Department of Forestry Wild life and Environmental Sciences

B.Sc. 2 nd Semester

(Principles and Practices of Silviculture)

Modal Answer

Maximum Marks: 60

Note : Attempt any 5 questions. Question no. one is compulsory

Q. 1 Compulsory Question :

Fill in the Blanks (20*1=20)

- -------*Dry Pruning*------------
- --------*Thinning Cycle*--------.
- -----------*Dominants*------------.
- ----*Pruning*----------
- ----------*Wet Nursery*---------.
- ------*Life history and general characteristics of trees*----------------------------
- ------ *Renewal of forest crop by sowing or planting* ----------------------------
- ------*Renewal of forest crop by self sown seeds*---------------------------
- -------*Wood of tropical trees*---------------------------
- -------*Wood of temperate tree*--------------------------
- -----*Trees of hot regions*-----------------------------
- -------*Trees of cold regions*---------------------------
- ---------*Trees which never shed their leaves*-------------------------
- ------- *Trees which shed their leaves during particular season* ----------------------
- --------*Having facility of good irrigation*--------------------------
- --------*Not -having facility of good irrigation* --------------------------
- ---------*Pruning of dead and dying dry branches*-------------------------
- ------- *Pruning of green branches* ---------------------------
- -—*Water present in between soil particles available to plants*-----------------------
- -------*Water in soil excess of the capillary capacity*-flow underground due to gravity-------------

Q.2 Differentiate following terms:

1. Even aged forest :Even aged or regular forest is defined as a forest composed of even aged wood. The term even aged is applied to a stand consisting of trees of approximately the same age. Difference up to 25 % of rotation age may be allowedin cases where a stand is not harvested for 100 years or more.

Uneven aged forest :Uneven aged forest is defined as forest composed of trees of markedly different ages. The term uneven age is applied to crop in which individual stems very widely in age the range of difference being usually more than 20 years and in case of long rotation crop more than 25% of the rotation.

2. Production and protection forest

Production forest :Forest managed for produces. Forest which are managed and maintained for meeting the demand of communication, industry, defense and other general purpose of public importance.

Protection forest :Forest wholly or partly covered with woody growth, managed primarily to regulate stream flow, prevent erosion, shifting sand or to exert other beneficial influences.

3.Soil structure and texture

Soil Texture: The relative proportion of the various size groups of individual soil particles. The individual size groups are referred to as soil separates. Soil groups are recognized as clay (<0.002mm), silt (between 0.002 & 0.02mm), fine sand (between 0.02 &0.2mm), coarse sand (between 0.2 & 2mm) and gravel (>2mm). Coarse textured soil is called light soil and fine textured soil is called heavy soil.

Soil Structure

The arrangement of individual soil particles into aggregates of definite size and shape. Clod (>25mm), prism, crumb (3mm), granules (upto6mm), etc are soil aggregates and their sizes differ.

4.Forest and Forestry

Forest : Forest is an area set aside for the production of timber and other forest produce or maintained under woody vegetation for certain indirect benefits which it provides. In legal terms : forest is an area of land proclaimed to be forest under forest law. In ecological terms forest is a plant community predominately of trees and other woody vegetation.

Forestry : Forestry is the theory and practices of all that constitute the creation, conservation and scientific management of the utilization of resources. It is concerned with raising cultivation and protection and management of forest crop.

Q.3 Describe the topographic factors of locality? How does topography of the land influence the vegetation?

Topography: It is the description of the physical features of a place.

Topographic Factors can be classified into:

- Configuration of land surface
- Altitude
- Slope
- Aspect and exposure

1. Configuration of the land surface

- It influences vegetation through its effect on temperature, wind movement, etc.

- In a hills and valley country, sunlight reaches the valley late in the morning and disappears early in the afternoon.

- The shade of the neighboring hills makes valley colder in winter and that of radiated heat makes the valley hot. So, diurnal and seasonal temperatures of the valley differ from the temperatures on the hills. Pool frost occurring on hills and in valleys affects the vegetation.

- It also affects wind movements. It results in more rain in the east and less in the western Nepal. It has greater influence on humidity and temperature variance eventually affects vegetation of the site.

2. Altitude

- It affects vegetation through solar Radiation, temperature and rainfall

- The intensity of radiation goes beyond optimum limit has a dwarfing effect on shoot, the growth of root being favored.

- Temperature as it is higher and lower the optimum level, affects the species composition and the site quality.

- Similarly, rainfall affected by altitude affects the temperature and moisture resulting in the change in the nature of vegetation. It has been estimated that about half the water vapor in the air lies below 2000m while three quarters lies below 4000m and so, high mountain range is a very effective barrier for the monsoons.

3. Slope

- Slope affects run-off and drainage having a profound influence on the moisture regime of the soil. As a general rule, the steeper the slope, the greater the run-off and better the drainage.

- Slope modifies the intensity of insolation, temperature and moisture of the surface soil

- Slope also affects erosion and depth of soil as greater the slope, greater the erosion. The depth of soil in the hills varies with the increasing slope.

- Thus, slope affects vegetation of the site through afffecting the run-off, insolation, temperature, moisture and depth of soil

4. Aspect and Exposure

- Aspect-the direction towards which a slope faces

- Exposure-the relation of a site to weather conditions, especially sun and wind

- Both determine the amount of insolation received by a hill slope. In Nepal, southern slope is warmer than the northern slopes and consequently temperature differs.

- We can see different species on different aspect of a hill.

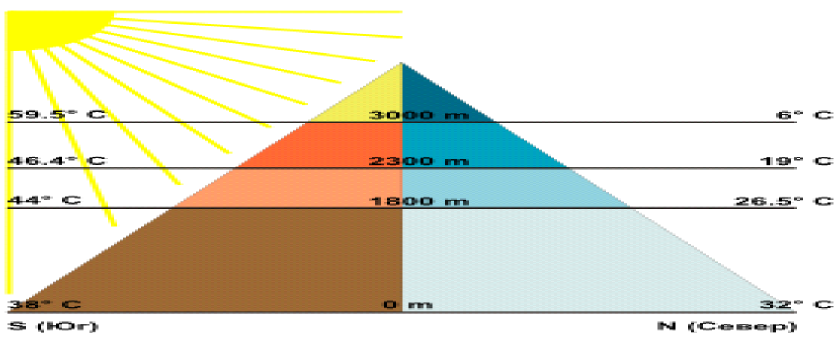
- Similarly, different aspects receive insolation differently. The eastern slope is exposed to the sun in the earlier part of the day and so dew is seen. In the morning, soil moisture has not melted resulting in seedlings being killed. Whereas, the western aspect has desiccating effect due to noon's sun.

Q.4 Is Climate an important factor in forest? Explain the development of various forest types on the basis of climate?

Climate is average wearher condition prevalent in any locality.Climatic factors are defiened as light atmospheric temperature, pressure, humidity, wind and other features of climatic, regional, local and seasonal that influence vegetation.

Temperature, humidity, soil composition, and solar radiation are important factors in determining altitudinal zones, which consequently support different vegetation and animal species.

A variety of environmental factors determines the boundaries of altitudinal zones found on mountains, ranging from direct effects of temperature and precipitation to indirect characteristics of the mountain itself, as well as biological interactions of the species. Determining causal factors is complicated by the many interactions that are possible, and by the fact that for each species there is both an upper and a lower limit. Further, it is often assumed that zonation produces discrete communities along an elevation gradient. While it is certain that species change, determining whether the vegetation changes as discrete communities requires careful measurement and statistical tests



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Temperature

Decreasing air temperature usually coincides with increasing elevation, and this decreasing temperature most directly influences the length of frost or ice days at different altitudes of the mountain. Decreasing air temperature usually coincides with increasing elevation, and this decreasing temperature most directly influences the length of frost or ice days at different altitudes of the mountain. On the other hand, for mountains located in deserts, the extreme high temperatures also limit the ability of large deciduous or coniferous trees to grow, while shrubs and grasses thrive near the base of mountains In addition, plants are especially sensitive to soil temperatures and have very specific ranges that support healthy growth.

Humidity

The humidity of certain zones, including precipitation levels, atmospheric humidity, and potential for evapo transpiration, varies with altitude and is a significant factor in determining altitudinal zonation. The most important variable is precipitation at various altitudes.[9] As warm, moist air rises up the windward side of a mountain, the air temperature cools and loses its capacity to hold moisture. Thus, the greatest amount of rainfall is expected at mid-altitudes and can support deciduous forest development. Above a certain elevation the rising air becomes too dry and cold, and thus the density of trees becomes more sparse and eventually are reduced to scrub or dwarfs shrubs. Although rainfall may not be a significant factors for some mountains, atmospheric humidity can be more important climatic stresses that affect altitudinal zones. Both overall levels of precipitation and humidity influence soil moisture as well. One of the most important factors that controls the lower boundary of the forest level is the ratio of evaporation to soil moisture.

Solar radiation

Light is another significant factor in the growth of trees and other photosynthetic vegetation. The earth's atmosphere is filled with water vapor, particulate matter, and gases that filter the radiation coming from the sun before reaching the earth's surface. Hence, the summits of mountains and higher elevations receive much more intense radiation than the basal plains. Along with the expect e arid conditions at higher elevations, shrubs and grasses tend to thrive because of their small leaves and extensive root systems.[1]However, high elevations also tend to have more frequent cloud cover, which compensates for some of the high intensity radiation.

The physical characteristics and relative location of the mountain itself must also be considered in predicting altitudinal zonation patterns. variation in the tree line based on mountain size and location. This effect predicts that zonation of rain forests on lower mountains may mirror the zonation expected on high mountains, but the belts occur at lower altitudes. A similar effect is exhibited in the Santa Catalina Mountains of Arizona, where the basal elevation and the total elevation influence the altitude of vertical zones of vegetation.[11]

Other factors

In addition to the factors described above, there are a host of other properties that can confound predictions of altitudinal zonations. These include: frequency of disturbance (such as fire or monsoons), wind velocity, type of rock, topography, nearness to streams or rivers, history of tectonic activity, and latitude. The nutrient content of soils at different altitudes further complicates the demarcation of altitudinal zones. Soils with higher nutrient content due to higher decomposition rates or greater weathering of rocks would better support larger trees and vegetation. However, predicting what altitudes yield these conditions is difficult to determine and varies with each mountain studied. For example, for mountains found in the tropical rain forest regions, lower elevations exhibit fewer terrestrial species because of the thick layer of dead fallen leaves covering the forest floor.[2] At this latitude more acidic, humose soils exist at higher elevations in the montane or subapline levels.[2] On the other hand, weathering is hampered by low temperatures at higher elevations in the Rocky Mountain of the western United States, resulting in thin coarse soils.

- tree line varies with local climate, but typically the tree line is found where mean monthly soil temperatures never exceed 10.0 degrees C and the mean annual soil temperatures are around 6.7 degrees C. In the tropics, this region is typified by montane rain forest (above 3,000 ft) while at higher latitudes coniferous forests often dominate.
- lowest section of mountains varies distinctly across climates and is referred to by a wide range of names depending on the surrounding landscape. Colline zones are found in tropical regions and Encinal zones and desert grasslands are found in desert regions.
  - Tropics): Characterized by deciduous forests when in oceanic or moderately continental areas, and characterized by grassland in more continental regions. Extends from sea level to about 3,000 feet (roughly 900 m). Vegetation is abundant and dense. This zone is the typical base layer of tropical regions.
  - Deserts): Characterized by open evergreen oak forests and most common in desert regions. Evaporation and soil moisture control limitation of which environments can thrive. Desert grasslands lie below zones. Very commonly found in the Southwestern United States.

Desert grassland: Characterized by varying densities of low lying vegetation, grasslands zones cannot support trees due to extreme aridity. Some desert regions may support trees at base of mountains however, and thus distinct grasslands zones will not form in these areas

Different types of forests

India has a diverse range of forests: from the rainforest of Kerala in the south to the alpine pastures of Ladakh in the north, from the deserts of Rajasthan in the west to the evergreen forests in the north-east. Climate, soil type, topography, and elevation are the main factors that determine the type of forest. Forests are classified according to their nature and composition, the type of climate in which they thrive, and its relationship with the surrounding environment.

Forests can be divided into six broad types, with a number of sub types.

Moist tropical

Montane sub tropical

Wet evergreen		Broad leaved
Semi-evergreen		Pine
Moist deciduous		Dry evergreen
Littoral and swamp		

Dry tropical

Montane temperate forests

Dry deciduous		Wet
Thorn	Moist	
Dry evergreen		Dry

Sub alpine

Alpine

Moist

Dry

Moist tropical forests

Wet evergreen

Wet evergreen forests are found in the south along the Western Ghats and the Nicobar and Andaman Islands and all along the north-eastern region. It is characterized by tall, straight evergreen trees that have a buttressed trunk or root on three sides like a tripod that helps to keep a tree upright during a storm. These trees often rise to a great height before they open out like a cauliflower. The more common trees that are found here are the jackfruit, betel nut palm, jamun, mango, and hollock. The trees in this forest form a tier pattern: shrubs cover the layer closer to the ground, followed by the short structured trees and then the tall variety. Beautiful fern of various colours and different varieties of orchids grow on the trunks of the trees.

Semi-evergreen

Semi-evergreen forests are found in the Western Ghats, Andaman and Nicobar Islands, and the Eastern Himalayas. Such forests have a mixture of the wet evergreen trees and the moist deciduous tress. The forest is dense and is filled with a large variety of trees of both types.

Moist deciduous

Moist deciduous forests are found throughout India except in the western and the north-western regions. The trees have broad trunks, are tall and have branching trunks and roots to hold them firmly to the ground. Some of the taller trees shed their leaves in the dry season. There is a layer of shorter trees and evergreen shrubs in the undergrowth. These forests are dominated by sal and teak, along with mango, bamboo, and rosewood.

Littoral and swa mp

Littoral and swamp forests are found along the Andaman and Nicobar Islands and the delta area of the Ganga and the Brahmaputra. It consists mainly of whistling pines, mangrove dates, palms, and bulletwood. They have roots that consist of soft tissue so that the plant can breathe in the water.

Dry tropical forests

Dry deciduous forests are found throughout the northern part of the country except in the North-East. It is also found in Madhya Pradesh, Gujarat, Andhra Pradesh, Karnataka, and Tamil Nadu. The canopy of the trees does not normally exceed 25 metres. The common trees are the sal, a variety of acacia, and bamboo.

Thorn

This type is found in areas with black soil: North, West, Central, and South India. The trees do not grow beyond 10 metres. Spurge, caper, and cactus are typical of this region.

Dryevergreen

Dry evergreens are found along the Andhra Pradesh and Karnataka coast. It has mainly hard-leaved evergreen trees with fragrant flowers, along with a few deciduous trees.

Montane sub tropical forests

Broad-leaved forests

Broad-leaved forests are found in the Eastern Himalayas and the Western Ghats, along the Silent Valley. There is a marked difference in the form of the vegetation in the two areas. In the Silent Valley, the poonspar, cinnamon, rhododendron, and fragrant grass are predominant. In the Eastern Himalayas, the flora has been badly affected by the shifting cultivation and forest fires. These wet forests consist mainly of evergreen trees with a sprinkling of deciduous here and there. There are oak, alder, chestnut, birch, and cherry trees. There are a large variety of orchids, bamboo and creepers.

Pine

Pine forests are found in the steep dry slopes of the Shivalik Hills, Western and Central Himalayas, Khasi, Naga, and Manipur Hills. The trees predominantly found in these areas are the chir, oak, rhododendron, and pine. In the lower regions sal, sandan, amla, and laburnum are found.

Dry evergreen

Dry evergreen forests normally have a prolonged hot and dry season and a cold winter. It generally has evergreen trees with shining leaves that have a varnished look. Some of the more common ones are the pomegranate, olive, and oleander. These forests are found in the Shivalik Hills and foothills of the Himalayas up to a height of 1000 metres.

Montane temperate forests

Wet

Wet montane temperate forests occur in the North and the South. In the North, it is found in the region to the east of Nepal into Arunachal Pradesh, at a height of 1800–3000 metres, receiving a minimum rainfall of 2000 mm. In the South, it is found in parts of the Niligiri Hills, the higher reaches of Kerala. The forests in the northern region are denser than in the South. This is because over time the original trees have been replaced by fast-growing varieties such as the eucalyptus. Rhododendrons and a variety of ground flora can be found here.

In the North, there are three layers of forests: the higher layer has mainly coniferous, the middle layer has deciduous trees such as the oak and the lowest layer is covered by rhododendron and champa.

Moist

This type spreads from the Western Himalayas to the Eastern Himalayas. The trees found in the western section are broad-leaved oak, brown oak, walnut, rhododendron, etc. In the Eastern Himalayas, the rainfall is much heavier and therefore the vegetation is also more lush and dense. There are a large variety of broad-leaved trees, ferns, and bamboo. Coniferous trees are also found here, some of the varieties being different from the ones found in the South.

Dry

This type is found mainly in Lahul, Kinnaur, Sikkim, and other parts of the Himalayas. There are predominantly coniferous trees that are not too tall, along with broad-leaved trees such as the oak, maple, and ash. At higher elevation, fir, juniper, deodar, and chilgoza can be found.

Sub alpine

Sub alpine forests extends from Kashmir to Arunachal Pradesh between 2900 to 3500 metres. In the Western Himalayas, the vegetation consists mainly of juniper, rhododendron, willow, and black currant. In the eastern parts, red fir, black juniper, birch, and larch are the common trees. Due to heavy rainfall and high humidity the timberline in this part is higher than that in the West. Rhododendron of many species covers the hills in these parts.

Alpine

Moist

Moist alpines are found all along the Himalayas and on the higher hills near the Myanmar border. It has a low scrub, dense evergreen forest, consisting mainly of rhododendron and birch. Mosses and ferns cover the ground in patches. This region receives heavy snowfall.

Dry

Dry alpines are found from about 3000 metres to about 4900 metres. Dwarf plants predominate, mainly the black juniper, the drooping juniper, honeysuckle, and willow.

Q.5 What are the symptoms of Drought conditions? Discuss the adaptation in plants to adjust with drought conditions. Give the name of 5 tree species which are drought resistant?

Too little water can cause wilting, leaf scorch (browned leaf edges), early fruit drop, stem dieback and plant death. It can also make a plant more susceptible to harmful diseases and pests. Plants draw in water from the soil, use it for plant growth, and then water is released from stems and leaves through a process called transpiration. Plants begin to wilt and suffer drought stress when the transpiration rate exceeds water up-take. Drought is most prevalent in the long days of the summer and can also effect evergreens during dry, windy winters. Also, dry breezes contribute significantly to drought stress.

Signs of drought stress

During a drought, especially such a prolonged drought as we are having, plants may exhibit any of the following:

- upward curling or rolling of leaves
- yellowing and browning of leaves, particularly along leaf edges and tips
- interior needle and leaf drop on conifers
- leaf, blossom, and fruit drop
- under-sized leaves
- twig and branch dieback

There are a variety of plant adaptations which enable certain species to survive a drought. One of the most common adaptations is that which succulents (such as cactuses) use, whereby they store water in the fleshy pulp of the plant, whether it be in its leaves or its trunk. Other adaptations include:

- Some plants have roots that go down deep to reach the water table.
- Other plants have roots that spread wide to take advantage of surface water.
- Some plants, such as the mulga in Australia, have tiny leaves which grow upwards to catch rain droplets. Their branches and trunks are shaped to capture and channel as much condensation as possible down to a central root system.
- Spinifex, a grass of the desert, has roots which grow both away from the plant to get surface rainwater and also grow down to reach deeper groundwater. Their leaves curl inwards, making a hollow tube which helps stop water droplets from evaporating.
- River red gums grow alongside waterways in Australia. They grow very slowly during drought, but even new seedlings have a single root that will grow straight down to the groundwater. When the river suddenly floods, and perhaps even stays flooded for a long time, the river red gum has floating bundles of roots which take oxygen out of the water so the trees do not drown.

- 5 tree species which are drought resistant:
  - *Acacia arabica*
  - *Gmelina arborea*

- *Boswellia serrata*
- *Dalbergia latifolia*
- *Acacia catechu*

Q.6 Discuss the use of forest nursery? Write the steps taken for development of forest nursery?

Forest Nursery

(1) A production unit that grows planting stock (seedlings and saplings) of forest trees and shrubs.

(2) An area or place where forest seedlings are grown. There are forest, forest-improvement, and landscape nurseries. In addition, nurseries are categorized as small (up to 3 hectares [ha]), medium (3–20 ha), and large (more than 20 ha).

A nursery is a place where plants are propagated and grown to plantable size. To make a good plantation, good nursery stock is essential. Major mortality of seedlings in their plantations is due to the wrong size or poor health of the seedlings at the time of planting. In addition, poor seedlings are likely to have slower growth, to be less able to compete with weeds, and to be more liable to damage by insects and pests. Further, in a poor nursery, fewer seedlings will be raised from a given quantity of seed, and there will be considerable waste of money and time. After planting, the plants are immediately exposed to a harsh environment, and are at their most susceptible to damage from drought, grazing, fire, insects etc. Thus sound nursery practice is the foundation of a successful plantation scheme.

Temporary forest nurseries are created for one-time or repeated (up to five years) growing of planting stock. Usually part of forestry farms and logging and timber distribution establishments, they occupy small areas and are located near the site where a forest is to be planted. Permanent forest nurseries, which are intended for long-term use, are independent enterprises. Level plots or plots sloping no more than 3 are selected for forest nurseries. In the forest and forest-steppe zones they have western and southwestern exposures, and in the steppe zone, western, northwestern, and northeastern exposures. In arid regions permanent forest nurseries are located near bodies of water. Closed basins and depressions and plots less than 20 m from the edge of a forest are unsuitable for forest nurseries. The soils must be coarse and sufficiently fertile.

Permanent forest nurseries consist of several sections. Valuable ornamental plants and industrial tree and shrub species are set out in the stock section. There may also be an orchard, berry patches, vineyards, and poplar and willow groves. Grafting material, cuttings, and seeds are kept in this section. Collections of new and valuable species and forms of trees and shrubs are kept in the dendrological section.

Steps for Nursery Development:

1. Nursery Site selection : The selection of an appropriate nursery site is the most important decision for efficient production of good quality plants. It must start from a well defined statement of the objectives of the nursery, which must include details such as:

1.the number of plants to be produced each year
2.the species
3.the type and size of plants
4.the location of the plantations and villages to be supplied,
5.the expected life of the nursery etc.

The selection needs to be agreed upon at least six months before the first seed is sown. The following are some of the technical factors which need to be considered:

2. Water supply: A reliable and adequate source of water supply is essential for all forest nurseries. The ideal situation is where there is perennial stream at a higher level than the nursery, and fairly close to it, so that water can be diverted from the stream to the nursery in high density polythene pipe (which should be buried 15 cm deep). Also essential to know whether the water is used by other farmers for irrigation to

avoid conflict. Water requirements will vary wit the climate and the species to be grown. It is estimated that 1000 Eucalyptus plants in polypots requires 30 liters of water every day during dry season. Thus a nursery raising 20,000 plants will require 600 liters of water per day. This may be slightly less in hills.

3. Availability of labor: A lot of labor is required for the construction of the nursery and later on periodically for tasks such as soil transportation and pot filling. The nursery should be located where it is possible to obtain labor without great difficulty at most of the times of the year.Siting a nursery on a main trail near a village will also increase awareness among common people and will participate in reforestation programme. • Availability of suitable soil: In nursery where plants are to be raised in polypots, large quantity of sandy loam or loam soil with well drain property, preferably forest top soil will be required. But if we have only heavy soils like clay, then sand mixture is also required. For bare root nursery, a deep loamy soil with well drain property is necessary.

4.The source of soil and sand are close to the site so that 6 loads can be delivered in one man-day then 10 people could complete the work in less than 4 days, but if it is so far away that only 2 loads can be delivered in a day, it would take 30 people to complete in 4 days. At a rate of Rs 100 per day the cost would be Rs 4000, for nearer soil and Rs 12,000 for distance soil (3 times more cost). This will clearly show the importance of site selection.

5. Access: The nursery should be as close as possible to the centre of the area where plants are to be planted later. It may be necessary to construct a short access road to connect the nursery to the main road; if possible this access road should be usable at all seasons of the year.

6. Aspects: Slopes facing south are much warmer than those facing north. So at high altitude, above 1200 m, south facing slope is preferable. Also we should find out if the area is shaded in the morning or evening by adjacent hills or ridges. The higher the nursery site, clear of obstruction from shade.

7 Slope: Completely flat land should be avoided to prevent from logging during monsoon rains. Otherwise good drainage system should be constructed. Even at high altitudes, flat areas are more likely to frost than gentle slopes. The ideal slope is about 5 degrees, which is enough to allow; proper drainage. Avoid very steep slopes, to prevent erosion. Average slopes should be terraced wide enough to accommodate a normal nursery bed of a meter in width, plus paths on each side to allow access to the beds. Also a stepper sloping nursery means that laborers spend a good deal of energy climbing up and down.

8.Exposure to frost, strong winds and flooding: At high altitudes, sites which are particularly liable to frost damage should be avoided. Such areas with frost chances are valley bottoms and other sides where the downward flow of cold night air is common due to dense belt of trees or shrubs below the site. Other natural hazards should also be avoided. Areas threatened by landslides, subject to flooding or strong winds must be avoided.

9. Availability of land: It is important that at the site chosen for the nursery there should be enough land to raise the number of seedlings needed, and if possible room for expansion. A very small nursery raising 20,000 plants in 3/7 inch pots, and keeping the plants in a nursery for a year could require one ropani (500m2) of land , this includes potting beds, 20% extra for losses and damage, paths between the beds, soil storage, thatched shelter, compost making area etc. But for sloping sites the land requirement may be double say 2 ropani. The size of the nursery greatly depends upon the number of plants to be produced, the time they will remain in the nursery, as well as the quality and slope of the site. It is also important to ascertain who owns the land. If it is government, an application must be made for nursery set up. If it’s a permanent nursery, there is also a provision for transfer to panchayat or committee for certain period of time. If it a privately owned land it is important to formalize the use of the land by obtaining a letter fromthe owner agreeing to its use as a forest nursery for certain period of time.

Nursery design and construction:

Design: The nursery design will vary according to the type of plants to be raised, topography of the land (terraces/ slopes) etc. Before construction starts, draw a sketch plan, as possible.

Measurements should be preferably be made with a tape, or a distance can be paced. The plan must include:

1. Fence or wall
2. Internal paths
3. Water tanks & distribution system

4 Seedbeds
5 Soil storage shelter
6. Working area
7. Compost making area etc.
8.Construction: The land must first be cleared of all rocks, stumps, trees and shrubs. While working for the terraces, drains should be built as early as possible to prevent rain from damaging the works.
9.Drains: Great attention must be given to drainage system, especially in nurseries on steep slopes. The object is to minimize erosion, while directing excess water away from the site. Drains should be built along the top edge and down the sides of the nursery. Terraces should slope very gently inwards and with a slight “fall” along their length, so that water flows to the back of the terrace and then along it into a main drain. If drained outward, there is great chance for soil slipping down.
10.Fence or wall: It is necessary that all animals are totally excluded from the nursery, so a fence or wall must be built. A stone wall 1.8m high is ideal. It should be about 60 cm below ground and 120 cm above, when measured from the outside, and with a layer of thorny shrubs on top of it. A stone wall is effective and long lasting. A very simple entrance gate is recommended to avoid chances of being left open.
11.Nursery beds: Ideal size of the bed is 1-1.2m It should not be wider than 1.2 m because of the difficulty of reaching into the centre for weeding, watering, manuring etc. while beds narrower than 1m is wastage of land. The length of the bed is relatively less important, though 5-10m may be convenient for drain purpose. If possible, the beds should be oriented from East to West to provide better shade against the midday sun. Paths should be 50 -60 cm wide, which provides adequate space to squat and work from. This means on terraced land the terraces should be Atleast 2 m wide. When the area for the beds has been leveled, mark out the corners and the edges with wooden sticks and strings. Flat stones can then be set on edge in trenches
along these boundary lines to support the beds. Stones should be 10-12cm protruding above soil level. Compact the ground around the stones to prevent them falling over. Sometimes, half split bamboo or poles are also commonly used to support nursery beds. Sunken beds should not be used, because of the risk of water logging.
12.Other structures: A water proof thatched soil storage shelter is needed which is large enough to store all the potting mixture requirements and to provide some working space. Soils should be stored under this shade to prevent running out due to rain. In larger and permanent nursery, 2.5 m high shade house is very important for filling pots, seed storage, pricking out small seedlings and can also serve as an office for stock record maintenance.
13. Check list of expandable materials for tree nurseries:
14. Seeds, Soil, Sand, Compost
15. Polypots: 3/7 inch & 4/7 inch
16.Heavy gauge polybagsfor seed storage Wire, strings, mesh wire, nails Soap Pens, pensils, water proof marker pens
17. Registers: Nursery, Seed. Visitor
Pate kuto, Chuche kuto, Sickle, Kodalo, Knife, Khukri, Axe, Doko, Scissors, Secateurs,
18.Germination trays, Plant carrying trays, Soil and sand sieves, Hammer etc. Watering can with roses.
19.Planning & Record Keeping

Objective: Planning of nursery should be done at community level, visit the planting sites and discuss the reason for planting, what are the species to be planted (try to limit the number to a maximum of 4), start by growing local spp. with which the people are familiar.

- Time of seed collection & Sowing: One or the main constraints on nursery plans is the availability of seed. Each and every seeds have different collecting seasons. The plan of seed collection is very essential.

- Calendar of operations: By making a comprehensive calendar that includes all activities for all species, it is easy to see how much labor and materials are needed at each each season. This calander forms the basic of the budget. It also indicates when extra labor is needed and materials must be ordered that cannot be obtained locally.

Q.7 Write the process of seed germination under natural condition? What are the factors responsible for seed germination?

Renewal of forest crop by self sown seed depends upon :

- Seed production
- Seed dispersal
- Germination
- Seed establishment

Seed production: the most important prerequisite of natural regeneration from seed is production of adequate quantity of seed. Production depends upon species, age of trees, size of crown, climate.

Seed dispersal: Seed produced by trees are dispersed by wind, water, gravity. Birds and animals.

Seed germination

Germination is the growth of an embryonic plant contained within a seed; it results in the formation of the seedling.ls. All fully developed seeds contain an embryo and, in most plant species some store of food reserves, wrapped in a seed coat. Most seeds go through a period of dormancy where there is no active growth; during this time the seed can be safely transported to a new location and/or survive adverse climate conditions until circumstances are favorable for growth. Dormant seeds are ripe seeds that do not germinate because they are subject to external environmental conditions that prevent the initiation of metabolic processes and cell growth. Under proper conditions, the seed begins to germinate and the embryonic tissues resume growth, developing towards a seedling.

Process of Seed germination

Once the pollen grain lands on the stigma of a receptive flower (or a female cone in gymnosperms), it takes up water and germinates. Pollen germination is facilitated by hydration on the stigma, as well as by the structure and physiology of the stigma and style. Pollen can also be induced to During germination, the tube cell elongates into a pollen tube. In the flower, the pollen tube then grows towards the ovule where it discharges the sperm produced in the pollen grain for fertilization. The germinated pollen grain with its two sperm cells is the mature male microgametophyte of these plants.

The part of the plant that first emerges from the seed is the embryonic root, termed the radicle or primary root. It allows the seedling to become anchored in the ground and start absorbing water. After the root absorbs water, an embryonic shoot emerges from the seed. This shoot comprises three main parts: the cotyledons (seed leaves), the section of shoot below the cotyledons (hypocotyl), and the section of shoot above the cotyledons (epicotyl). The way the shoot emerges differs among plant groups.

Factors affecting germination

Seed germination depends on both internal and external conditions. The most important external factors include temperature, water, oxygen and sometimes light, It require different variables for successful seed germination. Often this depends on the individual seed variety and is closely linked to the ecological conditions of a plant's natural habitat. For some seeds, their future germination response is affected by environmental conditions during seed formation; most often these responses are types of seed dormancy

- **Water** - is required for germination. Mature seeds are often extremely dry and need to take in significant amounts of water, relative to the dry weight of the seed, before cellularmetabolism and growth can resume. Most seeds need enough water to moisten the seeds but not enough to soak them. The uptake of water by seeds is called imbibition, which leads to the swelling and the breaking of the seed coat. When seeds are formed, most plants store a food reserve with the seed, such as starch, proteins, or oils. This food reserve provides nourishment to the growing embryo. When the seed imbibes water, hydrolytic enzymes are activated which break down these stored food resources into metabolically usefulchemicals.[2] After the seedling emerges from the seed coat and starts growing roots and leaves, the seedling's food reserves are typically exhausted; at this point photosynthesis provides the energy needed for continued growth and the seedling now requires a continuous supply of water, nutrients, and light.
- **Oxygen** - is required by the germinating seed for metabolism.[3] Oxygen is used in aerobic respiration, the main source of the seedling's energy until it grows leaves.[2] Oxygen is anatmospheric gas that is found in soil pore spaces; if a seed is buried too deeply within the soil or the soil is waterlogged, the seed can be oxygen starved. Some seeds have impermeable seed coats that prevent oxygen from entering the seed, causing a type of physical dormancy which is broken when the seed coat is worn away enough to allow gas exchange and water uptake from the environment.
- **Temperature** - affects cellular metabolic and growth rates. Seeds from different species and even seeds from the same plant germinate over a wide range of temperatures. Seeds often have a temperature range within which they will germinate, and they will not do so above or below this range. Many seeds germinate at temperatures slightly above room-temperature 60-75 F (16-24 C), while others germinate just above freezing and others germinate only in response to alternations in temperature between warm and cool. Some seeds germinate when the soil is cool 28-40 F (-2 - 4 C), and some when the soil is warm 76-90 F (24-32 C). Some seeds require exposure to cold temperatures (vernalization) to break dormancy. Seeds in a dormant state will not germinate even if conditions are favorable. Seeds that are dependent on temperature to end dormancy have a type of physiological dormancy. For example, seeds requiring the cold of winter are inhibited from germinating until they take in water in the fall and experience cooler temperatures. Four degrees Celsius is cool enough to end dormancy for most cool dormant seeds, but some groups, especially within the family Ranunculaceaeand others, need conditions cooler than -5 C. Some seeds will only germinate after hot temperatures during a forest fire which cracks their seed coats; this is a type of physical dormancy.

  Most common annual vegetables have optimal germination temperatures between 75-90 F (24-32 C), though many species (e.g. radishes or spinach) can germinate at significantly lower temperatures, as low as 40 F (4 C), thus allowing them to be grown from seed in cooler climates. Suboptimal temperatures lead to lower success rates and longer germination periods.
- **Light or darkness** - can be an environmental trigger for germination and is a type of physiological dormancy. Most seeds are not affected by light or darkness, but many seeds, including species found in forest settings, will not germinate until an opening in the canopy allows sufficient light for growth of the seedling.[2]

Internal factors affect seed germination are

1. Permeability to water

2. Permeability to O2

3.Development of embryo

4. After ripening

5. Vibility

6. Seed size

1. Permeability to water : Hard seed coat prevents moisture reaching the seed embryo.

2. Permeability to O2: due to hard seed coat.

3.Development of embryo: When seed embryo is not fully developed.

4. After ripening : When embryo is developed but not chemically ready

5. Vibility : potential capacity of seed to germinate

6. Seed size : very minute seed may washed away while big seed not properly coverd.

Seed Dormancy

- Prior to emergence, plant embryos experience dormancy – either external or internal. Externally, a seed's hard outer coat prevents absorption of essential gases and water that are necessary to break dormancy. Internally, chemical seed sensors communicate unfavorable environmental conditions such as cold weather that would kill premature embryo emergence.

Some live seeds are dormant and need more time, and/or need to be subjected to specific environmental conditions before they will germinate. Seed dormancy can originate in different parts of the seed, for example, within the embryo; in other cases the seed coat is involved. Dormancy breaking often involves changes in membranes, initiated by dormancy-breaking signals. This generally occurs only within hydrated seeds.[4] Factors affecting seed dormancy include the presence of certain plant hormones, notably abscisic acid, which inhibits germination, andgibberellin, which ends seed dormancy. In brewing, barley seeds are treated with gibberellin to ensure uniform seed germination for the production.

Viability

- Potential for germination makes a seed viable. Malformation of seed embryos and incomplete endosperm development are two factors that render them inviable. Inside a seed is the germ layer, beneath which a plant embryo lies dormant until conditions are favorable for growth. The emerging embryo sprouts by pushing through the germ layer; hence the term germination.

Seedling establishment

In some definitions, the appearance of the radicle marks the end of germination and the beginning of "establishment", a period that ends when the seedling has exhausted the food reserves stored in the seed. Germination and establishment as an independent organism are critical phases in the life of a plant when they are the most vulnerable to injury, disease, and water stress. The germination index can be used as an indicator of phytotoxicity in soils. The mortality between dispersal of seeds and completion of establishment can be so high that many species have adapted to produce huge numbers of seeds

Q.8 What are crown thinning and ground thinning discuss their field applicability's?

Thinning is the cutting down and removal of a proportion of trees in a forest crop. It is carried out primarily to provide more growing space for the remaining trees, which leads to an increase in volume of individual trees. Thinning also provides the farmer with an intermediate source of timber revenue before the final crop is cut down at the end of the rotation.

Thinning of conifers aims to maximize total production per hectare, in broadleaves the main purpose of thinning is to produce well balanced, even crowns on the final crop trees. Conifer thinning is carried out on a 5 year cycle normally, starting when the trees are near 20 years of age. These thinning operations are carried out until the crop is completely cut down.

Thinning in forestry is the selective removal of trees, primarily undertaken to improve the growth rate or health of the remaining trees. This may be done to make the stand more profitable in an upcoming final felling.

Thinning has most been developed as a science in Central Europe. There are significant developments in this by Carlowitz 1713, Dhamel du Monceau 1750, Robert Hartig 1791, Cotta 1817, Seebach 1845, Heyer 1854, Kraft 1884, Borggreve 1891, Biolley 1901 and Schädelin 1934. These methods have been applied outside of Europe to many forests around the world, based on this basis.

Overcrowded trees are under competitive stress from their neighbors. Thinning may be done to increase the resistance of the stand to environmental stress such as drought, insect infestation or extreme temperature.

A thinning in which the trees removed have little or no economic value is called a pre-commercial thinning. Ecological. Thinning is a variant of this being trialled for use in forest conservation in chemical thinning is a form of non-commercial thinning in which the trees are killed while they stand by injecting a chemical such as Round Up) into a cut made in the stem. This reduces the number of live stems remaining, providing a benefit to those that remain and may be undertaken where the cost of a traditional thin is high. It can also be done on very exposed sites where breaking the canopy through a traditional thinning operation would expose the stand to a high risk of windthrow.

The goal of thinning is to control the amount and distribution of available growing space. By altering stand density, foresters can influence the growth, quality, and health of residual trees. It also provides an opportunity to capture mortality and cull the commercially less desirable, usually smaller and malformed, trees. Unlike regeneration treatments, thinnings are not intended to establish a new tree crop or create permanent canopy openings.

Common thinning methods:

- Low Thinning (*thinning from below* or *German thinning*)
- Crown Thinning (*thinning from above* or *French method*)
- Selection Thinning (*thinning of dominants* or *Borggreve method*)
- Mechanical Thinning (*row thinning* or *geometric thinning*)
- Free Thinning

Objects of Thinning

The idea behind thinning is to concentrate the volume increase in a smaller number of trees, resulting in wider individual trees and a greater proportion of sawlog, the most valuable timber size class. An important concept in thinning is the yield class (YC) of the tree. The yield class is a measure of the growth of the tree crop on an annual basis. A tree crop of yield class 20 will put on $20m^3$ per hectare per year over the lifetime of the crop. This volume increase holds true whether there are 2,500 trees per hectare or 460 trees per hectare.

Methods of Thinning

Thinnings can be selective or systematic. A selective thinning is one in which the trees are removed or retained on their individual merits. Systematic thinning involves the removal of trees according to a predetermined system, such as line thinning.

The trees are either manually harvested, using chainsaws, or machine harvested, using processing machines. The branches are cut off, and the trees are cut into specific lengths and stacked, to await extraction by forwarder or skidder.

Skidders are tractors with cable drums attached, that extract by lifting one end of the load clear of the ground and pulling it out with the other end dragging on the ground. Forwarders are generally purpose-built tractor units that extract timber lifted entirely clear of the ground. The timber is carried on a linked trailer or integral rear bunk. All forwarders use a fitted loading crane. Having stacked the harvested timber beside a road, articulated lorries transport the timber to the mill.

Factors to Consider before Thinning

- Ground conditions
- Degree of access
- Availability of markets
- Availability of machinery
- Size of crop area
- Availability of harvesting skills

Tree classification for thinning :

- Dominant : All three which form upper most leaf canopy have free leading shoots.

Class symbol - I

- Ia - Normal crown and good stem
- Ib - Defective crown and stem
- Ic - Very defective
- Id - Whip very thin bole

II. Dominated : height of tree is ¾ of I and free leading shoots

Class symbol - II

- IIa - Normal crown and good stem
- IIb - Defective crown and stem

III. Suppressed : Trees which are ½ of the ht of best trees and shaded by I and II class trees.

Class symbol - III

IV. Dead trees : All bent and badly leaned . Class symbol - IV

V. Diseased trees: is infected with parasites to such an extent their growth is seriously affected .

Class symbol - IV

Ground thinning : The method of thinning that consist in removal of inferior individuals of a crop starting from suppressed classthen taking the dominated class and lastly some of the domoinants. It is applied to regular crops

Grade of thinning Removal of tree category

Light	A grade	V, IV, III
Moderate	B grade	V, IV, III, IIb, Id
Heavy	C grade	V, IV, III, II I b, Ic, Id
Very heavy	D grade	V, IV, III, II I b, Ic, Id and some Ia
Very heavy	E grade	Heaviest grade of thinning that can be done in crop without making permanent gap

Application of ordinary thinning :

- Method is applicable in case of light demander trees which are left behind in struggle for existence.
- Where there is market for small size timber.
- Areas infested with climbers.
- Areas where danger of soil erosion is least.

Crown thinning : The method of thinning that consist in removal of dominants. Dominated and suppressed stems are retained unless they are dead, dying or desised.

Grade of thinning		Removal of tree category
Light	L.C grade	V, IV, Id, Ic many Ib and few Ia
Heavy	H. C. grade	removing all remaining Ib and some Ia but not II and III.

Application of crown thinning :

- Method is applicable in case of moderately shade tolerant species for existence.
- Where there is market for big size timber.
- Method is perticluerly suitable for dry areas where there may be danger of site deterioration.
- Areas where danger snow frost and drought so only dominant tree dies.
