Lecture 1: Systems thinking, system diagrams, systems analysis

Lecture 2: Ecosystems, Succession, Dynamics, Complex systems cycle (Holling)

Lecture 3: Human population

Lecture 4: Agriculture

Lecture 5: Energy basis for socio-ecological development: from solar to fossil fuels back to solar

Lecture 6: Global Climate Change

Lecture 7: Ecological Economics and Ecosystem Services

Lecture 8: Urban systems

Lecture 9: Sustainability and Sustainable Development Goals

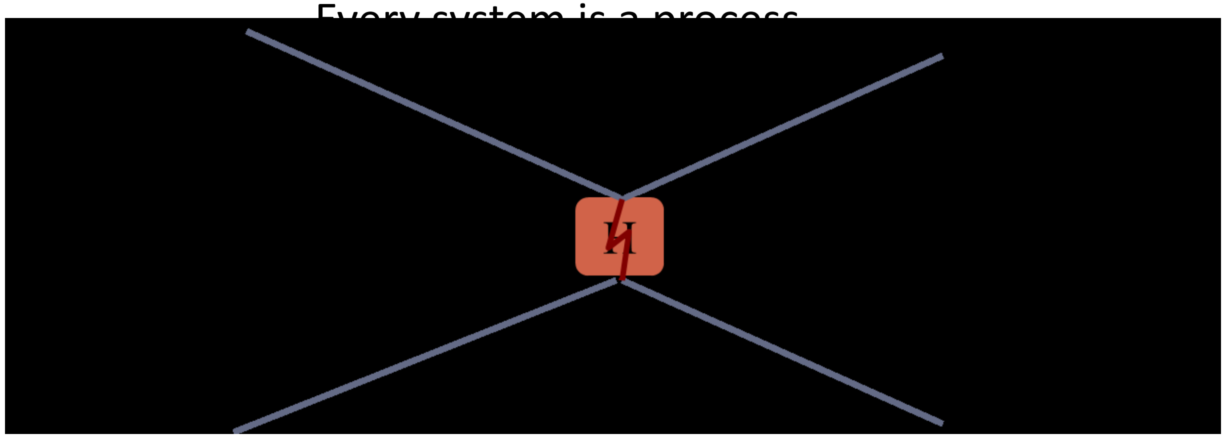
Lecture 1: Systems thinking, system diagrams, systems analysis

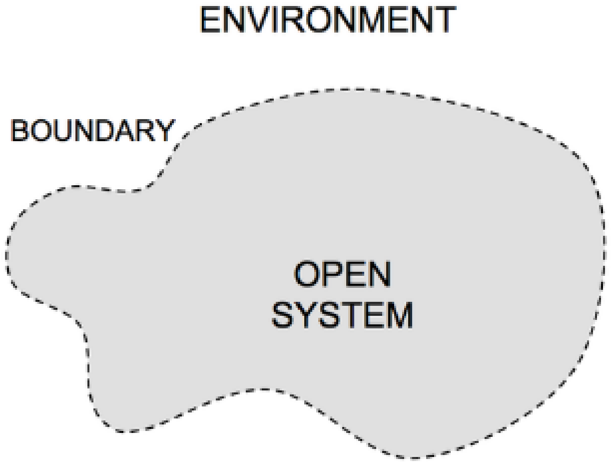
System boundaries

- What is part of your question and what is not?

- How you determine this first part largely determines the answers the question

Every system is a process





Unintended consequences

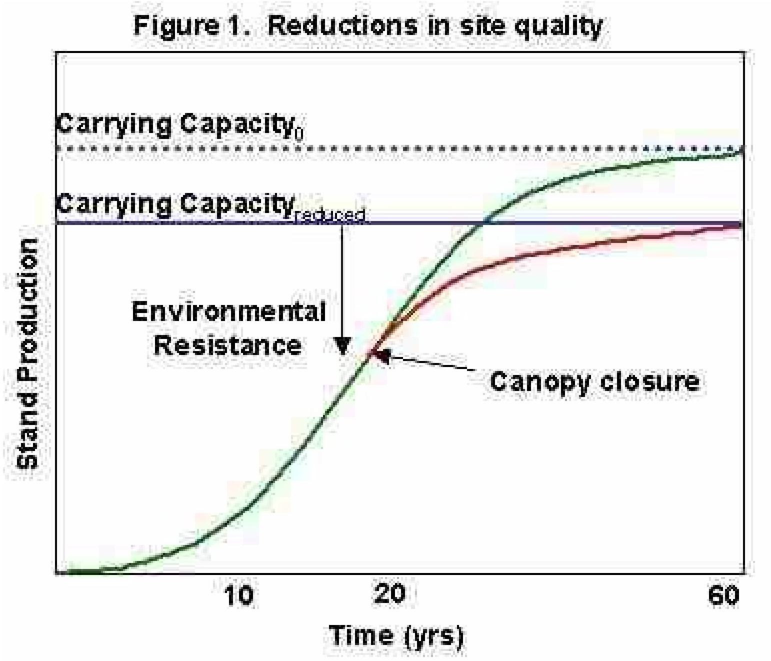
- Acid precipitation/rain
- Ozone depletion
- Eutrophication
- Global climate change
- Automobile dependency
- …
- All of today’s major environmental problems emerge from yesterday’s solutions.

Key systems concepts

- Input-Output models
- Feedback
- Time lags
- Exponential growth
- Irreversibility

Carrying Capacity

- max number of individuals of a species that can be sustained by an environment without decreasing the capacity of the environment to sustain that same amount in the future.



Lecture 2: Ecosystems, Succession, Dynamics, Complex systems cycle (Holling)

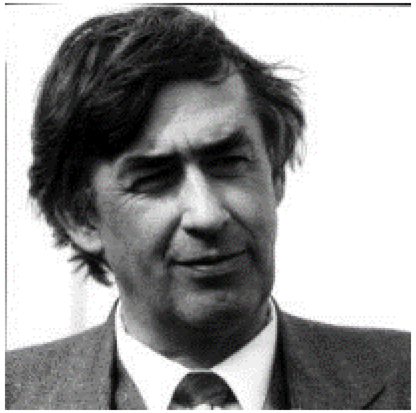
Ecosystem has

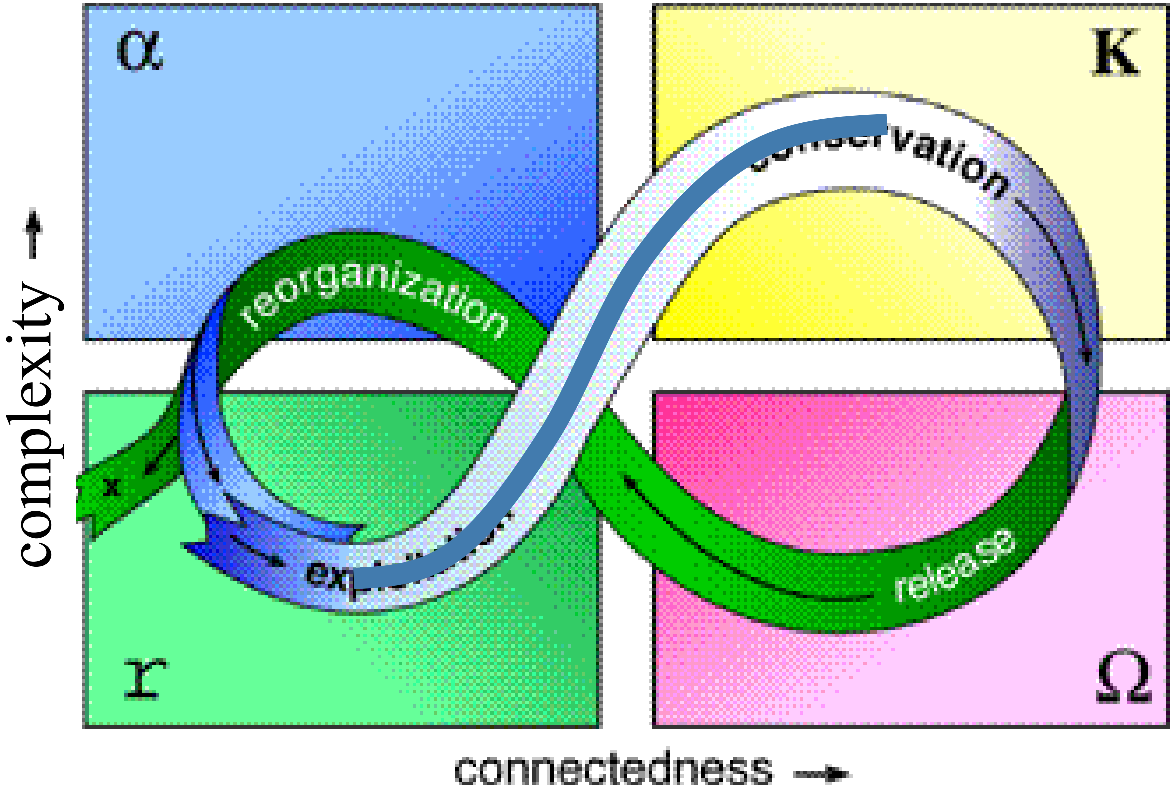
- structure (parts) and
- function (processes) and is
- dynamic (orderly change called succession)

- Two main functions are
  - Transfer/Exchange of energy
  - Cycling of material (particularly nutrients)

Complex Systems Cycle: Holling's 4-stage model of ecosystem dynamics

Logistic growth only captures part of the cycle

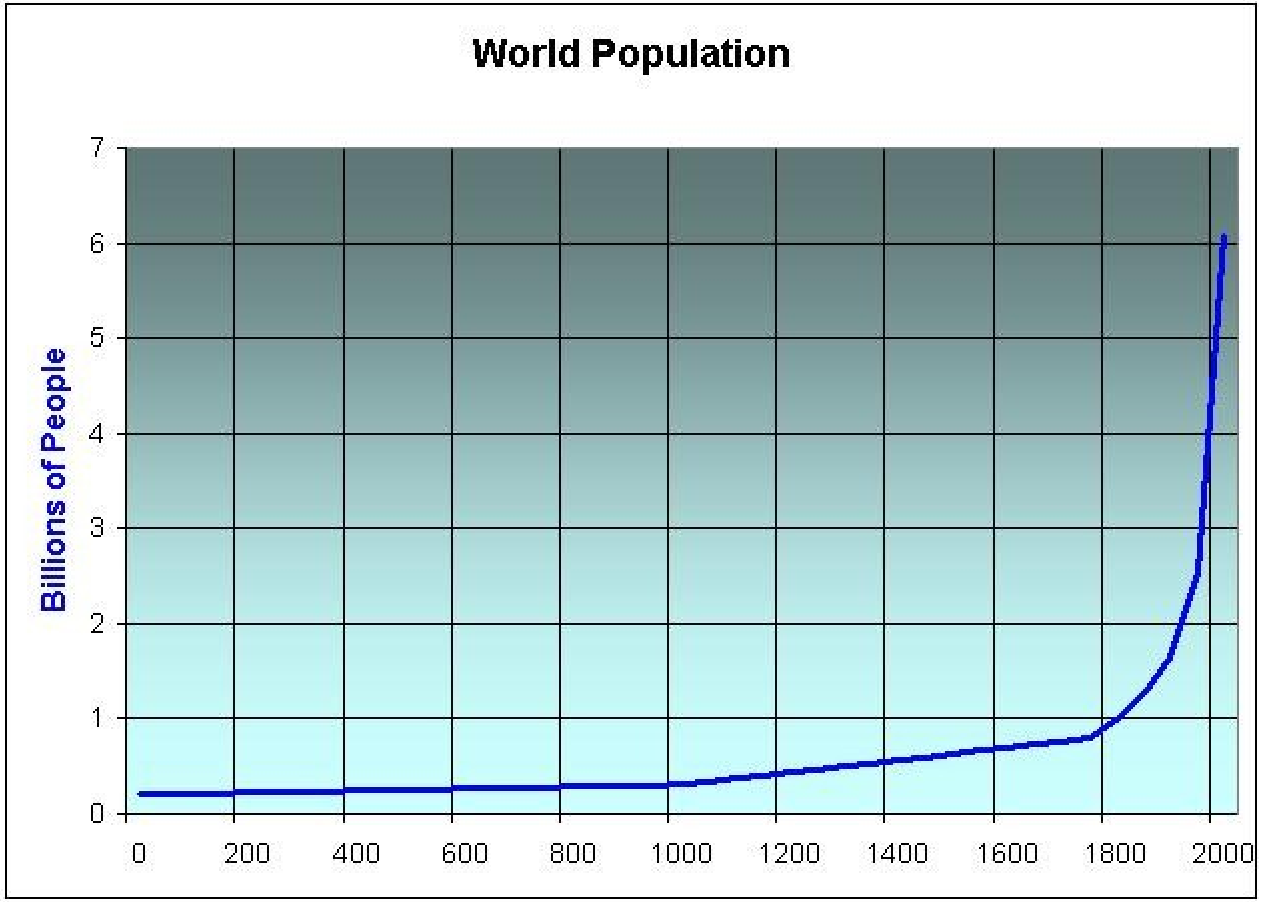




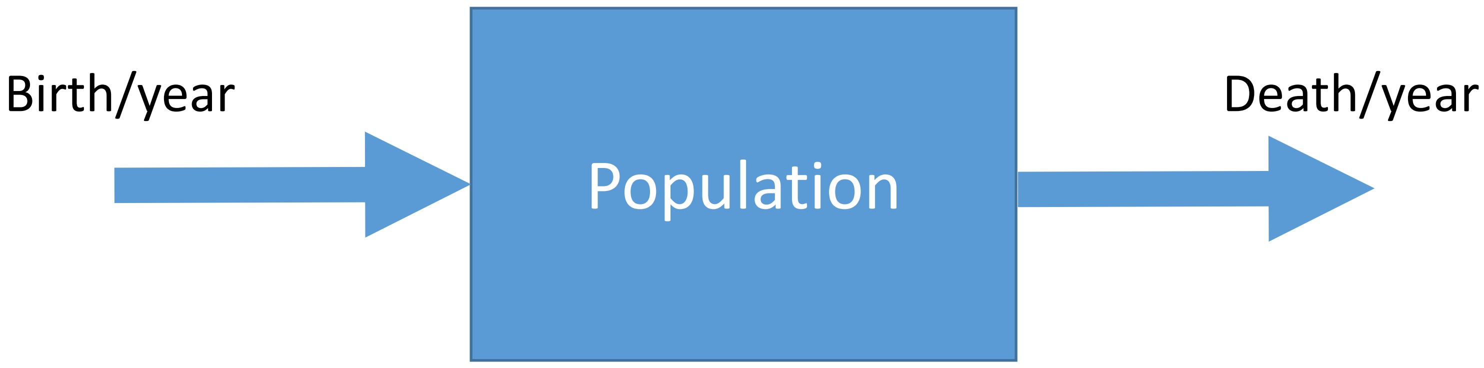
Lecture 3: Human population

Human Population

- World 7,679,302,210



Growth rate = Birth rate – Death rate

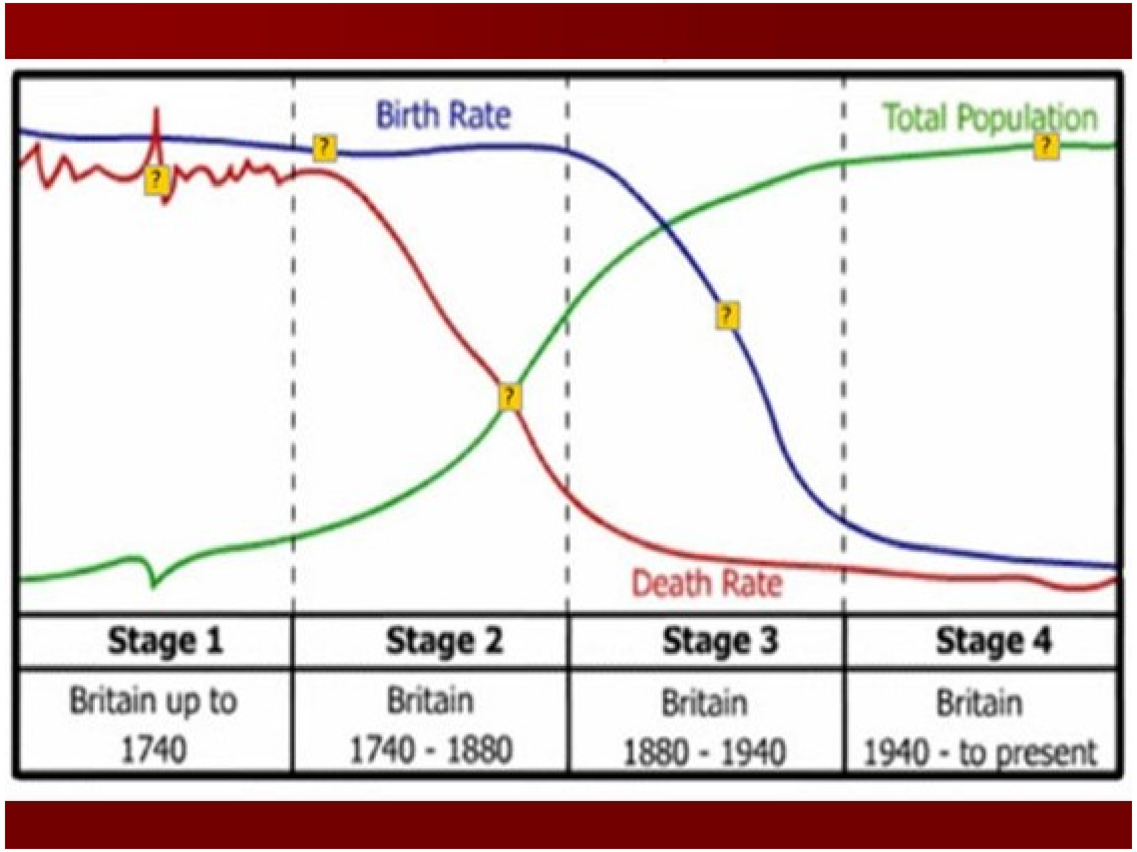


Crude Growth Rate = Crude Birth Rate – Crude Death Rate
Crude = # Per 1000

Demographic Transition

50/1000

10/1000



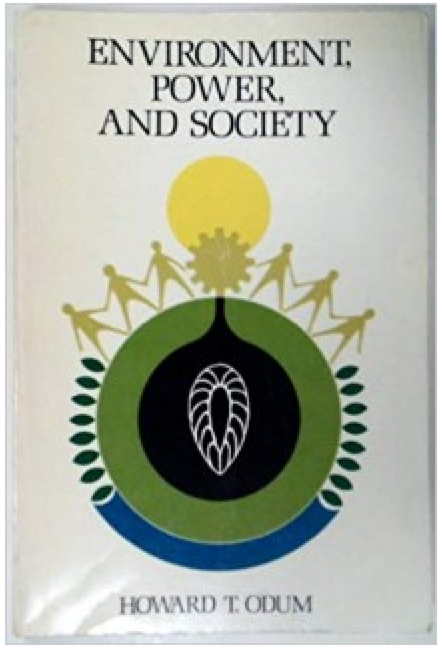
Lecture 4: Agriculture

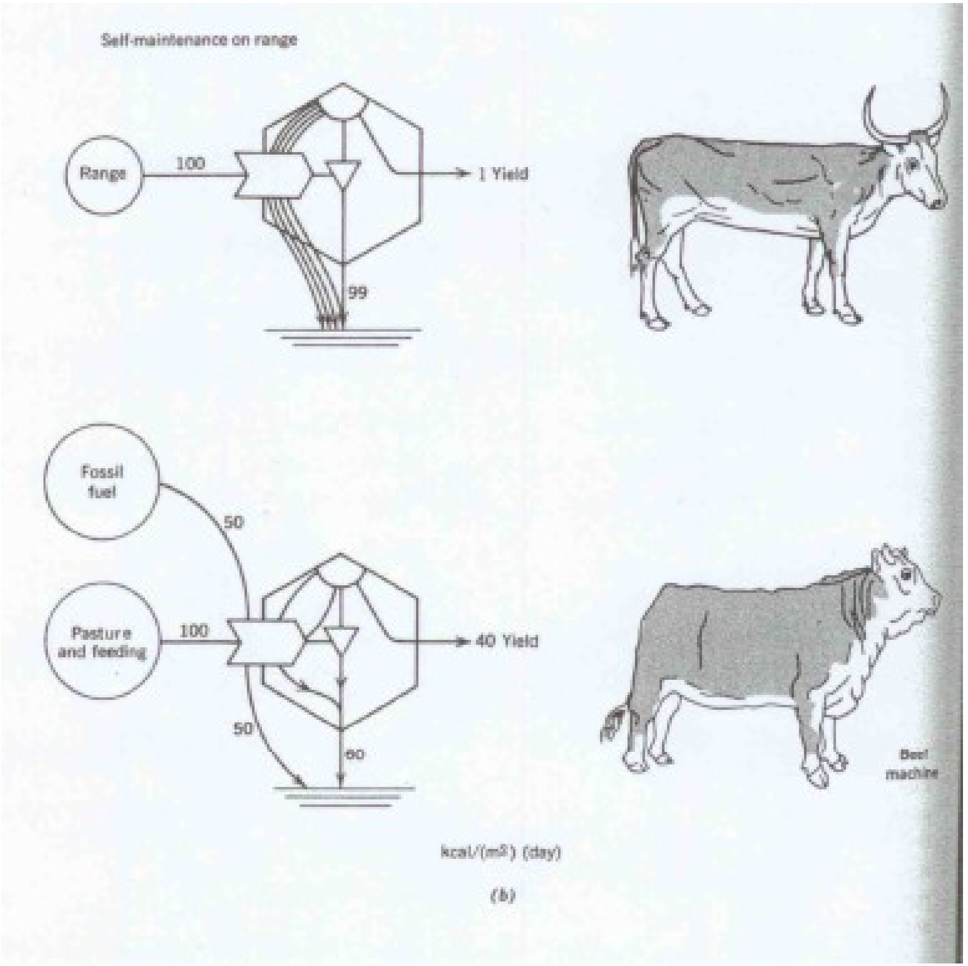
5 ways that agro-ecosystems differ from ecosystems

1. Stop ecological succession – requires energy
2. Large areas of a single species – monoculture, reduces soil fertility because the specific requirements of that species
3. Planted in neat rows makes it easier for pests (real systems are complex)
4. Food chains are greatly simplified – competitors and pests eliminated box and arrow
5. Plowing – erosion, damage to the physical structure of the soil

Environment, Power, and Society

Role of thermodynamics and energetics in human society (HT Odum, 1971)





Alternatives to conventional agriculture

Ways to reduce erosion
- Contour plowing
- Terracing
- Strip cropping
- No till farming

Ways to maintain soil fertility
- Strip cropping
- Crop rotation
- Cover crops
- Leaving land fallow
- Polyculture
- Permaculture

Urban farming

Organic farming

Lecture 5: Energy basis for socio-ecological development: from solar to fossil fuels back to solar

Energy is the ability to do work

1st Law of Thermodynamics:

energy cannot be created or destroyed

2nd Law of Thermodynamics:

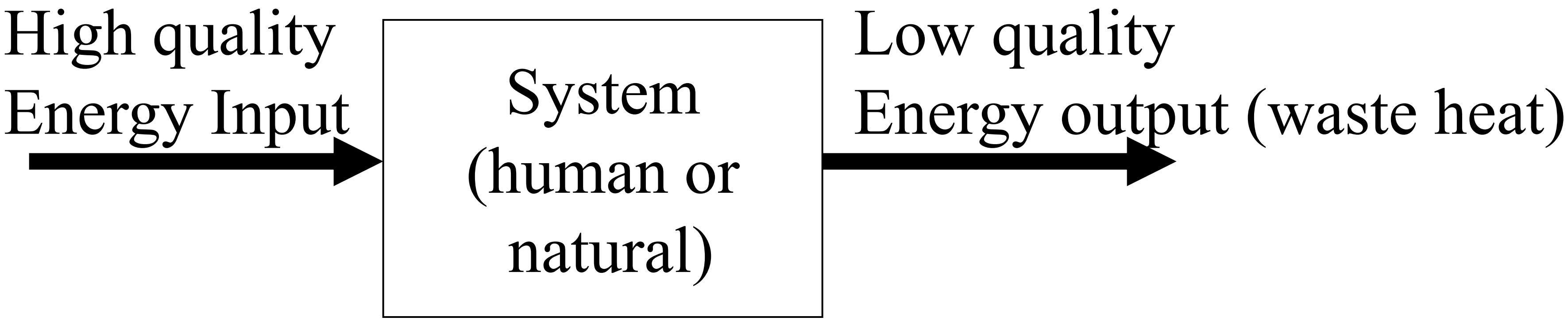
energy goes from a high quality to a lower quality during each energy transformation; while energy is conserved, it's ability to do work decreases

Forms of energy: potential, kinetic, thermal, chemical, electrical, etc.

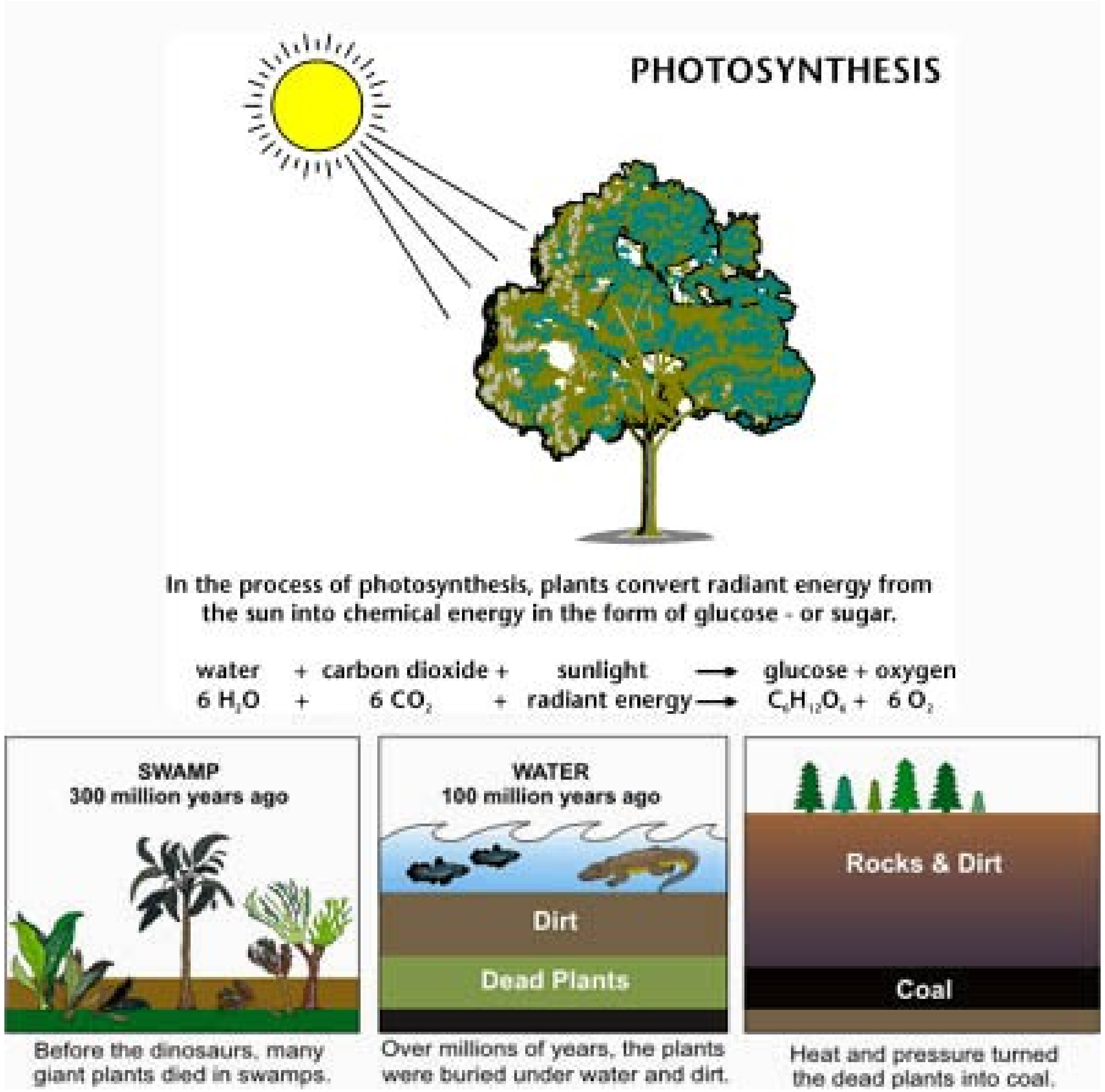
Energy is key to Sustaining system structure and complexity

Natural and human systems build and maintain order and organization by taking in high quality energy, using it, and passing degraded energy outside of the system boundary.

Our society is dependent on the energy flows that support it AND having a sink for the waste.

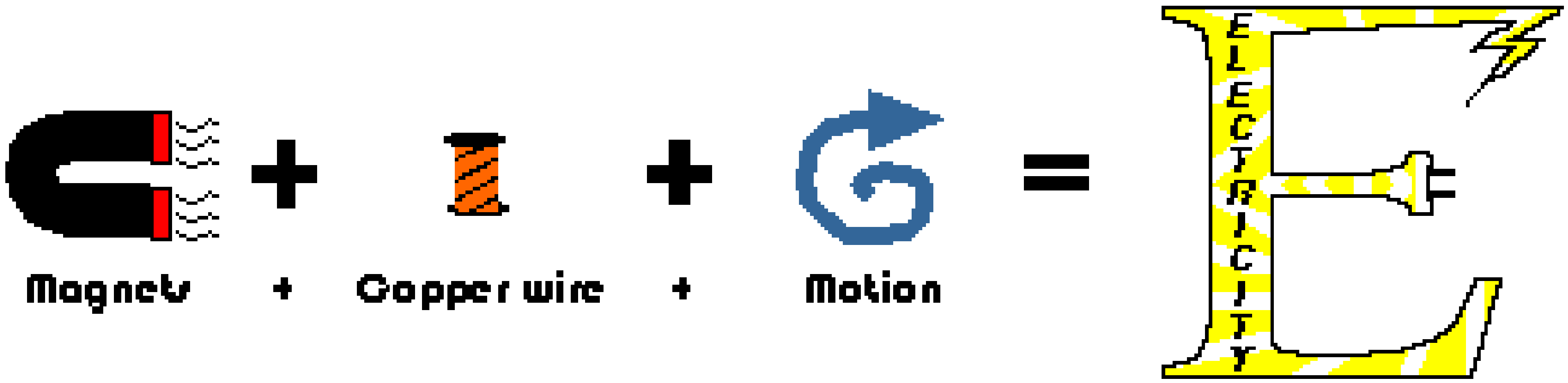


Fossil Fuels are derived from partially decomposed organic materials transformed in Earth's crust by pressure, heat and bacterial processes. It takes millions of years for these organisms to chemically change into fossil fuels.



Electricity Generation
whether from fossil fuels, nuclear, renewable fuels, or other sources - is usually* based on the fact that:

"When copper wire is moving through a magnetic field, an electric current is generated in that wire."



www.hawaii.gov/dbedt/ert/electgen.html

* exceptions are electrochemistry (batteries) and photovoltaic effect

Energy use in daily life

(Ecological Footprint – measuring your impact)

- Household consumption
- Transportation
- Diet

Energy Future

Transition to Renewables
(cleaner and sustainable)

Increased Efficiency and Conservation in all sectors

Reduce need for transportation through wise development decisions

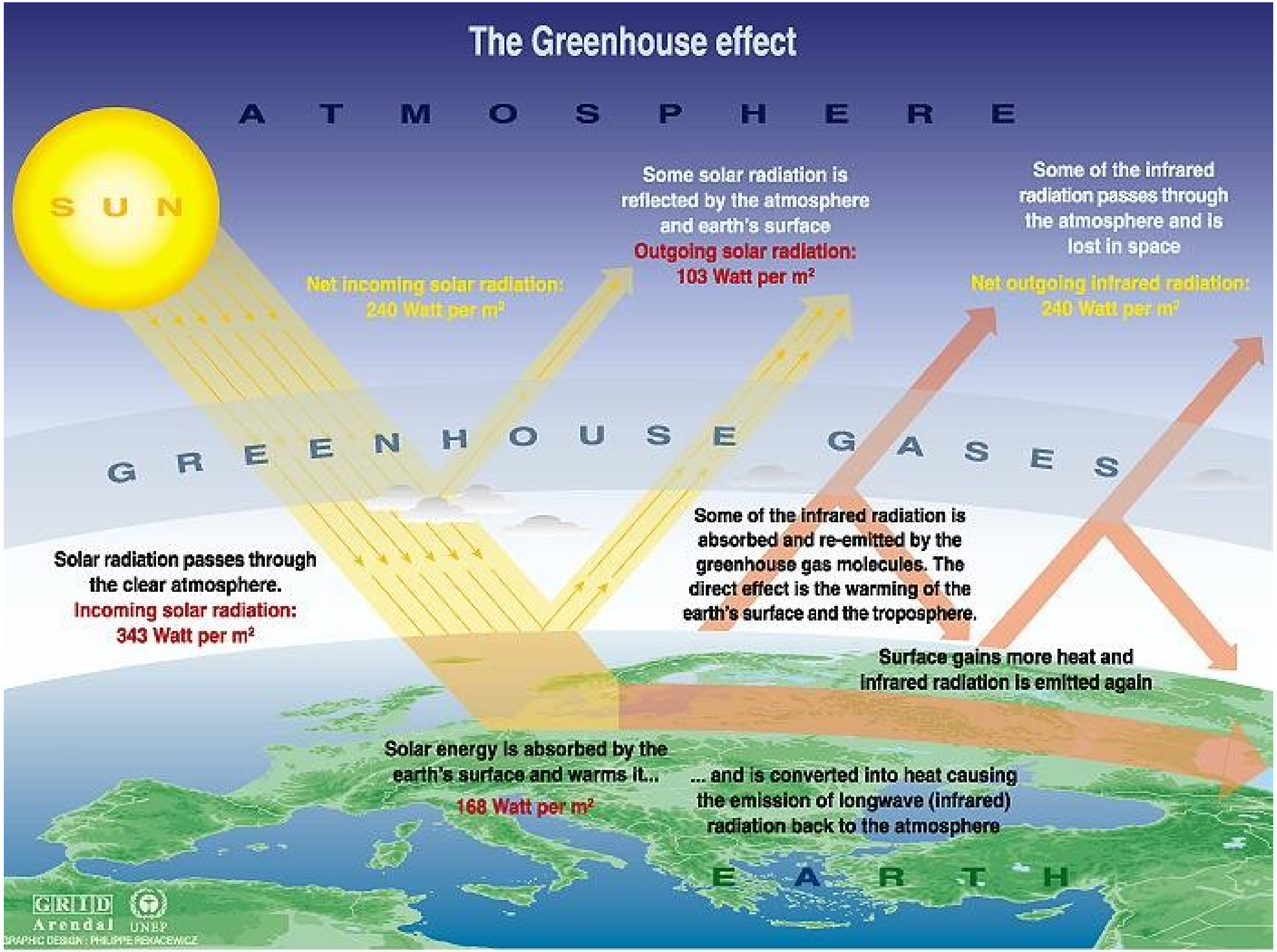
Lecture 6: Global Climate Change

Three Climate Basics

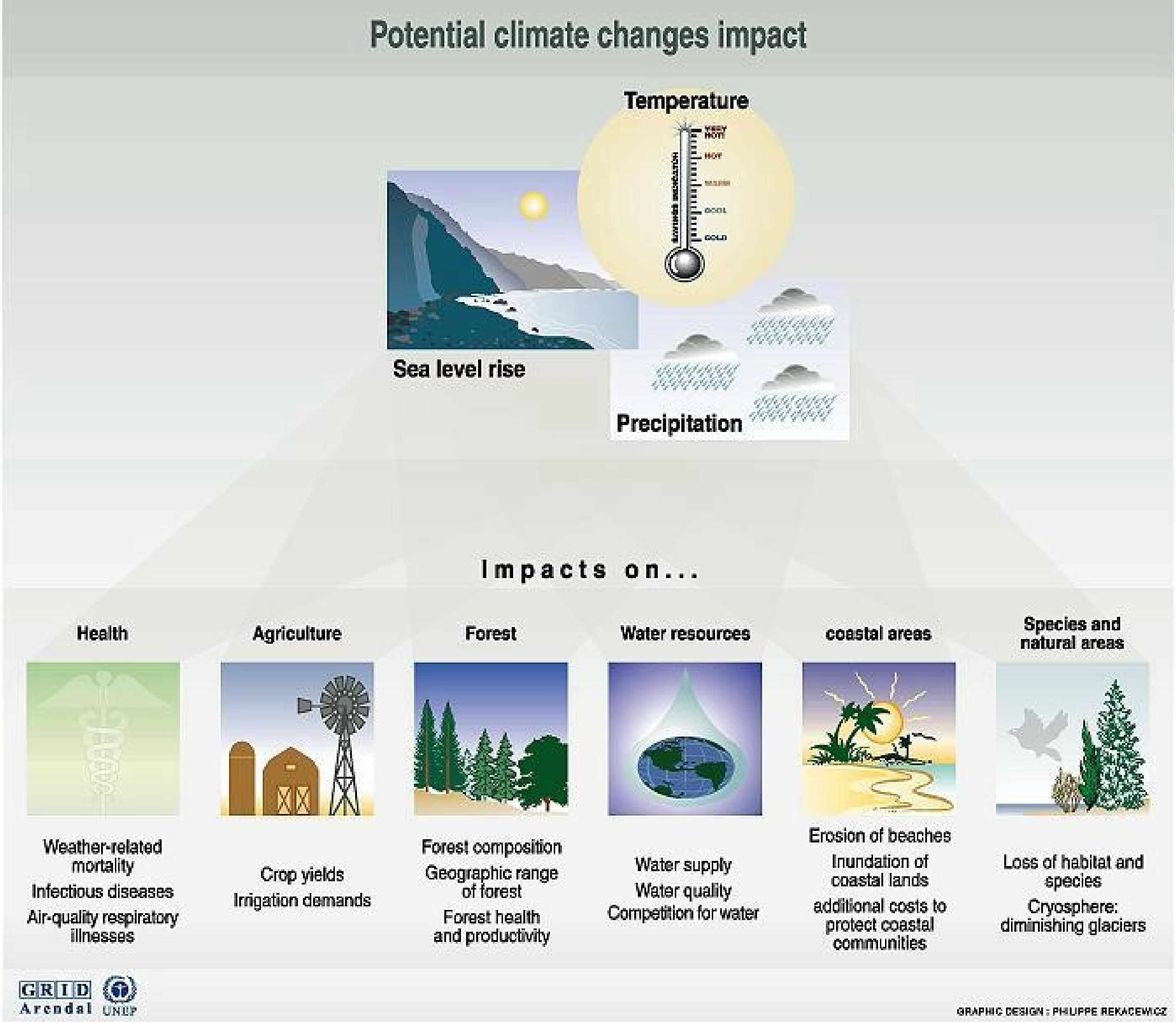
1) Earth and Sun are at different temperatures, therefore radiate energy at different wavelengths
    - Earth – long-wave – infrared radiation
    - Sun – short-wave – visible light radiation

2) Certain gases (GHG) in the atmosphere respond to energy at different wavelengths (passing short, absorbing long)

3) The concentration of greenhouse gases in the atmosphere is increasing



Sources: Okanagan university college in Canada, Department of geography, University of Oxford, school of geography; United States Environmental Protection Agency (EPA), Washington; Climate change 1995, The science of climate change, contribution of working group 1 to the second assessment report of the intergovernmental panel on climate change, UNEP and WMO, Cambridge university press, 1996.



Source: United States environmental protection agency (EPA).

Mitigation Measures

More efficient use of energy

Greater use of low-carbon and no-carbon energy

- Many of these technologies exist today

Improved carbon sinks

- Reduced deforestation and improved forest management and planting of new forests
- Bio-energy with carbon capture and storage

Lifestyle and behavioural changes

AR5 WGIII SPM

But delaying mitigation will substantially increase the challenges associated with limiting warming to 2°C

Lecture 7: Ecological Economics and Ecosystem Services

Drivers of Unsustainability

- HUMAN POPULATION INCREASE
  - Agriculture
  - Shelter
  - Mobility
  - Stuff

Use Energy and Material Resources

causes

- Land use change
- Habitat loss
- Deforestation
- Alter biogeochemical cycles

Leads to

Climate Change
Eutrophication
Acid precipitation
Ozone Depletion
Smog
…

Why environmental resources have been poorly conserved in the past?

1. *Nature's rate of return of ecosystem services leads us to over exploitation*
   - Living off the flow is too slow, how we want to grow
   - Poor understanding of growth, exponential growth
2. *Externalities*
   - Indirect cost not paid for by producer and consumer as part of a transaction
   - When a decision (for example, to pollute the atmosphere) causes costs or benefits to individuals or groups other than the person making the decision
3. *Pressure for resource consumption*
   - Economic and institutional growth paradigm
   - 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 satisfactions, our ego satisfactions, in consumption
   - Marketing

Steps forward

- Market corrections for externalities
- Ecosystem Services now guiding policy decisions
- Consider other “quality of life indicators”
  - Genuine Progress Index
  - Index of Sustainable Economic Welfare
  - Human Development Index
  - Gross Happiness Index
- Development of Steady State Economics
- Change the growth oriented mindset

Lecture 8: Urban systems

Urban Ecosystems
Socio-ecological-economic systems

Three issues:

1) understanding a city as a system
2) understanding specific environmental impacts of cities
3) understanding a city as a sense of space (human niche)

Importance of place

- Protection and investment in place
- Finding the balance of what the environment offers: sustaining (and enhancing) those flows
-
- Geography of Nowhere

Place worth protecting

Lecture 9: Sustainability and Sustainable Development Goals

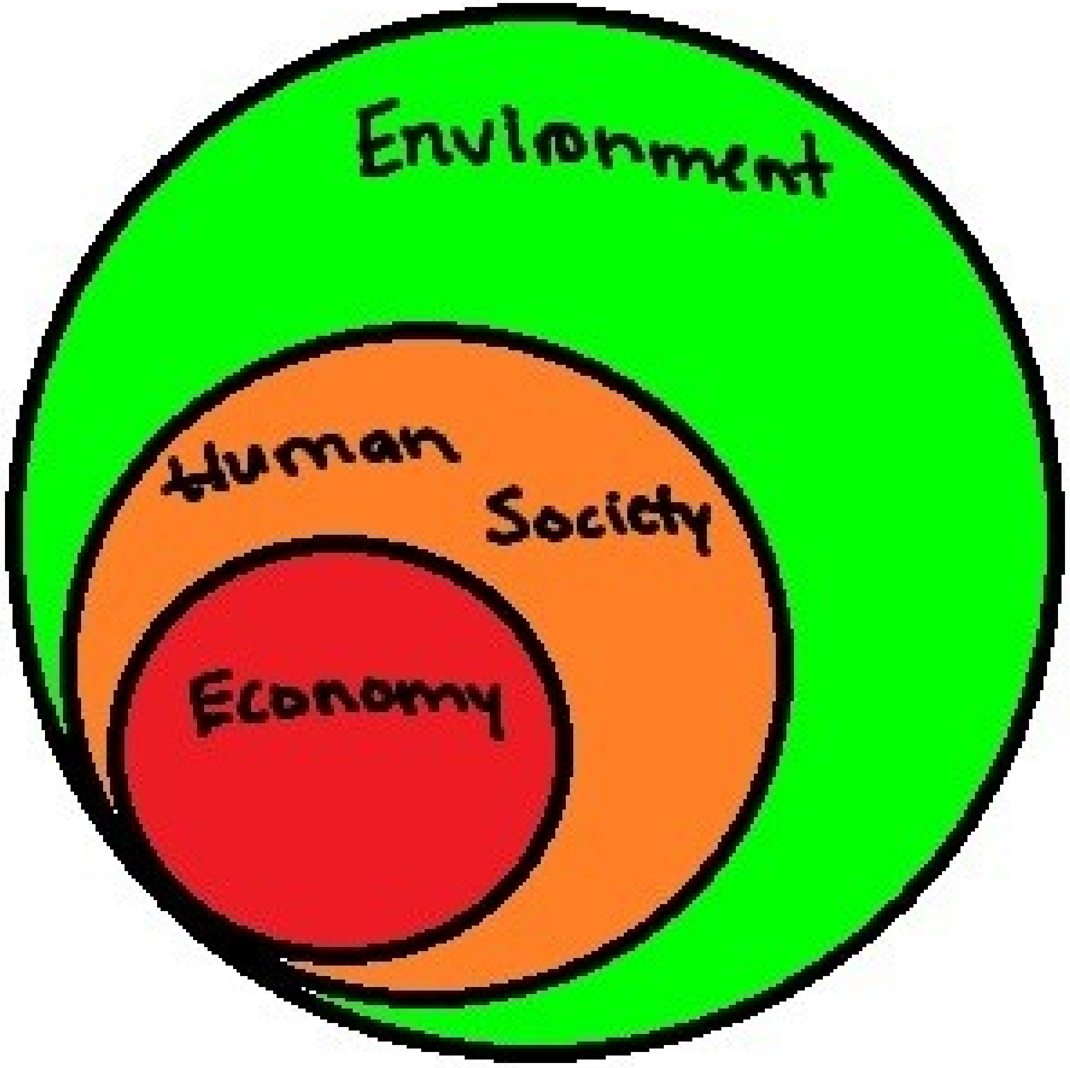
Sustainable Development vs Sustainability

- Sustainable Development: “development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs” – *Our C* *Future*/ Brundtland Report, 1987

What are our “needs”?

- Sustainability: “the capacity to endure; how systems remain diverse and productive over time” – wikipedia

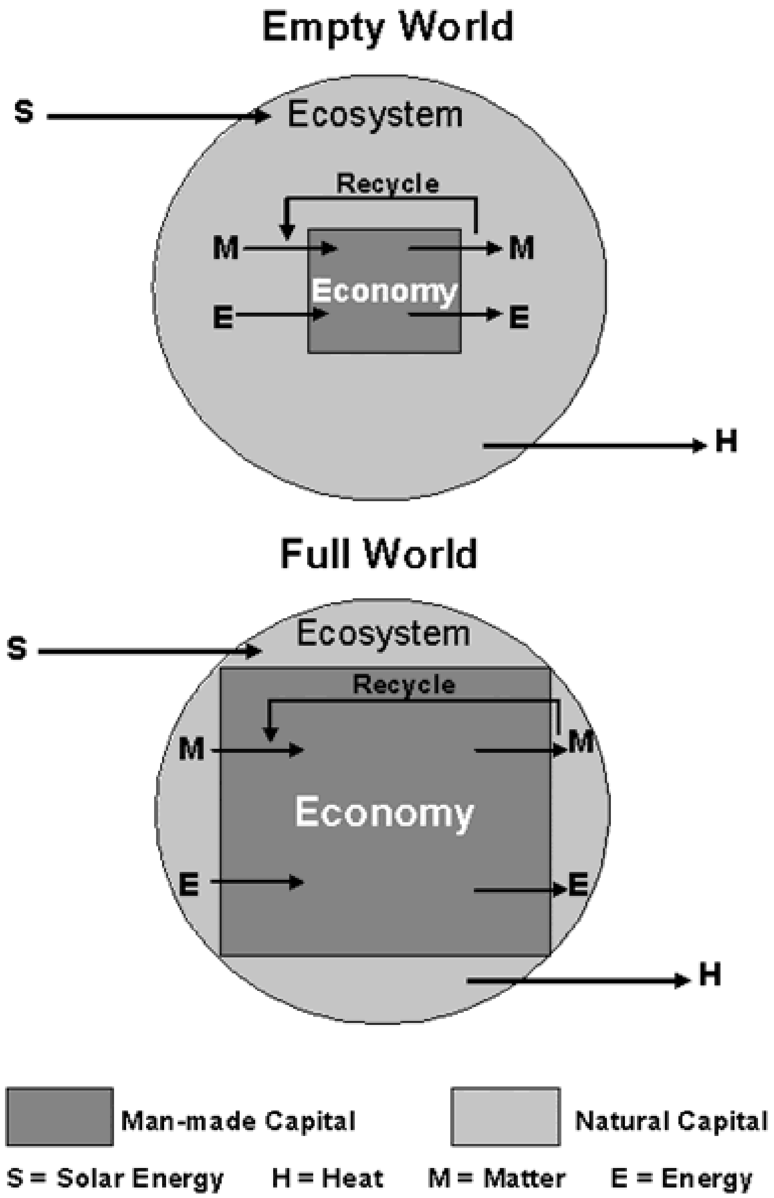
Environment is foundation for all aspects, others are subsets



Emergence of humans, from a minor component of natural system to predominant occupant

Scale of humanity has increased greatly putting pressure on all natural resources

The changes have come so fast our customs, ethics, and religious patterns may not have adapted to them.



Conclusions: Sustainability is a property of interaction networks

- Reliable Inputs
- Healthy Outputs
- Recycling of material – my output is your input

- Processes functionally linked together - my useful byproducts happen in the act fitting into the network