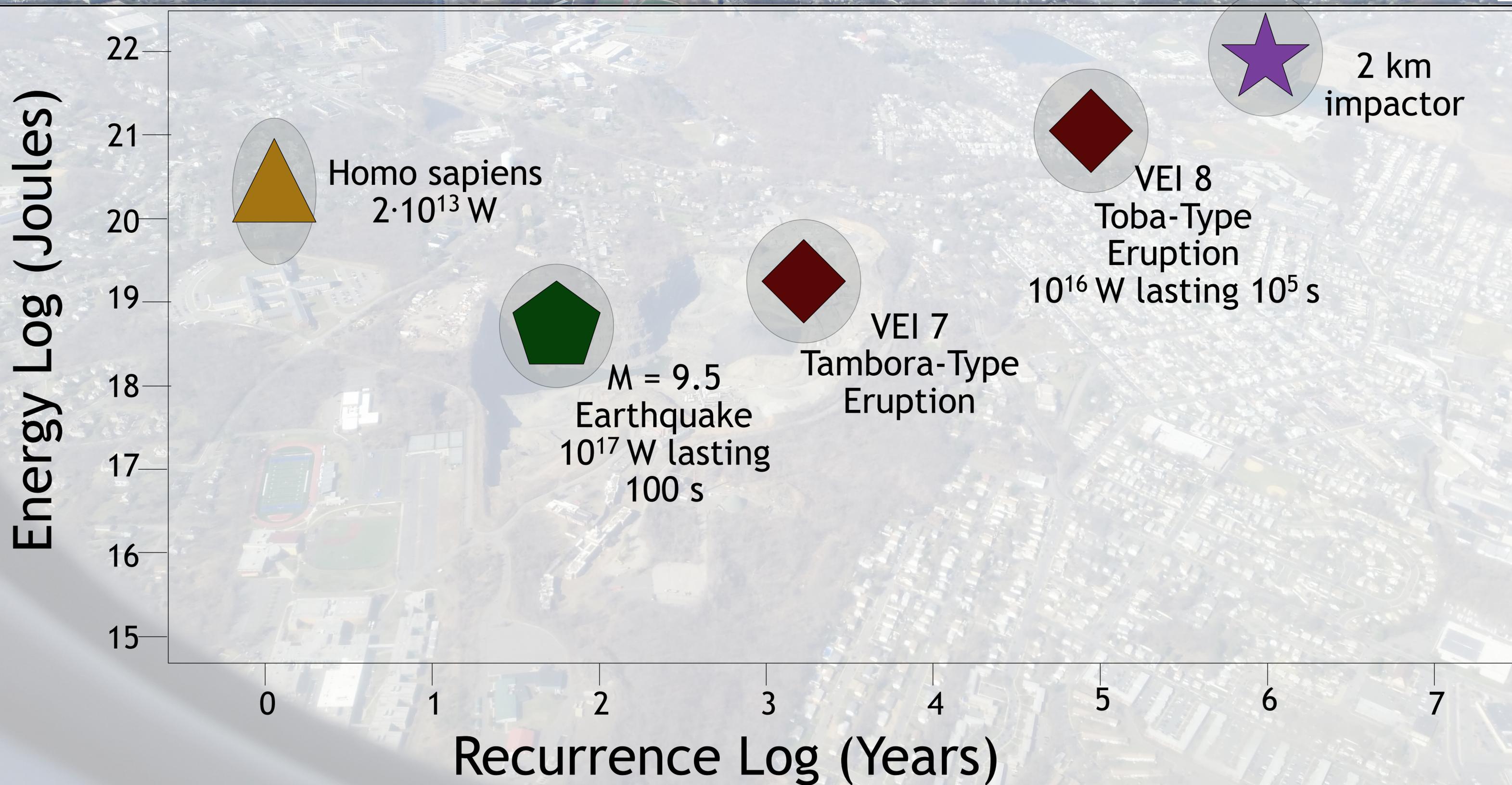
# The Diagnosis: Creating Human Wealth Without Regard for Natural Wealth



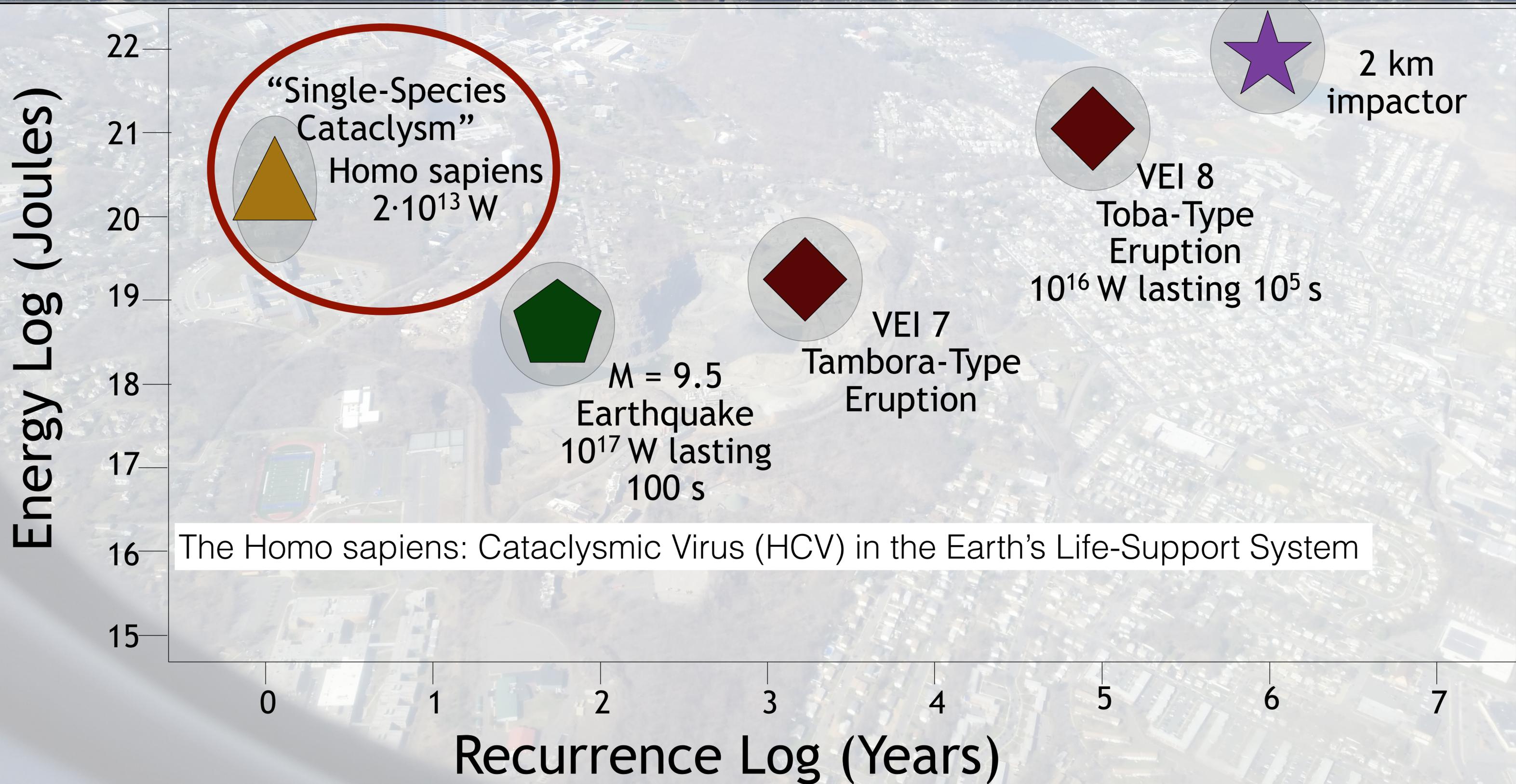
# The Diagnosis: Creating Human Wealth Without Regard for Natural Wealth



# The Diagnosis: Creating Human Wealth Without Regard for Natural Wealth

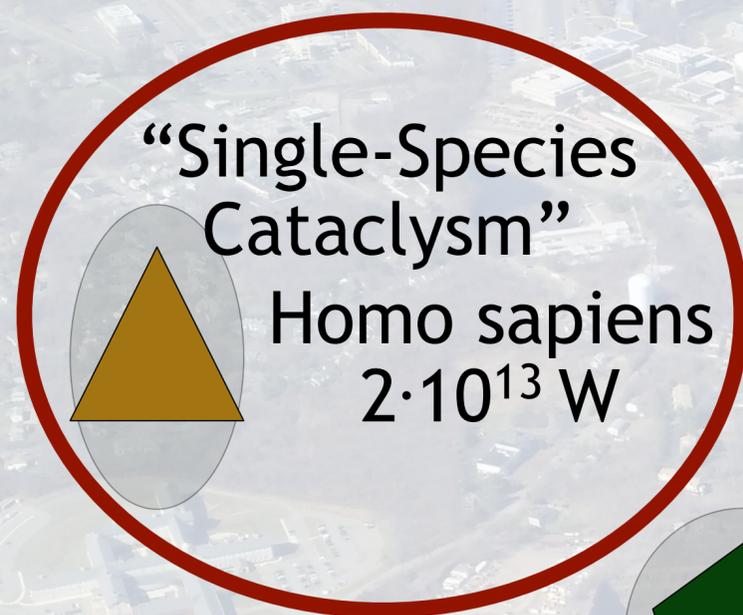


# The Diagnosis: Creating Human Wealth Without Regard for Natural Wealth



Energy Log (Joules)

22  
21  
20  
19  
18  
17  
16  
15



The Homo sapiens: Cataclysmic Virus (HCV) in the Earth's Life-Support System

Can the “virus” transform itself into the “healer”?

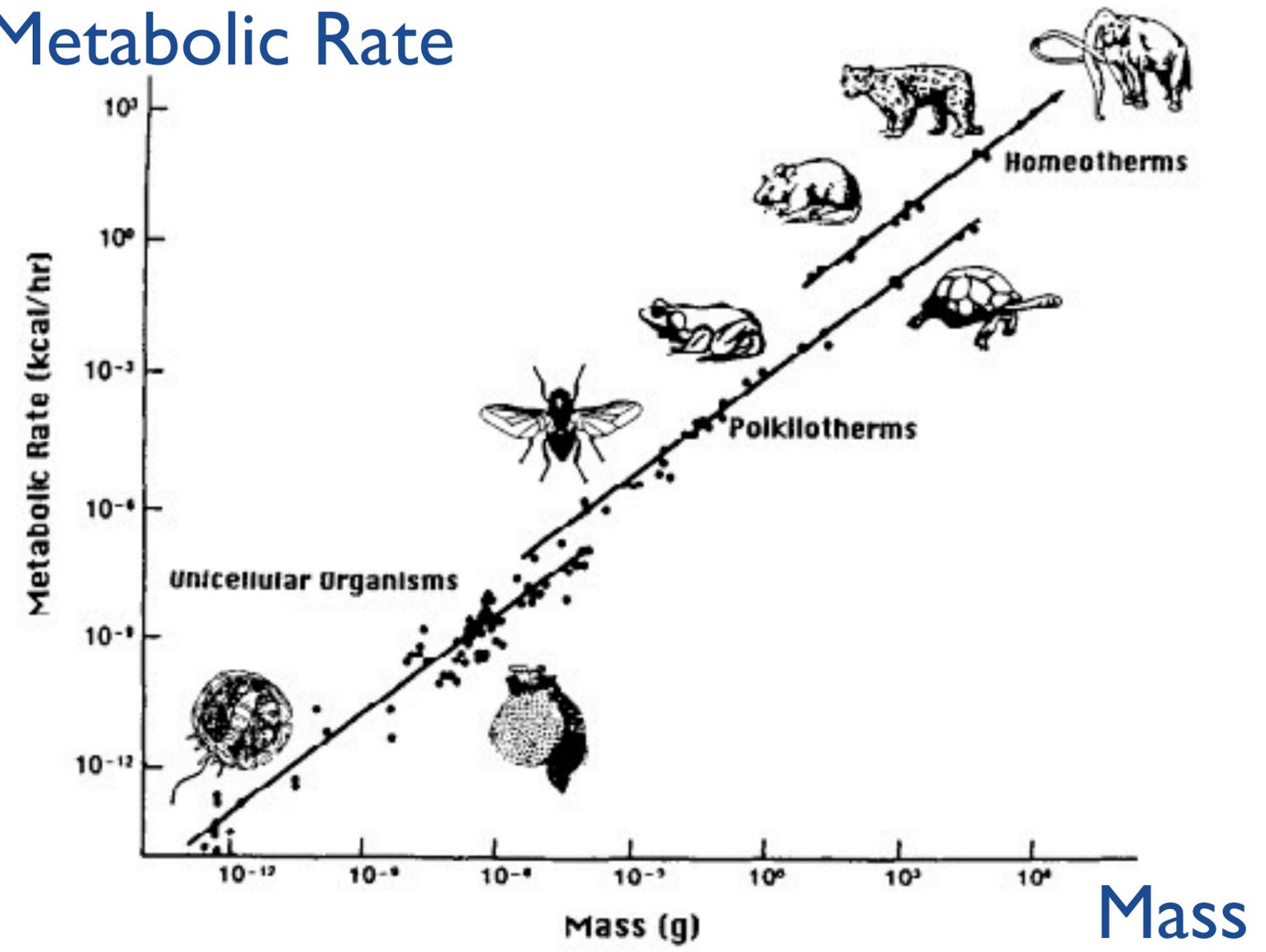
Recurrence Log (Years)

# The Diagnosis: Creating Human Wealth Without Regard for Natural Wealth

Out of Scale

Scaling law for metabolic rate:  
 $Y = Y_0 * M^{(3/4)}$

## Metabolic Rate



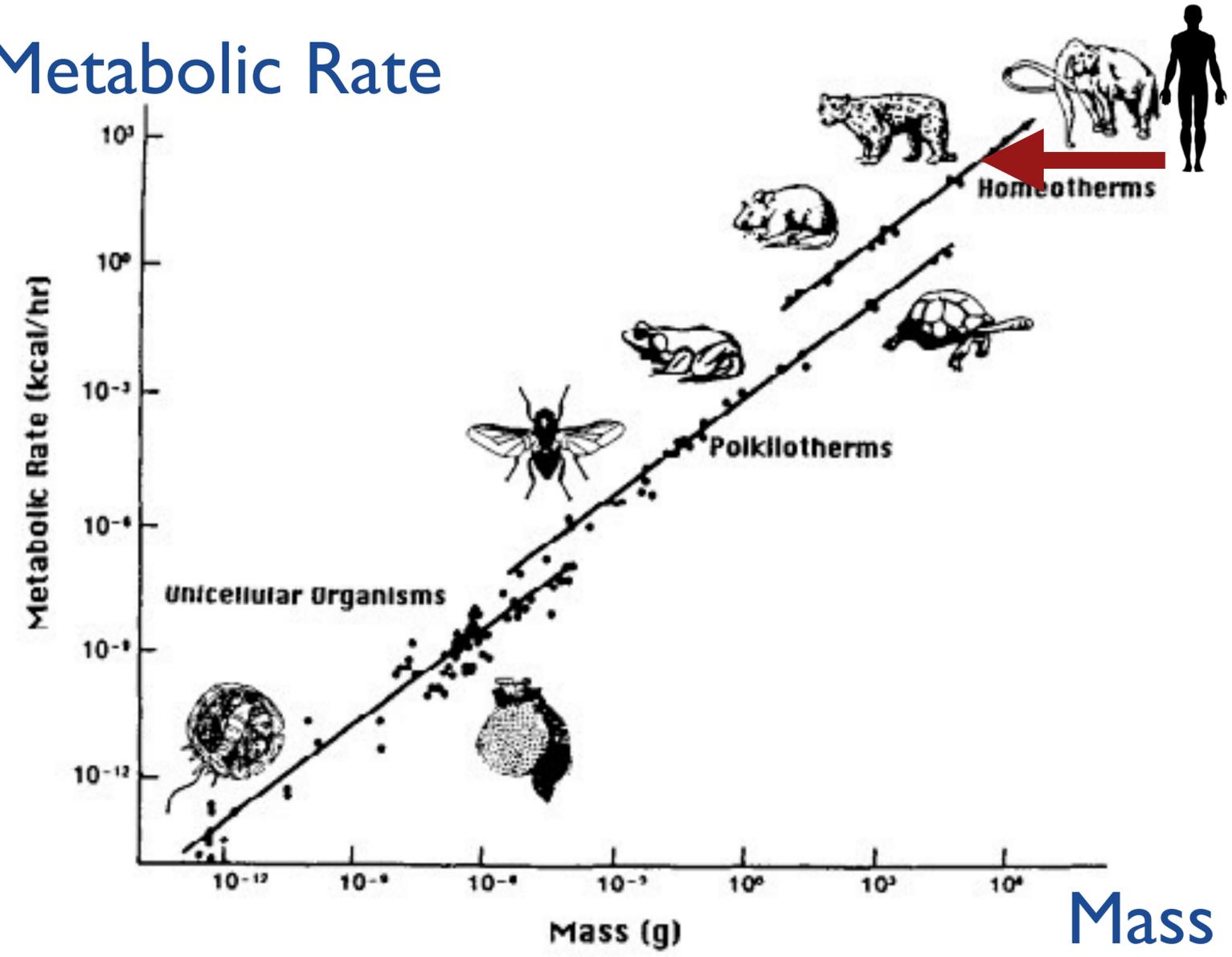
# The Diagnosis: Creating Human Wealth Without Regard for Natural Wealth

Out of Scale

Scaling law for metabolic rate:  
 $Y = Y_0 * M^{(3/4)}$

human:  $Y = 50 - 100$  Watt

## Metabolic Rate



Mass

# The Diagnosis: Creating Human Wealth Without Regard for Natural Wealth

Out of Scale

Scaling law for metabolic rate:

$$Y = Y_0 * M^{(3/4)}$$

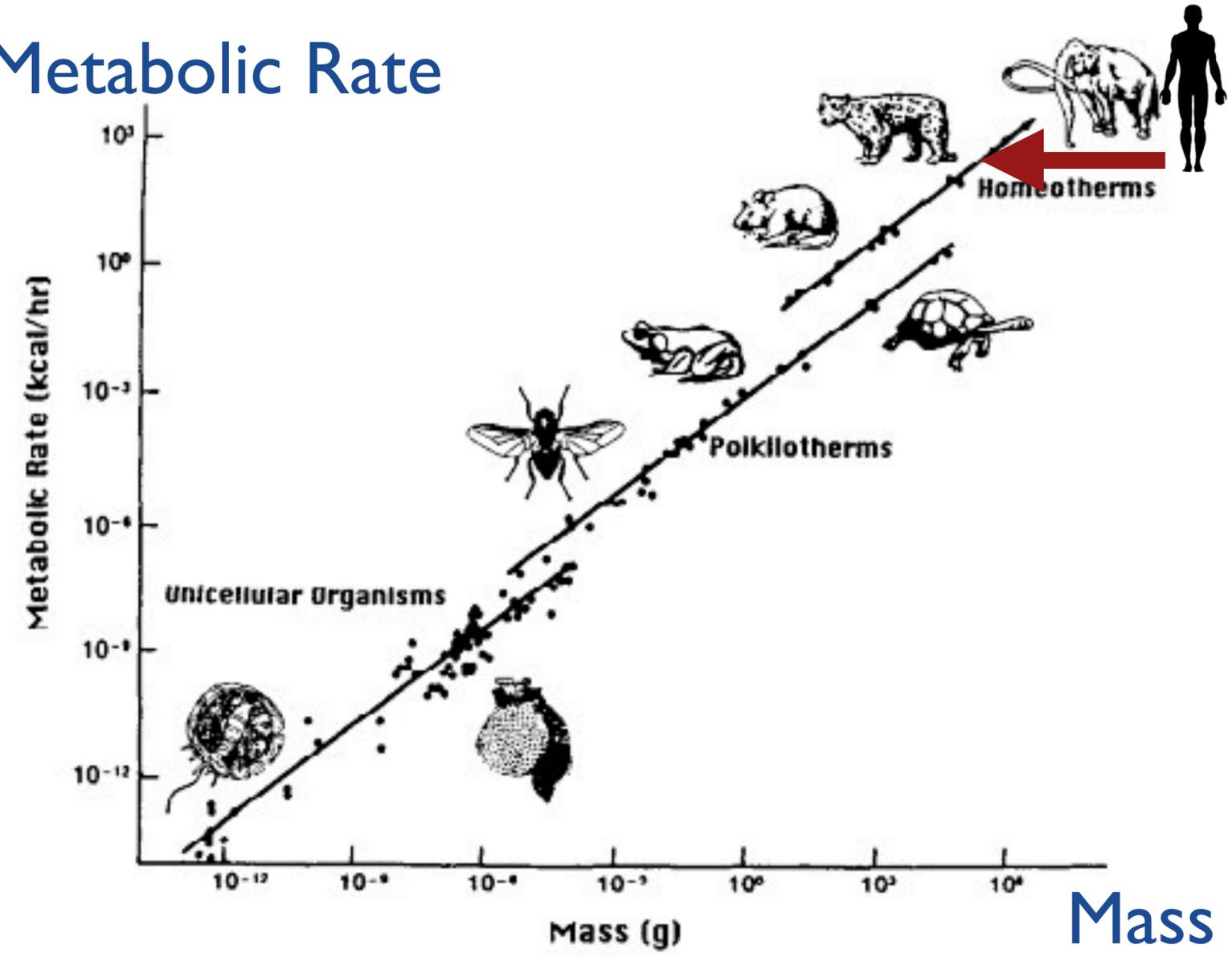
human:  $Y = 50 - 100$  Watt

Extended metabolic rate:

$$Y_E = Y + C_E$$

( $C_E$ : total energy consumption)

## Metabolic Rate



# The Diagnosis: Creating Human Wealth Without Regard for Natural Wealth

Out of Scale

Scaling law for metabolic rate:

$$Y = Y_0 * M^{(3/4)}$$

human:  $Y = 50 - 100$  Watt

Extended metabolic rate:

$$Y_E = Y + C_E$$

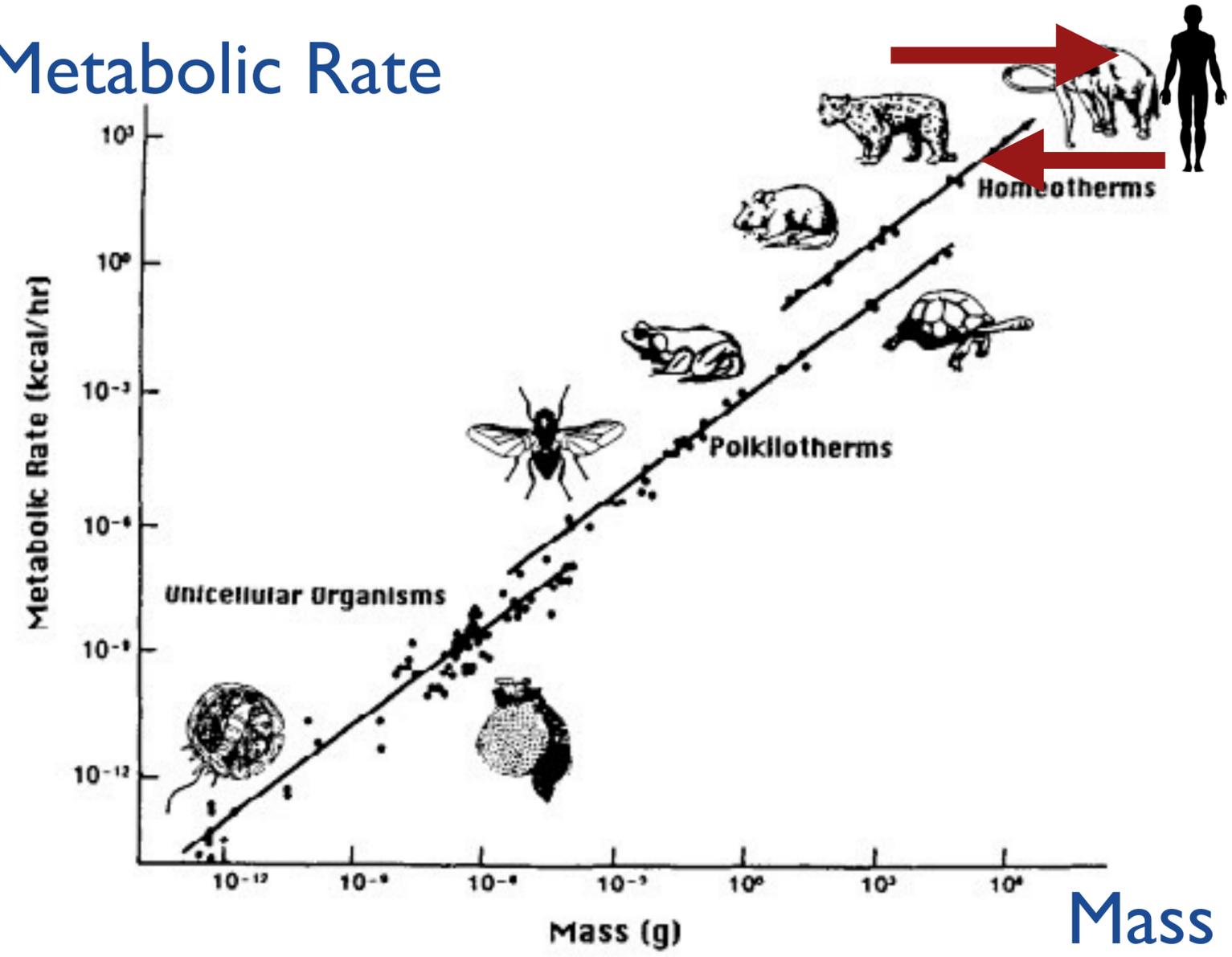
( $C_E$ : total energy consumption)

Energy consumption per capita:

Global Average:  $Y_E = 2,835$  Watt

$M = 10$  metric tons

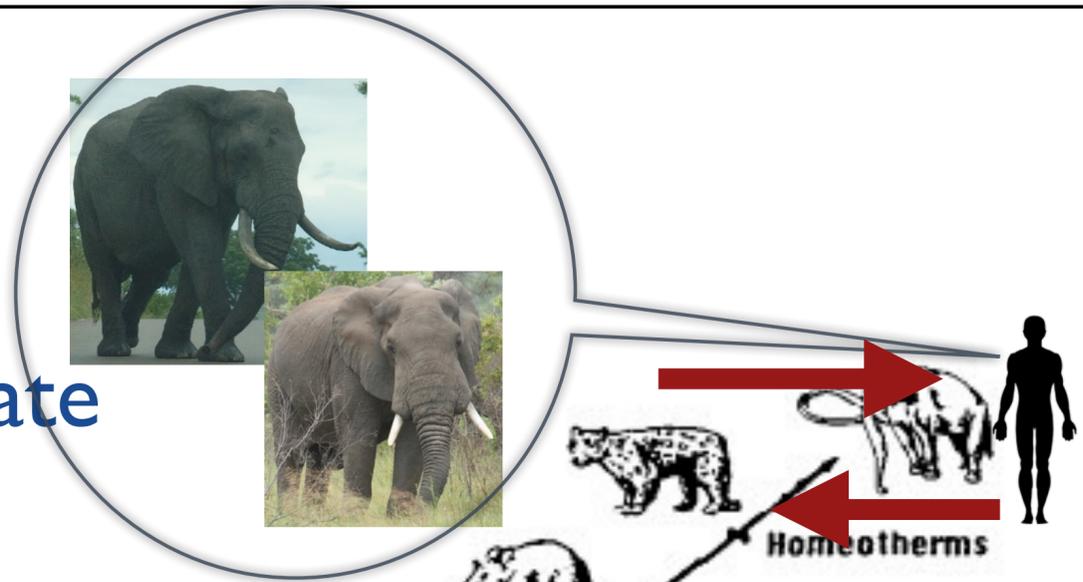
## Metabolic Rate



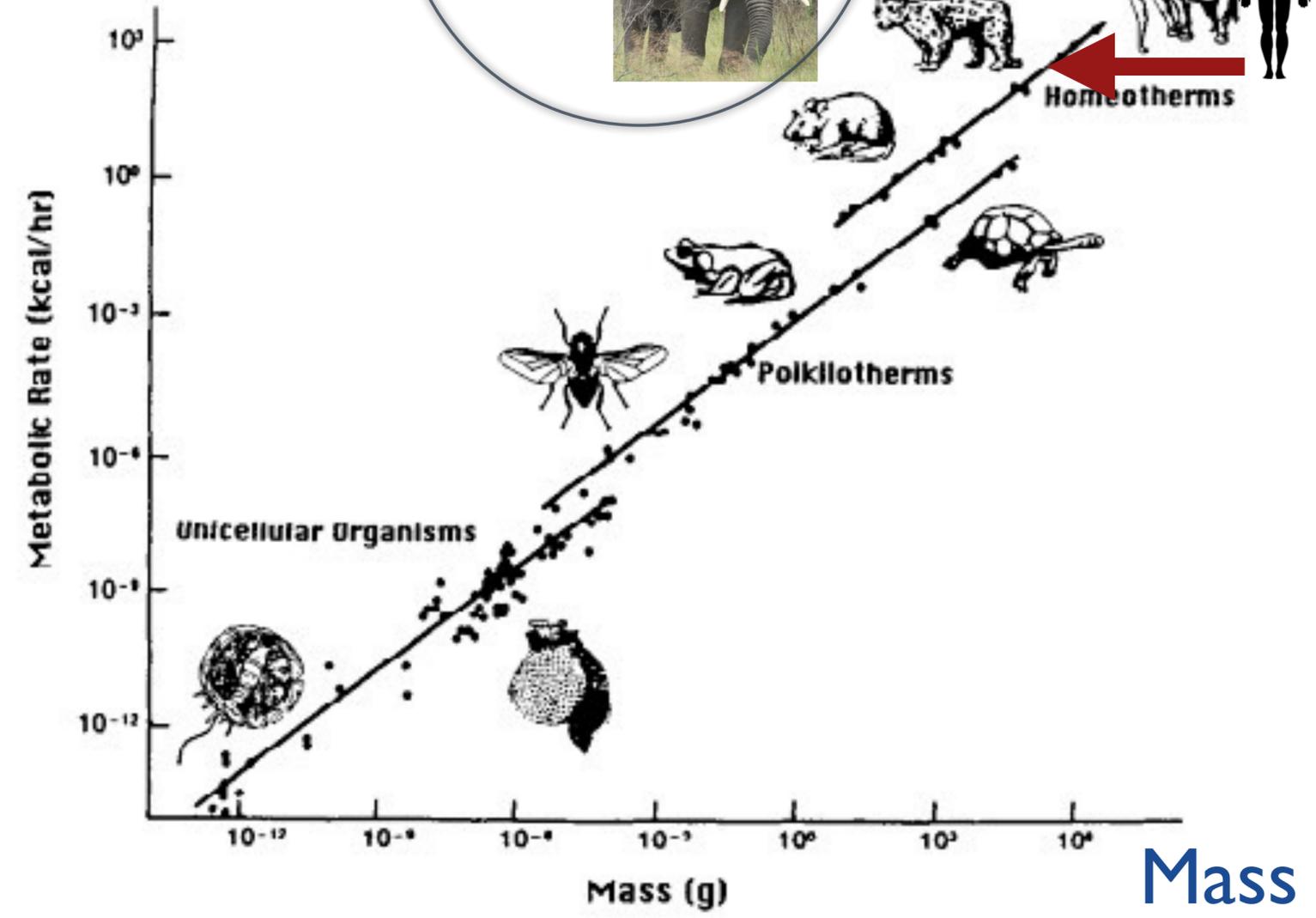
Mass

# The Diagnosis: Creating Human Wealth Without Regard for Natural Wealth

Out of Scale



## Metabolic Rate



Scaling law for metabolic rate:

$$Y = Y_0 * M^{(3/4)}$$

human:  $Y = 50 - 100$  Watt

Extended metabolic rate:

$$Y_E = Y + C_E$$

( $C_E$ : total energy consumption)

Energy consumption per capita:

Global Average:  $Y_E = 2,835$  Watt

$M = 10$  metric tons

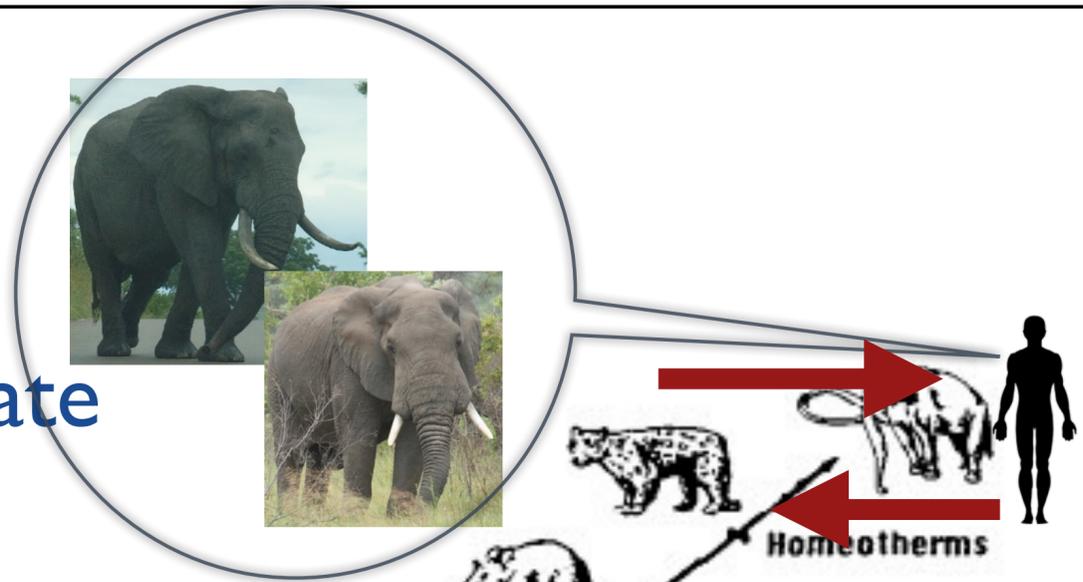
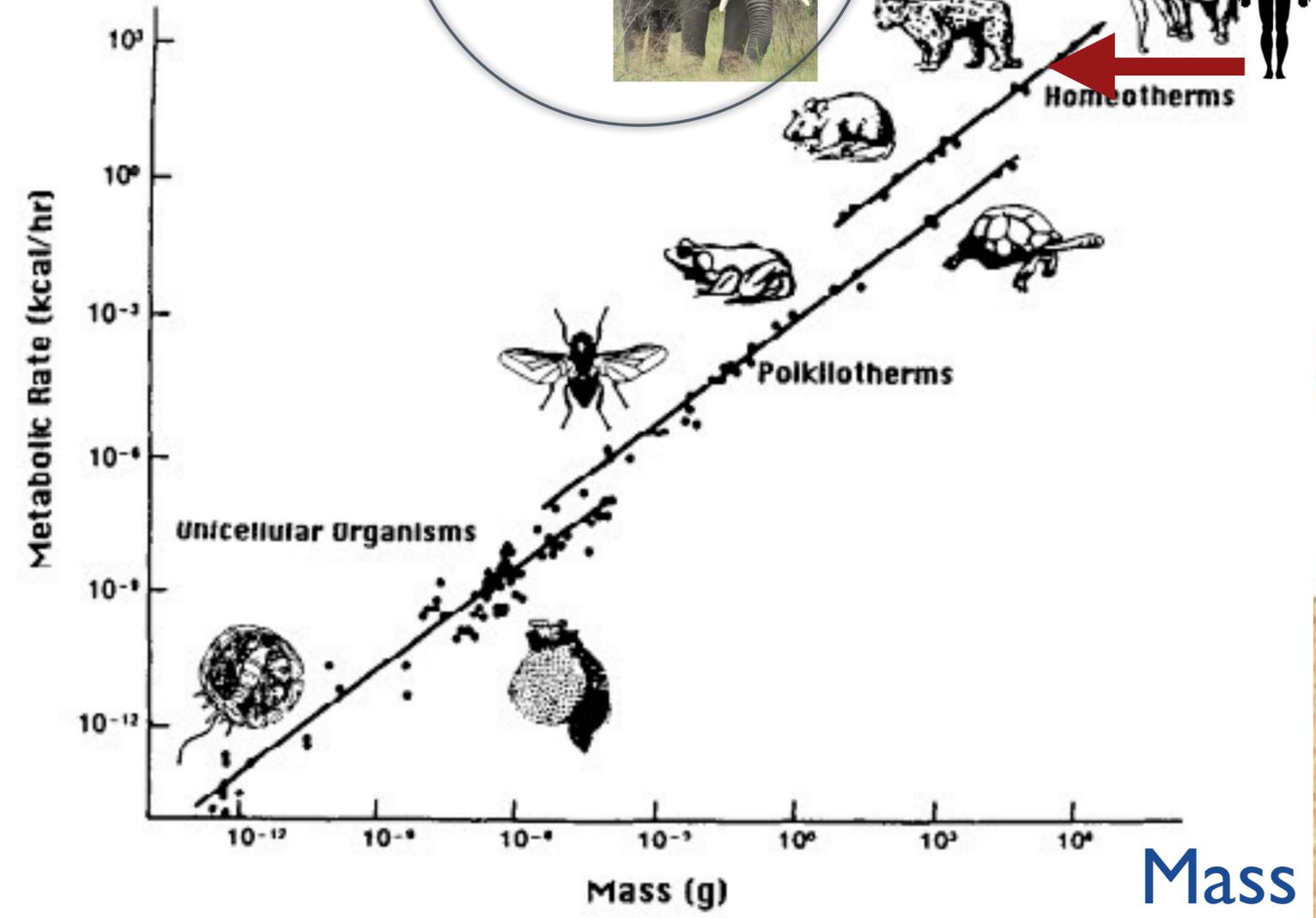
Humanity has an extended metabolic rate equivalent to 14 Billion elephants (2.7 Billion for the U.S. alone)

# The Diagnosis: Creating Human Wealth Without Regard for Natural Wealth

Out of Scale

Scaling law for metabolic rate:  
 $Y = Y_0 * M^{(3/4)}$   
human:  $Y = 50 - 100$  Watt

## Metabolic Rate



14 Billion elephants: a heavy "load" for Earth

## Breaking Scaling Laws

How could Homo sapiens “break” the scaling law?

## Breaking Scaling Laws



# The Remarkable *(But Not Extraordinary)* Human Brain

A novel technique for counting neurons is changing our appraisal of just how special the human brain really is

By Suzana Herculano-Houzel

ILLUSTRATION BY JEAN FRANÇOIS PODEVIN



## Breaking Scaling Laws

- Brain is the most energy-demanding part in an organism.
- Brain to body ratio is limited by energy available to the organism to sustain the metabolic rate.

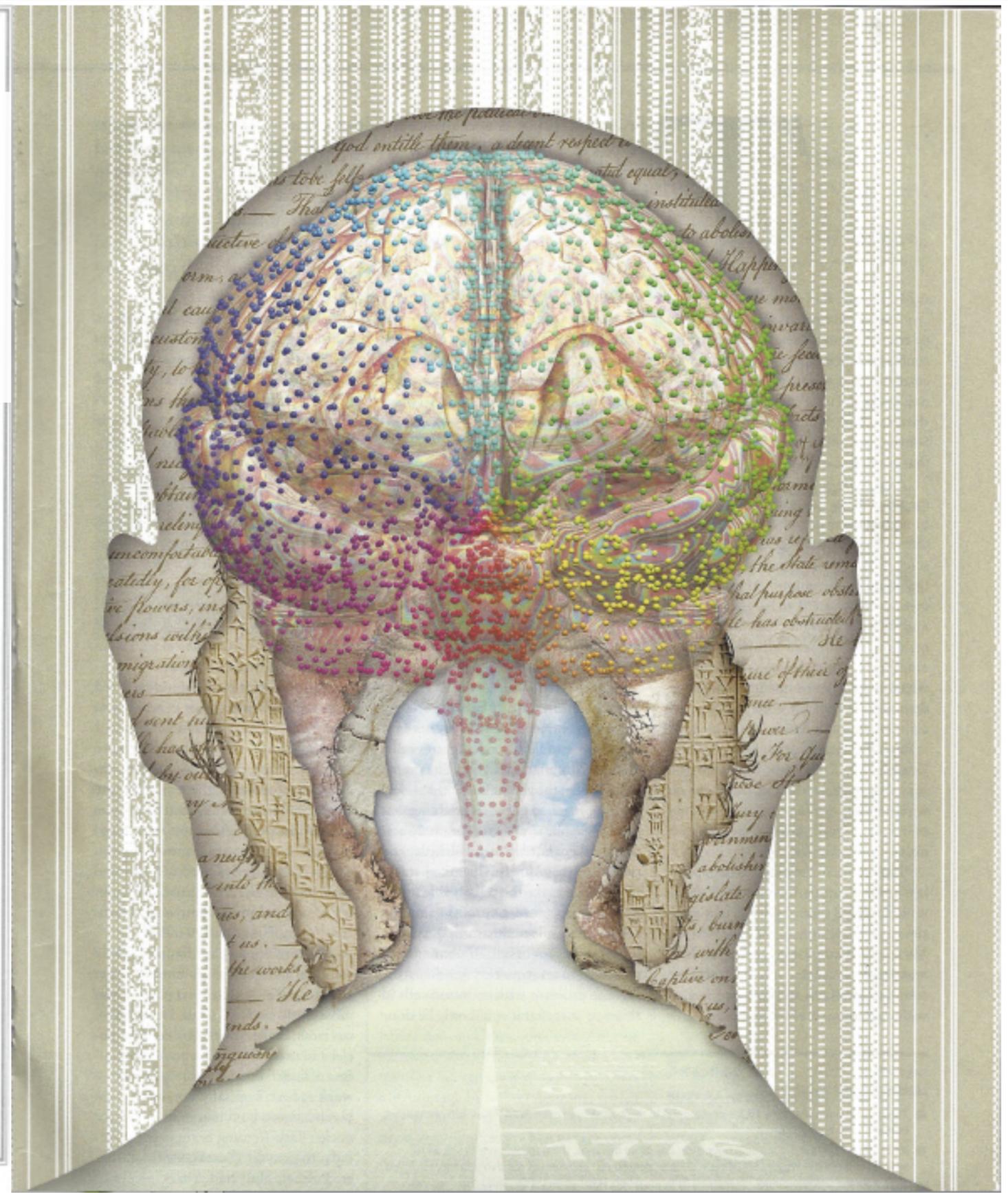
**The Remarkable**  
*(But Not Extraordinary)*  
**Human Brain**

A novel technique for counting neurons is changing our appraisal of just how special the human brain really is

By Suzana Herculano-Houzel

ILLUSTRATION BY JEAN FRANÇOIS PODEVIN

36 SCIENTIFIC AMERICAN MIND MARCH/APRIL 2017



# The Diagnosis: Creating Human Wealth Without Regard for Natural Wealth

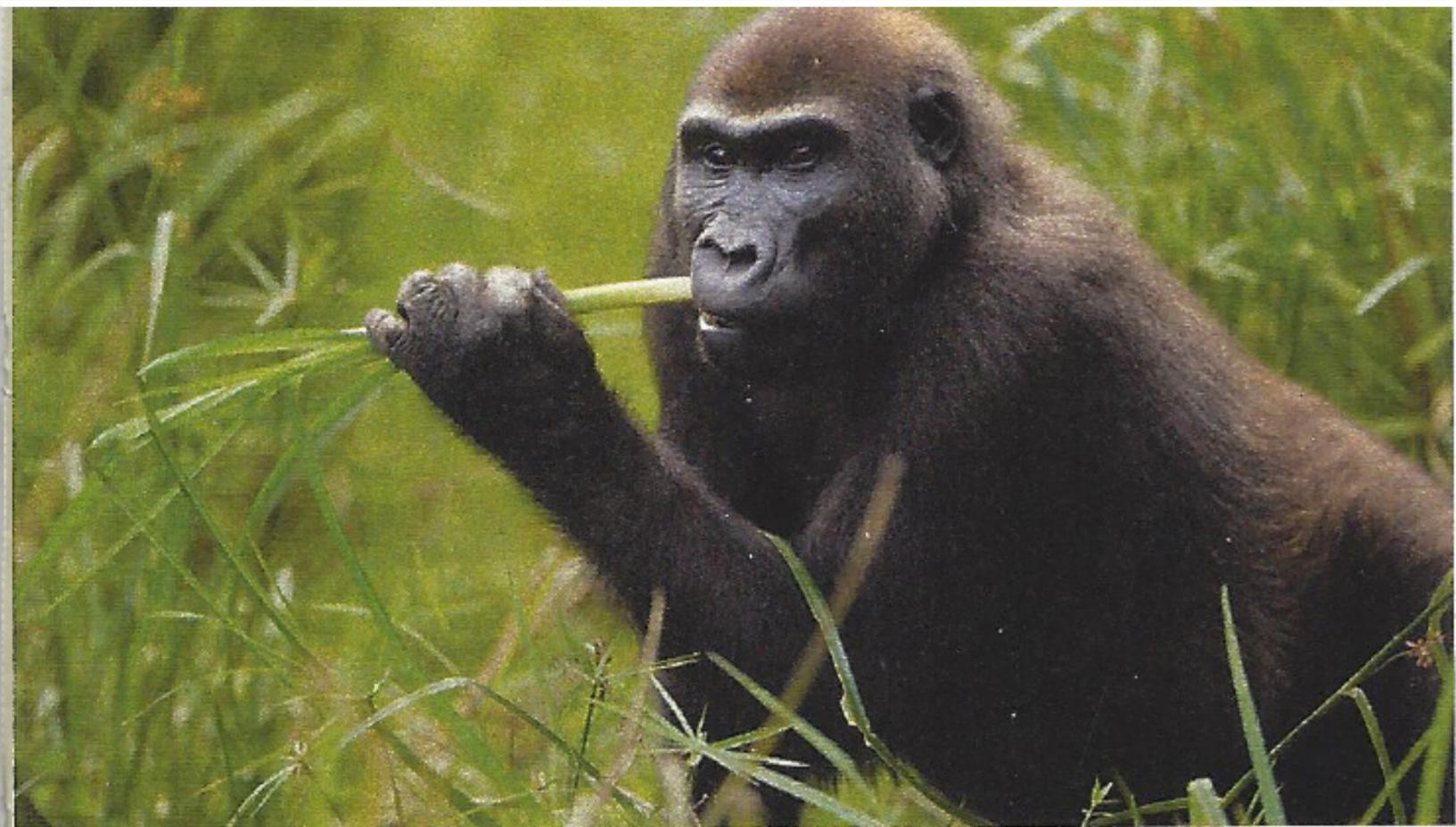
## Breaking Scaling Laws

Brain is the most energy-demanding part in an organism.

Brain to body ratio is limited by energy available to the organism to sustain the metabolic rate.

Great apes such as gorillas and orangutans need to spend hours foraging to have enough energy to sustain the large body frames.

They cannot afford larger brains.



The  
Remarkable  
(But Not Extraordinary)  
Human  
**Brain**

A novel technique for counting neurons is changing our appraisal of just how special the human brain really is

By Suzana Herculano-Houzel

ILLUSTRATION BY JEAN FRANÇOIS PODEVIN



# The Diagnosis: Creating Human Wealth Without Regard for Natural Wealth

## Breaking Scaling Laws

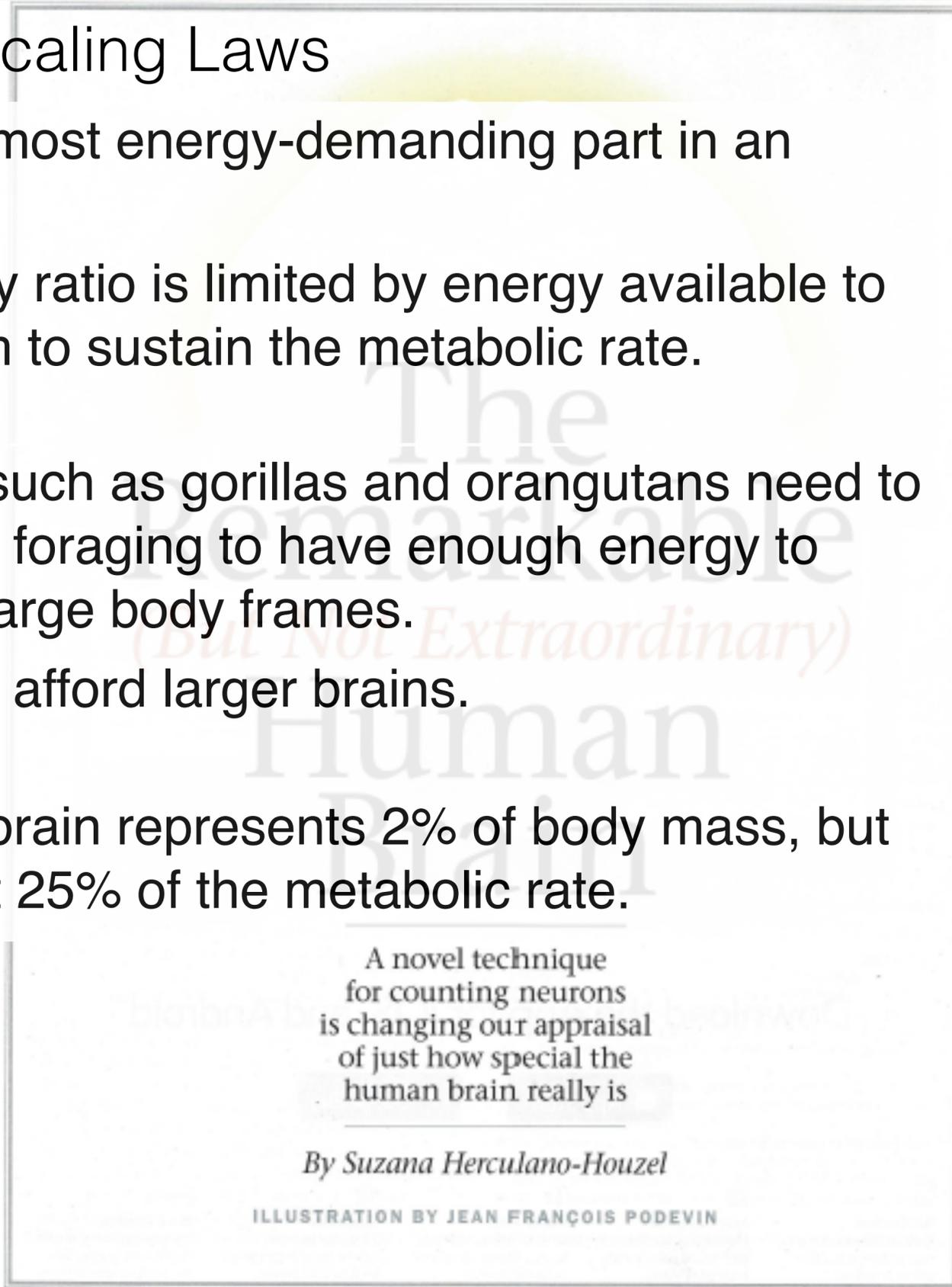
Brain is the most energy-demanding part in an organism.

Brain to body ratio is limited by energy available to the organism to sustain the metabolic rate.

Great apes such as gorillas and orangutans need to spend hours foraging to have enough energy to sustain the large body frames.

They cannot afford larger brains.

The human brain represents 2% of body mass, but it uses about 25% of the metabolic rate.



# The Diagnosis: Creating Human Wealth Without Regard for Natural Wealth

## Breaking Scaling Laws

Brain is the most energy-demanding part in an organism.

Brain to body ratio is limited by energy available to the organism to sustain the metabolic rate.

Great apes such as gorillas and orangutans need to spend hours foraging to have enough energy to sustain the large body frames.

They cannot afford larger brains.

The human brain represents 2% of body mass, but it uses about 25% of the metabolic rate.

Supporting a large, more efficient brain requires high-energy, easy to process food:

Homo sapiens achieved this by using fire to process food (particularly meat)

ILLUSTRATION BY JEAN FRANÇOIS PODEVIN



# The Diagnosis: Creating Human Wealth Without Regard for Natural Wealth

## Breaking Scaling Laws

Brain is the most energy-demanding part in an organism.

Brain to body ratio is limited by energy available to the organism to sustain the metabolic rate.

Great apes such as gorillas and orangutans need to spend hours foraging to have enough energy to sustain the large body frames. They cannot afford larger brains.

The human brain represents 2% of body mass, but it uses about 25% of the metabolic rate.

Supporting a large, more efficient brain requires high-energy, easy to process food: Homo sapiens achieved this by using fire to process food (particularly meat)

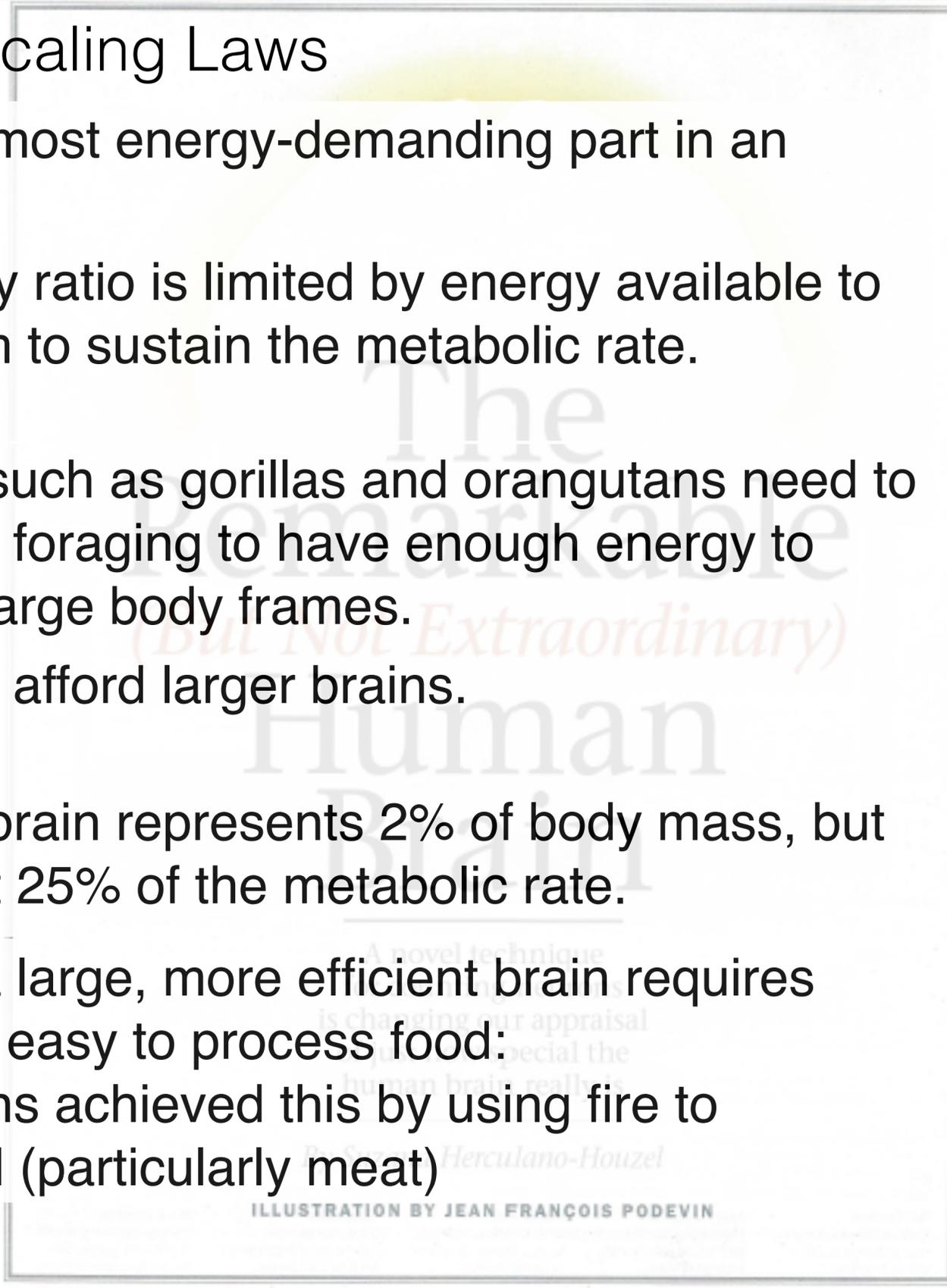
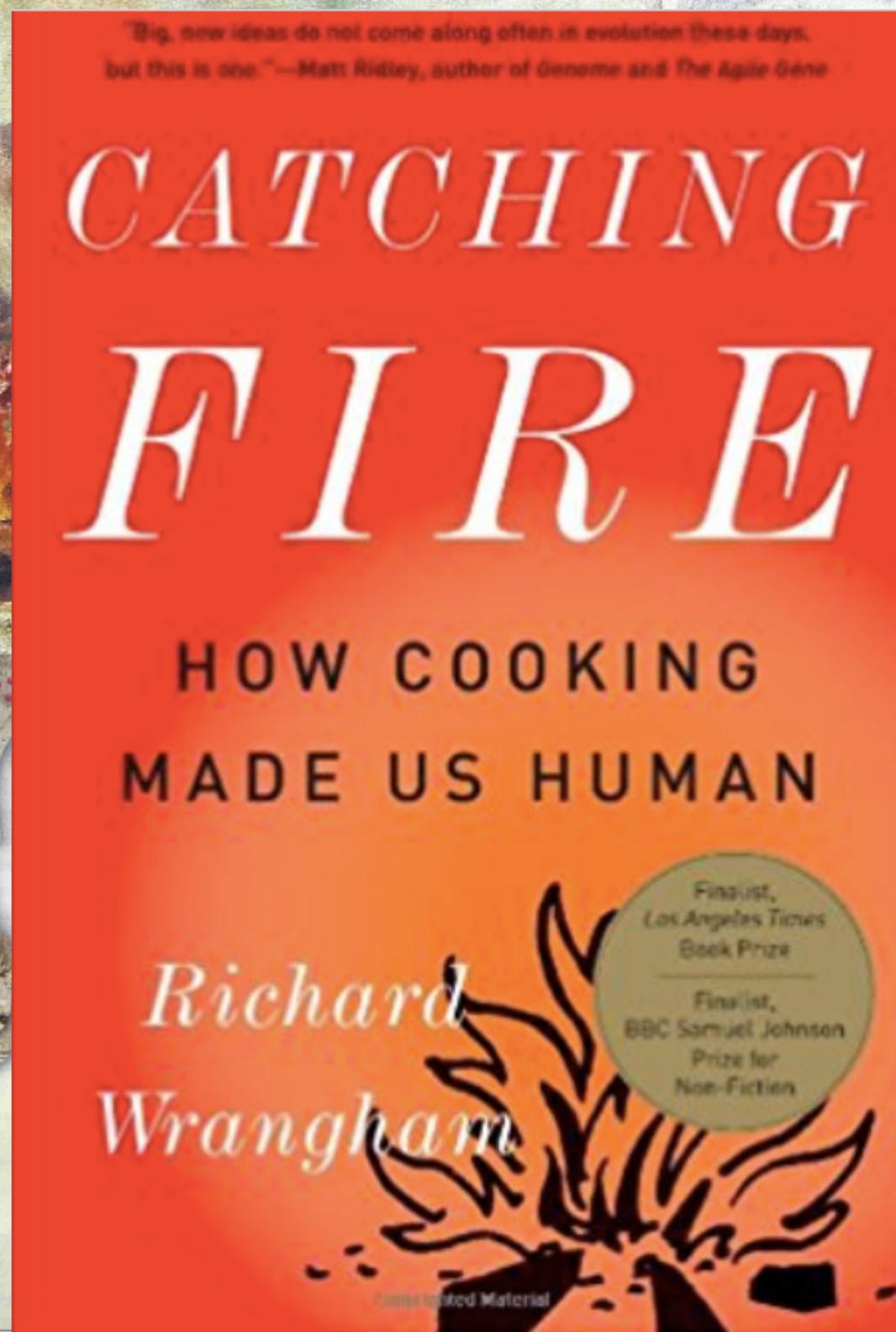


ILLUSTRATION BY JEAN FRANÇOIS PODEVIN



"Big, new ideas do not come along often in evolution these days, but this is one." —Matt Ridley, author of *Genome* and *The Agile Gene*

# CATCHING

# FIRE

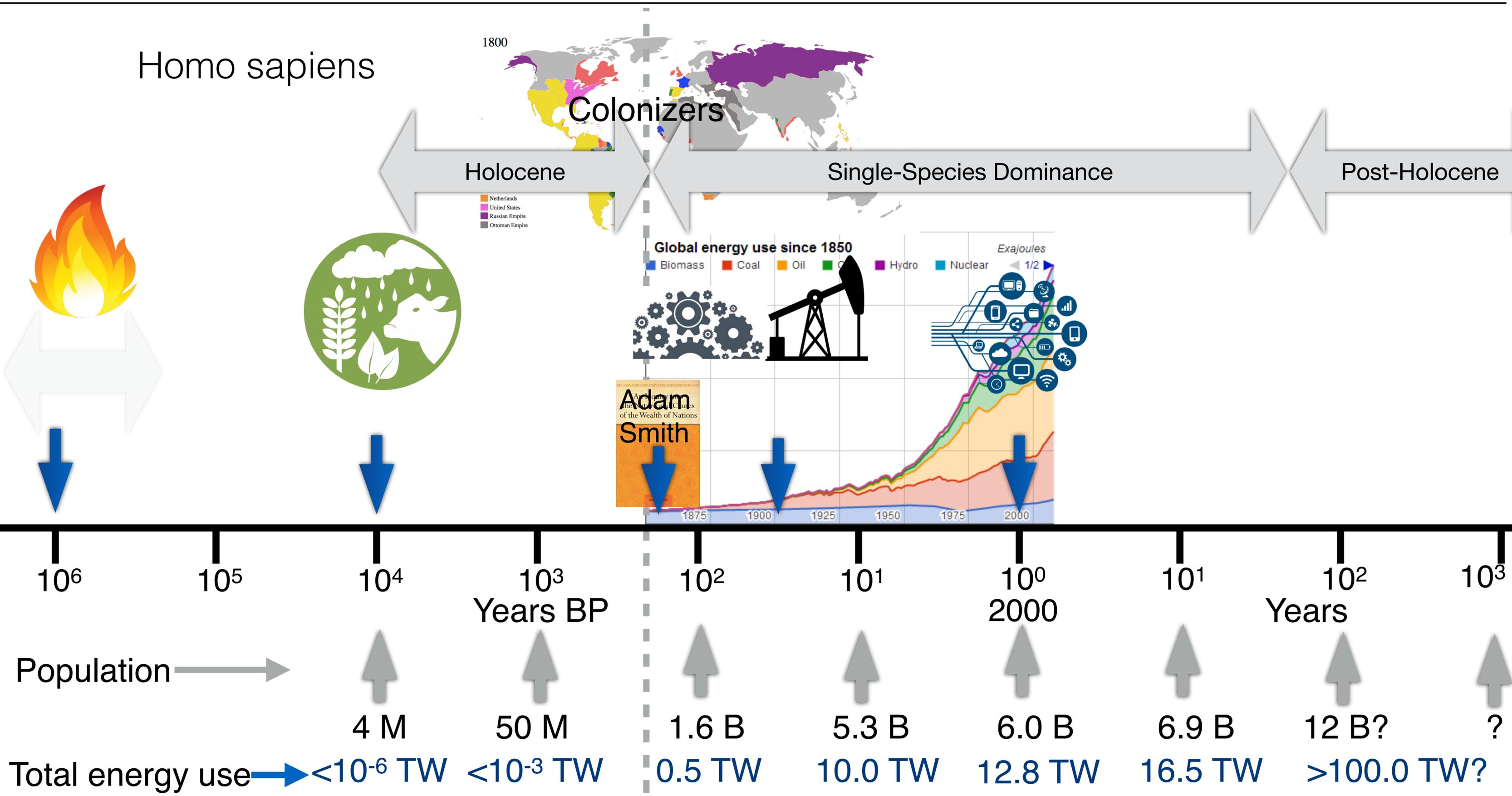
HOW COOKING  
MADE US HUMAN

Richard  
Wrangham

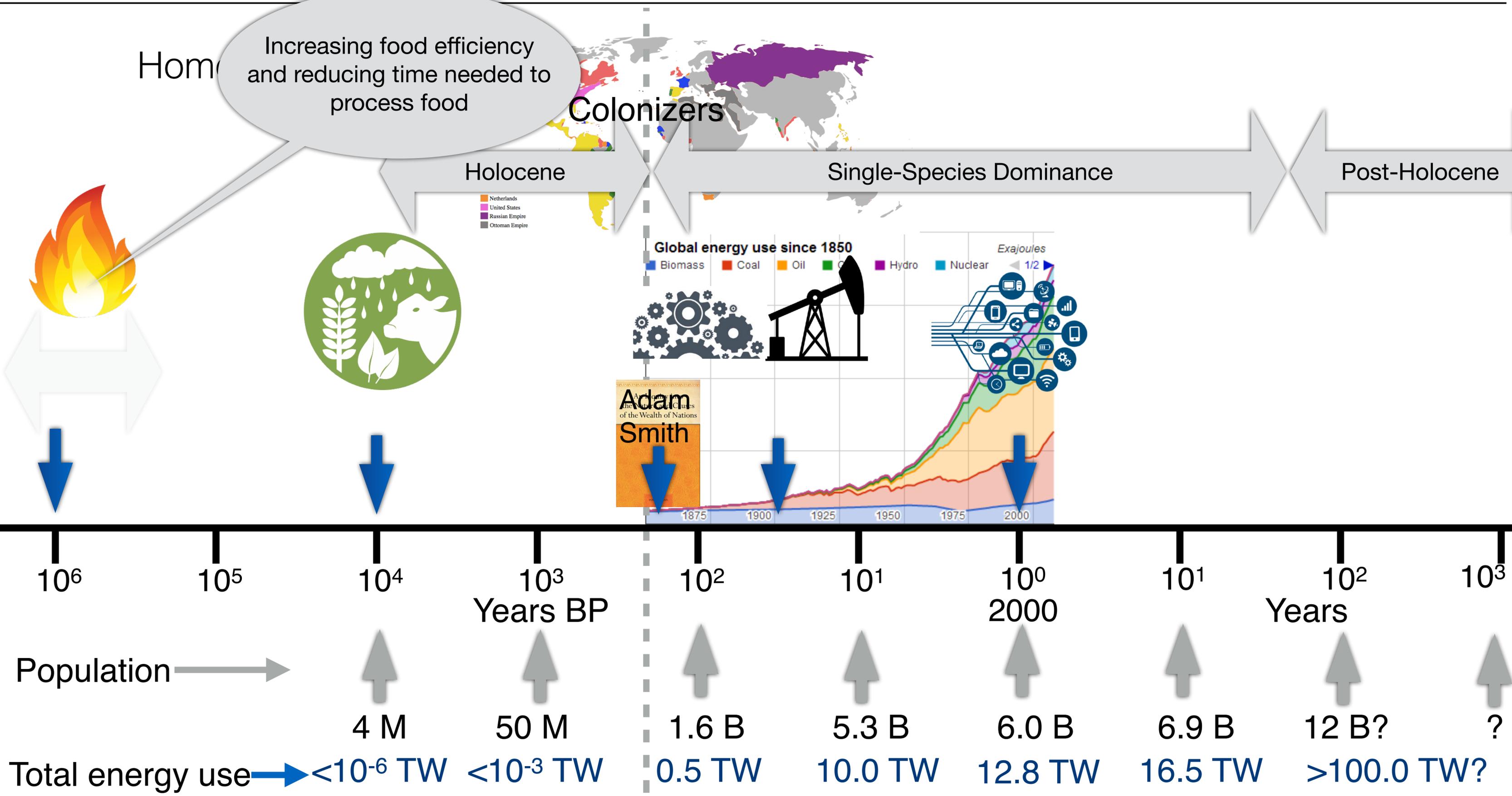
Finalist,  
Los Angeles Times  
Book Prize

Finalist,  
BBC Samuel Johnson  
Prize for  
Non-Fiction

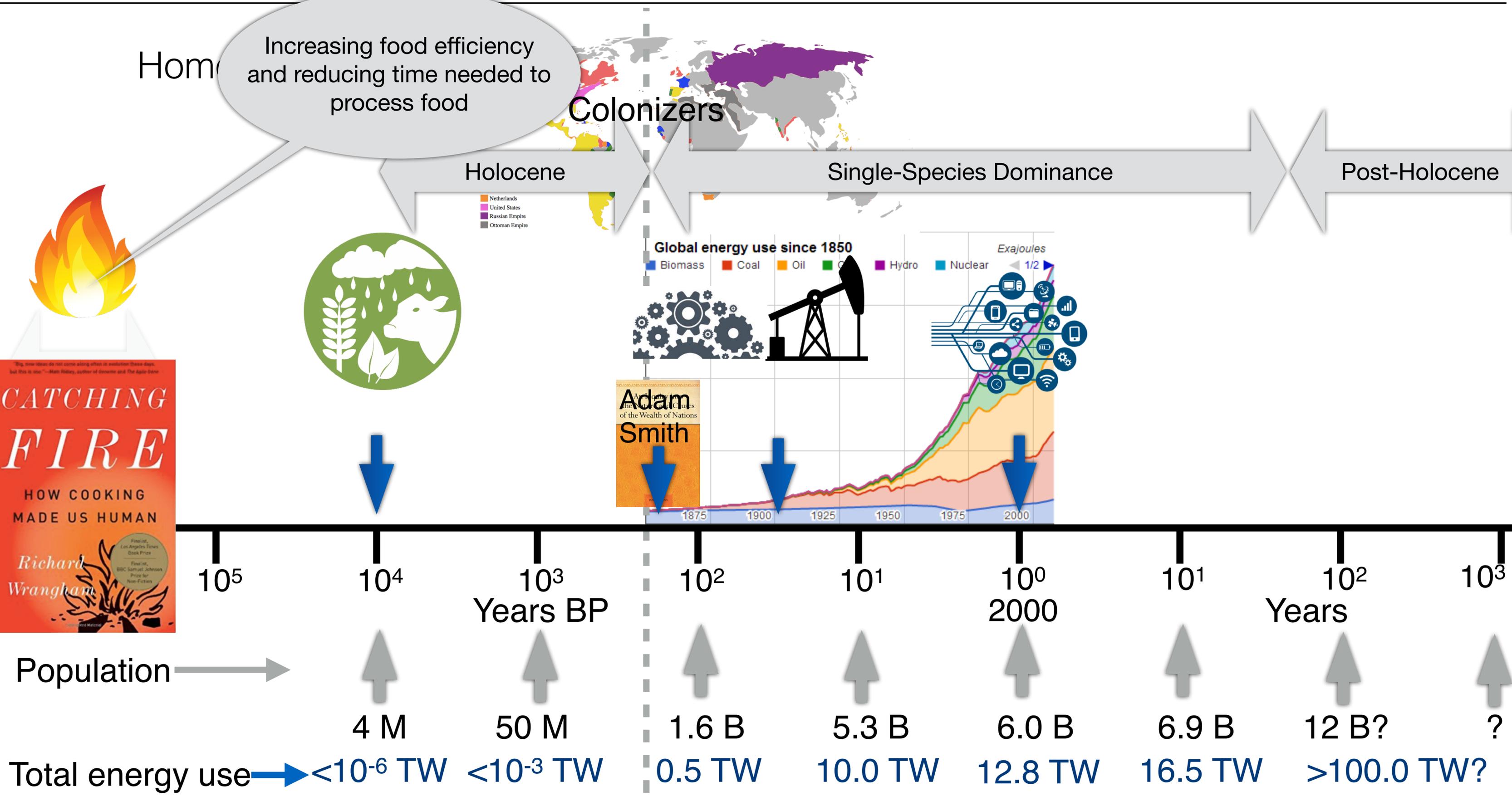
# The Diagnosis: Creating Human Wealth Without Regard for Natural Wealth



# The Diagnosis: Creating Human Wealth Without Regard for Natural Wealth

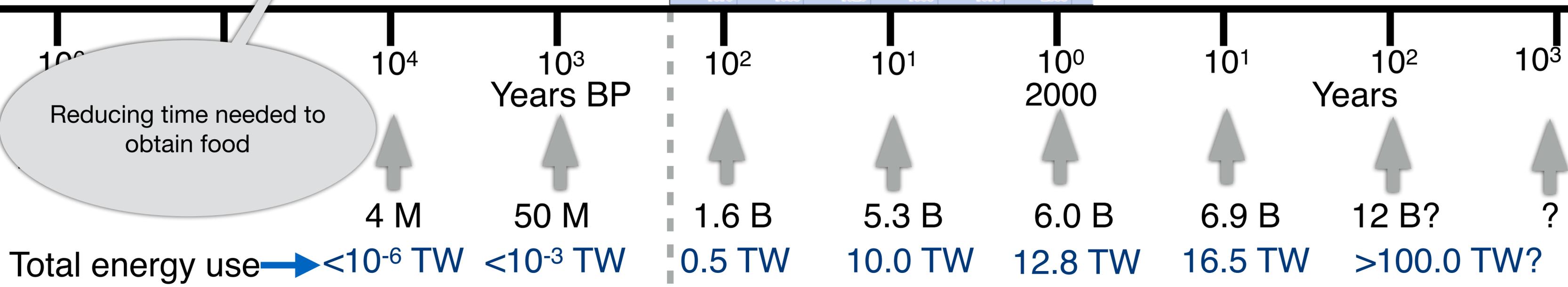
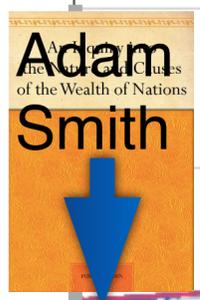
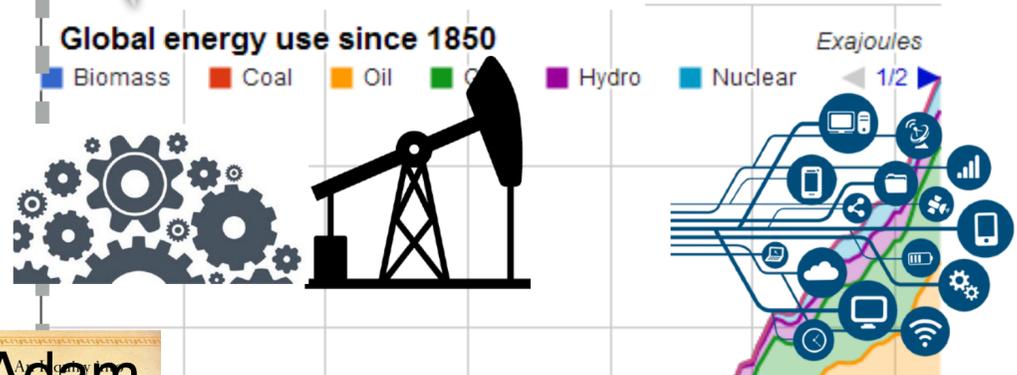
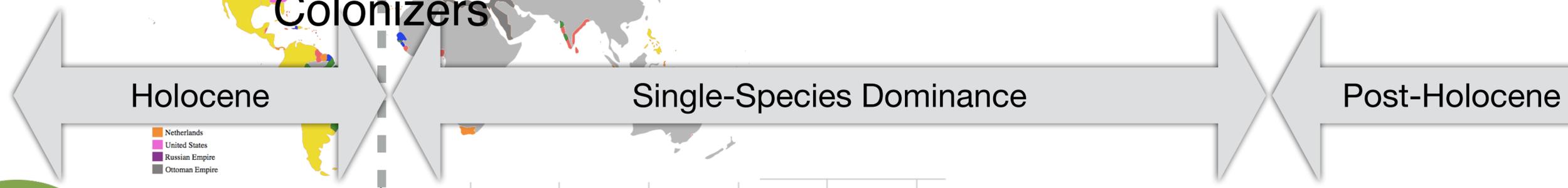


# The Diagnosis: Creating Human Wealth Without Regard for Natural Wealth



# The Diagnosis: Creating Human Wealth Without Regard for Natural Wealth

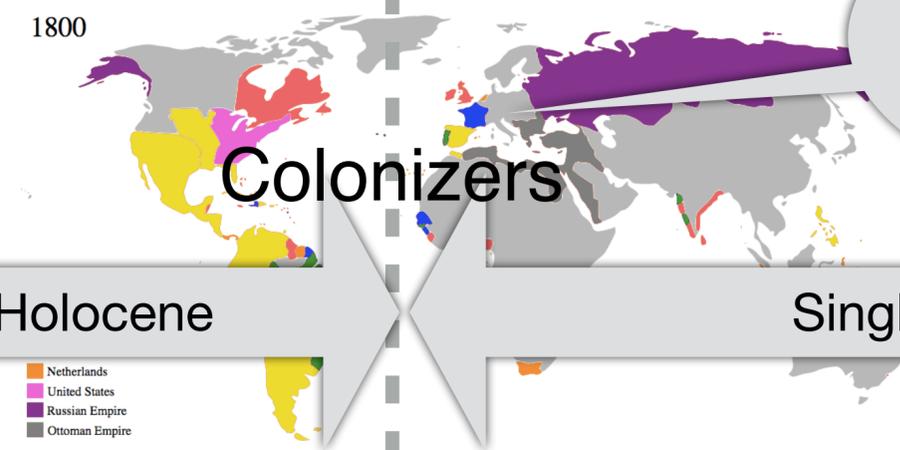
Homo sapiens



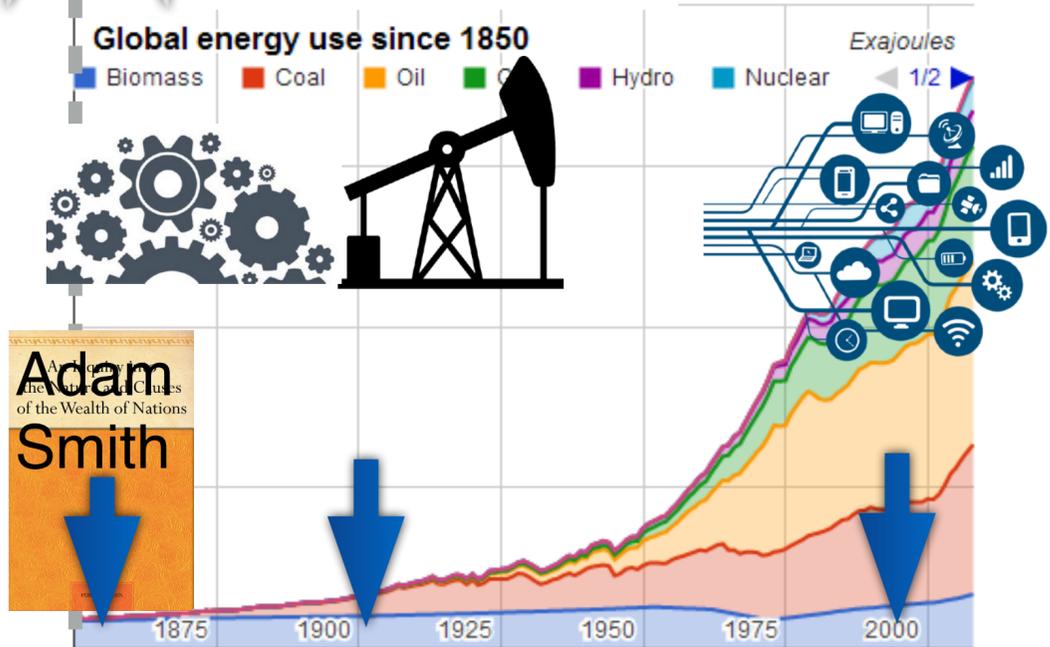
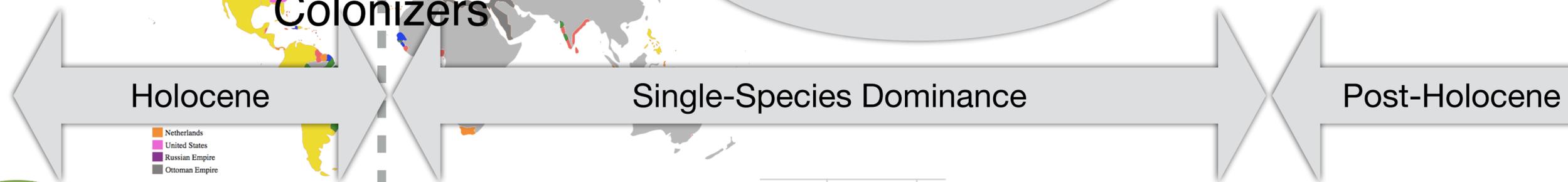
# The Diagnosis: Creating Human Wealth Without Regard for Environmental Wealth



Homo sapiens

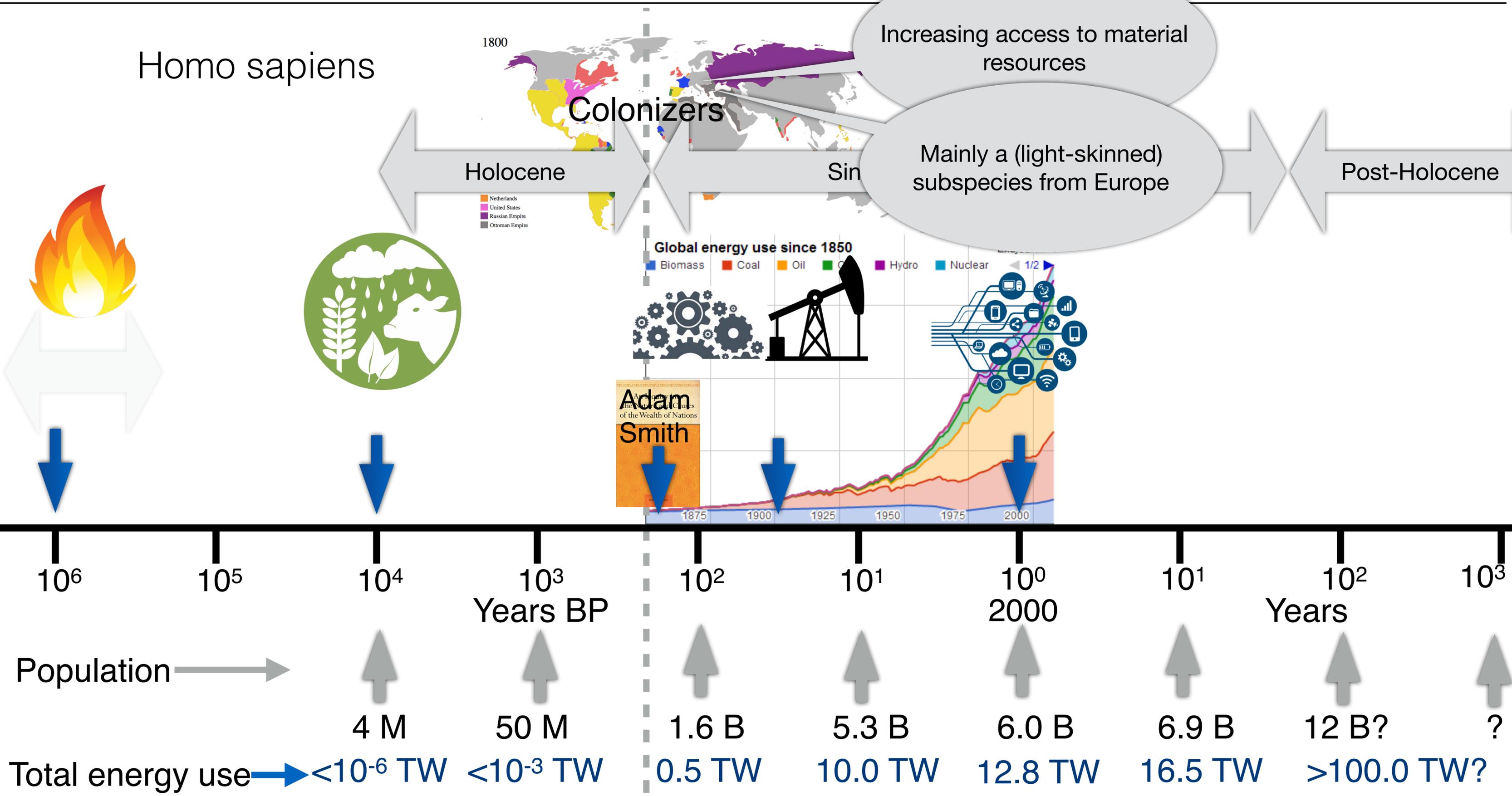


Increasing access to material resources

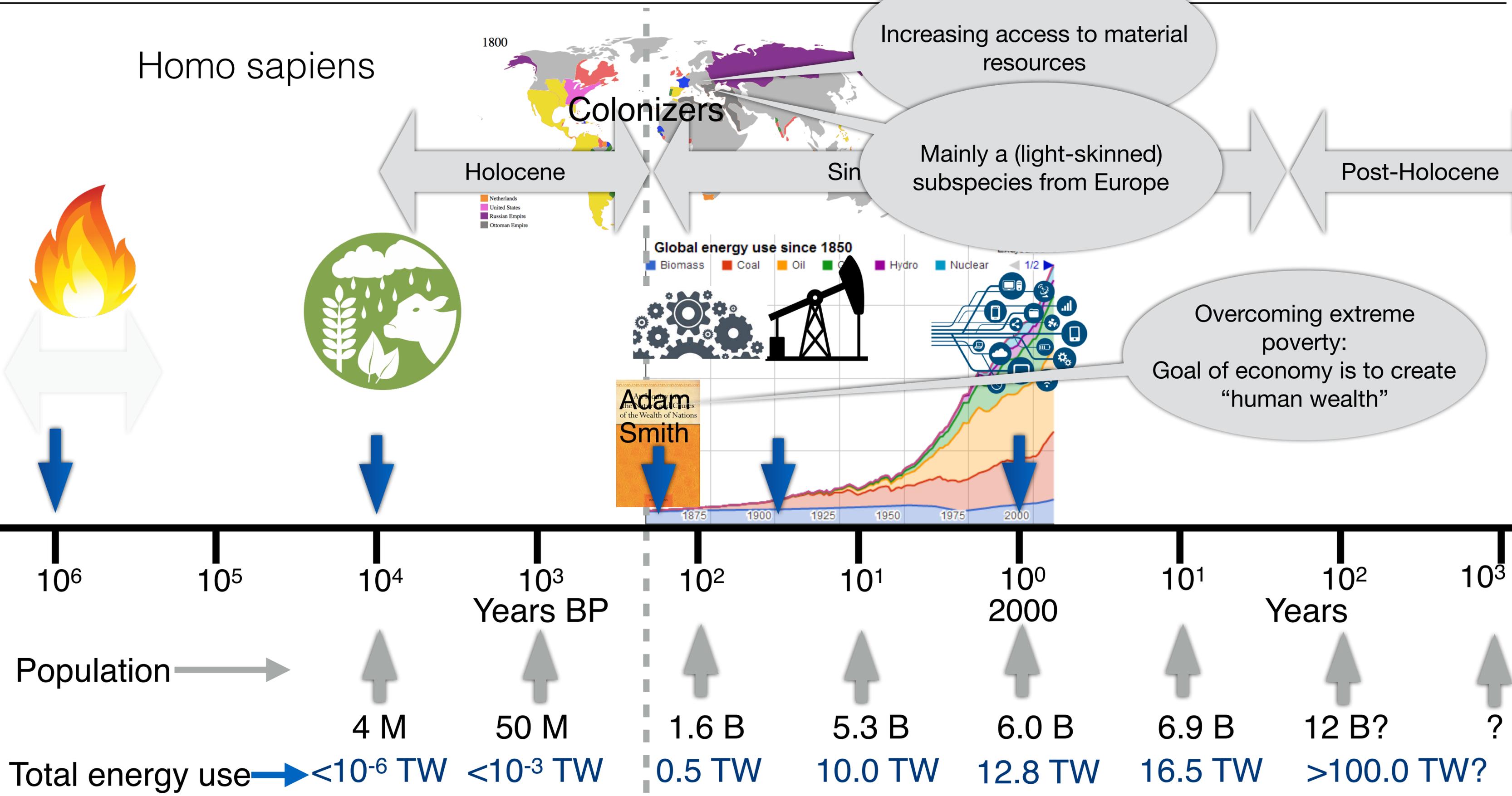


Time	Population	Total energy use
$10^6$ Years BP		$<10^{-6}$ TW
$10^5$ Years BP		
$10^4$ Years BP	4 M	$<10^{-3}$ TW
$10^3$ Years BP	50 M	
$10^2$ Years BP	1.6 B	0.5 TW
$10^1$ Years BP	5.3 B	10.0 TW
$10^0$ (2000)	6.0 B	12.8 TW
$10^1$ Years	6.9 B	16.5 TW
$10^2$ Years	12 B?	$>100.0$ TW?
$10^3$ Years	?	

# The Diagnosis: Creating Human Wealth Without Regard for ... Wealth

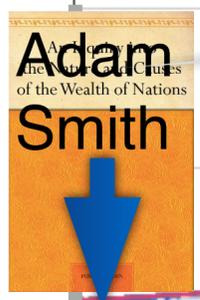
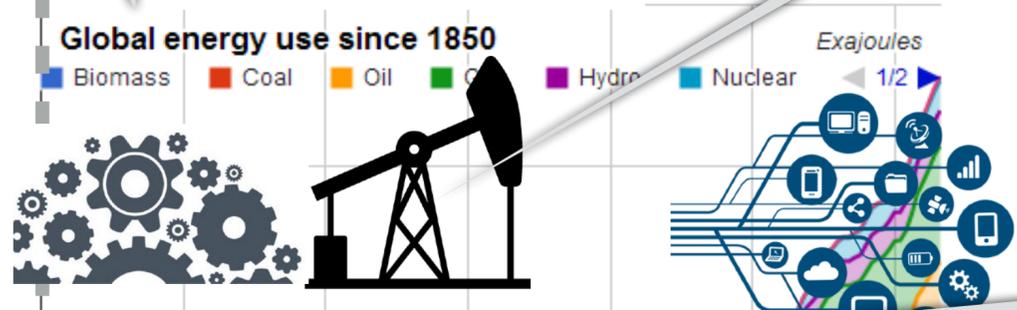
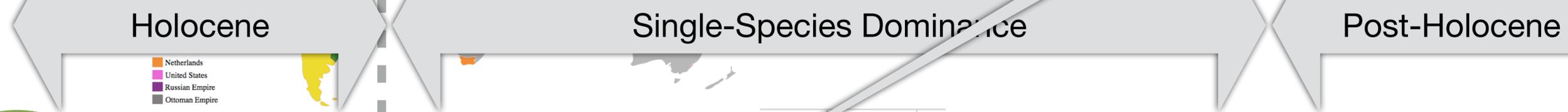


# The Diagnosis: Creating Human Wealth Without Regard for Environmental Wealth



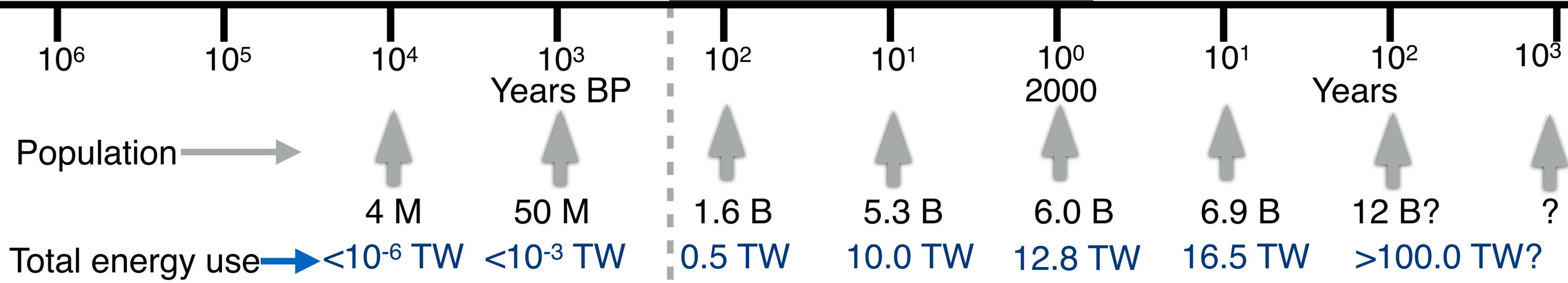
# The Diagnosis: Creating Human Wealth Without Regard for Natural Wealth

Homo sapiens



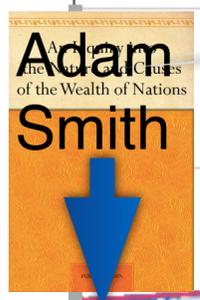
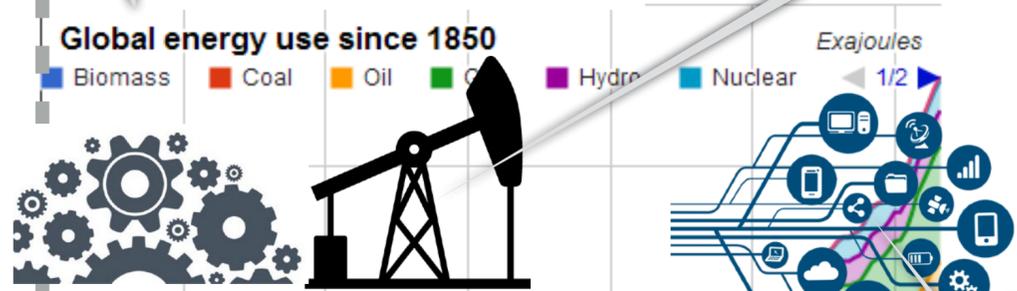
Overcoming extreme poverty:  
Goal of economy is to create  
"human wealth"

Easy access to seemingly infinite energy combined with technology



# The Diagnosis: Creating Human Wealth Without Regard for Natural Wealth

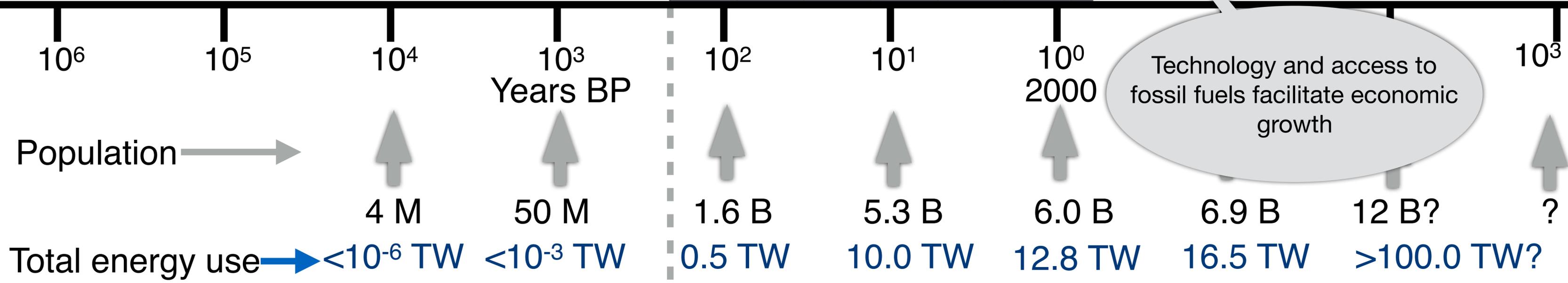
Homo sapiens



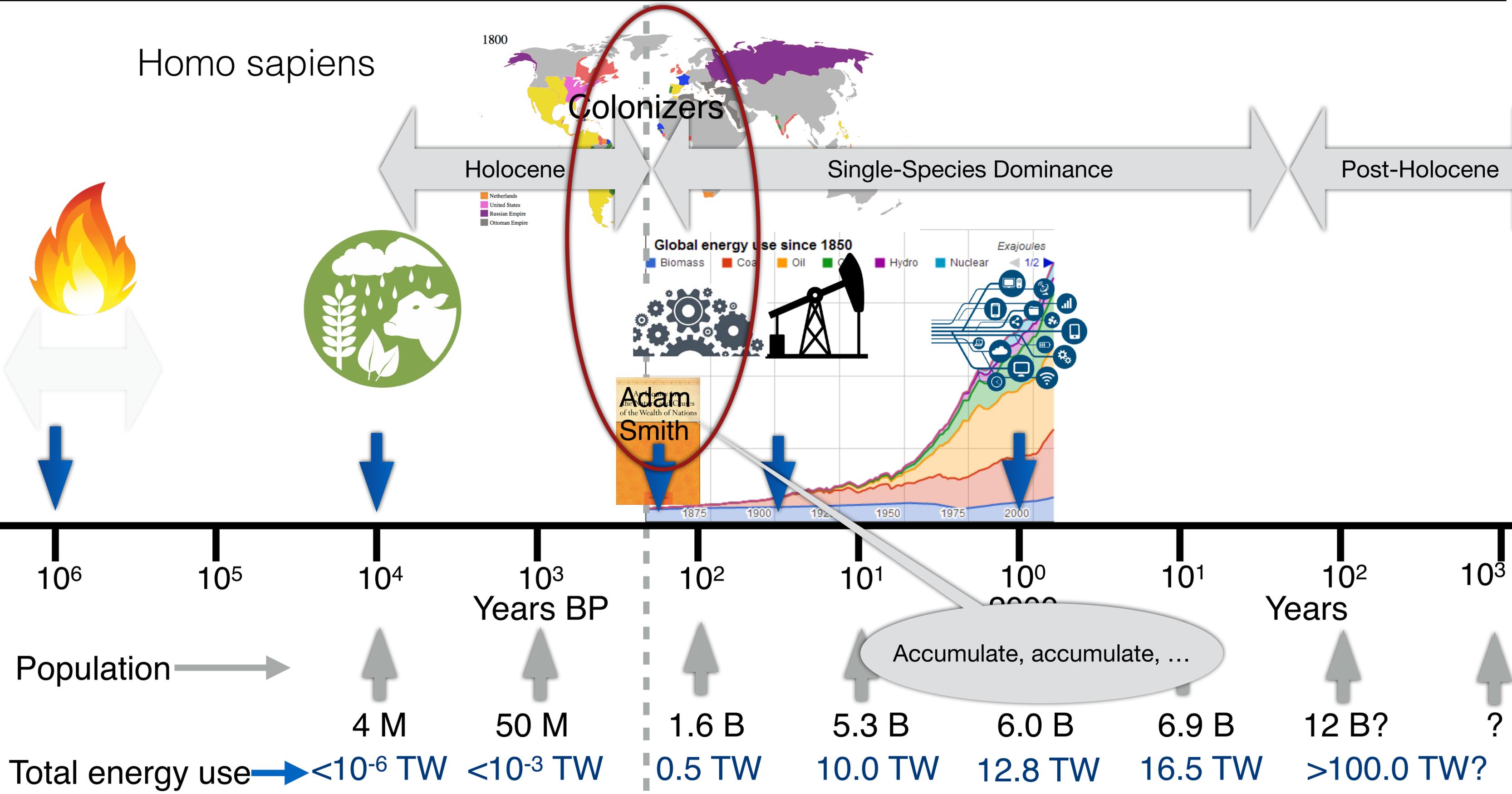
Overcoming extreme poverty:  
Goal of economy is to create "human wealth"

Technology and access to fossil fuels facilitate economic growth

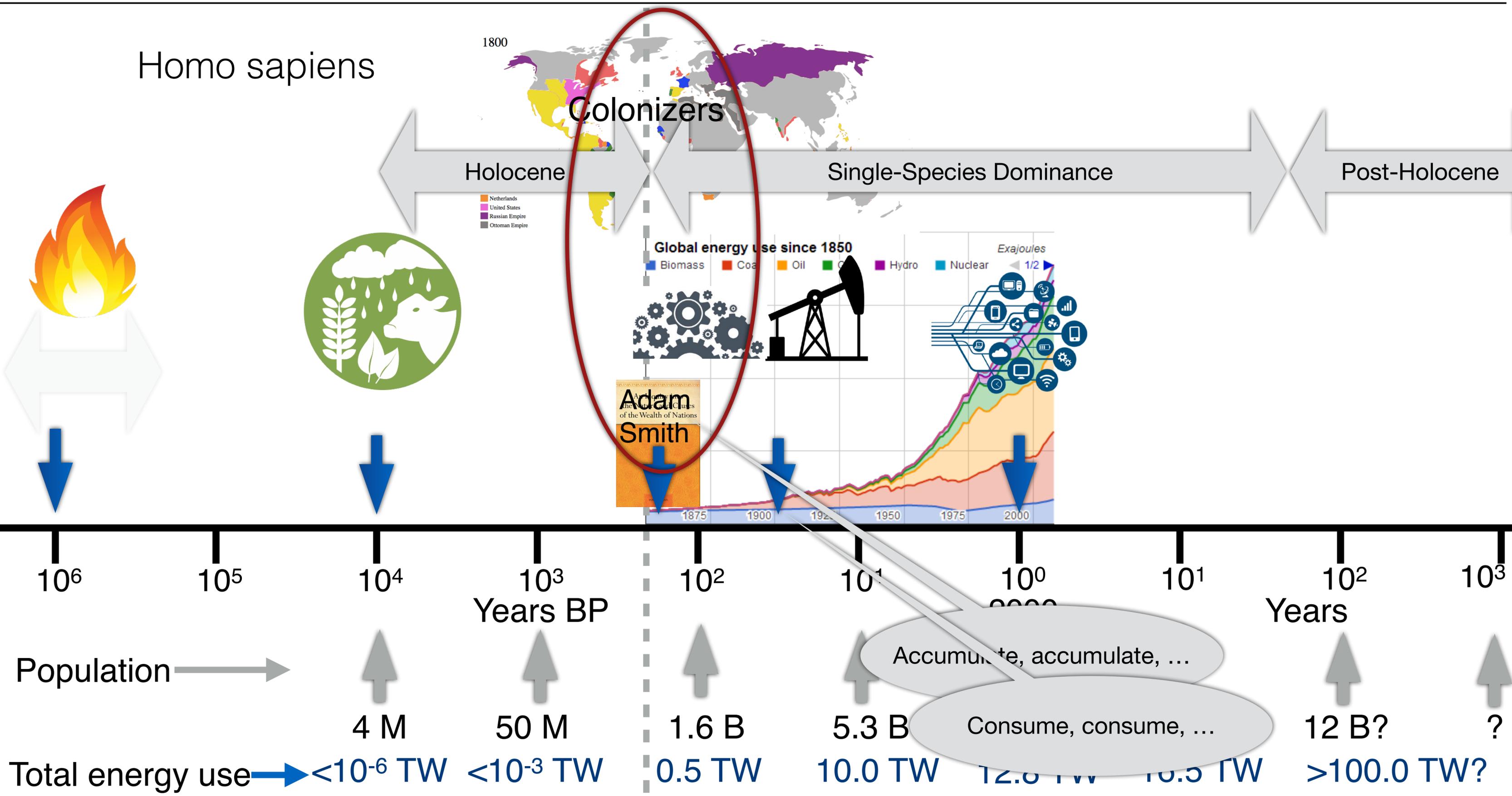
Easy access to seemingly infinite energy combined with technology



# The Diagnosis: Creating Human Wealth Without Regard for Natural Wealth

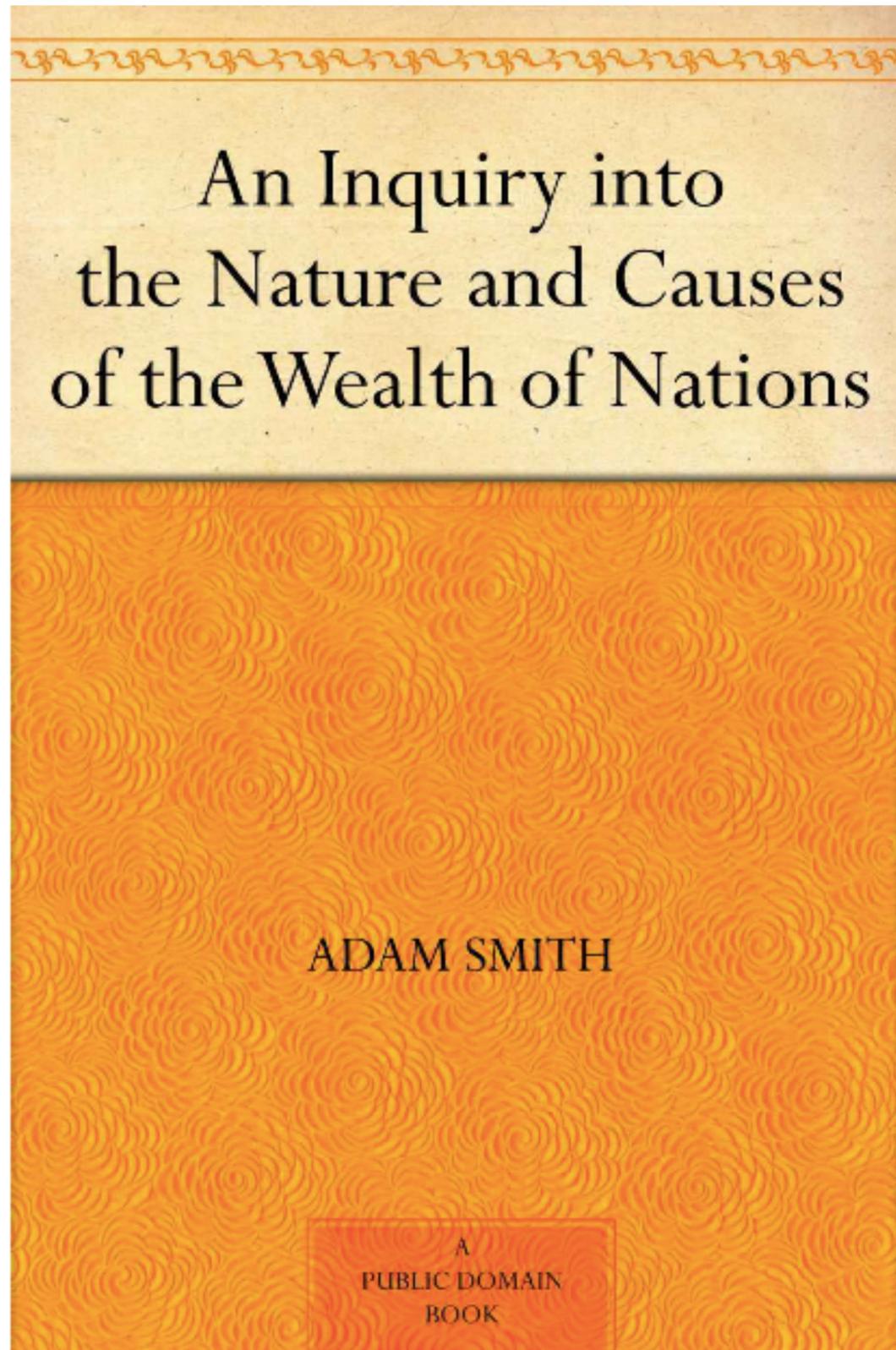


# The Diagnosis: Creating Human Wealth Without Regard for Natural Wealth



# The Diagnosis: Creating Human Wealth Without Regard for Natural Wealth

## Our Mainstream Economic Model



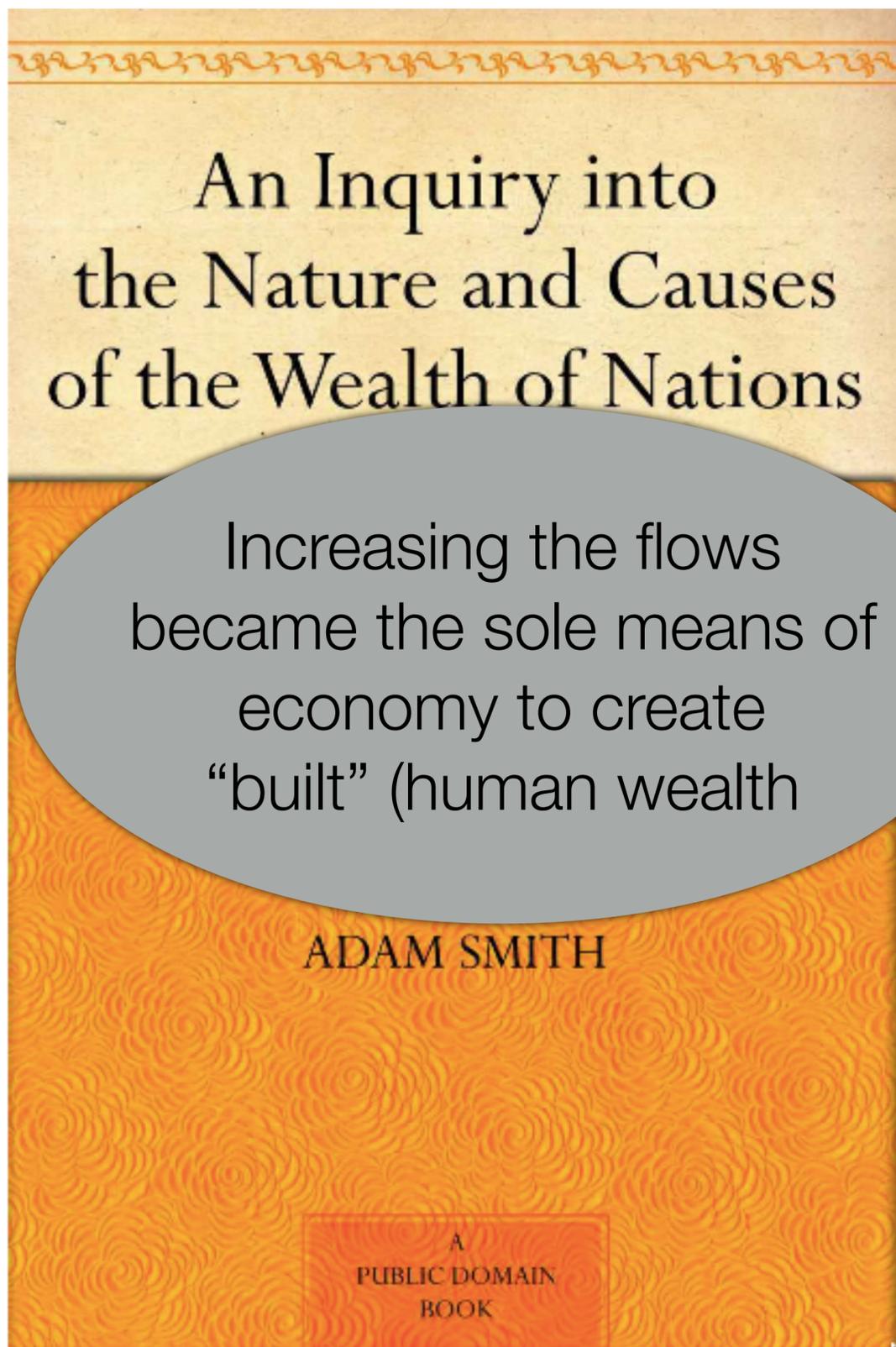
*Published in 1776*

The current mainstream model of the global **economy** is based on a number of assumptions about the way the world works, what the economy is, and what the economy is for. These assumptions arose in an earlier period, when the world was relatively empty of humans and their artifacts. Built capital was the limiting factor, while natural capital was abundant. It made sense not to worry too much about environmental “externalities,” since they could be assumed to be relatively small and ultimately solvable. It also made sense to focus on the growth of the market economy, as measured by gross domestic product (GDP), as a primary means to improve human welfare. And it made sense to think of the economy as only marketed goods and services and to think of the goal as increasing the amount of these that were produced and consumed.

The Worldwatch Institute. State of the World 2013: Is Sustainability Still Possible? (Kindle Locations 2921-2927). Island Press. Kindle Edition.

# The Diagnosis: Creating Human Wealth Without Regard for Natural Wealth

## Our Mainstream Economic Model



Increasing the flows became the sole means of economy to create “built” (human wealth

The current mainstream model of the global **economy** is based on a number of assumptions about the way the world works, what the economy is, and what the economy is for. These assumptions arose in an earlier period, when the world was relatively empty of humans and their artifacts. Built capital was the limiting factor, while natural capital was abundant. It made sense not to worry too much about environmental “externalities,” since they could be assumed to be relatively small and ultimately solvable. It also made sense to focus on the growth of the market economy, as measured by gross domestic product (GDP), as a primary means to improve human welfare. And it made sense to think of the economy as only marketed goods and services and to think of the goal as increasing the amount of these that were produced and consumed.

The Worldwatch Institute. State of the World 2013: Is Sustainability Still Possible? (Kindle Locations 2921-2927). Island Press. Kindle Edition.

*Published in 1776*

# The Diagnosis: Creating Human Wealth Without Regard for Natural Wealth



Pandemic

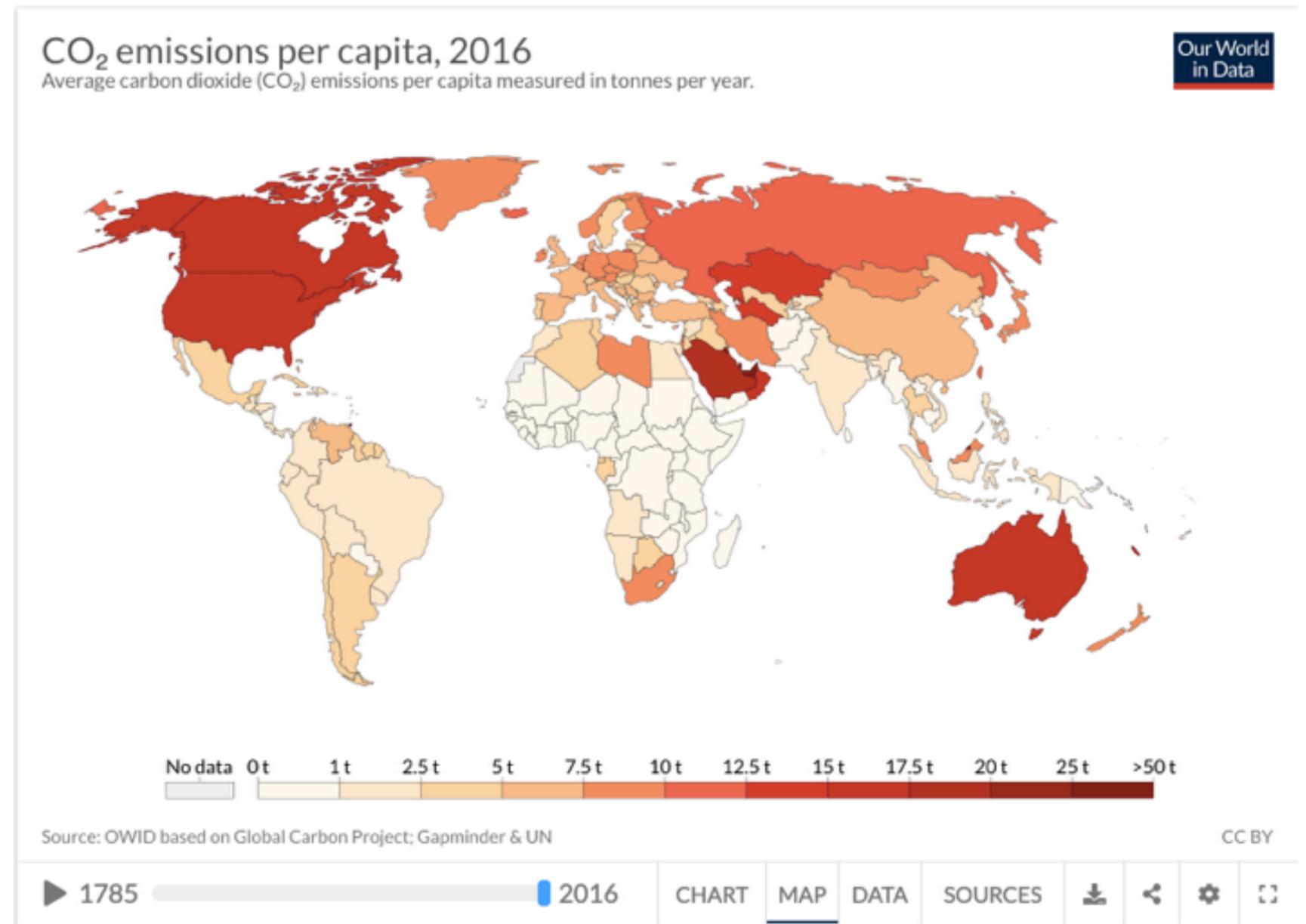
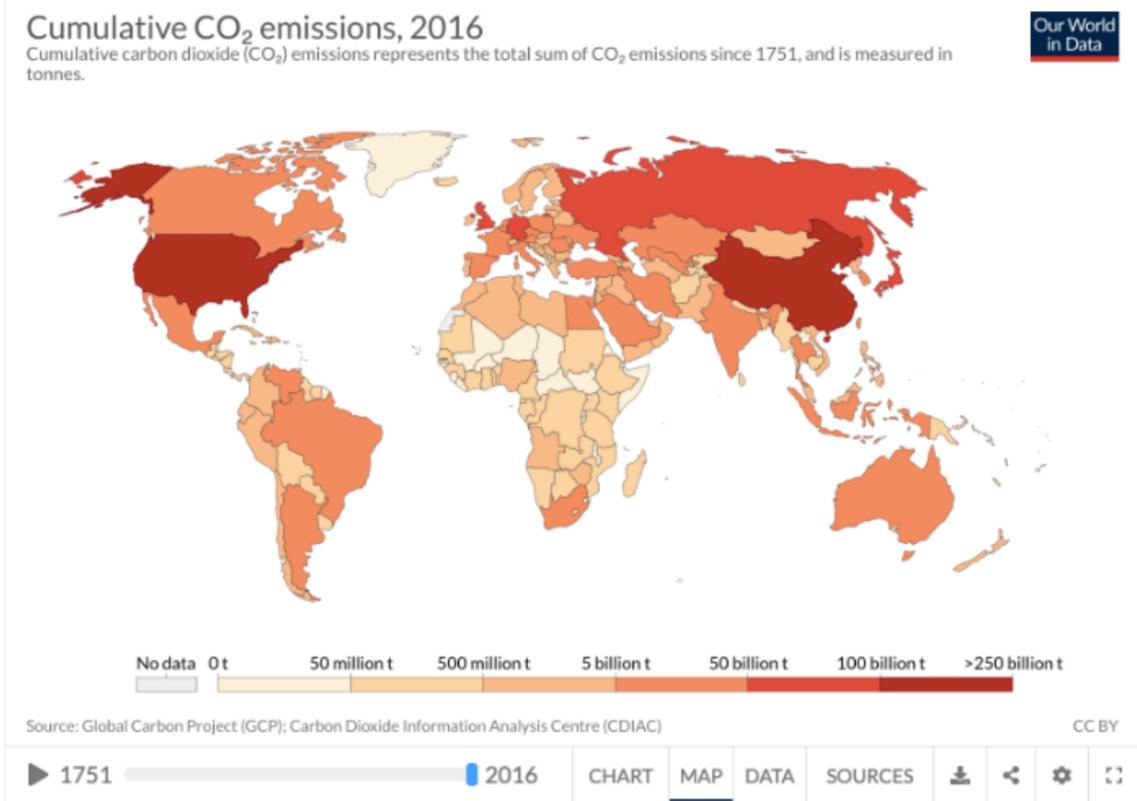
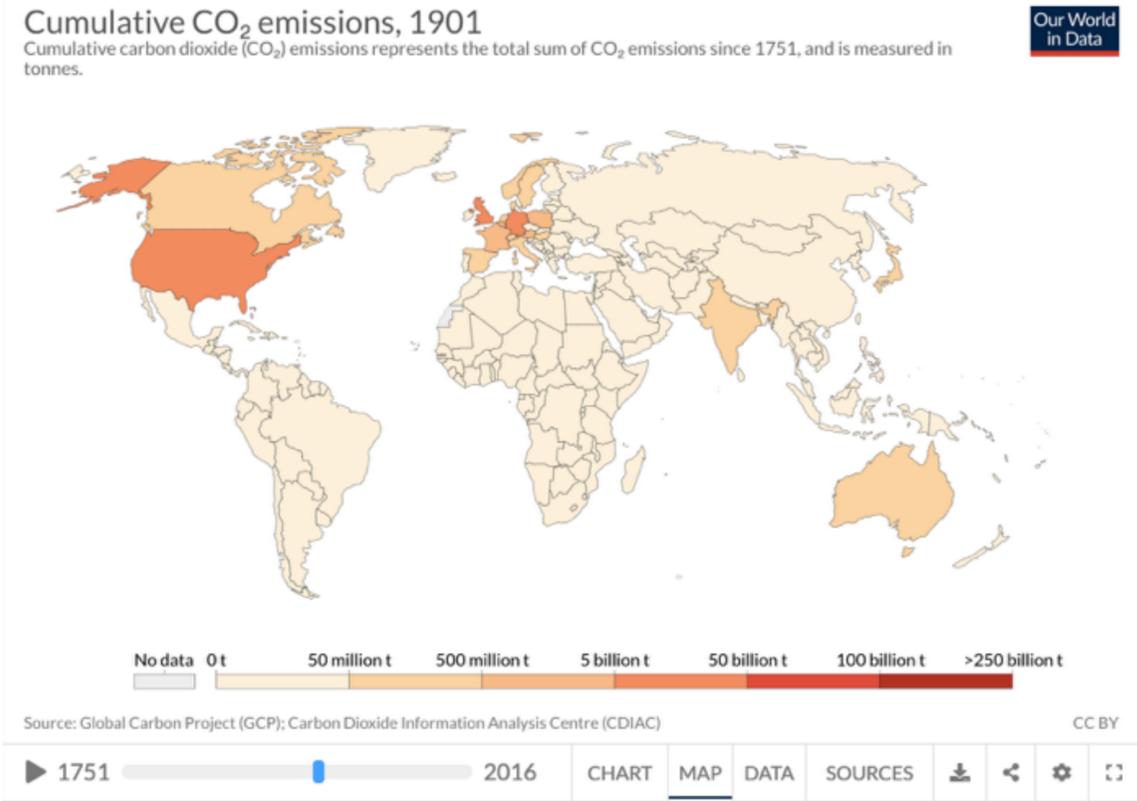
Large Debt

Large  
Wealth  
Increase



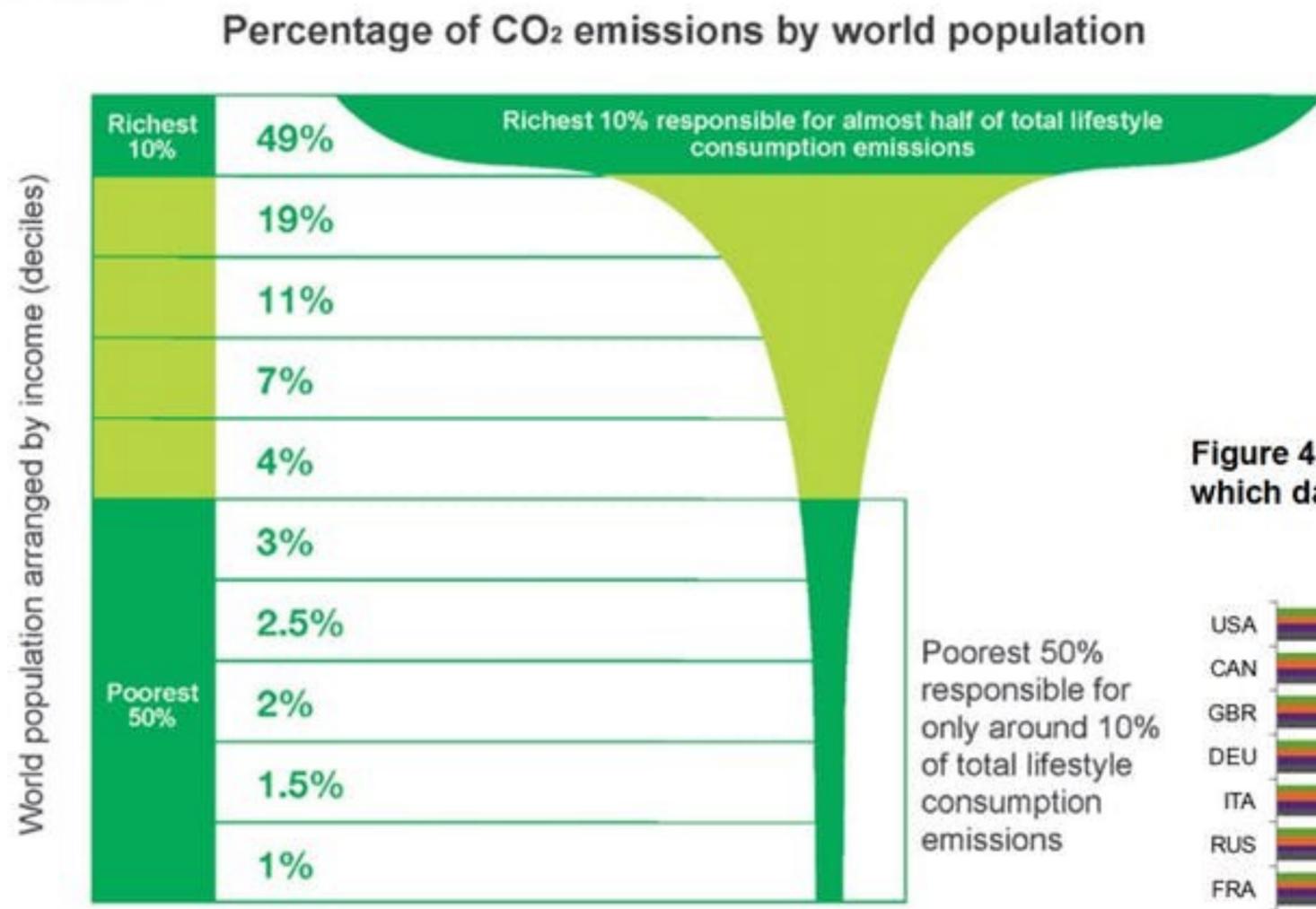
# The Diagnosis: Creating Human Wealth Without Regard for Natural Wealth

## Inequality of Emissions: - geographically



# The Diagnosis: Creating Human Wealth Without Regard for Natural Wealth

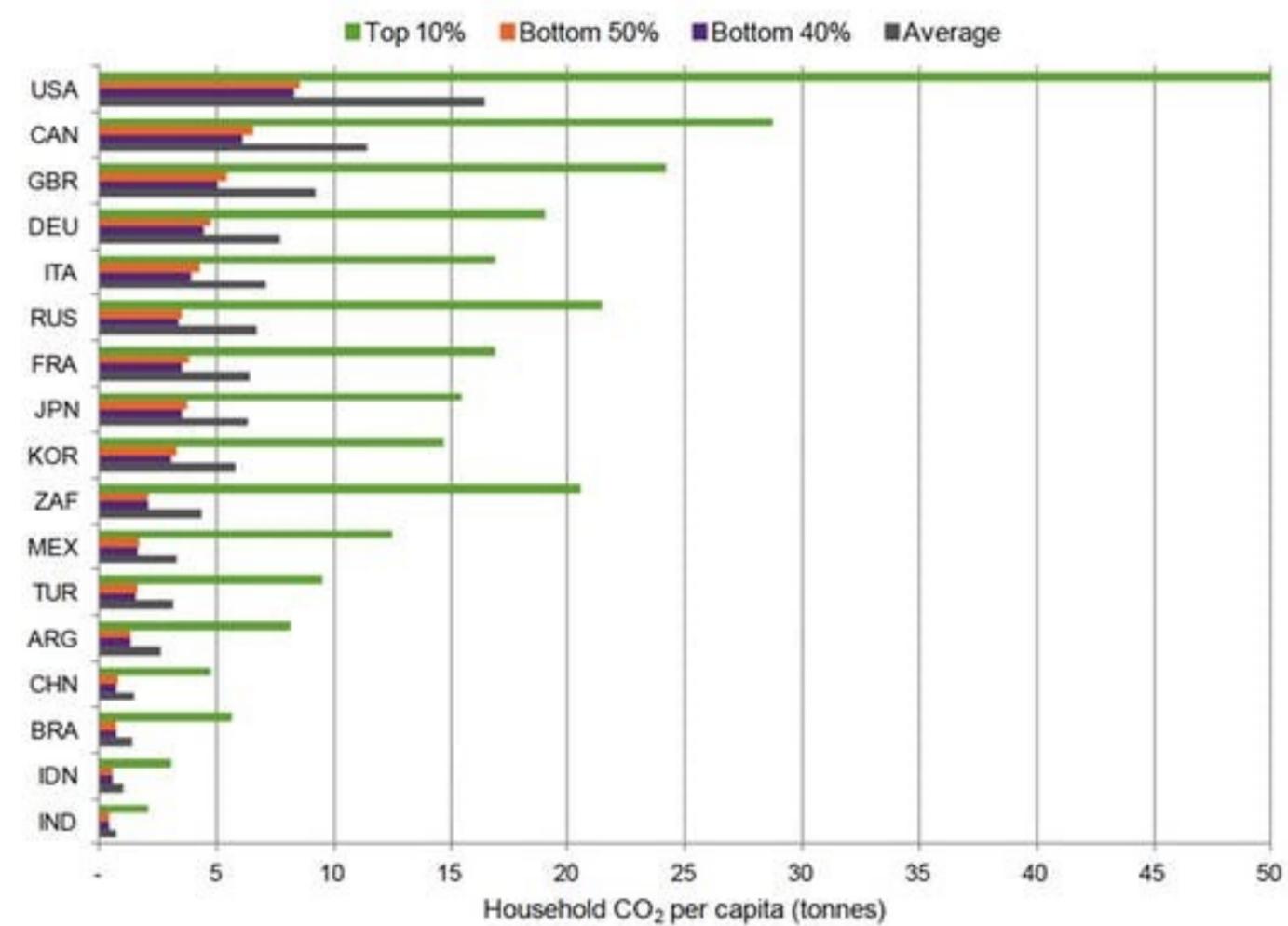
Figure 1: Global income deciles and associated lifestyle consumption emissions



Source: Oxfam

## Inequality of Emissions - with wealth

Figure 4: Per capita lifestyle consumption emissions in G20 countries for which data is available



*The vast majority of the world's richest 10% high emitters still live in rich OECD countries, although that is slowly changing.*

# Key Points

---

## Purpose of Economy

The *de facto* purpose of economy is to meet the needs of the present while safeguarding the Earth's life-support system, on which the welfare of all current and future generation depends.

The current “official” purpose of economy is to create human wealth, and this official purpose is in conflict with the *de facto* purpose.

## Syndrome of Modern Global Change

The Holocene was a “safe operating space for humanity” allowing the emergence of a dominant species

During the last few hundred years, humanity has made large and rapid planetary changes, accelerated existing and introduced new flows in the planetary physiology.

The system is outside the “normal range” and in the dynamic transition into the Post-Holocene.

## Diagnosis

Making the creation of human wealth the “official” purpose of economy and economic growth the overarching goal turned humans into the “Anthropogenic Cataclysmic Virus” (ACV) in the Earth's life-support system.

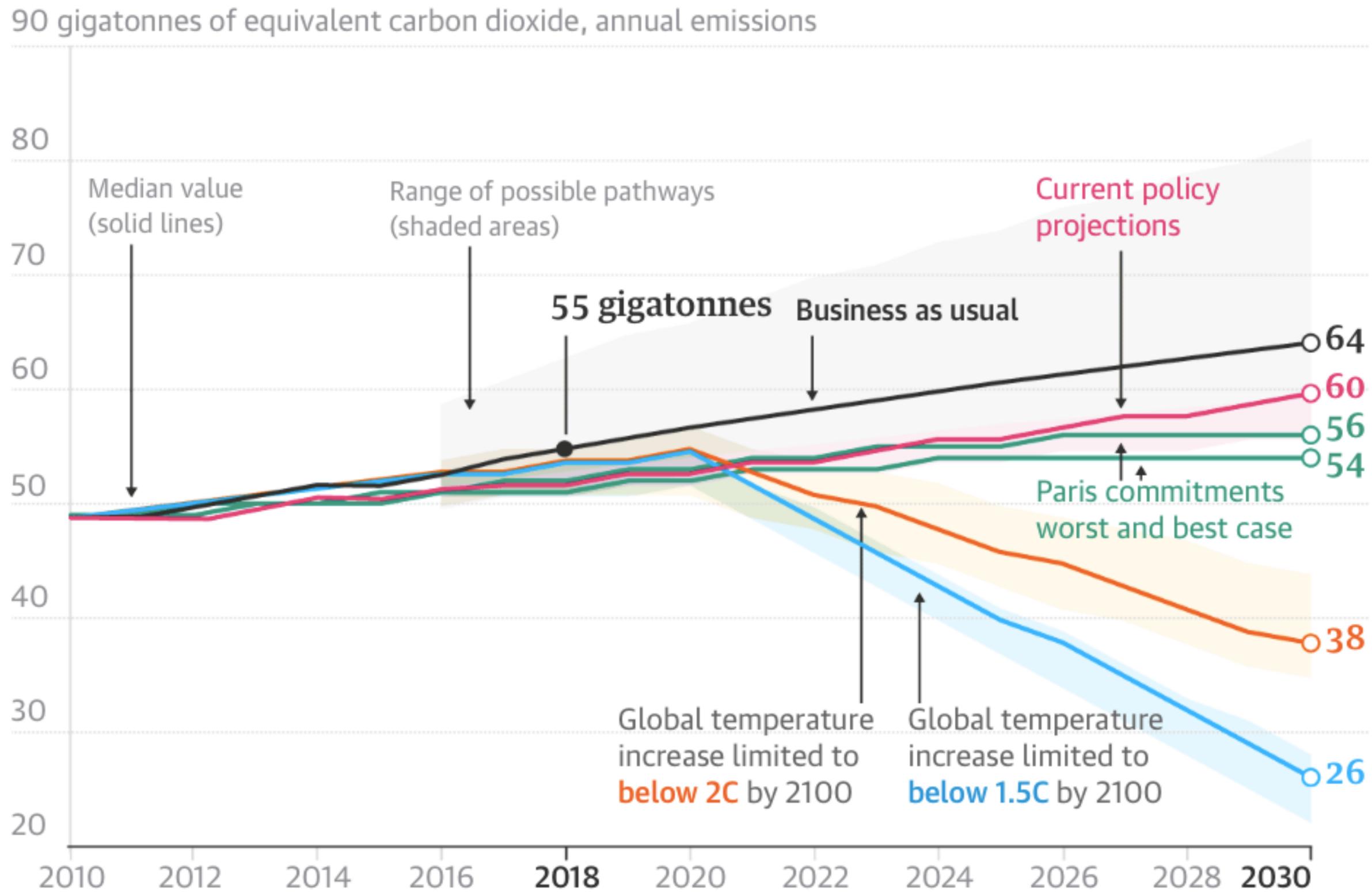
Easy access to seemingly unlimited energy allowed humans to accelerate flows in the Earth's life-support system and sustain rapid population growth and increasing demands.

# Can the Economy in Modern Society Work Without Polluting the Environment with Our Growing Waste?

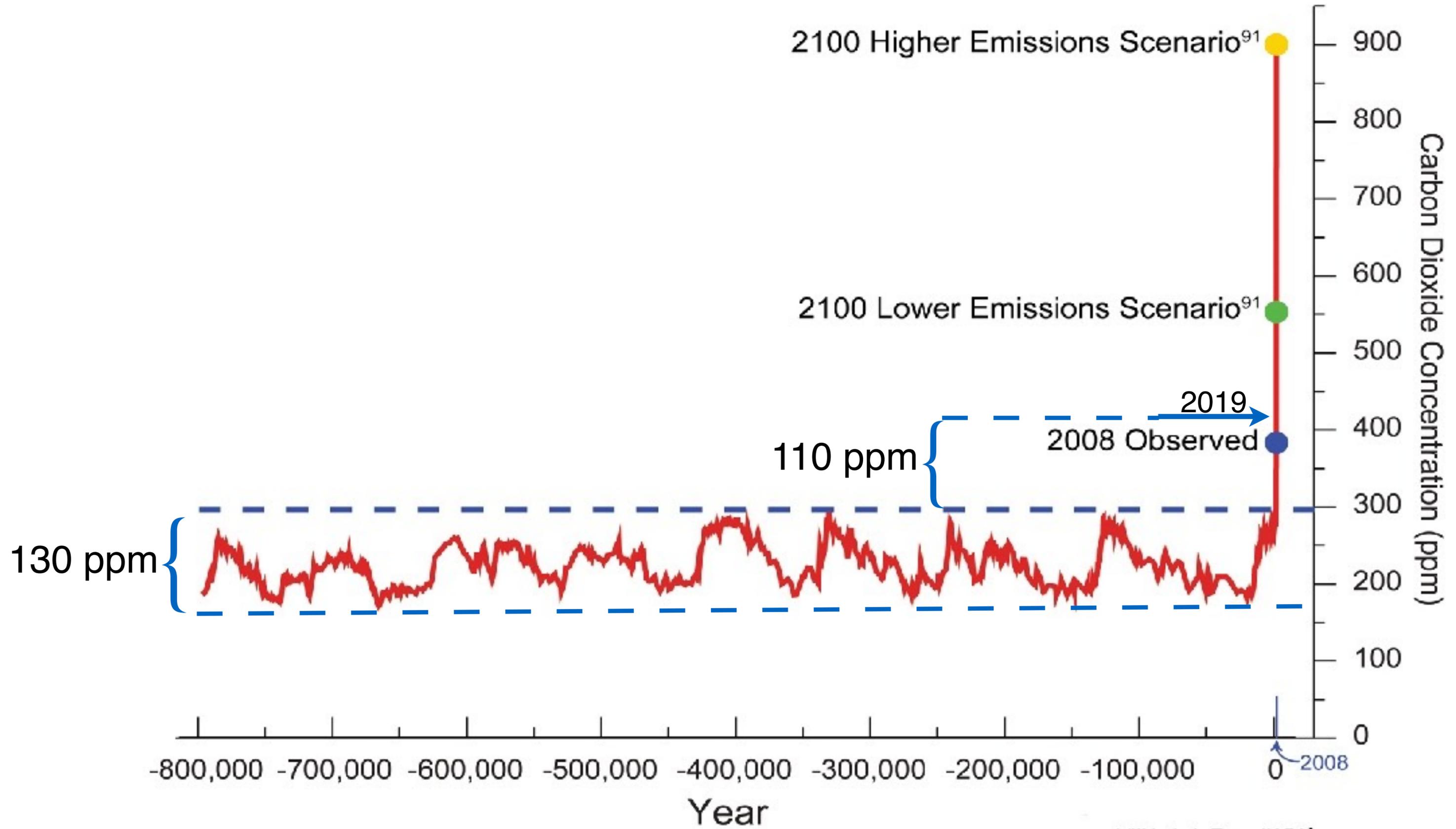
- The Purpose of Economy
- The Syndrome of Modern Global Change
- The Diagnosis: Creating Human Wealth without Regard for Natural Wealth
- The Prognosis: Running out of Resources while Polluting the Environment
- The Therapy: Changing the Official Purpose of Economy

Hans-Peter Plag  
Old Dominion University  
Norfolk, VA, USA

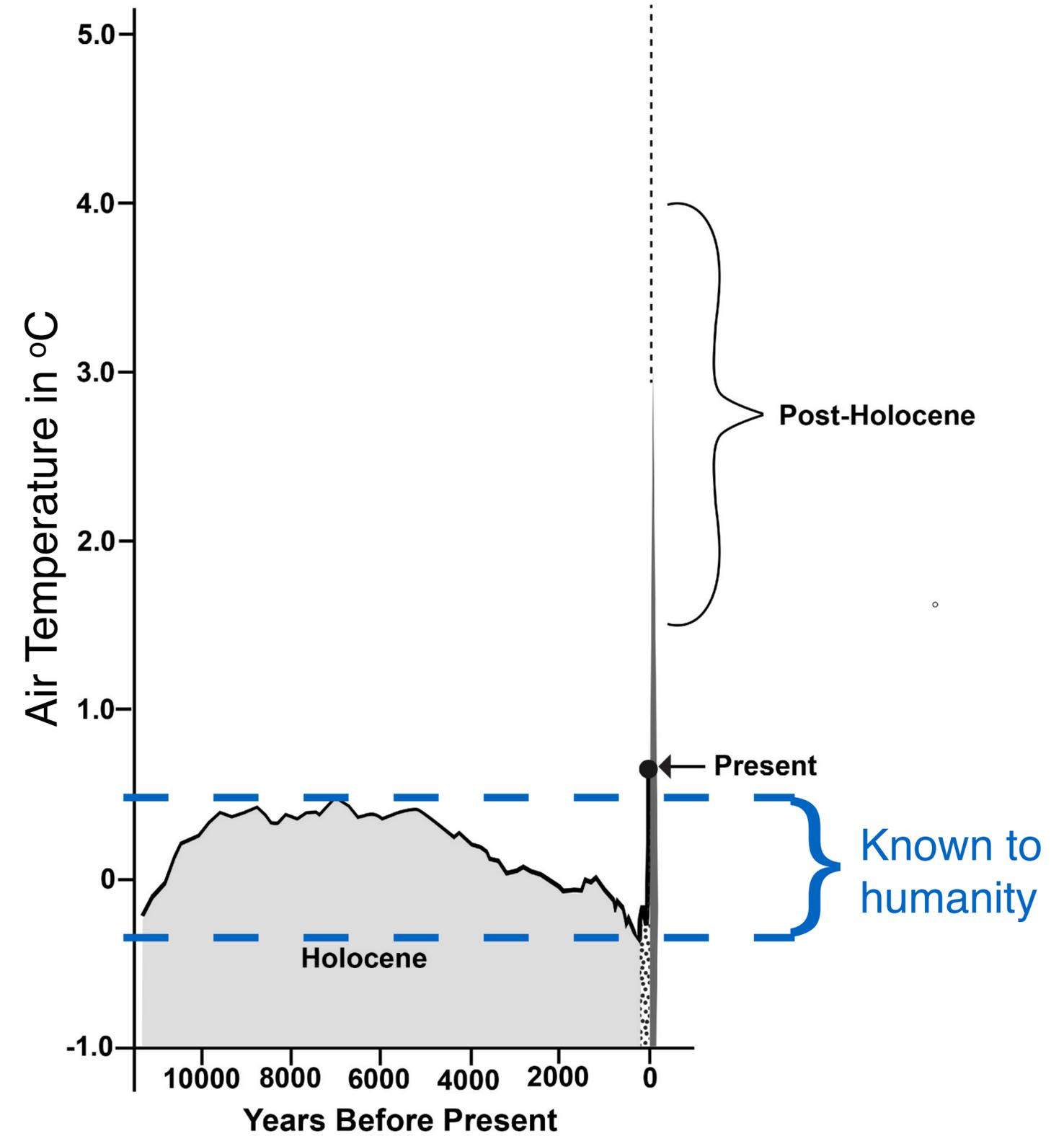
# The Prognosis: Running out of Resources while Polluting the Environment



# The Prognosis: Running out of Resources while Polluting the Environment



# The Prognosis: Running out of Resources while Polluting the Environment



# The Prognosis: Running out of Resources while Polluting the Environment

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

Keyword, Author, or DC

Home Articles Front Matter News Podcasts Authors

NEW RESEARCH IN Physical Sciences Social Sciences

RESEARCH ARTICLE

## Future of the human climate niche

Chi Xu, Timothy A. Kohler, Timothy M. Lenton, Jens-Christian Svenning, and Marten Scheffer

PNAS first published May 4, 2020 <https://doi.org/10.1073/pnas.1910114117>

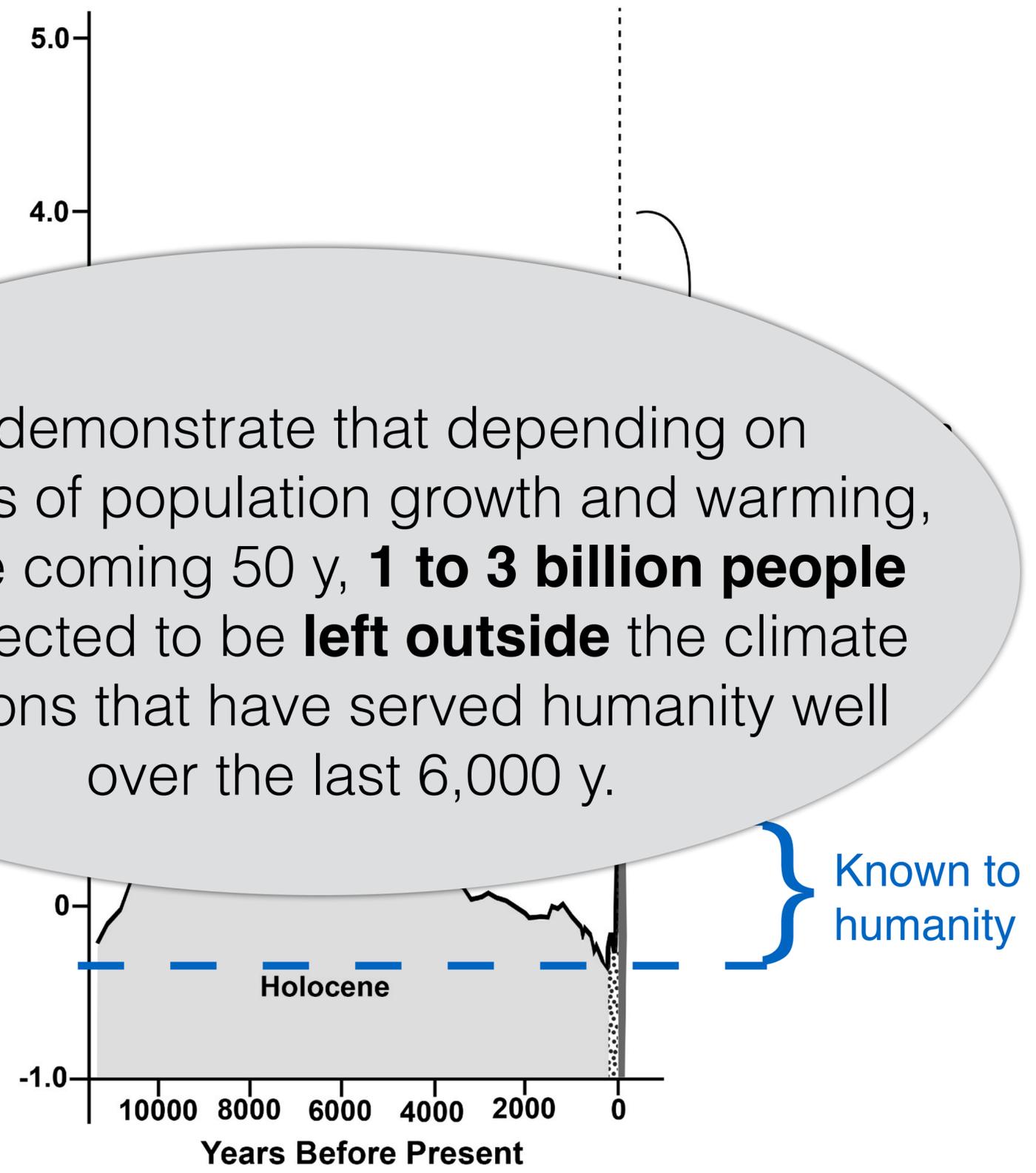
Contributed by Marten Scheffer, October 27, 2019 (sent for review June 12, 2019; reviewed by Victor Galaz and Luke Kemp)

Article Figures & SI Info & Metrics PDF

### Significance

We show that for thousands of years, humans have concentrated in a surprisingly narrow subset of Earth's available climates, characterized by mean annual temperatures around -13 °C. This distribution likely reflects a human temperature niche related to fundamental constraints. We demonstrate that depending on scenarios of population growth and warming, over the coming 50 y, 1 to 3 billion people are projected to be left outside the climate conditions that have served humanity well over the past 6,000 y. Absent climate mitigation or migration, a substantial part of humanity will be exposed to mean annual temperatures warmer than nearly anywhere today.

We demonstrate that depending on scenarios of population growth and warming, over the coming 50 y, **1 to 3 billion people** are projected to be **left outside** the climate conditions that have served humanity well over the last 6,000 y.



# The Prognosis: Running out of Resources while Polluting the Environment

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

Home Articles Front Matter News Podcasts Authors

NEW RESEARCH IN Physical Sciences Social Sciences

RESEARCH ARTICLE

## Future of the human climate niche

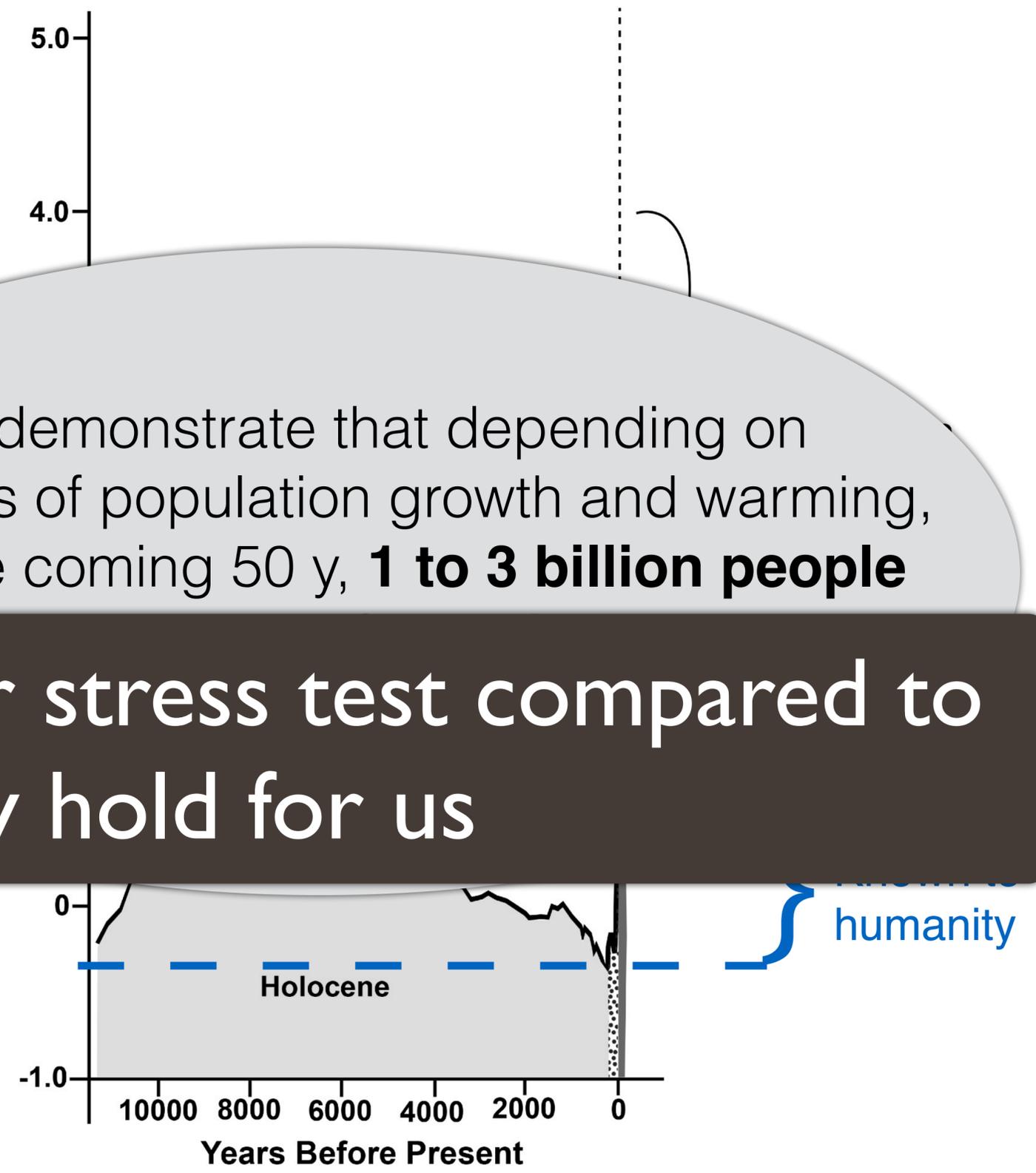
Chi Xu, Timothy A. Kohler, Timothy M. Lenton, Jens-Christian Svenning, and Marten Scheffer

PNAS first published May 4, 2020 <https://doi.org/10.1073/pnas.1910114117>

We demonstrate that depending on scenarios of population growth and warming, over the coming 50 y, **1 to 3 billion people**

The current pandemic is a minor stress test compared to what the future may hold for us

We show that for thousands of years, humans have concentrated in a surprisingly narrow subset of Earth's available climates, characterized by mean annual temperatures around -13 °C. This distribution likely reflects a human temperature niche related to fundamental constraints. We demonstrate that depending on scenarios of population growth and warming, over the coming 50 y, 1 to 3 billion people are projected to be left outside the climate conditions that have served humanity well over the past 6,000 y. Absent climate mitigation or migration, a substantial part of humanity will be exposed to mean annual temperatures warmer than nearly anywhere today.



# The Prognosis: Running out of Resources while Polluting the Environment

## Assessing the risk ...

The screenshot shows the IPBES website header with the logo and navigation menu. Below the header is a large image of a terraced open-pit mine. A text box overlaid on the image reads: "Media Release: Worsening Worldwide Land Degradation Now 'Critical', Undermining Well-Being of 3.2 Billion People". Below this text is a button that says "Click here to access the media release". At the bottom of the screenshot, there is a "Welcome to IPBES" section with a brief description of the organization and a "Find out more" button.

### We can't engineer our way out of an impending water scarcity epidemic



### GLOBAL WARMING OF 1.5 °C

an IPCC special report on the impacts of global warming of 1.5 °C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty

### Summary for Policymakers

This Summary for Policymakers was formally approved at the First Joint Session of Working Groups I, II and III of the IPCC and accepted by the 48<sup>th</sup> Session of the IPCC, Incheon, Republic of Korea, 6 October 2018.

### Mammal diversity will take millions of years to recover from the current biodiversity crisis

Matt Davis, Søren Faurby, and Jens-Christian Svenning

PNAS published ahead of print October 15, 2018 <https://doi.org/10.1073/pnas.1804906115>

### Climate-driven declines in arthropod abundance restructure a rainforest food web

Bradford C. Lister and Andres Garcia

PNAS published ahead of print October 15, 2018 <https://doi.org/10.1073/pnas.1722477115>

# The Prognosis: Running out of Resources while Polluting the Environment

## Assessing the risk ...

We have a huge amount of data and knowledge ...

The screenshot shows the IPBES website header with the logo and navigation menu. Below the header is a large image of a terraced open-pit mine. A text box overlaid on the image reads: "Media Release: Worsening Worldwide Land Degradation Now 'Critical', Undermining Well-Being of 3.2 Billion People". Below this is a button that says "Click here to access the media release". At the bottom of the screenshot, there is a "Welcome to IPBES" section with a brief description of the organization and a "Find out more" button.

The IPCC logo is displayed at the top, with the text "INTERGOVERNMENTAL PANEL ON climate change". Below it, the title "GLOBAL WARMING OF 1.5 °C" is written in large blue letters. Underneath, a blue text block reads: "an IPCC special report on the impacts of global warming of 1.5 °C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty".

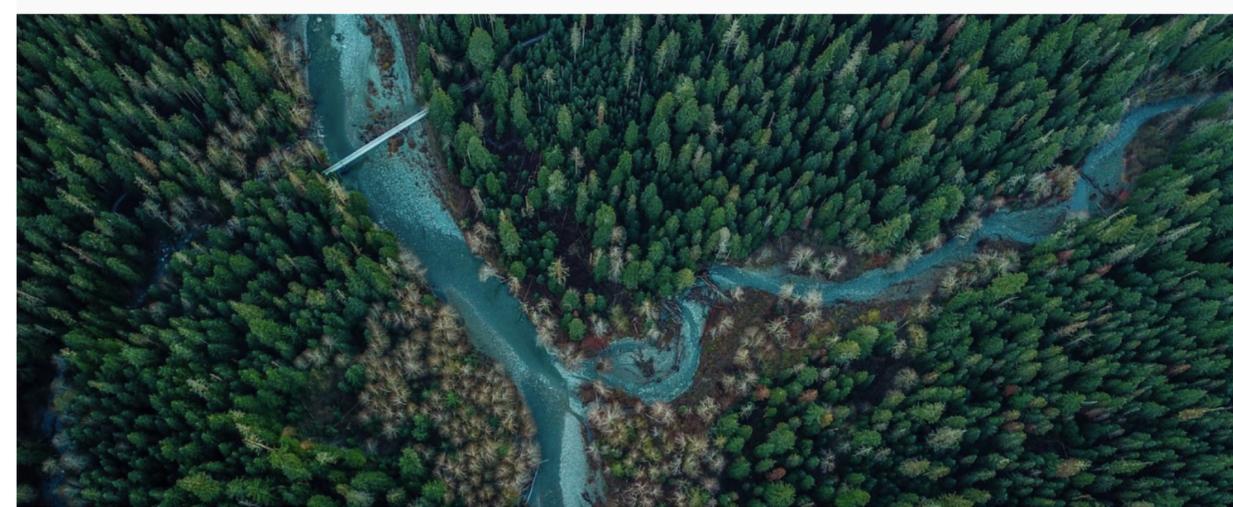
## Mammal diversity will take millions of years to recover from the current biodiversity crisis

Matt Davis, Søren Faurby, and Jens-Christian Svenning  
PNAS published ahead of print October 15, 2018 <https://doi.org/10.1073/pnas.1804906115>

## Climate-driven declines in arthropod abundance restructure a rainforest food web

Bradford C. Lister and Andres Garcia  
PNAS published ahead of print October 15, 2018 <https://doi.org/10.1073/pnas.1722477115>

## We can't engineer our way out of an impending water scarcity epidemic



*Summary for Policymakers*

This Summary for Policymakers was formally approved at the First Joint Session of Working Groups I, II and III of the IPCC and accepted by the 48<sup>th</sup> Session of the IPCC, Incheon, Republic of Korea, 6 October 2018.

# The Prognosis: Running out of Resources while Polluting the Environment

## Assessing the risk ...

We have a huge amount of data and knowledge ...

The screenshot shows the IPBES website header with the logo and navigation menu. The main content area features a large image of a terraced open-pit mine with a central reservoir. Overlaid on the image is a text box: "Media Release: Worsening Worldwide Land Degradation Now 'Critical', Undermining Well-Being of 3.2 Billion People" with a "Click here to access the media release" button. Below the image is a teal banner with the text "Welcome to IPBES" and a "Find out more" button.

The IPCC logo is displayed at the top. Below it, the title "GLOBAL WARMING OF 1.5 °C" is written in large blue letters. Underneath, a subtitle reads: "an IPCC special report on the impacts of global warming of 1.5 °C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty".

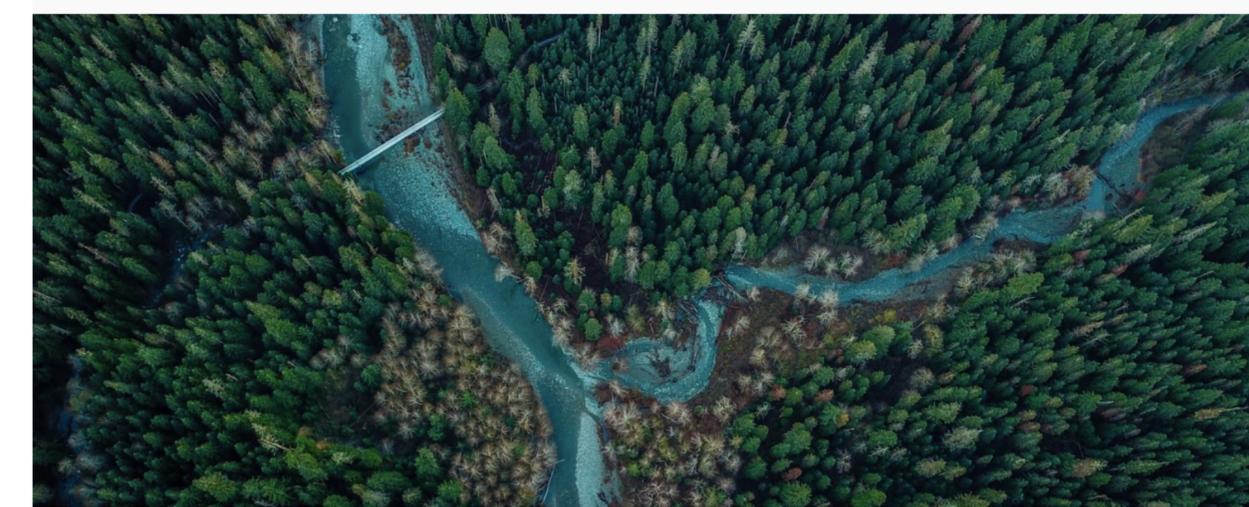
## Mammal diversity will take millions of years to recover from the current biodiversity crisis

Matt Davis, Søren Faurby, and Jens-Christian Svenning  
PNAS published ahead of print October 15, 2018 <https://doi.org/10.1073/pnas.1804906115>

## Climate-driven declines in arthropod abundance restructure a rainforest food web

Bradford C. Lister and Andres Garcia  
PNAS published ahead of print October 15, 2018 <https://doi.org/10.1073/pnas.1722477115>

## We can't engineer our way out of an impending water scarcity epidemic



## Summary for Policymakers

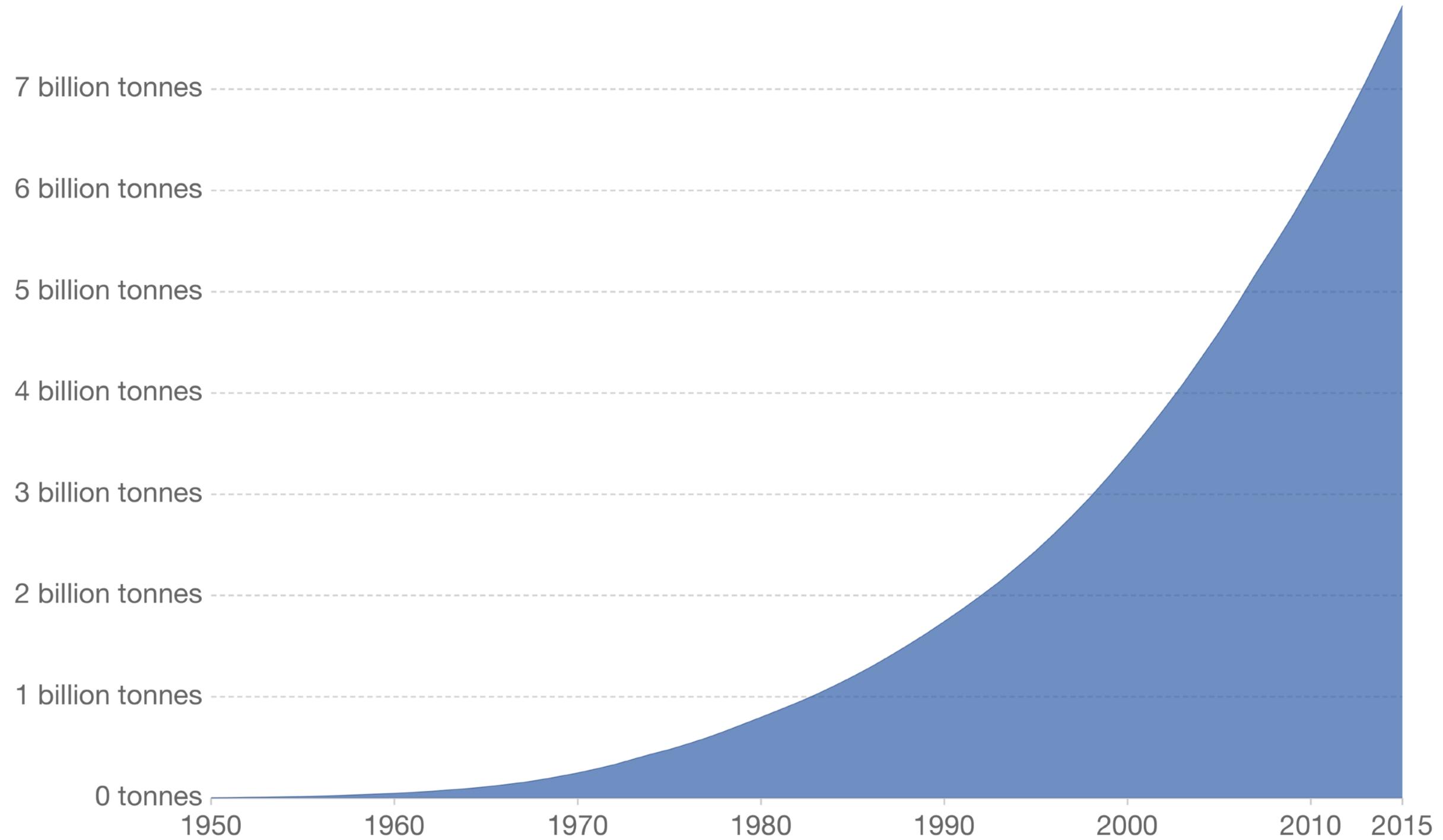
This Summary for Policymakers was formally approved at the First Joint Session of Working Groups I, II and III of the IPCC and accepted by the 48<sup>th</sup> Session of the IPCC, Incheon, Republic of Korea, 6 October 2018.

- Pollinators
- Freshwater ecosystems
- Marine biosphere
- ...

## Cumulative global plastics production, 1950 to 2015

Cumulative global production of plastics, measured in tonnes.

Our World  
in Data



Source: Geyer et al. (2017)

CC BY

# The Prognosis: Running out of Resources while Polluting the Environment



2% annual increase in production:

2025: 550 Mt

2035: 670 Mt

2045: 817 Mt

Total production:

2015: 7 Bt

2045: 26 Bt

1% in the ocean: 260 Mt

In coastal built environment prone to

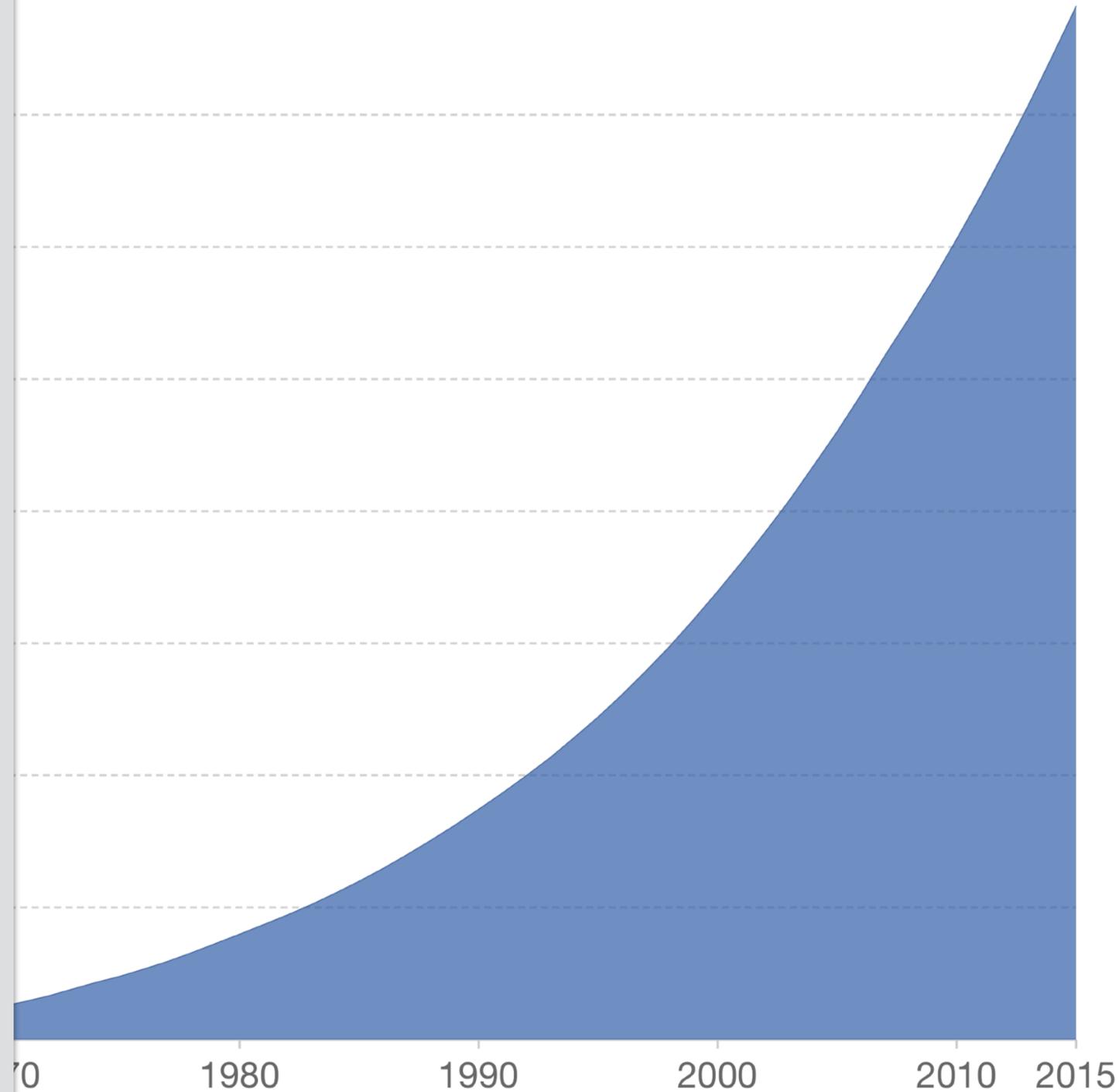
disasters:

1.7 Bt

Production, 1950 to 2015

in tonnes.

Our World  
in Data



2% annual increase in production:

2025: 550 Mt

2035: 670 Mt

2045: 817 Mt

Total production:

2015: 7 Bt

2045: 26 Bt

1% in the ocean: 260 Mt

In coastal built environment prone to  
disasters:

1.7 Bt

Production, 1950 to 2015  
in tonnes.

Our World  
in Data

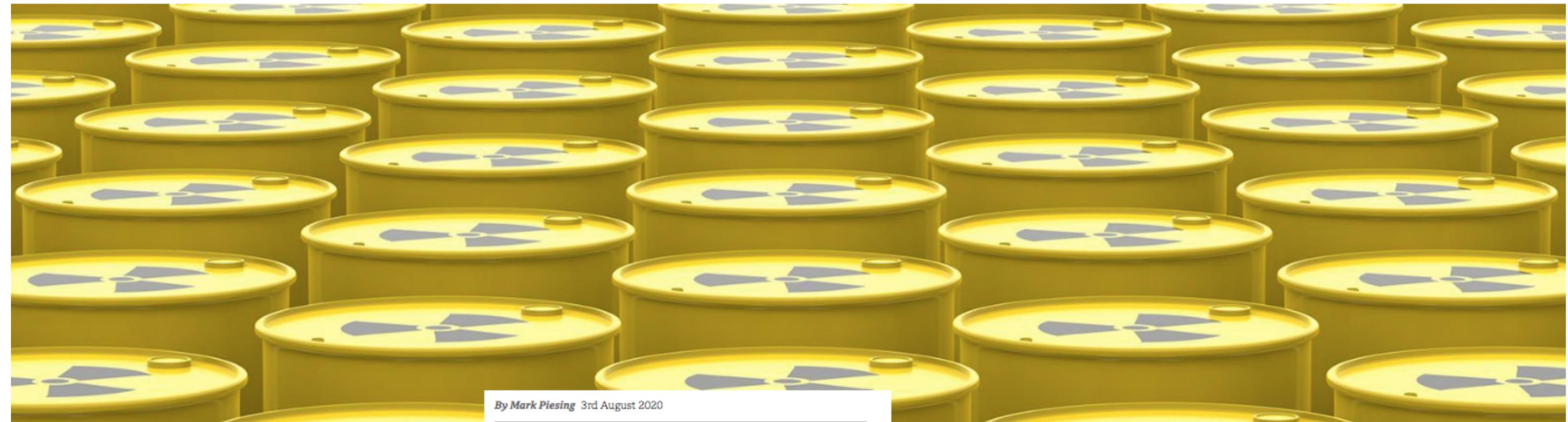
Plastics in the planetary physiology  
will impact the 500 Billion to  
1 trillions of people to come during  
the next 5,000 years.

Does the plastics crisis violate the  
rights of those not yet born?

1970 1980 1990 2000 2010 2015

NUCLEAR

How to build a nuclear warning for 10,000 years' time



*By Mark Piesing* 3rd August 2020

The nuclear waste buried far beneath the earth will be toxic for thousands of years. How do you build a warning now that can be understood in the far future?

NUCLEAR

How to build a nuclear warning for 10,000 years' time



We've got to start thinking beyond our own lifespans if we're going to avoid extinction

*Sonia Sodha*

By Mark Piesing 31

The nuclear was for thousands of can be understood

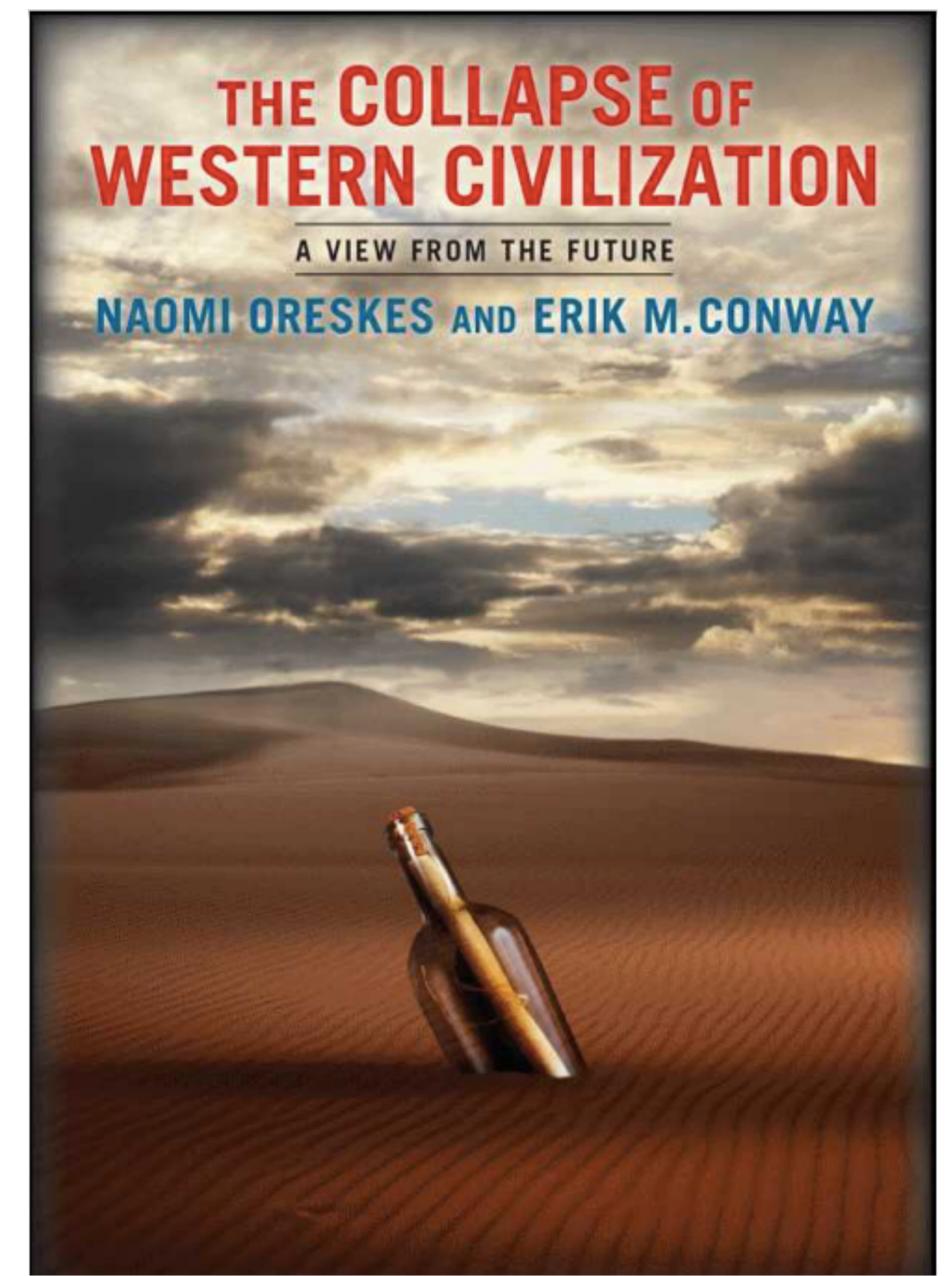


Short-term analysis of ways to save society, and indeed humanity, is useless

Assessing the risk ...

# The Prognosis: Running out of Resources while Polluting the Environment

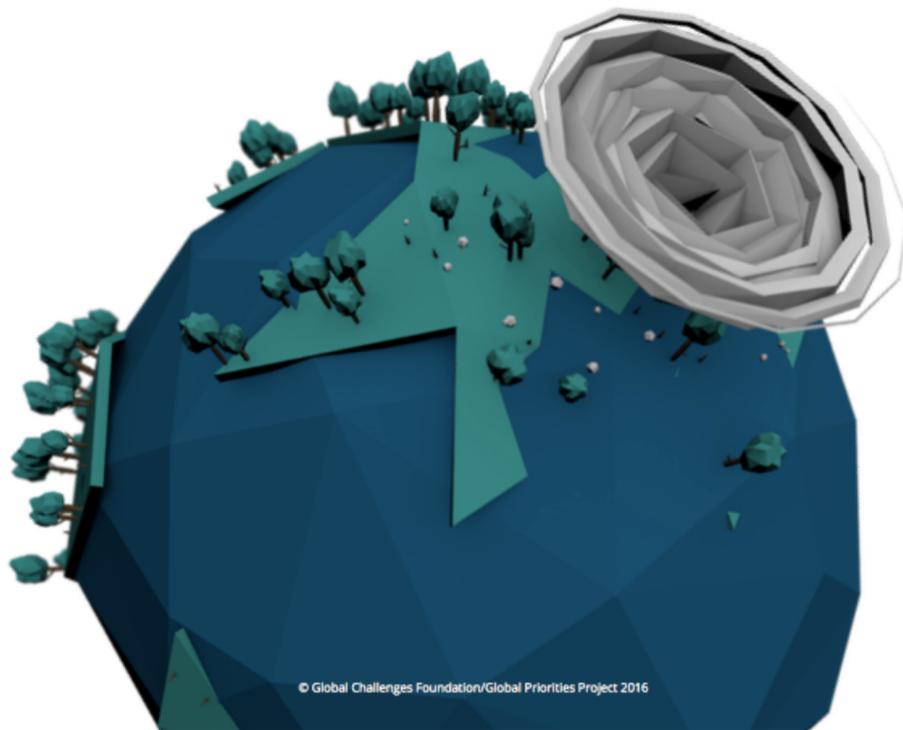
Assessing the risk ...



Assessing the risk ...

Global  
Challenges  
Foundation

## Global Catastrophic Risks 2016

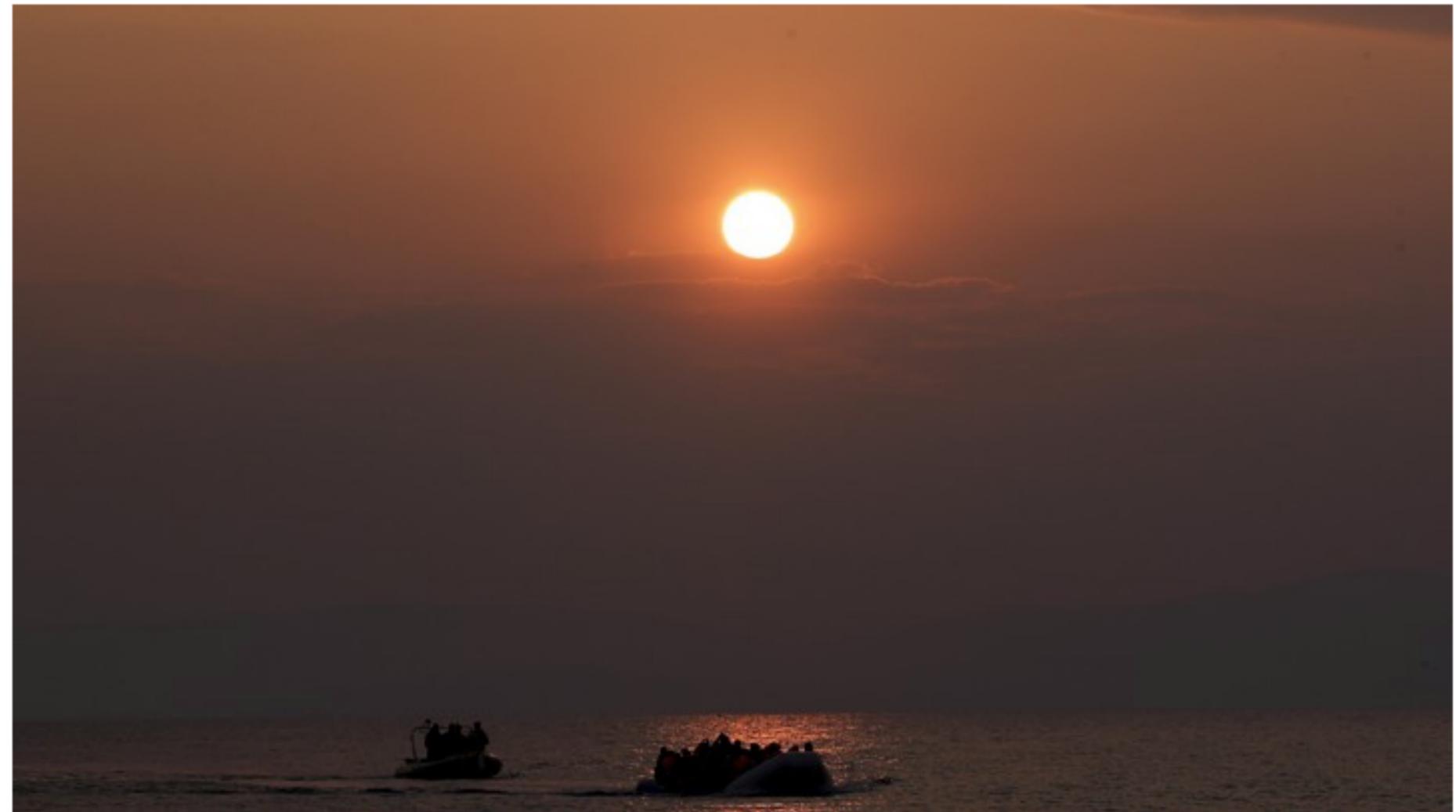


### TECHNOLOGY

## Human Extinction Isn't That Unlikely

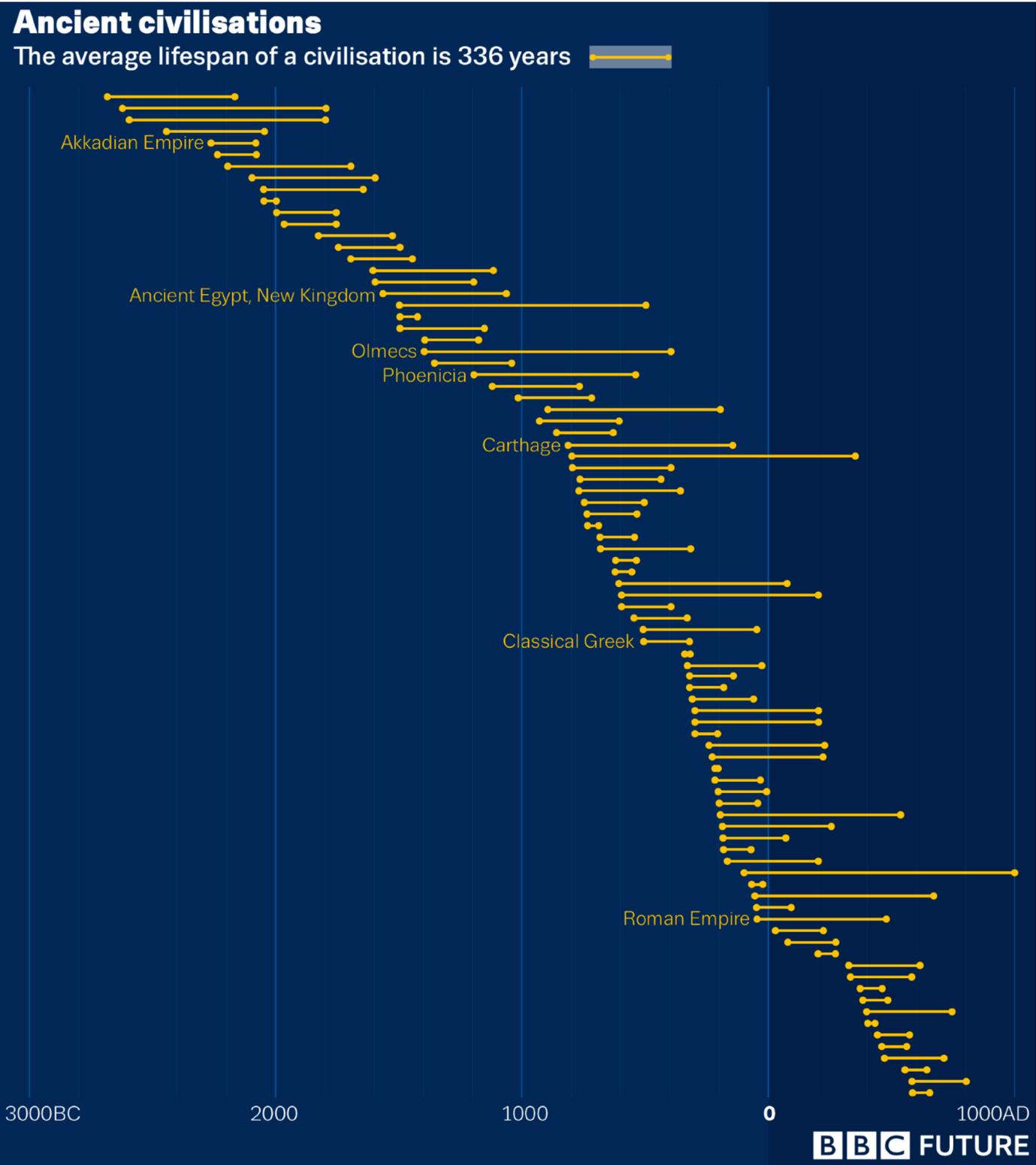
“A typical person is more than five times as likely to die in an extinction event as in a car crash,” says a new report.

ROBINSON MEYER APR 29, 2016

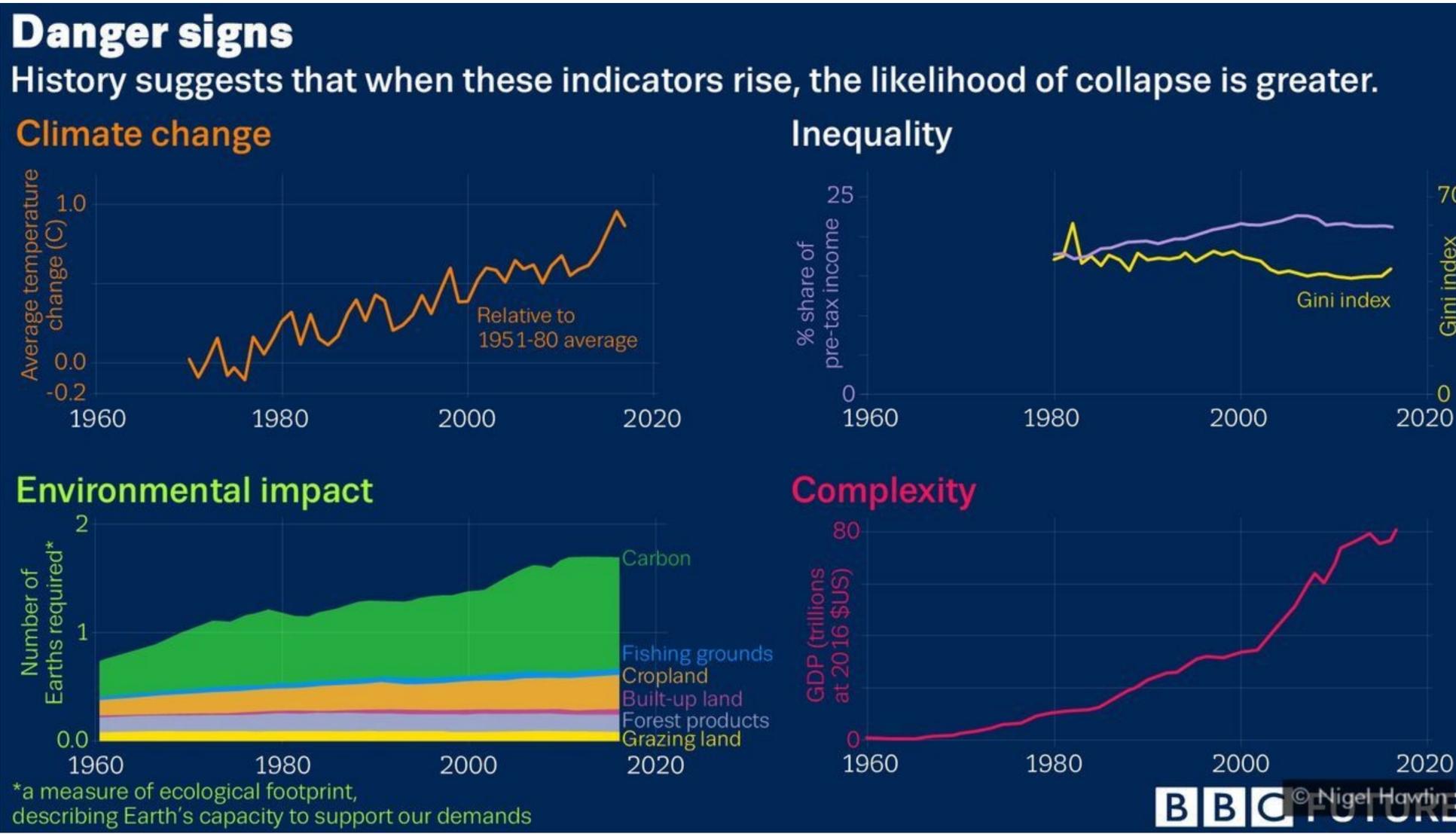
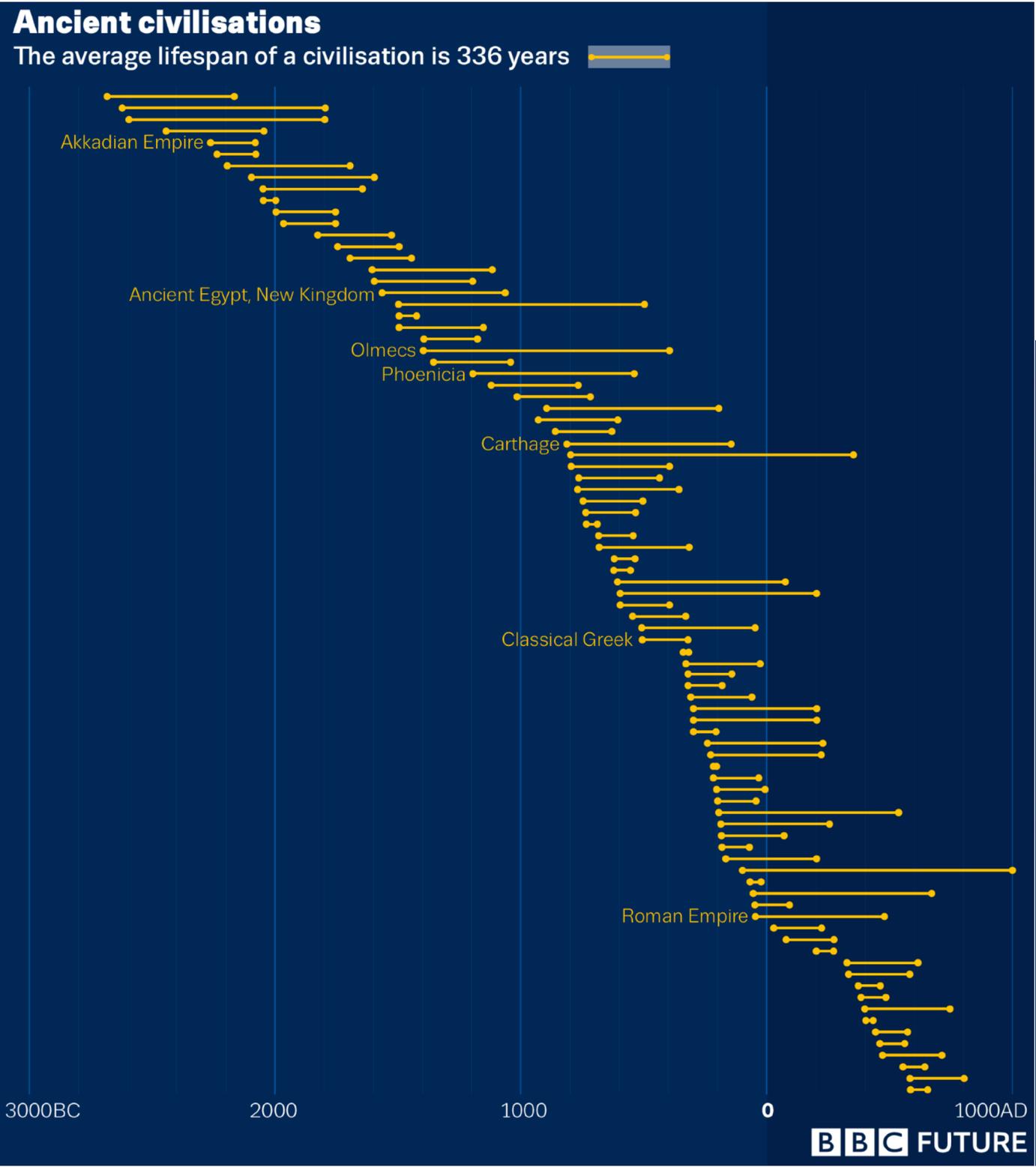


The sun rises as a dinghy carrying refugees and migrants approaches the shores of the Greek island of Lesbos. (ALKIS KONSTANTINIDIS / REUTERS)

# The Prognosis: Running out of Resources while Polluting the Environment

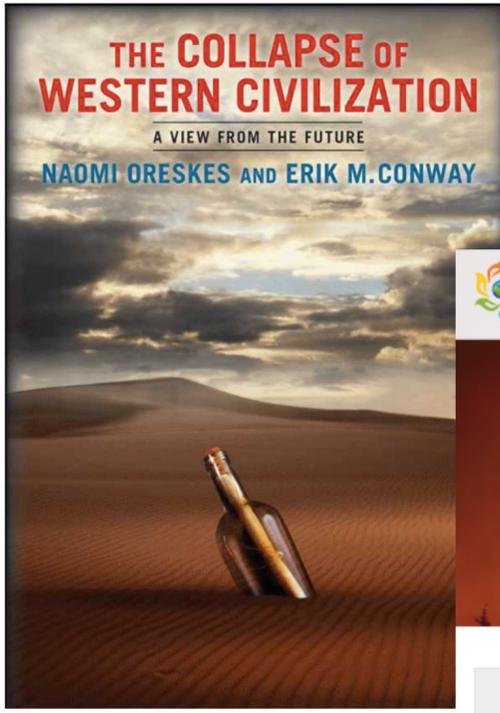
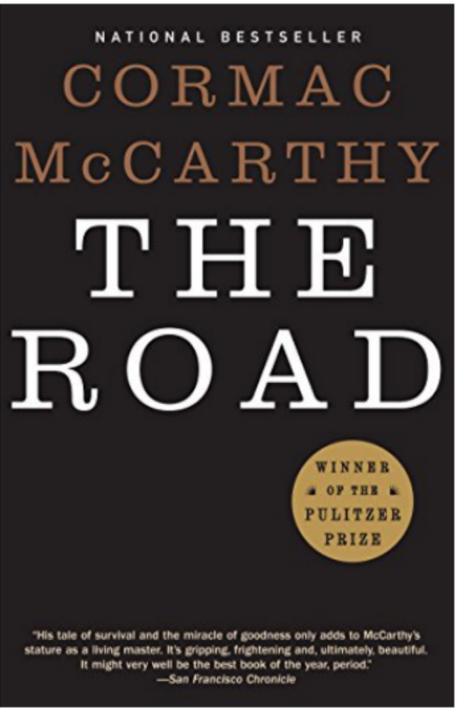
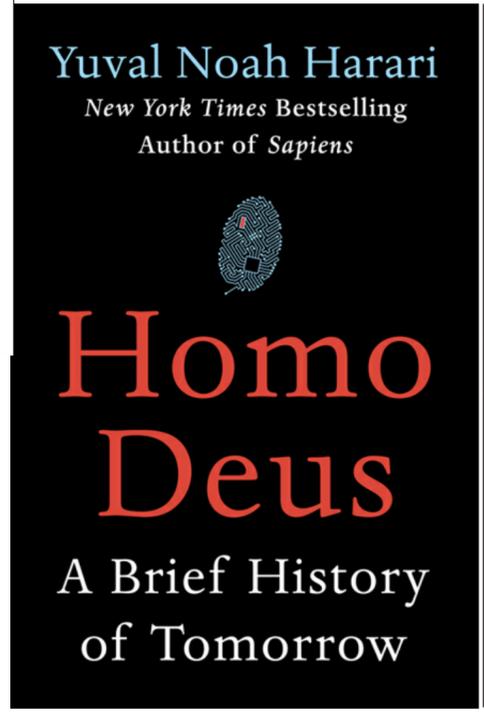
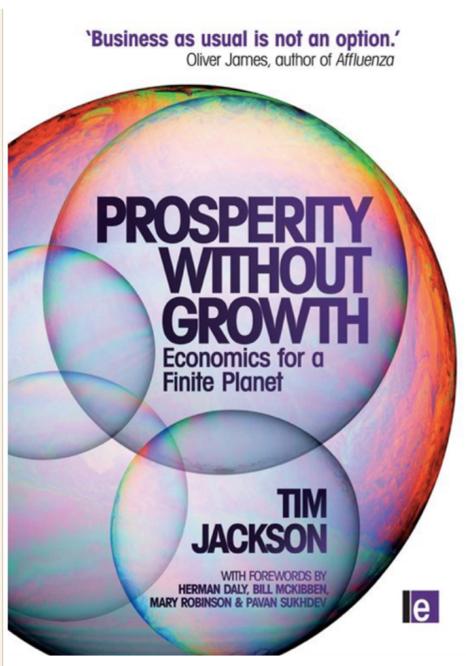
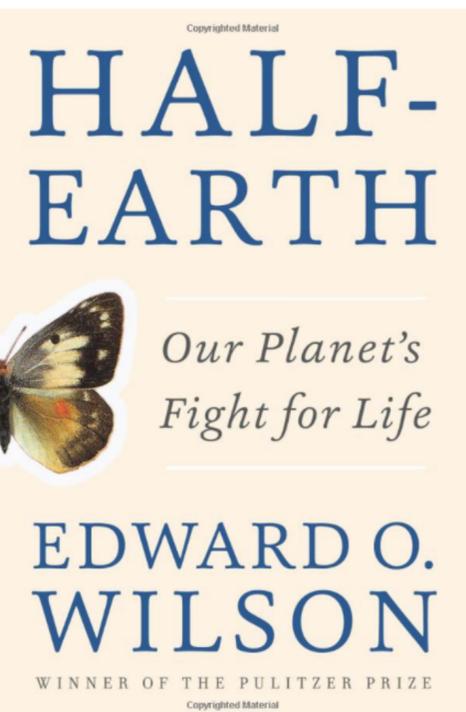


# The Prognosis: Running out of Resources while Polluting the Environment



## Homo sapiens: An Exceptional Success Story

### Spectrum of Possible Futures



Science-based warnings to humanity

Deep Adaptation: Preparing for the time after the total social collapse - Who do we want to be then?

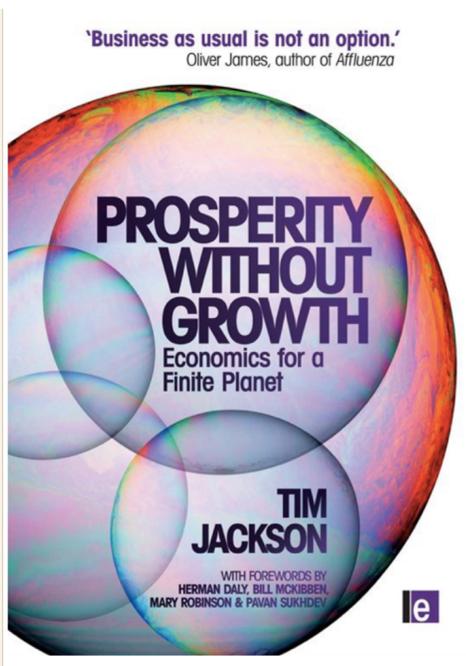
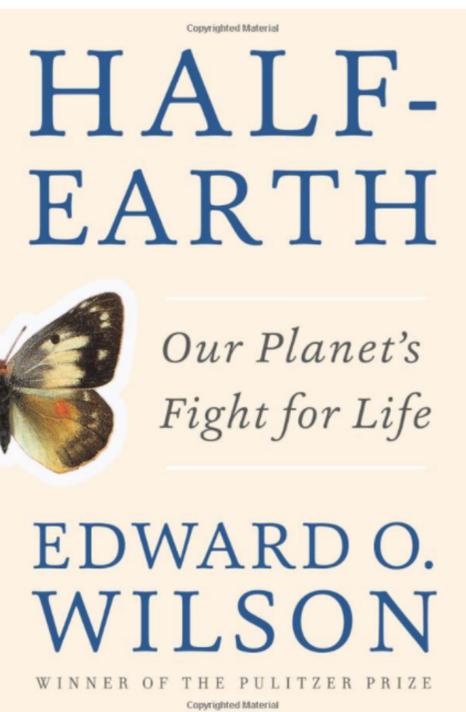
**Deep Adaptation**

This blog post includes the following:

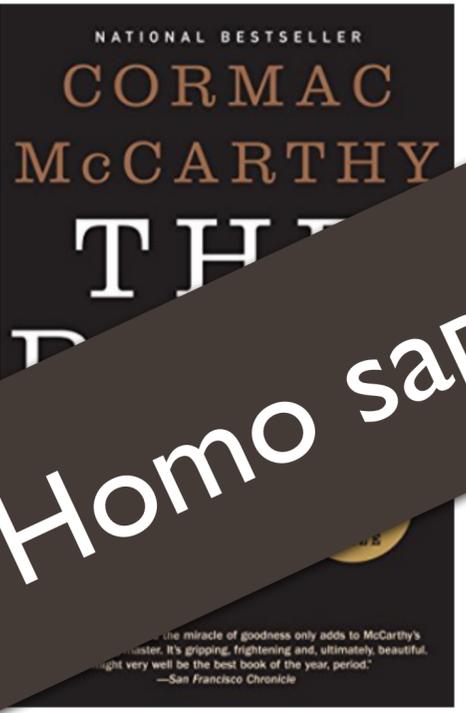
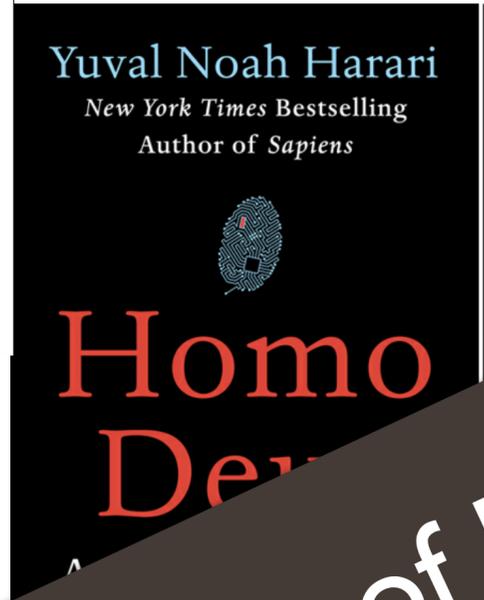
- An opportunity to learn about and understand the term "Deep Adaptation". The term comes from the paper [Deep Adaptation: A Map for Navigating Climate Tragedy](#) by Jem Bendell, which has greatly changed the landscape of what we are doing in the Scientists' Warning Initiative. An excerpt from the abstract of this paper follows; however, the reader is urged to take the time to read the full content of the paper by clicking the link. **Note:** There is a link at the bottom of this post where you can download the full resolution Deep Adaptation Badge image.
- A note from Alison Green, a member of Scientists' Warning's Advisory Council, about her experience travelling and co-presenting with Stuart to the Foresight Group at the European Commission in Brussels. A video of the actual presentation given



## Homo sapiens: An Exceptional Success Story



### Spectrum of Possible Futures



Is the Success Story of Homo sapiens going to continue?

Science brings to humanity

Adaptation: Preparing for the time after the total collapse - Who do we want to be then?



**Deep Adaptation**

This blog post includes the following:

- An opportunity to learn about and understand the term "Deep Adaptation". The term comes from the paper [Deep Adaptation: A Map for Navigating Climate Tragedy](#) by Jem Bendell, which has greatly changed the landscape of what we are doing in the Scientists' Warning Initiative. An excerpt from the abstract of this paper follows; however, the reader is urged to take the time to read the full content of the paper by clicking the link. **Note:** There is a link at the bottom of this post where you can download the full resolution Deep Adaptation Badge image.
- A note from Alison Green, a member of Scientists' Warning's Advisory Council, about her experience travelling and co-presenting with Stuart to the Foresight Group at the European Commission in Brussels. A video of the actual presentation given



# Key Points

---

## Purpose of Economy

The *de facto* purpose of economy is to meet the needs of the present while safeguarding the Earth's life-support system, on which the welfare of all current and future generation depends.

The current “official” purpose of economy is to create human wealth, and this official purpose is in conflict with the *de facto* purpose.

## Syndrome of Modern Global Change

The Holocene was a “safe operating space for humanity” allowing the emergence of a dominant species

During the last few hundred years, humanity has made large and rapid planetary changes, accelerated existing and introduced new flows in the planetary physiology.

The system is outside the “normal range” and in the dynamic transition into the Post-Holocene.

## Diagnosis

Making the creation of human wealth the “official” purpose of economy and economic growth the overarching goal turned humans into the “Anthropogenic Cataclysmic Virus” (ACV) in the Earth's life-support system.

Easy access to seemingly unlimited energy allowed humans to accelerate flows in the Earth's life-support system and sustain rapid population growth and increasing demands.

## Prognosis

The planet is heading rapidly towards tipping points and a very different system state.

The growth-focused economy is the root cause of the global challenges and poses an existential risk.

# Can the Economy in Modern Society Work Without Polluting the Environment with Our Growing Waste?

- The Purpose of Economy
- The Syndrome of Modern Global Change
- The Diagnosis: Creating Human Wealth without Regard for Natural Wealth
- The Prognosis: Running out of Resources while Polluting the Environment
- The Therapy: Changing the Official Purpose of Economy

Hans-Peter Plag  
Old Dominion University  
Norfolk, VA, USA

## Please, let's not go back to normal

Par Collectif

Publié le 06 mai 2020 à 06h00

🔒 Réservé à nos abonnés

Partage



TRIBUNE | **If we want to avoid ecological disaster, world leaders and citizens must act now, write actress Juliette Binoche and astrophysicist Aurélien Barrau in a call to arms signed by more than 200 artists and scientists.**

The Covid-19 pandemic is a tragedy. This crisis is, however, inviting us to examine what is essential. And what we see is simple : « *adjustments* » are not enough. The problem is systemic.

The ongoing ecological catastrophe is a meta-crisis : the massive extinction of life on Earth is no longer in doubt, and all indicators point to a direct existential threat. Unlike a pandemic, however severe, a global ecological collapse will have immeasurable consequences.

## Please, let's not go back to normal

Par Collectif

Publié le 06 mai 2020 à 06h0

III Réservé à nos abonnés

TRIBUNE | **If we want to avoid ecological disaster, citizens must act now, write actress Juliette Binoche, astrophysicist Aurélien Barrau in a call to arm 200 artists and scientists.**

The Covid-19 pandemic is a tragedy. This crisis is, however, an opportunity to examine what is essential. And what we see is simple enough. The problem is systemic.

The ongoing ecological catastrophe is a meta-crisis. The future of life on Earth is no longer in doubt, and all indicators point to an existential threat. Unlike a pandemic, however severe, a global ecological collapse will have immeasurable consequences.

200 artistes et scientifiques

The pursuit of consumerism and an obsession with productivity have led us to deny the value of life itself :

that of plants, that of animals, and that of a great

number of human beings. Pollution, climate change, and the destruction of our remaining natural zones has brought the world to a breaking point.

For these reasons, along with the urgency of renewing with a politics of social equity, we believe it is unthinkable to « go back to normal ».

The radical transformation we need – at all levels – demands boldness and courage. It will

not take place without a massive and determined commitment. We must act

now. It is as much a matter of survival as of dignity and coherence.

## Please, let's not go back to normal

200 artistes et scientifiques

The pursuit of consumerism and an obsession with productivity have led us to deny the value of life itself :

of plants, that of animals, and that of a great

of human beings. Pollution, climate change, and the destruction of

of natural zones has brought the world to a breaking point.

**boldness and courage:**  
The pandemic has taught us that if we need to change, we can change.

For these reasons, along with the urgency of renewing with a politics of social equity, we believe it is unthinkable to « go back to normal ». The radical

transformation we need – at all levels – demands boldness and courage. It will not take place without a massive and determined commitment. We must act now. It is as much a matter of survival as of dignity and coherence.

TRIP  
citizens  
astrophysicist Au  
200 artists and scientists.

The Covid-19 pandemic is a tragedy. This crisis is, however, an opportunity to examine what is essential. And what we see is simple enough. The problem is systemic.

The ongoing ecological catastrophe is a meta-crisis: the future of life on Earth is no longer in doubt, and all indicators point to an existential threat. Unlike a pandemic, however severe, a global ecological collapse will have immeasurable consequences.

# The Therapy: Changing the Official Purpose of Economy



UNITED NATIONS

TRANSFORMING OUR WORLD:



THE 2030 AGENDA FOR SUSTAINABLE DEVELOPMENT

**SUSTAINABLE DEVELOPMENT GOALS**

<b>1</b> NO POVERTY	<b>2</b> ZERO HUNGER	<b>3</b> GOOD HEALTH AND WELL-BEING	<b>4</b> QUALITY EDUCATION
<b>5</b> GENDER EQUALITY	<b>6</b> CLEAN WATER AND SANITATION	<b>7</b> AFFORDABLE AND CLEAN ENERGY	<b>8</b> DECENT WORK AND ECONOMIC GROWTH
<b>9</b> INDUSTRY, INNOVATION AND INFRASTRUCTURE	<b>10</b> REDUCED INEQUALITIES	<b>11</b> SUSTAINABLE CITIES AND COMMUNITIES	<b>12</b> RESPONSIBLE CONSUMPTION AND PRODUCTION
<b>13</b> CLIMATE ACTION	<b>14</b> LIFE BELOW WATER	<b>15</b> LIFE ON LAND	<b>16</b> PEACE, JUSTICE AND STRONG INSTITUTIONS
<b>17</b> PARTNERSHIPS FOR THE GOALS			

**Sendai Framework for Disaster Risk Reduction 2015 - 2030**

United Nations Climate Change

Home COP 25 **Process and meetings** Topics Calendar Climate action Documents and decisions About us

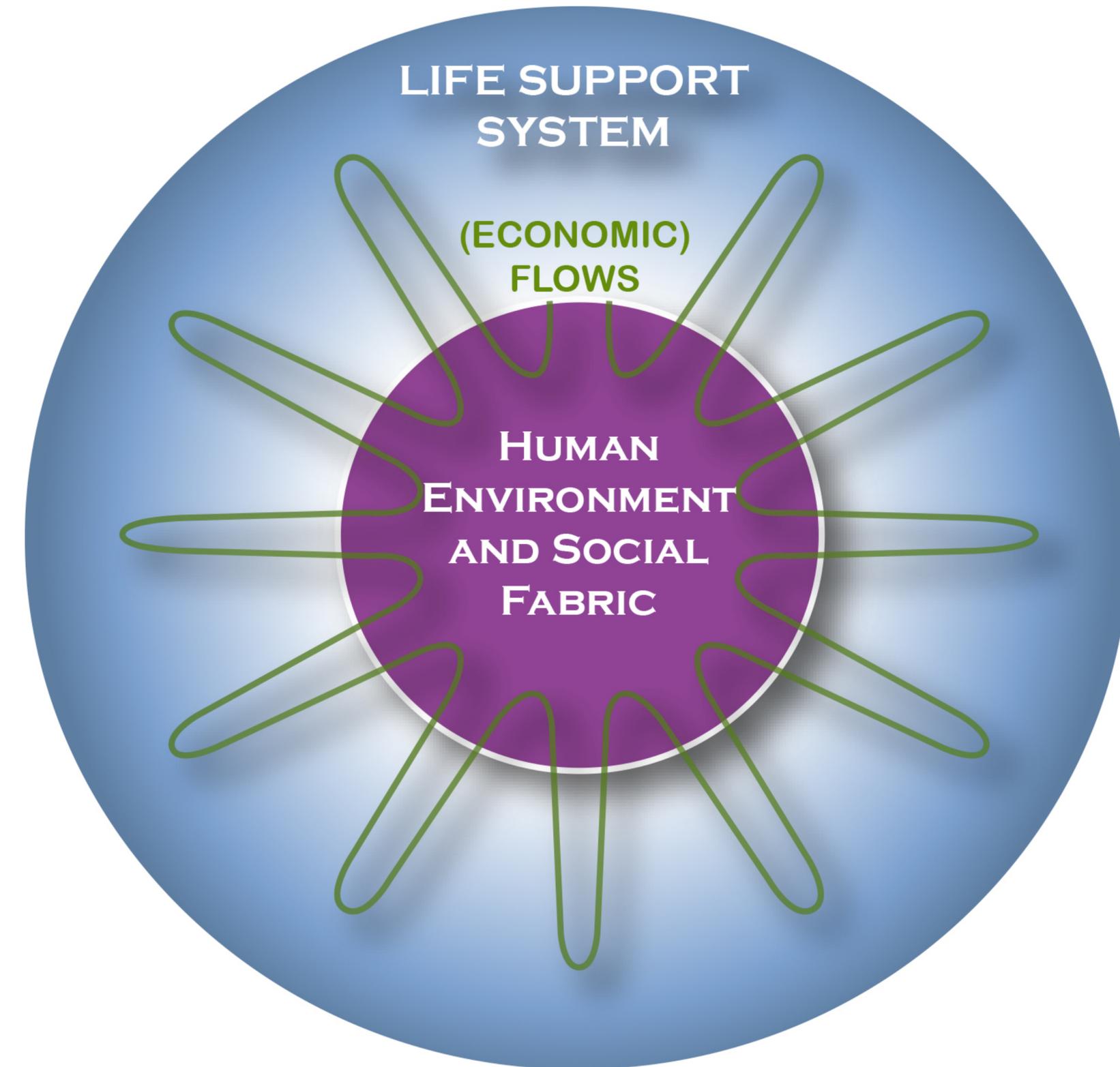
Process and meetings >> The Paris Agreement >> The Paris Agreement

## The Paris Agreement

### Paris Agreement: essential elements

The Paris Agreement builds upon the Convention and for the first time brings all nations into a common cause to undertake ambitious efforts to combat climate change and adapt to its effects, with enhanced support to assist developing countries to do so. As such, it charts a new course in the global climate effort.

- Arabic
- Chinese
- English
- French
- Russian



## Importance of flows

Strategies for Sustainability:

1. To consume nature's flows while conserving the stocks (that is, live off the 'interest' while conserving natural capital).
2. To increase society's stocks (human resources, civil institutions) and limit the flow of materials and energy. *Brown et al. (2004)*
3. Ensure that the returns to nature do not degrade the planetary life-support system. *Plag and Jules-Plag (2018)*

## Importance of flows

Strategies for Sustainability:

1. To consume nature's flows while conserving the stocks (that is, live off the 'interest' while conserving natural capital).
2. To increase society's stocks (human resources, civil institutions) and limit the flow of materials and energy. *Brown et al. (2004)*
3. Ensure that the returns to nature do not degrade the planetary life-support system. *Plag and Jules-Plag (2018)*

A Species that has unparalleled power to grow and change the planetary physiology must exercise self limitation:

- a small family ethics and responsible procreation; *Rieder (2016)*
- limitation of wealth creation and accumulation *Plag (2020)*

## Importance of flows

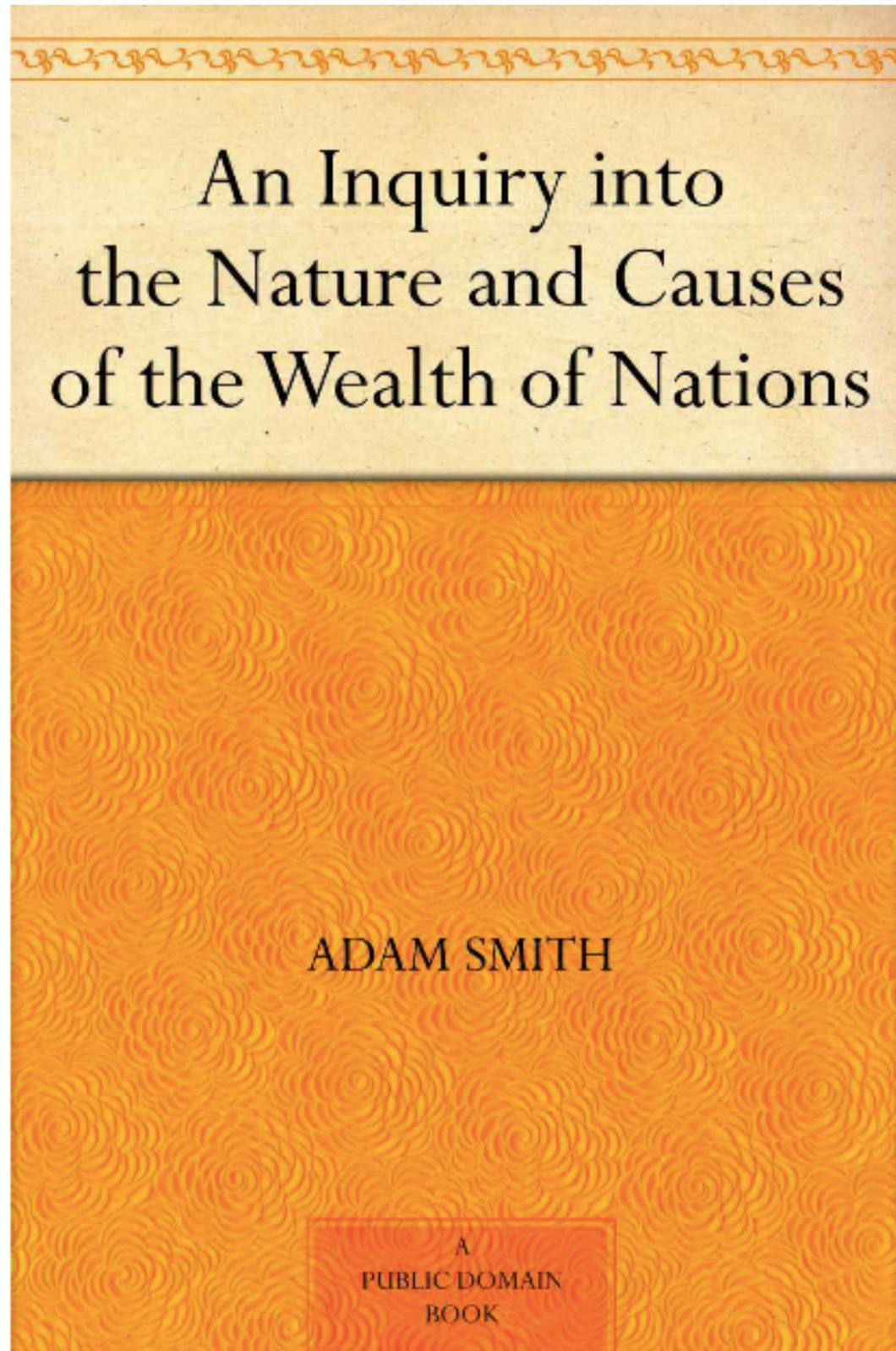
Strategies for Sustainability:

1. To consume nature's flows while conserving the stocks (that is, live off the 'interest' while conserving natural capital).
2. To increase society's stocks (human resources, civil institutions) and limit the flow of materials and energy. *Brown et al. (2004)*
3. Ensure that the returns to nature do not degrade the planetary life-support system. *Plag and Jules-Plag (2018)*

A Species that has unparalleled power to grow and change the planetary physiology must exercise self limitation:

- a small family ethics and responsible procreation; *Rieder (2016)*
- limitation of wealth creation and accumulation *Plag (2020)*

## Importance of Mainstream "Official" Economic Model



- Purpose of economy is to increase human wealth;
- Earth and its natural wealth is basically infinite.

*Smith (1776)*

*Published in 1776*

- Purpose of economy is to increase human wealth;
- Earth and its natural wealth is basically infinite.

*Smith (1776)*

# OUR COMMON FUTURE

THE WORLD COMMISSION  
ON ENVIRONMENT  
AND DEVELOPMENT

- Purpose of economy is to increase human wealth;
- Earth and its natural wealth is basically infinite.

*Smith (1776)*

"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs".

*WCED (1987)*



Intercontinental network for the promotion of social solidarity economy

Who we are    **What is SSE**    WSFTE 2020    Continental networks    Working Are

## What is Social Solidarity Economy

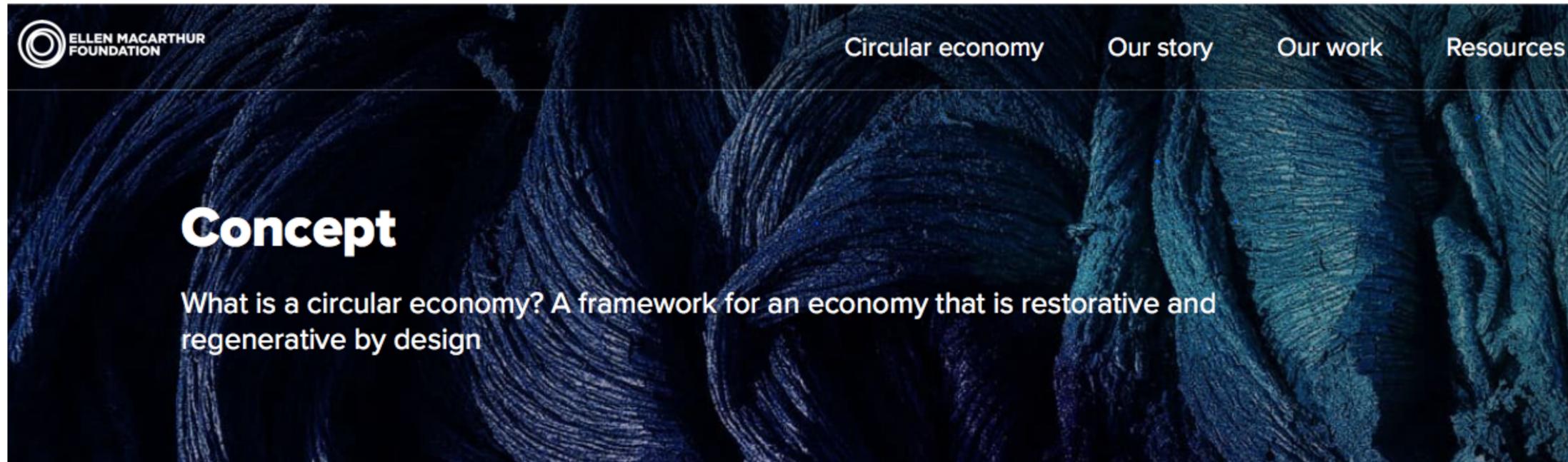
### WHY SOLIDARITY-BASED ECONOMIC PRACTICES

“ Today, perhaps as never before, more people are becoming aware that capitalism has turned our lives and our planet into a commodity. A system that is environmentally unsustainable and socially unjust, and that it is not able to guarantee the happiness and dignified life conditions of all persons in any place on the planet. **Carlos Askunze, REAS Spanish network of solidarity economy.**

### WHAT IS SOCIAL SOLIDARITY ECONOMY

“ *The Social Solidarity Economy is an alternative to capitalism and other authoritarian, state-dominated economic systems. In SSE ordinary people play an active role in shaping all of the dimensions of human life: economic, social, cultural, political, and environmental. SSE exists in all sectors of the economy production, finance, distribution, exchange, consumption and governance. It also aims to transform the social and economic system that includes public, private and third sectors. SSE is not only about the poor, but strives to overcome inequalities, which includes all classes of society. SSE has the ability to take the best practices that exist in our present system (such as efficiency, use of technology and knowledge) and transform them to serve the welfare of the community based on different values and goals.*

*(...) SSE seeks systemic transformation that goes beyond superficial change in which the root oppressive structures and fundamental issues remain intact.*

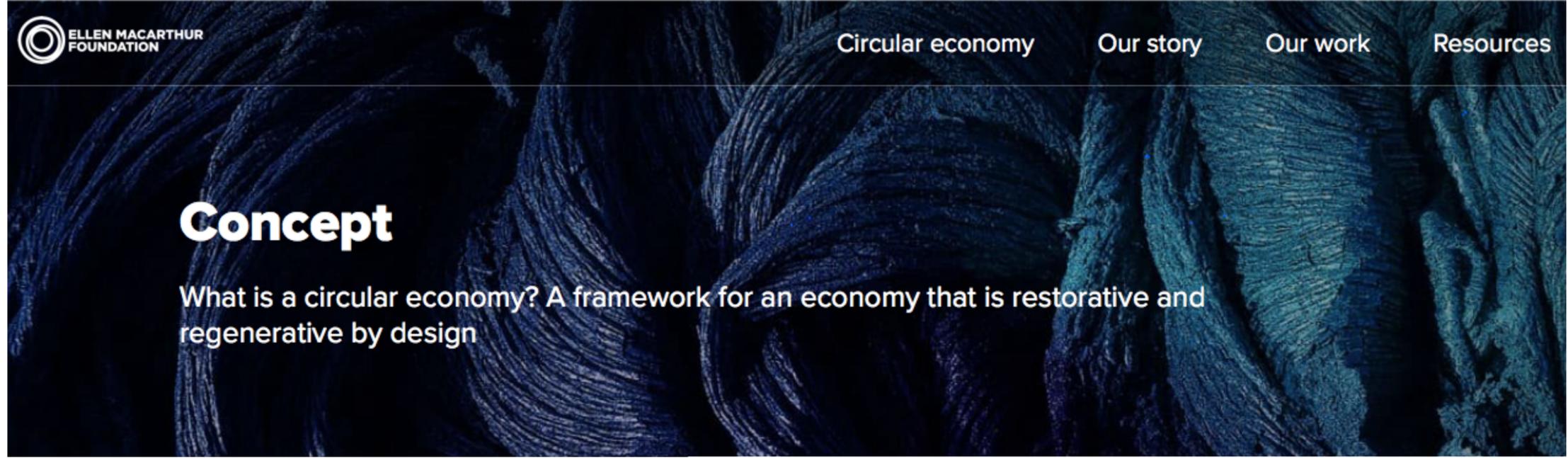


## What is a circular economy?

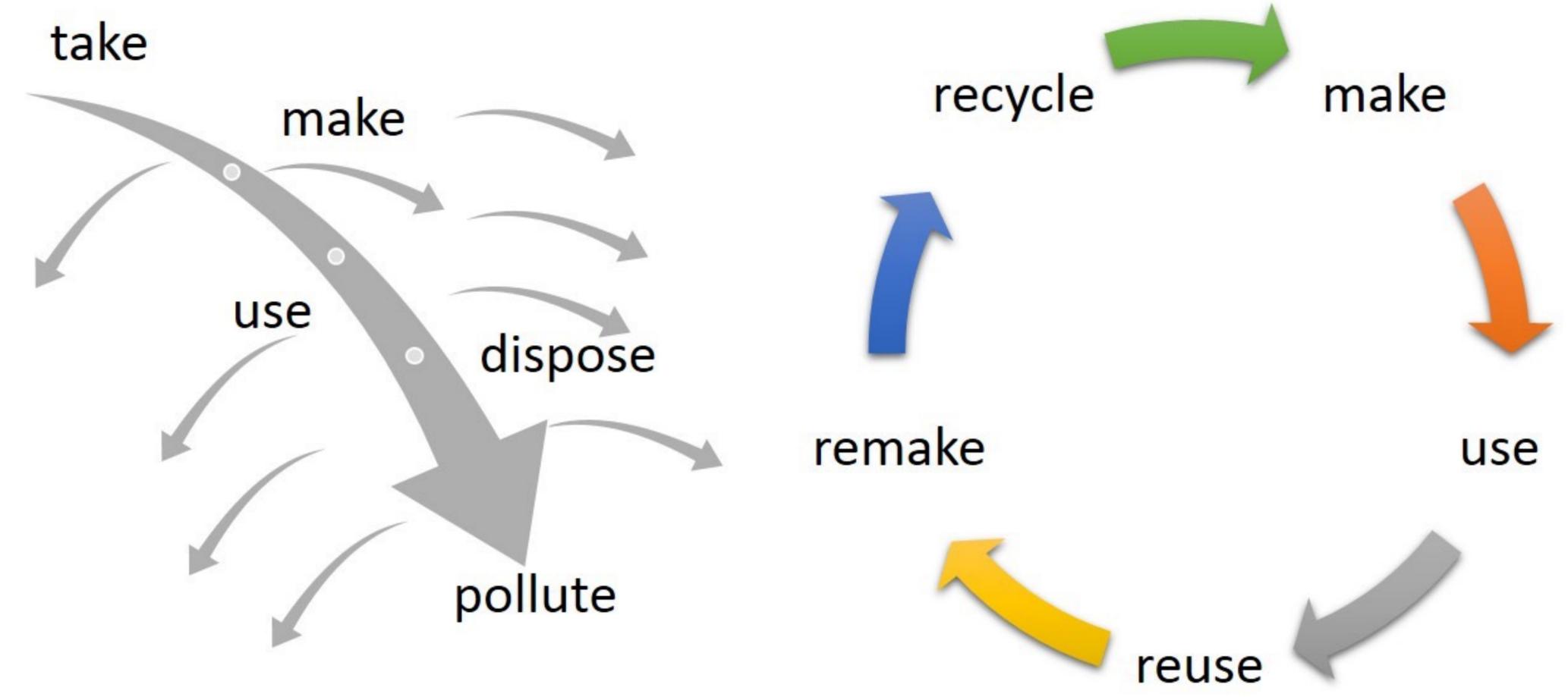
Looking beyond the current take-make-waste extractive industrial model, a circular economy aims to redefine growth, focusing on positive society-wide benefits. It entails gradually decoupling economic activity from the consumption of finite resources, and designing waste out of the system. Underpinned by a transition to renewable energy sources, the circular model builds economic, natural, and social capital. It is based on three principles:

- Design out waste and pollution
- Keep products and materials in use
- Regenerate natural systems

# The Therapy: Changing the Official Purpose of Economy



A circular economy seeks to rebuild capital, whether this is financial, manufactured, human, social or natural. This ensures enhanced flows of goods and services. The system diagram illustrates the continuous flow of technical and biological materials through the 'value circle'.





## More Recycling Won't Solve Plastic Pollution

It's a lie that wasteful consumers cause the problem and that changing our individual habits can fix it

By Matt Wilkins on July 6, 2018



Credit: Dave and Les Jacobs Getty Images

Recycling plastic is to saving the Earth what hammering a nail is to halting a falling skyscraper. You struggle to find a place to do it and feel pleased when you succeed. But your effort is wholly inadequate and distracts from the real problem of why the building is collapsing in the first place. The real problem is that single-use plastic—the very idea of producing plastic items like grocery bags, which we use for an average of 12 minutes but can persist in the environment for half a millennium—is an incredibly reckless abuse of technology.

# The Therapy: Changing the Official Purpose of Economy

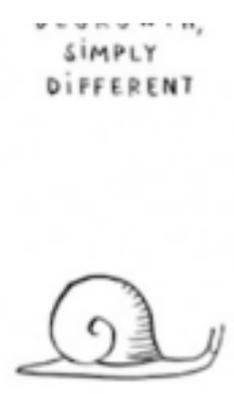
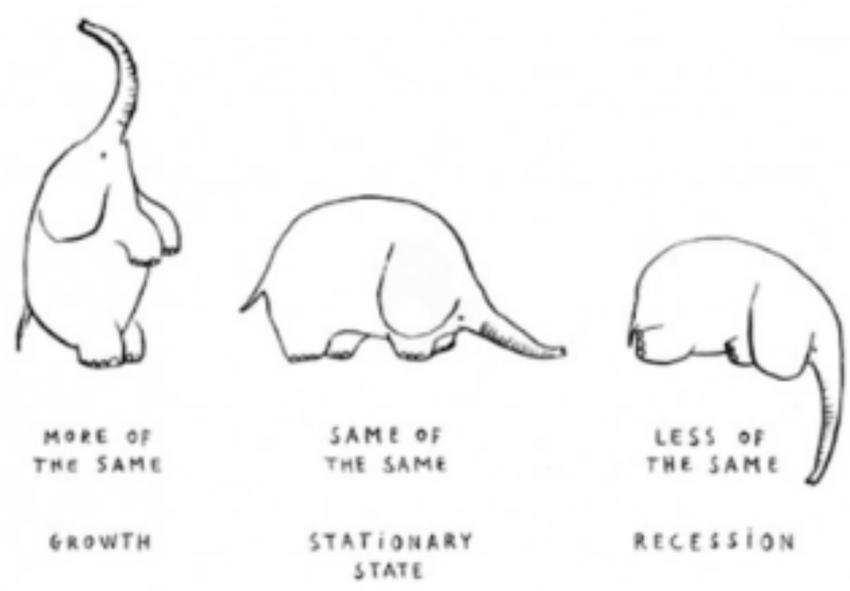
- Donations
- Newsletter
- degrowth?

<https://www.degrowth.info>



- Home
- Degrowth
- Blog
- Library
- Projects
- Conferences
- Get involved
- About us

English ▼



**LESS**  
↓ ↓ ↓ IS ↑ ↑ ↑  
**MORE**

**HOW DEGROWTH  
WILL SAVE  
THE WORLD**

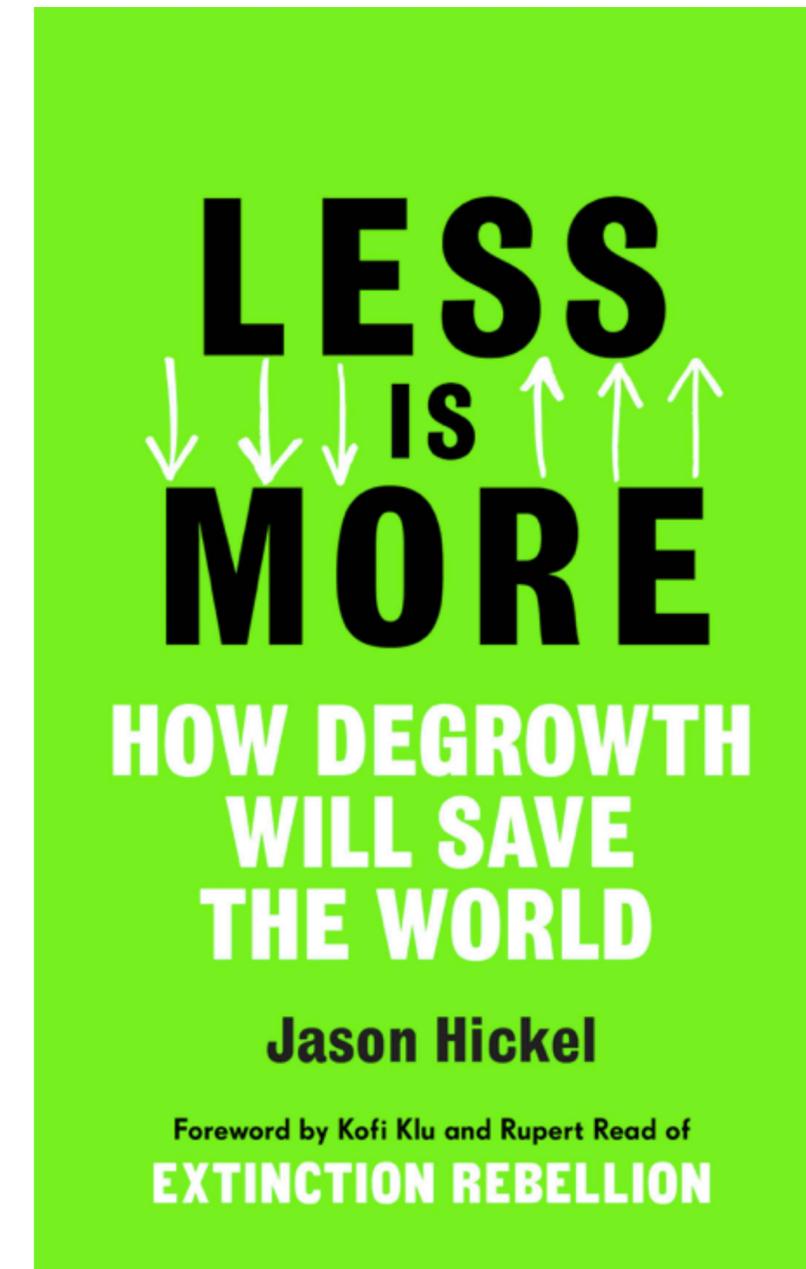
**Jason Hickel**

Foreword by Kofi Klu and Rupert Read of  
**EXTINCTION REBELLION**

[Donations](#)[Newsletter](#)[degrowth?](#)<https://www.degrowth.info>[Home](#)[Degrowth](#)[Blog](#)[Library](#)[Projects](#)[Conferences](#)[Get involved](#)[About us](#)[English](#)

## Essential for degrowth is:

- Striving for a self-determined life in dignity for all. This includes deceleration, time welfare and **conviviality**.
- An **economy** and a **society** that sustains the natural basis of life.
- A reduction of production and consumption in the global North and liberation from the one-sided Western paradigm of development. This could allow for a self-determined path of social organization in the global South.
- An extension of **democratic** decision-making to allow for real political participation.
- Social changes and an orientation towards **sufficiency** instead of purely technological changes and improvements in efficiency in order to solve ecological problems. We believe that it has historically been proven that **decoupling** economic growth from resource use is not possible.
- The creation of open, connected and localized economies.



# OUR COMMON FUTURE

THE WORLD COMMISSION  
ON ENVIRONMENT  
AND DEVELOPMENT

- Purpose of economy is to increase human wealth;
- Earth and its natural wealth is basically infinite.

*Smith (1776)*

"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs".

*WCED (1987)*

**COMMENT**

**ENVIRONMENT** Conservationists call for a global zoning exercise for roads **p.200**

**HISTORY** Ripping yarn of the ape-man of Victorian England **p.210**

**EVOLUTION** First biography of W. D. Hamilton, the gentle giant of genetics **p.212**

**FUNDING** Australia's grant system wastes centuries of researchers' time **p.214**



- Purpose of economy is to increase human wealth;
  - Earth and its natural wealth is basically infinite.
- Smith (1776)*



"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs".

*WCED (1987)*

"Sustainable Development is a development that meets the needs of the present while safeguarding Earth's life support systems, on which the welfare of current and future generations depends."

*Griggs et al. (2013)*

## Sustainable development goals for people and planet

Planetary stability must be integrated with United Nations targets to fight poverty and secure human well-being, argue **David Griggs** and colleagues.

The United Nations Rio+20 summit in Brazil in 2012 committed governments to create a set of sustainable development goals (SDGs) that would be integrated into the follow-up to the Millennium Development Goals (MDGs) after their 2015 deadline. Discussions on how to formulate these continue this week at UN headquarters in New York. We argue that the protection of Earth's

life-support system and poverty reduction must be the twin priorities for SDGs. It is not enough simply to extend MDGs, as some are suggesting, because humans are transforming the planet in ways that could undermine development gains. As mounting research shows, the stable functioning of Earth systems — including the atmosphere, oceans, forests, waterways, biodiversity and biogeochemical cycles — is

a prerequisite for a thriving global society. With the human population set to rise to 9 billion by 2050, definitions of sustainable development must be revised to include the security of people and the planet. Defining a unified set of SDGs is challenging, especially when there can be conflict between individual goals, such as energy provision and climate-change prevention. But we show here that it is possible. By ▶



- Purpose of economy is to increase human wealth;
- Earth and its natural wealth is basically infinite.

*Smith (1776)*

"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs".

*WCED (1987)*

"Sustainable Development is a development that meets the needs of the present while safeguarding Earth's life support systems, on which the welfare of current and future generations depends."

*Griggs et al. (2013)*



- Purpose of economy is to increase human wealth;
- Earth and its natural wealth is basically infinite.

*Smith (1776)*

"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs".

*WCED (1987)*

"Sustainable Development is a development that meets the needs of the present while safeguarding Earth's life support systems, on which the welfare of current and future generations depends."

*Griggs et al. (2013)*

Humanity needs an economy that meets the needs of the present while safeguarding Earth's life support systems, on which the welfare of current and future generations of all human and non-human animals depends.



- Purpose of economy is to increase human wealth;
- Earth and its natural wealth is basically infinite.

*Smith (1776)*

"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs".

*WCED (1987)*

"Sustainable Development is a development that

**Do we want to transform the virus that we are in Earth's life-support system into the healer?**

*Anggo et al. (2010)*

Humanity needs an economy that meets the needs of the present while safeguarding Earth's life support systems, on which the welfare of current and future generations of all human and non-human animals depends.

- Purpose of economy is to increase human wealth;
- Earth and its natural wealth is basically infinite.

*Smith (1776)*

"Sustainable development is development that meets



**Do we have the global governance to transform the purpose of Economy?**

"Sustainable Development is a development that

**Do we want to transform the virus that we are in Earth's life-support system into the healer?**

*Unggoh et al. (2010)*

Humanity needs an economy that meets the needs of the present while safeguarding Earth's life support systems, on which the welfare of current and future generations of all human and non-human animals depends.

# The Therapy: Changing the Official Purpose of Economy

## Global Order: The “Global Ruling Class”



Futures  
Volume 42, Issue 9, November 2010, Pages 1007-1018

### The study of futures, and the analysis of power

Bernd Hamm   
[Show more](#)

<https://doi.org/10.1016/j.futures.2010.08.017> [Get rights and content](#)

#### Abstract

This study attempts to find out in which direction global power distribution is shifting. This is expected to shed light on the chances we have to build a democratic, ecologically sustainable and socially just world future society. The paper raises and explores, to some extent, three questions: (1) Who is the emerging global ruling class, and does it develop some sort of class consciousness? (2) What are the means used by the global ruling class in the class struggle? and (3) What are likely consequences for the future of global society?

### Power and the Global Ruling Class. Who Rules the World?

#### The End of Democracy as We Know It

By [Bernd Hamm](#)  
Global Research, June 04, 2014

Region: USA  
Theme: Global Economy, History, Religion, Terrorism, US NATO War Agenda

Share Like 8 Tweet Email Share 3



*This paper starts with summarizing the major theoretical elements in the definition of a global ruling class. It then examines how neoconservatives in the US took power and used regime change to create chaos in other regions. A strategy of tension is used to press the population into conformity. But the real revolution is to what extent factual politics escape any attempt to democratic control. Three case studies show how far the Deep State already goes. Democracy is on the brink of survival.*

# The Therapy: Changing the Official Purpose of Economy

## Global Order: The “Global Ruling Class”



The study of futures, and the analysis of power

Bernd Hamm   
[Show more](#)

<https://doi.org/10.1016/j.futures.2010.08.017> [Get rights and content](#)

**Global Ruling Class of approximately 350 billionaires**

### Abstract

This study attempts to find out in which direction global power distribution is shifting. This is expected to shed light on the chances we have to build a democratic, ecologically sustainable and socially just world future society. The paper raises and explores, to some extent, three questions: (1) Who is the emerging global ruling class, and does it develop some sort of class consciousness? (2) What are the means used by the global ruling class in the class struggle? and (3) What are likely consequences for the future of global society?

## Power and the Global Ruling Class. Who Rules the World?

The End of Democracy as We Know It

By [Bernd Hamm](#)

Global Research, June 04, 2014

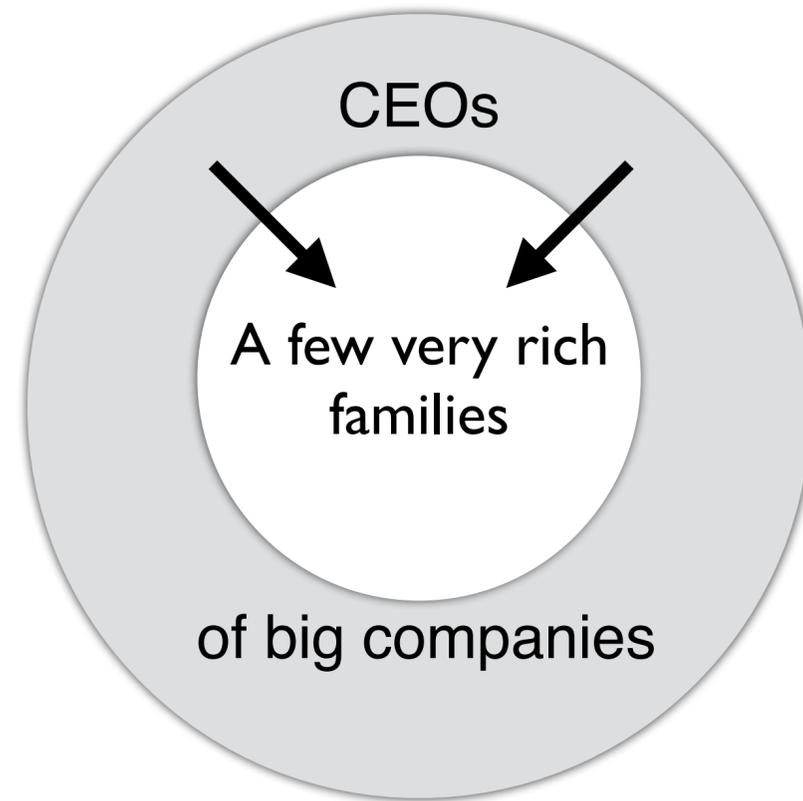
Region: USA  
Theme: Global Economy, History, Religion, Terrorism, US NATO War Agenda

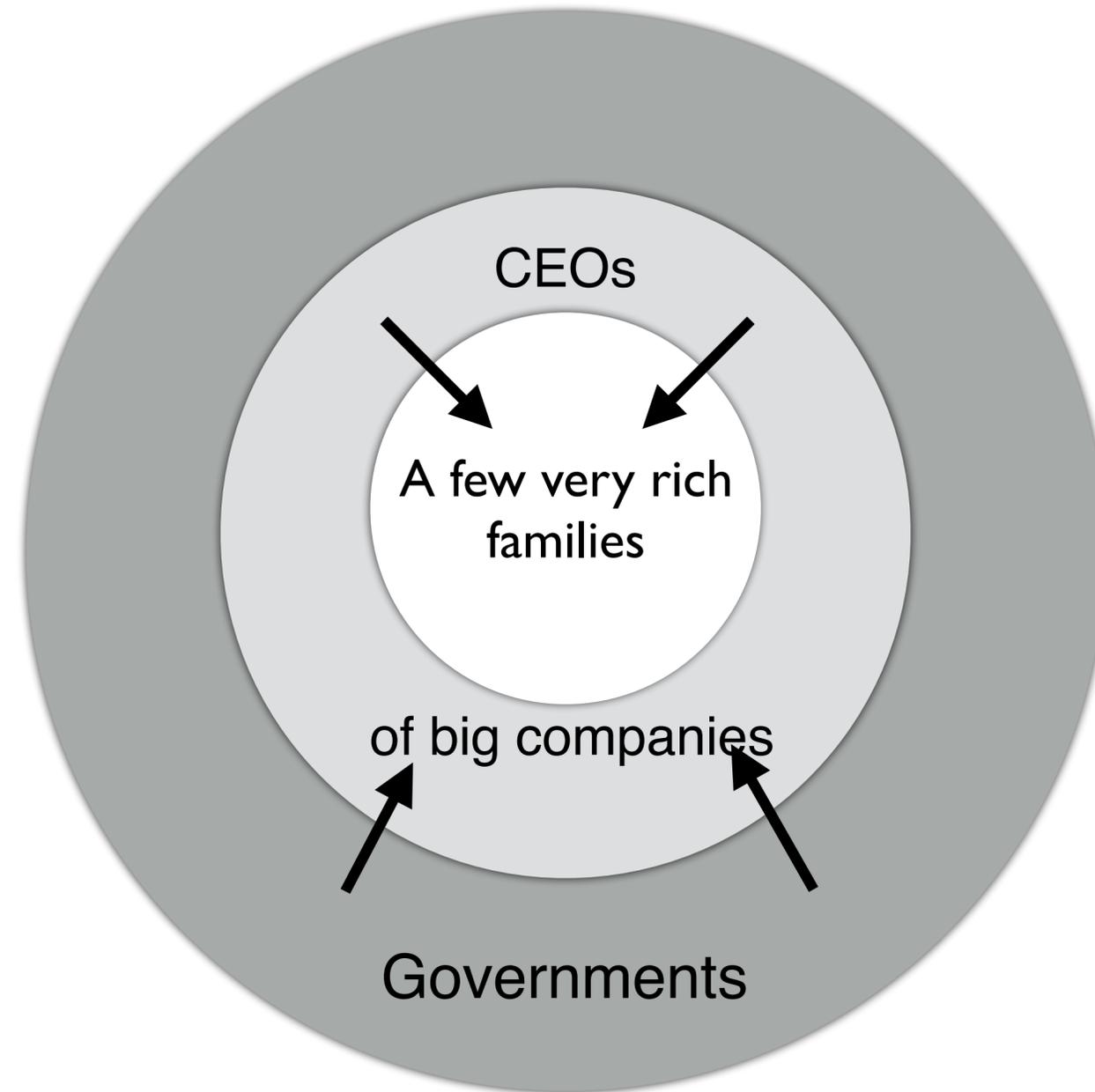
Share < 3 Like 8 Tweet < 0 Email < 0 Share < 3

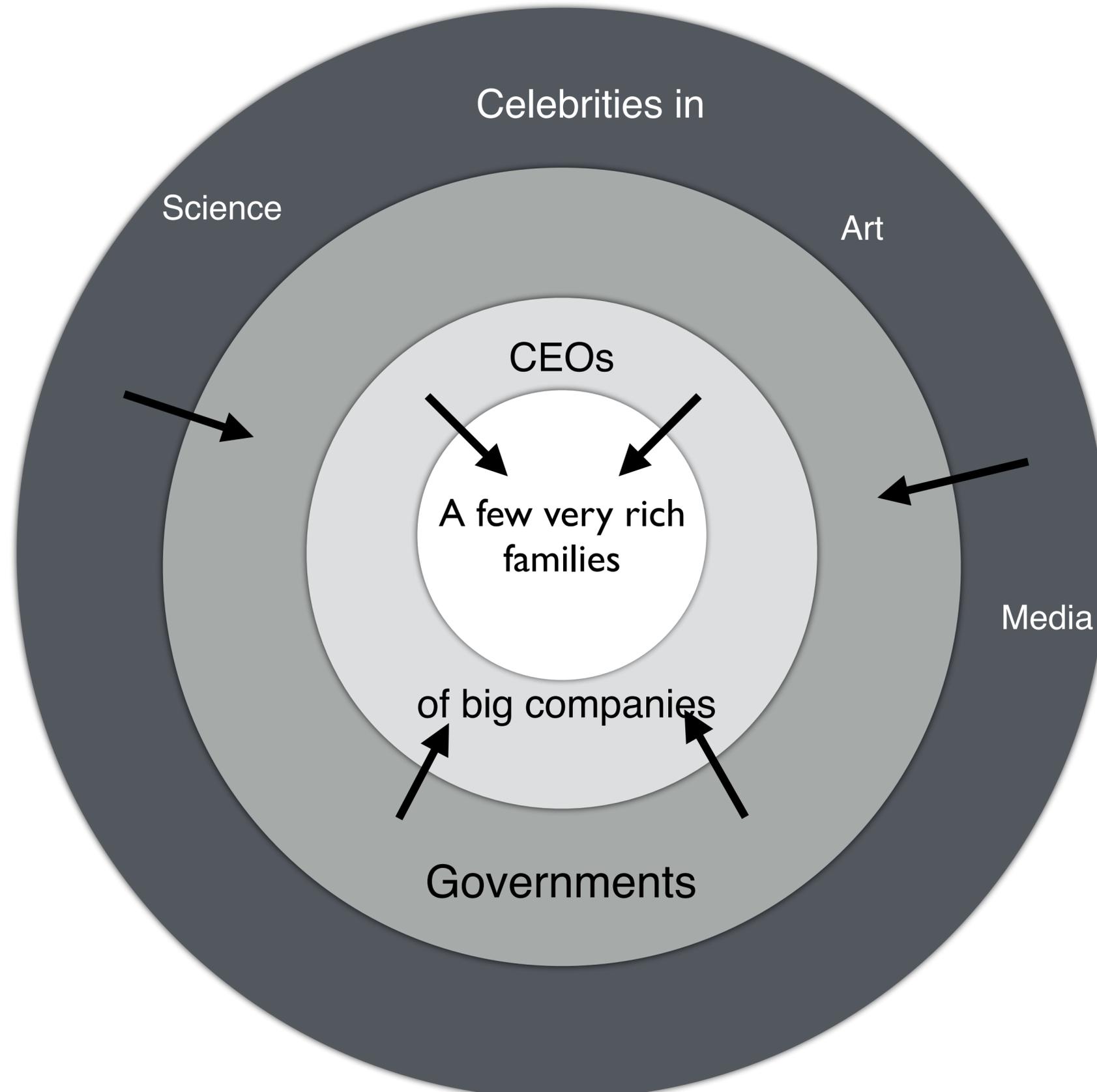


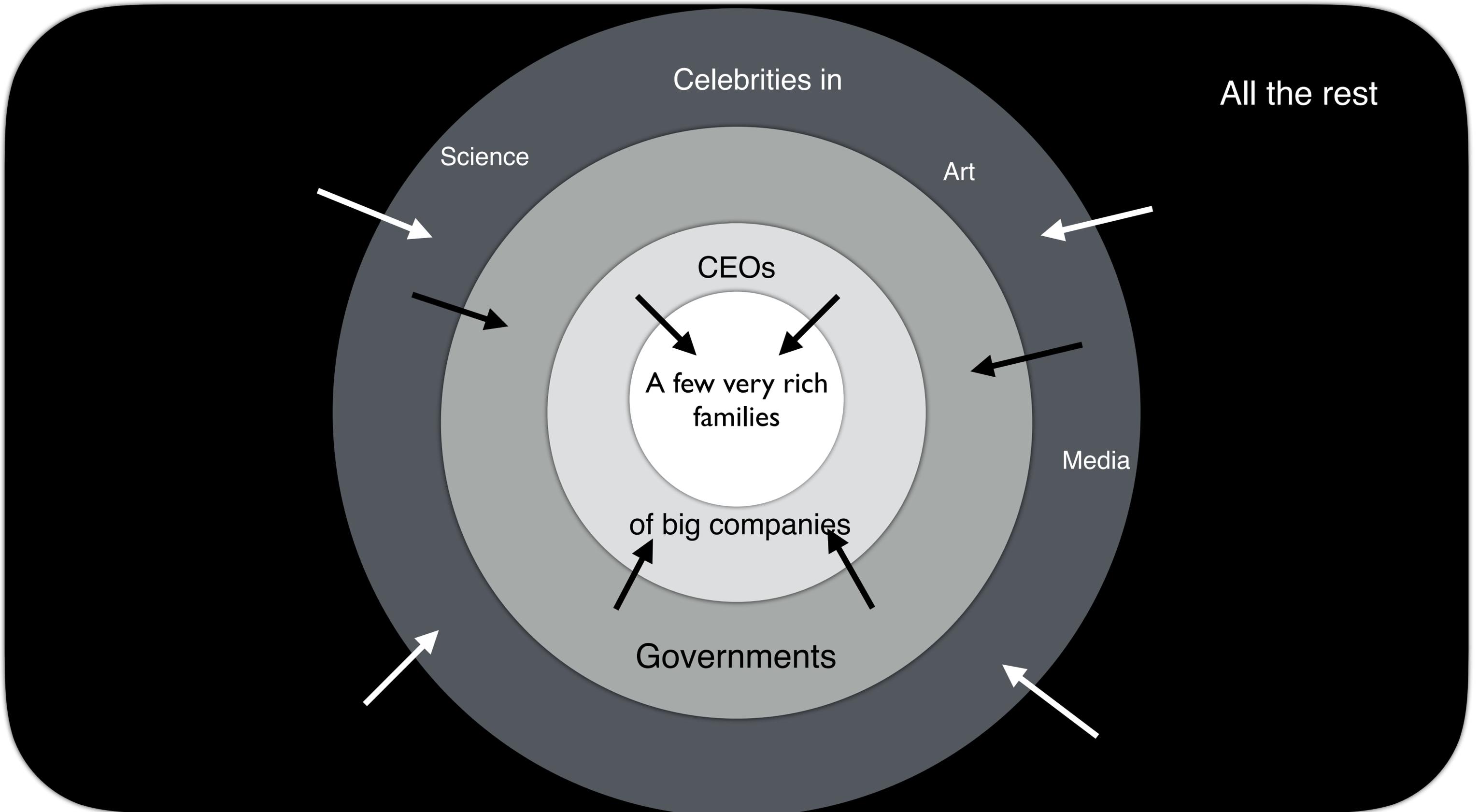
*This paper starts with summarizing the major theoretical elements in the definition of a global ruling class. It then examines how neoconservatives in the US took power and used regime change to create chaos in other regions. A strategy of tension is used to press the population into conformity. But the real revolution is to what extent factual politics escape any attempt to democratic control. Three case studies show how far the Deep State already goes. Democracy is on the brink of survival.*

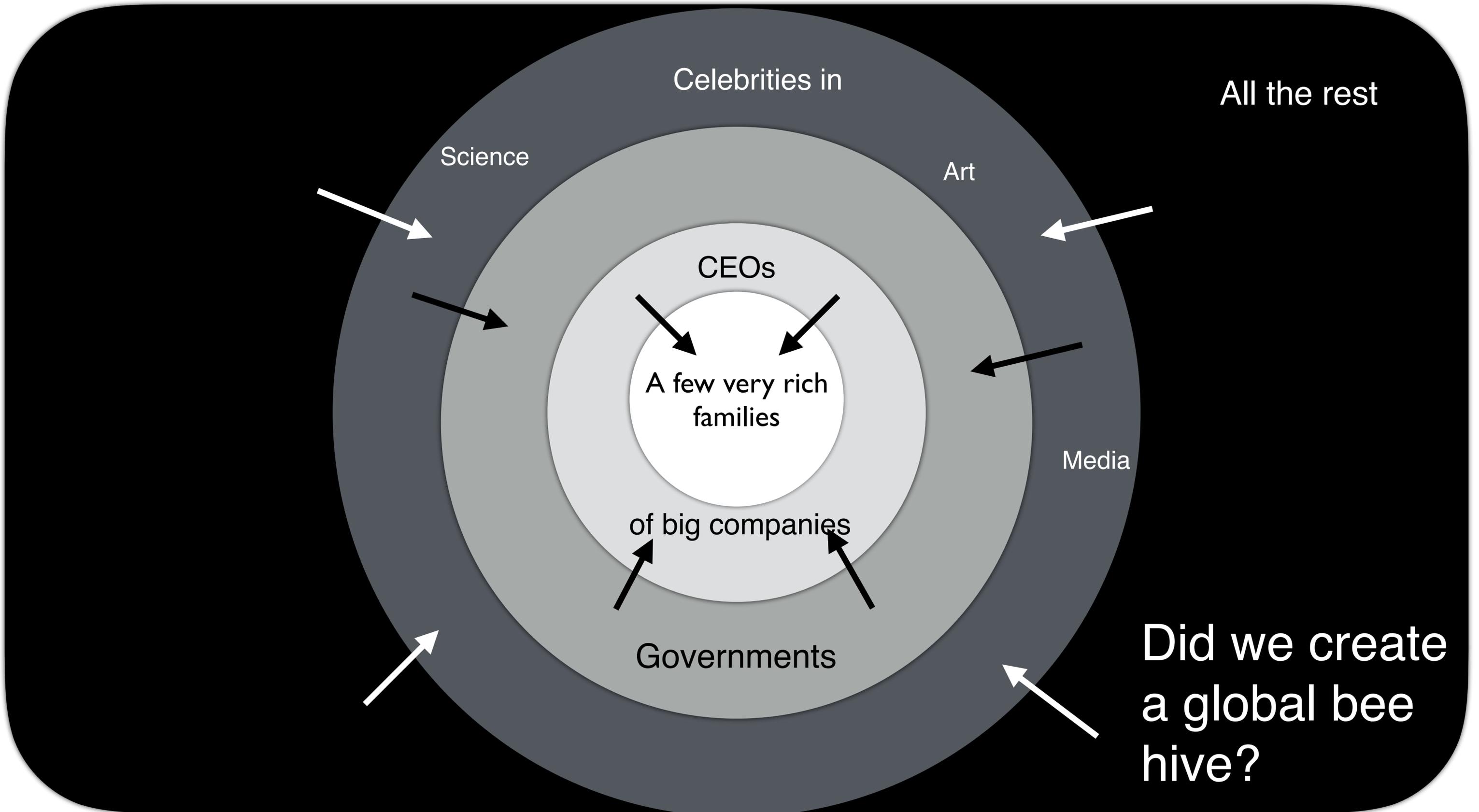
A few very rich families











# Key Points

---

## Purpose of Economy

The *de facto* purpose of economy is to meet the needs of the present while safeguarding the Earth's life-support system, on which the welfare of all current and future generation depends.

The current “official” purpose of economy is to create human wealth; this official purpose is in conflict with the *de facto* purpose.

## Syndrome of Modern Global Change

The Holocene was a “safe operating space for humanity” allowing the emergence of a dominant species

During the last few hundred years, humanity has made large and rapid planetary changes, accelerated existing and introduced new flows in the planetary physiology.

The system is outside the “normal range” and in the dynamic transition into the Post-Holocene.

## Diagnosis

Making the creation of human wealth the “official” purpose of economy and economic growth the overarching goal turned humans into the “Anthropogenic Cataclysmic Virus” (ACV) in the Earth's life-support system.

Easy access to seemingly unlimited energy allowed humans to accelerate flows in the Earth's life-support system and sustain rapid population growth and increasing demands.

## Prognosis

The planet is heading rapidly towards tipping points and a very different system state.

The growth-focused economy is the root cause of the global challenges and poses an existential risk.

## Therapy

Aligning the official purpose of economy to the *de facto* purpose: Meeting the need of the present while safeguarding the Earth's life-support system on which the welfare of all current and future generations depends

A new global order and governance that can handle the coming social, economic, and environmental challenges ...