DATE 30/8/2019

Ecosystem

Ecosystem – An ecosystem is a functional unit of nature, where living organisms interact among themselves & also with their surrounding physical environment.

– The term Ecosystem was Coined by AG Tansley (1935).

– Ecologist Considers the entire biosphere as a Global ecosystem. (comprised of many local ecosystem on earth)

– Ecosystem is open system.
Recieves input in form of Solar energy & inorganic nutrient results in productivity or Synthesis of food.

– Food with contained energy passes through various component of ecosystem through food chain & Nutrient & web cycling.

– Matter circulates in ecosystem gives out energy as well as matter as output.

Ecosystem : Structure and Function

- Ecosystem can be either natural or artificial

Natural ecosystem

- Capable of maintaining & operating themselves, without interference of man.

They are classified as.

(1) Terrestial ecosystem - Forest, Grassland, desert etc.

(2) Aquatic ecosystem - Pond, lake, river, wetland, estuary etc.

Artifical ecosystem

- These are maintained & manipulated by man for different purpose - e.g Cropland, aquarium etc.

Components of Ecosystem

An ecosystem has two components.

Abiotic Components

Non-living components Consists of temperature, water, light etc.

Biotic Components

— Biotic Component of an ecosystem are Classified as-

1. Producers
   All green plants are called producers.

— In terrestrial ecosystem herbaceous & woody plants are producers.

— In aquatic ecosystem Phytoplanktons & Some algae are producers called autotrophs.

2. Consumers
   All animals depend directly or indirectly on plants (autotrophs) they are also known as heterotrophs.

3. Decomposers
   these are also called Saprobes or Saprophytes or mineralisers.
   Moulds & Mushrooms are largest decomposers of forest floor.

Structure and Functions of Ecosystem.

- Interaction b/w of biotic & abiotic components results in Physical structure that is calculated by characteristic of each type of ecosystem.

Two major important structural features of an ecosystem are -

1. Species Composition
It is calculated by the identification & enumeration of plant and animal species of an ecosystem.

2. Stratification
It is the vertical distribution of different species occupying different levels in an ecosystem,

e.g → trees occupy top vertical strata or layer of a forest, shrubs the second & herbs & grasses occupy the bottom (third) layers.

- Important functional aspects of an ecosystem are

- i° Productivity
ii° Decomposition
iii° Energy flow.
iv Nutrient cycling.

POND ECOSYSTEM

A pond is fairly a self-sustainable unit.

— The pond water (abiotic component) consist Contains all the dissolved inorganic and organic materials and soil deposited at its bottom. The solar input, the cycle of temperature day-length & other climatic conditions regulate the rate of function of entire pool.

— Autotrophic components are phytoplanktons, algae & floating, submerged and marginal plants found at the edges.

— Consumers are zooplanktons which are free swimming and bottom dwellers.

— Decomposers are fungi, bacteria & flagellates found abundantly in the bottom of the pond.

Pond system perform all functions of an ecosystem & of the biosphere as a whole i.e.
autotrophs convert inorganic materials into organic materials with the help of solar energy, heterotrophs consume autotrophs & decomposers decompose & mineralise dead organic materials to release them back for reuse by the autotrophs.

- These events repeated over & over again, however, energy flow is unidirectional towards the higher trophic levels.

- At each trophic level, a part of energy is dissipated & is lost as heat to the environment.

Productivity

- Constant input of solar energy is basic requirement for any ecosystem to function & sustain.

- Rate of synthesis of energy containing organic matter or biomass by any trophic level per unit area in unit time is called its productivity.

- Expressed in terms of $g^{-2} yr^{-1}$ or $(Kcal m^{-2}) yr^{-1}$

- Productivity of an ecosystem categorised as Primary & Secondary.

Primary Productivity

- Amount of biomass produced per unit area over a period of time by plants during photosynthesis.

- Expressed in terms of weight (g^{-2}) or energy ($Kcal m^{-2}$)

☆ Primary productivity has two aspects.

1. Gross Primary Productivity (GPP)

- Rate of biomass production during photosynthesis
- A part of GDP is utilized by plants.

2. Net Primary Productivity (NPP)

- Net rate of biomass production by plants (excluding its utilization)
- Gross Primary Productivity minus respiration losses

$$[NPP = GPP - R]$$

↳ Respiration losses.

⁂ - Annual NPP of the ~~Odd~~ whole biosphere is approx 170 billion tons organic matter.

Productivity of the oceans are only 55 billion tons. Rest of course is on land.

Factors Affecting Primary Productivity

i) Plant species inhabiting a particular area.

ii) Various environmental factors

(a) Light → Sunlight ultimate source of energy. availability of less light in an aquatic ecosystem has less productivity than terrestrial ecosystem. minimum light receive at poles therefore productivity is comparatively low on poles.

(b) Temperature → Regulates activity of an enzyme. So, optimum temperature is required for proper function of enzyme.

(c) Moisture → Rain (humidity) increases the productivity of the ecosystem but desert have lower primary productivity as soil is deficient in moisture.

iii) Nutrients availability → Nutrient essential for growth of Producer. Thus higher availability of nutrients ensure greater Primary productivity.

iv) Photosynthetic efficiency of plants → C_4 plant are more productive as compared to C_3 plant because some plants have more efficiency to trap sunlight. So, they accumulate more productivity.

Secondary Productivity

- Amount of new biomass produced per unit area over a period of time by consumers.

Decomposition

- Process in which complex organic matter are broken down into simpler forms.
- Organisms which help in decomposition called Decomposers

Detritus

- Detritus is the raw material for decomposition
  - Dead plant remains
  - Dead animal remains
  - Fecal matter

Step involved in process of decompositions are —

(1) Fragmentation

- Detritus is broken down into simpler particles.
- Organisms which help in fragmentation are Detritivores (e.g. Earthworm).

② Leaching

- Dissolves out the Soluble Constituents from the detritus
- Soluble nutrients precipitate as unavailable salts

③ Catabolism

- Enzymes from decomposers (bacteria, fungi) further breakdown detritus into simpler forms.

④ Humification

- This step of decomposition occur in the Soil.
- Humus formation takes place.
  - Brown/Black organic matter that provides nutrients to the plant.
  - Amorphous in nature
  - Increases water retaining capacity of Soil.
- Colloidal in nature that's why it is very slow decompose it serves as a reservoir of nutrients.

⑤ Mineralization

- Release of minerals/inorganic nutrients by further degradation of humus by micro-organisms is termed as 'mineralization'.

Factors Affecting Rate of Decomposition

- aerobic process (decomposition)

1. Chemical composition of detritus —
decomposition is slower, if detritus is rich in lignin & chitin while, it is quicker if it is composed of nitrogen & water-soluble substances like Sugars.

2. Climatic factors —
Warm & moist environment favour decomposition while, low temperature and anaerobiosis conditions inhibit decomposition resulting in build of organic materials.

Energy Flow in Ecosystem

- Sun is the source of energy for all ecosystems on earth. Except for deep sea hydrothermal ecosystem.

- Total incident solar energy, less than 50% is photosynthetically Active Radiation (PAR)

- Plant utilise only 2-10% of PAR to sustain the entire living world

- Flow of energy is unidirectional.
- Energy flow refers to the flow of energy from Sun to plants to various organisms of ecosystem.
- No energy that is trapped into an organism remains in it forever.

First law of thermodynamics

- Energy can neither be created nor destroyed, it can only be transformed from one form to another.

2nd law of thermodynamics

- The state of entropy of the universe will increase with time.

The Consumers may be of following types.

1. Primary Consumers → Consumers that feed on plants directly, are called primary consumers or herbivores.
2. Secondary Consumers → those animals, which eat other animals, who eat plants are called Secondary Consumers. (Primary ~~Consu~~ Carnivores)
3. Tertiary Consumers → those animals who feeds on Secondary consumer for their nutrition. (Secondary carnivores)

FOOD CHAIN

- Series of living organism feeding on one another.

(Transfer of energy from green plants through a sequence of organism, in which each eats the one below in it the chain and is eaten by the one above is called a Food chain.)

TYPES OF FOOD CHAIN

- Grazing Food Chain (GFC)

- Starts with Green plants (producers).
- Macroscopic organisms are involved.
- Energy comes from Sun.
- Capture Solar energy & feeds the energy into the food chain through photosynthesis.

- Grass → Goat → Man
(Producer) (Primary consumer) (Secondary consumer)

- Detritus Food chain

- Starts with decomposers (fungi & bacteria)
- Takes place in soil
- Sub-Soil & microscopic organisms are involved.

- Energy comes from detritus.
- Decomposition of dead remains takes places.
- Decomposers secrete digestive enzymes that breakdown dead & waste which are later absorbed by them.

Dead leaves → Woodlouse → Black bird
(Producer) (Primary consumer) (Secondary Consumer)

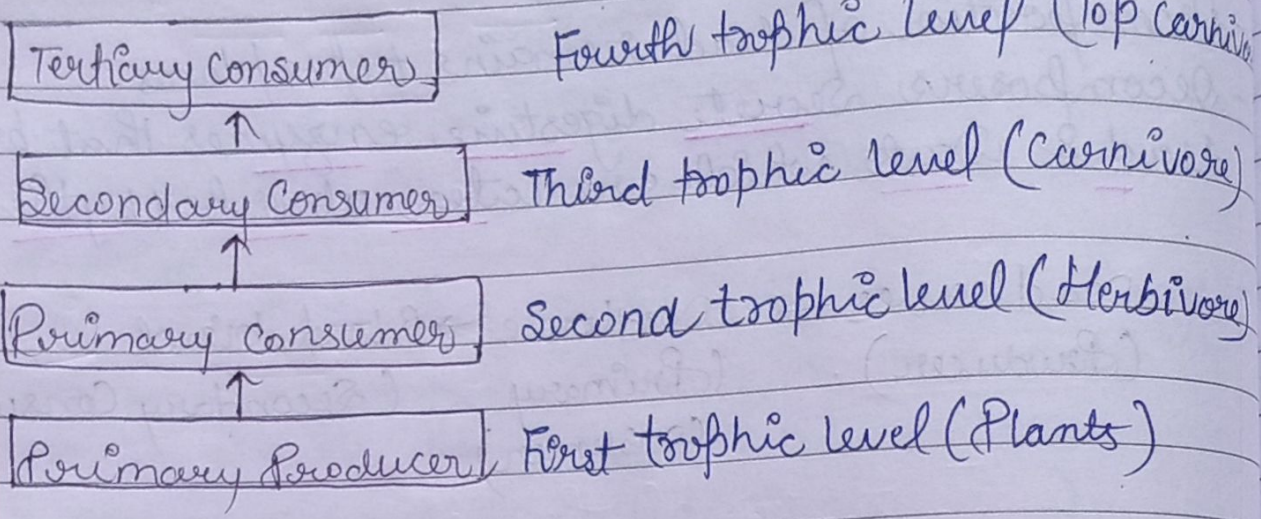
NOTE A much larger fraction of energy flows through Detritus Food chain (DFC) than the Grazing Food chain (GFC) in a terrestrial ecosystem and vice versa.

FOOD WEB

- Consists of many food chains, as it is seen that the GFC is connected to DFC at same level.
- Therefore, naturally interconnected food chains constitute a food web.

TROPHIC LEVEL

- Each level of a food chain is termed as a Trophic level.
- Based on the relationship among the organism and the source of their nutrition or food, organisms occupy a specific place in food chain called trophic level.



Standing Crop

- Total biomass of a trophic level at a given time.
- Biomass is expressed in terms of fresh/dry weight.
- is measured as the mass of living organisms or the number in an unit area.

Ten per cent Law (10% Law)

- Given by Lindeman in 1942.
- Each step of food chain when food energy is transferred from one trophic level to the next higher trophic level, some energy is lost as heat & only 10% of energy is transferred to next level.

- The number of trophic levels in the GrFC is restricted as the transfer of energy follows 10% Law.

Ecological Pyramids

- Diagrammatic illustrations of connection b/w different trophic levels in term of energy, biomass & number of organisms.

There are 3 ecological pyramids that are usually studied.

1. Pyramid of number

It represent total number of organisms at each trophic level.

It is always upright

But in a tree ecosystem, Pyramid of number is inverted.

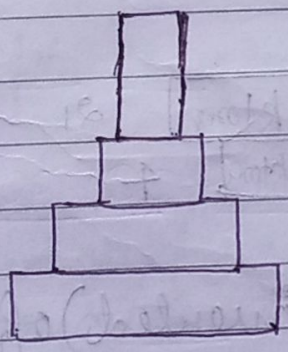


Fig - Pyramid of numbers in a grassland ecosystem.

2. Pyramid of biomass

It represents total weight of the organisms in each trophic level.

i. upright, e.g in Grasslands.

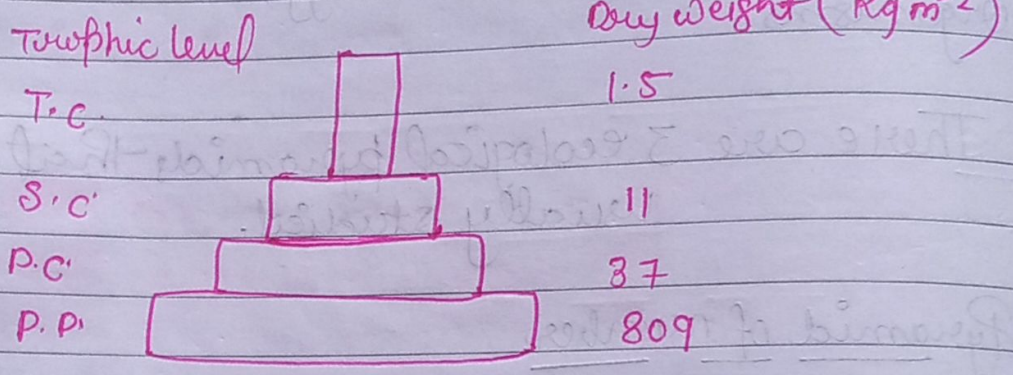


Fig- Pyramid of biomass shows a sharp decreases in biomass at higher trophic levels.

ii. Inverted e.g in Pond ecosystem

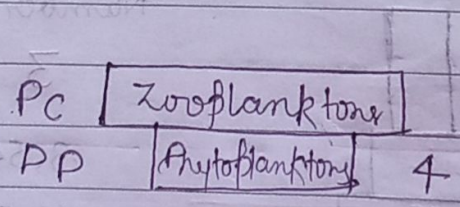


Fig- Pyramid (inverted) of biomass- Small standing crop of phytoplankton supports large standing crop of zooplankton.

3- Pyramid of energy

It represents total energy of the organisms in each trophic level.

Pyramid of energy always upright.

- it can never be inverted because some energy is always lost as heat at each step.

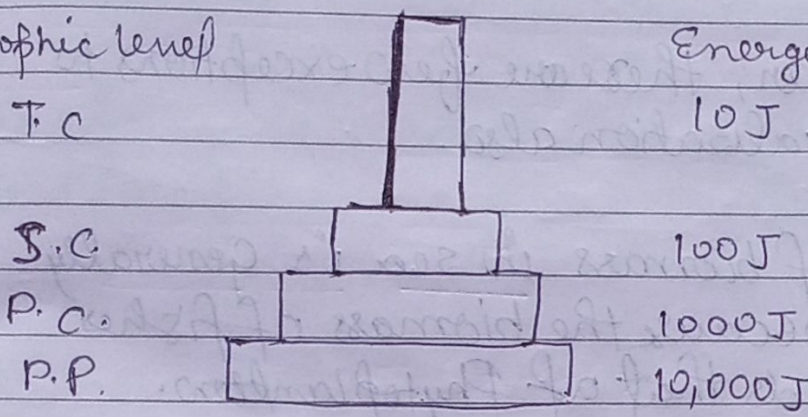


Fig- An ideal pyramid of energy with primary producers storing only 1% of solar energy as NPP.

Important points about ecological pyramids are given below.

i. Trophic level represents a functional level, not a species as such.

ii. Given species may occupy more than one trophic level in the same ecosystem at the same time.
e.g → Sparrow is primary consumer when it eat fruit, peas etc, & Secondary consumer when it eat insects & worms.

iii. In most ecosystem, all the pyramids of number, biomass, energy are upright. i,e, producers are more in number & biomass than the herbivores & herbivores are more in number & bimass than Carnivores.

iv. Energy at lower trophic level is always more than higher trophic level.

However, there are few exceptions to this generalisation also.

v. Pyramid of biomass in sea is generally inverted because the biomass of fishes far exceeds that of Phytoplankton.

vi. Each bar in the energy pyramid indicates the amount of energy present at each trophic level in a given time or ~~one~~ annually per unit area.

Limitations of Ecological Pyramids

i. Food webs are not considered.

ii. Decomposers are not included in the pyramids.

iii. Single organism belonging to multiple trophic level is not considered.

iv. It assumes a simple food chain, something that almost never exists in nature.

Ecological Succession & Nutrient Cycling

Biotic communities are not stable. They constantly change in composition & structure in response to the changing environmental conditions.

- This change is orderly and sequential, parallel with the changes in physical environment.

Ecological Succession

- Gradual change in the composition/structure of species in a given area over time.
- Some species colonise an area & their population become numerous, while some decline & even disappear.
- entire sequence of communities that successively change in a given area called Sere (s).
- Individual transitional communities are termed as Seral stages or Seral communities.
- Changes during ecological succession lead finally to a community that is in near equilibrium with the

environment and is called a climax community.

– The species that invade bare area are called pioneer species.

☆ Each climax community, there are following changes that occur in successive seral stages.

i. Change in diversity of species of organisms.
ii. Increase in the number of species & organisms.
iii. Increase in total biomass.

– Community present today in the world have come to be because of succession that has occured over millions of years since life started on earth.

Actually succession & evolution are parallel processes.

Types of ecological Succession

① Primary Succession

– Process of succession starts in area where no living organisms existed.
e.g bare rock, newly formed pond

or reservoir & newly cooled lava.
establishment of new biotic community is generally slow process. Like produce fertile soil on bare rocks, it takes several 100 to 1000 years under favourable climatic conditions.

② Secondary Succession
Process of succession starts in areas where which lost all living organisms that existed there.
e.g abandoned farmland, burned or cut forest, lands that have been flooded.

It is faster than Primary Succession because of availability of some soil/ sediment and water.
Hence climax community also reached more quickly.

☆ Also encourage some species and discourage or eliminate other species.

Succession of Plants

- Based on nature of habitat, whether it is water or dry area there are two types of successions.

① Hydrarch Succession →
- Succession starts in wet areas.
- Progresses from hydric to mesic conditions.

- During Primary succession in water, pioneer species are the small Phytoplanktons. These phytoplantons are replaced with time by free-floating angiosperms, then by rooted hydrophytes, sedges, grasses & finally the establishment of trees occurs.

At last, formation of Stable climax forest takes place. Water body convert into land.

Xerarch Succession

- Succession starts in dry areas
- Progress from xeric to mesic conditions

Lichens are pioneer species in the primary successions on rocks as they secrete acid that dissolve rocks helping in weathering & soil formation.

Later, small plants like bryophytes emerged which are able to take hold in small amount of soil. These bryophytes, with time were succeeded by bigger plants.

After several more stages of successions, ultimately a stable climax forest community tend to form.

The climax community remains stable as long as the environment remains unchanged.

★ The important fact is that all successions whether taking place in water or on land, proceed to a similar mesic climax community.

Nutrient Cycling (Biogeochemical cycle)

Organisms need a constant supply of nutrients to grow, reproduce & regulate various body functions & the amount of nutrients such as carbon, nitrogen, phosphorus, calcium etc. present in soil at any given time, is referred to as the standing state.

It varies with the kind of ecosystem & also on seasonal basis.

Movement of nutrients through various components of ecosystem. Called biogeochemical cycles.

Types of Nutrient cycle

① Gaseous cycle

- Transportation of nutrient through atmosphere.
- example → Carbon cycle, nitrogen cycle, water cycle, oxygen cycle.

② Sedimentary cycle

- Transportation of nutrients through Earth's crust. ☆
- Examples :- Sulphur cycle, Phosphorus cycle.

In both cycles environmental factors like temperature, PH, Soil nature & moisture & can regulate the rate of release of nutrients into the atmosphere.

- Function of reservoir is to meet the deficit, which occurs due to imbalance in the rate of influx & efflux.

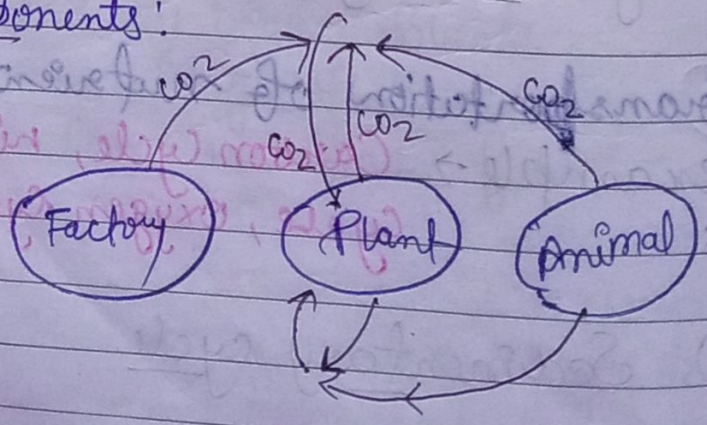
Gaseous Cycle (carbon)

- Comparatively faster than others, e.g- Carbon Cycles & nitrogen cycle.

- Biogeochemical cycle through which Carbon is exchanged b/w various components of Earth.

Important Components:

- Atmosphere
- Biosphere
- Oceans
- Sediments.



Carbon cycle- Carbon constitutes 49% of dry weight of organisms and it is next only to water. About 71% Carbon is found dissolved in oceans. This oceanic reservoir regulates the amount of CO_2 in atmosphere.

Approximately 4×10^{13} kg of Carbon is fixed in the biosphere through photosynthesis annually.

Carbon fixation or Carbon assimilation refers to the conversion process of inorganic Carbon (CO_2) into organic compound. CO_2 is returned to atmosphere via respiratory activities of producers & consumers.

Decomposers also contribute substantially to CO_2 pool by their processing of waste materials & dead organic matter of land or oceans.

Burning of wood, forest fire are additional sources for releasing CO_2 into the atmosphere.

Sedimentary cycle

- Reservior is earth's crust.
- Biogeochemical cycle through which phosphorus is exchanged b/w various components of earth.
- Atmosphere does not play a major role in phosphorus cycle.
- Comparatively slower than gaseous cycle e.g- Phosphorus cycle & Sulphur Cycle.

Phosphorus cycle

Phosphorus is a major constituent of biological membranes, nucleic acids & cellular energy transfer systems.

Animal shell, bones & teeth are made up of Phosphorus only.

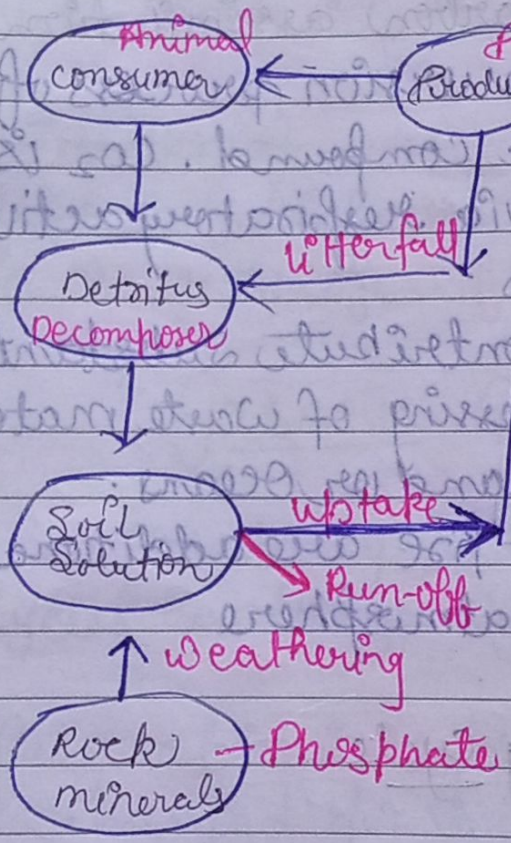


Fig - Terrestrial ecosystem Phosphorus cycling

The natural reservoir of phosphorus is rock. Which contains phosphorus in the form of Phosphates.

When rocks are weathered, minute amounts of these phosphates dissolve in soil solution and are absorbed by the plant roots and finally animals and herbivores obtain phosphorus from those plants.

The waste products and the dead organisms are decomposed by phosphate - solubilising bacteria releasing phosphorus.

Ecosystem Services

- Healthy ecosystems are the base for a wide range of economic, environmental & aesthetic goods & services.

Ecosystem services are the products of ecosystem processes.

e.g → Healthy forest ecosystem.

Robert Constanza & his colleagues recently have tried to put price tag on the nature's life-support services.

Researches have put a price tag of US $ 33 trillion a year on these fundamental ecosystem services, which we utilise for free.

This is almost twice the value of global ~~Gross~~ Gross National Product (GNP), which is of US $ 18 trillion. Out of the total cost of various ecosystem services, soil formation accounts for 50%

tribution of other services like recre
nutrient cycling, are less than 10% e
cost of climate regulation & habita
wildlife are about 6% each.