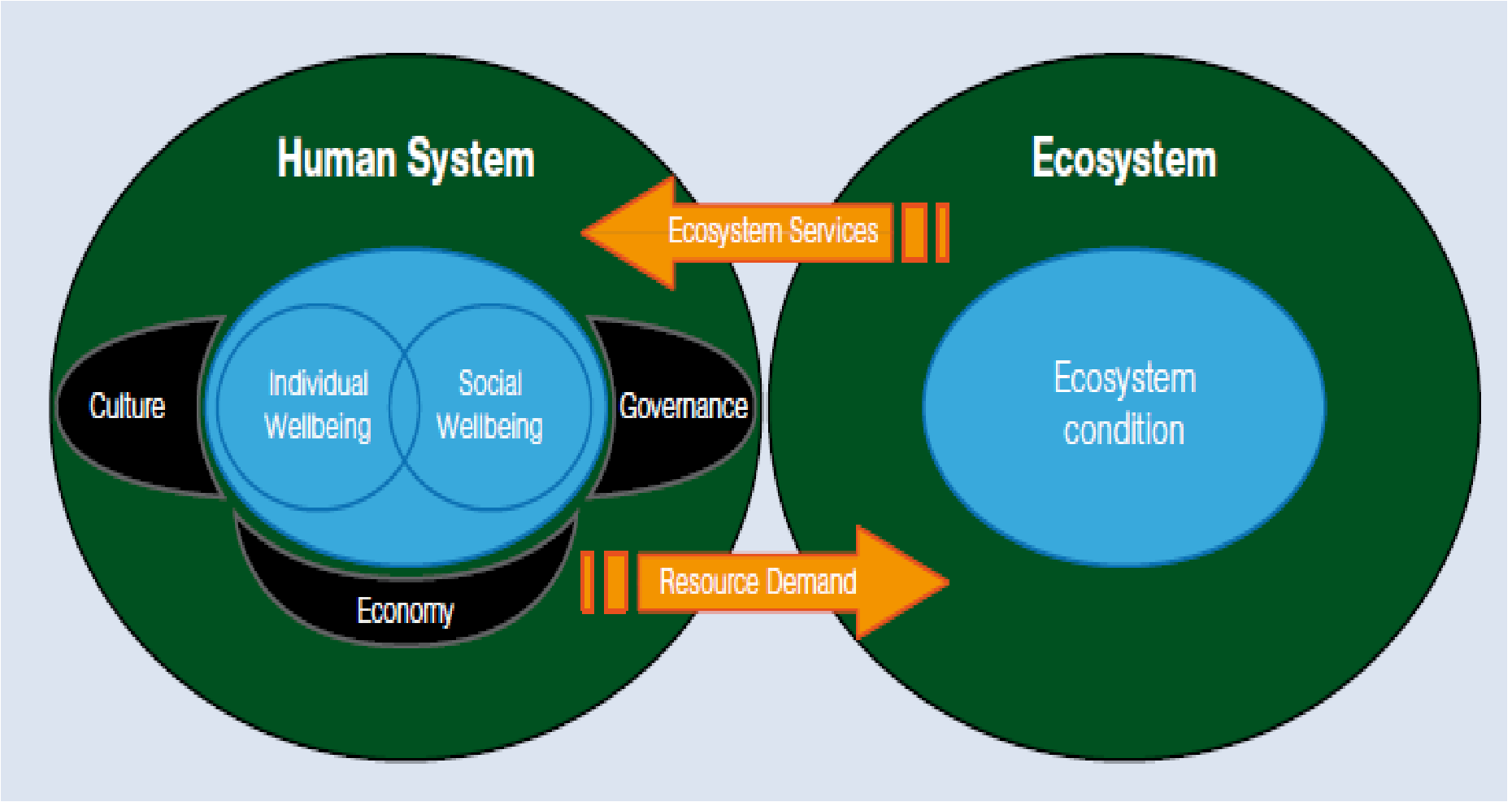
1 - The challenges of unsustainable change and growth

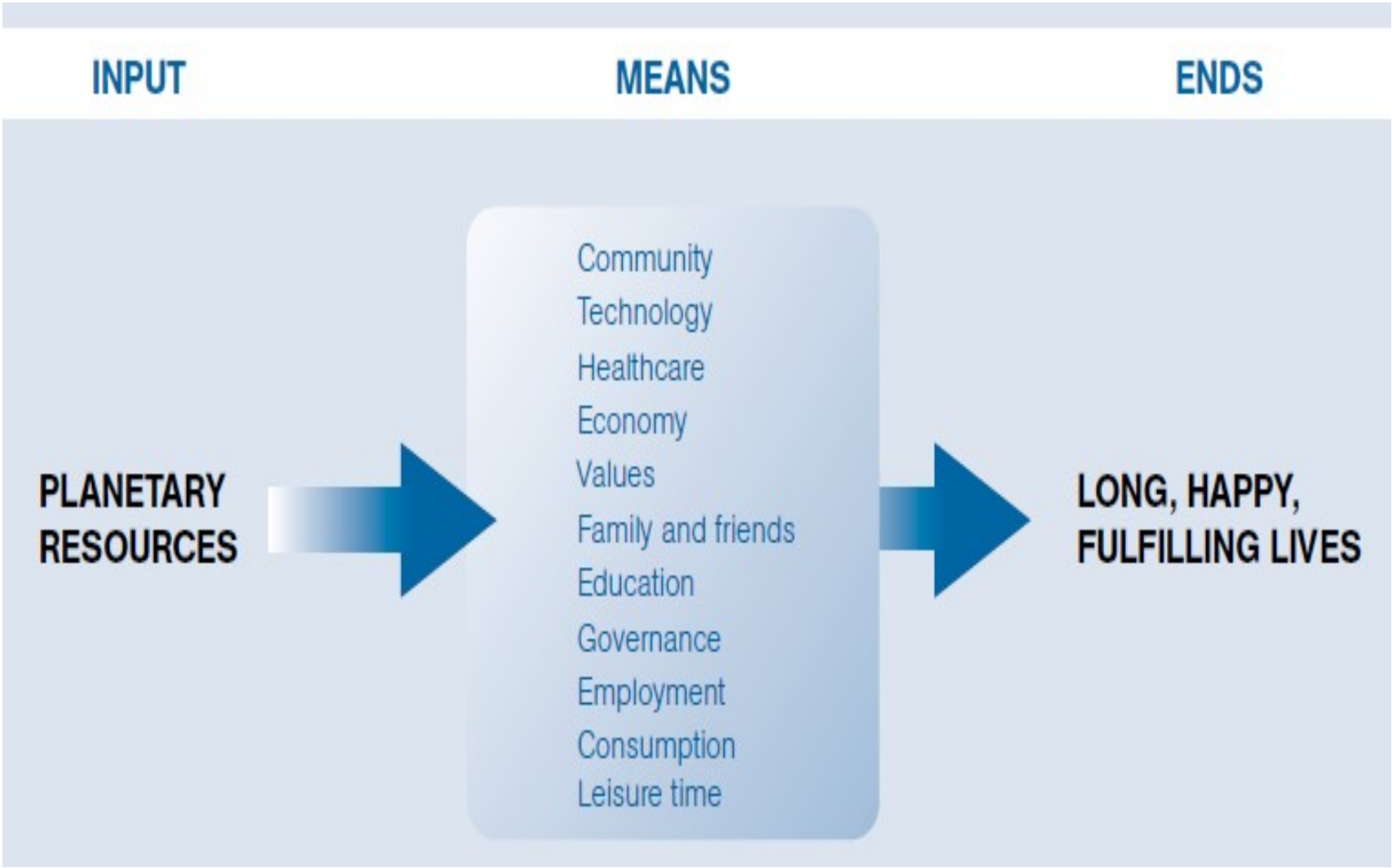
An introduction to natural systems (of climate, natural resources, water and energy) and human-based systems (social, economic, cultural and political), and the scientific and other evidence for the causes, interactions, effects and impacts of their changes.

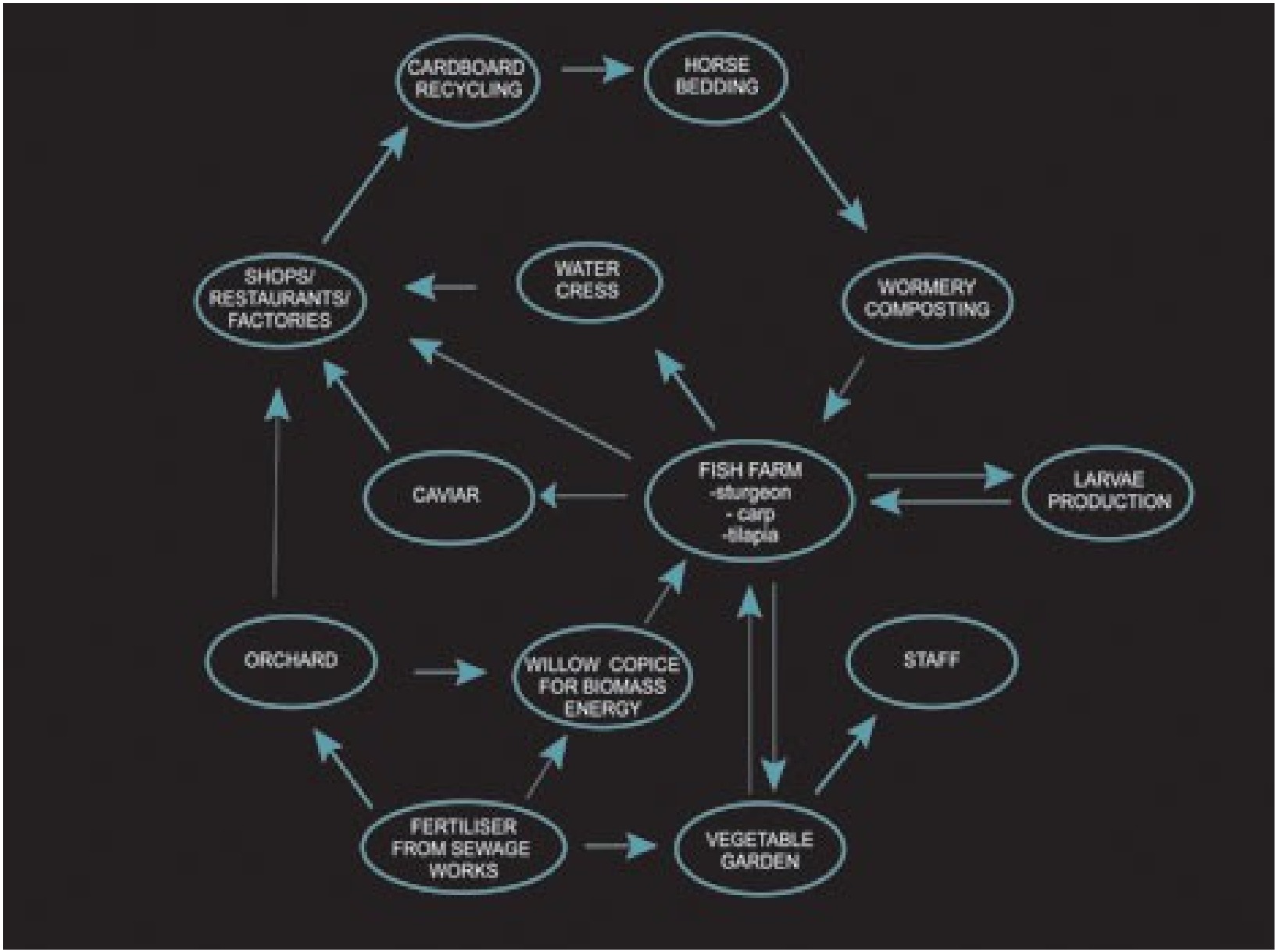
Key Objectives

- To understand the scientific and other evidence for the causes, interactions, effects and impacts of changes to natural systems (of climate, natural resources, water and energy) and human-based systems (social, economic, cultural and political).
- To learn the value of holistic, systems thinking that recognises their dependence on natural systems and the dynamic, and sometimes unpredictable, way systems interact.
- To explore the basic science behind issues such as the loss of biodiversity, climate change, resource depletion and economic growth.

1 Systems and system thinking


Human System
Ecosystem
Ecosystem Services
Culture
Individual Wellbeing
Social Wellbeing
Governance
Economy
Ecosystem condition
Resource Demand


INPUT
MEANS
ENDS
PLANETARY RESOURCES
Community
Technology
Healthcare
Economy
Values
Family and friends
Education
Governance
Employment
Consumption
Leisure time
LONG, HAPPY, FULFILLING LIVES


CARDBOARD RECYCLING
HORSE BEDDING
SHOPS/ RESTAURANTS/ FACTORIES
WATER CRESS
WORMERY COMPOSTING
CAVIAR
FISH FARM -sturgeon - carp -tilapia
LARVAE PRODUCTION
ORCHARD
WILLOW COPICE FOR BIOMASS ENERGY
STAFF
FERTILISER FROM SEWAGE WORKS
VEGETABLE GARDEN

Systems Thinking

Traditional linear thinking

eg. Cause (fossil fuel) – Effect (cheap, easy energy source) – Stop.

Systems thinking

eg. Cause (fossil fuel) – Effect (short-term energy source) - Effect (Pollution) – Effect (increasing full cost and declining amount of fossil fuel) – Effect (Wasteful use of resource) - Impact (……)

Three Rules of systems thinking

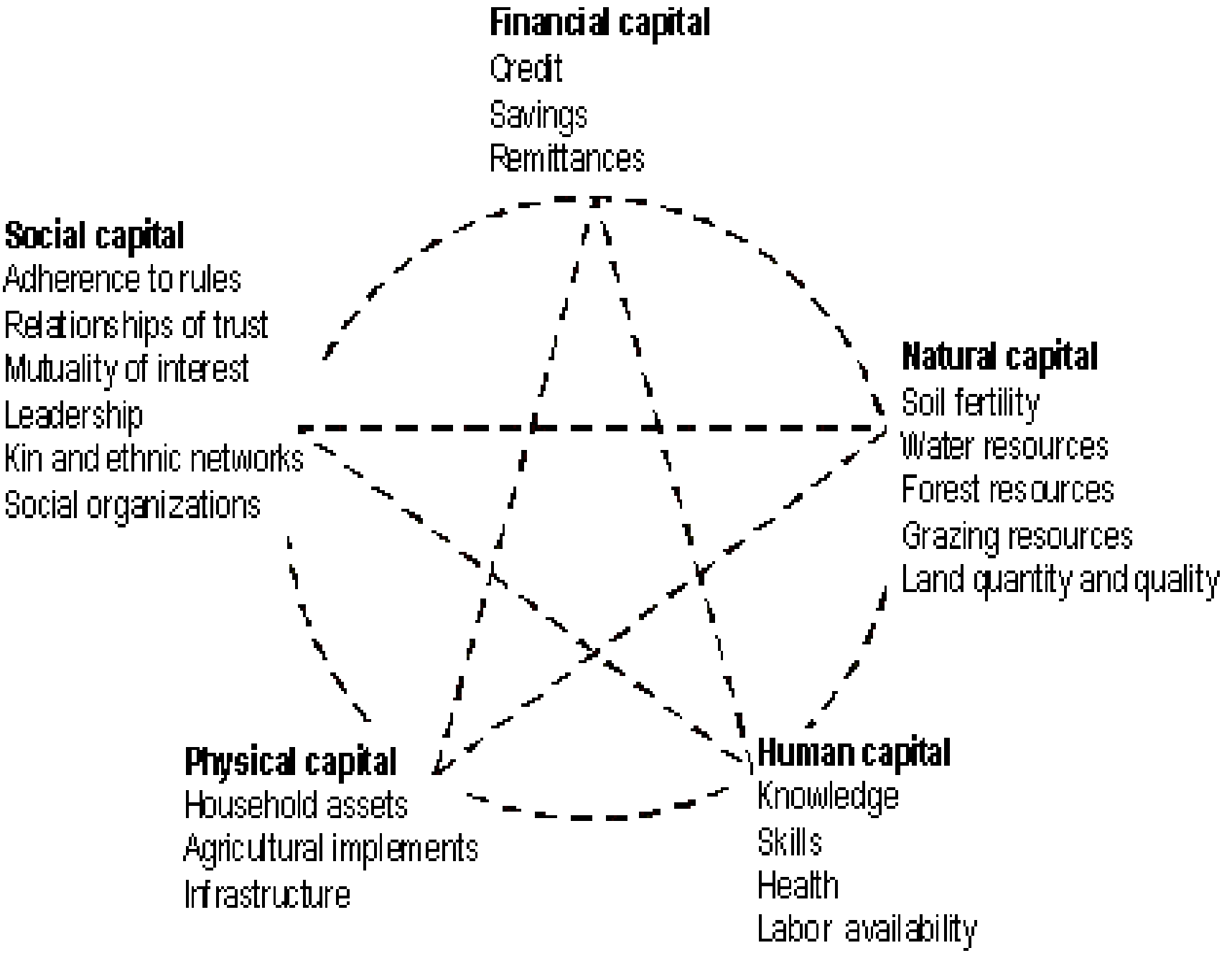
- Every change has implications.
- Everything affects everything else.
- There is no such thing as a free lunch.

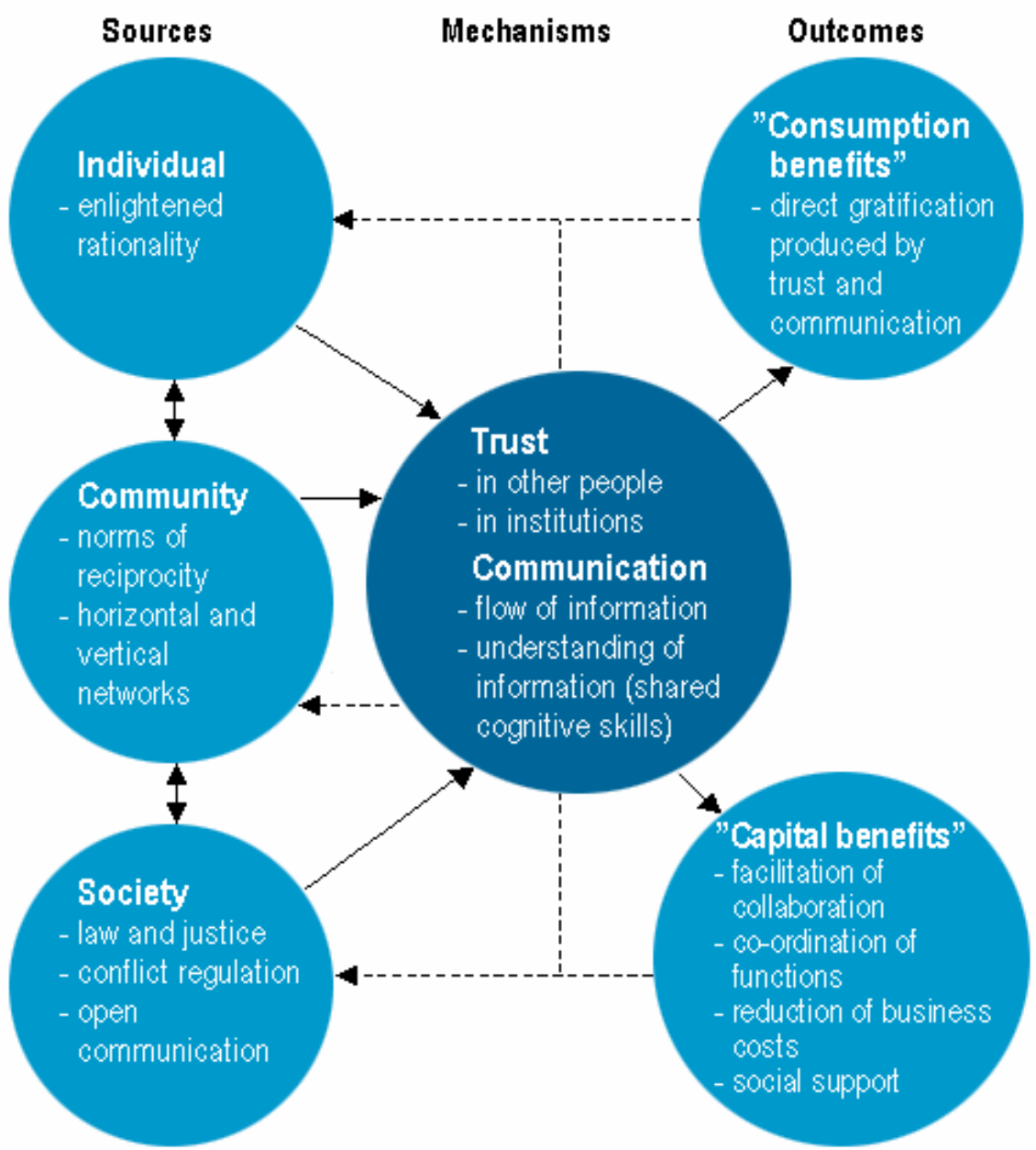
2 Five Capitals Model

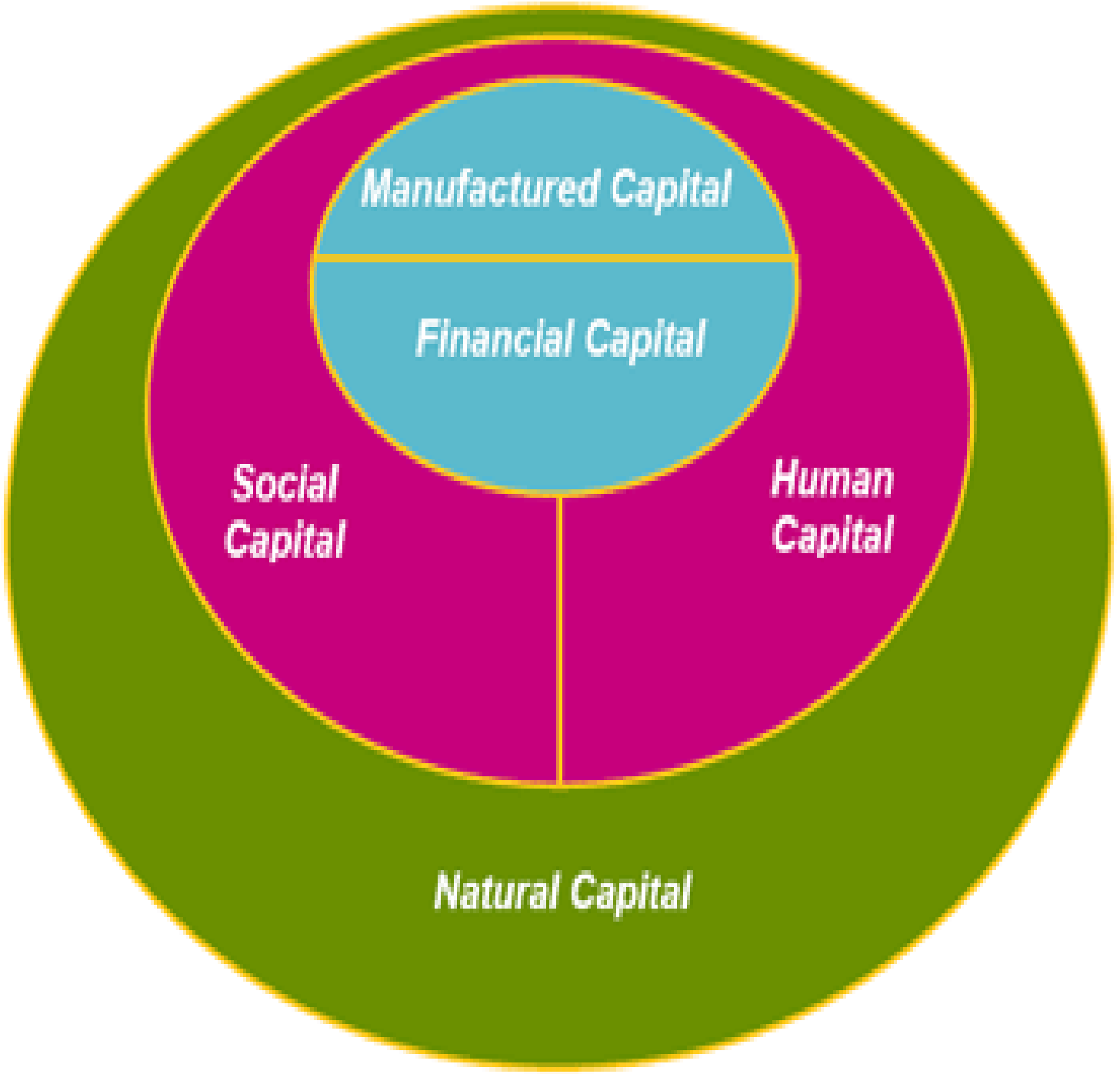
- Individuals
- Community
- Natural resources
- Money
- Buildings and infrastructure

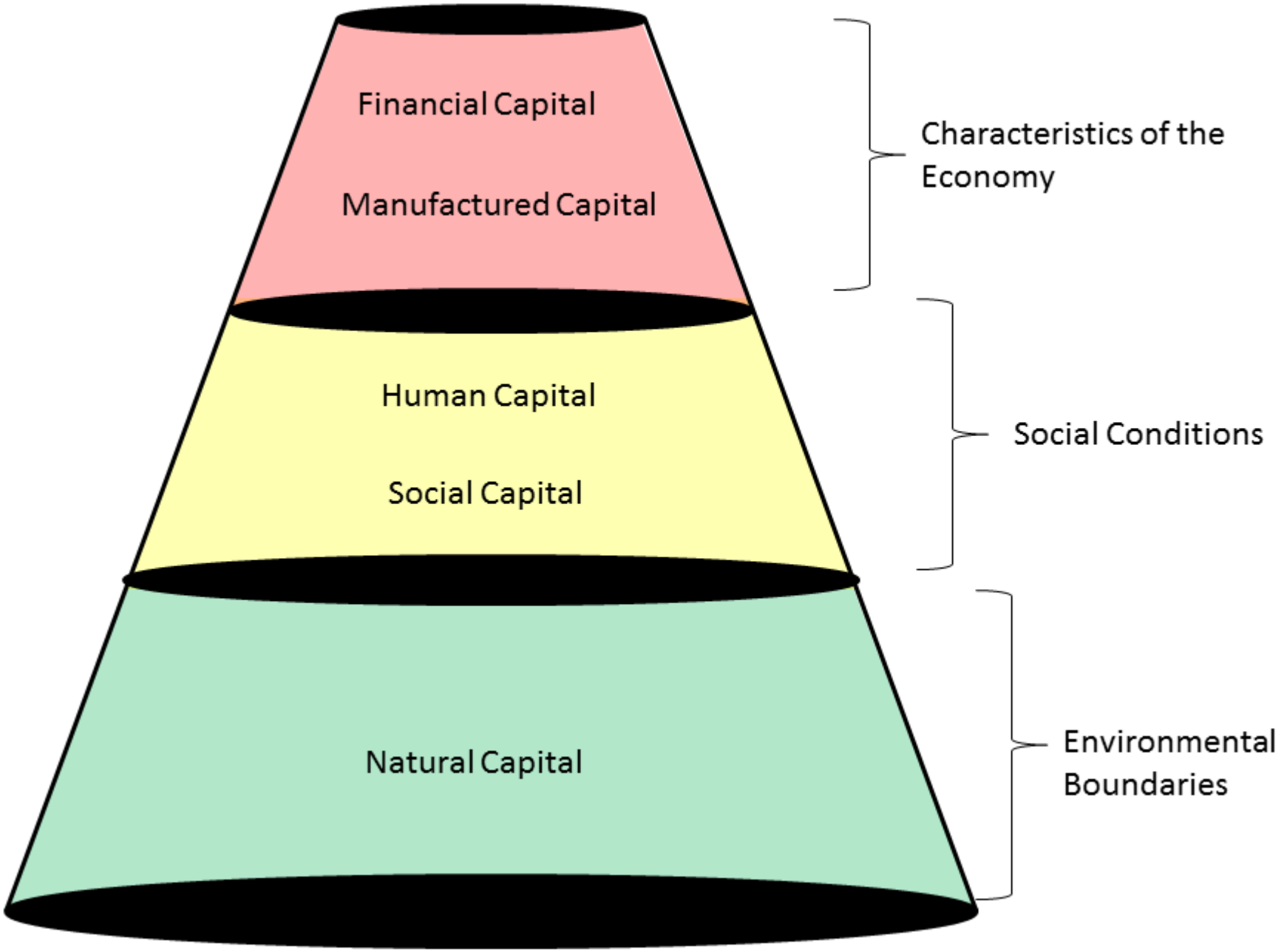
2 Five Capitals Model

- Individuals – Human capital
- Community – Social capital
- Natural resources – Natural capital
- Money -Financial capital
- Buildings and infrastructure – Manufactured capital


Financial capital
Credit
Savings
Remittances
Social capital
Adherence to rules
Relationships of trust
Mutuality of interest
Leadership
Kin and ethnic networks
Social organizations
Natural capital
Soil fertility
Water resources
Forest resources
Grazing resources
Land quantity and quality
Physical capital
Household assets
Agricultural implements
Infrastructure
Human capital
Knowledge
Skills
Health
Labor availability


Sources
Mechanisms
Outcomes
Individual
- enlightened rationality
"Consumption benefits"
- direct gratification produced by trust and communication
Community
- norms of reciprocity
- horizontal and vertical networks
Trust
- in other people
- in institutions
Communication
- flow of information
- understanding of information (shared cognitive skills)
Society
- law and justice
- conflict regulation
- open communication
"Capital benefits"
- facilitation of collaboration
- co-ordination of functions
- reduction of business costs
- social support


Manufactured Capital
Financial Capital
Social Capital
Human Capital
Natural Capital


Financial Capital
Manufactured Capital
Human Capital
Social Capital
Natural Capital
Characteristics of the Economy
Social Conditions
Environmental Boundaries

3 Entropy and Energy

Laws of Thermodynamics

1st Law – Conservation Law - Energy cannot be created or destroyed but can be transformed from one form to another.

Everything is energy.

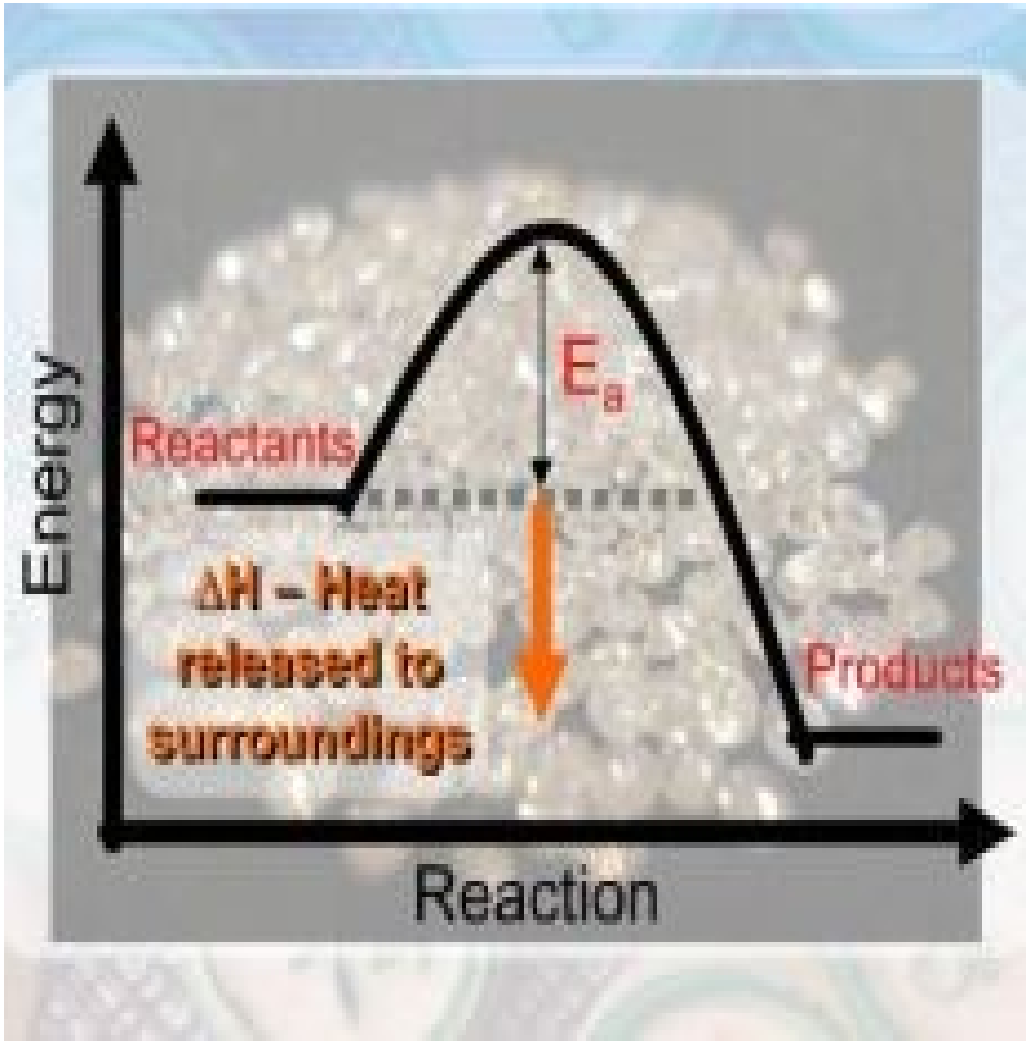
Entropy

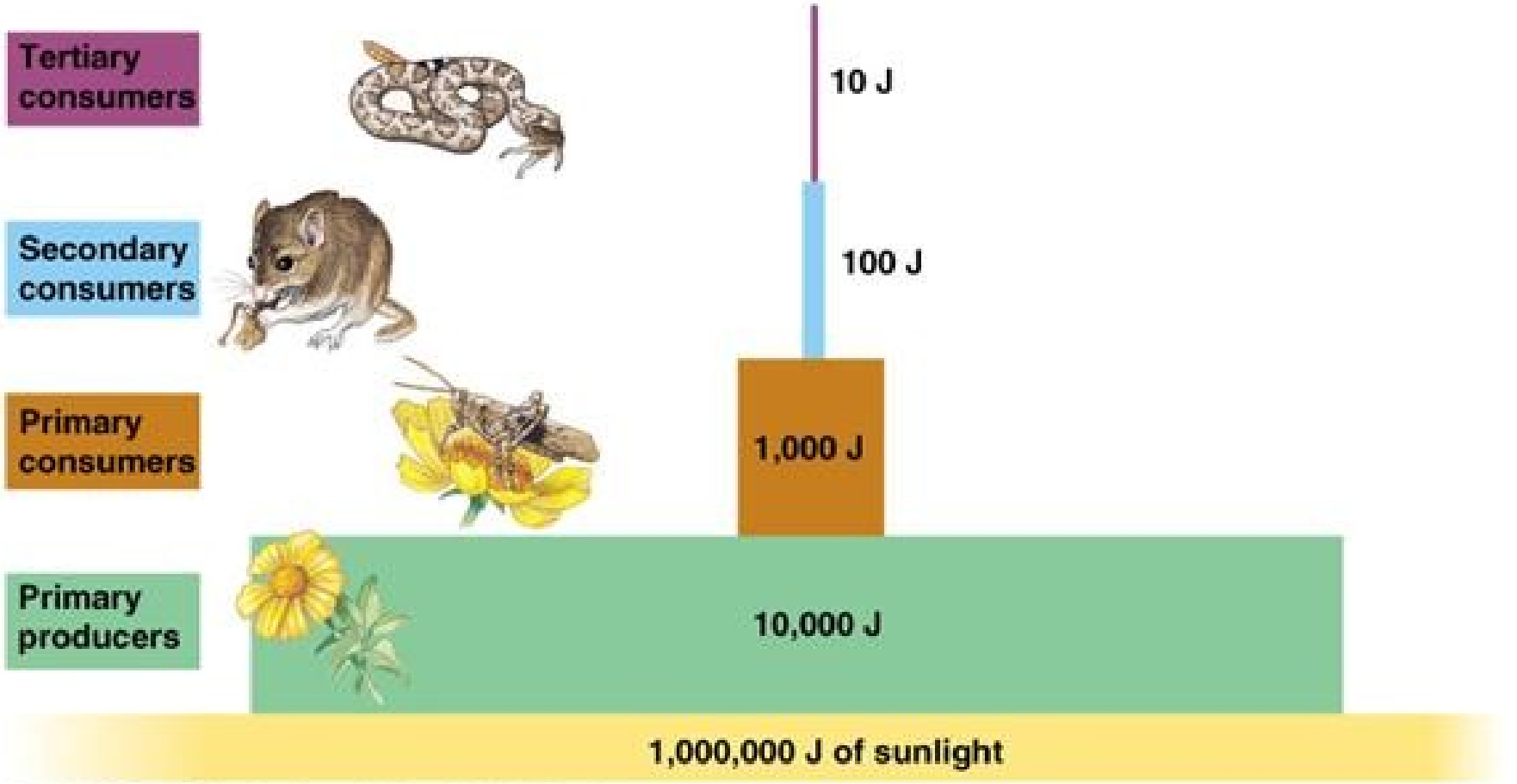
2nd Law – Entropy Law
For each energy transformation the available energy to perform work is decreased

ie. The Entropy (increase in unavailable energy) is increased.

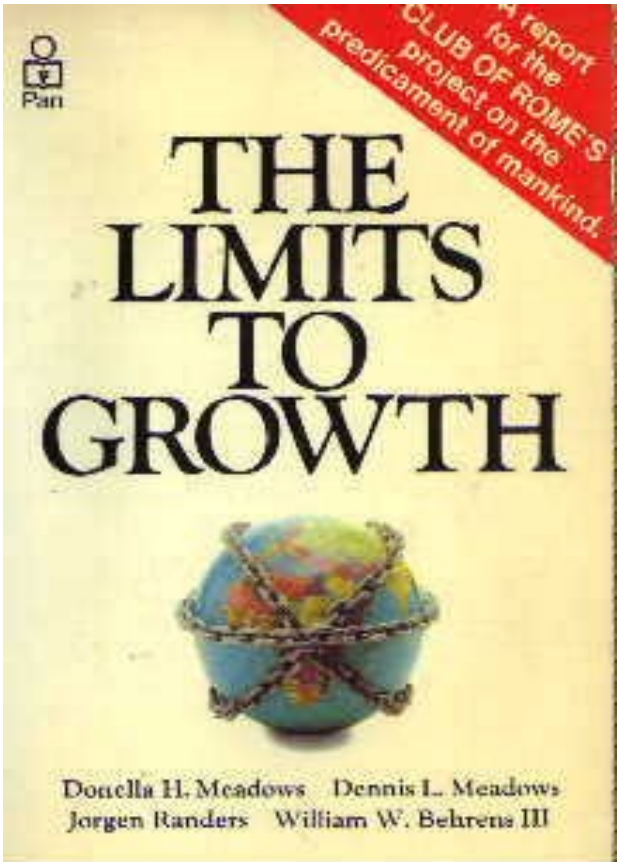
(For each energy transformation a certain penalty is exacted).

Energy moves on a one-way path from usable to non-usable.

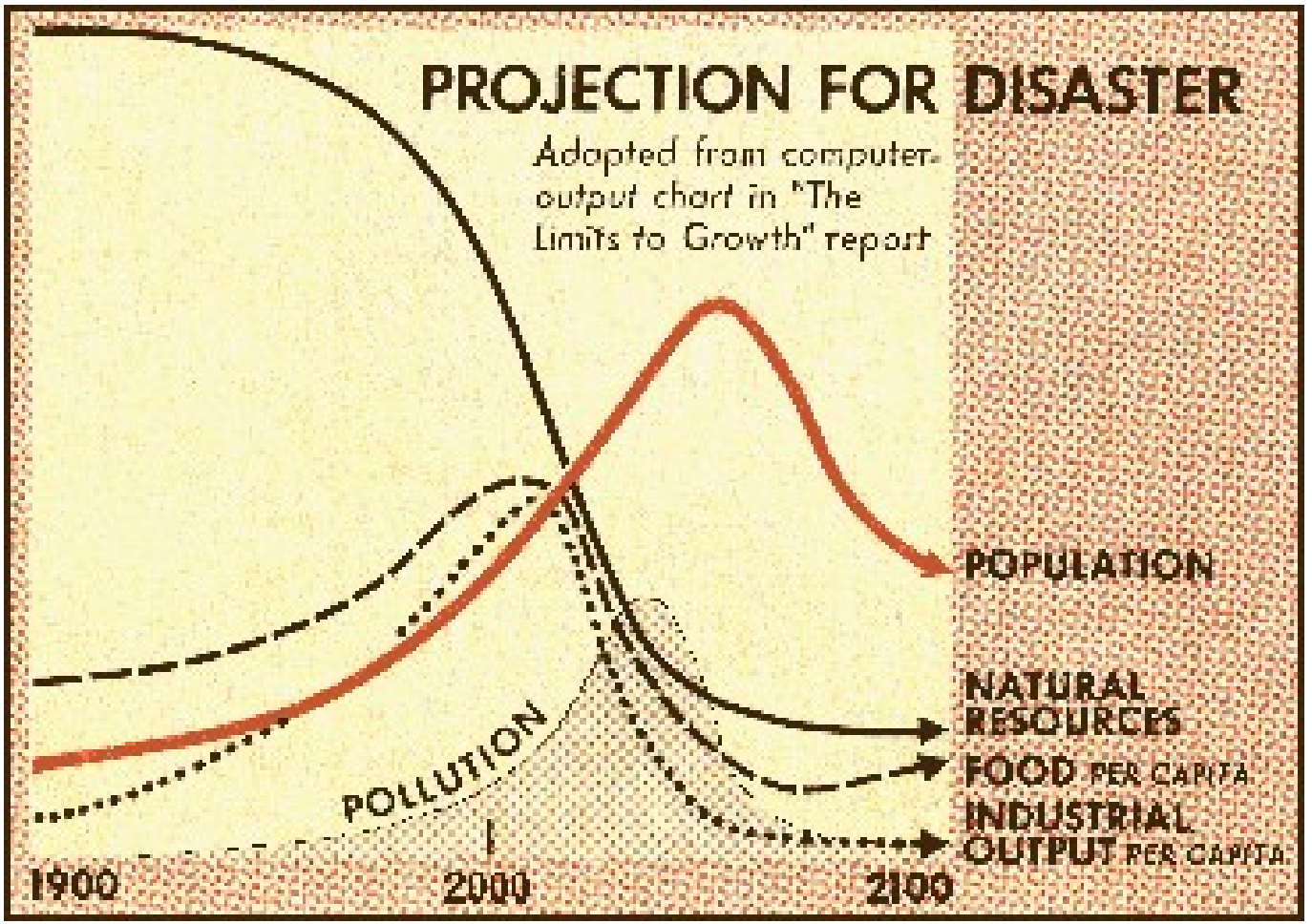


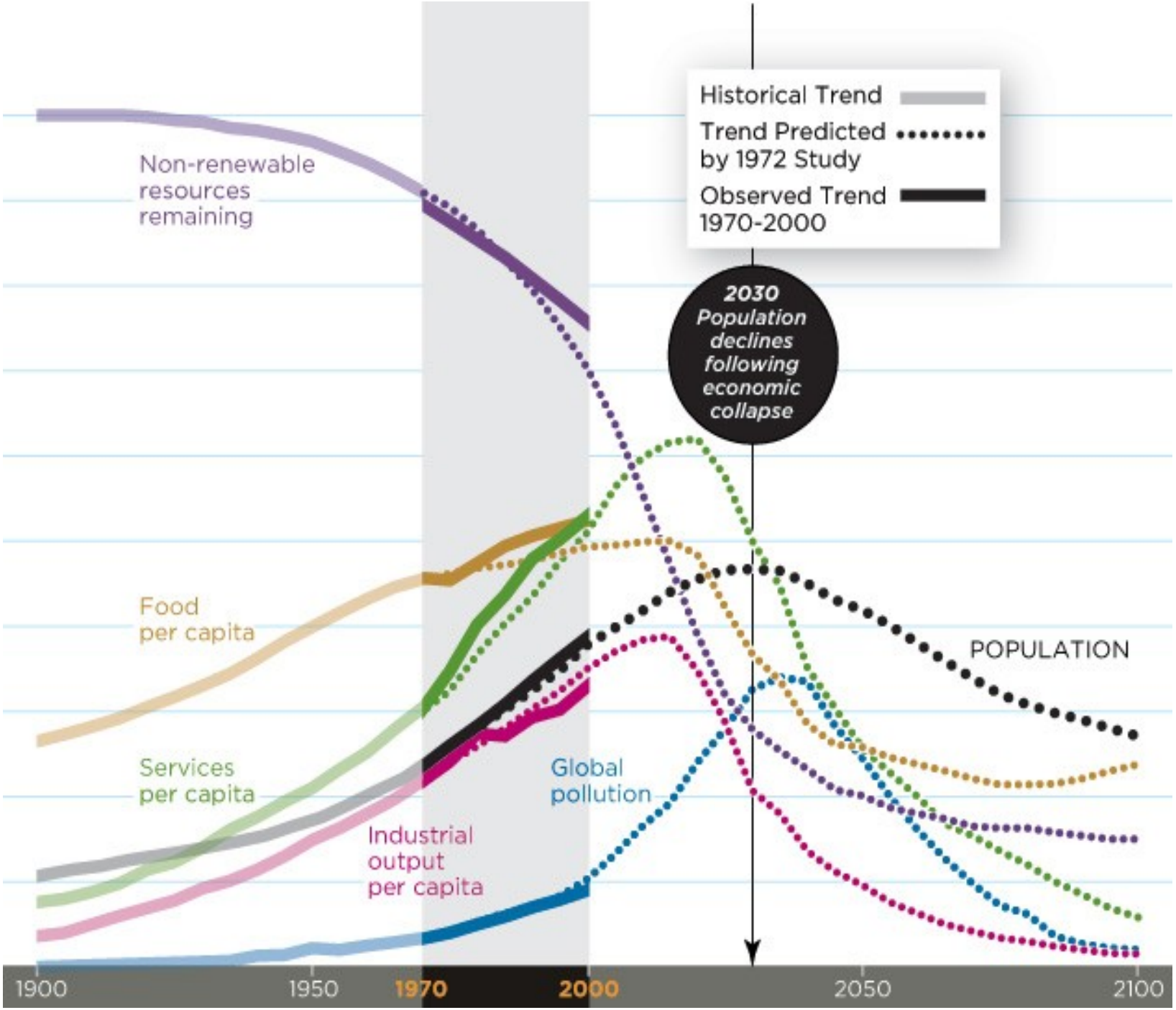


4 Limits to Growth



Film The Limits to growth film, 7 mins.

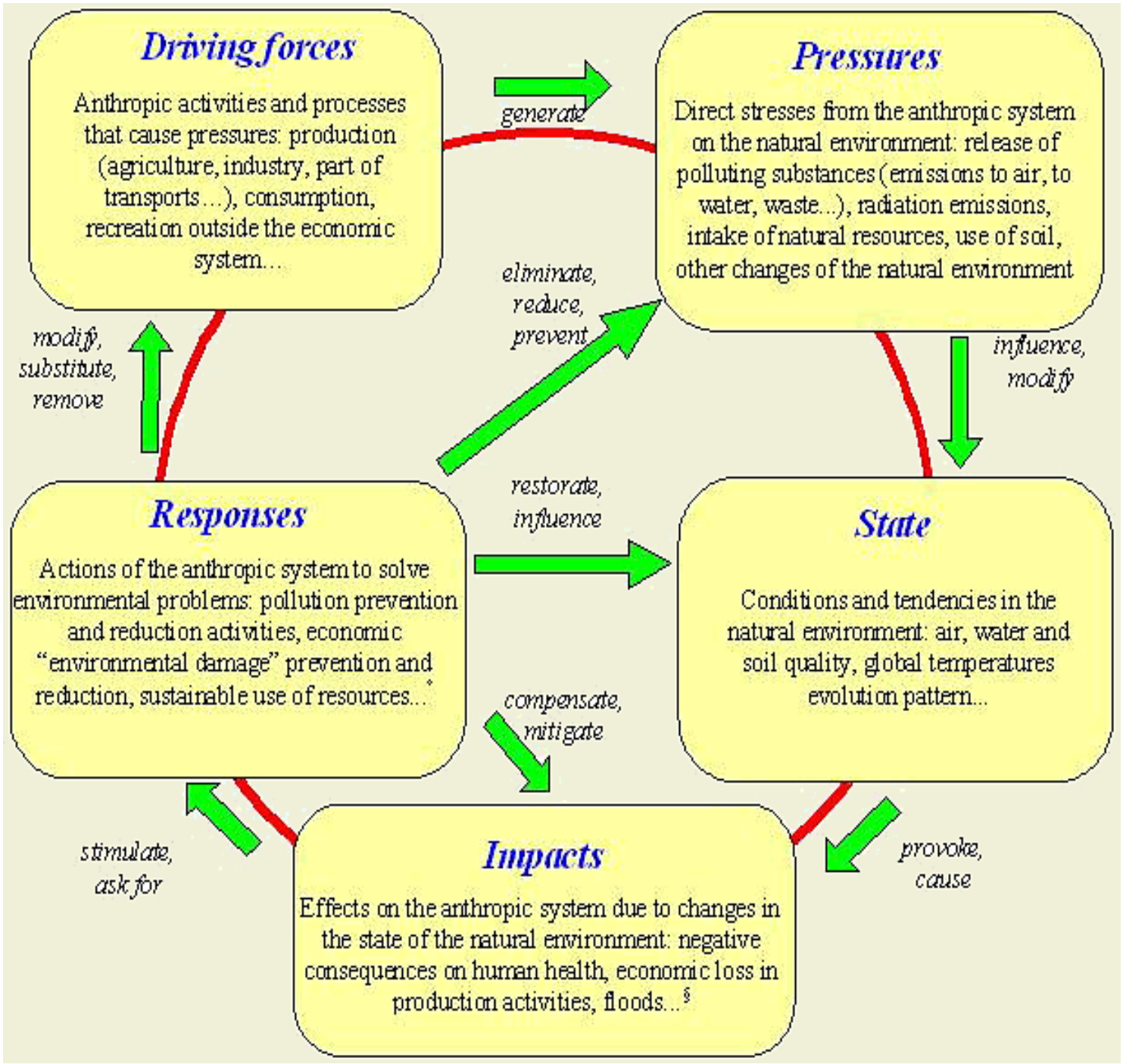


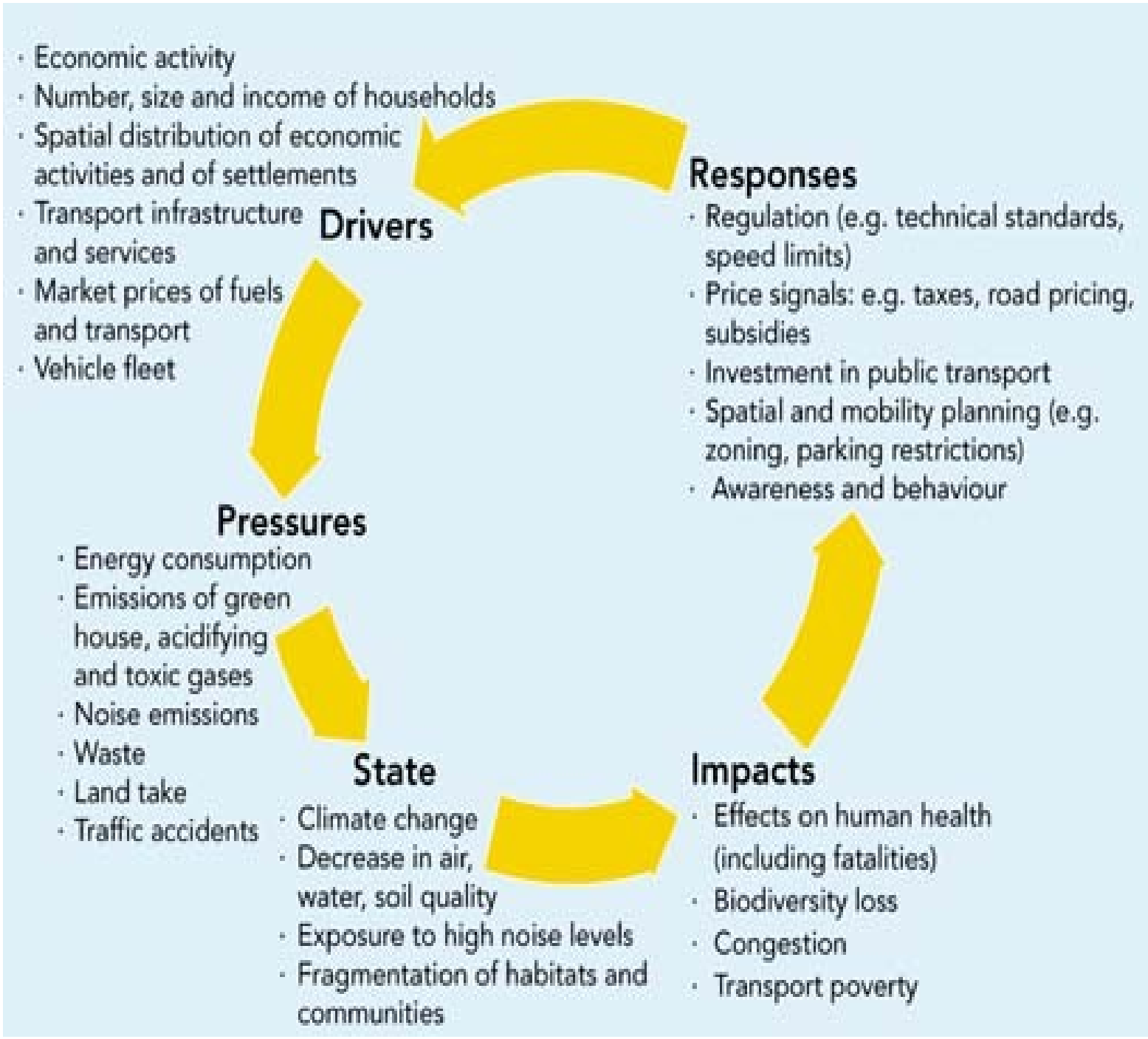

Historical Trend
Trend Predicted by 1972 Study
Observed Trend 1970-2000
2030 Population declines following economic collapse
Non-renewable resources remaining
Food per capita
Services per capita
Industrial output per capita
Global pollution
POPULATION
1900
1950
1970
2000
2050
2100

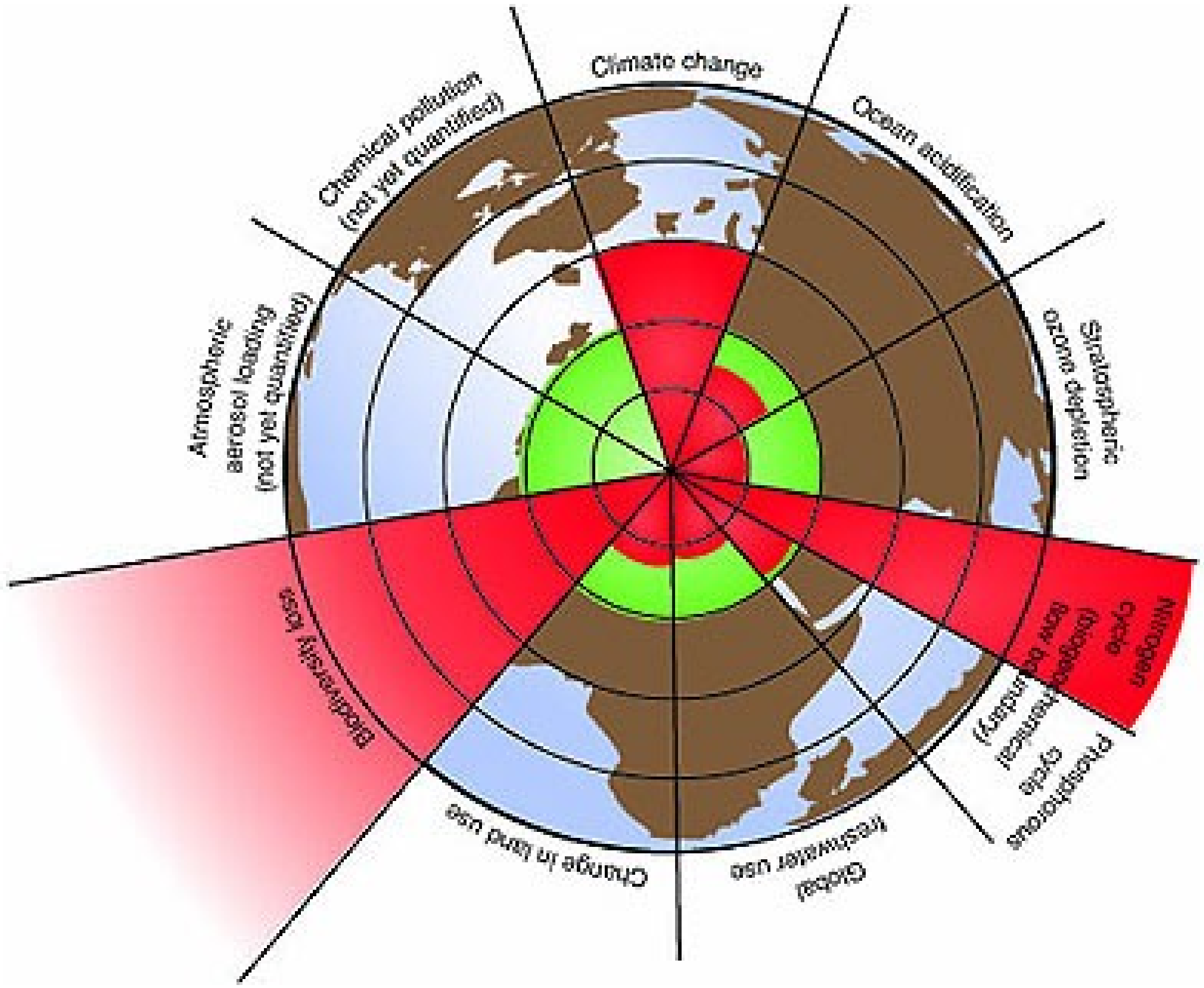
5 Change in Natural Systems

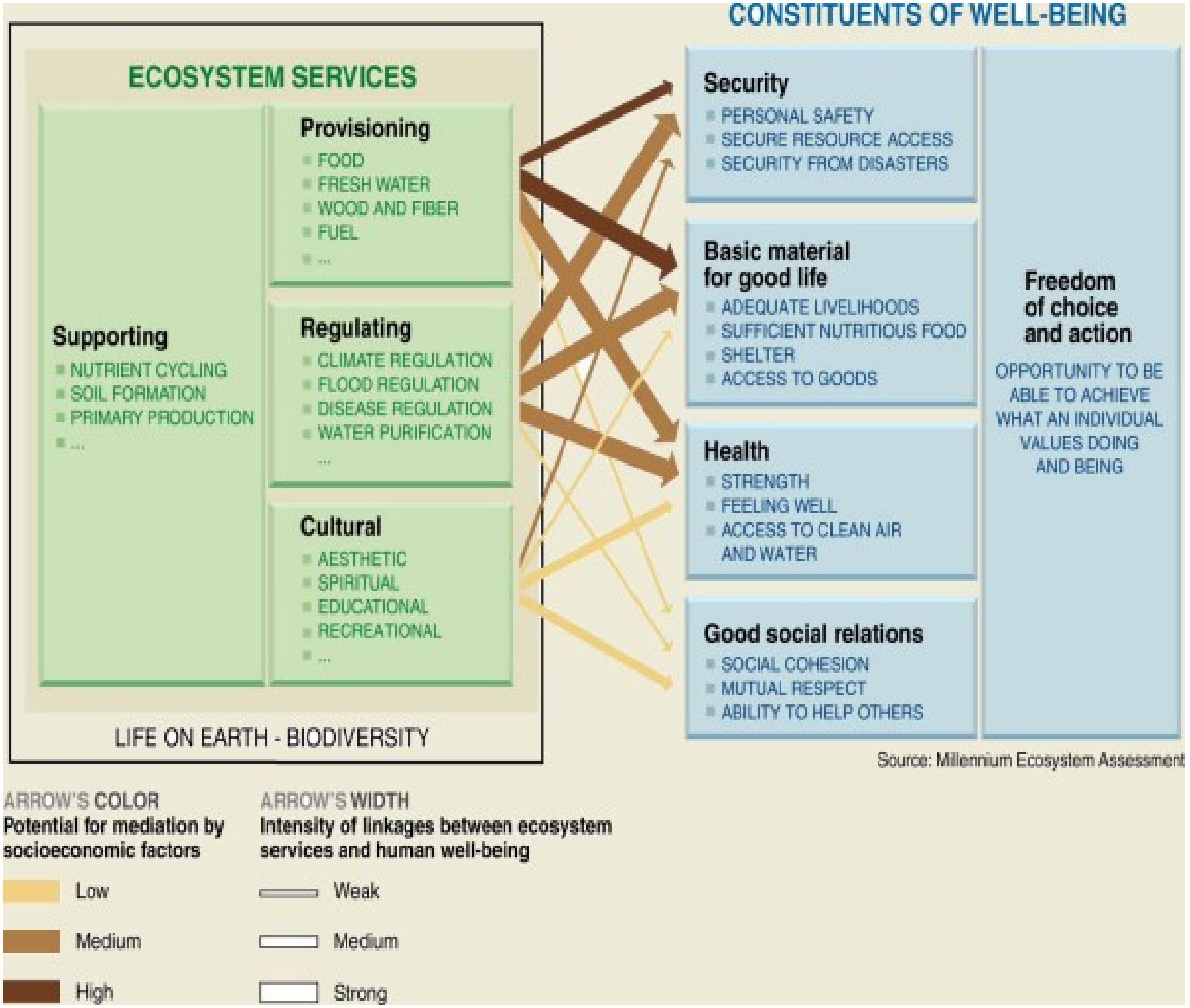
Film Bad futures – Age of stupid animation

Film Wasting energy – Age of stupid animation


Driving forces
Anthropic activities and processes that cause pressures: production (agriculture, industry, part of transports…), consumption, recreation outside the economic system…
generate
Pressures
Direct stresses from the anthropic system on the natural environment: release of polluting substances (emissions to air, to water, waste...), radiation emissions, intake of natural resources, use of soil, other changes of the natural environment
eliminate, reduce, prevent
influence, modify
modify, substitute, remove
restorate, influence
Responses
Actions of the anthropic system to solve environmental problems: pollution prevention and reduction activities, economic "environmental damage" prevention and reduction, sustainable use of resources...*
State
Conditions and tendencies in the natural environment: air, water and soil quality, global temperatures evolution pattern...
compensate, mitigate
stimulate, ask for
provoke, cause
Impacts
Effects on the anthropic system due to changes in the state of the natural environment: negative consequences on human health, economic loss in production activities, floods...§


Drivers
· Economic activity
· Number, size and income of households
· Spatial distribution of economic activities and of settlements
· Transport infrastructure and services
· Market prices of fuels and transport
· Vehicle fleet
Pressures
· Energy consumption
· Emissions of green house, acidifying and toxic gases
· Noise emissions
· Waste
· Land take
· Traffic accidents
State
· Climate change
· Decrease in air, water, soil quality
· Exposure to high noise levels
· Fragmentation of habitats and communities
Impacts
· Effects on human health (including fatalities)
· Biodiversity loss
· Congestion
· Transport poverty
Responses
· Regulation (e.g. technical standards, speed limits)
· Price signals: e.g. taxes, road pricing, subsidies
· Investment in public transport
· Spatial and mobility planning (e.g. zoning, parking restrictions)
· Awareness and behaviour


Climate change
Ocean acidification
Stratospheric ozone depletion
Nitrogen cycle
Phosphorous cycle
Global freshwater use
Change in land use
Biodiversity loss
Atmospheric aerosol loading (not yet quantified)
Chemical pollution (not yet quantified)

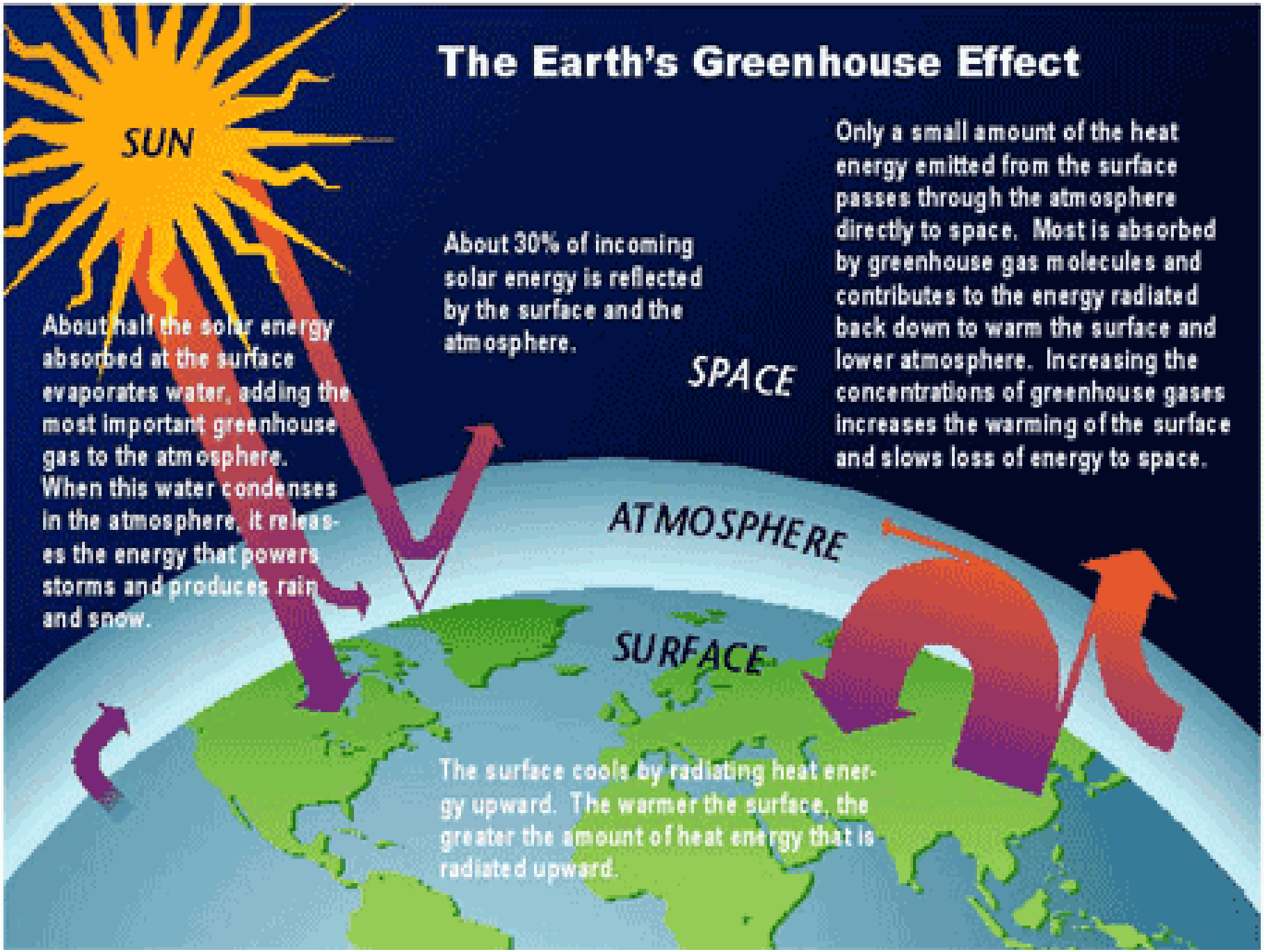

ECOSYSTEM SERVICES
Supporting
NUTRIENT CYCLING
SOIL FORMATION
PRIMARY PRODUCTION
...
Provisioning
FOOD
FRESH WATER
WOOD AND FIBER
FUEL
...
Regulating
CLIMATE REGULATION
FLOOD REGULATION
DISEASE REGULATION
WATER PURIFICATION
...
Cultural
AESTHETIC
SPIRITUAL
EDUCATIONAL
RECREATIONAL
...
LIFE ON EARTH - BIODIVERSITY
CONSTITUENTS OF WELL-BEING
Security
PERSONAL SAFETY
SECURE RESOURCE ACCESS
SECURITY FROM DISASTERS
Basic material for good life
ADEQUATE LIVELIHOODS
SUFFICIENT NUTRITIOUS FOOD
SHELTER
ACCESS TO GOODS
Health
STRENGTH
FEELING WELL
ACCESS TO CLEAN AIR AND WATER
Good social relations
SOCIAL COHESION
MUTUAL RESPECT
ABILITY TO HELP OTHERS
Freedom of choice and action
OPPORTUNITY TO BE ABLE TO ACHIEVE WHAT AN INDIVIDUAL VALUES DOING AND BEING
Source: Millennium Ecosystem Assessment
ARROW'S COLOR
Potential for mediation by socioeconomic factors
Low
Medium
High
ARROW'S WIDTH
Intensity of linkages between ecosystem services and human well-being
Weak
Medium
Strong

6 Climate

Film **Powerdown,** ActionAid

Film Eddsworld – climate change animation

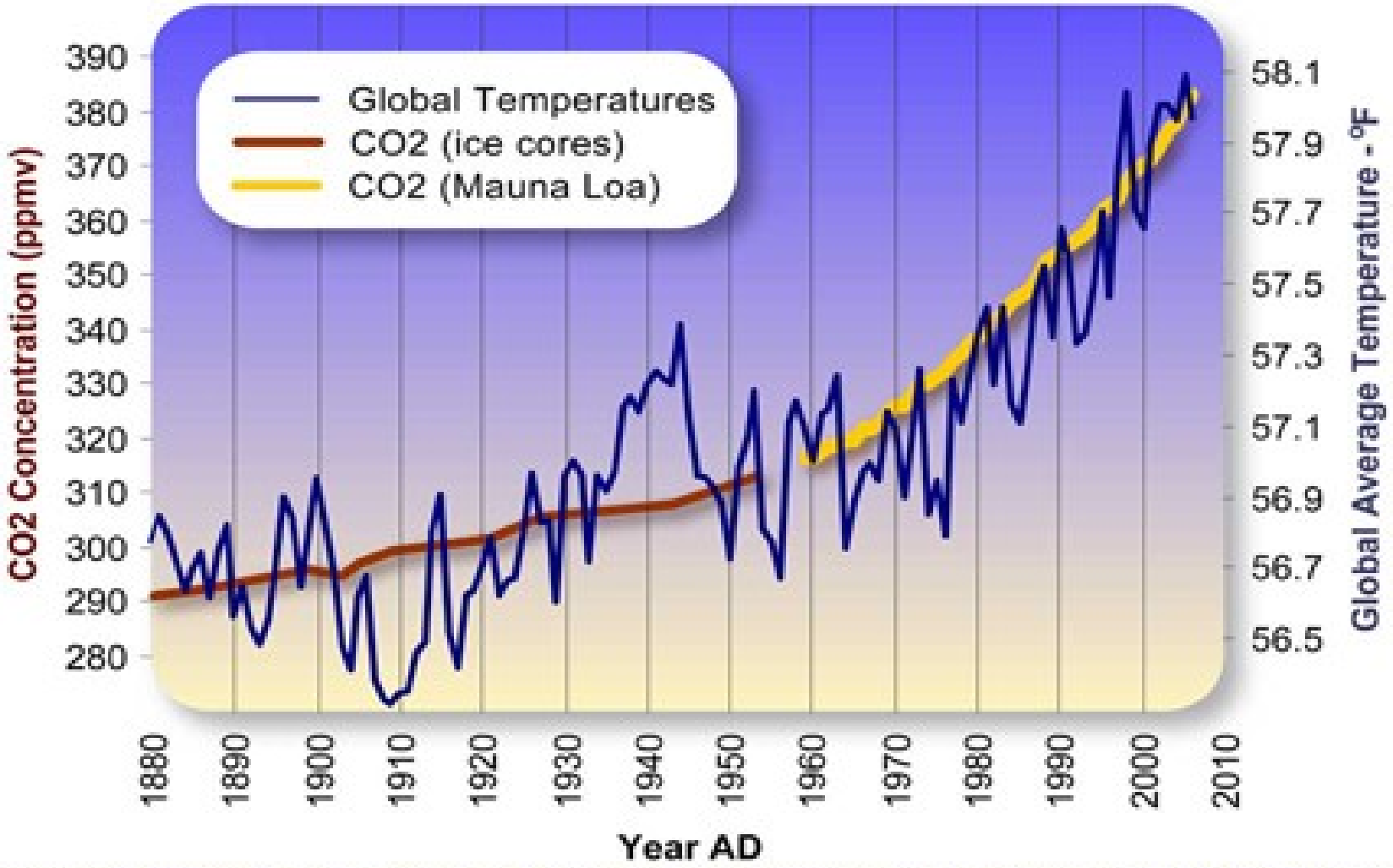
Film Local solutions on a sinking paradise, Carteret Islands


The Earth's Greenhouse Effect
SUN
About 30% of incoming solar energy is reflected by the surface and the atmosphere.
SPACE
Only a small amount of the heat energy emitted from the surface passes through the atmosphere directly to space. Most is absorbed by greenhouse gas molecules and contributes to the energy radiated back down to warm the surface and lower atmosphere. Increasing the concentrations of greenhouse gases increases the warming of the surface and slows loss of energy to space.
About half the solar energy absorbed at the surface evaporates water, adding the most important greenhouse gas to the atmosphere. When this water condenses in the atmosphere, it releases the energy that powers storms and produces rain and snow.
ATMOSPHERE
SURFACE
The surface cools by radiating heat energy upward. The warmer the surface, the greater the amount of heat energy that is radiated upward.

Greenhouse gases

- Water vapour
- Carbon dioxide (CO2)
- Methane (CH4)
- Nitrous oxide (N2O)
- Other gases
- Aerosols

Global Average Temperature and Carbon Dioxide Concentrations, 1880 - 2006



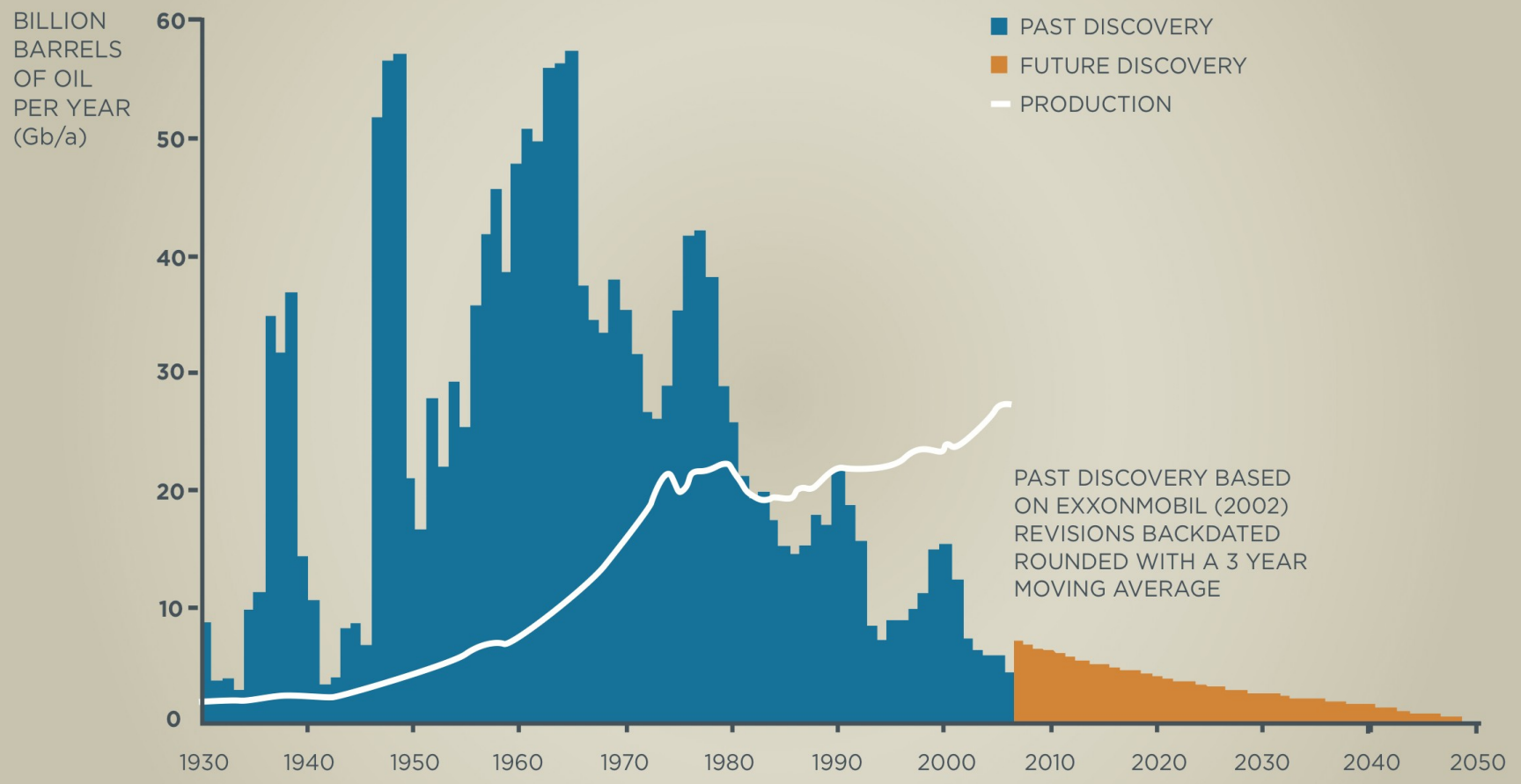
Data Source Temperature: ftp://ftp.ncdc.noaa.gov/pub/data/anomalies/annual.land_and_ocean.90S.90N.df_1901-2000mean.dat
Data Source CO2 (Siple Ice Cores): http://cdiac.esd.ornl.gov/ftp/trends/co2/siple2.013
Data Source CO2 (Mauna Loa): http://cdiac.esd.ornl.gov/ftp/trends/co2/maunaloa.co2
& http://www.esrl.noaa.gov/gmd/webdata/ccgg/trends/co2_mm_mlo.dat

Graphic Design: Michael Ernst, The Woods Hole Research Center

7 Fossil Fuels and Minerals

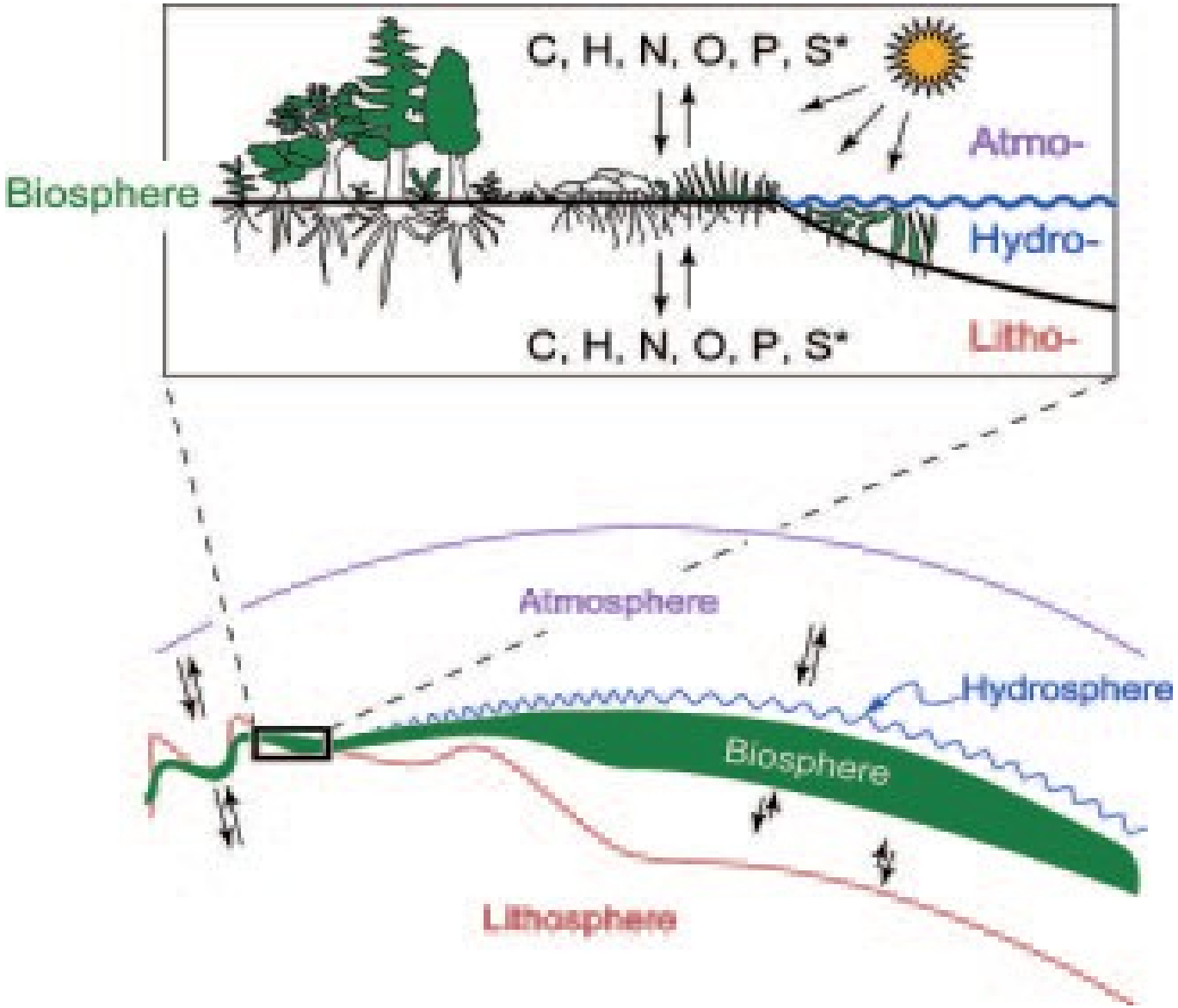
Film There's no tomorrow, 34 mins.

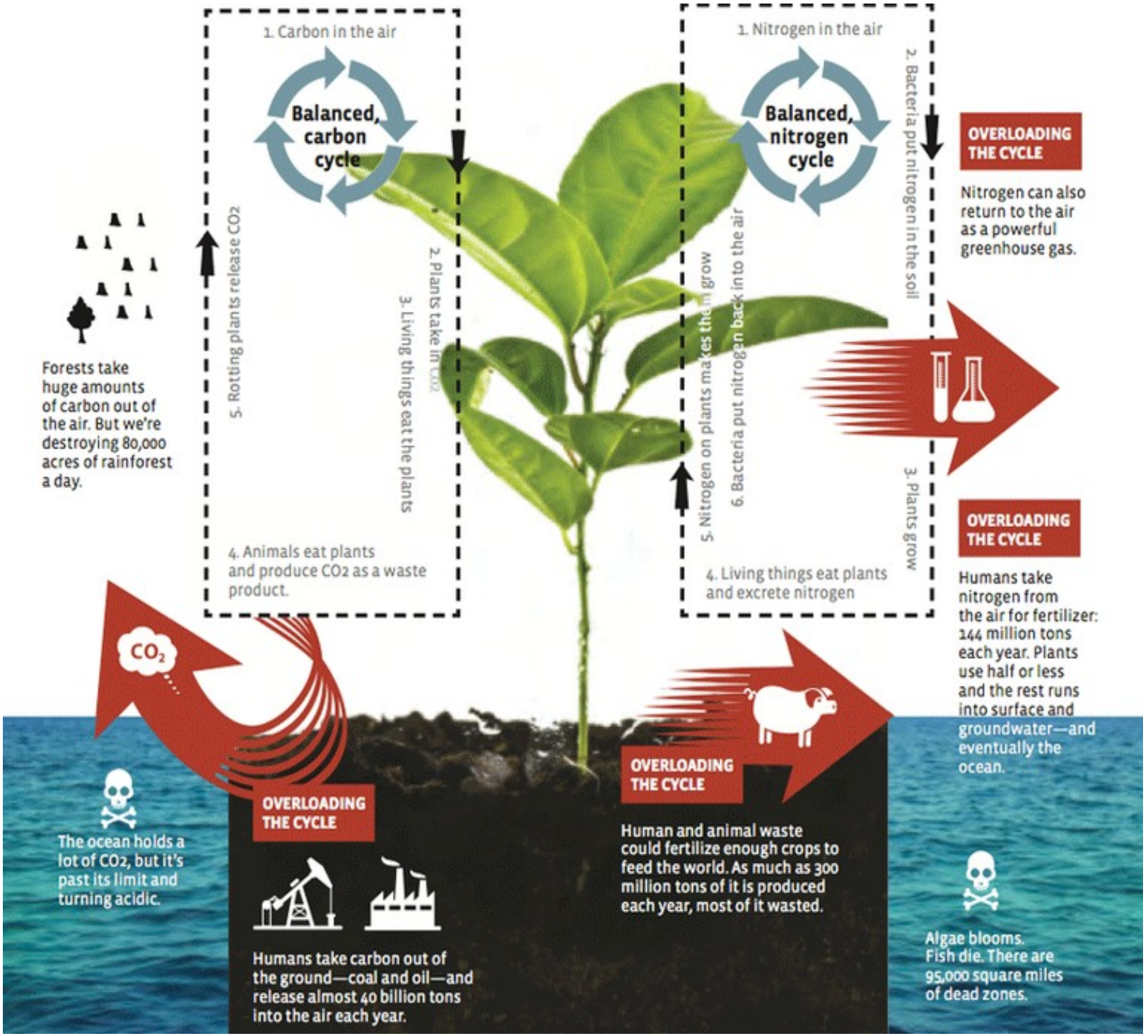
THE GROWING GAP OIL, DISCOVERY AND PRODUCTION

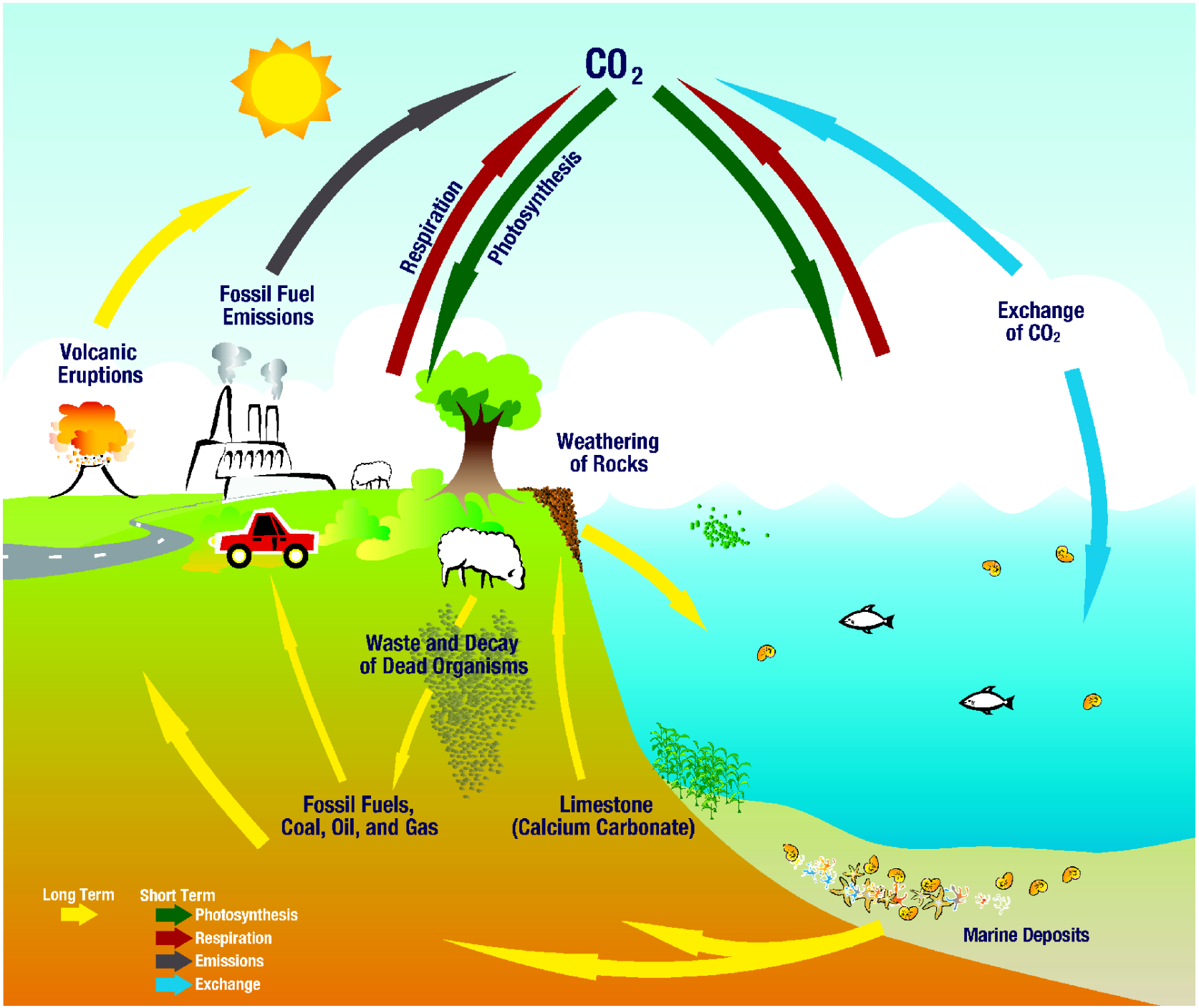


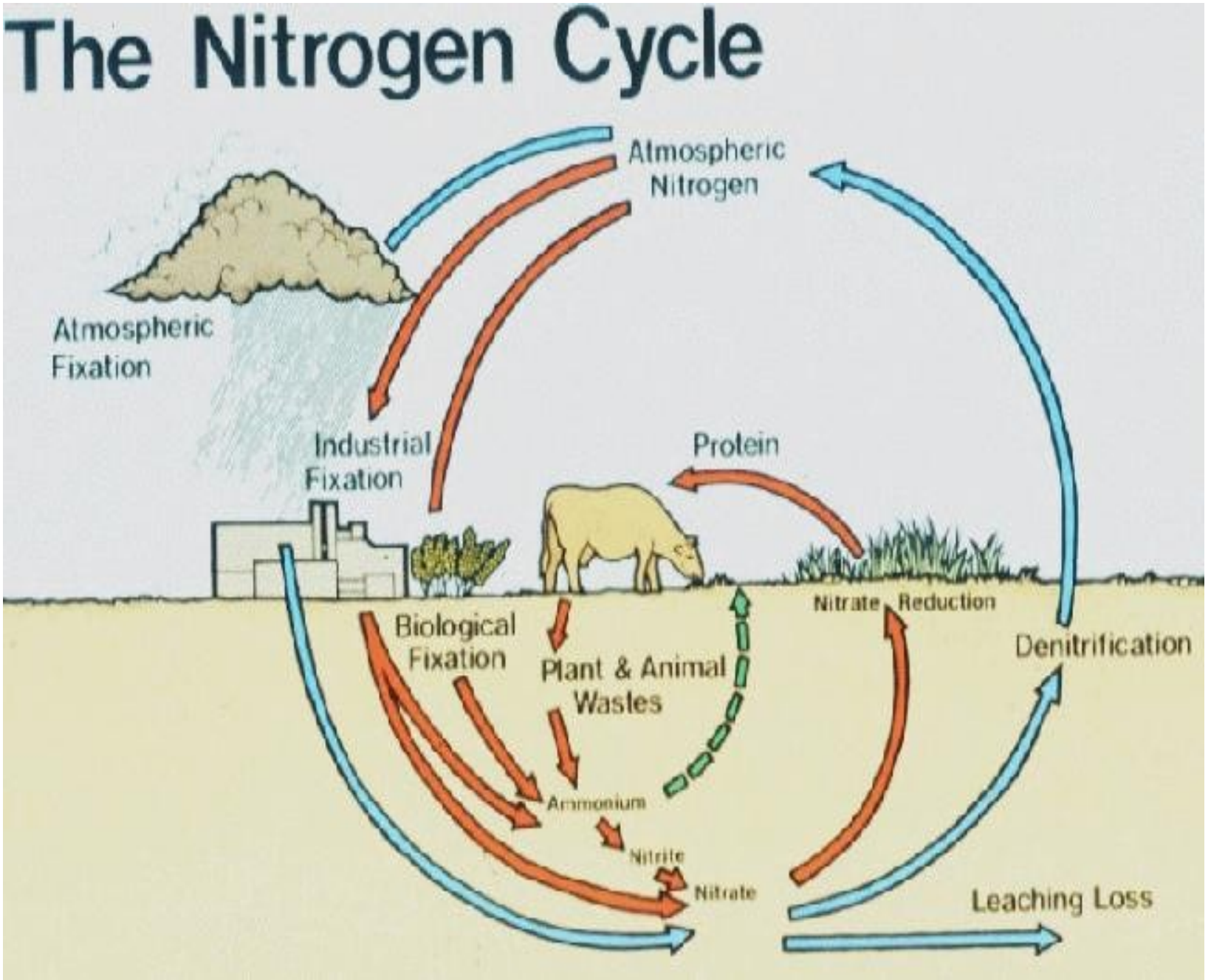
ELLEN MACARTHUR FOUNDATION

8 Nutrients


C, H, N, O, P, S*
Atmo-
Biosphere
Hydro-
C, H, N, O, P, S*
Litho-
Atmosphere
Hydrosphere
Biosphere
Lithosphere

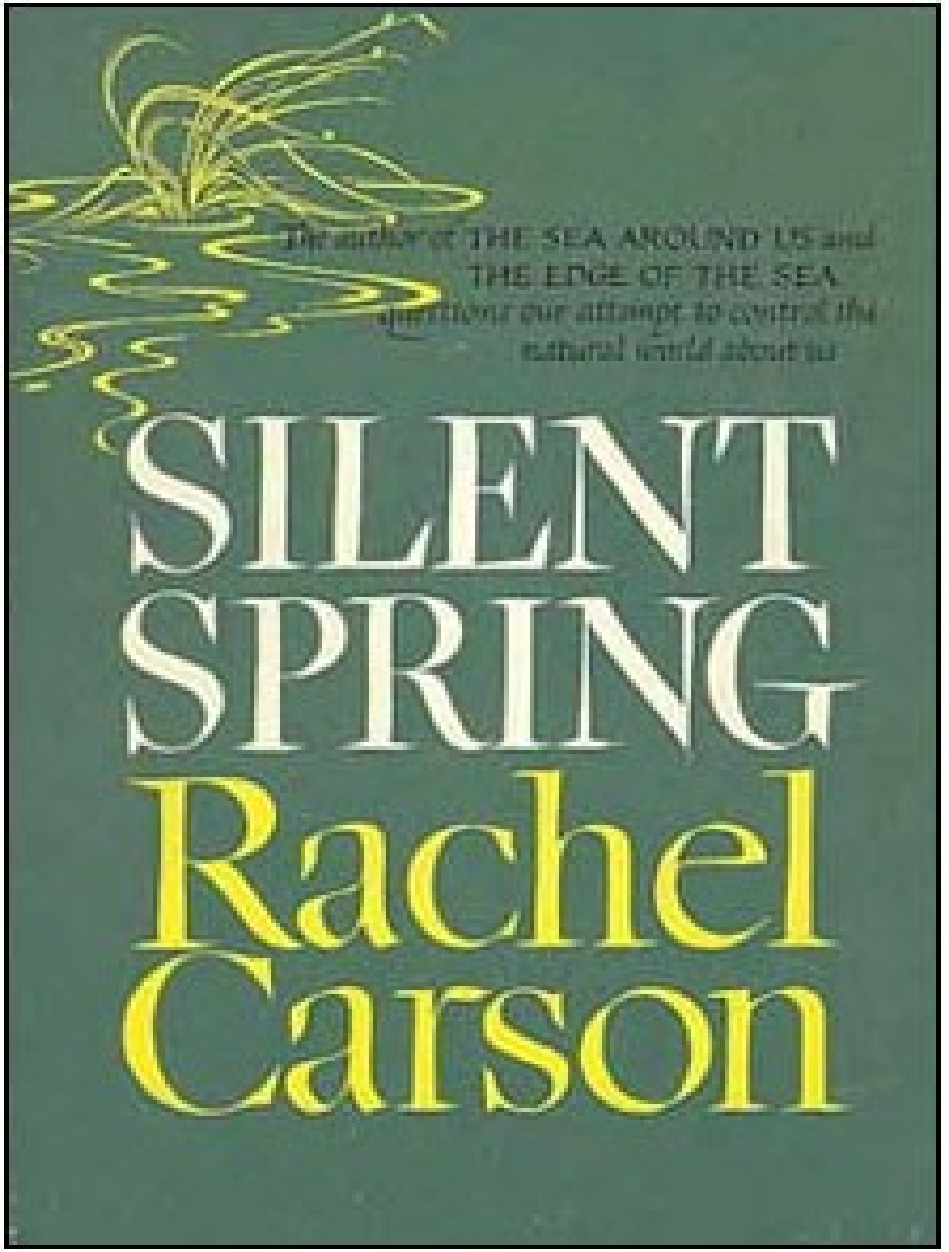

1. Carbon in the air
Balanced, carbon cycle
2. Plants take in CO2
3. Living things eat the plants
4. Animals eat plants and produce CO2 as a waste product.
5. Rotting plants release CO2
Forests take huge amounts of carbon out of the air. But we're destroying 80,000 acres of rainforest a day.
1. Nitrogen in the air
Balanced, nitrogen cycle
2. Bacteria put nitrogen in the soil
3. Plants grow
4. Living things eat plants and excrete nitrogen
5. Nitrogen on plants makes them grow
6. Bacteria put nitrogen back into the air
OVERLOADING THE CYCLE
Nitrogen can also return to the air as a powerful greenhouse gas.
OVERLOADING THE CYCLE
Humans take nitrogen from the air for fertilizer: 144 million tons each year. Plants use half or less and the rest runs into surface and groundwater—and eventually the ocean.
CO2
OVERLOADING THE CYCLE
The ocean holds a lot of CO2, but it's past its limit and turning acidic.
OVERLOADING THE CYCLE
Humans take carbon out of the ground—coal and oil—and release almost 40 billion tons into the air each year.
OVERLOADING THE CYCLE
Human and animal waste could fertilize enough crops to feed the world. As much as 300 million tons of it is produced each year, most of it wasted.
Algae blooms. Fish die. There are 95,000 square miles of dead zones.

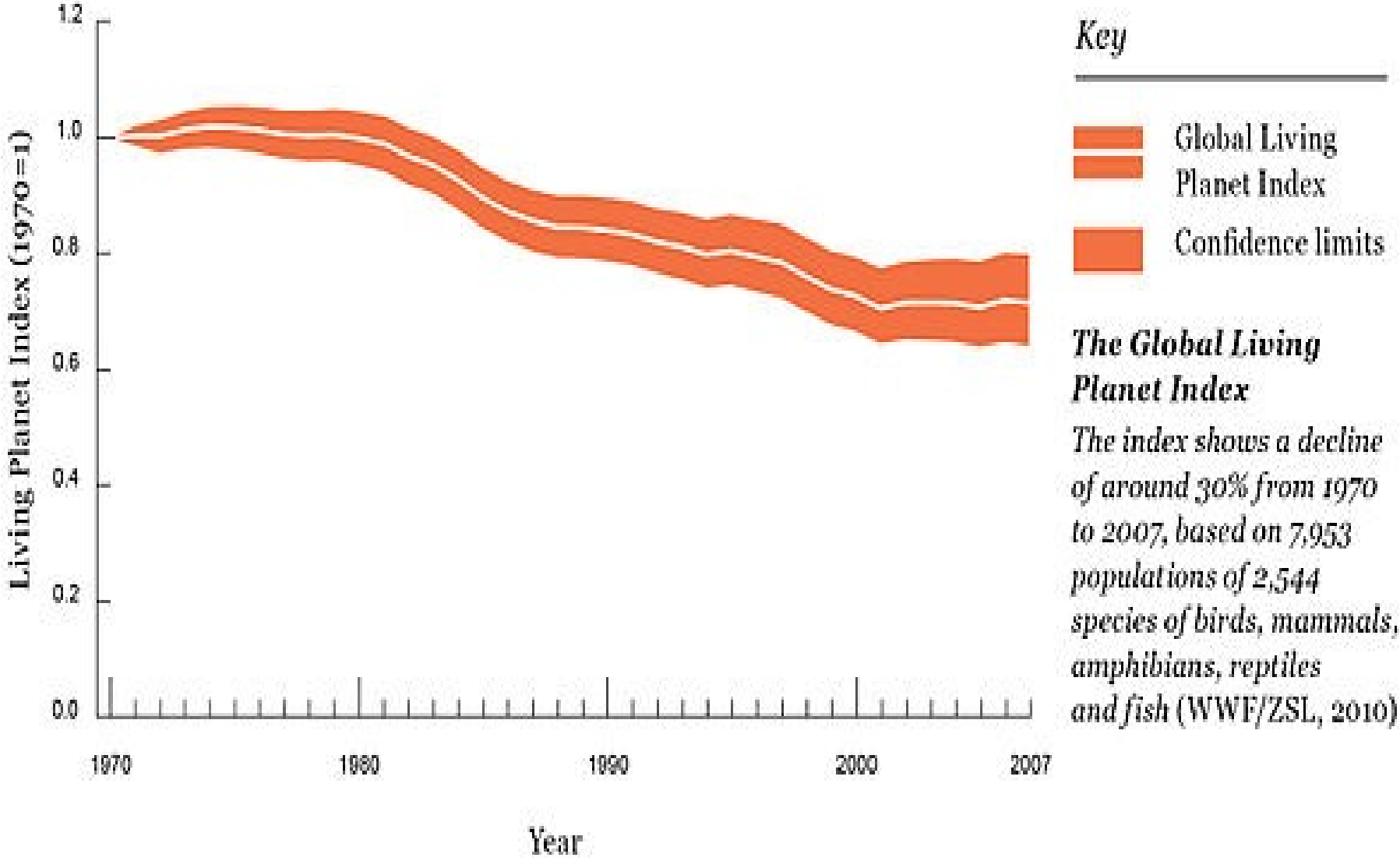

CO_2
Respiration
Photosynthesis
Fossil Fuel Emissions
Volcanic Eruptions
Exchange of CO_2
Weathering of Rocks
Waste and Decay of Dead Organisms
Fossil Fuels, Coal, Oil, and Gas
Limestone (Calcium Carbonate)
Marine Deposits
Long Term
Short Term
Photosynthesis
Respiration
Emissions
Exchange


The Nitrogen Cycle
Atmospheric Nitrogen
Atmospheric Fixation
Industrial Fixation
Protein
Nitrate Reduction
Biological Fixation
Plant & Animal Wastes
Denitrification
Ammonium
Nitrite
Nitrate
Leaching Loss

9 Biodiversity

Film Global Biodiversity Outlook 3


the author of THE SEA AROUND US and
THE EDGE OF THE SEA
SILENT
SPRING
Rachel
Carson


Living Planet Index (1970=1)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
1970
1980
1990
2000
2007
Year
Key
Global Living Planet Index
Confidence limits
The Global Living Planet Index
The index shows a decline of around 30% from 1970 to 2007, based on 7,953 populations of 2,544 species of birds, mammals, amphibians, reptiles and fish (WWF/ZSL, 2010)

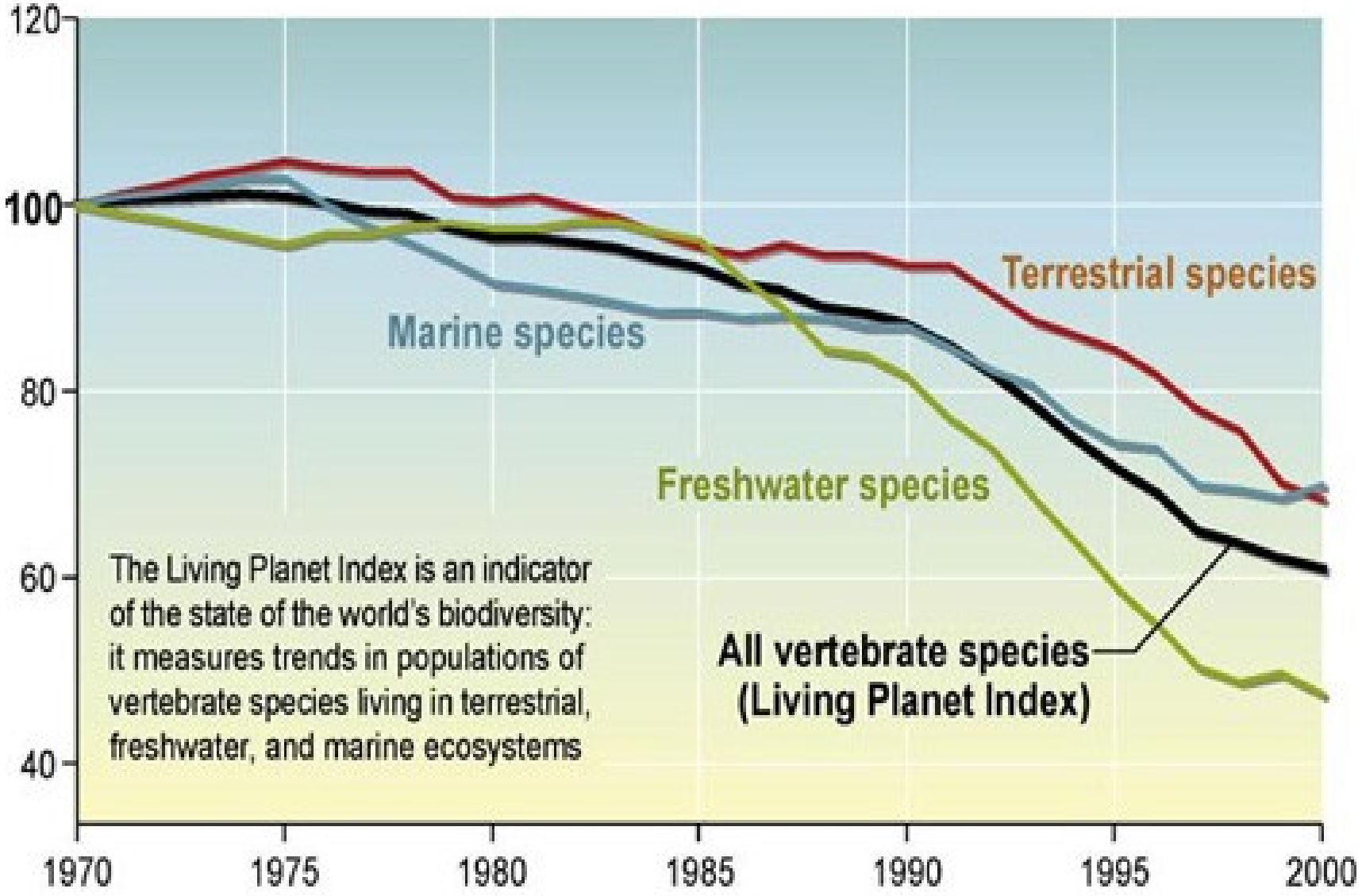

Population Index = 100 in 1970
120
100
80
60
40
1970
1975
1980
1985
1990
1995
2000
Terrestrial species
Marine species
Freshwater species
All vertebrate species
(Living Planet Index)
The Living Planet Index is an indicator of the state of the world's biodiversity: it measures trends in populations of vertebrate species living in terrestrial, freshwater, and marine ecosystems
Source: WWF, UNEP-WCMC

Figure 1: The Global Living Planet Index
The index shows a decline of around 30% from 1970 to 2008, based on 9,014 populations of 2,688 species of birds, mammals, amphibians, reptiles and fish. Shading on this, and all Living Planet Index figures represents the 95% confidence limits surrounding the trend; the wider the shading, the more variable the underlying trend (WWF/ZSL, 2012).

Key

Global Living Planet Index

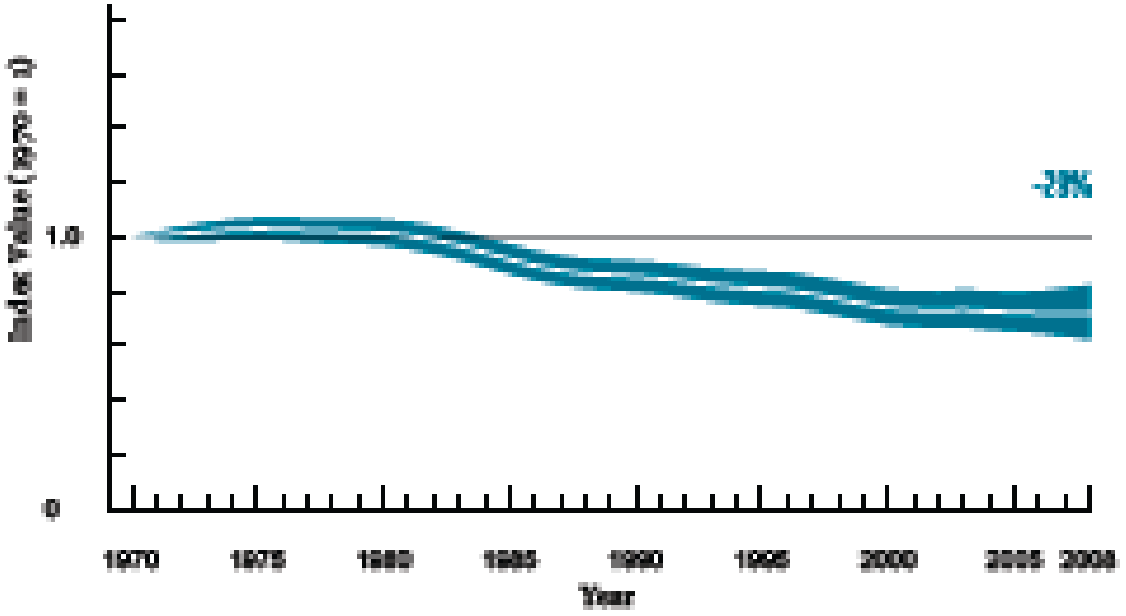
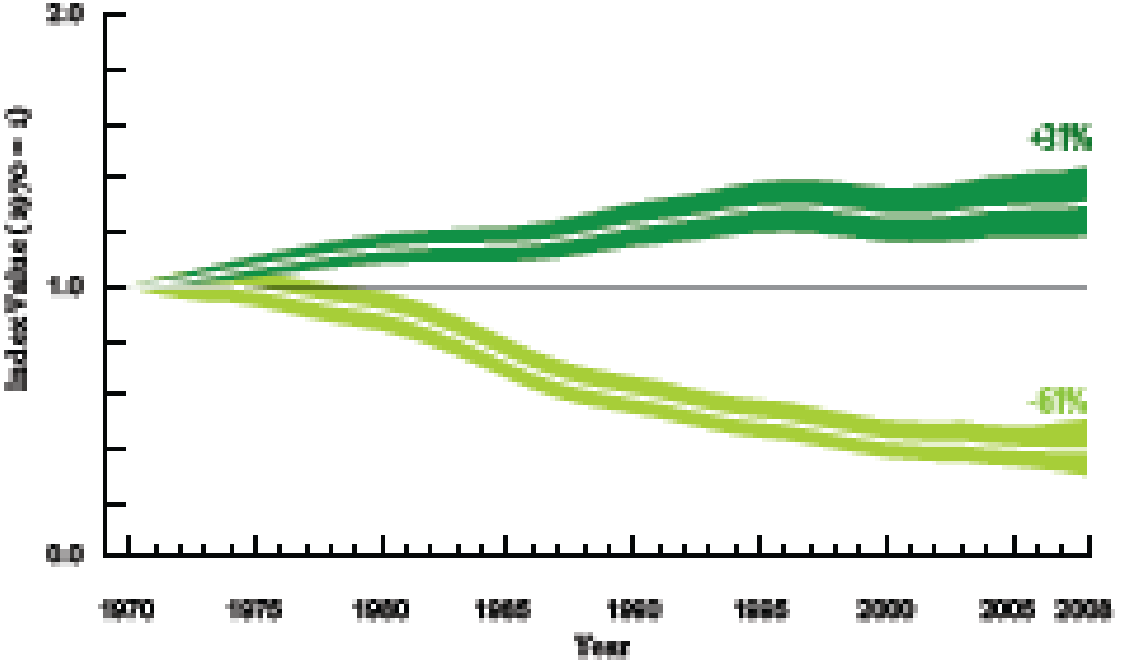


Figure 2: The Tropical and Temperate Living Planet indices
The global tropical index shows a decline of around 61% between 1970 and 2008. The global temperate index shows an increase of around 31% over the same period (WWF/ZSL, 2012).

Key

Tropical Living Planet Index

Temperate Living Planet Index



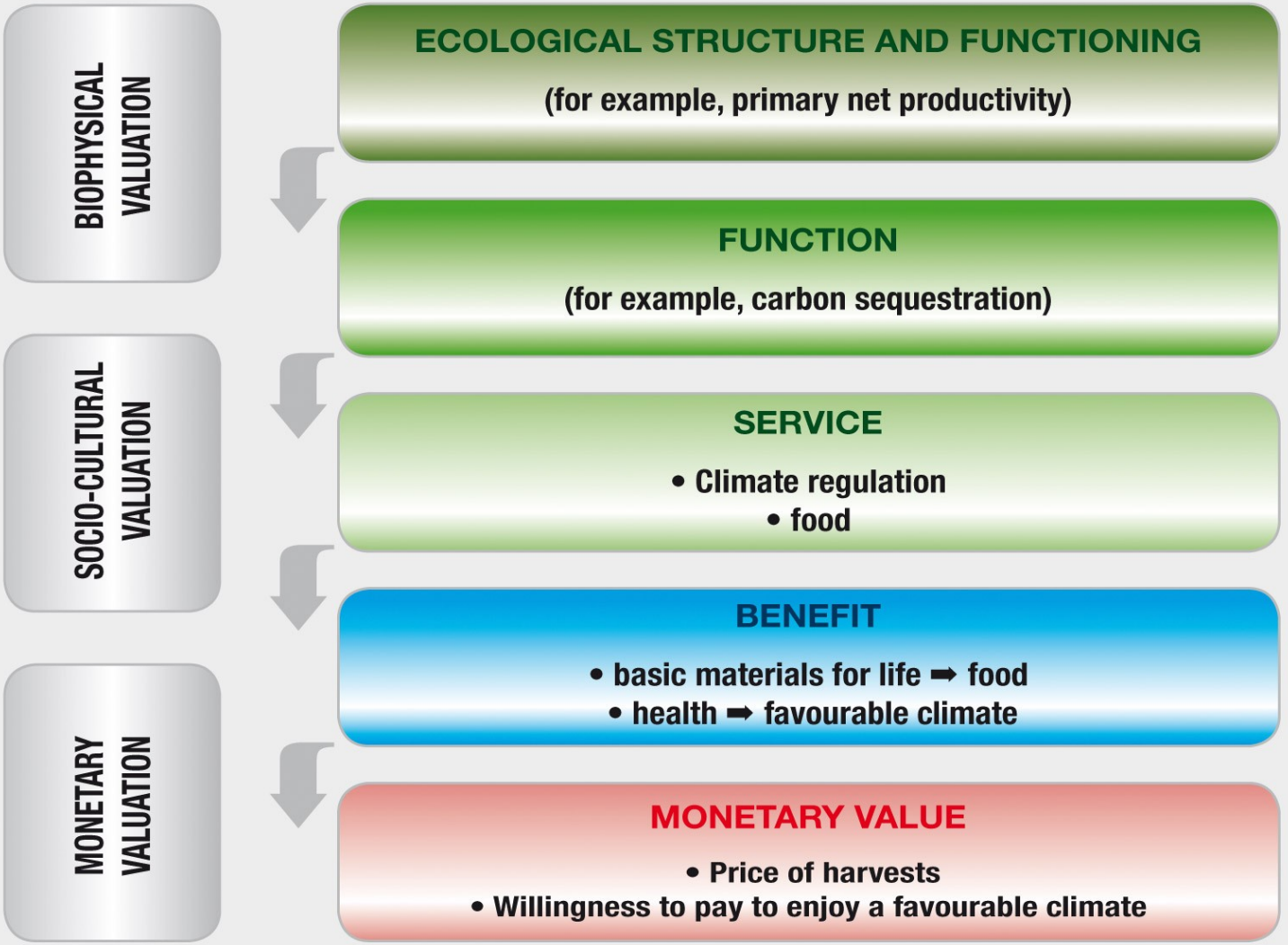
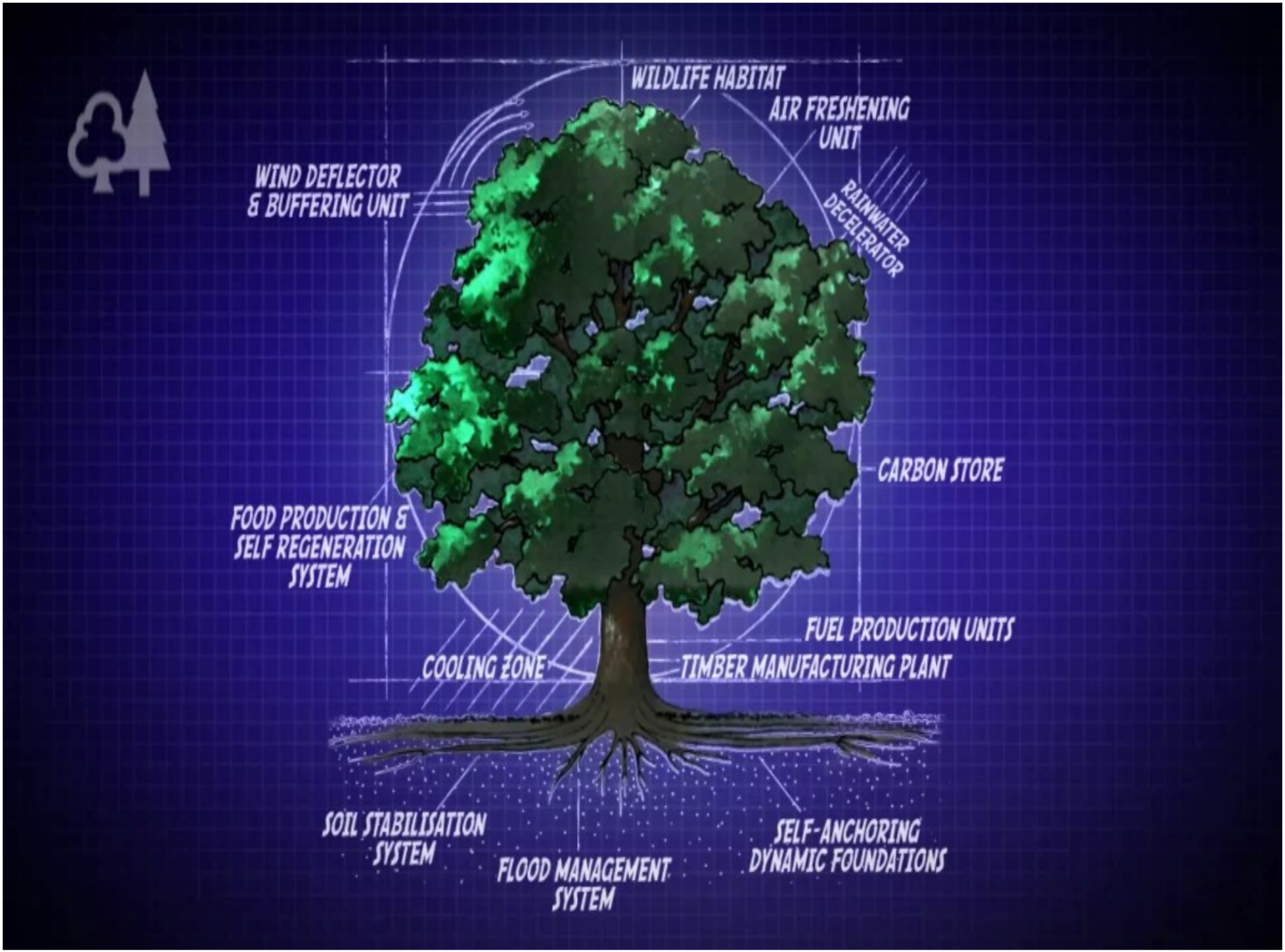
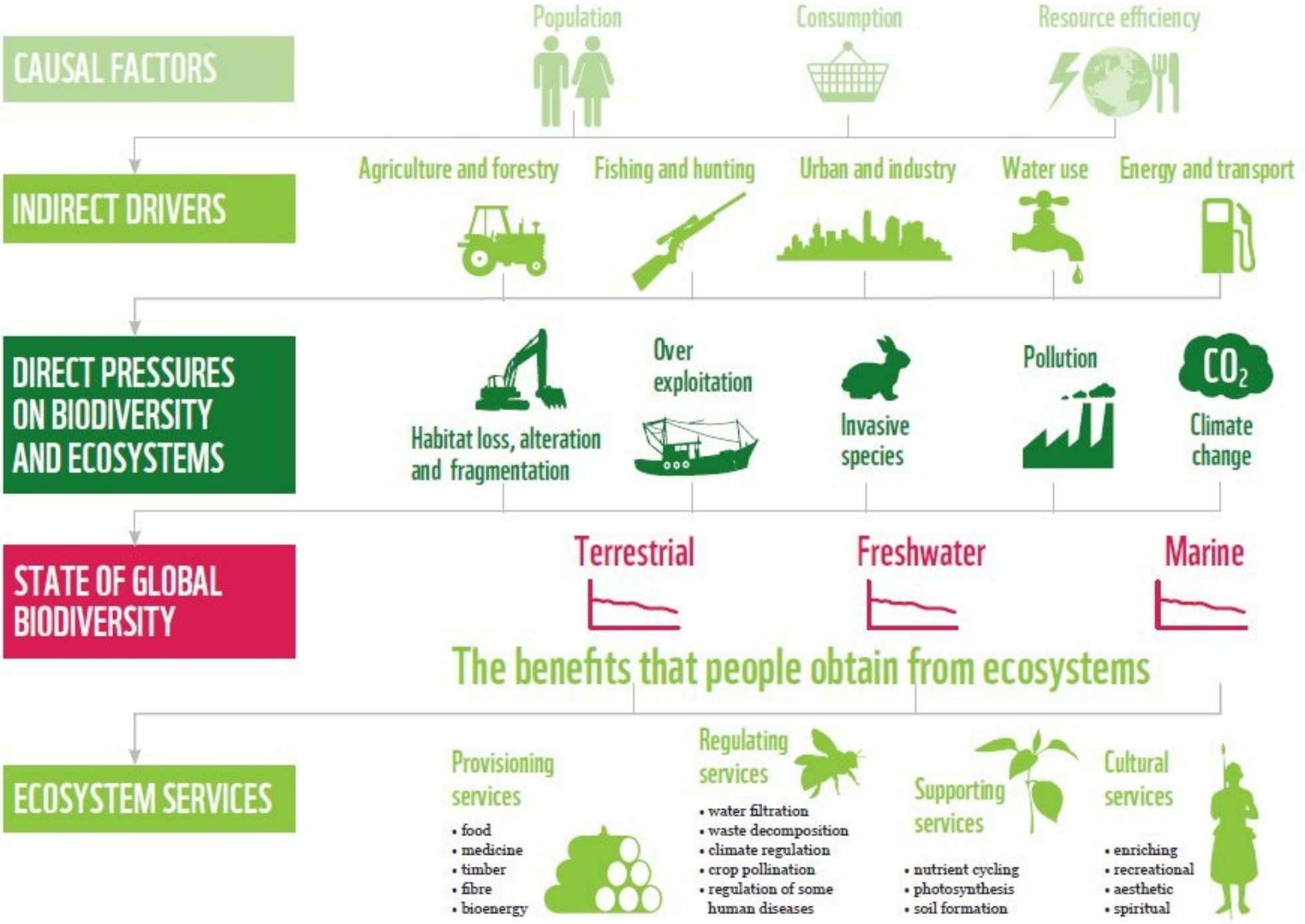
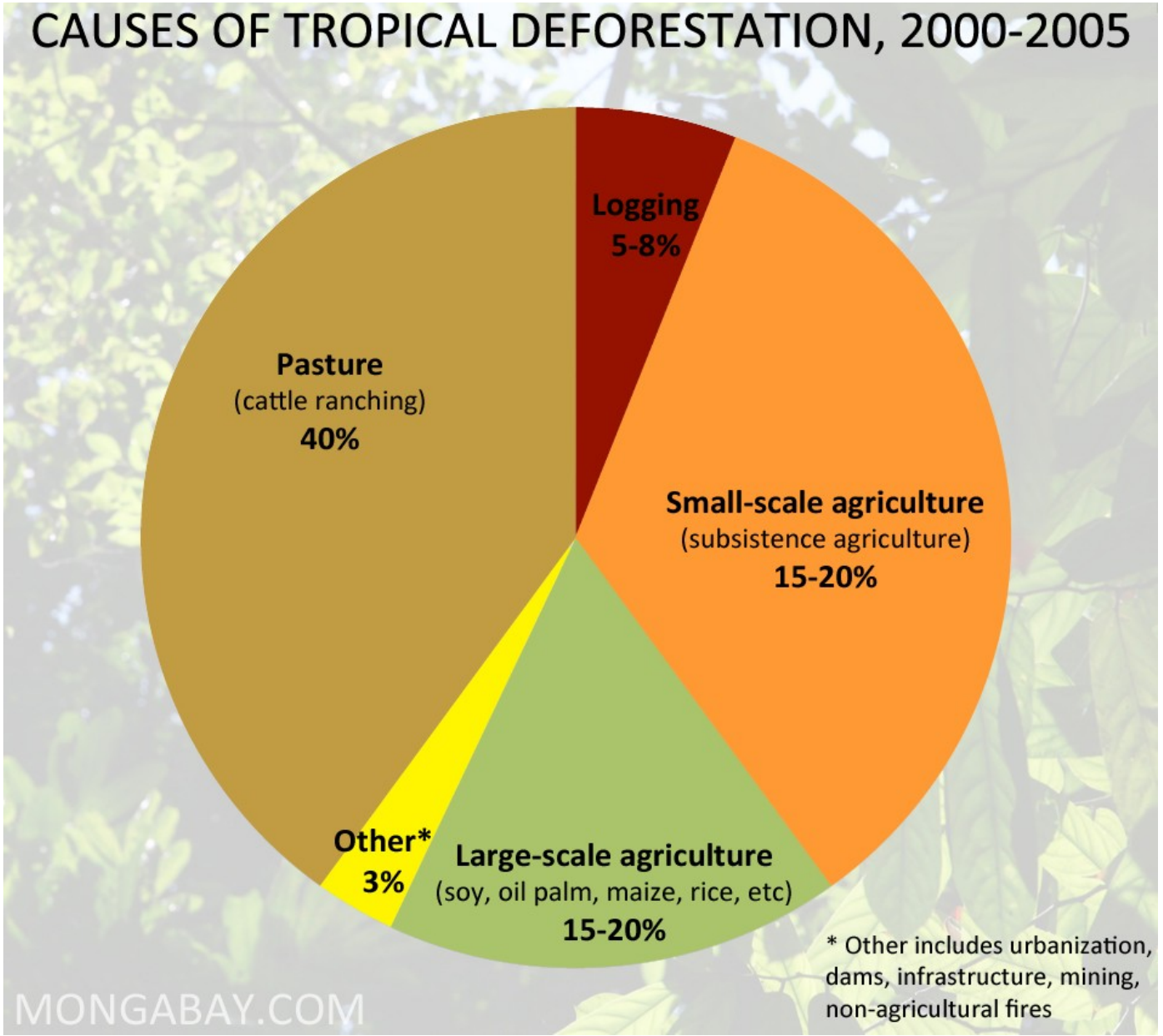


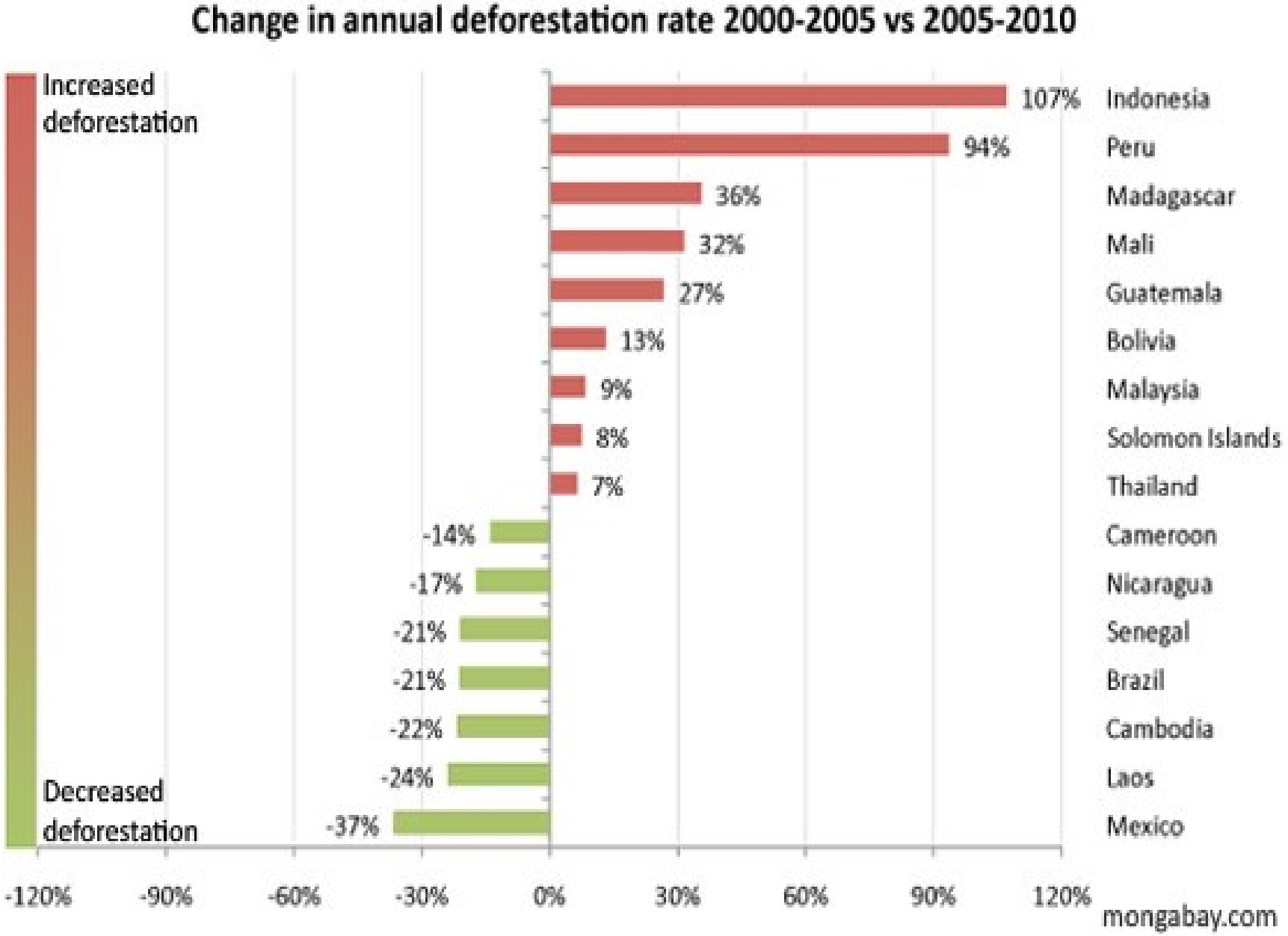
Figure 2. Phases in valuing ecosystem services.

Valuing ecosystems requires biophysical (for example, characterisation of ecological functions), social (for example, people's needs) and economic (monetary and non-monetary contributions to human welfare) information to be integrated. The traditional compartmentalisation into disciplines is a serious obstacle to integrating this information. Figure after Haines-Young and Postching (2010), published in *Ecosystem Ecology: a new synthesis,* Cambridge University Press.

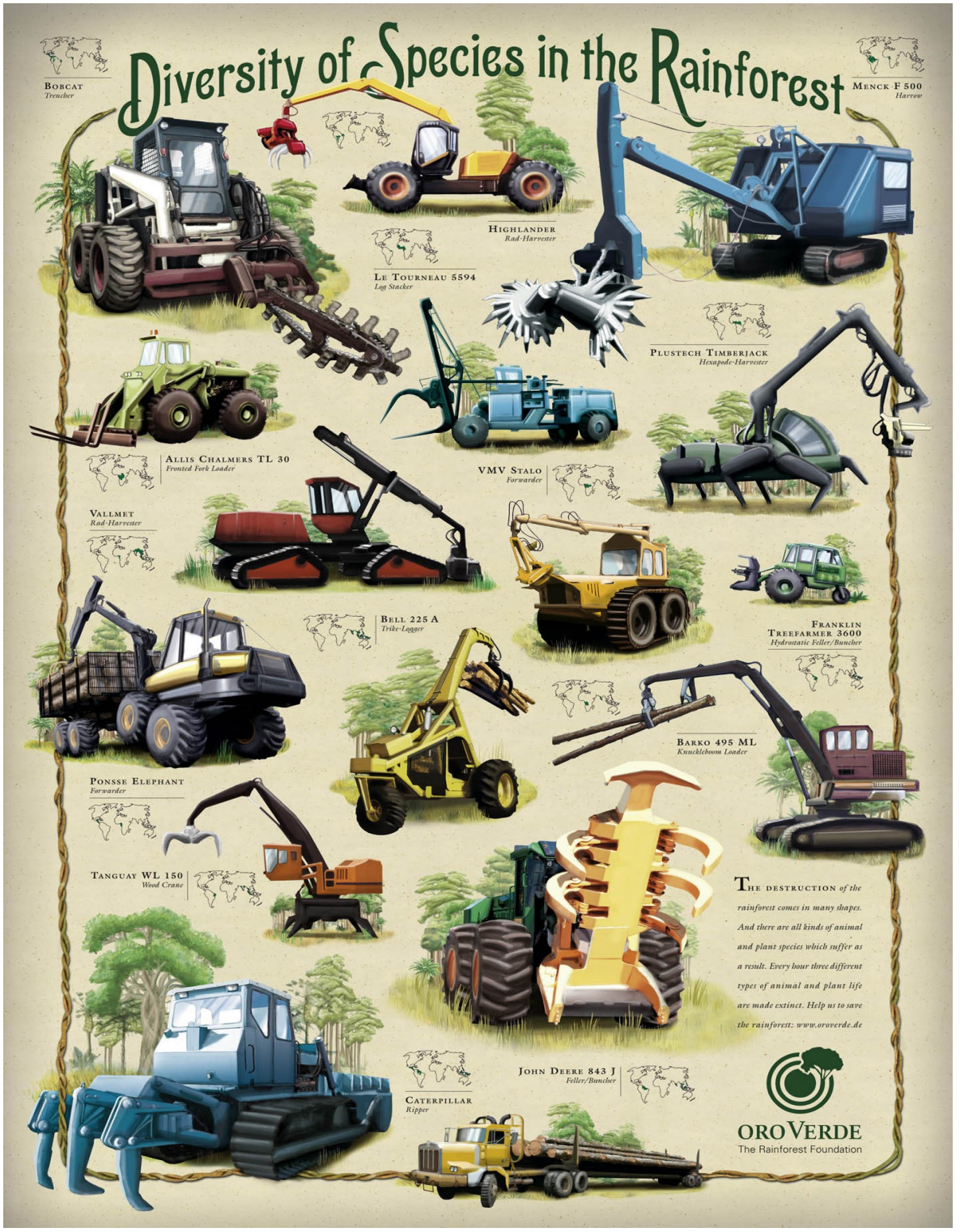

WILDLIFE HABITAT
AIR FRESHENING UNIT
WIND DEFLECTOR & BUFFERING UNIT
RAINWATER DECELERATOR
CARBON STORE
FOOD PRODUCTION & SELF REGENERATION SYSTEM
FUEL PRODUCTION UNITS
COOLING ZONE
TIMBER MANUFACTURING PLANT
SOIL STABILISATION SYSTEM
FLOOD MANAGEMENT SYSTEM
SELF-ANCHORING DYNAMIC FOUNDATIONS


CAUSAL FACTORS
Population
Consumption
Resource efficiency
INDIRECT DRIVERS
Agriculture and forestry
Fishing and hunting
Urban and industry
Water use
Energy and transport
DIRECT PRESSURES ON BIODIVERSITY AND ECOSYSTEMS
Habitat loss, alteration and fragmentation
Over exploitation
Invasive species
Pollution
CO_2
Climate change
STATE OF GLOBAL BIODIVERSITY
Terrestrial
Freshwater
Marine
The benefits that people obtain from ecosystems
ECOSYSTEM SERVICES
Provisioning services
• food
• medicine
• timber
• fibre
• bioenergy
Regulating services
• water filtration
• waste decomposition
• climate regulation
• crop pollination
• regulation of some human diseases
Supporting services
• nutrient cycling
• photosynthesis
• soil formation
Cultural services
• enriching
• recreational
• aesthetic
• spiritual


CAUSES OF TROPICAL DEFORESTATION, 2000-2005
Logging
5-8%
Small-scale agriculture
(subsistence agriculture)
15-20%
Large-scale agriculture
(soy, oil palm, maize, rice, etc)
15-20%
Other*
3%
Pasture
(cattle ranching)
40%
* Other includes urbanization, dams, infrastructure, mining, non-agricultural fires
MONGABAY.COM


Change in annual deforestation rate 2000-2005 vs 2005-2010
Increased deforestation
Decreased deforestation
107%
Indonesia
94%
Peru
36%
Madagascar
32%
Mali
27%
Guatemala
13%
Bolivia
9%
Malaysia
8%
Solomon Islands
7%
Thailand
-14%
Cameroon
-17%
Nicaragua
-21%
Senegal
-21%
Brazil
-22%
Cambodia
-24%
Laos
-37%
Mexico
-120%
-90%
-60%
-30%
0%
30%
60%
90%
120%
mongabay.com

Diversity of Species in the Rainforest



The destruction *of the rainforest comes in many shapes. And there are all kinds of animal and plant species which suffer as a result. Every hour three different types of animal and plant life are made extinct. Help us to save the rainforest: www.oroverde.de*

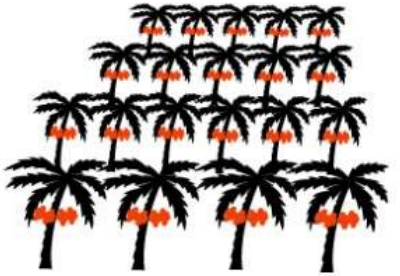
ORO VERDE
The Rainforest Foundation


BORNEO RAINFOREST
MONGABAY.COM

WHAT'S YOUR CONNECTION TO RAINFOREST DESTRUCTION?

Rainforests are **hotspots of biodiversity** and filter vast amounts of carbon from the atmosphere.

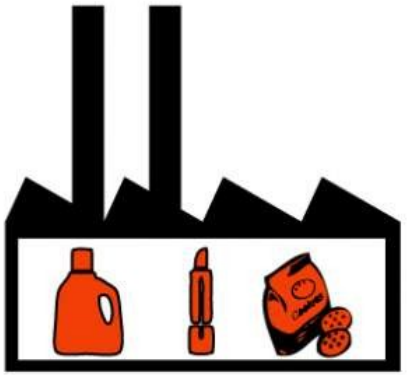
Rainforest destruction for **palm oil** plantations is driving species extinction, massive carbon pollution and community conflict.



Palm oil plantations turn rainforests into biological deserts.

85% of the world's **palm oil** comes from Indonesia and Malaysia.

Cargill trades **25%** of the world's **palm oil** and is the largest importer of palm oil into the United States.



Palm oil is used to make **food products, cosmetics, soaps and detergents.**

50% of all packaged goods sold in the grocery store contain **palm oil.**

Rainforest destruction is likely found in every room of your home.

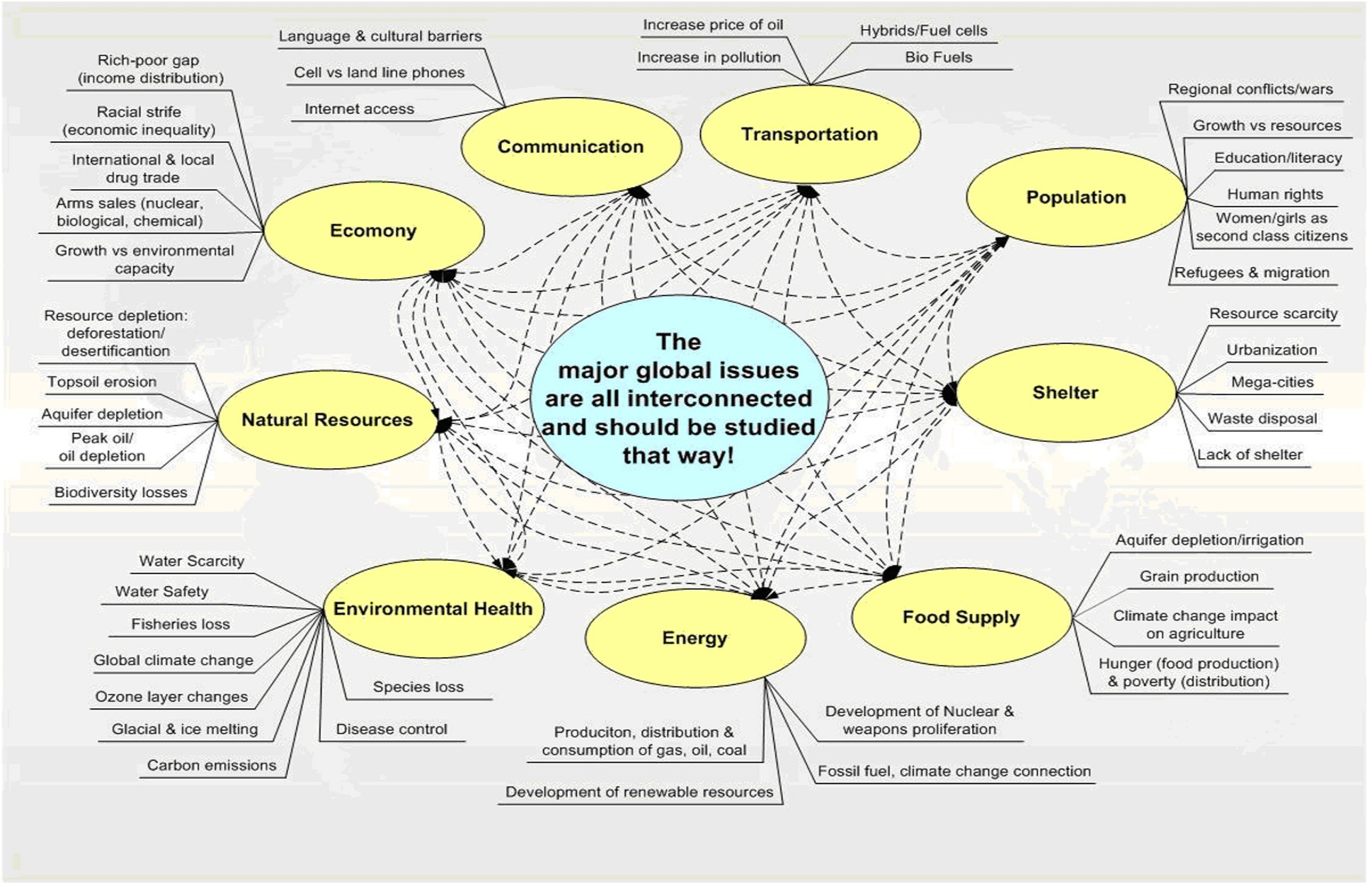
Stop **Cargill**'s rainforest destruction.

Start by sharing this graphic and spreading the word about:

THE PROBLEM WITH PALM OIL.


...SO, AS YOU SEE, IT HAS IMPACT ON MANY SECTORS OF OUR SOCIETY AND...
BIODIVERSITY
Relations
climat
social
economic
ecosystems
diversity
monocult
agriculture-biological
human resources

10 Changes in the human-based systems



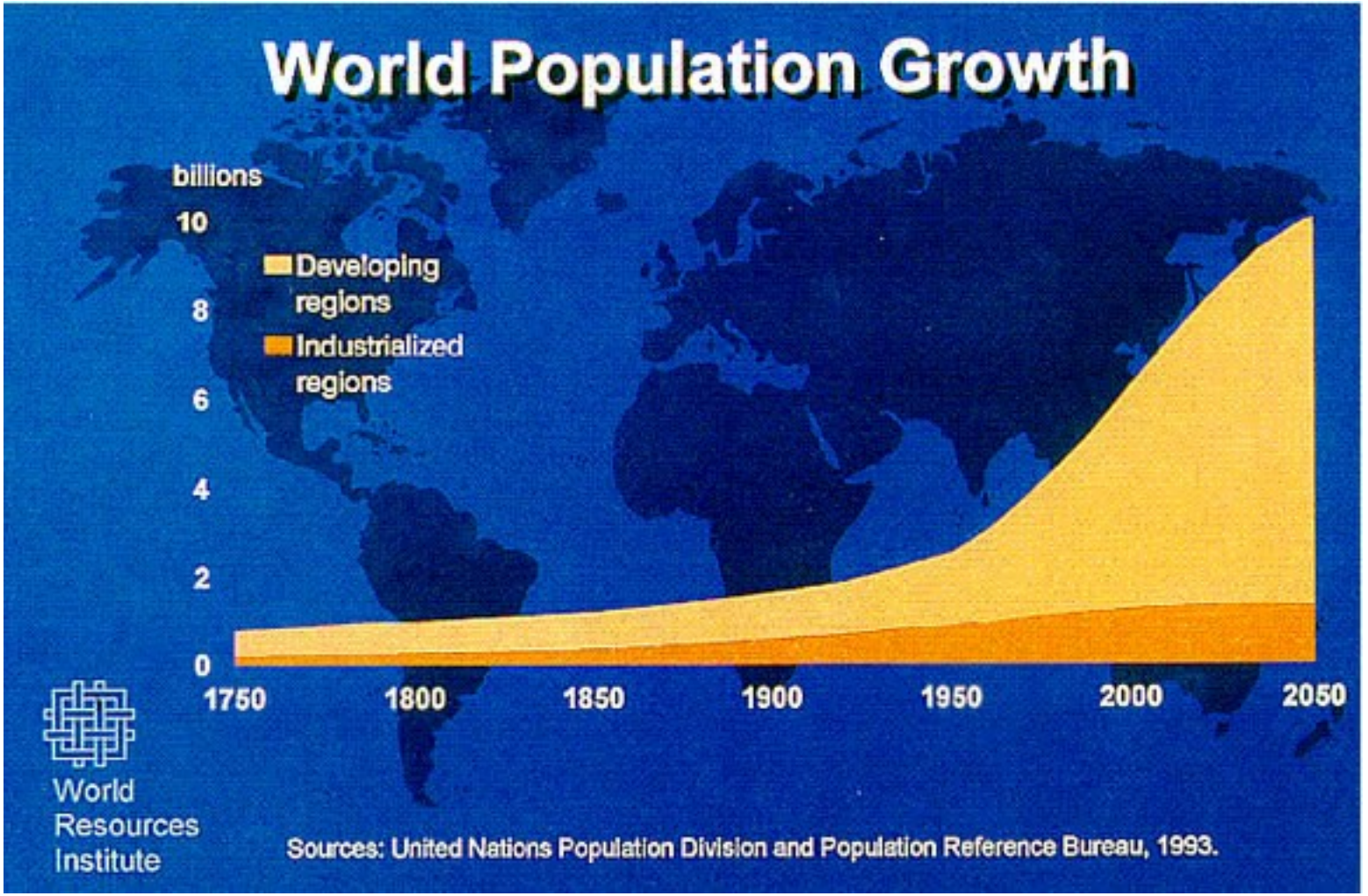
11 Economic growth

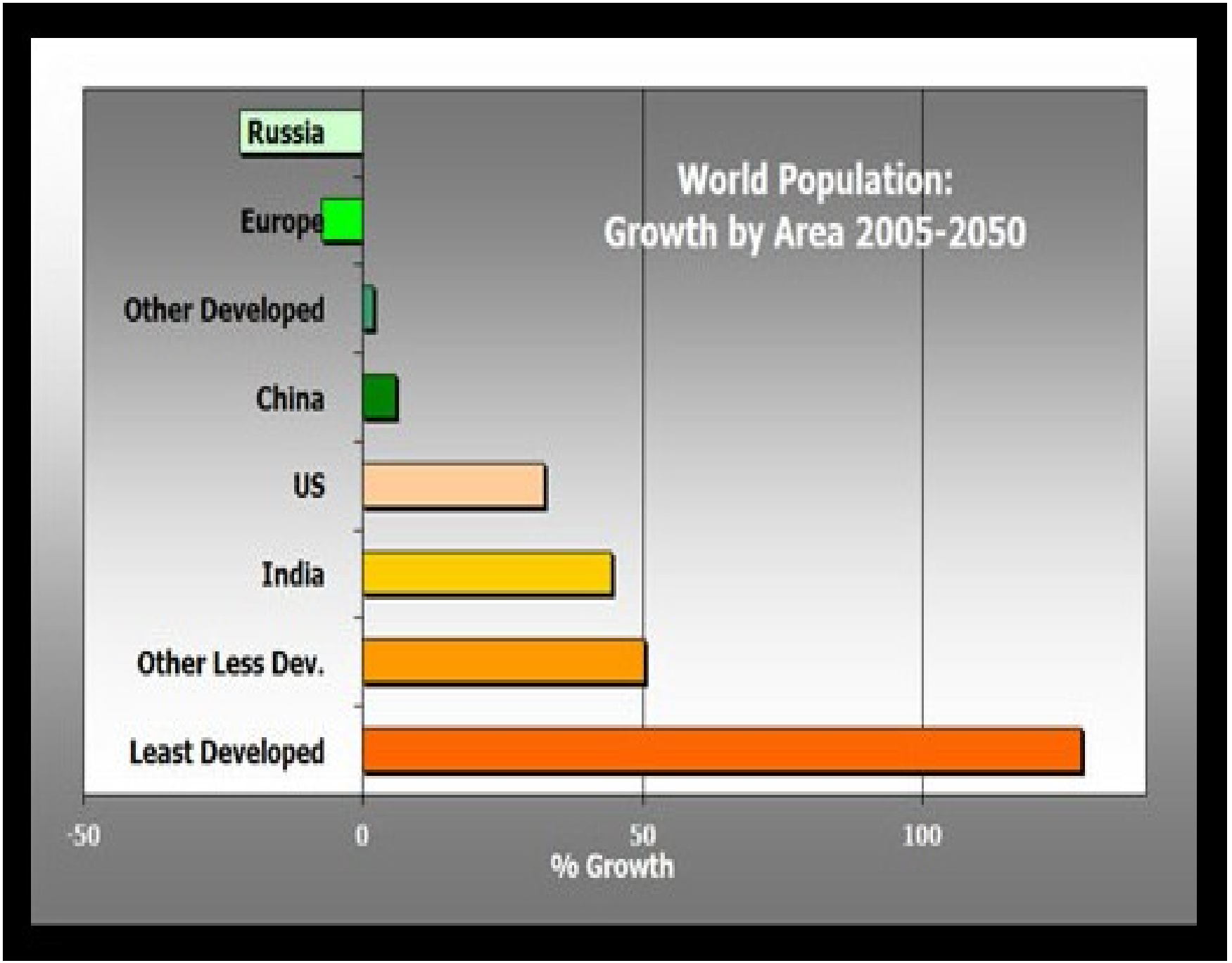
Film Going beyond GSP

Film Trade Justice - why world trade rules need to change

'STEADY AS SHE GOES'

12 Population Growth




World Population:
Growth by Area 2005-2050
Russia
Europe
Other Developed
China
US
India
Other Less Dev.
Least Developed
-50
0
50
100
% Growth

13 Consumption Growth

Film ***Consumerism – Age of stupid animation***

Film Big Ideas That Changed The World - Consumerism

Film Buy it, Use it, Break it, Junk it, it's Toxic

Film **Affluenza**, 60 minute film

14 Production Growth

Film The Story of stuff - Videos on stuff, bottled water, cap and trade, cosmetics and electronics.

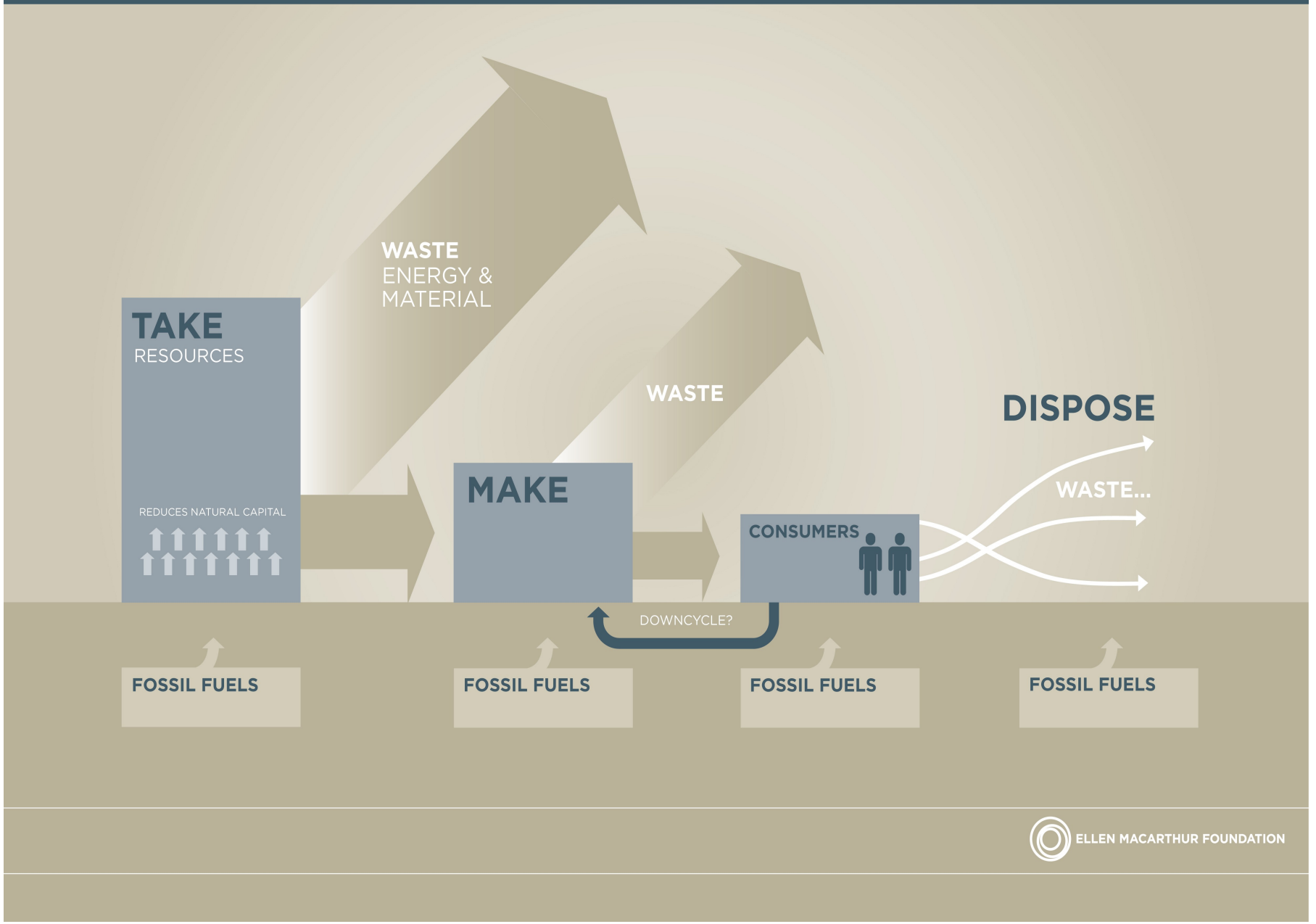
Film The corporation

Film War for resources – Age of stupid animation

15 Linear Economy

Film Get Loopy 12 mins.

LINEAR ECONOMY



ELLEN MACARTHUR FOUNDATION

16 Ecological Footprints

Film Mathis Wackernagel: The Ecological Footprint

THE COMPONENTS OF THE ECOLOGICAL FOOTPRINT

Carbon

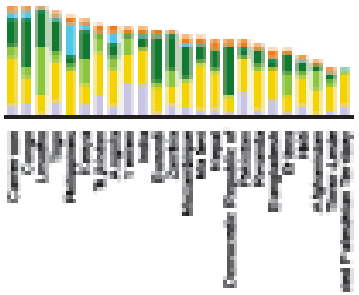
Represents the amount of forest land that could sequester CO_2 emissions from the burning of fossil fuels, excluding the fraction absorbed by the oceans which leads to acidification.

Cropland

Represents the amount of cropland used to grow crops for food and fibre for human consumption as well as for animal feed, oil crops and rubber.

Grazing Land

Represents the amount of grazing land used to raise livestock for meat, dairy, hide and wool products.

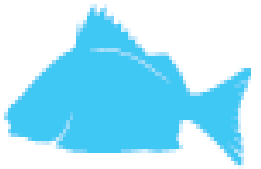


Forest

Represents the amount of forest required to supply timber products, pulp and fuel wood.

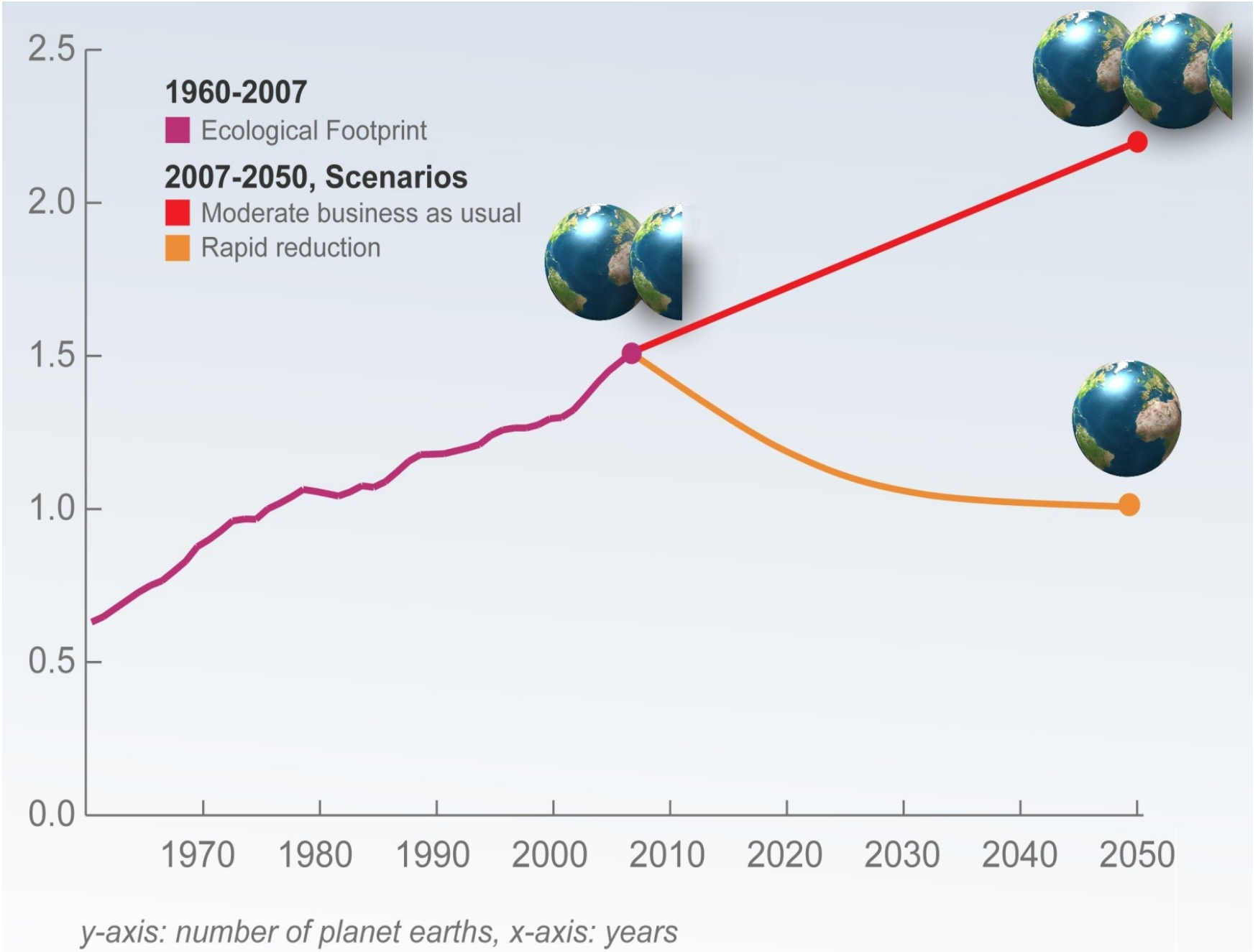
Built-up Land

Represents the amount of land covered by human infrastructure, including transportation, housing, industrial structures and reservoirs for hydropower.

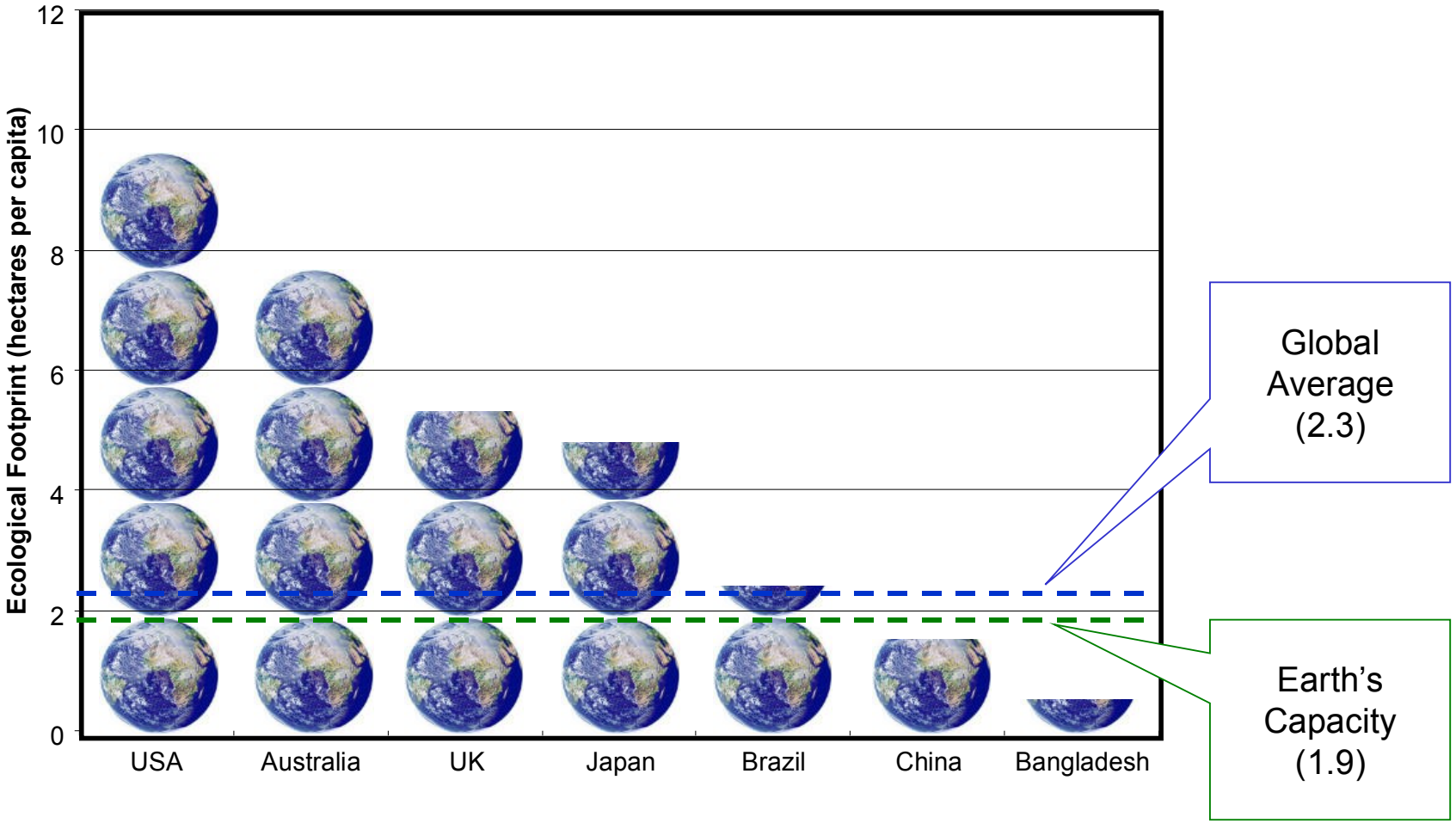


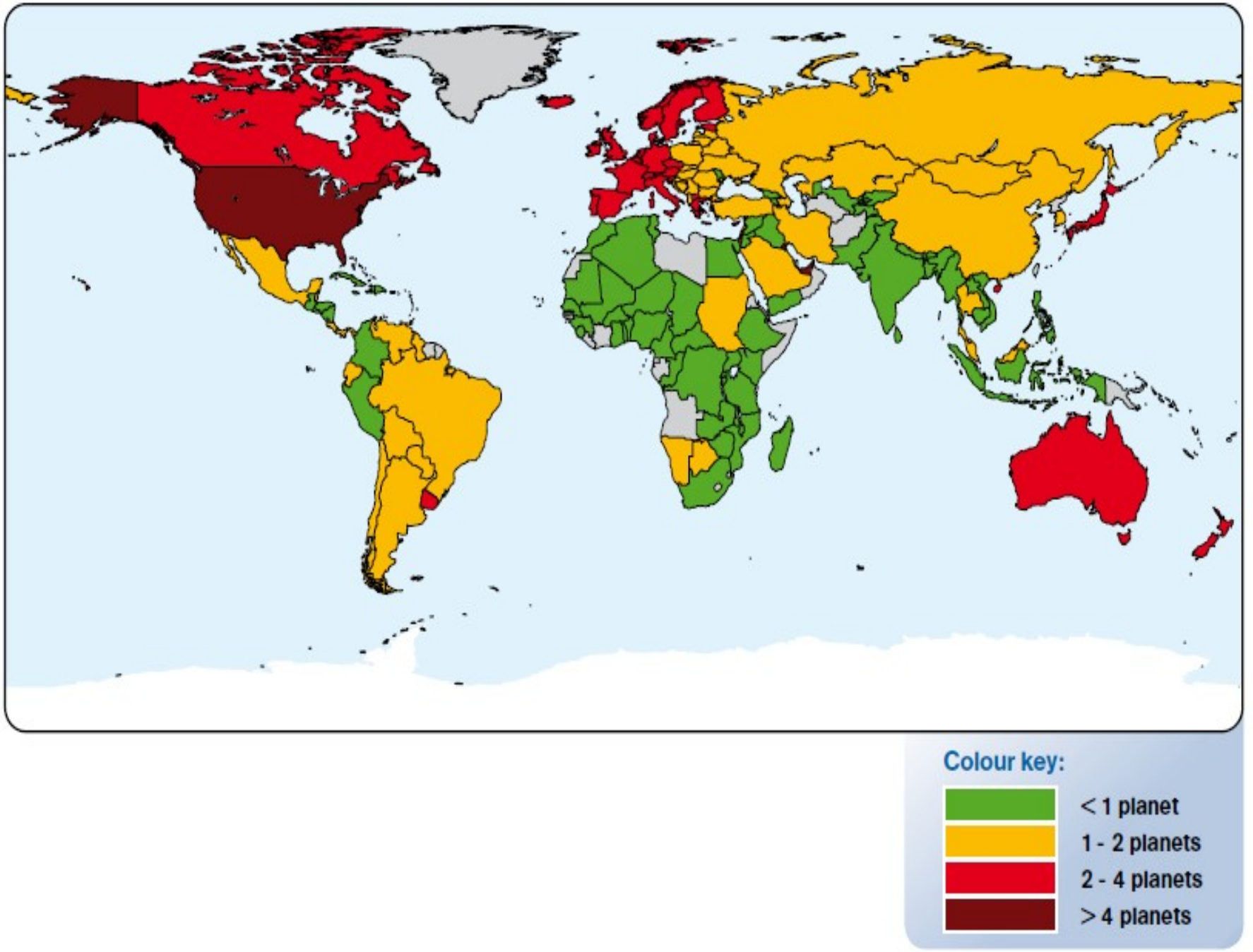
Fishing Grounds

Calculated from the estimated primary production required to support the fish and seafood caught, based on catch data for marine and freshwater species.

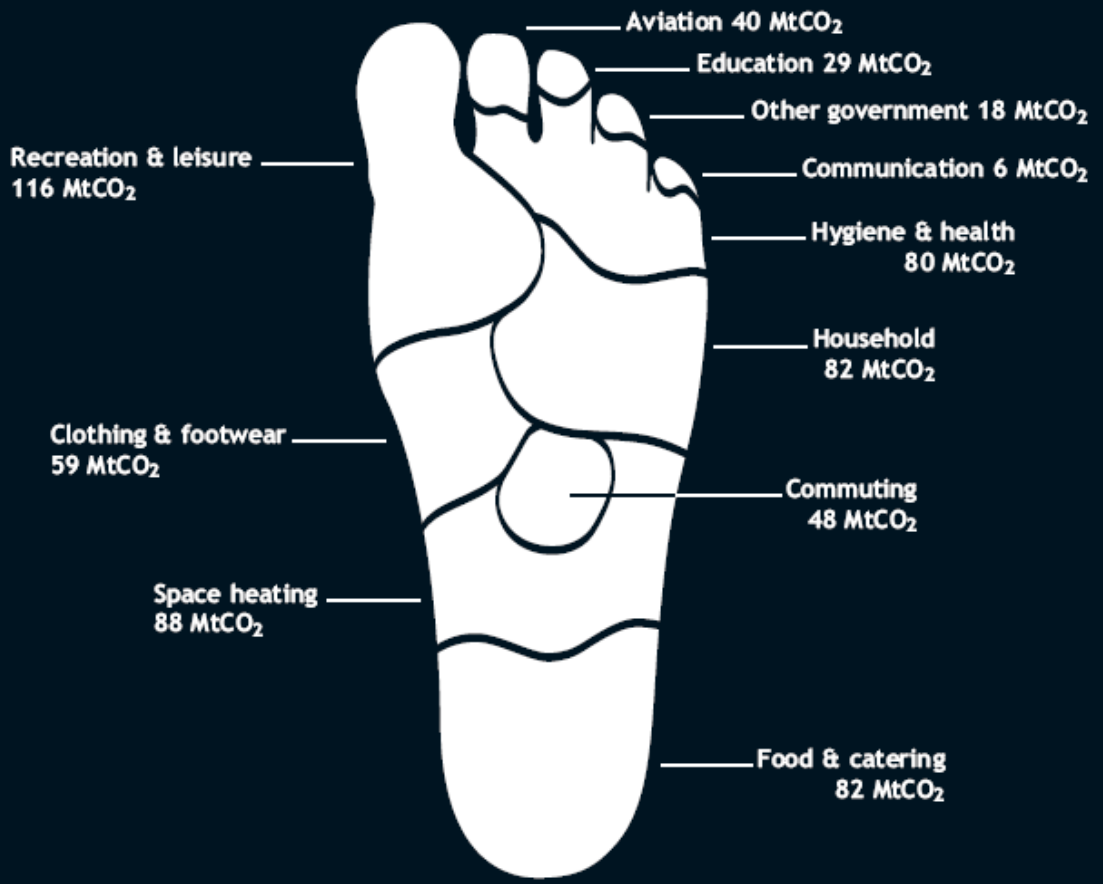

2.5
2.0
1.5
1.0
0.5
0.0
1960-2007
Ecological Footprint
2007-2050, Scenarios
Moderate business as usual
Rapid reduction
1970
1980
1990
2000
2010
2020
2030
2040
2050
y-axis: number of planet earths, x-axis: years

Per Capita Ecological Footprint for Selected Countries




Colour key:
< 1 planet
1 - 2 planets
2 - 4 planets
> 4 planets

Understanding the UK's carbon footprint is the first step in reducing it.



Now let us help reduce yours.

The UK's carbon footprint is 648 million tonnes CO_2, the annual emissions embedded in everything we do*. With the Carbon Trust, individual businesses can reduce their footprint through proven carbon management and by developing the lower carbon products and services that consumers will increasingly demand. This will not only benefit business but the UK as a whole. Call us today on 0800 085 2005 or visit www.carbontrust.co.uk

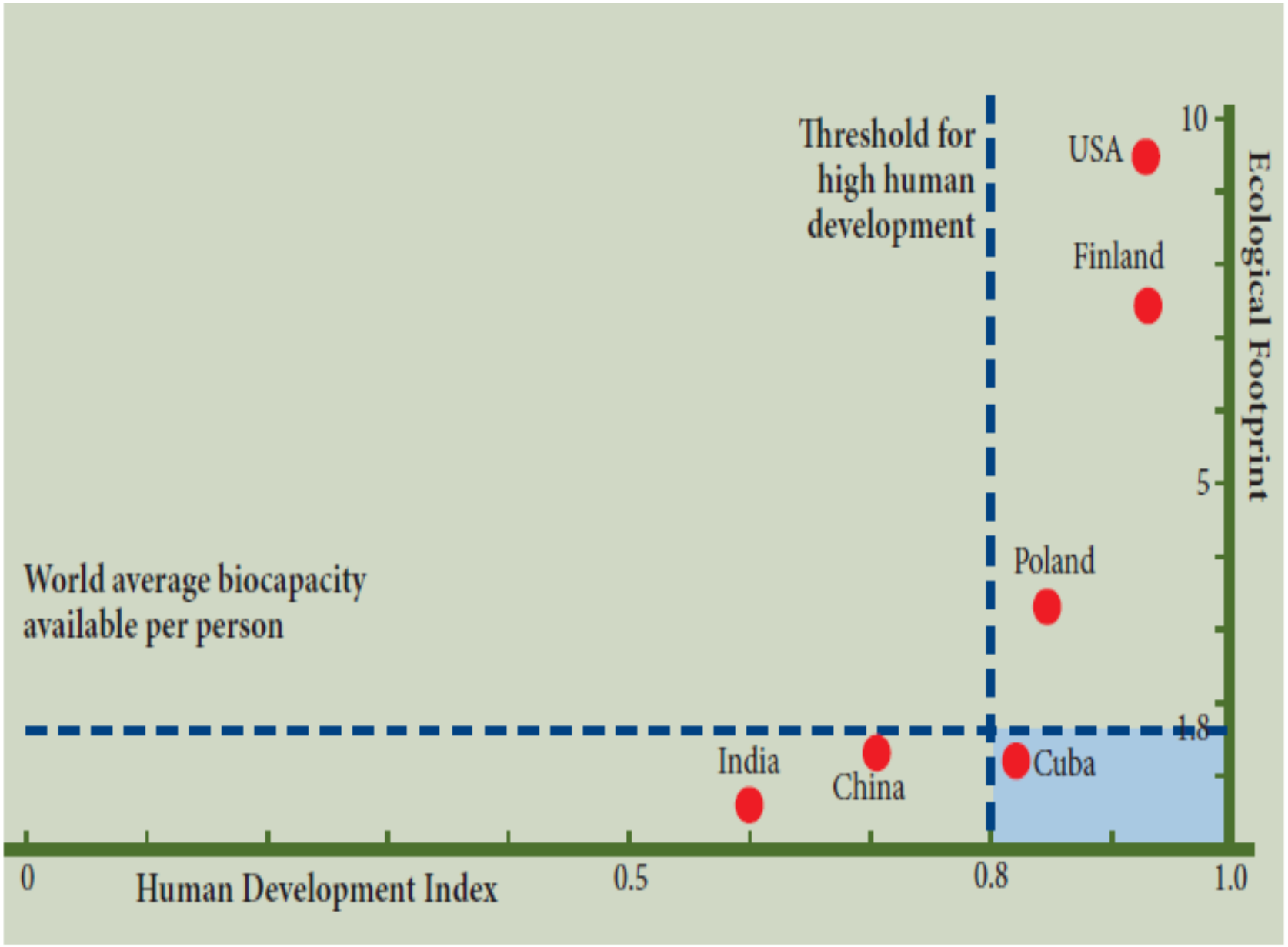
CARBON TRUST
Making business sense of climate change

*Source: Carbon Trust Report (CTC403), 'The carbon emissions embedded in all that we consume', using the UK Carbon Attribution Model, centre for Environmental Strategy, 2006

17 Human Development Index

Film The miniature Earth

Film Human Development Report 2007/2008: Climate change and human development


Threshold for high human development
USA
Finland
Poland
Cuba
China
India
World average biocapacity available per person
10
5
1.8
Ecological Footprint
0
Human Development Index
0.5
0.8
1.0