<u>Model Answers</u>

AS-2306

M.Sc. Forestry (First Semester)

Paper: Forest Ecology and Biodiversity Conservation

Maximum Marks: 60

Q.1. Part-A : Multiple choice questions.

i. Indri-indri lemur is found in;

   Ans. Madagascar

ii. Which of the following pairs of an animal and a plant represents endangered organisms in India?

   Ans. *Bentinckia nicobarica* and Red panda.

iii. Which group of vertebrates comprises the highest number of endangered species?

   Ans. Mammals

iv. Which one of the following is not included under in-situ conservation?

   Ans. Botanical Garden

v. Temperate forests include all of the following except.

   Ans. Tundra

Part-B:

i. **Species richness**: Species richness is the number of different species represented in an ecological community, landscape or region. Species richness is simply a count of species, and it does not take into account the abundances of the species or their relative abundance distributions. In contrast, species diversity takes into account both species richness and species evenness.

ii. **Cline:** A gradual change in a character or feature across the distributional range of a species or population, usually correlated with an environmental or geographic transition.in biology and ecology, an ecocline or simply cline (to possess or exhibit gradient, to lean) describes an ecotone in which a series of bio- communities display a continuous gradient. The term was coined by the English evolutionary biologist Julian Huxley in 1938. More technically, clines consist of ecotypes or forms of species that exhibit gradual phenotypic and/or genetic differences over a geographical area, typically as a result of environmental heterogeneity. Genetically, clines result from the change of allele frequencies within the gene pool of the group of taxa in question. Clines may manifest in time and/or space.

iii. **Beta diversity:** The diversity between or among more than one community present along an environmental gradient or in the same place over time (eg. Soil acidity) or the variety of organism within a region arising from turnover of species among habitats.

iv. **Diversity index:** A numerical value derived from the number of individuals per taxon (abundance) and the number of taxa present (richness) or in other words A **diversity index** is a quantitative measure that reflects how many different types (such as species) there are in a dataset, and simultaneously takes into account how evenly the basic entities (such as individuals) are distributed among those types.

v. **Endangered species:** Species that are threatened with imminent extinction includes species whose numbers or habitats have been reduced through critical level. The phrase 'endangered species' colloquially refers to any species that fits this description whereas conservation biologists typically with it refer to species that are designated Endangered in the IUCN Red List, wherein "endangered" is the second most severe conservation status for wild populations, following Critically Endangered. 3079 animals and 2655 plants are endangered worldwide, compared with 2000 levels of 1102 and 1197, respectively. The amount, population trend, and conservation status of each species can be found in the Lists of organisms by population.

Q.2 Define succession. How climax formation happens in a community. How a climax controls the climate around its system.

Ans. Succession is the observed process of change in the species structure of an ecological community over time. The community begins with relatively few pioneering plants and animals and develops through increasing complexity until it becomes stable or self-perpetuating as a climax community. The ″engine″ of succession, the cause of ecosystem change, is the impact of established species upon their own environments. A consequence of living is the sometimes subtle and sometimes overt alteration of one's own environment.

It is a phenomenon or process by which an ecological community undergoes more or less orderly and predictable changes following a disturbance or initial colonization of new habitat. Succession may be initiated either by formation of new, unoccupied habitat (*e.g.,* a lava flow or a severe landslide) or by some form of disturbance (*e.g.* fire, severe wind throw, logging) of an existing community. Succession that begins in new habitats, uninfluenced by pre-existing communities is called primary succession, whereas succession that follows disruption of a pre-existing community is called secondary succession.

In ecology, climax community, or climatic climax community, is a historic term that expressed a biological community of plants and animals and fungi which, through the process of ecological succession — the development of vegetation in an area over time — had reached a steady state. This equilibrium was thought to occur because the climax community is composed of species best adapted to average conditions in that area. The term is sometimes also applied in soil development. It, nevertheless, has been found that steady state is more apparent than real, particularly if long enough periods of time are taken into consideration. Not with standing that, it remains a useful concept.

The idea of a single climatic climax, which is defined in relation to regional climate, originated with Frederic Clements in the early 1900s. The first analysis of succession as leading to something like a climax was written by Henry Cowles in 1899, but it was Clements who used the term "climax" to describe the idealized endpoint of succession.

A climax community is one that has reached the stable stage. When extensive and well defined, the climax community is called a biome. Examples are tundra, grassland, desert, and the deciduous, coniferous, and tropical rain forests. Stability is attained through a process known as succession, whereby relatively simple communities are replaced by those more complex. Thus, on a lakefront, grass may invade a build-up of sand. Humus formed by the grass then gives root to oaks and pines and lesser vegetation, which displaces the grass and forms a further altered humus. That soil eventually nourishes maple and beech trees, which gradually crowd out the pines and oaks and form a climax community. In addition to trees, each successive community harbors many other life forms, with the greatest diversity populating the climax community.

Similar ecological zonings occur among marine flora and fauna, dependent on such environmental factors as bottom composition, availability of light, and degree of salinity. In other respects, the capture by aquatic plants of solar energy and inorganic materials, as well as their transfer through food chains and cycling by means of microorganisms, parallels those processes on land.

The early 20th-century belief that the climax community could endure indefinitely is now rejected because climatic stability cannot be assumed over long periods of time. In addition non climatic factors, such as soil limitation, can influence the rate of development. It is clear that stable climax communities in most areas can coexist with human pressures on the ecosystem, such as deforestation, grazing, and urbanization. Polyclimax theories stress that plant development does not follow predictable outlines and that the evolution of ecosystems is subject to many variables.

Q.3Expalin the following with suitable examples;

a). Productivity

Productivity is the ratio of output to inputs in production; it is an average measure of the efficiency of production. Efficiency of production means production's capability to create incomes which is measured by the formula real output value minus real input value. In ecology, productivity or production refers to the rate of generation of biomass in an ecosystem. It is usually expressed in units of mass per unit surface (or volume) per unit time, for instance grams per square metre per day ($g\ m^{-2}\ d^{-1}$). The mass unit may relate to dry matter or to the mass of carbon generated.

b). Primary productivity:

Primary production is the synthesis of new organic material from inorganic molecules such as H_2O and CO_2. It is dominated by the process of photosynthesis which uses sunlight to synthesize organic molecules such as sugars, although chemosynthesis represents a small fraction of primary production.

c). Secondary productivity.

Secondary production is the generation of biomass of heterotrophic (consumer) organisms in a system. This is driven by the transfer of organic material between trophic levels, and represents the quantity of new tissue created through the use of assimilated food. Secondary production is sometimes defined to only include consumption of primary producers by herbivorous consumers (with tertiary production referring to carnivorous consumers), but is more commonly defined to include all biomass generation by heterotrophs.

Organisms responsible for secondary production include animals, protists, fungi and many bacteria. Secondary production can be estimated through a number of different methods including increment summation, removal summation, the instantaneous growth method and the Allen curve method. The choice between these methods will depend on the assumptions of each and the ecosystem under study. For instance, whether cohorts should be distinguished, whether linear mortality can be assumed and whether population growth is exponential.

d). Net primary productivity.

Net primary production is the rate at which all the plants in an ecosystem produce net useful chemical energy; it is equal to the difference between the rate at which the plants in an ecosystem produce useful chemical energy (GPP) and the rate at which they use some of that energy during respiration. Some net primary production goes toward growth and reproduction of primary producers, while some is consumed by herbivores.

NPP = GPP - respiration [by plants]

Q.4. How carbon is fixed by forests? Explain how carbon controls the forest community dynamics? Give suitable examples.

Ans. Forest trees have a counter role in capturing the carbon from atmosphere. Since carbon fixation is a metabolic pathway which is common for all plants as determined by carbon fixation in photosynthesis, along with C_3, $C_4$and CAM metabolic pathways. This process which converts carbon dioxide and ribulose bisphosphate (RuBP, a 5-carbon sugar) into 3-phosphoglycerate through the following reaction:

CO_2 + RuBP → (2) 3-phosphoglycerate

Carbon Fixation through forests is based on two premises. First, carbon dioxide is an atmospheric gas that circulates globally and, consequently, efforts to remove greenhouse gases from the atmosphere will be equally effective whether they are based next door to the source or on the other side of the globe. Second, green plants take carbon dioxide gas out of the atmosphere in the process of photosynthesis and use it to make sugars and other organic compounds used for growth and metabolism. Long-lived woody plants store carbon in wood and other tissues until they die and decompose at which time the carbon in their wood may be released to the atmosphere as carbon dioxide, carbon monoxide, or methane, or it may be incorporated into the soil as organic matter.

Plant tissues vary in their carbon content. Stems and fruits have more carbon per gram dry weight than do leaves, but because plants generally have some carbon-rich tissues and some carbon-poor tissues, an average concentration of 45-50 percent carbon is generally accepted. Therefore, the amount of carbon stored in trees in a forest can be calculated if the amount of biomass or living plant tissue in the forest is known and a conversion factor is applied.

Carbon fixation through forestry is a function of biomass accumulation and storage. Therefore, any activity or management practice that changes the biomass in an area has an effect on its capacity to store or sequester carbon. A variety of forest management practices can be used to reduce the accumulation of greenhouse gases in the atmosphere, through different approaches. One is by actively increasing the amount or rate of accumulation of carbon (i.e., “sink” creation or enhancement). The second is by preventing or reducing the rate of release of carbon already fixed in an existing carbon “pool”. For forest plantations the first mechanism is important.

New tree planting results in the creation of new carbon sinks, i.e., carbon fixation during tree growth in afforestation, reforestation, forest rehabilitation, or agroforestry schemes. In the context of the Kyoto Protocol, these activities conform to the concept of Article 3.3. Although carbon sequestration is often discussed in the context of the establishment of new forests, carbon fixation can also be achieved by improving the growth rates of existing forests. This can be achieved through silvicultural treatments such as thinning, liberation treatments, weeding or fertilization. Since substantial amounts of carbon are stored in soils management practices that promote an increase in soil organic matter can also have a positive effect. These activities fit into the spirit of Article 3.4 of the Protocol.

When considering carbon storage, not all forests are equal. Generally, longer-lived trees with high density wood store more carbon per volume than short-lived, low density, fast-growing trees. However, this does not mean that carbon offsets which involve big, slow-growing trees are necessarily better than those involving plantations of fast-growing trees and *vice versa* .

The amount of the carbon available for the forests is a central process governing the dynamics of forest structure and also the carbon cycling through these terrestrial ecosystems. It is the principle means through which carbon is transferred from live biomass to the soil and atmosphere & vice versa and thus serves a critical role in determining whether forest ecosystems act as net carbon sources or sinks .we know that carbon is an essential component for various metabolic pathways like photosynthesis. If the amount of the carbon increases the rate of the photosynthesis increases i.e. the accumulation of the organic matter in the forest ecosystems increases but this increase will be up to a specific point (Law of limiting factor).Not only the distribution of this carbon will only be responsible for accumulation of biomass in forest ecosystems but this carbon may also play a great role in the forest tree species stratification. Forest tree species ecology is governed by number of biotic and abiotic factors carbon being one of these components. The availability of carbon in the surrounding will determine the distribution of the forest tree species and hence the dynamism of its vegetation is affected. Some species have high carbon fixing efficiency (steno-carbon species) some species have low carbon fixing efficiency (eury-carbon species).so on the basis of the requirement and availability of carbon we can say that the distribution and dynamics of forest communities is correlated.

Q.5. How global warming influences the forest community dynamics? Explain in detail how forest helps in repairing the damage caused due to global warming.

Ans. The forest communities are structured and governed by number of biotic and abiotic factors. Temperature is one of the important factors which influence the forest community dynamics. Increase or decrease in the temperature will change the floral and faunal composition of a forest ecosystem. Since increase in the surface temperature of our planet is what we say "global warming". Global warming is perhaps the most serious and far-reaching environmental threat we face today. Global warming is attributed to an increase in greenhouse gases, like carbon dioxide, which results from burning fossil fuels such as coal and petroleum. Years of scientific research and study have led to a clear agreement by the Intergovernmental Panel on Climate Change and thousands of scientists that the earth is warming due to human activity. The following trends in forest ecosystems structure, composition and dynamics should be expected as a result of global warming.

Forest disturbances such as fire and defoliating insects will likely increase, causing a reduction in the average age of trees (although old-growth forests will persist because of natural refugia, ecological inertia, and stochastic variation). Forests will likely become simplified due to the ascendancy of weedy species. The movement of existing forest types northward and toward higher elevations will likely cause extirpation of species where natural or human-induced habitat bottlenecks are encountered.

Increasing temperatures can lead to longer growing seasons and more plant growth which can store more carbon or become fuel for fires. Longer fire seasons will likely occur due to earlier drying of fuels. Milder winters (more frost-free days) and warmer summers will allow insect populations to increase. Warmer temperatures will also increase rates of respiration and decomposition which release CO_2 to the atmosphere, yet this effect might be partially countered by drying of soil surface layers which limits respiration.

Changes in forest disturbance regimes will likely be tightly coupled with the changes described above and may overshadow the direct physiological effects of climate change on plants and trees. It is reasonable to anticipate increased disturbances from wildfire, flooding, wind and storm damage, insect damage, and invasive species. Disturbance typically disrupts photosynthesis and favors respiration/decomposition processes thereby liberating CO_2.

Forests could play a role in cooling the atmosphere as they are important natural 'sinks' that absorb CO2 for their photosynthesis. But this is only one of the ways in which forests interact with the climate, this can’t be achieved just by preventing forests from being cut down, but through afforestation (new plantings) and reforestation (replanting of deforested areas) of non-forested lands. Forests play the following role in combating global warming and its damages;

Particularly in the tropics, where vegetation grows rapidly and therefore removes carbon from the atmosphere more quickly, planting trees can remove large amounts of carbon from the air within a relatively short time. Here, forests can store as much as 15 tonnes of carbon per hectare per year in their biomass and wood.

FAO and other experts have estimated that global carbon retention resulting from reduced deforestation, increased forest regrowth and more agro-forestry and plantations could make up for about 15 percent of carbon emissions from fossil fuels over the next 50 years.

Harvested wood is also a carbon sink -- wood used in construction or for furniture effectively stores carbon for centuries. High-energy construction materials used in place of wood, such as plastics, aluminum or cement, typically require large amounts of fossil fuels during manufacturing. Replacing them with wood therefore has additional benefits in terms of reducing carbon emissions.

Similarly, the use of wood fuel instead of oil, coal and natural gas, can actually mitigate climate change. Although burning wood and biomass does release carbon dioxide into the air, if those fuels come from a sustainably-managed forest, those carbon releases can be offset by replanting. Indeed, if managed properly, forests can supply bioenergy virtually without contributing any greenhouse gas to the atmosphere.

Forest communities will likely face increased seasonal drought stress. Higher temperatures will increase evaporative losses from soils and increase transpiration from plants. “Forests at upper (cold) and lower (dry and/or hot) timberlines are most likely to show strong direct effects of climatic variation on tree growth, since they are closer to their physiological limits and, therefore, more prone to stress at these locations”[10]. Interestingly, “shade-tolerant trees show greater growth responses to CO_2 than do shade-intolerant species because of more efficient use of light, water, and nutrients”. This could account in part for the proliferation of shade tolerant ladder fuels in our forests.

Forest trees grow better when night-time temperatures are about 5 degrees C cooler than day-time temperatures, because lower or higher night time respiration reduces the use of carbohydrates and allows more carbohydrates to be stored or used for growth. If climate change increases the temperature difference between day and night then plants may suffer because of imbalance between respirations to photosynthesis.

In this way the composition, structure and dynamics of the forest communities will be affected with this serious threat i.e. global warming.

Q.6.Define national park. How national parks help in conservation of FGR? Explain Jim Corbett National Park and its role in FGR conservation.

Ans. National Park is an area having adequate ecological, faunal, floral, geomorphological, natural or zoological significance. The National Park is declared for the purpose of protecting, propagating or developing wildlife or its environment, like that of a Sanctuary. The difference between a Sanctuary and a National Park mainly lies in the vesting of rights of people living inside. Unlike a Sanctuary, where certain rights can be allowed, in a National Park, no rights are allowed. No grazing of any livestock shall also be permitted inside a National Park while in a Sanctuary, the Chief Wildlife Warden may regulate, control or prohibit it. In addition, while any removal or exploitation of wildlife or forest produce from a Sanctuary requires the recommendation of the State Board for Wildlife, removal etc., from a National Park requires recommendation of the National Board for Wildlife (However, as per orders of Hon'ble Supreme Court dated 9th May 2002 in Writ Petition (Civil) No. 337 of 1995, such removal/ exploitation from a Sanctuary also requires recommendation of the Standing Committee of National Board for Wildlife). International Union for Conservation of Nature (IUCN), and its World Commission on Protected Areas, has defined "National Park" as its *Category II* type of protected areas.

Conservation of biodiversity (the variety of our native species and the ecosystems they form) is the central purpose of these protected area networks. High levels of biodiversity keep ecosystems healthy and resilient, which means that they continue providing vital ecosystem services such as nutrient cycling, climate regulation, air and water purification and pollination. Protecting biodiversity is vital to safeguard our economy; our cultural, spiritual and aesthetic values; and the intrinsic value of species and ecosystems.

Unfortunately, the biodiversity of NSW is in steep decline, with nearly 1000 species of plants and animals listed as threatened, 76 of which are believed to be extinct. More than half of all mammal species in NSW are threatened. There are many pressures on native species and ecosystems, including land clearing for agriculture, mining and urban expansion, overexploitation (e.g. through too much logging or fishing), invasive species and diseases, and climate change.

Our system of national parks and other protected areas is the cornerstone of conservation Of FGR. They are vital for the stabilisation and recovery of threatened species. National parks and other reserves provide a 'backbone' of core conservation areas in NSW, which can then be linked by conservation efforts on all land tenures across the landscape.

Jim Corbett National Park is the oldest national park in India and was established in 1936 as Hailey National Park to protect the endangered Bengal tiger. It is located Uttarakhand and was named after Jim Corbett who played a key role in its establishment. The park was the first to come under the Project Tiger initiative.

The park has sub-Himalayan belt geographical and ecological characteristics. An ecotourism destination, it contains 488 different species of plants and a diverse variety of fauna. The increase in tourist activities, among other problems, continues to present a serious challenge to the park's ecological balance.

Corbett has been a haunt for tourists and wildlife lovers for a long time. Tourism activity is only allowed in selected areas of Corbett Tiger Reserve so that people get an opportunity to see its splendid landscape and the diverse wildlife. In recent years the number of people coming here has increased dramatically. Presently, every season more than 70,000 visitors come to the park from India and other countries.

Corbett National Park comprises 520.8 km^2. area of hills, riverine belts, marshy depressions, grass lands and large lake. The elevation ranges from 1,300 feet (400 m) to 4,000 feet (1,200 m). Winter nights in Corbett Park are cold but the days are bright and sunny. It rains from July to September.

Dense moist deciduous forest mainly consists of sal, haldu, pipal, rohini and mango trees, and these trees cover almost 73 per cent of the park. The 10 per cent of the area consists of grasslands. It houses around 110 tree species, 50 species of mammals, 580 bird species and 25 reptile species. This national park have protected and preserved a number of flora and fauna which are the important components of our forest genetic resources. The important flora and fauna protected in this vary national park and being the hub of FGR are given as;

Flora

A total of 488 different species of plants have been recorded in the park. Tree density inside the reserve is higher in the areas of *Sal* forests and lowest in the *Anogeissus-Acacia catechu* forests. Total tree basal cover is greater in Sal dominated areas of woody vegetation. Healthy regeneration in sapling and seedling layers is occurring in the *Mallotus philippensis*, *Jamun* and *Diospyros tomentosa* communities, but in the Sal forests the regeneration of sapling and seedling is poor.

Fauna

Over 586 species of resident and migratory birds have been categorised, including the crested serpent eagle, blossom-headed parakeet and the red jungle fowl ancestor of all domestic fowl. 33 species of reptiles, seven species of amphibians, seven species of fish and 36 species of dragonflies have also been recorded. Bengal tigers, although plentiful, are not easily spotted due to the abundance of camouflage in the reserve. Thick jungle, the Ramganga river, and plentiful prey make this reserve an ideal habitat for tigers who are opportunistic feeders and prey upon a range of animals. The tigers in the park have been known to kill much larger animals such as buffalo and even elephant for food. The tigers prey upon the larger animals in rare cases of food shortage. There have been incidents of tigers attacking domestic animals in times when there is a shortage of prey. leopards are found in hilly areas but may also venture into the low land jungles. Small cats in the park include the jungle cat, fishing cat and leopard cat. Other mammals include barking deer, sambar deer, hog deer and chital, Sloth and Himalayan black bears, Indian grey mongoose, otters, yellow-throated martens, Himalayan goral, Indian pangolins, and langur and Rhesus macaques. Owls and Nightjars can be heard during the night.

Q.7. Explain the following

a) Ecology of forest landscapes

Ecology of forest landscapes or Forest landscape ecology is the science of studying and improving relationships between ecological processes in the environment and the forest ecosystems. This is done within a variety of landscape scales, development spatial patterns, and organizational levels of research and policy.

As a highly interdisciplinary science in systems ecology, forest landscape ecology integrates biophysical and analytical approaches with humanistic and holistic perspectives across the natural sciences and social sciences. Landscapes are spatially heterogeneous geographic areas characterized by diverse interacting patches or ecosystems, ranging from relatively natural terrestrial and aquatic systems such as forests, grasslands, and lakes to human-dominated environments including agricultural and urban settings. The most salient characteristics of forest landscape ecology are its emphasis on the relationship among pattern, process and scale, and its focus on broad-scale ecological and environmental issues related to a forest ecosystem. These necessitate the coupling between biophysical and socioeconomic sciences. Key research topics in forest landscape ecology include ecological flows in landscape mosaics, land use and land cover change, scaling, relating landscape pattern analysis with ecological processes, and landscape conservation.

Forest landscape ecologists use a wide vocabulary to discuss the patterns that they try to analyze.

- Configuration: The arrangement of elements (biotic and abiotic)
- Connectivity: Continuity of a habitat across a forest landscape
- Fragmentation: The breakup of a forest landscape in to patches or spots
- Patch: An area that differs in some way from the surrounding forest landscape

Tools of Forest Landscape Ecology

Forest landscape ecology uses many tools that aid in the visual and statistical analysis of spatial patterns across a stretch of a forest land. The following is a list of various tools that forest landscape ecologists use:

- **Models:** a model is an abstract representation of a particular system, process, or occurrence. The models in this field can be physical, verbal, or mathematical. The most complicated and perhaps most useful to landscape ecologists are mathematical models that are based on complex formulas. In order to simplify very complex systems of relationships, mathematical models predict and explain patterns and phenomena.
- **Remote Sensing:** Very simply remote sensing is the gathering of information without physically contacting with the object of study. Photographic, optical, thermal, and microwave are the most common types. The main purpose of this tool is to understand spatial patterns by the differences in reflectance values of subjects.
- **Geographic Information Systems (GIS):** GIS software use to comparing the layers of spatial information and can analyse the patterns of forest landscape. Often the information gathered from remote sensing can be converted and provide the data input for GIS.

b) **Spatial heterogeneity**:

Spatial heterogeneity is a property generally ascribed to a landscape or to a population. It refers to the uneven distribution of various concentrations of each species within an area. A landscape with spatial heterogeneity has a mix of concentrations of multiple species of plants or animals (biological), or of terrain formations (geological), or environmental characteristics (e.g. rainfall, temperature, wind) filling its area. A population showing spatial heterogeneity is one where various concentrations of individuals of this species are unevenly distributed across an area; nearly synonymous with "patchily distributed."

Environments with a wide variety of habitats such as different topographies, soil types, and climates are able to accommodate a greater amount of species. Spatial heterogeneity is a concept parallel to ecosystem productivity, the species richness of animals is directly related to the species richness of plants in a certain habitat. Vegetation serves as food sources, habitats, and so on. Therefore if vegetation is scarce, the animal populations will be as well. The more plant species there are in an ecosystem, the greater variety of microhabitats there are. Plant species richness directly reflects spatial heterogeneity in an ecosystem.

Q.8.Give The comparative account of the structure and function of a pond and forest ecosystem and describe the energy dynamics in both ecosystems.

Ans. A pond is a quiet body of water that is too small for wave action and too shallow for major temperature differences from top to bottom. It usually has a muddy or silty bottom with aquatic plants around the edges and throughout. However, it is often difficult to classify the differences between a pond and a lake, since the two terms are artificial and the ecosystems really exist on a continuum. Generally, in a pond, the temperature changes with the air temperature and is relatively uniform. Lakes are similar to ponds, but because they are larger, temperature layering or stratification takes place in summer and winter, and these layers turnover in spring and fall.

Ponds get their energy from the sun. As with other ecosystems, plants are the primary producers. The chlorophyll in aquatic plants captures energy from the sun to convert carbon dioxide and water to organic compounds and oxygen through the process of photosynthesis. Nitrogen and phosphorus are important nutrients for plants. The addition of these substances may increase primary productivity. However, too many nutrients can cause algal blooms, leading to eutrophication.

Producers

Phytoplankton's, literally "wandering plants," are microscopic algae that float in the open water and give it a green appearance. They carry out photosynthesis using carbon dioxide that is dissolved in the water and release oxygen that is used by the bacteria and animals in the pond. Phytoplankton are not actually plants-they are protists

Periphytic algae are microscopic algae that attach themselves to substrates and give the rocks and sticks a greenish brown slimy appearance. They also carry out photosynthesis and produce oxygen, often near the bottom of the pond where it can be used by decomposers.

Submerged plants grow completely under water

Floating plants include plants that float on the surface and plants that are rooted on the bottom of the pond but have leaves and/or stems that float.

Emergent plants are rooted in shallow water but their stems and leaves are above water most of the time.

Shore plants grow in wet soil at the edge of the pond.

Consumers

Zooplanktons are microscopic animals that eat phytoplankton or smaller zooplankton. Some are single-celled animals, tiny crustaceans, or tiny immature stages of larger animals. Zooplanktons floats about in the open water portions of the pond and are important food for some animals. Invertebrates include all animals without backbones. Macro invertebrates are big enough to be seen with the naked eye. Some of them are only found in clean water. Vertebrates are animals with backbones. In a pond these might include fish, frogs, salamanders, and turtles.

Decomposers

Animal waste and dead and decaying plants and animals form detritus on the bottom of the pond. Decomposers, also known as detritovores, are bacteria and other organisms that break down detritus into material that can be used by primary producers, thus returning the detritus to the ecosystem. As this material decomposes it can serve as a food resource for microbes and invertebrates. During decay microbes living on detritus can pull nutrients from the overlying water thus acting to improve water quality. In the process of breaking down detritus, decomposers produce water and carbon dioxide.

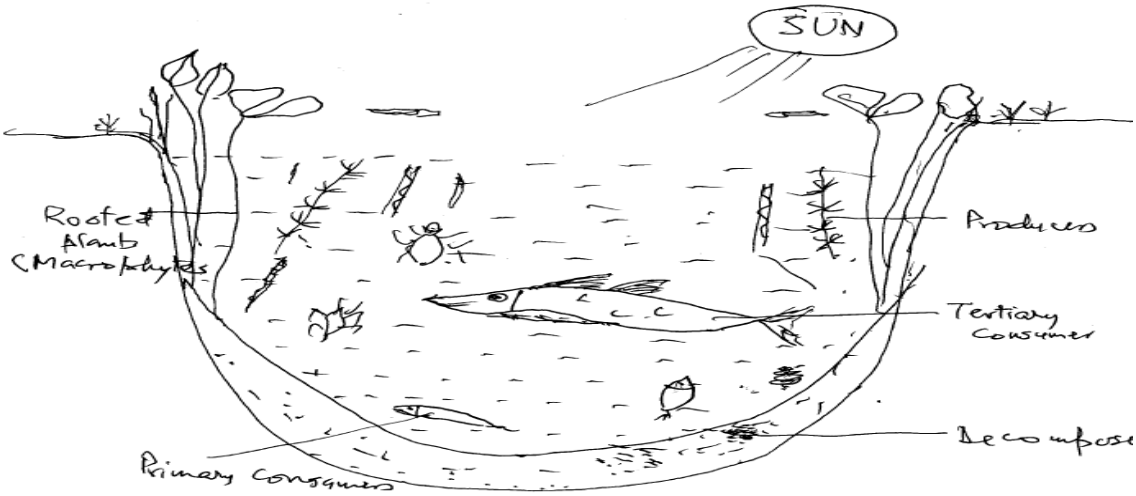

Fig. Pond ecosystem: A. Producers - Macrophytes
Phytoplanktons

B. Consumers :
Primary consumers
Secondary consumers
Tertiary consumers

Forest Ecosystem structure and function:

Forests are three-dimensional systems whose biophysical structure plays major roles in ecosystem function and diversity A forest ecosystem is one major ecologic unit that exists as "home" for a community of both native or introduced, classified organisms. The forest ecosystem is just one of a number of unique ecosystems including prairies, deserts, Polar Regions and great oceans, smaller lakes and rivers. A forest ecosystem typically is associated with land masses covered in trees and those trees are often classified by foresters into forest cover types. Forest ecosystems are dominated by trees that can mature to at least 2 metres in height and provide a canopy of at least 20% cover, together with all the native wildlife, including birds, mammals, marsupials, amphibians, reptiles, insects, plants, as well as moss, fungi, micro-organisms and non-living things such as water, soil and air interacting within the same area. Non-living things can also be referred to as 'abiotic' factors, while living things are often called 'biotic'. Simply the structure of forests is the three-dimensional arrangement of individual trees, has a profound effect on how ecosystems function and cycle carbon, water, and nutrients. The various components of a forest ecosystem are as following

Abiotic components: These include basic inorganic and organic compounds present in the soil and atmosphere. In addition dead organic debris is also found in littered forests. Further the natural light conditions are different in forests due to complex stratification in the vegetation .

Biotic components : The various biotic components , representatives from the three functional groups of a forest ecosystem are

Producer organisms: in a forest the producers are mainly trees that show much species diversity and greater degree of stratification. The trees are of different kinds depending upon the type of forest developed in the climate. The dominant species of trees that are producers in major types of forest ecosystems are Sal, Teak, Pine, Cedar, Chir pine, Terminalia species, Spruce, Abies, Khair, . Besides various species of trees there are also present shrubs and ground vegetation which are included in producer category.

Consumer organisms: In a forest ecosystem the consumers are of three main types-Primary, Secondary and Tertiary consumers.

The **primary consumers** are herbivorous which feed directly on producers these include the smaller animals such as ant, beetel, bug, spiders, squirrels, mouse feeding on tree leaves and larger animals such as elephant , deer, antelope, giraffe grazing on shoots and fruits of trees.

The **secondary consumers** are carnivorous and feed on primary consumers these include birds, lizards, frog, snakes, fox etc

The **tertiary consumers** are secondary carnivorous and feed on secondary consumers these include top carnivorous like lion, tiger etc.

Decomposers:

These include a wide variety of saprophytic microorganisms like bacteria and actinomycetes, fungi. They attract the dead or decayed bodies of organisms and thus decomposition takes place. The dead and decayed bodies are decomposed, consumed and there nutrients are released for tree use. The rate of decomposition in tropical and subtropical forests is faster in comparison to temperate forests.

Functional aspects of a forest ecosystem

1) Energy cycles. The ultimate source of energy of all ecosystems is solar radiation. In forest ecosystem how this energy is transferred from one tropic level to next tropical level is the cycling of energy in a forest ecosystem and how the physiological activities are associated with these this energy transfer.

2) Food chains linkage within a forest ecosystem like grazing food chain, detritus food chain etc.

3) Diversity-interlink ages between the species is one of the important functioning of a forest ecosystem.

4) Nutrient cycles-biogeochemical cycles like carbon cycling, oxygen cycling, and the sedimentary or gases cycling of nutrients immobilization or mineralization within a forest ecosystem.

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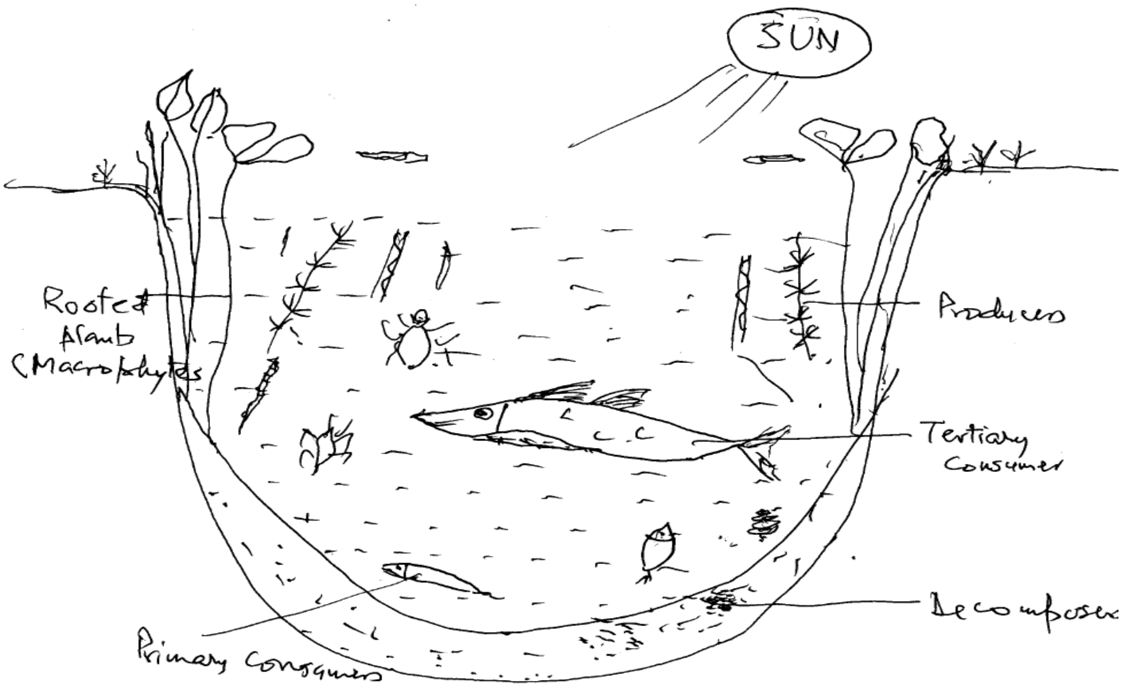

Fig. Pond ecosystem: A. Producers - Macrophytes
Phytoplanktons