ENV210

Sustainability

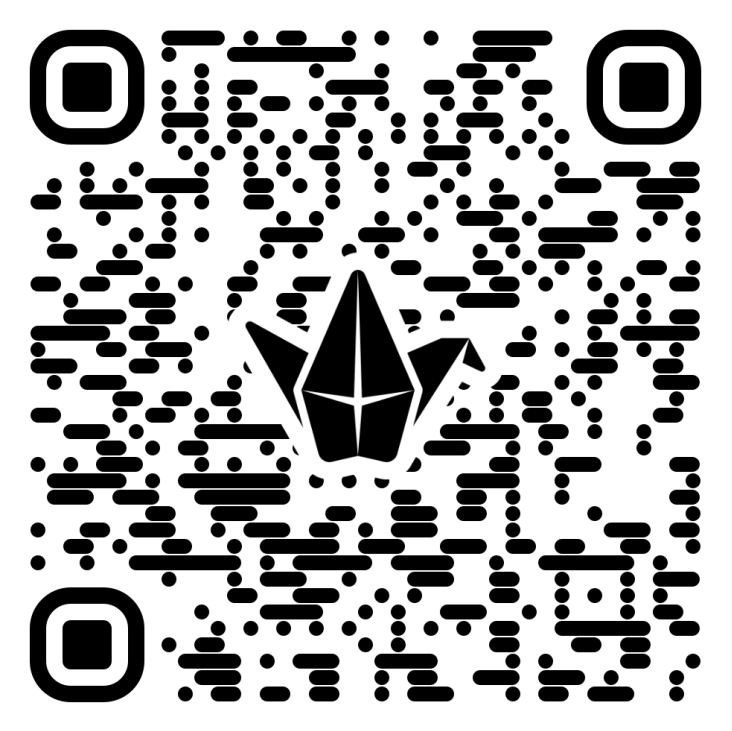
Winter 2026

Lecture 1

04

Defining Sustainability

WHAT IS SUSTAINABILITY?



https://padlet.com/alannabodo/what-is-sustainability-w9r9mwfg4u0boae6

LINGUISTICALLY

Enduring into the long-term future

Refers to systems and processes that are able to operate and persist on their own over long periods of time

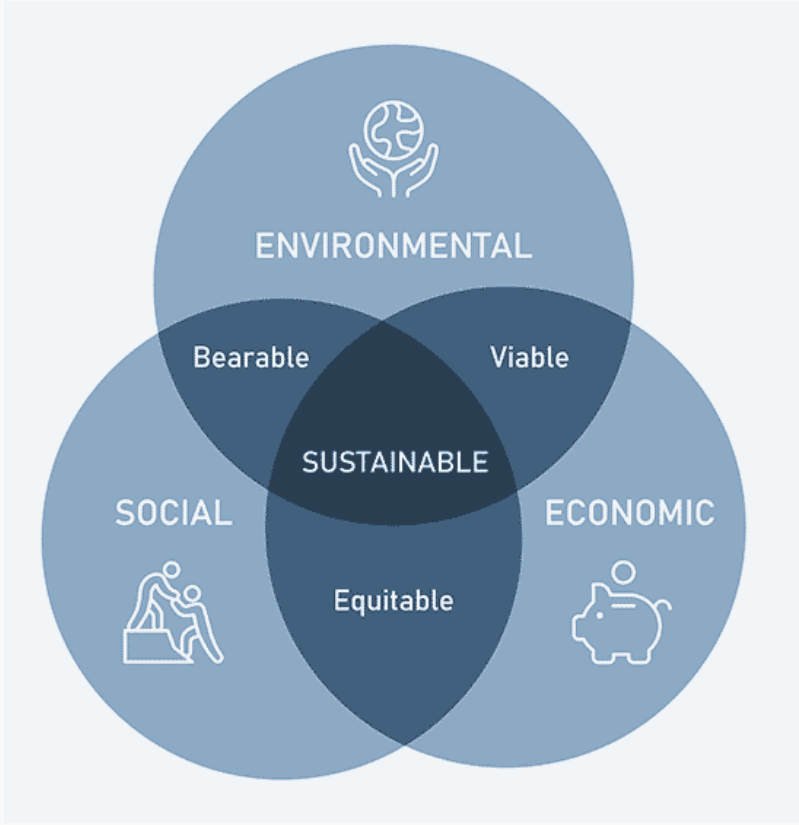
- As an adjective: “able to continue without interruption”
- Latin verb: ***sustinēre*** – “to maintain, sustain, support, endure”
    - From the roots: ***sub*** “up from below” and ***tenēre*** “to hold”
- Early ties to forestry and mining in Germany (1713)

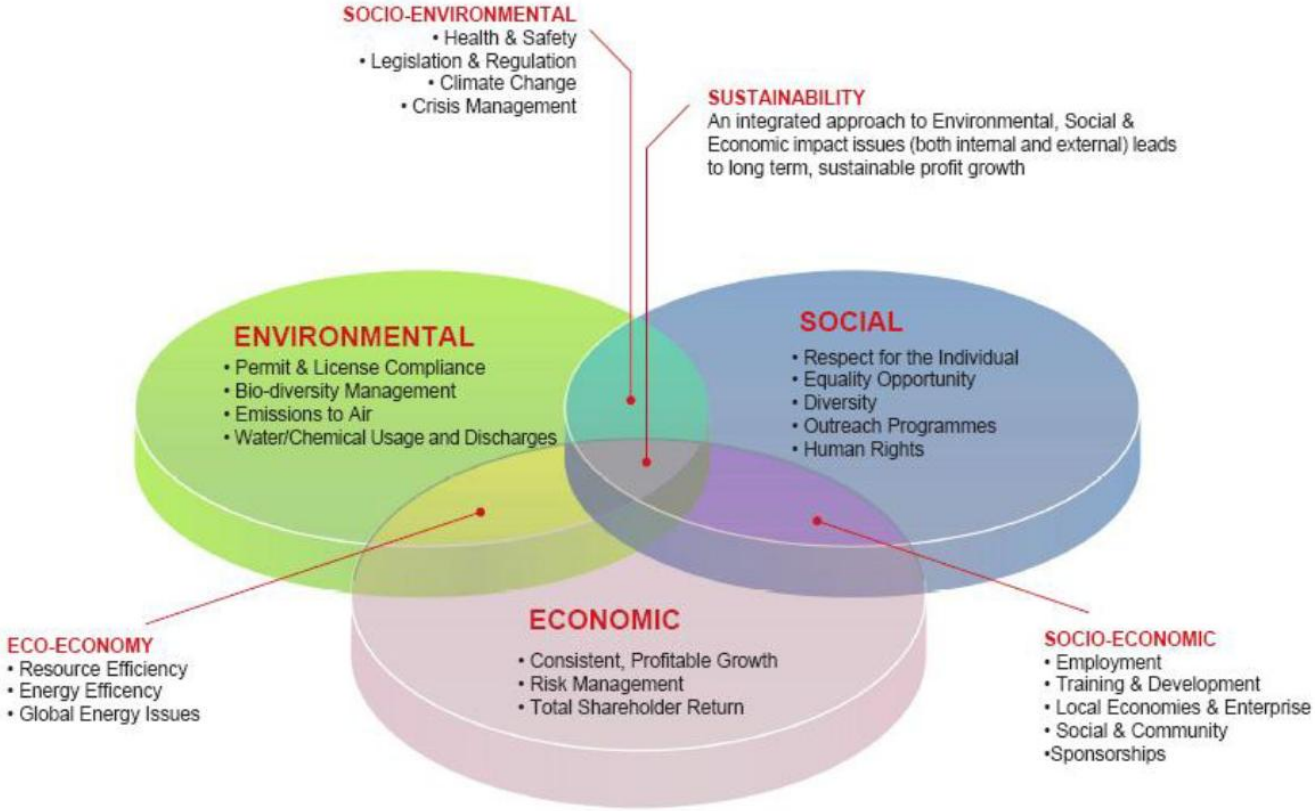
REALISTICALLY

- Sustainability goes beyond environmentalism – applies to all systems
- Complex, interrelated systems
- “wicked problems”
- E.g. does poverty cause environmental destruction or does environmental destruction cause poverty?

MODELS OF SUSTAINABILITY

“Triple Bottom Line” Model

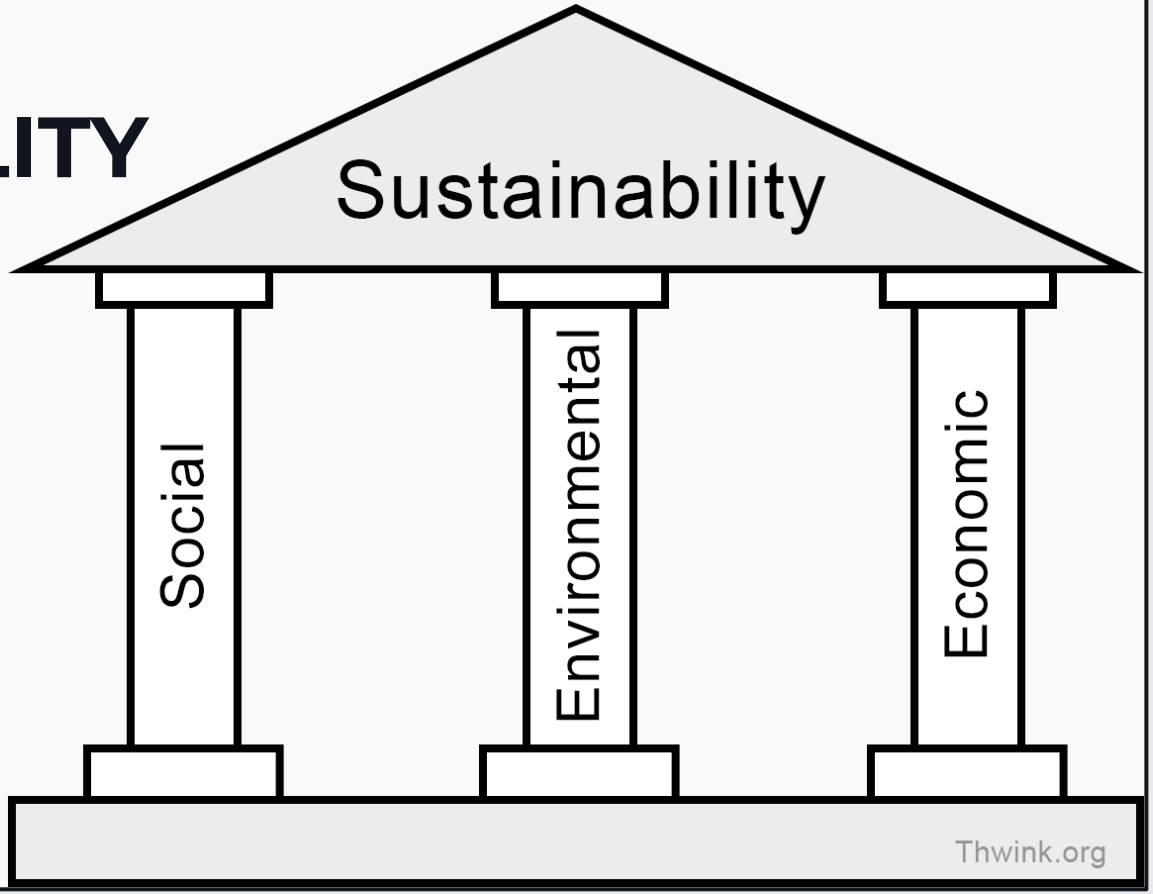




"Triple Bottom Line" from a Business Perspective

MODELS OF SUSTAINABILITY

“Three Pillars” Model



MODELS OF SUSTAINABILITY

"The Nested Hierarchy" Model

STRONG VS. WEAK SUSTAINABILITY

Anthropectric view

"The Nested Heirarchy" Model

- Human capital and natural capital are complementary but not interchangeable
- Economic activity cannot continue without resource inputs from the natural environment (i.e. no substitutes for natural capital)

economy and society don't operate/exist equal to the environment

What's missing from these definitions?

Elements of:

- Technology - impacts and promotes
- Political systems - how business operate, who is in charge of the country
- Corporations and consumers
- Scale – temporal, spatial?
- Individual accountability - the way that we move
- Anything else?

SDG THEMES: 5P MODEL

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

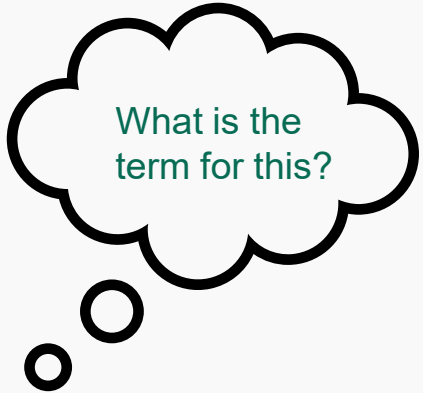
- The Brundtland Commission

05

SUSTAINABLE SYSTEMS

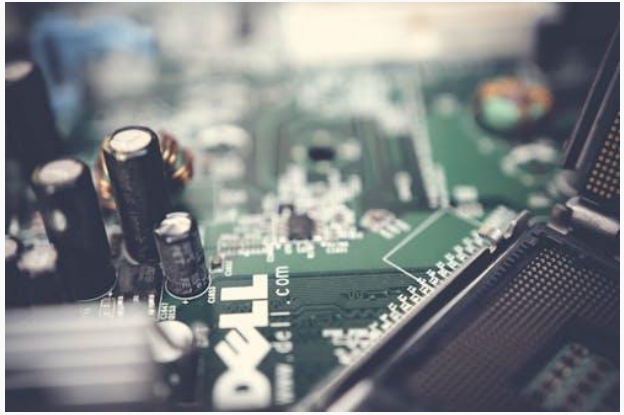
SYSTEMS THINKING

- The study of sustainability is the study of systems – a coherently organized set of interconnected elements that make up a whole
- The properties of the whole cannot be predicted by looking at the parts
- **Emergent properties** arise from the relationship and interactions between the parts
- Systems are nested within other systems

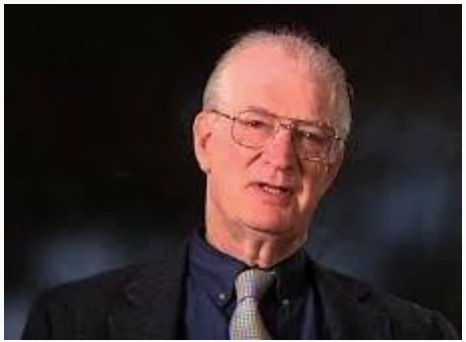


SYSTEMS THINKING: CAPACITY

- Carrying capacity: the maximum number of individuals a given environment can support indefinitely.
- Ecological footprint: the demand placed on nature for resources consumed and wastes absorbed. This figure is expressed as land area.
- Carrying capacity is the inverse of EF
- We are currently operating at 140% of our capacity globally. We are in overshoot



SYSTEMS THINKING: CAPACITY



Herman Daly identified 4 conditions to avoid overshoot

1. maintain the health of ecosystems (our life-support systems)
2. use renewable resources at a rate no faster than they can be regenerated
3. use nonrenewable resources at a rate no faster than they can be replaced by the discovery of renewable substitutes
4. and emit wastes and pollutants at a rate no faster than the rate at which they can be safely assimilated

CARRYING CAPACITY

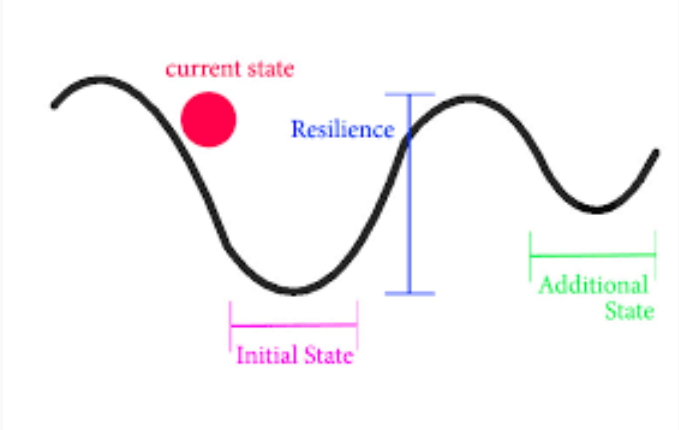
- Humans have overshot Earth's carrying capacity – depleting resources and producing waste at unprecedented rates
- **Natural capital** – the resources and services provided by the Earth system
- **Renewable resources** – can support human activities indefinitely as long as we do not use them at a faster rate than they can regenerate
- Natural capital provides ecosystem services, the biological functions that support life

RESILIENCE

- Resilience science originated in the field of ecology
- “At the heart of resilience thinking is a very simple notion – things change” – Walker and Salt (2006)
- **Resilience** is the capacity of a system to accommodate disturbance and still retain its basic function and structure
- The capacity to cope with change

RESILIENCE

- A resilient system adapts to changes without losing it's essential qualities
- Resilient systems:
  - Are self-organizing
  - Feature diversity, modularity and connectivity
- Can apply to ecosystems (forests, oceans) or social systems (cities, nations)
- Diversity gives a system flexibility



SUSTAINABILITY VS. RESILIENCE

- Interrelated but not synonymous concepts
- Complementary frameworks that work toward the same goal
- **Sustainability**: identifies long-term goals, develops strategies to achieve them, evaluates using indicators
- **Resilience:** emphasizes change as a normal condition, recognizes that a system may exist in multiple stable states, focuses on building **adaptive capacity**

"Sustainability prioritizes outcomes; resilience prioritizes process" – Charles Redman

05

The Planetary Boundaries

Stockholm Resilience Centre | Stockholm University

In 2009 a group of scientists undertook a collaborative research effort to define crucial processes and global boundaries to ensure the planet remains in a stable “safe operating space” The following are the 9 planetary boundaries which are interconnected – typical of complex systems


Climate Change


Novel Entities


Ozone
Depletion


Aerosol Loading


Ocean
Acidification

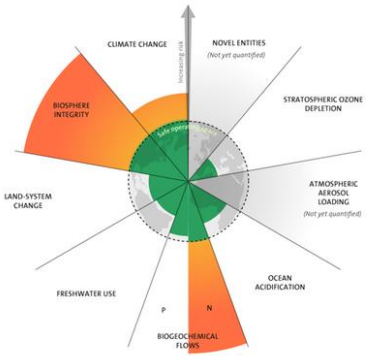

Biogeochemical
Flows


Freshwater
Change


Changing our
natural landscapes
Land System
Change

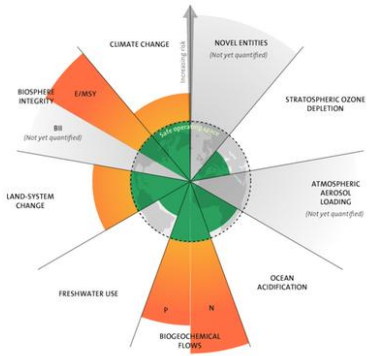

Biosphere
Integrity

2009



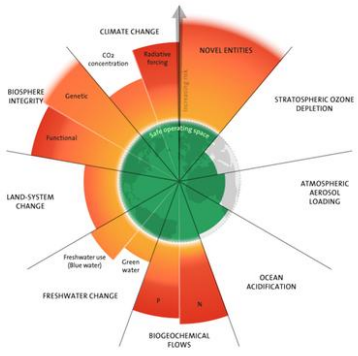
7 boundaries assessed,
3 crossed

2015



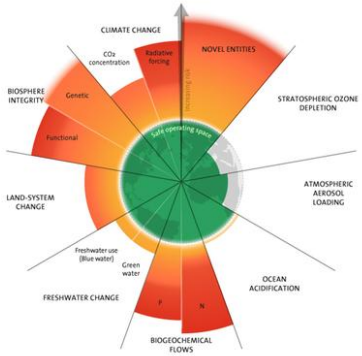
7 boundaries assessed,
4 crossed

2023



9 boundaries assessed,
6 crossed

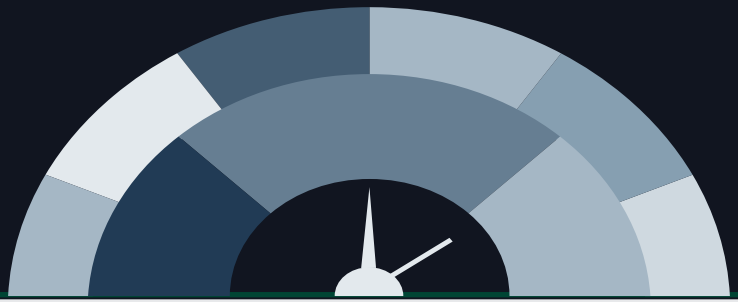
2025



9 boundaries assessed,
7 crossed

06

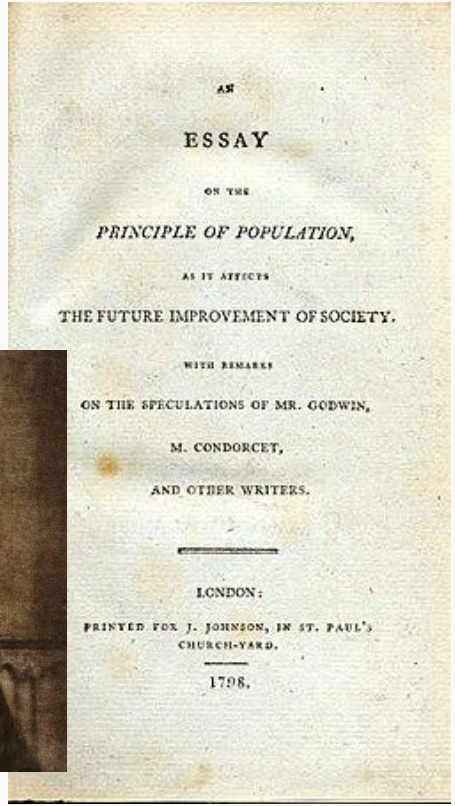
So how did we get here?



ENVIRONMENTAL HISTORY

The study of human relationships to the natural world

- Can economic growth and ever-improving standards of living continue?
- Thomas Malthus - “An Essay on the Principle of Population” (1798)



AN

ESSAY

ON THE

PRINCIPLE OF POPULATION,

AS IT AFFECTS

THE FUTURE IMPROVEMENT OF SOCIETY.

WITH REMARKS

ON THE SPECULATIONS OF MR. GODWIN,

M. CONDORCET,

AND OTHER WRITERS.

LONDON:

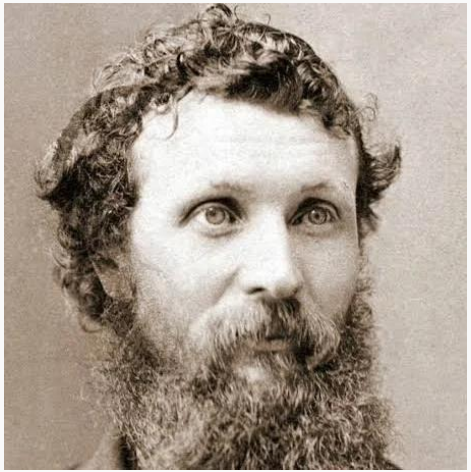
PRINTED FOR J. JOHNSON, IN ST. PAUL'S CHURCH-YARD.

1798.

KEY MOMENTS IN TIME – the 1800s

Henry David Thoreau – one of the first Americans to question the belief that nature and its resources were inexhaustible

George Perkins Marsh – used scientific reasoning to show how the rise and fall of past civilizations were connected to overuse of resources



John Muir – a naturalist who explored the North American wilderness. Championed the idea of national parks to save wilderness

FROM CONSERVATION TO ECOLOGY

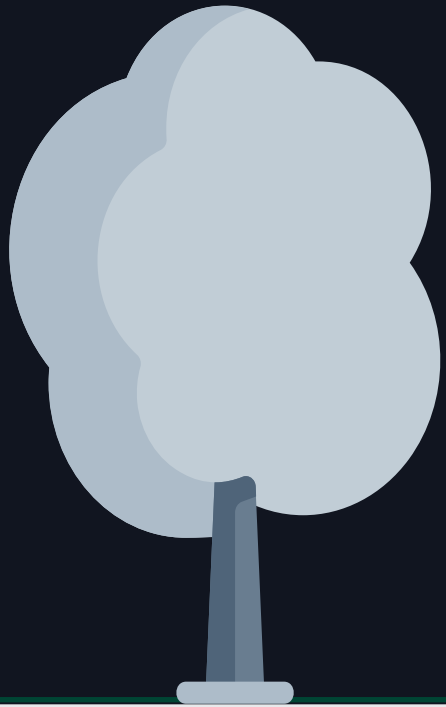
Theodore Roosevelt (US president from 1901-1909)

- A passionate conservationist
- 1903 – established the first National Wildlife Refuge
- Antiquities Act to protect the Grand Canyon

In the 20th century, the science of ecology blossomed. The focus shifted from objects to relationships and connections
Ecology – Greek word “oikos” meaning household

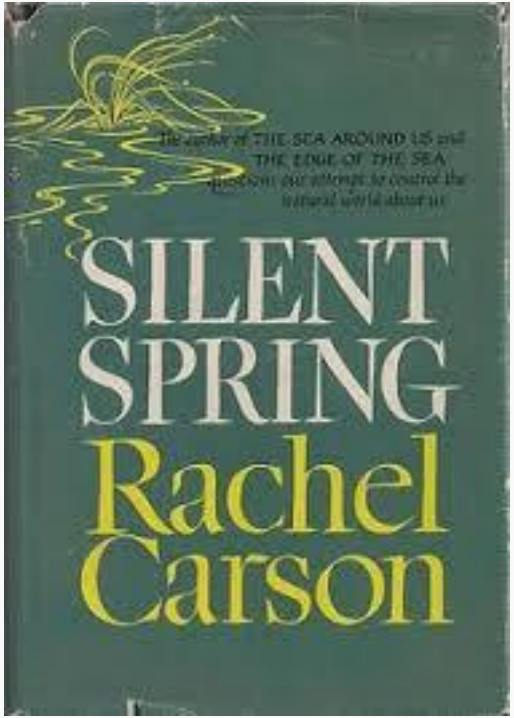
07

The Environmental Movement



SILENT SPRING

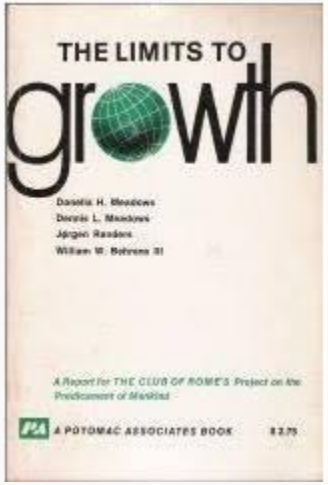
- The start of the environmental movement in the 1960s and 1970s
- Rachel Carson's "Silent Spring" kicked off the movement in 1962 – documenting destructive effects of pesticides on the environment



THE CUYAHOGA RIVER ON FIRE

THE 1970S

1972: Limits to Growth report raised awareness of the Earth's physical limits to growth
1970's: first ever Earth Day. This led to years of activism and participation
1970s:" Worldwatch Institute, Greenpeace, NRDC were founded
1970s: Love Canal in the US puts environmental threats from hazardous waste in the public spotlight



ENVIRONMENTAL JUSTICE

1982: Warren County, North Carolina

- Disposal site for polychlorinated biphenyls (PCBs), a toxic chemical
- The neighbourhood was primarily African American – raising issues of environmental racism
- Protests began immediately
- In 1987 Ben Chavis published a report on racial justice, “Toxic Wastes and Race in the United States”

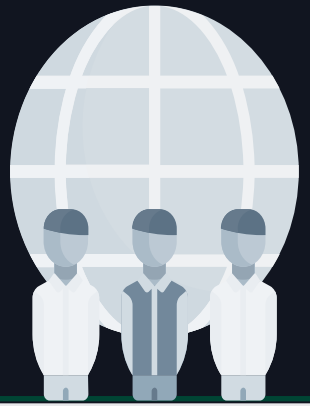
EJ IN CANADA

The Story of Grassy Narrows

https://www.youtube.com/watch?v=9E06pWtCHIg&t=3s

08

Modern and Future Sustainability



Global

- In 1968 the Apollo 8 mission sent astronauts around the moon
- On December 24th, the astronauts entered the lunar orbit planning to take photos of the moon's surface
- They looked up to see the Earth rising over the moon's horizon and took a photo
- "Earthrise" reached Earth by a live broadcast
- People began to use the term "spaceship Earth" as a reminder that this world on which we live is finite and the only home we have

Modern Sustainability

- The 1990s and 2000s were lively years in the field of sustainability
- Numerous sustainability-related organizations were established, and educational institutions began offering environmental programs
- Sustainability science became a recognized discipline

Im made by candian scholars at ubc

Future Sustainability

- The Anthropocene – a new geological epoch and unprecedented period in which human activity has become the primary driver of planetary change
- We are no longer in the Holocene – a period of warm and stable climate conditions between ice ages when humans developed

This course will examine sustainability as an integrative concept: and the social, cultural, political, and economic factors within the constraints of the biophysical environment

ENV210

Sustainability

Winter 2026

Lecture 2: The biosphere

Agenda

01 Announcements

02 Ecological Sustainability

03 Ecosystem Services

04 Anthropocentrism vs Ecocentrism

05 Climate Change

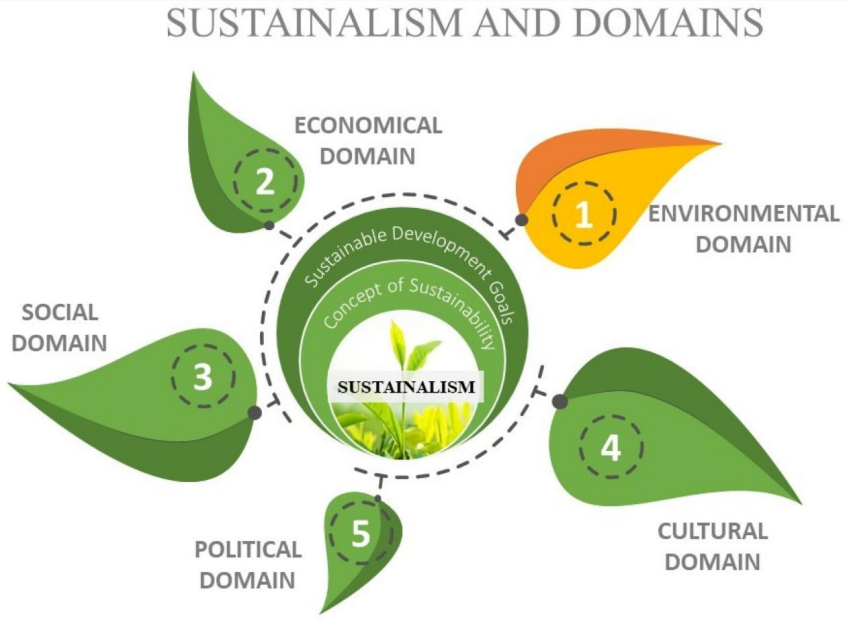
06 Deniability?

07 Classifying Resources

08 Natural Resource Management

02

Ecological Sustainability

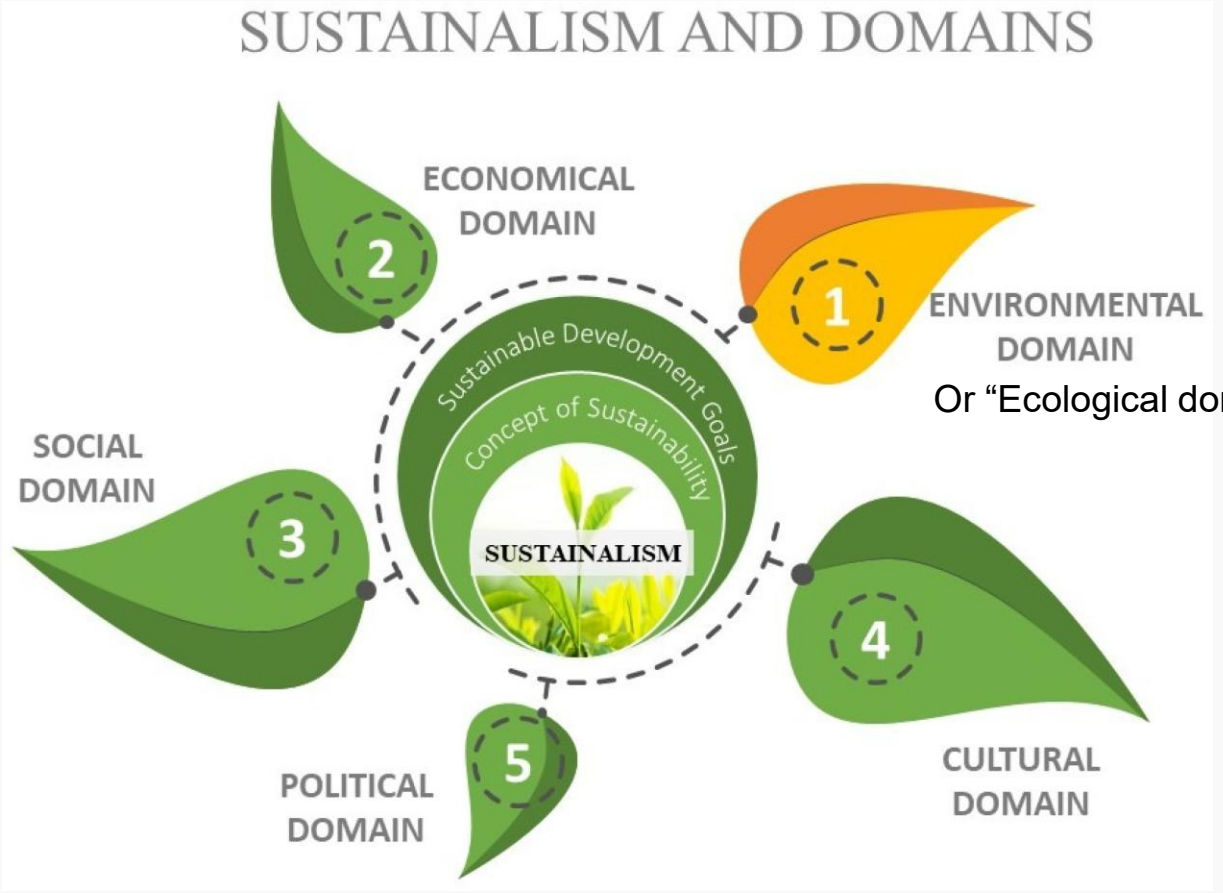


Sustainalism – a multifaceted concept of sustainability, covering its evolution, laws, principles, as well as the different domains and challenges related to achieving it in the modern world

Strengths and drawbacks of capitalism, socialism and communism have failed to address sustainable development.

A holistic approach is necessary.

Hariram, N. P., Mekha, K. B., Suganthan, V., & Sudhakar, K. (2023). Sustainalism: An Integrated Socio-Economic-Environmental Model to Address Sustainable Development and Sustainability. *Sustainability*, *15*(13), 10682. https://doi.org/10.3390/su151310682



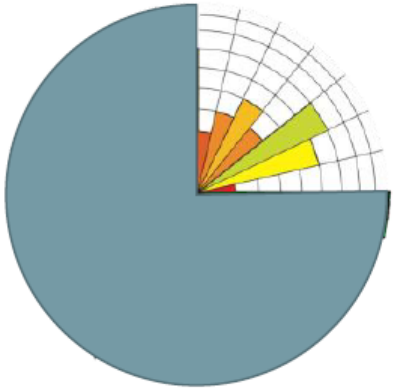
Or “Ecological domain”

Ecological sustainability

- What are some of the concepts and principles that inform our ideas and practices in the realm of ecological sustainability?
- Also we need to consider the world we are living in today:
  - What are the environmental constraints on human activities?
  - In what important ways is the environment changing?
  - How can we understand these changes and the ways they are affecting human and ecological systems?
  - Why are we now having discussions about sustainability and how is that related to what's happening in the natural environment?

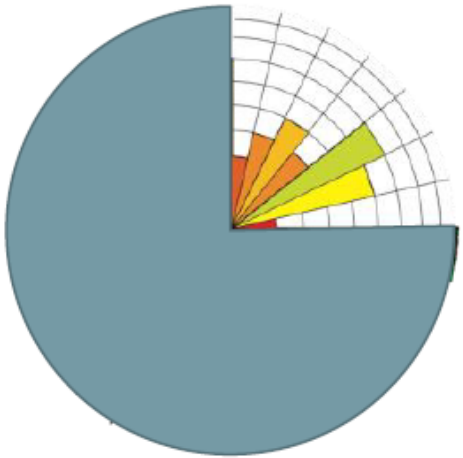
Circles of Sustainability

- The ecological domain: practices and meanings that occur across the intersection between social and natural realms, focusing on human engagement with and within nature, and the built environment
- Perspectives and aspects:
  1. Materials and Energy
  2. Water and Air
  3. Flora and Fauna
  4. Habitat and Settlements
  5. Built-form and Transport
  6. Embodiment and Sustenance
  7. Emission and Waste



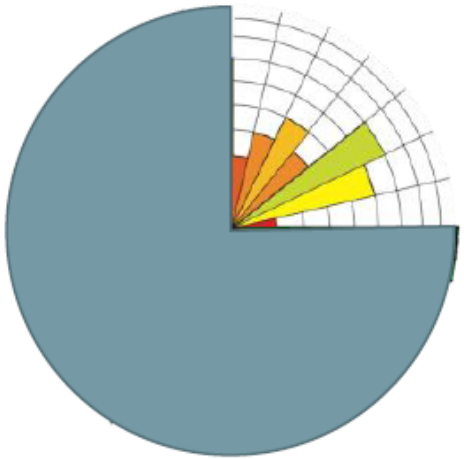
1. Materials and Energy

- Availability and Abundance
- Soil and Fertility
- Minerals and Metals
- Electricity and Gas
- Petroleum and Biofuels
- Renewables and Recyclables
- Monitoring and Reflection



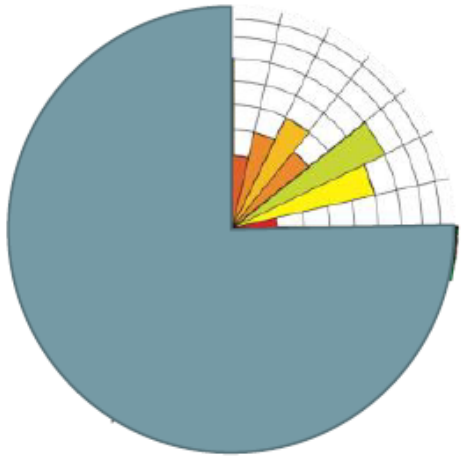
2. Water and Air

- Vitality and Viability
- Water Quality and Potability
- Air Quality and Respiration
- Climate and Temperature
- Greenhouse Gases and Carbon
- Adaptation and Mitigation Processes
- Monitoring and Reflection



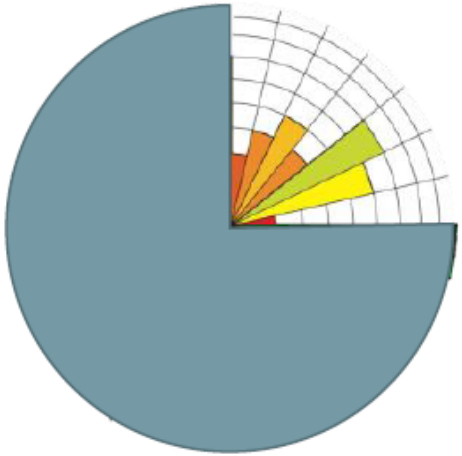
3. Flora and Fauna

- Complexity and Resilience
- Biodiversity and Ecosystem Diversity
- Plants and Insects
- Trees and Shrubs
- Wild Animals and Birds
- Domestic Animals and Species Relations
- Monitoring and Reflection



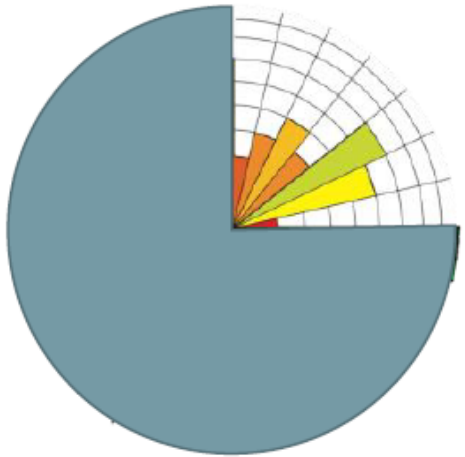
4. Habitat and Settlements

- Topography and Liveability
- Original Habitat and Native Vegetation
- Parklands and Reserves
- Land-use and Buildings
- Abode and Housing
- Maintenance and Retrofitting
- Monitoring and Reflection



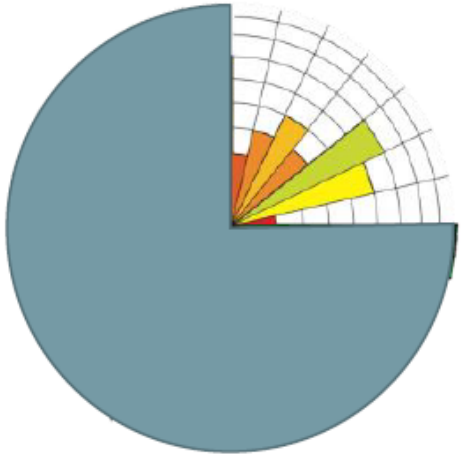
5. Built-Form and Transport

- Orientation and Spread
- Proximity and Access
- Mass Transit and Public Transport
- Motorized Transport and Roads
- Non-motorized Transport and Walking Paths
- Seaports and Airports
- Monitoring and Reflection



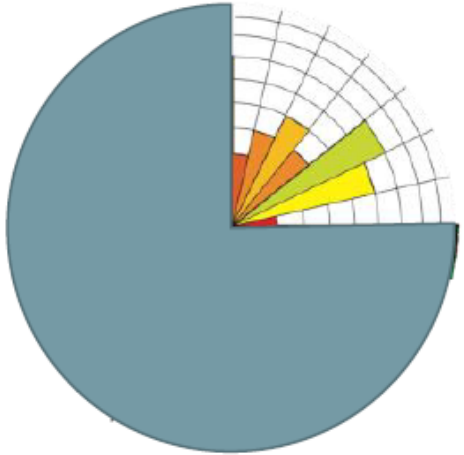
6. Embodiment and Sustenance

- Physical Health and Vitality
- Reproduction and Mortality
- Exercise and Fitness
- Hygiene and Diet
- Nutrition and Nourishment
- Agriculture and Husbandry
- Monitoring and Evaluation



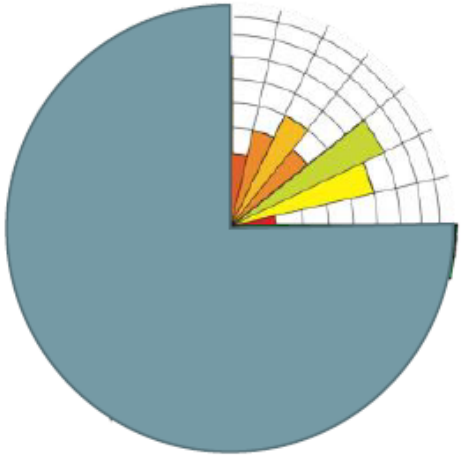
7. Emission and Waste

- Pollution and Contamination
- Hard-waste and Rubbish
- Sewerage and Sanitation
- Drainage and Effluence
- Processing and Composting
- Recycling and Re-use
- Monitoring and Evaluation



Ecological Domain

- Perspectives and aspects:
  1. Materials and energy
  2. Water and air
  3. Flora and fauna
  4. Habitat and settlements
  5. Built-form and transport
  6. Embodiment and sustenance
  7. Emission and waste
- Do you agree with them?



03

Ecosystem Services

Ecosystem services

- Benefits that humans gain from the natural environment and from properly functioning ecosystems
- Four categories (Millennium Ecosystem Assessment 2005)
  - Supporting services
  - Provisioning (goods and) services
  - Regulating services
  - Cultural services
- Ecosystem goods and services are the starting place for placing an economic value on the environment

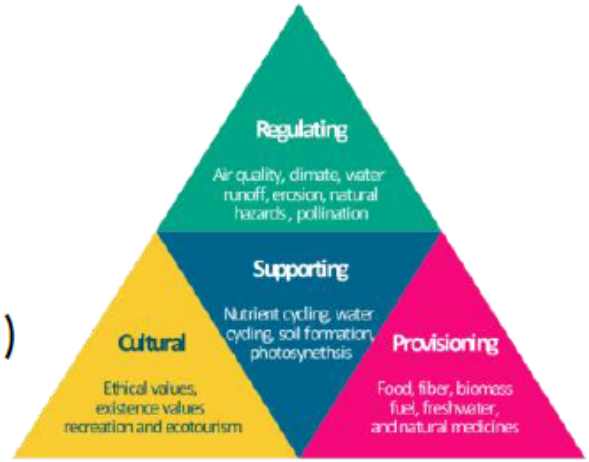
Ecosystem services

Source: Millennium Ecosystem Assessment (2005)

Ecosystem services

- Supporting services:
  - Nutrient cycling
  - Primary production
  - Maintenance of biological diversity
  - Soil formation
  - Habitat provision
  - Pollination
  - Water cycling
- Foundational – necessary for all other ecosystem services

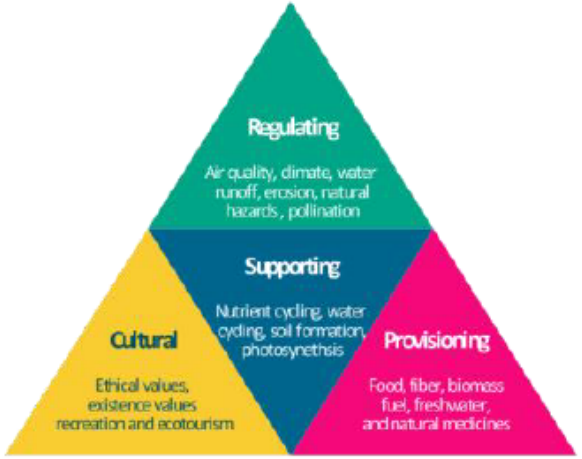
Ecosystem services



- Provisioning (goods and) services:
  - Food (e.g., crops, fish, meat, nuts, wild foods, etc.)
  - Genetic resources (e.g., crop genetic diversity)
  - Medicinal resources (e.g., pharmaceuticals)
  - Fibers (e.g., cotton, hemp)
  - Fresh water
  - Raw materials (e.g., lumber, fuelwood, fodder, minerals, fertilizer)
  - Energy (e.g., wind, hydropower, biomass fuels)
  - Ornamental items (e.g., feathers, flowers, shells, etc.)

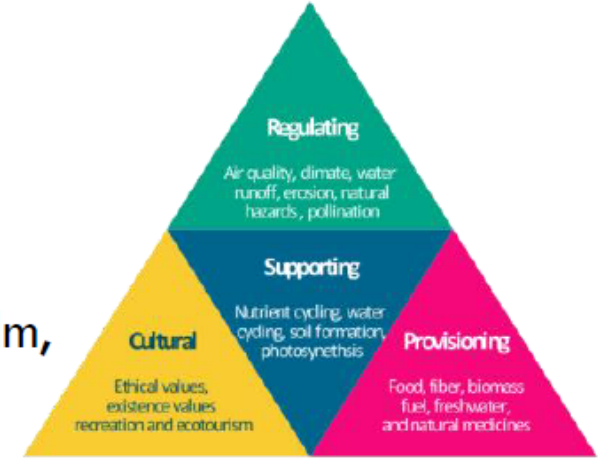
Ecosystem services

- Regulating services:
  - Carbon sequestration and climate moderation
  - Moderation of extreme events
  - Predation (regulating prey populations)
  - Waste decomposition and detoxification
  - Purification of water
  - Purification of air
  - Biological control of pests and diseases
  - Erosion prevention



Ecosystem services

- Cultural services
  - Cultural and aesthetic (e.g., nature as motif in film, books, painting, folklore, national symbols, etc.)
  - Spiritual and historical (e.g., religious or heritage value of nature, traditional knowledge)
  - Recreational experiences for mental and physical health (e.g., ecotourism, outdoor sports, and recreation)
  - Science and education (e.g., school excursions, scientific discovery)



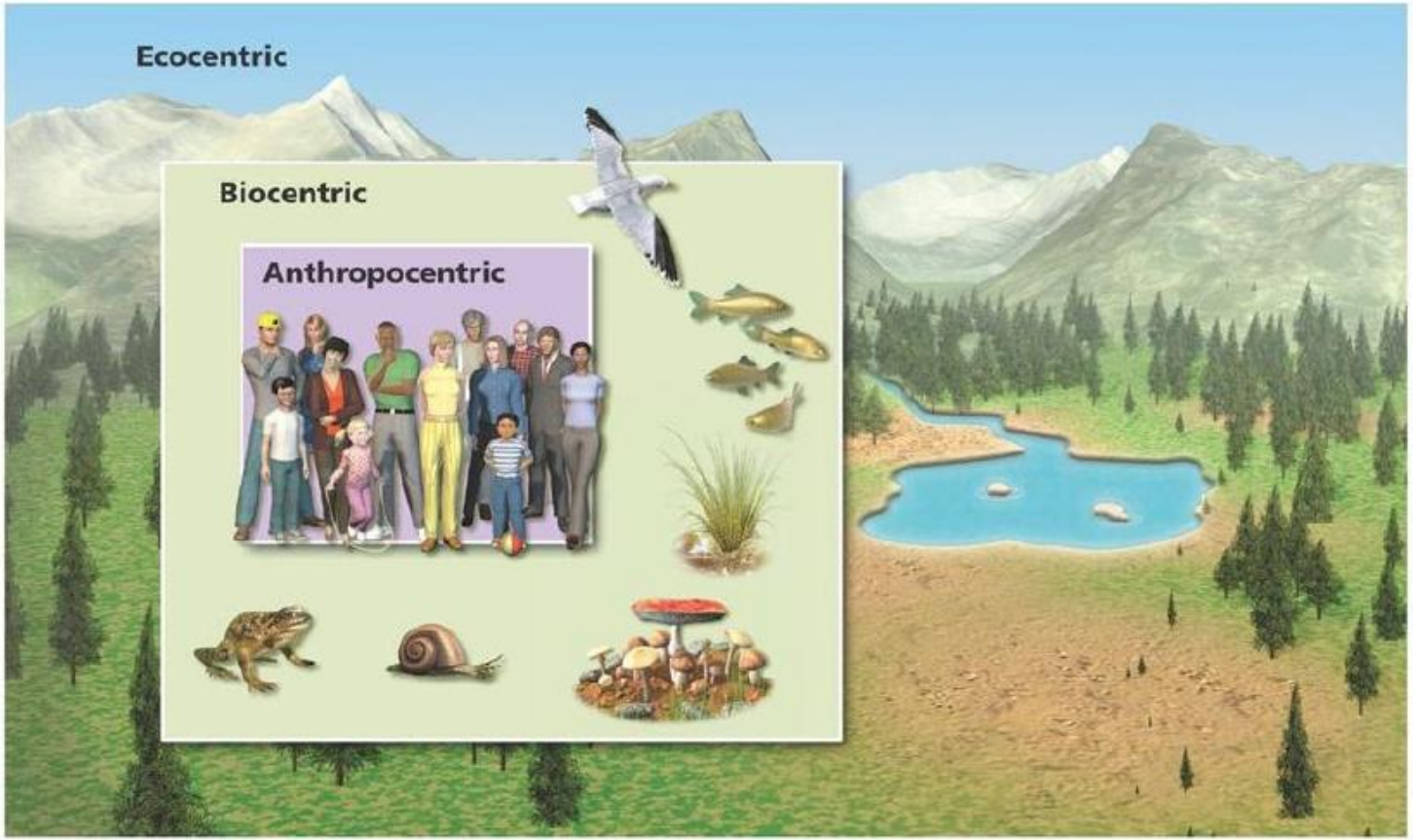
04

Anthropocentrism vs. Ecocentrism

Anthropocentrism vs ecocentrism

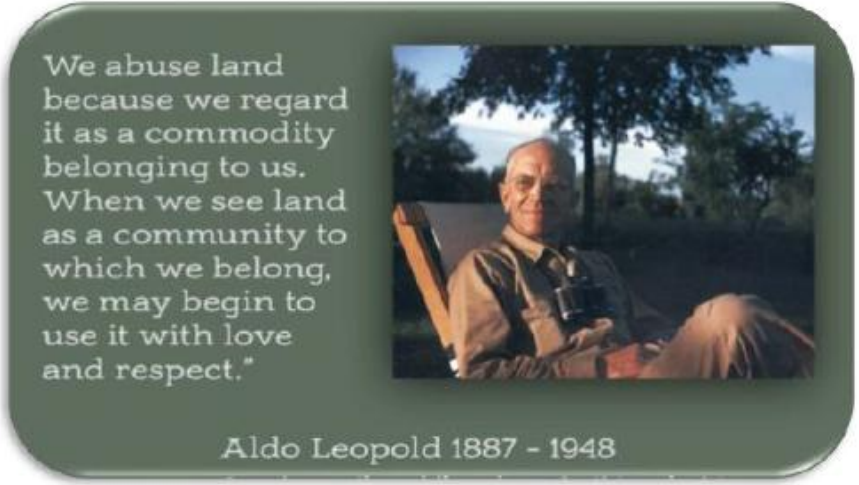
- Anthropocentric: humans as the most important or central element of existence
- Ecocentric (biocentric): ecosphere (or biosphere) as the central element of existence
  - Importance of all species and natural features
  - Intrinsic value of all natural entities, separate from their value or usefulness to people

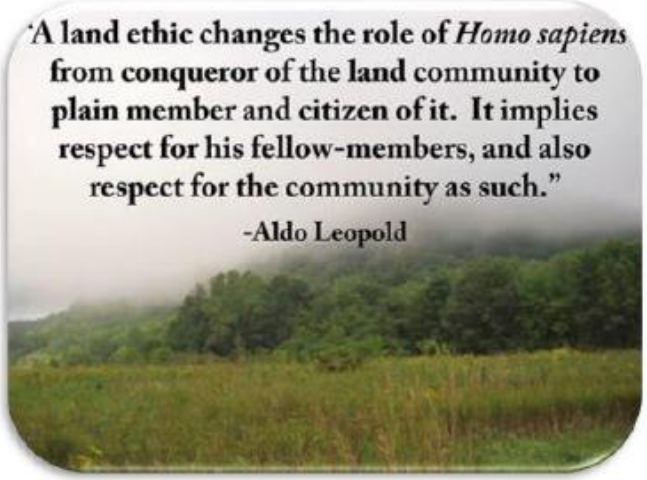
Three ethical worldviews



Ecocentric perspectives

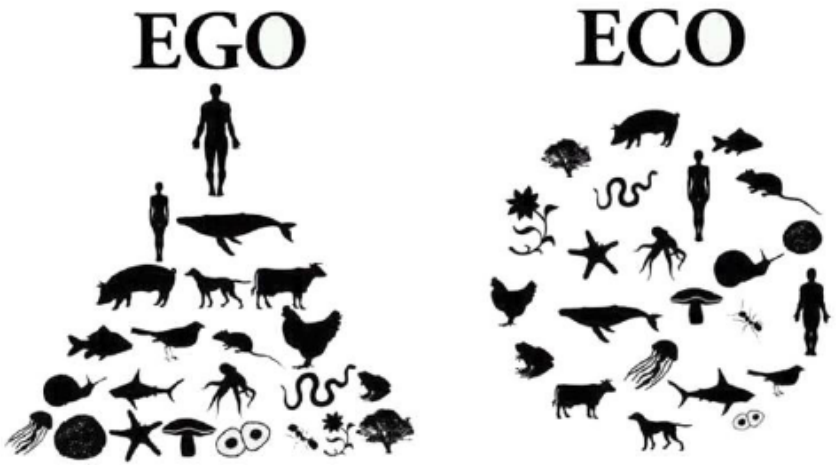
- The Land Ethic (Leopold, 1949)
  - Rejects human-centered views of the environment
  - Preservation of healthy, self-renewing ecosystems





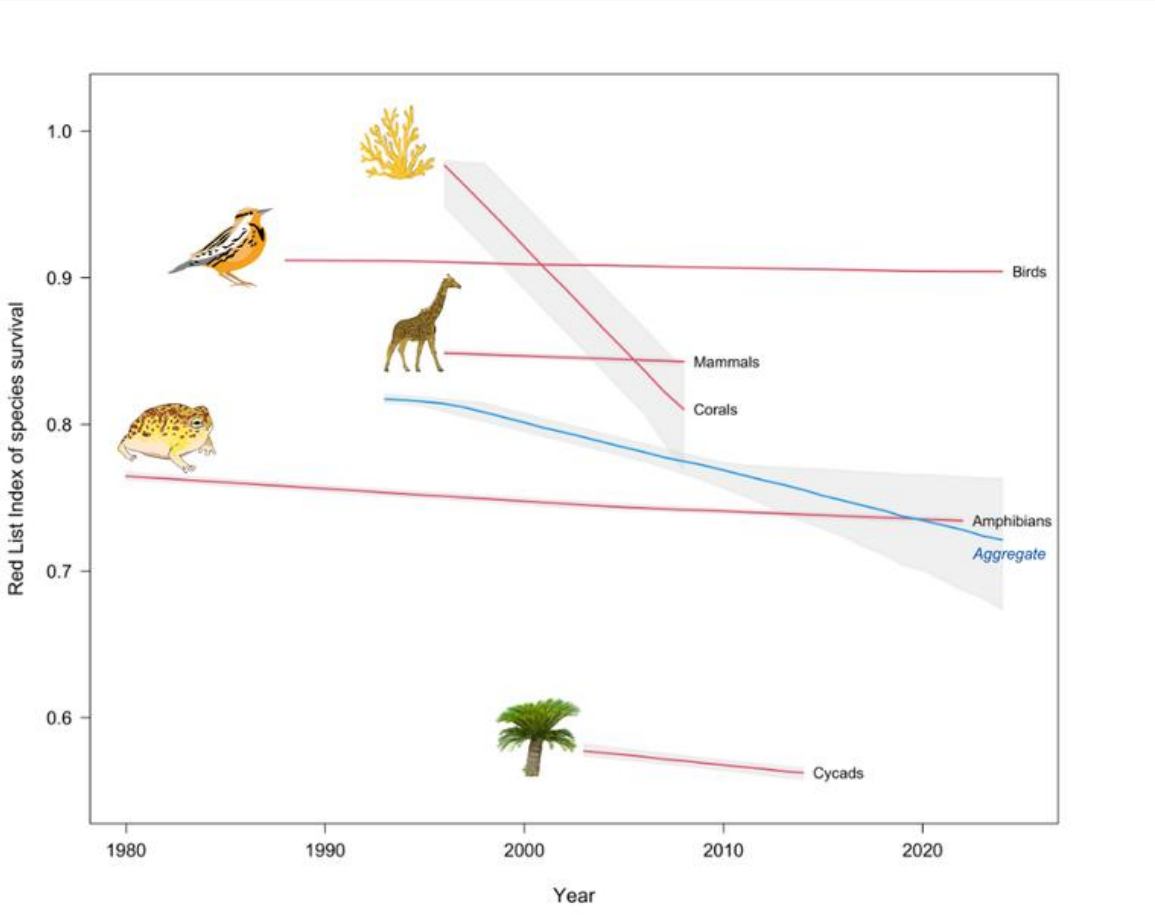
Ecocentric perspectives

- Deep Ecology (Naess, 1973)
  - Inherent worth of all living things regardless of their utility for humans
  - Humans one of many components of the global ecosystem

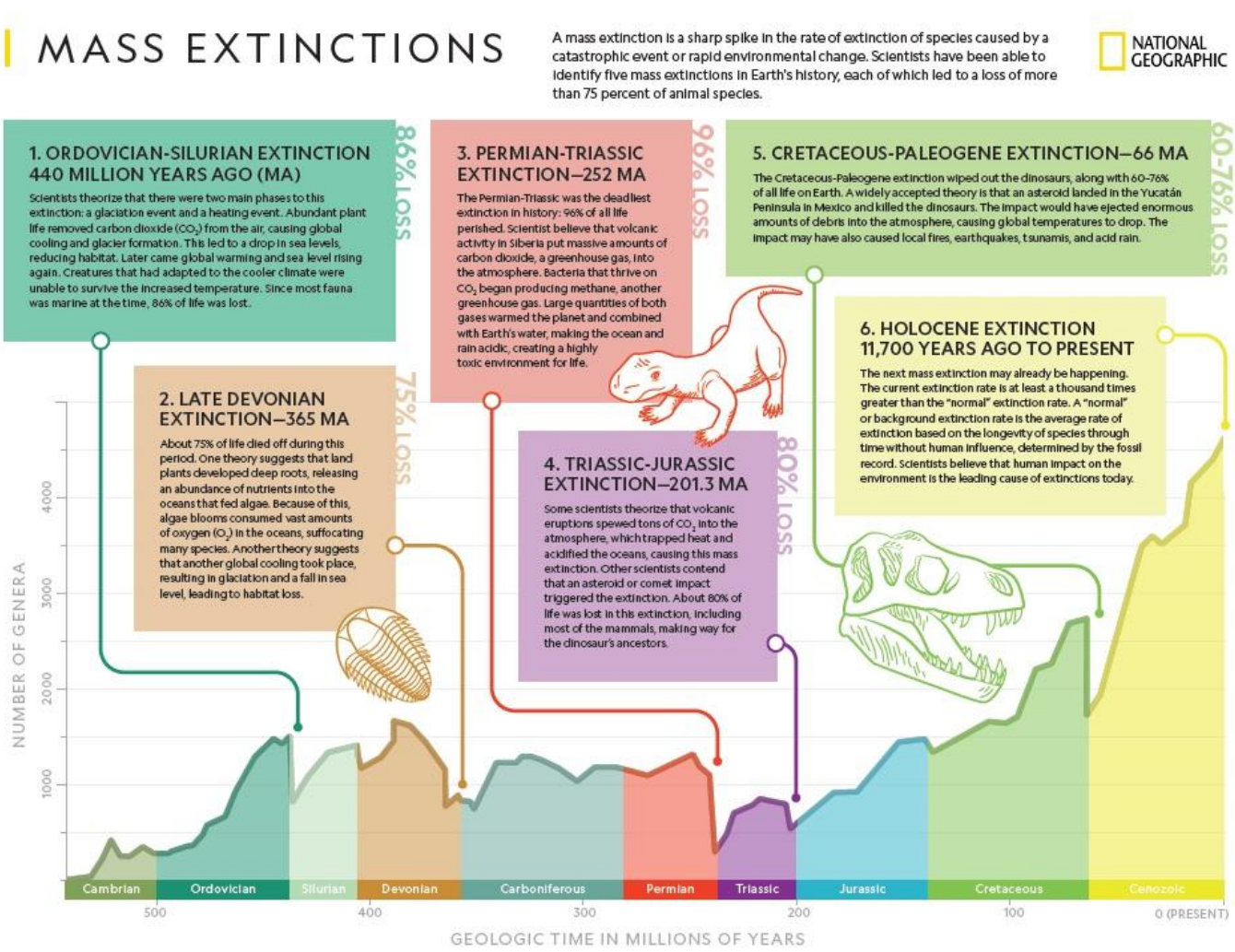


Ecocentric perspectives

- Gaia Hypothesis (Lovelock and Margulis, 1970s)
  - Earth as a self-regulating complex system through cybernetic feedbacks
  - Planetary homeostasis "actively pursued"


Red List Index of species survival
1.0
0.9
0.8
0.7
0.6
1980
1990
2000
2010
2020
Year
Birds
Mammals
Corals
Amphibians
Aggregate
Cycads

Are we in the 6th mass extinction?

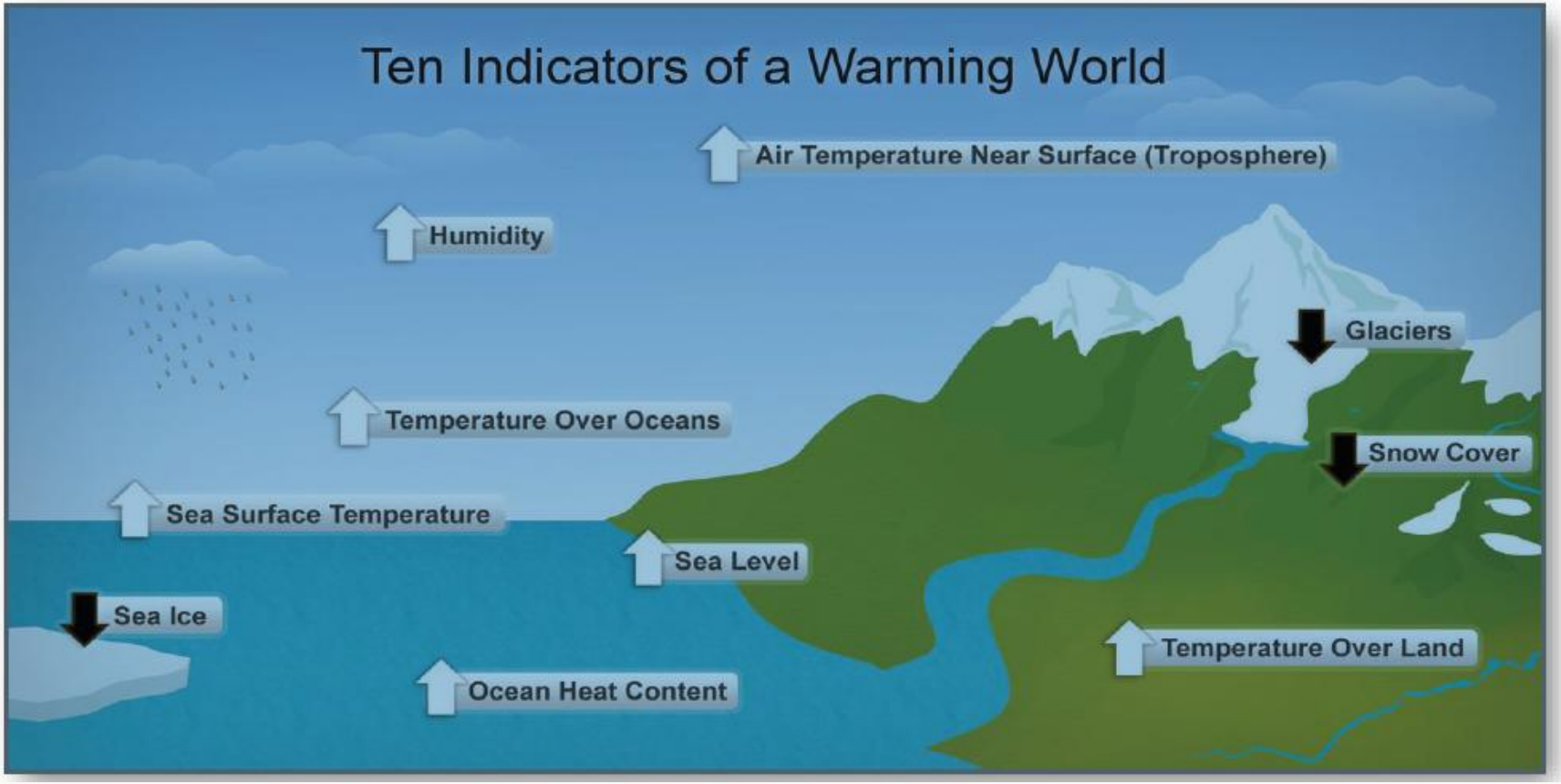


05

Climate Change

Climate change as the backdrop

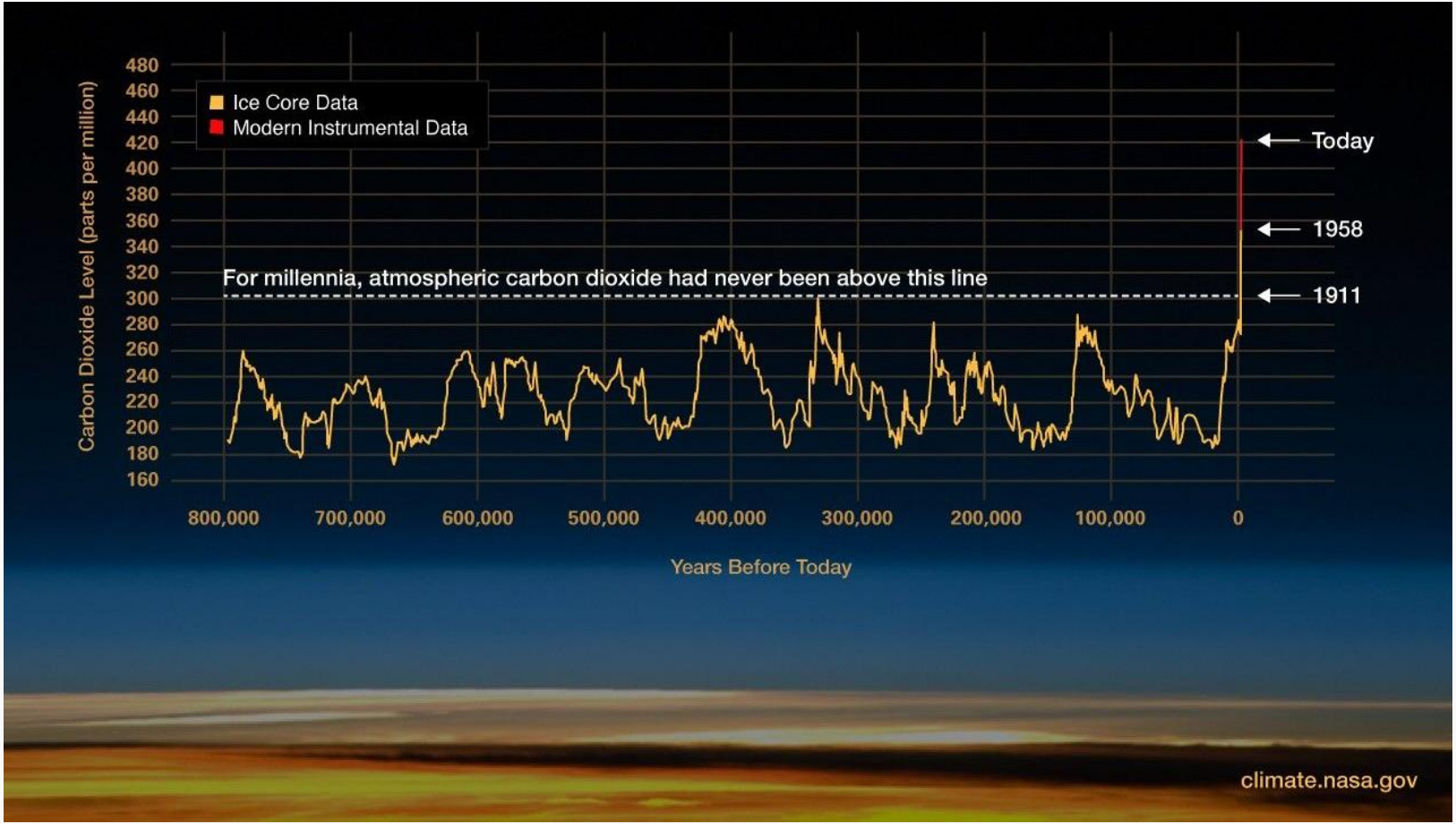
- Climate change is the most noticeable signal of environmental change because it's happening so quickly
  - Climate change is THE BIG THING that we have to deal with – critical window for decisive action
    - By 2030, we will pass the point by which we can keep global average temperature rise to below 2°C
  - Others argue that focusing on climate change leads people to ignore the other major changes associated with the "Great Acceleration"
    - Techno-optimism: "All we have to do is figure out how to take the excess CO_2 out of the atmosphere and we'll be fine…"


Ten Indicators of a Warming World
Air Temperature Near Surface (Troposphere)
Humidity
Glaciers
Temperature Over Oceans
Snow Cover
Sea Surface Temperature
Sea Level
Sea Ice
Temperature Over Land
Ocean Heat Content

What evidence do we have?

- While Earth's climate has changed throughout its history, the current warming is happening at a rate not seen in the past 10,000 years.
- According to the Intergovernmental Panel on Climate Change (IPCC), "Since systematic scientific assessments began in the 1970s, the influence of human activity on the warming of the climate system has evolved from theory to established fact."[1]
- Scientific information taken from natural sources (such as ice cores, rocks, and tree rings) and from modern equipment (like satellites and instruments) all show the signs of a changing climate.
- From global temperature rise to melting ice sheets, the evidence of a warming planet abounds.

NASA, 2024


Carbon Dioxide Level (parts per million)
480
460
440
420
400
380
360
340
320
300
280
260
240
220
200
180
160
Ice Core Data
Modern Instrumental Data
Today
1958
1911
For millennia, atmospheric carbon dioxide had never been above this line
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
Years Before Today
climate.nasa.gov

06

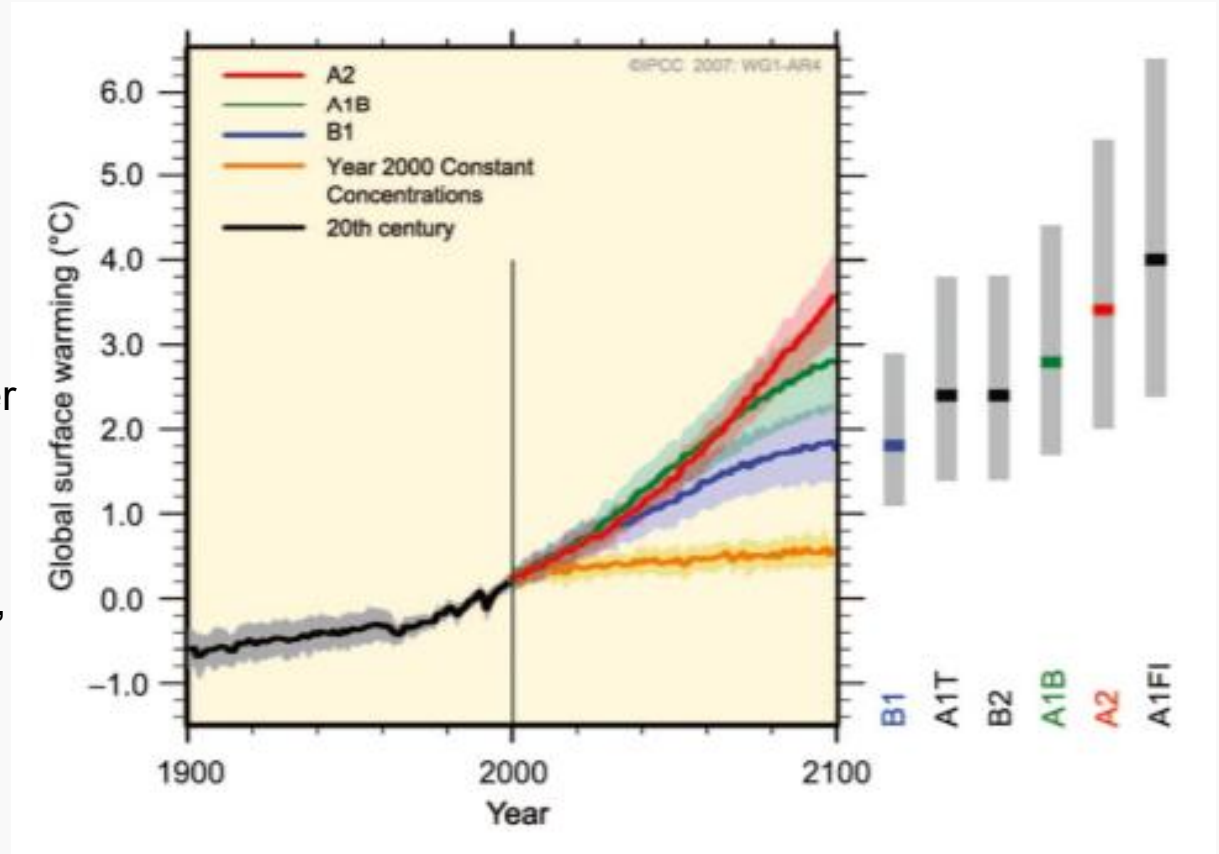
Climate Deniability

Science, uncertainty, and policy

- Our environment is changing: Why is there still debate about these things?
  - Climate change – the environmental, economic, social, and governance challenge of this generation
  - Climate change as the driver of society towards sustainability…?
- Science thrives on questions, but…
  - Not always very good at communicating important scientific concepts
  - Public, press, and policymakers often misinterpret the meaning of scientific debate and uncertainty

"…novice readers were unable to identify the two different types of uncertainties in this graph without substantial guidance."

"Novice readers on the other hand, not having this background could only describe what they saw, which wasn't as informative, *"There is just one black line and then there are many coloured lines, and something grows and distributes I think*""



McMahon, R., Stauffacher, M. and Knutti, R., 2015. The unseen uncertainties in climate change: reviewing comprehension of an IPCC scenario graph. Climatic change, 133(2), pp.141-154.

Science, uncertainty, and policy

- Scientific uncertainty should not stop us from dealing with activities that pose significant risk
- Precautionary Principle:
  - If there is even a very small risk of significant harm, the action should be avoided or the risk mitigated
  - Burden of proof on the proponent to show the action will not be harmful
  - Regulatory controls should incorporate a margin of safety
  - Activities that present uncertain potential for significant harm should be subject to the best technology available to minimize the risk

Abrupt and irreversible change

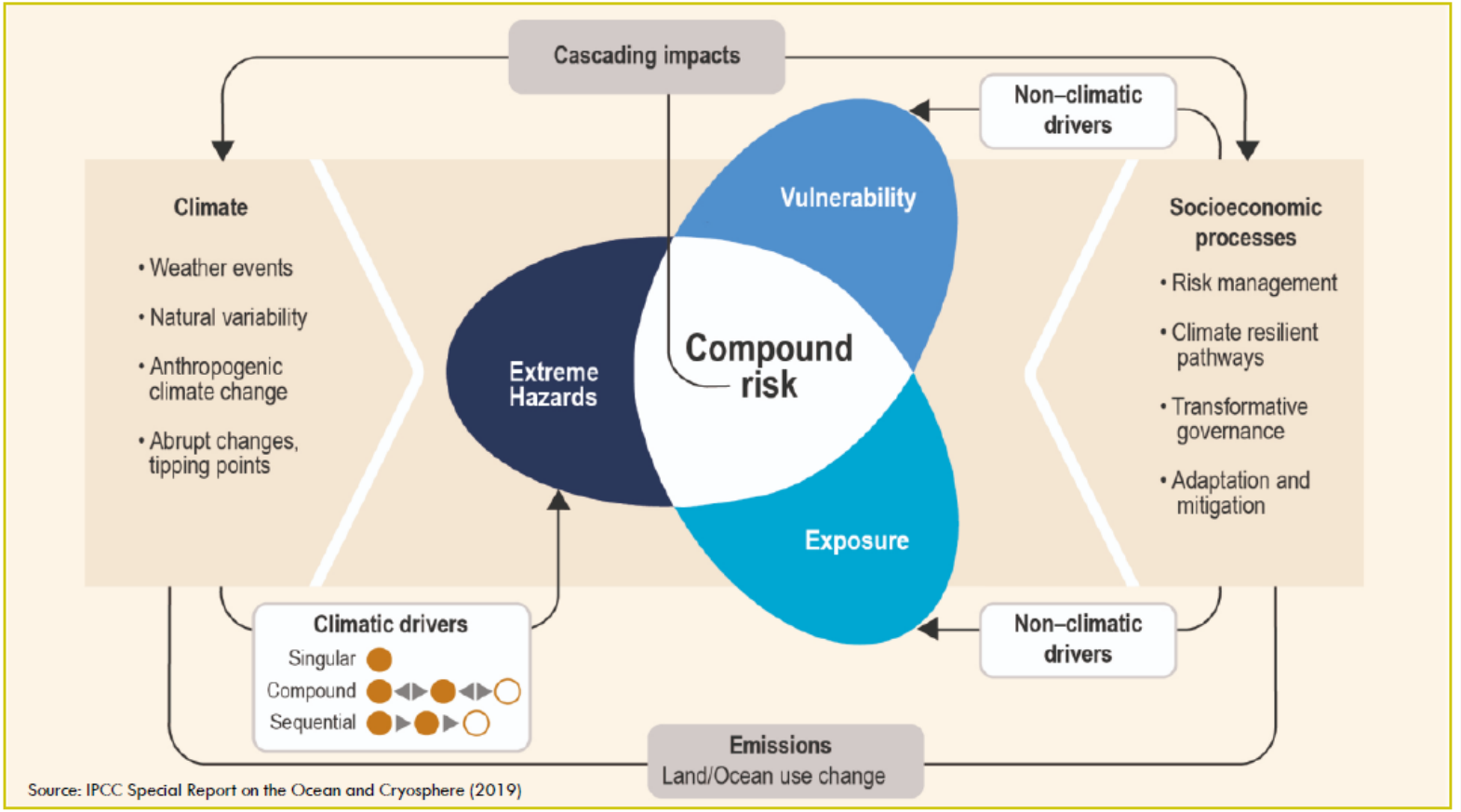
- Increasing concern over…
  - Risks from extreme weather and cascading events
  - Changes that may be irreversible (100s to 1000s of years)
  - Large-scale changes that may happen abruptly (decades)
  - Thresholds and tipping points
    - "A level of change in system properties beyond which a system reorganises, often in a nonlinear manner, and does not return to the initial state even if the drivers of the change are abated"

      - IPCC Special Report on the Ocean and Cryosphere (2019)

Abrupt and irreversible change

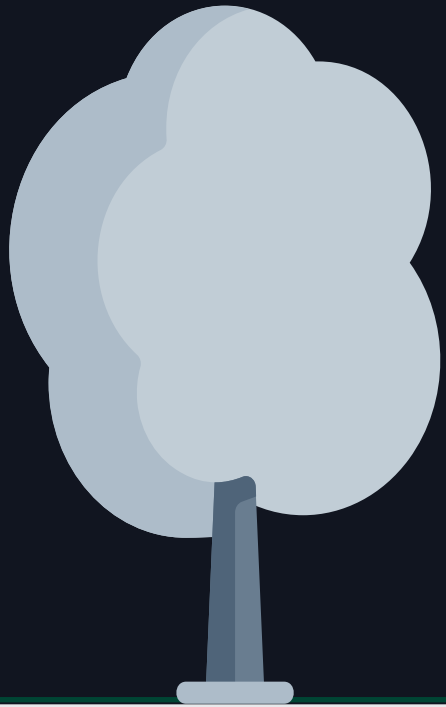
- Includes things like…
  - Shutdown of Atlantic Meridional Oceanic Circulation
  - Melting of Arctic sea ice
  - Methane releases from melting permafrost
  - Ocean acidification
  - Collapse of ice sheets
  - Loss of biodiversity in areas with extreme climatic change

- IPCC Special Report on the Ocean and Cryosphere (2019)


Cascading impacts
Non–climatic drivers
Climate
• Weather events
• Natural variability
• Anthropogenic climate change
• Abrupt changes, tipping points
Vulnerability
Extreme Hazards
Compound risk
Exposure
Socioeconomic processes
• Risk management
• Climate resilient pathways
• Transformative governance
• Adaptation and mitigation
Climatic drivers
Singular
Compound
Sequential
Non–climatic drivers
Emissions
Land/Ocean use change
Source: IPCC Special Report on the Ocean and Cryosphere (2019)

07

Classifying resources



Classifying resources

- Something that is valued by humans
  - Consumption (e.g., wood, meat, oil, minerals, etc.)
  - Non-consumptive uses (e.g., outdoor recreation)
  - Other types of resources (e.g., traditional ecological knowledge, human skills, etc.)
- Natural resource management has tended to focus on:
  - Goods, rather than services
  - Market-based rather than non-marketable goods
  - Individual materials or locations (e.g., a forest) rather than a whole system

Classifying resources

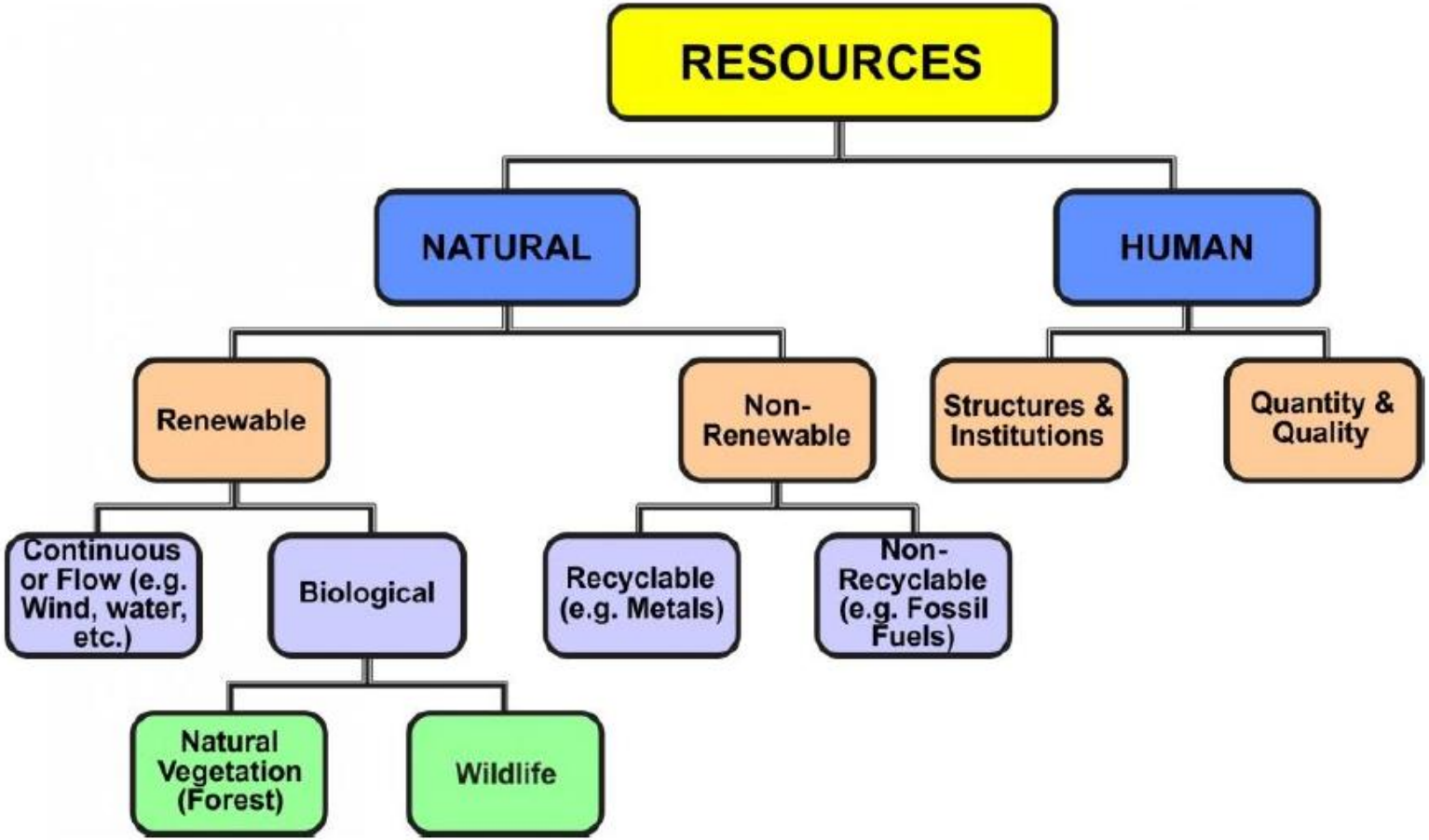
- Natural resources are inherently complex
- Classification can be based on type:
  - Biotic resources: obtained from the biosphere, e.g., crops, meat, fish, wood, soil + some alternative energy resources = "Living resources"
  - Abiotic resources: non-living things, e.g., land, water, air, oil, minerals + some alternative energy resources = "Earth resources"

Classifying resources

- Natural resources are inherently complex
- Classification can be based on renewability:
  - Perpetual: will never run out (inexhaustible)
  - Renewable/replenishable: rate of renewal exceeds rate of human withdrawal or consumption (in principle)
  - Nonrenewable: not renewable or replenishable (on a human time scale)
  - Other (e.g., critical flow resources)

Classifying resources

- Natural resources are inherently complex
- Classification can be based on economic characteristics:
  - Type of capital: land, labour, financial
  - Ownership: private, public, commons, etc.
  - Feasibility and commercial viability and status of extraction efforts: economic vs sub-economic, etc.



Source: https://www.nirmancare.com/blog/index.php?controller=post&action=view&id_post=150

Embodied resources

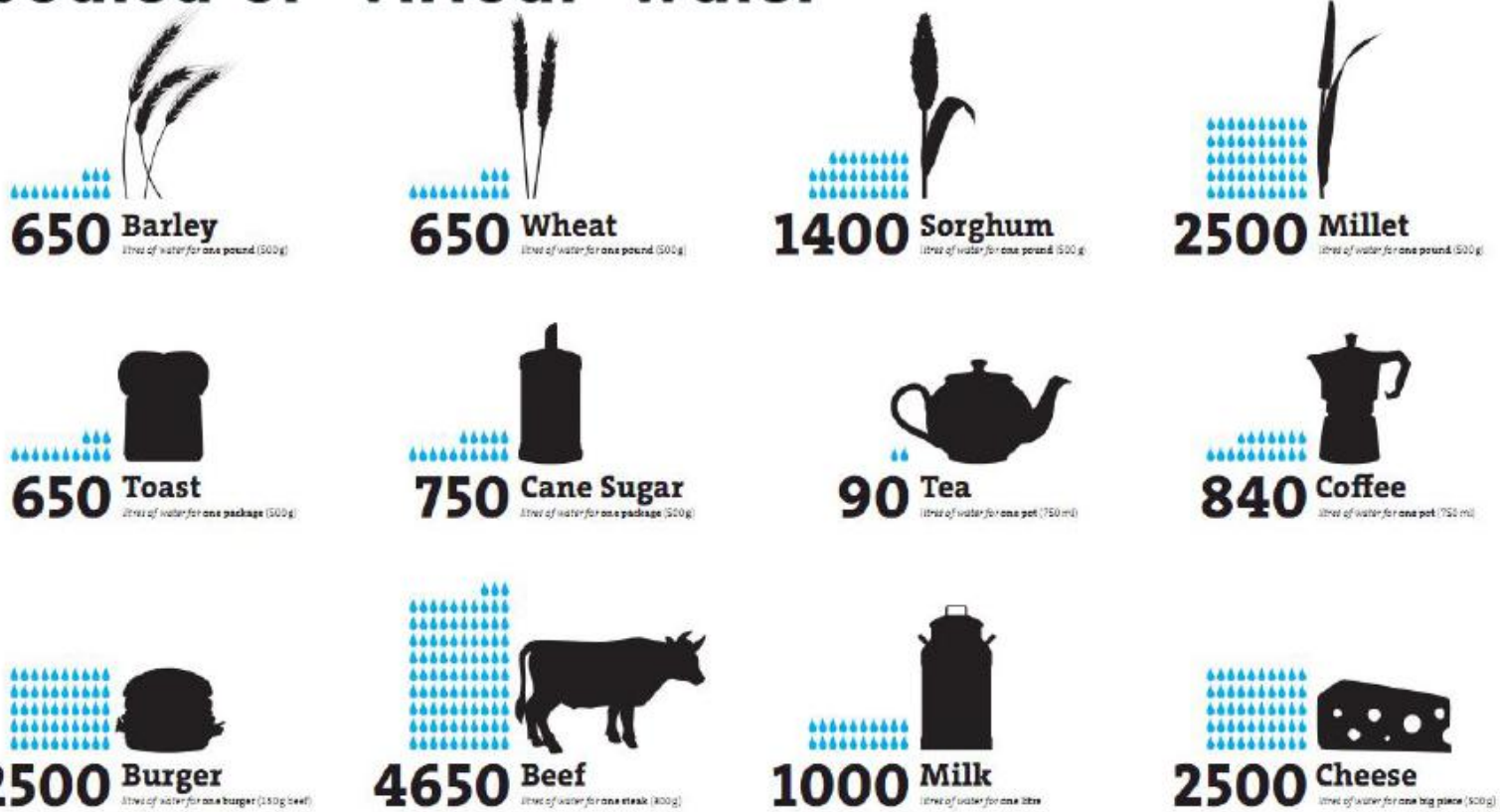
- Embodied or "virtual" resources: Resources used in production and use of an item, as if it were incorporated into the item itself
  - Initial: resources consumed in the acquisition of raw materials, processing, transportation, and use in construction, production, or manufacturing
  - Recurring: resources consumed to maintain, repair, restore, refurbish, or replace components or materials during the life of the building or product
  - Often includes resources used for final disposal or dismantling of the product

Embodied or 'virtual' energy

the embodied energy in one brick building **is equivalent to** **32,000 litres of gasoline**

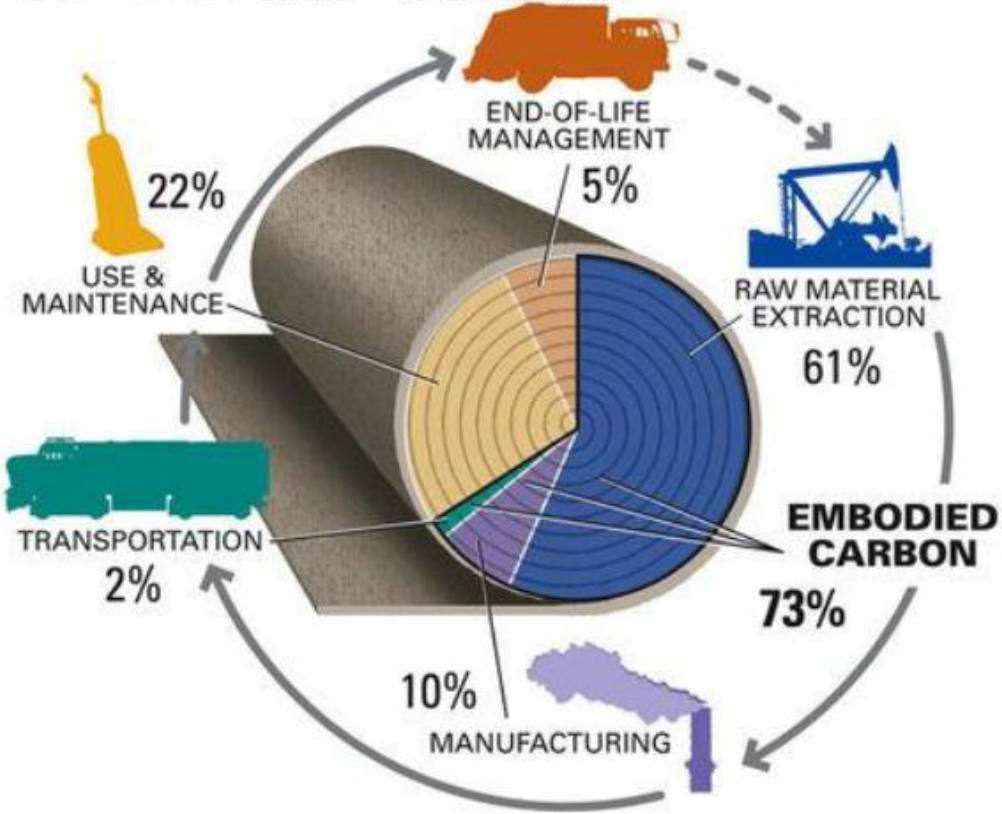
=

Embodied or 'virtual' water



Source: The Virtual Water Project http://virtualwater.eu/

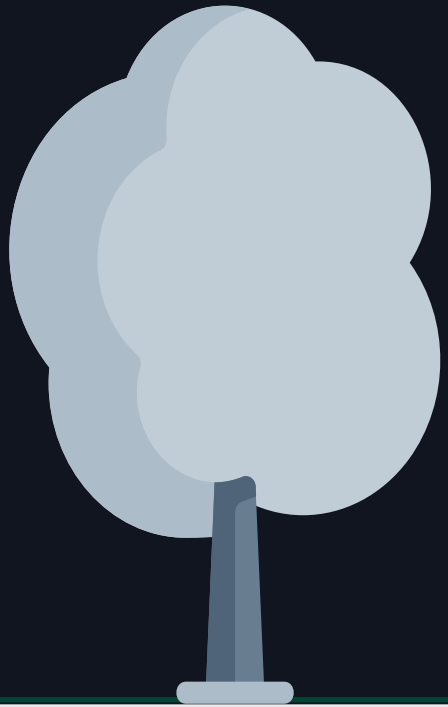
Embodied or 'virtual' carbon



Source: Building Green https://www.buildinggreen.com/primer/embodied-carbon-measuring-how-building-materials-affect-climate

07

Natural Resource Management



Natural resource management

- Approaches to sustainable natural resource management include:
  - Command-and-control (top-down, regulatory)
  - Community-based (bottom-up, consultation with stakeholders)
  - Adaptive management (plan-act-review-revise)
  - Integrated natural resource management (systems-based, preserving the integrity of natural systems)

Natural resource management

- Sustainable use and management of renewable resources is – in principle – possible (but difficult)
- And what about nonrenewables…? Is "sustainability" even a possibility?

Energy resources for the future

- No form of energy extraction is without environmental impacts
  - Laws of Thermodynamics
- Sustainable energy is about:
  - Minimizing the negative impacts – responsibility
  - Eliminating concerns about supply – affordability
  - Maximizing the social benefits – accessibility
- Sustainable energy is fundamental to everything else we might want to achieve

Take-home messages

- Ecosystem services are the provisioning, regulating, supporting and cultural benefits provided from healthy ecosystems
- Anthropocentrism views humans as the most important element of the Earth's system
- Ecocentrism and biocentrism take a more holistic approach
- Climate change is the most noticeable signal of global environmental change
- Despite robust scientific evidence, climate change denial is prominent… communication?
- We can classify resources based on type, renewability or economic classification
- There are 4 main approaches to sustainable natural resource management
- Sustainable energy is about minimizing impacts and maximizing social benefits

Questions

ENV210

Sustainability

Winter 2026

Lecture 3: The human sphere

Students wanted for a study on Students' Experiences of Resilience in the Post-Secondary Context

We are looking for research participants who are:

→ Ages 17-35 years old

→ Current undergraduate or graduate students at the University of Toronto, and

→Live in Toronto (or greater Toronto area)

Participation involves completing the same online survey twice in Winter 2026 and potential participation in a 60-90-minute online focus group discussion.

You will earn $20 for completing both surveys ($10 each) and an additional $20 for participation in the focus group!

If you are interested in participating this study, please email us at oise.studentwellness@utoronto.ca

This study has been approved by the University of Toronto Ethics Board (Protocol #00049495).
Principal investigator: Dr. Chloe Hamza (chloe.hamza@utoronto.ca). We are based out of the Ontario Institute for Studies in Education.

Land Acknowledgement

We wish to acknowledge this land on which the University of Toronto operates. For thousands of years it has been the traditional land of the Huron-Wendat, the Seneca, and the Mississaugas of the Credit. Today, this meeting place is still the home to many Indigenous people from across Turtle Island and we are grateful to have the opportunity to work on this land.

Agenda

01 Announcements

02 Recapping the 3 pillars

03 Human impact

04 Past, present and future populations

05 The Demographic Transition

06 Economics

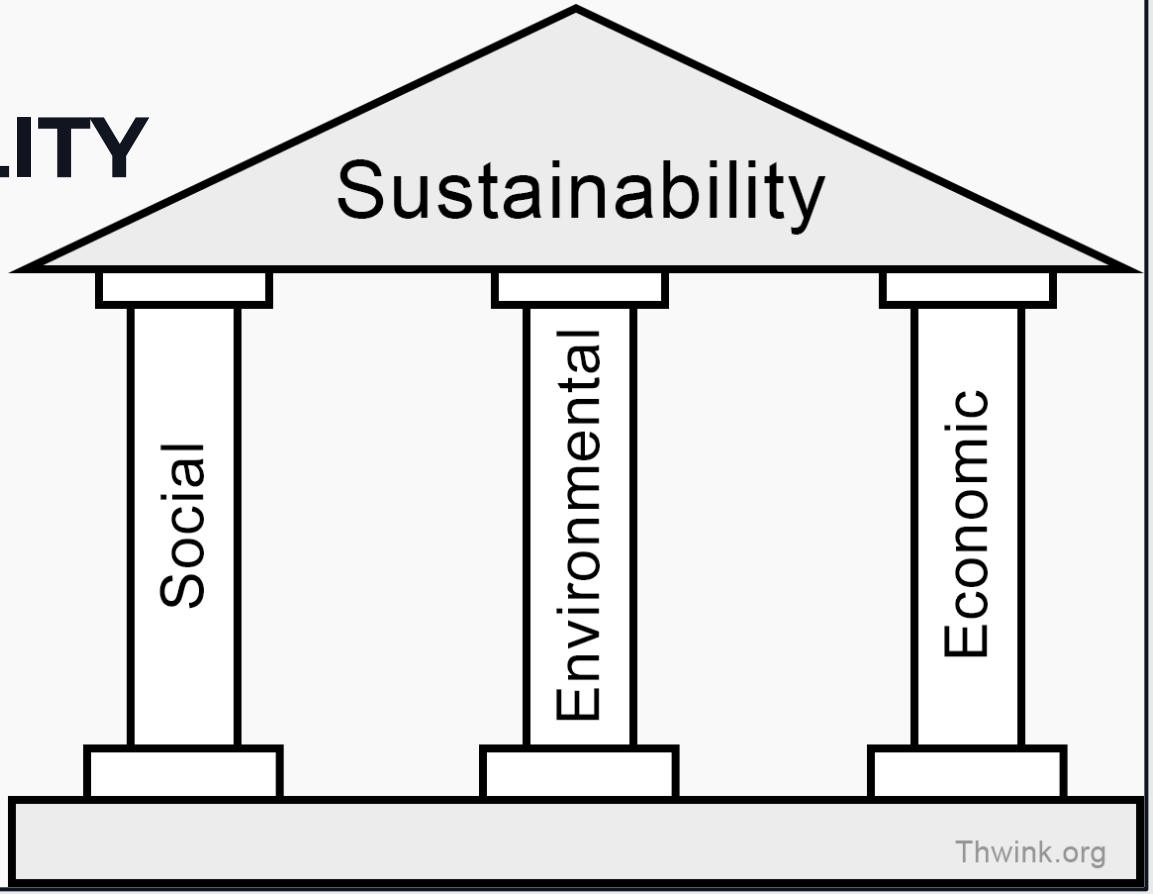
07 Governance

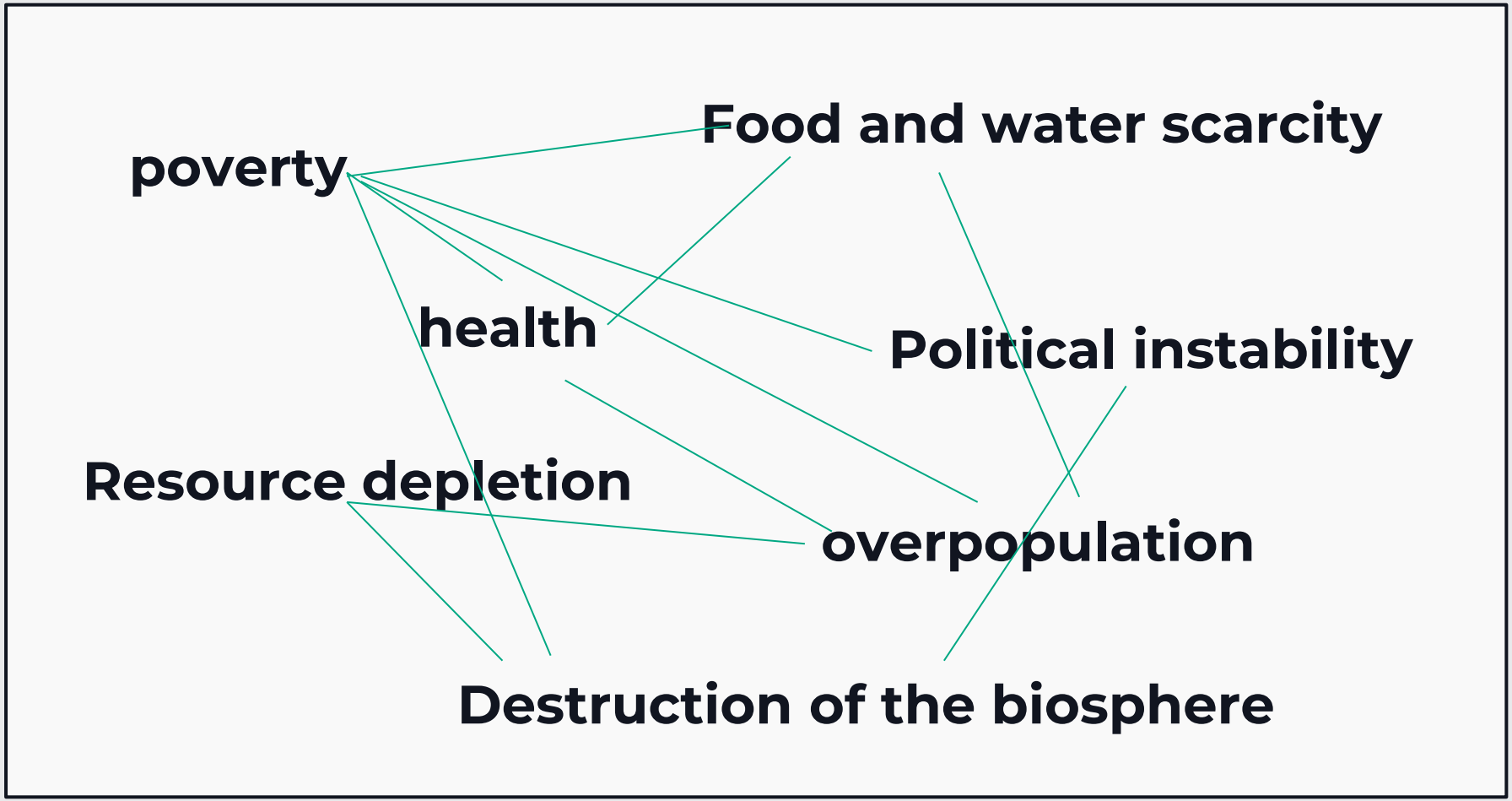
02

The three pillar model: recap

MODELS OF SUSTAINABILITY

“Three Pillars” Model



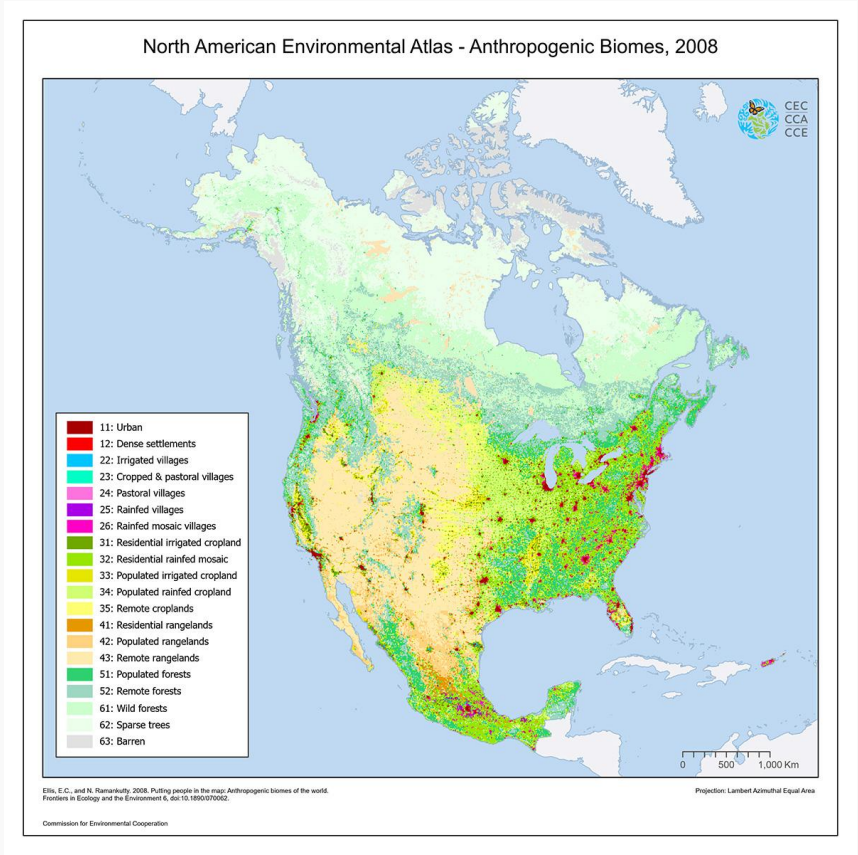

Food and water scarcity
poverty
health
Political instability
Resource depletion
overpopulation
Destruction of the biosphere

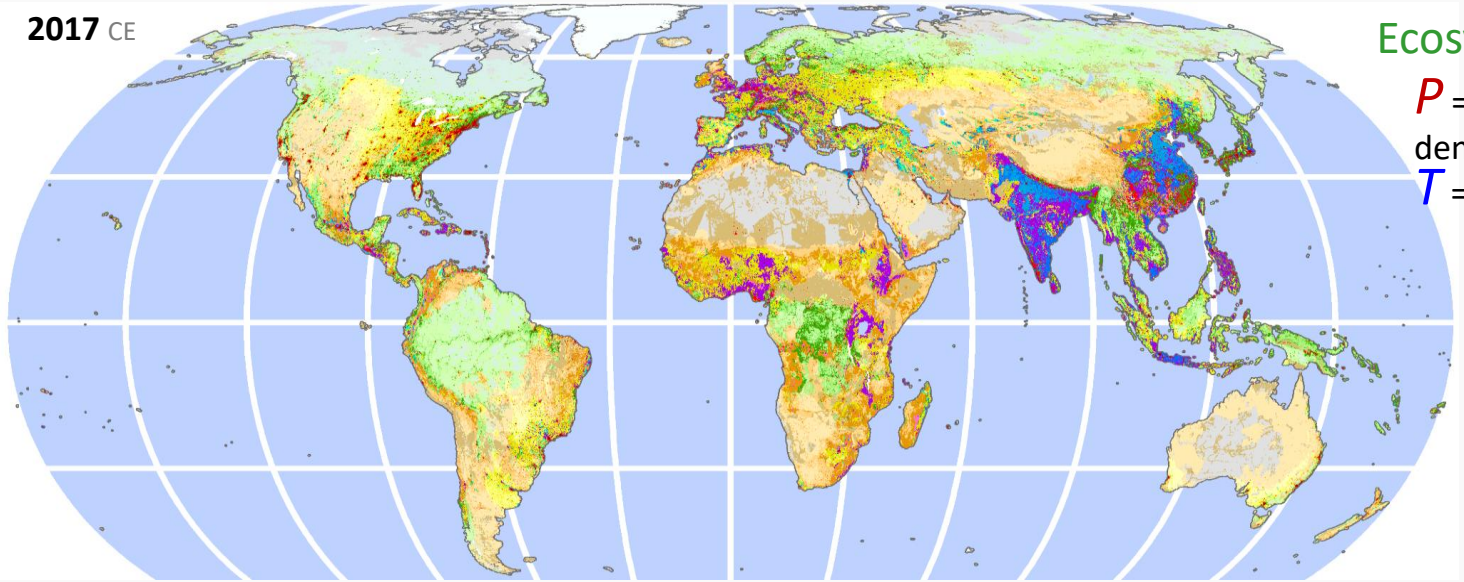
03

Human impacts

Anthromes

- “anthropogenic biomes”
- Human systems with natural ecosystems embedded within them
- Cover more than 75% of Earth’s ice-free surfaces
- Classified by combinations of land use and human population density





Ecosystems = $f(P,T)$

P = Population density

T = Land use

Intensive

Densely Settled

Dense Settlements
- Urban
- Mixed settlements

Villages
- Rice
- Irrigated
- Rainfed
- Pastoral

Croplands
- Residential irrigated
- Residential rainfed
- Populated
- Remote

Rangelands
- Residential
- Populated
- Remote

Cultured
- Residential woodlands
- Populated woodlands
- Remote woodlands
- Inhabited drylands

Wildlands
- Woodlands
- Drylands
- Ice

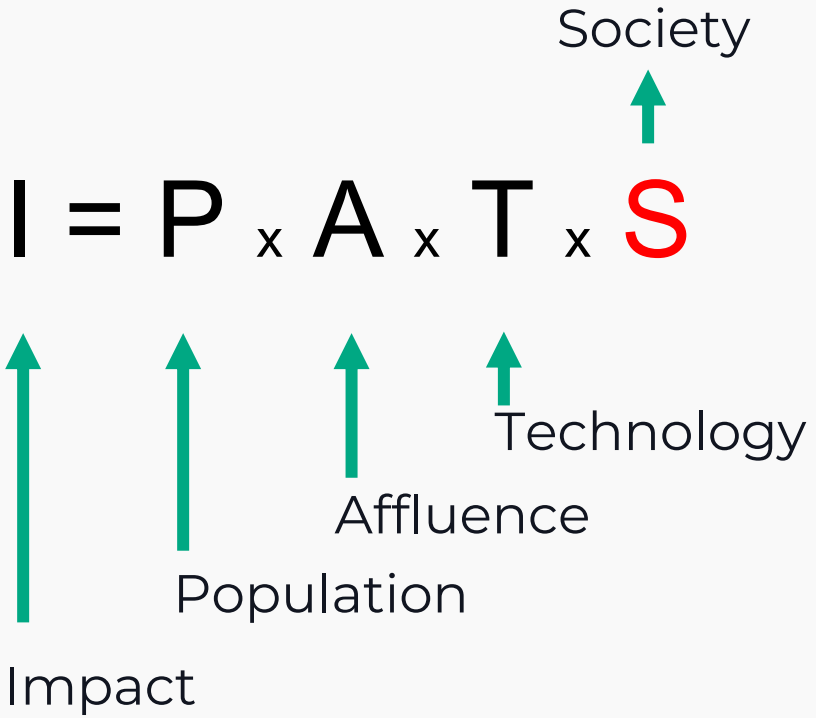
Ellis *et al.* 2021 *PNAS* **Anthromes 12K** (DGG v1)

Anthroecology Lab
anthromes.org

Measuring Human Impact

- Environmental scientists summarize the drivers of environmental degradation
- Developed by Paul Ehrlich and John Holdren in 1971

- Which nations have the most room for improvement?
- Which component poses the greatest threat?



04

Population through time

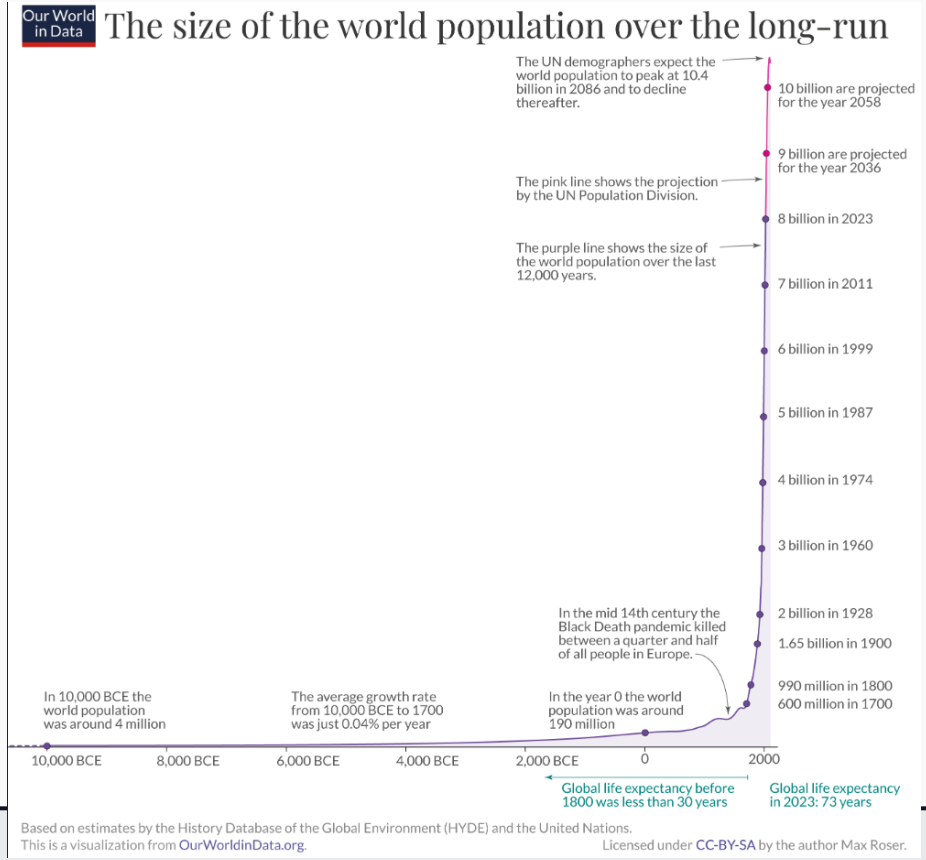
Early *Homo sapiens*

Fossils of early *Homo sapiens* found in Morocco (Callaway, 2017, *Nature*)

- First appeared on the planet 150,000 years ago (contested)
- Survived as “hunter-gatherers”
- Short life expectancy
- Population was small and limited by available food
- What were the conditions of the Earth like?
- The most recent ice age ended 12,000 years ago, pushing us into the Holocene Epoch

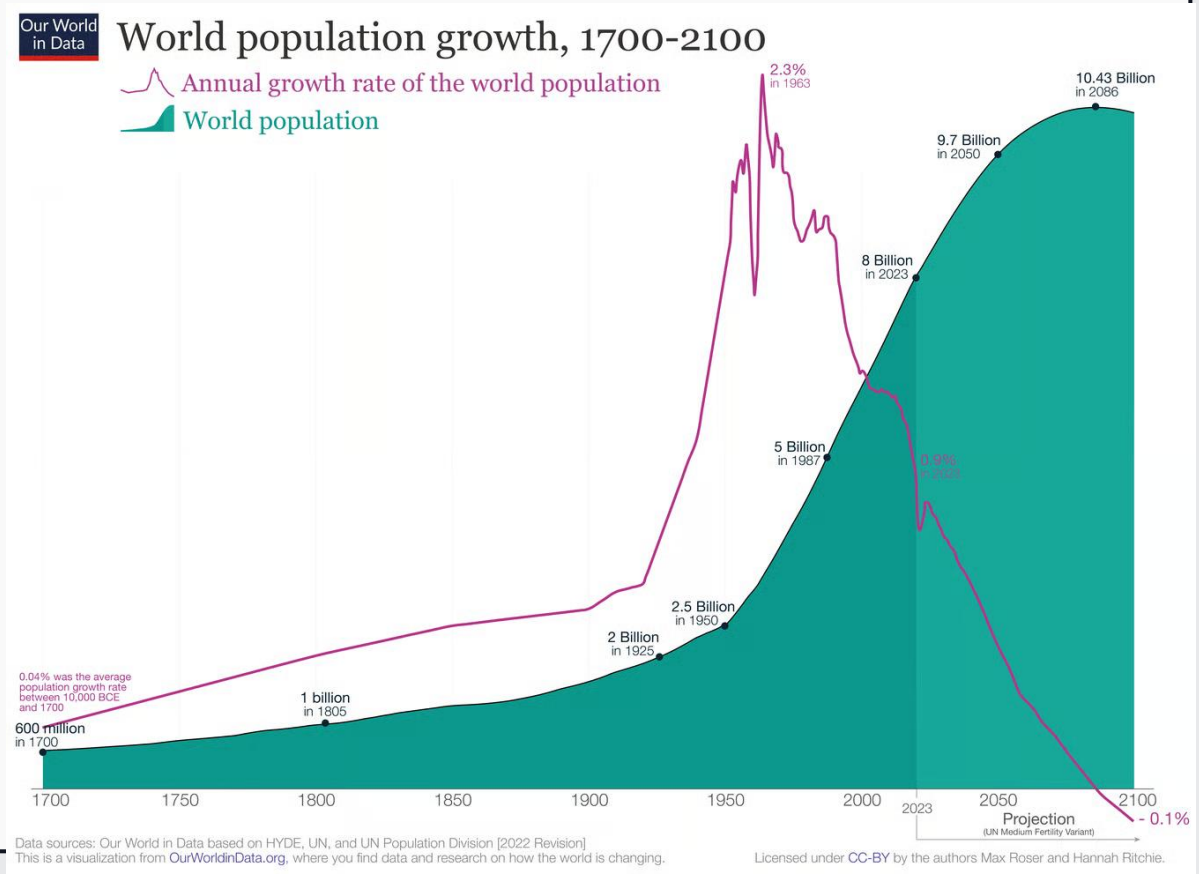
Key moments in time: The agricultural revolution

- Shift from hunting and gathering to growing crops and raising domestic animals
- Settled in villages
- Food storage
- Complex societies with:
- Distribution of labour
- Social hierarchies
- Trade



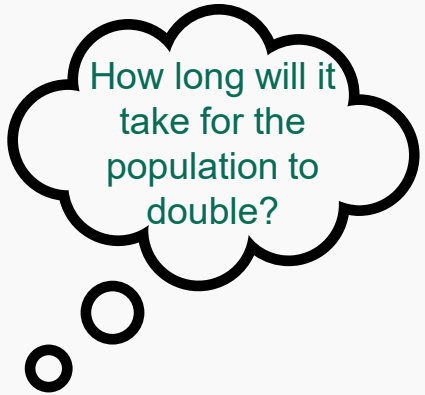
The industrial revolution and medical advancements

- Launched in the mid 1700s with the harnessing of fossil fuels
- Petroleum products
- By 1804 the world's population reached 1 billion
- Improved sanitation and the development of vaccines led to a drop in infant mortality



Exponential Growth

- If the population growth rate remains steady, the size of our population will increase by larger numbers with each generation
- The “rule of 70” can be used to estimate the doubling time of human population. 70 / growth rate = doubling time
- The global population growth rate has fallen – today it is slightly over 1%.



Demography

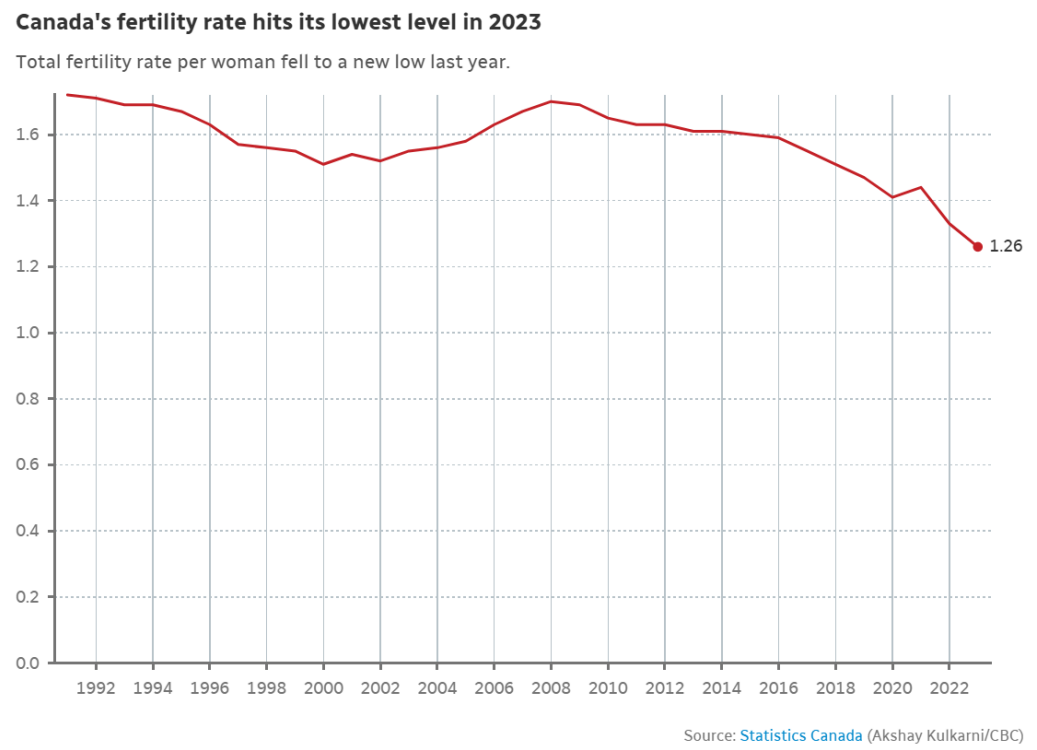
- Population ecology: the study of growth, decline and changes in populations. When applied to human populations, this field is known as demography.

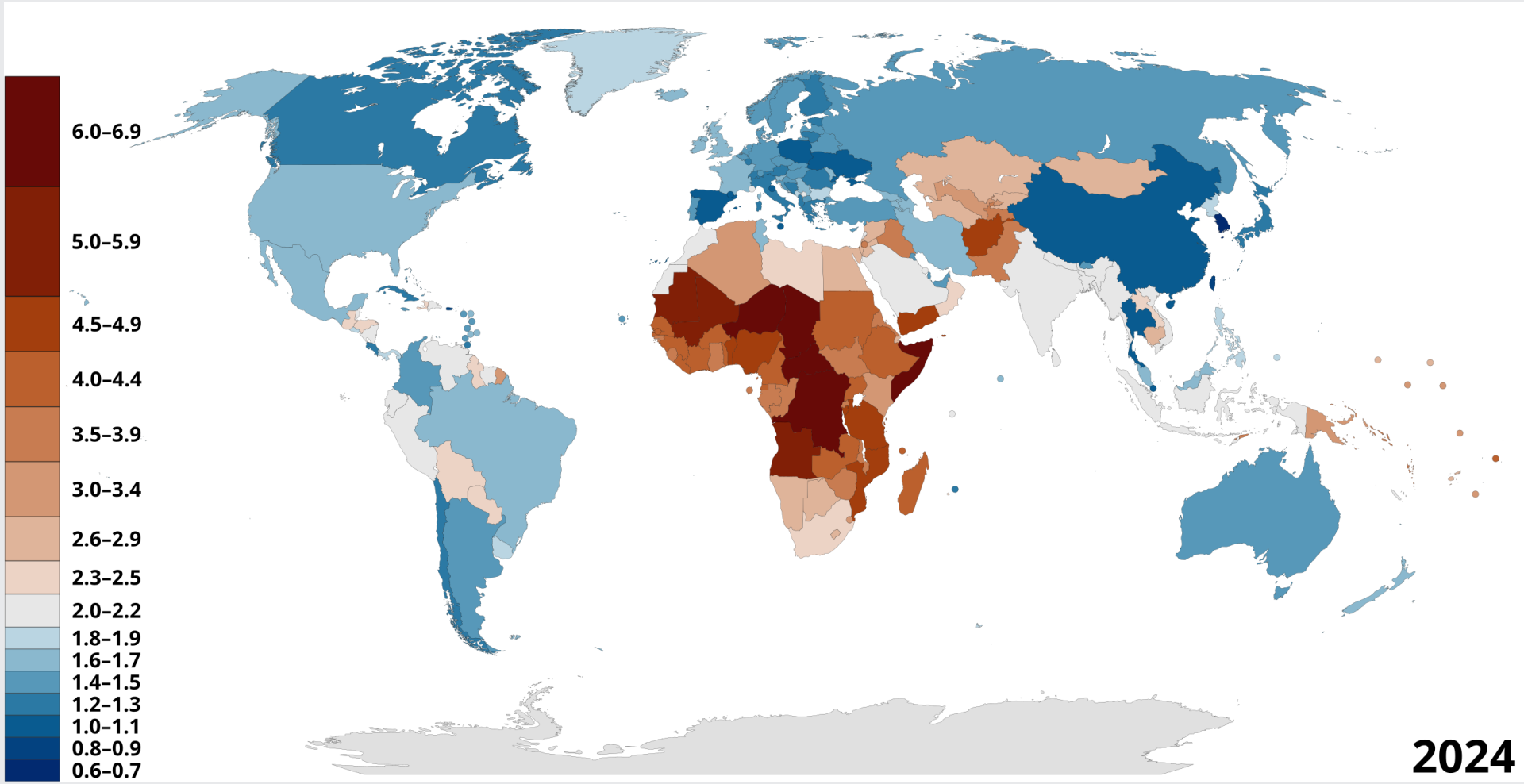
- Birth rate: the total number of people born in a given year
- Total fertility rate (TFR): the number of children born per woman during her lifetime
- Replacement fertility rate (RFR): the number of births per woman that will keep the population size constant at zero population growth

- For humans, the **RFR is 2.1** (to compensate for infant and child mortality)
  - This means if the TFR drops below **2.1**, human population will decline
  - If it even slightly exceeds **2.1** human population will experience exponential growth

Demography

- Worldwide fertility rate in 1960 was **4.3** children per woman (peak growth rate)
- By 2000 the fertility rate dropped to **2.6** worldwide
- In developed/industrialized nations, fertility rates are now at or below the replacement level
- Global populations continue to grow – particularly in developing/pre-industrialized nations.

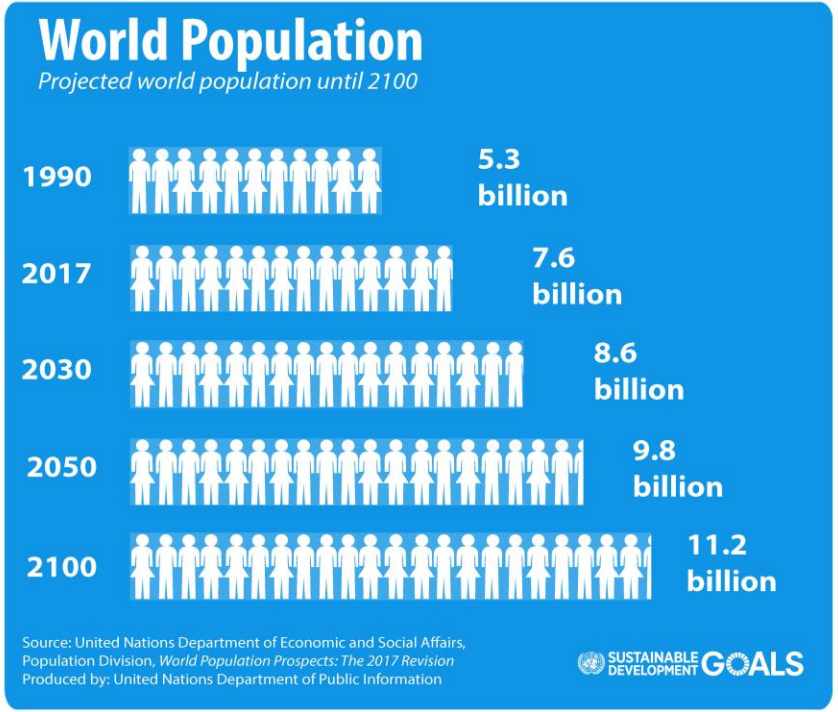



6.0–6.9
5.0–5.9
4.5–4.9
4.0–4.4
3.5–3.9
3.0–3.4
2.6–2.9
2.3–2.5
2.0–2.2
1.8–1.9
1.6–1.7
1.4–1.5
1.2–1.3
1.0–1.1
0.8–0.9
0.6–0.7
2024

Future populations

Demographers predict 4 trends in the world's human population over the next 50 years:

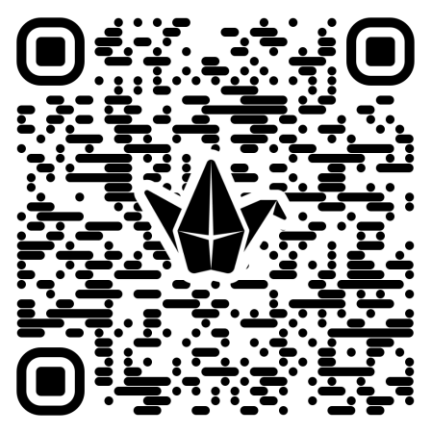
1. The population will be older than it was in the previous century and bigger than it is now
2. It will continue to grow but at a slower rate
3. Migrations will continue
4. Populations will be increasingly urban



Future populations

- Virtually all future growth will be in urban areas
- In the next 15 years, the world's rural population will remain approximately constant (3 billion) while the world's urban population will double (from 3 to 6 billion)

What implications will this have in Canada? Globally?



https://padlet.com/alannabodo/what-implications-will-predicted-urban-growth-have-qsej75mfiim9uoxt

05

The demographic transition

The demographic transition

- Several elements of the transition to a sustainable world are inextricably connected: population growth, social inclusion and a new economic model
- The demographic transition: a period of population growth that occurs as countries move from one stage of development to the next
- Developing societies: high birth rates, high death rates
- Developed societies: low birth rates, low death rates

What factors drive this transition?

Social progress

- Factors affecting high birth rates are poverty and lack of education → lead to perpetual poverty and lack of opportunity
- 3 dimensions of social progress that are essential to stabilizing populations:
  - Education
  - Employment
  - Reproductive health
- These are also most important predictors of falling birth rate

SWEDD program, World Bank (2019)

Policy

- National laws and policies drive improvements in social progress and stabilizing the population
- Thailand, Iran, Brazil all have public policies that have prioritized these outcomes
- China had the world's most controversial population policy
  - It was successful in population control but led to infanticide and a disproportionate amount of elderly people and makes

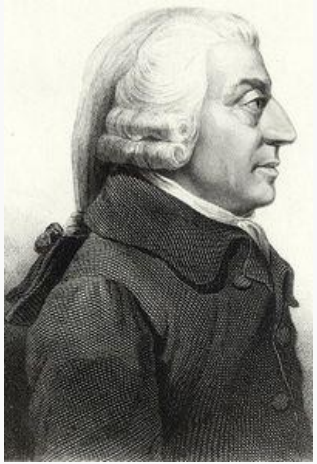
Like all complex systems, this highlights the need for a holistic approach to sustainable populations

06

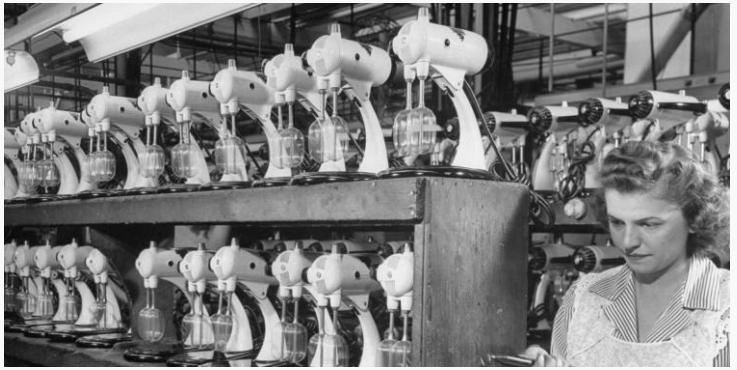
Economics

Economics

- With the advent of agriculture, the idea of ownership appeared – of surplus food, of land and the exchange of labour and money
- The industrial revolution brought oil, natural gas and an explosive increase in consumer goods – sparking economic growth
- 1776 – “The Wealth of Nations” by Adam Smith asked why some nations had become much wealthier than others.
- Smith proposed that individuals acting purely out of self interest are guided by the markets



- Over the 19th century economic was the focus of classical economists like Thomas Malthus (recall Lecture 1) and Karl Marx
  - Asked whether growth could be continued indefinitely or were there limits?
- Industrial production ramped up during WW2 – a period filled with scientific discovery and invention
- Society adopted pesticides, plastics, TV sets, refrigerators, air conditioning – all supported by inexpensive and efficient energy
- Development was now possible in whole new regions



History.com