Hornbill Classes

2024

# FORESTRY

## UPSC

## INDIAN FOREST SERVICE

## TOOLKIT

Detailed Syllabus Based ANALYSIS + Linkage of Concepts with PYQs + Infused with Infographics & Maps

*Paper - 1*

# SILVICULTURE

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*To all our successful candidates in*

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Forestry Comprehensive Course

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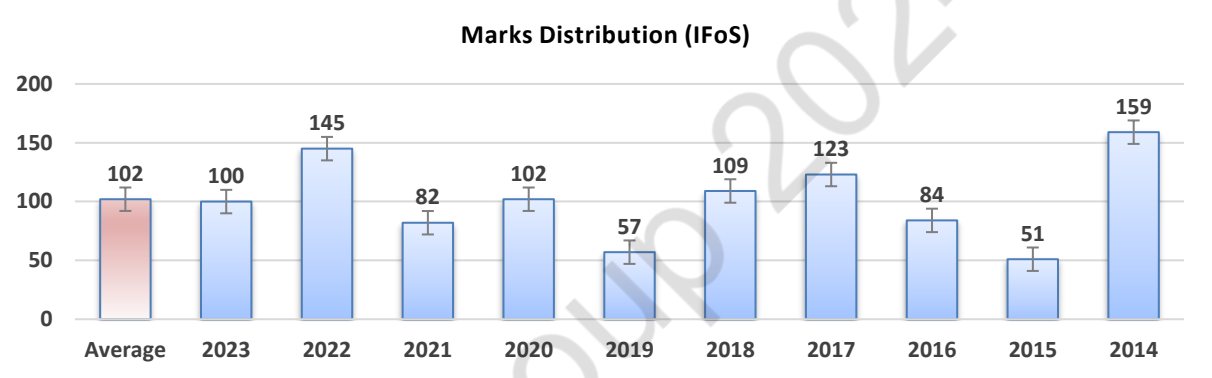
CHAPTER 1

# SILVICULTURE

*General Silvicultural Principles* : Ecological and physiological factors influencing vegetation, natural and artificial regeneration of forests; methods of propagation, grafting techniques; site factors; nursery and planting techniques. Nursery beds, polybags, and maintenance, water budgeting, grading and hardening of seedlings; special approaches; establishment and tending.




The *shoot portion* of seedlings of some tree species like *Sal* and *Sandal*, under *natural regeneration*, keeps on *drying year after year* but the *roots remain alive*. Discuss [IFoS 2023; Paper – 1/Q1 (a) | 8 M]

*Approach*

1. **Understand the question** – Here, the examiner is asking for a "Discussion," which means a concise and informative explanation with a focus on concepts, examples, causes or contributing factors, solutions, and its importance in the natural forest ecosystems.
2. **Introduction:** Start by defining the "dying back" phenomenon with *suitable examples and growth stage*
3. **Main Body** : Briefly explain why this occurs, along with other contributing factors, using appropriate *Diagrams* and *Examples*. Follow this with suitable solutions.
4. **Conclusion :** Summarize the *ecological importance of this phenomenon* and its role in enhancing the *forest's resilience to climate change*.

"*Dying Back*" is a phenomenon observed in certain plant species, including *Shorea robusta*, where the *shoot portion of a seedling dies off year after year, while the root system remains alive*. This occurs often in *recruit & Seedling phase* in certain species, particularly those *adapted to dry climates*.

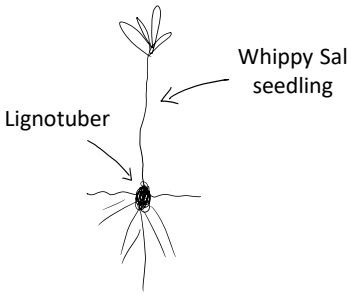
Every year, with the onset of the monsoon, the shoot portion of the seedling begins to grow. However, due to *severe weed competition*, *adverse micro-climatic/Edaphic factors*, and *Physiological constrains*, the new shoots often remain small and whippy, unable to grow further (Stagnating at this stage). As an ecological

adaptation, when the plant cannot survive under these circumstances, it sacrifices the shoot portion by the middle or end of the monsoon season to conserve energy and resources. The following year, it tries again to grow more vigorously, using the stored resources to combat the same challenges. This cycle can continue for up to 18-20 years, during which the seedling is unable to form a permanent shoot. However, the root system remains alive and continues developing. In some years, when adverse factors are absent, the seedling may produce a shoot that survives, allowing the plant to continue developing from that point to form a mature tree.

This phenomenon occurs in ***Shorea robusta*** (*Sal*), ***Terminalia tomentosa*** (*Ain*), ***Pterocarpus santalinus*** (*Redsanders*), ***Bombax ceiba*** (*Kapok*), and ***Boswellia serrata (Salayi)***.

**FACTORS RESPONSIBLE FOR DYING BACK**

- *Dense overhead canopy* & *inadequate light* : The absence of proper light conditions retards photosynthesis and plant growth suffer badly.
- *Dense weed growth* = high competition for moisture, and minerals resources.
- *Undecomposed leaf litter* : works as a physical barrier, and roots cannot reach the soil.
- *Accumulation of* $CO_2$ : when the excess moisture or waterlogging condition persists for a longer time, soil $CO_2$ level increases to 2.8 and seedlings start dying back.
- *Regular Fire incidences during hot-dry season.*
- *Attacks of nematodes, root borers (Pemmene theristhis), heartwood borers (Haplocerambyx spinicornis)*, Defoliators (Lymantria mathura), etc.
- *Frost & Drought (Dehydration of sal seedlings)*
- *Grazing & browzing* by herbivores.
- *Compact soil* surface
- High water table in *tarai region.*




**SIGNIFICANCE OF DYING BACK**

- **Stress Response** : By shedding less vital parts, the tree can conserve energy and resources to focus on survival.
- **Regeneration :** dying back can stimulate the growth of new, more resilient shoots. This can be particularly beneficial in harsh environments.

**SOLUTIONS**

- Weeding, cleaning-off excess leaf litter and climber cutting to reduce unnecessory competition.
- **Removal of dense middle-story vegetation** : Species such as *Mallotus philippensis* and *Syzygium cumini* should be cleared to improve light condition = soil temperature.
- **Controlled burning** : Reduce excess soil moisture, improve environmental hygiene, clear old slash and debris, and manage future fire risks.
- **Proper fencing and isolation trenches** : These measures help reduce biotic pressure (Controlled grazing).
- **Soil hoeing and working** : Interim measures for loosening compacted topsoil, while surface exposure and desiccation are long-term strategies to prevent dehydration of sal seeds.
- **Faciliting natural regeneration** by using artificial methods to enhance natural regeneration.

While dying back may appear to be a negative phenomenon, it is often an adaptive strategy that helps *Shorea robusta* survive in challenging environments. By understanding the ecological significance of dying back, we can better appreciate the resilience of this important tree species and its contribution to forest ecosystems.

**Linked Questions**

- Explain the *role of fire* in silviculture of *Shorea robusta* [IFoS 2011; Paper – 1/Q1 (b) | 10 M].
- Explain the *role of fire* in the regeneration and seedling establishment of *Shorea robusta* [Arunachal PSC Civil (mains) 2015-16].

In *Shorea robusta* forests, controlled or prescribed burning is often used to create favourable conditions for seed germination and seedling establishment. By removing leaf litter, dead wood, and competing vegetation, fire exposes mineral-rich soil, enhancing the chances of successful regeneration of Sal seeds.

*Positive roles*

- ***Reducing Understory Competition*** : Fires help in reducing dense undergrowth and shrub layers that compete with Sal seedlings for sunlight, water, and nutrients.
- Fire can act as a ***natural hygiene agent*** by clearing away diseased or pest-infested trees and controlling fungal infections.
- **Nutrient Recycling :** Nutrients locked in the vegetation return to the soil as ash = Enhances soil fertility and promotes the healthy growth of new Sal seedlings.
- Controlling future Fire Hazards
- *Fire can stimulate the germination of dormant seeds in the soil, releasing a new cohort of seedlings. This is most common in plants with seeds that have thick, hard seed coats that prevent germination by keeping oxygen and water away from the seed inside [This point not suit with Sal seed].*

*Negative roles*

- Intense fires can directly kill seedlings, saplings and local biota
- Damaged seedlings = fungal infection increases
- Hardling of soil surface = degrade its quality

**Similar Questions**

- Comment upon the *Dieback (dying back)* phenomenon in *Shorea robusta*. Is it a problem or a adaptation? [IFoS 2015; Paper – 1/Q1 (a) | 8 M]
- Comment Critically on the following – Reasons of *dying Dalbergia sissoo*. [IFoS 2012; Paper – 1/Q1 (h) | 5 M]
- What is the phenomenon of *dying back* of *Sal seedlings*? What factors are responsible for it and how it is to be addressed ? [OPSC Civil (Main) 2019 | 20 m]

Calculate the ***quantity of seeds*** (kg) required to establish a *Teak Plantation* over an area of 10 ha. [IFoS 2023; Paper – 1/Q1 (b) | 8 M]

*Approach*

1. **Understand the question** – The examiner is asking for the ***quantity of seeds in kilograms*** (not in numbers), without giving much consideration to ***Seed Weight***, ***Plantation Spacing***, or ***Germination Percentage***. This means we can used standard information whenever required. The examiner is ***more focused on the method of solving*** the problem rather than on the specific data or exact answer.
2. **Introduction** : List all necessary data in a clear format for a smooth start.
3. **Main Body** : Briefly solve the problem, first without considering germination percentage and then with it.
4. **Conclusion :** Summarize the findings

*Given Information*

- Quantity of seeds (Teak) = ? (in Kg)
- Planted area (in hectare) = 10 Hec.

*Standard information*

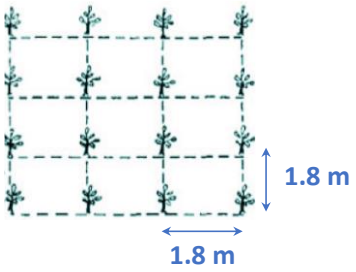
- Standard Spacing (Teak) = 1.8 m × 1.8 m
- Seed weight = 600 to 800 seeds per kg (here, we take 600 Seeds per kg for consideration)
- Germination percentage = 50 % (Standard).

**Total seeds required for 1 hectare**

$$\text{Seeds} = \frac{100 \times 100}{quare\ of\ the\ side\ of\ the\ planting\ square} \text{ (Formula)}$$

$$= \frac{100 \times 100}{1.8 \times 1.8}$$

**= 3,086 Seeds**




**For 10 Hectare area** = 3,086 × 10 = **30,860 Seeds**

∵ Standard Seed weight = 600 Seed / kg

∴ ***Quantity of seeds*** (kg) required = 30,860/600 = **51.4 kg**

If we consider that about 50% of seeds fail to germinate (germination percentage = 50%), to ensure successful regeneration in this scenario, we would need to sow 2 seeds at each point instead of 1. This way, if one seed fails to germinate, the other ensures germination overall. However, this approach doubles our seed requirements.

∴ ***Quantity of seeds*** (kg) required (after considering germination %) = 51.4 × 2 = **102.8 kg**

*Linked* Questions

Calculate the *number of seeds* required to raise a 20 hec. plantation with 4m x 4m spacing and an *extra plant in-the centre* of each square. *Plant percentage of the species is 75%* [IFoS 2017, Paper – 1/Q1 (e) | 8 M; OPSC Civil (Main) 2018 | 20 M]

*Given Information*

- Planted area = 20 Hec.
- Spacing = 4 m × 4m
- with a quinquennial plantation (one extra plant in the centre of each square)
- Seed of a required species in a seed lot = 75 % (That means, there is about 25 % impurity)

Total seeds required for 1 hectare

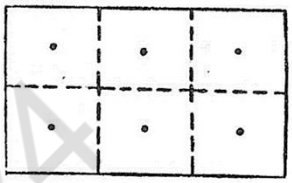
$$\text{Seeds} = \frac{2\times100\times100}{\text{quare of the side of the planting square}}$$

Double the number in Quincunx plantation

1 hectare Area size

$$= \frac{2\times100\times100}{4\times4}$$

$$= 1250$$



Quincunx planting

Total seeds required for 20-hectare area

$$= 1250 \times 20 \ = 25{,}000$$

∵ The plant percentage of the species is 75%. This can be interpreted in two ways :

- If 100 seeds are planted, only 75 survive in the first year.
- The seed lot contains 75% seeds of the required species, with the remaining 25% being impurities such as seeds from *unwanted species* or *dead* and *immature seeds*.

Therefore, to obtain 100 viable seeds of the desired species, we need to purchase a seed lot containing 133.33 seeds $\left(100 \times \frac{4}{3}\right)$ = **33.33% more seeds** than the actual requirement to account for the impurities in the seed lot.

∴ Therefore, to get 25,000 seeds we require seeds that are

$$= 25000 \times \frac{4}{3}$$

= **33,333 Seeds**

Therefore, we would need approximately **33,333** seeds to raise a 20-hectare plantation with the 4m x 4m given spacing, Quinquennial plantation and 75 % plant per cent.

**Similar Question**

- How do we calculate the *seed requirement of a species* while raising a nursery? Also, explain the method of calculating the *number of plants required per hectare for plantation* [IFoS 2011 | Paper – 1/Q1 (e) | 10 M].
- Calculate *quantity of seed* that would be required for *raising 10-hectare plantation of* ***Sal***. Given planting *distance is 3 x 3 meter*, Number of *seed/kg is 500* and *plant percent is 70* [OPSC Civil (Main) 2016 | 20 m].

What is frost hole? How does frost affect regeneration? [IFoS 2023; Paper – 1/Q1 (d) | 8 M]

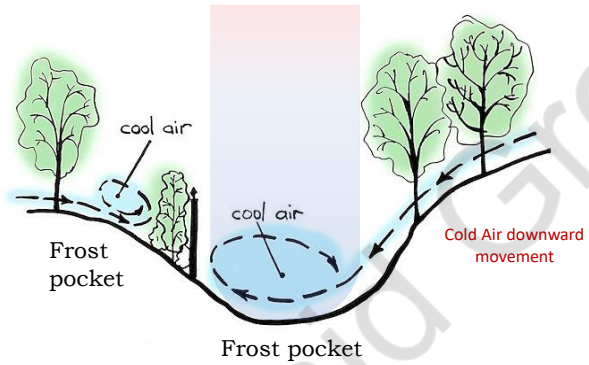
*Approach*

1. **Understand the question** – The examiner is asking about frost holes, the reasons behind their formation, how they affect forest regeneration in both positive and negative ways, and the way forward.
2. **Introduction** : Define frost holes with suitable diagram.
3. **Main Body** : Why or how do they form? How do they affect forest regeneration?
4. **Conclusion :** Include precautionary notes for forest management.

*Frost pockets* or *frost holes* are valleys or low-lying areas (Depressions) within a larger region where cold air naturally flows downhill and collects, making them subject to *frequent frost*.

**WHY FROST POCKETS FORM**

- **Cold Air Drainage** : In valleys and foothill regions, cold air, being denser than warm air, tends to flow downhill and settle in low-lying areas. These areas become frost pockets.
- **Radiational frost** : In mid-latitude regions, during long, cold, clear winter nights with calm wind conditions, the ground loses heat through radiation, leading to colder temperatures near the surface. This effect is amplified in frost pockets.




**NEGATIVE EFFECT OF FROST**

- The killing of young seedlings and their parts due to the freezing and expansion of intracellular fluid, resulting in cell breakage. This is especially harmful to sensitive new growth or de-hardened shoots in early summer (late frosts).
- Soil lifting or frost heaving due to the expansion of soil mass by freezing soil water, leading heavy damage to the root system.
- Frost cracks : Development of longitudinal fissures on the main stem due to the shrinking of the outer layer, making the tree more susceptible to diseases.
- Formation of canker : Repeated frost injuries over the years result in callus formation.
- Cold-induced photoinhibition, which can lead to *die-back* or tree death.

**POSITIVE ROLE OF FROST**

- By killing non-native flora, it prevents the invasion of foreign species and reduces unnecessary competition with local flora and fauna.

- Cold frost chilling is necessary for breaking seed dormancy in some species, *i.e.*, Douglas fir, Deodar, etc.
- Pest and disease control : As many cannot survive in these harsh environments.
- works as a tool to prevent the dominance of any one species in a habitat.
- Freezing and thawing help improve soil structure by breaking up hard surface layers.

To enhance the survival rates of plantations in frost-prone regions, we typically select ***frost-hardy plant species***. Additionally, we avoid establishing **monocultures**, add organic **mulch**, and employ **hardening** techniques on nursery-raised seedlings to bolster their resistance to frost and low temperatures. Moreover, ***seed-origin seedlings*** are often preferred for their adaptability to local conditions.

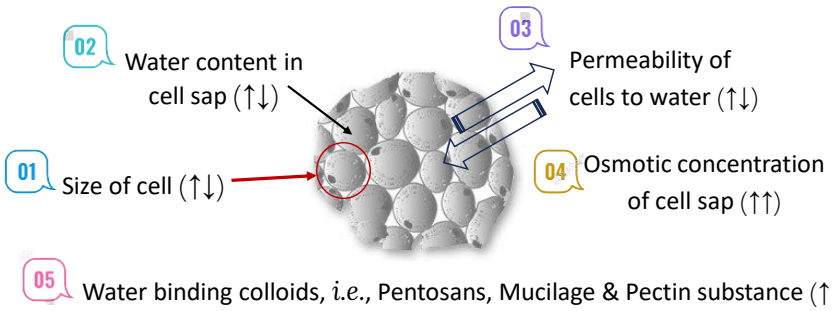
**Linked Questions**

- *Frost resistance* in trees depends on the *internal* and *external factors* explain [IFoS 2020 | Paper – 1/Q1 (b) | 8 M].
- Explain the term *Hardening off*. What are the *internal factors* affecting forest resistance? [IFoS 2015 | Paper – 1/Q3 (a) | 10 M].
- Write on *internal and external factors* responsible for forest resistance in trees [OPSC Civil (Main) 2021 | 10 m].

Frost means the *chilling of air below the freezing point*. This Sub-frizzing temperature might be lethal to the plants. However, due to few specific mechanisms many temperate and sub-tropical species easily thrive under this condition.

**INTERNAL FACTORS THAT MAKE THEM RESISTANT TO FROST**

- **Water content in the cell** : On average, Water makes up about 70 % volume of a plant cell. A Higher amount of cell water = more increment in the volume of water during freezing inside the cell = damages the cell wall and its organelles, and also blocks its metabolic process. It means more water = Low resistance and *vice versa*.
- **Osmotic concentration of cell colloids** : water-binding colloids like Sugar, mucilage, pectin substance, and Antifreeze proteins (like ***dehydrin***) increase osmotic concentration and leave a very small amount of water free to freeze on one side; on another side, they also reduce its freezing point. It means Higher osmotic concentration = less chance for the cell to freeze.




- **Permeability of cell to water** : in the high permeable cell wall, during the freezing process inside the cell, the excess water moves out quickly, so less possibility of rupturing the cell membrane and cell walls.
- **Cell size** : Smaller cells are harder than larger cells due to their small volume surface ratio and more readily bind their water molecules with their colloids

**EXTERNAL FACTORS THAT MAKE THEM RESISTANT TO FROST**

- **Temperature** : Sudden fall in temperature is much more injurious than its gradual fall even for partially hardy plants because rapid fall increases the danger of internal ice formation.
- **Season of growth** : Plants that can withstand extremely cold conditions during winter may be killed by slight frost during spring.
- **Mineral nutrients** : Nitrogen stimulates vegetative growth and therefore reduces frost-hardiness. Whereas, a higher dose of Phosphorus and potassium increases resistance.
- **Light** : lesser the duration of light = poor new growth = greater frost-hardiness.
- Water availability in the soil

**Linked Questions**

- Describe the following term – (i)…., (v) *Hardening* [IFoS 2020 | Paper – 1/Q2 (a) | 2 M].
- Explain the term *Hardening off*. What are the *internal factors* affecting forest resistance? [IFoS 2015 | Paper – 1/Q3 (a) | 10 M].
- Write notes on the following – (i) *Grading* and *hardening* of seedlings [IFoS 2009 | Paper – 1/Q2 (a) | 5 M]
- Write short notes on - Hardening of seedlings [UPPSC (ACF) 2020]

***Hardening off*** is a natural process by which indoor-grown plants prepares for the harsher outdoor environment, *i.e.*, drought, cold, heat, etc. gradually by exposing them to the particular stress.

- Importance : It enables them to withstand the actual environmental conditions they will face when planted in forest area. It encourages a shift from soft, succulent growth to firmer, harder growth
- Procedure : ~~[in case of 5 or 8 M questions]~~



**Similar Question**

- Explain the terms – *Frost cracks*, *Frost hardy* and *frost tender* with names of suitable species [OPSC Civil (Main) 2021 | 10 m].
- Describe different *types of frost* and list some of the *tree species* on the basis of their frost tolerance ability [OPSC Civil (Main) 2006 | 30 m].

Write the botanical names of three tree species each of [IFoS 2023; Paper – 1/Q1 (e); 8 M].

(a) Non-coppicers,

(b) Poor coppicers,

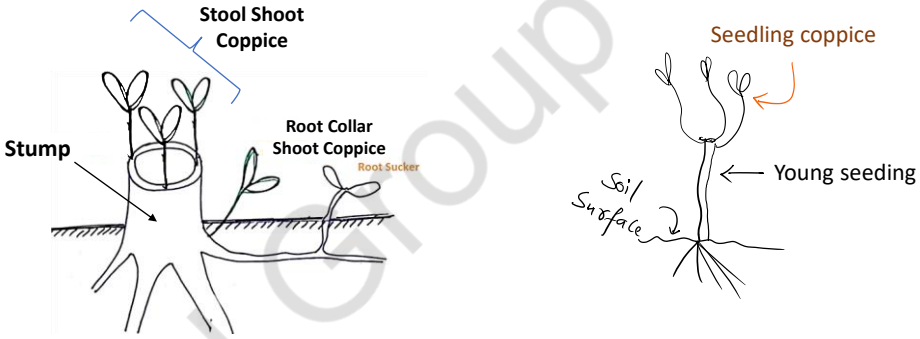
(c) Good (fair) coppicers and

(d) Strong coppicers.

*Approach*

1. **Understand the question** – अब इसमें क्या बचा understand करने के लिये ? .
2. **Introduction** : Define "coppicing" to start the discussion smoothly with a diagram
3. **Main Body** : Present in a tabular format for easier understanding. Always remember to use the scientific name (properly underlined) and include the common name in brackets.
4. **Conclusion :** Include if possible and time permits.

Coppice is a method of vegetative reproduction in which the seedlings, plants, or trees of a species when cut from near the ground level, produce coppice shoots. A coppice shoot is a shoot arising from an adventitious bud at the base of a woody plant that has been cut near the ground or burnt back.




| | |
|---|---|
| Non coppicers | Most of conifers like *Pinus roxburghii (Chir-pine)*, *Cedrus deodara* (*Deodar*), and *Abies pindrow* (Silver-*Fir*), etc. |
| Bad or Poor coppicers | *Acacia nilotica* (Babool), *Adina cordifolia* (Haldu), *Madhuka indica* (Mahua), *Bombax ceiba* (*Red-silk cotton tree*), *Casuarina equisetifolia* (Casuarina), *Populus ciliata* (poplar). |
| Good or Fair Coppicer | *Pterocarpus marsupium* (Bijasal), *Terminalia bellerica* (Baheda), *Hardwickia binate* (Anjan), *JugIans regia* (Akhrot), etc. |
| Strong coppicers | *Tectona grandis* (Teak), *Shorea robusta* (Sal), *Dalbergia sissoo* (Shisham), *Acacia catechu* (Khair), *Albizzia lebbeck* (Black siris), *Emblica officinalis* (Aaonla), *Eucalyptus globulus*, *Butea monosperma* (Dhak or Palash), *Diospyros melanoxylon* (Tendu), *Salix alba*, *Azadirachta indica* (Neem), *Prosopis juliflora* (Khejri), etc. |

Describe the ***seed collection*** and ***storage methods*** of the following tree species

[IFoS 2023; Paper – 1/Q2 (a); 15 M].

(i) *Santalum album*
(ii) *Chukrasia tabularis*
(iii) *Cedrus deodara*
(iv) *Azadirachta indica*
(v) *Dalbergia latifolia*

*Approach*

1. **Understand the question** – a brief intro of species and its seed collection and storage methods
2. **Introduction** : in very short – about a species (one–by–one)
3. **Main Body** : *Seed Collection* : various methods that we adopted for that particular species with one diagram

   *Storage method* : various suitable methods

**(i)** ***Santalum album (Sandal wood)*** : A small to medium-sized, *Evergreen*, *light-demanding*, *partially root parasite tree* found in *tropical moist & dry deciduous* and *moist semi-deciduous* forests of the southern peninsular region of India, at altitudes up to 1500 meters.

**Seed Collection** :

**Storage methods** :

**(ii)** ***Chukrasia tabularis (Chukrasia tabularis)*** : Primarily growing in tropical evergreen and semi-evergreen forest areas like - North East India, Andaman and Nicobar, Western ghat, etc.

**Seed Collection** :

**Storage methods** :

**(iii)** ***Cedrus deodara (Deodar)*** : It is a *large evergreen tree* with *horizontal branching*, commonly found throughout the western Himalayas, ranging from Afghanistan to western Nepal.

**Seed Collection** :

**Storage methods** :

**(iv)** ***Azadirachta indica (Neem)*** : Neem is a *medium-sized* tree, reaching heights of 12 to 15 meters, with a *broad, rounded crown*. It typically thrives in *tropical dry deciduous* and *thorn forests*, particularly in semi-arid regions at elevations up to 1,500 meters.

**Seed Collection** :

**Storage methods** :

**(v)** ***Dalbergia latifolia* (Rose wood)** : It is a *large deciduous* tree, reaching heights of 20 to 30 meters, with a fairly *rounded crown* and a *dimorphic root system* consisting of both horizontal and vertical roots. The tree is widely distributed from the Sub-Himalayan tracts and the plains of Uttar Pradesh to south Sikkim, in Jharkhand, Central, Western, and Southern India.

**Seed Collection** :

**Storage methods** :

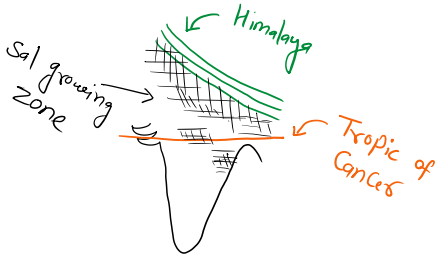


Write the factors which affect the *natural regeneration* of Sal (*Shorea robusta*). Discuss the procedure to obtain natural regeneration of ***moist*** Sal forests [IFoS 2023; Paper – 1/Q2 (b); 15 M].

*Approach*

1. **Understand the question** – The question highlights the issue of Sal's natural regeneration and the factors affecting it, followed by the procedure for addressing these challenges in a specific type of forest, the "Moist Sal forest."
2. **Introduction** : Begin with the basics about Sal and its distribution for a smooth start.
3. **Main Body** : Discuss the various factors affecting the natural regeneration process, followed by ways to address these challenges.
4. **Conclusion :** Emphasize the ecological significance of Sal in North Indian forests.

***Shorea robusta*** (Sal) is a *light-demanding*, *medium-sized* (10-15 meters in height), *evergreen tree* naturally growing in the northern Indian plains, extending from Punjab to the Assam Valley. Despite its ecological significance, the natural regeneration in the "*Moist Sal forests*" is facing numerous challenges.

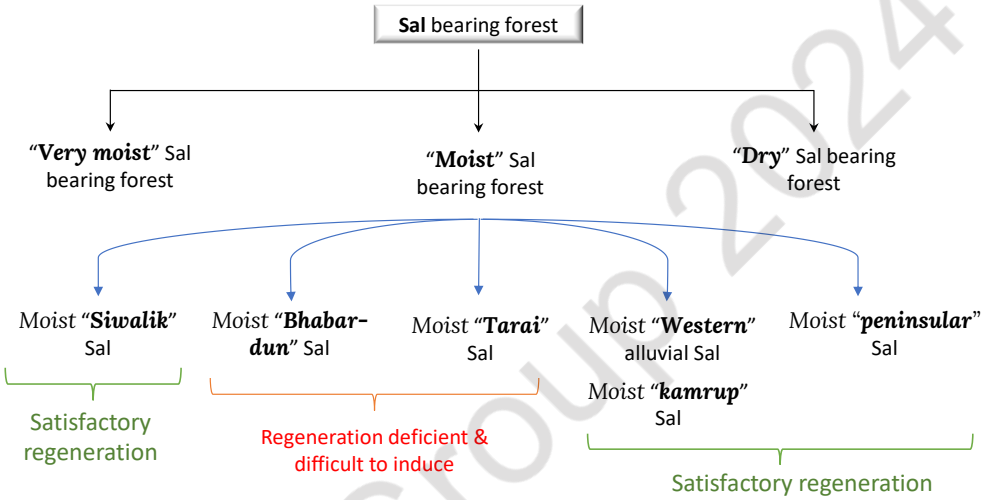



- **Climate** : *frequent Frost*, & Droughts, *Accumulation of* $CO_2$ in sub-surface soil, and *waterlogging condition* persists for a longer time often induced dying back.
- **Soil Conditions** : Sal trees thrive in well-drained, sandy-loam soils. Soil fertility, pH, and moisture content significantly affect germination and seedling growth.
- *Undecomposed leaf litter* : works as a physical barrier, and roots cannot reach the soil.
- *Dense overhead canopy* & *inadequate light* retards photosynthesis and plant growth suffers badly. Heavy weed growth further grieves the situation.
- *Dense weed growth* = high competition for light, minerals, space, and water.
- **Biotic Pressures** : (1) Uncontrolled **Grazing & Browsing** can reduce seedling survival by feeding on them. (2) Human activities, such as **illegal logging** and heavy **seed collection** for **"Ral"**, can adversely affect regeneration. (3) **Heartwood borer attacks** on seedlings can impede the regeneration process.

- **Fire** : Sal forests are adapted to periodic fires, which help clear undergrowth and create favourable conditions for regeneration. However, intense or frequent fires can damage seedlings and disrupt regeneration
- **Seed Viability** : Sal seeds have very short viability, typically lasting only one week. Factors like seed maturity and storage conditions affect regeneration. Good seed years occur approximately every 3 to 5 years.

**OBTAINING NATURAL REGENERATION**

Sal trees are naturally grown across a vast expanse from Punjab to the Assam Valley (above the Tropic of Cancer), and each region has its own specific local issues. Therefore, it is not possible to make a general observation




In *hilly and plain areas*, regeneration is satisfactory, but in *Tarai-bhabhar* region and *alluvial plains*, natural regeneration is challenging. Recommended operations to support natural regeneration include

- Conducting **control burning** before a good seed year to clean the surface and creating hygiene.
- **Soil working** before the seed falls + Slash disposal + Fumigation
- **Fencing** the regeneration area with deer-proof fencing.
- **Repeating weeding & Shrub cutting** : annually for the first 3-4 years, preferably during rains,
- Avoiding seeding felling in normally thinned mature stands with existing canopy gaps. Gradually remove the **top canopy** in at least in 2-3 stages.
- **Middle story** : Heavily thinning dense foliage trees (*e.g., Mallotus philippensis, Kydia calycina, Syzygium cumini*), retaining only light-crowned species.
-

**Similar Question**

Discuss the *natural regeneration* in Sal, give *steps recommended* for ensuring its successful regeneration [IFoS 2014; Paper – 1/Q5 (a); 8 M].

**Note**: In the original paper, there is a typo where "*Soil*" was used instead of "*Sal*"

Explain the following [IFoS 2023; Paper – 1/Q4 (c); 15 M].

(*i*) Lignotuber
(*ii*) Root sucker
(*iii*) Vermiculite
(*iv*) Buttresses
(*v*) Ortet and Ramet

*Approach*

**Understand the question** – In such types of questions, we need to follow 4 things :

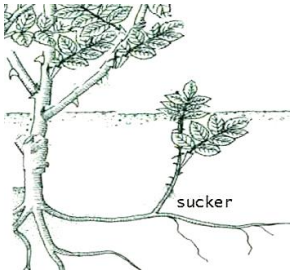
① Explain the key term,
② Provide examples,
③ Discuss its importance; and
④ Draw a neat and clean diagram.

It is optional to write further about its types, in case you are unable to complete the other given sub-questions and want to use the available space and time to avoid losing marks.

(i) **Lignotuber** : It is a woody, underground *starchy swelling* found at the stem base or root crown of some plant species. It contains a reserve of nutrients and dormant buds that allows the plant to regrow after damage, such as wildfire or severe weather, *i.e.*, in *Eucalyptus*.

**Importance** : helps the plant survive adverse conditions by protecting its regenerative capacity underground.

(ii) **Root sucker** : These are the *new shoots that arise from the superficial roots* of the parent plant, *e.g.*, *Dalbergia sissoo*, *Diospyros melanoxylon*, etc.,




**Importance** : It helps the plant to reproduce asexually. This is crucial for species that thrive in areas prone to disturbances like wildfire, severe insect/pest attacks, or any climatic adversaries.

(iii) **Vermiculite** : It is a *hydrous magnesium iron silicate mineral*. It is characterized by its platy structure and its ability to *expand significantly when heated* (called *exfoliation*). This expansion property is due to the presence of water molecules between the mineral's layers.

**Importance** : In Forest nurseries, used in soil mixes to improve aeration, water retention and nutrient availability. Often blended with soil, or compost to create a lightweight growing medium.

**Animal Care** : It is also utilized as a bedding material for reptiles and insects because of its moisture-retention properties.

(iv) **Buttresses** : They are the large, flat triangular plates of wood at the base of the tree's trunk, usually vertical, and connect the base of the stem with roots more strongly.

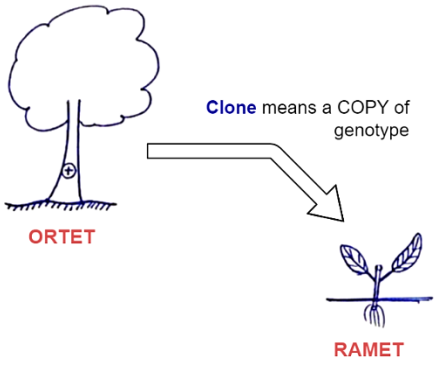
**Example** : Common in tropical rainforest trees, *i.e.*, *Bombax ceiba (Red silk cotton), Pterocarpus marsupium, Artocarpus heterophyllus (Jackfruit or Kathal), Terminalia myriocarpa,* etc.

**Importance** : Provide additional support to the tree's trunk, prevent it from toppling over in strong winds or heavy rains, particularly in regions with shallow soil or high water table.

(v) **Ortet and Ramet** :

- **Ortet** : This is the original plant from which clones are derived. It serves as the genetic source for vegetative propagation.
- **Ramet** : A ramet is an individual clone derived from the ortet.

**Importance** : Ramets ensure genetic uniformity that desirable for the production of



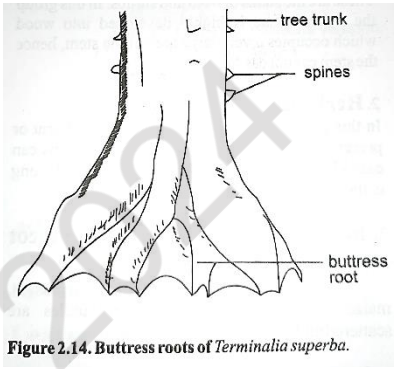



**Figure 2.14. Buttress roots of** *Terminalia superba.*

Discuss the significance of *exotics* in tree improvement. Name four exotic tree species
[*Linked Q* | IFoS 2023; Paper – 1/Q5 (b); 8 M].

*Approach*

1. **Understand the question** – The question consists of three parts : ① Exotics : Definition, ② *Significance in tree improvement*, and ③ 4 examples with source of origin.
2. **Introduction** : Define exotics with explanation
3. **Main Body** : Significance in tree improvement (Covering at least ½ writing space) + 4 examples with a diagram showing source of origin (Country).
4. **Conclusion :** any recent examples with precautionary note.

Exotics are the species that are not native to a particular region or ecosystem but have been introduced from other geographical areas, either deliberately or accidentally, *i.e.*, *Casuarina equisetifolia* introduced from Indonesia.

**Significance**

Our Current tree improvement programs are more focusing on integrating exotic species' genotypes with local ones to enhance various ecological and economic outcomes

- **Increase productivity of Indian forest** : Certain genotype of Eucalyptus, poplar, sea-buck thorn, Teak, etc. are used t to improve growth rates, biomass production, and overall forest yield. These hybrids are productive, fast growing, climatically resilient, and having better carbon capturing efficiency.
- **Developing new species for industrial needs** : **Beema Bamboo**, a sterile, pest-resistant, thornless clone of *Bambusa balcooa*), are developed specifically for biofuel and charcoal industries. Similarly,

**Bankia**, a thornless variety of *Acacia nilotica*, is used for timber. These species are selected and improved upon for their desirable traits, like rapid growth, resistance to disease, and higher yields. **Bankia** are also gaining popularity for landscaping and green spaces due to their safe, attractive appearance and rapid growth.

- **Wider Species Selection**: Exotic species provide foresters with a broader palette of trees adapted to specific conditions, especially when suitable indigenous species are lacking. For example, some exotic trees may be more drought-resistant or tolerant of degraded soils, making them invaluable in regions facing environmental stress.
- **Shared Research and Development**: Introducing exotic species enables countries to share and apply global research in tree improvement, speeding up advancements in forestry science
- **Fewer Natural Pests** : Since exotic species are new to the ecosystem, they often have no any local pests and diseases compared to native species. This can result in higher survival rates and productivity in the early stages.

*Significance in tree improvement and not advantages of exotics*



**Examples**

| SN | Species | Place of introduction | Country of origin |
|---|---|---|---|
| 1 | *Acacia auriculiformis* | North Indian plain | Australia |
| 2 | *Acacia tortilis* | Dry area of Rajasthan (jodhpur) | Israel |
| 3 | *Casuarina equisetifolia* | Mainly coastal areas | Indonesia - Australia |
| 4 | *Cinnamomum camphora* | South India (KR-KN-TN) | China - Japan |
| 5 | *Cryptomeria japonica* | Darjeeling region | Japan |
| 6 | *E. globulus* | Nilgiri | Australia |
| 7 | *E. tereticornis* | Pan India | Australia |
| 8 | *Hevea brasiliensis* | KR - TN | Brazil |
| 9 | *Populus deltoides* | Tarai region | North America |
| 10 | *Prosopis juliflora* | Central India | Mexico |

*if possible, show them through a graph*

**Linked Questions**

- Are non-native tree species an *Option* or a *Threat* in forest ecosystem / Plantation under climate change?
  [IFoS 2021; Paper – 1/Q1 (d); 8 M].
- Write the *problems* and *prospects* of exotic tree species in India with suitable examples
  [IFoS 2018; Paper – 1/Q3 (c); 15 M].
- What are the exotic species? Briefly describe the *advantages* and *problems associated* with exotic forestry?
  [IFoS 2000; 15 M | Karnataka PCS (RFO) 2007, 2011].

The introduction of non-native tree species into forest ecosystems, especially under the backdrop of climate change, is a complex issue with both potential benefits and risks. While they can offer certain advantages, they also pose significant threats to biodiversity and ecosystem stability.

**Potential Benefits of Non-Native Tree species**

- ***Climate Resilience*** : Some non-native species, like *Prosopis juliflora*, perform better under dry, rugged conditions and high biotic pressure in the Chambal ravines compared to native species. This is making forests in these areas more resilient to the impacts of climate change.
- ***Carbon Sequestration*** : Fast-growing species like *Casuarina*, *Eucalyptus*, etc. effectively fixed more carbon = helps in achieving 2.5 to 3 billion ton Intended Nationally Determined Contributions (INDC).
- Enrichment plantations of fast-growing and high-quality species increase the ***productivity & yield of our degraded forests***.
- Exotics ***provide a much wider choice of species*** suited to specific site conditions and industrial requirements, especially when no suitable indigenous species are available (e.g., *Casuarina* for coastal afforestation, *Hippophae* (Sea-buckthorn) for cold desert afforestation).
- Some may ***perform well in exotic land*** than their natural habitat due to the absence of pests & diseases outside of their natural habitat, at least for some rotation, *i.e.*, The leaf-eating insect in *Eucalyptus* species is quite common in Australia, whereas in India, it is absent.
- ***Research and development from one country*** can be shared and utilized by other countries, e.g., Israel's research on *Acacia tortilis* for afforestation in the Aravali region.
- It can also help to meet the immediate requirements of our industry, *e.g.*, *Eucalyptus*, and *Poplar* for paper production, *Hevea brasiliensis* for rubber production, etc.

**Threats of Non-Native Species**

- ***Obnoxious Potential*** : They are considered *ecologically less valuable* and often *outcompete native species* for resources such as water, nutrients, and light. This can ***disrupt local ecosystems***, ***reduce biodiversity***, and alter ecosystem functions like nutrient cycling and water regulation.

  Example : In 2022, the Madras High Court issued rulings regarding the removal of *Prosopis juliflora* around water bodies due to its invasive nature, as the species aggressively competes with native plants and disrupts the environmental balance.

- **Degrading Water table and Soil Health** : Exotic species like Eucalyptus not only consume more water than native species but also cause allelopathy and degrade soil health. For instance, a standard *Eucalyptus* tree requires 200 liters of water per day.
- **Creating annoying** : The Gujarat Forest Department has recently banned the planting of exotic *Conocarpus trees* across all areas, including forests, nurseries, and non-forest zones. Once used for ornamental purposes in cities, these trees are now known to cause cough, asthma, and allergies. Additionally, they serve no benefit to local wildlife and can damage telecom, water, and sewer lines. Russian poplar is causing allergies in the Kashmir Valley.
- Exotics may introduce new pests and diseases that can harm native forests.
- They often become susceptible to *local insect pests*, *i.e.*, pink disease in Eucalyptus spp.

- **Genetic Pollution** : Crossbreeding between non-native and native species may occur, potentially diluting the genetic diversity of native species. This can reduce the native species' ability to adapt to changing environmental conditions.
- ***Unable to produce viable seed***, Eucalyptus has remained incapable of producing viable seeds outside of the Nilgiris even after more than 200 years of introduction.
- *Introduction & acclimatization process took a long time* and may not serve the purpose of immediate needs.
- The health issue of Russian poplar in J&K, *Prosopis cineraria* in Telangana.

***Conclusion*** : Use term *Carbon credit* + *INDC* + *Carbon sequestration potential* + increasing *productivity of Indian forest* + making them *climatically resilient*.

*Linked* Questions

- What are the different factors governing the successful introduction of an exotic tree species? [IFoS 2020; Paper – 1/Q6 (c); 10 M | Karnataka PSC (ACF/RFO) 2015].
- Explain in details norms to be followed while introducing exotic tree species. Outline and explain the steps to be considered for the introduction of exotic species [IFoS 2008; Paper – 1/Q8 (a); 20 M].

Exotics are non-native tree species growing outside their natural habitats. Their successful introduction into a new habitat is largely influenced by a variety of biological, ecological, and human-related factors.

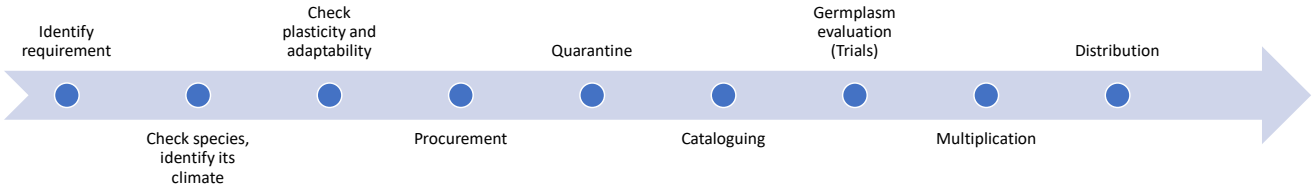
## FACTORS GOVERNING THE INTRODUCTION OF EXOTICS

- **Climatic Compatibility & Economic Importance** : Exotics are chosen only after establishing their economic importance and determining if they can thrive in the local climate, e.g., *Hevea brasiliensis* for rubber production in Kerala.
- **Invasive potential** : Some exotic species exhibit aggressive growth, lack natural predators, and adapt easily, making them hard to control. Once established, they can disrupt native ecosystems, harm biodiversity, and cause ecological imbalances.
- **Ecological Adaptability** : Exotic species can impact local ecosystems by affecting soil, water, and nutrient cycling. Examples include the poplar in Kashmir causing pollen allergies and Conocarpus in Gujarat impacting locals health and environments.
- **Technical challenges** : Exotics also requires advanced technical skills to manage and control their production and potential negative effects.
- **Economic Considerations** : The availability of funds and economic feasibility plays a crucial role. If growing certain species like junipers (for the pencil industry) is not economically viable, industries may prefer importing them instead.
- **Aesthetic Value** : Many exotic species are introduced for their ornamental value, such as unique flowers or foliage, enhancing the visual appeal of gardens, parks, and landscapes.

## INTRODUCTION STEPS

- *Identify climatic* and other locality site factors as well as *Homo climes* or *iso climes* in the world.

- *Check the Plasticity & adaptability* of the targeted species into the wide ranges of periodic environmental stresses, *e.g.*, *Eucalyptus cameldulensis* can grow in the semi-arid region, whereas Eucalyptus Globulus in normal mesophytic conditions. So, they require almost similar silvicultural operation and management practices.




- *Procurement of germplasm* : by Gift / Purchase / Collection
- *Quarantine* : Keep material isolated to prevent disease spreading / Fumigation / other necessary treatments.
- *Cataloguing*: Name, Place of origin, Features, etc.
- *Germplasm Evaluation* & *Preliminary trials* in the arboretum for its performance in the local environment, seed viability, its physical & mechanical properties and to identify its obnoxious or harmful effect on the local environment, if any.
- *Multiplication* & *Distribution*.

**Linked Questions**

- Discuss the reasons for widespread use of exotics for plantations and specific advantages of exotics over native species (8m) [IFoS 2016 | ~~Paper – 1/Q1 (b)~~ | 8 M]. [*Also in*, OPSC Civil (Main) 2018 | 20 m].
- Plantation forestry in India is based on exotics. Justify your views with suitable examples [OPSC Civil (M) 2017 | 20m].

Plantation forestry in India relies heavily on exotic species due to their fast *growth rates*, *economic value*, and *adaptability to local conditions*. These exotics have played a critical role in meeting the country's increasing demand for timber, paper, and other forest products.

*Example*

- **Eucalyptus** : Introduced from Australia, for pulp, paper, and timber industries because of their fast-growing nature makes them ideal for commercial plantations. However, they have been criticized for depleting groundwater.
- ***Hevea brasiliensis*** (Rubber tree) is extensively planted in Kerala for rubber production. The favourable tropical climate in Kerala allows for its successful growth, making it a cornerstone of India's rubber industry.
- **Poplar (Populus deltoides)** : Widely planted in northern India, particularly in Punjab and Haryana, poplar is used in the plywood and paper industries.

**Widespread use of exotics because**

- **Economic consideration** : They may have *faster growth rates*, *higher yields*, or *desirable qualities* such as disease resistance or tolerance to specific environmental conditions, making them highly suitable for commercial plantations.

- Cater to expanding *market demands for specific products*.
- *Ability to thrive in diverse environments* : This adaptability can help mitigate risks associated with uncertain growing conditions and provide more consistent yields.
- *Genetic diversity* : Ensures resilience and adaptability to changing environmental conditions or disease pressures.

**Similar Question**

- Comments upon - Exotics in Indian Forestry [IFoS 2012; 5 M | UKPSC (RFO) 2015; OPSC Civil (Main) 2018].
- What are the relative merits of indigenous species and exotic species [Arunachal PSC Civil (mains) 2015-16]
- Write the botanical names of five exotic trees along with their country of origin [MHPSC (ACF) 2012; 10 m]

What are *biofertilizers* ? Enlist the *factors associated with the mycorrhizal development* in trees. Discuss the *types of mycorrhizae* [IFoS 2023; Paper – 1/Q8 (a) | 15 M].

*Approach*

1. **Understand the question** – The question consists of three parts : (1) Biofertilizers: Definition and explanation, (2) Mycorrhizal Development in soil: Factors influencing it, and (3) Types of Mycorrhizae : Classification with characteristics.
2. **Introduction** : Briefly define biofertilizers and their types.
3. **Main Body** : Discuss the various factors influencing mycorrhizal development, including abiotic factors (soil properties, temperature, moisture) and biotic factors (plant species, microbial community).

   **Types of Mycorrhizae** : Classify into Ecto, Endo, and Ecto-endo mycorrhiza with their short explanation and diagrams.
4. **Conclusion :** Role of mycorrhiza in forest development.

*Biofertilizers* or *Microbial inoculants* - are the artificially developed *culture of useful microorganisms* of soil and plant origin, which inoculants to the roots of seedling nursery beds or plantation sites, *i.e.*, Rhizobium.

**TYPES OF BIOFERTILIZERS** (in very short)

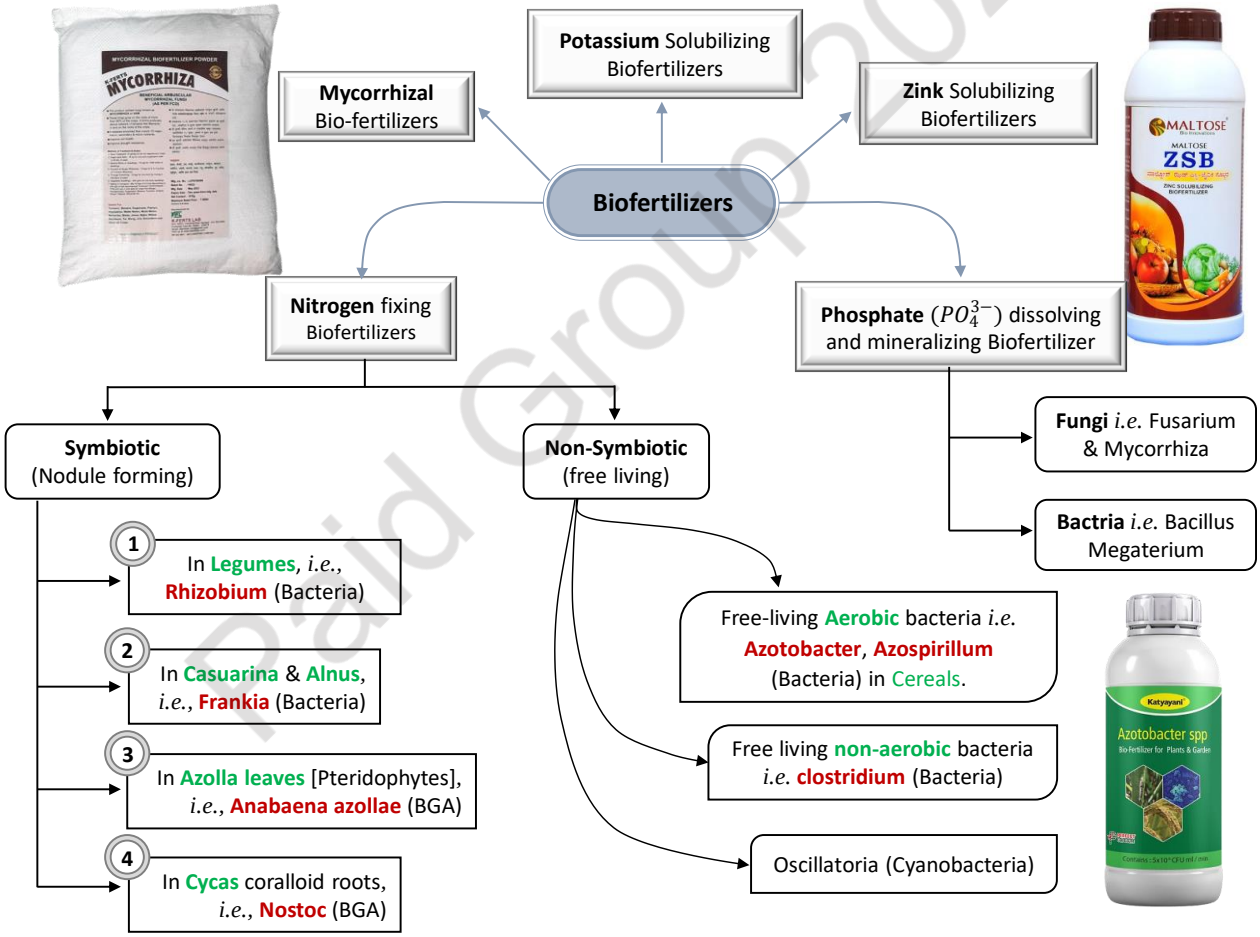
Flowchart given on next page (Space constrain)

**FACTORS ASSOCIATED WITH THE MYCORRHIZAL DEVELOPMENT**

Mycorrhizal development is influenced by a range of factors, both environmental and biological.

- **Climatic factors**
  - Adequate moisture and moderate temperatures favour mycorrhizal development.
  - Increased temperatures and altered precipitation patterns, potentially from climate change, may affect the ability of mycorrhizal fungi to form relationships with plants.
- **Edaphic factors**
  - Soil pH : Slightly acidic to neutral pH levels are generally more conducive to mycorrhizal development.
  - Soil Texture : Sandy soils, due to better aeration, often support better fungal growth.
  - Organic Matter : High levels of organic matter can improve fungal colonization and growth.
  - Application of substances like pesticides, herbicides, compost, and biochar can either enhance or suppress mycorrhizal colonization depending on the chemical composition and application frequency.

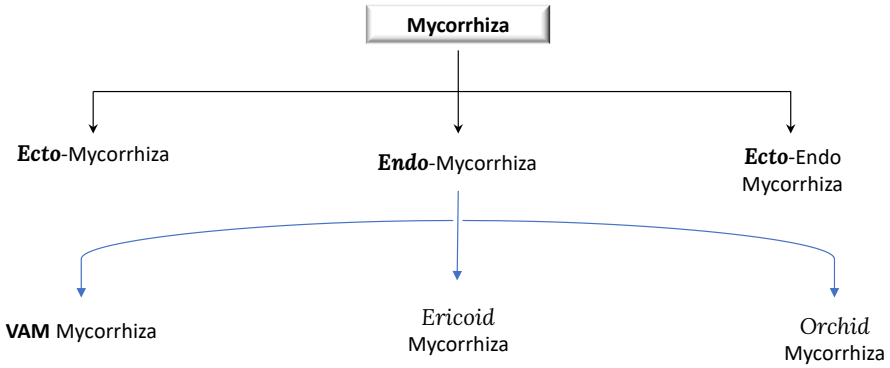
- **Biotic factors**
  - The abundance of mycorrhizal fungal spores in the soil is essential for colonization. Areas with poor spore presence may see reduced mycorrhizal development.
  - Plant Species : Different plant species vary in their compatibility with mycorrhizal fungi. Some are obligate mycorrhizal (requiring fungi to thrive).
  - Human Activities : Land-use changes (deforestation, urbanization) and agricultural practices (monoculture, overgrazing) can disrupt mycorrhizal communities.
- **Plant Genotype** : Some plants are more receptive to mycorrhizal associations than others
- **Socio-Economic factors**
  - Availability of funding and resources for sustainable or organic farming can influence the implementation of practices that support mycorrhizal development.
  - Government policies and incentives related to organic farming, conservation, and land management also play a role in promoting or hindering these symbiotic relationships






**TYPES OF MYCORRHIZAE**

Mycorrhiza is the *symbiotic* relationship between *fungi and higher plants* (*Myco = Fungi* + *Rhiza = Rhizome = Roots*). Here, fungi are composed of fine, tubular filaments called *Hyphae* make a network around the root)

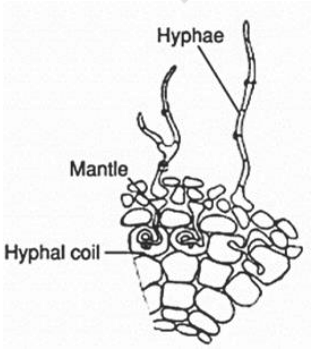



- **Ecto-Mycorrhiza** : Under this, fungal mycelium forms a thick ***mantle sheath*** around the lateral roots, and some *mycelia penetrate between the cortical cells, surrounding them* by forming a network of hyphae called the ***Hartig net***.
  - Fungal partners : ***Ascomycetes*** & ***Basidiomycetes***.
  - Higher plants : *Pinus roxburghii* (*Chir-Pine)*, Cedrus deodara (*Deodar)*, Abies pindrow (Silver-Fir), *Salix alba (Salix)*, *Casuarina equisetifolia (Beefwood)*, and *Eucalyptus etc*.

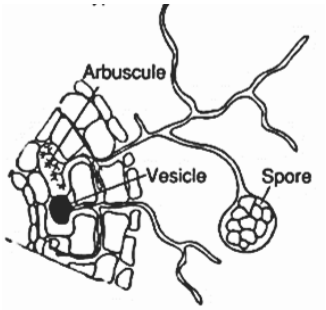
- **Endo-Mycorrhiza** : under this, Fungal hyphae entered the cell and ***established direct contact with the cortex cells' cytoplasm***. As they established direct contact, there is no need to form a *Herting net* or *fungal Mantle*.
  - *Most common types of mycorrhiza* and reported in almost 90% of herbaceous and woody plants

***Types***

- Vesicular-Arbuscular (VAM) Mycorrhiza : A type of association in which the ***Phycomycetes*** fungal hyphae form tree-like structures called ***arbuscules*** and globular structures called ***vesicles*** inside the cortical cells, to facilitating direct nutrient exchange between the hyphae and the plant, primarily for *phosphorus*.
- Ericoid Mycorrhiza : A relationship between ***Ascomycete*** fungi and plants in the ***Ericaceae*** family (such as blueberries and cranberries), distinguished by the formation of unique ***hyphal coils*** within root cells during establishment of connections with the plants.
- Orchid Mycorrhiza : A symbiotic association between ***orchids*** and ***Basidiomycete*** fungi, characterized by the formation of dense coils, known as pelotons, within the cortical cells.

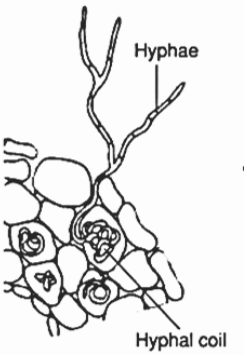



Arbutoid mycorrhiza



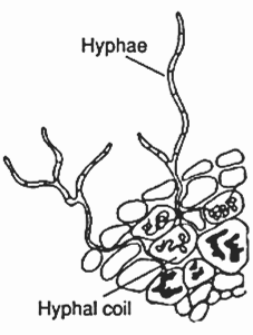

VAM Mycorrhiza

***Phycomycetes*** fungal




Ericoid Mycorrhiza

Cranberries and ***Ascomycete*** fungi.




Orchid Mycorrhiza

***orchids*** and ***Basidiomycete*** fungi

- **Ecto-Endo-Mycorrhiza (*Arbutoid mycorrhiza*)** : An association in which basidiomycetes' fungal hyphae not only form a metal sheath and Hartig net but their hyphae also enter the intracellular space of cortical cells and form coiled structure to establish a direct connection, *e.g.*, Beech and Pinus contorta (Lodgepole pine).

**Similar Question**

- Explain the *role of mycorrhizae* in plant growth and development of forest trees [IFoS 2022; Paper – 1/Q7 (b) | 10 M].
- Discuss in detail, the soil *kind of mycorrhiza* and the *benefits derived by the plant* from them [IFoS 2017; Paper – 1/Q5 (b) | 8 M].
- Difference between *Ectomycorrhizae* and *Endomycorrhizae* [IFoS 2014; Paper – 1/Q5 (d)(i) | 4 M]; [IFoS 2012; Paper – 1/Q3 (a)(v) | 4 M].
- write a note on the '*role of microorganism* and *rhizobium* in *amelioration of forest soils* [IFoS 2013; Paper – 1/Q6 (c) | 10 M].
- Differentiate between ***Ectomycorrhizae*** and ***endomycorrhizae*** with respect to structure and function [IFoS 2011; Paper – 1/Q7 (b) | 10 M].

# SILVICULTURE
## (2022)

**IFoS 2022** : What is *precision silviculture*? Explain the silvicultural techniques for the following. [Paper – 1 | 15 m] – (a) *Dalbergia Sissoo*, (b) *Eucalyptus tereticornis*

**Approach** : (1) Introduction – a few lines about *precision silviculture*.

(2) Draw a flowchart about its importance in the forest and wildlife sector [Points 1 & 2 should cover about 1/3 of the answer area].

(3) Write down the Silvicultural techniques of *Dalbergia sissoo* and *Eucalyptus tereticornis* with at least a figure [Cover about 2/3 area of your answer].

Precision silviculture means that *every variable in the tree farming system*, such as site preparation, identification of suitable tree species, the number of seedlings planted per unit area, quality of the planting material used, control of surrounding vegetation, fertilization, etc., is precisely matched to a site's soil and weather conditions (*site-specific silvicultural prescriptions*) with *modern digital techniques*. This approach improves operational efficiency and promotes sustainable extraction of forest produce.

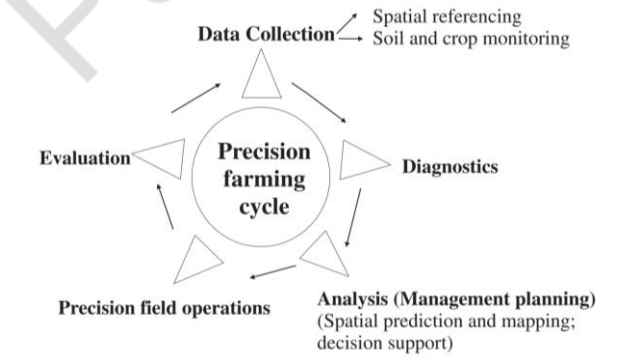



**Figure** : Precision farming cycle and its components

Precision silviculture ensures the following –

- Selecting and planting the appropriate tree species based on the unique characteristics of each site, leading to improved survival

***Precision Farming***, or ***Precision Agriculture***, or *Information – intensive agriculture*, or *Prescription farming*, or *Target farming*, or *Site-specific crop management*

*Precision Farming* is a holistic and environmentally friendly strategy in which farmers can vary input use and cultivation methods – Including application of seeds, fertilisers, pesticides, and water, variety selection, planting, tillage, and harvesting — to match varying soil and crop conditions across a field.

Farmers employ GPS technology, which integrates satellite and ground sensors, along with sophisticated information management and field operation tools. This enables them to comprehensively comprehend and efficiently manage soil and landscape resources. As a result, cropping inputs such as fertilisers, water, and other resources are applied with greater precision, moving beyond conventional "one-fits-all" approaches and leading to a substantial increase in crop production.

rates of seedlings.

- Variable rate application of nutrient supplements, herbicides, and pesticides, based on site-specific needs and guided by GPS.
- Regularly monitoring the health of trees in a timely manner.
- Automating site operations to enhance efficiency.
- Conducting forest valuation and tracking wood during transport.
- Utilizing spatial data on tree growth, yield, and environmental conditions to develop growth and yield models for future management strategies.

## DALBERGIA SISSOO

*Shisham* is a *medium size*, *deciduous tree* with a *relatively well-developed crown* and *dimorphous root system* (both horizontal and vertical roots). *Pan India distribution* except in temperate and alpine climates.

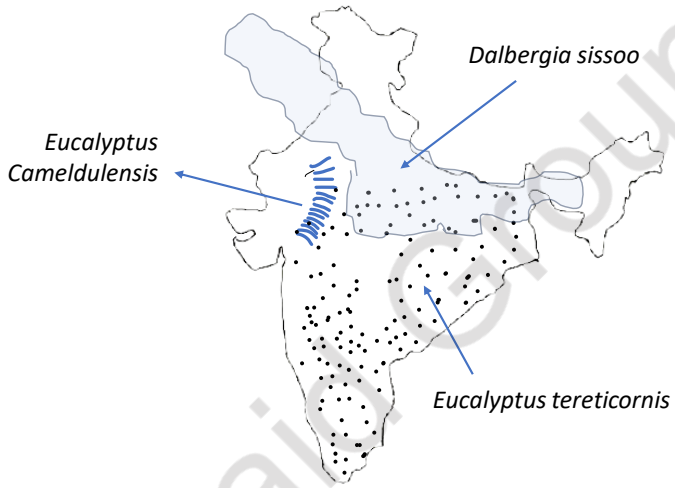



**Figure** : *Dalbergia sissoo* natural distribution range and artificial plantation of *Eucalyptus tereticornis*

Silvicultural techniques for supplementing natural regeneration or plantation projects

- *Site Selection* : Opt for well-drained loamy and alluvial soils.
- Regeneration : (a) gather seeds from healthy mature trees between February and March for *artificial regeneration*. Plant them in containers with appropriate nutrients, moisture, shade, and protection. Stump planting is also commonly practised. (b) Encourage *natural regeneration* by damaging roots (root suckers) and inducing coppice formation.
- *Planting* : Typically carried out in linear or square patterns during the rainy season.

### PRECISION FORESTRY?

Precision forestry is defined as planning and conducting site-specific Forest management activities and operations to improve wood product quality and utilisation, reduce waste, increase profits and maintain the quality of the environment.

Precision forestry is analysing spatial and temporal variability based on natural biology and environmental resources (for instance, soil properties, topography, soil moisture content, microclimate, outbreak of diseases and insect pests etc.). This information is used to plan and conduct site-specific forest management operations to minimise forest outputs. Now precision forestry is used in almost every aspect of forestry production, from soil management to yield modelling.

This question pertains to *Silviculture techniques*. In other words, we need to discuss how to apply different methods of Silviculture, from site preparation, regeneration, and tending operations to harvesting, rather than focusing on the properties of Silviculture properties that we study in the Silviculture system topic.

- *Tending & Pruning* : *Dalbergia sissoo* is a light-demanding species. Light pruning is necessary to promote straight stem growth.
- *Pest Management* : Control *Plecopera reflexa* using gunny bag traps.

**EUCALYPTUS TERETICORNIS**

Eucalyptus tereticornis is a tall *evergreen tree* that is native to Australia. It requires direct overhead light for proper growth. This tree is found throughout India, except in alpine and arid regions. It has two cycles of flowering and fruiting annually. Since it is an evergreen, Eucalyptus tereticornis sheds and renews its leaves throughout the year.

- Regeneration : through seed and coppice
- Tending operations :

**IFoS 2022** : How do *Sacred groves* help in the conservation of biodiversity? [Paper – 1 | 8 m]

**Approach** : (1) Introduction – what are *Sacred groves*?
(2) Draw a diagram/figure
(3) Its role in the Biodiversity Conservation
(4) Conclusion : Regarding climate change and current policies

***Sacred Groves*** are forest patches that are owned, protected and managed by the *rural communities* as abodes of specific deities, *i.e.,* The Gompa forest in Arunachal Pradesh.

- It is our ancient tradition of nature conservation.
- Hunting and logging are usually strictly prohibited within these patches

Role in forest and wildlife conservation are –

- It *serves as a haven* for a diverse range of plant and animal species. They act as an undisturbed habitat for the native flora and fauna, including endangered and rare species.
- It acts as a *natural buffer*. Protecting the surrounding forest ecosystem from encroachments, logging, and other forms of human disturbance [**Ecosystem Conservation**]
- Sacred groves act as *natural watersheds*, helping to regulate water flow and prevent soil erosion. Preserving these groves helps maintain local microclimates, nutrient cycling, and overall *ecosystem stability*.

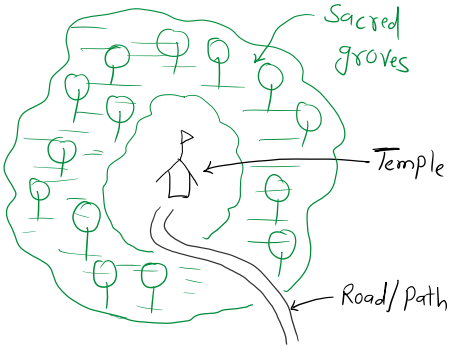



*Figure* : A Sacred grove

**CHALLENGES IN ITS CONSERVATION**

- Lack of recognition & legal status
- Increasing people's apathy
- Increasing plastic and chemical pollution
- Climate change impact

- Often harbour ancient and rare species of plants and trees, including those with unique genetic traits [**Genetic Preservation**]
- It holds immense ***cultural and spiritual importance*** for the communities that consider them sacred. These groves are often associated with religious, cultural, rituals, and traditional medicine practices.
- It also serves as an *outdoor classroom* for learning about biodiversity, forest ecology, and traditional ecological knowledge [**Education and Awareness**].

With the recognition of sacred groves as unhindered carbon capturing and watershed recharge units, the government has begun promoting and safeguarding them under 'community reserves' as per the Wildlife (Protection) Amendment Act, 2002.

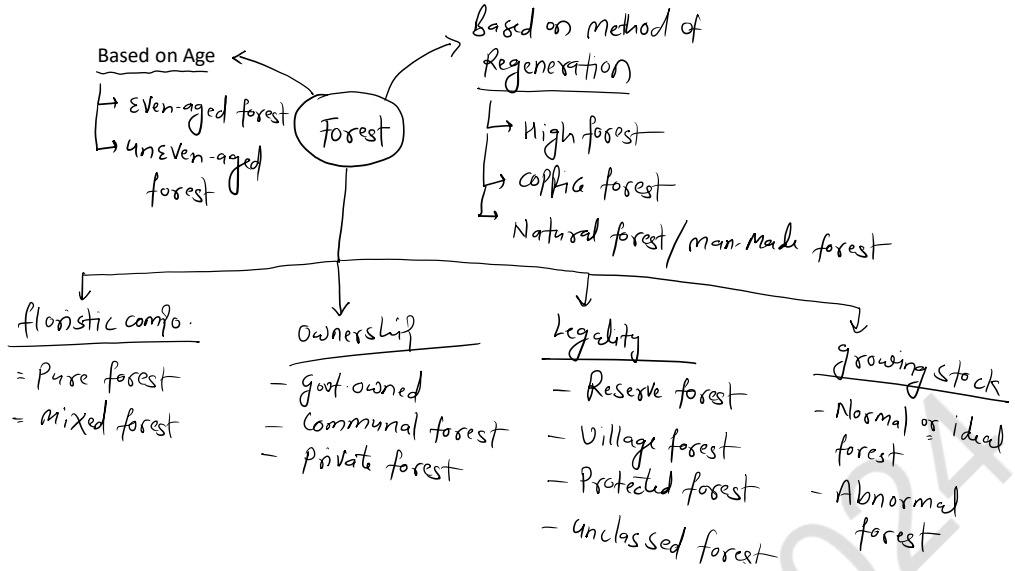
**IFoS 2022** : What is the *purpose of classifying forests* ? How are the forests classified for silvicultural management? [**Paper – 2** | 8 m].

**Approach** : (1) Introduction – Purpose?
(2) Flow chart : few other classification (In very short, Optional)
(3) Purpose of classification

Purpose / objectives of classifying forest can include

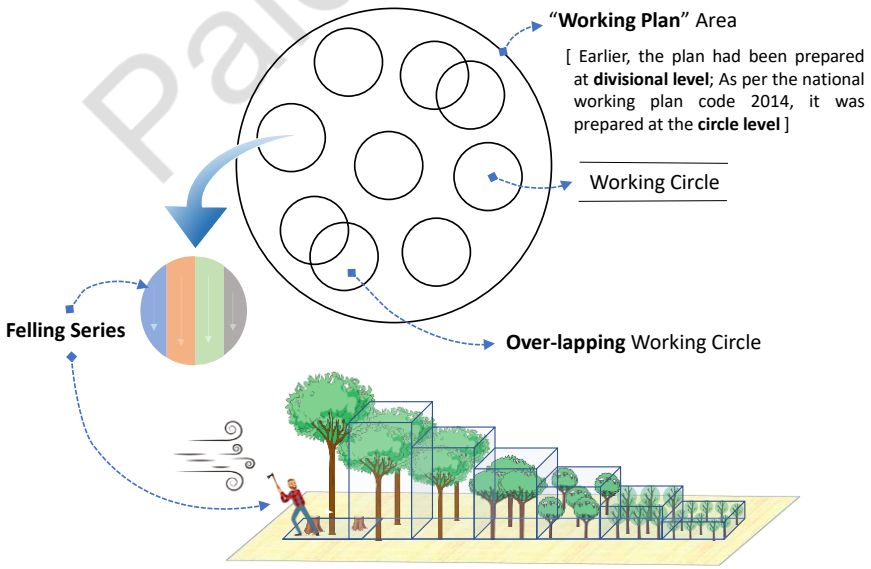
- To provide a *standardized system for identifying, describing,* and *mapping* different types of forests based on their characteristics, such as tree species composition, canopy structure, and ecological function. This information can be used in decision making process related with *conservation*, *management*, *administration*, *research*, *land-use planning* and *record-keeping*.
- Identifying the *areas of high biodiversity* or *ecological significance* for conservation and sustainable management.
- *Developing sustainable management plans* : By understanding the characteristics of different forest types, managers can develop plans that are tailored to the specific needs of the forest ecosystem.

**FOREST CLASSIFICATION ON VARIOUS BASIS (FLOW CHART)**




From the point of view of Silvicultural management, forests are classified into – (a) Working circle, (b) Felling series, (c) Cutting section, (d) Coupes, (e) Periodic blocks.

- **Working Circle** : The forest management unit is a **working plan**, which is prepared at the Forest Division level. As the area covered by the Working Plan is often large and heterogeneous in sites conditions and crop compositions, different silvicultural treatments may have to be given to the different parts of Working Plan area, and different working rules, called prescriptions are created for each part. Such parts are known as **Working Circles** (W.C).



- **Felling series** : When working circle areas are diverse, we usually divide them into several **felling series** to ensure efficient and effective control and distribution of work (silvicultural treatments) in different areas, as well as preserving the socio-economic interests of tribals, the eco-system, and sustainable yield.
- **Coupe** : in clear-felling system, a Felling series is divided into a number of Annual coupes (Annual felling areas), equal to the number of years in the rotation
- **Cutting section** : Sometimes it may be desirable to avoid fellings in contiguous coupes in successive years for silvicultural considerations, such as danger from fire and/or insect attack. In such cases, a felling series is divided into a number of cutting sections

**IFoS 2022** : Explain the silvicultural practices that help in the *modification of site factors* in forestry [Paper – 1 | 15 m]

**Approach** : (1) Introduction – about site / locality factors?
(2) why necessary to modify
(3) Silvicultural practices that use as a tool in modifying these locality factors

*Site* or *locality* or *Habitat* factors are the sum of all effective climatic, edaphic, topographic, and biotic conditions of a particular area where a plant community lives. This means Site factors are all biotic and abiotic factors of an area that interact and influence vegetation occurrence, distribution, and growth.

*Modifying habitat factors* can be done for different reasons, such as preventing habitat degradation, supporting regeneration and growth of local vegetation, increasing production and productivity from a unit area, helping animals adapt to their environment, or restoring ecosystem functions.

*Silvicultural practices that are used as a tool for habitat modification*

- *Site Preparation* : Altering soil conditions involves tasks like levelling, tilling, weeding, and clearing the planting area. This includes removing gravel, incorporating Bio-fertilizers (FYM), and managing the watershed.
- Using the availability of *light as a tool* to regulate the decomposition of organic matter, promote the growth of new crops, and secondary growth and check weed growth.
- *Cultural operations like Weeding, cleaning and climber cutting* are used for cleaning the surface area, removing undesirable and poor-performing species, problematic lianas, vines and climbers. Additionally, this practice

reduces the risk of potential outbreaks resulting from diseases or pest infestations.

- *Girdling of unwanted growth*
- *Mulching* : A layer of material spread over the soil's surface is known as mulch. Mulch serves various purposes, such as preserving soil moisture (to decrease runoff and evaporation), controlling weed growth, offering thermal insulation to the soil, and enhancing soil fertility and health by promoting microbial activities.
- *Fencing* : preventing damaging agencies from entering the forest area.
- *Afforestation & Enrichment plantation* : Open site with little or no vegetation is vulnerable to soil erosion and evaporation loss, thus necessitates site cover, which can be afforestation etc.
- *Fire management* : Introducing evergreen tree species along firebreaks, clearing and controlled burning of forest debris, and other fire management strategies.

**IFoS 2022** : "Success of commercial forest plantations depends on *site-specific and strategic planning*" Justify the statement [**Paper – 2** | 8m].

**Approach** : (1) Introduction – about commercial plantations?
(2) Map : Important commercial plantation areas with species name (Scientific name)
(3) Issues and challenges of these commercial plantations and site-specific planning.

Commercial forestry plantations involve the planting and growing of trees, mainly exotics, on a large scale with the primary aim of producing timber or other forest products. These production systems, characterised by high input and high output, are typically managed for profit. Their failure results in significant economic losses, in addition to socio-economic and environmental complications such as biodiversity loss, allelopathy, over-exploitation of soil resources, watershed damage, and harm to the local forest ecosystem.

*There are several key factors that directly influence the outcome of forest plantation projects.*

**IFoS 2022** : Describe the *adverse climatic factors* causing damage to forests [**Paper – 2** | 15 m].

**Approach** : (1) Introduction – about climatic factors?
(2) Types of damages caused by these factors (in detail in the figure)
(3) precautionary measures or Solutions to these factors (In short)

The climatic factors are the various weather phenomena like light, atmospheric temperature, humidity, wind, etc., prevalent in any forest locality and influence its vegetation in occurrence, distribution, and growth. Adverse climatic factors can significantly harm forests, leading to ecosystem disruptions, biodiversity loss, and Socioeconomic challenges. Some of the key adverse climatic factors that cause damage to forests include

*High temperature* :

*Frost & Snow* :

*Drought* :

*Flood* :

*Snow* :

**IFoS 2022** : What are the *biotic and abiotic stresses* on trees? Explain the responses of trees to these stresses [**Paper – 2** | 8 m].

**Approach** : (1) Introduction – about biotic and abiotic stresses
(2) A flowchart
(3) Physiological, Chemical, and morphological responses

Living (Biotic) and Non-living (abiotic) stresses are two categories of environmental factors that can affect forest vegetation.

***Biotic tresses*** : living organisms such as pests, pathogens, and other organisms that directly affect tree health.

- Insects like beetles, borers, caterpillars, and aphids can attack trees, feeding on leaves, stems, or roots and causing damage.
- Fungal, bacterial, and viral pathogens can infect trees, leading to diseases such as pink disease in Eucalyptus and teak defoliation.
- Competing vegetation, commonly referred to as weeds, can compete with trees for nutrients, water, and sunlight, potentially affecting tree growth and health.
- Larger organisms like deer, rabbits, or rodents can browse on tree foliage or bark, causing damage or hindering growth.

***Abiotic stresses*** : non-living environmental factors that can impact trees. These stresses are often related to unfavourable physical or chemical conditions. Examples include –

- Extremely high or low temperatures - can affect tree physiology and metabolism, leading to stress or damage.
- Lack of water availability - can cause drought stress in trees, impacting their ability to carry out essential functions and leading to wilting or even death in severe cases.

- Flooding - Excessive water saturation in the soil can suffocate tree roots, causing oxygen deprivation and root damage.
- Salinity - High salt levels in soil or water can be detrimental to tree health by affecting water uptake and causing toxicity symptoms.
- Poor soil quality, such as compacted soil, nutrient deficiencies, or imbalanced pH levels, can limit tree growth and Vigor.
- Pollution : Air pollution, including high levels of ozone, sulfur dioxide, or heavy metals, can negatively impact tree health and vitality

Trees have evolved various responses to cope with both biotic and abiotic stresses. These responses can be categorised into physiological, morphological, and biochemical adaptations.

➲ **Physiological Responses**

- *Sunken Stomata* to reduce water loss through transpiration.
- *Adjusting Leaf Angle* to minimize exposure to excessive sunlight, reducing the risk of overheating.
- *Altering Growth Rates* : During periods of stress, trees may adjust their growth rates by slowing down or redirecting resources to prioritize essential functions or areas of the tree that are less affected.
- *Shedding Leaves* : Trees may shed leaves prematurely in response to stress and reducing water loss.

➲ **Morphological Responses**

- *Deep Rooting* : In dry or nutrient-poor soils, trees may develop deep root systems to access water and nutrients from deeper soil layers.
- *Lateral Root* Proliferation
- *Thicker Bark* : to provide a physical barrier for protection against insect pests, pathogens, and forest fire
- *Epicormic Shoots* : After disturbances like fire or pruning, trees may produce new shoots called epicormic shoots, which can help regenerate foliage.

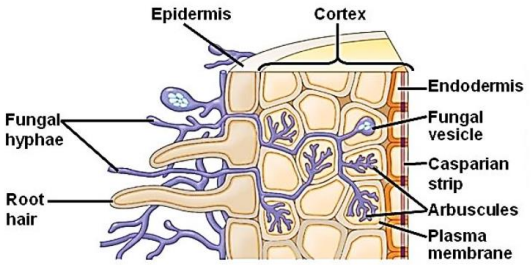
➲ **Biochemical Responses**

- *Production of Stress Proteins* : Trees synthesise specific proteins called stress proteins or heat shock proteins that help protect cells from damage caused by stress.
- *Antioxidant Production* : In response to oxidative stress caused by pollutants or other environmental factors, trees increase the production of antioxidants to counteract the harmful effects.
- *Altered Metabolic Pathways* : Trees can modify their metabolic pathways to adapt to stress conditions, enabling them to continue essential processes even under adverse circumstances.

**IFoS 2022** : Explain the *role of mycorrhizae* in plant growth and development of forest trees [Paper – 1 | 10 m].

**Approach** : (1) Introduction – about Mycorrhiza?
(2) Structure/Figure
(3) Role of mycorrhiza

*Mycorrhiza* is the symbiotic relationship between fungi and higher plants (Myco = Fungi + Rhiza = Rhizome = Roots). Mycorrhizal fungi are composed of fine, tubular filaments called *hyphae* (singular *hypha*).




**Endomycorrhizae**

Role of Mycorrhiza

- *Better absorption of soil moisture and minerals* by increasing net water absorption surface area as fungal filaments work as root hairs that also help plants for increasing *drought tolerance*.
- *Increase availability of unavailable minerals* to the plant : Some minerals become unavailable or unabsorbable, called fixation (*i.e.*, phosphate fixation), to the plant because of soil pH. Fungal hyphae release organic acids that make it in available form, so the plant can sustain itself even under harsh/unfavourable soil conditions, especially when the soils are deficient in phosphorus.
- *Nitrogen Fixation* : Some fungi also fix atmospheric nitrogen and make it available to the plant = The plant can grow in nitrogen deficit soil where other plants cannot.
- *Produce some growth hormones*, *i.e.*, Auxin, gibberellin that further boost up the plant's root & shoot growth
- *Phosphate reservoir* : Nearly 80–90 per cent of the absorbed phosphate remains in the fungal sheath. Thus, the fungal sheath may act as a reservoir of nutrients (especially phosphate) and release them as the occasion demands under adverse conditions.

**IFoS 2022** : Explain the role of mycorrhizae in plant growth and development of forest trees (10 m)

**IFoS 2017** : Discuss in detail, the kind of mycorrhiza and the benefits derived by the plant from them (8m)

**IFoS 2010** : How are Ecto-mycorrhizal fungi beneficial in managing soil born diseases of forest nurseries ? gives examples (10 m).

**IFoS 2008** : Explain Mycorrhiza and their importance in forest Nursery (10 m).

*Advantage with mycorrhizae* fungi inoculation [Karnataka PCS

- *Mycorrhiza-induced resistance* (MIR) – Mycorrhiza provides systemic protection against a wide range of attackers by inducing systemic resistance (ISR) after pathogen infection through -
    - Improvement of plant nutrient status will help plants to fight competition, and biotic - abiotic stresses.
    - Changed root morphology and structure to promote root colonization by non-pathogenic rhizobacteria & other microbial flora.
    - Decreasing space for attachment to other fungi groups, *i.e.*, dumping off fungi.
    - Inter-plant signaling : Plants Use Mycorrhizal Fungi (*hyphal networks*) to Warn each other of incoming threats through defensive proteins like Allelochemicals.

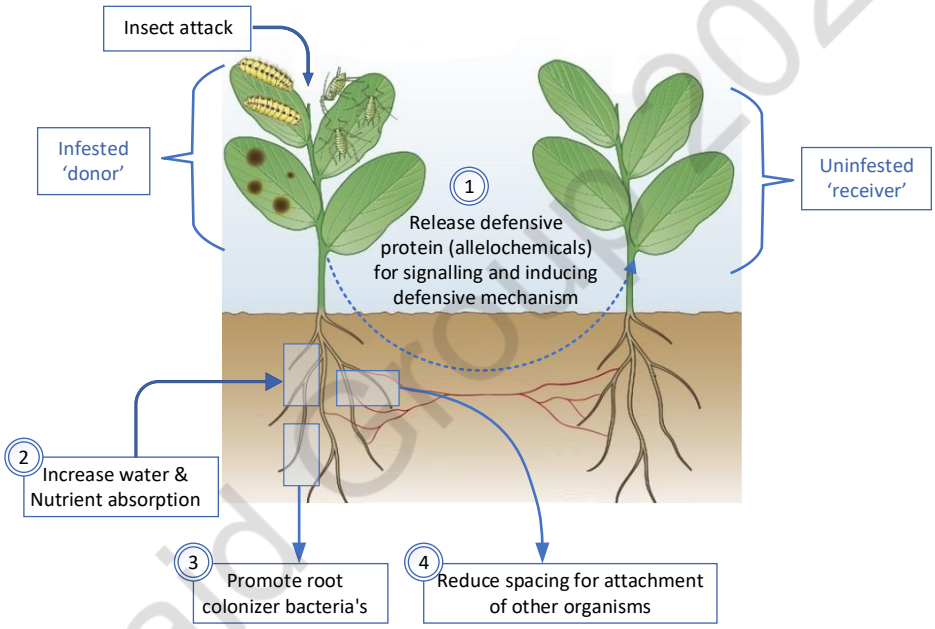



**Figure** : Role of mycorrhiza in plant's defence



**IFoS 2022** : What are *commensalism*, *Amensalism*, *Mutualism* and *symbiosis*? Write the function of an ecosystem [**Paper – 2** | 10 m]

**Approach** : (1) Introduction – about interactions and these terminologies with examples + 1 or 2 figures
(2) Function of an ecosystem

In a forest ecosystem, a plant species influences the growth, progress, and distribution of other plant species, wild animals and microbes through a variety of mechanisms.

- **Commensalism** : a type of interaction between two species where one species derives benefits such as shelter (Protection), moisture, nutrients, or



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space (light), while the other remains unaffected in terms of harm or benefit, *e.g.*, Orchid

- **Amensalism** : is the interaction between two different species, in which one species is harmed, and the other is neither benefitted nor harmed, *e.g.*, Eucalyptus causing Allelopathy to the wheat food crop.
- **Mutualism** : a type of symbiosis where both species involved benefit from their interaction, leading to advantages for their survival or reproduction. If they are separated from each other, then they will not die
- **Symbiosis** : involves a close interaction between two distinct species residing in close proximity. Lichen is a symbiotic association between an alga and a fungi. Both of these live together for their mutual benefit. Within this interaction, the fungus retains water, offers protection, and serves as a suitable habitat for the algae. In return, the alga provides the fungus with carbohydrate nourishment. Moreover, the algae have the ability to convert atmospheric nitrogen into a usable form, which they supply to the fungus. This kind of mutual interdependence helps lichens to grow on dry, barren rocks where other plants fail to survive. Thus, if algal and fungal partners are separated from each other, then they will die.

**FUNCTION OF AN ECOSYSTEM**

- Regulating the essential ecological processes, supporting life systems and rendering stability. Soil and water conservation (Watershed recharge), improve water quality.
- Cycling of nutrients between biotic and abiotic components.
- Maintaining a balance among the various trophic levels.
- Flow of energy from one trophic level to another.
- Decomposition of organic matter and production of biomass.
- Climate regulation
- Biodiversity conservation
- NTFP/Timber production = Tribal economy

Why does ecology matter to a forester? Describe the various ecosystem services accruing from the terrestrial forest ecosystem and the mangrove forest ecosystem [GPSC RFO (Main) 2021 | 10 m]

**IFoS 2022** : Discuss the *significance of bamboo flowering* [Paper – 1 | 8 m]

**Approach** : (1) Introduction – about flowering in bamboo?
(2) Flowchart : Types of flowering with examples
(3) Significance of bamboo flowering – *Stakeholder* analysis

*Bamboo* is a type of grass of the *Poaceae family*. Unlike others, it has three types of flowering.

- **Continuous (Annual) flowering** : under which species keep flowering year after year without dying. *Arundinaria falcata* (a bamboo species growing in

Shivalik and the inner Himalayan region from Himachal Pradesh to Arunachal Pradesh) and *Ochlandra travancorica* (bamboo species growing in the Malabar region) are showing this type of flowering.

- **Gregarious flowering** : When a patch of forest is mainly made up of one species of bamboo, and all start flowering roughly at the same time. *Most of the bamboo species* show *gregarious flowering* after a long period and usually die after it.
- **Sporadic flowering** : When a bamboo forest starts flowering at different times without showing any flowering pattern, even individual stems (culms) of the same clump bloom at different times. it seems that it may be induced by environmental factors such as drought or cold instead of genetics. Example – *Gaudua angustifolia* (Columbian timber bamboo).

**IFoS 2010** : Differentiate between the *gregarious* and *sporadic* flowering in bamboo (4m).

Bamboo flowering after 40 years may push Tadoba to the brink.

A secretion of bamboo, a fine, siliceous matter, called 'tabasheer', found in the stem of bamboos like Phyllostachys bambusoides, is used in Ayurvedic medicines as a cooling tonic, to treat cough and asthma and even as an aphrodisiac.

Culturally, bamboos are close to the Assam tribal people. A flute called '*eloo*', made from the bamboo species *Dendrocalamus tulda*, is played by the priest during the 'Dree festival' to drive away evil spirits.

### SIGNIFICANCE OF BAMBOO FLOWERING

- *Ecological impact* : massive flowering events provide a massive food source for various animals, including rodents, birds, and insects, which feed on bamboo seeds and flowers. The increased availability of food can lead to population booms of these animals.
- Death and destruction of large swaths of land = clearing space for new vegetation and growth.
- This would also lead to food scarcity since several animals depend on this plant = Animal deaths and migration due to the plague = reduce population pressure on an area.
- *Reproductive Strategy* : During "masting" or "gregarious flowering, a large number of bamboo plants within a given species will flower and produce seeds simultaneously. This increases the chances of successful pollination and seed dispersal = *increases species survival changes*.
- *Boost tribal economy* : Plays a vital role in providing raw materials for various products (Bamboo rice), construction, and crafts.
- *Scientific Research* : Bamboo flowering events allow researchers to study various ecological and evolutionary processes. Studying these events can help scientists understand the mechanisms behind the long flowering intervals, the ecological impacts of masting, and the role of bamboo in maintaining biodiversity

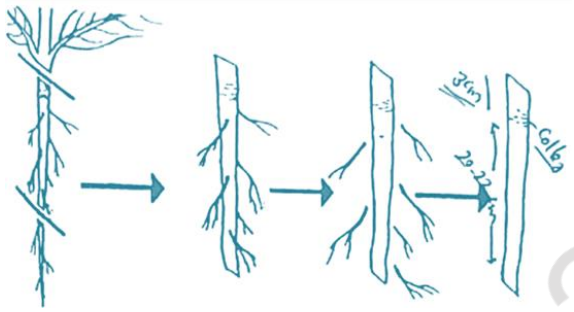
**IFoS 2022** : What is *root : shoot cutting*? Write the names of five tree species which are propagated by this method [Paper – 1 | 10 m]

**Approach** : (1) Introduction – about stump with its significance

(2) Procedure with diagram

(3) Scientific name of 5 tree species [follow ICBN rules]

A Root-Shoot cutting or Stump is a vegetative propagating material comprising the lower part of the stem (2-3 cm in length) and a taproot that is 20 to 30 cm long, devoid of lateral roots. It is employed for species characterised by robust tap root formation, heightened coppicing ability, and actual challenges in regenerative establishment due to poor site quality and the presence of local weed growth.



For making a stump, plants are taken out of the bed with naked roots. Plants with a collar diameter equal to the thumb's thickness (1.5-2.0 cm) and tap roots not less than 30 cm long are selected to prepare stumps. After plant selection, the *shoot* is trimmed to a 3 cm portion using a sharp knife or pruning scissors. All lateral roots are pruned. The taproot is cut around 20-22 cm from the collar. In moist areas, the root length may be reduced to 15 cm, and in dry areas, it may be increased to 30 cm.

Species that can be propagated by this method are as follows

1) *Tectona grandis*
2) *Dalbergia sissoo*
3) *Gmelina arborea*
4) *Acacia catechu*
5) *Pterocarpus santalinus*

**IFoS 2022** : Explain the techniques for upgradation and *hardening of nursery seedlings* of *Lagerstroemia lanceolata* [Paper – 1 | 8 m]

**Approach** : (1) Introduction with need of hardening

(2) Upgradation & Hardening techniques

Upgrading and hardening of nursery seedlings of *Lagerstroemia lanceolata*, are essential steps to ensure their successful transition from the controlled nursery environment to the more challenging conditions of the outdoors. These techniques help the seedlings adapt to water and temperature stresses,

develop stronger structures, and become better equipped to thrive in their intended harsh local conditions.

Techniques for upgrading and hardening nursery seedlings

- *Gradual Exposure* : Gradually expose the seedlings to outdoor conditions over a period of time. Start by placing them in a sheltered spot with indirect sunlight and minimal wind. Then, their exposure to sunlight, wind, and temperature fluctuations progressively increases. This process helps the seedlings acclimate to the changing environment without causing shock.
- *Reduced Irrigation* : Gradually decrease the frequency of irrigation as the seedlings develop. This encourages the seedlings to develop a more extensive and robust root system as they search for water deeper in the soil. However, ensure that the seedlings do not become overly stressed due to drought.
- *Transplantation* from small containers to larger pots before moving them outdoors. This gives the roots more space to grow and prevents them from becoming root-bound.
- *Fertilization* : Apply a balanced and diluted fertiliser during the hardening phase for healthy growth as the seedlings adapt to new conditions.
- *Pruning* : Lightly prune the seedlings to encourage branching and denser growth. This can help the plants develop a sturdier structure and prevent them from becoming too leggy or top-heavy.

**IFoS 2020** : Describe the term – Hardening

**IFoS 2015** : Explain the term *Hardening off*. What are the internal factors affecting forest resistance? (10m)

**IFoS 2009** : Write short notes on the Grading and hardening of seedlings

Write short notes on - Hardning of seedlings [UPPSC (ACF) 2020]

*Hardening off : The natural process by which plants gradually adapt to drought, cold or heat by exposing them to a particular stress. This term is also used for preparing seedlings in a forest nursery or greenhouse for planting out by gradually reducing watering, shade and/or shelter resulting in the hardening of plants.*

**IFoS 2022** : How are *nurseries classified* in India? What is a clonal nursery? Explain the nursery technique for *Casuarina equisetifolia* [Paper – 1 | 15 m]

**Approach** : (1) Introduction – About nursery & its types
(2) Upgradation & Hardening techniques

Forest nurseries are dedicated enclosed facilities where planting material is grown for transplantation purposes. These nurseries play a vital role in afforestation, reforestation and enrichment plantation projects to maintain and enhance forest ecosystems.

1) Based on Duration/management

- *Permanent Nurseries* : These nurseries are usually centrally located and conveniently situated by the roadside for supplying planting material for plantations over a large area. Permanent nurseries have a suitable

layout, road, inspection paths, beds for sowing and transplanting, irrigation and drainage facilities, seed store, labour hut, etc.

- *Temporary Nurseries* : Established to meet the requirement of one or two years of plantation work and generally established near or inside the plantation area

2) Based on the availability of moisture

- *Dry Nurseries* : maintained without irrigation or artificial watering. Usually inside the forest area.
- *Wet Nursery* : If the water source is available

3) Based on Ownership

- *Government nurseries* : owned and managed by the forest department
- *Private nurseries* : run by individuals, families, or corporations
- *Cooperative nurseries*

4) Based on Specialization / Uses

- *Ornamental Nurseries* : These nurseries primarily focus on growing ornamental plants, including decorative trees.
- *Vegetable Nurseries* : grow various types of vegetable plants.
- *Medicinal Plant Nurseries* : These nurseries focus on growing medicinal plants and herbs that are used in traditional medicine.
- *Forest Nurseries* : propagation of trees specifically for afforestation and reforestation.

5) Based on Purpose

- *Commercial Nurseries* : the primary goal of generating a profit by selling seedlings
- *Research and Demonstration Nurseries* : research centres where new plant varieties, cultivation techniques, and agricultural practices are tested and showcased
- *Conservation Nurseries* : focus on propagating and conserving rare, endangered, or indigenous plant species.

**CLONAL NURSERY**

A clonal nursery is a specialised enclosed facility that focuses on propagating plants through asexual reproduction methods, such as cuttings, budding, grafting, Air layering or tissue culture, to produce genetically identical offspring (clones).

This type of nursery is designed to produce disease-free, higher genetic planting material of uniform quality at a large scale in a short time.

**NURSERY TECHNIQUE FOR *Casuarina equisetifolia***

Casuarina is a *light-demanding*, *medium-sized* (10-15 m in height), *exotic evergreen* tree with a *conical-shaped crown* and an extensive *deep tap root system*.

- Seed Collection : harvest cones from healthy mid-age parent trees.
- Seed treatment : Scarification : Casuarina seeds have hard seed coats that may require scarification to break dormancy.
- Transplanting :
- Light and Temperature :
- Hardening off : Before transplanting the seedlings outdoors, gradually expose them to outdoor conditions to acclimate them. Start with a few hours of indirect sunlight and gradually increase exposure over a week or two.

**IFoS 2022** : Differentiate between *thinning cycle* and *thinning intensity*. Why is thinning essential for the management of *forest stand*? Describe the *merits and demerits of French thinning* [Paper – 1 | 15 m]

**Approach** : (1) Introduction – *thinning cycle* and *thinning intensity*?
(2) Need/Requirements of thinning
(3) Merits & Demerits of French Thinning

Thinning cycle and thinning intensity are two concepts often utilised in tending operations to describe the management practices related to the selective removal of trees from a forest stand, aiming to achieve specific objectives.

| Thinning Cycle | Thinning intensity |
|---|---|
| It is periodic in nature and generally constant | It depends on the site conditions and the level of thinning required. |
| It is the time interval between two successive thinning operations | It is the number of trees that fell in a single thinning operation |
| It aims to organise the forest in consonance with the working plan | It aims to remove deformed, diseased, old trees along with thinning operations. |
| It facilitates secondary growth in tree species like diameter growth | It reduces site vulnerability against possible pathogen attacks, improving |

**THINNING OPERATIONS ARE ESSENTIAL FOR THE MANAGEMENT OF FOREST STANDS BECAUSE OF –**

- *To remove dead, dry, diseased*, and weakened trees that may become a source of infection to the remaining healthy ones
- *To obtain a desirable crop composition*
- To reduce the number of trees in the stand so that the remaining ones get *more space for crown and root development*
- To remove trees of poor forms, such as crooked, forked, roughly branched, or moribund form, so that all future increment is concentrated only on the best trees
- *Provide intermediate financial return*

**FRENCH THINNING**

Under this, the *less promising trees of the top crown are being removed in the best available individuals' interest*. The dominated and suppressed stems are retained to help in natural pruning unless they are dead, dying, or diseased.

**ADVANTAGES**

- As lower canopy retained = Checks soil erosion + Weeds & shrubs growth + damaging effect of frost, snow etc.
- Shade-bearing trees are also protected.
- The side branches are naturally pruned due to the presence of lower crown classes.

**DISADVANTAGES**

- Dominant trees may be adversely affected due to tough root competition for moisture and nutrients with a lower canopy.
- It requires experience and skill.
- Lower tree classes also created difficulties while carrying out silvicultural operations, e.g., marking, felling, logging, and extraction of the thinned material.
- The diseased and insect-infested trees of lower crown classes are always sources of infection for the main crop.

**IFoS 2021** : How are *forest sites* classified on the basis of vegetation?
[Paper – 1 | 10 m]

**Approach** : (1) Introduction
(2) Flowchart : Classification
(3) Classification in detail

Various methods and criteria are used to classify forest sites based on vegetation, including dominant plant species, density, structure, and ecological characteristics. These classifications help researchers, ecologists, and land managers better understand and manage different types of forests.

*Flaw chart*

**CLASSIFICATION**

- *Very dense species vegetation* : in these forests, the canopy density is more than 70 %. In this vegetation, generally dominant and dominated species are found, and the grass growth is minimal owing to less sunlight penetration to the ground.
- *Dense species vegetation*- in these forests, the canopy density is between 40-70%. In this type of vegetation dominant and suppressed species are found.
- *Open forest* : A forest where canopy density is less than 40% but more than 10 per cent is considered an open forest. here generally suppressed trees are found along with few dominated tree species.
- *Scrubland* : Those areas where forest cover is less than 10 % are considered scrubland. Here few suppressed species are found along with scrubs.
- *Non- forest* : a forest that does not lie in the above criteria is considered a non-forest area.

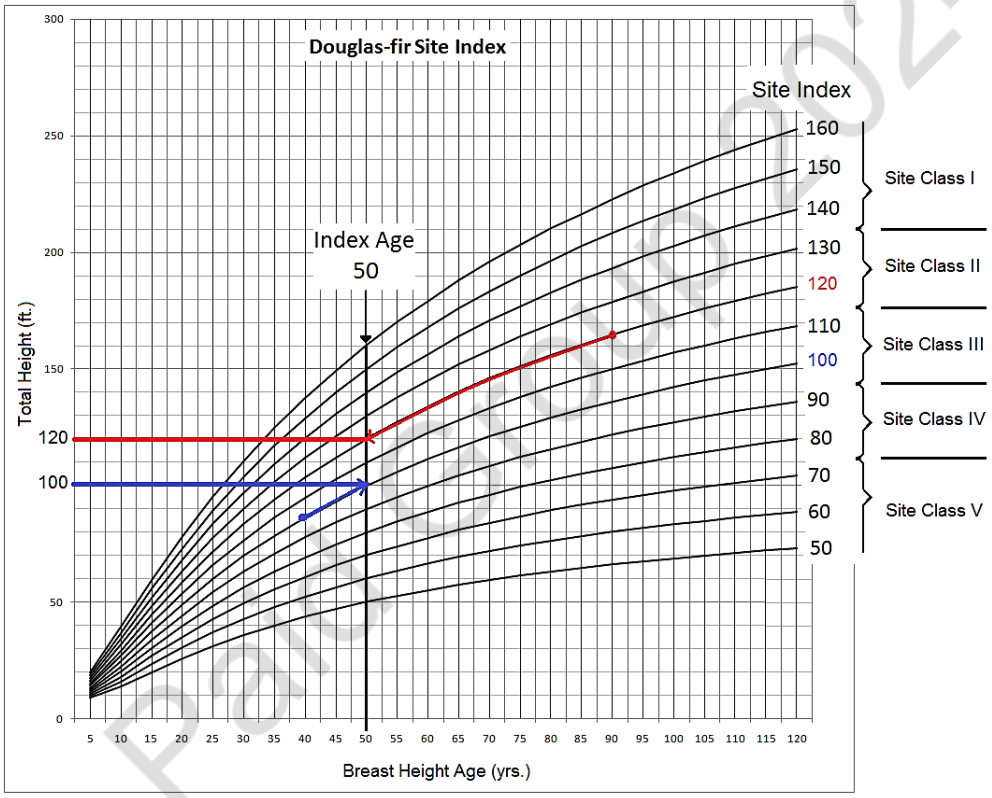
**IFoS 2021** : What is the *Site Quality* Index? How does it differ from fractional site quality? Explain any one method used for developing site quality classes with the help of a neat diagram [**Paper – 2** | 15 m]

*The site quality index is the average height* of the *dominant* and *co-dominant trees on the site at a given age (base age). Typically, the base age for hardwoods is 50 years, and for softwoods is 25 years. Whereas the Fractional site quality* is defined as the site quality expressed as a decimal subdivision of the height range of half a quality class, the figures running 0.0 to 2.0 within the whole quality class.

For example, a SI of 75, base age 50, means that the average height of the dominant and co-dominant trees on a site will be 75 feet when they are 50 years old ($SI_{50}$ = 75). The higher the SI, the higher the site productivity (which means trees will grow faster than on a site with a lower SI). To calculate SI, count their numbers, Total height, and ages of these trees.

The site Index approach is the most common method used for accessing site-quality classes

Site Index is determined by measuring the height of dominant or codominant trees (usually one of the economically important species) at a standard reference age. The reference age is typically 50 years, although it can vary depending on the tree species and local conditions.






Steps :

- Height Measurement : Measure the height of dominant or codominant trees of the target species on the site.
- Reference Age : Choose a standard reference age (*e.g.*, 50 years) for the calculation.
- Site Index Calculation : Calculate the Site Index using the formula –
  Site Index = (Height of Trees at Site / Height of Trees at Reference Age) × 100
- Quality Classes : Once you have the Site Index value, you can classify the site into quality classes. For example :

Class I: Site Index > 120

Class II: 100 < Site Index ≤ 120

Class III: 80 < Site Index ≤ 100

Class IV: 60 < Site Index ≤ 80

Class V: Site Index ≤ 60

The classes can be adjusted based on species-specific requirements and local conditions

**IFoS 2021** : Do the trees of the same species have different responses to *light conditions* at different ages? [Paper – 1 | 8 m]

Trees of the same species may respond differently to light based on their age, due to changes in physiological traits, growth patterns, and developmental stages as they mature.

*Draw a figure*

For example, **Sal** (*Shorea robusta*) can *persist under moderate shade*, but its best development is obtained under a complete *overhead light*. During their initial growth phases, a certain degree of partial shade is essential for optimal development. Deodar trees can tolerate moderate shade during their early growth stages, but they require unobstructed overhead light to achieve robust progress in later phases.

Why trees of the same species might have varying responses to light conditions at different ages?

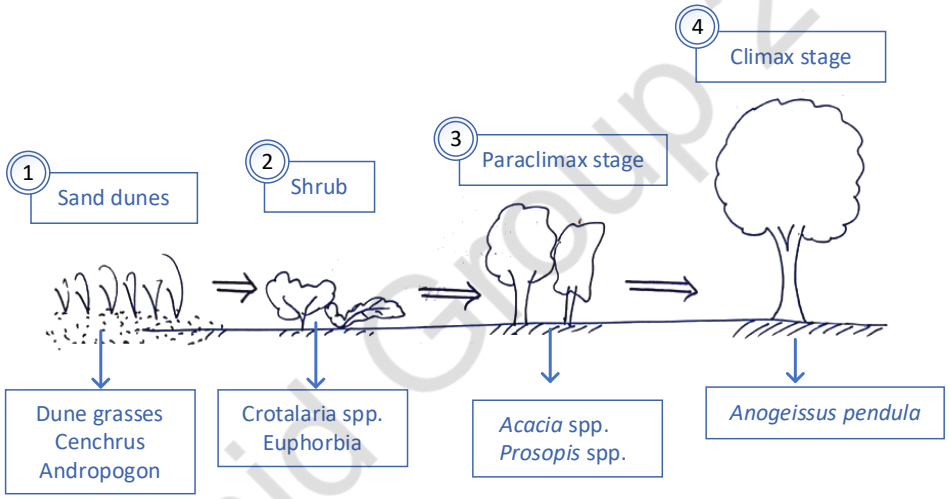
- *Developmental Stage* : Young trees are typically more sensitive to changes in light conditions because they are actively growing. As trees age, their growth rate may slow down, and they might become more acclimated to their specific light environment.
- *Competition* : Young trees might be more susceptible to competition with other plants for sunlight, water, and nutrients. Older trees that have established themselves might be better equipped to handle such competition.

- Trees can adapt to their specific light conditions over time. This can include changes in leaf morphology, physiology, and growth habits.

**IFoS 2021** : What is meant by *climax* in ecological succession? Give an example and describe types of ecological succession [**Paper – 2** | 8 m]

In ecological succession, the term "climax" refers to the stable and final stage of a succession process in a specific ecosystem or habitat. It represents the point where the community of plants and animals has reached a state of balance and equilibrium with the environmental conditions of that particular area. If external disturbances are minimal, species composition and environmental conditions remain consistent over time. The climax community is thus considered the endpoint of ecological succession.

Figure :




Example : *Anogeissus pendula* (Dhok or button tree) forest around Aravali mountain range

**DIFFERENT TYPES OF ECOLOGICAL SUCCESSION**

(a) On the basis of previously available organic matter

- **Primary succession**: When the process of succession starts on land, there is no previously available organic matter, which means succession starts on freshly opened soil. *Example* : Succession in alpine areas after nudation of land by a heavy landslide.
- **Secondary Succession** : When the succession process starts on the field, there was previously available organic matter present, which means succession starts on the old site. So the rate of succession is faster than primary succession. *Example* : development of forest vegetation after forest fire incidence.

(b) Based on the cause of succession

- **Autogenic succession**: After the succession has begun, the community modifies itself and its own environment and replaces its own with a new community. It means there was no external interference, *i.e.,* the Amazon rainforest.
- **Allogenic succession**: the replacement of one community by another due to external forces.

(c) On the basis of the nature of substratum

- Xerarch succession: when succession (especially primary) starts on dry rock material, windblown send and mineral matter under extremely dry conditions.
- Mesarch succession: when succession begins on moist and well-aerated soil material.
- Hydrarch succession: when the succession process starts in water or very wetlands, *i.e.,* ponds, lakes, marshes, etc.

**IFoS 2021** : What factors are considered important while *choosing a species* under avenue plantation? [Paper – 1 | 8 m]

Choosing a species for road-side (avenue) plantation involves considering several important factors to ensure the success, aesthetics, and sustainability of the planted trees.

- Local climate and Soil Conditions
- Species growth behaviour : Fast-growing species might provide quicker shade and visual appeal, but they can also require more maintenance and pruning.
- Canopy Size and Shape : Trees with well-defined canopies can create a uniform and aesthetically pleasing appearance.
- Brittleness of branches
- Root System : Some trees have invasive root systems that can damage sidewalks, roads, and underground utilities.
- Pest and Disease Resistance : Trees that are resistant to local pests and diseases will have a better chance of thriving without the need for constant interventions.
- Aesthetics : Choose species that align with the desired visual aesthetics of the avenue. Consider factors like flower colour, leaf texture, fall foliage, and overall appearance.

- Wildlife Value : Some trees provide habitat and food for local wildlife
- Cultural or historical significance to the local community.
- Local Regulations : Be aware of any local regulations or guidelines that pertain to tree planting

**IFoS 2021** : Are *non-native* tree species an option or a threat in forest ecosystems / Plantation under climate change? [Paper – 1 | 8 m]

Exotic (Non-native) tree species can be both an option and a threat in forest ecosystems and plantations under climate change, depending on various factors including their adaptability, potential invasiveness, Socio-economic implications, and the specific goals of forest management.

*As an option*

- It *Provides a much wider choice of species* suited to the site and other requirements, especially when there are no suitable indigenous species
- *R & D of 1 country* can be shared and utilized by other countries.
- Some may *perform better in exotic land* than in their natural habitat due to the *absence of pests & and diseases outside of their natural habitat*, at least for some rotation, *i.e.*, the leaf-eating insect in Eucalyptus species is quite common in Australia, whereas in India it is totally absent.
- *Fast-growing* + higher quality of product = *increased productivity and production* of our forest.

***Disadvantages of exotics***

- They are considered *ecologically less valuable than indigenous species*; they do not have any linkage with the local ecosystem for the next few years. Even in the absence of insect pests (Controlling biotic factors), this species can *become obnoxious*.
- Become susceptible to *new insect pests*, *i.e.*, Pink disease in *Eucalyptus* spp.
- *The introduction and acclimatization process took a long time* and may not serve the purpose of immediate needs.
- *Unable to produce viable seeds*, *i.e.*, after more than 200 years of introduction, Eucalyptus is still unable to produce viable seeds outside of Nilgiri.
- The health issue of Russian poplar in Kashmir valley. *Prosopis cineraria'* issue in Telangana.

**IFoS 2021** : Why is the *grading* operation of nursery seedlings essential for successful forest plantations? [Paper – 1 | 10 m]

Success in plantations largely depends on the quality of the seedlings and transplants used for planting. It is, therefore, necessary that the seedlings be graded in the Nursery before these are prepared for transport to the plantation site.

The criteria that may be adopted for grading the seedlings may include the seedlings' age, size of the seedlings, root-shoot characteristics, vigour, infection of insect pests and diseases, etc.

In nurseries, the height of the seedlings and their age is usually considered for grading the seedlings. For conifers, the seedling height of 25 to 50 cm and broad-leaved species, a height of 50-100 cm, is considered the optimum size.

Several categories of seedlings need to be rejected. These include –

- Undersized seedlings,
- Seedlings with poor root growth,
- Seedlings infested with insect pests and diseases and
- Damaged seedlings

*Why essential for successful plantation*

- It helps us segregate poor-quality plants and healthy plants.
- In forest plantation the seedling to subjected to varying degrees of stress. Grading operation helps us in finding out which species has the ability to survive in such condition
- Grading of seedlings helps in determining the performance of seedlings in the longer run.
- Seedling grading helps us in providing desired characteristics to the crop

**IFoS 2021** : What do you mean by *tending* operations? Enumerate various tending operations carried out in forest crops. Discuss improvement feeling [Paper – 1 | 15 m]

Tending operations refers to those methods that help in the growth of plants by providing them sufficient sunlight, removing unnecessary competition between tree species, and removing weak and diseased trees which might become the source of epidemic in the forest.

- Weeding : It involves the removal of weeds from the forest.

- Cleaning : It involves cleaning the site by removing leaf litter, and tree branches and it also involves soil working
- Pruning : it involves the removal of live or dead branches from the tree. It helps in facilitating light movement which helps in stem increment.
- Thinning : It involves the removal of trees from the forest stand. The trees removed here are generally weak, diseased, or deformed in shape. It helps in limiting competition between trees.
- Girdling : It is usually adopted where the felling of a tree is not possible. Thus here the bark of the tree is removed which facilitates the death of trees.
- Climber cutting : Climbers are those species which use other plants for their growth. It results in the deformation of the bole of the parent tree, thus prompting them to cut the climber in order to achieve the desired shape.
- Improvement felling : It is usually carried out in the uneven-aged forest where the less valuable species or inferior species is cleared from the forest in order to pave the way for healthier ones to grow with minimum competition. In this felling, multiple other tending operations are also included like Thinning, Climber cutting, cleaning operation etc.

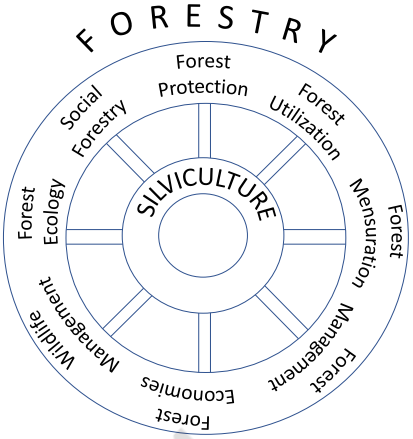
**IFoS 2020** : Define *silviculture*. Relate the applications of silvicultural to different branches of forestry [Paper – 1 | 8 m]

**Approach** : (1) Write down the definition of silviculture as an introduction part.
(2) Now, start writing some 2/3-line para about this relationship (Silviculture *v/s* other branches of forestry), and then draw a flowchart / Diagram.
(3) Write down the remaining part related to the relationships in a point-wise format

Silviculture is the art and science of cultivating forest crops. It works as a hub (Backbone) of the forestry wheel, where other forestry branches, *i.e.*, Forest protection, Forest Management, Forest Mensuration, etc., are supported by Silviculture.

- **Silviculture & Forest Protection**: Under forest protection, we direct the activities that prevent & and control the damages caused by humans, insects, pests, animals, forest fires, etc. Here, Silvicultural principles would help us to - (a) mix the crop composition to increase insect/pest resistance, (b) introduce evergreen species for controlling forest fires, and (c) grow live fencings to prevent animal damage.

- **Silviculture and forest Utilization** : Here, silviculture helps in – (a) the cultivation of economically more valuable and high-grade forest produce. (b) Sustainable harvesting and extraction of forest products with reducing impact over local watershed and ecosystem.




- **Silviculture and Forest mensuration** : Silviculture deals with raising forest crops and forest mensuration to determine the result of applied applications or methods of silvicultural treatments to decide the best treatment to be given for commercial timber production.
- **Silviculture and Forest Management** : Silviculture deals with the techniques and operations that result in the improvement of forest regeneration, productivity, reduction in crop rotation period, and improvement of wildlife habitat, including the production of minor forest produce. Whereas, Forest management prescribes the time and place where the silvicultural techniques and operations should be carried out so that the objectives of management are achieved.
- **Silviculture and Forest economics** : to interrelate with silvicultural operation costs with the cost-benefit ratio of the resultant crop, management cost, and investment opportunities in the forest enterprises.
- Silviculture and wildlife management
- Silviculture and Forest Ecology

**Note** : A question can be written in many ways and here is a small attempt to do it. However, we believe you can write an even better answer than this.

**IFoS 2020** : ***Frost resistance*** in trees depends on internal and external factors. Explain [Paper – 1 | 8 m].

~~**Approach** : (1) Write down a few points about frost as an introduction.~~
~~(2) Now, start writing about frost resistance due to Internal factors with diagrams or Flowcharts.~~
~~(3) Write down external factors~~
~~Note : Remember the page/Text limits~~

~~Frost means the chilling of air below the freezing point. This Sub-frizzing temperature might be lethal to the plants. However, due to few specific mechanisms many temperate and sub-tropical species easily thrive under this condition.~~

~~**INTERNAL FACTORS THAT MAKE THEM RESISTANT TO FROST**~~

- ~~**Water content in the cell** : On average, Water makes up about 70 % volume of a plant cell. A Higher amount of cell water = more increment in the volume of water during freezing inside the cell = damages the cell wall~~

and its organelles, and also blocks its metabolic process. It means more water = Low resistance and *vice versa*.

- **Osmotic concentration of cell colloids** : water-binding colloids like Sugar, mucilage, pectin substance, and Antifreeze proteins (like ***dehydrin***) increase osmotic concentration and leave a very small amount of water free to freeze on one side; on another side, they also reduce its freezing point. It means Higher osmotic concentration = less chance for the cell to freeze
- **Permeability of cell to water** : in the high permeable cell wall, during the freezing process inside the cell, the excess water moves out quickly, so less possibility of rupturing the cell membrane and cell walls.
- **Cell size** : Smaller cells are harder than larger cells due to their small volume surface ratio and more readily bind their water molecules with their colloids

**EXTERNAL FACTORS THAT MAKE THEM RESISTANT TO FROST**

- **Temperature** : Sudden fall in temperature is much more injurious than its gradual fall even for partially hardy plants because rapid fall increases the danger of internal ice formation.
- **Season of growth** : Plants that can withstand extremely cold conditions during winter may be killed by slight frost during spring.
- **Light** : lesser the duration of light = poor new growth = greater frost-hardiness.
- **Mineral nutrients** : Nitrogen stimulates vegetative growth and therefore reduces frost-hardiness. Whereas, a higher dose of Phosphorus and potassium increases resistance.
- **Water availability in the soil**

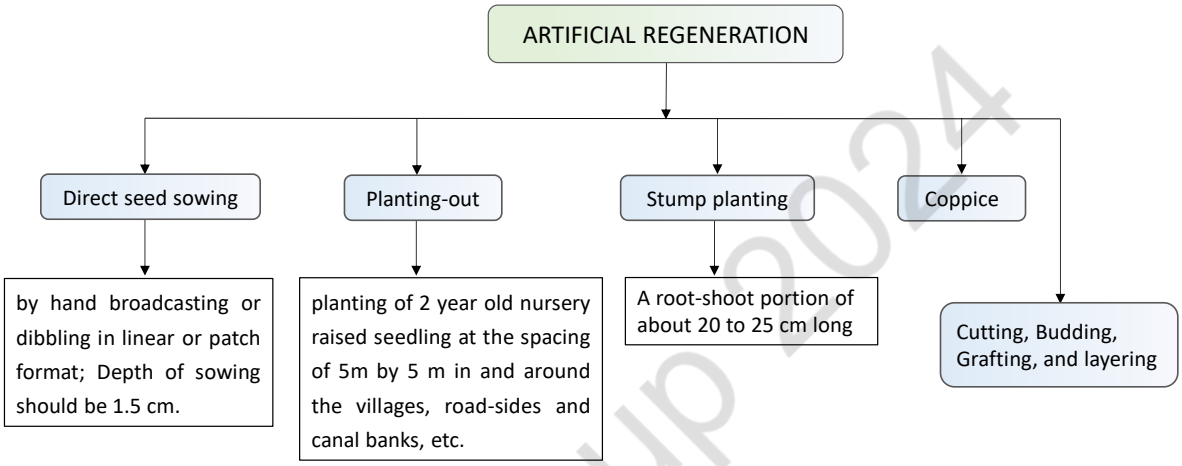
**IFoS 2020** : Describe the methods of ***artificial regeneration*** of ***Tamarindus indica*** [Paper – 1 | 8 m]

**Approach** : (1) Introduction : few lines about tamarind and its distribution or on artificial regeneration
(2) Body : Draw a flow chart of various artificial regeneration methods and describe them one by one.

Tamarind (Imli) is a medium-sized deciduous tree of *dry savanna* (Tropical Africa), and in ancient times, it was introduced to Asia by *Arab traders*.

**ARTIFICIAL REGENERATION**

- Direct seed sowing – by hand broadcasting or dibbling in linear or patch format; Depth of sowing should be 1.5 cm.
- Planting-out : planting of 2-year-old nursery-raised seedlings at the spacing of 5m by 5 m in and around the villages, road-sides and canal banks, etc.
- Stump planting : A root-shoot portion of about 20 to 25 cm long
- Cutting, Budding, Grafting, and layering
- Coppice

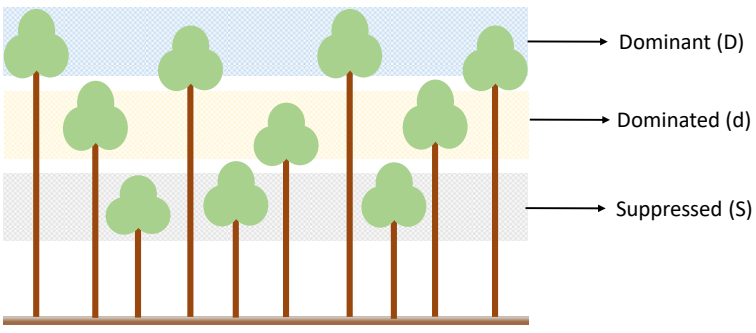



[Note : When you do not have much to write, use flowcharts, diagram and graphs to fill the gap, instead of writing things in a paragraph mode].

**IFoS 2020** : Describe the following terms (10 m) – (a) Dominant, (b) Dominated, (c) Crop height, (d) Top height, (e) Hardening [Paper – 1 | 8 m]

**Approach** : Write-down their definitions, and if possible add some diagrams/flowcharts as well

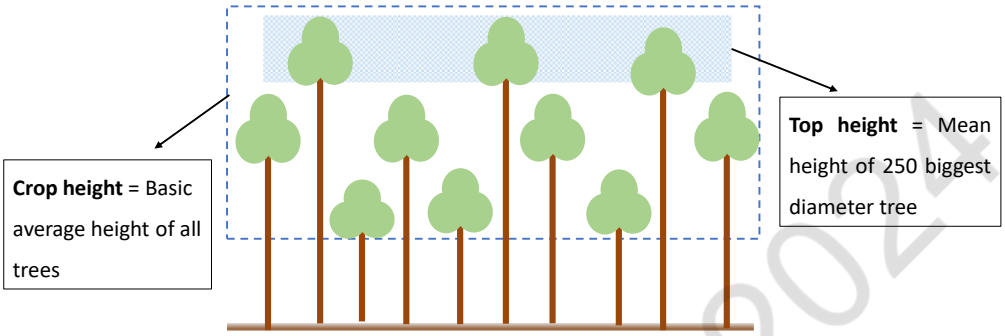
(a) **Dominant** [D] : All those trees forming the uppermost leaf canopy, and represented by the symbol 'D'. These may be sub-divided into – Predominant ($D_1$) and Co-dominant ($D_2$)



(b) **Dominated** [d] : Trees that do not form part of the uppermost leaf canopy, but definitely have the leading shoots that are not overtopped by neighbouring trees; and height of about ¾ of the tallest trees.

(c) **Crop height** : It is the average height of a regular crop as determined by Lorey's formula.

(d) **Top Height** : the height corresponding to the means basal diameter of the 250 biggest diameters per hectare as read from the height diameter curve.




(e) **Hardening** : Hardening is the process of exposing transplants (seedlings) gradually to outdoor conditions. It enables them to withstand in actual environmental conditions they will face when planted outside of the nursery. It encourages a change from soft, succulent growth to a firmer, harder growth.

**IFoS 2020** : What are *Orthodox and Recalcitrant seeds*? Give five examples for each of these categories of seeds [Paper – 1 | 10 m].

**Approach-1** : (1) Introduction : few lines about seed and then (2) define both terms with 5 examples of each,
Note : *Always underline the scientific name*

Seeds are the **mature ovule** with contains **embryo**, **seed coat** and **food reserve** in the form of cotyledons. On the basis of storage behaviour seed could be sub-divided into

- **ORTHODOX SEEDS**: All those seeds that *can be dried up* to low moisture content (≈ 5%, wet basis) and can be stored for low or sub-freezing temperatures for a long time *without losing their viability*. Orthodox seeds are mostly hard-coated.

  **Examples** : *Acacia nilotica, Acacia catechu, Albizzia lebbeck, Prosopis juliflora, Cassia siamea*, etc.

- **RECALCITRANT SEED** : Seeds that *do not survive under low moisture content* stresses (below 20 to 30 %) and *lose their germination capacity*.

These seeds are primarily large and have high moisture content, which cannot be dried without causing injury.

**Example** : Seeds of *Azadirachta Indica, Syzygium cumini, Shorea robusta, Dipterocarpus turbinatus, Mangifera indica,* etc.

*Approach-2* : Write down the two-column difference between orthodox and recalcitrant seeds with examples

| ORTHODOX SEEDS | RECALCITRANT SEED |
|---|---|
| All those seeds that *can be dried up* to low moisture content (≈ 5%, wet basis) and can be stored for low or sub-freezing temperatures for a long time *without losing their viability*. Orthodox seeds are mostly hard-coated. | Seeds that *do not survive under low moisture content* stresses (below 20 to 30 %) and *lose their germination capacity*. These seeds are primarily large and have high moisture content, which cannot be dried without causing injury. |
| **Examples** : *Acacia nilotica, Acacia catechu, Albizzia lebbeck, Prosopis juliflora, Cassia siamea*, etc. | **Example** : Seeds of *Azadirachta Indica, Syzygium cumini, Shorea robusta, Dipterocarpus turbinatus, Mangifera indica,* etc. |

**IFoS 2020** : Write down the ***pre-sowing seed treatments*** for the following tree species [Paper – 1 | 15 m | *Linked Q*] –

(a) *Tectona grandis,* (b) Santalum *album,* (c) *Dalbergia sissoo,* (d) Albizia *lebbeck,* (e) *Acacia nilotica.*

**Approach** : (1) Introduction : few lines about Pre-sowing treatments and its objectives
(2) Body : write down them One – by – One.

Before seed-sowing, we treated them with various physicochemical processes – (1) to remove seed dormancy, (2) to avoid being consumed by insect pests, birds, and rodents, (3) to improve uniformity in size, and (4) ensure its successful germination and establishment by supplementing growth stimulating hormones.

(a) ***Tectona grandis*** : Large size seeds with Hard & thick seed-coat prevented the reaching of moisture and oxygen to the embryo.
Removing Exogenous seed coat dormancy – by (i) Alternate wetting and drying treatment – 24 hours each for the next 15 days, (ii) Partial fermentation with animal dung pastes treatment, (iii) Light fire treatment,

(iv) Mechanical scarification, (v) immersion of seeds in cold water for several days, etc.

(b) ***Santalum album*** : Seed dormancy, Consumption by bruchids & rodents and availability of host plants are the most limiting factors for seed germination and establishment. Resulting, in low and prolonged germination and poor establishment of seedlings.

Removing seed dormancy : Gibberellic acid, cow urine, cow dung slurry and chemicals such as $HNO_3$, and $H_2SO_4$.

Seed pelleting : with paste of fertilizers, Insecticides ~~(and fungicides)~~, and Mycorrhizal spores.

(c) ***Dalbergia sissoo*** : (i) Soaking in water for 24 hours, (ii) Hot water treatment (80 to 100°C for few minutes).

(d) ***Albizzia lebbeck***

(e) ***Acacia nilotica***

**To remove Exogenous seed dormancy** – (i) Soaking in water for 24 hours, (ii) Mechanical Scarification damaging the seed coat by rubbing the seeds on sandpapers or seed or (iii) Acid treatment (Chemical scarification) – pouring seeds in $H_2SO_4$ solution, (iv) Hot water treatment (80 to 100°C for few minutes).

**Seed pelleting** with Insecticides, fungicides, growth hormones and fertilizers - To avoid Insect-Pastes and rodent attack + ensure germination.

**IFoS 2020** : What are the different factors governing the successful *introduction of an exotic* tree species? [Paper – 1 | 10 m]

**Approach** : (1) Introduction : few lines about exotics
(2) Body : Factors

To meet the increasing industrial demands, our plantation forestry has heavily shifted toward exotic due to higher production and productivity, faster growth rate, disease-free production as well and its ability to withstand under some adverse conditions as compared to indigenous species.

However, Successful introduction of an exotic largely depends upon the -

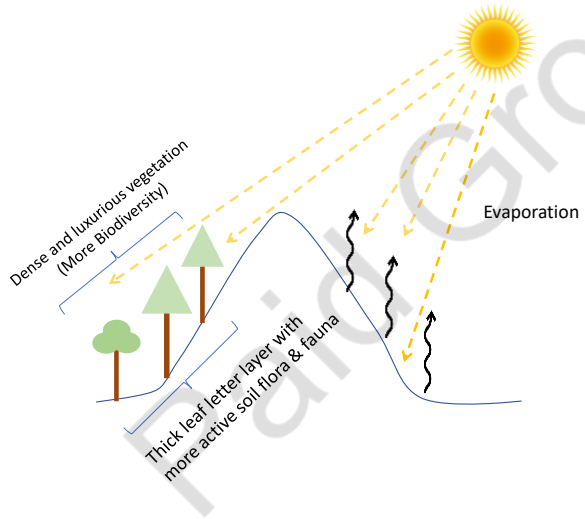
- Local climatic factors –which we are willing to introduce. And it should be similar.
- Edaphic factors -
- Ecological factors - exotic should not cause any allelopathic effect or produce chemicals like Mimosine which is dangerous for herbivores, or should over-exploit our soil and water resources and make them non-fertile.

Exotic or Non-native species are those that grow in areas outside of their natural geographical range; or species growing in areas where they do not naturally occur, *i.e.,* Eucalyptus in India.

- Should be fast growing to increase production + Disease free (Absence of natural pastes)
- Availability of skilled workforce, Infrastructure and funds for procurement, acclimatization and distribution of germplasm. Acclimatization time and cost should be minimal.
- Community and market Acceptance
- Availability of sanitary and phytosanitary measures – to avoid introduction of new insect-pastes.

**IFoS 2020** : How does *slope aspect impact forest stand* characteristics and soil properties ? [**Paper – 2** | 10 m]

**Aspect** is the direction of the slope of the land with respect to the geographical North or the position of the sun (*i.e.*, the Northern face of the Himalayas). Which directly controls the availability of soil moisture, solar radiation intensity, Wind pressure and local temperature. As a result, they also indirectly control the characteristics of local vegetation and soil properties.




**EFFECT ON CHARACTERISTICS OF FOREST STAND** : Sunny slopes keep less moisture because of stronger solar radiation and higher evaporation. Therefore, *plants growing on sunny slopes are mainly grasses and scrubs, and having fibrous roots*, they are more likely to be *drought- and radiation-resistant*. In comparison, shade-loving plants such as forbs are dominant on shady slopes with deep tap root systems, and biodiversity-rich.

* Despite being on the same latitude in the middle Himalayan valleys, the dense forests of Deodar are growing in the southern aspect, while the Fir and Spruce forests at the northern aspect. However, the difference in

insolation in the southern and northern aspects near the equator is small. That is why this difference is not felt in the south Indian hills.

* Similarly, the Eastern aspect is cooler because it gets insolation in the morning when the air temperature is low, and often Dews is still on the vegetation's surface. Whereas, in the western aspect, Sunstrike is when the air temperature is higher and hot winds have already been generated. This causes a more desiccating effect on vegetation.

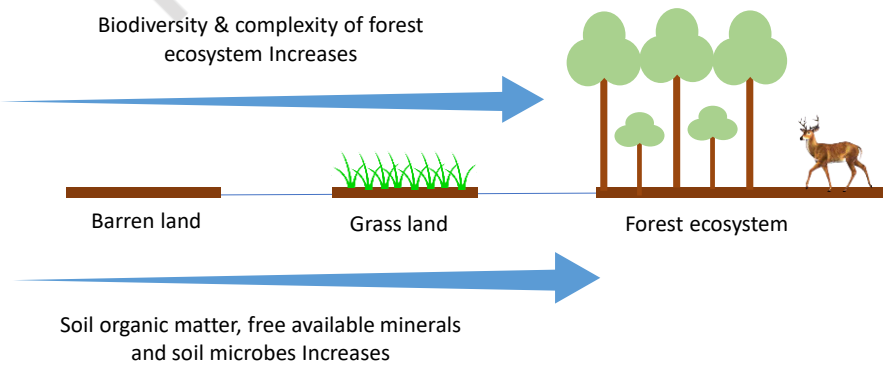
**EFFECT OF ASPECT ON SOIL PROPERTIES** : Plant biomass is high on the northern slope, resulting in high organic carbon in the soil, better nutrient cycling, and higher activity of the microbial community. However, high temperatures in sunny aspect areas in cold alpine areas lead to higher microbial activity and better soil nutrition status.

**IFoS 2020** : What are the structural and functional changes that occur in a forest ecosystem during succession? [**Paper – 2** | 15 m]

Succession is the process of replacing one set of biotic communities with another set of more advanced and different natural biotic communities.

**STRUCTURAL CHANGES DURING SUCCESSION**

- Vertical stratification of species - This includes the development of different canopy layers
- Species composition- due to succession the species composition changes from herbs to shrubs and trees
- Species diversity- due to succession, the diversity in the flora and fauna increases
- Biomass accumulation- the relative biomass of the site is increasing in succession




**FUNCTIONAL CHANGES DURING SUCCESSION**

- Nutrient cycling- the succession also helps in increasing soil nutrient increase due to nutrient cycling and nutrient retention.

- Productivity- the site productivity increase which can be witnessed due to increasing tree density.
- Ecosystem services provided by forests also improve during succession which can be seen in terms of moisture availability, air quality etc.

**IFoS 2019** : Write the scientific names of four major tree species in each of the *Southern Tropical Semi-Evergreen Forest* and *Northern Tropical Wet-Evergreen Forest* [Paper – 1 | 8 m].

- **Southern tropical *semi-evergreen* forests** are Predominantly evergreen forests with few deciduous species and distributed over western ghats and Andaman & Nicobars region. Examples (1) *Dipterocarpus terbinatus*, (2) *Xylia xylocarpa*, (3) *Hopea parviflora*, (4) Mangifera *indica,* etc.
- **Northern Tropical Evergreen Forest** : primarily distributed in the Assam Valley region with dominant species like (1) *Dipterocarpus*, (2) *Mesua ferrea*, (3) *Shorea assamica*, (4) *Bamboosa bamboo, etc.*

**IFoS 2019** : Explain the *modern nursery techniques* for production of quality planting stock [Paper – 1 | 8 m].

With increasing demands of nursery raised seedlings due to increasing government-led plantation work like the Green Highway project, Green India mission, Bamboo mission, etc. provide boos-up and investment opportunities for private sectors to invest in modern nursery technology.

Some advanced technologies for the production of planting stock are as follows:

- *Tissue culture /micropropagation* : For the production of *disease-free high-quality clonal stock* in large numbers in relatively shorter periods. *Artificial Seed* production through tissue culture now replacing our issue of unavailability of good quality seed with specific insect/pest or climatic factors resistance power.
- *Propagation structures* : Growing planting stocks in highly controlled conditions such as in playhouses, mist chambers, glass houses or green net areas enhances the vigour and survival rate of the seedlings.
- *Seed treatment* : Proper adoption of seed treatment helps in improving the germination percentage and storage period of treated seeds. Example : Gamma-ray treatment
- *Root trainers* : Root coiling can be reduced considerably by using root trainers and it also improves the root structure of the planting stock.

- *Automated sensors* : By incorporating automated sensors giving timely reading on soil temperature, soil water level, soil nutrient content, soil pH, humidity etc. timely and effective management can be undertaken.
- Increasing use of *cutting-edge technology* like Sensors for auto-detection of soil Humidity, soil temperature, pH, insect-pest attacks and automatically spraying the required fertilizer and pesticide.

**IFoS 2019** : Discuss the factors which influence the ***choice*** between ***natural*** and ***artificial regeneration*** [Paper – 1 | 8 m].

**Regeneration** or **Reproduction** is the act of replacing the old crop with younger ones, either naturally or artificially (Man-made plantation).

**FACTORS AFFECTING THE CHOICE BETWEEN ARTIFICIAL AND NATURAL REGENERATION**

- **Availability of Funds and time** – for the regeneration project. Natural regeneration is a time-consuming process compared to artificial once which takes hardly a few months. However, artificial requires a huge **skilled labour workforce, infrastructural support, and financing**. We generally prefer Artificial regeneration in commercially viable projects like CAMPA, Industrial buffer plantation, etc.
- **Marketing and pricing support** : If the main purpose of raising the plantation is the production of either firewood timber or pulpwood market support should be needed to absorb this production cost.
- **Social and cultural factors** : They also affect the rate of development of the plantation. Local demands adversely affect industrial plantations.
- our **INDC** or **national/international obligations**.
- Availability of new technology and accessibility to the forest areas

**IFoS 2019** : What are the different ***types of grafting*** ? Explain 'Cleft Grafting' with neat sketches [Paper – 1 | 8 m].

Grafting is the Art of joining plant parts together in such a way that they will readily unite and continue to grow as one plant. Grafting can be done in many ways and some important types of grafting are as follows –

- *Approach grafting or Inarching* : The stock plant is bought near the mother plant and the branches of comparable diameter are severed and joined together to form a union.

- ***Side grafting or veneer grafting*** : A grafting method in which the scion is attached on the sides of the stock and the aerial head of the stock is permitted to grow until the formation of union between stock and scion.
- ***Bridge grafting*** : Mainly undertaken as a technique to repair the girdling in trees.
- ***Bark grafting*** : Scion is inserted into the portion of wood (stock) where the bark separates the wood.
- ***Saddle grafting*** : A graft made by fitting a deep cleft at the end of the scion over a wedge at the end of a stock of similar diameter so that the two cambiums can form a union.
- ***Whip/ splice/ Tongue grafting*** : Grafting in which a tongue-shaped cut is made both in scion and stock and joined at the severed portion to form a union.

**CLEFT GRAFTING**

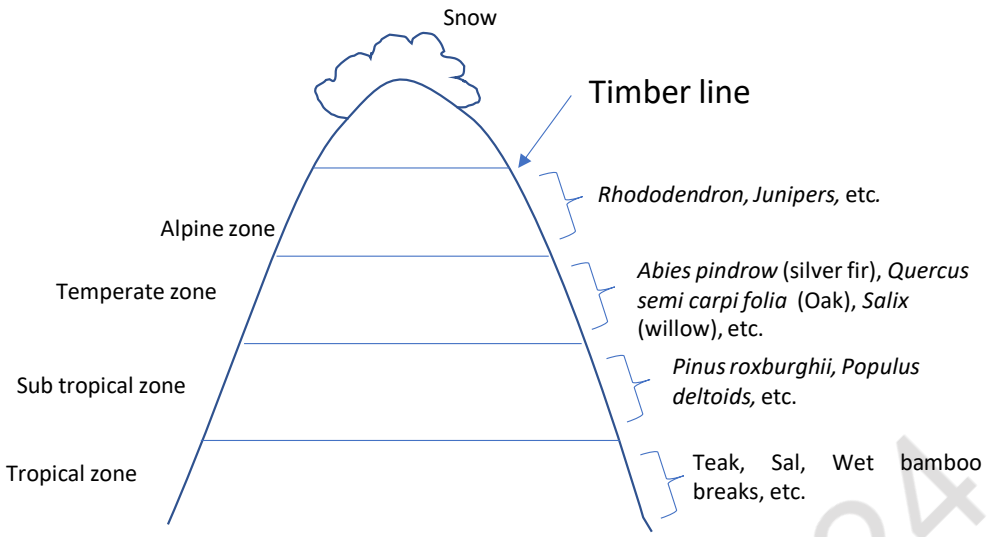
Under this, we joined the small-size scion's piece (the upper portion of a plant with desired characteristics) with the comparatively much larger size rootstock (the lower portion with a well-established root system). This method allows for the combination of desired traits from both the scion and the rootstock, resulting in a stronger, more resilient, and potentially faster-growing plant.

*Steps*

- Choose the Right Time
- Select the Site
- Prepare the Scion
- Insert the Scion
- Secure the Graft
- Seal the Graft
- Monitor and Care
- Post-Graft Care

**IFoS 2019** : Draw a schematic diagram showing *altitudinal zonation of forest vegetation* [Paper – 1 | 10 m]

Altitude is the height of a place from mean sea level. With increasing altitudes, we generally experience a decrease in temperature, pressure, rainfall and the soil fertility; whereas wind velocity and solar radiation increase and all these result zonation of vegetation.

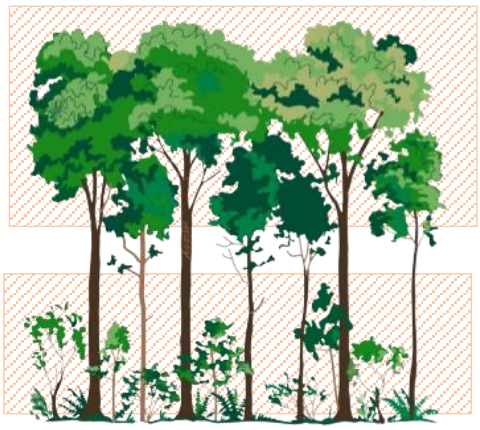



**IFoS 2019** : Explain different *grades of thinning*. Discuss in brief the *thinning practices adopted for teak plantations* [Paper – 1 | 15 m]

Thinning are the felling operations made in an *immature even-aged stand* for the purpose of *improving the growth and form* of the trees that remain, *without permanently breaking the canopy*.

**GRADES OF THINNING**

- **Mechanical thinning** : Under this, we cut the trees by using some thumb rules like cutting off alternate trees in each row or removing alternate rows. it may be by using a stick (So-called stick thinning).
- **Ordinary thinning (Also known as Low thinning and German thinning)** : Under this, we remove inferior individuals starting from the suppressed class, and then taking the dominated class and ultimately some of the dominant class. it is further divided into A, B, C, D, and E grades.



**CROWN THINNING**

*Also known as* ***Thinning from above***

or ***French thinning*** or ***High thinning***.

**ORDINARY THINNING**

**Low Thinning** or **German thinning**

or **thinning from the below**.

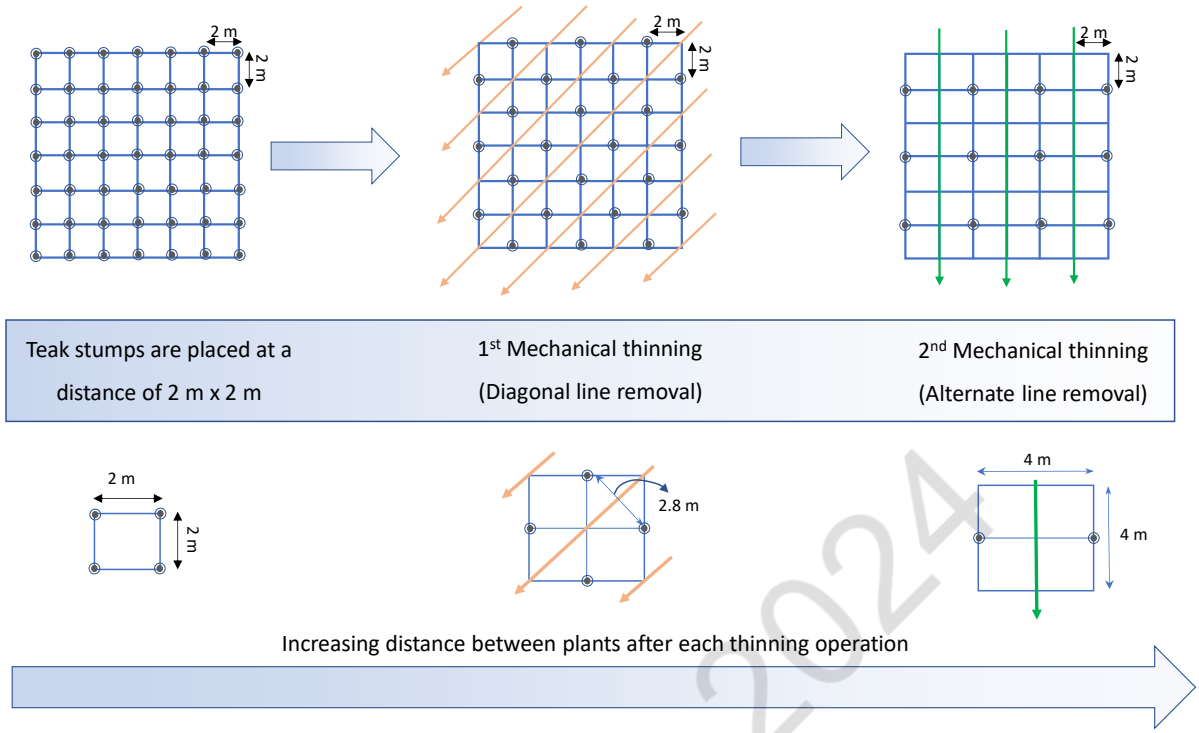
- **Crown thinning (French thinning or high thinning)** : Under this, the *less promising trees of the top crown are being removed in the best available individuals' interest*. The dominated and suppressed stems are retained to help in natural pruning of them in natural pruning unless they are dead, dying, or diseased. It is further divided into (a) light crown thinning and (b) heavy crown thinning.
- **Free thinning** (Also known as *Elite Thinning* or *Single Stem Silviculture*) : Under this, 'elites' are first selected in numbers appropriate to the crop's size or age with particular regard to their stem form and uniform spacing. Once the elites are identified, the remaining crop is considered from the point of view of their effect on the elites, if their removal is likely to help the elite will remove it or if it helps in site protection or no effect of the elite can leave them to avoid unnecessary labour cost.
- **Advance or Craib's thinning** : thinning is carried out before the competition among individual trees has set in. The surplus individuals are taken out regularly to remove the unnecessary competition from the residual ones.
- **Numerical thinning** : Thinning is carried out according to the stand density index.

**THINNING PRACTICES IN TEAK PLANTATION**

Teak plantations by large are managed under mechanical thinning, however, we can also adopt

- **Ordinary thinning**
- **Crown thinning**
- **Elite thinning** at some places.

**Under mechanical thinning** : teak initially planted at 2 m × 2 m spacing; the 1st mechanical thinning is done when the crop attains a height of ≈ 8/9 meters (4th year after plantation). In this thinning, alternate plants are removed in each row resulting 50 % reduction in the number of plants. 2nd mechanical thinning is carried out after the next 4/5 years in which we remove alternate lines.




**IFoS 2018** : Justify that the study of ***silvics*** is essential for the successful afforestation program in India [Paper – 1 | 8 m]

Silvics deals with the **life history** and biological characteristics of individual trees and communities. This includes how trees grow and reproduce and how the physical environment influences their phenological behaviours and physiological character. In general, silvics translates scientific knowledge into practical information about the habitat or site requirements for the successful establishment and development of forest stands.

The study of Silvics, or the ecological and physiological characteristics of trees and forests, is essential for the successful afforestation program in India for several reasons.

First, *understanding the specific needs and growth patterns of different tree species* is crucial for selecting the appropriate species for a particular location and soil type.

Second, silvics can inform *decisions on planting density, spacing, and pruning for optimal growth* and survival of the trees.

Third, silvics can provide information on the *potential for invasiveness of certain species*, as well as their potential to provide ecosystem services such as carbon sequestration and wildlife habitat.

Overall, incorporating knowledge of silvics into afforestation programs can improve the success rate and long-term sustainability of reforestation efforts in India.

**IFoS 2018** : Explain *different kinds of thinning* and its application in the forest
[Paper – 1 | 8 m]

Thinning is the felling operations made in an *immature even-aged stand* for the purpose of *improving the growth and form* of the trees that remain, *without permanently breaking the canopy*.

**GRADES OF THINNING**

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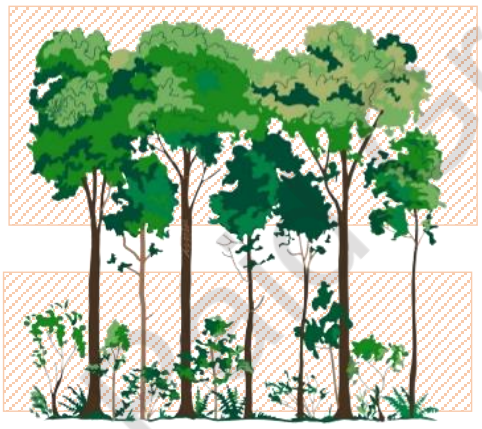

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**APPLICATION OF THINNING IN FORESTRY**

* Thinning operations help in the production of both, large-size and small-size timber as per market requirements, *i.e.,* Nilambur teak production.
* Helps in managing forest's composition, structure and diversity by harnessing its tangible and intangible benefits.
* It helps in the successful introduction of exotics in Indian forests as well as managing and enriching of forest.
* helps in Removing unnecessary competition b/w forest vegetation, proper development of soil and carbon sink.
* It also helps in improving the carbon-capturing capability of the forest.

**IFoS 2018** : Explain the *Eco-physiological factors* that are more concerned to the silviculturist [Paper – 1 | 15 m]

The effects and responses of forest to the various silvicultural operations depend upon the various local eco-physical factors, therefore the Silviculturist have to know what they are. how they affect forest vegetation and how vegetation shows the effect of silvicultural operation when these factors are active

**FACTORS**

- Climatic factors : enlist various factors that you read in silviculture notes
- Edaphic factors : Do the same with it
- Biotic factors : do the same with it as well
- Topographic factors : same

The success or failure of our silvicultural operations and the plantation work depends upon these factors

**IFoS 2018** : Can '*climate change*' change the period of **phenology**? share with examples [Paper – 1 | 10 m]

Phenology is the seasonal changes in the plant behaviours over a year, it shows when it has flowering, fruiting, leaves shedding etc.

Plants' physiological and phenological behaviours are linked with the seasonal pattern, and their biological clock is adjusted with it as an evolutional adaptation. Example - Flowering and fruiting in *Acacia nilotica* are adjusted with our Indian monsoon and start from December – January, so its fruit matures at least before the onset of Monsoon.

Now climate is changing with increasing global warming, so our weather also shifting accordingly affecting our forest vegetation throughout -

- For induction of flowering in the plant's particular temperature (High or Low) and duration of light required *i.e.,* Apple required snowfall for its flowering and often *failed to flower in the year where there was no or negligible snowfall* occurs and *vice versa*.
- Evergreen temperate forests (*i.e.*, forests in the middle Himalayan region) now *start showing deciduous character* gradually.
- Raising temperature *increased leaf-shedding period* in tropical dry deciduous vegetation of central India.

**IFoS 2018** : Write in detail about the ***influence of parent rock*** in the ***distribution of tree species*** [Paper – 1 | 8 m].

Parent rocks are the main source of base material for the soil formation and the mineral nutrition of the plant. Therefore, its composition and distribution also affect the plant's distribution like –

- In the western Himalayas, Chirpine occurs mainly on *quartzite rocks*, while blue pine occurs on *mica schist*. As the Kashmir and Kulu valleys have practically no quartzite formation, Chir is conspicuous by its absence in these valleys; if quartzite occurs at higher altitudes, Chir appears there, *i.e.*, In Parbatti valley (H.P.), deodar occurs at lower altitudes on old and fresh alluvium. In contrast, Chir occurs above deodar at higher altitudes on quartzite.
- *Cupressus torulosa* occurs mainly on limestone rocks, as in the Chakrata hills of Uttarakhand.
- While teak grows on lime-rich rocks, Sal usually avoids them. Teak is absent from quartz and black cotton soil and often avoids laterite sand where found. It is usually stunted.
- *Xylia Xylocarpa* occurs gregariously in laterites.

- *Dendrocalamus strictus* is practically absent in Orissa from quartzite soils.

However, the influence of parent material/Soil on a particular species or forest type is, sometimes, due its effect on depth of soil, moisture retentivity, and availability of nutrients and not because of its own chemical composition.

**IFoS 2018** : Write the problem and prospects of *exotic tree species* in India with suitable examples [Paper – 1 | 15 m]

Exotics are the trees that are growing outside of their natural habitat. Despite having some good production property and market value, several exotic species create some problems like -

- They are ecologically less valuable and do not have any linkage with the local ecosystem and sometimes become obnoxious, *i.e.*, *Prosopis juliflora* in Telangana – Andhra region.
- Become susceptible to new insect pests, *i.e.*, Pink disease in Eucalyptus spp.
- The introduction & acclimatization process took a long time and heavy initial investment.
- Unable to produce viable seed to sustain them shelve after introduction.



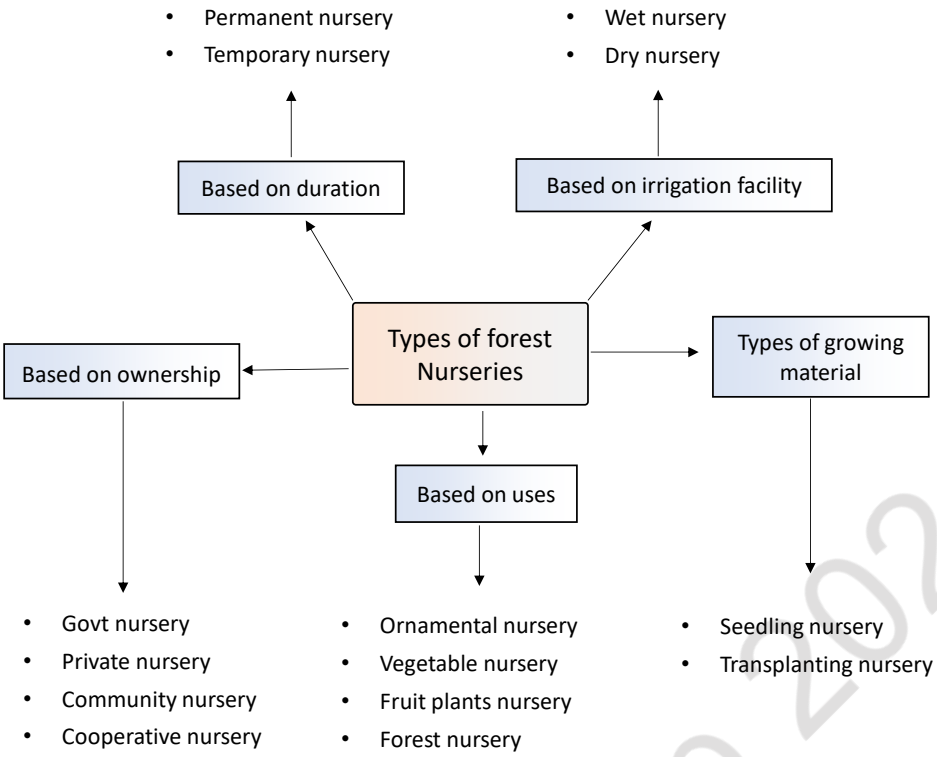
**FUTURE PROSPECT**

Now, with the increasing issue of global warming and climate change, our native vegetation facing serious phonological disturbances and has not started failing to regenerate itself naturally. Maybe the exotics and tree breeding become the only source to make our forest more climatically resilient.

**IFoS 2018** : Enlist different *types of nurseries* and write different types of nursery beds used in a nursery [Paper – 1 | 7.5 m]

Nurseries are enclosed or partially enclosed areas where we raise planting material artificially under controlled conditions for plantation and conservation purposes.

**TYPES OF *Nurseries***



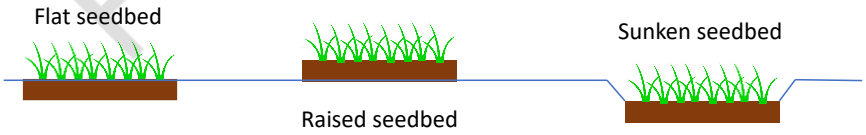

**TYPES OF *Nursery Beds***

**(a) Based on the level of platform**

Level or flat beds : Platform at an equal level with the surface. In Normal rainfall areas, *i.e.*, Teak.

Sunken bed : In Dry localities, where water loss is an issue. It takes about 10 to 30 cm deeper. The prime aim for making this type of bed is to avoid water flow outside the bed, *i.e.*, Khejari Nursery in Arawali.

Raised bed : made in high rainfall areas, about 10-15 cm above ground level with the support of bricks, stones, or bamboo culms. Suitable for seeds that do not require too much moisture.




**(b) Based on uses**

Seedling beds : used for raising seedlings

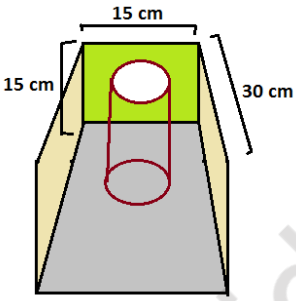
Transplanting beds : seedling is transplanted for further development and easy transportation.

**IFoS 2018** : Enlist different *types of containers* used in a forest nursery and explain different methods of seed sowing followed in a nursery [Paper – 1 | 7.5 m]

Nursery containers are the structural frame that we used to raise planting material outside of the traditional nursery bed or for transplantation purposes.

**TYPES OF CONTAINERS**

- *Brick container* : prepared with a mixture of local soil, sand, and, Farmyard manure ( in 1 : 1 : 1 ratio). A 10 cm deep cavity is created at its top for plantation. A most suitable method of plantation in sandy areas.
- *Dona or cup* : cups made by leaves of *Bauhinia vahlii* were sometimes used in Madhya Pradesh to plant teak seedlings.
- *Bamboo basket* & Bamboo tubes
- *Earthen pots* made locally have been used for planting in some areas.
- *Polybag* : most commonly used material in recent times because – (a) are light in weight (b) have greater strength and durability (c) comparatively cheaper (d) Available in abundance with any size/shape/dimension, (e) Negligible weight.
- *Root trainers* : Root Trainers are an excellent growing system for seeds seedlings. To remove your plants easily without any damage to their root system.




Brick container

Polybag

Roots trainer

**METHODS OF SEED SOWING IN NURSERY**

- **Hand broadcasting** : The desired quantity of seeds is sown directly by hand. However, it required that the seed should be larger in size. In the case of minute seeds of species, *i.e.,* Eucalyptus spp. It should be mixed with earth or sand before broadcasting.
- **Dibbling** : Both space and depth can be maintained.
- **Drilling** : With the help of a board, trenches are made and then seeds are 'Sown in the trenches made by the board

**IFoS 2018** : What is *succession* and *climax*? Give the causes of forest succession [**Paper – 2** | 10 m]

*Succession* is the process of replacing one set of biotic communities by another set of most advanced and stable communities in a progressive manner. The *Climax* stage is a mature final and stable community of this succession process which maintains itself for a long period in equilibrium with that particular environmental condition.

**CAUSES OF SUCCESSION**

- ***Initiating Causes*** : to make the bare area (NUDATION) to the new succession process by destroying the existing one, through climatic or biotic factors, *i.e.*, Land sliding, soil erosion & deposition, volcanic eruption, long-term waterlogging, deforestation, Forest fire, coastal and estuarine deposition.
- ***Continuation Causes*** : that continue the movement of the succession process through various seral stages, *i.e.*, Migration, ecesis, aggregation, competition, reaction, etc.
- ***Stabilizing Causes*** : They finally established the colony according to the local area climate, soil or complex of factors.

**IFoS 2018** : Write the *soil-water relationship* of any forest area. Describe the influence of the water table in the growth and development of tree species [Paper – 1 | 10 m]

The soil-water relationship in a forest area is a critical factor that significantly influences the growth and development of tree species. This relationship encompasses the interaction between soil properties, water availability, and the water table level. The water table refers to the underground level where the soil and rock are permanently saturated with water. It plays a crucial role in determining the health and distribution of tree species within a forest ecosystem.

*Positive relationship*

- Water plays an active role in the weathering of rocks thus helping in the formation of soil
- Different soil particles play an important role in water purification
- Water helps in the deposition of valuable silt which helps in increasing the fertility of the soil
- Soil plays an important role in groundwater deposition.

*Negative relationship*

- Water is an active geomorphic agent which plays an important role in erosion, *e.g.*, Chambal ravines

- Waterlogging in any area results in anaerobic soil condition

*Role of the water table in forest development*

- high water table result in growth of trees that have superficial root system which is not wind firm.
- Lower water table area requires special measures for earlier growth of any tree species.
- Low water table causes capillary action in soil which results in the presence of salts in the upper layer of soil, which decreases fertility.

**IFoS 2018** : What is hydrology? Describe the role of hydrology in the planning and management of watershed development. Do tree species improve the infiltration rate, soil temperature, water level, and hydrological cycle? Justify with a few examples [Paper – 1 | 15 m]

Hydrology refers to the study of water on the Earth's surface and beneath the Earth's surface. Further, it includes water movement, its distribution, and physical and chemical properties.

Role of hydrology in watershed development

- Sedimentation and erosion control
- Flood and drought management
- Help in water resource planning
- Modelling and stimulation of the watershed region
- Environmental protection by understanding the ecology around the watershed, thus helping in preparing riparian buffers and other measures to conserve ecology in the region.
- Help us in forming integrated watershed management which helps us in sustainable development in the region.
- Management of water quality in the region

Tree species play an important role in the management of infiltration rate by inducing stem flow. Further, their roots also help in the percolation of water downwards thus helping in increasing the infiltration rate.

Tree species influence soil temperature by preventing direct insolation from falling in the ground, thus reducing temperature. Further due to decomposition of organic matter, the temperature of soil is also influenced.

Water level - Some tree species like Eucalyptus extract more water which affects the water level of the site adversely.

Hydrological cycle – Tree species play an important role in the hydrological cycle by moderating evaporation loss, and increasing infiltration of water.

**IFoS 2017** : Give four examples of uses of *Pollarding* in Indian forestry
[Paper – 1 | 8 m]

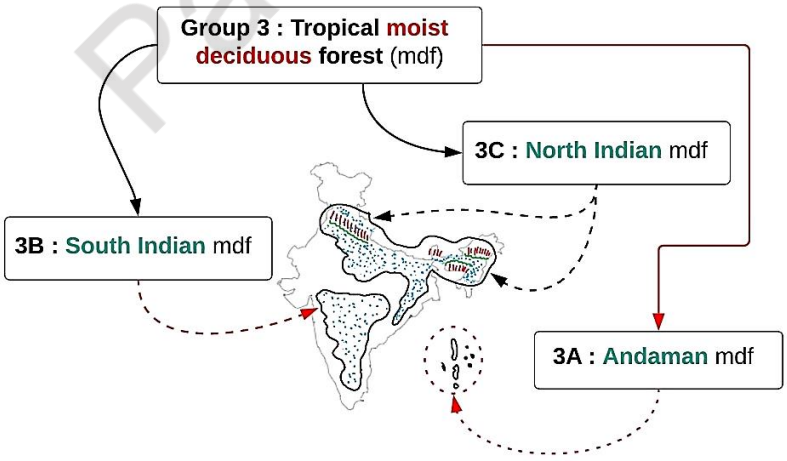
Pollarding is the act of cutting trees at a height (usually about 2m to 2.5m from the ground), to protect the new shoots from grazing and browsing animals.

***Uses of Pollarding***

- For the production of cottage industries linked small-size timber, *i.e.*, *Salix alba* (willow) in Kargil and Kashmir valley for cricket bat manufacturing.
- *Hardwickia binata* : in Kurnool (A.P.), for bast fibre production.
- *Cotoneaster bacillaris* is pollarded to obtain walking sticks.
- Pollarding provides fodder and fuelwood as intermediary products, *i.e.*, *Grewia oppositifolia* is pollarded in UK & foothills in UP to get shoots for fibre and fodder.

**IFoS 2017** : Enlist *four groups* of forest types under the **moist tropical forest** as per the Champion and Seth classification of forest types [Paper – 1 | 8 m].

Champion and Seth classified moist tropical forests into *3 Sub-Groups*. **[3A]** Andaman moist deciduous forest, **[3B]** South Indian moist deciduous forest, and **[3C]** North Indian moist deciduous forest.




- *Andaman Moist Deciduous Forest* : These forests are predominantly found in Andamans and are associated with evergreen forests. Important species

include *Cannarium euphyllum, Pterocarpus delbergiodes, and Salmelia* spp., *etc*.

- *Southern Tropical Moist Deciduous Forest* : Distributed over mountain region and plains of entire south India (From MP to Tamil Nadu) having moderate rainfall. Forests of Tectona grandis belongs to this. Other important species of this forest type includes *Terminalia*, *Lagerstomia* and *Pterocarpus*.
- *North Indian Tropical Moist Deciduous Forest* : Excluding the dry North-West region, moist deciduous forests can be found throughout North India. The annual rainfall of this region varies from 1000 mm to 2000 mm. *Shorea robusta* constitutes an important species.

**IFoS 2017** : Regulation of *solar radiation* gives a powerful tool to the forester, Justify [Paper – 1 | 10 m]

Solar radiation is one of the important site factors which affects the growth and vigour of any trees. Also, better light conditions can be used as a tool to obtain a maximum volume of quality timber

- The crop till the pole stage can be allowed to grow under congestion so that lower branches of trees do not get sufficient light due to shade created by the upper branches or canopy resulting in the death of lower branches. This natural pruning of lower branches helps in obtaining long clean bole.
- When tree crowns are restricted to the upper part of trees, it results in the development of a more cylindrical stem form.
- Light stimulus provided by creating heavy openings in crops towards the end of their life, after having been raised in closed crops results in rapid volume increment, called light increment.

**IFoS 2017** : A soil can be wet, yet physiologically dry. How? What steps are suggested to correct the problem? [Paper – 1 | 10 m]

Physiologically dry soil means water is present in the soil but is not available to plants either because of high salt concentration, unavailability of water in liquid form or due to poor aeration. These conditions happen in saline marshes, cold deserts and water-logged soils respectively.

- Physiological dryness of soil due to high salt concentration can be corrected by improving the drainage or by the method of leaching. If we add enough water to the soil, salt present in the soil gets dissolved and

will move them below the root zone. Improved drainage will also give the same result. Another possible way to tackle the issue is by the use of suitable chemicals to neutralize the effect of salt.

- Cold deserts experience physiological dryness of soil due to lack of water in liquid state. Measures like adding suitable chemicals which can increase the freezing point of water help in overcoming the issue. However considering the cost-benefit ratio, this is not a practical solution for the problem. Important soil work carried out in such soils are trench-cum-pit type and irrigation-cum-drainage type. Improving drainage conditions in turn improves soil characteristics. Proper soil working and the addition of organic matter helps in enhancing good drainage.
- Physiologically dry soil in water-logged regions happens due to poor aeration and this condition can be rectified by improving the drainage. In India, planting in such areas is done either on ridges or on raised mounds.

**IFoS 2017** : Enlist the advantages and disadvantages of vegetative propagation. What future do you foresee for it in forestry? [Paper – 1 | 10 m].

Vegetative propagation or asexual method of propagation is one in which the multiplication or reproduction of plants happens from any vegetative parts (*i.e.*, Cutting, Budding, Grafting, coppicing, suckers, etc), other than the seeds.

**ADVANTAGES OF VEGETATIVE PROPAGATION ARE**

- This is the only method of propagating plants which produce non-viable seeds or recalcitrant seeds, *i.e.*, Eucalyptus.
- Offspring (Ramets) have the same genotypes as the mother plant (Ortet), hence large-scale production of market-linked uniform produces is possible.
- Vegetatively propagated trees are usually of low height = facilitating easy pruning, spraying and harvesting operations.
- In some special cases, the rootstocks have tolerance to salinity, pest and disease resistance and these characteristics can be suitably exploited for beneficial uses.
- Vegetatively propagated plants take less time to reach maturity and hence have a shorter rotation period.
- Difficulties in obtaining seeds, their processing and storage can be avoided by adopting vegetative propagation.

**DISADVANTAGES OF VEGETATIVE PROPAGATION ARE**

- Vegetative propagation is feasible only for certain plant species.
- It requires more aftercare to maintain the survival rate.
- Special platforms and provisions have to be created, which is difficult and is costly.
- Vegetative parts can't be stored for a long time once taken/ separated from the mother plant.
- Transportation to distant places is difficult.
- Plants propagated through vegetative means are more susceptible to pests and diseases.

As most of trees *do not produce good quality seeds every year*; some *facing difficulties during seed germination and establishment* due to global warming and high biotic pressure; *Genetic makeup of offspring also not similar with mother* tree (in the case of seeds), and sometimes its *hard to collect them from remote terrains*. Whereas, vegetative methods like root cuttings, stem cuttings, branch cuttings, suckers etc., can be obtained at any season, this problem can be overruled. The easy establishment and faster growth rate enable the production of the required size timber in the shortest time.

**IFoS 2017** : Discuss in detail, the kinds of *Soil Mycorrhizae* and the benefits derived by plants from them [Paper – 1 | 8 m].

Mycorrhiza refers to the symbiotic association of fungi with the roots of vascular plants. The roots of almost all vascular plants are associated with mycorrhiza and the infected feeder roots are termed mycorrhizae.

There are mainly three types of mycorrhizal association.

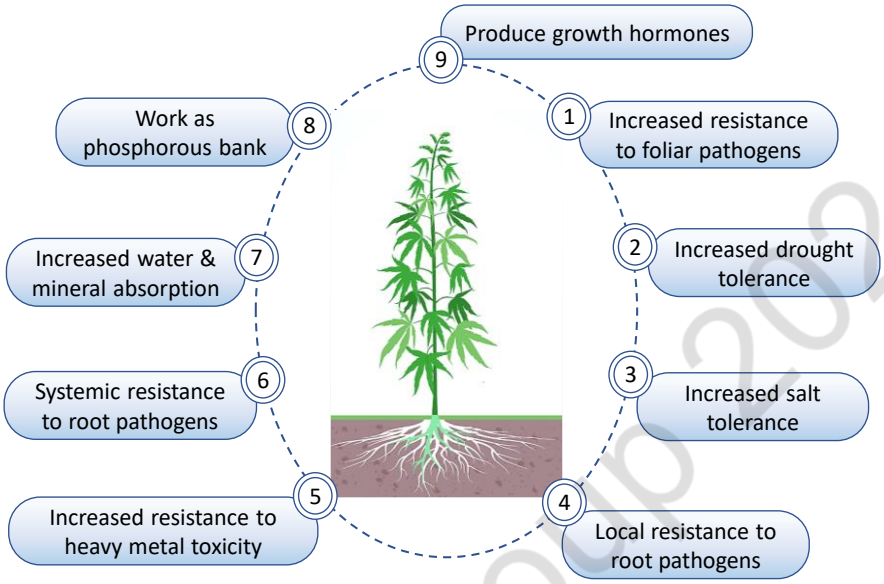
- **Ecto-mycorrhizae :** In this type of fungal association, the fungus covers the outer portion of the roots completely. It penetrates between the cells and separates them in the primary cortex.
- **Endo mycorrhizae :** In endo-mycorrhizal type infection, the fungus mycelium forms coils and various swellings within a certain group of cells of the primary root cortex.
- **Ecto-endo mycorrhizae :** Both the *ectomycorrhizae* and *endomycorrhizae* are found in this type of fungal association with vascular plants.

**BENEFIT TO THE PLANTS**

- *Better absorption of soil moisture and minerals* by increasing net water absorption surface area as fungal filaments work as root hairs that also

help plants increase *drought tolerance*.

- *Increase availability of unavailable minerals* to the plant : Some minerals become unavailable or unabsorbable, called fixation (*i.e.*, phosphate fixation) to the plant because of soil pH. Fungal hyphae release organic acids that make it in available form, so the plant can sustain even under harsh/unfavourable soil conditions, especially when the soils are deficient in phosphorus.




- *Nitrogen Fixation* : Some fungi also fix atmospheric nitrogen and make them available to the plant = plant can grow in nitrogen deficit soil where other plants cannot.
- *Produce some growth hormones*, *i.e.*, Auxin, gibberellin that further boost up the plant's root & shoot growth.
- *Phosphate reservoir* : Nearly 80–90 per cent of the absorbed phosphate remains in the fungal sheath. Thus, the fungal sheath may act as a reservoir of nutrients (especially phosphate) and release them as the occasion demands under adverse conditions.
- *Mycorrhiza-induced resistance (MIR)* – Mycorrhiza provides systemic protection against a wide range of attackers by inducing systemic resistance (ISR) after pathogen infection through Inter-plant signalling.

**IFoS 2017** : Define *succession*. Explain different types of succession in detail, citing suitable examples. Discuss various theories of succession [**Paper – 2** | 15 m].

Succession is the process of replacing one set of biotic communities by the another set of more advanced and different nature biotic communities.

## TYPES OF SUCCESSION

- **BASED ON AVAILABLE ORGANIC MATTER**

  (a) ***Primary succession*** : When the process of succession starts on freshly opened soil (there was no previously available organic matter), The rate of succession is slower. Example : Succession in alpine areas after nudation of land by a heavy landslide

  (b) ***Secondary succession*** : When the succession process starts on the old sites which had been destroyed due to fire, erosion, burning, grazing etc., is called secondary succession.

- **BASED ON CAUSE OF SUCCESSION**

  (a) *Autogenic Succession* : after the succession has begun, the community modified itself and its own environment and replaced its own with a new community. It means there was no external interference, *i.e.,* the Amazon rainforest.

  (b) *Allogenic Succession* : when the replacement of one community by another due to external forces.

- **BASED ON THE NATURE OF SUBSTRATUM**

  (a) *Xerarch Succession* : when succession (especially primary) starts on dry rock material, windblown send and mineral matter under extremely dry conditions.

  (b) *Mesarch Succession* : When succession begins on moist and well-aerated soil material.

  (c) *Hydrarch Succession* : when the succession process starts in water or very wetlands, *i.e.,* ponds, lakes, marshes etc.

**MAJOR THEORIES**

- ***Mono Climax Theory*** or ***Climatic Climax Theory*** **:** Given by *FE clement*. According to this theory, the only climatic condition involved in controlling succession so there is only one type of climax community formed.
- ***Poly Climax Theory*** : Proposed by *Tansley* to counter Clement's theory, Tensely suggests the climax community is never actually controlled by single factors. This theory considers that the region's climax vegetation consists of not just one type but a mosaic of vegetational climaxes controlled by soil moisture, nutrients, topography, slope, aspect, fire, grazing, etc. So, when the development of communities is controlled by climate, they described them as a *climatic climax*, when it due to -

  * Edaphic conditions then called → edaphic climax
  * If because of Biotic disturbances, then called → biotic climax

* or due to topography where dominant factor → topographic climax.

- ***Information Theory*** : Proposed by Fosberg (1967) and Odum (1969). According to this theory, succession is a function of energy balance and nutrient cycling. The climax stage is reached when the amount of energy and nutrients received from the environment by the vegetation is equal to it given to the environment it returns through leaf litter and other metabolic activities.
- ***Climax Pattern Hypothesis*** : According to *Whittaker* (1953), climax communities are patterns of populations varying according to the total environment. Thus, there is no discrete number of climax communities, and no one factor determines the structure and stability of a climax community. Whereas the mono-climax theory allows for only one climatic climax in a region and the poly-climax theory allows several climaxes, the climax-pattern hypothesis allows continuity of climax types varying gradually along environmental gradients and not separable into discrete climax types.

**IFoS 2017** : Name the *method of thinning* that best promotes genetic improvement of the regular stand besides controlling density. Give reasons in support of your answer [Paper – 1 | 8 m].

Thinning operations are the tending operations where we remove inferior, diseased trees from the stand in order to facilitate light penetration, reduce competition between species and improve site quality.

*Free thinning* or Single-Tree Selection is a type of thinning where plants who fulfil these criteria are selected based on the criteria in terms of their age, bole diameter and other suitable parameters and the remaining trees are felled. As a result of this felling, only the superior trees are left in the stand having high growth potential.

This method has several advantages that make it particularly effective for promoting genetic improvement and maintaining stand diversity

- *Conservation of Genetic Diversity* : Trees with desirable genetic traits, such as rapid growth, resistance to pests or diseases, and adaptability to local conditions, can be identified and preserved. This helps maintain a diverse gene pool that supports the long-term resilience and adaptability of the stand.
- *Natural Selection Process* : Over time, the fittest and most suitable individuals will contribute more to the next generation, leading to an overall improvement in the genetic quality of the stand.

- *Improvement in the stand condition* : introduce superior genetic material into the stand through successive thinning.
- Reduced competition among trees, which can lead to improved growth rates and overall health.

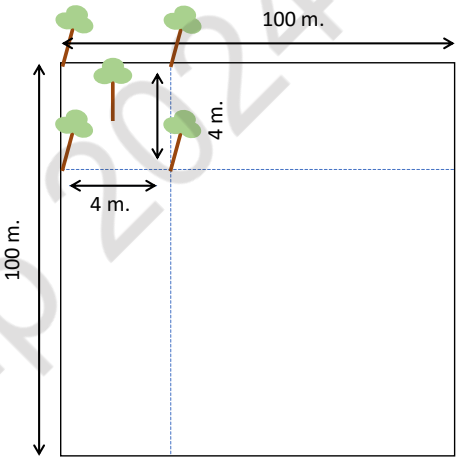
**IFoS 2017** : Calculate the number of *seeds required* to raise a 20-hectare plantation with 4 m x 4 m spacing and an extra plant in the centre of each square. Plant percentage of the species is 75% [Paper – 1 | 8 m]

Suppose one seed produces one plant, therefore the number of seeds (plants) required per hectare are

= 625 + 576 = 1201

Total area = 20 hectares

Total seed requirements = 20 × 1201 = 24,020




Here, we found that our seed lots have 25 % impurities, which means, we get only 75 seeds of a selected species out of 100 seeds.

Therefore, we required = *32,026 Seeds* to get 24,020 Seeds (Plants) of a selected species.

**IFoS 2017** : Some rural communities are opposed to *chir-pine* and advocate of removal of chir-pine and its replacement with broadleaved multipurpose trees. What is your reaction in this matter [Paper – 1 | 10 m].

Chir pine (*Pinus roxburghii*) is an evergreen tree species belonging to the family Pinaceae and grows in altitude ranges between 1000-2,500 m. It can be grown in quartzite-rich soil.

Since the local is advocating broadleaved multipurpose trees in place of Chir pine, the problems which may occur with multipurpose species are-

- Broadleaved multipurpose tree species are less likely to survive in extreme snowfall in the region as due to the weight of snow the species may break down.
- Multipurpose tree species are more vulnerable to grazing, browsing etc., which may result in site degradation
- Part of the plantation is also carried out in slopes, where the soil is devoid of nutrients, thus multipurpose tree species may not survive in such site

- Government planning of the region- The government adopted Chir pine because it fulfils their industrial demand for lightweight timber, resin etc. which cannot be fulfilled through multipurpose.

Based on such conditions I will try to convince villagers to promote the cultivation of Chir pine and not broadleaved multipurpose trees because, in the long run, it will fulfil their requirements much better than multipurpose trees. In order to gain their support, JFM can be started in which the participation of villagers can be sought.

**IFoS 2017** : What is *sub-climax*? Explain its importance in the context of Indian forestry [Paper – 1 | 10 m].

Sub-climax refers to the stage in ecological succession preceding the climax stage. Such a stage is achieved due to natural or manmade factors like forest fires.

*Figure*



Importance of Sub-climax in Indian Forestry

- It helps in the regeneration of some of the forest species.
- It helps in inducing new flush shoots in species which are instrumental in collecting minor forest produce like Tendu leaves.
- It helps in inducing certain properties in plants like fire resistance.
- This serene stage is vital for the survival of wild animals like Rhino.
- It helps in preventing the expansion of invasive species in Indian forests and plantations.
- It also improves soil quality by clearing litter and removing soil pathogens.

**IFoS 2017** : Explain the classification of forest types of India by Champion and Seth. Enlist major forest types and their group [**Paper – 2** | 10 m].

Champion and Seth classified the forest based on the ecosystem approach and considered vegetation, temperature, climate, soil etc. Thus, it classified the forest into five major groups and 16 types

- Major Group 1 –Tropical forest- it is further classified into seven groups like

    1. Tropical wet evergreen forest
    2. Tropical Semi-evergreen forest
    3. Tropical moist deciduous forest
    4. Tropical littoral and swamp forest
    5. Tropical dry deciduous forest
    6. Tropical thorn forest
    7. Tropical dry evergreen forest

- Major Group 2- Mountain Subtropical forest- they are further classified into

    8. Mountain subtropical broad leaves hill forest
    9. Mountain subtropical Pine Forest
    10. Mountain Subtropical dry evergreen forest

- Major Group 3 - Mountain temperate forest

    11. Mountain wet temperate forest
    12. Himalayan moist temperate forest
    13. Himalayan dry temperate forest

- Major Group 4 - Sub Alpine Forest

    14. Subalpine forest

- Major Group 5 - Alpine Forest

    15. Moist alpine forest
    16. Dry alpine forest

68 AIR

**Diwakar Swaroop**

Forestry Comprehensive Course

72 AIR

**Rajesh Kumar**

Forestry Comprehensive Course

74 AIR

**Krishna Chaitanya**

Forestry Comprehensive Course

75 AIR

**Harveer Singh Jagarwar**

Forestry Comprehensive Course

76 AIR

**Akash Dhanaji Kadam**

Forestry Comprehensive Course

78 AIR

**Himanshu Dwivedi**

Forestry Comprehensive Course

80 AIR

**Sumit Dhayal**

Forestry Comprehensive Course

82 AIR

**Priyadarshini**

Forestry Comprehensive Course + Test Series

91 AIR

**Sucheet Balkal**

Forestry Comprehensive Course

93 AIR

**Harshad Hinge**

Test Series

96 AIR

**Maharshi Kumar**

Forestry Comprehensive Course

97 AIR

**Akash Kumar**

Forestry Comprehensive Course

104 AIR

**P R Sarbajit**

Forestry Comprehensive Course

105 AIR

**Pawan K. Meena**

Forestry Comprehensive Course

110 AIR

**Keshav Prasoon**

Forestry Comprehensive Course + Test Series

111 AIR

**Nagabhushana S**

Forestry Comprehensive Course

113 AIR

**Shewale Vyankatesh G.**

Forestry Comprehensive Course

123 AIR

**Chandra Bhushan**

Forestry Comprehensive Course

127 AIR

**Shubham Kanoujia**

Forestry Comprehensive Course + Test Series

128 AIR

**Harsh Verma**

Forestry Comprehensive Course + Test Series

134 AIR

**Gaugin Gyanendra Singh**

Forestry Comprehensive Course

# 64 Out of 147 Total Selections in

## Indian Forest Service (IFoS) 2023