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DEPARTMENT OF BOTANY

LEARNING RESOURCE

FOREST BOTANY

Introduction to Forest in India

Total geographical area of India is 32, 80,500 sq. km (328.8M ha) Total forest area 7, 50,500.00 sq. km (75.06 M ha)

Agricultural area is about 46.4%

The second National Forest Policy was enunciated (decided) in 1952 as per which 33.33% of land should be under forest for proper ecological balance. In hills 60% area should be covered under tree cover. During last tow decades 2 million ha forest was diverted for non- forest purpose, Agro-industry, power and irrigation projects, housing etc.**Government has enacted the Forest Conservation Act. 1980** to ensure that no reserve forest can be diverted to any other type of forest and that no forest and that no forest land can be used for any non forest purpose.

Out of total area under forest, 45.6 million ha (60%) area is in use and another 14.8 million ha (20%) area potentially exploited and remaining unexploited area as on Himalayan states, North Eastern regions and Andaman Nicobar islands.

Sources of energy consumption in India are: Coal, 16.5% Oil 10.0% Electricity 15.7% wood 37.6% Cowdung 8.7% and Vegetation waste 11.5%

Forest:

The wood is derived from the Latin word "Eairs" means "outside" Therefore forests are areas covering practically all uncultivated or untended lands covered with rather tall and dense tree growth.

Definitions and Terms used in Forestry

1. **Forestry:** Forestry has been defined as „the theory and practice of all that constitutes the creation, conservation and scientific management of forests and the utilization of their resources.
2. **Silviculture:** The terms silviculture, commonly refers only to certain aspects of theory and practice of raising forests crops. **OR** Silviculture pertains to the establishment, development, are and reproduction of forests crops.
3. **Pollarding:** This is a process in which the branch of a plant is cut off in order to produce a flush of new shoots. Pollarding is carried out at a height which is above the reach of browsing animals. It has been widely adopted on salix trees in Kashmir Valley.
4. **Lopping:** It pertains to the cutting of branches or even young stems. This leads to the development of new shoots. It is carried out on Diospyros (Temburni) for bidi industry, also in number of broad leaved species for fuel and fodder and as *Quercus incana* (Indiana oak), morus etc, for rearing silkworm.
5. **Pruning:** Means the cutting of branches from the bole in order to maintain the quality of timber.
6. **Taungya system:** It was first evolved in Burma in 1850 as a mode of replanting vast teak areas. Taungya is a Burmas word. (Toung hill, ya - cultivation). This is a modified from of shifting cultivation of which the labour has permission to raise crop on the land, but, with this, they are responsible for planting, of the forest species, also for protection and well being of the plantation. After about five years or so, they are required to move to another patch of land.
7. **Coppice:** When certain plants or seedling are cut from near ground level, they produce a flush of fresh shoots. This is known as coppicing
8. **Seed orchards:** are plantations which may raised exclusively with the aim of producing seed.
    1. **Seed Production areas or seed stands:** Which are area set aside exclusively for the purpose (i) to produce seed of high quality from genetically superior trees available in the stand (ii) to concentrate seed collecting operation in a small sphere or area. The seed stands are established by removal of the inferior frees, seed

orchards are plantation of genetically superior trees isolated to reduce pollination from genetically inferior once. Seeds orchards may be of two types: (i) Clonal: raised by grafting clones of superior trees on 2-3 year old seedlings (2) Seedling raised from obtained from seeds of superior trees.

9. **Pricking out:** When the seedlings have to be kept in the nursery for more than a year, it must be transferred to beds, other than the seedling beds. This is known as pricking out or to transplant small seedlings individually in to nursery beds or boxes.

10. **Wind breaks:** Is a protective plantation in a certain area, against strong winds. It is usually comprised of a few rows of trees (or shrubs) spaces at 0.5 to 2.5 m apart.)
11. **Shelter belts:** is a wide zone of trees, shrubs and grasses, planted in rows, usually at right angles to the direction of the prevailing winds. Its aims are:
    a. To deflect the air current.
    b. To reduce the velocity of prevailing winds
    c. To provide general protection
    d. To protect the leeward area from the desiccating effects of hot winds.
12. **Tending:** Tending is a board terms given to operation which are carried out for the well being of forest crops, at any stage of it life, involving operation both on the crop itself and on its competing vegetation e.g. weeding, cleaning, thinning, improvement feeling etc. However, tending does not include operation concerning, regeneration such as regeneration feeling, soil working, control burning etc.
13. **Felling:** Felling comprise of removal of trees either singly or in small groups scattered all over the forest.
14. **Afforestation:** Establishing a forest by artificial means on an area on which not forest vegetation has existed for a long time in the past.
15. **Reforestation:** Re-establishing a forest, by artificial means on an area which previously bore forest vegetation, and which may have been felled or otherwise cleared in the recent past.
16. **Age crop:** The age of a regular crop corresponding to its crop diameters.
17. **Age classification:** The division of a crop according to difference in age **OR** the allotment of woods to age classes.
18. **Alpine:** Zone of vegetation where winter is server, slow fall heavy, the mean annual temperature is 450F and the mean January temperature below 300F. In India Himalayan at the altitude above 10,000 ft.
19. **Basal area:** The area of the cross section of a stem at breast height, when applied to a crop, the sum of basal areas of all the stems or the total basal areas per unit area.
20. **Bole:** The main stem of a tree.

21. **Breast height:** Almost universally adopted as the standard height for measuring the girth, diameter and a basal areas of standing trees. India 4‟6” (1.37m). InU.K. and most commonwealth countries 4‟.3” (1.30m)
22. **Coupe:** A felling area, usually one of an annual series unless otherwise stated. Preferable numbered with Roman numbers as, I, II, III etc.
23. **Crown:** The upper branchy part of the tree above the bole.
24. **Dendrology:** The identification and systematic classification of trees.
25. **Reserved forests:** an area so constituted under the Indian Forest Act or other Forests law.
26. **Protected forests:** A legal terms for an area subjected to limited degrees of protection under the provision of Chapter IV of the Indian Forest Act.
27. **Unclassed forest:** Forest land owned by Government but not constituted in to a reserved, village or protected forest.

28. **Log:** The stem of a tree or a length of stem or branch after felling and trimming.
29. **Logging:** Operation comprising felling of trees, limbing, bucking and transportation of the resulting product out of the forest timber harvesting (Bucking-Act of being)
30. **Pole:** A young tree from the time when the lower branches begin to fall off to the time when rate of height growth begins to slow down and crown expansion becomes marked.
31. **Raft:** An assemblage of logs, timbers or bamboos tied together or enclosed within a boom for transport by floating.
32. **Scrub:** Inferior growth consisting chiefly of small or stunted trees and shrubs.
33. **Stand:** An aggregation of trees or other growth possessing sufficient uniformity in composition, constitution, age arrangement or condition, to be distinguished from adjacent crops and forming a silvicultural unit.
34. **Succession:** The gradual replacement of one community by another in the development of vegetation towards a climax

Silviculture

Silviculture is an important subject of forestry. It is tie forestry as Agronomy in to agriculture, in that it is concerned with the technology of crop production. It has been defined in a number of ways. Following are the accepted definitions of silviculture.

1. Silviculture is that branch of forestry which deals with the establishment, development, care and reproduction of stands of timber. By Tourney and Karstien

2. Silviculture is the art and science of cultivating forest crops. By Indian Forest and forest products Teminology (1957)

3. Generally, The science and art of cultivating (e.g. growing and tending) of forest crops, based on a knowledge of silvios. More particularly, the theory and practice of establishment, composition, constitution and growth of forests. By Society of American Foresters (1983)

4. Silviculture refers to certain aspects of theory and practice of raising forest crops, methods of raising tree crops, their growth and after care up to the time of final harvesting. By Rao (1987)

In simple words, Silviculture is the growing and tending stands of trees. Silva is the Latin word for forest and culture for cultivation. Therefore, without exaggeration, Silviculture is the Real art of forest.

Silviculture is very important and essential when human beings wish to manage the forests.

a. To accelerate the wildlife, timber and forage production.
b. To increase the Recreation values and Watershed values.

Object of Silviculture

Silviculture is improved limitation of nature. In nature, we find a large number of species coming up at one place. Some individuals die out of competition, some attain top canopy while others remain at lower levels. Silvicultural factors are usually controlled by economic considerations. If there are a large number of species, perhaps a forester would select some of them which are economically more important. Also the forester may remove the trees which are likely to die out of suppression. Since our knowledge of economic and natural factor is not perfect, it is not always possible to determine how far to divert from purely natural course. In nature, succession is a process in which one species or group of species is replaced by another species or group of species and a stage comes when more stable species appears. The study of silviculture enables the foresters to know the whole course of natural succession on a given site and also the manner and the speed of existing crop being replaced or altered. This knowledge helps the foresters to determine where and how to control the succession. The important objectives of silviculture can be summarised as under:

1. **Control of Crop Composition and Production of Species of More Economic Value:**

Under natural conditions, a large number of species form the crop inferior or less valuable species may flourish at the expense of the desirable species. The control is exercised by two ways:

i. By removing or cutting inferior species
ii. By creating more favourable conditions for the regeneration and growth of desirable species.

2. Control of Stand Density, for Production of Maximum Volume:

In the natural forests, trees are likely to grow either too dense or too open. If the trees are too dense- the wood production is distributed over large number individuals and none of them grow to the optimum size. If the trees are too less, the production would be less, though individual trees may grow sufficiently with higher dimensions. If the trees are too less, they will not be able to utilise the site, effectively and may be even inadequate to regenerate the area. Both these conditions are not good for maximum wood production.
Silviculture helps to maintain or retain sufficient number of trees per unit area so that by optimum use of soil, maximum wood production is ensured. Substantial increase in production can be ensured by thinning dense prop through salvaging the trees otherwise these trees would have died.

3. Afforestation of Blank and Under Stocked Areas:

There is a large area of forests which is blank or under stocked due to fire, encroachments, illicit fillings, or some natural causes. These areas are however, suitable to bear tree growth. Silviculture helps us to afforest these areas with suitable trees by planting or by seedling. Silviculture guides to know the best period of seed collection, nursery technique, plantation details, etc. to complete afforestation.

4. Production of Quality Timber:

In unmanaged forests, because of intense competition or little competition, quality timber is not produced. A large number of trees are malformed, defective and sometimes diseased.
Proper control of damaging agencies can increase the production. Insects,fungi,fire,wind, grazing,lopping, etc. which affect the quality of the timber are controlled by suitable Silvicultural techniques and methods.

5. Control on Rotation Period:

Rotation is counted period in years from regeneration to harvesting. In unmanaged forests, if there are more number of trees, the growth of individual tree is slow consequently, they take longer period to reach to harvestable size. The knowledge of silviculture helps to regulate the density of the crop at various sizes / ages which helps to reach exploitable size much faster. Thus, rotation of a crop can be reduced by regulating the density of the crop. It also helps in identifying short rotation crops.

6. Facilitate Management and Use of Forests:

In unmanaged forests, good forests exist in difficult areas, where it is difficult to manage and harvest the timber. In managed forests, it is easy to plant the growth and distribution of forests so that the produce is used efficiency and economically. It is possible to arrange the forest in different localities in such age classes and species composition that management becomes easy.

7. Creation of Man Made Forests and Introduction of Exotics:

Silvicultural techniques help us to replace wholly or partly, natural forests by man mad forests of the same species or by other species. If the existing, forest does not contain valuable and the desirable species. It can be planted with such important species. If the forest consists of desirable species but it is not regenerating properly, it can be harvested and regenerated artificially. Identification of suitable exotics depending upon geographical location, raising trail, plantations, selection of suitable exotics species, perfecting the nursery and plantation techniques of the exotics are some of the silvicultural techniques which help in introduction of exotic species on a large scale.

8. Protection of Site and Intangible Returns:

The main object of silviculture is to provide maximum protection to the site so that intangible returns from the forests are ensured. Important intangible returns include, moderating climate, increasing precipitation, reducing soil erosion and floods conserving soil and water increasing water yields providing shelter to a large number of wild animals, etc. Silviculture helps to understand the requirement of a tree and its effect on the site. The species, which are likely to deteriorate the site, are discarded. Only such species which afford complete protection to the site and ensure continuous flow of intangible benefits are preferred.

Functions & Types of Forest in India

Function of forests:

Sr.No.	Particulars	Functions
1	Productive	They provide timer, fuel, charcoal, beedi , leaves, was and resins, fruits, tanning, materials, manure leaves, grass, bamboo, gums, lac etc.
2.	Protective	Forests protect water sheds, catchments of rivers and streams against erosion.
3.	Aesthatic	Forests add good appearance, landscaping and a thrilling

		atmosphere to the locality.
4	Recreational	Forest provides picnic resorts and opportunities for sport like hiking, trekking, wild life watching, bird watching.
5	Scientific	Study of ecological process can be made
6	Ameliorative	Forests improve climate and reduce pollution
7	Hygienic	Forests improve the environment and help in reduction of noise, purify the air and give out oxygen to the atmosphere.
8	Industrial developments	Forest meet the need for raw material for industrial development such as Paper pups, rayon grade pulp, saw milk ply wood, hard board etc.

Forest types of Indian:

1. Tropical wt ever green forest
2. Tropical semi evergreen forest
3. Tropical moist deciduous forests (Southern and northern types)
4. Littoral and Swamp forests
5. Tropical dry deciduous forest
6. Tropical thorn forest
7. Tropical dry ever green forest
8. Sub tropical broad leaved hill forest
9. Sub tropical dry evergreen forest
10. Mountain wet temperate forest
11. Himalayan moist temperature forest
12. Sub alpine forest
13. Himalayan dry temperate forest
14. Sub alpine forest
15. Most alpine scrub
16. Dry alpine

The above types are called natural ecosystems. Ecosystems are the natural climax forests, resulting from a long process of ecological succession of plants and associated animals life, undisturbed by man.

What is a Forest?

A forest is defined as the area of land that is covered by trees. The Food and Agriculture Organisation of the United Nations defined forest as “Land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 percent, or trees able to reach these thresholds in this situation”. It does not include land that is predominantly under agricultural or urban use.

By using this definition, Global Forest Resources Assessment 2020 has concluded that the total forest lands cover about 4.06 million hectares or 10 million acres of land which sums up to 31% of the total land on the Earth’s surface in the year 2020.

Forests are important for the survival of all living beings. They are vital for our life as they provide oxygen, food, shelter, fuel, and means of livelihood for the tribal people living in and around the forest area. Forests are home to 80% of the global terrestrial biodiversity and are the source that fulfills all basic needs for adjacent human settlements. Everything from the oxygen we breathe to the wood used from fuel to use in construction comes from forests. It is a self-nourishing system, which is a host to a number of organisms. The ecosystem of every forest includes both biotic (living) and non-biotic components. The biotic components include plants, trees, shrubs, vines, grasses, mosses, algae, fungi, insects, mammals, birds, reptiles, amphibians, and microorganisms.

Forests are Made of Four Main Layers as Shown Below.

1. **Emergent Layer:** The tallest trees in the forest are around 200 feet from the emergent layer. These trees have broad leaves and get abundant sunlight.
2. **Canopy Layer:** The canopy layer is just below the emergent layer. It is thickened by a maze of smooth oval leaves and branches. It is the primary layer of the forest.
3. **Understory Layer:** Sunlight cannot reach the layers below the canopy layer and hence the plants develop larger leaves to absorb it.
4. **Forest Floor:** Sunlight cannot reach the forest floor and hence, it is dark and humid in this layer. It offers a rich source for the growth of fungus. Dead leaves, branches, and dead animals decay in this layer.

There are three major forest zones based on the distance from the equator, which are

1. Tropical,
2. Temperate, and
3. Boreal forests.

Tropical rainforests have different subcategories as follows:

- Evergreen
- Seasonal
- Dry
- Montane
- Tropical and subtropical

Subcategories of temperate forests include moist conifer, evergreen broad-leaved, dry conifer, Mediterranean, and temperate broad-leaved rainforest. Boreal forests grow in higher latitudes, where the temperatures reach the freezing point.

Types of Forests

Forests are primarily referred to as the terrestrial ecosystem of the Earth. They are widely spread all over the surface of the Earth. The majority of the forest land is concentrated in just 5 major countries and those are Brazil, the United States, China, Canada, and the Russian Federation. About 45% of the forest land that is the largest forest share is in the tropical zone followed by temperate, boreal, and subtropic domains. Thus, the forests are divided into three major types as follows.

1. **Tropical Forests:** Tropical forests generally lie between 23.5^0 N and 23.5^0 S latitudes. The temperature that prevails in this forest is around 68^0 and 77^0 Fahrenheit throughout the year. They normally experience 100 inches of rainfall every year and thus do not have any winter season. This type of forest avails broad leaves trees that are in majority in this forest and they normally grow 82 to 115 feet tall. Vines, ferns, mosses, orchids, and palms are the alternative variations that are found here. The various categories of tropical forests are evergreen, seasonal, dry, montane, tropical and subtropical, coniferous, and subtropical.
2. **Temperate Forests:** The temperate forest is further divided into two subcategories and those are temperate deciduous forests and temperate coniferous forests. Temperate deciduous forests are mostly

found in Japan, China, Europe, and a few parts of Russia as well as in the eastern part of the United States and Canada.

In this forest, precipitation occurs all year long and it experiences distinctive seasons. Precipitation comes in the form of rain in spring, summer, and fall and it snows heavily in winters. Temperate deciduous forest saves a range of about 30 to 60 inches annually and thus the soils are very fertile here. The floor of this forest is covered with ferns, mosses, and wildflowers. Oak, apples, and birch trees are the dominant trees of this forest.

Temperate forests are mostly found in coastal regions that have heavy rainfall and very mild winters. Thus, they are also found in the regions of inland mountains that have very mild climates. The regions include New Zealand, Southern Japan, Pacific Northwest in the United States and Canada, South-Western South America, and a few parts of North-Western Europe. They have a prolonged growing season with very high precipitation. They are also characterized by moist climates. The rainfall received by this forest is around 50 and 200 inches of rain per year. The soil of this forest is very rich with a thick layer of decaying matter. The conifers are the dominant trees of this forest. These trees grow very tall and are credited to the high precipitation level and moderate temperature.

3. **Boreal Forests:** Boreal forests are also known as taiga forests, better found between 50 and 60 degrees north latitude. Siberia, Canada, North Asia, and Scandinavia are a few of the areas that have boreal forests. About 65% of the boreal forests are concentrated in Scandinavia. These forests are characterized by very long winters and very short summers. They receive between 15 and 40 inches of precipitation annually, most of which is snow. They have an undermined rate of decomposition and a very thin layer of soil because of the very cold temperature. The trees that are found in these forests are mostly evergreen trees. Some of the examples of these trees are pine, spruce, and fir. Due to its very dense canopy, it has very limited vegetation.

What is the Importance of Forests?

Forests are natural habitats for many animals. The trees supply oxygen to the atmosphere. They affect the rainfall in a particular region. They also provide us with wood, medicines, food, perfumes, paper, clothes, etc.

Trees are the world's largest storehouses of carbon which is important to maintain global temperatures. The rise in carbon levels is believed to be the main reason behind global warming. In spite of the advantages of forests, deforestation has become very rampant in the modern era causing several problems like pollution, soil erosion, and climate change. Here are some of the reasons that explain the importance of forests for all living beings (See figure 1) and why they should be preserved proactively.

Uses of Trees to Absorb Greenhouse Gases

Forests maintain the ecosystem by absorbing greenhouse gases like carbon dioxide that are believed to be the reason for climate change. Carbon is stored in the biomass within the forests. Tropical forests alone harbor a huge amount of carbon (around a quarter of a trillion tons) that can be disastrous if it is released into the atmosphere.

Importance of Trees to Provide a Natural Habitat

Forests provide a sustainable environment for the survival of millions of animals. It is home to several species including snakes, turtles, crocodiles, insects, birds, butterflies, monkeys, and other wild animals. It provides an ecosystem for the animals to thrive. The forest floor is also a rich medium for microorganisms, which are essential for the conversion of dead matter into nutrients. Forests are also home to indigenous people who depend on them for their livelihood.

Importance of Forests as Watershed Regions

Forest-based water tables, rivers, streams, and lakes are critical sources of water. The green cover preserves the water reserves from sun radiation. The Amazon forest is home to the world's largest watershed and river system.

Importance of Forests to Support Biodiversity

Globally, around 90% of the species including various plants and animals thrive in forests. They offer the necessary habitat and support biodiversity. They are home to the genes of biodiversity.

Importance of Forests to Purify the Air

Photosynthesis is a critical function of plants to generate food and energy. Plants, shrubs, and trees absorb carbon dioxide from the atmosphere during the daytime and release oxygen. According to an estimate, an acre of mature trees can provide oxygen for 18 people. They act as giant lungs purifying the air in the atmosphere by removing carbon dioxide and maintaining balanced levels of oxygen that we breathe every day. Trees absorb odours and pollutant gases like ammonia and sulphur dioxide out of the air. These toxins are trapped in the leaves and barks.

Importance of Trees to Regulate Global Temperatures

Forests provide green cover which absorbs the Sun's radiation and keeps the temperature down. They regulate atmospheric temperature through evapotranspiration and breeze. Forests also promote rainfall that helps in maintaining the water table and a cool climate. Deforestation has the opposite effect causing the global temperature to rise dramatically.

Importance of Forests to Enrich the Soil

Dead leaves and broken branches ultimately are converted to soil through the decomposition process and this conversion enriches the soil with nutrients. Microorganisms present in the soil convert the biodegradable material to simpler particles that can be utilized by the plants again. Trees have very strong roots that hold the soil intact in cases of floods or any other reasons that cause soil erosion. They are very critical in hilly areas or stream slopes as they slow the runoff and keep the soil intact. Uncontrolled soil erosion can destroy the fertile soil leading to barren conditions.

Importance of Forests to Regulate the Water Cycle

Forest is an important component of the water cycle process. They regulate evaporation, condensation, and precipitation of the water. They also nourish the aquifers thereby replenishing groundwater supplies. Trees allow the rainwater to flow down the trunk into the soil thereby preventing the stormwater from carrying pollutants to the ocean. They act as giant sponges that filter water and recharge the water table.

Importance of Forests in Our Life

Forests are rich in herbs, plants, and trees of medicinal value. The extracts, seeds, leaves, and bark from these plants and trees treat several diseases while being non-toxic to the human body. Some examples include quinine, curare, rosy periwinkle, wild yams, extracts of willow trees, calabar bean, and samambaia.

Forests Provide Economic Benefits

Forests have a lot to offer to human beings. Every component of a tree including leaves, branches, stem, bark, fruits, seeds, and root are useful. Forests provide wood, timber, raw materials, vegetables, and fruits, which have significant economic value. The timber is used in construction and making furniture. Wood is also essential in the production of paper. The rubber extracted from trees is used to make several products. Even green waste has economic significance.

Millions of trees are chopped off every year to support the increasing need of human beings. We have to take proactive measures to preserve forests and increase the green cover in the interest of millions of living beings that depend on them.

Thus, there are two types of benefits of forests on an economic front and they are direct benefits and indirect benefits. For instance, the contribution of forests towards the national income of India is increasing gradually. About 0.86 % of the forest wealth of India was contributed towards the gross domestic product in the year 1970-71. It has increased gradually to 1.8% in 1990-91. All the direct benefits are accounted for by forest resources that contribute around 2.9 % to the net domestic product for the country as a whole. Also, about 179

million cattle, 58 million buffaloes, and 120 million other livestock are provided for by the forests of the country. The forest has been declared the home of 500 types of animals.

About 15 lakh people are engaged as woodcutters, sawyers, Carters, and craftsmen and in other related forest industries and therefore are full-time employed because of the presence of forests. They are also homes for the submerged class in the country; for instance, there are about 38 lacs of tribals that found homes in various forests. 10,000 is considered as an ecological and economical part and parcel of the forest environment. There are about 5000 species of wood out of which 450 are commercially valuable and are specially used for extracting acetic acid methyl alcohol acetone, certain oils, and valuable drags like sulphonamide and chloroform. The total volume of timber which is one of the most economically viable wood in the country is about 85,696 M3 of which 93% and non-coniferous and only 7% of coniferous.

The indirect economic benefits consist of rendering the climate that increases the relative humidity of the atmosphere and therefore the precipitation increases by the forest. Sustainable feeding offspring water supply and reduction in violent floods are regulated by the forest and also makes the floor of the water in the river continuous.

This forest also channels the land by protecting it from the evil of erosion and climate access that in the end performs as a valuable and more expressible service that generates revenue than those rendered by the defense force of the country. Various worms, insects, and various miniature organisms feed on the humans and the tunnel in the soil, thus, making it suitable as a portion of food for the plants. Forests also act as a natural defense against aerial attack by covering the entire land with its canopies.

FORESTRY has been defined as, 'the theory and practice of all that constitutes the creation, conservation and scientific management of forests and the utilization of their resources.
Forest is derived from LATIN word Foris mean OUT SIDE A forest is a large area where trees grow close together.
Based on aims or objectives, forestry may be classified

1. Protection or environmental forestry :
- protection of the land against wind and water erosion.
- regulation of the water cycle.
- wildlife conservation.
- moderation of climatic conditions

2. Commercial or Production forestry : -
- production of timber for saw mills, match factories and other wood based industries.

3. SOCIAL FORESTRY:
- This is the practice of raising forests outside traditional forests areas, usually with involvement of large sections of the society. Social forestry has attained a high level of importance in India.

4. Non-commercial farm forestry :
- It involves the raising of trees by individual farmers for their own domestic needs. Such programmes are mainly based on non-commercial incentives and are taken up in areas of severe fuel wood or agricultural timber shortage.

5. Commercial farm forestry
- under which farmers grows trees on a commercial basis on farm lands. Usually taken up in areas where there ready market for wood or other forest based product. FAQ (1980) has described this as "turning peasant into entrepreneurs and producers".

6. Community forestry
- Community forestry involves the raising of trees un public or community land rather than on privately owned lands as in the case of farm forestry.

7. Urban forestry

- This type of forestry has been described as the management of public and privately owned lands in and adjacent to urban centres. One distinguishing feature between rural and urban forestry is that urban forests and trees have more aesthetic value than rural trees.

8. Extension Forestry :

- practice of forestry in areas devoid of tree growth and other vegetation and situated in places away from the conventional forest areas with the object of increasing the area under tree growth.

9. Intensive Forestry :defined as 'the practice of forestry with the object of obtaining the maximum in volume and quality of products per unit area through the application of the best techniques of silviculture and management.

10. Farm Forestry :Itis the practice of forestry on farms in the farm of raising rows of trees on bunds or boundaries of field and individual trees in private agriculture land

Direct benefits of forest

- They provide homes for indigenous wildlife
- They encourage the return of endangered species
- The roots reduce erosion in rain seasons and dry areas
- They replenish the ground with nutrients from the air such as nitrogen
- They retain groundwater supporting surrounding growths
- They rebuild worn soils and improve agricultural productivity
- They provide food, fodder, fuelwood, fertilizers, fibers, finance, fruit and medicinal products.
- They sustain eco-system balance and bio-diversity
- Wild life habitat
- Air filtering and removal of particulates
- Noise abatement
- Temperature amelioration in the cities

- Green belt for moisture storage zone
- Effect on property value
- Nutrient cycling
- Social values and ecotorism
- Economic values
- They create microclimate conditions for life to flourish
- They have provided medicines for centuries including for; Malaria, heartburn, lung diseases, rheumatism, flu and leprosy etc.,

BRANCHES OF FORESTRY

1) Silviculture defined as: It is that branch of forestry which deals with the establishment, development, care, and reproduction of stands of Timber (Tourney and Korstian).

Silvics is 'the study of life history and general characteristics of forest trees and crops with particular reference to environmental factors.

2) Forest mensuration: It is branch of forestry which deals with 'the determination of dimensions, form, volume, age and increment of logs, single trees, stands or whole woods.

3) Forest utilization: It is concerned with the harvesting, conversion, disposal and use of the forest produce.

4) Forest management: practical application of the scientific, technical and economic principles of forestry.

5) Forest Economics It is deal with the forest as a productive asset and subject to economic laws. forest economics works out the cost of production including rental of land and compound interest on capital spent in raising the crop, and compares it with the sale proceeds to decide whether raising of the crop is economically profitable or not.

6) Multiple use forestry pertains to the simultaneous use of forests for meeting two or more objects which may often be of partly conflicting nature.

7) Recreational Forestry: the practice of forestry with the object of raising flowering trees and shrubs mainly to serve as recreation forests for the urban and rural population.
Also known as Aesthetic forestry defined as 'the practice of forestry with the object of developing or maintaining a forest of high scenic value.'

8) Forest protection It is concerned with 'the activities directed towards the prevention and control of damage to forests by man, animals, fire, insects, disease or other injurious and destructive agencies
9) Forest biology &Tree Improvement. Application of forest genetics principles within a given silvicultural system for the purpose of improving the genetic quality of the forest.
- Its goal is to improve the genetic value of the population while maintaining genetic diversity.
- Meeting this goal means that genetic improvement is aimed at the population level, rather than improvement of breeds or inbred lines.

Forest biology diversity means the variability among forest living organisms and the ecological processes of which they are part; this includes diversity in forestswithin species, between species and of ecosystems and landscape

10) Natural resource management : refers to the management of natural resources such as land, water, soil, plants and animals, with a particular focus on how management affects the quality of life for both present and future generations.
It brings together land use planning, water management, biodiversity conservation, and the future sustainability of industries like agriculture, mining, tourism, fisheries and forestry.

11) Forest productivity and Utilization :
Productivity of forest land is defined in terms of the maximum amount of volume that the land can produce over a given amount of time.
Site quality is measured as an index related to this timber productivity
Productivity : rate of generation of biomass in an ecosystem. It is usually expressed in units of mass per unit surface (or volume) per unit time, for instance grams per square metre per day (g m^{-2} d^{-1}).

The per capita forest area in the country is 0.08 ha as compared to the world average of 0.64 ha. The total removal of fuel-wood from forestland is estimated at 270 million tonnes annually.
- 59.79 m3/hectare (SFR 2005) with only 0.7 m3/hectare/year productivity against the world average of 2.1 m3/hectare/year.
- The mean annual increment (MAI) of India's forests is assessed to be less than 0.5
- 2015 FSI released total forest and tree cover is 79.42 million hectare, which is 24.16 per cent.
-
- 2017 FSI - Forest and tree cover combined is 8,02,088 sq km or 24.39 per cent

Forest coverage in India is 21.54 per cent
- 2019 FSI - Forest and tree cover combined is 8,07,276 sq km or 24.60 per cent
- Total forest cover of the country is 712,249 square kilometres which is 21.67 percent of the geographical area of the country.
- There has been an increase in forest cover in Karnataka, Kerala, Andhra Pradesh, Jammu and Kashmir and Himachal Pradesh in the last two years.
- Forest Area-wise Madhya Pradesh has the largest forest cover in the country followed by Arunachal Pradesh, Chhattisgarh, Odisha and Maharashtra.

LOCALITY FACTORS
It may be "the circumstances that affect the results of the prevailing biotic, climatic, physiographic and the edaphic conditions of a site".

Khanna (cf. Negi 1983) “The effective climatic, edaphic, topographic, and biotic conditions of a site which influence the vegetation of the locality.”
Locality mean constitutes all biotic and abiotic factors of a site (Habitat or Site). Factor- a circumstance that affects the results of some observations (BCFT 1953). Four broad groups of locality factors

1. Climatic factors,
2. Physiographic factors,
3. Edaphic factors and,
4. Biotic factors.

1. CLIMATIC FACTORS : It is defined as “light, atmospheric temperature, pressure and humidity, winds and other features of climate the regional, local and seasonal that influence the vegetation”.

i. LIGHT :Light is very essential for life on this earth.Light requirement: Amount of light necessary for the satisfactory development of a ‘species. Some species need light at the initial stages for their good growth
Main natural resources of light are Sunlight, Moonlight, Starlight, and Luminescent organisms.
Tree Nature Based on Light
The trees are divided into two groups, viz.,
(1) Sciophilous called Heliophilous trees which prefer shade to sunlight Eg: (fir) Abies pindrow, Ficus lacor, Morus alba
(2) Photophilous trees which prefer sunlight for their growth are known as photophilous trees, example,
(a) Strong Light Demander e.g., khair (Acacia catechu), Acacia nilotica, Albizia lebbek etc.
(b) Moderate Light Demander. eg: Buteamonosperma, Celtisaustralis,Holopteleaintegrifolia
(c) Light Demander :Aegle marmelos, Bauhinia variegate & Diospyros melanoxylon

Effect of Sunlight on Vegetation
(1) Photosynthesis.
(2) Heating Effect. young seedlings are much affected in comparison to trees.
(3) Increase in transpiration.
(4) Effect on vegetation distribution.
(5) Effect on shape of plants.
(6) Stomatal activities are hastened.
Photoperiod the response of plants to changes in the photoperiod

Photo periodism : response in the ontogeny of an organism to the relative duration of the day and night.

- Photosynthesis,
- Mineral nutrients,
- Reserve food in the plants, etc.

Classification of Plant based on Photoperiodism
1) Short-day plants : It flower when daylight is less than a critical length (14 hrs). They flower in the late summer, fall, or early winter. Eg; Chrysanthemum, Datura stromonimum
2) Long day plants : Long-day plantsflower when daylight is increasing. They flower in the spring and early summer. Eg: Jowar, radishes and many cereal varieties.
3) Day neutral plants: They flower when critical daylight is 14 hrs, Eg. Tobacco, Cotton
4. Intermediate plants: Flowering only when day is neither too long or shot :
Eg: Xanthium stumarium: 2- 3 hrsie 15.5 hrs Mikania seandens
5. Ambiphotoperiodism: Flowering occurs rapidly only when SD/LD is intermediate day length Eg. Media elegans: 8 hrs or 18-24 hrs day

ii. TEMPERATURE (a) Minimum, (b) Maximum, and (c) Optimum.
(a) Minimum temperature. Lowest temperature at which any plant/tree can easily survive. Eg. Marine algae -survive below the 0°C
Tropical plants retard the growth at about 20°C.
(b) Maximum temperature. plant/tree can survive only when maximum temperature effect varies from species. Eg. Celtis australis and Acacia species

Minimum temperatures can be recorded just before the sunrise (5.30 AM).
The temperature also varies in accordance with altitude and latitude. 1°C fall in temperature for every 100 m rise in altitude.
Temperature decreases towards north or south, away from the equator.

Effects of Temperature on plants
(1) Injury to physiology.
(2) Dryness of plant : Abies pindrow and spruce (Picea smithiana) seedlings start to wilt beyond the temperature of 36°C.
(3) Disturbance of vital activities. growth of the tree and susceptibility to attack by the bacteria.
(4) Excessive transpiration.
(5) Cracking of stems.

Vegetation classified in relation to Temperature

Vegetation type	MAT 0C
1. Alpine forest	≤ 7
2. Temperate forest	7 -17
3. Sub tropical forest	17 - 25
4. Tropical forest	≥ 25

iii) FROST: It is due to lowering down of the temperature. The frost, occurs when there is cooling of air temperatures below the freezing point. The temperature even goes below up to (—ve) 24°C which is supposed to be extreme case.
Classification of Frost
(1) Radiation frost. Frost occurring in nights with a clear sky, produced by loss of heat by radiation. At the time of this frost, a rapid cooling of air layers takes place just at the surface of earth. Therefore, a rapid loss of heat by radiation may cause this frost.
(2) Advective frost. It is produced by cold air brought from elsewhere. It occurs usually in the form of pockets.
(3) Pool frost. Accumulation to a considerable depth of heavy cold air flowing down into natural depressions from the adjoining area region. Occurred in valley areas.

Damages due to Frost
Young plants are affected and get killed.
Lifting of seedlings above their normal soil levels as a result of the expansion of soil mass & freezing of soil water.
Cracking.
Cankers. cankers are caused by the attack of certain fungi due to frost.
Characteristics of plant to Frost Resistance
Moisture content. Higher moisture content of the soil / plant may resist the effect of frost.
Temperature. higher the temperature, the cooling effect of frost will be reduced to a great extent.
Cell Size in Plant. small cell size may be free passage of the energy which reduces the effect of frost.
Classification of tree Species due to Frost effect.
(i) Frost Hardy Species tree species which can tolerate the effect of frost and there is no damage of any kind Acacia catechu, Anogeissus pendula
(ii) Partially Frost Hardy Species tolerate the frost to some extent but not fully resistant to frost.
Adina cordifolia, Anogeissus latifolia, Salix alba (Willow), Morus alba
(iii) Frost susceptible Acacia nilotica, Azadirachta indica Tectona grandis, Terminalia arjuna.
How to protect from Frost Injury ?
I) In Nurseries. (1) Provide Shade. (2) Smoke Screens. (3) Watering in Morning.
(4) Use of Mulch. (5) Covering with Sheet.
II) In Plantations. (1)Weeding

(2) Shelter wood. Uttaranchal about 40 trees per ha are kept as frost protection shelter wood.
(3) Nurse crop:it is a crop of trees or shrubs, which is introduced in a plantation of less hardy species to help it to grow and therefore, as soon as the purpose is served, it is removed.
iv) RAINFALL: The rain is the water drops from the clouds. The process of falling of water drops from the clouds to the ground is termed as rainfall.
Phase of Water circulation
1. Precipitation in the form of rain/snow.
2. Return to atmosphere by evaporation.
3. Evaporation from seas, oceans, rivers,
4. Transpiration in plants and animals.
5. Drainage due to underground channels, ponds, canals, etc.
Significance importance
- Water is vital to all life,
- Cell growth,
- photosynthesis
- Absorption of nutrients
- temporarily stored in living beings

The forest of tropics are classified according to zones of Rain fall

Zone	Rain Fall	Vegetation
1. Desert zone	0 – 10 cm	Herbs & shrubs
2. Arid zone	10 – 40 cm	Euphorbaceae & Cactacea
3. Dry Zone	40 -- 100 cm	Acacia species
4.Moist zone	100- 200 cm	Teak , D latofolia, Sandal, Terminelia spp,
5. Wet Zone	Above 200 cm	Michalia champaca Mesua fera, calophyllum inophyllum

v) HUMIDITY :
"The amount of invisible water vapour present in the atmosphere in the gaseous form".
1. Aabsolute humidity: The amount of water vapour per unit volume of space".
2. Relative Humidity: The ratio of the amount of water vapour present in the air to the amount required for saturation at the same temperature (BCFT 1953).

vi) WIND : The horizontal movement of air along the surface of earth is called wind.
Beneficial effect:
* Bring fresh carbon dioxide and helps in photosynthesis process
* Helps in pollination
* Seed dispersal.
Harmful effect:
1). Deforestation,
2) Dwarfness
3) Fire in forest
4) Increase evaporation/transpiration

vii) DROUGHT. Drought is a deficiency of precipitation and higher temperature, hence affect adversely agricultural production and economy.
Characteristics of drought hardy:
1. Resistance of protoplasm to dehydration,
2. Small leaf area,
3) Thick cutin,
4) Reduction in number of stomata

5) efficient conducting system,
6) Shedding of leaves etc. Acacia nilotica, A. sengal, Prosopis species, Neem, Tamarind and Pongammia pinnata.

Drought sensitive: Teak and Sal

II. Physiographic / Topographic factors: It include the form and structure of the land surface. It is irregularities in earth surface which affect climate and soil which affect the development of vegetation.
Elements:
1) Configuration of land
2) Altitude/ Elevation
3) Slope in steepness,
4) Aspect/ Exposure
Eg: Northern side: Virgin forest hygrophilous ground vegetation.
Southern: xerophytes vegetation.
Length & Shape of slope: Outer Himalaya: luxuriant vegetation
Middle & Inner Himalaya: Dry with poor vegetation.

III) Edaphic factors: The ecological influences characteristic of soil, brought by its physical and chemical characteristics." parent material, soil composition, soil texture, structure, porosity, soil moisture, soil reaction, drainage, humus soil, Soil temperature, CN ratio, Micro-organisms etc.,. Plants classified according:
Psamophytes; plants grow on sand, Ex. Acacia sengal Lithophytes ; plants found on Rocks. Linaria species. Halophytes Brugariapolyrhiza.
IV) Biotic factors- It is an interactions with other organisms influence a species' success. All organisms depend on others directly or indirectly for food, shelter, reproduction, or protection.

Symbiosis is nothing but mutualism or living together "interspecific &relationship between two organisms in which both the partners are benefited"
Mutualism -both species benefit
Parasitism: one organism lives inside or on another organism and harms it.
Tapeworms live in the intestines of mammals, where they absorb large amounts of their hosts' food.
Fleas, ticks, lice, and leeches live on the bodies of mammals and feed on their blood and skin.
The parasite obtains all or part of its nutritional needs from the host organism.
Generally, parasites weaken but do not kill their host, which is usually larger than the parasite
Amensalism : Interspecific relationship between two organisms in which one partner is benefited & another is strongly harmed
Commensalism - one organism benefits and the other is neither helped nor harmed.
Proto cooperation : Survival depends on each other but not essential for survival of each Population. Eg: Sandal + Casuarina.
Competition: two individuals competing for the same resource
Predation: one individual feeds on another

FOREST TYPES:
A category of forest defined with reference to its geographical locations, climatic and edifice factors composition and conditions.
Aims of Forest classification;
1. Purely for academic reasons.
2. To prescribe the correct silvicultural& management.
3. For better understanding of the forest ecosystem as a whole

Basis Characteristics for Forest classification:

1. Physiognomy : General appearance of forest community.
2. Structure : Alignment of different layers in a forest.
3. Floral composition: Used as a basis to bring out finer details.
4. Habitat condition: General environment of forest community, include climatic and edaphic factors.
5. Physiography: Natural features of land on which forest grows.
6. Function : Morphological traits such as leaf, stem and root characters.

Different methods of FOREST classification:

1. Based on Botanical method: Group on bases of Physiography, structure, composition and dynamic.

a) Age :1) Even age and 2) Uneven age

1. Even-aged stand is one in which the trees are within 80 percent of a given age, relative to the rotation length. Trees within a stand as one or two age classes. In even-aged forests the upper canopy will appear smooth because the trees are generally all in one height class. In a similar way the diameters of the trees in an even-aged stand willwillbe uniformly grouped around an average diameter.
2. Uneven-aged silviculture with three or more age classes.Conversely, in uneven-aged stands trees will be distributed with many heights, so several canopy layers are present. Tree diameters will vary greatly with many trees in the small diameters and continuous decreasing numbers of trees in each successively larger diameter class.

b) forest based on method of regeneration :

1) High forest, 2) Coppice forest, 3) Plantation forest.

1) High forest: It is a type of forest originated from seed or from planted seedlings. a high forest usually consists of large, tall mature trees with a closed canopy.
2) Coppice forest: It is in which the new crop originates mainly from shoot / stool coppice and where the rotation of the coppice is short.
3) Plantation forest : are a type of managed forest in which the trees are planted of the same age and generally of the same species, and are intended to maximize the production of wood fiber.

c) Composition of forest : 1) Pure forest 2) Mixed forest.

1) Pure forest:A forest in which one species makes up 80% or more of the total number of trees.
2) Mixed forest: species. It is forest composed of trees of two or more species intermingled in the same canopy. Forest in which at least 20 percent of the trees are of the each species.

d) based on ownership of forest :1) Govt. forest

i) Reserved forest: Forests are owned by Government of India and natural habitat which has high degree of protection from hunting, poaching and are often upgraded to status of wildlife sanctuaries and national parks. National Parks are Wildlife sanctuaries are reserved forest areas in India and home to a large number of wild animals and birds

ii) Protected forest: Protected Forest of India are natural areas where the habitat and resident wild species have certain degree of protection. There are two types of protected forest in India, demarcated and un-demarcated protected forest

iii) Village forest: Communal Forest also called as village forest which is governed by local communities and used for Medicinal plantation, recreation and religious purposes. Maharashtra and North East Indian states have most of the forest communal forest land, where local people are managing forest for biodiversity.

2) Private forest:

Supreme Court in the order states "the principal question for consideration is whether the mere issuance of a notice under the provisions of Section 35(3) of the Indian Forest Act, 1927 is sufficient for any land being declared a “private forest” within the meaning of that expression as defined in Section 2(f)(iii) of the Maharashtra Private Forests

3) Corporate forest: It is a forest or woodland area owned by a corporate body rather than a state or individual.

e) forest based on growing Stock 1) Normal forest, 2) Abnormal forest.
i) Normal forest: It is an ideal forest with regard to growing stock, age class distribution and increment and from which the annual or periodic removal of produce equals to the increment and can be continued indefinitely without endangering future yields.
ii) Abnormal forest : A forest in which, as compared to an acceptable standard, the quantity of material in the growing stock is in deficit or in-excess or in which the relative proportions of the age or size classes are defective.

f) based on Management 1) Intensive forest 2) Extensive forest.
1) Intensive forest: Utilization of a wide variety of forest management and silvicultural techniques in order to maximize the productivity of a unit of forest area.
2) Extensive forest: by the monetary investment per unit area of land, or by the number of stand entries per rotation, or by a combination of those metrics.

g) based on Functions:
1) Production forest 2) Protection forest 3) Recreation forest/ Bioaesthetic forest.

h) Exploitation/ Logging. 1) Accessible & 2) Inaccessible forest.

i) based on Biotic interference. 1) Primary & 2) Secondary succession.

j) based on Ecology: 1) Climax forest 2) Riparian forest 3)Riverian forest.
ii) Riparian forest - woodlands along the banks of stream or river timberland, woodland, forest, timber - land that is covered with trees and shrubs.
iii) Riverian forest: The riverine forests in the province of Sindh occur along both banks of the Indus River. As a result, the riverine forest area is shrinking alarmingly while less salt tolerant species have almost disappeared.

2. Based on Ecological methods :
Classification of Forest types : by Chamion & Seth (1964)
Forest type:-A unit of forest vegetation which possesses broad characteristics in physiognomy and structure sufficiently pronounced to permit its differentiation from other such unit
I. Tropical Forest.
1. Wet evergreen forest: Dense tall forest, entirely evergreen, eg. Dipterocarpus spp (South), Shorea robusta (North)
2. Semi evergreen forest: Dominants including deciduous species but evergreens predominate. Eg.Terminelia spp, Artocarpus hirsuta
3. Moist deciduous forest: Dominants mainly deciduous but some dominants and lower storey largely evergreen. Top canopy 25 Mts higher.eg Tectona grandis, Bombax spp, Bambo
4. Littoral and swamp forest: Mainly evergreen of varying density and height but always associated predominantly with wetness. Eg.Casuarina spp, Xylocarpus spp
5. Dry deciduous forest: Entirely deciduous. Top canopy rather light and rarely over 25 Mt ht & Generally 8 – 10 mt ht. Eg.,Acacia catechu, Red sandars & Embelica officinalis
6. Thorn forest :Deciduous with low thorny trees and xerophytes predominating. Canopy more or less broken &Ht under 10 mt.Eg.,Acacia spp, Prosopis spp
7. Dry evergreen forest: Broad leaved evergreen trees predominate with some deciduous emergent often dense but under 20 mt height. Eg.,Manilkora hexandra, Mabafuxi folia
II. Montane subtropical forest :
8. Subtropical broad leaved forest : Broad leaved largely evergreen. Eg.,Eugenia spp, Qurecus spp.

9. Subtropical pine forest: Pine association predominates. Eg. Pinus roxburghi & P.khasia
10. Subtropical dry evergreen forest: Low xerophytic forest & Scrub.
eg., Rhododendran spp, Maganolia spp.
III. Montane temperate forest:
11. Montane wet temperate forest: Evergreen forests with conifers. Eg. Rhododendran niligaricum, Acacia modesta
12. Himalayan moist forest: Evergreen mainly temperate sclerophyllous oaks & coniferous. Eg.,Cidurus deodar, Quercus spp
13. Himalayan dry forest: Open coniferous forest with spare temperate xerophytic under growth. Eg.,Picea spp, Pinus spp
IV. 14) Sub-alpine forest:
Stunted deciduous or ever green forest usually in close formation, forest with or without conifers. Eg.,.Rhododenron spp Abiesdusa spp.
V. Alpine scrub forest:
15. Moist alpine: Low but often dense scrub. Eg., Junifera spp & Rhododenron spp
16. Dry alpine : Xerophytic scrubs in open formation. eg., Caragana spp & Salix spp

FOREST SUCCESSION:

Defined as Replacement of one set of biotic community or biota by another set of different nature or
It deals with replacement of biota of an area by one of different nature or a series of changes that takes place in plant community coincide with the changes in the habitat.
It was first used by "Thoreau"
"Caw1es" described the change in vegetation on Sand dunes
Pioneer species: A species that invades a bare area such as newly exposed soil or rock surface.
Properties of Pioneer:
* Very less exacting

* Tolerant to adverse climatic condition.
* Tolerant to adverse soil condition.
* Addition OM
* Arrest the more & more silt.
* Improvement of forest covers condition.
* Improvement in moisture retentively of the soil.
* Change in temperature condition for the better.

Theory of plant Succession:
Theory of plant succession was given by Clements (Mono climax theory)
Basic features of this theory is,
i. There is a continual change in the vegetation as a result of interaction of plant community and the habitat factors.
ii. The succession is inherently and inevitably progressive and the end product is the climax.
iii. The succession is the progressive development of vegetation on the same site in course of time. P1ant Succession: It is defined as "the gradual replacement of one community by her in the development of vegetation towards a climax". This is the culminating in plant succession for a given environment.
Causes of plant Succession
1. Initial causes -
i) Primary succession:1. Erosion 2.Physiography 3. Elevation &Subsidence
ii) Secondary succession : 1. Climate 2. Physiography 3. Biotic factors
2. Continual causes : 1. Migration 2. Ecesis/Establishment 3. Grouping & aggregation
The causes of succession may be classified as
1. Initial causes: are those causes which provide the basis for succession to takes place. Thus in case of primary succession they are responsible for creation of a new soil. while in case of secondary succession. they are responsible for making the soil bare.
The initial causes of primary and secondary successions are listed below

1. Initial causes of primary succession

a. Erosion: Wind and water erosion erode the soil and deposit elsewhere, thus new soils are created. e.g., Alluvial deposits, coastal sands, land slips and scree.

b. Physiography: The configuration of land surface helps the agents of the erosion i.e., wind, water and gravity to create new soils.

c. Elevation and subsidence: Seismic disturbances result in elevation and subsidence of the soil resulting in the formation of new soils. Due to this river beds are silted up or rivers change their courses leaving original beds for starting primary succession.

Similarly, geological disturbances in the Himalayas result in the formation of new soil for primary succession.

2. Initial causes of Secondary succession

a. Climate: Climate is the initial cause when the vegetation is destroyed by the action of drought. wind, snow or frost. A fair portion of a forest may be killed by drought. Wind may lay bare an area by uprooting the original crop. Snow may similarly, destroy forest by sliding.

b. Physiography: It is the initial cause when configuration of land surface is responsible for the destruction of vegetation.

c. Biotic factor: is an initial cause when the forest is destroyed as a result of the activity of man, his animals or even wild animals.

3. Continuing causes: are those causes of succession which help the development plant communities and their replacement by other plant communities.

They consist of the following.

a. Migration: is defined as "the mass movement of plants from one place to another. It begins when the germule (spore, seed, fruit, or plant" leaves the parent area an ends when it reaches the final resting place".

b. Ecesis or establishment: is defined as 'the whole process by a plant establish itself in a new area from germination or its equivalent (e.g. rooting of some detached portion) to reproduction whether sexual or asexual.

c. Grouping and aggregation: is defined as "the grouping, following establishment of scattered colonizing invaders as result of propagation".The colonizers invade new areas gradually and in course of time, the colonize:' make a closed canopy.

d. Competition: is defined as "the struggle for available food, light and moisture which takes place among species and individuals in an assemblage of plants".

e. Reaction: is defined as "the effect of vegetation on the site". It is the most important factor responsible for succession. The effect of the vegetation on the site can he grouped into following two classes;

i. Effect on climatic factors ii. Effect on soil

I. Effect on climatic factors

a. Alter the light conditions.

b. Decreasing the day air temperature and reducing the diurnal range.

c. Reduces the wind velocity.

d. Reduces the danger of radiation frost,

e. Increasing relative humidity.

ii. Effect on site

a. Addition of organic matter.

b. improve the structure of soil.

c. Improving the nutrient status of the soil.

d. Improvement of the stability of the soil.

e. Development of maturity of the soil. Examples1 of Primary Succession:

Bare site□ Shrubs/Grasses□Pinusnwallichiana□Cedrusdeodara + Picectsmithiana + Pinuswallichiana□Abiespindrow + Piceasmithiajia + Quercusaemicarpifolict

Types of Plant Succession .

I. On the basis of moisture condition of the place

1. Xerarch succession: is defined as “the succession initiated in extremely dry situations such as bare rock, wind blown sand, rocky talus slopes etc’
Xeroseres: the different stages in a xerarch succession

Xerosere is further divided into
i. Lithosere: the xerosere which originates on rock surface.
ii. Psammosere: the xerosere which originates on sand.
2. Hydrarch succession: is defined as “the succession beginning in water, or very wet land as in ponds, lakes, marshes etc”.Hydrosere: the different stages of hydrarch succession.
II. On the basis of presence or absence of vegetation in the place

1. Primary succession: defined as “the succession which takes place on sites which have previously not borne vegetation”.
It is also called as Autogenic succession, because it takes place as a result of autogenic factors. Autogenic factors are defined as “the dominant factors of change in which are due only to the individuals in a plant community.
2. Secondary succession: is defined as “the succession which takes place on site after the destruction of the whole or part of the original vegetation”.
also called as Allogenic succession, as it takes place due to allogenic factors. Allogenic factors are “the factors which operate, independently of the plants themselves, to alter the habitat gradually and thus cause changes in vegetation. Eg.. Clearing, burning, grazing, storm, erosion, deposition, landslide
3. Retrogression: is defined as “the reversion to some earlier stage of succession consequent on the introduction of an adverse factor”. -
Generally retrogression stages are lower in height and more xerophytic in character . In extreme cases e.g., fire, clearing etc, the entire vegetation may be destroyed.
4. Induced succession: Man tries to control the succession in such a way that a managed steady state is maintained which is different from the natural steady state and where from a good amount of community production is harvested. Eg.Agril done after clearing vegetation in the shifting.
5. Cyclic succession: it involves repeated occurrence of certain stages of succession when certain specific conditions are created in a community. As soon as old trees die or removed, the juvenile plants of the same species on getting adequate light and space suddenly show active growth and occupy the upper storey.

Importance of the study of plant Succession
1. Classification of forests in to forest types.
2. Deciding silviculture system to be adopted for the management of the existing crop.
3. Deciding silviculture operations to maintain the forests at a desired successional stage..
4. Choice of species for artificial regeneration:
5. Determination of successional stage of economically most valuable crop and the method of obtaining it.

FOREST REGENERATION:
It is defined as “the renewal of a forest crop by natural or artificial means”. To regenerate: means “to renew a forest crop by natural or artificial means”. Methods of Regeneration of forest crops are;
1. Natural regeneration
2. Artificial regeneration
3. Natural regeneration supplemented by artificial regeneration

I. Natural Regeneration: It is defined as “the renewal of a forest crop by self sown seed or by coppice or root suckers”. It also refers to the crop so obtained,
Thus, the natural regeneration may he obtained from the following two main sources;
1. from seed
2. from vegetative parts

1. From seed : When regeneration is obtained from seed forms a crop, it is called Seedling crop. It is defined as "a crop consisting of a seedlings neither planted nor of coppice or root sucker origin, but originating in-situ from natural regeneration". When this seedling crop grows in to a forest, it is called a High Forest.
Natural regeneration from seed depends on

1. Seed production
II. Seed dispersal
III. Seed germination
IV. Seedling establishment
1. Seed production: It is most important factor for natural regeneration. The production of seed depends upon;
i. Species: Some species produce seeds every year and others at intervals. So based on that seed years are described as Good, Moderate and Poor, depending on the quantity of seed produced
Seed year: "A year in which a given species bear seed abundantly". e.g., Teak, Babul, Khair, Sissoo seed every year, deodar, fir spruce seed at an interval of years.
ii. Age of the trees: Age of the trees also affects the seed production. Middle aged trees produce abundant quantities of fertile seeds
iii. Size of the crown: Bigger the crown, seed production is more.
II. Seed dispersal: The seed produced by the trees are dispersed by the agencies such as wind, water, gravity, birds and animals.
a. By wind: Conifers, Salix, Casuarina, Pterocarpus marsupium.
b. By water:: Most of Mangroves, Dalbergia, Teak
c. By gravity : Oaks, Juglans regia,
d. By birds: Prumus, Mulbery, Terminelia spp, Diospyros melanoxylon
e. By animals: Acacia arabica, Prosopis julifora & Ziziphus jujuba,

III. Seed germination: After the seed dispersal a lot of seed is destroyed by insects, birds and rodents. The others germinate, provided they are deposited on the suitable soil.
Seedling year: is defined as "a year in which a given species produces abundant first year seedlings ' It is also designate a year, in terms of the amount of natural seedling regeneration produced by a particular species, as Good, Fair, Poor or Very Poor.

IV. Seedling establishment: Even if the germination is good, but large number of seedlings die at the end of rains or as a result of frost during winter or drought during summer. In addition, other factors such as weeds, grazing, burning, this may kill them.
Establishment is defined as the "development of a new crop, naturally or assisted, to a stage when the young regeneration, natural or artificial, is considered safe from adverse influences such as frost, drought or weeds and no longer needs special protection or tending operations other than cleaning, thinning and pruning".
The following factors affect establishment of seedlings
i. Climatic factors: Light, Temperature (High and low), Frost
ii. Edaphic factors: Moisture, Nutrients, Soil aeration, Soil structure, Texture
iii. Biotic factors: Grass and other competing Weed growth, Insects, Pathogens, Grazing, Fire, Wild animals. and iv. Genetic factors
Natural Regeneration from VEGETATIVE PARTS
Vegetative reproduction is defined as "asexual reproduction in plants from some part of the plant body, e.g., of trees by coppice or root suckers, stems or branch cuttings".
When regeneration is obtained by coppice forms a crop. it is called Coppice crop and when it develops in to a forest, it is called as Coppice forest.
Advantages of vegetative reproduction
1. One plant produces several plants.
2. This is useful when the plant is not capable of producing seed.

3. The plants obtained from vegetative parts grow faster than the seedlings and cost less.
4. The capacity can be used for genetically improvement of the species.

Methods of vegetative reproduction

1. Coppice: A shoot arising from an adventitious bud at the base of a woody plant that has been cut near the ground or burnt back. Syn: Stool shoot

a. Seedling coppice: is defined as the "coppice shoots arising from the base of seedlings that have cut or burnt back. eg., In Teak and Sal forests it is widely followed.

b. Stool coppice: is the "coppice arising from the stool or a living stump".

Factors affecting the natural regeneration by coppice

i. Species :

Strong coppicers: Acacia catechu, Albizia sp. Neein, Anogeissus sp. Cassia fistula, Dalbergia sp. Nelli, Eucalyptus globulus, Prosopis juliflora, Salix sp. Sal, Teak, Nerale

Fair coppicers: Hardwickia binnata, Quercus sp. Terininalia tomentosa, T. bellarica

Coppices badly: Adina cardifolia, Bombax ceiba, Casuarina equiseufolia, Madhuca latifolia, Populus ciliata

Do not coppice: Pinus roxburghi, P. wallichiana

ii. Age of the tree: Younger saplings and poles coppice readily and profusely. Older trees have less coppicing power.

iii. Season of coppicing: Best season is spring, before growth season starts.

iv. Height of the stump: It varies with species, but the stump height of 15 -25 cm is most suitable.

v. Rotation: the rotation should be short.

vi. Silviculture system: should he worked under Clear felling system, because the coppice shoots are strong light demanders.

2. Root suckers: is that method of vegetative reproduction in which a root of a plant is partially or wholly cut to produce a shoot called Root sucker.

Root sucker: A shoot arising from the root of a woody plant.

e.g., Butea monosperma, Dalbergia Sissoo, D. latifolia, Bombax ceiba, Prosopis cineraria

3. Root-Collar shoots: Shoots arise from the junction of the root and shoot. These produce better trees than stool shoots.

Cutting: is that method of vegetative reproduction stem, branch or root is placed in the soil or other medium.

Root-Shoot cutting: is a young plant with pruned tap root and severed stern used for planting (Synonymously called as Stump). e.g., Teak

4. Layering: Inducing development of roots on branches while they are still attached to the trees is called layering.

Mainly two types: i. Soil layering, ii. Air layering

5. Grafting: is the method of vegetative reproduction, in which a portion called Scion of one plant is applied to Stock, usually rooted, which is another plant with the object of securing vegetative union between the two, when the scion is detached from the parent plant and the shoot of the other plant is severed, to produce a new plant to be planted.

Scion: Any un-rooted portion of a plant used for grafting or budding on a rooted stock. Stock: A rooted plant on which a scion is grafted

6. Budding: is that method of vegetative reproduction in which a bud with some portion of the bark of a genetically superior plant is grafted on an inferior plant, so that it may it may produce shoot when the old shoot of the stock is cut off.

7. Pollarding; Pollard is defined as "a tree whose stein has been cut off in order to obtain a flush of shoots, usually above the height to which the browsing animals can reach.

Example.1. Salix is pollarded in the Kashmir valley to produce shoots for wicker

2. Hardwickia binnata is pollarded in Andra Pradesh to produce shoots suitable for fibre extraction.

II. ARTIFICIAL REGENERATION

It is defined as “the renewal of a forest crop by sowing, planting or other artificial methods”.
Normally such crop is called by other name Plantation, which is defined as “a forest crop raised artificially, either by sowing or planting”.
Wilding: is defined as “a naturally grown seedling used for forest planting”.
Objectives of Artificial regeneration: 1. Reforestation and 2. Afforestation
1. Afforestation: is defined as “the process of establishment of a forest by artificial means on an area from which forest vegetation has always or long been absent”.
3. Reforestation: “restocking of felled or otherwise cleared woodland by artificial means”.
Objectives of Reforestation: Following are the main objectives of reforestation;
1. To supplement natural regeneration
2. To give up natural regeneration in favour of artificial regeneration. When the natural regeneration of the desired species is slow, then artificial regeneration is adopted.
3. To restock forests destroyed by fire and other biotic factors
4. To change the composition of the crop
5. To introduce exotics

TENDING OPERATIONS
Tending is defined as operations carried for the benefit of a forest crop at any stage of its life between the seedling and mature stage; it essentially covers operations both on the crop itself and on the competing vegetation.
It includes following operations.
1) Weeding
2) Cleaning
3) Pruning
4) Thinning

1. Weeding
Weeding is removal of weed to reduces the competition for moisture, nutrient and light and provides sufficient space for growing. “Any unwanted plant that interferes or tend to interfere with the growth of the individuals of favored species is called weed.” Therefore removal of weeds is called as weeding and it can be defined as “a tending operation done in the seedling stage in a forest crop, that involves the removal or cutting back of all weeds.”
Methods of weeding:
i) Mechanical method
The weeds are uprooted by mechanical means by using some implement. If the weeds are uprooted there will be no chance to come up again.
ii) Biological method
Mechanical method of weeding is very costly operation in any planting programme. In biological method diseased organism or insect is used which is harmless to the plants but eradicates weed. Use of parasitic plants, browsing by livestock or rodents, use of suitable cover crop, use of fire etc. Are used in biological control.
iii) Chemical method
The chemicals known as weedicide and herbicides are used to control weeds. Before using them its correct doses should be determined the chemicals are- 2, 4 Dichioro-phenoxy acetic acid, 2, 4, 5- trichloro phenoxy acetic acid, (2, 4, 5-T), ethyl esters etc. The chemicals are applied on the foliage of plants.

2. CLEANING
Cleaning is carried out in the sapling crop and is defined as the cutting or lopping made in order to free the best individuals from undesirable ones on the same as which inferior with the better grown individuals of the favoured species. Cleanings are carried out to cut down light competition.
Eg: In conifer plantations, cleaning operation is done to remove Indigofera, Desmodium and Rubus etc. In teak forest Lantana camera and bamboos are removed during cleaning operation

Objectives:

1. To improve light conditions.
2. To reduce root competition and transpiration water loss.

The cleaning is performed with the help of sharp instruments e.g. axe, spades, hackers etc. The extent of cleaning operation depends on various factors such as growth rate of species, site conditions and economic consideration. Cleaning should be carried out whenever it is noticed that the desired individuals are threatened with overtopping. More cleaning is required for light demander species whereas shade bearer species require less intensive cleaning.

Season, frequency and duration of cleaning

Cleaning is usually done during rainy season,
if it not possible it may be done during winter and summer.
Frequency depends upon the density of shrubs and their growth after cutting

Methods of cleaning

1. Selective cleaning: cleaning is done selectively round the stems forming the future crop
2. Whole cleaning: over the whole area

Method depends upon silvicultural requirements of the species and cost considerations

Operations during cleaning

Cutting back of shrubs and rank herbaceous growth interfering with the growth of saplings of the desired species as well as its associates
Cutting back of individuals of inferior species when interfering with the growth of saplings of the desired species.
Cutting back of malformed or diseased individuals of desired species
Singling of coppice shoots of the favoured species
Climber control

Indirect method of weeding and cleaning in plantations

Burring
Deep and thorough soil preparation
Closer spacing
Planting is preferred over sowing

Some of the species that are removed by cleaning are

Teak forests- Mainly bamboos

Sal forest- Mallotus, Clerodendron, kydia, Ardesia etc.

Deodar forests- Rubus, Indigofera, Bluepine, Oaks etc.

Singling :

Should also be carried out as a part of cleaning operation in the early stages of the life of a tree in which forked or multiple stems are reduced to a single stem to improve tree form.
This also boosts up height growth.
This operation is important for timber species e.g. teak, shisham etc.

Climber cutting or control

The climbers are harmful when the trees are young. If not removed they do a lot of damage to young plantations.
In older trees also, the climbers constrict the stem and deteriorate the value of wood.
The climbers should be cut near to the ground and care should be taken to check regrowth at the cut end.
All climbers should be cut during monsoon period.
Moist deciduous forests- Bauhinia vahlii, Butea parviflora, Vitis spp, Mikania cordata etc.
Conifer forests- - Dioscorea spp., Rose spp., Vitis spp., Hedera spp etc

PRUNING

It has been seen that trees in the early life are covered with branches. These branches grow thicker with the pace of time, i.e., the age of the tree. The branch makes the wood of tree as knotty and defective and also decreases the increment of height. To get a good timber, then knots are removed from the branches well in time.
It is defined as, the removal of live or dead branches or multiple leaders from the standing trees for the improvement of the trees or its timber".

Classification: The following are the classes of pruning
(a) Dry Pruning - It is the pruning of dead branches;
(b) Green Pruning - It refers to the pruning of living branches.
(c) Natural Pruning. It is also known as Self-Pruning. It has been designated as a slow process and can continue throughout the life span of a forest tree/forest crop. Due to the attack of several agents like fungi, and insect-pests, the branches break and fall either render their own weight or due to wind action.
It is usually defined as, "the natural death and falling of branches of standing trees from such causes as deficiency of light, decay snow and the ice also."

(d) Artificial Pruning. Like natural pruning, the artificial pruning is also important.
Definition "the pruning carried out by the forester without waiting for mature to do it in the dense natural crop or where nature fails to do it due to artificially large spacing between stems in man made forests / plantations to reduce the cost of formation and rotation.
How to reduce cost of artificial pruning ?
(i) Pruning must be restricted to the species which are used in industries where knot-free timber is the requirement.
(ii) It must be carried out on the best stems which are supported to form the final crop.
(iii) The height upto which pruning is carried out must be as low us possible so that it is approachable for operation.
(iv) The pruning must be started early in the life of crop so that thin type of branches are available for pruning purposes.

How to Prune ?
Pruning should be carried out in such a manner that there should not he any damage to the bark of the tree (any form of tree). Very good tools must be used. These tools can be, hand saw, long-handled chisel, long-handled-saw pruning shears, or the axes. The best tool has been recognized as that hand saw which is a low-cost tool and efficient also.

Bud-Pruning is also practised in the forest crops of various species.
Definition: the rubbing off the internal buds to prevent the growth of branches as a measure to get knot-free timber." If, the buds are removed, there will not be any branch and no need of pruning. It is supposed to be the cheapest method to get knot-free timber.
Bud-pruning is applied to many species such as Salix alba, Populus spp., Morus spp and some Pines. Rough cloth, gunny bags are used for this purpose. It is not practised on large scale.

Improvement felling
The improvement felling is defined as the removal or destruction of the less valuable trees in a crop in the interest of the better growth of the more valuable individuals. This is carried out usually in a mixed, uneven aged forest.
Salvage cuttings
The salvage cutting removes the trees that are injured or dead due to various factors such as fire, fungi, insect, wind etc
Sanitation cuttings
They represent precautions to reduce the spread of damaging organisms to the residual stand

THINNING

Definition: As a felling made in an immature stand for the purpose of improving the growth and form of the trees that remain, without permanently breaking the canopy

Objectives of thinning

i) To improve the hygienic condition
ii) To create best conditions of growth
iii) Salvage the anticipated losses of the merchantable volume
iv) To obtain desirable composition of crops
v) Retaining seed bearers
vi) Improvement in wood quality
vii) To obtain intermediate yield and increase net yield and financial out-turn
viii) Decomposition of raw humus
ix) To reduce risk of disease and pests.

Thinning cycle: the planned interval which elapses between successive thinning in the same area
Thinning intensity: as an indication in numerical terms the extent to which the crop is thinned
Thinning regime: as the whole set of thinning carried out in a crop from the earliest stage to maturity

Methods of thinning

1. Mechanical thinning.
2. Ordinary or low thinning.
3. Crown thinning
4. Free thinning
5. Advance thinning
6. Maximum/numerical thinning.

1. Mechanical thinning: In this type of thinning the trees are removed by some thumb rule. eg. removal of alternate rows, removal of alternate diagonals, or removal of every second, third, fourth line etc.

Two types of Mechanical thinning:

1. Row thinning: In which trees are removed in lines or rows.
2. Spacing thinning:

- This mechanical thinning method is well suited to plantations having uniform productivity.
- In teak plantations at a spacing of 2m X 2m (2500 trees/ha).
- The alternate diagonals are removed in first thinning (5th year)
- The alternate rows are removed in second thinning (10th year).
- The number of trees after first and second thinning would become 1250 and 625 per ha.

2. Low or ordinary thinning

This is also known as ‘german thinning’ or thinning from the below and consists of the removal of inferior individuals starting from the suppressed class, and then taking the dominated class and ultimately some of the dominant class

Grades of ordinary thinning

i. A grade: Light thinning: Removal of dead and diseased tree.
ii. B grade: Moderate thinning: In addition to trees in A grade further removal of defective dominated stems and whips.
iii. C grade: Heavy thinning: It includes trees in grade A and B and all remaining dominated, defective co dominants that may be removed without making lasting gaps in canopy.
iv. D grade: Very heavy thinning: This includes trees of all above grades and some good dominants. The left over trees are with good boles and crowns, well spaced and evenly distributed over the site for future development.

Advantages of ordinary thinning:

1. Market demands for small timber
2. Suited for light demander species e.g. teak, sal, chirpine, sissoo, semal,, shivani etc.
3. Simple to apply and even a less trained staff can mark the trees for felling.
4. improves the hygienic condition due to diseased and insect infected trees are removed.
5. It preferred where climber infestation is a problem but not be carried out where in soil erosion.

6. Vigorous trees are retained for fast growth.
7. Removal of lower crown classes help in the natural regeneration of the species.

Disadvantages of ordinary thinning:

1. In several areas where the thorny bushes, undesirable trees and climber infestation is heavy, the removal of trees of lower crown classes is troublesome and expensive.

2. Thinning is carried out after the trees have remained in competition. Due to this the whole crop including dominants is already affected due to adverse effect of competition.
3. In a situation where the predominant and dominants are not able to utilize the site perfectly, the lower class may be useful.
4. In absence of the demand or market of small thinning poles, the thinning material can not be utilized economically.
5. There is always danger of exposure of the soil. Many of these trees may therefore be retained as soil cover and as in insurance against causalities among the larger trees.

3. Crown thinning:

This is also known as "thinning from above". This is a kind of selective thinning in which thinning is primarily directed to the dominant trees in a regular crop, the less promising ones being removed in the interest of the best available individuals;

Types pf crown thinning:

i. Light crown thinning: This consist in the removal of dead, dying, diseased and wolf trees with such of the defective and after them the better dominates, as are necessary to leave room for further development of the best available trees evenly distributed over the area.

ii) Heavy crown thinning: The final crop is targeted to achieve certain stockings e.g. 500 to 600 trees per ha. The dominated and suppressed trees are not removed.

Advantages of crown thinning:

1. Checks soil erosion and damage due to frost, snow, wind etc. is reduced. Shade bearing trees are also protected.
2. Side branches are pruned in a better way due to the presence of trees of lower crown classes.
3. Lower crown classes help in controlling weeds and shrub growth,
4. removal of some dominant trees provide light and shelter for some co-dominated trees to develop, many of which may later take their place among the dominants

Disadvantages of crown thinning:

1. The dominant are adversely affected when growth factors are limited and there is tough root competition for moisture and nutrients.
2. The lower tree classes make difficult various operations e.g. marking, felling, logging and extraction of the thinned material.
3. It requires experience and skill.
4. The diseased and insect infested trees of lower crown classes are always sources of inspection for the crop.

4. Free thinning:

This is also called HECK'S free thinning and is a modification of crown thinning. It is also called "Elite thinning" or "single stem Silvicultural".
The emphasis is made on freeing the selection of most promising stems called "elite or alpha stems" from the competition of their less promising neighbors

5. Advance thinning

It differs from all other methods described above as thinning is carried out before the competition among individual trees has set in.
The surplus individuals are taken out regularly for the advantage of the residual ones.
This may cause loss of total volume production but should ensure maximum growth of the elite trees.

Advance thinning was tried for Sal, teak and Chirpine stands in India.

6. Maximum / Numerical thinning
Where the yield table exists, it can be used as standard of reference.
During thinning the number of stems per unit area, diameter and height serve as a guiding factor for the optimum density of the crop.

AGROFORESTRY:
It is a collective word for all land use systems and technology in which woody perennials are deliberately grown on same land management unit as agriculture crops and/or animals either in form of spatial arrangement or temporal in sequence.

Advantages of Agroforestry:
1. Increase food and fodder production by exploiting complimentary effect of trees on crops/pasture and taking advantage of border rows.
2. Produce firewood, small timber for use in agriculture, quality timber for construction purpose etc.,
3. Conserve soil and water.
4. Increase the fertility level of land.
5. Maintain ecological balance.
6. Increase natural predators – birds, small mammals, and reptiles, which prey upon the numerous insect pests.
7. Break the wind which accelerates the evapo transpiration to desiccation, withering etc., in low rainfall areas reducing the yields per unit area.
8. Change the yields per unit area.
9. Provide shade for there life of management and animals working in the field.
10. Reclaim waste lands through agroforestry which is called as biological reclamation.
11. Encourage honey bee keeping underneath trees and fish culture in farm ponds by conserving water.
12. Provide recreation to the farm families.
13. Provide employment during off-season.

Disadvantages of AF:
1. Competition of trees with food crops for space, sunlight, moisture and nutrients which may reduce crop yield.
2. Damage to food crop during tree harvest operation.
3. Potential of trees to serve as host to insects, pests which harmful to crop,
4. Rapid regeneration by prolific tress, may take over entire field.
5. Required more labour inputs and higher shade exposer.
6. Longer period required for trees to grow to maturity.
7. More complex les well under stood and more difficult to apply compared to single crop forms.

Important Criteria for tree selection in AF:
1. Non interference with main crop.
2. Easy establishment and fast elongation.
3. Ability to fix atmospheric nitrogen.
4. Easy to decomposition of litter.
5. Non toxic effect on soil nutrient and crops with chemicals.
6. Multiple uses and high yield.
7. Possibility to regulate the shade easily.
8. Deep thrusting tap rooted species.
9. Select legume trees have light crowns.
10. Reduce their competitive effects on food crops.
11. Adoptability to local climatic condition.

AGROFORESTRY SYSTEM CLASSIFICATION

According to Nair (1987) Agroforestry system can be classified as following criteria

I. STRUCTURAL CLASSIFICATION

. Structure of components : Defined as"In-terms of its components and expected role of each."

i. Composition of components

a. Agri-silviculture b. Silvi-pasture c. Agri-silvi-pastsure system

d. Agri – Silvi – Horticulture system

a. Agri- Silviculture

Agri silvilcuture covers all systems in which land is used to produce both forest trees and agricultural crops, either simultaneously or alternatively.

Agri Silviculture also includes growing agricultural crops with forest trees. Tree crops include Eg: Teak/Melia dubea / citrus/ rubber + Soya bean /Maize/ sunflower.

b. Agri – Silvi- Pasture system:

If a unit of land is managed under crop rotations or practices, which may include production of food grains, fodder and wood has provision for grazing cattle, system called as Agri-Silvi-pasture system.

Eg: Teak + Safflower+ Ginny grass

c. Silvi – Pasture System

The Silvi-Pasture-System means a land management system in which forests are managed for production of wood as well as for rearing of domesticated animals. The trees may include both wood yielding trees and fodder yielding trees. Eg: Sesbenia grandiflora, Subabul, Albizia lebbeck

d. Agri – Silvi-Horticulture System

In this system, 1-2 rows of horticulture plants are planted in a strip along the contour line at a distance of 15-30 meters. The inter strip space can be utilized for planting quick growing tree species like, Casurina/ Subabul/ Dalbergia sissoo + Soyabean / maize+ Sapota with a view to obtain biomass production.

e. Horti – silvi – Pasture System

The selection of multipurpose tree, fruit tree and grasses entirely depends upon soil and climatic conditions of the particular place. Eg: Banana + Hardwickia binata /Teak + Ginny grass

f. Apiculture with trees : Trees for honey production

g. Aquaforestry : Trees lining fish ponds, tree leaves being used as 'forage' for fish

ii. Arrangement of components

a. Spatial : i. Mixed dense ii. mixed sparse iii. Strip/zonal iv. Boundary

b.Temporal: i. Coincident ii. Concomitant iii. Intermittant iv. Interpoloted v. Separate

iii. Stratification of components

a. Single layered b. Double layered c. Multiplelayered

II. FUNCTIONAL CLASSIFICATION:

This implies that agroforestry systems have a productive function yielding one or more products that usually meet basic needs, as well as a service role (i.e., protecting and maintaining the production degree of commercialization, can systems)

a. Productive agroforestry system

b. Protective agroforestry system

c. Mulipurpose agroforestry system

1) SHELTER BELTS:

These are belts / block consisting of several rows of trees established at right angle to the prevailing wind" is called as Shelter Belts.

Merits:

1. To deflect air currents.
2. To reduce the velocity of prevailing winds.

3. Protecting to leeward area against effects of wind erosion.
4. To provide food, fodder and timber for farmers.

Demerits:

1. Main crop major land is occupied from trees.
2. They impact shading effects on agriculture crop.
3. If trench is not made their roots may complete with near by plants of crop for soil moisture & nutrient.

Types of Shelter belts:

1. Wind proof: It is dense rows of trees and shrubs are planted.
2. Permeable: It is filtering and breaking the force of the wind. Which allow some wind to pass through are most suitable.
3. Porus : It having some gaps in planting.

Shape & composition: It is "Triangular shape"& raising tall trees in centre.

Orientation : depends on direction and velocity of prevailing wind. It is raised in Quadrangles.

2) WIND BREAK:

Defined as "Rows of tall quick growing trees planted around the garden / field which helps in breaking the force of wind" is called as Wind break.

Merits:

1. To protect livestock from clod wind.
2. To protect crops & pasture from hot drying wind.
3. To prevent soil erosion.
4. To provide habitat for wild life.
5. To reduce evaporation from farm land.
6. To improve the microclimate for growing crops. To shelter people and live stock.

Demerits wind break:

a. Main crop major land is occupied from trees.
b. They impact shading effects on agriculture crop.
c. If trench is not made their roots may complete with near by plants of crop for soil moisture & nutrient

3) Shifting Cultivation: Fallows are crop land left without crops for period ranging from one season to several years. To recover depleted soil nutrients. It is called as Jhum.

Merits:

- 1) All crops are grown in estimate mixture ie.,8 – 13 crops, on same land.
- 2) Tools are used for digging soil for dibbling/ sowing seeds.
- 3) Abandoned land is gives higher crop slopes.
- 4) Jhuming is done only on hills slopes.

Demerits:

- 1 Faulty land use system
- 2. More skilled labour required.
- 3. Denudation flora become weak and grows sparsely.
- 4. Cause on Environmental degrading.

III) Ecological classification

Agroforestry system characterizations pertain to specific ecological conditions of different geographical regions. It is thus easy to find several descriptions of agroforestry systems in, say, the highland, subhumid tropics (or the tropical highlands, as they are popularly known).

For example, in the tropical highlands, one of the main considerations would be the protective role (soil conservation potential) of agroforestry, whereas in sparsely-populated, semiarid savannas, silvopastoral systems producing livestock and fuelwood would be more common.

IV) Classification based on socioeconomic criteria

Socioeconomic criteria such as scale of production and level of technology input and management, have also been used as a basis for classifying agroforestry systems. for example, grouped systems into

1) commercial, 2) intermediate and 3) subsistence systems.

1) Commercial is used when the major aim of the system is production of the output for sale.

Eg: plantation crops such as rubber, oil palm, and coconut, with permanent understories of food crops, or integration of pasture and animals;

2) Intermediate" agroforestry systems are those that are intermediate between commercial and subsistence scales of production and management, i.e., production of perennial cash crops and subsistence crops undertaken on medium-to-small-sized farms where the cash crops satisfy cash needs, and the food crops meet the family's food needs. The main features distinguishing the intermediate system from the commercial system at one end and from the subsistence system on the other, are holding size and level of economic prosperity.

Eg: Intermediate systems, plantation crops such as coffee, cacao, and coconut.

Suitable species for Agroforestry:

a) Suitable tree species for agroforestry system:

- Leucaena leucoephala (subabul) Cassia siamea
- Dalbagia Sissoo Sesbanea grandiflcra
- Gravellea robusta Acacia nilotica
- Tectona grandis Albizzia lebbeck
- Azadirachta indica Hardwickia binata

b) Suitable grass species for agroforestry system.

- Stylosanthus hamate, Stylosanthus scabra, Cenchrus ciliaris
- Cenchrus setigerus, Dichanthium annalatum, Pannicum maximum

ALLEY CROPPING (Hedge row inter cropping)

Growing of Agricultural crops in between alleys of woody species in hedges is called as Alley cropping. Or Intercropping system in which selected species of trees/shrubs are planted in rows in association with food crops (Alleys). Ex: Subabul / Gliricidia + Jowar crops.

Benefits of alley cropping are

- to reduce evaporation and soil erosion
- Protect crops
- Enhance wildlife habitat
- suppressed weeds,
- add nutrients and organic matter to top soil and helps in nitrogen fixation

Taungya system: Defined: It is combined stand of woody and agricultural species during early stages of establishment of plantations.

taung= hill, Ya= cultivation. it is Burmese word coined in burma in the 1850. it is introduced in India in 1890 by Brandis.

It is modified name of shifting Cultivation. In which the labour is permitted to raise crops in an area but only side by side with the forest species planted by it. The practice consist of land preparation, tree planting, growing agricultural crops for 1-3 years, until shade becomes too dense and then moving on to repeat the cycle in a different area.

Merits of taungya system:

1. Weed & climber growth is suppressed.
2. Regeneration of forest species are in cheap.
3. Increase forest wealth of the country.
4. Full utilization of available land for food production.

Demerits:

1. Land exposes for erosion and loss of soil fertility.
2. More exploitation of human labour.

3. Forest trees are not adequately carried by cultivators if once settled.
4. Insecure land tenure.

Types of Taungya systems:

1. Departmental taungya: Agricultural crops & tress plantation are raised by the Forest department by employing a number of laborers on daily wages. To keep suppress weed growth.
2. Leased taungya : Plantation is given on lease to the person who offer the highest money for raising crops stipulate number of years and ensure care of tree plantation.
3. Village taungya: It is most successful system, crops are raised by the people who have settled down in a village inside forest for this purpose. Land allotted is 0.8 to 1.7 Ha per family for 3 – 4 years.