# Module 1:

- Introduction: Concept of an ecosystem- structure and functions of ecosystem. Components of ecosystem - producers, consumers, decomposers, Food chains, food webs, ecological pyramids, Energy flow in ecosystem. Bio-geo- chemical cycles, Hydrologic cycle

- Components of Environment and their relationship, Impact of technology on environment, Environmental degradation. Environmental planning of urban network services such as water supply, sewerage, solid waste management.

# Introduction

## (David Orr,1991)- If today is the typical day on planet earth

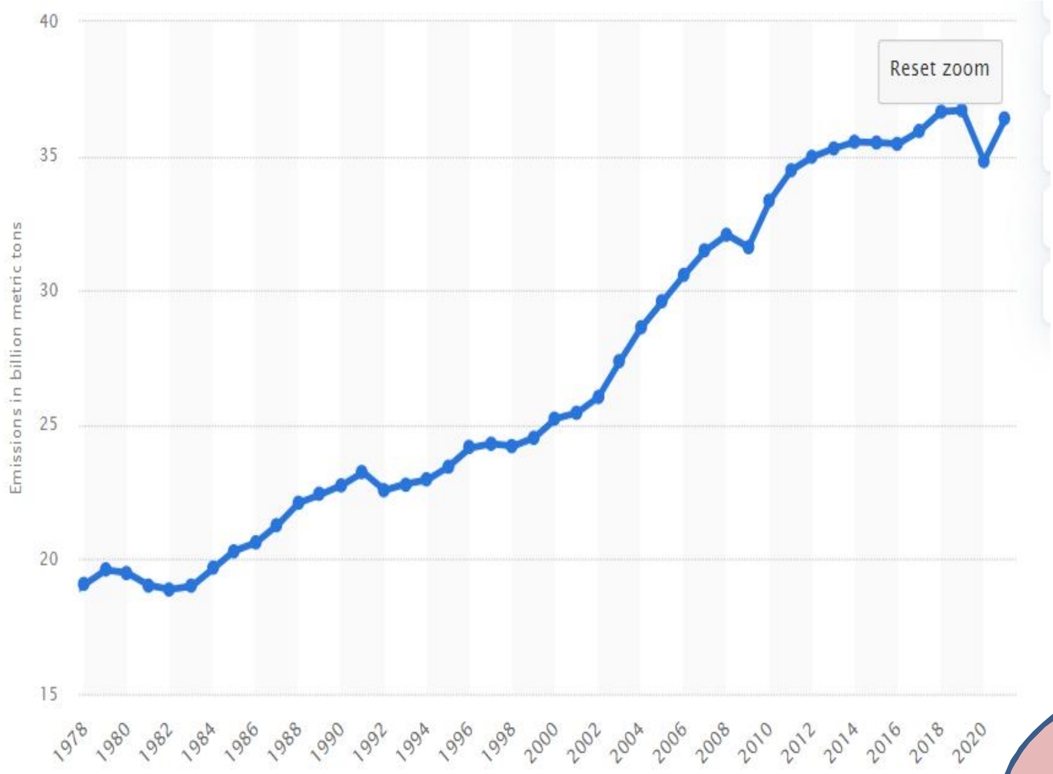
We will lose 116 square miles of rainforest or about an acre a second

We will lose 72 square miles of land to encroaching deserts

We may lose 40 to 100 species, this is we are talking about a typical day on planet

# Introduction

- ❑And tonight, the earth will be little hotter
- ❑Global warming
- ❑We still have lot of carbon being added to the atmosphere

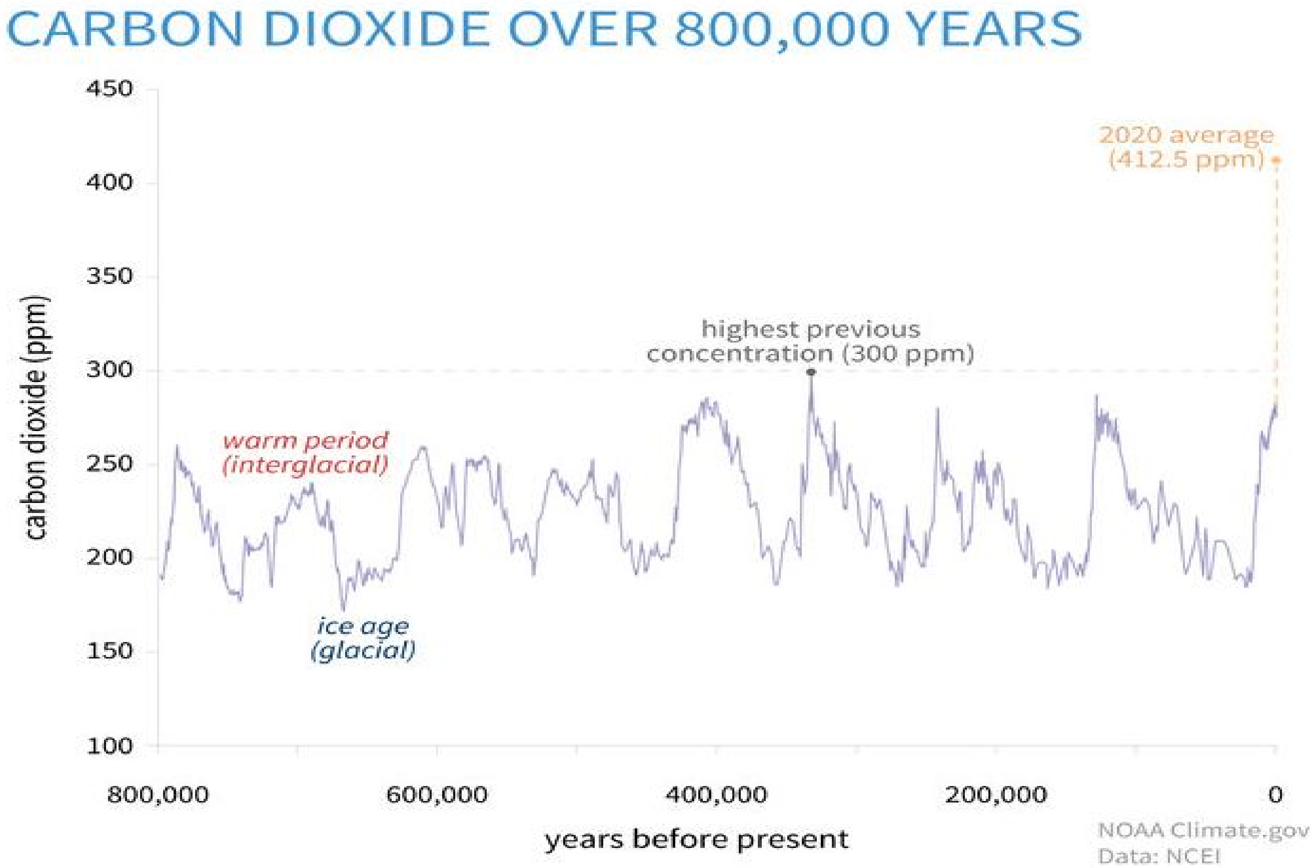



NOAA Climate.gov

Waters more acidic
putting more and more
carbon dioxide,
nitrous oxide,
sulphur oxides into the
atmosphere,
this comes back as rain and the
water is becoming more and more
acidic.

As engineers we need to
know how the planet earth
works and we need to
understand ecology.

# Introduction




Global atmospheric carbon dioxide concentrations ($CO_2$) in parts per million (ppm) for the past 800,000 years. The peaks and valleys track ice ages (low $CO_2$) and warmer interglacials (higher $CO_2$). During these cycles, $CO_2$ was never higher than 300 ppm. On the geologic time scale, the increase (orange dashed line) looks virtually instantaneous. Graph by NOAA Climate.gov based on data from Lüthi, et al., 2008, via NOAA NCEI Paleoclimatology Program. *[Correction: August 20, 2020. An earlier version of this image had an error in the time scaling on the X axis. This affected the apparent duration and timing of the most recent ice ages, but did not affect the modern or paleoclimate carbon dioxide values.]*

# Ecology

**Definition:**

- it is defined as the scientific study of the processes influencing the **distribution and abundance of organisms, the interactions among organisms and the interactions between organisms and the transformation and flux of energy and matter** - Ernst Haeckel (1866)

- It emphasizes both **living and non-living components** of the natural world.

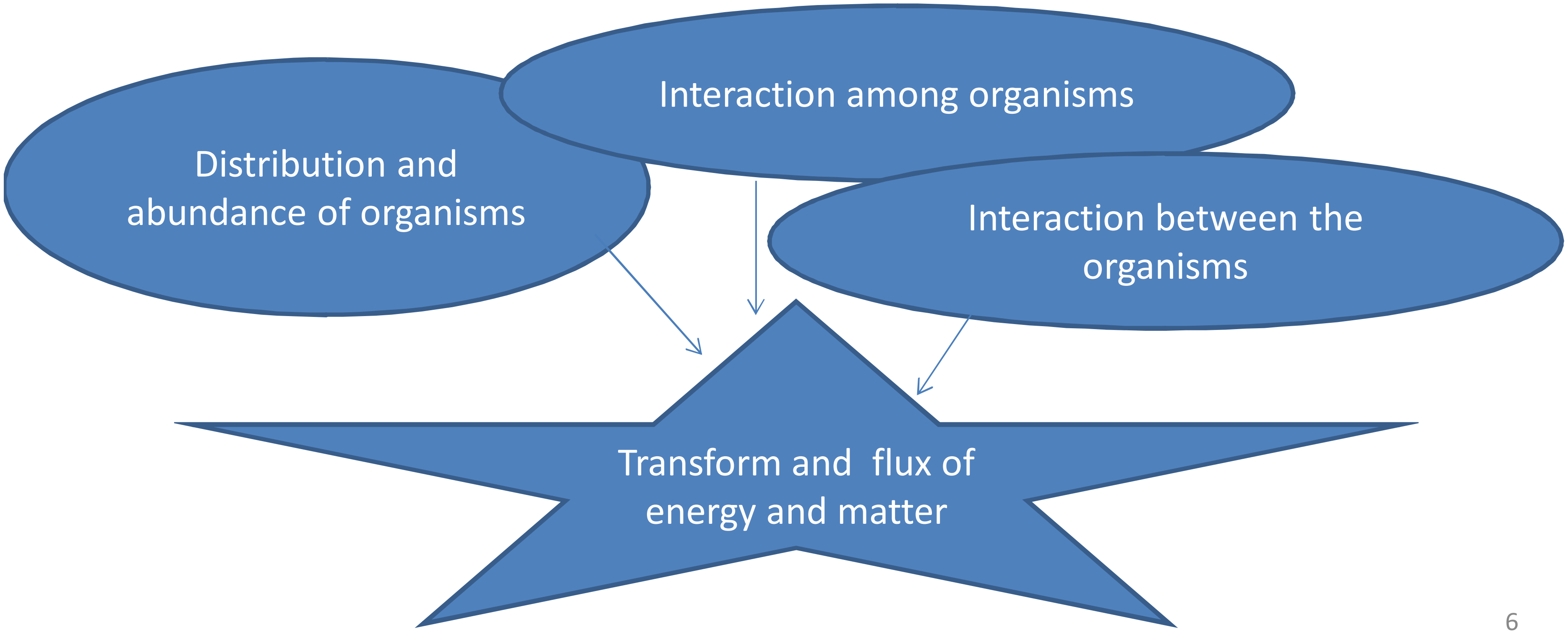
•it is called the **study of distribution of organisms**- Andrewartha and Birch (1954)

•so which reinforces the focus on organism as the core of ecology.

Evelyn Hutchinson defined ecology as the sc**ience of the universe**.

# Ecology

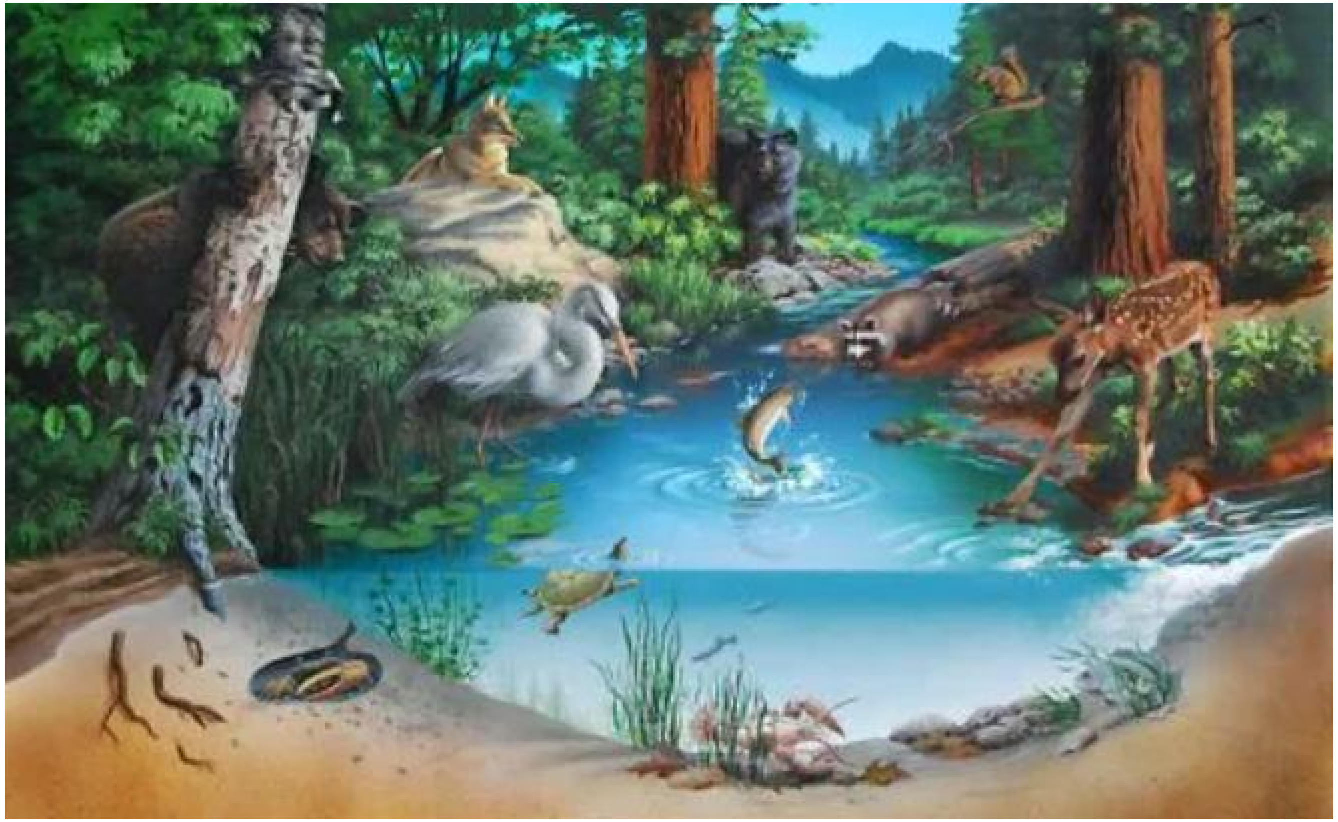
ecology is a study of **the processes**,
it could be chemical process, it could be physical process,



# Ecosystem

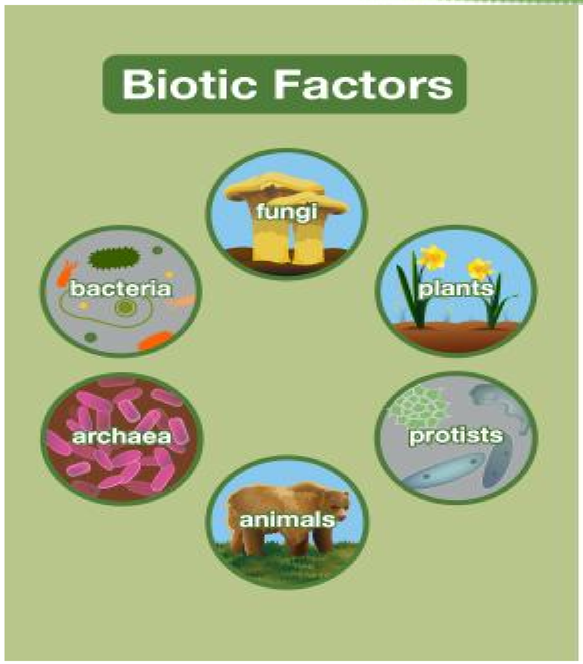
Boundary of ecosystem:

- **Ecosystem is a region in which the organisms and the physical environment** form an **interacting unit**. Within an ecosystem there is a complex network of interrelationships.
- E.g tree, pond --- simple ecosystems. Forest ecosystem

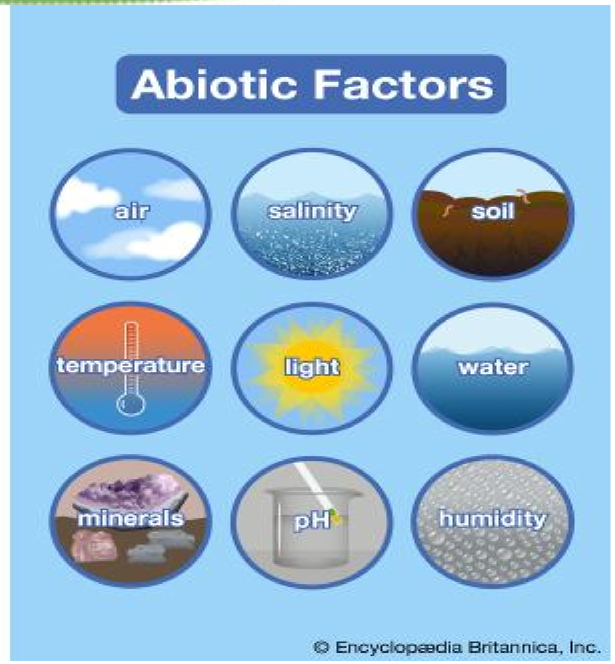


# Ecosystem

Plants
Animals
Micro-organisms
Environment
Interactions
Biotic (living)
Abiotic (non-living)
Physical and Chemical
Energy and matter flow/transform

Biotic Factors
fungi
bacteria
plants
archaea
protists
animals

Abiotic Factors
air
salinity
soil
temperature
light
water
minerals
pH
humidity
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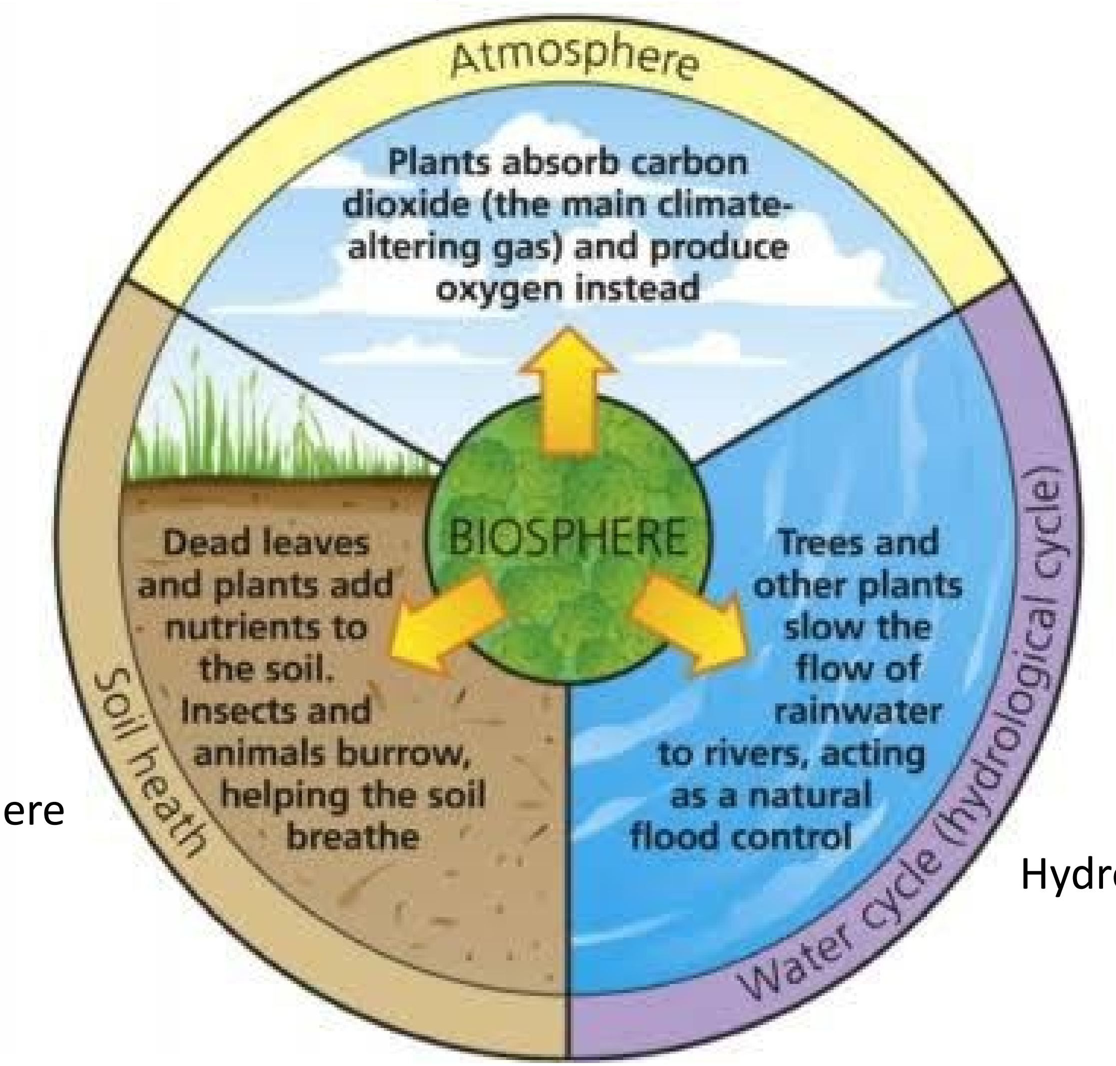
# Ecosystem

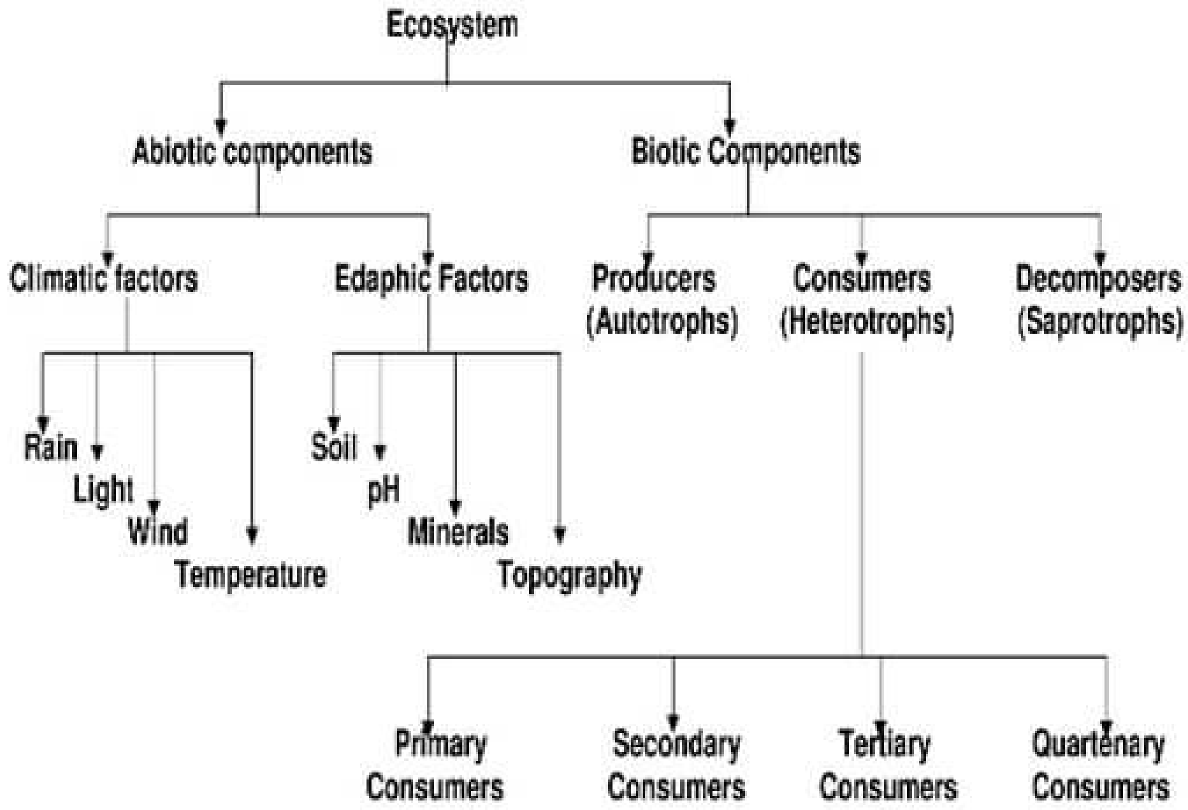
Lithosphere



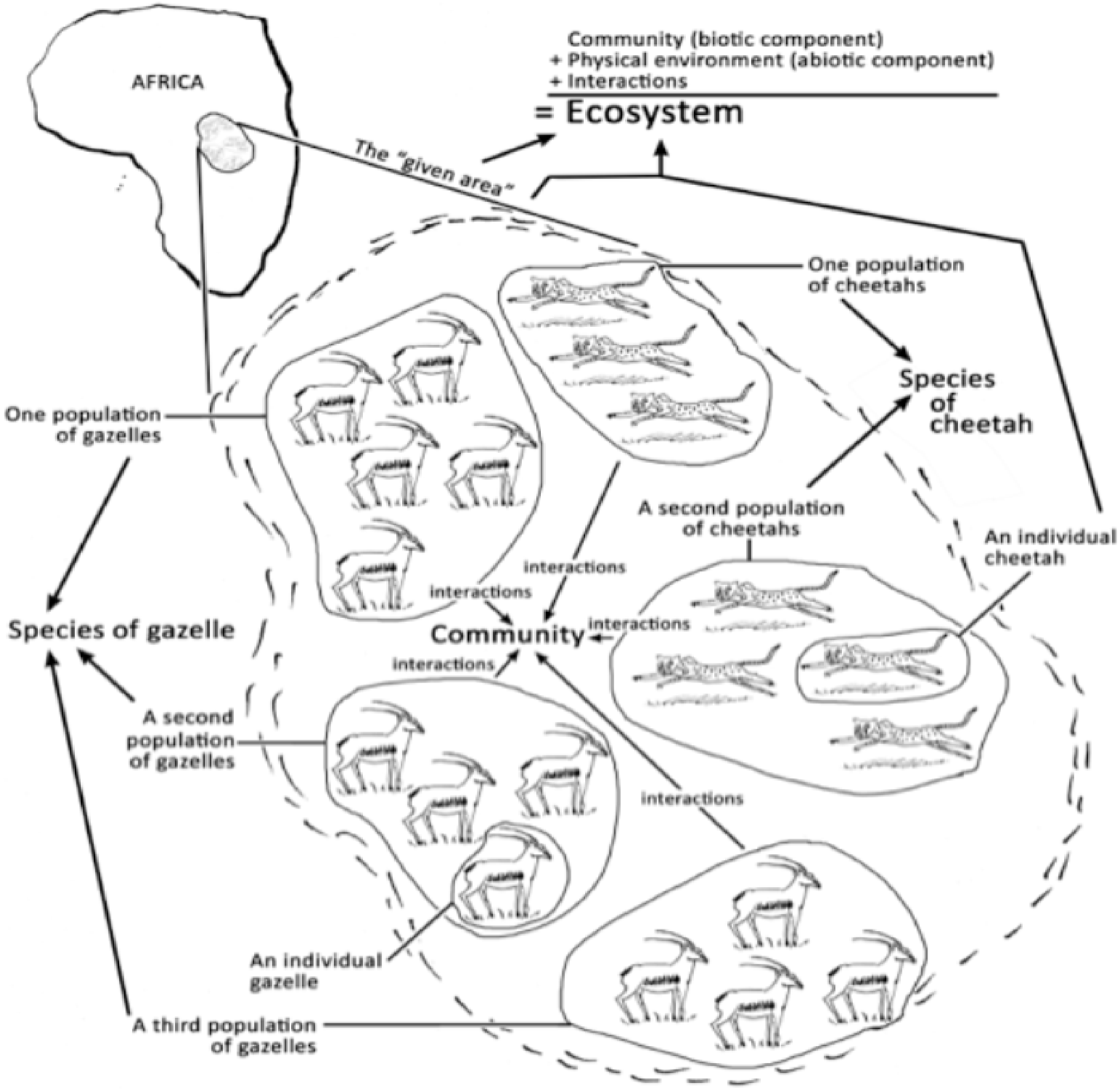

Hydrosphere

# Ecosystem

## Components of Ecosystem

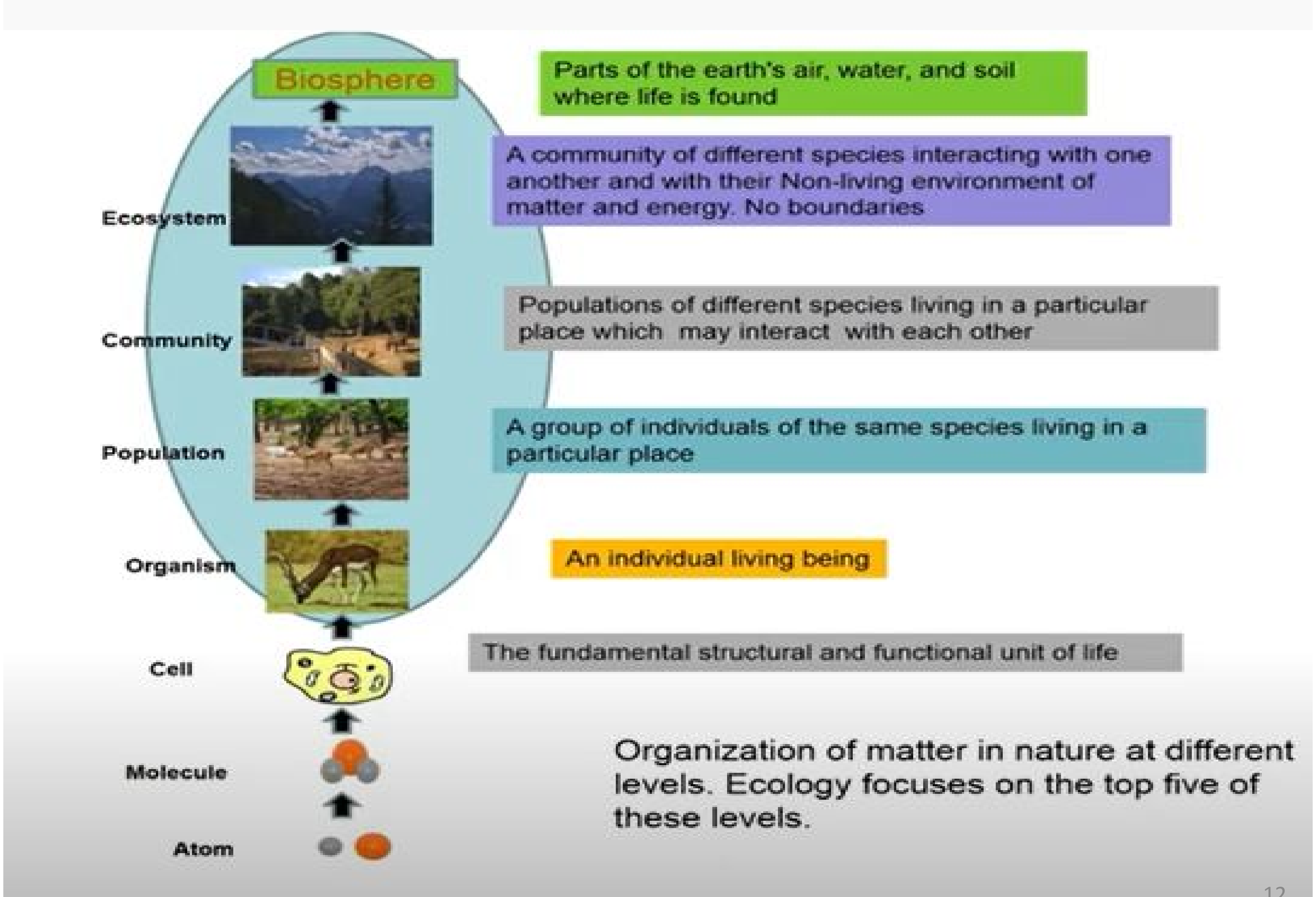


# Levels of ecosystem




- **Individual**
- **Population**
- **species**
- **community**
- **ecosystem**

# Levels of ecosystem




nptel.ac.in/courses/

# Ecosystem

- A complex ecosystem
- For example,
  - Weather affects plants,
  - Plants use minerals in the soil and are food for animals,
  - Animals spread plant seeds
  - Plants secure the soil, and
  - Plants evaporate water, which affects weather

# <u>Case Study</u>

## Inter-relations in Ecosystem- Case study

Keoladeo was declared a national park

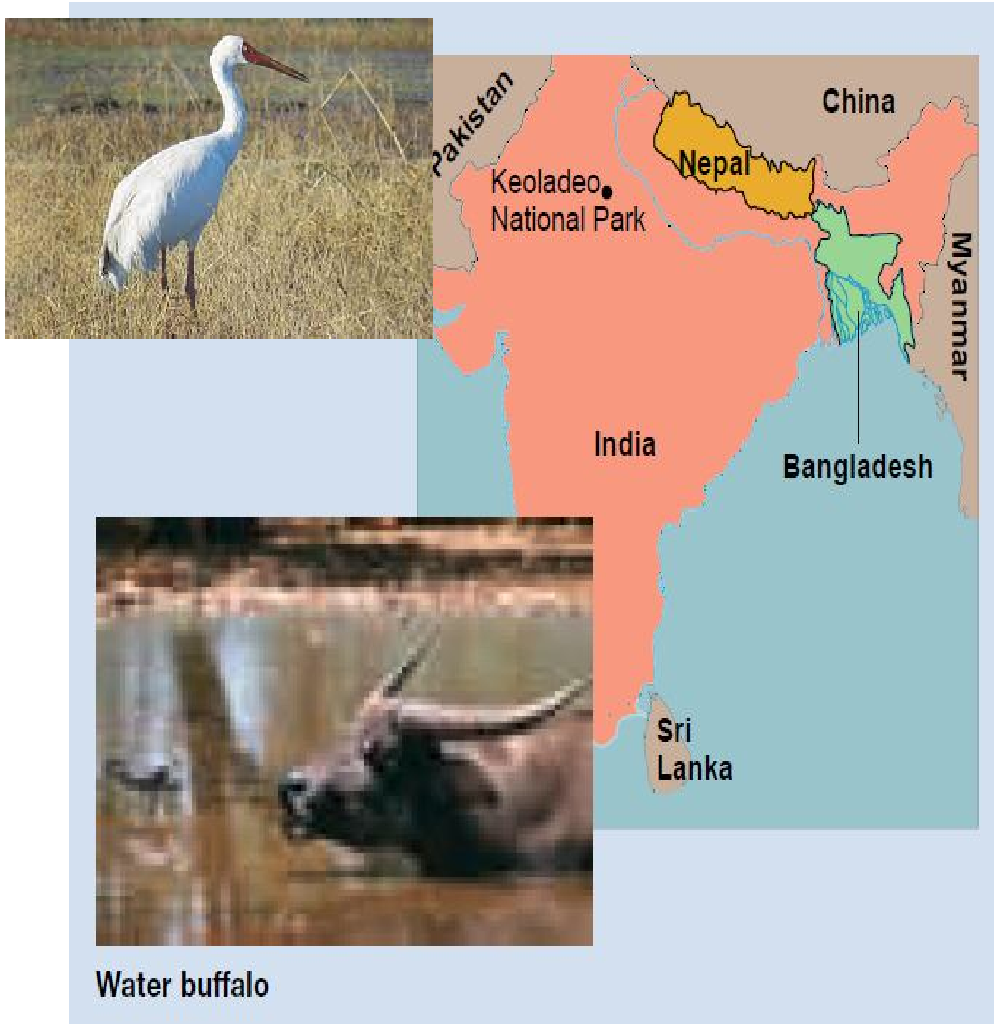
- In 1982, Keoladeo was declared a national park and was designated as a World Heritage Site by the UNESCO in 1985.

- **Water buffalo, certain aquatic plants, and the Siberian crane coexisted in a three-way relationship**.

- Local villagers were prohibited from using the land to graze their cattle and water buffalo

- Cranes to dig up rhizomes and tubers of the aquatic plants for food.

- the weeds grew to their full height and in solid masses that created a physical barrier for crane



Water buffalo

Enger and Smith, 2010

# How ecology is studied?

- **Organism Level:**
  - Individual of a particular species
  - Population of a species

- **Habitat based studies:**
  - Terrestrial (forest, desert, grassland etc)
  - Aquatic (marine, estuarine, freshwater)

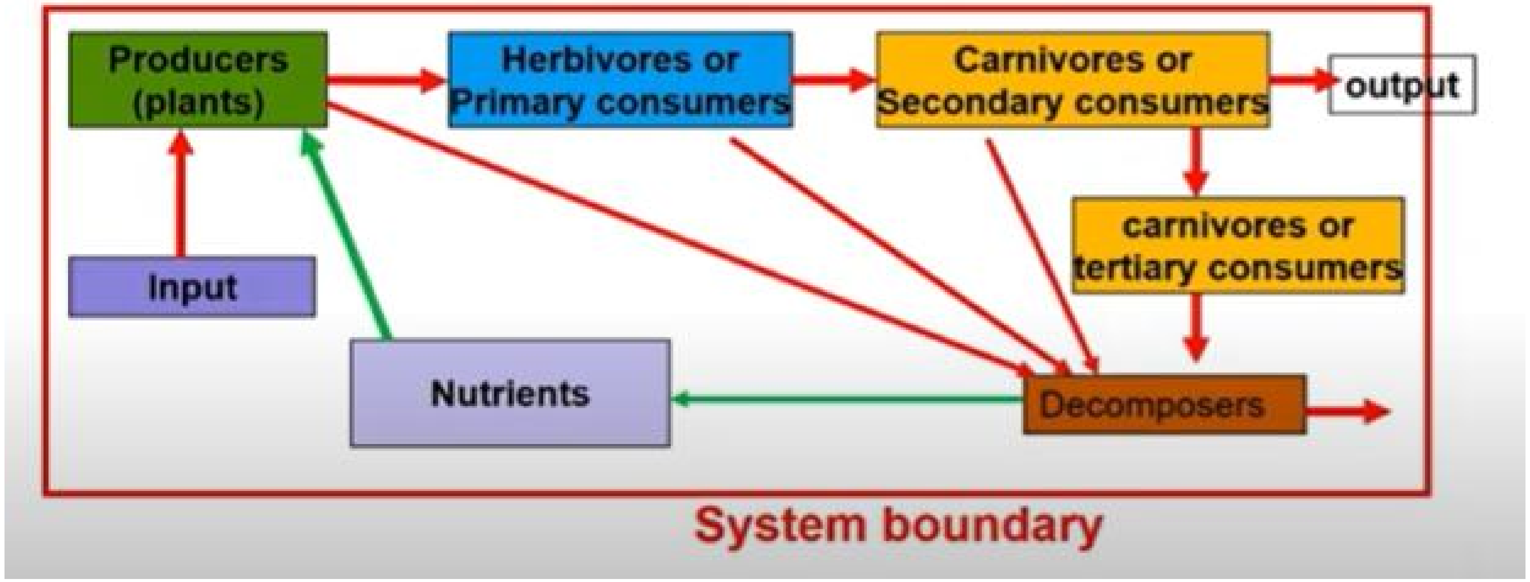
# System Concept in ECology

A group of interacting, interrelated, or interdependent parts made up of matter and energy that form a complex whole.

Anything that uses matter and energy to organize, maintain, or change itself (e.g., the sun, a glass of water, a frog, a city)

- Isolated (no exchange of energy or matter with the environment)
- closed (exchanges energy but not matter and attain true thermodynamic equilibrium with the environment)
- open systems (exchange of energy and matter. Thermodynamically they are not in true equilibrium but are in dynamic steady state)

The living organisms (biotic community) of a habitat and their non-living environment function together as one unit called the ecological system or ecosystem



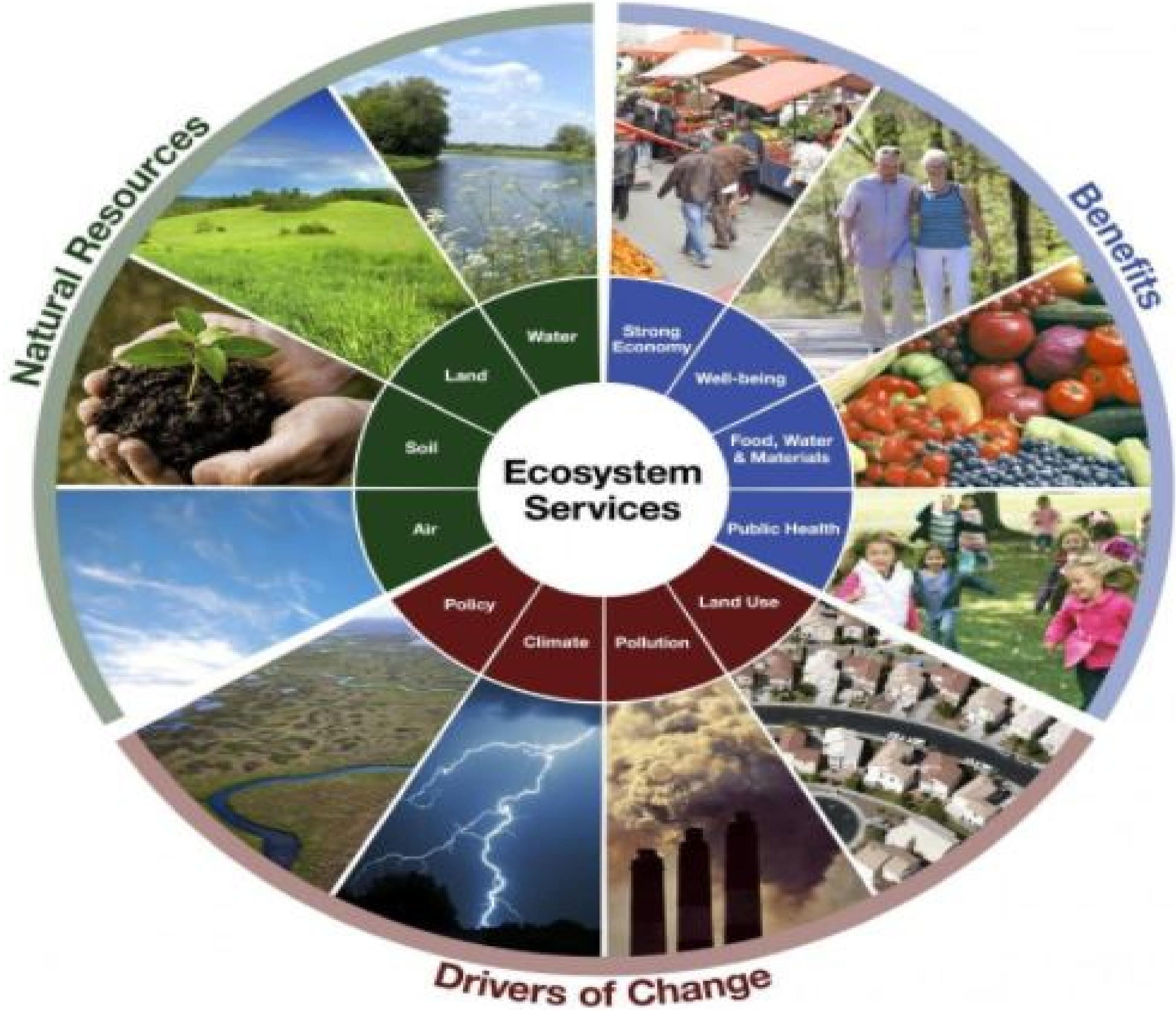
# Ecosystem services

- Ecosystem services
  - **Supporting life**
    - Produce natural capital (fuel, fibre and $O_2$, air, water, food- sustain life)
  - **Regulation of climate**
    - Primitive time-starting of evolution – reductive
    - Oxidation and reduction
    - Plants- releasing $O_2$ and taking $CO_2$
    - Temperature maintenance – Current average temp if increased - $2^0$ C– result in catastrophic effects

# Ecosystem services

- Ecosystem services
  - **Biochemical cycles-** $CO_2$, $H_20$, Nitrogen, Phosphorus, sulphur cycle etc. – reaction between living organisms and surrounding
  - **Water filtration-** Self purification capacity
  - **Soil formation-** microbes –decaying, health  living soil mass with nutrients that can provide
  - **Erosion control**
  - **Flood protection**

# Ecosystem services



# Ecosystem services

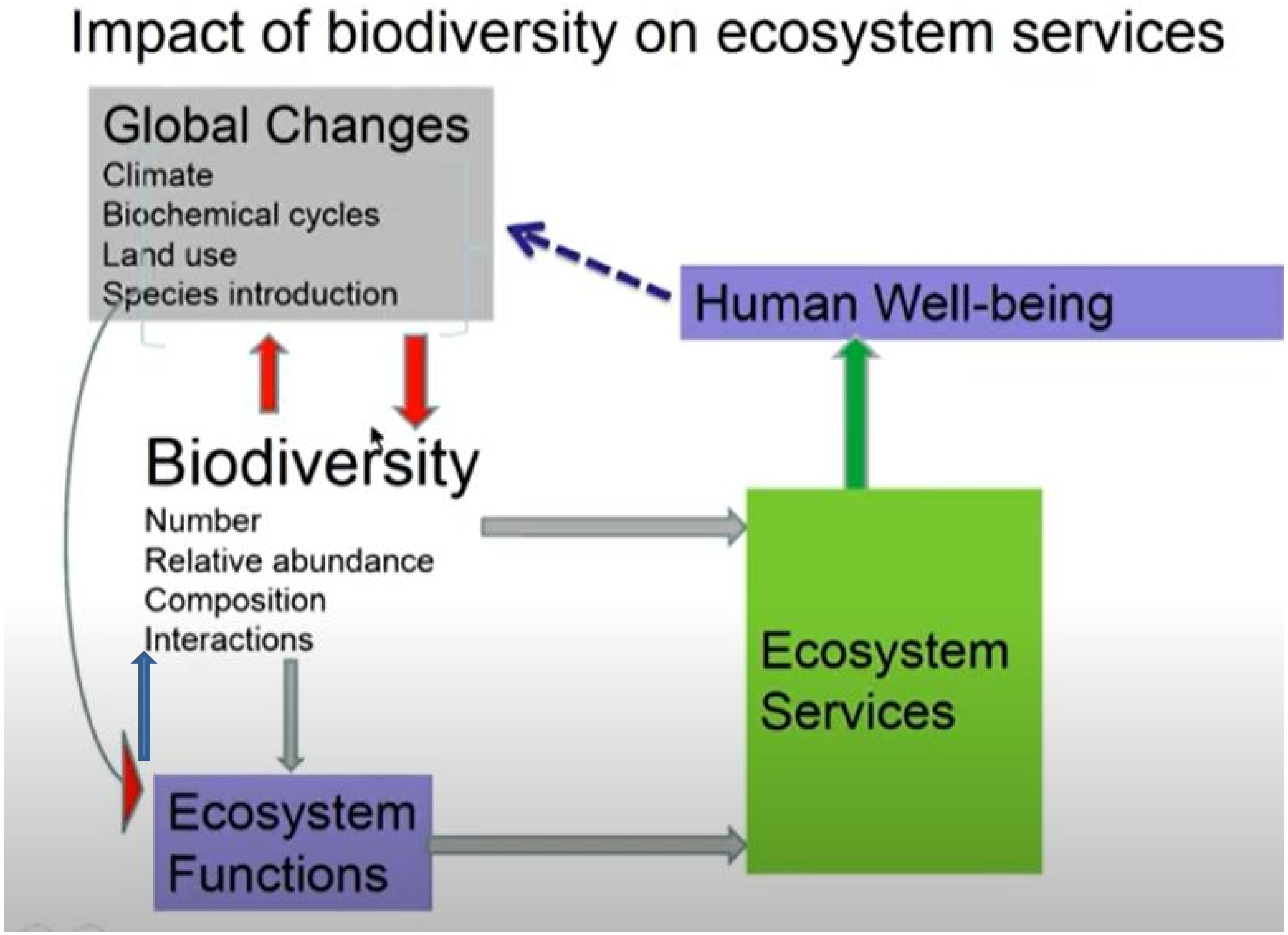
Millennium Ecosystem Assessment

- 2001-2005 by UN
- More than 1500 scientists – How to put the ecosystem services into economics !

*Whether we and our politicians know it or not, Nature is party to all our deals and decisions, and she has more votes, a longer memory, and a sterner sense of justice than we do.* – Wendell Berry

# Ecosystem function

- Ecosystem services are output of its function

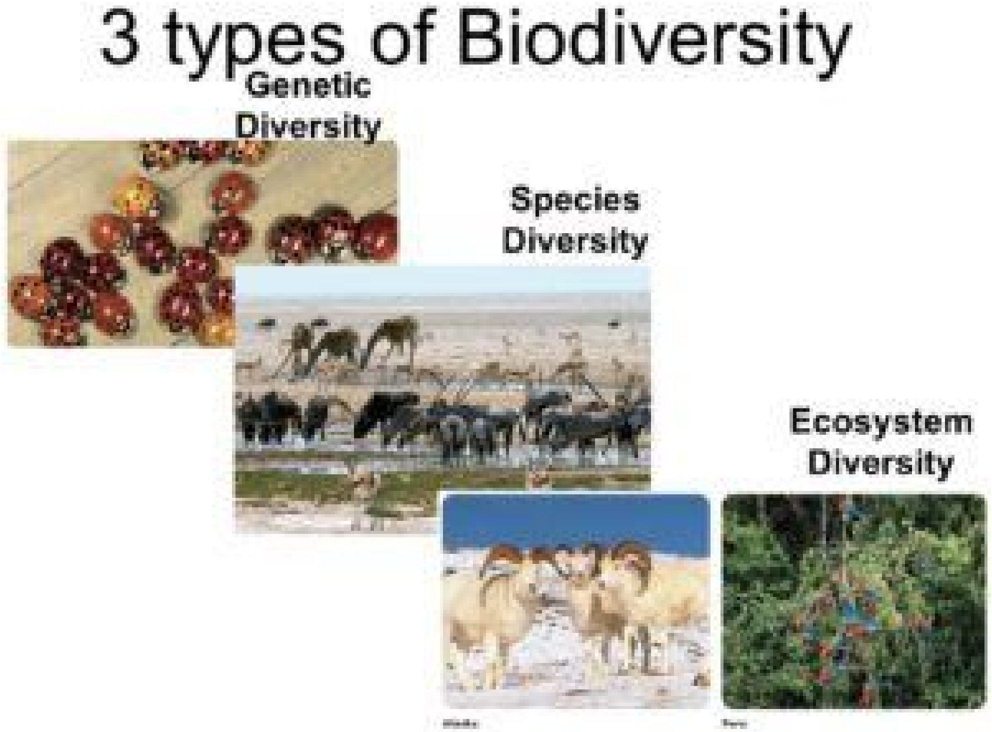


# Biodiversity

**Each human being is very different from all others. This genetic variability is essential for a healthy breeding population of a species.**

**The number of species of plants and animals that are present in a region constitutes its species diversity.**

**There is a large variety of different ecosystems on earth, which have their own complement of distinctive interlinked species based on the differences in the habitat.**



# Ecosystem Functions

- Regulating Functions
- Production Functions
- Habitat Functions
- Information functions

**Regulating Functions**

1. Gas regulation
2. Climate regulation
3. Disturbance regulation
4. Water regulation
5. Water supply
6. Soil retention
7. Soil formation
8. Nutrition regulation
9. Waste treatment
10. Pollination
11. Biological control

Grut et al., 2002

# Ecosystem Functions

## Production Functions

1. Food
2. Raw Materials
3. Genetic Resources
4. Medicinal resources
5. Ornamental

## Habitat functions

1. Refugium function
2. Nursery function

## Information function

1. Aesthetic information
2. Recreation
3. Cultural and artistic information
4. Spiritual and historic
5. Science and education

Grut et al., 2002

# Ecosystem Functions
# (Costanza et al., 1997, De Groot, 1992, De Groot et al., 2000.

| | Functions | Ecosystem processes and components | Goods and services (examples) |
|---|---|---|---|
| | *Regulation Functions* | *Maintenance of essential ecological processes and life support systems* | |
| 1 | Gas regulation | Role of ecosystems in bio-geochemical cycles (e.g. $CO_2/O_2$ balance, ozone layer, etc.) | 1.1 UVb-protection by $O_3$ (preventing disease). 1.2 Maintenance of (good) air quality. 1.3 Influence on climate (see also function 2.) |
| 2 | Climate regulation | Influence of land cover and biol. mediated processes (e.g. DMS-production) on climate | Maintenance of a favorable climate (temp., precipitation, etc) for, for example, human habitation, health, cultivation |
| 3 | Disturbance prevention | Influence of ecosystem structure on dampening env. disturbances | 3.1 Storm protection (e.g. by coral reefs). 3.2 Flood prevention (e.g. by wetlands and forests) |
| 4 | Water regulation | Role of land cover in regulating runoff & river discharge | 4.1 Drainage and natural irrigation. 4.2 Medium for transport |

# Ecosystem Functions
# (Costanza et al., 1997, De Groot, 1992, De Groot et al., 2000.

| | | | |
|---|---|---|---|
| 5 | Water supply | Filtering, retention and storage of fresh water (e.g. in aquifers) | Provision of water for consumptive use (e.g.drinking, irrigation and industrial use) |
| 6 | Soil retention | Role of vegetation root matrix and soil biota in soil retention | 6.1 Maintenance of arable land. |
| | | | 6.2 Prevention of damage from erosion/siltation |
| 7 | Soil formation | Weathering of rock, accumulation of organic matter | 7.1 Maintenance of productivity on arable land. |
| | | | 7.2 Maintenance of natural productive soils |
| 8 | Nutrient regulation | Role of biota in storage and re-cycling of nutrients (eg. N,P&S) | Maintenance of healthy soils and productive ecosystems |
| 9 | Waste treatment | Role of vegetation & biota in removal or breakdown of xenic nutrients and compounds | 9.1 Pollution control/detoxification. 9.2 Filtering of dust particles. |

## Ecosystem Functions
## (Costanza et al., 1997, De Groot, 1992, De Groot et al., 2000.

| | | | |
|---|---|---|---|
| 10 | Pollination | Role of biota in movement of floral gametes | 10.1 Pollination of wild plant species. 10.2 Pollination of crops |
| 11 | Biological control | Population control through trophic-dynamic relations | 11.1 Control of pests and diseases. 11.2 Reduction of herbivory (crop damage) |
| | *Habitat Functions* | *Providing habitat (suitable living space) for wild plant and animal species* | Maintenance of biological & genetic diversity (and thus the basis for most other functions) |
| 12 | Refugium function | Suitable living space for wild plants and animals | Maintenance of commercially harvested species |
| 13 | Nursery function | Suitable reproduction habitat | 13.1 Hunting, gathering of fish, game, fruits, etc. 13.2 Small-scale subsistence farming & aquaculture |
| | *Production Functions* | *Provision of natural resources* | |
| 14 | Food | Conversion of solar energy into edible plants and animals | 14.1 Building & Manufacturing (e.g. lumber, skins). 14.2 Fuel and energy (e.g. fuel wood, organic matter). 14.3 Fodder and fertilizer (e.g. krill, leaves, litter) |
| 15 | Raw materials | Conversion of solar energy into biomass for human construction and other uses | 15.1 Improve crop resistance to pathogens & pests. 15.2 Other applications (e.g. health care) |

# Ecosystem Functions
# (Costanza et al., 1997, De Groot, 1992, De Groot et al., 2000.

| | | | |
|---|---|---|---|
| 16 | Genetic resources | Genetic material and evolution in wild plants and animals | 16.1 Drugs and pharmaceuticals. 16.2 Chemical models & tools. 16.3 Test- and essay organisms |
| 17 | Medicinal resources | Variety in (bio)chemical substances in, and other medicinal uses of, natural biota | Resources for fashion, handicraft, jewelry, pets, worship, decoration & souvenirs (e.g. furs, feathers ivory, orchids, butterflies, aquarium fish, shells, etc.) |
| 18 | Ornamental resources | Variety of biota in natural ecosystems with (potential) ornamental use | |
| | *Information Functions* | *Providing opportunities for cognitive development* | |
| 19 | Aesthetic information | Attractive landscape features | Enjoyment of scenery (scenic roads, housing, etc.) |

# Ecosystem Functions
# (Costanza et al., 1997, De Groot, 1992, De Groot et al., 2000.

| | | | |
|---|---|---|---|
| 20 | Recreation | Variety in landscapes with (potential) recreational uses | Travel to natural ecosystems for eco-tourism, outdoor sports, etc. |
| 21 | Cultural and artistic information | Variety in natural features with cultural and artistic value | Use of nature as motive in books, film, painting, folklore, national symbols, architect., advertising, etc. |
| 22 | Spiritual and historic information | Variety in natural features with spiritual and historic value | Use of nature for religious or historic purposes (i.e. heritage value of natural ecosystems and features) |
| 23 | Science and education | Variety in nature with scientific and educational value | Use of natural systems for school excursions, etc. Use of nature for scientific research |

# Case study- China- Forest Ecosystem

ELSEVIER

Ecological Economics

Volume 38, Issue 1, July 2001, Pages 141-154

ANALYSIS

## Ecosystem functions, services and their values – a case study in Xingshan County of China

Zhongwei Guo [a], Xiangming Xiao [b], Yaling Gan [c], Yuejun Zheng [d]

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https://doi.org/10.1016/S0921-8009(01)00154-9

# Case study- China- Forest Ecosystem

Xingshan County is situated in the west part of Hubei Province, China and covers about 2316 $km^2$.

The area of forestland reaches 107 000 ha,

accounting for 50.64% of the total land area of the county.

Table 1. Forest ecosystem services assessed in this study

| Type | Benefit | Services | Functions |
|---|---|---|---|
| Ecosystem goods | Direct economic value | Timber and other forest products | |
| | | Taking forest tour | |
| Ecosystem services | Indirect economic value | Water conservation | Hydrological flow regulation |
| | | | Water retention and storage |
| | | Soil conservation | Reduction of soil disuse |
| | | | Prevention of silt accretion |
| | | | Decrease of soil deposit |
| | | | Protection of soil fertility |
| | | Gas regulation | Carbon fixation |
| | | | Oxygen supply |

# Case study- China- Forest Ecosystem

| Type | Ecosystem service | Value (million RMB) |
|---|---|---|
| *Direct value* | | 54.23 |
| | Timber and other forest products | 48.43 |
| | Taking forest tour | 5.8 |
| *Indirect value* | | 528.73 |
| | *Water conservation:* | |
| | Hydrological flow regulation | 59.78 |
| | Water retention and storage | 3.59 |
| | *Soil conservation:* | |
| | Reduction of land disuse | 2.94 |
| | Prevention of silt accretion | 78.02 |
| | Decrease of soil deposit | 50.38 |
| | Protection of soil fertility | 241.3 |
| | *Gas regulation:* | |
| | Carbon fixation | 46.45 |
| | Oxygen supply | 46.27 |
| Total value | | 582.96 |

# Forest Ecosystem

- High rainfall
- Large number of organism and flora
- Highly diverse population
- Stability of ecosystem is very sensitive

# Forest Ecosystem –

- Based on leaf characteristics
  - Coniferous
  - Broad leaved

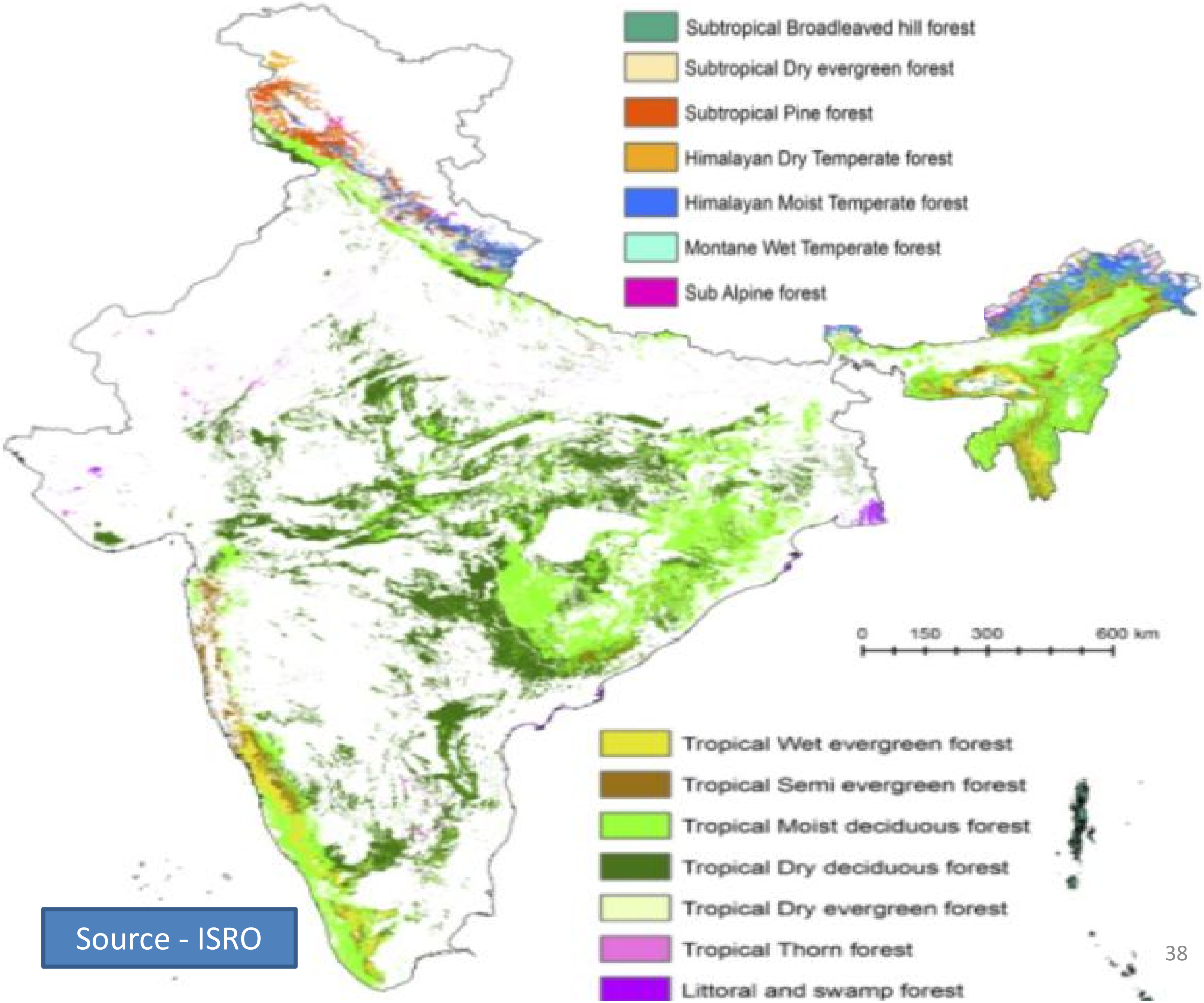
- Based on tree species
  - Evergreen
  - Deciduous
  - Xerophytic (Thorn trees)
  - Mangroves

Types of forests

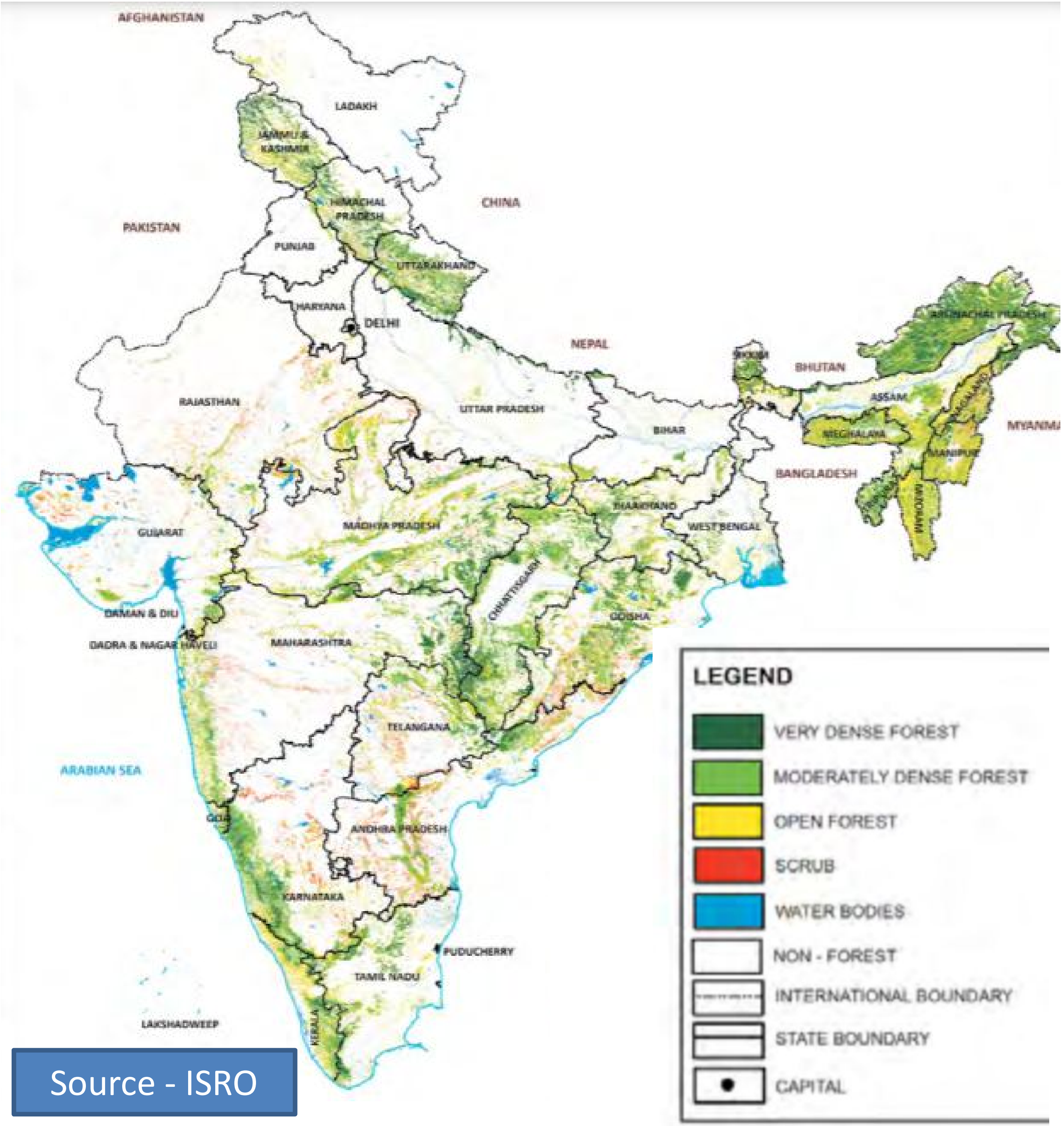
- Tropical rainforests (No dry season)
- Tropical deciduous forests (Average Rainfall)
- Tropical scrub forests (Hottest season)
- Temperate rainforests (Broadleaf with heavy rainfall)
- Temperate deciduous forest
- Evergreen coniferous forest (Woody plants with normal temperature)

Components of forest ecosystem-

- Abiotic Components – Soil, Temp, Climate etc.,
- Biotic Components – Producers, Consumers- Primary, Secondary, Tertiary
- Decomposers – Micro-organism , Fungi etc.,


Subtropical Broadleaved hill forest
Subtropical Dry evergreen forest
Subtropical Pine forest
Himalayan Dry Temperate forest
Himalayan Moist Temperate forest
Montane Wet Temperate forest
Sub Alpine forest
0 150 300 600 km
Tropical Wet evergreen forest
Tropical Semi evergreen forest
Tropical Moist deciduous forest
Tropical Dry deciduous forest
Tropical Dry evergreen forest
Tropical Thorn forest
Littoral and swamp forest

Source - ISRO




Source - ISRO

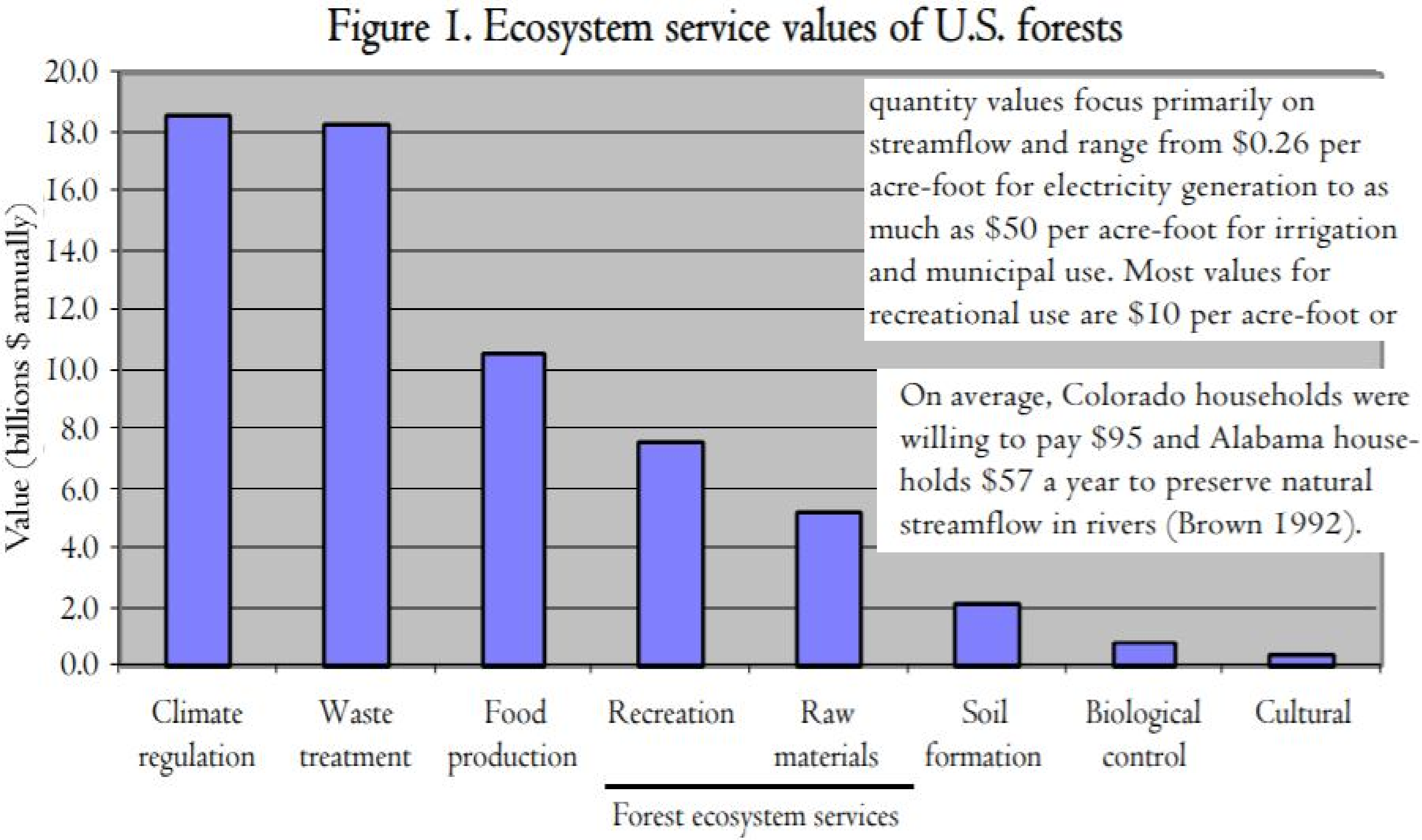
- ✓**Dense Forest with a canopy density more than 70%,**
- ✓**Moderately Dense Forest with a canopy density between 40-70%**
- ✓**Open Forest with a canopy density between 10- 40%.**
- ✓**The tree cover is assessed following a methodology involving remote sensing based stratification**

**Source:** INDIA STATE OF FOREST REPORT 2019,

Forest Survey of India Ministry of Environment, Forest & Climate Change

# Service of forest ecosystem

- **Watershed Protection**
- **Atmospheric regulation**
- **Soil Erosion Control**
- **Wind Erosion Control**




Krieger, D.J., 2001. Economic value of forest ecosystem services: a review.

# Grassland Ecosystem

- Marginal rainfall
- Vegetation is dominated by grasses
- Unimproved wild-plant communities
- Densely populated

# Types of Grassland Ecosystem

- Temperate grasslands (receiving 25–100 cm of annual precipitation)
- Tropical grasslands (receiving up to 150 cm of annual precipitation)
- Desert grasslands (receiving 25–45 cm of annual precipitation)

Joseph, B., 2006

**Table 1** The area of global grasslands

| Grassland type | Whittaker and Likens (1975)[a] | | Atjay et al. (1979)[a] | | Olson et al. (1983) | | PAGE (White et al. 2000) | |
|---|---|---|---|---|---|---|---|---|
| | Million $km^2$ | Percent[b] | Million $km^2$ | Percent[b] | Million $km^2$ | Percent[b] | Million $km^2$ | Percent[b] |
| Savanna | 15.0 | 11.6 | 12.0 | 9.3 | × | × | 17.9 | 13.8 |
| Tropical woodland and savanna | × | × | × | × | 7.3 | 5.6 | × | × |
| Dry savanna and woodland | 8.5[c] | 6.6 | 3.5 | 2.7 | 13.2[d] | 10.2 | × | × |
| Shrublands[e] | × | × | 7.0 | 5.4 | × | × | 16.5 | 12.7 |
| Non-woody grassland and shrubland | × | × | × | × | 21.4 | 16.5 | 10.7 | 8.30 |
| Temperate grassland | 9.0 | 7.0 | 12.5 | 9.7 | × | × | × | × |
| Tundra | 8.0 | 6.2 | 9.5 | 7.3 | 13.6 | 10.5 | 7.4 | 5.7 |
| Total | 40.5 | 31.3 | 44.5 | 34.4 | 55.5 | 42.8 | 52.5 | 40.5 |

× signifies data are not available or have been combined with other categories

[a]Desert and semidesert scrub not included

[b]Total land area used for the world is 129,476,000 $km^2$ excluding Greenland and Antarctica

[c]Includes woodland and shrubland

[d]Includes dry forest and woodland

[e]Includes warm, hot, or cool shrublands

# Features of grassland ecosystem

- Temperature
- Precipitation
- Humidity
- Topography
- Unadaptive plants and animals

# Grass land ecosystem-Services

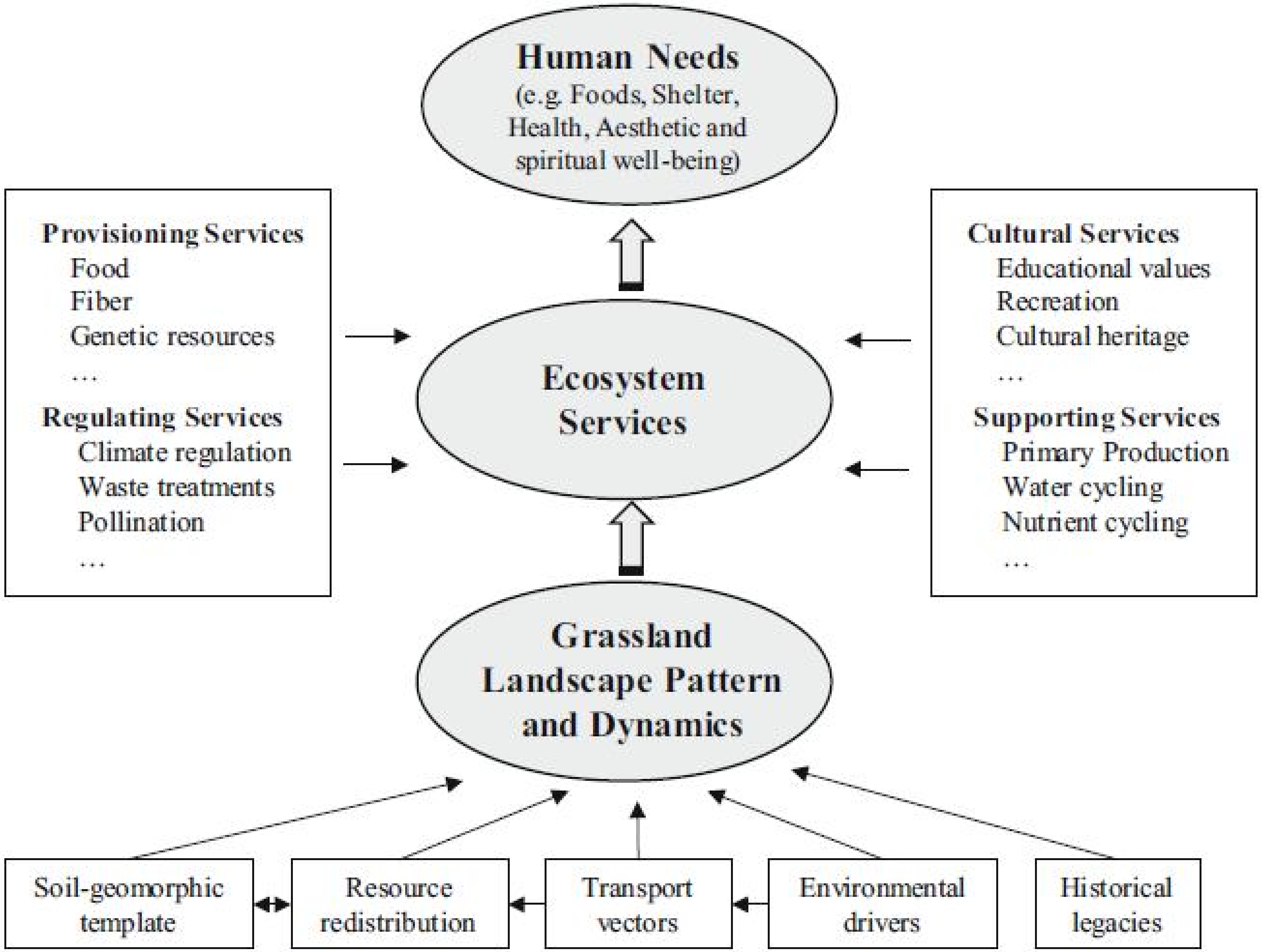
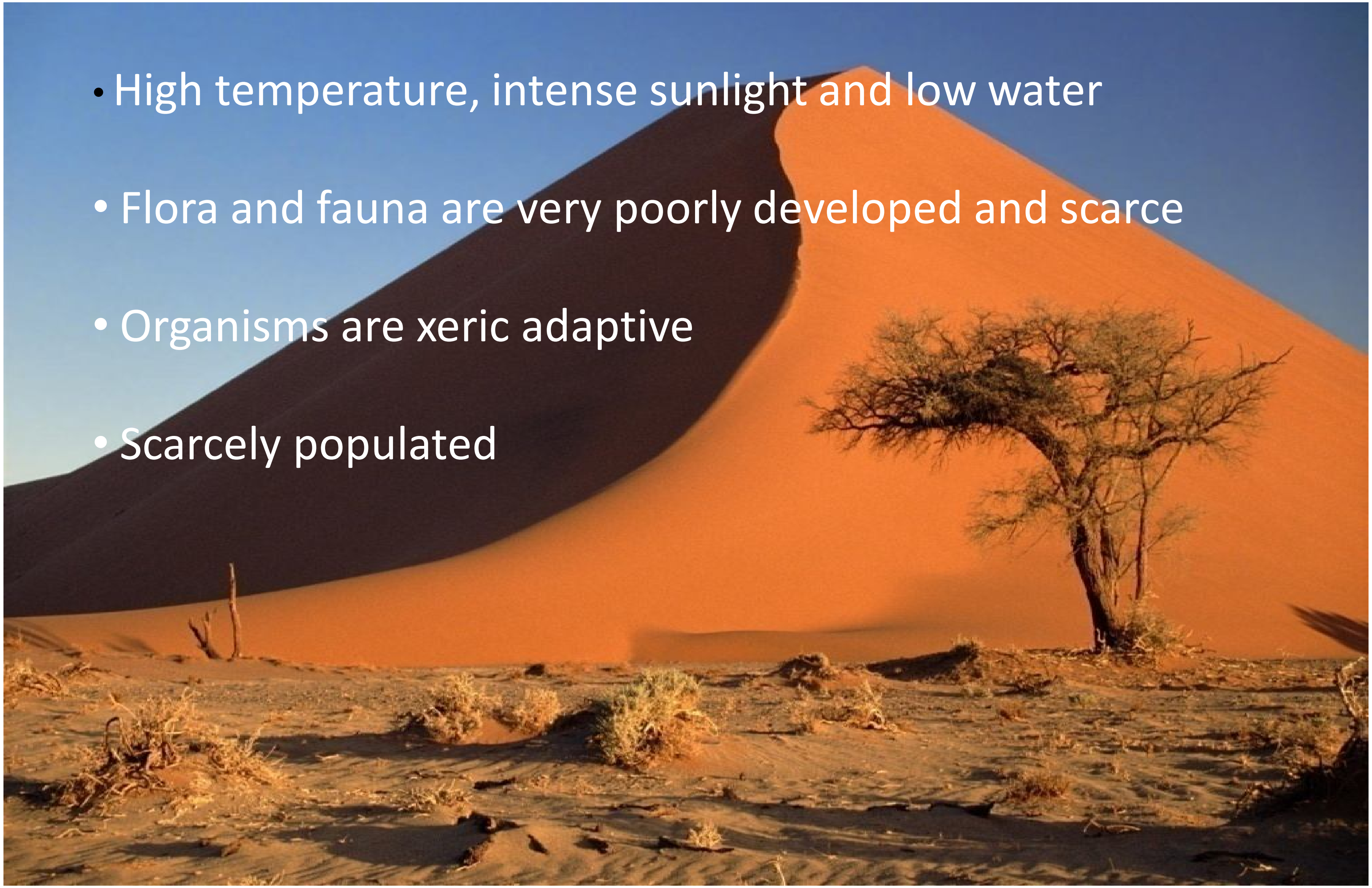



**Fig. 1** Main ecosystem services of grasslands and their interactions with the grassland landscape and human needs (Modified from Campbell et al. 1996, White et al. 2000 and Havstad et al. 2007)

Zhao et al., 2020

# Desert Ecosystem



- High temperature, intense sunlight and low water
- Flora and fauna are very poorly developed and scarce
- Organisms are xeric adaptive
- Scarcely populated

# Desert Ecosystem

- These ecosystem occurs in regions where evaporation exceeds precipitation
- Rainfall is less than 25 cm per year
- They have species of various diversity and consist of drought resistant plants

# Types of desert

- Sand desert
- Stony desert
- Rock desert
- Plateau desert
- Mountain desert
- Cold desert

# Sand desert

# Rock desert

# Stony desert

# Plateau desert

# Mountain desert

# Cold desert

# Desert Ecosystem

- Deserts are of 3 types:

1) Tropical Deserts (Driest and Hottest) like Sahara Desert
2) Temperate Deserts (Day as summer and night as winters) like Mojave Desert
3) Cold Deserts (Cool winters and warm summers) like Gobi Desert

# Features of desert ecosystem

- Rainfall
- Temperature
- Soil
- light
- Plants  and animals are adapted to live in extremities

# Services of desert ecosystem

- Solar energy resource
- Mineral resource

# Aquatic Ecosystem

- Low temperature and sunlight
- Soil and vegetation is submerged
- Flora and fauna had adapted
- Densely populated.

# Types of Aquatic ecosystem

- Ocean
- Lotic: Free flowing like rivers
- Lentic: Still like pond, lakes
- Wetland

# Lake Ecosystem

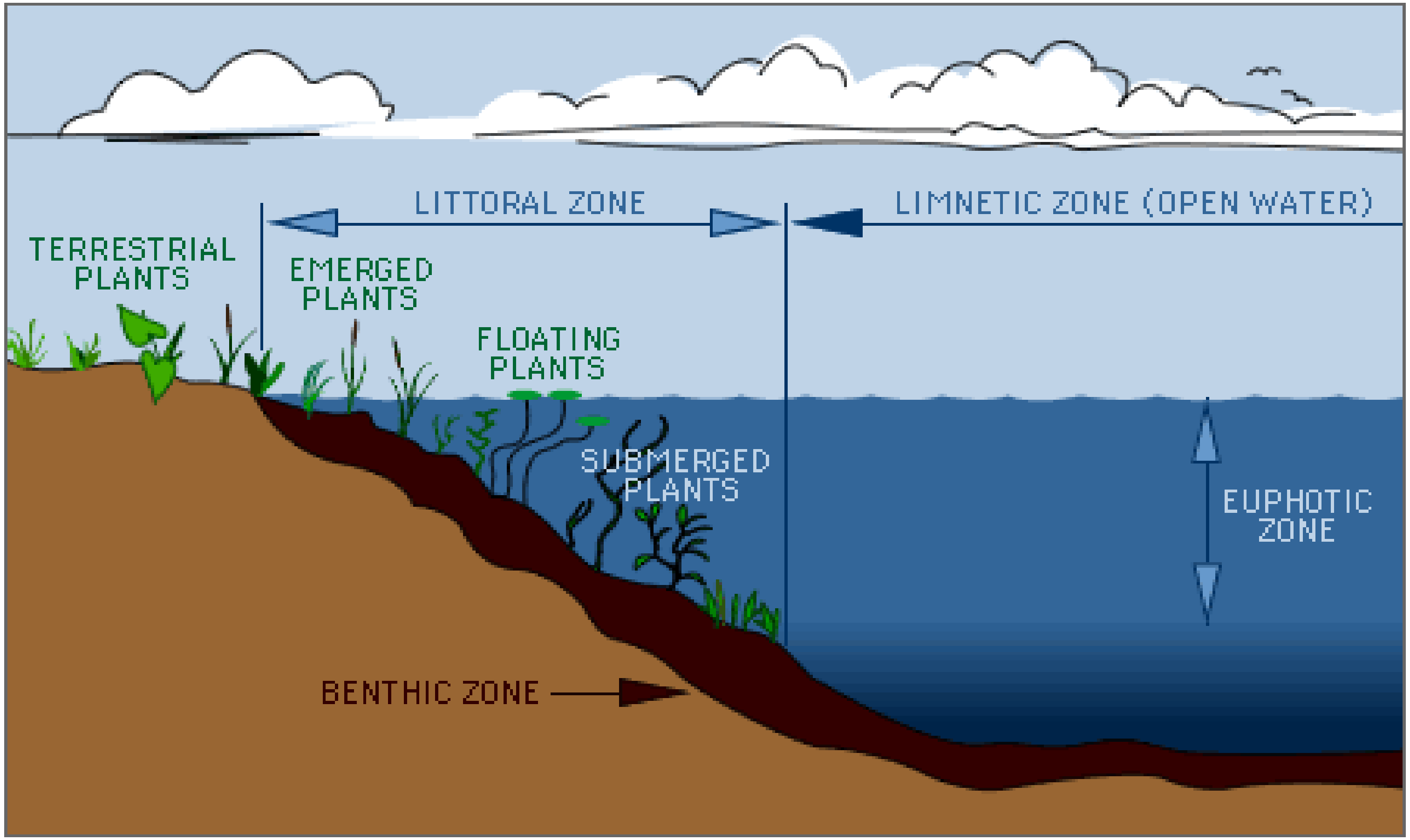
- Lakes have been found to exhibit distinct zones of biological activities, largely determined by availability of light and oxygen
- The most important biological zones are:

1) Euphotic Zone
2) Littoral Zone
3) Benthic Zone

# Zones in Lake Ecosystem

1) Euphotic Zone: Upper layer of water through which sunlight can penetrate. All plant growth occurs in this zone.
2) Littoral Zone: The shallow water near the shores in which rooted plants exist
3) Benthic Zone: Bottom sediments in a lake comprise this zone. Dead organisms are decomposed in this zone.

# Lake Ecosystem



# Features of aquatic ecosystem

- Light and temperature
- Current
- Chemistry
- Competitive organism

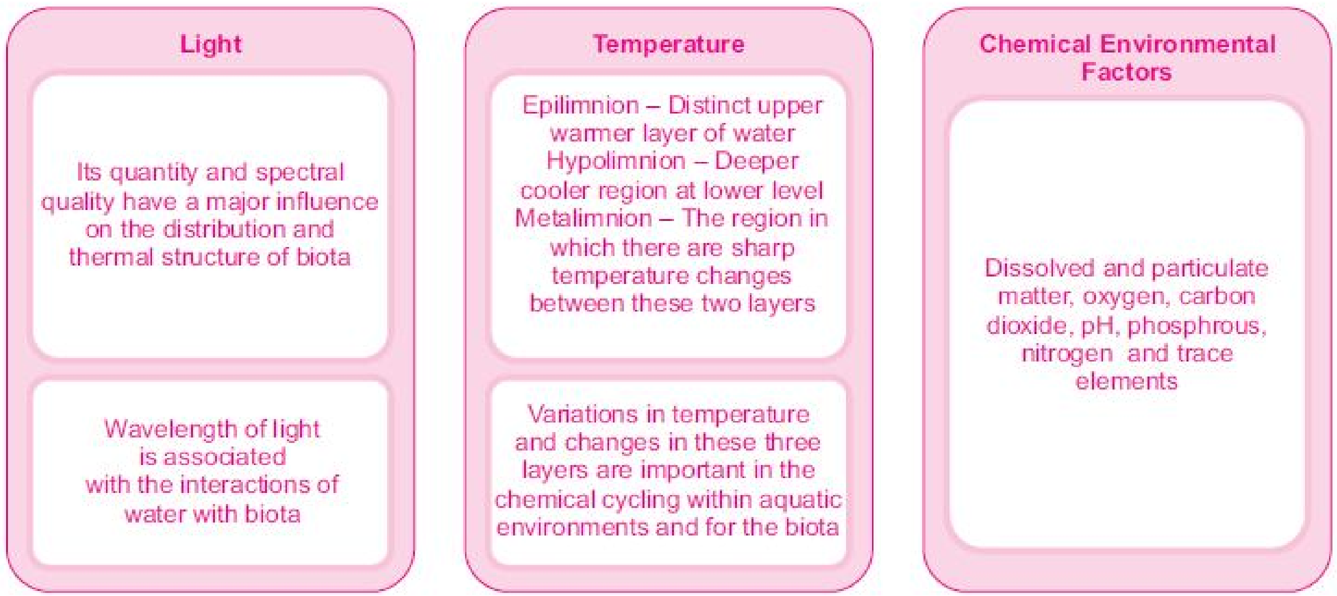



**Fig. 2.11** *Environmental Factors Affecting the Aquatic Ecosystem Performance*

Source: Joseph B , 2006

**Light**

Its quantity and spectral quality have a major influence on the distribution and thermal structure of biota

Wavelength of light is associated with the interactions of water with biota

**Temperature**

Epilimnion – Distinct upper warmer layer of water
Hypolimnion – Deeper cooler region at lower level
Metalimnion – The region in which there are sharp temperature changes between these two layers

Variations in temperature and changes in these three layers are important in the chemical cycling within aquatic environments and for the biota

**Chemical Environmental Factors**

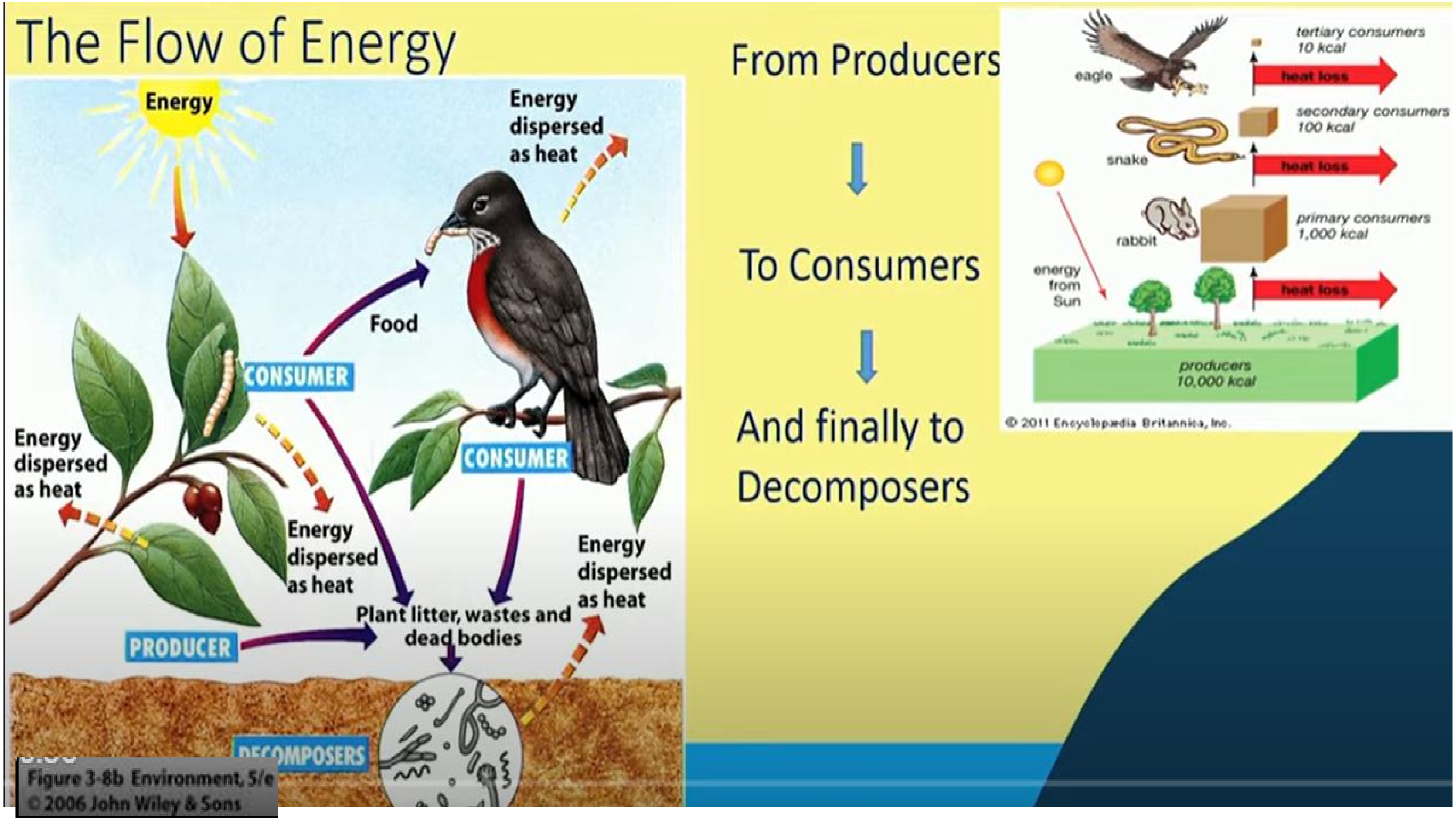
Dissolved and particulate matter, oxygen, carbon dioxide, pH, phosphrous, nitrogen and trace elements

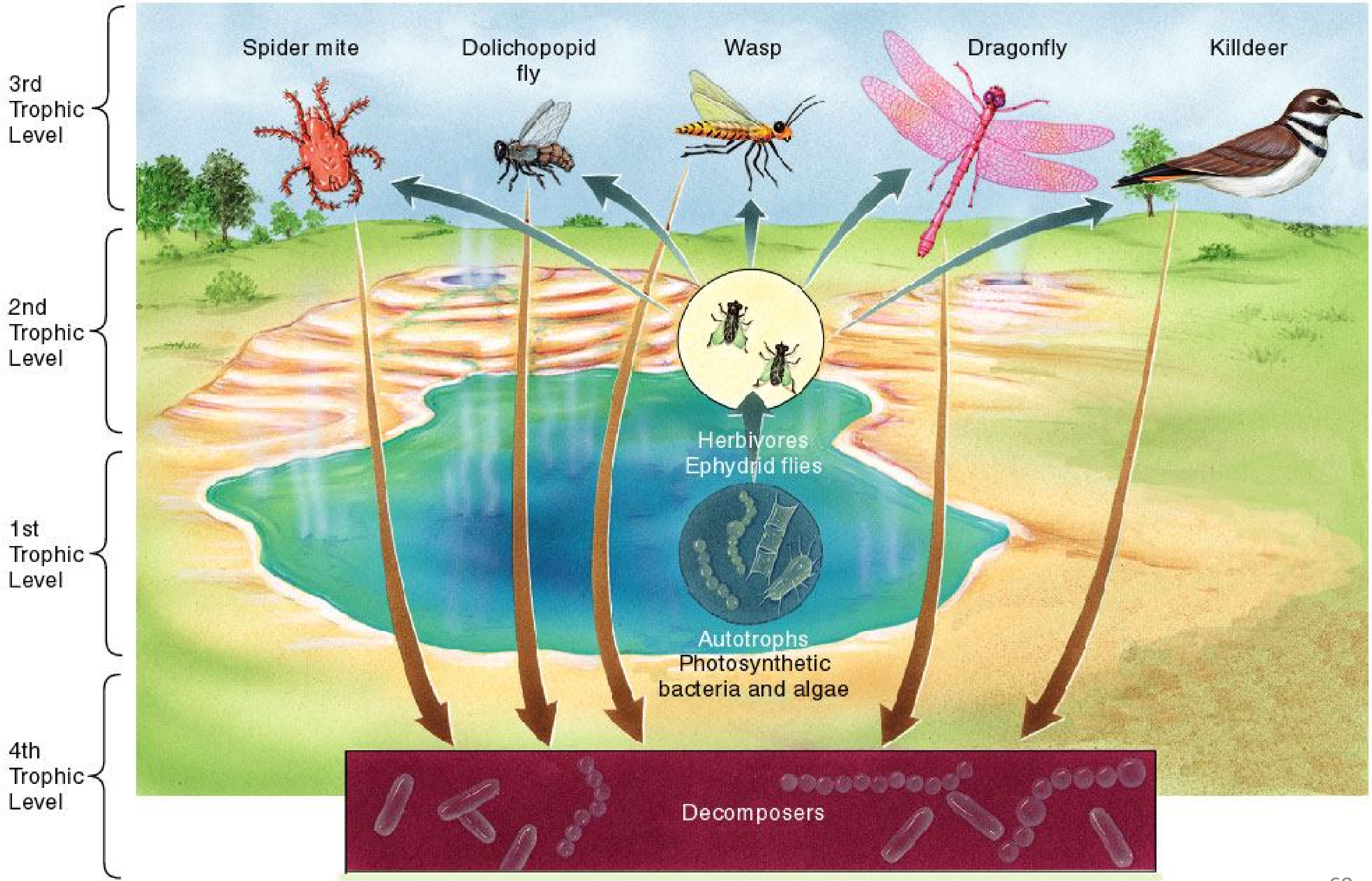
**Fig. 2.11** *Environmental Factors Affecting the Aquatic Ecosystem Performance*

# Services of Aquatic Ecosystem

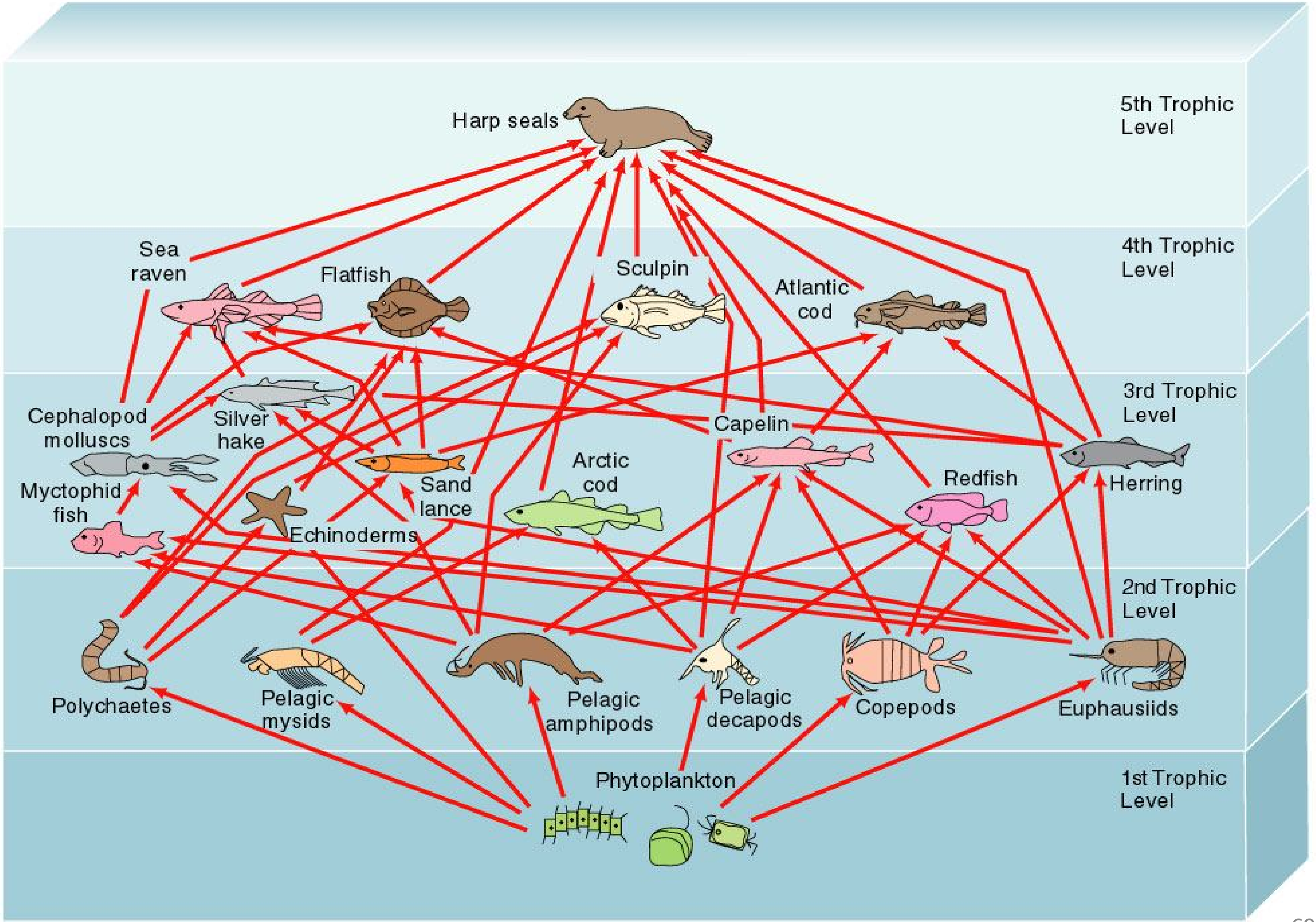
- Recycles nutrients
- Purify water
- Responsible for proper rainfall
- Attenuate floods
- Recharge ground water

# Energy Flow in Ecosystem



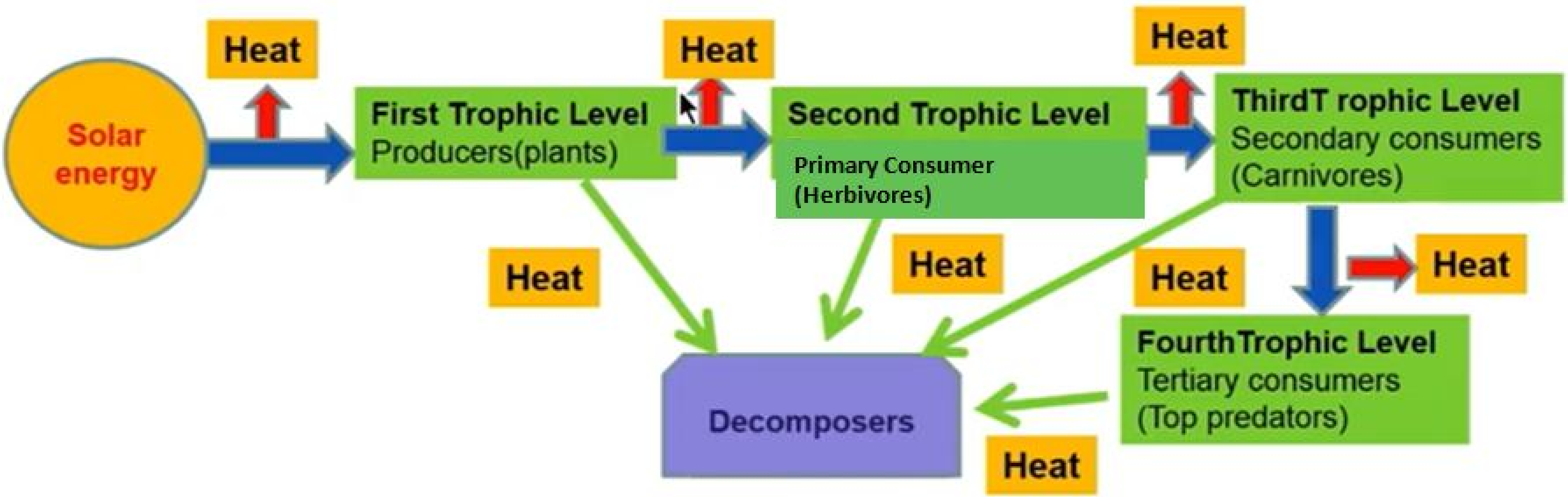



Souce: Google Images




Souce: Google Images

- Energy collected by plants from the Sun flows through ecosystems in food chains and food webs




Source: NPTEL SWAYAM

nptel.ac.in/courses/

# Ecological Pyramids

- Graphic representation of trophic structure and function of ecosystem, starting with producers at the base and successive trophic levels at the apex is known as ecological pyramid
- They are of 3 types:

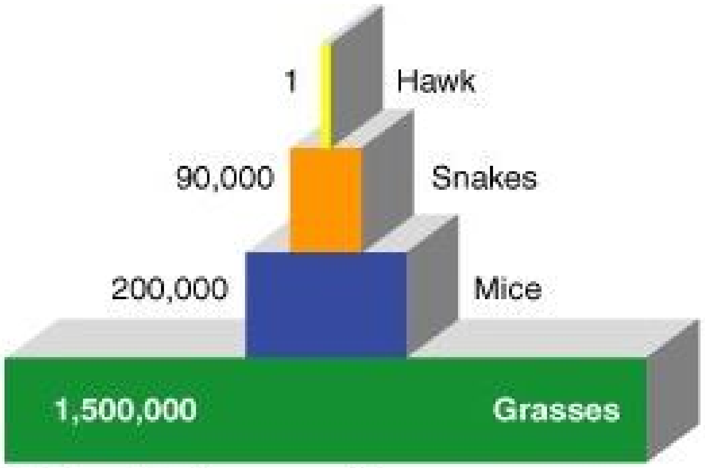
1) Pyramids of numbers
2) Pyramids of Biomass
3) Pyramids of Energy

# Pyramids of Numbers

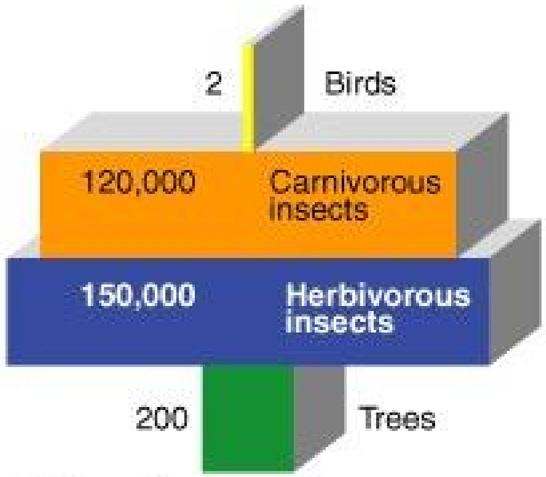
- It represents the **number of individual** organisms at each trophic level of a food chain per unit area at any time
- Generally represented by number per sq.m
- It can be upright or inverted depending upon type of ecosystem and food chain

Pyramid of numbers-

- Eltonian pyramids- Developed by Charles Elton
- Number of individuals per species
- Does not consider individual sizes or biomass.
- Need not be always upright

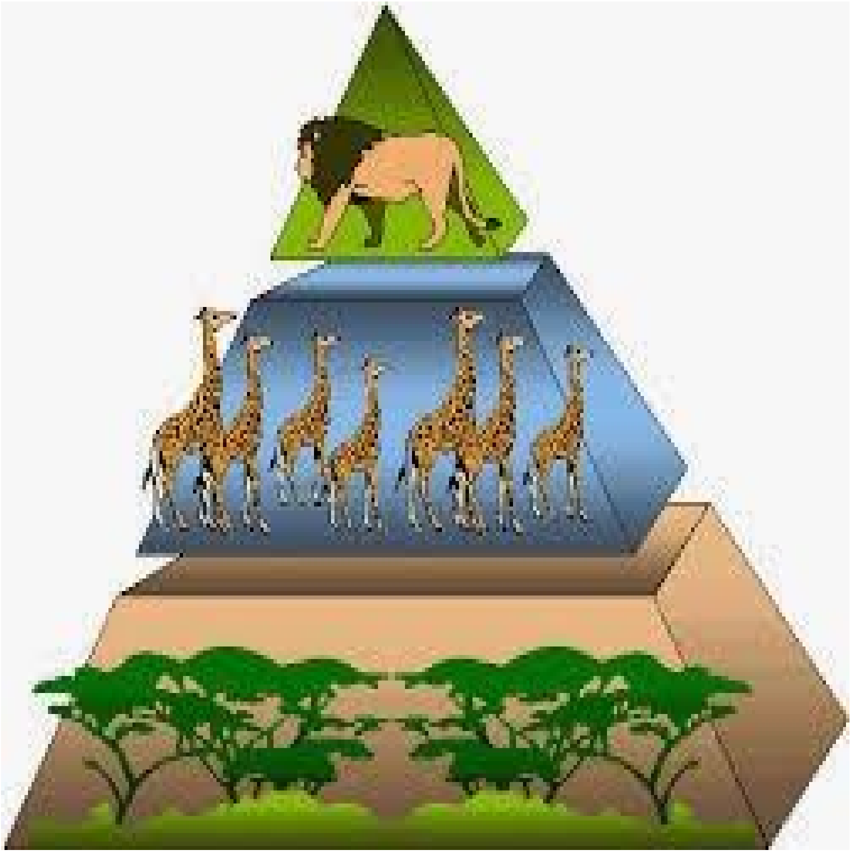


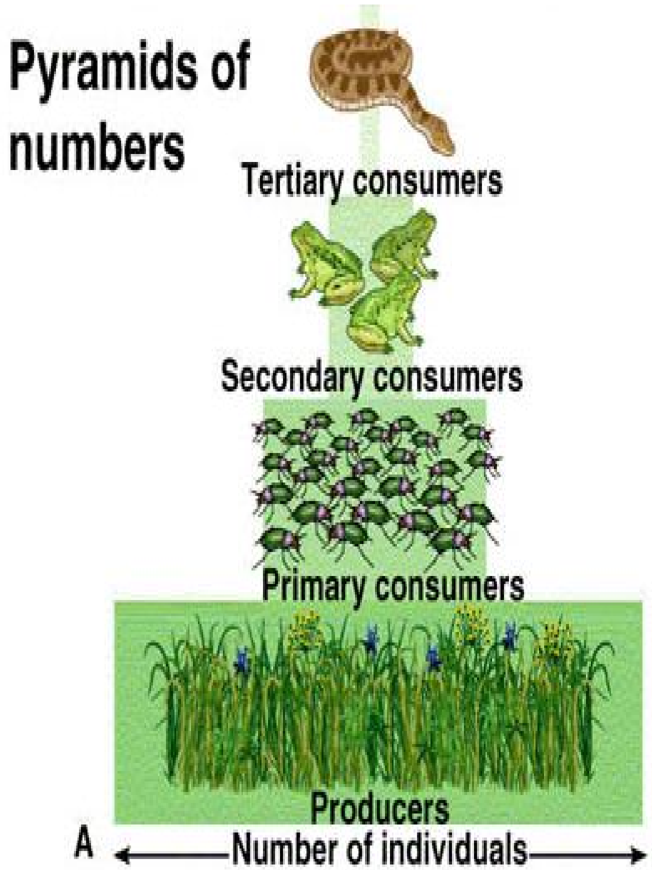

(a) Grassland community



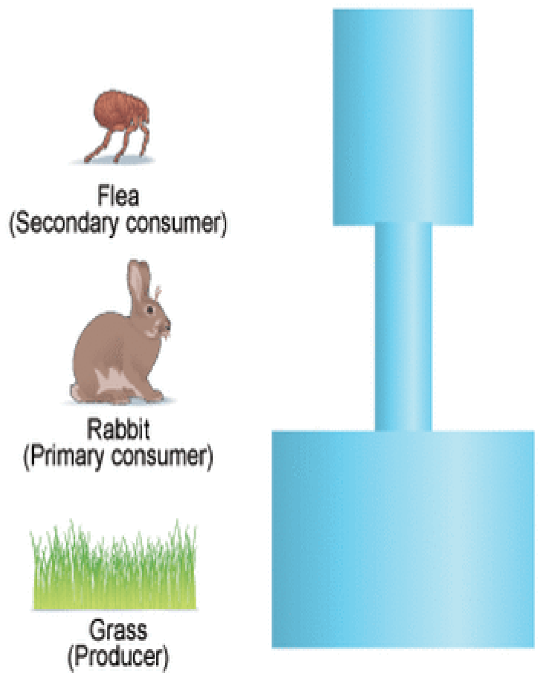

(b) Forest community

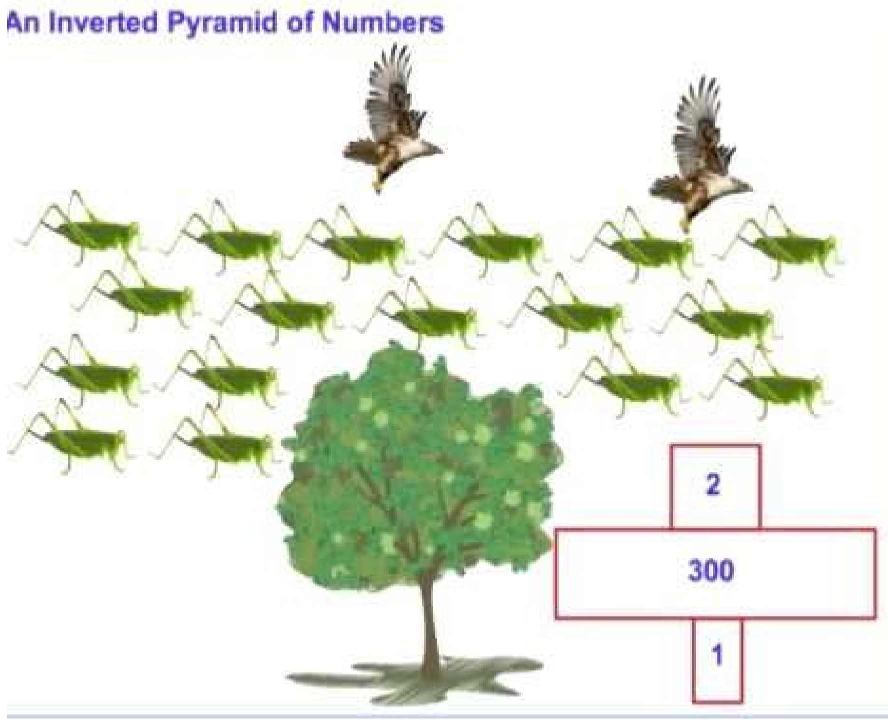
# Pyramids of Numbers





# Pyramids of Numbers



# Pyramids of Numbers

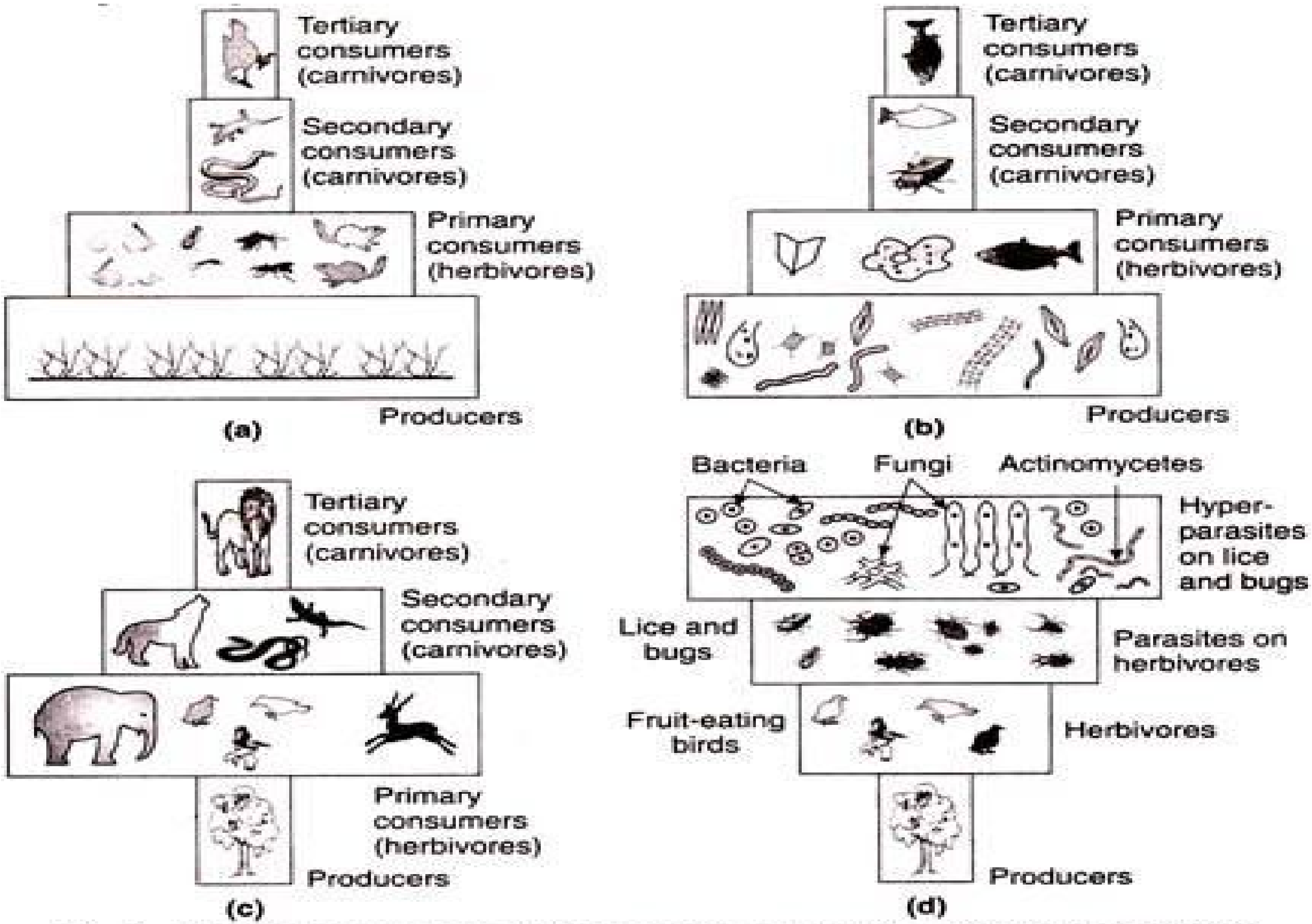



Fig. 6. Pyramid of numbers (a) Grassland ecosystem, (b) Pond ecosystem, (c) Forest ecosystem and (d) Parasitic food chain.

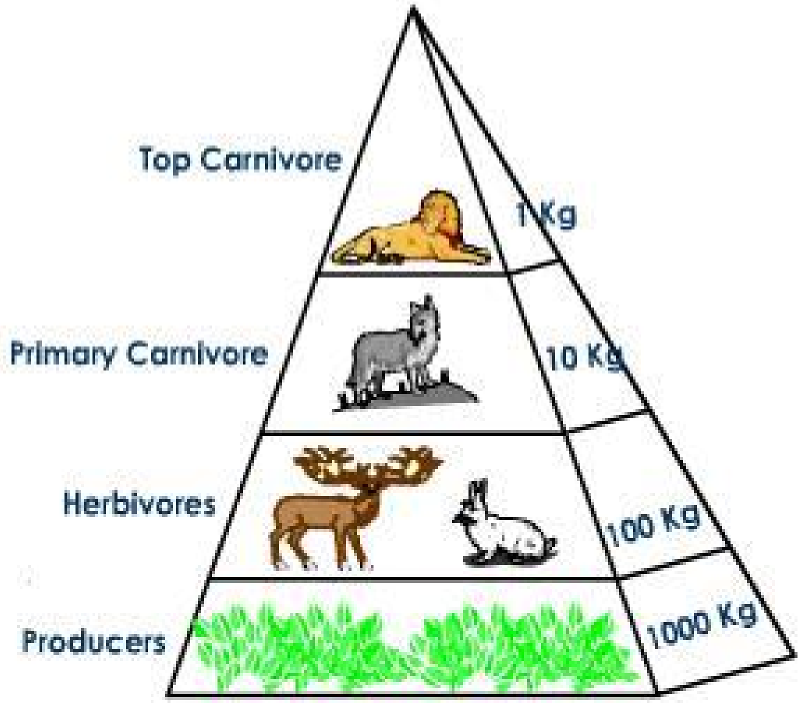
# Drawbacks

- The pyramid does not take into account **size of individual organism** i.e all organisms are considered equal in size
- **Number of individuals** in a trophic level depends upon the **availability of biomass**
- For example, a tree supports several insects but several trees will support a single elephant or herbivore

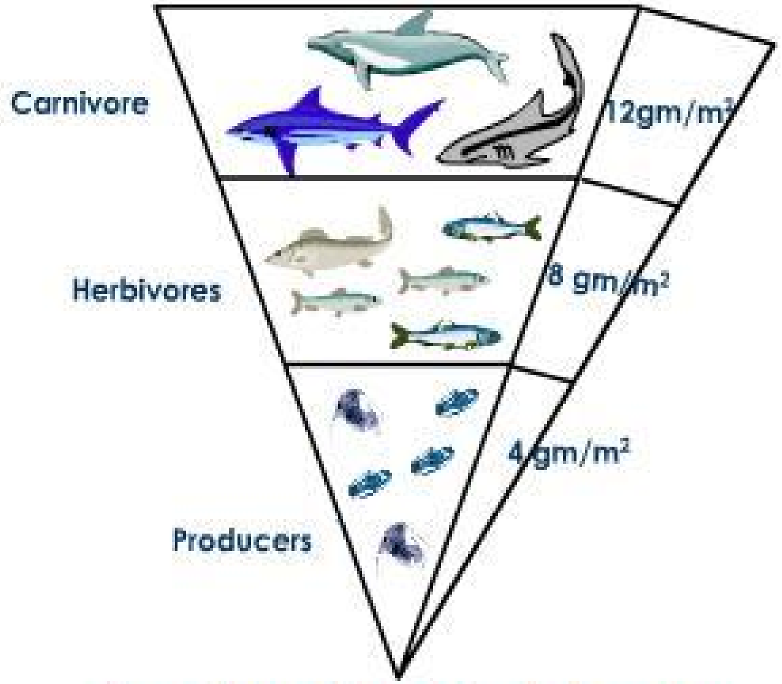
# Pyramid of Biomass

- It is based upon the total biomass at each trophic level in the food chain
- It can also be **inverted or upright**
- It is represented by grams/ sq.m i.e dry matter available

# Pyramid of Biomass




Upright Pyramid of biomass in a Terrestrial Ecosystem




Inverted Pyramid in an Aquatic Ecosystem

# Drawbacks

- Each trophic level indicates standing crops which is different in different seasons for example, a deciduous tree has more biomass in spring but less in winter

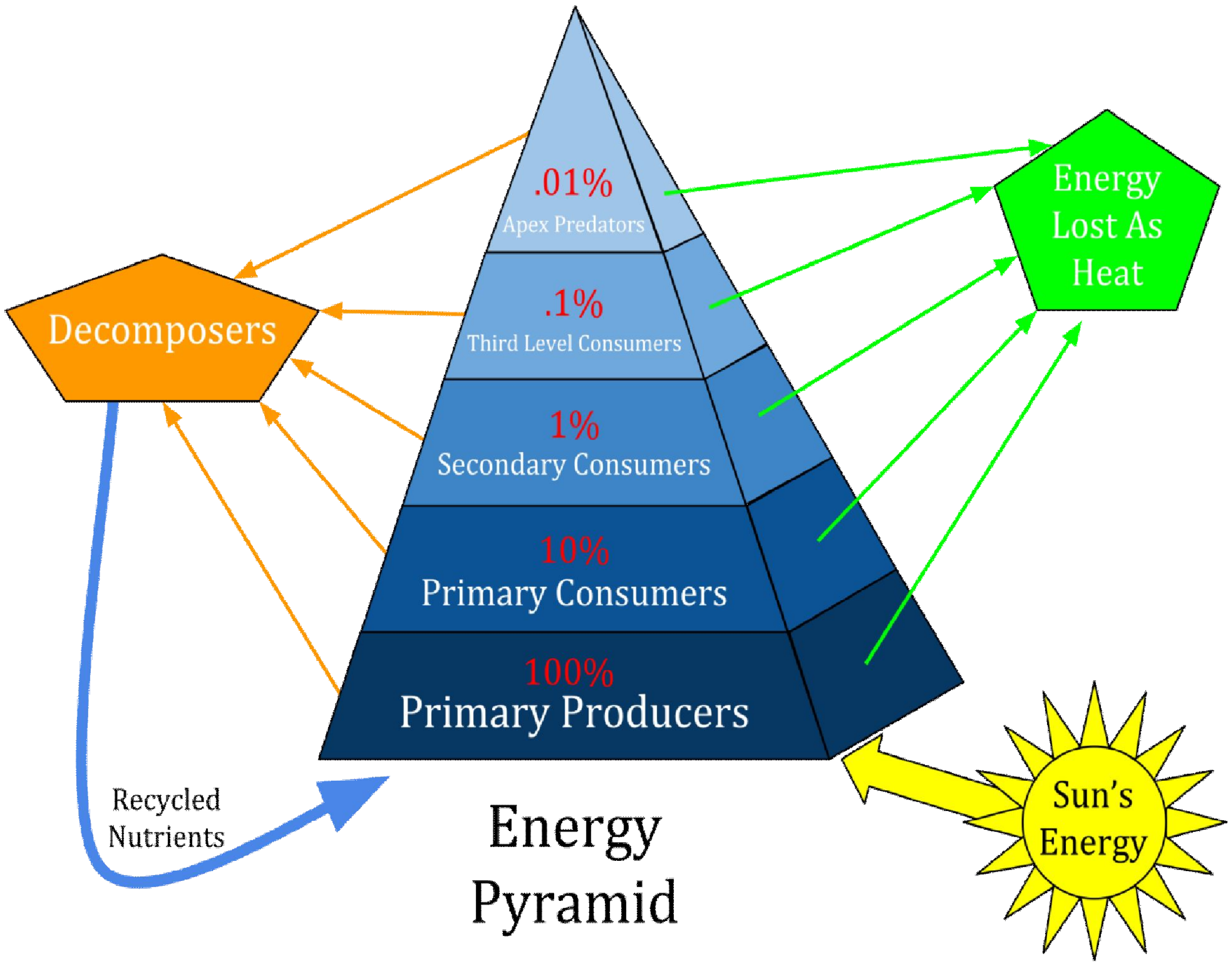
- Life span of individuals is not taken into consideration i.e. less lifetime organism may have higher biomass

- Biomass differs in its energy content in different organisms

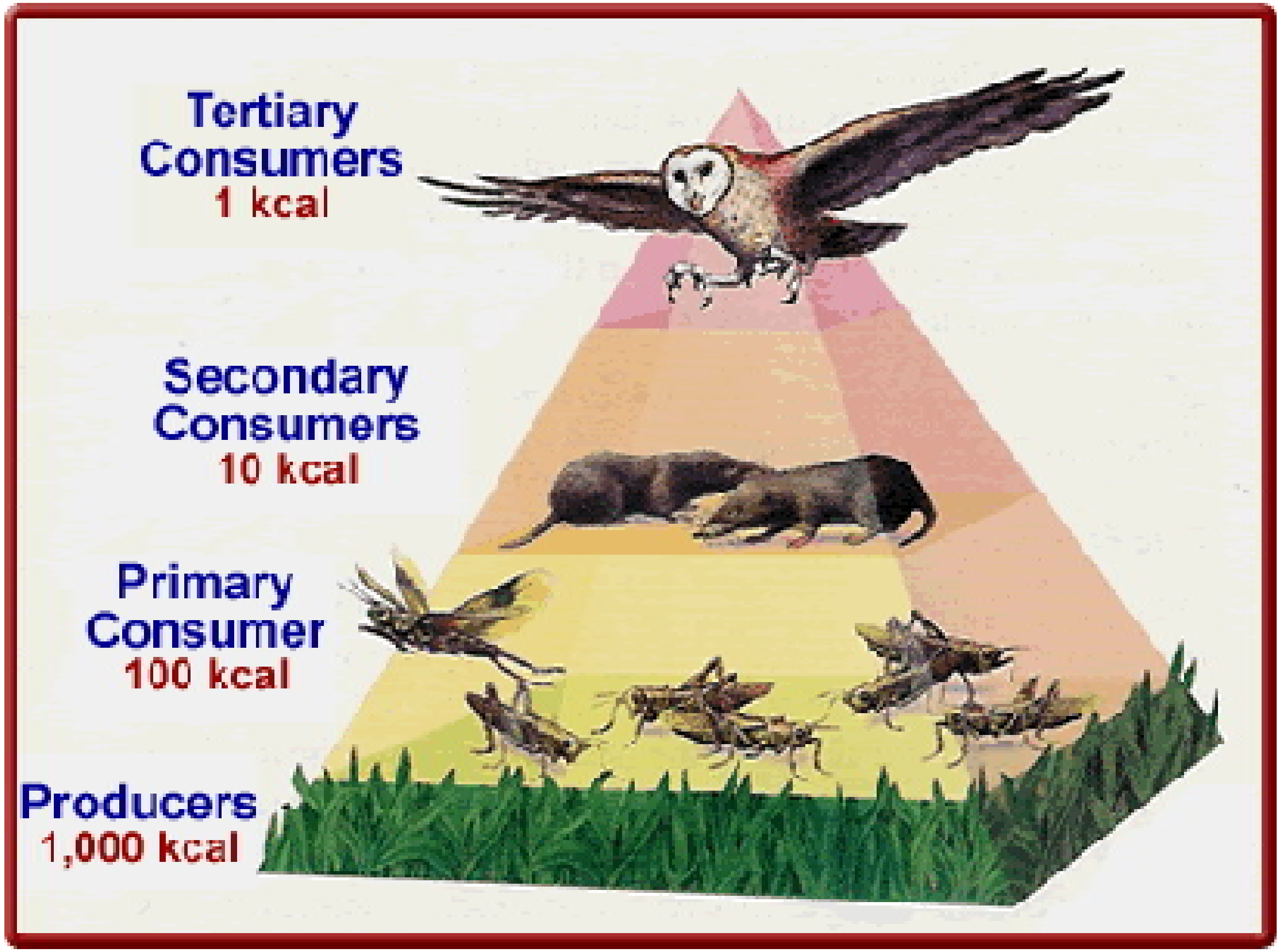
# Pyramids of Energy

- In this type of pyramid, the amount of energy present in each trophic level is represented
- It is presented by kcal/sq.m/year
- Such type of pyramid gives the best representation and is always upright
- There is always a sharp decline in energy level at each trophic levels

# Pyramids of Energy



# Pyramids of Energy



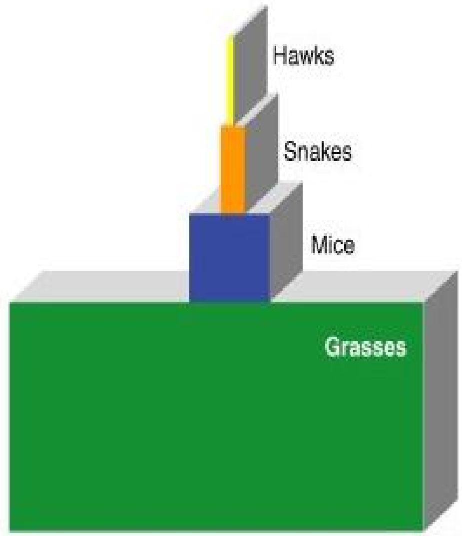
# Advantages

1) Always upright
2) Based on productivity
3) Gives the idea of actual amount of energy received at each trophic level

- Such type of pyramid gives by far the best overall picture of functional aspects of ecosystem

## Energy Pyramid

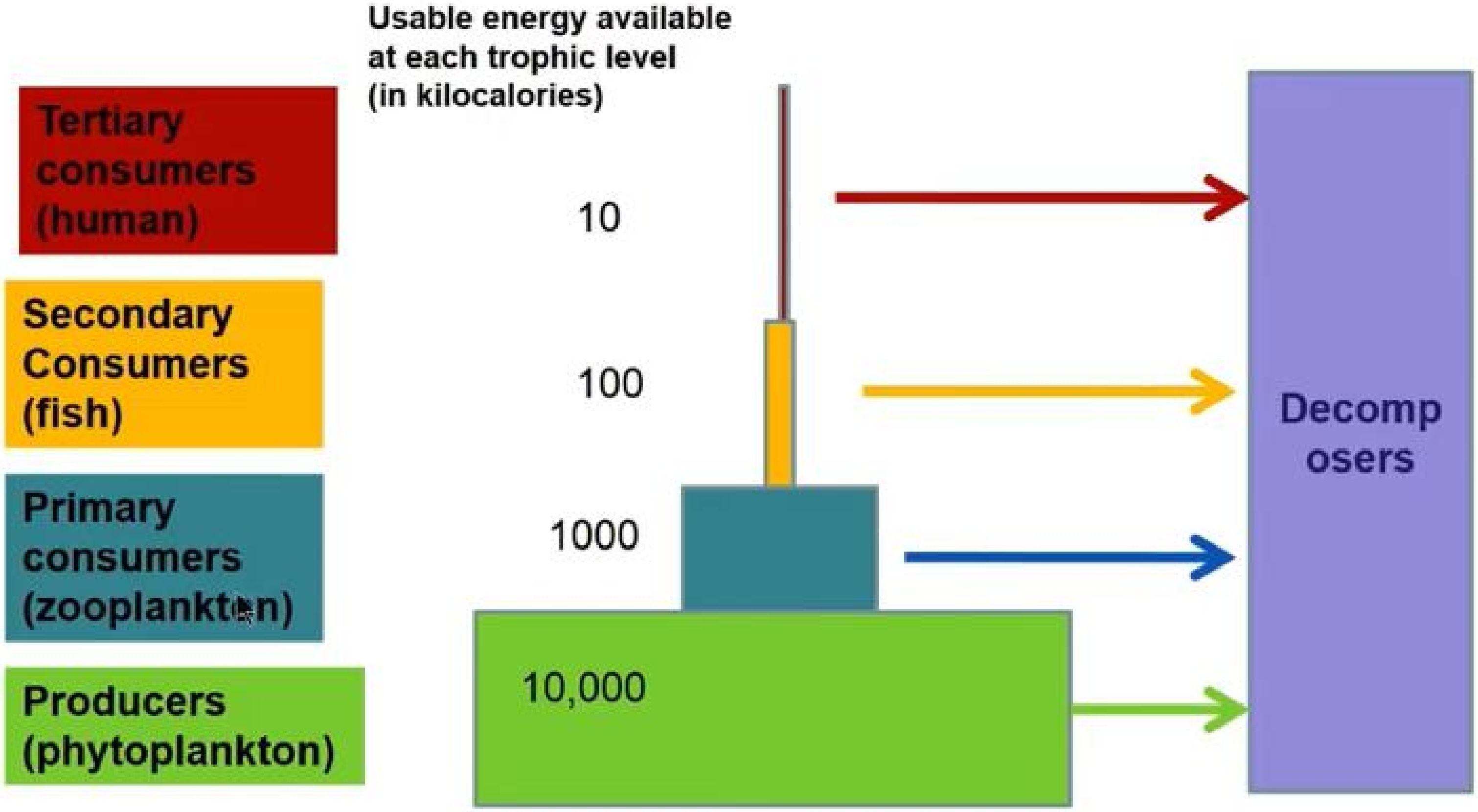
- The greatest amount of energy is found at the base of the pyramid.
- The least amount of energy is found at top of the pyramid.
- **Energy pyramids can never be inverted.**




*(e)* **Energy levels of a stable community** (kcal/day)

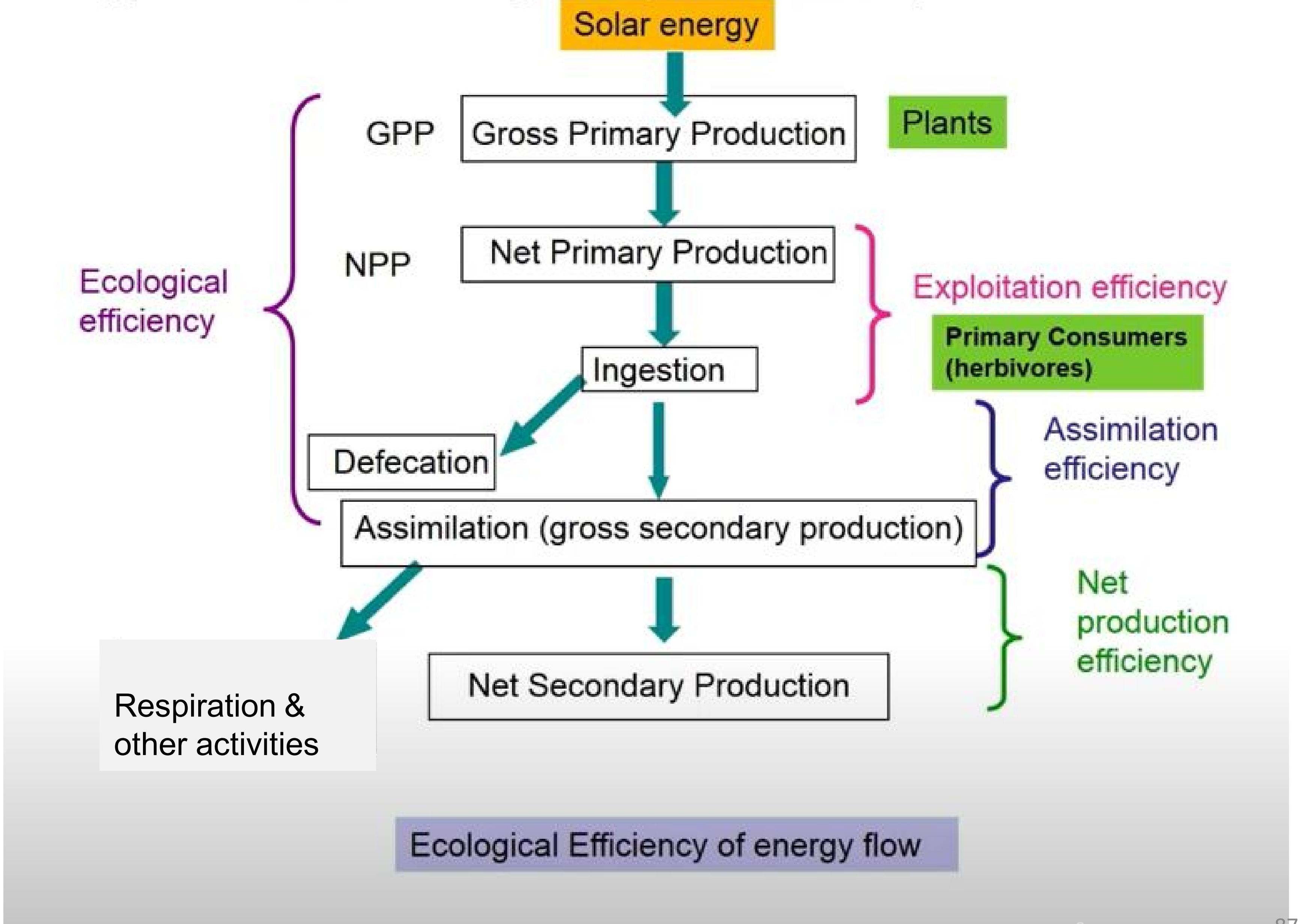
# Energy and material flow in the

Generalized *pyramid of energy flow* showing the decrease in usable chemical energy available at each succeeding trophic level in a food chain or web.
Ecological efficiency varies from 2- 40%, with 10% efficiency common.




Source: NPTEL SWAYAM

## Energy and Material Flow through Ecosystems- Efficiency



# Ecological efficiency

- Direct energy harvesting- solar energy harvesting agent- plants which are producing it.

- energy is flowing through the ecosystems in food chains, and webs.

- as energy flows through ecosystems in food chains, and webs, the amount of **chemical energy available to organisms at each succeeding tropic level decreases.**

# Ecological efficiency

- Efficiency with which the energy is flowing at each tropic level or Efficiency with which one tropic level extract energy from other.
- Plant extract energy from Sun, Herbivorous extract energy from plant. All this happens at different efficiency
- So, how does energy and material flow through these ecosystems is an important thing.
- Ecological efficiency can be defined in various way--- such as NPP

# Ecological productivity

- Ecological productivity refers to the primary fixation of solar energy by plants and subsequent usage of the energy by herbivores then by carnivores and so on which creates a complex food web

- **Gross primary production** is the first stage which is like taking energy from sun

- Plants convert that energy into useful glucose or matter and that glucose is transferred from the plants. Plants used the energy for respiration etc.

- NPP= GPP- loss due to respiration

- Net primary production that is what is the plant mass that **we see growing on earth**

# Ecological productivity

- Herbivores eat the plants, so that is the next level of energy flow.

- **Exploitation efficiency:** efficiently a herbivore is exploiting the available food sources that is present there.

- Primary consumer--- Ingest the food and some amount will be defecated and **lost from the system** and remaining things will be assimilated part of which will be used for their growth. So, this energy is considered as the **gross secondary production** here.

- **Assimilation** at this stage is the energy remaining as after defecation

- Energy being used for respiration and other activities and remaining amount that is the net secondary production, so basically net secondary productivity

- Ecological efficiencies defined as the sum of this or the processes that goes on from gross primary production till assimilation of the nutrients in a herbivore.

# Ecological efficiency of Plants

Plants- Net Primary Productivity (NPP) and Efficiency

- The rate at which plants synthesise glucose from $CO_2$ and $H_2O$ using photons from solar energy is Net Primary Productivity. Methods of measuring primary production are:
  - Harvest method
  - Oxygen measurement (light and dark bottle method)
  - $CO_2$ measurement (terrestrial ecosystems)
  - Aerodynamics method ($CO_2$ flux in a community measured using sensors)
  - pH method
  - Indirect methods such a Leaf Area Index (LAI) using satellite imaging

Source: NPTEL/SWAYAMCOURSE/

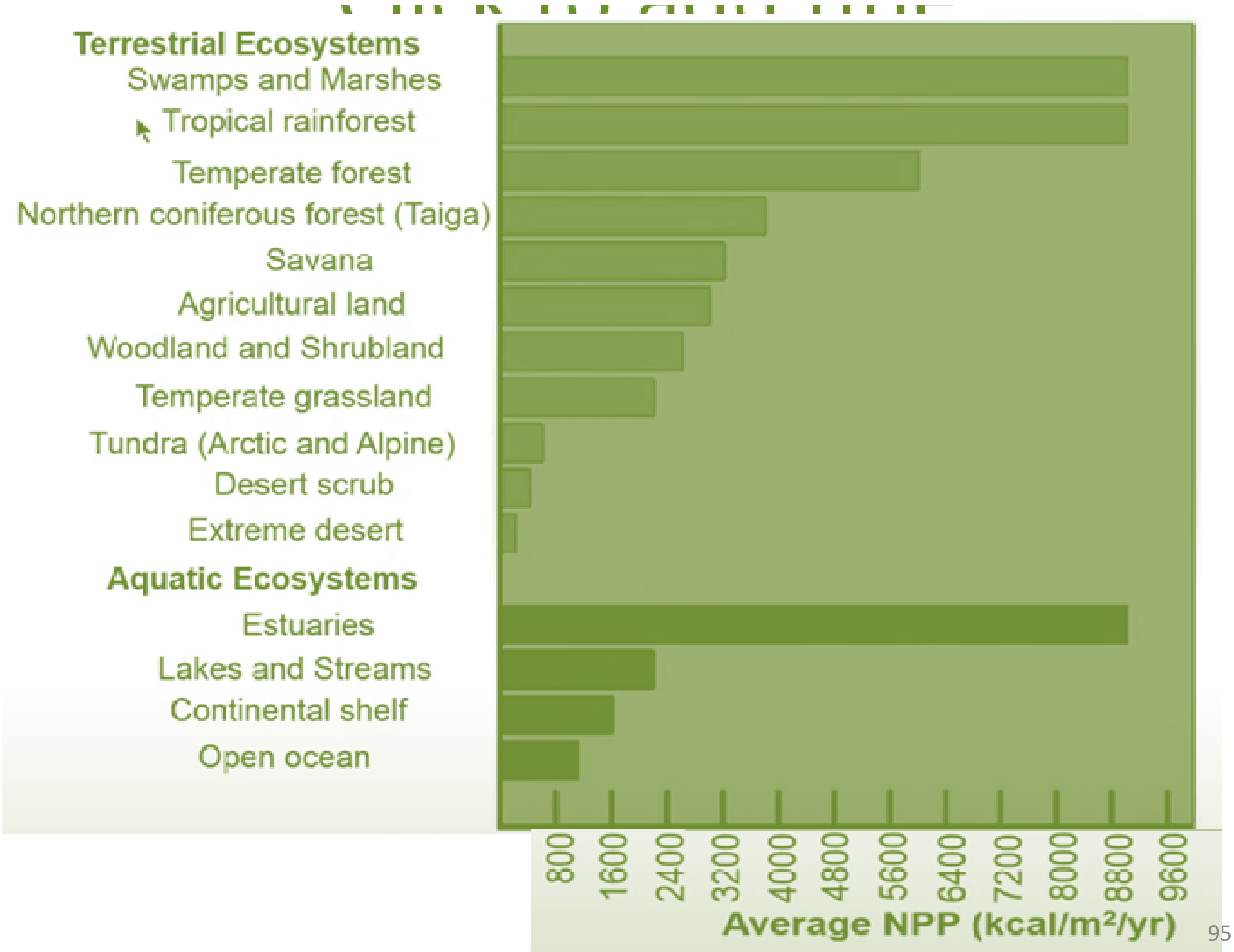
# Ecological efficiency of Plants

**Light & dark bottle method:**

- In this method, a sample of water is placed into two bottles
- One bottle is stored in the dark and the other in a lighted area.
- Only respiration can occur in the bottle stored in the dark.
- The decrease in dissolved oxygen (DO) in the dark bottle over time is a measure of the rate of respiration.
- Both photosynthesis and respiration can occur in the bottle exposed to light
- Difference between the amount of oxygen produced through photosynthesis and that consumed through aerobic respiration is the **net productivity.**
- The difference in dissolved oxygen over time between the bottles stored in the light and in the dark is a measure of the total amount of oxygen produced by photosynthesis. **The total amount of oxygen produced is called the gross productivity.**

# Question

- If we cut a forest and in stead of that we put an agricultural land.
- We are putting green cover by cutting another green cover? Is this fine?
  - No, Because ecological efficiency is different for different plants


Terrestrial Ecosystems
Swamps and Marshes
Tropical rainforest
Temperate forest
Northern coniferous forest (Taiga)
Savana
Agricultural land
Woodland and Shrubland
Temperate grassland
Tundra (Arctic and Alpine)
Desert scrub
Extreme desert
Aquatic Ecosystems
Estuaries
Lakes and Streams
Continental shelf
Open ocean
800
1600
2400
3200
4000
4800
5600
6400
7200
8000
8800
9600
Average NPP (kcal/m²/yr)

# Transfer of matter in ecosystem

**<u>What happens to matter in ecosystems</u>**

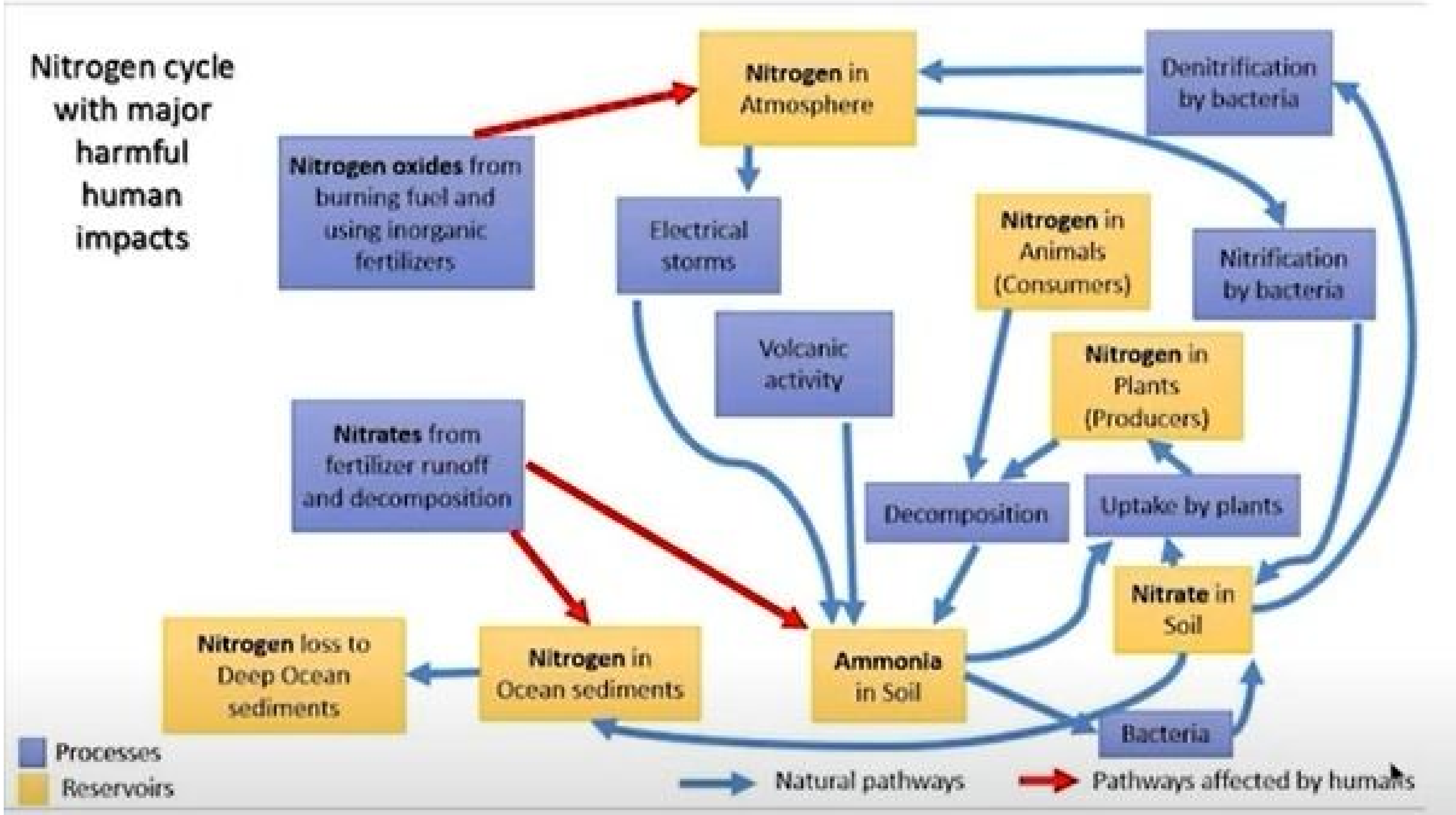
- Matter in the form of nutrient cycles (**biogeochemical cycles**) within and among ecosystems and the biosphere
- Human activities are altering the chemical cycles
- Water or hydrologic cycle
- Carbon cycle
- Nitrogen cycle
- Phosphorous cycle
- Sulphur cycle

# Bio-geochemical Cycles

- The cyclic exchange of nutrient materials between living organisms and their non-living environment is called as bio-geochemical cycles
- This cycle includes

1) Hydrological or Water cycle
2) Gaseous cycle
3) Sedimentary cycle

# Nitrogen Cycle and Human Impact

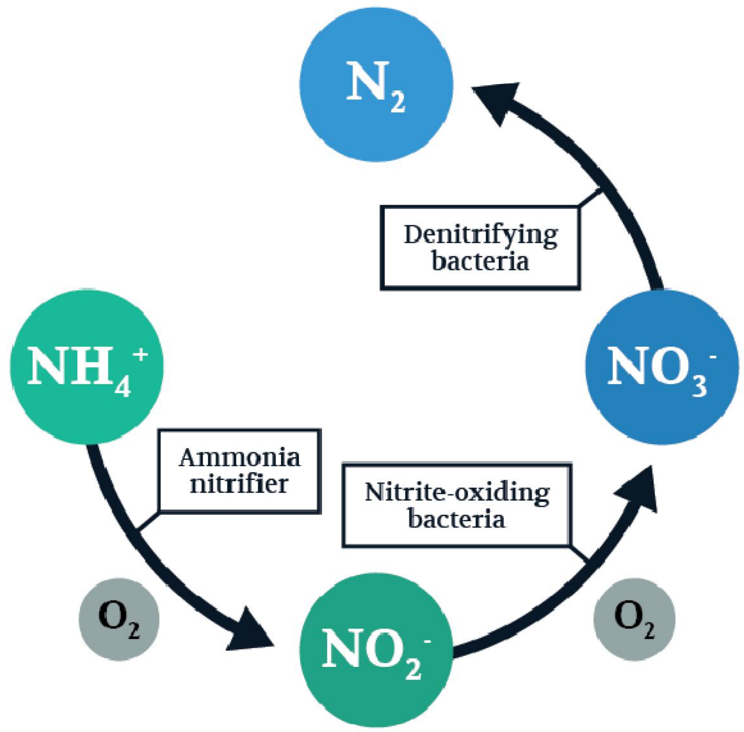


# Nitrogen Cycle and Human Impact

- Red arrows indicate in the previous fig are the pathways which are affected by human activities.
- Blue boxes- Nitrogen processes, eg: lightening, volcanic eruption, bacteria
- Yellow boxes- Reservoir or storage of $N_2$
- E.g: nitrogen oxides which are from burning fuel and using inorganic fertilizers are released into the atmosphere, and that affects again the other natural flow of nitrogen into the environment.

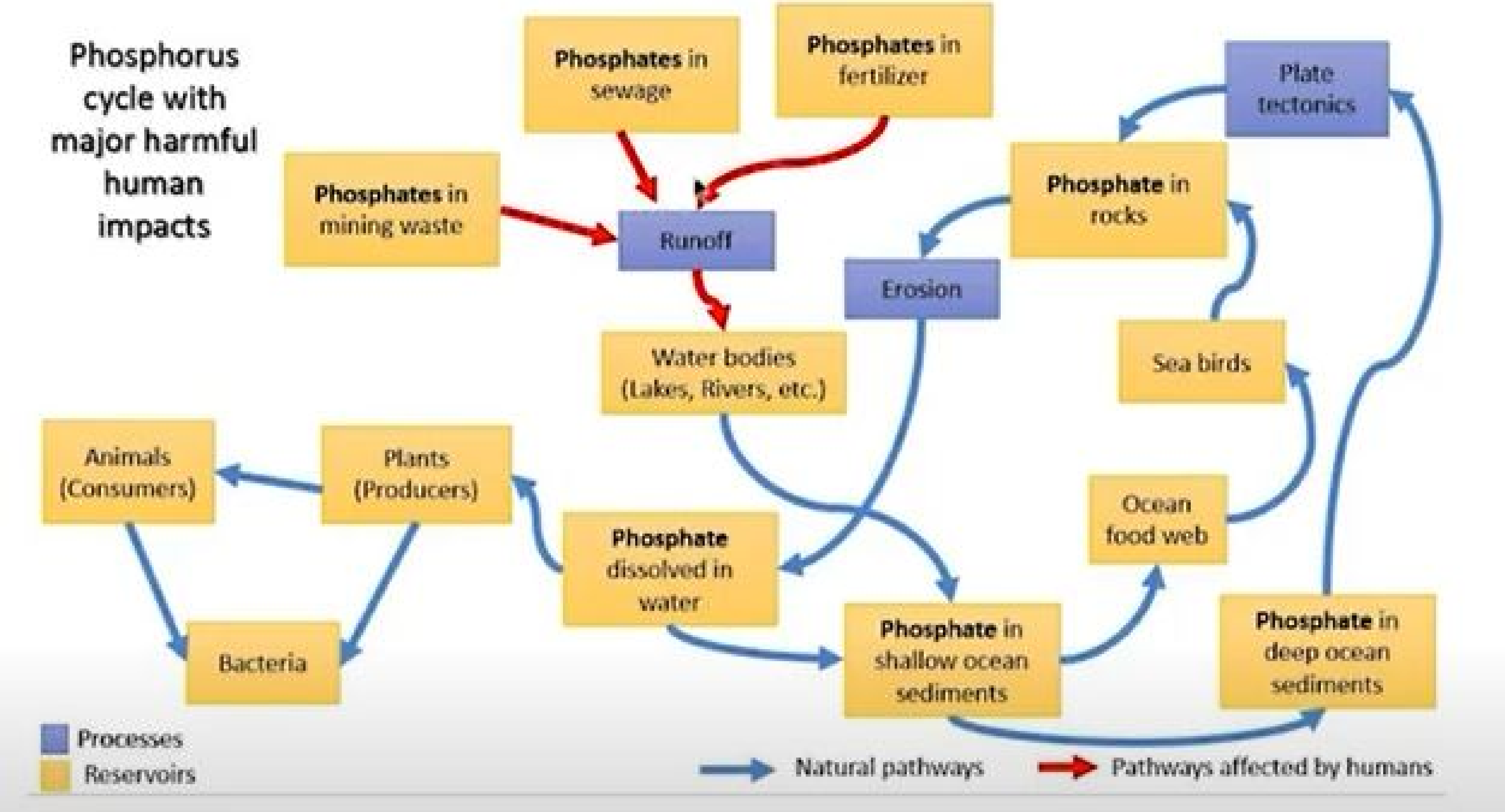
# Nitrogen Cycle

- Nitrification: Nitrifying bacteria oxidizes ammonia to nitrite and then to nitrate
- Denitrification: Under anaerobic conditions, denitrifying bacteria converts nitrate to nitrogen gas

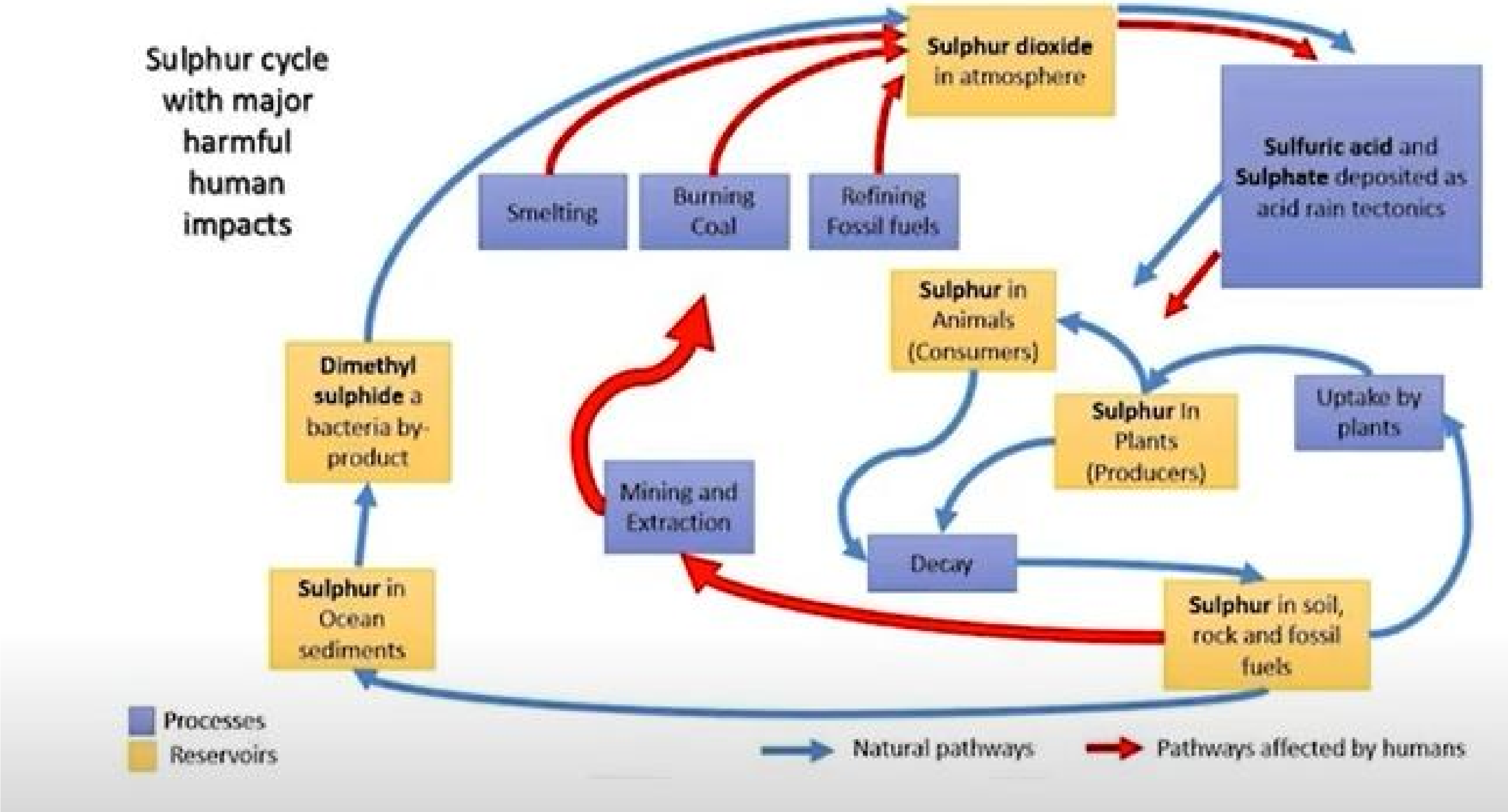



Reaction route of conventional nitrification and denitrification

# Phosphorous Cycle and Human Impact



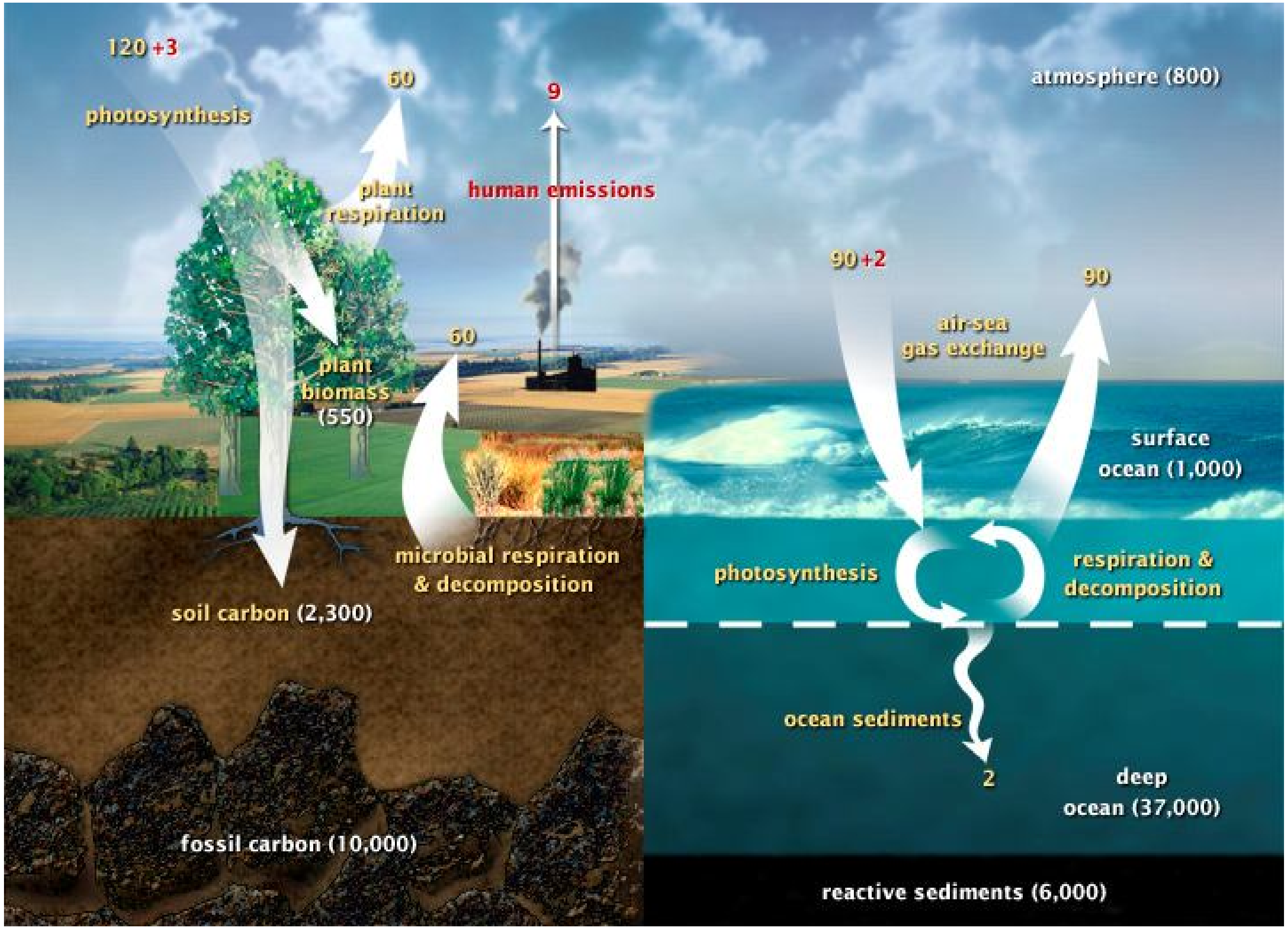
# Sulphur cycle and Human Impacts



# Carbon Cycle

- Carbon in the form of carbon-dioxide is taken up by green plants as raw material for photosynthesis
- The organic matter synthesized are passed from producers to consumers
- During respiration, plants and animals release carbon back to the surrounding as carbon-dioxide
- The dead bodies of plants and animals as well as the body waste which accumulates carbon compounds are decomposed by micro-organisms and releases carbon-dioxide

# Carbon Cycle



# Human Impact on Environment

Source: The Hindu

# Human Impact on Environment

Source: the Hindu

Water pollution (or aquatic pollution) is the contamination of water bodies, with a negative impact on their uses. It is usually a result of human activities. Water bodies include lakes, rivers, oceans, aquifers, reservoirs and groundwater. Water pollution results when contaminants mix with these water bodies.

What is the human impact on water pollution?

They affect the quality of rainwater and of water resources both above and below ground, and damage natural systems. The causes of freshwater pollution are varied and include industrial wastes, sewage, runoff from farmland, cities, and factory effluents, and the build-up of sediment.

## Ten Things You Can Do To Reduce Water Pollution

"Just because it disappears, doesn't mean it goes away"

DO NOT pour fat from cooking or any other type of fat, oil, or grease down the sink. Keep a "fat jar" under the sink to collect the fat and discard in the solid waste when full.

DO NOT dispose of household chemicals or cleaning agents down the sink or toilet.

DO NOT flush pills, liquid or powder medications or drugs down the toilet.

Avoid using the toilet as a wastebasket. Most tissues, wrappers, dust cloths, and other paper goods should be properly discarded in a wastebasket. The fiber reinforced cleaning products that have become popular should never be discarded in the toilet.

Avoid using a garbage disposal. Keep solid wastes solid. Make a compost pile from vegetable scraps.

Install a water efficient toilet. In the meantime, put a brick or 1/2 gal container in the standard toilet tank to reduce water use per flush.

If your home has a sump pump or cellar drain, make certain it does not drain into the sanitary sewer system.

Run the dishwasher or clothes washer only when you have a full load. This conserves electricity and water.

Use the minimum amount of detergent and/or bleach when you are washing clothes or dishes. Use only phosphate free soaps and detergents.

Minimize the use of pesticides, herbicides, fertilizers. DO NOT dispose of these chemicals, motor oil, or other automotive fluids into the sanitary sewer or storm sewer systems. Both of them end at the river.

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# Human Impact on Environment

Source: The Hindu

# Human Impact on Environment

Source: The Hindu

# Human Impact on environment

- Buildings in the US consume more than 30% of their total energy and 60% of electricity annually (oil and coal based)
- Average US citizen uses 1,86,000 calories of energy per day (basic need 2,200-3000 cals)
- They consume **$18 \times 10^9$ litres** of potable water per day to flush toilets.
- For every 100 g of product, we create 3,200 g of waste
- On average food travels about **2000 km** from where it is grown/produced to where it is eaten

- The level of environmental destruction rises with the volume of stuff consumed and with the distance it travelled

- "**Ecological footprint**" of an average North American is about 5 hectares of arable land/person/year

- But the world has only 1.2 hectares of usable land per person!

**Ecological Footprint**

Is the measure of the land required to grow our food, process our organic wastes, sequester our $CO_2$ and provide our material needs

# Carbon foot print

- A carbon footprint is the **total greenhouse gas (GHG**) emissions caused directly and indirectly by an individual, organization, event or product.

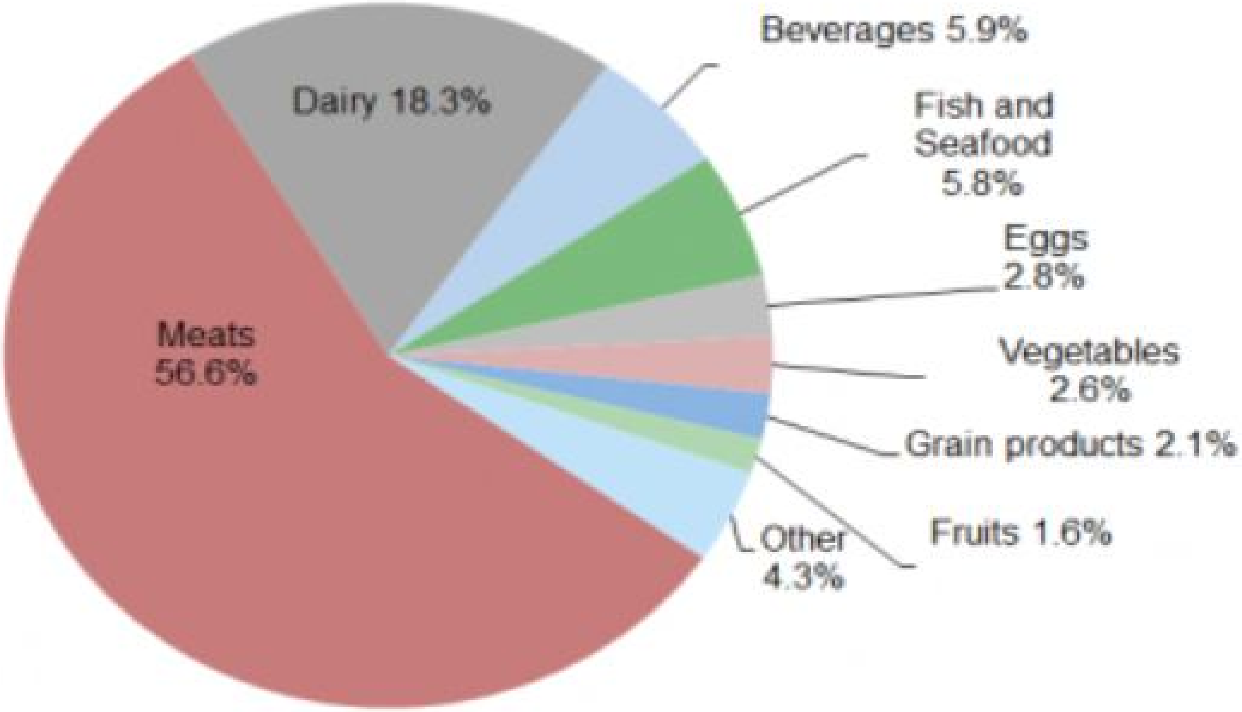
- Emissions resulting from every stage of a product or service's lifetime (material production, manufacturing, use, and end-of-life).

- Throughout a product's lifetime, or lifecycle, different GHGs may be emitted, such as **carbon dioxide ($CO_2$), methane ($CH_4$), and nitrous oxide ($N_2O$), ChloroflouroCarbon etc**

- greater or lesser ability to trap heat in the atmosphere. These differences are accounted for by the global warming potential (GWP) of each gas, resulting in a carbon footprint in units of mass of **carbon dioxide equivalents ($CO_2e$)**

- A typical U.S. household has a carbon footprint of 48 metric tons $CO_2$e/yr.

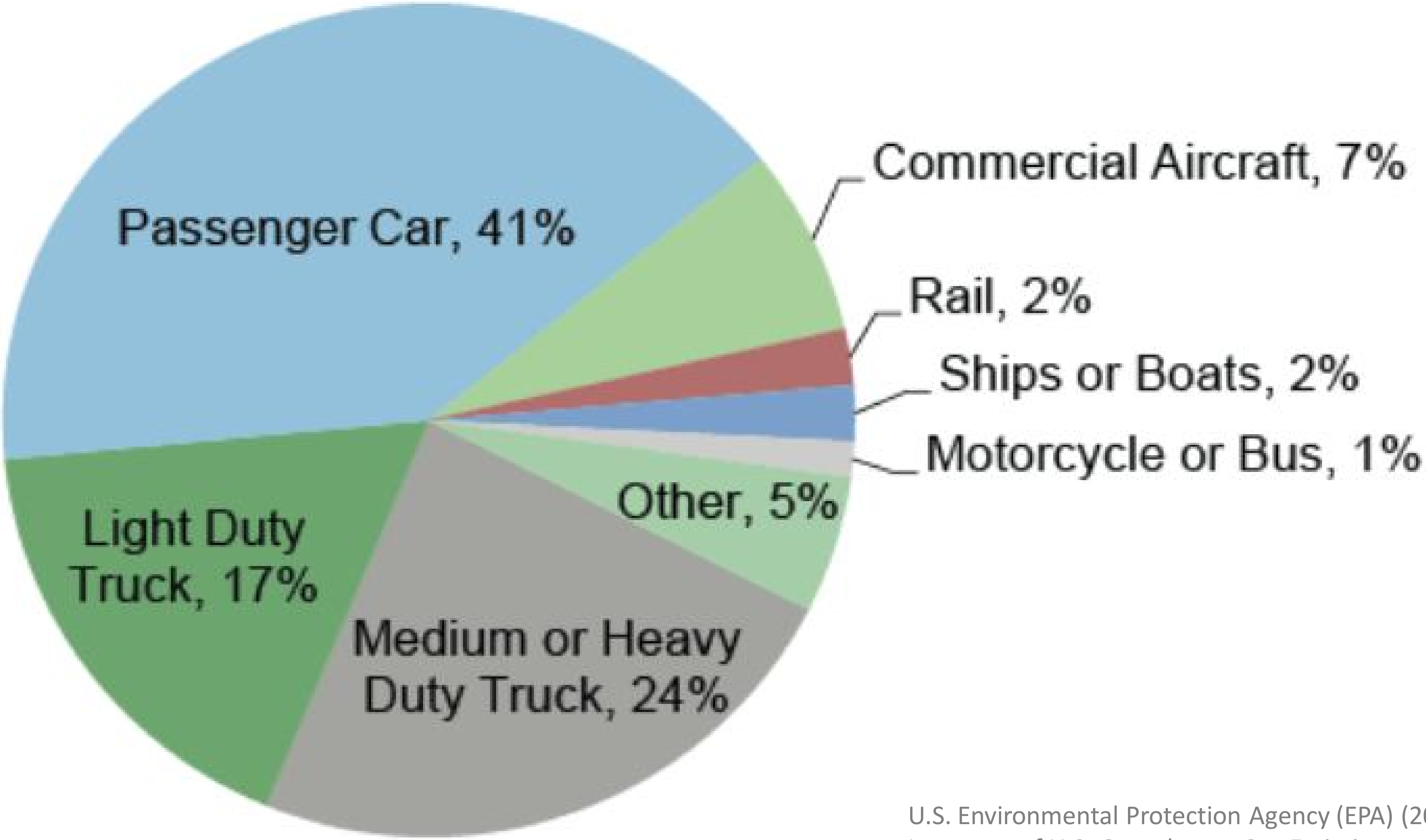
GREENHOUSE GASES CONTRIBUTION BY FOOD TYPE IN AVERAGE DIET




POUNDS OF $CO_2E$ PER SERVING[13]

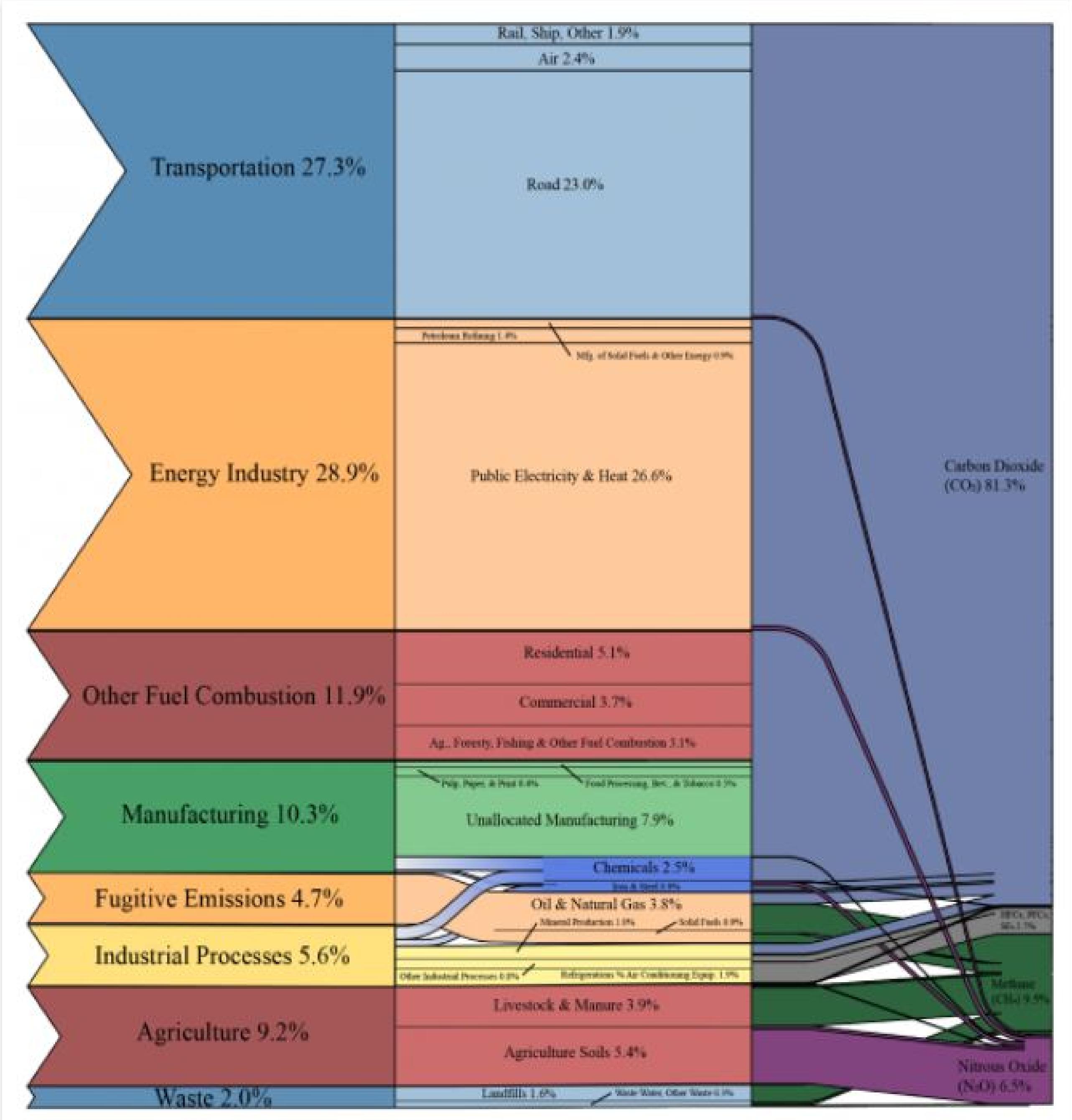
Heller, M.C., et al. (2018). Greenhouse gas emissions and energy use associated with production of individual self-selected US diets. Environmental Research Letters, 13(4), 044004

TRANSPORTATION GREENHOUSE GASES, 2019[6]




U.S. Environmental Protection Agency (EPA) (2021) Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990 - 2019

## U.S. GREENHOUSE GAS EMISSIONS, 2018[28]




U.S. EPA (2020) 2020 Common Reporting Format (CRF) Table.

# Carbon and Ecological Footprint Calculators

- U.S. Environmental Protection Agency:

www.epa.gov/carbon-footprint-calculator/

- The Nature Conservancy:

www.nature.org/greenliving/carboncalculator/

- Global Footprint Network:

https://www.footprintcalculator.org/

## Effect of Air Pollution on Human Health

Exposure to air pollution can affect everyone's health. When we breathe in air pollutants, they can enter our bloodstream and contribute to coughing or itchy eyes and cause or worsen many breathing and lung diseases, leading to hospitalizations, cancer, or even premature death.

Both short- and long-term exposure to air pollution can lead to a wide range of diseases, including stroke, chronic obstructive pulmonary disease, trachea, bronchus and lung cancers, aggravated asthma and lower respiratory infections

Human health is also severely affected by particulates in the atmosphere. The particulates can cause nasal irritation and swelling. It can also cause a running nose. Air pollution can also have an inflammatory effect on the heart – it can elevate blood pressure and aggravate pre-existing conditions of the heart.

Air pollution affects all things. It is harmful to our health, and it impacts the environment by reducing visibility and blocking sunlight, causing acid rain, and harming forests, wildlife, and agriculture. Greenhouse gas pollution, the cause of climate change, affects the entire planet.

Thinning of the protective ozone layer ( due to air pollution) can also cause increased amounts of UV radiation to reach the Earth, which can lead to more cases of skin cancer, cataracts, and impaired immune systems. UV can also damage sensitive crops, such as soybeans, and reduce crop yields. Crop and forest damage.

## List Of 10 Common Diseases Caused By Air Pollution

Air pollution is a major environmental and health risk. Here is a list of 10 diseases caused by air pollution.

Cardiovascular Diseases

Cancer

Neurological Disorders

Gastrointestinal Disorders

Kidney Diseases

Liver Diseases

Skin Diseases

Asthma

Bronchitis

Chronic Obstructive Pulmonary Disease

## What are the effects of water pollution on human health?

More than 50 kinds of diseases are caused by poor drinking water quality, and 80% of diseases and 50% of child deaths are related to poor drinking water quality in the world. However, water pollution causes diarrhea, skin diseases, malnutrition, and even cancer and other diseases related to water pollution