Chapter 4

Forest Ecology

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Abstract

Human actions are supporting the destruction process in earth and are transforming the interactions among forests, land and water resources. Thus, forest ecosystems are continually changing and degrading with the passage of time. This conversion, induced by external factors is mainly defined by those internal ecosystem processes, which are essential for conservation of biodiversity. It is imperative to conserve all biome types as each hold several unique kinds of life forms. Preserving the various forest types is indispensable for the sustainable maintenance of earth ecosystem. The study of ecological methods is essential in dealing forest's resources because it states interactions that linkage biotic systems, of which human beings are primary component, with physical system on which they rely. The aim of ecosystem science is to incorporate information from the studies of interactions among individuals, populations, communities and their abiotic environment, as well as changes in their relationships. The flow of the energy and material by organisms and physical environment formulate a framework for understanding the variety of forms and working of earth's biological and physical processes. There is a rising indebtedness that a systematic understanding of forest ecosystem is crucial to manage the biodiversity, water resources and in regulating the atmospheric composition, that governs the Earth's climate. By educating the peoples about the

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results of human activities, a good considerate to conserve the earth's forest biomes can be obtained. The forest zones, which have been damaged, mostly will never recoup their original shapes, however conservancy will support to save them away from getting worsen.

Key words: Earth; Forest; Ecology; Autecology; Synecology; Ecosystems

4.1. Introduction

The term ecology was first used by Ernst Haeckel in 1866. Ancient Greek philosophers Aristotle and Hippocrates set the bases of ecology in their studies about the natural history. Then current thought of ecology converted into a science that is more rigorous in late 19th century. The word ecology has been formed from two Greek words (oikos-home and logos-the study). Therefore, ecology is defined as the study of an organism at its natural home. The two senses of ecology are widely used such as:

i. Andrewartha (1961) defined ecology "The scientific study of abundance and distribution of the organisms"

ii. Odum (1971) stated ecology "The study of relationships of organisms or groups of organisms with their environment"

At the developmental stage of ecology, there has been controversy between different schools of thoughts. To remove the barriers, ecology needs to be defined in a way that favors the common opinion. Therefore, a group of ecologists mutually approved a definition in the Institute of Ecosystem Studies, Millbrook, New York (Kemp 1992): which is described as

"Ecology deals with the scientific study of processes effecting the abundance and distribution of organisms, interactions of organisms, and the transformation and flux of energy and matter"

- Basic ecological concepts revolve around the four principles
- The ecological system is wide and comprises of interactions of its components.
- This interrelated system encompasses both abiotic and biotic constituents.
- The system in ecology has a control on energy flow as well as nutrients flow.
- Energy from solar governs over the flow of all the energy and nutrients.

Ecology has a broader scope and encompasses an extensive range of interacting levels, covering from micro-level (cell) to planetary scale (biosphere). There are numerous applications of ecology such as in natural resource management (agriculture, forestry, rangelands and fisheries), conservation biology, community health, city planning (urban ecology), human social interactions (human ecology), basic and applied sciences etc. Resources and organisms constitute the ecosystem that form the biophysical feedback mechanism, which control practices related to nonliving and living elements of the planet. Ecosystem endure life assisting tasks

and create natural capitals like biomass productivity (fuel, fiber, medicines and food), regulating the climate, water filtration, biogeochemical cycles, flood protection, erosion control, soil formation, and many other natural processes of scientific, economic, and historical values (Buchsbaum et al. 1972).

Ecology covers a wide range of allied disciplines and various scientists like physiologists, geneticists, taxonomists, ecologist etc. concentrate on respective aspects of ecosystems. In the subsequent discussion, description of different sub-disciplines of ecology has been provided.

- **Physiological ecology**- refers to environmental factors, which affect the physiology of organisms.
- **Population ecology**- deals with the distribution, dynamics, and structure of populations.
- **Community ecology**- describes the interactions among individuals and populations of different species.
- **Evolutionary ecology**- is defined as the studies of the evolutionary histories of species and their mutual relations.
- **Landscape ecology-** is the study of improvement in the relationships among ecological processes in environment and ecosystem.
- **Ecosystem ecology**- deals with mass balancing of elements and their interactions. The fluxes of elements are mainly attached to each other, and often one limiting element controls the flux of other elements.

The study of ecosystem should exploit all the approaches defined above to know the complexity, ecological processes and provide useful information for managers. In all aspects of ecology, the convergence of information, different approaches and disciplines lead to major breakthroughs in the understanding of an ecosystem (Kulhavý et al. 2014).

4.2. Concept of Ecosystem

A British ecologist named Tansley (1935) in his publication initially used the word “ecosystem”. This word is derived from a Greek word; Eco means "Environment" System means, "Complex coordinates unit”. Tansley created the idea to focus on the significance of transfers of elements between environment and their organisms. In nature, numerous communities of organisms live together and cooperate with each other along with their environment as an ecological component. Ecosystem is considered as a community of living organisms (animal, plant and microbes) in combination with nonliving elements of the environment (soil, air and water), cooperating as a system. It is an efficient component of nature about the complex interaction of abiotic (non-living) and biotic (living) factors e.g. forest is a good example of an ecosystem. Ecosystems have been classified as follows:

a) **Man-made ecosystems**

   i. Depend upon solar energy-e.g. aquaculture ponds and agricultural fields

   ii. Depend upon fossil fuel e.g. industrial and urban ecosystems

b) **Natural ecosystems**

   i. Depend on solar radiations e.g. forests, grasslands, deserts oceans and rivers. They afford fuel, food, fodder and medicines

   ii. Depend on solar radiations and energy subsidies (other sources) such as rain, tides and wind, e.g., tidal estuaries and tropical rain forests

4.2.1. Forest, Forest Ecology and Forest Ecosystem

a) **Forests** can be defined as native or local segments of landscapes where ecological and biological processes and conditions are controlled by the trees. Trees are mostly large, perennial long-lived plants also categorized by a large woody stem and extensive root system. The longevity and size of trees make them able to govern other plants by commandeering soil, light and other resources. This allows trees to regulate the important ecological functions, to govern the habitats for animals, microbes and other plants, and perform a role in defining the wealth of other organisms in forest. Thus, trees regulate the soil developmental processes, hydrological cycle, microclimate, and the ecological features of streams in forest ecosystem.

b) **Forest ecology** is a very diverse and essential branch of ecology that deals with tree species and environment. It is the systematic study of interrelated patterns, processes, flora, fauna and ecosystems in the forests. A forest ecosystem is a piece of natural woodland comprising of animals, plants and microorganisms (biotic part) working with all non-living (abiotic part) factors in the environment. Forests are examined at different structural levels, from the individual organism to the ecosystem. However, as the term forest includes an area inhabited by more than one tree, forest ecology most often focuses on the level of the population, community and ecosystem. However, the presence of trees makes forest ecosystem and their study distinctive in various ways.

c) **Forest ecosystem** refers to an area of the landscape; differ in size from a local stand to a whole continent, where the functions, structure, interactions, complexity and patterns of change with time are controlled by trees (Perry et al.2008).

4.2.2. Key Attributes of Forest Ecosystem

There are five key attributes of forest ecosystem

i. **Structure**

The basic structural components of forest ecosystems are dead and living components like animals, plants, soils microbes, organized in vertical and horizontal patterns. The physical environment involves the soil, atmosphere and geological substrates. Microclimate and topography are also essential ecosystem components, but are not structural parts in the strict sense.

ii. **Function**

In forest ecosystem, interaction of living and dead organisms along abiotic environment leads in the combining of physical (light) or chemical energy with soil chemical nutrients, geological substrate, and water to make the organic molecules, which form the living organisms. The energy for the formation of these molecules in the forest ecosystem is mostly provided by photosynthesis process. The raw resources for their productions are delivered by the flow of different nutrients in the ecosystem.

iii. **Complexity**

Forest ecosystems are considered by the composite groupings of various life forms, from lichens and bryophytes to different types of shrubs and herbs, to climbers and trees. Dead animals and plants material carries the energy for varied microbes and animals, which help to decay the organic material and make available the nutrients again for uptake by microbes and living plants. The relations between the dead organic matter, living organisms, and the physical environment contribute to the complexity of ecosystems.

iv. **Interaction between components**

A basic feature of a forest ecosystem is the relationship among the structural components. For example, soils influence the plants and plants affect the soil development. Climate affects the vegetation and soil development process, but plants transform local climate to create microclimate. Vegetation can affect regional climatic features and vegetation at global level performs a key role in global climate. Microbes and animals influence the plants, and then plants largely determine which microbes and animals will be affecting them.

v. **Change over time**

In ecosystems; nothing is as sure as change. Just as plants grow up, mature and inevitably die, ecosystems suffer renewal because of ecosystem disruption. Ecosystems grow and mature, and are ultimately disturbed and the renewal process is repeated. This change with the passage of time is essential to the ecosystems and in many cases, is a necessary condition for long-term stability of historical ranges of variations in their function, complexity, structure, and interactions of their components (Waring and Running 1996).

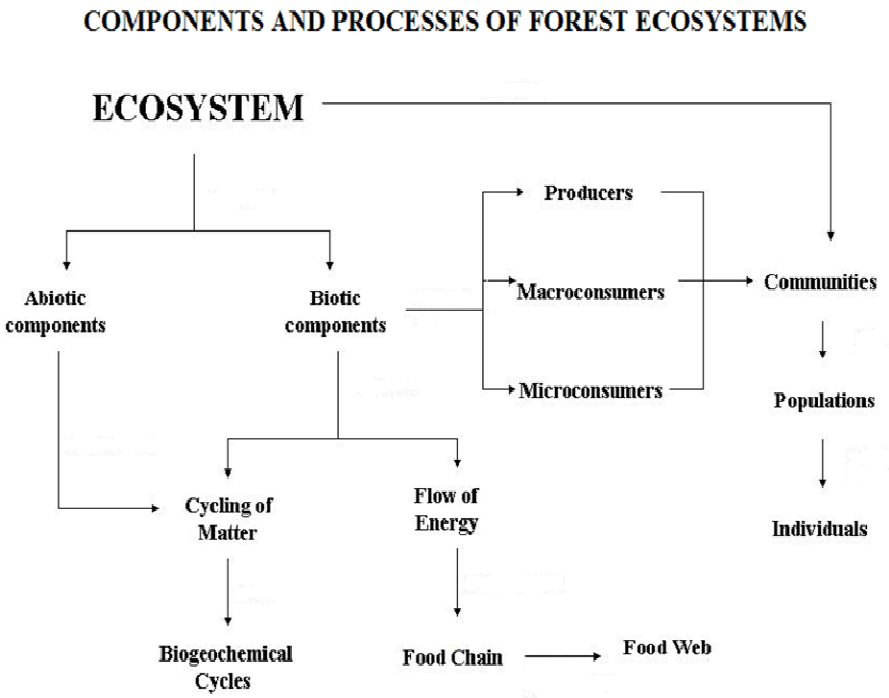

Fig. 4.1 Describing the components and processes of forest ecosystems.

Source: Modified from Kemp (1992)

4.3. Components and Processes of Forest Ecosystems

4.3.1. Components of Forest Ecosystems

A forest ecosystem comprises of living and non-living components. Organisms (plants, animals, algae, bacteria and fungi) make the organic or living portion of the ecosystem. The physical environment (air, light, water, temperature, soil, minerals and climate) creates the non-living portion. The word 'environment' denotes specially to the nonliving portion of the ecosystem. The living portions of an ecosystem are called the biotic components and the non-living portions are the abiotic components (figure 4.1). Both components cooperate with each other to sustain the ecosystem. A forest ecosystem is a functional part of nature covering complex relationship among its abiotic (non-living) and biotic (living) components. Details of two components are as under (Schulze et al. 2005; Smith and Robert 2012).

4.3.1.1. Abiotic Components (Nonliving)

Abiotic (Nonliving) components of a forest ecosystem comprise all chemical and physical factors that affect the living organisms e.g. air, soil, water, rocks etc. Hence, it is an accumulation of inorganic and organic elements found in an

ecosystem. Several climatic factors, which influence the function of ecosystem, are also a part of this. The abiotic components are vital for the biosphere because life cannot occur without water, sunlight, air and minerals. The nonliving component can be classified into subsequent three groups

a) **Physical factors:** Physical factors consist of temperature, sunlight, rainfall, humidity and air pressure. These factors limit and sustain the development of organisms in an ecosystem.

b) **Inorganic substances:** Inorganic substances contain oxygen, carbon dioxide, nitrogen, phosphorus, sulphur, soil, water, rocks and other minerals.

c) **Organic compounds:** Organic compounds include lipids, carbohydrates, proteins and humic materials. They are the structure masses of living systems; therefore, make a linkage among abiotic and biotic components.

The organisms of forests ecosystem are adjusted to distinctive physical environment of the forest habitat. These essential abiotic factors comprise water, sunlight, soil, wind and temperature.

i. Sunlight

The sun supplies warmth, light and energy for almost all forest ecosystems on the earth. Sunlight commands the photosynthesis in plants that are the core producers in maximum terrestrial ecosystems. Inside a forest, very less sunlight extents up to the forest floor than spread on the tops of the trees. This variable amount of sunlight generates diverse microhabitats. In aquatic environment, sunshine gives the energy for photosynthetic producers such as algae.

ii. Water

Water is necessary for all the organisms on earth. In forest ecosystem, water plays crucial role for survival and in response, ecosystem maintains the hydrological cycle. Plants are much adapted which save them from losing too much water and drying out e.g. Trees of Pine have needle-shaped leaves along with waxy coating. This shape of leaves lessen the quantity of water that vaporizes into air. Similarly, aquatic organisms also maintain their water loss and water uptake; otherwise, their cells may rupture due to osmosis.

iii. Temperature

Temperature is a very important component of forest ecosystem. Mostly the living organisms survive within a narrow range of temperatures, from around 0°C to 50°C. A small number of organisms can keep an active metabolism below 0°C, and most organisms' enzyme stop working and lose shape above 50°C. However, extraordinary adaptations permit certain species to survive at extreme temperatures. Several species of prokaryotes can flourish in hot springs as hot as 80°C and nearby deep-sea vents that are even hotter.

iv. Soil

In forest ecosystem, soil is an essential component, which affects the growth and distribution of vegetation. The combination of abiotic components (wind, ice, and rain) and the activities of living things (plants, microorganisms and earthworms) on the rocks and minerals of Earth's crust produce soil. The soil structure and chemical composition in an ecosystem determine the types of plants that can grow there. Similarly, in aquatic ecosystems the features of the underlying sand or rock define the types of plants and algae that can grow there.

v. Wind

Wind influences the activities and distribution of organisms in numerous ways. Winds control movement of rain and clouds on the earth. Wind also stirs up water in lakes, streams and ponds, making the currents, which result in bringing up nutrients from the bottom. Several land plants rely on winds for the dispersal of their seeds and pollen.

4.3.1.2. Biotic Components (Living Components)

Biotic components (living organisms) in a forest ecosystem can be categorized as producers (autotrophs) or consumers (heterotrophs) depending upon their food sources.

a) **Producers** (autotrophs, i.e. self-feeders) can synthesize organic nutrients, which they need, by using the simple inorganic compounds from environment: for example, terrestrial green plants on land surface and small algae in aquatic ecosystem make their food thru photosynthesis. The green plants produce the food for the whole ecosystem by photosynthesis. These plants are also called as autotrophs, because as they take carbon dioxide from air, absorb water and nutrients from soil, and capture solar energy for photosynthesis.

b) **Consumers** (heterotrophs, i.e. other feeders) are those living organisms that cannot synthesize their own food but directly or indirectly depend on producers for food. They are called heterotrophs and they eat food produced by autotrophs. Consumers, based on their food preferences and food habits, can be further classified into three broad categories.

   i. **Herbivores:** In food chain, herbivores are stated as primary consumers. They are plant eaters and feed directly on plants e.g. deer, rabbits, cattle, etc.

   ii. **Carnivores:** They are meat eaters and they feed on herbivores (primary consumers) therefore known as secondary consumers e.g. lions, tigers etc.

   iii. **Omnivores:** Those organisms, which depend upon plants and animals for their feed e.g. human, pigs, sparrows, etc.

c) **Decomposers**are called saprotrophs. They are commonly fungi and bacteria, which feed on decayed and dead organic matter of animals and plants by releasing enzymes outside their body on the decaying matter.

They perform a very significant role in reprocessing of nutrients in the forest environment. They are also called detritus feeders or detrivores. Decomposers digest and breakdown the complex organic molecules of dead organic matter (detritus) into simple inorganic compounds. In response, they absorb the soluble nutrients as food e.g. fungi, bacteria and mites.

Regarding forest ecosystem components, abiotic factors decide where a species is able to live, however, biotic factors often govern the species success. Numerous key biotic factors comprise different interactions among individuals. Mostly individuals are in competition with members of their own species as well as with other species. Living components depend upon an ecosystem for food, water, and air as well as other things they need for their survival. In return, living things influence the ecosystem in which they live. Plants are an important source of food and as biotic factor in forest ecosystems affect other biotic and abiotic components. The types of plants found in a specific ecosystem will also determine the types of animals that can survive there (Seymour and Hunter 1999).

4.3.2. Processes of Forest Ecosystems

Ecosystems are multifaceted dynamic systems, which perform numerous functions (Figure 4.1). There are few different processes that are fundamental in all the forest ecosystems (Odum and Barrett 2004; Thomas and Packham 2007).

4.3.2.1. Energy Flow through Ecosystem

In forest ecosystem, the major part of energy comes from sunlight by which plants synthesize food. During photosynthesis, plants transform light energy into chemical energy, which assist in the growth of branches, leaves, fruits, seeds, and wood. Herbivores obtain energy by consuming plants, carnivores by consuming other animals, and decomposers by the decay of animals and plants. In decomposition process, nutrients become accessible to soil fauna and flora, and then energy is released to environment. No part of the energy used by animals comes back to plants; this whole process is referred as energy flow. This conversion of energy from plants to animals also contributes to the dynamic nature of a forest ecosystem. Forest ecosystems are functioning by using the sun energy in the process of photosynthesis. The leaves of green plants absorb the solar energy and transform hydrogen, carbon, and oxygen into simple sugar form. That is again transformed into complex compounds such as cellulose, which is key constituent of wood fiber. A mature forest ecosystem yields many tons of sugar and various other compounds per acre each year. When a tree dies, it starts to decompose and microorganisms that decompose leaves, twigs and wood, consume some of the stored energy. As energy comes from sun and flows through an ecosystem, certain form of energy is lost to environment in heat form at each level during decomposition and metabolism (Figure 4.2).

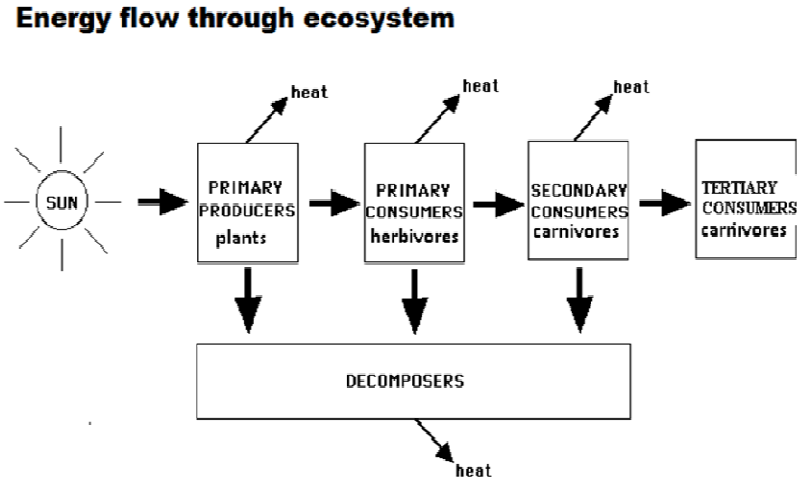

Fig. 4.2 Showing the process of energy flow through a forest ecosystem

4.3.2.2. Food Chain and Food Web

In each ecosystem, food chain is made up of producers, consumers, and decomposers. In forest ecosystems, producers can be trees, shrubs etc. but consumers are the components of ecosystem that depend on other components for their food. Every time an animal consumes another organism, ultimately energy moves to the consumer. For example, foxes, deer, rabbits, hawks, owls, snakes, insects and spiders are the examples of consumers in a forest ecosystem. There are three categories of consumers in ecosystem i.e. herbivores, carnivores, and omnivores. The decomposers are part of ecosystem, which survive on dead organisms and convert them into simple forms that are source of energy. Decomposers comprise of fungi, bacteria and mushrooms. Ultimately, producers, consumers and decomposers build different food chains.

In an ecosystem, there are more than one food chains for the organisms as every organism eat more than one type of foods or eaten by more than one kind of predators. Arrays of interactions develop out the complex system of overlapping and interconnecting food chains in an ecosystem is known as food web. In an ecosystem, there can be many food chains and the combination of many food chains is called as food web. Food webs present accurate models of energy flow through an ecosystem. Flow of energy in an ecosystem occurs through food chains, by transferring the energy from one organism to another (Figure 4.3).

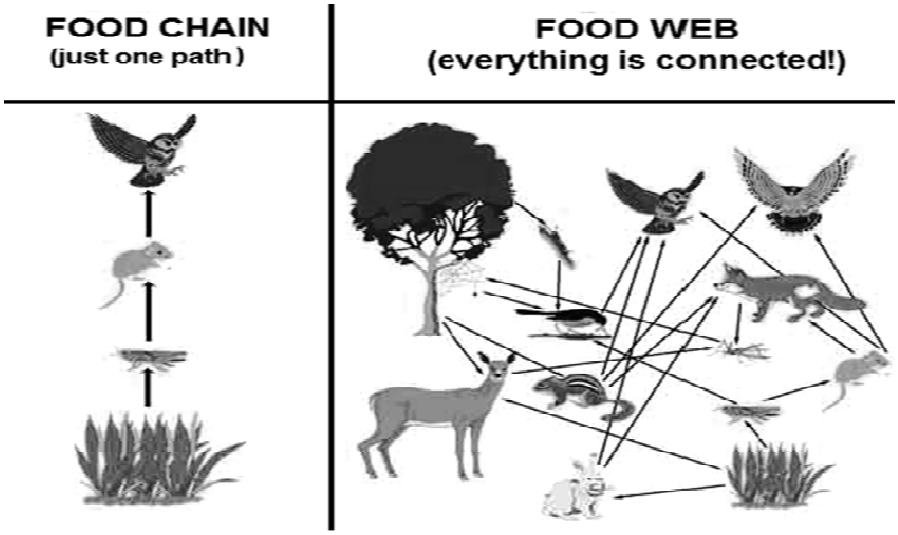

Fig. 4.3 Difference between Food chain and Food web in a forest ecosystem.
Source: Modified from Odum and Barrett (2005)

4.3.2.3. Trophic Level

In a forest ecosystem, trophic level is a phase of food chain occupied by an organism. Every stage of food chain is regarded as trophic level. From each trophic level, organisms get their energy whereas those organisms who share a trophic level obtain energy from the same point. The quantity of energy passing through the trophic levels reduces successively. At each stage in a food chain or web, energy got by organism is used to endure itself and remaining is passed on succeeding trophic level. In ecosystems, trophic levels are not linear however; they are interconnected and form a food web.

e.g. (Grasses→ Grasshopper → Frog → Snake → Eagle) (Figure 4.3)

Every point in food chain is named as trophic level. In above example grasses represent the 1st, and eagle represents the 5th trophic level. Similarly, trophic levelscan be categorized from level 1 with plants to level 5 with predators, are numbered successively as shown in Figure 4.4.

i. **Trophic level 1:** At level 1 plant and algae exist which create their own food and are named as primary producers.

ii. **Trophic level 2:** In this level, herbivores are present which consume plants and are named as primary consumers.

iii. **Trophic level 3:** Carnivores at level 3 eat herbivores and are named as secondary consumers.

iv. **Trophic level 4:** This level includes the carnivores, which eat other carnivores and are named as tertiary consumers.

v. **Trophic level 5:** At level 5 apex predators are present which have no predators and found at the top of food chain.

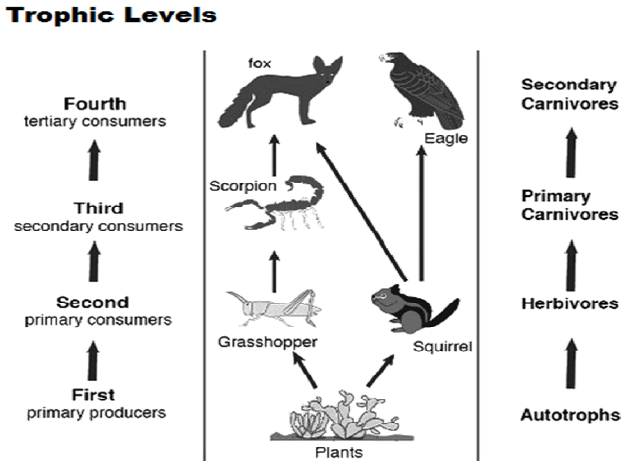

Fig. 4.4 Description of Trophic levels in a forest ecosystem

4.3.2.4. Ecological Pyramid

An ecological pyramid is also known as energy pyramid or trophic pyramid. It is basically a graphical illustration which is designed to demonstrate biomass production at each trophic level in a forest ecosystem. They are pyramidal in shape and the producer is at the base of the pyramid and makes the first trophic level in food chain whereas later levels of the pyramid symbolize the herbivore, carnivore and top carnivore levels respectively. The ecological pyramids are of three different forms:

i. **Pyramid of number:** This characterizes the relationship among the number of producers, herbivores and carnivores at succeeding trophic levels. It describes the number of organisms at each trophic level. For instance, in a forest ecosystem the number of producers (trees, shrubs, herbs) are in large number than the number of herbivores (deer, antelopes, elephants) and the carnivores (lion and tiger). In some cases, the pyramid of number can be reversed, i.e. herbivores are larger in number than primary producers (e.g. many insects feed on a single tree).

ii. **Pyramid of biomass:** It refers to total standing biomass at each trophic level. Standing biomassrepresentsthe mass of the living material at any given time. It is expressed in gram/unit area or kilo cal/unit area. Mostly in terrestrial ecosystems pyramid of biomass is upright. Total biomass of producers will be highest and further biomass would go on decreasing from producers to top carnivores.

iii. **Pyramid of energy:** This shows the total quantity of energy at each trophic level. Energy is denoted in terms of rate like cal/unit area/unit time or kcal/unit area /unit time. Energy pyramids are not inverted. The maximum amount of energy occurs at the base of the pyramid whereas

minimum amount of energy is found at the top of the pyramid (Figure 4.5).

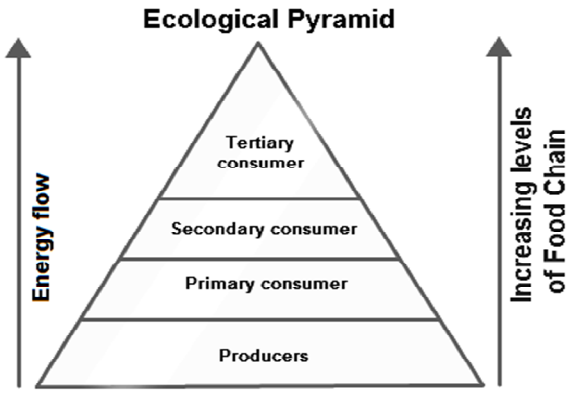

Fig. 4.5 Illustrating the ecological pyramid in a forest ecosystem.

Source: Modified from Odum (1971)

4.3.2.5. Biogeochemical Cycles

Biogeochemical cycleis a path overwhich chemical substances travel through both bioticand abiotic parts of the Earth. It is a cyclic sequenceof changes, which comes again to starting point andcan be repeated. The main biogeochemical cycles contain nitrogen cycle, phosphorus cycle, oxygen cycle, sulphur cycle, carbon cycle and water cycle. In a forest ecosystem, energy flow is linear however, nutrients flow is cyclic. The nutrients cycle from dead residues of the organisms back to soil by decomposers and absorbed again from soil by roots of plants which passes on to herbivores and carnivores. This cycled movement of the nutrients is necessary for life and called nutrient cycle or biogeochemical (Bio=living, geo=rock, chemical=element) cycle. The whole earth is a sealed system i.e. nutrients are neither exported nor imported from this biosphere. The word "biogeochemical" states that geological, chemical and biological factors are involved in it. Biogeochemical cycle always includes hot equilibrium status: stability in the cycling of the elements and whole balance may involve universal scale. As biogeochemical cycle defines the movements of matters on the entire sphere, their study is inherently multidisciplinary.

4.3.2.6. Ecosystem Productivity

The measurement of productivity enables us to determine the rate of photosynthesis and increase in biomass of a forest ecosystem. Yet, all natural activities in plants finally depend on solar energy whereas solar radiation alone does not control the gross primary production. All plant types need water, soil nutrients, carbon dioxide and sunlight for the process of photosynthesis. It also depends on moisture, temperature, and nutrients availability. Temperature governs the metabolism rate in plants, which in turn regulates the photosynthesis procedure. The optimum temperatures for production range from 15°C to 25°C i.e. optimal range of photosynthesis. Water is a main prerequisite for photosynthesis and the leading chemical element of most plant cells. In dry areas, there is a linear rise in net primary production with increase in availability of water. The productivity of

plants, particularly at the local scale, can be governed by the availability of nutrients. Nearly 20 to 30 elements are regarded crucial for plant growth and metabolism. These necessary nutrients are sometimes assembled into two types: micronutrients and macronutrients. Plants use the macronutrients for the manufacture of structural molecules and for constructing a range of organic molecules used in metabolic processes. There are only two macronutrients used by plants that exist in less concentration for plant uptake: phosphorus and nitrogen. When limiting, these two nutrients regulate the quantity of plant production that can take place. Plants need micronutrients in minor quantities for the making of less common organic molecules or as ions to catalyze certain metabolic processes. Generally, micronutrients are abundantly viable and do not lower the plant productivity.

4.3.2.7. Ecosystem Equilibrium

Forest ecosystems have capacity of maintaining their equilibrium condition. This self-regulation of ecosystem is known as homeostasis. There are numerous factors: like climate, species introduction, and species extinction that can change the equilibrium on which an ecosystem fluctuates. The climate change can affect the dominant plant species and better-matched plants might move into the area. Resultantly, dominant plants become extinct and the organisms that once depended on these plants will also become extinct or be forced to change their behavior. Consequently, a new equilibrium will be developed. Ecosystems continuously change with the passage of time. The series of ecosystem changes are known as ecological succession. Succession occurs when one community gradually replaces the other community with the changes in the environment. As succession in a community continues, it's finally becomes a climax community. The community becomes ecologically stable unless disturbed by some unusual event. Forest succession is a systematic change as the plants grow taller, larger, and compete with other plants for nutrients, light, water and destroying them. In ecosystem disturbance is expected to occur certainly in the form of fire, disease, insect, flood, wind, and other natural actions. Several common forest operations cause natural disorder to certain extent. Usually, disturbances open up the canopy of forests and permitting setting up of fresh plants. However, in many of our forests disturbances like roads, dams, logging, fire, and prescribed burning due to human influence have negative effects. When disruption arises over the massive forest areas, more time is needed for regaining and to maintain the equilibrium.

4.4. Factors Sffecting Tree Growth

Like every organism on the earth, trees are strongly influenced by different environmental factors. Environmental factors comprise everything other than plants, which influence the plant life. Hence, the basic information about interrelationship between trees and environment is indispensable. Trees differ markedly from each other in their distribution, growth, adaptation, phenology, regeneration, etc. These changes in trees can often be associated with prevailing environment. The factors affecting tree growth in the field can be broadly studied under two approaches mentioned as below (Gurevitch et al. 2006).

- Autecology approach
- Synecology approach

4.4.1. Autecology Approach (auto-self, logy-knowledge)

Autecology deals with the ecology of an individual species and its population therefore, termed as "species ecology". It also studies the individual organism including its life histories, behavior, adaptations with its environment comprising all the parameters of ecological importance. Autecology is the level of integration between the environment and the individual species. Autecology mostly involves the discussion about the environmental factors. Environment is a complex of various factors, which interact not only with organisms but also among themselves. Each factor consists of three levels, minimum level is one below which tree cannot survive. Optimum level is the best for tree growth and the maximum level is one above which tree cannot survive. The importance of these factors keeps on changing and depends upon the type of tree species, their growth and season of the year etc. In return, trees also affect these factors. Environmental factors can be classified into followings categories (Kimmins 2004).

1) Climatic factors
2) Water factors
3) Topographic factors
4) Edaphic factors
5) Biotic factors

1. Climatic factors

Climatic factors involve precipitation, humidity, light temperature and wind. These factors affect the life processes as of plants and are undoubtedly most important than all other factors. The above mentioned climatic factors are discussed one by one as below:

a) **Precipitation** directly and indirectly influences the trees by atmospheric humidity and water contents in the soil. In atmosphere, water vapors on cooling condenses to form clouds, which on further cooling forms the rain, snow, hail, dew, etc.

   Rainfall- rainfall refers to the drops of water that come down from the clouds, when water vapors in clouds condenses around dust particles, they form tiny droplets that ultimately get too big for the cloud to hold so they fall and grow larger as they accumulate more water on their way down. Whereas, drizzle consists of smaller droplets of water that slowly move toward the earth surface.

   Hail- hail is formed when water droplets repeatedly descent through cold area in the atmosphere, consequently, freezing the water in the shapes of balls which may be of significant weight and size. It exerts severe harm to the plants particularly to the small seedlings.

Snow- snow is another form of precipitation, which not only acts as shield to check evapotranspiration from the soil and plants but on melting it also enters the soil directly as rain does and entertain as a source of water.

Dew- dew is formed when water vapors in air meets cold surfaces, moisture condenses on the surface in the form of small droplets of water called as dew.

When the above mentioned all forms comes down on the earth they are named as precipitation. Area receiving high precipitation is always considered as the area with dense tall vegetation. Therefore, years of abundant rainfall are also regarded as the years of abundant forest growth rate. Total amount, intensity, form and frequency of precipitation all control the survival and growth of trees species.

b) **Temperature** is an important climatic factor because it controls the several physiological functions in plants. Plant metabolic processes are high at certain temperature called optimum but low at minimum and maximum temperature. Both very high and low temperature has negative effect on the growth of plants. Plants significantly vary in temperature tolerance not only from species to species but also within same species in different seasons of the year. Overall, there are insignificant metabolic functions at temperature higher than 40°C or below 0°C. Temperature along with combination of moisture define the over-all distribution of vegetation. Vegetation is mainly described by the heat. Thus, the plants, which grow in cold climate, cannot grow in hot climates and vice versa. Trees are usually more sensitive to temperature extremes at their early growth periods and temperature extremes are more severe near the ground surface. However, provision of mulch, moisture and shelter can decrease the temperature extremities near soil surface. Plants can be classified based on the temperature requirements such as;

   i. Megatherm- Plants which live in the high temperature throughout the year e.g. equator and tropical region rain forest

   ii. Mesotherm- Plants that favor high temperature in summer alternating low temperature in winter e.g. deciduous forest of tropical and subtropical zones

   iii. Microtherm- Plants that found in the temperate and high altitude (upto12000 ft.) e.g. mixed coniferous forest

   iv. Hekiskotherm- Plants of arctic and alpine zones with low temperature (above 12000 ft.) e.g. alpine vegetation

c) **Humidity:** In atmosphere, humidity always exists in the form of invisible suspension of water vapors. Normally, the water holding capacity increases with the rise in the temperature. Relative humidity is influenced by atmospheric pressure, exposure, wind, vegetation and presence of water contents in the soil. In an unsaturated or dry condition, the water vapor concentration of the air is commonly stated as relative humidity. In plants

transpiration and absorption of water is directly related with the relative humidity in the atmosphere. Lesser the relative humidity in air, higher the rate of transpiration and absorption of water by plants. Humidity is also dependent upon the blowing or still wind. Blowing wind supports to enhance the transpiration rate by removal of moisture-laden air from around the stomata of the transpiring plants. The atmosphere is assumed to be saturated when the atmosphere contains the maximum possible amount of water vapors at specific pressure and temperature. On the other hand, if the temperature of the saturated atmosphere is lowered, the ability of holding water vapors falls and consequently, some water condenses as rain, snow or dew.

d) **Wind:** Air in motion is called wind. It plays significant role in the movement of gases, water vapors and small soil particles in environment. The wind action as an ecological factor may be direct or indirect. The direct effects of wind are usually obvious in the region where high wind velocities occur. Violent and strong winds may cause flattering of herbaceous plants to the ground, referred as lodging. Strong winds also carry and move the soil particles that cause a scratchy action on the tender braches and leaves of various plants. Indirect effects of wind are physiological which involve influence on the transpiration rate in plants. Strong winds accelerate the transpiration rate in plants and plants fail to maintain internal water balance consequently suffer desiccation. Wind velocity increases with an increase in height above the soil surface so that large plants are more prone to high rate of transpiration than smaller ones.

e) **Light:** Light is considered as a factor of great ecological importance in the environment. It is mainly used for the synthesis of food by green pigment in plants. Out of the total sun energy, reaching to the earth only 2 % is utilized during photosynthesis process and almost 10% is used in various physiological functions. In plants, the stored chemical energy in the food is used for numerous other biochemical activities. The requirement of different light periods by plants is referred as photoperiod. Based on photoperiod, the plants are categorized as short day and long day plants. However, the plants that show slight response to the day length are called day neutral plants. Plants can also be categorized according to the relative requirements of sunlight or shade. Those plants that develop finest in full sunlight are known as heliophytes and those that develop at less light intensities are known as sciophytes. There are some facultative heliophytes, which grow well in less amount of light but can also develop fine in full sunlight. Correspondingly there are some heliophytes that grow good in sunlight but can also fairly grow in shade are called as facultative sciophytes. However, there are distinct morphological and anatomical variations between the leaves of plants growing in sun and in shade and even between sun exposed leaves and shade exposed leaves of same plants.

2. Water factors

Among all the environmental factors that affect the distribution and growth of plants, water is known as most vital for all the life processes. Water encompasses almost 70% of earth surface and found in lakes, streams, ponds and oceans. In nature, water moves in circular fashion called hydrological cycle. For all the physiological processes like photosynthesis, transpiration and translocation of food material water is very important. Water also plays significant role in pollination, fertilization processes in flowers and dispersal of flowers and seeds. Maximum plants have adjusted in nature according to the amount of moisture available to them. On the basis of habitats, plants have modified themselves morphologically and anatomically and accordingly they are classified as

i. Hydropytes- plants growing in water reservoirs like ponds, lakes, streams or rivers.

ii. Amphibiophytes- moisture loving plants, which grow on very moist and swampy places i.e. on the side of pond ditches, rivers, etc.

iii. Mesopytes- plants which grow in habitats, which are neither dry nor wet, and temperature of the air is neither too high nor too low.

iv. Xerophytes- plants living in xeric habitats where there is scarcity of water, found in arid region, on rocks, sandy soil and steep slopes.

3. Topographic factors

Topographic or physiographic factors include the form, behavior and structure of earth surface such as hills and their slopes, elevations, aspects, valleys and coastal areas. In prevailing climatic conditions of an area, topographic factors have a great influence on the vegetation. It affects the growth of plants in two ways: by producing the variations in local climate and by changing the edaphic factors of the area. Forms of land and direction of sloppy faces have strong indirect effects on the growth of trees. Altitude, slope and aspects are main constituents of lands configuration. These features have very strong modifying effect on the temperature, duration of growing season, soil moisture and precipitation. Major components of physiographic factors are discussed here under:

a) **Altitude**- It describes the height of a certain area from sea level. As we move towards higher altitude, climatic variations become more and more severe and vegetation also changes. Altitude tends to create contrasting local climates.

b) **Slope-** Slope isalso a topographical factor that effects the variations in the habitats. Slope of the ground influences the distribution of vegetation by affecting the insolation, soil stability, movement of water as well as level of water.

c) **Aspect-** Aspect or exposure of mountains towards sun is another physiographic factor. Sometime quite different vegetation is perceived on the two aspects of the mountains.

4. Edaphic factors

Edaphic factors are very important like other environmental factors for the growth of plants. Climatic factors are of utmost importance in determining the characteristics of vegetation over extensive areas but within general climatic zones, edaphic factors are also essential for the local differences in vegetation. Plants grow in the soil, which provides the nutrients for them, and also act as reservoir of water for the plants. However, most plants grow well where soil pore spaces are not exclusively occupied by either water or air. Warming (1895) has categorized the plants on the basis of soil types. He characterized the plants found on acid soil as Oxylophytes, on saline soil as Halophytes, on sand as Psammophytes, on rock surface as Lithophytes and in rock crevices as Chasmophytes. The main components of soil affecting the plant growth are discussed as follows

a) **Soil texture**-Relative proportion of soil particle sizes is referred as soil texture. It indirectly affects plants by producing the variations in soil water and soil air. The water amount available to the plants from soil is determined largely by the texture of soil.

b) **Soil structure**-Soil structures are formed when the merging of individual soil particles occurs with the help of soil colloids into various forms, shapes and sizes (1-10mm in diameter). Aggregation of soil is very important with the increase in the fineness of texture. More the degree of aggregation in soil the more favorable the soil for growth of plants. Aggregations make soil permeable to water; assist heat transfer, and increase aeration and water holding capacity.

c) **Soil organic matter**-It is dead remains of plants in soil, which is lightweight and less radically mixed with other soil components. Organic matter makes the soil porous and increases the percolation, aeration and absorption of water, therefore, organic matter is a pool of nutrients and oxygen that is essential for plant growth.

d) **Soil organisms**-Soil microorganisms are mainly responsible for decomposition of organic material and making it available to the plants. The large soil organisms are responsible for significant mixing and weathering of soil. Nitrogen fixing organisms are directly responsible for soil fertility, improving soil structure, aggregate stability, and fertility, and as whole affect the soil environment and the plant growth.

e) **Soil water**-It is essential in order to meet the water requirements of plants. Soil water also acts as solvent through which necessary minerals and salts are absorbed by plants in dissolved state. It compensates the continuous loss of water from plant during transpiration. Both shortage and excess of water in soil are harmful for the plant growth. Precipitation (rain, snow & hail) is the ultimate source of water to soil but rain act as the principal source.

f) **Soil air**-It mostly inhibits the pore spaces among the soil particles. Oxygen is required for the respiration of roots and other underground parts of the plants. Soil air is significant to the plants since seed germination and

microbial activities within soil depend upon it. Many seeds will not germinate unless soil is aerated. It is also essential for the respiration of micro and macro organism of the soil that is important for decomposition of plants and animals thus improving the soil fertility.

g) **Soil temperature-**The temperature is a factor of vital concern for plant growth. The amount of the heat that is absorbed into the soil is controlled by climate, altitude, aspect of the land, soil color and vegetation coverage. Plant growths as well as biological and chemical functions are greatly influenced by the soil temperature. Soil temperature also regulates the soil air to some extent. Functional activity of root decreases as the temperature change from an optimum degree.

5. Biotic factors

Biotic factors determine the relations among plants, between plants and animals, and soil micro flora and fauna. In biotic factors, most important one is the effect of man on the plants. Trees are continuously influenced by other trees, crops, weeds, insects and man. They are seriously exposed to these factors at the seedling stages. Fungi, bacteria, virus, nematodes and other soil microbes act as main agents who alter the chemical and physical properties of soil, increase or decrease soil fertility, which has great influence on the growth of vegetation. Some soil microbes live in close association with plants, both benefiting from each other and mycorrhizas are the good example of such symbiosis. It has been noted that mycorrhiza also plays an essential role for successful growth of many plant species. Grazing animals disturb the plants by making the injury or by complete removal of species mainly at the seedlings stages. By trampling grazing animals harmfully influence the aeration of soil, rendering it compact and hard and finally making it unfit for plant growth. Mechanical, chemical and biological warfare and regular use of pesticides, herbicides and weedicides by man have also exhibited great role in the devastation of vegetation. Modifications made by fire are another biotic factor due to human activities if small areas are affected by surface fire the vegetation normally return to normal state though long and severe crown fire may destroy all plants and animals as well as soil humus and seeds.

4.4.2. Synecology Approach

Synecology is called as the "ecology of communities". It deals with the study of communities; their compositions, behaviour and their relationship to the environment e.g. study of a forest in which Eucalyptus tree grows or grassland in which animals graze. A forest is a relatively stable and complete system of interacting biotic community and abiotic environment as its components. Synecology approach generally includes the discussion on following components (Kimmins 2004).

1. Nature of plant communities

Plant community is the sum of total plants in an area growing on sand dunes, bare rocks, flats plains, or in water. Plant community is also referred as an aggregation of individuals with mutual relationships among themselves and environment.

Mutual relationships in the individuals of community are comprised of all the direct or indirect effects that the organisms have upon each other, the most significant of which is competition. Based on the soil and environment, a forest consists of various kinds of plants i.e. huge tree, large shrub, small shrub and ground flora, etc. Existence of lower layer depends upon the shade of the trees above them, which make them to adapt as the undergrowth whereas if the plant has to survive for long time they have to adapt themselves in their habitat. Climate of an area determines the types of the plants that may survive there, thus vegetation types like grasslands or forest is a product of complex of climatic factors, consequently, climate of region can also be assessed from vegetation types.

2. Development of plant communities

Development of plant communities in a barren area includes different stages like migration, ecesis, aggregation, competition, reaction and stabilization.

a) **Migration:** The bare areas which are free from the seeds or other propagules involves the migration of pioneers i.e. the movement of germules, seeds, and spores etc. from their original areas into new sites. The factors effecting the migration are dispersing agents, mobility, distance and topography. Plants may be classified based on their part distribution e.g. i-plant distributed, ii-spore distributed, iii-fruit distributed, iv-seed distributed, v-offshot distributed. Besides the dispersal mechanism of plants the possibility of migration also depends upon the dispersing means e.g. man, animals, water, and wind.

b) **Ecesis:** The process of propagule growth and their adjustment in the new area is called ecesis. It involves three main phases i.e. germination, growth and reproduction. When seed does not germinate immediately after detaching from parent plant is said to be in dormant stage. This stage may prolong to a period of few weeks, months or even years. Suitable depth at which seed is sown is main condition for the successful germination. At seedling stage when the plant just started to live on its own it has to face very severe competition among themselves and with other species. If the ecesis has to be successful, seedling must grow, establish and reproduce in the neighboring habitats also.

c) **Aggregation:** When the plants have established themselves in new habitat, they try to dominate the area by the same species and develop in the form of colonies is called as aggregation. Aggregation may be simple or mixed. Simple aggregation is the grouping and growing of seedlings around the parent plants. Mixed aggregation is the slow spreading and intermingling of the neighboring plants also with other species due to the process of migration.

d) **Competition:** The simple and mixed aggregation leads to the competition. Competition always arises when two plants demand for nutrients, light or water more than the supply. It is the general charisma of the all plant communities. If the competition is within species, and make same demands upon the same supply at same time is called intraspecific

competition. When the competition is between different species, it is called interspecific competition. A dominant plant does not compete with secondary dominant one, undershrub, herbs or ground flora because each layer and each species have different requirements of nutrients, water, light, space and with the passage of time each plant adjust itself to prevailing conditions.

e) **Reaction:** When a plant community adjusted itself to a new habitat; it applies certain effects on its surroundings and nearby plants is called as reaction. Several reactions are the direct outcomes of the plants activities like decrease in water by absorption and increase of humidity due to transpiration. Death and decay of plants or plant organs leads to the integration of sufficient organic matter into the soil, therefore, changing the chemical and physical properties of soil.

f) **Stabilization:** A series of progressive reactions produced by a series of plant communities in an area is called as succession. Each step of succession is known as sere. Reactions of each sere, generally produce conditions favorable to new invaders, which succeed the previous one and become the dominant, the new invaders with the passage of time produce a new reaction favorable to another community. Eventually times come when no reaction is possible and habitat cannot be reformed more. At this stage, a stable community comes into existence and become more or less balanced with the climate.

3. Mutualism and Symbiosis

It is a relationship between two or more species, when both species get mutual benefits. Similar relations among species are also known as cooperation. Mutualism might be categorized in terms of closeness of association, the closest being symbiosis, that is often confused with mutualism. In the interaction, one or both species may be obligate, means they cannot survive in short or long term without the other species. In parasitism, the profits of the relationship only occur to one organism whereas other is spoiled. Competition has harmful influence on both companions, but there are also associations, which are helpful to both sides called mutualism. It may be a loose association or one in which both allies are completely dependent on each other. The word symbiosisis to define the latter state. There are some examples of mutualism and symbiosis such as relations between fungi or bacteria and higher plants that can be just a close relation. Leguminous plants mostly have root nodules with nitrogen fixing bacteria. There are several plant-fungus relations i.e. mycorrhiza fungus survives either in root tissues or thoroughly cover it and sends fungal threads into soil.

A nearly whole interdependence between two organisms may be present during pollination among plants and animals. The plants offer nectar to insects or birds that come to flowers and transfer the pollens from one flower to another. The relationship is commonly very close, that both pollinator and flower form distinct structures to select specific partners. For seed dispersal, numerous plants are again dependent on animals to which they provide food to appeal them. The seeds of fleshy fruits have a solid covering to protect them from the enzymes in the

digestive system of animals whereas some seeds pass through animal guts to breakdown dormancy. Animal to animal mutual relationships are generally a bit looser than the examples considered so far. For example, cattle egrets accompany with cattle and get benefit by eating insects disturbed by cattle. The cattle will get help from the warning of the egrets when a predator approaches. Further birds eat ticks and other parasites from the skin of herbivores, from which the mutual assistance are clear.

4. Biodiversity

Biodiversity is expressed as the degree of variations of life. It is the abundance and diversity of life form processes, functions, and structures of plants and animals and other living organisms in the ecosystem. Biologists mostly describe the biodiversity as the sum of all genes, species, and ecosystems in an area. It can discuss about genetic variations, species variations, and ecosystem variations in an area or biome. Therefore, biodiversity might be explained at the level of genes, species, communities, and ecosystems. Each biodiversity level has three parts: structural diversity, compositional diversity and functional diversity. The variations in habitats and species diversity are mostly used as indicators of health of ecosystems. Terrestrial biodiversity inclines to be maximum at low latitudes around equator that might be due to the effect of hot climate and high-level primary production.

Young forests commonly have more number of individual species as compared to mature forests. However, old forests sustain some species, which cannot stay alive in younger forests due to more complex habitat requirements of species. The features of older forest contain decaying logs, trees, shrubs, and often a multilayered canopy that supports dwellers communities. Biodiversity need to be understood in the perspective of scale and level of biological associations. Generally, managing biodiversity at landscape level is most reasonable which is producing diversity of various habitats over a vast geographic area and offer the long-term ecological benefits. There are three traditional levels around which biodiversity has been documented i.e. genetic diversity, species diversity, and ecosystem diversity.

a) **Species diversity** is the effective number of various species, which are present in an assemblage of individuals. It involves two components, species evenness and species richness. Species richness refers to the simple count of species, while species evenness tells how equal the abundances of species are. Localized species richness at a particular place is called alpha diversity, but biotic community often changes in a traverse of the landscape and creating locally different habitats within a forest: beta diversity measures the extent of such change along a gradient. Gamma diversityis similar to alpha diversity but is a measure of species richness across a range of habitats within a larger geographical area, which may include forests and other types of vegetation.

b) **Ecosystem diversity is** the diversity of an area at ecosystem level. This term varies from biodiversity as it discusses the variations in species rather than at ecosystem. Ecosystem diversity can also denote to the variability

of ecosystems present in biosphere, variety of species and ecological processes found in various physical settings.

c) **Genetic diversity** is defined as the biodiversity level, which deals with total number of genetic features in the genetic makeup of a species. Genetic diversity helps the populations to adjust into the changing environments. With more variation, it is more likely that few members of population will have variations of alleles, which are suitable for environment. These individuals are more likely to live and produce offspring and population will continue for generations' due to success of these individuals.

5. Distribution and Abundance

Distribution of species means the range of conditions in which species exist; and abundance is number of species, which occur within that range, this is also population size. To describe distribution, we can start with all surviving species in world and ask ourselves why in any area we discover only a small number of them. There are many factors responsible for this. Geographical obstructions stop numerous species from reaching regions where they might be able to survive. This of course is associated to the dispersal way of the organism in question. Geographical separation is best understood on islands, but large rivers or mountains can act as barriers and isolated areas of a certain habitat in between other habitats can be viewed as islands too.

In case of diseases, safety actions such as confinement are essential to prevent them from spreading into new areas. Only those organisms that are adjusted to the climatic conditions and for which all basic requirements are fulfilled can survive. However, a large number of them will not be present due to competition. It is exposed by the fact that in garden several plants that would not survive otherwise can be grown-up when weeding eradicates the competitors. Even among those species that can find a niche without serious competitors, certain will not survive in an area due of parasites and predators. The last two factors also affect the abundance of the species present. Roughly speaking the quantity of existing food controls the carrying capacity, the maximum number of organism that can occur. If the circumstances are positive, every population can develop speedily at a high growth rate. Generally, most of the young's (or seeds for plants) will not survive and territorial performance inclines to control the numbers by keeping them at a balanced value.

6. Succession

The series of ecosystem changes are also known as ecological succession. In analyzing forest communities, various patterns of plant growth arise; one of these is called as succession. It is rather predictable and often lengthy system in which one community replaces another ending at climax community that is self-perpetuating. There are two types of succession primary succession and secondary succession. Primary succession occurs in areas that are devoid of any life and secondary succession occurs where the living community has been partially or completely damaged. As succession in a community continues, it finally becomes a climax

community. This community is ecologically stable except disturbed by some unusual events.

All the animals and plants exist in specific environment to which they are specially adjusted. As the changes occur in environmental conditions, the species of plants and animals also reveal changes. The process through which communities of plants progressively change with the passage of time is termed as succession. The first stage of succession is bare land that may take several years to reach final climax stage. Once a forest is at climax stage, the process of succession starts to stop. At climax stage forest community is constant, comprising of trees, which only preserve themselves, and can sustain for several hundred years. To demonstrate the various stages of succession, firstly the changes start to appear following the abandonment of a cultivated area. The first plant species to grow in the field are grasses and weeds and are named as pioneer species. In next three to five years, several small trees can be found there. These tree species are hardy and are capable to survive with full sunlight and changes in weather condition. As trees settle in the area, they start to provide the shade to other vegetation. Pioneer weeds and grasses are not able to survive with extra shade and are gradually replaced with shade-tolerant species of grasses and weeds. After 10 to 15 years, shrubs and young trees in the field converted into dominant species. At this stage, grasses and weeds have been excluded because of the reducing amounts of sunlight. Finally, individual trees develop well beyond the shrubs level, reach sexual maturity and produce seeds. Afterwards many years the cultivated field transformed into a green forestland. However, in nature, plant communities are continually changing.

Long-lived hardwood species shade the forest floor and small changes are observable, as these species remained intact to make environment that satisfy their requirements. This forest field is now regarded as climax community and remains in this condition until a distressing force such as hurricane, human effects or fire causes the succession to start again. A forest ecosystem has much tolerance that involves the maximum and minimum environmental conditions compulsory for an organism to live. In this tolerance, various adaptations are established to support species, to contest positively and sustain in ecosystem. Though succession is considered as well-organized process but viewing at the overall ecosystem one may find several variations in this system. Changes in successional process come for a number of reasons i.e. microclimate, soil condition and disturbances. This variety of habitats can be found in several natural ecosystems (Figure 4.6).

7. Survival

In forest ecosystem not all the tree seedlings that have regenerated and established themselves in an area essentially live, grow and reach maturity, several of them die during the process of development. The phenomenon in which many individuals that remained safe from death and reaches maturity is called survival. Foresters are highly concerned in the surviving individual's tree seedlings because these set up our future final crop and profit. Surviving individuals of different populations follow the three basic schemes of survivals;

a) Less survival at early age (very high early mortality) and high survival at intermediate and late age. Usually trees adopt this process of growth.

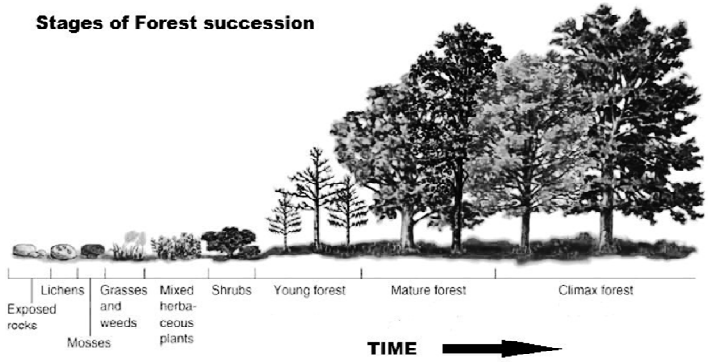

Fig. 4.6 Showing the different stages of secession in forest ecosystem
Source: Walter (2015)

b) Almost uniform rate of survival (nearly uniform rate of mortality) during the several growth stages. Marine organism generally follows this growth pattern.

c) Very high survival in early and intermediate age (very low mortality) and low survival at advanced age. Human population in advanced countries adopt this pattern

In nature, there are groupings of above any two or all three patterns for different populations. Species characteristics and environmental factors regulate the choice of survival pattern. As specified earlier, trees follow the first growth pattern. Therefore, all silvicultural and protective efforts should be focused on the initial years of forest seedlings in order to help the young seedlings and saplings. Once the saplings reach pole stage these are more or less completely safe from most different destructive agencies. Hazards and risk are commonly high only in initial years of growth. Ecological studies in this way may help in selecting suitable actions at proper time in order to promote or depress the particular population.

4.5. Biomes of the World

4.5.1. Meaning of Biome

Biomes are called "the world's major communities, classified based on dominant vegetation and described by the adaptation of organisms to specific environmental conditions. A biome is considered as the largest division of the biosphere. Biomes are explained by their biotic (living) and abiotic (non-living) components. The term biome is a short form of biological home. There is no unity between the scientists as far as the classification and definition of biome is concerned. Biome can also be described as a vast natural ecosystem where we analyze the total collection of animals and plants communities. All the biota has least common features and all the

areas of biomes are defined with more or less similar environmental conditions. However, a biome contains both animals and plant communities but commonly known and named based on its dominant vegetation, that usually makes the maximum biomass (Pomeroy et al. 1988).

4.5.2. Factors Effecting Biomes

Several factors influence the location, size, and character of biomes. Main factors are as follow

- Length of day light and darkness
- Length of growing season
- Mean temperature as well as differences in temperature
- Precipitation which consist of total amount, variations over intensity and time
- Wind flow which includes speed, duration, frequency and direction
- Slope
- Soil types
- Drainage
- Animal and plant species

4.5.3. Classification of Biomes

An ultimate classification (Table 4.1) of biomes is

1) Terrestrial biomes (land)
2) Aquatic biomes (comprising marine biomes and freshwater biomes)

There are two key bases of classifying biomes, which are discussed as below

a. Based on climate with emphasis on moisture availability

Biomes are classified by moisture availability to plants ranging from abundant (forest biome) to almost scarce (desert biome). However, in each biome, temperature differs much from low to high latitude and from low to high altitude. Therefore, there is a need to sub-divide each biome into further sub-types. But according to this grouping, there are four major types of biomes:

i. Forest biome

ii. Savanna biome

iii. Grassland biome

iv. Desert biome

b. Based on climate and vegetation

This classification describes a close relationship between the climatic types of the world and the world distributional patterns of plants and animals. As vegetation and climate have close relationship, the world is divided into several biomes types.

Table 4.1: Classification of biomes based on climate and vegetation

Biomes of first order (Based on climatic zones)	Biomes of second order (Based on vegetation)	Biomes of third order (Combination of climate and vegetation)
1. Tropical Biome	a. Tropical Forest Biome	i. Evergreen Rain-Forest Biome
		ii. Semi-evergreen Forest Biome
		iii. Deciduous Forest Biome
		iv. Semi-deciduous Forest Biome
		v. Montane Forest Biome
		vi. Swamp Forest Biome
	b. Savanna Biome	i. Savanna Forest Biome
		ii. Savanna Grassland Biome
	c. Desert Biome	i. Dry and arid desert Biome
		ii. Semi-arid Biome
2. Temperate Biome	a. Boreal Forest Biome (Taiga Forest Biome)	i. North American Biome
		ii. Asiatic Biome
		iii. Mountain Forest Biome
	b. Temperate Deciduous Forest Biome	i. North American Biome
	c. Temperate Grassland Biome	ii. European Biome
	d. The Mediterranean Biome	i. Soviet Steppe Biome
	e. Warm Temperate Biome	ii. North-American Parries Biome
		iii. Pampa Biome
		i. Australian Grassland Biome
		ii. Southern Hemisphere Biome
3. Tundra Biome	a. Arctic Tundra Biome	
	b. Alpine Tundra Biome	

4.5.4. Description of World's Major Biomes

Biomes are classified in various ways. Five major types of are discussed step wise as below (Whittaker 1975; Pomeroy et al. 1988).

1) Aquatic
2) Deserts
3) Forests
4) Grasslands
5) Tundra

1. Aquatic

Water is considered as mutual linkage among five biomes that form the major portion of biosphere and covering about 75% of the earth surface. Aquatic areas hold several species of animals and plants, consisting of both small and large types. With scarcity of water, maximum life forms would not be able to sustain themselves and earth would be an abandoned place. The aquatic biome can be categorized into two basic regions, marine and freshwater.

a. Freshwater regions

Freshwater is determined as having less salts contents, normally lower than 1%. Animals and plants in freshwater areas are settled to less salt concentration and would not be able to live in regions of high salts content. There are various kinds of freshwater regions e.g. ponds and lakes, streams and rivers, and wetlands. The characteristics of these three zones are described as below.

i. Ponds and Lakes

These regions vary in size from just a few square meters to thousands of square kilometers. Several ponds are seasonal; remain active just for a couple of months however, lakes can occur for hundreds of years or even more. Ponds and lakes can have less diversity of species as they are often separated from one another and from other water sources like oceans and rivers. Temperature fluctuates in lakes and ponds seasonally. In summer season, temperature may vary from 4°C near bottom to 22°C at the top level. In winter, temperature at bottom can be 4°C whereas at the top is 0°C. In between the two layers, there is a narrow zone named thermocline where temperature of water fluctuates promptly. However, during spring and fall seasons, there is a mixing of top and bottom layers due to wind, which make the almost constant water temperature about 4°C.

ii. Streams and Rivers

They are water bodies, which are flowing in one side direction. Streams and rivers can exist universally, they originate from headwaters, which might be snowmelt, springs, or even lakes, and move all the way to their mouths, generally another water channels or ocean. The features of a stream or river vary during the flow from the source to mouth. The temperature is lower and water is clean, has more oxygen level at the source than at the mouth. In the mid area of stream or river the width increases and diversity of species increases, several algae and aquatic green plants can be located there. Towards the mouth of river or stream, the water converts to murky due to sedimentation; reducing the amount of oxygen, light and there is less floral diversity.

iii. Wetlands

Wetlands are defined as the regions of standing water, which support water plants. Swamps, bogs and marshes are all regarded as wetlands. Plants species adjusted to very humid and moist environments are called hydrophytes. These comprise cattails, pond lilies, tamarack, sedges, and black spruce. Wetlands are considered to have maximum species variety as compare to all the ecosystems. Numerous species of birds, reptiles, amphibians and furbearers can be found in wetlands. Wetlands are not regarded as freshwater ecosystems because there are certain salt marshes, which have high salts concentration; these support different species of grasses and animals.

b. Marine regions

Marine regions comprise of about three-fourths of earth's surface and consist of coral reefs, estuaries and oceans. Algae from marine areas provide most of world's oxygen and absorb a massive amount of carbon dioxide from the atmosphere. The loss of seawater by evaporation becomes the source of rainwater for the land.

i. Oceans

Oceans are considered as the biggest among all ecosystems and are huge bodies of water, which covers earth's surface. Similar to ponds and lakes

regions, the oceans are divided into different areas: pelagic, abyssal, intertidal, and benthic. These four areas have a vast variety of species. Several authors has describe that oceans comprises of the richest species diversity.

ii. Coral Reefs

They are extensively dispersed in shallow warm waters. Naturally, the major organisms existing in coral reefs areas are corals. Corals are attractive, as they comprise of both algae and tissues of animal polyp. Meanwhile water of reefs incline to be nutritionally poor; corals gain nutrients from algae through photosynthesis and by spreading tentacles to find planktons from water. Beside the corals, the fauna consists of numerous species of invertebrates, microorganisms, octopuses, sea urchins, sea stars and fishes.

iii. Estuaries

Estuaries are regions where freshwater from rivers or streams combine with the oceans. This intermixing of waters with various salt concentrations produces a very exciting and sole ecosystem. Micro flora such as algae, and macro flora, like seaweeds, marsh grasses, and mangrove trees, can be found there. Estuaries also support different types of fauna, comprising a variety of crabs, worms, waterfowls etc.

2. Deserts

Deserts spread over one-fifth area of Earth's surface and exist where rainfall is lower than 50 cm/year. Mostly deserts are found at low latitudes, such as Sahara of North Africa and deserts of southwestern U.S., Mexico, and Australia. Another type of deserts called cold deserts, exist in the basin and range area of Utah and Nevada and in the region of western Asia. All the deserts contain significant range of particular vegetation, along with specific vertebrate and invertebrate animals. Desert soils normally have ample nutrients, as they need simply water to convert into productive but contain no or less organic material. Hazards are frequent in the form of cold weather, unusual fires and rare but extreme rainfalls. Deserts normally offer little shelter to animals from the sun. Desert biomes can be categorized based on numerous features. There are four major kinds of deserts

a) Hot and Dry
b) Semiarid
c) Coastal
d) Cold

a. Hot and dry desert

The main four deserts of this category are found in North America, which are Chihuahuan, Sonoran, Mojave and Great Basin. From outside the U.S. consist of Neotropical (South and Central America), Southern Asian realm, Australian and Ethiopian (Africa). The seasons are mostly warm during the whole year and severe hot in summer. Temperature show daily extremes as atmosphere contains low humidity to stop sun's rays. Mean annual temperature range from 20-25°C and extreme maximum ranges from 43.5-49°C. Minimum

temperature occasionally fall up to -18°C. Rainfall is normally very less and occur in small bursts after long rainless phases. Soils are categorized as course-textured, shallow, rocky or gravely with fair drainage and have no subsurface moisture. The particles of fine sand and dust are blown everywhere and accessibility of canopy is very scarce. Plants are mainly small woody trees and ground laying shrubs. Leaves are completely equipped with water saving features. They incline to be thick, small and coated with a thick layer of cuticle. The animals consist of small carnivores, arachnids, insects, birds and reptiles. They remain inactive in safe hideaways in hot day and come out to feed at dawn, dusk, or at night when desert is cooler.

b. Semiarid desert

The main deserts of this kind involve the Great Basin, sagebrush of Utah and Montana. They also consist of Nearctic realm (Newfoundland, Greenland, North America, Russia, northern Asia, and Europe). The summer seasons are moderately dry and long, like hot deserts whereas winters commonly carry poor rainfall. The average summer temperature usually range from 21-27°C and does not rise above 38°C whereas temperature in evening is cool at about 10°C. Besides, condensation of dew produced in night cooling may exceed or equal to rainfall received by some deserts. In hot deserts, rainfall is very low and average annual rainfall differs from 2-4 cm. The soil can vary from sandy and fine-textured to lose rock trashes, gravel or sand. In areas with sloppy mountains, soil is rocky, shallow or gravely with fair drainage. In each type, there is no availability of subsurface water. The spiny nature of numerous plants species in semiarid desert protects them from harsh situations. Mostly plants have glossy or silvery leaves, which help them to reflect more radiant energy. These plants also have an unpleasant taste or odor. Naturally, several animals protect themselves in underground burrows where they are isolated from aridity and heat. These animals comprise mammals like rats, rabbits, kangaroo, insects; such as grasshoppers, ants, reptiles; like snakes, lizards while birds such as burrowing owls.

c. Coastal desert

These deserts are found in moderately cool to warm regions similar to the Nearctic and Neotropical realm. Atacama of Chile is a good example of coastal desert. The winter of coastal deserts is cool followed by long and moderately warm summer. The average temperature in summer varies from 13-24°C; winter temperature is 5°C or below. The maximum annual temperature is about 35°C and the minimum is about -4°C. The maximum annual precipitation over a long period of years has been 37 cm with minimum 5 cm. The soil is categorized as fine-textured along with medium level salts concentration. Its normally have good drainage and porosity. Plants usually have extensive root systems near soil surface therefore; they take benefits of any rainfall. Mostly plants with fleshy and thick leaves or stems can absorb and store large quantities of water for further usage. Certain animals have specific adaptations to survive with desert heat and scarcity of water. Some toads close themselves in burrows with gelatinous secretions and stay inactive up to nine months until

good rainfall occurs. Some insects lay eggs, which stay inactive until environment is appropriate for hatching. Other fauna comprises reptiles (lizards and snakes), insects, amphibians, birds (golden eagle, great horned owl and bald eagle), and mammals (coyote and badger).

d. Cold desert

Cold deserts are described by cold winter with snowfall and high rainfall during winter season and occasionally in summer season. They are found in Greenland, Antarctic and Nearctic realm. They are defined by moist, short and moderately warm summer along with long, cold winter. The mean summer temperature ranges from 21-26°C and winter temperature from -2 to 4°C. The mean annual precipitation varies from 15-26 cm and winter receives fair level of snow. The soil is heavy, salty and silty however, it comprises of alluvial fans with relatively porous and good drainage. The plant species are usually scattered and height may range from 15 cm to 122 cm. The mostly plants have spiny leaves and are deciduous. Commonly found animals are kangaroo rats, kangaroo mice, pocket mice, grasshopper mice, antelope ground squirrels and jackrabbits. All of them are burrowers except the jackrabbits. Some lizards also do the burrowing and moving of the soils. Deer's are only found in the winter season.

3. Forests

Today, forests cover about one-third of Earth's surface, account for two-third of the leaf area of land plants, and hold almost 70% of carbon found in the living things. Forests are becoming the main losses of civilization because human population have increased from past several thousand years, and causing deforestation, pollution in this important biome. Presently forest biomes that are dominated by woody vegetation and trees can be categorized based on various features, with seasonality being most important. Different forest types are found within each of these broad groups. There are three main kinds of forests, classified based on the latitude

a) Tropical
b) Temperate
c) Boreal forests (taiga)

a. Tropical forests

Tropical forests are described by highest diversity level of the species. They are found around the equator at latitudes 23.5°S and 23.5°N. Key feature of tropical forests is their distinctive seasonality: winter is lacking, and only two seasons exist (dry and rainy). Length of daylight is 12 h and fluctuates slightly. Temperature ranges from 20-25°C and change little during the year. Precipitation occurs uniformly round the year with annual rainfall; beyond 2000 mm. Soil is considered as acidic and nutrient deficient. Decomposition rate is fast and soil is subjected to high leaching. Canopy of tropical forests is continuous and multilayered, allowing the fewer light penetration. Trees are usually 25-35 m tall, along buttressed trunks, mostly evergreen with large

leaves and shallow root system. In tropical forests, plants like orchids, bromeliads, vines (lianas), ferns, mosses, and palms are present. Fauna comprises of various bats, birds, small mammals, and insects. Unfortunately, more than half of tropical forests have already been damaged. More subdivisions of this category are described by seasonal rainfall distribution

i. Evergreen rainforest- without dry season

ii. Seasonal rainforest- short dry period in wet tropical region (forest shows seasonal changes as trees undergo developmental changes simultaneously, but general character of vegetation remains same as in evergreen rainforest)

iii. Semi evergreen forest- long dry season (upper tree story comprises of deciduous trees, while lower story is still evergreen)

iv. Moist/dry deciduous forest (monsoon)-the length of the dry season increases further as rainfall decreases (all trees are deciduous)

b. Temperate forests

Temperate forests are found in northeastern Asia, eastern North America, and western and central Europe. This biome is described by well-defined seasons with a distinct winter. Temperate forest are distinguished with moderate climate and growing season of 140-200 days during 4-6 frost-free months. Temperature can range from -30°C to 30°C. Precipitation (75-150 cm) is uniformly dispersed during the year. Soil is productive and developed with decaying material. Canopy of forests is moderately dense that permits the light to enter which promote the well-developed differentiated understory vegetation and faunal variety. Flora is described by 3-4 tree species per square kilometer and contains species such as oak, beech, hickory, hemlock, basswood, cottonwood, maple, elm, willow, and spring flowering herbs. Rabbits, skunks, squirrels, birds, deer, mountain lion, timber wolf, fox, bobcat, and black bear are characterizing fauna. Only isolated leftovers of original temperate forests have remained. Further division of this group is described by the distribution of seasonal rainfall

i. Moist conifer and evergreen broad leave forests-dry summers and wet winters (rainfall in winter and winter is relatively mild)

ii. Dry conifer forests- less precipitation, at higher elevations

iii. Mediterranean forests- precipitation mostly in winter, less than 1000 mm per year

iv. Temperate coniferous- mild winters with high annual precipitation, greater than 2000 mm

v. Temperate broad leaved rainforests- mild, frost-free winters, high precipitation more than 1500 mm and evenly distributed throughout the year

c. Boreal forests or taiga

Taiga or boreal forests are characterized as the biggest terrestrial biomes. They exist between 50 and 60°N latitude and located in broad belt of Eurasia and North America: two-thirds in Siberia with rest in Scandinavia, Canada and Alaska. Seasons are distributed into long, cold, dry winters and short, moist, and moderately warm summers. The duration of the growing season in boreal forests is almost 130 days. Temperature is very low and precipitation occurs mostly in snow form, 40-100 cm annually. Soil is thin, acidic and nutrient-poor. Light penetration through canopy is poor and consequently, understory vegetation is less. Flora contains mostly cold-tolerant evergreen conifers with needle shape leaves, such as fir, pine and spruce. Fauna comprise hawks, woodpeckers, moose, weasel, lynx, bear, wolf, fox, deer, hares, shrews, and bats. Present widespread logging in boreal forests can soon cause their vanishing from earth.

4. Grasslands

Grasslands are categorized as the lands that are dominated by grasses rather than large trees or shrubs. In Miocene and Pliocene Epochs, which cover a period of about 25 million years, mountains rose in western North America and produce a continental climate suitable for grasslands. Prehistoric forests have deteriorated and grasslands became common. After the Pleistocene Ice Ages, grasslands stretched out in range as hotter and drier climate prevailed globally. There are two major types of grasslands:

a) Tropical grasslands (Savannas)
b) Temperate grasslands

a. Savanna

Savannas are defined as grasslands with dotted individual trees. Savannas of one type or another occupy nearly half surface of Africa and large area of Australia, India and South America. Savannas are occurring in warm climate where annual rainfall ranges from 50.8 to 127 cm per year. Rainfalls occur in six or eight months of the year, followed by long drought periods when fire chances are higher. Savannas, which are formed by climatic conditions, are called climatic savannas. However, savannas, which are made by soil conditions and are not wholly maintained by fire, are referred as edaphic savannas. A third type of savanna, known as derived savanna, is formed because of peoples clearing forestlands for cultivation purposes.

The soil of savannas is porous, with speedy drainage and has only a thin layer of humus that provides nutrients to vegetation. The major vegetation comprises of forbs and grasses. Different types of savannas sustain different grasses because of differences in soil and rainfall; normally few types of grasses are more successful than others in a specific area. Savannas are defined by both rainy and dry seasons. Seasonal fires play a key role in the savanna's biodiversity. A fire is a feast for several animals, such as birds, which come to

fire sites to eat stick insects, beetles, grasshoppers, mice, and lizards that are driven out by fires.

Though dry leaves and stems of grasses are burned by fire, the grasses deep roots remain undamaged. These roots with reserves starch are ready to produce new growth when soil becomes moisten. The dispersed shrubs also survive on food reserves in their roots, however; they wait time to grow above soil. Different from grasses and shrubs, trees survive fire by holding some moisture in their aboveground parts throughout dry season. When the rainfall occurs, the savannas experience a new life at this time. Animals consist of zebras, buffaloes, giraffes, kangaroos, mice, ground squirrels, moles, snakes, beetles, termites, leopards, hyenas, lions etc. There are also some environmental issues concerning the savannas such as overgrazing, poaching, and clearing of the land for cultivation of crops.

b. Temperate Grassland

Temperate grasslands is defined by having grasses as the dominant species and usually large shrubs and trees are absent. Temperature fluctuates more from summer to winter season and rainfall is low in temperate grasslands as compared to savannas. The main examples are the puszta of Hungary, veldts of South Africa, pampas of Argentina and Uruguay, steppes of former Soviet Union, and prairies of central North America. Temperate grasslands have cold winter and hot summer. Rainfall is moderate and amount of annual rainfall affects the height of vegetation, with tall grasses in wet areas. The soil condition of temperate grasslands is dark and deep with productive upper layer.

Numerous species of grasses grows best in a specific grassland environment. The erratic fires, periodic droughts, and grazing by large mammals all stop the woody trees and shrubs from becoming established. However, scarce trees and few non-woody species, also rise among grasses. Precipitation in temperate grasslands commonly happens in early summer and late spring however average annual rainfall is around 50.8 to 88.9 cm. The temperature varies throughout the year and summer temperature can be high over 38°C whereas winter temperatures can be low as -40°C.

The fauna consists of zebras, gazelles, rhinoceroses, lions, wolves, wild horses, prairie dogs, mice, coyotes, deer, foxes, badgers, grouses, blackbirds, meadowlarks, quails, sparrows, owls, hawks, snakes, spiders and grasshoppers. There are some environmental issues concerning with temperate grasslands. Few natural prairie areas have remained, mostly have been converted into grazing lands or farms as they are treeless, flat, covered with grass, and have rich soil. Temperate grasslands can be further subdivided. Prairies are grasslands with tall grasses whereas steppes are grasslands with short grasses. Prairie and steppes are similar however, information specified above relates to prairies. Steppes are dry area of grasslands with cold winter and hot summer. Steppes are found in the interior of Europe and North America.

5. Tundra

Tundra is defined as the coldest among all the biomes. It is distinguished for its frost-molded landscape, little precipitation, very low temperature, simple vegetation structure, short growing season and poor nutrients. Dead organic matter acts as a source of nutrients pool. The two main nutrients are phosphorus and nitrogen however, phosphorus is made by precipitation and nitrogen is produced by biological fixation. Tundra is divided into two types:

a) Arctic tundra
b) Alpine tundra

a. Arctic tundra

Arctic tundra occurs in northern hemisphere, surrounding North Pole and extending south to the coniferous forests of taiga. The arctic is famous by its cold, desert-like environment where growth period varies from 50 to 60 days. The average winter temperature is -34°C but average summer temperature is 3-12°C that allows this biome to sustain life. Rainfall can vary in different areas of arctic. A sheet of permanently frozen subsoil named permafrost occurs, comprising of gravel and finer material. There is no deep root system in vegetation of arctic tundra; though, there is diversity of plants, which can withstand cold climate. There are about 1,700 types of plants in arctic and subarctic that includes low shrubs, sedges, liverworts, mosses, and grasses. Plants are usually short and group together to stand with snow and cold temperature during the winter.

The artic fauna is very diverse: Herbivorous mammals consist of caribou, voles, lemmings, squirrels and arctic hares. Carnivorous mammals are arctic wolves, foxes, and polar bears. Migratory birds include falcons, sandpipers, ravens, terns, Snowbirds, and gulls. Insects are flies, moths, mosquitoes, and grasshoppers. Fishes include flatfish, cod, trout and salmon. Animals are modified to live in long, cold winter and to breed their young ones quickly in summer. Several animals hibernate in winter due to food deficiency; they also travel to south in winter, as birds do. Amphibians and reptiles are few because of extremely cold temperature. Due of continuous immigration and emigration the population in arctic tundra frequently fluctuates.

b. Alpine tundra

Alpine tundra comprises mountains all over the world at high altitude where trees cannot grow. The growth season is only for almost 180 days. The temperature at night is generally below freezing point. The soil in alpine tundra is well drained. The plants are like to those of arctic ones and include dwarf trees, tussock grasses, small-leafed shrubs, and heaths. Animals in alpine tundra are also well adjusted for example Mammals were mountain goats, sheep, elk, Birds consisted grouse like birds, Insects included beetles, grasshoppers, butterflies, etc.

4.5.5. The Importance and Conservation of Biomes

Over the past few decades, the increasing human actions have quickly damaged several ecological habitats in entire world. It is essential to conserve all kinds of biomes, as each comprises several distinctive forms of life (fauna and flora). However, the constant heavy misuse of certain biomes, such as forest and aquatic biomes may have consequences that are more critical. Forests are very significant because they are homes of maximum diverse biotic communities of the biosphere. Within these biomes, there exist potential medicinal and several thousands of undiscovered and unseen species of plants and animals. In addition, forests have a universal climate-buffering capacity, so their damage may lead large-scale changes in worldwide climate. The day-by-day increased demand for homes, industry, paper, and other wood products have hindered the conservation process. More recently, peoples have started to understand that logging has devastated much of the forests in the whole world. Judicious use of forests and struggles to regrow trees has assisted to slow down depletion process of these plant populations. From few years, this forests destruction has been occurring at an alarming rate. Public awareness to this misuse has aided to lessen the problem somewhat; however, numerous challenges are still to be faced. Aquatic biomes are also very significant, they support life, and numerous species live in it for all or part of their lives. Freshwater biomes are source of water for drinking and for crop irrigation purposes. The world's oceans have even more influence on the global climate than forests. Pollution and overfishing have threatened to make the oceans into ecologically damaged regions. By educating peoples about the results of human activities, we can all gain a good understanding to preserve the earth's natural biomes. Unfortunately, the zones, which have been damaged the most, will never recover their original forms, but protection and management will support to keep them from becoming worsen (Olson et al. 2001).

4.6. Conclusion

The ecosystem approach describes the ecological understanding of resources for long-term sustainability of ecosystem and provision of important ecosystem services to the society. Forest ecosystems are directly influenced by the actions like land conversion, resource harvest and indirectly impacted by human induced changes in atmosphere, soil and hydrology. Since human actions intensely affect the earth ecosystems, it is required that we should also take the responsibility for their protection and conservation. An essential component of that responsibility must be to decrease the rate and extent of global changes in biotic and abiotic components. Recent development must be consisting of an increased ability to handle the environmental and natural limiting factors. This increased power to control should be accompanied by a better sense of responsibility for the forests conservation. The understanding of ecology is extremely interdisciplinary, based on many aspects like hydrology, climatology, ecology, and geology that contribute efforts to conserve earth forests. Ecosystem ecology states interactions among organisms and their environment as an integrated system, which control the pools and fluxes of energy and materials through ecological system. From last few years,

it has become increasingly clear to the world's population, that conservation of floral diversity in a broader sense is compulsory. Several plants species that have not been used for any purpose but can become important sources of food or medicine, if analysis is carried out. However, the destruction of forest ecosystems on a universal scale is such that several species will wipe out before they have been investigated scientifically. Forest ecosystems have to necessarily conserve the diversity in nature. Maintaining forests is necessary to regulate the water flow of whole earth system. Dynamic management of all forest ecosystems is compulsory to maintain ecosystems functions in response of anthropogenic changes and to sustain the provision of goods and services that humans receive. Ecosystem management confesses the impact of our inability to forecast future circumstances with certainty. The basic principle behind ecosystem management is that peoples are vital components of regional systems and planning for sustainable future need solutions, which are economically, ecologically and culturally justifiable. Maintaining the forest ecosystems diversity in nature is of prime importance. We are however at beginning stage to understand the consequences of these forest ecosystem changes. Mostly peoples get benefits from common natural resources such as forests and grazing lands but no one cares to look after them. For several human activities, there are always short-term benefits to few peoples, whereas there is a long-term cost to the environment and consequently to the community at large. Alas, there is only one earth, therefore we should be very cautious not to destroy its natural resources (Anonymous 2010, 2012).

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