INTRODUCTORY SILVICULTURE

For

B. Sc. Forestry students

Full Marks-50 (SFB 350 S)

by

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TWO WORDS

I prepared these slides in brief for B. Sc. Forestry students, KAFCOL for the subject " **Introductory Silviculture"** that were used during teaching in the classroom in 2010. Detailed class note was provided to the students, where I have acknowledged all the materials used for the purpose. But, I could not acknowledge all the manuscripts to minimize the number of slides.

These slides must be useful for the learners of silviculture &/or persons who are preliminary interested in the forestry field although these slides are not likely to be sufficient to fulfill the interest of the learners and/or students. Sorry for not managing fonts and colors uniformly. Thanks for using these slides for your own purposes.

Regards,

Bechu K. V. Yadav

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UNIT- 1: INTORDUCTION

1.1 DEFINITION AND OBJECTIVES OF SILVICULTURE

1.2 COMMON TERMS IN SILVICULTURE

1.3 RELATION OF SILVICULTURE WITH OTHER BRANCHES OF FORESTRY

1.1 DEFINITION AND OBJECTIVES

DEFINITION

1. "*The art and science of cultivating forest crops*" (Indian Forest and Forest Products Terminology)
2. **Silviculture** *refers only to certain aspects of the theory and practice of raising forest crops* (Champion and Seth)
3. **Silviculture** is that branch of forestry which deals with the establishment, development, care, and reproduction of stands of timber.

Silvics is the study of life history and general characteristics of forest trees and crops with particular reference to environmental factors, as the basis for the practice of silviculture.

- Silviculture includes both silvics and their practical application.
- Silviculture is not a purely biological science which has no relation with economics.

OBJECTIVES

1. Production of species of economic value (Propagation of more valuable and useful species to meet the multifarious requirements of the people)
2. Production of larger volume per unit area/increasing the productivity of the forests
3. Production of quality timber
4. Reduction of rotation
5. Raising forests in blank areas/unproductive areas
6. Creation of man-made forests in place of natural forests
7. Introduction of exotics

OBJECTIVES contd…

Similarly,

8. Control of stand structure
9. Control of composition
10. Control of stand density
11. Conservation of site quality
12. Increase employment opportunities
13. Increase the production of fuel and fodder
14. Development of forest industries
15. Derive environmental benefits
16. Protection and reduction of losses

1.2 SOME COMMON TERMS

Seedling: A plant grown from seed till it attains a height of about one metre

Sapling: A young tree from the time when it reaches about one metre (3') in height till the lower branches begin to fall (L.S. Khanna, 1981)

- ✓ A small tree, usually between 4 and 10 cm diameter at BH and height more than one metre (DoF, 2004).

Pole: A young tree from the time when the lower branches being to fall off to the time when the rate of height growth begins to slow down and crown expansion becomes marked.

- ✓ A young tree usually between 10 and 30 cm in diameter at BH (DoF, 2004).

Tree: The stage of growth beyond the pole stage when the rate of height growth begins to slow down and crown expansion becomes marked. Or Woody plant having one erect perennial stem or trunk at least 30cm dbh and 4 metres of height (DoF, 2004).

COMMON TERMS Contd…

Sustained Yield: The material that a forest can yield annually or periodically in perpetuity

Stand: A group of trees that occupies a specific area and is similar in species, age and condition

Canopy: The forest cover of branches and foliage formed by tree crowns

Virgin Forest: Natural forest uninfluenced by human activity.

Growing stock: Sum (by number or volume) of all the trees in a forest or in a specified part of the forest

Rotation: The planned number of years between the formation

Stagheaded: The condition of the tree with dead upper branches projecting above the green portion of the crown

Wind throw: Uprooted by wind

Wind firm: Able to withstand strong winds without being thrown or broken

1.3 RELATION WITH OTHER BRANCHES OF FORESTRY

Forest Mensuration: Silviculture deals with raising of forest crops, forest mensuration deals with measurement of diameter and heights of crop so produced, calculation of its volume, age, etc., for sale and research to decide the best treatment to be given to the crop while it is being raised.

Forest Utilization: Silviculture deals with cultivation of forest crops, forest utilization is concerned with the harvesting and disposal of crops so produced

Forest Economics: Silviculture deals with cultivation of forest crops, forest economics works out the cost of production including rental of land and compound interest on capital spent in raising the crop. It compares the cost of production by different methods and then decide the most profitable method of raising that crop.

1.3 RELATION WITH OTHER BRANCHES OF FORESTRY

Forest Management: It manages forest crops according to the dictates of the policy and prescribes the time and place where the silvicultural techniques and operations are carried out to attain the goal of management.

Forest Protection: A knowledge of the injuries caused to forests by the local human and animal population, both domestic and wild, insects, fungi and other adverse climatic factors and preventive and remedial measures to counteract them, whereas silviculture is concerned with raising forest crops

Forest Ecology: It is concerned with forest ecosystem. It deals with different species of flora and fauna, whereas silviculture deals with their cultivation and maximization of their production.

2. ENVIRONMENTAL (LOCALITY) FACTORS

2.1 Definition and Classification

2.1.1 Definition

Environment: All the biotic and abiotic factors of a site

Locality Factors: The effective climatic, edaphic, topographic and biotic condition of a site, which influence the vegetation of the locality, also referred to as habitat factors.

2.1.2 Classification

1. Climatic factors 2. Topograpic factors

3. Edaphic factors 4. Biotic factors

5. Other factors (Pollution, stress)

UNIT- 2.2 CLIMATIC FACTORS

Climate: The average weather conditions prevalent in any locality.

Climatic Factors:

1. Solar radiation: (a) Light (b) Heat and temperature
2. Moisture
3. Wind

1. Solar radiation

The energy radiated by sun reaches the in the form of electromatic waves of length ranging, ranging nearly from 290 mμ to 5300 mμ. Visible wavelength-39% (400 to 720 mμ), ultraviolet wavelength-1%(<400 mμ) and infrared-60% (720 mμ)

Light:

Light is part and parcel of solar radiation, the requirement of which varies with species. Various species show varying tolerance to light intensities. But they depend on stages of development, eg. Sal is light demander, but requires partial shade in the beginning or earliest stage. So, to classify the species, detail information on conditions of species are required. On this basis, they are classified as follows:

1. **Light demander:** A species that requires abundant light for its best development, eg. Sal, Teak, Banjh, Khote salla, Gogre salla, Sissoo, Simal, etc.
2. **Shade bearer:** A species capable of persisting and developing under shade, eg. Deodar, Bijay Sal, Khashru, *Cuppressus torulosa, Picea smithiana*, etc.

Light: contd...

3. **Shade demander:** A species requiring some degree of shade at least in its early stages, for its normal development, eg. Sindure, Jamun, Loth salla, *Abies pindrow*, etc.

Importance

1. **Chlorophyll Formation:** Light of any wavelength or low intensity is sufficient to form chlorophyll. Without light, plants become pale yellow and have thin internodes, a condition known as *etiolation*. Chlorophyll decomposes in bright sun light; thus formation and decomposition both go on simultaneously when the plant is exposed to light.
2. **Functioning of stomata:** Light influences daily opening and closing of stomata, which affects respiration and photosynthesis.

Light: contd…

3. **Photosynthesis:** The light used in photosynthesis is a small amount of the total light that falls on a leaf. It has been estimated that light used in it is less than 2% of the light energy incident on well-illuminated leaves. There is usually sufficient light even in dense forest for this important physiological activity.
4. **Growth**: Forest trees generally require about 1 to 1.5% of the full sun light in moderate intensity of light. The best growth takes place in moderate light if food is available. Quality of light refers to the wavelength of the light spectrum or colors. Violet and ultra-violet light bring about dwarfing effect. Photoperiod varies with altitude and latitude (*photoperiod is the relative length of day and night to which the plant is exposed).* Light affects breaking of dormacy, germination, leaf fall and flowering. Extremely high intensity of light increase transpiration excessively, stem remain short and develop smaller leaves.

Light: contd…

5. **Form and quality of trees:** Height growth is retarded in intense light conditions. Trees growing is shade are usually taller than those growing in open. Light causes formation of relatively large crown and so rapid growth.
6. **Species stratification, size and structure of leaves:** Full light reaches the top canopy and lower canopies receive only escaped light results in the stratification. Light also affects the size, colour and structure of leaves. The leaves exposed to full light are smaller than those in partial light. Many forest trees develop different anatomical structure in their leaves in shade as compared to those grown in sun. Light also affects the arrangement of leaves.

Temperature

While energy received is constant, the temperature of various place on the earth is different because it is affected by the following factors:

1. **Latitude:** As the latitude increases, the temperature decreases. Temperature is highest at equator.
2. **Altitude:** It has been estimated that there is a fall of 1°c in mean temperature in the hills for every 270m rise in altitude. As the altitude increases, temperature decreases.
3. **Distance from the sea:** The farther a place from the sea, the greater are the diurnal and seasonal ranges of temp.
4. **Winds:** If winds are from the sea side, their effect is more marked. Due to winds, east of Nepal has more rain than that of west. Mustang undergoes minimum rain.

Temperature contd…

5. **Mountains :** The direction of the mountain ranges affects temperature through its effect on winds and rainfall.
6. **Cloudiness:** As clouds screen off the sun, their presence affects temperature.
7. **Presence or absence of forest vegetation:** The rays of the sun strike bare sites directly and such places are therefore hotter than the places covered with forest vegetation. The crowns of trees obstruct the rays of sun before they can reach the ground and thus reduce the temperature of the place.

Temperature contd…

Kinds and their importance:

I. Air Temperature

(i) It increases transpiration, photosysnthesis and respiration.

(ii) It increases microbial activities on soil surface causes decomposition of organic matter and release of nutrients to be available of trees.

(iii) It affects activities of enzymes, which practically stop at 50 or 0°c

(iv) It increases cambial activities in the shoot portion

(v) It affects growth of trees

(vi) It affects germination of seeds

Temperature contd…

Kinds and their importance:

II. **Soil Temperature**

(i) It affects absorption of soil moisture, which is better between 27 and 35°c

(ii) It affects cambial activities particularly in temperate climate and so growth starts earlier in warmer soils than in colder soils

(iii) Higher soil temperature is indicative of multiplicity of vegetation and vice versa.

(iv) It limits the particular species to the particular sites.

Frost : Chilling of air below the freezing point.

Depending on the mode of occurrence, it is classified as:

1. **Radiation frost:** It occurs on nights with clear sky, produced by loss of heat by radiation. It occurs in plain and kills back young plants. Whenever ice crystals are formed on the ground and other objects near the surface, it is called *ground frost* or *hoar frost*.
2. **Pool Frost:** The accumulation to a considerable depth of heavy cold air flowing down into natural depression from adjoining areas. It occurs in hill and valley country
3. **Advective frost:** A frost produced by cold air brought from elsewhere

When an area is affected by frost more than other areas inthe locality, it is referred to as *frost pocket* or *frost hole* or *frost locality*.

Frost : contd…

Frost Injuries:

a. Killing of young plants or their parts
b. Death of plants due to damage to cells
c. Injuries to the crowns of poles and saplings
d. Frost cracks
e. Formation of Canker

The species killed back by frost is called ***frost tender*** and thespecies which pose power to withstand frost without being damaged are called ***frost hardy.***

Frost hardy: Khair, Sissoo, Khote salla, Bayer, Mahuwa, etc

Moderately frost hardy: Banjhi, Karma, Simal, Satisal, Gamhari, Kimbu, etc.

Frost Tender : Babul, Nim, Teak, Arjun, Asna, etc

Factors affecting frost resistance

A. Internal Factors

i. Size of cell
ii. Water content
iii. Osmotic concentration
iv. Permeability of water
v. Water-binding colloids

B. External Factors

i. Temperature
ii. Light
iii. Mineral nutrition

Hardening off

- It is the natural process by which plants become adopted to drought, cold or heat
- This term is also used for preparing seedlings in nursery, for planting out by gradually reducing watering, shade and/or shelter resulting in hardening off plant.

Moisture:

Importance

A. **Importance in physical activities:** Moisture is essential for germination, viability of seeds, transpiration, respiration of plants, which can not be possible in its absence. It is the single medium for absorption of soil minerals and gases in the plants. It is one of the raw materials required for photosynthesis. It is required not only for translocation of manufactured food, but also for all kinds of chemical reactions taking place in the plant.

B. **Importance in soil formation processes:** Moisture is required for physical as well as chemical weathering resulting in the formation of soil.

Moisture: contd…

A. **Influence on vegetation:** It determines the nature of vegetation that would survive in a particular area. It determines the species, their number per unit area, height, diameter and volume growth of trees and other vegetation. So, it can be used as a basis for classifying vegetation in broad temperature zones.

Sources of Moisture

i. Precipitation in the form of rain, snow or hail
ii. Dew and hoar frost
iii. Invisible condensation of moisture

Wind

Positive effects

1. Wind brings fresh supplies of carbon dioxide to the foliage of trees and thus helps in photosynthesis
2. Wind helps in pollination of anemophilous flowers
3. Wind helps in the dispersal of seed of many forest trees. Eg. *Toona ciliata, Bombax ceiba, etc*

Harmful effects

Direct harmful effects: Tapering in the boles, bending, uprooted, branches damaged, growth affected, etc

Indirect harmful effects: Fans up forest fire resulting in fire damage; increase evaporation; wind erosion and removes fertile soil depositing sand, etc.

2.3 TOPOGRAPHIC FACTORS

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

- describes configuration of the ground, its altitude, slope, aspect, etc.
- affects vegetation through climate, soil formation processes, soil moisture, soil nutrients, etc.

Topographic Factors can be classified into:

1. Configuration of land surface
2. Altitude
3. Slope
4. Aspect and exposure

TOPOGRAPHIC FACTORS contd…

1. Configuration of the land surface

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

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

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

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

TOPOGRAPHIC FACTORS contd…

2. Altitude:

It affects vegetation through solar Radiation, temperature and rainfall

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

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

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

TOPOGRAPHIC FACTORS contd…

3. Slope

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

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

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

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

TOPOGRAPHIC FACTORS contd…

4. Aspect and Exposure

Aspect- the direction towards which a slope faces

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

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

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

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

Bioclimate

The climate defined by these modified or adjusted climatic factors is called bioclimate.

Climatic factors influence the vegetation collectively but not individually and separately. While affecting vegetation collectively, these factors modify the influence of each other to certain extent. For example,

Total rainfall of a place has a certain effect on vegetation. But the effect of total rainfall is modified by the number of rainy days. The effect of total rainfall and number of rainy days is further modified by the amount of evaporation.

Similarly, to describe moisture as a climatic factor, temperature, precipitation and their related factors are to be studied.

Microclimate

The climate of small areas, which differs significantly from the general climate of the area; chiefly the climate under a plant or other cover, differing in extremes of temperature, moisture, etc., from the climate outside that cover. If proper attention is not given to this important factor, silviculture operations such as natural or artificial regeneration may fail completely due to the local adverse or limiting factors responsible for the microclimate.

Microclimate affects solar radiation, temperature, rainfall, humidity of the site resulting in the difference in the species composition.

2.4 EDAPHIC FACTORS

Edaphic factors are defined as 'ecological influences properties of the soil brought about by its physical and chemical characteristics'.

Soil: can be recognized as surface soil, sub-soil and forest soil. If a section of soil is observed from its surface to the underlying rock, horizons (layers) are seen. A vertical section with respect to the sequence of layers are called soil profile. Eg. A^{oo} horizon surface litter; A^{o} horizon- humus layer; A horizon- Uppermost layer of mineral soil; B horizon- layer formed by washing down from A horizon, etc.

Classification of Soil-Soil is classified into two major groups: Soils whose properties are influenced mainly by the parent material are called **Endodynamorphic**, whereas properties influenced by factors other than parent material is **Ectodynamorphic.**

EDAPHIC FACTORS contd…

Importance

(i) The seeds germinate in the soil and the roots go inside the soil not only to anchor but also to provide nutrients & water

(ii) Soil provides air to the roots

(iii) It affects rate of growth of trees, yield of trees and natural regeneration

(iv) Forester can improve the productive capacity of soil, whereas climatic and topographic factors are beyond the control of foresters.

(v) Species composition of a forest depends on the properties of soil

EDAPHIC FACTORS contd…

A. **Physical Properties:** Supply of moisture, nutrients and airaffect physical properties of soil cause significant influence on tree growth. Such properties of soil relate chiefly to its texture, structure and porosity.

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

EDAPHIC FACTORS contd…

Importance

Soil texture plays crucial role for nutrient supplies, aeration, root development, moisture relations, etc

(i) Nutrient supplies: The fine-textured soils are high in nutrient status; but sandy soils are low in fertility.

(ii) Aeration: Coarse-textured soils are better aerated than clayey soils.

(iii) Root development: percentage of soil particles affect root development.

(iv) Moisture relations: Coarse-textured soils are easily drained; fine-textured soils are poorly drained and hold much water on the large surface area

EDAPHIC FACTORS contd…

2. Soil Structure

The arrangement of individual soil particles into aggregates of definite size and shape. Clod (>25mm), prism, crumb (3mm), granules (upto 6mm), etc are soil aggregates and their sizes differ.

Importance

(i) It affects soil moisture and soil air relations

(ii) It is an indication of nutrient status and activity of micro-organisms in the soil

(iii) It affects soil erosion. Crumb is least liable to erosion while single-grained structure is most liable to erosion

EDAPHIC FACTORS contd…

3. Soil Porosity

The extent to which gross volume of the soil is unoccupied by solid particles. Pore space is the space unoccupied by soil particles. Clayey soil has very small pore spaces and retain too little air, on the other hand sandy soils are well-aerated. *Capillary porosity* is the portion of soil not fulfilled by water when the soil is wet, whereas *Non-capillary Porosity* is the air space in a soil at field moisture capacity.

Importance

(i) It determines moiture and air relations of the soil

(ii) It affects internal drainage and diffusion of soil air.

EDAPHIC FACTORS contd...

B. Chemical Properties:

The soil is known to be the chemical laboratory of nature in which various chemical decomposition and reactions taking place in a hidden manner. The major chemical properties which affect plant growth are discussed below in brief;

1. Cation Exchange Capacity 2. Soil Acidity 3. Silica-sexquioxide Ratio

1. Cation Exchange Capacity

The total capacity of soil for holding cations and is usually expressed in terms of milli-equivalents per 100gms of oven dry soil. An equivalent is the quantity chemically equal to one gm (No. of hydrogen atoms=6.02×10^{23}) of hydrogen and so a milli-equivalent is equal to 0.001gm of hydrogen.

EDAPHIC FACTORS Cation Exchange Capacity contd…

Soil has both positive and negative charge, yet negative charge is of much greater magnitude, which has capacity to absorb positively charged ions from the soil solution. The cations absorbed are Ca, Mg, K, Na and H. The exchangeable cations of Ca, Mg, K, Na are all associated with compounds which are more basic than acid in reaction. So, these are referred to as exchangeable bases, while H as exchangeable acid.

Therefore, cation exchange is the process by which a colloidal nucleus absorbs certain cations from the soil solution and gives up other cations held by it in equivalent quantities. Symbolically , CEC always stands for cation exchange capacity.

EDAPHIC FACTORS Cation Exchange Capacity contd…

Importance

(i) CEC is a sort of store house of mineral nutrients, which determine total amount of nutrients available to plants

(ii) CEC determines the rate of fertilizers to be applied to nursery and plantation soils. Eg. In fine-textured soils, where CEC is high, large amounts of fertilizers can be applied

(iii) It determines the degree to which exchange is saturated with bases as compared with hydrogen. If H-ions predominate, the soil becomes acidic. But if bases predominate, the soil may be neutral to alkaline.

(iv) It helps in the choices of species for successful plantation

(v) It helps in proper and complete soil utilization

EDAPHIC FACTORS contd…

2. Soil Acidity

Acidity of a soil solution is due to an excess of hydrogen ions over hydroxyl ions. But if hydroxyl ions are in excess over hydrogen ions, the solution becomes alkaline. Pure water contains equal amount of hydrogen and hydroxyl ions and is, therefore, said to neutral. Those concentration of ions are indicated by **P^H** . P^H of 7 indicates neutrality, higher values indicate alkalinity and lower values acidity. P^H value does not remain constant throughout the soil profile. It usually varies from horizon to horizon.

Importance of P^H value

P^H value has a profound influence on the distribution and growth of forest trees directly as well as indirectly through its influence on the availability of nutrients, activities of soil

EDAPHIC FACTORS Importance of P^H value contd…

Soil organisms, physical properties of soil as given below:

(i) P^H value indicates what species would be successful in a particular soil, eg. Sal grows best in soils with P^H 4.5 to 5.5; Teak occurs best in P^H 6.5 to 7.6

(ii) P^H value affects the availability of nutrients. Increase in P^H results in increased availability of calcium. Nitrogen is best available when P^H is between 6 to 8

(iii) value determines the degree of maturity of soil and the stage of development in plant succession. Soil acidity is associated with maturity of soil and climax vegetation, whereas basic soils are indicative of immaturity.

EDAPHIC FACTORS contd…

3. Silica-sesquioxide Ratio

As a result of loss of silica by leaching, sesquioxides get accumulated in the soil profile. The relation between silica and sesquioxides of soil, is known as silica-sesquioxide ratio. Increase in sesquioxides results in decrease in cation exchange capacity and moisture retentivity of soil

EDAPHIC FACTORS contd…

Soil Organic Matter: Organic fraction of the soil, which includes plant and animal residues at various stages of decomposition. It is commonly determined as those organic materials which accompany the soil when put through a 2mm sieve.

Litter: The uppermost layer of organic debris (dead vegetable matter) on a forest floor, freshly fallen or only slightly decomposed and consisting chiefly of leaves but also including bark fragments, twigs, etc. Since it lies on the soil as the topmost layer, it constitutes A^{oo} horizon of the soil profile. All the fallen leaves, twigs, litter, etc are termed as liiter.

EDAPHIC FACTORS contd…

Humus: The more or less decomposed organic matter of the soil which may form a separate layer or be intimately mixed with the mineral particles. There different kinds of humus. They are sour humus, raw humus, mild humus and leaf mould.

Importance of humus

(i) Humus get mixed with soil, it improves its structure increasing their water holding capacity and rate of percolation of moisture

(ii) It makes sandy soils more cohesive, thereby improving their structure

(iii) It makes clayey soil more permeable to air and water

(iv) It is a great source of plant nutrients

(v) Its addition to the soil increases cation exchange capacity

EDAPHIC FACTORS contd…

Factors affecting formation of humus

(i) Nature of forest, its composition, age, etc

(ii) Climatic factors

(iii) Soil organisms and other animal life

(iv) Nature of soil

(v) Lopping, removal of leaf litter by human beings or its destruction by burning

(vi) Micro-climate

2.5 BIOTIC FACTORS

The influence of living organisms is said to be biotic factors. These factors have a profound influence on vegetation not only by their direct interaction but also through their effect on soil and therefore determine the nature of vegetation that can exist in a place.

Biotic factors can be described under the following titles:

1. Influence of plants
2. Influence of insects
3. Influence of wild animals
4. Influence of man and his animals

BIOTIC FACTORS contd…

1. Influence of plants

When vegetation comes up on a site for the first time, plants gradually increase in number and start competing with each other for essential requirements of life, i.e. food and light by desired and/or undesirable species.

Competition between desired species depends on their power to produce abundant seed every year, to disperse it widely, and to germinate and grow even in adverse condition, their rate of growth, moisture requirement, mode of branching, browsing, longevity, fire, etc

Besides desired species, there are some undesirable species affecting the growth of trees of the favored species. Undesirable species may be weeds or harmful species.

BIOTIC FACTORS contd…

Undesirable harmful species may be studied as follows:

(i) Parasites

(ii) Epiphytes

(iii) Climbers

(iv) Abnoxious weeds

(v) Fungi

(i) Parasites

Parasites grow on some living plant called host and penetrate their sucking roots into the host plant called hautoria. They do not draw moisture and mineral nutrients from soil. Sanal tree is a root and valuable parasite.

Eg. Common parasites- *Cuscuta reflexa, Cassytha filiformis*

Partial parasites- *Viscum, Loranthus, Arceuthobium*

BIOTIC FACTORS contd…

(ii) Epiphytes

Epiphyte is a plant growing on but not nourished by another plant. They only take the help of other plant in getting access to light. Eg. *Ficus bengalensis, F. religiosa, orchids, etc.*

(iii) Climbers

A herbaceous or woody plant that climbs up or other support by twinning round them or by holding on to them by tendrils, hooks, aerial roots or other attachments. Large woody climbers in tropical areas are called *liana.* They depend on other plants for physical support or to get access to light. They damage the trees by killing them or by making groove or by bending the trees. Eg. *Bauhinia vahlii, Butea superba, ipomea, etc.*

BIOTIC FACTORS contd…

(iv) Obnoxious weeds

Obnoxious weed reaches in an area and spreads fast. It coppices well and becomes a serious obstacle in the regeneration. For example; *Lantana camera, Eupatorium odorantum*.

(v) Fungi

A large number of fungi attack forest trees and their attack, besides reducing quality of timber of trees attacked, sometimes change the form and structure of forest communities. They cause damping off in seedlings, wood rot and root rot in poles and trees, thereby killing them or making the timber altogether useless.

BIOTIC FACTORS contd…

2. Influence of insects

Insects are important part of forest ecosystem. But some of them are harmful such as *Hoplocerambyx spinicornis*(Sal borer), *Hapalia machaeralis (*Teak defoliator), *Hyblea puera (*Teak skeletonizer), *plecoptera reflexa, Hypsipyla robusta, etc*

3. Influence of wild animals

Wild animals are also crucial part of forest ecosystem, which help in pollination of flowers and dispersal of seed. However, they damage the forest crops considerably. For example; Cheetals, Sambars and Nilgai affect on sal regeneration. Porcupines destroy seedlings of bamboo, khair and simal. Pigs, elephants and monkeys damage seedlings samplings and poles by breaking the branches and uprooting them.

BIOTIC FACTORS contd…

4. Influence of man and his animals

Man is responsible for managing forests, yet he continues to be the most powerful agent in destroying forests in many ways. There are some ways of damaging forest vegetation. They are;

(i) Deforestation and denudation

(ii) Lopping

(iii) Removal of dry leaves

(iv) Collection of flowers and fruits

(v) Grazing

(vi) Firing

(vii) Encroachment

Unit-2.6 Pollution

Pollution is defined as a contamination by a chemical or other agent that renders part of the environment unfit for intended or desired use. These uses

also and very importantly include all wildlife and ecological

requirements to sustain life in all its natural forms.

Pollution damages the Earth's land, water and air. It results in contamination of the earth's environment with materials that interfere with human health, the quality of life, and the natural functioning of ecosystems. Pollution is usually caused by human actions, but can also be the consequence of natural disasters. Pollution can also occur from disruption or damage to wastewater collection and treatment infrastructure due to severe natural events like hurricanes or flooding. Most types of pollution affect the immediate area surrounding the source, and reduce as you move away from the source.

Pollution is often caused by the garbage that people throw on the ground or into oceans, lakes or rivers.

Unit-2.6 Pollution contd…

Kinds of pollution:

1. Air Pollution
2. Water Pollution
3. Noise Pollution
4. Soil Pollution
5. Gaseous Pollution
6. Thermal Pollution
7. Sewage Pollution
8. Radioactive Pollution

Unit-2.6 Pollution contd…

Pollution Effects On Plants and Trees:

Although there are so many effects on humans, animals, plants and the environment by pollution, we only discuss the effects of pollution on plants and trees. Some of them are outlined here as follows:

Air Pollution

Acid rain can kill trees, destroy the leaves of plants, can infiltrate soil by making it unsuitable for purposes of nutrition and habitation

Ozone holes in the upper atmosphere can allow excessive ultraviolet radiation from the sun to enter the Earth causing damage to trees and plants

Ozone in the lower atmosphere can prevent plant respiration by blocking stomata (openings in leaves) and negatively affecting plants' photosynthesis rates which will stunt plant growth; ozone can also decay plant cells directly by entering stomata

Unit-2.6 Pollution contd…

Water Pollution

- May disrupt photosynthesis in aquatic plants and thus affecting ecosystems that depend on these plants
- Terrestrial and aquatic plants may absorb pollutants from water (as their main nutrient source) and pass them up the food chain to consumer animals and humans
- Plants may be killed by too much sodium chloride (ordinary slat) in water
- Plants may be killed by mud from construction sites as well as bits of wood and leaves, clay and other similar materials
- Plants may be killed by herbicides in water; herbicides are chemicals which are most harmful to plants

Soil Pollution

- May alter plant metabolism and reduce crop yields
- Trees and plants may absorb soil contaminants and pass them up the food chain

Unit-2.6 Stress

Stress is an altered physiological condition caused by factors that tend to disrupt the equilibrium. Strain is any physical and chemical change produced by a stress (Gaspar *et al., 2002). The term stress is used with various meanings,* the physiological definition and appropriate term as responses in different situations.

Stress is simply a fact of nature forces from the outside world affecting the individual. The individual responds to stress in ways that affect the individual as well as their environment. Hence, all living creatures are in a constant interchange with their surroundings (the ecosystem), both physically and behaviorally.

The events that provoke stress are called **stressors**, and they cover a whole range of situations everything from outright physical danger to making a class presentation or taking a semester's worth of your toughest subject.

Unit-2.6 Stress contd…

1. Abiotic stress:

Abiotic stress is defined as the negative impact of non-living factors on the living organisms in a specific environment. The non-living variable must influence the environment beyond its normal range of variation to adversely affect the population performance or individual physiology of the organism in a significant way. Abiotic stress factors or stressors are naturally occurring, often intangible, factors such as intense sunlight or wind that may cause harm to the plants and animals in the area affected, e.g., Water stress, salt stress, wind stress, heat stress, drought stress, nutrient stress, etc. Stresses can be studied classifying into the following different kinds:

(i) Drought stress: It occurs when the available water in the soil is reduced and atmospheric conditions cause continuous loss of water by transpiration or evaporation. Drought stress tolerance is seen in almost all plants but its extent varies from species to species and even within species. Drought stress is characterized by reduction of water content, diminished leaf water potential and turgor loss, closure, nutrient metabolism and growth promoters.

Unit-2.6 Stress contd…

(ii) Water stress: water stress may result in the arrest of photosynthesis, disturbance of metabolism and finally the death of plant. Water stress inhibits cell enlargement more than cell division. It reduces plant growth by affecting various physiological and biochemical processes, such as photosynthesis, respiration, translocation, ion uptake, carbohydrates, nutrient metabolism and growth promoters

(iii) salt stress: there are wild plants that thrive in the saline environments along the sea shore, in estuaries and saline deserts. These plants, called halophytes, have distinct physiological and anatomical adaptations to counter the dual hazards of water deficit and ion toxicity. Salinity can affect any process in the plant's life cycle, so that tolerance will involve a complex interplay of characters. Research projects at Liverpool have investigated details of the physiology and biochemistry of salt tolerance and also looked at methods to screen overall plant performance that could be used in breeding programmes.

Unit-2.5 Stress contd…

(iv) heat stress: Heat stress often is defined as where temperatures are hot enough for sufficient time that they cause *irreversible* damage to plant function or development. In addition, high temperatures can increase the rate of reproductive development, which shortens the time for photosynthesis to contribute to fruit or seed production. I also will consider this as a heat-stress effect even though it may not cause permanent (*irreversible*) damage to development because the acceleration does substantially reduce total fruit or grain yield.

(v) wind stress: Wind stress is visual stress incurred by wind causes damage to seedlings, breaking branches and even uprooting the whole plants. It helps to covert ground fires to crown fires.

(vi) nutrient stress: Nutrient stress is one of the major stresses causing dying back in plants. It causes due to the shortage of nutrients in soil such as nitrogen, phosphorus, iron, etc.

2. **Biotic stress:** Biotic stress would include such living disturbances as fungi or harmful insects, e.g., Animal (wild or domestic) stress, insect stress, fungi stress, etc. Fungi by rotting of heart wood, animals by breaking, trampling and grazing, insects by eating skeleton or leaves, etc cause stresses in plants either in natural or artificial.

UNIT-3 CONCEPT OF SUCCESSION

3.1 Introduction

Defs^{n}

Plant succession: The gradual replacement of one community by another in the development of vegetation towards a climax.

Climax: The culmination stage in the plant succession for a given environment

Sere: The series of plant communities resulting from processes of succession or any recognizable stage in plant succession.

Concept of plant succession

The idea of ecological succession goes back to the 14th century. The French naturalist, **Adolphe Dureau de la Malle** was the first to make use of the word *succession* about the vegetation development after forest clear-felling. In 1859, **Henry David Thoreau** wrote an address called "The Succession of Forest Trees" in which he described succession in an Oak-Pine forest. **Later Cawles** (1899) described the change in vegetation on sand dunes.

UNIT-3 CONCEPT OF SUCCESSION contd…

Clement's theory of succession/Mechanisms of succession

F.E. Clement (1916) developed a descriptive theory of succession and advanced it as a general ecological concept. His theory of succession had a powerful influence on ecological thought. Clement's concept is usually termed ***classical ecological theory***. According to Clement, succession is a process involving several phases:

Nudation: Succession begins with the development of a bare site, called Nudation (disturbance).

Migration: It refers to arrival of propagules.

Ecesis: It involves establishment and initial growth of vegetation.

Competition: As vegetation became well established, grew, and spread, various species began to compete for space, light and nutrients. This phase Is called competition.

Reaction: During this phase autogenic changes affect the habitat resulting in replacement of one plant community by another.

Stabilization: Reaction phase leads to development of a climax community.

UNIT-3 CONCEPT OF SUCCESSION contd…

Importance

(i) It is one of the bases for classification of forests into forest types

(ii) The species to be planted have to be selected keeping in view the stage of succession, otherwise it would result in failure.

(iii) Knowledge of succession shows that how the composition of the crop is changing and will change in future. It also indicates the factors by which the succession can be altered to the best advantage of the people.

CONCEPT OF SUCCESSION contd…

Basic features of the concept of plant succession are:

(i) *Continual change in the vegetation as a result of interaction of plant community and the habitat factors*;

(ii) *Progressive and the end product is the climax*; and

(iii) *Progressive development of vegetation of the same site in course of time*

Kinds

A. On the basis of moisture conditions of the place

1. Xerach succession: The succession initiated in extremely dry situations such as bare rock, wind blown sand, etc. The different stages in this succession are called Xerosere. Xerosere may be sub-divided into **Lithosere** which is defined as 'Xerosere which originates on rock surface' and **Psamosere** which is defined as the xerosere which originates on sand.

CONCEPT OF SUCCESSION Primary succession

2. Hydrach succession: The succession beginning in water, or very wet land as in ponds, lakes, marshes, etc and the various stages of this succession are called '*Hydrosere'.*

B. On the basis of the presence or absence of vegetation in the place

1. Primary succession (*Also called autogenic succession)*: The succession which takes place on sites which have previously not borne vegetation. The land slips are better sites because of the presence of original top soil mixed up in the rock pieces. The moisture retentivity of the soil is poor and the nutrient status extremely low. Under these difficult conditions, only a few species can grow. Their soils are migrated either by wind or water or both. They also start building up the true soil by adding humus through their leaf fall, improving nitrogen status by the fixation of N_2 by root nodules, arresting silt and stabilizing the soil. As they shade the ground, conditions become favorable for establishment of an undergrowth.

CONCEPT OF SUCCESSION

Primary succession contd…

The changed conditions replace the original colonizers which cannot regenerate in the changed conditions. As the soil conditions are very poor in the beginning, the number of species in the beginning remains small but as the condition improves, their number increases. Thus , the earlier stages of succession are easily recognized as they are generally uniform. But in the later stages, it becomes difficult to identify them. As for example, let us take a riverain succession and their stages;

1.Saccharum spontaneum----→ 2. Acacia catechu, Dalbergia sissoo ---→ 3.Acacia catechu, Holoptelia, Adina cordifolia, Albizia procera----------→ 4. Adina cordifolia, Bombax ceiba, Terminalia bellerica---------- ------→ 5. Adina, Terminalias, shorea robusta---→ 6. Shorea robusta, Lagerstroemia parviflora, Terminalia, Adina cordifolia

At first, *saccharam* grass grows on bare land or riverain sands, i. e primary succession. As the soil starts improving, the species go on Changing, i.e., serial stage of succession. And at last, Sal(*Shorea robusta* forest) becomes grown and established, i.e. Climax stage of succession

CONCEPT OF SUCCESSION

2. Secondary succession *(Also called Allogenic succession):* The succession which takes place on sites after the destruction of the whole or part of the original vegetation. Clearing, burning, grazing, erosion, deposition, landslide, storm, etc are allogenic factors, which factors are responsible for secondary succession.

So far as the forests of this country are concerned, they are subjected to fire, grazing and other maltreatments and so, secondary succession is very important. Unfavorable factors are mostly responsible for this succession, i.e. natural or biotic.

Secondary succession mostly follows ***retrogression or regression***, which is defined as the reversion to some earlier stage of succession consequent on the introduction of an adverse factor. Retrogression stages are lower in height and more xerophytic in character. In extreme cases, eg. Fire, clearing, etc. Sometimes, the entire vegetation may be destroyed.

CONCEPT OF SUCCESSION Secondary succession contd…

When the causes of retrogression are removed or the area from where vegetation has been completely destroyed is left to itself, the nature starts its work again, i.e., the vegetation starts progress. This progress is called **secondary succession,** which does not follow the same course as the primary succession. The colonizing species of the bare areas in primary succession and secondary succession may sometimes be the same. For instance, *pinus wallichiana, Anthocephalus cadamba, etc* colonize the land slips, gravel and clearings. In tropical evergreen forests, Secondary succession starts with *Acrocarpus fraxinifolius, callicarpa, Trema and Macaranga.* In the hills, secondary succession is often initiated by shrub growth.

3.3 Causes of Succession

It may be classified as below:

(i) Initial causes:

Primary succession

(a) Erosion: Wind and water erode the soil and deposit it elsewhere and vegetation changes.

(b) Physiography: The configuration of the land surface helps the agents of erosion, i.e. wind, water and gravity to create new soils, eg., land slide may take place on a steep slope, destroying the forest.

(c) Elevation and subsidence: Geological disturbances in the Himalayas result in the formation of new soil for primary succession.

Secondary succession

(a) Climate: When the vegetation is destroyed by the action of draught, wind, snow or frost.

3.3 Causes of Succession contd…

(b) Physiography: The configuration of the land surface helps the agents of erosion, i.e. wind, water and gravity to create new soils, eg., land slide may take place on a steep slope, destroying the forest.

(c) Biotic factor: A forest is destroyed by the activity of man, his animals, wild animals, insects, etc. causes soil modification, eg., heavy grazing, cutting, burning, etc.

(ii) Continuing causes

(a) Migration: Mass movement of plants from one place to another is called *migration*. It begins when germule (spore, seed, fruit or plant) leaves the parent area and reaches the final resting place. This depends upon the degree of mobility of their seeds or their germinating parts, nearness of the parent area, topography, etc.

(b) Ecesis or establishment: The whole process whereby a plant establishes itself in a new area from germination or its equivalent (eg., rooting of some detached portion) to reproduction whether sexual or asexual. Species' establishment on a new area can only be accomplished when the seeds germinate, which depends on the condition of seeds and sites.

3.3 Causes of Succession contd…

(c) **Grouping and aggregation:** The colonizers invade new areas gradually. The immigrants after establishment grow while more migration keeps on taking place. Thus in course of time, the colonizers make a closed canopy. Grouping following establishment of scattered colonizing invaders as a result of propagation.

(d) **Competition:** Competition starts for food, light and moisture which takes place among species and individuals. Competition is especially more intense among the individuals of the same species of a site and in the process, weakers are left behind in the struggle for existence.

(e) **Reaction:** The effect of vegetation on site is called reaction, which can be grouped into two classes:

(i) Effect on climatic factors (ii) Effect on soil

3.3 Causes of Succession Reaction contd…

(i) Effect on climatic factors: Vegetation affects climatic factors by

(a) Altering the light conditions

(b) Decreasing the air and soil temperature

(c) Reducing the wind velocity

(d) Reducing danger of radiation frost

(e) Increasing relative humidity

(ii) Effect on soil: The vegetation affects the soil by;

(a) Addition of organic matter

(b) Improving the structure of the soil

(c) Improving moisture retentivity of the soil

(d) Improving nutrient status of the soil

(e) Improving the maturity of soil

3.4 Concept of Climax contd…

Climax: Culmination stage of plant succession for a given environment. If succession is allowed to progress without disturbance, a stage is reached when no more improvement is possible in the soil and the vegetation. At that stage the vegetation is in equilibrium with the environment, and stays unchanged indefinitely by reproducing itself.

Mono-climax theory developed by Clements, who believed that in a general climate of a region, could be only one climax and these variations ultimately progress, even though slowly, towards that climatic climax. Mono-climax theory is assumed to occur only in one climatic climax.

As this is not possible, soil conditions differ even in a uniform area excluding climatic factors.

Thus, there can be more than one climax communities in one given climate, that is called *poly-climax theory.* Presently, the poly-climax theory has been more popular than the mono-climax theory.

3.4 Concept of Climax contd…

Characteristics of climax

- The vegetation is tolerant of environmental conditions.
- It has a wide diversity of species, a well-drained spatial structure, and complex food chains.
- The climax ecosystem is balanced. There is equilibrium between gross primary production and total respiration, between energy used from sunlight and energy released by decomposition, between uptake of nutrients from the soil and the return of nutrient by littefall to the soil.
- Individuals in the climax stage are replaced by others of the same kind. Thus the species composition maintains equilibrium.
- It is an index of the climate of the area. The life or growth forms indicate the climatic type.

3.4 Kinds of Climax contd…

Classification of Climax

Even though the concept of climax is still developing, it can be classified as follows:

(i) **Climatic climax:** It is the climax which owes its distinctive characters to climatic factors in conjunction with only such biotic influence as plants and animals naturally occurring in the area. Thought Clements considered climate as the dominant community – forming factor, he recognized the importance of soil, topography, relief and biotic factors as being additional dimensions to the main factor which delayed the progress of vegetation to a climatic climax.

(ii) **Edaphic climax:** A community which differs from the climatic climax of the area owing to the influence of special soil factors. Succession ends in an edaphic climax where topography, soil, water, fire, or other disturbances are such that a climatic climax cannot develop.

3.4 Kinds of Climax contd…

(iii) Pre-climax :The plant community immediately preceding in seral development of the climatic climax of the region and found under conditions drier than are usual in the climate of the region.

(iv) Post climax: A plant community more exacting than the climatic climax of a given and found exceptionally favorable site conditions within that region. It actually occurs on sites very much moister than the normal sites in that climatic region.

(v) Biotic climax or sub-climax: A climax which differs from the climatic climax of the area owing to the action of biotic factors.

3.4 Kinds of Climax contd…

(vi) Catastrophic Climax

Climax vegetation vulnerable to a catastrophic event such as a wildfire. For example, in California, Chaparral vegetation is the final vegetation. The wildfire removes the mature vegetation and decomposers. A rapid development of herbaceous vegetation follows until the shrub dominance is re-established. This is known as catastrophic climax.

(vii) Disclimax

When a stable community, which is not the climatic or edaphic climax for the given site, is maintained by man or his domestic animals, it is designated as Disclimax (disturbance climax) or anthropogenic subclimax (man-generated). For example, overgrazing by stock may produce a desert community of bushes and cacti where the local climate actually would allow grassland to maintain itself.

4. FOREST TYPES OF NEPAL

Many tree species occur over a wide range of altitude and ecological zones and they predominate in a given zone but may occur in zones above or below them. Classification based on ecological basis gives sufficient weightage to both vegetation and climate. Forest tree occur in very restricted areas have been omitted. The major forest types studied by J. K. Jackson (1994) are as under:

1. Tropical Forest (up to 1000 m)

i. *Shorea robusta* Forest

ii. *Acacia catechu-Dalbergia sissoo* Forest

iii. Other riverain Forest

iv. Grassland v. *Terminalia-Anogeissus* Deciduous Hill Forest

2. Sub-tropical Forest (1000 m to 1700 m)

i. *Pinus roxburghii* Forest

ii. *Schima-castanopsis* Forest

iii. *Alnus nepalensis* Forest

iv. Riverain forest with *Toona* and *Albizia* species

FOREST TYPES OF NEPAL contd…

3. Temperate Forest (2000 m to 3100 m)

i. Lower temperate Forest (2000 m to 2700 m)

a. *Quercus leucotricophora* and *Quercus lanata* Forest (Oak)

b. Quercus floribunda Forest

c. *Quercus lamellosa* Forest

d. Lower temperate mixed broad leaved forest with abundant *lauraceae*

e. *Pinus wallichiiana* Forest (Lower type)

ii. Upper temperate Forest (2700 m to 3100 m)

a. *Quercus semecarpifolia* Forest

b. Upper temperate mixed broadleaved Forest

c. *Rhododendro*n Forest

d. Upper temperate coniferous Forest

4. Sub-alpine Forest (3000 m to 4200 m)

i. *Abies spectabilis* Forest

ii. *Betula utilis* Forest

iii. *Rhododendron* Forest

iv. *Juniperus indica* steppe

v. *Caragana* steppe

5. Alpine Forest (up to 4500 m)

1. Tropical Forest

i. *Shorea robusta* Forest

Where natural vegetation remains, this covers the greater part of the zone. Dominant species- *shorea robusta;* Associate species- *Terminalia alata, Adina cordifoliafa, Anogeissus latifolia, Syzyzium cumini, Dillenia pentagyna, etc.* In hillside and plains, *shorea robusta* forests differ in their general appearance. In the plains, the trees are larger and denser than the hills. In the eastern Bhabar Terai Zone, a number of additional species are found.

ii. *Acacia catechu-Dalbergia sissoo* Forest: Found on newly deposited alluvium, often gravelly, along streams and rivers. If this alluvium is not eroded, this type of forest will eventually be succeeded by *shorea or* other types of forests.

iii. Other riverain Forest

Small strips of forest are to be found in moist localities near streams. *Syzyzium cumini* is dominant in western Nepal. This type of forest is not large and extends far from the stream banks.

iv. Grassland

Usually found on poorly drained clays, but in places may be the result of clearance of the forest for cultivation many years ago. Grass species such as *sacccharam spontaneum, Phragmites karka, Arundo donax, Eulaliopsis binata, etc.*The grasses may reach upto 4 m and is found in Rapti valley (Chitwan)

1. Tropical Forest contd…

e. *Terminalia-Anogeissus* deciduosus hill forest

It extends upto 1200m in western Nepal. It occurs in western Nepal in the foothills, where it replaces *shorea robusta* forest on south-facing slopes. Elsewhere it is confined to dry south-facing slopes in the larger river valleys. *Terminalia alata* and *Anogeissus latifolia* are dominant.

2. Sub-Tropical Forest

Altitude ranging from 1000 m to 2000 m in the west and 1000 m to 1700 m in the east.

***i. Pinus roxburghii* Forest:** It is found in the west of Nepal extensively. In the east, it is found in large river valleys. It is almost pure. In the far west at higher altitude, it may be associated with *Olea ferruginea, Pistacia* species, etc. In transitional areas, it may be mixed with *schima wallichii* or *shorea robusta*.

ii. *Schima-castanopsis* Forest: This replaces *Pinus roxburghii* forest in central and eastern Nepal. On moisture site, *Schima wallichii* occurs throughout with *Castanopsis indica* which is common below 1200m and *Castapsis tribuloides* above this altitude. *Schima-Castanopsis* forests cover very large areas of the mid-hills, but much of it has been cleared for cultivation and very small passages are left.

2. Sub-Tropical Forest contd…

iii. *Alnus nepalensis* Forest

It is found either in wet areas along streams or a colonizer of soil newly exposed by landslips. It is also frequently found on areas of abandoned cultivation. *Alnus nepalensis* is dominant and almost pure, with some *Lyonia ovalifolia* in places.

iv. Riverain forest with *Toona* and *Albizia* species

It is confined to narrow strips along streams and is very mixed in compositions. *Pandanus nepalensis* is frequently found in the understorey.

3 (i). Lower Temperate Forest

Altitude ranging from 2000m to 2700m in the west and 1700 m to 2400 m in the west. It can be further sub-divided as follows:

a. Forest of *Quercus leucotrichophera* and *Quercus lanata* (Oak)

Quercus leucotricophora is commoner in the west and *Quercus lanata* in the east . It is absent from areas of very high rainfall. These types of forest have often been either cleared for cultivation or heavily lopped fore cattle fodder.

3 (i). Lower Temperate Forest contd…

b. *Quercus floribunda* Forest

It is confined to western Nepal between 2100 m and 2850 m., where it replaces the *Quercus leucotricophora* forest on wet sites. It is associated with *Aesculus indica* and *Acer* spp.

c. *Quercus larmellosa* Forest

it is confined to high rainfall and wet areas of eastern Nepal. Elsewhere it is confined to north- and south-facing slopes. Its altitudinal range is between 1900 m and 2600 m. It is often associated with Lauraceae.

d. Lower temperate mixed broad leaved forest with abundant lauraceae

It is found between north or west facing slopes and in high rainfall areas. It contains a number of species of the Lauraceae family including *Machilus* species, *Cinnamomum tamala* , *Neolitsea cuipala* and *Litsea* species. *Michelia kisopa* is also frequent. It sometimes also contains *Quercus Lamellosa*. Much of this type of forest has been removed for cultivation.

3 (i). Lower Temperate Forest contd…

e. *Pinus wallichiiana* Forest

This species has a large altitudinal range from 1800 m to 4000 m. In the Lower temperate forest, it is found on dry south-facing slopes. Its distribution may be much affected by the human activities. It often colonizes abandoned cultivation.

3 (ii). Upper Temperate Forest

It occurs at altitudes from about 2700m to 3100m in the west and centre, and from 2400m to 2800m in the east.

a. Quercus semecarpifolia Forest

It is found in central and eastern Nepal between 2400 to 3000 m, but in the west, it extends up to 3700m in the Karnali region. *Rhododendron arboreum* and *Ilex dipyrena* are common understorey species.

b. Upper temperate mixed broadleaved Forest

It is found east of the Kali Gandaki river between 2400 m to 3150 m. It is very mixed in composition. *Acer* species and *Rhododendron arboreum* are common throughout and *Lauraceae (Litsea, Lindera, Neolitsea)* are common understorey trees. *Tsuga dumosa* often occurs in it and form almost pure patches on ridges and drier sites.

3 (ii). Upper Temperate Forest contd…

c. *Rhododendron* Forest

Rhododendron arboreum occurs in very moist places of far east Nepal. Besides, *Rhododendron barbatum, R. grande and R. falconeri* are typical of this type of forest.

d. Upper temperate coniferous Forest

In this type *Pinus wallichiiana*, which occurs at altitudes of upto 4000m, is distributed almost throughout. It is often almost pure especially on south-facing slopes. In moister area in western Nepal, it is associated with *Abies pindrow*, *Picea smithiana* and *Cedrus deodara*. This type of forest is common in Humla Jumla area. In very dry Mustang region, it is associated with *Juniperus indica*. In central and eastern Nepal *Pinus wallichiiana* forest, *Tsuga dumosa*, *Taxus baccata* and *Acer* species are common associate species.

4. Sub-alpine Forest

It is found between 3000m and 4200m in the west and around 3000 m in the east.

i. *Abies spectabilies* Forest

In western Nepal, *Abies spectabilies* is associated with *Quercus semecarpifolia* and extends to the tree line at more than 4000m. In central Nepal, it forms almost pure overstorey with an understorey in which *Rododendron* species and *Acer* species are common. *Larix grifithiana* and *L. himalaica* are common in the *Abies* forest, but rarely form pure stands.

ii. *Betula utilis* Forest

It is found between 3300m and the tree line. It is almost pure, with *Rododendron* and *Acer* species in the understorey. In western Nepal and the Humla-Jumla area, it is frequently mixed with *Abies spectabilies* and *Quercus semecarpifolia*.

iii. *Rhododendron* Forest

Rhododendron Forest often replaces other types of forest in western Nepal on very wet sites. There are a large number of species.

iv. *Juniperus indica* steppe

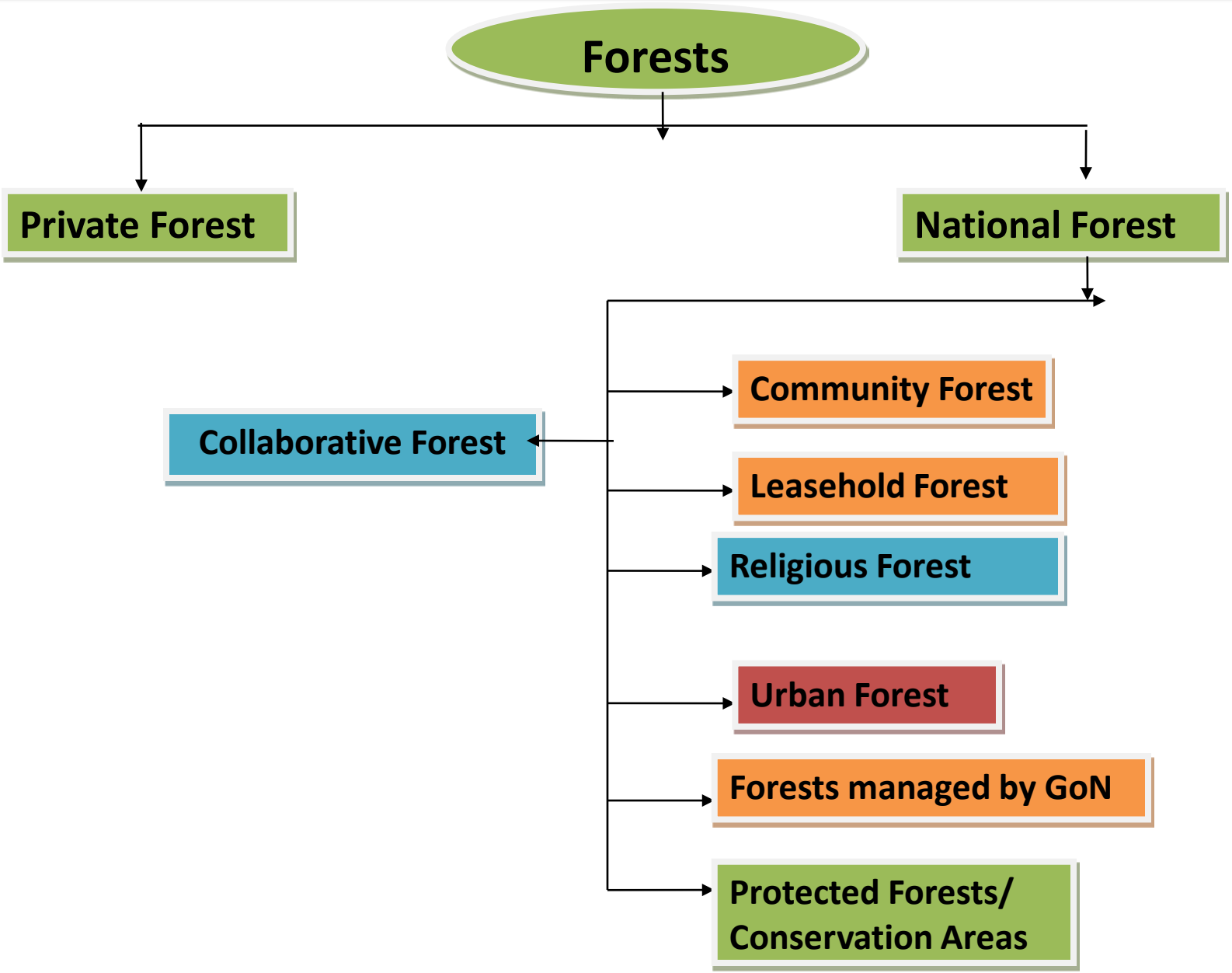
It is found north of the Himalaya in region having 350 mm and 500 mm rainfall. It is the only tree in such areas but has an open shrubby understorey.

v. *Caragana* steppe

Caragana species are low spiny shrubs rarely exceeding 1.5m high. They are dominant having less than about 250mm rainfall, such as Mustang area. In this type of vegetation, no trees are found.

5. Alpine Forest- It has no trees, but shrubby *Rhododendrons* and *Junipers* and some other shrubby species are found at lower elevations up to about 4500 m.

Unit-5 Forest Classification By Management & Ownership



Forest Classification: An Introduction

Nepal is rich in biodiversity and well-known for community forestry as a leading country in the world. Nepal occupies 0.09% of land area in the world, which has 2.3% of global biodiversities. It is unique in nature containing 350 plant species and 160 animal species that could not have found anywhere in the world.

With the rapid growth of population, erosion and deforestation resulting in the climate change, natural disasters and health hazards. Currently, Nepal has secured more than 20% of its landscape as a protected areas to prevent environmental degradation and conserve and upgrade its biodiversities. So, Nepal has strictly protected 18 plants and 39 animal species by laws. On the basis of management and ownership, forests of Nepal have been classified as given below and shown in the figure above:

5.3 Private Forest

Private forest refers to trees on private agricultural or forest land used to supplement animal fodder, fuel wood and other basic resources or simply to provide saleable produce. It may be trees in small woodlots or trees integrated with agricultural crops as agro-forestry. Growing more trees on farmland has a high national priority. The government supports development in private forestry for three reasons:

(i) It can significantly add to fodder and fuel wood resources reducing the pressure on national forests

(ii) It is vital to land stability and sound watershed management

(iii) Planting on private land has demonstrated social benefits, greater self sufficiency and improved income generation through entrepreneurial activity.

(iv) It help enrich the fertility status of nearby agriculture lands

The programme under the department has comprised only free distribution of seedlings, provision of technical support for their mgmt.

5.1 National Forest

1. **Protection Forest:** A patch of forests strictly protected by the government due to its sensitiveness such as potential heavily encroachment area, eroded area, sensitive to a specific flora or fauna (eg. Rhino century, Deer century, Vulture protection area, Dolphin protection area, etc.)
2. **Production Forest:** A patch of forests allocated by the government to produce specific produce (i.e., timber, fuel, fodder, resin, medicinal and aromatic plants) demanded by industries, organizations or their citizens. Sagarnath Forest Development Project is a typical example of this type of forests, where *Eucalyptus camaldulensis* and *Dalbergia sissoo (*previously planted) and some of *Albizia* species have been producing since the establishment of the project,1978.
3. **National Parks (NPs):** An area allocated to conserve, manage and utilize wild flora and fauna and their habitats. There are altogether 10 NPs in Nepal, including a newly established Banke National Park.

5.1 National Forest contd…

1. **Wildlife Reserves (WLRs):** An area allocated to conserve and manage wild flora and fauna and their habitats. There are altogether 4 WLRs
2. **Conservation Areas (CAs):** An area allocated by the government to protect and utilize the natural resources as per the integrated plan to uplift the livelihoods of the local people. There are altogether ten conservation areas in Nepal.
3. **Buffer Zone (BZs):** A part of national parks or wildlife reserves delineated by government for the use of local people to meet their basic needs of forest products in perpetuity and (to) preserve the NPs and WLRs from invasion of outsiders so as to preserve the flora and fauna of those NPs and WLRs.

5.2 Community Forest

Community forest (CF) is forest protected, managed and utilized by local forest user groups. In other words, a forest area handed over to a group of people entrusted to manage, use and protect under the provision of the Forest Act, 2049 and Forest Regulation, 2051.

Forest User Group: A group of local forest users organized together as per the Forest Act to protect, manage and use the forest resources of one or more areas.

This programme through the department of forests makes CF a reality for rural communities. It is not new to Nepal and was passed by Govt. of Nepal in 1978. Initial efforts were plantation oriented and large numbers of nurseries were sponsored. Forest decisions were made by administrative units of local govt. without consulting the local communities. To be CF, there should be an constitution and operational plan prepared by local user groups by the help of forest technician, who may be from District Forest Office or any other I/NGOs. There should not be bias on forest resources' uses for all the users and the names of traditional users left.

5.2 Community Forest contd…

Main objective

To achieve sustainable management of forest resources by converting accessible national forests into community forests on a phase wise manner.

Strategy

Handing over of accessible forest areas as CFs to the Forest User Groups (FUGs) for proper management and utilization of forest resources.

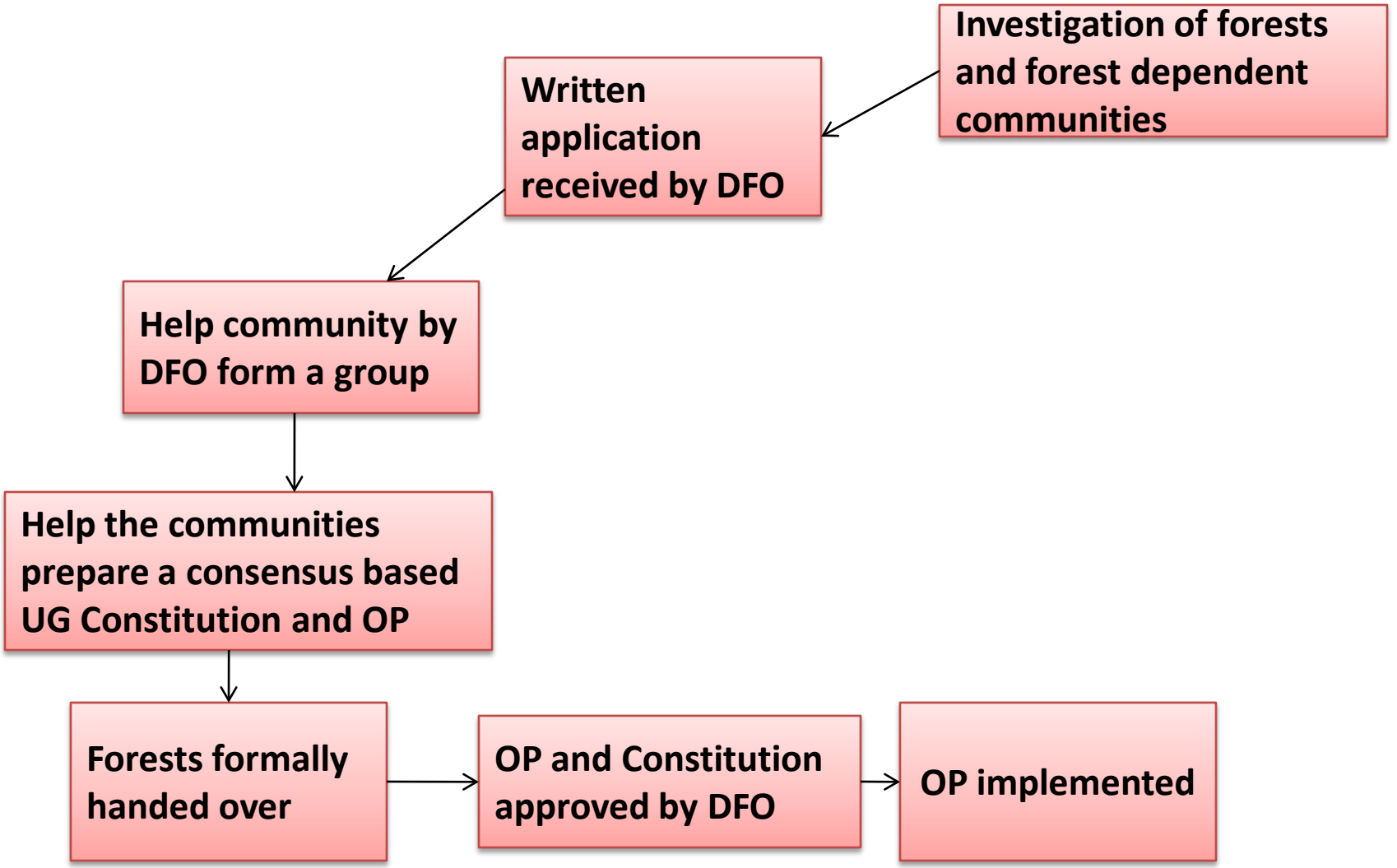
A good CF has a good decision making criteria giving priority on gender and discriminated castes and classes. There should be transparent income-expenditure registers maintained by CF User Committee able to be shown everywhere and everyone.

5.2 Community Forest contd…

Strength of CF Development Program

- ✓ An autonomous and independent institution by laws
- ✓ Participatory democratic program
- ✓ Legally recognized Forest Users with legal satus
- ✓ Responsibility bestowed upon the CFUGs
- ✓ Freedom to use forest products independently within the framework of constitution and the forest operational plan
- ✓ Provision of the use of CFUGs' fund for community forestry development and rural development including community development
- ✓ No tax on using forest products as the other national property
- ✓ Gender and discriminated castes and classes have opportunities to uplift their socio-economic status in the society

Steps of Community Forest handover contd…



5.4 Leasehold Forest

A patch of national degraded forests handed over to individual, organization or the poor people on lease of forty years with the aim of forest development and poverty reduction. Leasehold may be two kinds; one is for pro-poor and next one is for individual or organization. The first is to uplift the livelihoods of the poor who is under the poverty line of the country and another is to meet the demand of the forest based industries along with the development of forests. It is also a part of Master Plan for Forestry Sector, 1988.

5.4 Leasehold Forest contd…

Vision

To meet the demand of forest based industries through the management and development of national forests participating local poor people and organizations so as to reduce poverty and unemployment.

Objectives:

(i) To meet the demand of forest based industries

(ii) To utilize and sale the forest produce after maximizing the forest produce by plantation

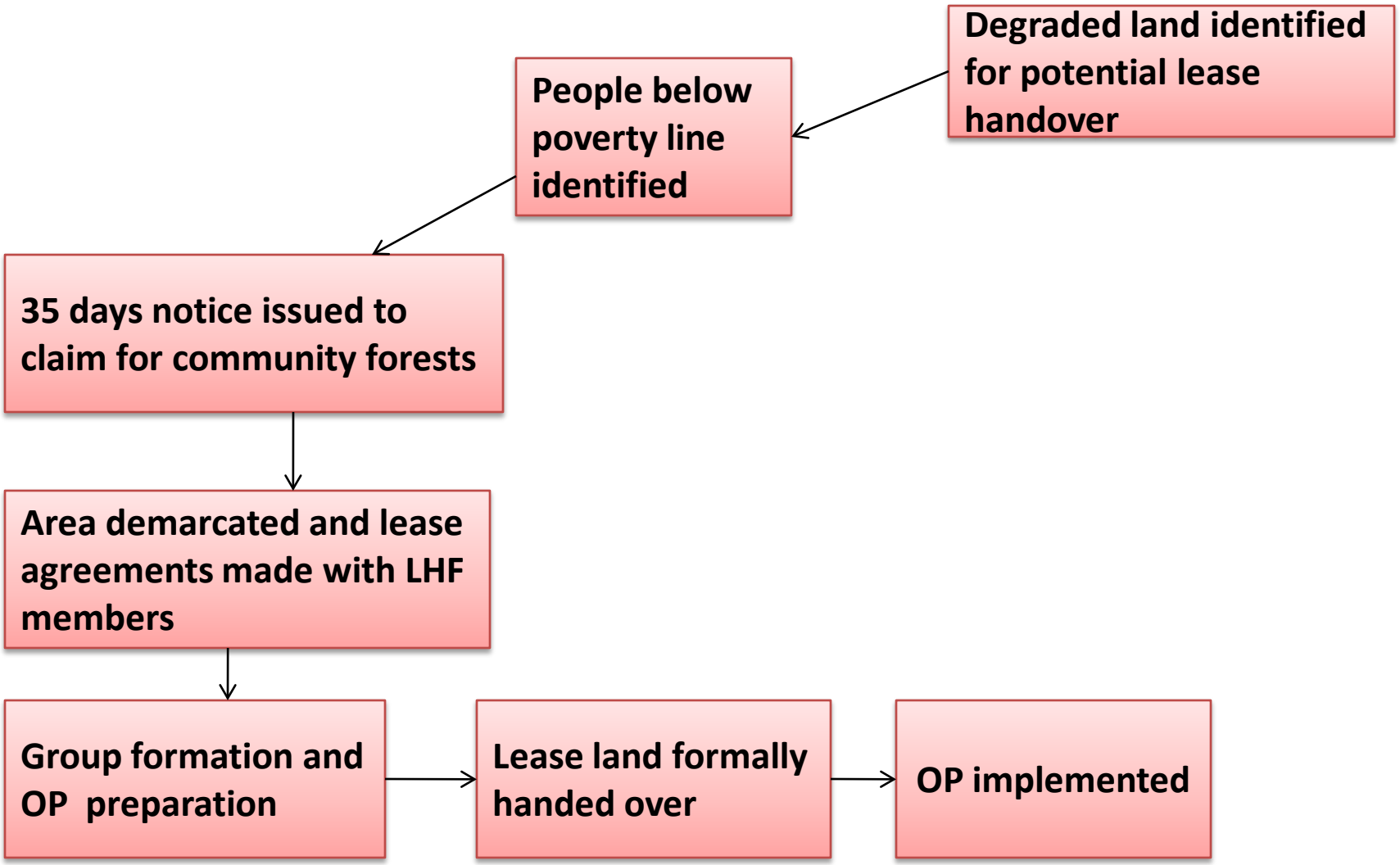
(iii) To conduct the eco-tourism

(iv) To produce beneficial insects, flora and fauna

(v) To conserve the environment through forest conservation

(vi) To uplift the livelihoods of the poor people

Steps of leasehold Forest contd…



Major Differences between Leasehold Forest contd…

CF	LHF
Bigger and richer forest land being managed by larger communities irrespective of the wealth status	Small and often degraded forest patches being managed by relatively poor people
The group normally manages forests in totality. Group might sometimes decide to allocate forest areas to smaller hamlets located close to a certain section of the forest. However, land division between the individuals is not a normal feature.	Forests, irrespective of what the guidelines suggest, are normally divided amongst the participating individuals who control the land virtually in a private way.
Income generating activities have been considered more recently. However, this takes a second place	Emphasis has been given to income generating activities through pasture/livestock related developments
Major thrust is forest management	Thrust is on livelihoods/IGA activities

Major Differences between Leasehold Forest contd…

CF	LHF
The group owns the funds in common. Those may be used for the community development works (schools, track building, etc) but may not at all be used for private purpose.	The generated funds are purely private and s/he may decide how s/he wants to use his/her money. This excludes community works.
Group membership is dynamic. Those who move from the locality lose their membership and those who migrate into the territory may negotiate for a membership. By the same token, the offspring of the members automatically inherit the membership after the family split or after the death of the person having the membership	Membership dynamism is severely limited due to the fact that lease contract gets signed with particular individuals. Inheritance issue thus is outstanding in LHF. It is also not clear what will happen if the person having the lease contract decides to migrate elsewhere. Cases can be found of additional membership in the group. However, the arrangements are of an *ad hoc* nature and do not have legal backing.

5.5 Religious Forest

A patch of national forest allocated and managed by institution or a religious group for the purpose of religion and culture and their uses limited to the religious purposes. For religious forest, a plan has to be prepared with the help of forest technician and approved by District Forest Officer to legalize it so that religious forest can use the facility of Department of Forests allocated.

Objectives:

- ✓ to conserve the religions and traditional cultures along with development of forests and biodiversity
- ✓ To manage and utilize the forests for the religious purposes as well as to meet the needs of the people involved in the activities
- ✓ To serve the helpless people from the sale of forest products for which decision made by the religious committee.

5.6 Urban Forest

A patch or strips of trees planted in the urban or semi-urban areas to protect the environment from its degradation and to decorate the urban landscape for their scenery. Urban Forestry aims at raising and management of trees and green areas in urban and semi-urban centre. Urban forestry includes management of municipal lands, management of watersheds in urban areas, wildlife habitats, opportunities for outdoor recreation, landscape design, recycling of municipal wastes, tree care, etc. Urban forestry includes green belts, parks and gardens, zoological parks, forest reserves, avenues

5.6 Urban Forest contd…

Effects of urban forests on environment

1. **Air quality improved:** absorption of air pollutants by leaves or soil surface.
   - ✓ Deposition of particulates and aerosols on surface of leaves
   - ✓ Sulphur di-oxide of air absorbed by trees
2. **Moderation of temperature:** Helps in controlling extremes of temperature
   - ✓ Provide shade that reduces solar radiation
   - ✓ Plants absorb heat as they transpire
3. **Noise reduction**: Noise levels reduced due to trees
4. **Micro-climate amelioration:** Micro-climate is ameliorated so that extremes are lowered
5. **Fauna:** Trees and other forms of vegetation harbor various faunal species which add to the quality of life in urban areas
6. **Erosion control**
7. **Landscape aesthetics:** Landscape aesthetics of plants are becoming more highly valued
8. **Water quality improvement**
9. **Carbon sequestration**

5.6 Urban Forest contd…

- Plant environmental (abiotic) stress constitutes a major limitation to urban forestry.

  The **major plant stresses** are: **drought, cold, heat, salinity, soil mineral deficiency, soil mineral toxicity**
- Besides these, acid rain, gaseous and particulate pollution, security lighting, and toxic wastes also cause stress

Stress encountered by plants:

- Compacted soil
- Insufficient nutrition
- Air pollution
- Little or excessive water supply
- Infestation by pests and pathogens
- Extension of day length by night lighting
- Light intensity variation from deep shade to full sun

5.6 Urban Forest contd…

- Reflection increases air temperature in urban areas
- Accidents, vandalism, neglect
- Hails, frost

Stress can be avoided/minimized by choosing a favorable site, preparing site for planting, selecting plant that are tolerant to site and relatively pest resistant and caring for plants to ensure vigorous growth

Urban plant species

- *Eucalyptus species*
- *Jacaranda mimosifolia*
- *Albizzia procera*
- *Polyalthia longifolia*
- *Azadirachta indica*
- *Melia azedirach*
- *Grevelia robusta*
- *Prunus cerasoides*

Collaborative Forest Management

Nepal embarked a new decentralized forest management modality called Collaborative Forest Management (CFM). CFM in general is loosely defined as a working partnership between the key stakeholders in the management of a given forest- key stakeholders being local forest users and state forest departments, as well as parties such as local governments, civil groups and non-governmental organizations, and the private sector (Carter and Gronow, 2006).

The same authors also defined CFM as a working partnership between the key stakeholders in the management of a given forest. Berkes (1997) stressed the importance of "trying to develop equitable partnerships, drawing upon the complementary strengths of forest departments and local users" in the co-management of forest resources. Equitable partnerships imply that each partner takes on a share of responsibility and reward for forest management, based on a clear understanding of and respect for the other partners' rights or entitlements.

Collaborative Forest Management contd..

Government of Nepal intends to manage the government managed forests of the Terai through the involvement of local government and people in decision-making, implementation, benefit-sharing and monitoring.

Main objective of CFM is to develop sustainable forest management in order to (i) fulfill the need for forest products, (ii) help reduce poverty by creating employment, (iii) maintain and enhance biodiversity (iv) increase national and local income through active management of the Terai and Inner Terai forests.

More specifically CFM aims to:

- ✓ create coordination mechanism for multiple stakeholders of Terai productive forests
- ✓ Participate multi-stakeholders in decision making from planning through implementation and monitoring to evaluation of active management of forests

Collaborative Forest Management contd..

- ✓ Develop mechanisms for sharing rights, responsibilities and benefits with due consideration of gender and social inclusion
- ✓ Develop mechanisms for distribution and marketing of forest products

Reasons of CFM in Terai:

- The population composition is far more diverse than in the hills and mountains
- The resource base is leading to greater revenue, which tends to be appropriated by the elites or socially stronger groups
- CF tends to be focused on nearby users, thus excluding the original users of Terai
- CF in the hills was introduced to tackle the problems of deforestation and to provide forest products for the local people, but this is not the case in the Terai.

Unit-6 Nursery

An area where plants are raised for eventual planting out is said to be **nursery**. It comprises of nursery beds, paths, irrigation channels, etc. 40% of seedlings were died (mortality - 40%) due to wrong size (generally small) or poor health of the seedlings at the time of planting found in the survey by Community Forestry Development Project in 1982/83. So, there will be waste of time and money if there is not a good nursery established considering critically. Sound nursery practice is the foundation of a successful plantation scheme.

Importance

- ✓Some species are not annual good seed bearer, but need to be planted annually. To meet the need of seedlings of such species, nursery is important.
- ✓Slow growing species need a nursery to be planting out to avoid competition
- ✓Roadside and urban plantation always need a nursery for their plantation
- ✓The best method of introduction of exotics is only by nursery
- ✓Planting of nursery-grown plants is the surest method of artificially regenerating poor and barren sites.
- ✓Casualty replacement is only possible by the plants grown in the nursery.

6.1 Types of Nurseries

On the basis of irrigational facility, nurseries are classified into:

1. Dry Nursery: It is ‘a nursery that is maintained without any irrigation or other artificial watering.’

2. Wet Nursery: It is ‘a nursery that is maintained by irrigation or other artificial watering during the dry periods’.

On the basis of size of seedlings, nurseries are classified into the following types:

1. Seedling nursery: A nursery which has only seedling beds, i.e., in which seedlings only are raised, no transplanting being done is called seedling nursery.

2. Transplant nursery: A nursery which has only transplant beds, in which seedlings are transplanted for preparation for forest planting is called transplant nursery.

But in Nepal, separate seedling and transplant nurseries are seldom made.

6.1 Types of Nurseries contd…

On the basis of duration of their use, nurseries are classified into:

1. **Temporary Nursery :** It is a nursery that is maintained for supplying stock for a short period after which it is abandoned. Normally, it is constructed in the plantation area & usually small in size. It is suitable for hilly regions.

Main features:

- ✓Constructed for a short period of time and smaller is size.
- ✓Manuring is not necessary
- ✓Mostly located near/inside the planting area and which is approprite chiefly for casualty replacement.
- ✓Elaborate soil preparation is not necessary.
- ✓Cost of transportation of seedlings to the planting sites is low
- ✓Seedlings of different species for mixed crops
- ✓Gap between lifting the stock from the nursery and actual planting is less
- ✓Special supervision is not required

6.1 Types of Nurseries contd…

Advantages

- ✓Usually constructed in newly cleared sites fairly rich in humus and so, manuring is not required. Eucalyptus nurseries are an exception to the general rules.
- ✓Minimum trouble with the weeds, destructive insects and diseases.
- ✓Enables raising of species in their optimum altitudinal zone in hills.
- ✓Cheap transport of planting stock without any serious damage or shock.

Disadvantages

- ✓Comparatively costly.
- ✓Difficult to supervise.
- ✓Proper supervision is not possible as it is made out of way places.
- ✓Due to lack of irrigation facility, the growth of seedlings is, usually slow and heavy mortality.

6.1 Types of Nurseries contd…

1. **Permanent Nursery**

It is a nursery that is maintained for supplying nursery plants for a long time on a permanent basis. It is intended to meet the requirements of one or more ranges and it is relatively larger in extent.

Main features

- ✓Fit for large and intensive work and intensively managed
- ✓Established wheres all the facilities are available, i.e., easy supervision, communication facilities, labors, etc.
- ✓Intensive Manuring and soil working are done in perpetuity
- ✓Used for large scale afforestation works, or distribution to the villagers under community and private forestry programme.
- ✓A large labour forces, tools and equipments are available
- ✓original cost of formation is high but is cheaper in the long run
- ✓Regular skilled supervision is done

6.1 Types of Nurseries contd…

Advantages

- ✓Varieties of planting stocks supply; such as root- shoot cuttings, grafted plants, layering, budding, polypot seedlings, etc.
- ✓Duration of service life is long and production cost is reasonable.
- ✓Meet the requirement of more ranges.
- ✓Supervision cost is low and can be easily supervised.
- ✓Easy transport of nursery stocks due to nearness of roads.
- ✓Plants are raised year after year for a long time on same site.

Disadvantage

- ✓Transportation of seedlings is difficult and costlier.
- ✓Establishment cost is high.
- ✓Manuring of beds annually & intensive soil working is essential.
- ✓Requires large labour forces through out the year which is difficult to available in agricultural seasons.

6.2 Nursery tools and equipments

Houses -soil shed, labor shed, office and store

Fencing materials: Barbed wire, mesh wire, Wooden or R.C.C. poles, “U” nails, Hammer, Wire pooler, strainer or cable puller or iron rod hook, Coaster, Enamel paints, Plain nails

For surveying

- Prismatic compass, plain table with accessories Abneys’ level , measuring tape, Ranging rod, Arrows etc.

For bed preparation

- Spades, (small & large), pick axes, Wooden hammer, Ropes, cotton or steel tape, Wooden pegs, Shovels', Khurpa, sickle, axes, Wooden planks, bricks, stones, bamboo’s splinters , etc.
- **For House**
- Thatch, weeds, leaves, thakal, bamboo, polythene sheet, wood

Tubes/tin sheets for irrigating or flooding nursery beds whenever required, which may be made from bamboo, tin, tiles or paper.

6.2 Nursery tools and equipments contd…

- Iron or wooden shade frame, Water cans, polythene pipe, sprinkler, tube well, or irrigation, Sprayers Polythene bag or tubes
- G.I. net for sieving sand and soil, Wooden seed box or metal or plastic seed tray
- Thick poly bags, canes, container or glass jar for storing seed.
- Small metal sieves and Nanglo – for sieving and winnowing of seeds.
- Cutting pliers, sharp knife, bill hook – for branch and root shoot cutting
- B.H.C. powder, potash, metacine, malathene and other insecticides, fungicides and pesticides.
- Forest topsoil, coarse and fine sand, compost, chemical fertilizers, small crushed or round gravel.
- Wheel byre, basket etc.
- **Atomizer** for irrigating minute/small seeded nursery. This is kind of pump to supply moisture in the seedbeds. It is also used for spraying herbicide or insecticide.

6.3 Construction of Nursery

Nursery layout varies as per the types of plants to be raised, the facilities to be provided, and the topography of the site chiefly in the case of nursery established on terraced land. While constructing nursery, site should be surveyed and demarcated and then all the trees , shrubs and stumps are to be cleared. After clearance, lay out of nursery is designed. Terraces should be constructed and leveled to design specific size of beds.

In designing the layout of a nursery, there should be **paths** in between nursery beds for holding seed trays and for inspection. **Stand-out beds** for seedlings in polypots. A **water distribution system**, including **a storage tank**, areas for storing soil and making compost, and **a store for tools and materials,** which can also serve as an office and shelter for the nursery foreman) are needed. In some places, it is necessary to dig **drains**.

6.3 Construction of Nursery

Space should be left in nursery for stumps or bare-root transplants. Depending on the nature of nurseries, there should be **a shade house** in which seedlings are pricked out. The whole nursery should be surrounded by a stock-proof **fence** or stone wall to reduce the costs of damages done by cattle or others. The shape of the nurseries should be as nearly as square as is practicable.

Similarly, a **seed store, garage for machineries**, etc are to be arranged. Before constructing the nurseries, a detailed plan should be prepared whether those different items are available or not, otherwise all the labor and expenditures will go in vain.

6.4 Preparation of Nursery Beds

Nursery bed is defined as 'prepared area in a nursery where seed is sown or into which transplants or cuttings are put. Nursery beds are classified into seedling beds and transplant beds. Similarly, considering the nature of lands, there may two kinds of beds. They are:

1. Sunken beds: In areas with long dry hot weather, beds are kept slightly below the general ground level. Such beds can be easily irrigated, during dry season. This type of beds are used for raising stock through vegetative propagation like cutting of popular, sissoo, mulberry, willows, and bamboos off sets. Besides these *Acacia nilotica, A. benthenwii, Prosopisjuli flora* etc.

2. Raised beds: In moister areas, nursery beds are raised 10-15cm above the level of the grounds, which can be supported either by bamboos or line of bricks, stones, etc. This prevents their edges from being eroded away during the rainy season or by irrigation or outside water from seeping into the bed. The species which are commonly raised on beds are Deodar, Kail, Spruce, Fir, Robinia, Walnut, Bird cherry, Ash etc.

6.4 Preparation of Nursery Beds

3. Level Beds

Level beds are commonly used for raising seedlings of Tuni, Eucalyptus, Ritha, Terminalia, Siris, Grevillia, etc. These species cannot tolerate standing water, their water requirement is also moderate.

Size of beds: It varies from locality to locality. Generally beds are 1-1.2m wide but sometimes, they are even kept upto 1.8m wide locally. This depends on seed beds, either stand out beds for polypots or beds for raising stumps or bare-rooted plants. Length of the beds is not important, though 5-10m must be convenient. If possible the beds should be oriented from east to west to provide better shade against the mid-day sun and not more than 5^0 . Seed beds and stand-out beds should be provided with frames on which shade can be placed; whether this is needed for beds for stumps or transplants depending on the species being raised. There should be 50-60cm wide between beds and the surrounding fence. This means that on terraced land, the terraces should be at least 2m wide.

6.4 Preparation of Nursery Beds

Soil Preparation:

After demarcation, the are dug in depth of 0.3-0.45m so that stone, roots, etc lying underneath are all dug out, picked and thrown outside the nursery. If the soil is gravelly, it should be sieved through a fine wire netting to remove gravels. Then, soil should be mixed with farmyard manure. At the same time, charcoal dust and ashes are also mixed to correct the acidity of soil and keep away worms. If there is a danger of white ant attack, Aldrex 5% dust should be mixed @ 75kg/ha.

In the hills, new terraces have to be built with the help of string and pegs, and the drainage network should be planned. the top-soil should be first removed carefully from the surface of the terrace and put in a pile, and after the terrace has been made it should be replaced on the terrace surface.

In general, the surface of the beds should be either flat or preferrably be given a slight camber. If the soil is heavy, a top dressing of washed river sand is usually given, which prevent to cake the watered beds and no splash during rains. Burning of dry grass and shrubs piled on beds reduces weed growth and is very beneficial for species having minute seeds eg. *Adina cordinfolia*.

6.5 Seed Treatment and Seedling Production

A. Seed Treatment

Seeds are to be tested before use or sowing in the beds or fields as the success or failure of artificial regeneration work depends on the quality of seeds. When the treatment is given before sowing in the field, it is called ***pre-sowing treatment***. If some species of seeds are not treated, germination may be delayed or germinate irregularly. And in order to hasten germination of such seeds, they have to be given treatment. Why seed treatments are necessary as :

1. To determine genuiness: Genuiness of seeds means purely desired seeds for producing plants in the beds, not mixed. Identification of such seeds is necessary. Sometimes, it is very difficult to identify the seeds. In such cases, it is necessary to collect a botanical specimen of the seed bearing plant and get it identified by an expert botanist.

2. To determine purity: Seeds may have other foreign matters, even if they are genuine. For the purpose, seeds are cleaned by winnowing or hand-picking. If samples of cleaned seeds are compared with the collected seeds. Purity can be determined easily.

3. To determine seed viability: Viability of seeds are can be determined by direct inspection or by physical or chemical test. Short viability (not more than three weeks) are for *Shorea robusta*, *Artocarpus lakoocha*

No doubt, viability by **direct inspection** is rough estimation mostly done by nepalese farmers. By the inspection, seeds having hollow, insect-eaten, mouldy or otherwise obviously bad are excluded as unviable.

6.5 Seed Treatment contd…

Physical test, which is done by winnowing or submersion in water. Similarly, **chemical test** may be done by using chemicals such as Indigo carmin in 1:1000-2000 has been reported to be the most useful. Some kinds of chemicals discolor the seeds whether their parts are genuine or not. If they are not genuine, their color becomes changed.

4. To test germination capacity: This type of test are practically done in the tray or beds, the germination is found out.

Methods of seed treatment before sowing in the beds:

1. Weathering

Weathering means exposing the seed to sun, wind and rain to crack its hard coat. When germination is seen to be just starting, the seed is spread out on mats to be exposed to sun, wind and rain. The seed is then dried in shade and bagged for sowing in the following rainy season.

2. Water Treatment

In water treatment, water either cold or hot, is used to hasten germination.

(i) Soaking in cold water for 24-48 hrs before sowing

This treatment is applied to most medium-sized dry seeds, eg., chir pine and many *leguminosae* species.

6.5 Seed Treatment contd…

(ii) Soaking in boiling hot water

Water is heated in a tray and then seeds are kept in hot trays just after removing from stove so as to crack the seed-coat, eg. *Albizia,* Oaks and chestnut. By this treatment, insects may be killed, if any.

3. Alternate wetting and drying: Nursery bed process and Pit process

It can be done either in nursery beds or in the pit of specific size (0.8m deep and 1to 1.2m square). In **nursery bed process,** 5mm thick layer of sand is laid and then covered with grasses and watered sufficiently. After 12 hrs, the grass is removed so that the seeds are exposed to sun and dries. Again, the grass is put back on seeds and watered. This continues for 2-3 weeks, when the seed starts germinating.

Similarly, in the **pit process,** bottom and sides of the pit are lined with teak leaves. Seed soaked in water warmed by sun during the day is placed in the pit separated by teak leaves of 6-10mm thick. After some layers, bamboo pipes are kept. The seeds are kept in the pit for about 10 days and watering is done every alternate day. The pit is then opened when seeds are expected to have germinated. Heavy watering must not be done.

6.5 Seed Treatment contd…

4. Passage through animal body

Some seeds germinate quickly if they are passed through the digestive system of the animals or poultry, eg., *Acacia arabica, Santalum album,* etc.

5. Mechanical Treatment

It refers to the mechanical cutting or filling of the hard coat of seeds so that moisture may reach inside. It is beneficial if fruit has 2 or 3 seeds, eg. Rudraksha, Lapsi, etc.

6. Chemical Treatment

Chemicals such sulphuric acid, sulphate of magnesium, etc are used to soften the seed-coat and renders them permeable to water.

7. Scorching or fire treatment

A fire through the teak forests stimulates germination. Therefore, the teak seed is sometimes spread on ground on a layer of leaves and given a light burn. But it is now not being used practically as this method is difficult to control.

6.5 Seed Treatment contd…

8. Stratification

The seeds are spread in layers of 1-2 cm deep altering with layers of sand, or charcoal about 5-7cm deep in boxes or baskets, stored in pits dug in the ground. This method is suitable in higher hill forests.

9. Fermentation

This method has been successfully used for teak. For this, seeds are spread on ground covered with grass which is kept moist. Fermentation is induced by adding innoculum for a cattle shed or drain. The bacterial action is allowed to continue for about 2 months when the seed is ready for dibbling.

Soil management and use of manure

Temporary nursery located in recently felled area or new good fertile site need not be manured but for permanent and semi-permanent nurseries, Manuring is quite essential. For this, Organic manure, Commercial fertilizers or Mycorrhiza are applied based on the qualities of soils. Additionally, other types of innoculation may be needed to produce large quantities of healthy seedlings

6.5 Seedling Production

A seedling is young plant saprophytes developing out of plant embryo from a seed up to one metre of height and the term seedling production is the production of seedlings for a certain purpose, especially plantation. The scope of seedling production has been brought by various issues on environmental protection, forest production, tree improvement, ecosystem balance, forest regeneration and many other programs. To fulfill the demand and objective of plantation, there are several techniques and procedures of seedling production developed by experiences and researches on it.

Appropriate site selection, site preparation, quality seed collection, seedlings establishment, storage, protection, management and supply are the components of high seedling yields. Use of efficient machines and strong supervision by experts has wide scope in it.

6.5 Seedling Production

Mostly seedlings are produced in a nursery either from seed or from vegetative parts. During the plant production, nursery should be established in which beds are prepared for seed sowing and germination of seeds, root-shoot cutting, etc. For very minute seeds, a seed tray for seedling production is prepared filled with different media such as coarse sand, fine soil, forest soil, etc. Sometimes, plastic covered shade house or green house is constructed, where seed trays are placed and seeds are sown in tray for quick germination because there are humidity and temperature controlled. After germination when seedlings gain height or form of 2-4 leaves, they are picked out and transplanted into poly bag or in other type of containers. Overhead shade is provided for root and shoots' setting and to gain resistance and gradually seedlings become hardened, overhead shade is removed when plants are ready to transplant.

6.5 Seedling Production

Seedling establishment

1. Seed Sowing

Seeds may be sown by two ways either directly into the pots or it may be sown first in seedbeds or seed trays and the seedling are later picked out into the pots. Generally, Sowing seeds directly into the pots should be used only with fairly large seeds having a germination percentage of more than 40%. Some species that are usually sown are *Acacia catechu, Artocarpus lakcocha, Bassia butyracea, Albizea spp., pinus* etc. Methods of direct sowing are also divided into three parts ;

(i) Broadcast sowing: in this method, the seeds are merely scattered over the surface of the soil. For example, *Alnus nepalensis* has been successfully established along the lamosangu –charikot road.

(ii) Line sowing: usually strips 30-45cm wide are cleared and hoed depth of 15cm or more. it commonly requires 15-20 times as much seed per hectare as would be needed if the same quantity of seeds was used to raise plants in nursery.

6.5 Seedling Production

(iii) Patch sowing and sowing in pits: This is sowing of seeds by forming pits and patches in nursery. The development of root of seedlings should be better in pits than patches. This is observed in *acacia catechu* forest in Pokhara valley.

The optimum time for sowing seeds on most sites is during the pre-monsoon rains as soon as the soil has been sufficiently moisture .In areas where snow can be relied on, sowing before the first snowfall often gives good results, the seed will germinate after the snow melts.

2. Cutting

Cuttings can be done differently such as Branch cutting, stem cutting and root shoot cutting.

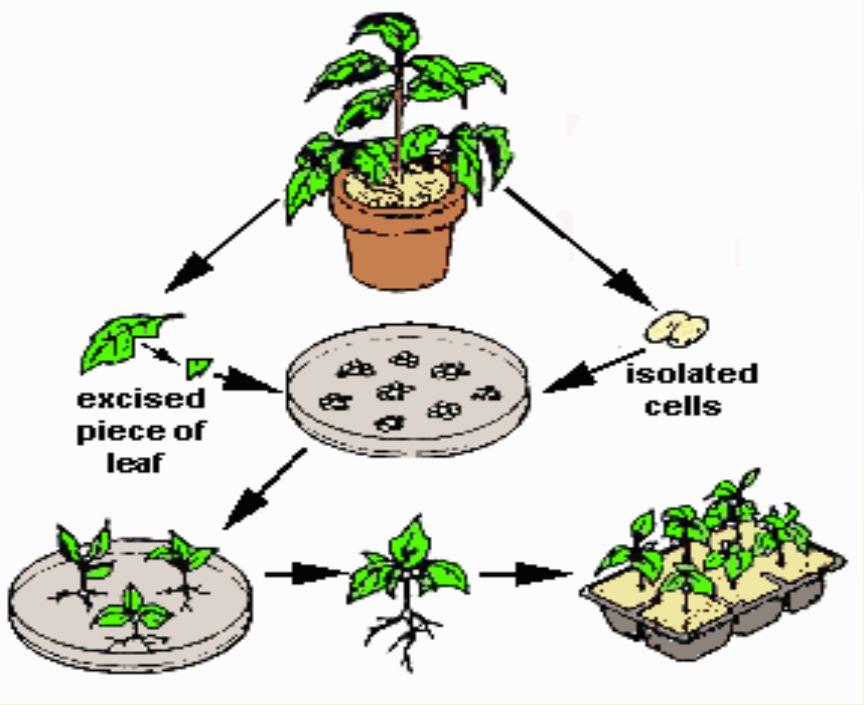
3. Layering: Layering can be done into two ways, i.e., Ground layering and Air layering.

4. Grafting: Cleft-graft, veneer-graft, splice/whip and tongue-graft and under-bark graft. A scion is used to stock for seedling production.

5. Budding: An bud of desired spps is used to stock of inferior species

6.5 Seedling Production

5. Tissue culture



Tissue culture (often called micro propagation) is a special type of a sexual propagation where a very small piece of tissue (shoot apex, leaf section, or even an individual cell) is excised (cut-out) and placed in sterile (aseptic) culture in a test tube, Petri dish or tissue culture container containing a special culture medium. The culture medium contains a gel (agar) with the proper mixture of nutrients, sugars, vitamins and hormones, which causes the plant part to grow at very rapid rates to produce new plantlets.

6.5 Seedling Production….. Tissue culture

It has been estimated that one chrysanthemum apex placed in tissue culture could produce up to 1,000,000 new plantlets in one year. Thus, tissue culture is used for rapid multiplication of plants. A very specialized laboratory is required for tissue culture. All the procedures are done in a laboratory and special ventilated cabinet that is as sterile as an operating room.

- Different techniques in plant tissue culture may offer certain advantages over traditional methods of propagation, including;
- The production of exact copies of plants that produce particularly good flowers, fruits, or have other desirable traits.
- To quickly produce mature plants.
- The production of multiples of plants in the absence of seeds or necessary pollinators to produce seeds.

6.5 Seedling Production……. Tissue culture

- The regeneration of whole plants from plant cells that have been genetically modified.
- The production of plants in sterile containers that allows them to be moved with greatly reduced chances of transmitting diseases, pests, and pathogens.
- The production of plants from seeds that otherwise have very low chances of germinating and growing, i.e., orchids and nepenthes.
- To clean particular plant of viral and other infections and to quickly multiply these plants as 'cleaned stock' for horticulture and agriculture.
- Plant tissue culture relies on the fact that many plant cells have the ability to regenerate a whole plant (totipotency). Single cells, plant cells without cell walls (protoplasts), pieces of leaves, or (less commonly) roots can often be used to generate a new plant on culture media given the required nutrients and plant hormones.

6.5 Seedling Production…….

Type of Containers

1. Container –raised plants (plants in polypots)

Raising plant s in polythene containers has become general practice for afforestation in tropical countries, mainly because the rate of survival of seedling is higher especially under unfavorable conditions. They also reduce the rate of failure due to the careless handling by inexperienced labor. Other advantage are that nurseries do not need good soil.

The slandered container for raising plants in the nursery is a polythene pots, 3inch*7inch (7.5cm*18cm) lay flat closed at the bottom and made up of transparent 200 gauge polythene with two holes on the side of drain out water. When filled each about 2.5cm in diameter. Black polythene pots are now being used raised seedlings as it is slower to degrade under the effects of sunlight, also prevents the growth of algae within the pots. Especially nurseries above 1500m elevation or where seedlings have to be kept in the pots for more than year, black polythene is preferable.

6.5 Seedling Production……. Type of Containers

2. Bare-root plants

In this system, seedlings are not grown in separate containers but together in a bed with thousand of plants of others. It is best suited to species with medium to large size seed e.g. *pinus spp.* The main advantages of bare-root are that they are much easier to transport than plants in containers.

3. Large ball-rooted seedling

These are plants of 75-150cm in the nursery for 12 months or longer, and lifted with a ball of soil around their roots 10-15cm in diameter, which is usually wrapped in grass, sacking etc. to keep it moist during transports. This is traditional method in Europe, practically for raising ornamental trees but has been largely replaced growing plants in large containers of plastic and other materials.

6.5 Seedling Production……. Type of Containers

4. Stump (roots and shoots cuttings)

Stumps are prepared by digging up plants from nursery beds, cutting off the stems a few containers above ground level, and shortening and trimming the roots. This method is much easier to transport than container raised plants and less subject than bare root plants.

5. Cutting and other vegetative propagated methods

The main use of cutting and other vegetatively propagated materials is when species to raise from seed or seed is not readily available. They also have the advantage of reducing the time needed in the nursery to obtain plants large enough for planting in the field. Another advantage of cuttings is that they are genetically identical with their parent trees so that trees of good form and vigor can be reproduced easily. Cuttings can be classified as: Stem cuttings, Leaf cuttings, Leaf bud cuttings & Root cuttings.

6.5 Seedling Production…Care and Handling of seedling

From the time you receive your seedlings until they are planted, proper care is vital to maintain their healthy condition. Remember, seedlings are perishable. So, it's the best to plant them as soon as possible once you have received your order. Here are a few seedling care and handling tips to keep in mind:

- Minimize exposure to wind and sun during transporting seedlings.
- Store in refrigerated location, if available.
- Allow for ventilation around stacked seedling packages.
- Protect seedlings from freezing temperatures.
- Mend any accidental tears in the seedling package with tape to reduce moisture loss.
- Do not water seedlings. Watering will wash away the protective gel applied to the roots at the nursery.
- Protect seedlings from direct sunlight and wind before and during planting.

7.1 Introduction to plantation activities in Nepal

As forests fulfill 80% of the energy needs and 35% of the feed needed for domestic animals in Nepal, Government of Nepal is well aware to supply the forest produce and prevent deterioration of the forests. So, National Forestry Plan, 1976 had provisions for afforestation works. This was followed by the Master Plan for Forestry Sector, 1988 went into questions of future supply and demand of forest products in considerable detail. This position was changed in 1978 when rules were promulgated whereby Panchayats could be allocated up to 2500 *ropani* of bare or sparsely forested government land for plantation in the hills whereas in the Terai, 200 *bigha* of such degraded forests for plantation to meet the demands of forest products.

The decentralization Act of 1982 and the Decentralization By-laws of 1984 provided forestry as one of the components of the district development plan for each district. After the promulgation of Forest Act, 1992 and Forest By-laws, 1994 gave all the responsibility of managing the nearby forests to the local traditional users so that

7.1 Introduction to plantation activities contd…

all the degraded barren lands may be planted with the active participation of local forest dependants.

After democracy in 1990, considerable area of plantations have been established by agencies such Nepal-Australian Forestry Project, Nepal Swiss Community Forestry Project and Numerous other bodies. By 1985, about 5000 ha were being planted annually. Not all the plantations were successful, and in some areas, there was a lack of people's participation apart from paying villagers to raise, plant and protect the trees.

Currently, community plantations have become the major plantation in Nepal financially and technically supported by District Forest Offices. Central level/Departmental plantation has almost removed from the programmes except exception. Partly, emphasis has been given on encouraging of tree planting by individual farmers. Farmers have been planting trees on their own land for many years, often using wild seedlings from the natural forest in the hills and from nurseries in the Terai. However, in recent years, this activity has increased considerably, in response to declining supply of forest products from common land/forests.

7.2 Artificial regeneration and its importance

The renewal of a forest crop by sowing, planting or other artificial methods. It also refers to the crop so obtained. It is also called plantation in another term, which is defined as ‘ a forest crop raised artificially, either by sowing or planting.’ A term wilding which is defined as ‘ a natural seedling used in forest planting.

Importance

- ✓It is the supplement of natural regeneration
- ✓It restocks forests destroyed by fire and other biotic factors
- ✓It help in changing the composition of the forest crop, mostly valuable species are introduced
- ✓It introduces exotic species
- ✓It is important for lands which are at risk of erosion and landslides
- ✓It helps improve the genotype or phenotypes of species
- ✓It meets the needs of forest products of forest dependants
- ✓It is mostly more resistant to insect-pests and diseases

7.3 Seed production, extraction and storage

7.3 Seed production

A good seed production is the foundation of successful plantation, which needs good seed year and orchard. Seed orchard should be free from hybridization, especially when selected provenances or genetically improved trees are being used. For native trees, it is generally better to use Nepal-grown seed where this is available. This is usually cheaper, and saves foreign exchange; also trees growing in Nepal will tend to be better adapted to local conditions than those growing in distant areas, often with very different conditions of climate and soil.

The simplest kind is the seed production areas. These are good stands, chosen by phenotypic characteristics, that are thinned or otherwise treated to stimulate seed production; sometimes poor phenotypes are removed. The seed orchard is restricted to stands planted for seed production and composed of trees to be of desirable genotypes from test of their progeny. They are usually established by vegetative propagation from the chosen genotypes and must be isolated from sources of contaminating pollen.

7.3 Seed production, extraction and storage

7.3 Seed production… contd…

To maintain a large and variable gene pool in the progeny, it is desirable to start with enough trees to have at least a dozen genotypes represented in each orchard unit that ultimately becomes a single seed source. Trees of the same genotype should be separated so as to enhance cross-pollination. The trees should be widely spaced and can sometimes be pruned in such a manner that they are easily climbed with the crowns remaining close to the ground. Seeds are collected from the seed orchard to produce seedlings. Storing surplus seed produced and collected in good seed years for use in poor seed years will reduce the need for imports.

Within Nepal, Seed production and collection has been organized on a national basis through the National Tree Improvement Programme, on a divisional or district basis, or by the staff of individual nurseries from nearby forests.

7.3 Seed production, extraction and storage contd…

7.3 Seed Extraction

The seeds have to be separated from the fruit before they are sown or stored. The methods of seed extraction vary with the kinds of fruit. They are:

(a) Pulpy and fleshy fruits

When seeds are to be sown immediately, as in the case of *Artocarpus, Michelia,* etc, it is necessary to remove the fruit pulp before sowing. Otherwise their germinative capacity falls, e.g., *Azadirachta indica.* The method of removing pulp varies with the kind of fruit.

Treading or beating can be done e.g., *Gmelina.* In some cases, it is done by hand after keeping the fruit in water in a container for sometime after which it is kneaded, pounded and squeezed while still in water until the seeds are freed and can be washed out. The soft pulp floats on water and the freed seed sinks to the bottom and thus two can be separated by decantation. Fleshy fruits with very small seeds e.g. *Morus, Anthocephalus,* etc) need special treatment. After depulping them in water, the water containing the pulp and seeds is put in a fine muslin cloth through which the water and the soft pulp can be squeezed out, leaving the seed behind.

7.3 Seed production, extraction and storage contd…

7.3 Seed Extraction…… contd…

(b) Dry fruits

The dry fruits can be classified into the following categories to extract seeds:

Those in which the entire fruit is sown with seed contained in it, e.g., Teak, Walnut, Oak, etc. These seeds do not require any extraction.

Those in which part of the fruit is sown with the seed contained in it, e.g., *Dalbergia sissu,* etc. Such seeds require only beating to break the fruit. For this purpose, seeds are kept in a gunny bag and given sufficient beating to break the fruit.

Those in which clean seed is sown, e.g., conifers. The usual method of extraction consists of spreading the ripe fruit in the sun on clean hard floor or in trays until they open up. They can then be shaken or beaten to separate the seeds. In some cases, the opened fruits eg,. *Bombax ceiba* are kept in a gunny bag of bamboo basket and churned with a wooden stick till the seeds are separated and collected from the bottom of the bag or the basket.

7.3 Seed production, extraction and storage contd…

7.3 Seed Storage

It is known that most of the species do not seed every year. So, it becomes necessary to collect and store the seeds in good seed years without impairing their quality for use in the lean year. The seeds of most commercial species can be stored for periods of 3 to 10 years and sometimes longer if held at low temperature and low moisture content in sealed containers. The proper moisture content varies from 4-12%, depending on the species, and the temperatures should be below 5^0c, preferably in the range from -17^0c to 0^0c. It is important to dry the seeds uniformly and to prevent fluctuations in moisture content during storage. Under these conditions, respiration continues at the low level necessary to keep the embryos alive and only small amounts of the stored carbohydrates are converted into carbon dioxide in the process. Polythylene bags make good containers because they are impermeable to water but not to oxygen and carbon dioxide. These attributes prevent changes in moisture content but allow slow exchange of the gases involved in respiration to continue through the container walls.

7.3 Seed production, extraction and storage contd…

7.3 Seed Storage…….contd…

Some calcitrant seeds are difficult/impossible to store, most of which have very short viability. Even though, they can be kept in cold, moist media; even if kept in refrigerated storage they may last up to a year or two.

As a general rule , the ideal storage conditions are those in which respiration and transpiration is reduced to a minimum without damaging the viability and strength of embryo. The methods of storage also vary with species as given as follows:

(i) Species with seed of transient viability:

Seeds having very short viability should be stored due to unfavorable weather conditions or labor availability. This is best done by spreading them in shade, on hard floor. Sprinkling of water should be given from time to time to prevent desiccation. In this way, they can be stored for 2-3 weeks, e.g., *Shorea* or most *Dipterocarps*, *Myrtaceae* and *Lauraceae*.

7.3 Seed production, extraction and storage contd…

7.3 Seed Storage……contd…

(ii) Species whose seeds ripen in autumn and germinate in spring

The species such as *conifers or Quercus,* of temperate region mostly show such characters. Generally, conifers require dry cold storage but the broad-leaved trees require wet cold storage,i.e., they have to be kept moist and at low temperature. Such seeds can be stored in pit keeping the top of seeds about 45-60cm below the ground level and covering them with soil. But it is difficult to handle the seeds.

(iii) Species whose seeds ripen in winter or summer and germinate in the following rainy season

Most species in the plains produce seeds in winter or summer and these seeds germinate in nature in the follwing rainy seaon. Thus they bear the varying termperatures and moisture conditions before germinating in rains. Such seeds can be stored in dry conditions either in a room or store house depening on quantities of seeds to be stored. Gunny bags or sealed tins or drums can be used to store the seeds in store house.

Desirable to store seeds with low moisture content (about 5% to orthodox seeds which can be stored for longer periods and 20-25% for recalcitrant seeds: which cannot be stored for longer periods)

7.4 Plantation Techniques

7.4.1. Pitting

Planting in pits prepared well in advance of planting is a common practice in South Asia. Pitting should be done while the ground still has some moisture in it and so is soft and easy to dig. Soon after the monsoon is a good time, but it may be better to wait until after the festivals of Dasain and Tihar, that is until November and December (Mansir and Paush). If it is impossible to make the pits at this time, it is better to wait until the pre-monsoon rains of April and May (Chaitra and Jesth) have moistened the soil, but this is a period of fairly high agricultural activity when people are sowing maize and preparing unirrigated land (*khet)* for cultivation. Above 2000m, the soil dries out, and pitting is to be done from January to May (Paush to Baisakh).

The standard pit in Nepal is circular, at least 30cm deep and 30cm in diameter at the bottom. Unless the sides of the pit are vertical the diameter at the top need to be greater than 30cm. Workers should be given 30cm sticks to check the depth and diameter of the pits. On slopes the depth of the pit should be measured at its centre. The most useful tool for pitting is a modified *kodali.* Mattocks are also suitable.

The top-soil of upto 15cm should be dug up and placed to one side of the pit, separate from the sub-soil from below 15cm.

7.4 Plantation Techniques contd…

7.4.2 Spacing

The optimum spacing in forest plantations depends on a number of factors. These include the rate of growth of tree, its form, the availability of nutrients and soil moisture, the effects of grass and weed competition, the danger of fire, the rotation to be used, the purpose of the plantation, the costs of plantation establishment and maintenance, etc. As for example, if fodder production is the main object of the plantation, very close spacing is preferable. Where saw-timber production is the main objective of the plantation, initially close spacing and progressively thinning them out to the final spacing desired.

Most trees grown for fodder, and fruit trees such as *juglas regia* (Okhar) and *Choerospondias scholaris* (Lapsi) need ample space for their crowns to develop and should be planted at a wide spacing such as 5m×5m or more. In between the rows, *Leucaena leucocephala* (Ipil-Ipil) can be planted at very close spacing. The advantages of close spacing are as follows:

- ✓ It reduces weeding costs and fire risks
- ✓ If a few deaths occur, these do not cause large gaps in the plantation
- ✓ The trees tend to grow straighter and produce lighter branches
- ✓ The total volume of wood produced is higher, especially on short rotations.

The main disadvantage is the cost. At a spacing of 1m×1m, 10,000 plants are needed per ha; at 2.5×2.5m only 1600 plants needed. Thus, to plant 1 ha at 1m×1m will need over six times as many nursery seedlings, and will cost over six time as much in pitting, planting and initial weeding than planting at 2.5×2.5m. Hence, the spacing of 2.5×2.5m has become standard in Nepal, which has been regarded as a reasonable compromise. At Sagarmatha, the spacing is 4m×2m for *Dalbergia sissoo* and 4m×1.7m for eucalypts. This will allow three years of crop cultivation between the trees.

7.5 Silviculture operations

7.5.1 Weeding

Any unwanted plant that interferes or tends to interfere with the growth of the individuals of favored species' is called a **weed**. **Weeding** is defined as 'a tending operation done in the seedling stage in nursery or in a forest crop, that involves the removal or cutting back of all weeds.

Objects:

✓To protect the crops from suppression

✓To reduce root competition for moisture and nutrients available in the soil

✓To reduce transpirational water loss

✓To improve light conditions

When?

It is done at seedling stage. A common practice for weeding is that it must be done before weeds start suppressing the seedling crops and when seedlings have stopped growing in the season. Weeding should be carried out when the weeds have tender roots and shoots, otherwise, it will be difficult to uproot. In plantation, weeding is done during and after the monsoon.

Although number of weedings depends upon the intensity of weed growth and the rate of growth of seedlings of the favored species, three weedings are usually done in first year, two in second year and one in the third year, whereas fast growing species require weeding for one or two years.

7.5 Silviculture operations contd…

7.5.1 Weeding…….contd……

Where?

In areas where weeds are tall and dense, light cannot reach the ground easily, which not only affect the regeneration but also obstructs the growth of species, because weeds grow at faster rate than the crop species. It can be done in nurseries, natural or artificial regeneration.

How?

In Nepal, it is customary to weed in a circle of 60cm in diameter round the plants, but this should be regarded as an absolute minimum. Increasing the diameter of the circle of one metre would be very desirable. In parts of the Terai and Bhabar Terai Zones where there is a dense growth of perennial grasses, weeding 60cm around the plants is certainly inadequate. Weeds should be pulled to come with the roots. While pulling out, seedlings of desired species should be held firmly between two fingers of one hand in order that they may not be disturbed. During the winter, seedlings need protection from frost. Therefore, weeding should be stopped by the end of September until the start of spring. The intensity of weed growth and rate of growth of crop species determine the number of weeding.

Limitation

Despite weeding removes all plants that compete with the crop species. Some crop species, by nature, love to have shade-partial or complete while some others are shade tolerant.

7.5 Silviculture operations contd…

7.5.1 Cleaning

A tending operation done in a sapling crop, involving the removal of inferior growth including individuals of favored species, climbers, etc., when they are interfering with better grown individuals of the favored species.

In cleaning, shrubs, individuals of inferior species, malformed or diseased, singling of favored species and climber cutting are done for the following objects:

Objects:

- ✓To reduce root competition and transpirational water
- ✓To improve light conditions
- ✓to provide adequate space for the growth of crops

The competition becomes so immense that there will be crown differentiation in the stand in the later stage. Some reach at dominant and dominated level, while others suppressed at lowest canopy. To observe uniform growth of a forest stand, cleaning operations are timely carried out.

7.5 Silviculture operations contd…

7.5.1 Cleaning… contd…..

When?

Cleaning is done when the crops reach at sapling stage. At sapling stage, plants compete each other to reach the top in order to obtain the light. The best time for cleaning is determined by the growth season of favored species, which is during the monsoon. It is certainly difficult to do the activities in the rainy season; hence cleaning is done before the onset of monsoon.

How?

The removal of any species from the forest is determined by the degree of interference with other species. The frequency of cleaning depends upon the intensity and rate of growth of shrubs after cutting. The cuttings should be done at heights that one feels comfortable during the activity but the leftover should always be at lower height than the crop species. It is not always necessary to clean the inferior species unless plants hamper the favored ones. Retaining them in such situation helps to maintain soil moisture in the locality.

Limitation

Cutting near the ground level results in vigorous coppice shoots, which have to be discouraged and as a result it would be more expensive.

7.5 Silviculture operations contd…

7.5.2 Casualty replacement

Whenever we plant seedlings in the plantation areas, they may not be 100% successful. Some of them are likely to get infested with grasses and weeds and pose a fire hazard in dry season resulting into gaps in plantation areas. In such condition, seedlings are re-planted or seeds sown to fill the gaps, such operation is called ***casualty replacement***, also called ***beating up,*** which is defined as restocking blanks in an artificially regenerated area with fresh sowings or plantings. These gaps are especially seen when plantation are grown by sown-seeds and those gaps are beaten up in August. Stumps or container plants are more suitable for filling blanks. Weeding helps in reducing the works of beating up.

Beating up work should be done by good planting stock so that it catches up with the rest of the crop. Planting out weak, small-sized plants or rejected thin stumps, is waste of time and money. Similarly, beating up work should not be done by species which would not go well with original species, e.g., fire tender *Michelia champaca* in Sal plantations.

7.5 Silviculture operations contd…

7.5.3 Thinning

It is the reduction of trees in an immature stand for the purpose of improving the growth and form of the trees that remain without permanently breaking the canopy of future trees.

Objects:

- ✓To distribute growth potential of a site amongst the trees retained.
- ✓To increase the net yield of timber and money from a stand
- ✓To obtain earlier returns from capital invested in a stand
- ✓To utilizethe thinned material
- ✓To shorten the rotation
- ✓To produce a different smaller size of timber which can meet a different object of management
- ✓To maintain hygienic conditions in the stand
- ✓To allow intermediate harvests of small and large woods before the final harvest satisfying the needs of the users
- ✓To favor natural regeneration in a stand though not of prime intention
- ✓To control species composition in a stand by removing undesirable species during the operation

7.5 Silviculture operations contd…

7.5.3 Thinning….contd…

When?

- ✓The time for thinning a stand is determined when the crowns of the adjacent trees are close together and there is no further space into which individual trees can grow
- ✓Removing of unwanted species carries out when there is a need to change species composition in a forest stand
- ✓When users demand of fuel wood and small wood has to be fulfilled
- ✓Thinning is done any time when dead and diseased trees are sighted.

How ?

- ✓The number of plants, inferior in quality, is reduced in one or several operations
- ✓Remove all dead and diseased trees at first instance. They can be removed at any time
- ✓Trees that are dying (75% dead) may be retained temporarily if removal of crops exposes the soil

Limitation

No numerical basis showing the levels of optimum basal area for the types of forest prevalent in the country has been found.

7.5 Silviculture operations contd…

7.5.3 Thinning….contd…

Major Kinds of thinnings:

(i) Mechanical thinning (*also called stick thinning*)

A thinning in which the trees to be cut are selected by some rule of thumb, e.g., trees in alternate diagonals or rows, alternate trees in alternate rows or every second, third, etc., line or a minimum spacing gauged by a standard stick.

(ii) Ordinary thinning (*Also called low thining or German thinning or thinning from below*)

The method of thinning in common use that consists in the removal of inferior individuals of a crop, starting from the suppressed, then taking the dominated and lastly some of the dominants.

9iii) Crown thinning (*High thinning or French thinning or thinning from above)*

A method in which thinning is primarily directed to the dominant trees in a regular crop, the less promising ones being removed in the interest of the best available individuals; the dominated and suppressed stems are retained if they are not dead, dying and diseased.

(iv) Free thinning (devised by Heck)

A method of thinning in which attention is concentrated on evenly spaced selected stems (called *elites* or *alpha* stems) which are retained until maturity or til the last thinning or two, thinning being directed to the removal of other stems hindering their optimum development.

7.5 Silviculture operations contd…

7.5.3 Thinning….contd…

(v) Maximum thinning

It is the modification of ***Heck's free thinning*** developed by Gehrhardt. It is defined as a method of thinning which ' aims at putting as high a proportion possible of the total potential increment of the area on the retained stems; from an early stage the number of such stems limited to the minimum that can fully utilize the growing tree. It is heaviest form of free thinning so that there are no trees other than elites. As the thinning is extremely heavy, it may result in deterioration of site due to exposure, infestation of the area with shrub growth, production of knotty timber.

(vi) Advance thinning (also *Craib's thinning*)

A thinning done in a regular crop in anticipation of suppression. It was developed by ***Craib*** and ***O'Connor*** for wattle and pine plantation in south Africa. Thinning is done after the trees have been adversely affected by the competition of their neighbors. It should be done before competition actually sets in.

(vii) Selection thinning

A method of thinning directed to obtain and/or maintain selection composition in a crop, with all diameter classes adequately represented.' It is carried out in all canopy classes removing the trees of the following characteristics:

- ✓Dead, dying and diseased trees
- ✓Inferior trees which restrict the development of their neighbors from all sides
- ✓Trees which are less valuable than their neighbors
- ✓Trees which are of no special importance as regards desirable crop mixture
- ✓Inferior trees standing over groups of well-grown advance growth which may also be thinned

7.5 Silviculture operations contd…

7.5.4 Pruning

It is a kind of management of crops at younger and/or older stage in which branches live or dead are removed for further improvement of crops to produce knot free timber. It is the removal of branches from the trees.

Objects of pruning:

- ✓To get clear, knot-free high grade timber
- ✓To meet the demand of fuel wood and fodder
- ✓To get access for inspection and reduce the chance of fire hazard

Kinds of pruning

On the basis of the kind of branches, pruning is classified into:

(i) Dry Pruning, i.e., Pruning of dead branches

(ii) Green pruning, i.e., pruning of living branches

7.5 Silviculture operations contd…

7.5.4 Pruning….contd…

On the basis of agency of pruning, it is classified into:

(i) Natural pruning

The natural death and fall of branches of standing trees from such causes as deficiency of light, decay, snow and ice. It is also known as *self-pruning.* Teak, most *Eucalyptus* species and kadam are good natural pruners.

(ii) Artificial pruning

The pruning done by forester without waiting for nature to do it in dense natural crops or where nature can not do it due to artificially large spacing between stems in man-made plantations to reduce cost of formation and rotation. It is a costly operation. So, artificial pruning is carried out considering the funds or outcomes.

When?

Trees cease growth during the winter. Therefore, winter is the best season to prune the trees. In other words, prune before the growth starts on trees. The best time for pruning is when crops are at early stage of life. Prune when the branches are thin. The time for first pruning should be done between 5-10 years of crop age. Dead branches may be pruned at any time.

7.5 Silviculture operations contd…

7.5.4 Pruning….contd…

How?

In order to get a free timber, cut the branches close to the cambium layer of stem. Do not leave branch stubs when pruning. Cut on the lower side of the branch before completing the removal with a cut from above. This avoids tearing off the stem. The damage on stem may help fungus and insects to attack.

Younger trees are pruned at 1/3rd the height of standing tree, while older trees are pruned at ½ of its height. Mature trees can be pruned up to 2/3rd height, if fodder and fuel wood scarcity is acute problem.

Use pruning saw (hand pruning saw or long-handled pruning saw) as far as practicable. Otherwise, local tools- Sickle and Khurpa are equally good, but should be very careful while pruning.

The purpose of pruning of fodder and fruit trees is to increase foliage and fruits, respectively. Pruning of fodder and fruit trees differ from that of timber objectives. Here, pruning is confined at secondary and tertiary branches leaving the leading branches untouched.

In difficult situation, always start cutting from the upper most branches and work your way down. The lower branches could be used for support.

Limitation

Pruning is a costly operation. Therefore, it is confined in pine plantation and fodder trees on farmlands.

Unit-8 Introduction to Silviculture System

8.1 Natural regeneration and its importance

Natural regeneration is defined as 'the renewal of a forest crop by self-sown seed or by coppice of root suckers. To regenerate means 'to renew a forest crop by natural or artificial means'. Thus, regeneration (*syn.* Reproduction) is defined as 'the renewal of a forest crop by natural or artificial means'.

Importance

- ✓Species always are well adapted to the localities
- ✓Multi-purposes species are grown naturally
- ✓Better conservation of biodiversities and amelioration of ecosystems
- ✓Meeting requirements of people and their domestic animals
- ✓Better wildlife habitats
- ✓More suited to conservation of soil and improvement of watersheds
- ✓Seedlings found have already be naturally hardened-off
- ✓Injurious or damaging species are found suppressed by natural pests or plants
- ✓Nursery grown seedlings are not necessary
- ✓Low cost and more net financial returns
- ✓Special Supervision of any kinds are not necessary
- ✓Vigorous growth of trees of favored species

8.2 Factors affecting natural regeneration

Factors affecting natural regeneration are given as follows:

1. Climatic Factors

(i) Solar Radiation and Light
(ii) Precipitation
(iii) Local Temperature
(iv) Humidity (Atmospheric Moisture)
(v) Frost
(vi) Snow Fall
(vii) Evapo-transpiration

2. Soil Factors

(i) Organic matter and nutrient status
(ii) Soil structure and texture
(iii) Soil Temperature
(iv) Chemical Properties of Soil
(v) Biological Properties of Soil
(vi) Erosion and Floods

8.2 Factors affecting natural regeneration contd…

3. Biological Factors

a) Man and his activities
b) Wild life and domestic animals
c) Diseases and Pests
d) Heavy growth of grasses and weeds
e) Forest fires

Factors affecting natural regeneration by coppice:

a) Species- coppicing power
b) Age of tree-pole and young trees
c) Season of coppicing- before spring
d) Height of stump-15 to 25 cm.
e) Rotation-short
f) Silvicultural system- clear felling

8.3 Methods of natural regeneration

A. From Seed B. From vegetative parts

A. Natural Regeneration (NR) from Seed

When regeneration obtained from seed forms a crop, it is called a seedling crop. It is neither planted nor of coppice or root-sucker origin but originating *in situ* from natural regeneration. When this seedling crop grows into a forest, it is called a high forest. **NR** from seed depends on the followings:

a) Seed Production
b) Seed Dispersal
c) Seed Germination
d) Seedling Establishment

(a) Seed Production: The most important consideration for natural regeneration from seed is the production of adequate amount of fertile seeds by the trees of the area or in the vicinity. The production of seed depends on the following:

Species, Age of trees, Size of Crown, Climate, and other external factors

A. Natural Regeneration from Seed

(b) Seed Dispersal

The seed produced by the trees is dispersed by the agency of wind, water, gravity, birds and animals. Some examples of seed dispersal by various agencies are given below:

Wind: Conifers, *Acer, Betula, Populus, Alnus , Salix, Terminalia, Dalbergia, Acacia , Adina , Bombax,* etc.

Water: Most mangrove species, *Dalbergia*, Teak, etc.

Birds: *Prunus,* Mulberry, *Diospyrus*, etc.

Animals: *Acaica arabica, Prosopssis juliflora, Zizyphus, Anthocephallus*, etc.

Gravity: Oak, *Juglans, Asculus*, etc.

8.3 Methods of natural regeneration

(c) Seed Germination

After dispersal, insects, birds and rodents destroy a lot of seeds. The others germinate provided they are deposited on suitable soil. Germination of seeds depends upon several internal and external factors listed below:

Internal Factors: Permeability to water, permeability to O_2, development of embryo (i.e., *Frixinus floribunda* takes one year), after ripening (i.e., *Juniperus macropoda*), viability of seeds, size of seeds, germination capacity, germination energy

External factors: Moisture, air, temperature, light (i.e., *Cassia fistula* or *Albizzia procera* requires light), seed Bed.

8.3 Methods of natural regeneration

(d) Seedling establishment

Even if germination is good, it does not mean that natural regeneration would be good because a large number of seedlings die at the end of rains or as a result of frost during winter or drought during summer. In addition, there may be other factors such as weeds, grazing, fire, which may kill the seedlings.

Thus, establishment is defined as the development of new crop 'naturally or assisted' to a stage when the young regeneration 'natural or artificial' is considered safe from normal adverse influences and no longer needs special protection or tending operation other than cleaning, thinning and pruning.

The following factors affect establishment of seedlings:

1. Development of roots
2. Soil conditions – Moisture, Aeration, Nutrients
3. Light
4. Other Climatic Factors- high or low temp.
5. Rainfall
6. Drip (Slash erosion)
7. Condition of grasses and other competing weeds
8. Grazing, Browsing and Fire
9. Composition of the crop

8.3 Methods of natural regeneration contd…

B. Natural Regeneration from vegetative parts

When regeneration obtained by coppice forms a crop, it is called coppice crop and when it develops into a forest, it is called coppice forest to differentiate it from the high forest. Natural regeneration by coppice can be obtained either by:

1. Seedling coppice: Coppice shoots arising from the base of seedlings that have been cut or burnt back. This method of obtaining natural regeneration is used for cutting back woody shoots and established reproduction which is not making any progress so that they may produce vigorous shoots and soon develop into saplings.

2. Stool coppice: Coppice arising from the stool or a living stump of a tree is called stool coppice. In this method, regeneration is obtained from the shoots arising from the adventitious buds of the stump of felled trees. The coppice shoots generally arise either from near the base of the stump or from its top. The shoots arising from near the top of the stump are liable to be damaged by the rotting of the upper portion of the stump as well as by wind, etc.

8.3 Methods of natural regeneration contd…

Vegetative reproduction can be obtained by any of the following methods:

1. Coppice

Vegetative reproduction in which the tree, plants or the seedlings of a species when cut near the ground level produce shoots.

2. Root Sucker (*A shoot rising from the root of a woody plant***)**

Vegetative reproduction in which a root of a plant is partially or wholly cut to produce a shoot called root sucker.

3. Cutting

Vegetative propagation in which a portion of the stem, branch or root is placed in the soil or other medium, in order that it may develop into a plant. Depending on the part of the plant used, cuttings may be classified into stem cutting, branch cutting, root cutting and root and shoot cutting. Root and shoot cutting is a young plant with pruned tap-root and severed stem used for planting.

8.3 Methods of natural regeneration contd…

4. Layering: Inducing development of roots on branches while they are still attached to the trees is called layering. Layering may be done in soil or in air and so layering is of two kinds: Air Layering and Soil Layering

5. Grafting: Vegetative propagation in which a portion called scion *(Any unrooted portion of a plant used for grafting or budding on a rooted stock*), of one plant is applied to stock (*A rooted plant on which a scion is grafted*), usually rooted, which is another plant, with the object of securing vegetative union between the two, when the scion is detached from the parent plant and the shoot of the other plant is severed, to produce a new plant to be planted out. Attempt is made to transport the scions to the grafting place within 24 hours.

6. Budding: A vegetative reproduction in which, a bud with some portion of the bark of a genetically superior plant is grafted on an inferior plant so that it can produce shoot when the old shoot of the stock is cut off. Bud is grafted on the stock in the form of a patch after removing the bark of the stock in that portion or by making an incision in the bark of the stock in the form of **T** and then fixing the scion inside it.

8.3.1 Classification of silvicultural systems

Introduction: Silvicultural system may be defined as a method of silvicultural procedure worked out in accordance with accepted sets of silvicultural principles by which, crops constituting mature forests are harvested, regenerated, tended and replaced by new crops of distinctive forms. It begins with regeneration felling and includes adoption of some suitable method of regeneration and tending of the new crop throughout of its life.

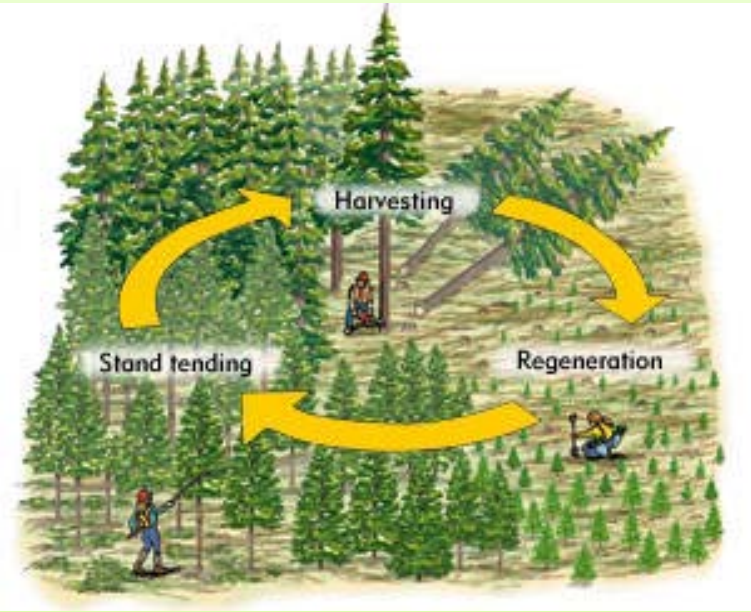


Fig. 1 Sequence of Silvicultural System

8.3.1 Classification of Silvicultural Systems contd…

Silvicultural systems have been classified in a variety of ways. The most commonly used classification is based primarily on the mode of regeneration. It is further classified according to the pattern of felling carried out in the forest crop. According to the method of regeneration, silvicultural systems are of following two types:

A. High forest systems and

B. Coppice systems

A. High forest systems:

High forest systems are those silvicultural systems in which the regeneration is normally of seedling origin, either natural or artificial or a combination of both and the rotation is generally long. The high forest systems are further classified on the basis of pattern of felling and mode of regeneration as well. A schematic classification of these systems is given here.

8.3.1 Classification of High Forests

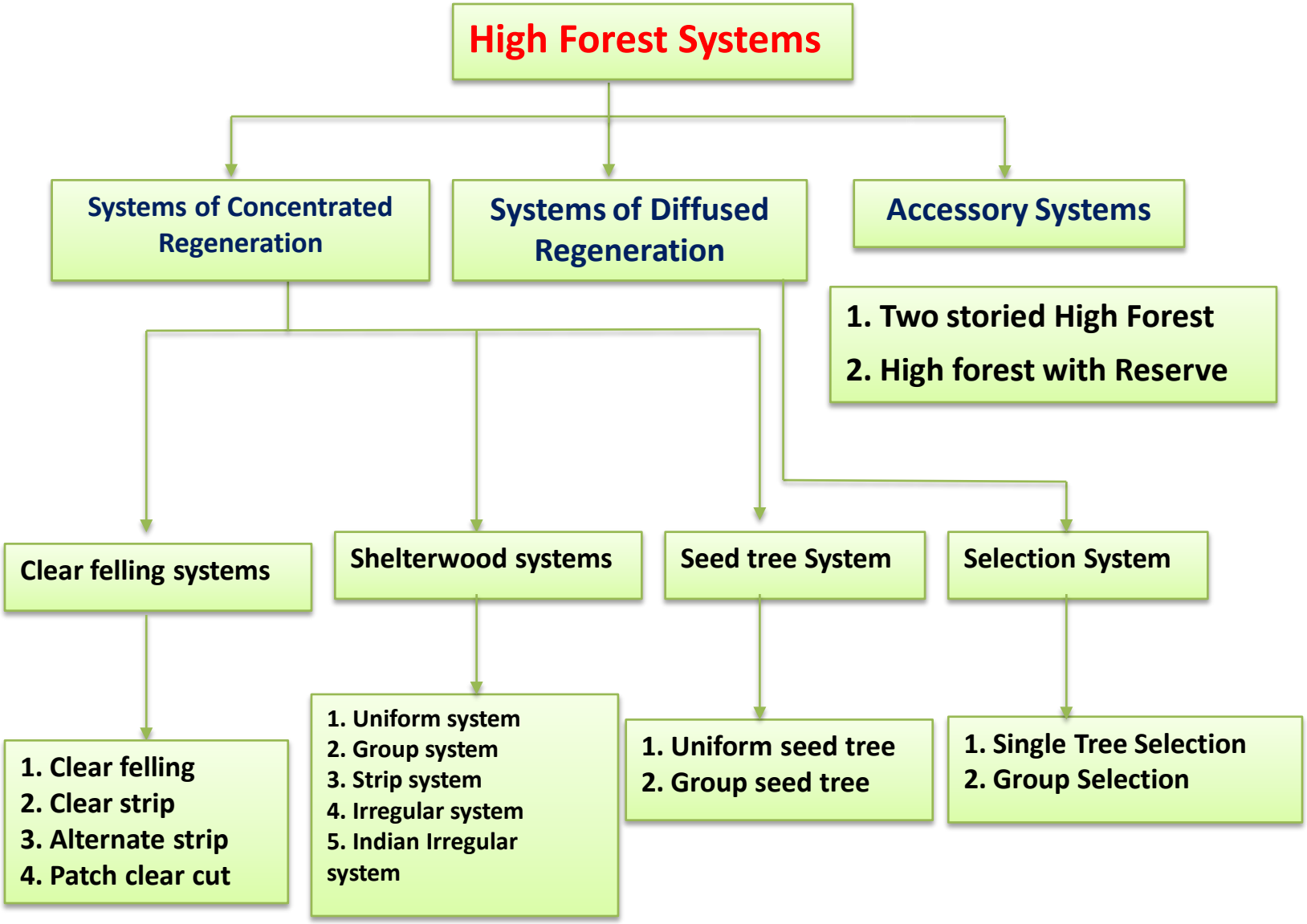


Fig. 2 Schematic Classification of Silvicultural System

Classification of Coppice System

That silvicultural system in which the crop originates mainly from coppice and the rotation is short is called coppice system.

Kinds of Coppice System (Low Forest System)

a) Simple Coppice System.
b) Coppice of Two Rotation System.
c) Shelterwood Coppice System.
d) Coppice with Standard System.
e) Coppice with Reserve System.
f) Coppice Selection System.
g) The Pollard System

8.3.2 Clear felling system

The clear felling system is a silvicultural system in which equal or equi-prodcutive areas of mature crop are successively clear-felled in one operation to be regenerated most frequently, artificially but sometimes naturally also. The new crop produced is absolutely even-aged. It requires large sums of money and large number of laborers to regenerate the forest artificially.

Fig.3-Clear Felling system

8.3.2 Clear felling system contd…

The area to be clear-felled each year in uniformly productive sites is l/n of the total area allotted to this system.

N = no of years in the rotation and is usually referred to annual coupe.

The coupes to be felled every year are made equi-productive.

Removal or felling of mature crop: According to definition, the entire crop of the coupe should be felled and removed in one operation but in practices following variations are observed.

✓Retention of some mature trees as frost protection measures or as an insurance against failure or as nurse crop to facilitate establishment of frost tender species.

✓Retention of promising groups of saplings and poles to prevent unnecessary sacrifice of immature crop of the desired species.

✓Isolated saplings and poles are ordinarily not retained as they may develop in to wolf trees.

8.3.2 Clear felling system contd…

Methods of obtaining regeneration:

The area can be regenerated sometimes naturally but mostly artificially

Artificial regeneration is preferred due to following reasons

1. It is the surest and quickest method of improving crop composition.
2. It facilities introduction of fast growing and high yielding exotics.
3. It provides better financial returns.
4. The regeneration is established sooner, so the area can be opened for grazing sooner.

Method of Artificial Regeneration:

(i) Departmental plantation

(ii) Taungia

a) Departmental Taungia

b) Leased Taungia

c) Village Taungia

Method of Natural Regeneration:

✓Natural regeneration from seed

✓Seeds stored in the area

✓Seeds received from outside

✓Natural regeneration from advanced growth

8.3.2 Clear felling system contd…

Advantages

- ✓It is simplest of all high forest system. It does not require a high degree of skill.
- ✓As felling is concentrated, the yield per unit area is more and consequently the cost of felling and extraction is low.
- ✓Introducing fast growing exotics and regulating composition of new crop through artificial regeneration is advantageous.
- ✓It makes the supervision of all operations easy.
- ✓There is no damage to new crop by felling

Disadvantages

- ✓It is the most artificial system.
- ✓Soil remain open there is more danger of soil deterioration and erosion
- ✓The danger of weeds and grass invasion increases.
- ✓It produces even aged crop, which is less resistant to damage by wind.
- ✓When the crop is pure it becomes more susceptible to damage by Insects, plant parasites and pathogens.

8.3.2 Variations in Clear felling system contd…

1. Alternate strip clear cut system

A silvicultural system in which clear felling is done in the form of strips and the clear strip alternate with unfelled strips of similar width. Clear cut strips are oriented at right angle to the direction of wind.

2. Progressive strip clear cut system

A silvicultural system in which, clear felling is done in the form of strips which progress successively in one direction across the regeneration area. The crop produced is even-aged considering each strip as a compartment.

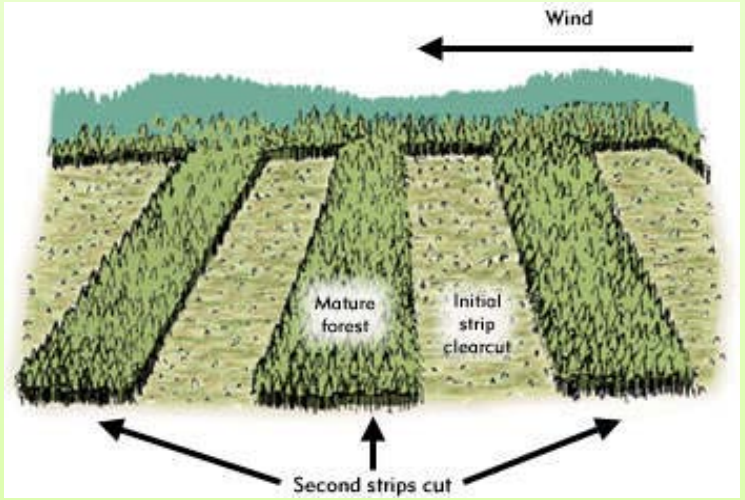


Fig. 4-Pattern of felling in alternate strip

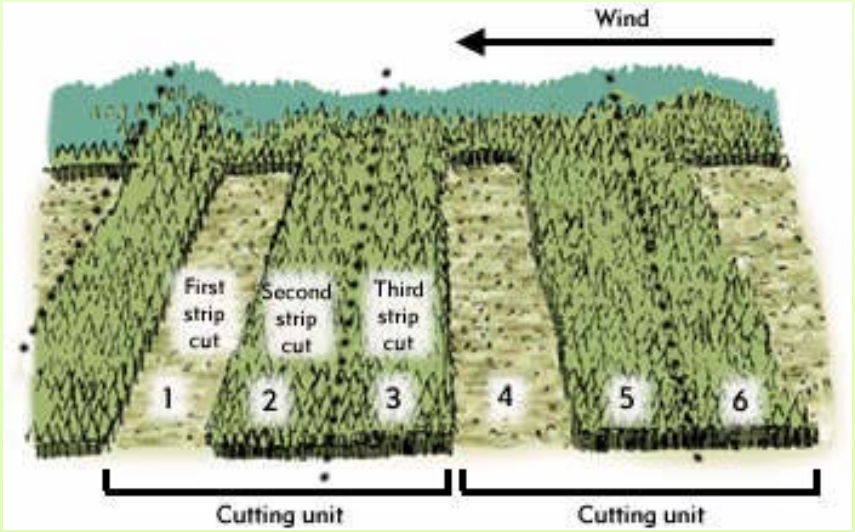


Fig.5 -Pattern of felling in progressive strip

8.3.2 Clear felling system contd…

3. Block or patch clear cut system : It is applied on rugged and irregular terrain or in even-aged stands that lack uniformity.

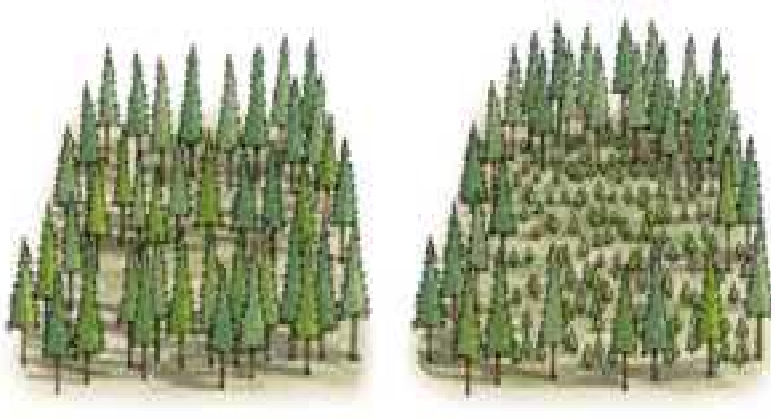


Fig.6-Patch clear cut system

Fig.7 -Seed tree

Fig. 8-Seed tree system

Seed tree system

In this method, the stand is clear felled except for a few seed trees, which are left standing singly or in groups to produce seeds for regeneration. After a new crop is established, these seed trees are removed or left indefinitely. The chief distinction from shelter wood system is that the seed trees are retained only for seed production and not enough to provide shelter. Seed Trees should have wind firm, seed producing ability with dominant crown and age of producing abundant seeds. Fig. see above.

8.3.2 Clear felling system contd…

Number and distribution of seed trees depend on following factors:

- ✓Amount of seed produced/tree
- ✓The no. of seed required
- ✓Seed Dissemination
- ✓Number of viable seed produced
- ✓Seed germination
- ✓Seedling establishment

Advantage: Ample opportunity for phenotypic selection, suitable for light demanding species.

Disadvantage: Under stocking, over stocking, damage by forest and drought.

Kinds of Seed Tree System

1. Uniform seed tree system

In uniform seed tree system, individual trees are more or less uniformly distributed throughout the block.

2. Group seed tree system

In a group seed tree system, seed trees are left in the block in small patches. These patches may be arranged in irregular groups or in strips.

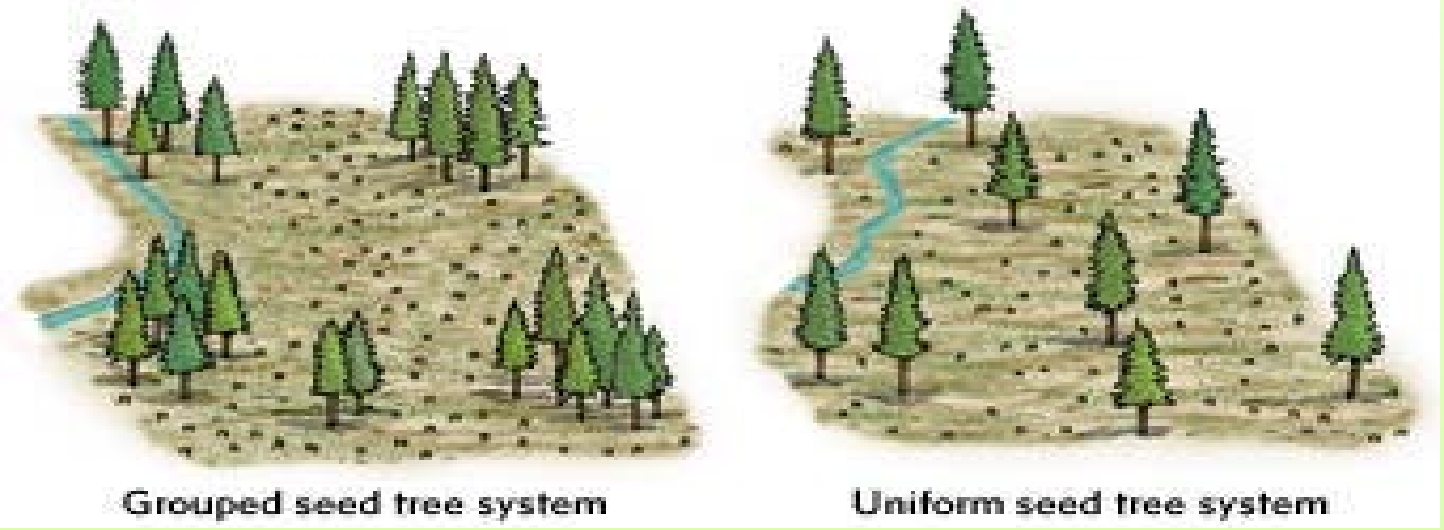


Fig.9-Group and uniform seed tree system

8.3.3 Shelter wood system

A silvicultural system in which the over wood is removed gradually in two or more successive fellings depending on the progress of regeneration. The primary intent of this system is to protect and shelter the developing regeneration.

The trees which are growing vigorously are retained to provide shelter, Seed, rapid diameter increment and value increment and protection of site against deterioration.

Criteria for leave-trees in shelter wood systems are: larger, dominant trees, wind firm trees, desirable species and desirable physical characteristics .

Fig.10-Shelter tree

Fig.11-Shelter wood system

8.3.3 Shelter wood system

Advantages

- ✓Marking and felling of trees of the over wood are simpler than selection system
- ✓Soil is not completely denuded so there is little risk of soil deterioration and erosion.
- ✓As the regeneration operations are carried out under the shelter of older crop, there is little danger of invasion of the area by weeds and grasses
- ✓The young crop is protected against adverse climatic factors such as cold, frost, etc.
- ✓As the regeneration is obtained from seeds obtained from best selected trees, the new crop is superior.
- ✓Suitable system for the regeneration of both light demander and shade bearer spps.
- ✓It makes supervision and control of various operations easy.
- ✓From aesthetic point of view, the system is superior to clear felling system.

Disadvantages

- ✓As the over wood is removed in more than one operation, there is much damage to the young crop.
- ✓The isolated seed bearers are susceptible to wind damage.
- ✓After seeding felling, invasion by weeds and regeneration may be affected.
- ✓weeding and cleaning have to be done for longer period and the natural regeneration becomes costly.

8.3.3 Shelter wood system contd…

Pattern of Fellings

A. Preparatory Felling: A felling made under a high forest system, usually towards the end of the rotation, with the object of creating conditions favorable to seed production and natural regeneration.

✓Create gaps in the canopy

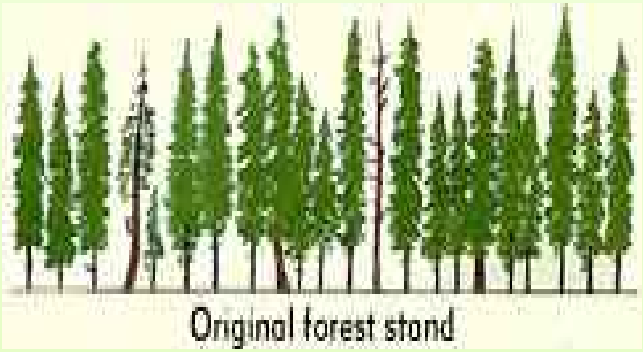
✓Create favorable conditions on the forest floor

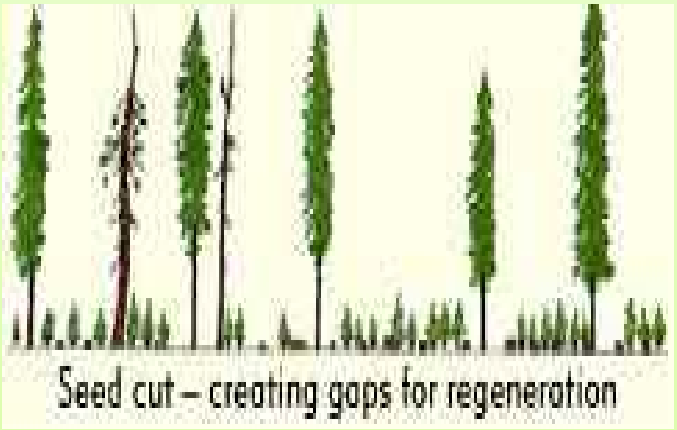
B. Regeneration felling: A felling made with a view to inviting or assisting regeneration under a shelter wood system. It includes seeding felling, secondary felling and final felling.

1. **Seeding felling:** Opening the canopy of a mature stand to provide conditions for securing regeneration from the seed of trees retained for that purpose. It is the first stage of regeneration felling.
2. **Secondary felling:** A regeneration felling carried out between the seeding felling and the final felling under a shelter wood system in order to gradually remove the shelter and admit increasing light to the regenerated crop. Removal of trees in secondary felling depends on progress of regeneration and its light requirement. It also helps in the manipulation of mixture of crop.

8.3.3 Shelter wood system contd…

3. Final felling: The removal of the last seed or shelter trees after regeneration has been affected under a shelter wood system. It is the final stage in regeneration felling when the area is completely stocked with established regeneration





Figs.12- Patterns of felling in shelter wood system

8.3.3 Shelter wood system contd…

Periodic Block:

It is necessary to divide the rotation period in to as many parts as the number by which the rotation is divisible by the time taken to regenerate an area.

Example;

If the rotation is 120 years and it takes 30 years to regenerate the area naturally.

The rotation will be divided into periods. As each of this part is felled and regenerated in a particular period, it is called a periodic Block.

120/30 = 4 periodic blocks

	Age Class (Age of crop in years)		
Period and Periodic block	**At the beginning of the period**	**At the end of period**	**Remarks**
I	91-120	1-30	After one rotation
II	61-90	91-120	
III	31-60	61-90	
IV	1-30	31-60	

8.3.3 Shelter wood system contd…

Kinds of Shelterwood Systems

1. Uniform shelter wood system(Uniform System)

The canopy is uniformly opened up over the whole area of a compartment to obtain uniform regeneration under the shelter of remaining old crop.

2. Strip shelter wood system

Regeneration felling is done in the form of strips successively from one side of the compartment, progressing against the direction of wind. The width of the strip varies according to local conditions.

Fig.13-Uniform Sheltwood system

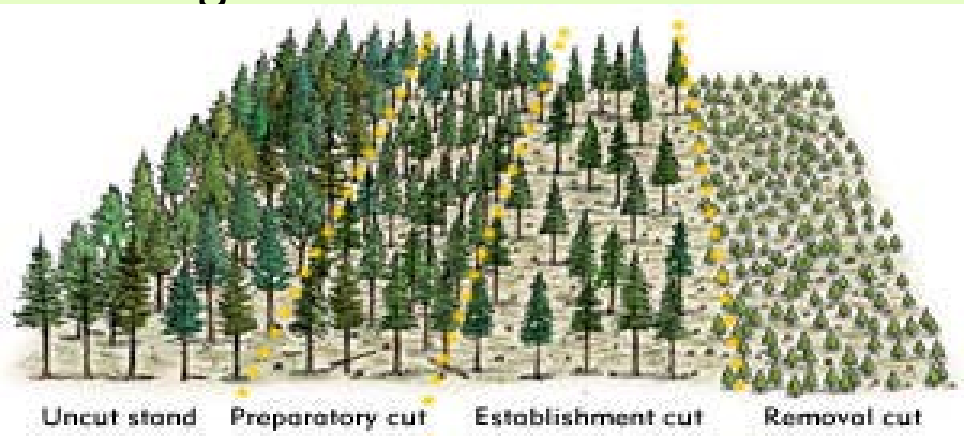


Fig.14-strip shelter wood system

8.3.3 Shelter wood system contd…

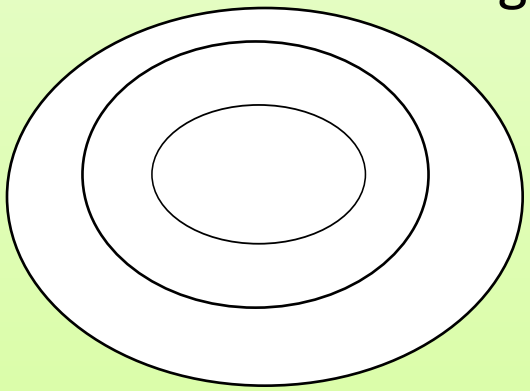
3. Group shelter wood system

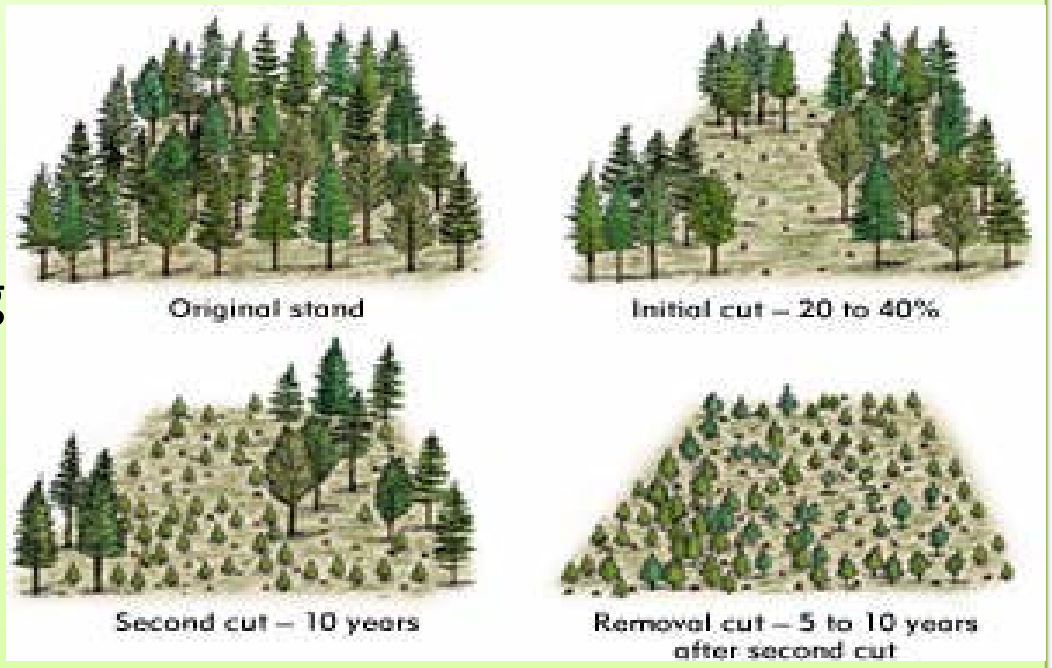
A silviculture system in which regeneration fellings, instead of being done uniformly all over the compartment, are carried out in scattered groups in which the foci of regeneration can be enlarged centrifugally to merge with each other ultimately. Advance growth is the main source of regeneration. It was tried in Deodar, Kail and Sal forests in India but it was not successful.

Smallest circle for Final felling

Medium circle for secondary “

Largest “ for seeding Felling

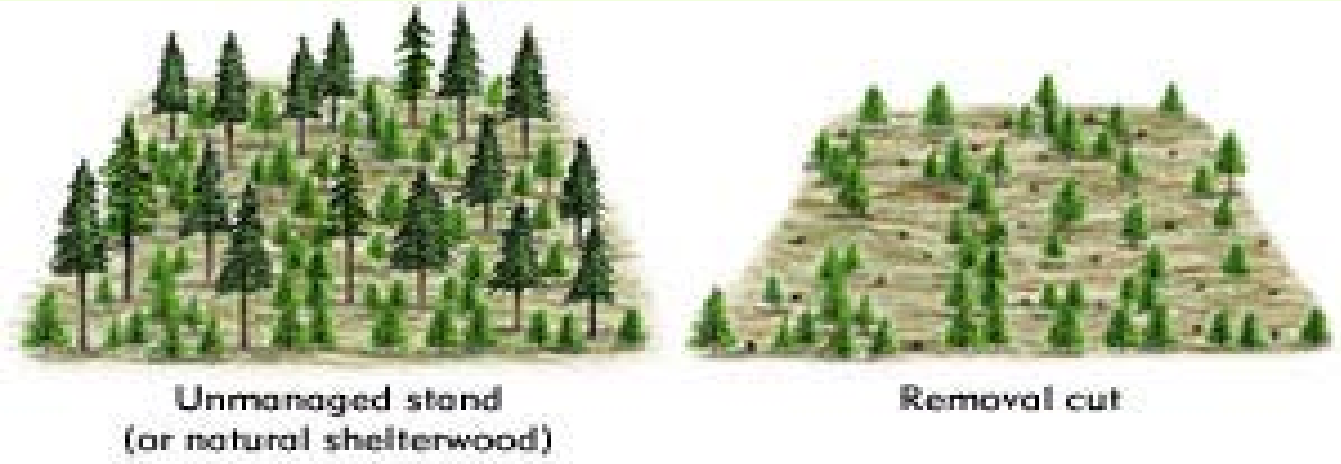




Figs.15-Group shelter wood system

8.3.3 Shelter wood system contd…

4. One cut shelter wood system: In this system, regeneration felling is done in one operation. It is applied only when advance regeneration is well.



Figs.16-one cut shelter wood system

5. Indian Irregular Shelterwood System

Silvicultural System is which mature crop with recalcitrant regeneration having large quantities of advance growth of various ages and sizes including immature poles and trees upto 40 cm dbh, which are retained as part of the future crop to complete regeneration work . The crop to be regenerated is opened up irregularly and the resultant crop is uneven aged. This system is applied to Sal, Deodar, Fir, Spruce and other evergreen forests in India.

8.3.3 Shelter wood system contd…

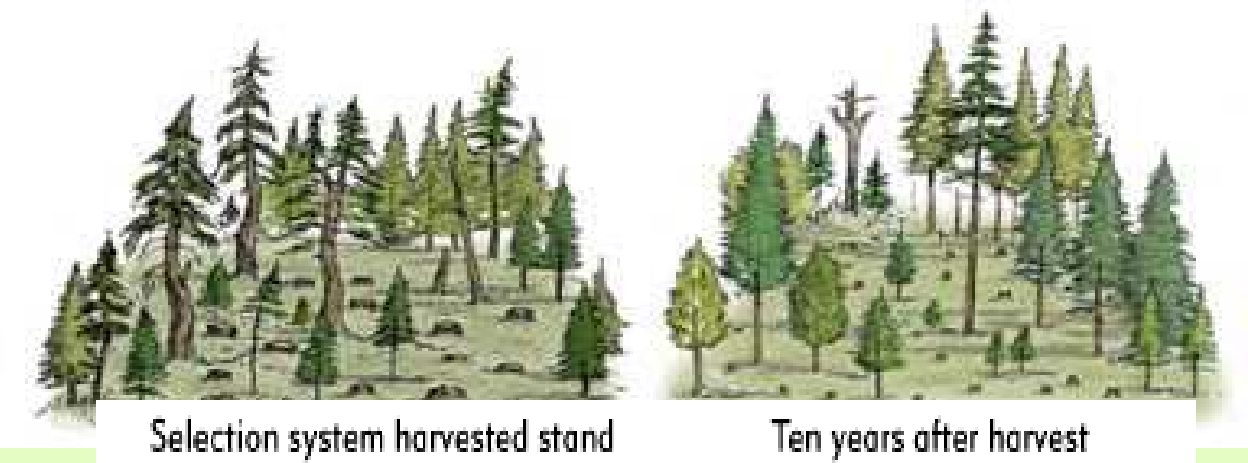
6. Irregular shelter wood system

Regeneration felling is on the pattern of group system but as the regeneration period is long, the crop produced is uneven aged or irregular. This is a compromise between shelter wood group system and selection system.

Figs.17-Irregular shelter wood system

8.3.4 Selection system

A silvicultural system in which felling and regeneration are distributed over the whole of the area and the resultant crop is so uneven-aged that trees of all ages are found mixed together over every part of the area. Such a crop is referred to as selection forest or all-aged forest. Regeneration operation is carried out throughout the life of crop.



Selection system harvested stand Ten years after harvest

Felling of trees all over the area of a forest is possible when the area is small but if the area is large it is not possible to fell the trees over the entire area annually. Therefore, Thus, felling is done in a coup after a certain number of years, which is equal to the number of coups. This interval is known as felling cycle, which is defined as the time between two successive main felling on the same area. The length of the felling cycle affects the silviculture of species, exploitation of forest, and the nature of crop produced.

8.3.4 Selection system contd…

Advantages:

- ✓It results in the production of all aged forest. Trees of all ages are mixed together on each unit of area. Then the growing space and site factors are fully utilized.
- ✓By maintaining continuous leaf cover, the selection systems conserve soil and moisture to the fullest extent possible.
- ✓The selection forest produced is most resistant to injuries by insect pests and adverse climate factors.
- ✓It prevents invasion of grass and weeds.

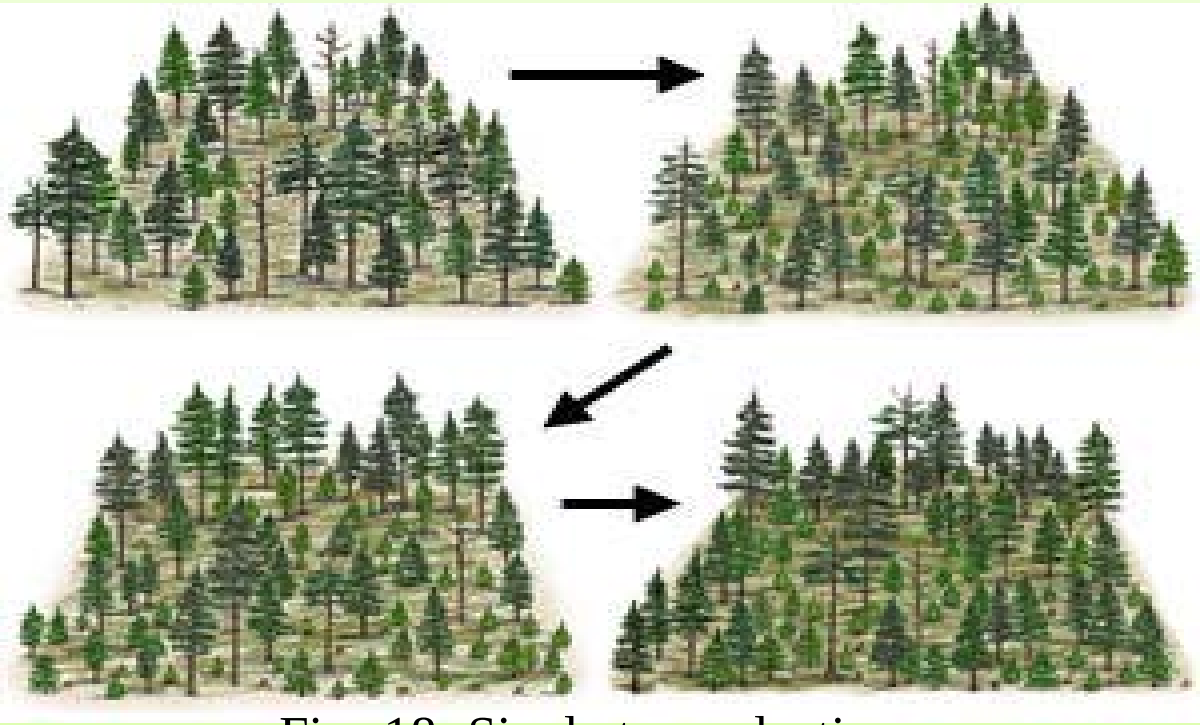
Disadvantages:

- ✓Considerable skill is required in carrying out marking and felling to ensure regeneration to come up in the gaps. This requires knowledge of silviculture of spps.
- ✓As mature trees to be removed are scattered, cost of logging and extraction is high.
- ✓Felling, logging and extraction causes damage to the young crop.
- ✓Seed is obtained from good as well as bad trees; there is genetic deterioration of future crop.
- ✓There is much damage to regeneration by grazing.

8.3.4 Selection system contd…

Selection system may be of following two types:

1. **Single tree selection system:** Single tree selection removes individual trees of all size classes more or less uniformly throughout the stand to maintain an uneven-aged stand.

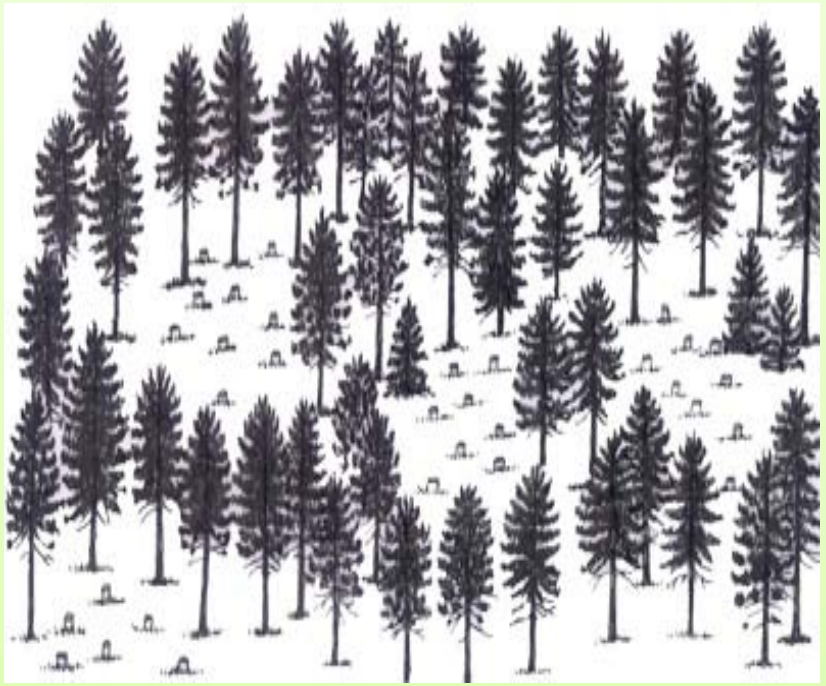


Figs.18 -Single tree selection

8.3.4 Selection system contd…

2. Group tree selection system

Group selection systems also promote uneven-aged stands with clumps of even-aged trees well distributed throughout the cutting unit.



Figs.19-Group tree selection system

8.3.5 Coppice System (Low Forest System)

The silvicultural system in which the crop is regenerated mainly from stool coppice and with short rotation is known to be coppice system. Reproduction is obtained from the shoots arising from the adventitious buds of the stump of felled trees. Coppice systems are further classified on the basis of pattern of felling and mode of regeneration as well

1. Simple coppice system

A silvicultural system based on stool coppice in which the old crop is clear felled completely with no reservation.

Figs.20-Simple coppice System

8.3.5 Coppice System contd…

Patter of felling in simple coppice system consists in clear felling a fixed area annually.

Area of coppice coupe = 1/n x total area. Where n is the number of years in rotation.

Season for coppicing:

✓The best season for coppicing is a little before the growth start in spring because at this time there is a large reserve food material in roots which is utilized by the coppice shoots.

✓During the dormancy period. (from Nov. – Feb./March)

Method of felling:

✓The stump should neither be too low nor too high.

✓The lower the stump, the better it is for coppice shoot.

✓But if the trees are cut very low there is a danger of the stump splitting and or drying up from top.

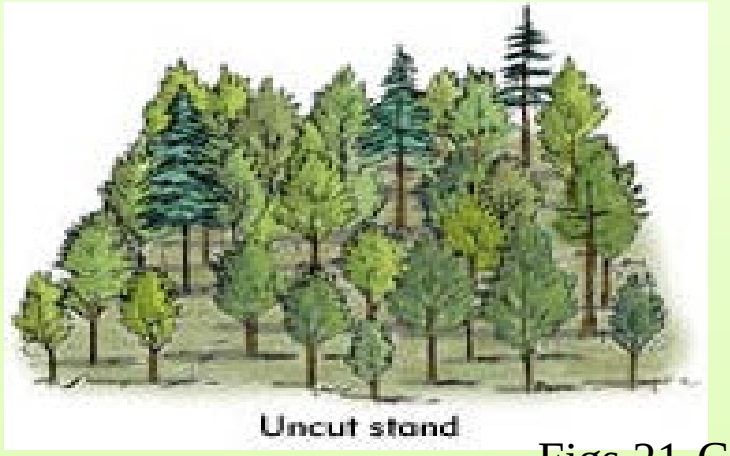
✓On the other hand, the higher the stumps, the greater the possibility of shoots being damaged by wind or animals.

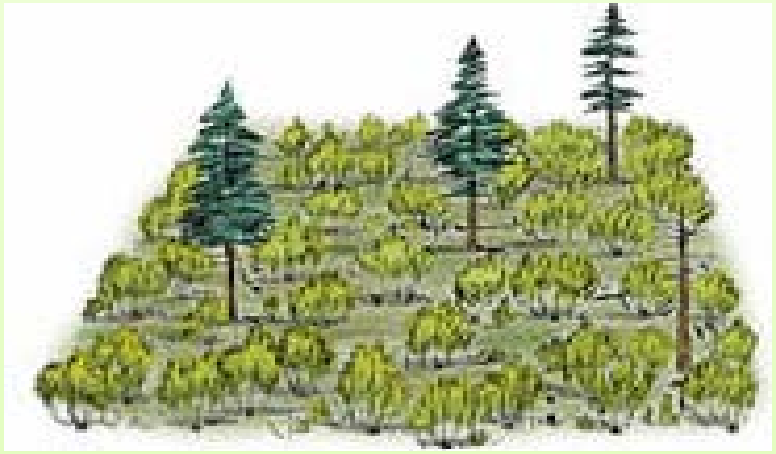
✓Stumps are usually kept, 15-25 cm high. (10 cm for eucalyptus)

8.3.5 Coppice System contd…

2. Coppice with standard system

It is silvicultural system based on stool coppice in which over wood of standards, usually of seedling origin and composed of trees of various ages, is kept over coppice for a period of multiple coppice rotation. It is usually applied in shade- tolerant species.





Figs.21-Coppice with standard

Purpose of standards: (i) To supply large size timber (ii) To protection against frost (iii) To enrichment of coppice (iv) To provide seedling regeneration (v) To increase in revenue

8.3.5 Coppice System contd…

Advantages:

- ✓There is greater protection to the soil.
- ✓Advantage of heavy shelterwood felling and selection system.
- ✓Standards serve as seed bearers and provide seed.
- ✓The investment is small and the net return is higher.
- ✓Aesthetically superior than simple coppice.

Disadvantages:

- ✓It requires great skill in maintaining correct balance between standards and coppice and between standards of different age classes.
- ✓This is a combination of simple coppice system and high forest system with the advantage of none.
- ✓It has an exhaustive effect on soil.
- ✓Felling and extraction cost is higher than high forest

8.3.5 Coppice System contd…

3. Coppice with Reserve system

A silvicultural system in which felling is done only in suitable areas likely to benefit, after reserving all financially immature growth of principal as well as other valuable miscellaneous species, either singly or in optimally spaced groups, trees yielding products of economic importance and protective reasons, first introduced in 1934-35.

Figs. 22-Reservation by area

Pattern of felling:

In this system, the emphasis is not on felling but on conservation. Distinguish areas which, require protection or some improvement felling and areas in which felling can be done according to the requirement of crop, local people, and site. Then felling may be from clear felling to practically no felling by reserving all trees, which may depend on areas or trees.

8.3.5 Coppice System contd…

Tending:

Tending should be done-clearing, climber cutting, and reduction of coppice shoots. Recently rotation has been discarded and suggested to work the forests on felling cycle of 10-15 years.

Character of the crop

The resultant crop under this system comprises of irregular groups of even aged coppice with uneven aged reserve crop scattered irregularly. Thus, taking the crop as whole, it is uneven aged.

Advantages:

- ✓It helps in improving the quality of locality as a result of soil and moisture conservation, maintenance of crop mixture.
- ✓It helps in improving the condition and composition of crop.
- ✓It fulfills the needs of local population and the requirement of industries.
- ✓It avoids the sacrifice of financially immature crop whose value increases. Thus it offers best financial returns per unit area.

Disadvantages:

- ✓Its execution requires a high degree of skill.
- ✓Reservation of a large number of trees affects coppice growth adversely

8.3.5 Coppice System contd…

Conditions of applicability:

- ✓When the crop varies greatly in density, composition, and quality and proportion of valuable species is low.
- ✓When most of the species are good coppicers and the coppicing power of most valuable species is vigorous.
- ✓When valuable species in the crop is light demanders.

Coppice with reserves system is not suitable:

- ✓When valuable species are shade bears and frost tenders.
- ✓When there is likelihood of invasion of fast growing obnoxious weeds, shrubs, and grasses such as *Lantana*, and *Imperata*.
- ✓When the crop does not contain valuable species and there is no hope to improving it by coppicing.
- ✓When it is not possible to protect the area against fire and grazing at least for five years after main felling.

8.3.5 Coppice System contd…

4. Coppice of Two Rotations System

A coppice system based on stool coppice in which after the initial coppicing of the crop at the beginning of the first rotation, part of the crop is not coppiced to produce large sized timber. The number of trees so reserved from being coppiced again in the second rotation, depends on the quantity of large sized timber required in the market.

5. Shelterwood Coppice System

A coppice system in which even in the initial coppicing, shelter wood (of almost 125 to 150 trees per ha) is retained for frost protection.

It is specially suited to frost tender species in frosty localities and forest hardy species, promising are selected, which are removed gradually when the coppice shoots are fully established and are free from frost danger. When coppice shoots are 5 years old, the shelter trees are to be reduced to 63 to 75 and after 10 years , all the shelter trees are removed. The resultant crop is even aged.

8.3.5 Coppice System contd…

6. Coppice Selection System

A coppice system in which fellings are carried out on the principles of selection system, but regeneration is obtained by coppice. The resultant crop is uneven aged can be suitably applied in *Acacia* species and also applied for the management of small area of poor quality *shorea* forest. In this system, the forest is divided into a number of annual coupes equal to number to the years in felling cycle. Only those trees which have attained the exploitable diameter fixed quite low are removed in main felling.

7. The Pollard System

Pollard is defined as a tree whose stem are cut off in order to obtain a flush of shoots, usually above the height to which the browsing animals can reach. This system is suitable when demand of fuelwood and fodder is high. For example, *salix, Hardwickia binata*, etc species are suited for pollarding, which have high coppicing power.

Accessory System

Accessory systems refer to those high forest systems which originate from even-aged systems by modification of technique, resulting in an irregular or two storeyed high forest.

Kinds: 1. Two-storeyed High Forest System

2. High Forest with Reserves System

3. Improvement Felling System

1. Two-storeyed High Forest System

A system which results in the formation of a two-storeyed forest having two strata in the canopy, but each of different species. For instance, deodar in the top canopy and Quercus in the lower storey, etc. sometimes, it is obtained by under-planting with the following objects:

(i) For soil protection (ii) For increasing the no. of valuable species

(iii) For propagation of species which can not be raised in the open

Accessory System Contd…

2. High Forest with Reserves System

An accessory silvicultural system in which selected trees of the crop being regenerated are retained for part or whole of the second rotation in order to produce large sized timbers.

The recent trends of reserving some trees of the old crop in the clear-felling system is an example of this system

In uniform system some trees are retained at the time of final felling for light increment.

3. Improvement Felling System

Actually, improvement felling is not a silvicultural system as it neither aims at regenerating crop, not producing a crop of distinctive characteristics. Large areas of degraded and poor forests are likely to remain under improvement fellings toprepare them for eventual management aiming at bringing the forests to the normal state. It is only treated as an accessory system suggested by Trevor.

Accessory System Contd…

Improvement felling is defined as a method of treatment involving essentially the removal of inferior growing stock in the interest of better growth of the more valuable individuals. It is usually applied to mixed uneven-aged forests. The following operations are usually done in this fellings:

(i) Dead, dying (>75% parts) and diseased trees

(ii) Saleable unsound over-mature trees

(iii) Unsound or badly shaped mature or immature trees

(iv) Thinning of congested groups of poles and trees

(v) Cutting back of badly –shaped and damaged saplings and advance growth

(vi) Removal of undesirable undergrowth or trees of inferior species

(vii) Climber cutting

Considerations for Silviculture Systems

A good silvicultural system is a long-term program of treatment designed to fit a specific set of circumstances (Smith, 1962). In fact, there is no cookbook for the application of silvicultural systems. A silvicultural system evolves over time as circumstance change and knowledge of them improves. Formulation of a silvicultural system should start with the analysis of the natural and socioeconomic factors of the situation.

A rational silvicultural system for a particular stand should fit logically into the overall management plan for the forest of which the stand is a part and represent the best possible amalgam of attempts to satisfy all the following major considerations:

1. Harmony with goals and characteristics of ownership
2. Provision for regeneration
3. Efficient use of growing space and site productivity
4. Control of damaging agencies
5. Provision for sustained yield
6. Optimum use of capital and growing stock
7. Concentration and efficient arrangements of operations
8. Resolution of conflicting objectives

CONVERSIONS

Conversion is defined as a change from one silvicultural system or one (set of) species to another. Thus, the concept of conversion involves a change in crop composition and/or silvicultural system by which the crops are regenerated and replaced by the new crops of distinctive form.

Change in crop composition

It is often necessitated from any of the following reasons.

1. Increasing yield from forest: Pine plantation in hills, Eucalyptus plantation in Sagarnath , Sissoo plantation in Kohalpur and in others in degraded Sal forest enrichment planting.

2. To meet the demand of industries: *Populus, Eucalyptus, Acacia, Bombax*, Teak, etc.

CONVERSIONS Contd….

B. Change in the Silvicultural System:

Change from one silvicultural system to another is mainly for changing the characters of the crop and/or for changing the method of obtaining regeneration. Silvicultural systems are changed for the following reasons:

1. Advantage of a Particular System

Selection or selection cum improvement felling replaced by Uniform System. C.W.S. or Selection System replaced by C.W.R.

2. Failure of an Existing System

In case of Fir and Spruce, uniform system was changed to Selection System or Clear felling with reservation followed by artificial regeneration. In case of Teak uniform system was changed to Clear felling followed by natural or artificial regeneration.

3. Advances in Silvicultural knowledge and perfection of regeneration techniques

4. Development of communication and increase in market demand

Techniques of Conversion

When a change in silvicultural system is desired, the entire area is not subjected to conversion at a time. Only a part of the forest is taken up under new system and rest is worked under old system where new areas are taken for conversion after completing conversion in the areas taken previously.

Pace or speed of conversion:

The conversion period means the period in which conversion is to be done. The conversion period is very important consideration. When the conversion period is short the conversion proceeds with a fast speed on the other hand if conversion period is long, the conversion is slow.

The following considerations affect the decision about the length of conversion period:

1.Sacrifice of immature crop (sacrifice is greater when conversion period short

2. Proportion of the over mature growing stock with negative increment. Larger the proportion of over mature trees, the conversion period should be short

Lesser ,, ,, ,, ,, ,, long.

Techniques of Conversion contd…

3. Hiatus between the age of first converted crop and the exploitable age at the end of conversion period

The decision on the length of conversion period should also take into account the age of first converted crop at the end of conversion period and compare it with exploitable age.

If the age of first converted crop is less than the exploitable age, there will be a hiatus at the end of conversion felling till the start of felling under the new system (uniform system).

Thus, the shorter the conversion period, the greater the hiatus. To overcome this difficulty, following two alternatives can be adopted.

1. The conversion period should be so fixed that the first converted crop is mature at the end of conversion period.

2. Part of the young immature crops should be retained as part of the future crops. These increase the mean age of converted crops and make them fit for exploitation earlier.

Glimpse on major Silvicultural Systems Applied in Terai Forests of Nepal

Nepalese forests are not being managed scientifically. There is no prescribed silvicultural system in Nepal. The first attempt to introduce scientific forest management in Terai, Nepal was made by Mr. E.A. Smithies, who came to Nepal as forest advisor in 1942. A forest working scheme for the Terai forests was prepared. This working scheme introduced selection-cum-improvement system of felling the Sal *Shorea robusta*, Sissoo *Dalbergia sissoo* and other mixed hardwood. Since then several attempts were made to introduce scientific forest management.

Unfortunately, scientific system of forest management has not yet been practiced, although, many forest management plans have been prepared. Sagarnath Forest Development Project initiated the conversion of Sal forest to plantation forest by clear felling in 1979/1980 (White, 1988). Thereafter, simple coppice and coppice with standard system are applied in the area. Another attempt has been made to introduce scientific forest management by UNDP/FAO at Rautahat in 1995 and at a few districts or locations by FINNIDA.

Glimpse on major Silvicultural Systems Applied in Terai Forests contd…

1. Selection System: Forest Division and Timber Corporation Nepal (TCN) implemented this system in Sal forest in Morang, Birganj and Kailali forest divisions in 2022/2023. Community Forest User Groups has been practiced the selective logging in their community forest since many years. But they and other sociologists think as the selection system.

2. Clear Felling system: Forest Management and Utilization Development Project (FMUDP)/ HMG did a trial of clear felling with advance regeneration of Sal forest in Manahari, Makawanpur district, Bara and Rautahat district (HMG/ FINNIDA, 1995). Sagarnath Forest Development Project (SEDP), Ratuwa Mai Plantation Project and Nepalgang Plantation Project converted the high Sal forest to plantation forest by clear felling (White, 1988). Actually it is not a clear felling system but it is a conversion.

3. Coppice with standard: It was also applied by FMUDP/HMGN in Makawanpur, Bara and Rautahat district leaving the 25 and 75 trees/ha as standard in different plots.

Glimpse on major Silvicultural Systems Applied in Terai Forests contd…

4. Simple Coppice system

Sagarnath Forest Development Project has applied this system in Eucalyptus species to produce fuel wood and electric poles as well. This system is suited in this locality and for this species also.

Forest Research Division (FRD) of the Department of Forest Research and Survey (DFRS) established the research plots for Terai Sal forest in Jogikuti of Butwal of Rupandehi district in 1998, Chukibari, Dharan of Sunsari district and Ratomate, Hetauda of Makawanpur district in 1989 respectively(FRD, 1991).