Natural Regeneration

Natural regeneration is defined as the renewal of a forest crop by self-sown seed or by coppice or root suckers.
It also refers to the crop so obtained.
The natural regeneration can be obtained from the following two source.
1.Natural Regeneration from Seed
2.Natural regeneration from vegetative parts(Coppice)

Natural Regeneration from Seed:

Natural regeneration from seed depends on the following
Seed Production
Seed Dispersal.
Seed Germination
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

1.Species:
All species do not produce seed annually and abundantly.

Some species like Teak, Acacia, and Sissoo etc. Produce seed annually.

While Deodar, Fir and Spruce etc. seed at an interval of years.

The quantity of seed produced by annual seeders varies. This variation in seed production is the seeding periodicity

Depending on the amount of seed produced, seed years are described as Good, Moderate, or poor

Moderate and Good seed years of some important species is mentioned as

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follows.

Species	**Moderate Seed years**	**Good Seed years**
Shorea robusta	2	3-5
Terminalia tomentosa	2	3-4
Pinus wallichiana	2	2-3
P. Roxburghi	3	4-5
Cupressus torolosa	3	7-8
Cedrus deodara	3	4-5
Picea smithiana	3	5-6
Abies pindrow	6	10

2. Age of Trees:

The age of trees also affects the production of adequate amount of fertile seeds

The seed produced by immature and over mature trees are sometimes infertile

Abundant amount of fertile seeds are produced from middle aged trees. Abundant amount of fertile seeds is produced by the trees when height growth is culminated and during this period carbohydrate produced is translocated to seed formation.

3. Size of Crown:

The size of the crown of trees also affect seed production

As a general rule, the bigger the crown, the larger the seed production

4. Climate:

Climate also affects the seed production. As a general rule warmer climate favors larger seed production

Hot dry airs are generally followed by heavy seed years on account of increase in Photosynthesis

Heavy rainstorms at the time of pollen dissemination reduce chances of pollination and good seed production

Late frost adversely affects seed production.

5. Other external factors:

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Injury by fire and insect attack reduces seed production by damaging the crown

If the damages are only concentrated on barks then it stimulates seed production by transporting carbohydrate to the seeds and not to the roots

Girdling also favors heavy seeding due to same reason.

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: All conifers and several dicots (Acer, Betula, Populus, Alnus , Salix Terminalia, Dalbrgia, Acacia , Adina and Bombax.

Water: Mangrove , Dalbergia, and Teak.

Bird: Prunus, Mulberry, and Diospyrus

Animals: Acaica arabica, Prosopssis juliflora, Zizyphus, and Anthocephallus.

Gravity: Oak, Juglans, and Asculus.

C. Seed Germination:
After dispersal insect 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 O2
Development of embryo (ie.Frixinus floribunda takes one year)
After ripening (ie.Juniperus macropoda)
Viability of Seeds
Size of seeds
Germination capacity
Germination energy

External factors:
Moisture

Air
Temperature
Light (ie. Cassia fistula or Albizzia procera requires light)
Seed Bed

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 them.

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 root
2.Soil condition
3.Moisture
4.Aeration
5.Nutrients
6.Light
7.Temp.(Frost, Drought)
8.Rainfall.
9.Drip (Slash erosion)
10.Condition of grasses and other competing weeds
11.Grazing, Browsing and Fire
12.Composition of the crop

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Silvicultural Systems

Silvicultural system may be defined as a method of silvicultural procedure by which forests are harvested, regenerated and tended.

It is a planed silvicultural treatment, which is applied to a forest crop throughout its life to get a distinctive form.

It begins with regeneration felling and includes adoption of some suitable method of regeneration and tending of the new crop throughout of its life.

Thus, it is just a technique perfected on the basis of knowledge of silviculture, but its application is governed by the requirements of forest management or to achieve the objectives of forest management.

The pattern of felling to be adopted in harvesting a mature crop to be regenerated:

It includes felling of a single tree to clear felling

The pattern of felling depends on:

1.Silvicultural requirement of the species to be regenerated.

2.Intensity of demand of forest products

3.Development of communication and other local conditions

The pattern of felling affects the form or character of the new crop. i.e. even aged and uneven aged. These form the basis of classification of silvicultural system.

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Classification of Silvicultural Systems

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:
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.

B. Coppice system:
Those silvicultural systems in which the crop originates mainly from coppice and the rotation is short.

The high forest systems and coppice 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.

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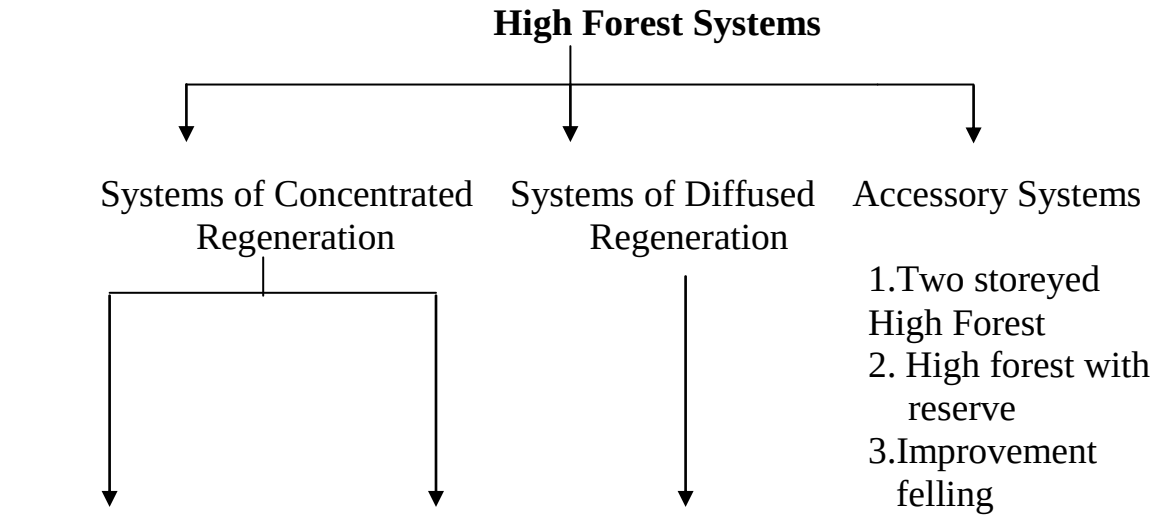

Clearfelling Systems	Shelterwood Systems	Selection System
1. Clearfelling System.	1. Uniform system	1. Single Tree Selection
2. The Clear Strip System	2. Group ,,	2. Group Selection
3. The Alternate Strip System.	3. Strip ,,	
	4. Irregular ,,	
	5. Indian Irregular System	

Coppice System (Low Forest System)

a. Simple Coppice System.
b. The Coppice of Two Rotation System.
c. The Shelterwood Coppice System.
d. The Coppice with Standards System.
e. The Coppice with Reserves System.
f. The Coppice Selection System.
g. The Pollarding

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MAJOR SILVICULTURAL SYSTEMS

A.High Forest Systems:

1. The clear felling system:

The clear felling system is defined as a silvicultural system in which equal or equi-productive areas of mature crop are successively clear-felled in one operation to be regenerated most frequently, artificially but sometimes naturally also.

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.

1. Retention of some mature trees as frost protection measures or as an insurance against failure or as nurse crop to facilitate establishment of forest tender species.
2. Retention of promising groups of saplings and poles to prevent unnecessary sacrifice of immature crop of the desired species.
3. Isolated saplings and poles are ordinarily not retained as they may develop in to wolf trees.

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:

*Departmental plantation
*Taungia
Departmental Taungia
Leased Taungia
Village Taungia

Method of Natural Regeneration:

*Natural regeneration from seed
*Seeds stored in the area
*Seeds received from outside
*Natural regeneration from advanced growth

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Variations in Clear-felling System:

* The clear strip system
* The alternate strip systems
*Clearfelling in patches
*Clearfelling with advanced regeneration
*Clear-felling with retention of sheltered

Advantages:

1. It is simplest of all high forest system. It does not require a high degree of skill.
2. As felling is concentrated, the yield per unit area is more and consequently the cost of felling and extraction is low.
3. Introducing fast growing exotics and regulating composition of new crop through artificial regeneration is advantageous.
4. It makes the supervision of all operations easy.
5. There is no damage to new crop by felling.
6. If properly tended the even aged crop produced have trees with cleaner and more cylindrical boles.
7. Entire crop is regenerated in one operation. Its establishment is quicker there by reducing the cost and rotation.
8. As the regeneration establishes early, the coupe can be opened up for grazing soon.
9. The distribution of age class is very regular.
10. The success or failure of regeneration is clear by the end of first year or in few years.

Disadvantages:

1. It is the most artificial system.
2. Soil remain open there is more danger of soil deterioration and erosion
3. The danger of weeds and grass invasion increases.
4. It produces even aged crop, which is less resistant to damage by wind.
5. when the crop is pure it becomes more susceptible to damage by Insects, plant parasites and pathogens.
6. It sacrifices all immature crops that may still be putting on valuable increment.
7. Growing space and site factors are not fully utilized.
8. Annual yield is less than uneven aged crops.
9. This system is not suitable on hilly area and slopes.
10. The system is aesthetically very bad.

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Seed Tree Method

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 may be 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.

On the basis of arrangements of seed trees the seed tree methods may be:
Single Tree Method.
Group Tree Method
Strips or Rows Method

Characteristic of Seed Trees.
1. Wind firmness: Trees with tapering boles are more resistant to wind.

2. Seed producing ability: The best trees are members of Dominant crown class having wide deep crowns and relatively large live crown ratio.

3. Age: Seed tree must be old enough to produce abundant fertile seeds, The age at which seed bearing begins in closed stand is the safest criteria.

Number and Distribution of Seed Trees: It depends on following factors

*Amount of seed produced/tree

*The no. of seed required

*Seed Dissemination

*Number of viable seed produced (depend on pollination. There will be low no of viable seed in isolated trees

*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.

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Shelterwood Systems

Shelterwood system is a silvicultural systems in which the over wood is removed gradually in two or more successive felling depending on the progress of regeneration.

In other words, the shelter wood system involves gradual removal of the entire stand in two or more successive felling extending over a part of the rotation.

The trees, which are no longer capable of increment in value, are removed to make room for regeneration to come in

The trees, which are growing vigorously, are retained to provide
(a) Shelter
(b) Seed
(c) Rapid diameter increment and value increment
(d) Protection of site against deterioration.

Kinds of Shelterwood system:
The varying patterns of regeneration felling and their distribution in space and time, results in a variety of shelterwood systems.

1.Uniform shelterwood system:
Regeneration felling is done by making uniform opening

2.Group shelterwood system:
Regeneration felling is done in scattered groups

3.The shelterwood strip system:
Regeneration felling is done in strips

4. Irregular Shelterwood System:
Opening is made irregularly.
Uneven aged crop is produced
There is a compromise between shelterwood group system & selection system

5.Indian irregular shelterwood system:
Uneven aged crop is produced and immature trees are retained as future crop
It is a compromise between Uniform System and Selection System.

6.One cut sheltered:
Removal of over wood in one operation if sufficient advance growth is present

1.Uniform Shelterwood System (Uniform System)

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The canopy is uniformly opened up over the whole are of a compartment to obtain uniform regeneration. It is also called as shelterwood compartment system or compartment system.

Pattern of felling:

Preparatory felling:

It is a felling made under a high forest system 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.

Seeding felling:

It is defined as opening the canopy of a mature stand to provide conditions securing regeneration from the seed of trees retained

This is the first stage of regeneration felling and the object is to make opening in the canopy all over the compartment so that favorable conditions are created for regeneration. There are two important considerations

1.Selection of trees to be retained:

*Genetically superior trees.

*The number of trees varies according to the silvicultural requirement of species.

*The shade bearing sp. and those with heavy seed-retain more seed trees (small opening)

*The light demanding sp. and those with light seed-retain less seed trees (large opening)

*For the same sp. opening is lighter in the drier areas than in moist areas.

*Seeding felling is done with caution if there is danger of invasion of grasses and weeds.

*Large no. of seed bearers on southern aspect and less no. of seed bearers on northern aspect for the same species.

2.The number of seed bearers:

*The number of seed bearers to be retained depends on:

*Seed requirement of the area.

*Amount of light to be admitted (shelter)

*Moisture condition

*Condition of weed growth

*Altitude and aspect.

Examples:

Species	**No. of seed bearers**	**Approx. Distance between trees**
Pinus roxburghii	12-18 on cooler aspect	24-30m.
	20-25 on warmer aspect	20-22m.
Pinus wallichiana	25-30	18-20m.
Cedrus deodara (Deodar)	45-50	14-15m.
Picea smithiana (Spruces)	45-50	14-15m.
Abies pindrow (Fir)	75-87	11-12m

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Secondary felling:
It is defined as a regeneration felling carried out between seeding felling and final felling in order gradually to 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.

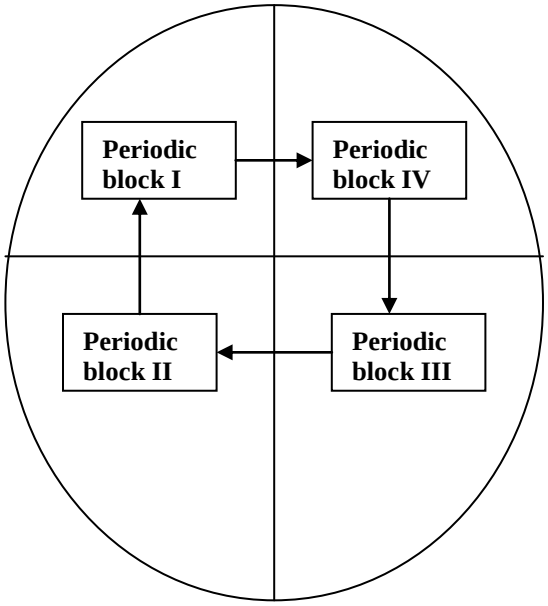
Final felling:
It is defined as the removal of the last shelter or seed trees after regeneration has been affected. It is the final stage in regeneration felling when the are is completely stocked with established regeneration which do not require shelter.

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	



Each area moves from one periodic block to other

Fig: Sequence of Movement of Forest in Various Periodic Blocks

Length of Regeneration Period: It Depends on:

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1. Frequency of seed years
2. Light requirement.
3. Other climate factors
4. Soil condition
5. Condition of grass and competing weed growth
6. Incidence of grazing, browsing, and fire

Allotment of areas to Periodic Block

(1) Permanent (Regeneration period is fixed)

$$\text{Area of Periodic Block} = \frac{\text{FS x P (Number of years in the period)}}{\text{R (Rotation)}}$$

$$= \frac{1000 \times 30}{120} = 250 \text{ ha.}$$

(a) Self contained

(b) Scattered (is adapted in India)

(1) Floating (Regeneration Period is not fixed)
(Simple Periodic Block)

$$= \frac{\text{FS x estimated regeneration period}}{\text{Rotation}}$$

$$= \frac{\text{Area of the felling series}}{\text{No. of periodic block}}$$

$$= 1000/4 \text{ or } 1000/5$$

Using the example of 4 PBs, silvicultural operations to be carried out in various periodic blocks will be as follows:

No. of PB	PB_I	PB_{II}	PB_{III}	PB_{IV}
Age of crops (years in the beginning of period	91-120	61-90	31-60	1-30
Silvicultural operation	Regeneration felling	Thinning if necessary preparatory felling if prescribed	Thinning	Cleaning, thinning

Numbering of Periodic Block
I,II,III,IV

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Advantages:

1. Marking and felling of trees of the over wood are simpler than in other shelterwood systems as well as selection system.
2. In this system the soil is not completely denuded so there is little risk of soil deterioration and erosion.
3. 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.
4. The young crop is protected against adverse climatic factors such as cold, frost, winds, drought etc.
5. As the regeneration is obtained from seeds obtained from best selected trees, the new crop is superior.
6. It is a suitable system for the regeneration of both light demander and shade bearer species. In mixed forest it is suitable to regenerate a mixture of different species by regulating of light reaching on forest floor.
7. As the new crop appears before the old one is harvested, the average length of rotation is shortened.
8. The growing space is more fully utilized as the regeneration grows under the shelter of older trees.
9. It makes supervision and control of various operations easy.
10. From aesthetic point of view the system is superior to clear felling system.

Disadvantages:

1. As the over wood is removed in more than one operation there is much damage to the young crop.
2. In mixed forest with species having different light requirement, the manipulation of canopy requires skill and knowledge of silvicultural requirement of species composing the mixture.
3. The isolated seed bearers are susceptible to wind damage.
4. In the species having long intervals between seed years, after seeding felling there may be invasion by weeds and regeneration may be affected.
5. In species with longer regeneration period, weeding and cleaning has to be done for longer period and the natural regeneration becomes costly.

The Group System:

Regeneration felling is carried out in scattered groups either because of presence of advance growth or to induce regeneration de-nova so that there foci of regeneration can be enlarged centrifugally to merge with each other ultimately. Nova

Advantage:

1. The young crop develops in more natural way.
2. Adjoining trees protects the young regeneration.
3. Little danger of the seed bearers being uprooted by windstorm.
4. Less damage of young crop by regulating the fall of trees in unfelled areas.

Disadvantages:

1. Existing advanced growth has to be located which is difficult in hills.

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2. Marking of seeding felling is difficult around group of advanced growth in hilly terrain.
3. The weeding and cleaning is difficult and costly.
4. As the work gets diffused its supervision and control becomes difficult.
5. Over extensive area, intensive working is not possible.
6. Requires individual attention of a single officer for about 30 years, which is not possible.

Shelterwood strip system:

Regeneration felling are 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, and may vary from 20 m to 30 or even more.

Advantage:

(1) It provides protection from wind.

Disadvantage:

(1) Laying out of strips, execution of felling, logging, transport of material, tending, protection against grazing and fire is difficult and not applied in India.

The Irregular Shelterwood 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 shelterwood group system and selection system.

Indian Irregular Sheltered System:

Silvicultural System is which the crop to be regenerated is open up irregularly and the resultant crop is uneven aged, a compromise between uniform system and selection system.

1. It provides for retention of groups of well-grown poles and immature trees (upto 40 cm. diameter) as the future crop.
2. It permits the adoption of selection felling on steep and rugged portion of compartment being worked under uniform system.

The Selection System

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The selection system is defined as 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. The selection system may be of following two types.

*Single tree selection
*Group selection

Felling of trees allover 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, the area to be worked under selection system is divided in to coups and felling is confined to one coup every year.
Ideal selection system
Periodic selection system

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.

Selection forest or all aged forest:

1. The felling and regeneration are distributed over the whole area.
2. Uneven aged - All aged.
3. Regeneration operations are carried out throughout the life of crop.

Conduct of felling: following categories of trees are generally removed.

(1) Dead, dying, diseased, misshapen or otherwise defective trees interfering with the growth of better trees.
(2) Trees of undesirable species
(3) Immature trees, which can be removed in judicious thinning carried out in different age classes.
(4) Mature tree of and above the exploitable diameter which will leave gaps for regeneration to come in
(5) Maintain proper proportion of diameter classes – **Maintain reveres 'J 'shaped curve.**

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Consideration for Application:

(1) Topography
(2) Catchment Areas
(3) Communication
(4) Market Requirement
(5) Silvicultural Considerations

Advantages:

(1) 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.
(2) By maintaining continuous leaf cover, the selection systems conserves soil and moisture to the fullest extent possible.
(3) The selection forest produced is most resistant to injuries by insect pests and adverse climate factors.
(4) It prevents invasion of grass and weeds.
(5) natural regeneration comes up without difficulty due to abundance of seed bearers, use of every seed year and the protection afforded to seedlings.
(6) The forest regenerate itself continuously, without any time limit.
(7) As the lower age class trees grow below the older trees, the selection system results in producing more growing stock in large size trees per unit area than the uniform system.
(8) This is best system of producing large size trees.
(9) It produces a forest which is superior biologically (Bio-diversity) as well as in its aesthetic and scenic value.

Disadvantages:

(1) 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 species.
(2) As the mature trees to be removed are scattered, cost of logging and extraction is high.
(3) Felling, logging and extraction causes damage to the young crop.
(4) Seed is obtained from good as well as bad trees, there is genetic deterioration of future crop.
(5) There is much damage to regeneration by grazing.
(6) As the area is extensive, strict fire protection is difficult. Thus accidental fires result in damaging the new crop.
(7) Success or failure of regeneration is difficult to assess.
(8) In a mixed crop with lower % of valuable species, when valuable sp. are removed there vacancies are filled up by less valuable species.
(9) Maintaining proper proportion of each diameter classes is very difficult and there will be Misconception of Reverse J shaped curve.
(10) It is difficult to know exact growing stock, normal distribution of tree sp. and DBH.
(11) Heavy felling.

Accessory systems

Accessory systems are those high forest systems, which originate from other even aged systems by modification of techniques, resulting in an irregular or two-storeyed high forest. The following accessory systems are commonly met with.

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i. Two storeyed high forest system
ii High forest with reserves system
iii Improvement felling

Two storeyed high forest system:

It is silvicultural system in which results in the formation of a two storeyed forest in which the canopy can be differentiated in to two strata, in each of which the dominant species is usually different. The crop in each storey is approximately even-aged, and is of seedling origin. The lower story may be obtained by natural regeneration by seed brought from outside, but usually by under-planting, which is done for one of the following objects.

or usually by enrichment planting for one of the following object.

For protection of soil
For increasing the proportion of valuable sp. (Enrichment planting)
For propagation of species, which can not be raised in the open.

Advantage:

Two storeyed high forests may be adopted for any of the following reasons.

1. To protect soil with the lower storey when the upper storey is incapable of doing so.
2. To increase production by growing two crops on the same land.
3. To propagate shade bearing sp. or frost tender sp.
4. To change the species gradually.
5. To provide for a vertical mixture in sp. composition.
6. To obtain early return.

Disadvantage

1. Under-planting is a difficult operations and unless done carefully , it is likely to fail
2. The under storey crop may affect the growth of upper storey crop.
3. The under-storey is likely to be damaged during thinning or felling in the upper storey crop.

Application

- Chirpine and Sal forest, where Sal grows under Chirpine
- Deodar grows under pure crop of Chirpine
- Oaks growing under Deodar and Chirpine crops.
- Introducing teak in Sal areas
- Introducing Sissoo in Sal areas
- Planting Mulberry under Sissoo

High Forest with reserves system:

In this system selected trees of the crop being regenerated are retained for part or whole of the second rotation, in order to produce large size timber i.e.

- clear felling system with reservation
- reservation of some trees during final felling in uniform sheltered system.

Improvement felling(TSI):

It is not a silvicultural system as it neither aims at regenerating the crop, nor producing a crop of distinctive characteristics. It is defined as the removal of inferior growing stock in the interest of better growth of more valuable individuals. It is usually applied to mixed uneven-aged forest. The following operations are usually done in improvement felling. s

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1. Felling of dead, dying, and diseased ($3D_s$) trees.
2. Felling of saleable unsound over mature trees which are not likely to survive up to the nest felling, provided these are not required for protection.
3. Felling of unsaleable over mature trees, if their removal benefits the other trees or regeneration.
4. Feelings of unsound or badly shaped mature or immature trees, if it benefit other trees. But it should not be a revenue filling.
5. Thinning of congested groups of trees and poles likely to benefit from the operation.
6. Removal of badly shaped and damaged saplings and advance growth expected to give better coppice shoot
7. Removal of undesirable undergrowth or trees of inferior species. Which are preventing or likely to prevent development of regeneration of the desired species.
8. Climber cutting

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Coppice Systems

The silvicultural system in which the crop is regenerated mainly from stool coppice and with short rotation. Reproduction is obtained from the shoots arising from the adventitious buds of the stump of felled trees.

Types of coppice system:

On the basis of pattern of felling the coppice system is of various types.

1. Simple coppice system.
2. The coppice of two rotation system.
3. The shelterwood coppice system.
4. The coppice with standard system.
5. The coppice with Reserve System.
6. Coppice Selection System.
7. Pollarding

Factors affecting natural regeneration by coppice:

1. Species- coppicing power.
2. Age of tree-pole and young trees.
3. Season of coppicing-before spring.
4. Height of stump-15-25 cm.
5. Rotation-short.
6. Silvicultural system-clear-felling.

Simple coppice system:

The simple coppice system is defined as a silvicultural system based on stool coppice in which the old crop is clear felled completely with no reservation.

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:

1. 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.
2. During the dormancy period. (from Nov. – Feb./March)

Method of felling:

1. the stump should neither be too low/high.
2. The lower the stump, the better it is for coppice shoot.
3. but if the trees are cut very low there is a danger of the stump splitting and or drying up from top.
4. On the other hand, the higher the stumps, the greater the possibility of shoots being damaged by wind or animals.
5. Stumps are usually kept, 15-25 cm high. (10 cm for eucalyptus)

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Precaution during felling:

1. Stump should not split during felling trees.
2. The bark did not get detach from the wood.
3. Stump should slope slightly in one direction.

Tending:

Cleaning is done to remove climbers and inferior sp. and to reduce the no. of shoots to two or three.

Thinning if necessary is carried out in fifth year and the no. of shoot is reduced to one/stool. This is called as singling out operation for pole or timber.

Advantage:

1. The system is very simple and does not require any skill in making.
2. The regeneration is more certain.
3. As coppice shoot grow faster in the beginning the cost of weeding, cleaning and protection is much less than in case of reproduction by seed.
4. The mean annual increment (MAI) of the coppice crop is much higher then that obtained under high forest.
5. The net returns on investment are relatively higher primarily due to short rotation and less investment.
6. Although it is shortsighted system but very suitable for producing fuelwood and small sized timber to fulfill the immediate need of the society.

Disadvantage:

1. The system tends to exhaust mineral substances in the soil.
2. This system is not permanent because the trees can not keep on coppicing indefinitely.
3. The coppice crop is liable to great damage by frost and wind.
4. This is not a very desirable system from aesthetic point of vies.
5. Risk of site deterioration (Soil erosion, weed invasion etc.)

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Coppice with standards system

It is silvicultural system based on 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 and as a permanent feature of the crop through out its life.

Purpose of standards:

1. Supply of large size timber
2. Protection against frost
3. Enrichment of coppice
4. To provide seedling regeneration
5. Increase in revenue

Thus, 1) Constitution of crop: lower storey (even aged coppice crop), upper storey (over wood of standards).
2) Rotation: two rotation- one for coppice and one for standard (multiple of coppice rotation).

Pattern of felling:

All trees except standards are clear felled and selection of standards depends on

1.Species:

The species of same or different sp. or a mixture of species.

2.Characteristics and quality of standards:

Standards should be as follow

1.most valuable species
2.long, clean bole with light foliage
3.capable of putting on increment and increasing in value
4.wind firm
5.light demanders

3.No. of standards:

Number of standards depend on following

1. Object of mgt.
2. Climatic factors (frost)
3. Silvicultural characteristics of species (light, frost etc.)
   - Standards should not occupy more than one third of the canopy (33%)
   - The space allotted to the standards is to be properly distributed amongst the various age classes.

4. Distribution of standards: Uniformly distributed over the whole area.

If .3% of canopy area is occupied by standards and there are three age class present than each age class will occupy 0.1% of canopy area. It means more no. of trees of lower age class.

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Advantages:

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

Disadvantage:

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

Conditions of Application of CWS:

1. Where there is demand of firewood, pole, and timber.
2. Where simple coppice is inhibited due to climatic factors and silvicultural characteristics of species.

C.W. S. Not suitable for:

1. If required no. of standards of desired species are not available.
2. Poles of valuable species have to be coppiced immaturely which can produce large timber if thinning is done.
3. It does not provide for retention of other trees for economic, silvicultural or protective consideration, howsoever important and necessary these may be.

Example:

Forest	**Coppice rotation**	**Standard rotation**
1. Sal	30 years	60 years
2. Jamun belt	20 or 30	40 or 60
3. Dry deciduous forest	30	90
4. Anogeissus pendula	40	80

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The coppice with Reserves 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 and first introduced in 1934-35. The tenth silvicultural conference held in 1961 recognized it as a definite silvicultural system and recommended its application to dry deciduous forest extensively.

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.

1. Reservation by Area:

a) Under stocked areas where felling is likely to retard the process of rehabilitation by nature.
b) Eroded areas or areas liable to erosion, strips of land along streams for soil conservation.
c) Area around springs, wells, camping sites and places of worship.
d) Areas having dense pole crop
e) High quality areas in which the crop is in its optimum condition. In such areas light improvement felling can be done if necessary.

2. Reservation by trees:

Reservation of individual trees up to a fixed girth class which is generally between 60-75 cm. with the following objectives:

1. Reservation of miscellaneous sp. for maintaining healthy mixture of species.
2. All advanced growth of valuable species up to 24 cm. gbh. is reserved.
3. Reservation for completing the stocking and supply of seed.

The rest of the crop is felled. The basic principle is the removal of all growth that has become financially mature unless its retention is required for protection of soil, maintenance of its fertility, for supply of seed, fruit or any other forest produce required by the local population, for supply of industrial timber and for meeting the requirement of Lac industry.

Mode of Regeneration:

Regeneration is generally obtained by coppice but advance growth and regeneration from seed also make substantial contribution to it.

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.

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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.

Advantage:

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

Disadvantage:

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

Conditions of applicability:

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

Coppice with reserves system is not suitable:

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

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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 crop 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 other in degraded Sal forest enrichment planting

2. To meet the demand of industry: Populus, Eucalyptus, Acacia, Bombax, Teak

B. Change in the Silvicultural System:

Change from one silvicultural system to other is mainly for changing the character of the crop and/or for changing the method of obtaining regeneration. Changes in silvicultural system is due to following:

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:

Uniform System to Sal in Haldwani failed and Indian irregular shelterwood system was adopted.
Uniform System to Deodar in Chakrata failed and Indian irregular shelterwood system was adopted.
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:

i. Conversion to Uniform:
By clear-felling followed by natural regeneration by seedling coppice as in Saranda (Bihar), South Raipur (M.P) for Sal, North Betul(M.P)for Teak
Taungia for Sal and Teak, in parts of UP, West Bengal, MP, Maharastra and Kerala.
ii. Indian Irregular Shelterwood System is usually applied in case of evergreens in Andaman and Arunachal Pardesh.

4. Development of communication and increase in market demand:

Selective felling or selection cum improvement changed to concentrated regeneration.

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

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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.

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 over come 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 crop should be retained as part of the future crop. These increases the mean age of converted crop and makes it fit for exploitation earlier.

Examples of Conversion:
Conversion to uniform by clear felling with natural regeneration and clear felling with artificial regeneration.

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Approx. Area = Area of Working circle x $\frac{\text{Working Plan Period}}{\text{Conversion Period}}$

PB1 allotted.
PBII unallotted.
PBIII converted or last PB.

1.Conversion to relatively less irregular crop by retaining young poles up to 20-30 cm. Diameter in clear felling.

2. Conversion from CWS to CWR (Dry deciduous forest of MP, 1935 larger scale). The area of working circle divided into three categories.

3. Conversion of coppice and CWS to high forest.
A.Conversion by natural regeneration (to retain the existing BL species)
i.Conversion of CWS to uniform broad-leafed high forest(by uniform).
ii.,, ,, ,, irregular ,, ,, ,,(by selection)
iii.,, ,, ,, coniferous high forest (in case of fir).

B.Conversion by artificial regeneration (To change sp. from BL- conifer)
i. Artificial conversion by clear felling.
ii. Artificial conversion under a sheltered (fir).
iii. Artificial conversion by groups(spruce).

FORMULATION OF SILVICULTURAL SYSTEMS

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A good silvicultural system is a long-term program of treatment designed to fit a specific set of circumstances

It is not likely to be something that has already been invented and can simply be selected from schematic description of silvicultural systems given in books

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

If silvicultural systems are not chosen readymade from a manual or book, it is logical to examine the various considerations that enter in to their construction and evolutionary development

In the first place, a rational silvicultural system for a particular stand should fit logically in to the over all management plan for the forest of which the stand is a part

Second, it should represent the best possible amalgam of attempts to satisfy all the following major considerations.

Considerations:

1.Hormony 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

1. Harmony with goals and characteristics of ownership:

Choice among all the alternatives of silvicultural treatments is greatly simplified by clarification of the objectives of ownership

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The objective of ownership clearly dictate the relative amounts of attention paid to management for timber, fuel wood, wildlife, forage, water and soil conservation, recreation, scenery or other benefits that forest may provide.

Analysis of the objectives of ownership will normally define the kind of vegetation to be maintained, the kind of trees that are to be grown, and the amount of time, money, and care that can be devoted to the process.

2. Provision for regeneration:

Only that system should be adapted which suits silvicultural requirement of the principal species to be regenerated.

The most important factors, which should be considered, are light requirement, seeding, and the ease of regeneration.

Considering the silvicultural requirement of the principal species and the owner's objective of management any one of the suitable methods of regeneration can be adopted.

3.Efficient use of growing space and site productivity:

Forest vegetation usually seems to fill all of the available growing space but not all plants growing are equally efficient or desirable.

One important goal of managing a forestland is, to see that all available growing space is filled with useful plants.

Maximum efficiency in use of growing space is more likely to be achieved with mixed or uneven-aged than with pure and even-aged stands.

4.Control of damaging agencies:

Any successful silvicultural system is modified by the objective of creating stands with adequate resistance to insects, pathogens, fire, wind or other injurious biotic or abiotic agencies.

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Most of the generalizations about the damaging agencies of the forest are more nearly true than falls, but they can not be accepted as a basis for silvicultural procedure without being scrutinized for applicability in each instance

Among these are the view that vigorous, fast growing trees are more resistant than less thrifty, slow growing ones; that mixed stands are safer than pure; that uneven-aged stands are more resistant than even-aged; and that close duplication of natural conditions will safeguard against many difficulties.

5.Provision for sustain Yield:

Perhaps the most noble and ambitious goal of forestry is that of making each forest the source of indefinitely sustained and uniform flow of wood and other benefits.

The difficulty of attaining this goal is greater the longer the production cycle of the benefit or the age of stand on which it is dependent.

Sustained yield is most difficult to achieve with timber and other benefits available only from stands that have ages measured in decades or centuries. However, sustained yield for timber has been prescribed in forest management through he following three methods.

Area method of yield regulation:

This consists basically of dividing the total forest area in to as many equally productive units as there are years in the planed rotation and harvesting one unit each year

Volume method of yield regulation:

In this method the basic procedure is to determine the allowable annual or periodic felling in terms of volume of wood with dew regard for the rate of growth, current and potential, and for the volume of growing stock, existing and desired.

The volume method of yield regulation is really a sophisticated and indirect way of applying the area method

In fact, it often depends on regulating diameter distribution and it might better be called as diameter limit cut method of yield regulation. This is suitable for ideal selection system.

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Combination of both:
A combination of both area method and volume method of yield regulation may some times be applied as in case of periodic selection system.

The above methods of forest regulation are simple in principle but difficult to apply, even if the owner's policy is to have sustained yield

The area method of regulating yield remains the most dependable technique of developing and guiding sustained yield.

Optimum Use of Capital and Growing stock:
It takes so long for trees to grow that silviculture, especially that for timber production, is powerfully affected by policies about long term investment of capital

These are following two quite different kinds of capital investments are made and it is important to analyze them separately.
*Treatment of monetary investments
*Investments in growing stock

Treatment of monetary investments:
The most obvious of two kinds of investments is the money actually invested out of pocket in the cost of growing trees and holding the land beneath them

A common way of analyzing these kinds of investments is by using compound interest calculations to compare the present net worth of different course of action

One of the most important uses of this particular analytical technique is the financial comparison of different systems of silvicultural treatments.

Comparison of present net worth help with choices of regeneration techniques, rotation length, thinning programs, logging methods and many other decisions made in formulating a silvicultural system.

Operational cost is also an important consideration. So, the systems in which cost of felling, logging, and extraction is less should be selected to reduce the operational cost or the investment in various operations. Hence, the concentrated systems are advantageous than diffused systems.

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Investments in growing stocks:

The second kind of capital investment in timber management silviculture is the value tied up in merchantable trees that are standing and growing

This investment is in income postponed rather than in money actually invested, unless one has recently purchased the trees of the growing stock

A good growing stock has a high stumpage value and the money that could be realized from its liquidation represents a substantial investment

It is desirable to manipulate the growing stock so that its increase in value represents an acceptable rate of compound interest return on its own value. The assessment of this situation is called financial maturity analysis.

Concentration and Efficient Use of Operations:

It is important to arrange stands so that costs, per unit of volume harvested will be kept at the lowest level consistent with other objective

Transportation is the component of logging costs most affected by the arrangements of stands

In considering the relationship between silviculture and logging cost, it is crucial to distinguish between area related transportation costs and those by handling and processing, which are most strongly affected by tree size.

Concentration of work reduces cost of felling, logging, and extraction operations. From this point of view, systems based on concentrated felling and regeneration, offer a great advantage over selection system which results in diffusion of works

Resolution of conflicting objectives:

It should be apparent that there is no inherent harmony among the various major objectives sought in managing forests

Such harmony can be created only by weighing the various objectives and above said consideration individually and formulating a silvicultural system that represent analytical compromises within forest management plans created by the same kinds of procedures

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Fortunately these conflicting objectives need be resolved only for particular forest or stands. Analysis of each situation will usually reveal a few ruling considerations. The necessity of giving first attention to these considerations will simplify and govern the solution.

Sometimes one is faced with two or more problems, each of which is separately soluble but which can be neatly combined in to a single solution

The process starts with a consideration of the goals of the forest owners. Each of the remaining objectives must receive some attention

Foresters are more able to formulate and prescribe silvicultural treatments than such lay people such as legislators, corporation directors, accountants, or users of forests.

However, when these other kinds of people represent the ownership of the forest public or private, it is they who determine the objectives of management and policies of use of the forest. The foresters should advise and tell what the potentialities are, but they should then be content to execute the policies.

Silvicultural Systems Applicable to Important Species

It is not wise to recommend any particular silvicultural system for a species. In fact silvicultural systems for a particular forest stand should be formulated or selected on the basis of important silvicultural characteristics of the species, forest condition, forest

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owner's objective of management, and several other consideration described earlier. However, looking on the important silvicultural characteristics and other considerations some of the important silvicultural systems, which may be applicable for different forests in various circumstances is prescribed here.

Sal (Shorea robusta):
Silvicultural Characteristics:

1. Strong Light demander
2. Good coppicer (stems up to 20-30cm in diameter)
1. Seedling die back due to frost, drought, fire, and dense overstorey
2. Annual seeder but good seed years after every 2 years
5. Light winged seeds and seeds dispersed by wind

Silvicultural Systems:

1. Selection system (group selection)
2. Irregular shelterwood system
3. Uniform shelterwood system
4. One cut shelterwood system
5. Clearfelling system (plantation by Taungia)
6. Coppice with standards
7. Coppice with reserves
8. Simple coppice

Khair (Acacia catechu):
Silvicultural characteristics:

1. Strong light demander
2. Seedlings are susceptible to severe frost
3. It is very drought resistant
4. It coppices well unless it is under shade of other species
5. Seeds produced in abundance
6. Seeds dispersed by wind and water
7. It requires protection from grazing and browsing

Silvicultural systems:

1. Clearfelling and plantation
2. Simple coppice
3. Coppice with standards
4. Seed tree method

Sisso (Dalbargia sissoo):
Silvicultural characteristics:

1. It is strong light demander
2. It is good coppicer

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3. Annual seeder and seeds produced abundantly
4. Seeds dispersed by wind and water
5. Older seedlings can tolerate mild frost
6. It should be protected against grazing and browsing

Silvicultural systems:
1. Seed tree method
2. Cleaerfelling and plantation by Taungia
3. Two storeyed high forest system
4. Simple coppice
5. Coppice with standards
6. Coppice with two rotation system

Khair and Sisso (Acacia catachu and Dalbergia sissoo):
Silvicultural systems:
1. Coppice with standards
2. Coppice with two rotation
3. Seed tree method
4. Clearfelling and plantation

Chilaune (Schima wallichii):
Silvicultural characteristics:
1. Moderately shade tolerant but later it benefits from full overhead light
2. It is capable of colonizing plantations of other species
3. It is not frost hardy
4. It coppices very well
5. Good seed year are frequent
6. Winged light seeds dispersed by wind

Silvicultural systems:
1. Simple coppice
2. Coppice with two rotation
3. Coppice with standards
4. Selection coppice
5. Selection System

Katus (Castanopsis species):
Silvicultural characteristics:
1. Moderately shade tolerant
2. It benefits from overhead light in later stage
3. It is frost hardy(C. Hystrix)
4. Young seedlings are frost tender(C. Tribuloides)
5. It coppices well

Silvicultural systems:
1. Simple coppice
2. Coppice with two rotation
3. Coppice with standard
4. Selection coppice

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5. Selection System

Asna (Terminalia tomentosa):
Silvicultural characteristics:
1. It is light demander
2. Seedlings can withstand moderately side shade but are killed by heavy shade
3. Seedlings are often killed back by frost
4. The tree is fairly tolerant to fire damage
5. It coppices well(up to 40cm. in diameter)

Silvicultural systems:
1. Single tree selection
2. Coppice with standards
3. Coppice with reserves
4. Shelterwood system

Oaks (Quercus species):
Silvicultural characteristics:
1. Tolerate shade when young
2. Seedlings are very shade tolerant(Q. incana)
3. Early frost kills seedlings
4. Seedlings frost resistant(Q. lamelosa and Q. semicarpifolia)
5. Growth of older trees is better in the open
6. It coppices well but above 10cm. diameter coppicing power reduces(Q. floribunda)
7. Seeds (Acorns) are large and have limited distribution by gravity

Silvicultural systems:
1. Simple coppice system
2. Coppice with standards
3. Coppice with two rotation
4. Selection coppice
5. Uniform shelterwood system

Chirpine (Pinus roxberghii):
Silvicultural characteristics:
1. Strong light demander
2. Seedlings require full overhead light
3. Seedlings are reasonably frost hardy
4. It is very fire resistant species
5. Seedlings over one year old killed by fire will send up new shoots
6. Abundant seed production but good seed years come after every 4-5 years
7. Seeds are light and dispersed by wind
8. Certain ability to coppice when small trees are felled but it is of little importance

Silvicultural systems:
1. Seed tree method
2. Uniform or irrefgular shelterwood system
3. Group selection

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4. Clearfelling with advanced regeneration/One cut Shelterwood

Bluepine (Pinus wallichiana):
Silvicultural characteristics:
1. Strong light demander
2. Seedlings are frost hardy
3. Less fire resistant than P. Roxburghii
4. Small seedlings may suffer from drought after and before mansoon
5. Seedlings will persist for some year under moderate shade but for good development full light is needed
6. It regenerates profusely where conditions are favorable
7. Abundant seed production but good seed years come after every 2-3 years
8. Light seeds and seeds dispersed by wind fairly to large distance up to 200m or more

Silvicultural systems:
1. Seed tree method
2. Uniform or irregular shelterwood system
3. Group selection
4. Clear felling with advanced regeneration.

Fir (Abies species):
Silvicultural characteristics:
1. It is highly shade tolerant
2. Prefer cool moist habitat
3. Tolerant to frost and snow
4. Very sensitive to fire
5. Seeds dispersed by wind(winged seeds)
6. Good seed years after every 3-4 years in A. Spectabilis and about 10 years in A. Pindrow

Silvicultural systems:
1. Single tree selection
2. Irregular sheterwood system
3. Uniform shelterwood system (75-87 seed trees/ha.)

Spruce (Picea smithiana):

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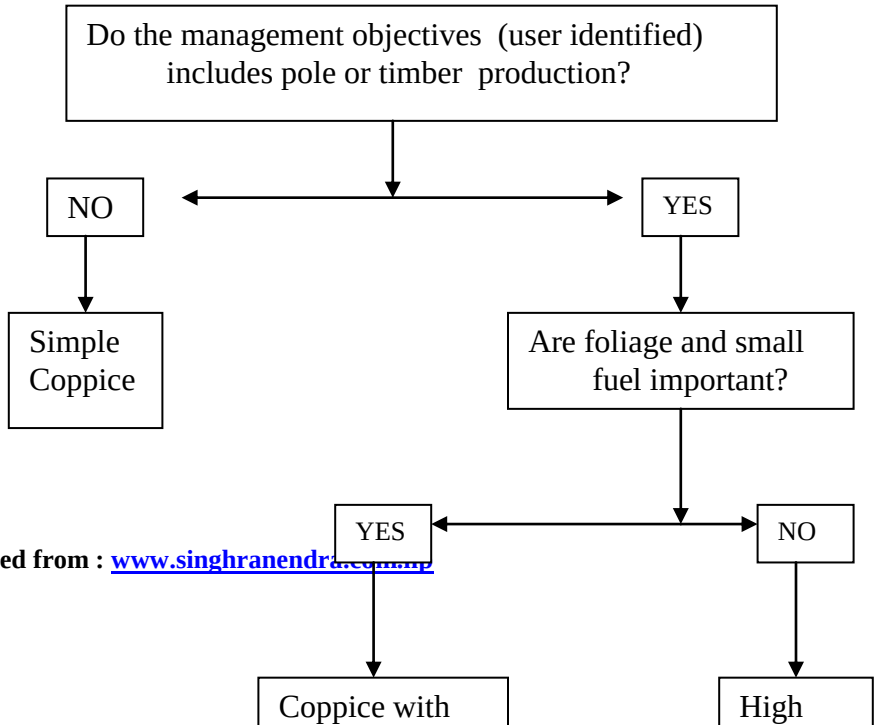
Silvicultural characteristics:
1. Shade bearer
2. Seeds dispersed by wind
3. Young seedlings do not suffer from frost
4. More of a pioneer often associated with blue pine

Silvicultural systems:
1. Single tree selection
2. Irregular shelterwood system
3. Uniform shelterwood system (45-50 seed trees / ha.)

Deodar (Cedrus deodara):
Silvicultural characteristics:
1. Shade bearer and young seedlings benefit from side shade
2. Winged seeds dispersed by wind
3. Young seedlings do not suffer from frost
4. Very sensitive to fire
5. Good seed years after every 3 years
6. Most of the seeds fall close to the parent tree
7. Profuse regeneration in favorable sites

Silvicultural systems:
4. Single tree selection
5. Irregular shelterwood system
6. Uniform shelterwood system (45-50 seed trees / ha.)

Choice of silvicultural systems and their application procedure (Thompsom, 1990).



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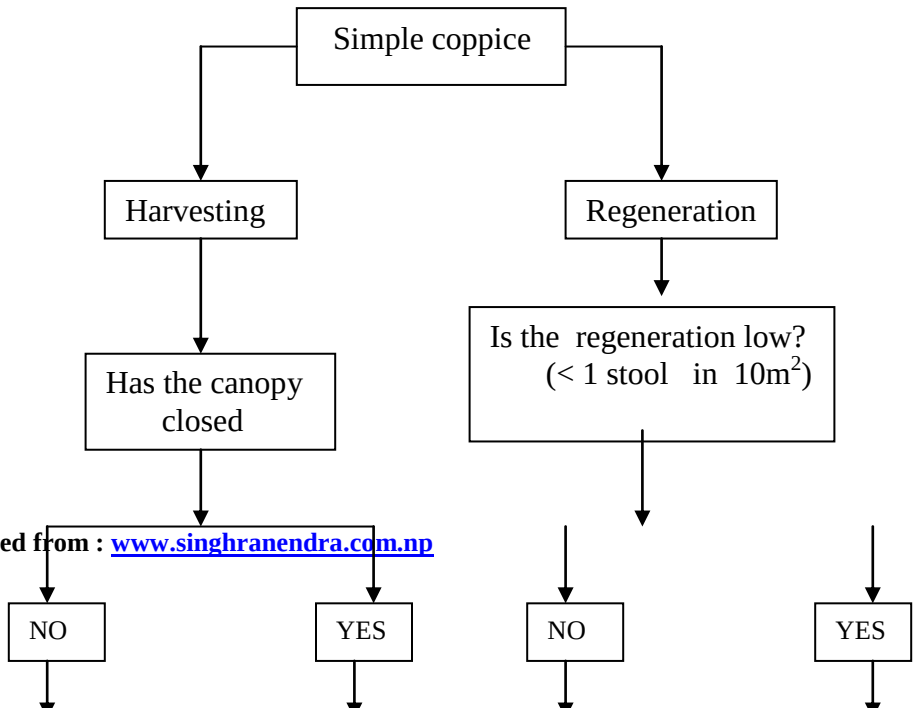
Decision making procedure for choosing a system

In this first stage one can identify the main system for the area. As management continues this decision may be altered or there may be an inherent trend from one system to another depending on access and the supply: demand situation for different products.

a) Simple coppice system



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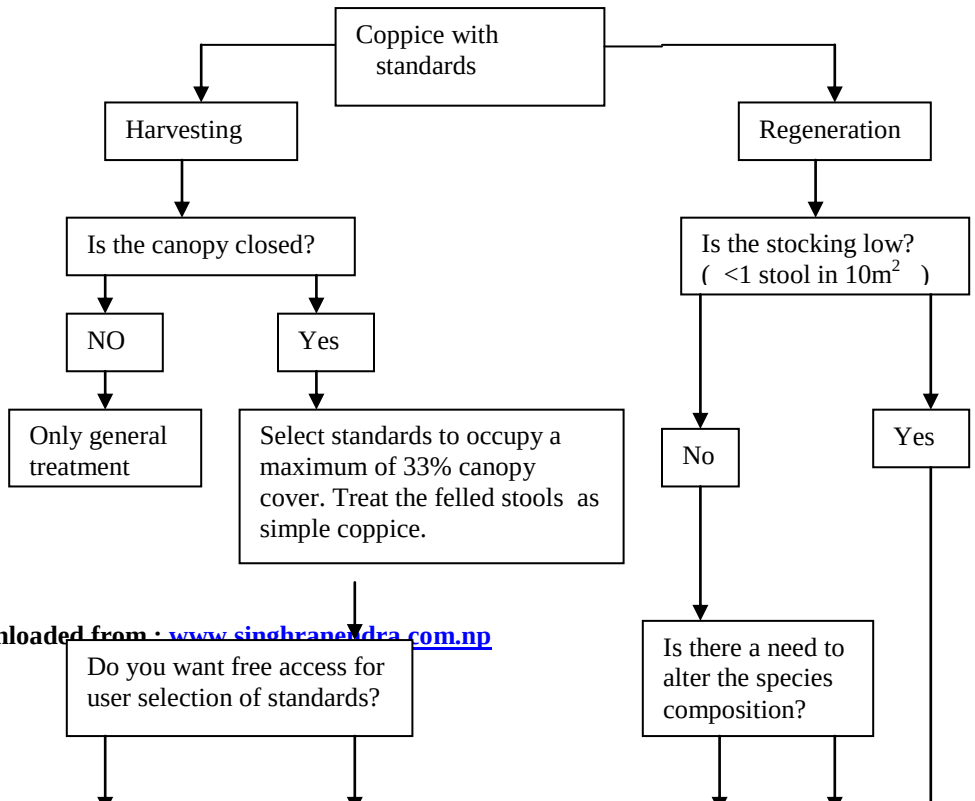
Only general treatment

(b) Coppice with Standard:



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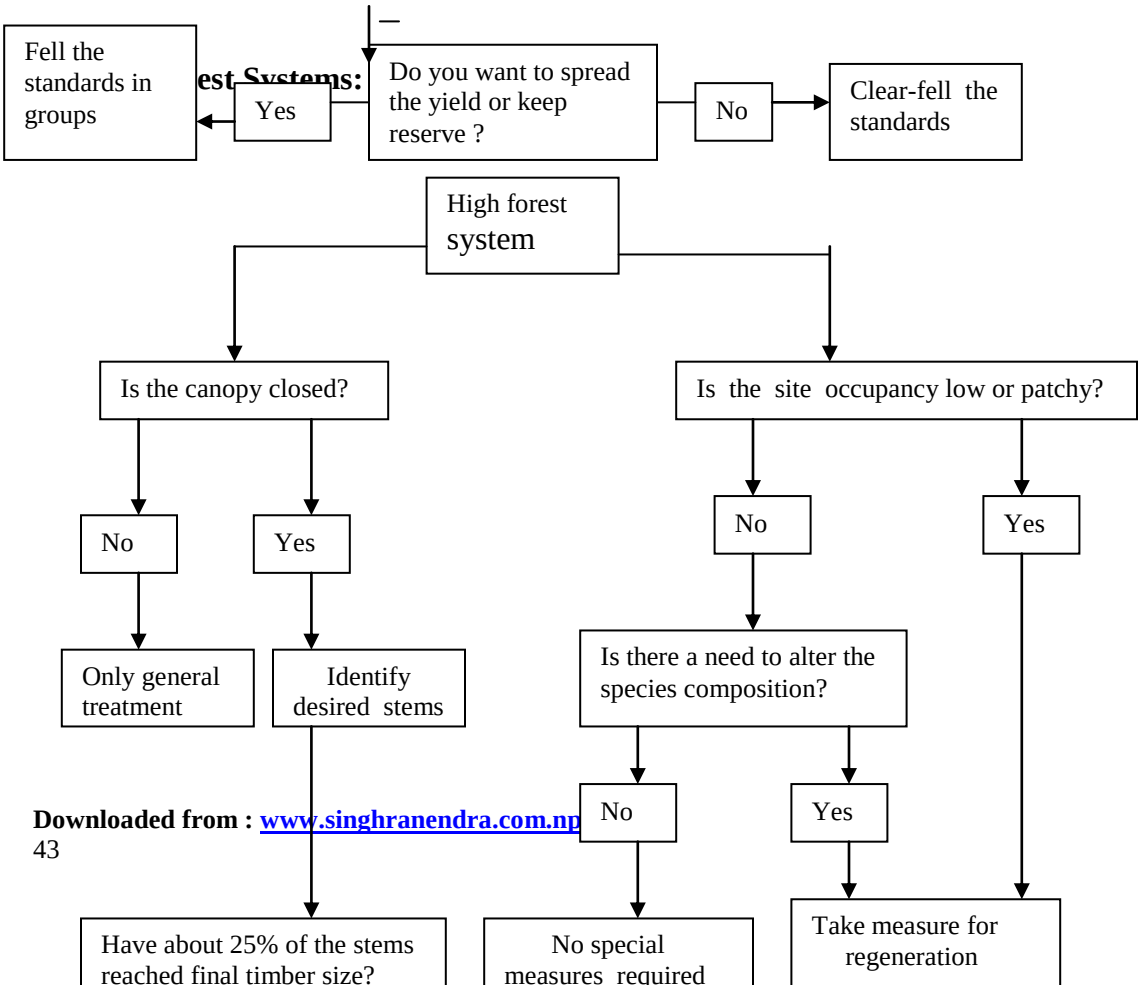
est Systems:



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