Yield Regulation

- By Area
- By Volume
- By Area & Volume
- By Volume & Increment of Growing Stock

Yield Regulation

- Calculation/ Determination of Quantity of Yield
- Designing of Felling Plan
- Provide safeguards to ensure sustenance
- To obtain maximum yield of the desired produce
- To limit the area of fellings so that it can be regenerated.

Definitions

- Yield:- Volume or Number of Stems that can be removed annually or periodically or area over which fellings may pass annually or periodically
- Final Yield:- All materials derived from main fellings
- Intermediate Yield:- Materials from Thinning or other operations preceding main fellings

Definitions – some more

- Normal Yield:- Yield from Normal Forests
- Total Yield:- Final + Intermediate Yields
- Yield Capacity:- Total Quantity of materials per annum that an area is capable of producing under Normal condition.

Yield & Silviculture Systems

- In India the Silviculture Systems adopted are:-
  - Clear Felling Systems
  - Shelterwood Systems
  - Selection Systems

Area Method 1- Annual Coupes by Gross or Reduced areas

- Area of the Felling Series- A ha
- Rotation fixed for the crop- R years
- Area of the annual coupes- A/R ha
- For accuracy- Reduced areas are used
- Reduction by – Site qualities and by stand or crop density
- Used in very uniform forest for mainly Clear Felling Systems with artificial regeneration.

Reduction Factor

- In forest areas even in even aged coupes soils and sites affect productivity differentially.
- Hence equal area are not necessarily equi-productive
- We need to make coupes equi productive for sustained yield by using a reducing factor
- Yield table data are normally from sample plots of normally stocked forests, giving ideal yield
- In actual forests such conditions are not available

Stocking

- Stocking is density on the stand.
- Depends on the productive capacity
- Amount of growing stock and take corrective actions. An aid for thinning in the stands.
- Stocking is best assessed by comparing the basal area of the actual forest with the basal area of the ideal forest.
- Stocking % =100 x Actual Basal area/ Yield table basal area

Equi-productive area

- RF for quality = MAI of QLTY to be reduced/ MAI of STD QLTY
- RF for density = Actual BA of forest to be reduced/ BA from yield table
- Reduced area = (Gross area) X (RF for quality) X (RF for Density)

Examples

Find the area of the annual coupe by reduced area & actual size of coupes, if the rotation is 25 years

Sl. No.	Crop Density	Area (ha)
1	1	300
2	0.75	200
3	0.50	400
4	0.25	100

Examples

Area of the annual coupe by red area and actual size of coupe (density), if the rotation is 25 years

Crop Density	Area (ha)	RF	Red Area (2x3)	Annual Coupe by Reduced Area (ha)	Actual size of annual coupe (ha) (5/3)	Year of felling
1	2	3	4	5	6	7
1	300	1/1=1.0				
0.75	200	0.75=0.75				
0.50	400	0.5/1=0.5				
0.25	100	0.25/1=0.25				
TOTAL	1000					

Example

Area of the annual coupe by red area and actual size of coupe (density), if the rotation is 25 years

Crop Density	Area (ha)	RF	Red Area (2x3)	Annual Coupe by Reduced Area (ha)	Actual size of annual coupe (ha) (5/3)	Year of felling
1	2	3	4	5	6	7
1	300	1	300			
0.75	200	0.75	150			
0.50	400	0.50	200			
0.25	100	0.25	25			
TOTAL	1000		675			

Examples

Area of the annual coupe by red area and actual size of coupe (density), if the rotation is 25 years

Crop Density	Area (ha)	RF	Red Area (2x3)	Annual Coupe by Reduced Area (ha)	Actual size of annual coupe (ha) (5/3)	Year of felling
1	2	3	4	5	6	7
1	300	1	300	675/25=27		
0.75	200	0.75	150	27		
0.50	400	0.50	200	27		
0.25	100	0.25	25	27		
TOTAL	1000		675			

Examples

Area of the annual coupe by red area and actual size of coupe (density), if the rotation is 25 years

Crop Density	Area (ha)	RF	Red Area (2x3)	Annual Coupe by Reduced Area (ha)	Actual size of annual coupe (ha) (5/3)	Year of felling
1	2	3	4	5	6	7
1	300	1	300	675/25=27	27	
0.75	200	0.75	150	27	36	
0.50	400	0.50	200	27	54	
0.25	100	0.25	25	27	108	
TOTAL	1000		675			

Examples

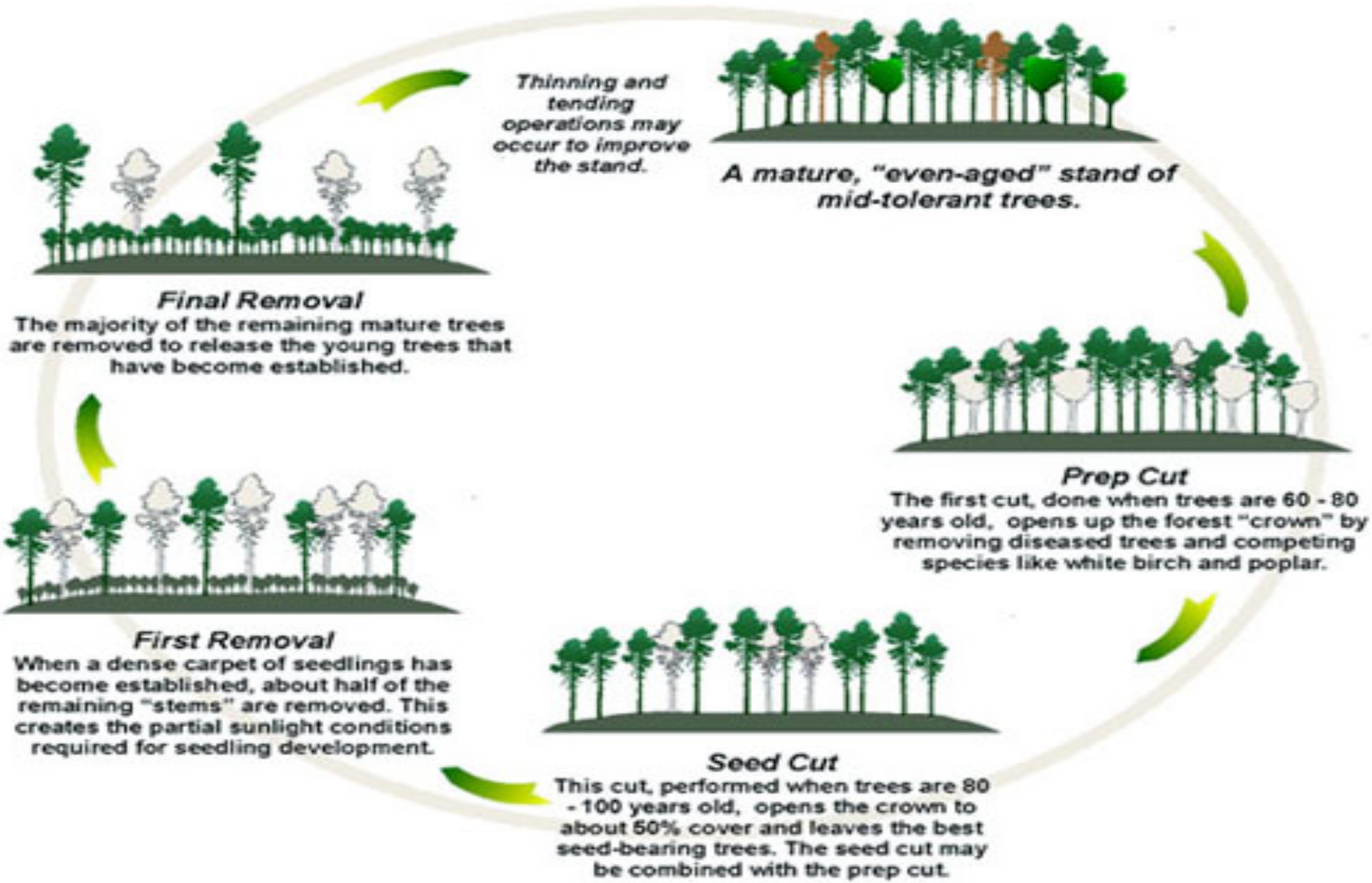
Area of the annual coupe by red area and actual size of coupe (density), if the rotation is 25 years

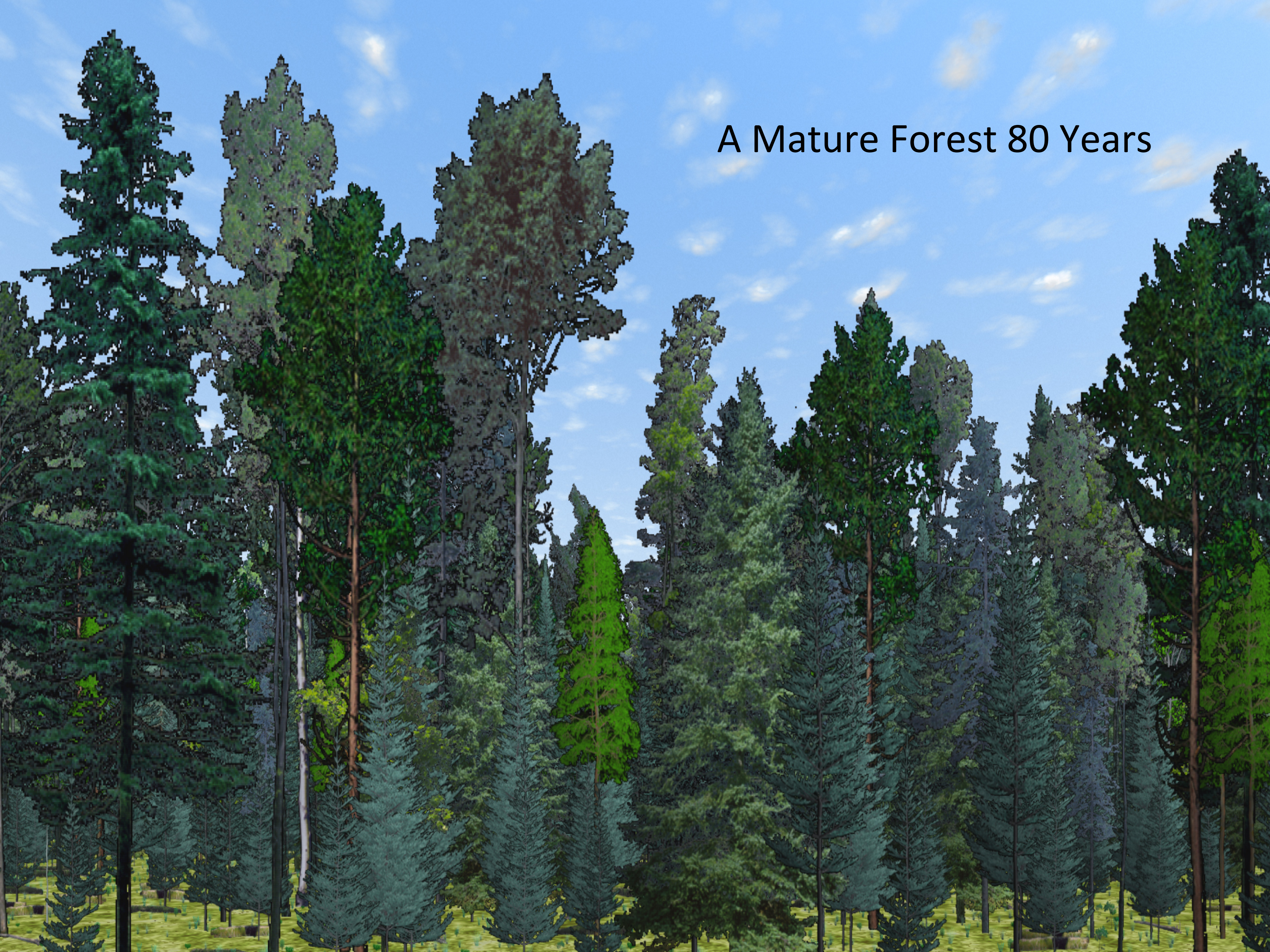
Crop Density	Area (ha)	RF	Red Area (2x3)	Annual Coupe by Reduced Area (ha)	Actual size of annual coupe (ha) (5/3)	Year of felling
1	2	3	4	5	6	7
1	300	1	300	675/25=27	27	1-11
0.75	200	0.75	150	27	36	12-17
0.50	400	0.50	200	27	54	18-24
0.25	100	0.25	25	27	108	25
TOTAL	1000		675			

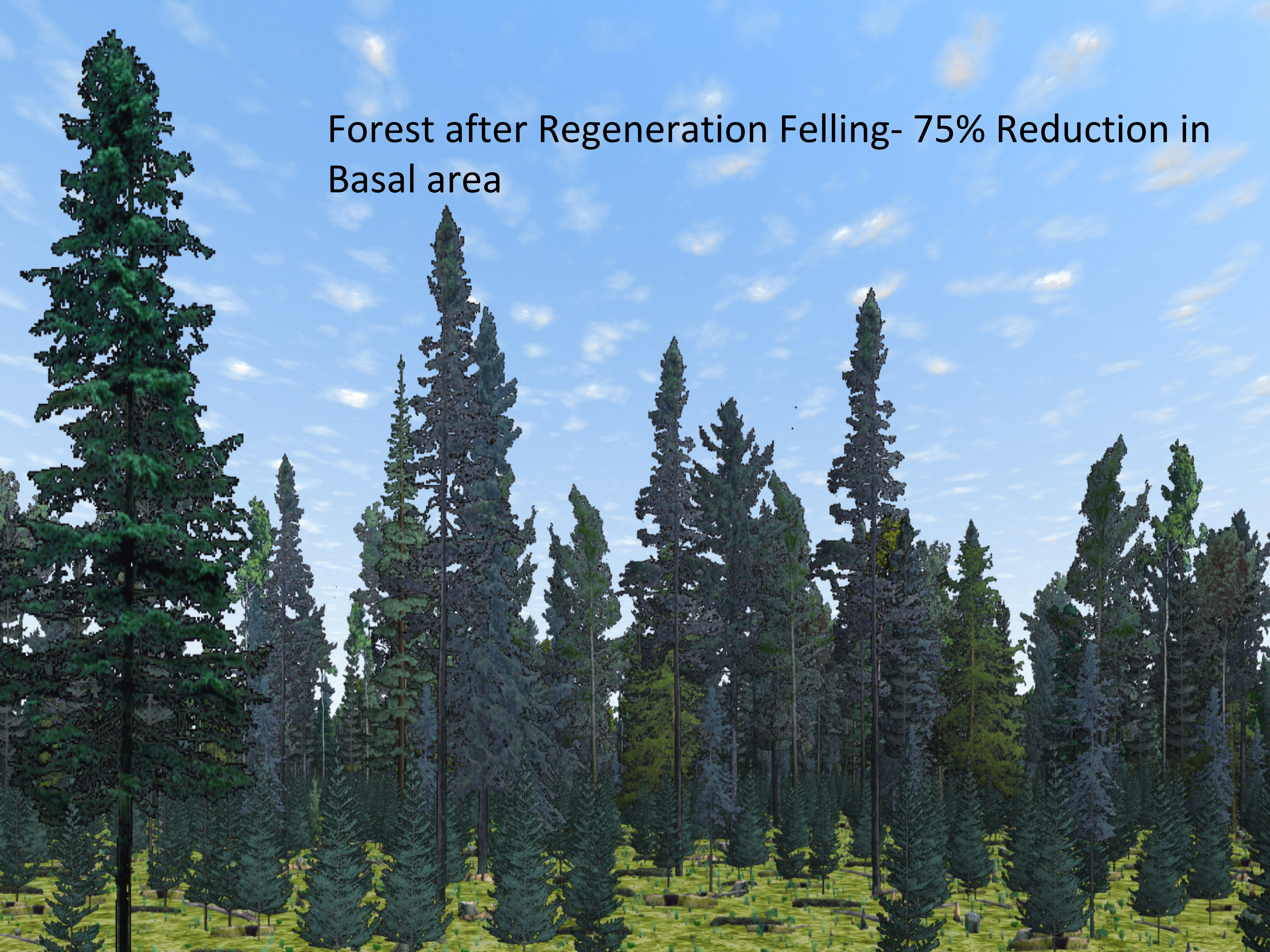
Method- 2- Yield Regulation in Shelterwood Systems

- Felling Series Need to be Identified- Area- A
- Rotation of the crop has to be determined- R years.
- Time taken for Regeneration to get established should be determined- P years. This will be called as Period.
- No of Periods in rotation- R/P
- Whole Felling Series then will be divided in to various Blocks- Each block is assigned to one period
- Yield is then regulated by
  - Area (Gross or reduced)
  - Volume
  - Area and Volume

Shelterwood System



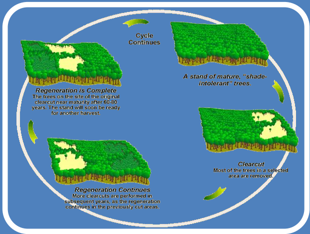

A Mature Forest 80 Years


Forest after Regeneration Felling- 75% Reduction in
Basal area


Forest after 10 Years of Regeneration Felling

Forest after Final Felling

Allotment of areas to various Periodic Blocks

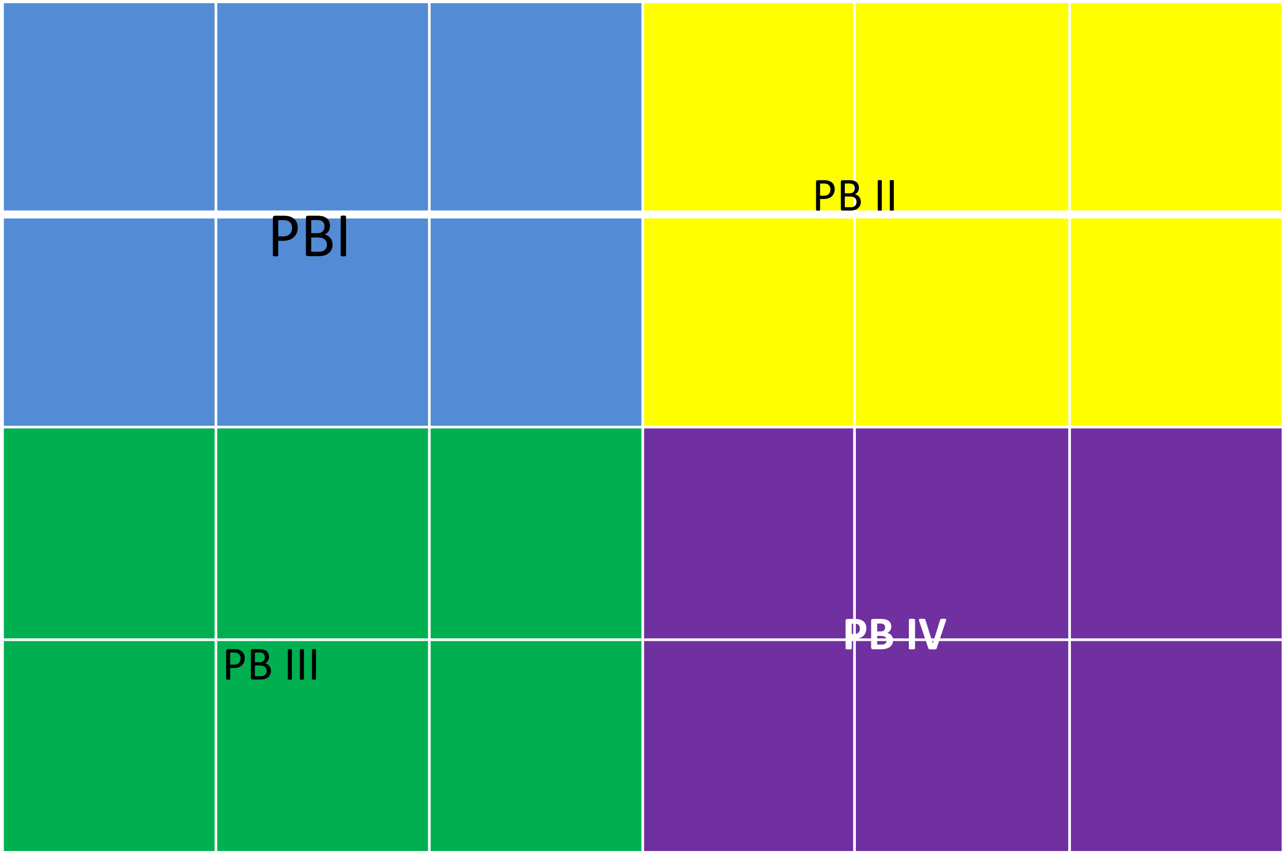


Permanent Periodic Blocks

Revocable Periodic Blocks

Floating Periodic Blocks

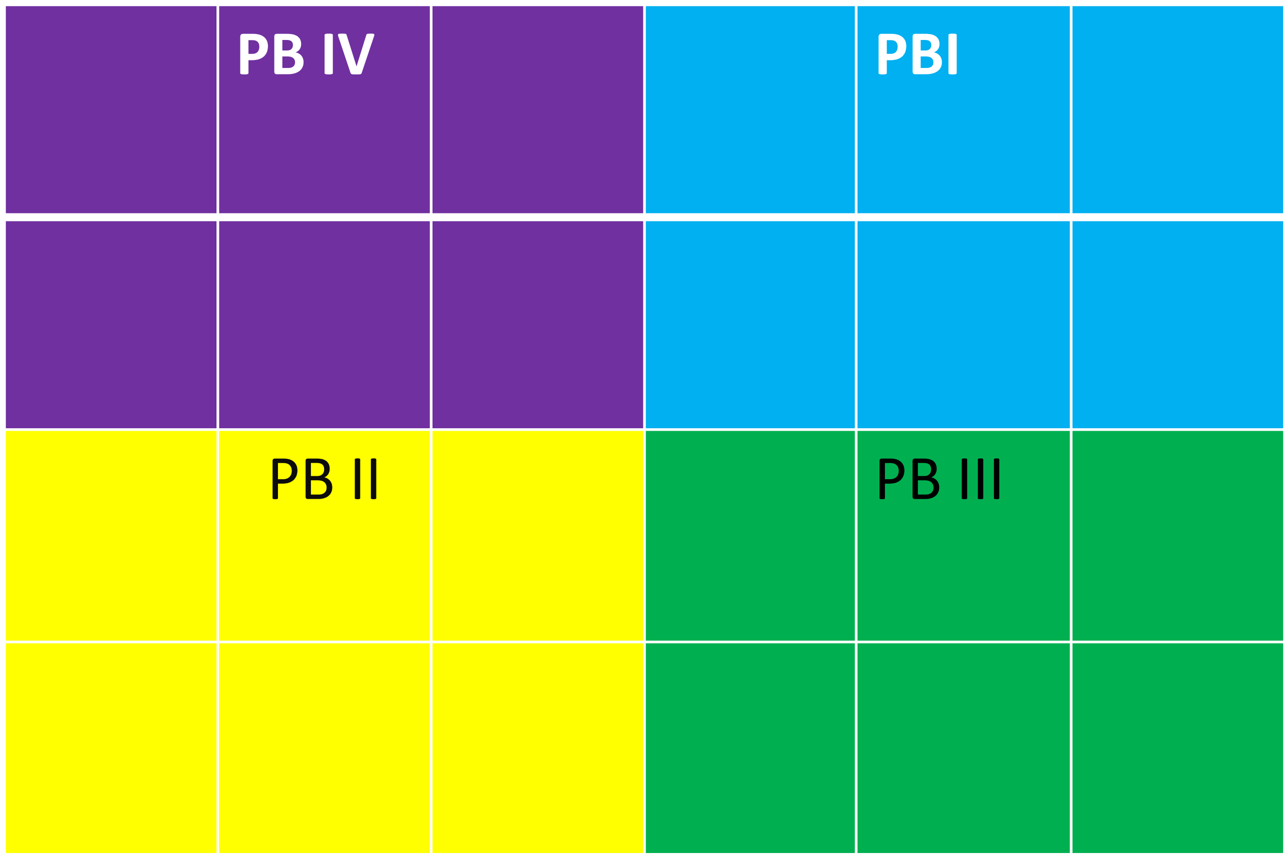
Permanent Periodic Blocks- Period 1



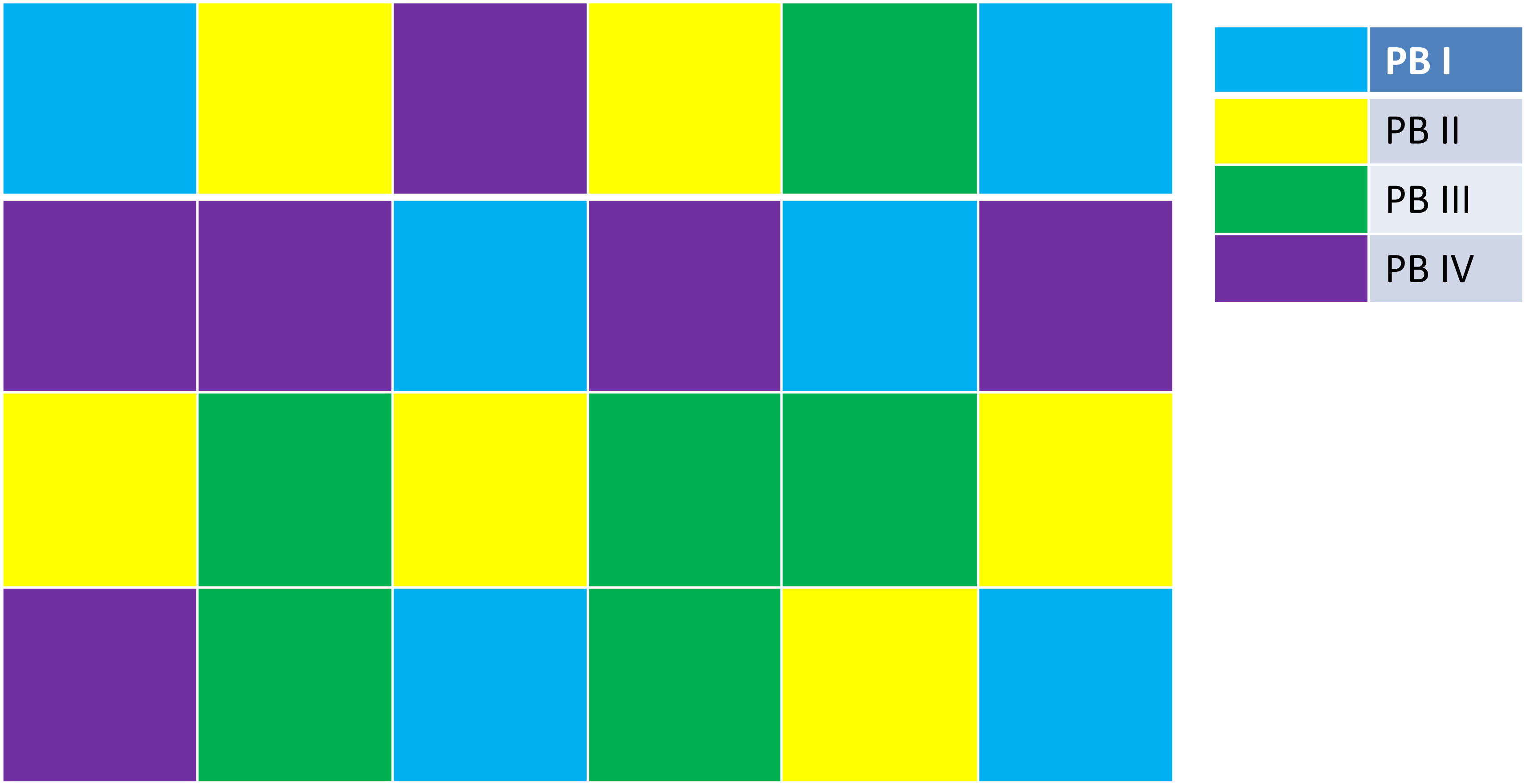
Area of Felling Series- 2400 ha, Rotation- 120 Years, Period- 30 Years

Area of Each Periodic Block- $\frac{2400 \times 30}{120} = 600$ ha

Permanent Periodic Blocks- Period 2



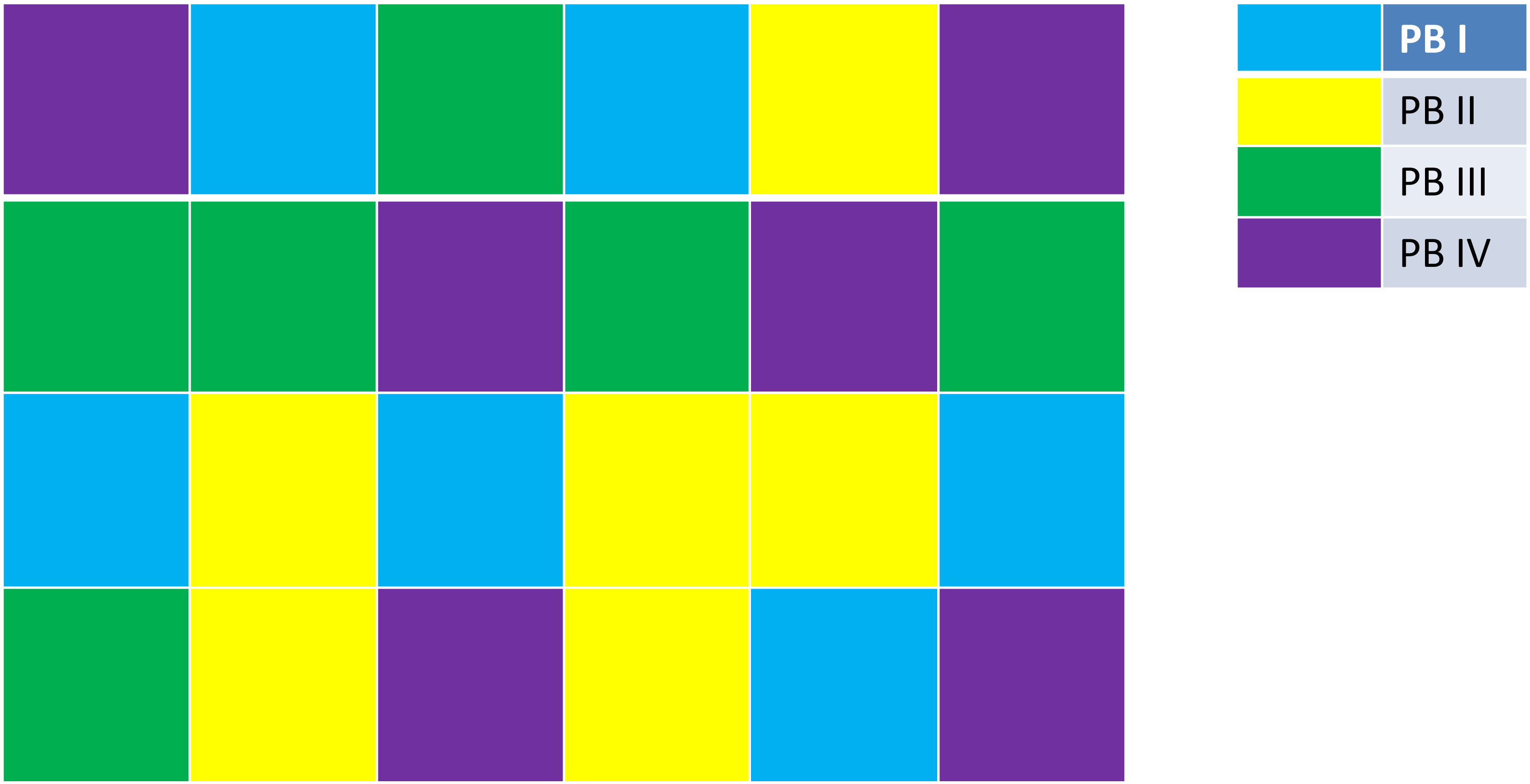
Permanent Periodic Blocks- Scattered areas- Period 1



Area of Felling Series- 2400 ha, Rotation- 120 Years, Period- 30 Years

Area of Each Periodic Block- $\frac{2400x\ 30}{120}$ = 600 ha

Permanent Periodic Blocks- Scattered areas- Period 2



The Procedure

- Calculation of reduced areas
- Determination of average ages of compartments
- General Condition of crop- Vigor, Regeneration
- Allotment of Compartments
- Shifting of Compartments to equalise the area
- Yield Calculation for the period.

How it Works……

Advantages

- It is easy to apply
- Leads to regularity of age gradation

Limitations

- Forests are not machines
- Very rigid
- No consideration of crop condition
- In unmanaged forest not possible to lay equiproductive coupes
- Regulation by area not feasible in mixed forest

Hufnagl's Modification

- The sustained yield by equalizing the area is feasible only in Normal Forest, where all age classes occupy equal area in forests. In actual condition this will not be found. The forest may have more areas under mature classes than in Normal Forest. Sometimes immature trees will be higher than Normal Forest Proportion.
- A smart Manager will not keep mature forest for long and will not sacrifice immature crop before time.

Hufnagl’s Modification- continued

- Therefore the smart decision is cut over-mature trees faster and wait for immature trees to grow up.

- Area of Annual Coupe higher when More Mature trees & Area of Annual Coupe Lower when More Mature trees.
- More Mature trees ↔ Higher Average Age
- More Immature trees ↔ Lower Avg Age

Hufnagl's Modification- continued

- It is therefore proposed that Annual Area or Yield may be modified as follows:-

$$AY/AvA = NY/NA \Longleftrightarrow AY = \frac{AvA.\ NY}{NA}$$

NA= Average Age of Normal Forest= Rotation/2

AvA= Average Age of Actual Forest- To be determined

AY= Annual Yield= Area of Annual Coupe

NY= Total Area of Felling Series/ Rotation

In the same manner the area of periodic blocks may be modified-

Area of PB/ Average Age= Area of Normal PB/ (R/2)

Area of Normal PB= A x P/R

Example- Area of FS= 1000 ha, Rotation- 80 years, Period- 20 Years, No of PBs= 4, Normal Area of PB= 250 ha

Age Class	Area of Class in ha	Average Age x Area	Actual Average Age
1-20	200	2000	45000/1000= 45 years
21-40	150	4500	
41-60	350	17500	
61-80	300	21000	
Total	1000	45000	

Normal Age of FS= Rotation/2= 40 , Therefore Modified area of Each PB would be Area of PB = 250 x 45/40 = 281 ha

The future forest areas

Time	Initial	After 20 years	After 40 years
1-20	200	281	250
20-40	150	200	281
40-60	350	150	200
60-80	300	369	269
Total	1000	1000	1000

Solution

Solution

Problem

- We have divided the PB-I area in each block
- The Annual Yield is to be calculated for each periodic block

Volume is fixed by ... The Annual Yield Period is to be therefore not known for only the seed trade areas in worked out. periodic block

Revocable Periodic Blocks- Period 1

Revocable Periodic Blocks- Period 2

Priority of Allotment in Revocable Allotment Method

Areas under Regeneration

↓

Areas affected by Severe damage- fire, storms, epidemics

↓

Areas with Mature crop having advanced growth

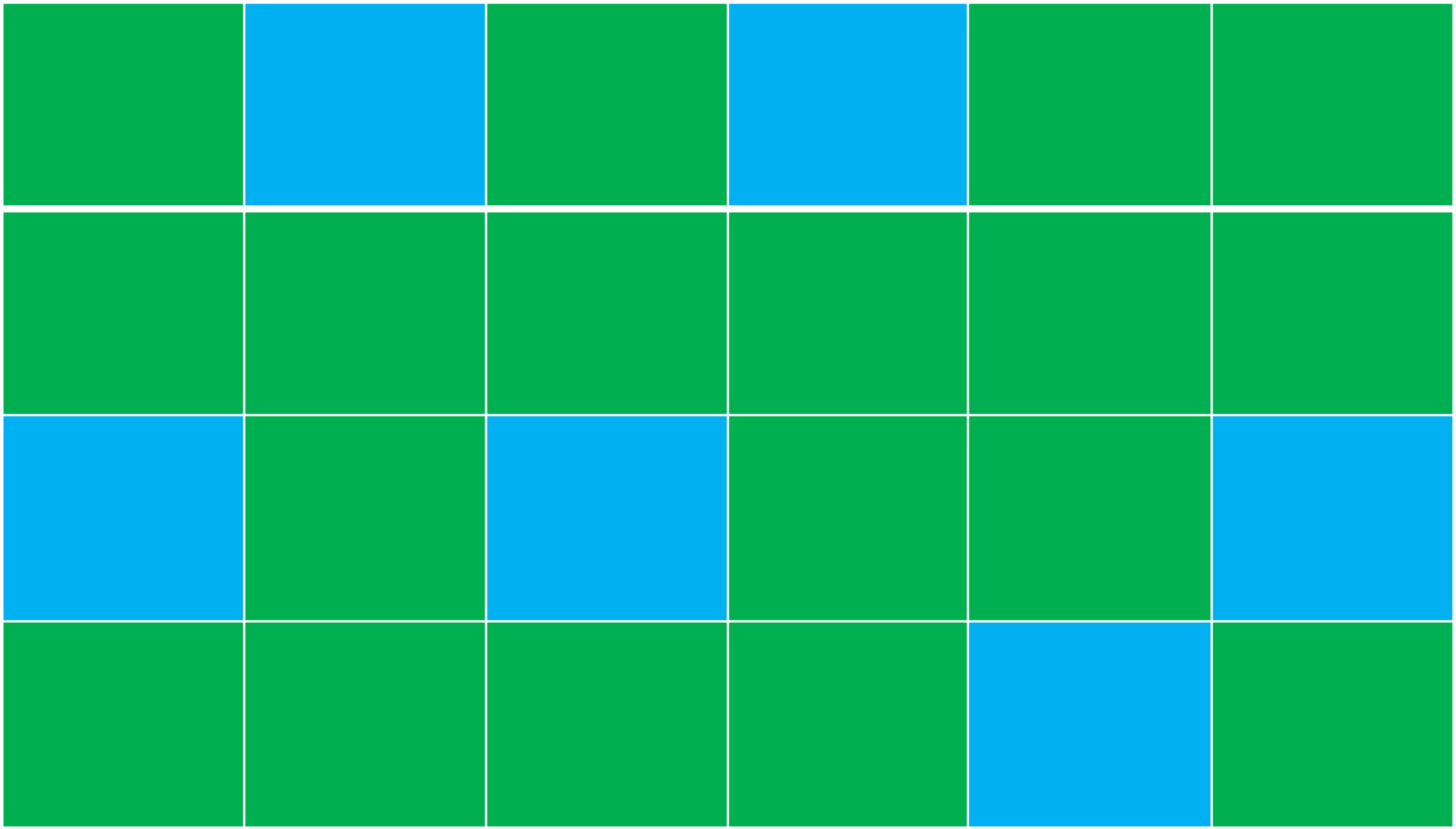
↓

Areas with Mature crop but not having advanced regeneration

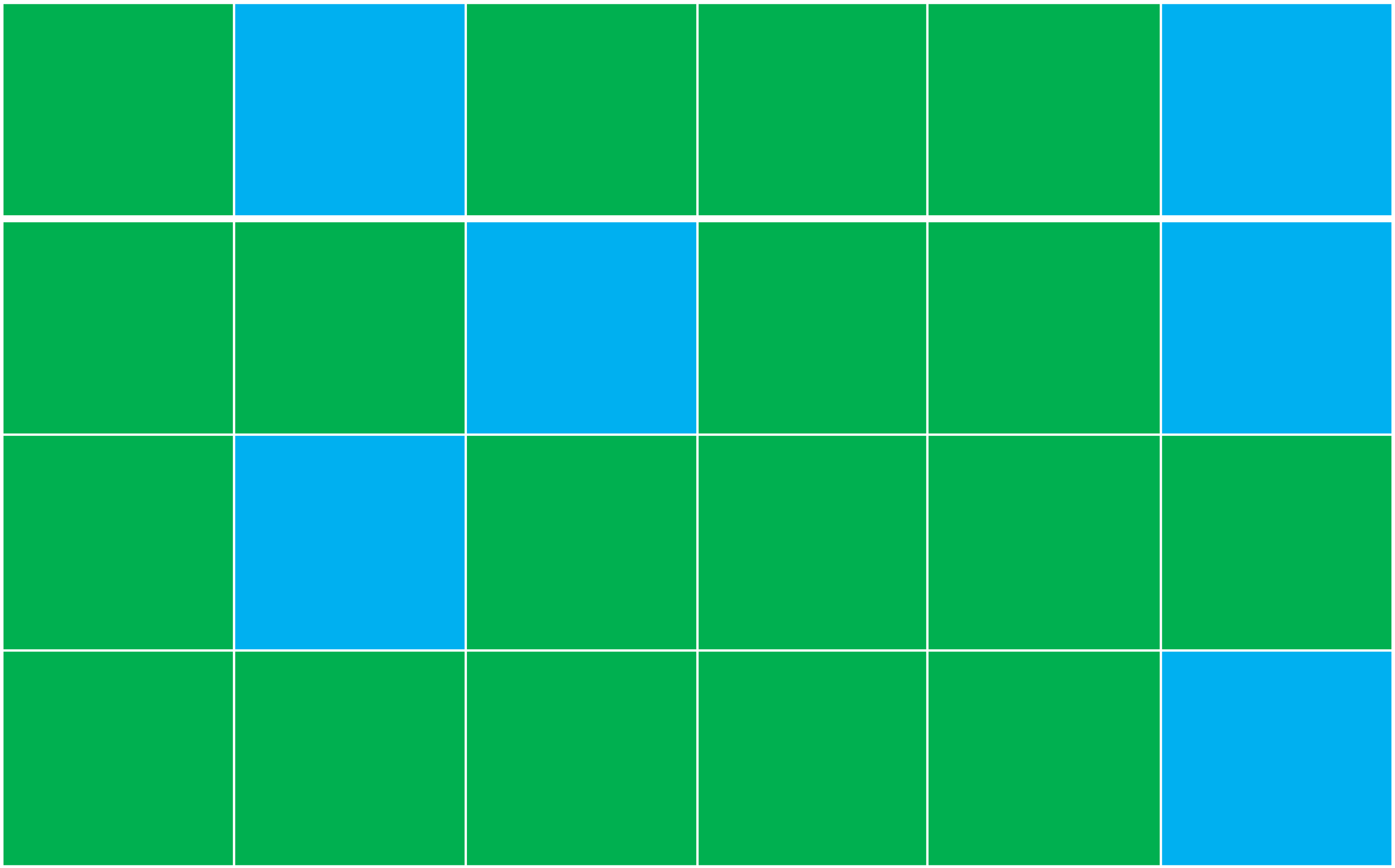
Main features of RPB method

- Allotment may be changed during next period.
- PB II may be carefully selected for preparatory treatments. But not necessarily selected for regeneration during next period.
- Compartments are scattered.
- Rotation loses the sanctity.

Single allotment Method- Period I



Single Allotment Method- Period II



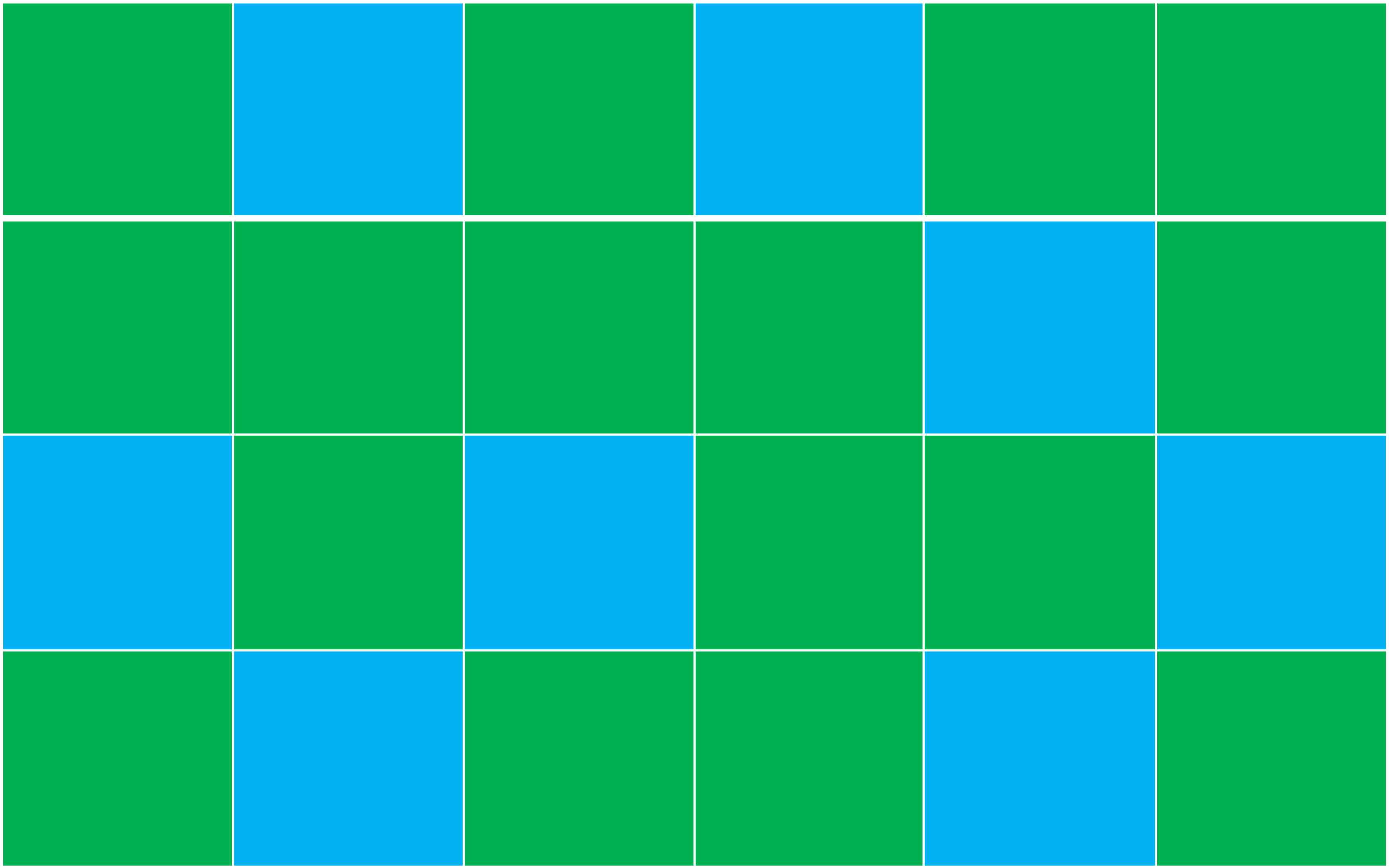
Main features of Single Allotment

- The compartments are only allotted to regeneration block
- Regeneration period is fixed and normal area of first period calculated.
- The rest of the area is also divided in one or two subunits for deciding suitable treatments.
- Partly regenerated areas are first allotted with the area reduced by stocking factors.

Area of FS- 500 ha; Rotation- 100 years; Regeneration period 25 years, Normal area of PB- 125 ha; BA- 24.3 m^2

Comp No	Area	Basal area	R Factor	R area	Total area
Partially Regenerated Compartments					
1	20	6.3	6.3/24.3	5.2	
5	15	6.5	6.5/24.3	4.0	
6	18	6.1	6.1/24.3	4.5	
9	22	5.5	5.5/24.3	5.0	18.7 or 19
New Compartments					
4	25	24.3	1	26	
7	23	24.3	1	23	
12	20	24.3	1	20	
15	19	24.3	1	19	
16	18	24.3	1	18	106
Total	180				125

Floating Periodic Block- Quartier Bleu



FPB Method

- Compartments are allotted at each working plan as follows:-
- ❑ Group I- Comptts under Regeneration
- ❑ Group II- Comptts brought under Regn
- Use Cotta's Formula for finding Annual Yield
- No Fixed Period- as per site and Species.
- Period/Rotation= Area of FPB/ Area of FS

Growing Flexibility in Periodic Block Methods

- Fixed PB
- Revocable PB
- Single PB

- Single PB with fixed period
- Elongated PBs with boundaries subject to
- Fixed PBs with Scattered

How to Calculate the Annual Yield

- Annual Yield is calculated for only PB I areas
- During the period all the volume in PB I is felled. Therefore find the Standing Volume in PB I
- Enumerate the trees in PB I or
- Use Yield table data- Age or Average dia- Read the standing volume
- If the Volume is V then Y= V/P

Annual Yield Cotta's Formula

- We have not taken in to account the increment accrued to trees while standing.
- Find out the Annual Increment- CAI for crop from Yield table or by field methods (i)
- At the start Whole Volume and at the end No tree- therefore only half of the increment is taken – (P.i)/2 in the whole period
- We will get V+ (P.i)/2 during the period so the Annual Yield is V/P+i/2

Example

- If 35000 CMT is the standing volume in PB1, Period is 35 years, and 300 CMT is the annual increment in PB1 then according to Cotta's formula what is the annual yield?

$$Ya = \frac{V}{P} + \frac{i}{2}$$

$$= \frac{35,000}{35} + \frac{300}{2}$$

$$= 1000 + 150$$

$$= 1150 \text{ cmt}$$

Example

Calculate the annual yield for PBI of a stand for 1000 hectare. The volume of the stand in PBI is 15,000 CMT. Rotation is 120 years and period of regeneration is 30 years. The PBI of the stand is putting annual increment of 100 CMT

$$Ya = \frac{V + Pi/2}{P} \quad \text{Or} \quad Ya = \frac{V}{P} + \frac{i}{2}$$

$$Ya = \frac{15000}{30} + \frac{100}{2}$$

$$= 500 + 50$$

$$= 550 \text{ CMT/Yr}$$

Example

Calculate the annual yield for PBI of a stand for 400 hectare. The volume of the stand in PBI is 18,000 CMT. Rotation is 80 years and period of regeneration is 20 years. The PBI of the stand is putting annual increment @ 1% /year

$$Ya = \frac{V}{P} + \frac{(VX0.01)}{2}$$

$$Ya = \frac{18000}{20} + \frac{(18000X0.01)}{2}$$

$$= 900 + 90$$

$$= 990 \text{ CMT/Yr}$$

Example

Deodar Felling Series in Uttarkashi Forest division is having total area of 2400 ha. The rotation has been fixed as 120 years. The areas are proposed to be worked under Uniform Shelterwood system with Floating Periodic Block Method. The compartments were then allotted to Floating Periodic Block and the total area of such compartments add up to 800 ha. Calculate the period in which the presently allotted block is to be worked. If the growing stock in this periodic block is 19200 CMT and the increment per ha is assessed as 0.4 CMT then work out the Annual Yield expected.

Given:- R= 120 years. Area of FS= 2400 ha. Area of FPB= 800 ha and Volume = 192000 CMT and i= 0.4x 800 =320 CMT then

Period= R x Area of FPB/ Area of FS= 120 x 800/2400= 40 years

Yield = V/ P+ i/2= 192000/40 + 320/2 = 4800+160 = 4960 CMT

Judeich's Stand selection method

- Basis: No system of yield regulation could be accurate over a long period if not revised frequently.

- Same principal as in floating PB method.

- Treatment of crop as per its needs.

- Regulates yield for a short period, say 10 years.

- Involves careful selection and allotment of more or less proportionate area of mature stands for felling and regeneration during plan period.

Judeich's Stand Selection Method

- **Suitable rotation and working plan period are fixed**
- **Mature compartments selected for felling and regeneration for working plan period on following principals:**
  - **Priority for regeneration.**
  - **Stands which must be felled to meet the silvicultural necessities.**
  - **Mature and over mature stands.**
  - **Stands whose felling is desirable for convenience (Falls between two mature stands).**

Judeich's Stand Selection Method

- Area is calculated following Hufnagl's method
- Yield is calculated following Cotta's method

1. Area Calculation

Normal coupe for the period = Total area x Regn period/rotation
= FS X P / R

Area of PB (actual coupe for the period) =
{FS X P / R} X {modification factor}

Modification factor = Actual Average age/ normal Average age

Normal Average age = ½ Rotation

Actual Av. age = Summation of product of area of compt. and average age/sum of all compts.
= ∑ Age class Area x Av age of class/ Total Area

I (E) Judeich's Stand Selection Method

Advantages

- Elastic
- Working based on actual conditions of crop
- Easy to correct mistake

Disadvantages

- Crops may become mixed w.r.t. age class distribution
- Sustained yield may be affected if too much freedom exercised in selecting crops for felling

Summary

1. Area and Volume Methods are used for calculating yield in forests normally under shelter wood systems
2. Various Forms of PB methods are used in ensuring regeneration and yield calculation starting from Fixed PB to Revocable PB to Single PB to Floating PB and Judeich stand selection method
3. The area for harvest varies depending upon selection of compartments under PB1
4. Yield in PB1 is calculated using Cotta's method
5. Cotta's method of yield calculation incorporates volume in Regeneration block (PB1) and increment put on the volume during regeneration period

Formula Methods

- **Methods based on volume and/or increment of Growing Stock are commonly called formula methods.**
- **Little or no consideration of age class distribution or the condition of the crop.**
- **Widely used due to their convenience.**
- **Use of an area check, when using formula methods is essential.**

III A (i) Von Mantel's Formula

- **Formula of glorious simplicity**
- **Involves determination of actual volume of GS**
- **Provides yield on final volume only**

In a normal forest the growing stock (GS) is the area of the triangle formed by the base (Rotation) and height (Increment)

$$GS = \frac{I \times R}{2}$$

$$I \times R = 2\,GS$$

$$I = \frac{2GS}{R}$$

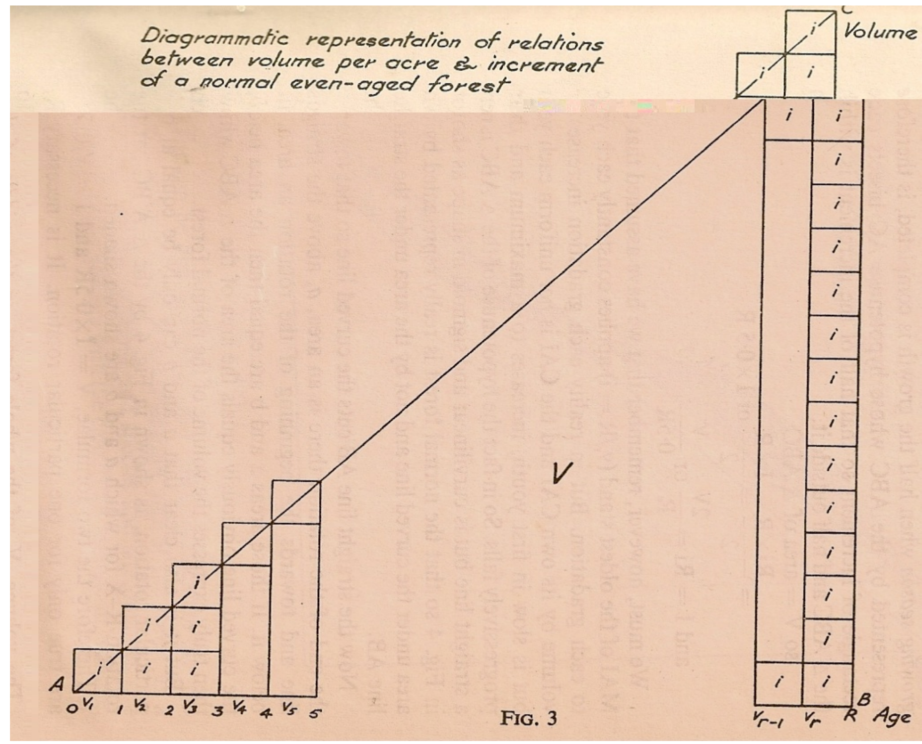


FIG. 3

INCREMENT

Age (Rotation)

V_1, V_2 ….. Vr Volumes of each gradation.

i = Yearly increment per unit area of each gradation

V= Area of △BC=(R*i) x R/2

= I x R/2 OR I x 0.5 R

And I= Ri= 2V/R OR V/0.5R

Von Mantel's Formula

Annual yield from any forest must bear the same proportion to the actual GS as normal increment bears to the normal GS

$$\frac{\text{Actual Yield (AY)}}{\text{Actual GS (AGS)}} = \frac{\text{Normal Yield (NY)}}{\text{Normal GS (NGS)}}$$

Von Mantel's Formula

$$\frac{\text{Actual Yield (AY)}}{\text{Actual GS (AGS)}} = \frac{\text{Normal Yield (NY)}}{\text{Normal GS (NGS)}}$$

AY = NY x AGS/NGS

= NY x AGS / (I x R/2)

= NY x AGS / (i.R x R/2)

= NY x AGS x 2/ R. (i.R)

= (i.R) x AGS x 2 /R. (i.R)

= 2 GS / R

Where NY = i x R

(During the rotation, the yield is twice the GS present at the beginning. The existing GS supplies the yield for half the rotation & the yield for remaining half of rotation comes from increment).

Von Mantel's Formula

Application

- **Best suited to regular, even aged Forest.**
- **Not suited to irregular forests, but followed for its simplicity.**

Von Mantel's Formula

Advantages

- ❖ Simple, easy to apply
- ❖ Regulates yield on actual GS
- ❖ Conservative yield and helps in enrichment of GS

Disadvantages

- ❖ The assumption that all age classes put on equal increment is wrong
- ❖ Does not consider composition of GS, Age class distribution and rate of growth
- ❖ Involves complete enumeration of GS- impractical
- ❖ Thinning yields are not included in the yield

Von Mantel's Formula

Q1 The growing stock of SCI working circle in Balaghat Forest Division is 86.69 CMT/ha. Out of this 30.08 CMT/ha are fruit bearing species and species with less than 1% availability, which are not to be harvested. Rotation is 100 years and felling cycle is 20 years.

What should be Yield /ha from the coupes as per Von Mantel's formula?

Net Growing Stock (GS) = 86.69- 30.08 = 56.61 CMT/ha

Annual Yield (AY) = 2GS/R = 2X 56.61/100 = 1.1322 CMT

since FC is 20, the coupe shall be visited after a gap of 20 years. Hence, removal should be

20 X AY = 20 X 1.1322 = 22.644 CMT

Masson's Formula: Exploitation % or Masson's Ratio

Yield (exploitation %) = 2/R % OR 200/R

Exploitation % = P = $\frac{\text{Annual Yield X100}}{\text{Growing Stock}}$

= { (2 GS/R) / GS}100

= 200/R Masson's Ratio

Calculate exploitation percent for a teak forest of:-

- 100 year rotation
- 80 year Rotation
- 50 year rotation
- 40 year rotation

Masson's Exploitation % = 200/R

Hence = 200/100 = 2%

200/80 = 2.5%

200/50 = 4%

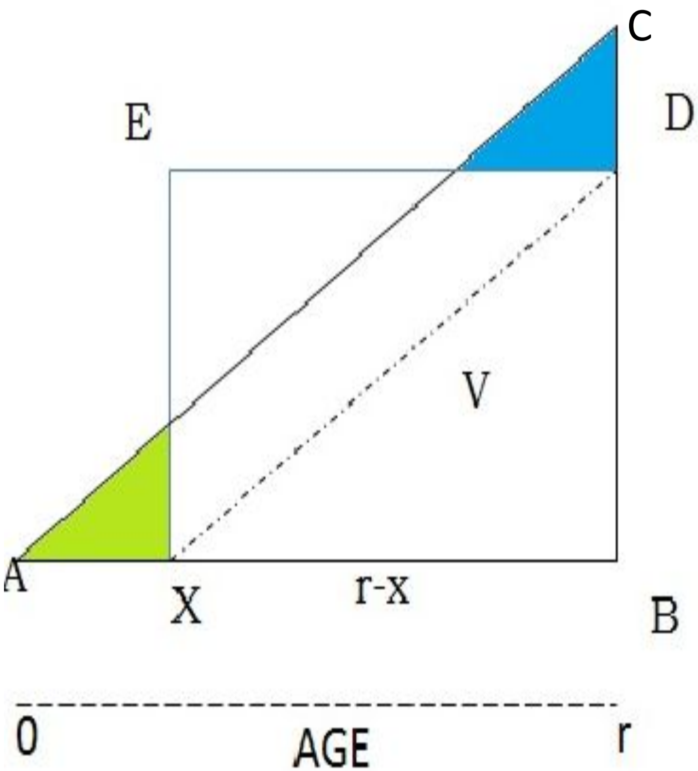
200/40= 5%

Note: Yield shall increase as we reduce rotation

Modifications of Von Mantel's Formula

- **Von mantel's formula requires measurement of entire GS, practically impossible to measure.**
- **Treating volume measured above certain limit (say 20cm stem timber limit) as GS volume may lead to considerable error**
- **Measuring GS down to very low limit may eliminate error but very expensive and time consuming**
- **Several modifications thus evolved**
- **Each modification tends to relate measured volume of a part of the GS to the volume of total GS**

SMYTHIES' MODIFICATION



- r = Rotation
- X = Age down to which enumeration is done (corresponding to Dia down to which Vol measured)
- ABC = Whole GS (Normal GS)
- V = Volume Enumerated (XB△D)
- Yield in r-x YRS = EXBD

  = TWICE XB△D= 2V

ANNUAL Yield = 2V/r-x

In an evenly managed 150 ha Sal forest of 100 years rotation, the dia of 20 cm is reached in 25 years. The volume of enumerated trees is 7500 CMT. Calculate the annual yield from the forest. What shall be AY/ha?

ANNUAL YD = 2V/r-x

=2x 7500/100-25

=2x7500/75

= 200 CMT

AY/ha = 200/150 = 1.33CMT

Smythies' Modification

Limitations

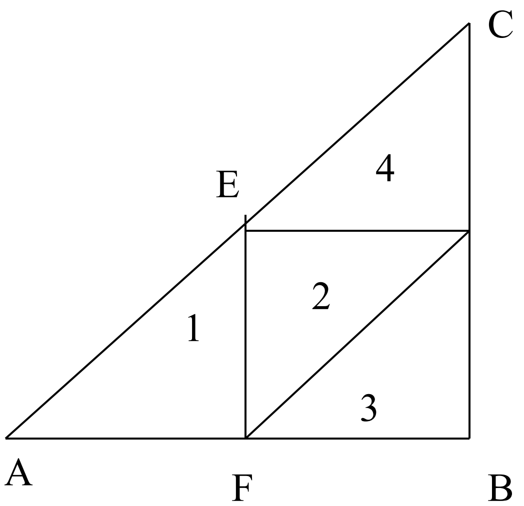
- **This pre supposes the existence of normal GS below the age of 'X' to supply the yield during the remaining years of rotation. This is a risky assumption.**

- **Yield is confined to only timber rather it should include all that is saleable**

III A (iii) Howard's Modification

- Evolved for the management of irregular forests
- Assumes that significant growth occures only after half the rotation is over
- Rotation corresponding to exploitable Dia/girth is determined
- Girth/Dia corresponding the half rotation age is determined
- Enumeration of trees done down to half rotation age
- Volume of GS enumerated to half R

Howard's Modification



△ABC = Growing Stock at Rotation R

FIG. BCEF (Enumerated GS upto half R)

= Volume (V)

¾ GS = V

GS = 4 V/3

AY = 2 GS / R

= 2 (4V/3)/R

= 8V/3R

Howard’s Modification

- **Limit of enumeration changes with change in R**

- **Limit also changes with change in Site quality**

Austrian Method

- **Annoymous austrian tax collector wanted to assess the annual yields from the forests for collection of tax.**

- **He suggested that annual yield during a rotation ought to be normal increment from a forest.**

- **If the actual gs is more than normal, excess over the normal should be removed over the R.**

- **If the actual is less than the normal, then less than actual increment should be removed so as tobring the GS to normal over R**

- **This period is equalization period generally R**

Austrian Method

- $Y = I + [(Va – Vn)/R]$

- Y = Annual yield
- Va = Actual GS
- Vn = Normal GS = I (R/2)
- I = Increment (MAI)
- R = Rotation (Equilization Period)

If the stand is normal Va=Vn & Y= M.A.I

In a 100 ha sal forest of Dehradun district the actual growing stock is 3800 CMT and normal growing stock is 6200. The average annual increment for the stand is 108 CMT. The forest is managed under 120 years rotation. Calculate the annual yield per ha.

AY = I + [(Va – Vn)/R]

=108 + (3800-6200)/120

= 108 - 2400/120

=108-20

= 88 CMT for 100 ha

Annual Yield /ha/yr = 88/100 = 0.88 CMT

Note: Since AGS is less than NGS harvest is less than MAI with a view to improve the stocking.

In a 200 ha teak forest the actual growing stock is 18800 CMT and normal growing stock is 15200. The average annual increment for the stand is 336 CMT. The forest is managed under 100 years rotation. Calculate the annual yield per ha.

AY = I + [(Va – Vn)/R]

=336 + (18800-15200)/100

= 336 + 3600/100

= 336+36

= 372 CMT for 200 ha

Annual Yield /ha/yr = 372/200 = 1.86 CMT

Note: Since AGS is more than NGS harvest is more than MAI with a view to decongest the stocking.

Austrian Method

❖ Application

- For regular & irregular forests

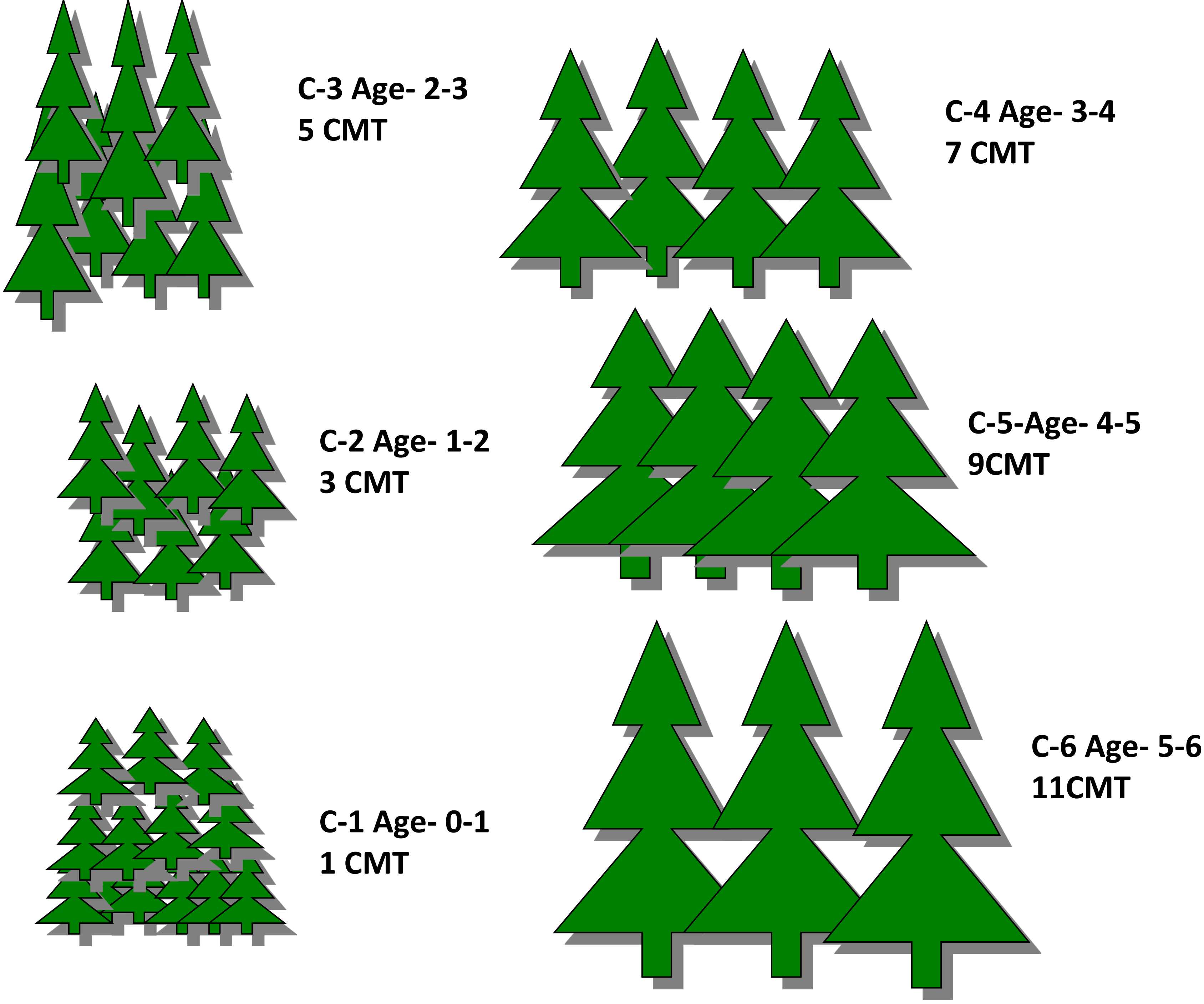
❖ Limitation

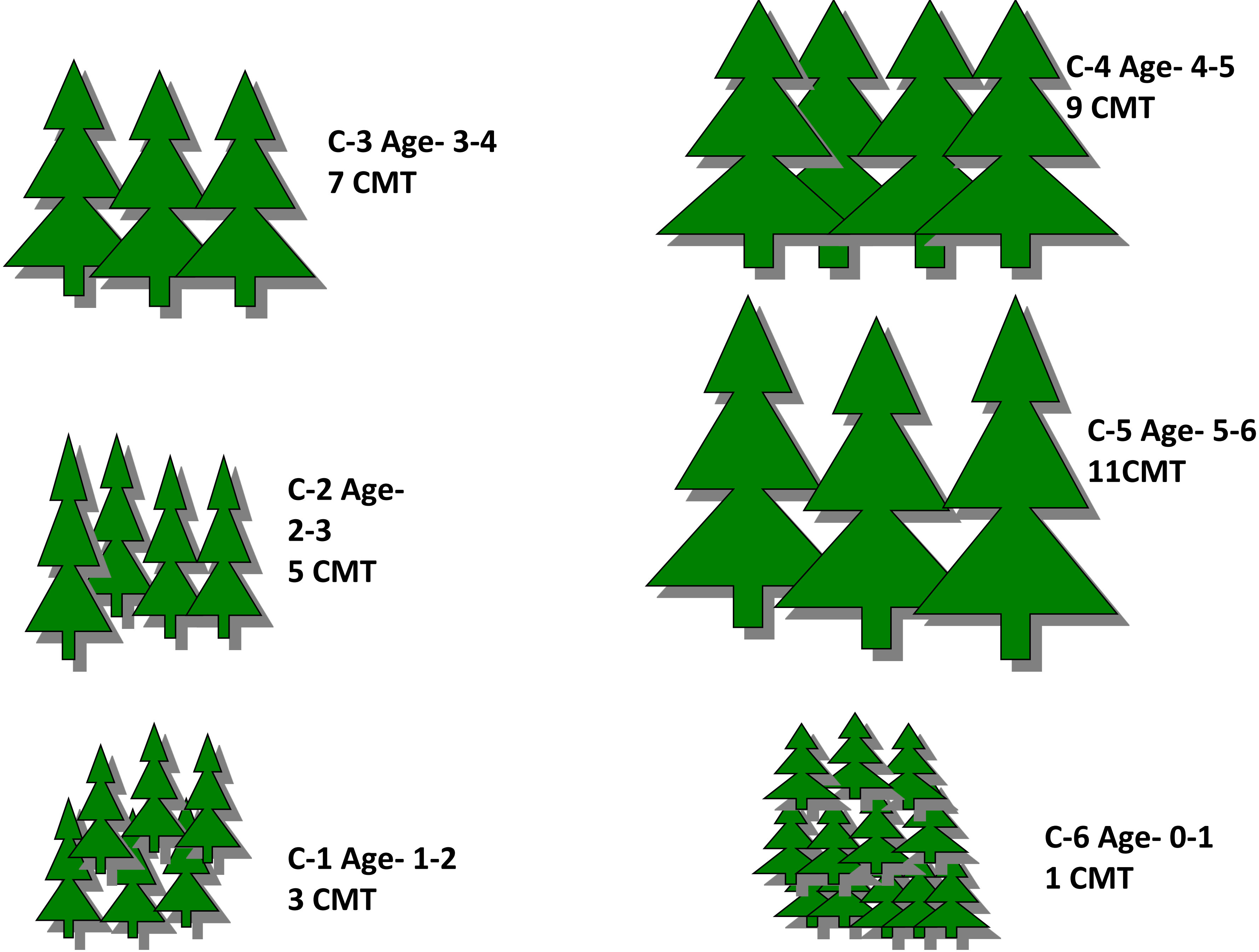
- Does not take into consideration the age class distribution.

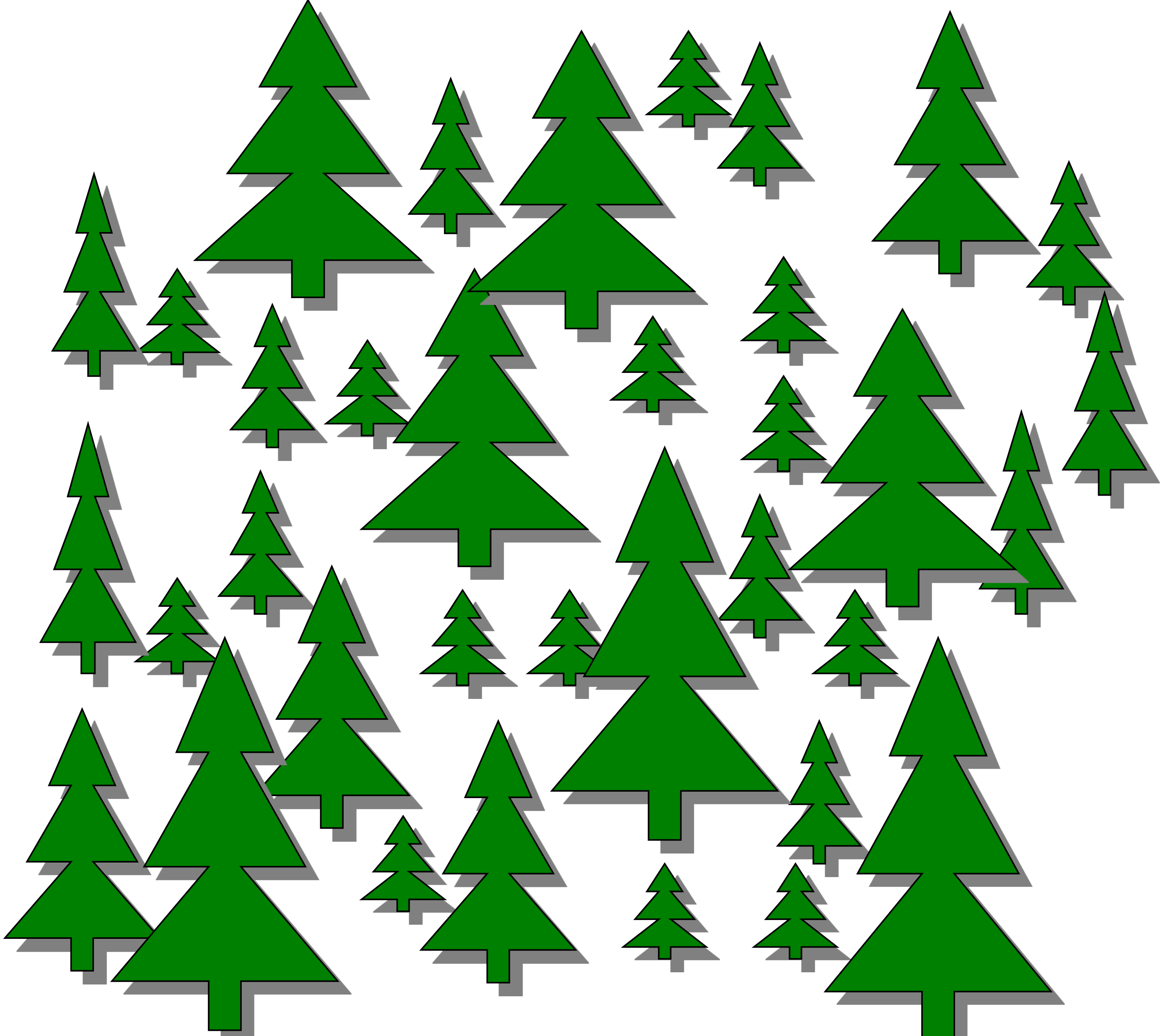
- It assumes that increment and normal GS are constant while both keep changing according to treatments given more so in irregular forest

Yield Regulation – Size Classes

- For selection forests
- For uneven aged and semi uniform forests
- Substitution of age classes with size classes


C-3 Age- 2-3
5 CMT
C-4 Age- 3-4
7 CMT
C-2 Age- 1-2
3 CMT
C-5-Age- 4-5
9CMT
C-1 Age- 0-1
1 CMT
C-6 Age- 5-6
11CMT

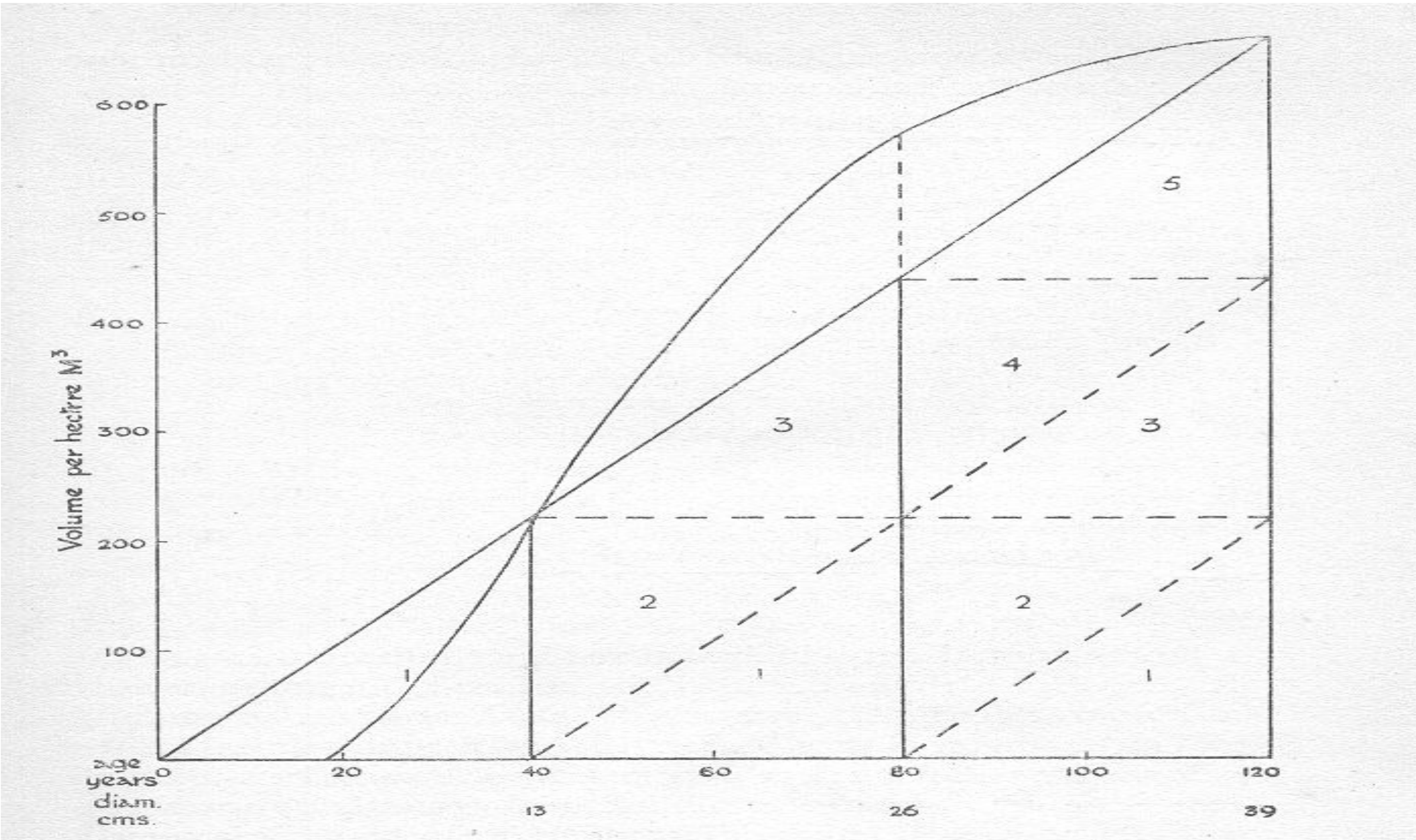

C-3 Age- 3-4
7 CMT
C-4 Age- 4-5
9 CMT
C-2 Age-
2-3
5 CMT
C-5 Age- 5-6
11CMT
C-1 Age- 1-2
3 CMT
C-6 Age- 0-1
1 CMT



D1.French Method of 1883 (Melard's formula)

- Three periods of rotation recoginised
  - Large wood
  - Medium wood
  - Small wood
- GS in 5:3:1 proportion
- Each comprising of 1/3rd of the forest area
- Large wood occupies 1/3rd of the rotation can be regenerated in 1/3rd of rotation
- Annual yield calculated based on Cotta's principle

French Method of 1883



Yield by Melard's formula

- AY = (Vol of large wood/one third rotation) + ½(annual increment on volume of large wood)
- Thinning is carried out in blocks other than the regeneration block
- Annual yield also includes thinning yield form medium and small wood
- AY = (Vol of LW/one third R) + ½(annual increment on LW) + 1/q (annual increment on MW)

Application

- Selection forest
- Irregular forests shelter wood system

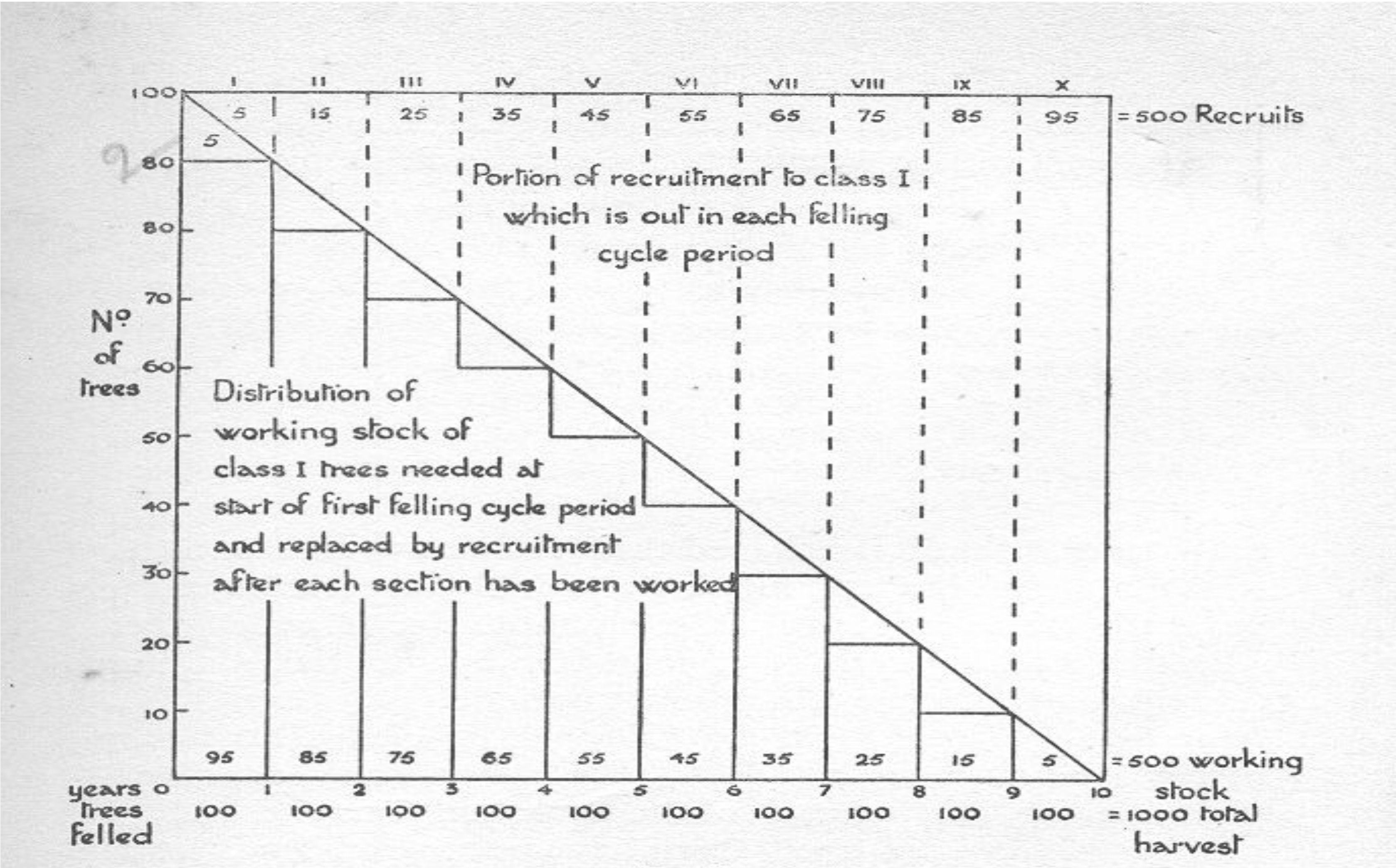
Brandis' Method

- A girth is fixed (exploitable) and only trees above the size are marked
- Number of trees in each dia class ennumerated
- Timing of passage from one dia class to another
- Casualty percentage of each dia class
- Felling cycle fixed

Increment and Yield

- Calculate average annual increment to Class I
- Yield = Average number of trees reaching exploitable size + Surplus trees of exploitable trees on the ground
- Surplus may be removed in one or more felling cycle

Working Stock



Cutting Cycle- 10 Years. 10 Annual Coupes. Average Annual Recuitment- 100 trees/ Annum. Each Coupe will have Recruitment of 10 trees per year

Coupe 1 **Year of Felling- 2013** **Time for Recruitment- 0.5 years** **Recruitment till felling- 5 Trees** **Working Stock Needed- 95 trees**	**Coupe 2** **Year of Felling- 2014** **Time for Recruitment- 1.5 years** **Recruitment till felling- 15 Trees** **Working Stock Needed- 85 trees**	**Coupe 3** **Year of Felling- 2015** **Time for Recruitment- 2.5 years** **Recruitment till felling- 25 Trees** **Working Stock Needed- 75 trees**	**Coupe 4** **Year of Felling- 2016** **Time for Recruitment- 3.5 years** **Recruitment till felling- 35 Trees** **Working Stock Needed- 65 trees**	**Coupe 5** **Year of Felling- 2017** **Time for Recruitment- 4.5 years** **Recruitment till felling- 45 Trees** **Working Stock Needed- 55 trees**
Coupe 6 Year of Felling- 2018 Time for Recruitment- 5.5 years Recruitment till felling- 55 Trees Working Stock	Coupe 7 Year of Felling- 2019 Time for Recruitment- 6.5 years Recruitment till felling- 65 Trees Working Stock	Coupe 8 Year of Felling- 2020 Time for Recruitment- 7.5 years Recruitment till felling- 75 Trees Working Stock	Coupe 9 Year of Felling- 2021 Time for Recruitment- 8.5 years Recruitment till felling- 85 Trees Working Stock	Coupe 10 Year of Felling- 2022 Time for Recruitment- 9.5 years Recruitment till felling- 95 Trees Working Stock

Working Stock

- Trees of exploitable size on the ground to enable the annual recruitment to exploitable size of the whole forest to be cut from a portion of the area each year
- Number of exploitable trees equal to half the annual recruitment rate will be required as working stock
- Working Stock= Recruitment x ½ of FC

Brandis' Method

- Flexible
- Suitable for mixed selection forests
- Enumeration can be done on broad dia classes – more practical
- Number of trees can be converted into volume if volume table exists
- Periodic enumeration could be expensive
- Calculating survival coefficients accurately is difficult
- In mixed forests obtaining regeneration of principle species may be difficult

Calculate Yield if Rotation 100 years, Felling cycle 20 years

Class	Dia class (inches)	No of trees	Age in years	Years in Class	Survival % to Class I	Net Harvestable Trees
I	□20	15000	88	-	95	13500
II	16 – 20	12250	74	14	80	9800
III	12 – 16	27000	56	18	60	16200
IV	8 -12	60000	32	24	40	24000
V	4 - 8	88000	16	16	20	22000

Annual Yield

Recruitment into Class I = 72000 in 72 years

Annual Recruitment = 1000 trees

Working Stock = 10000 trees

Surplus = 3500 trees

Yield = 1000 + (3500/20)

= 1175 trees

Annual Yield
(Recruitment during first FC only)

Recruitment into Class I = 15200 in 20 years

Annual Recruitment = 760 trees

Working Stock = 7600 trees

Surplus = 5900

Yield = 760 + (5900/20)

= 760 + 295 = 1055

Data requirement for Brandis Method

- Number of Class I II III IV trees
- Transition Period
- Survival Percentage till in Class I
- Working Stock
- Surplus of Class I trees
- Adjustment Period

Merits

- Based on Silviculture Requirements
- Suitable for tropical forest to be worked under Selection Felling
- Enumeration in Broad dia class

De-Merits

- Repeated enumeration
- Survival coefficients mere guesswork
- Complex and error prone
- Requires large data
- Natural Regeneration- based on chance

Calculate Yield if Rotation 160 years, Felling cycle 32 years- Burma

Class	Girth class (ft)	No of trees	Age in years	Years in Class	Survival % to Class I	Net Harvestable Trees
I	> 7	31523	156	-	95	29947
II	6-7	18114	130	26	85	15397
III	4.5-6	42768	93	37	70	29938
IV	3-4.5	101737	60	33	50	50869
V	1.5-3	150910	31	29	25	37728

Annual Yield

Recruitment into Class I = 133932 in 125 years

Annual Recruitment = 1071 trees

Working Stock = 1071 x 32/2= 17136 trees

Surplus = 12811 trees

Yield = 1071 + (12811/32)

= 1471 trees

Annual Yield
(Recruitment during first FC only)

Recruitment into Class I

Recruitment from Class II- 15397

Recruitment from Class III= 29938 x 6/37= 4855 trees

Total Recruitment = 15397+4855= 20252 in 32 years

Annual Recruitment = 633 trees

Working Stock = 10126 trees

Surplus = 19821

Yield = 633 + (19821/32)

= 633 + 619 = 1252 Trees

Smythies Safeguarding formula

Smythies Safeguarding formula

- There is a tendency to consider anything above the exploitable size as surplus which leads to depletion of GS – needs to be avoided

Smythies Safeguarding formula

- Basic assumption
  - Trees above exploitable dia exist in the forest
  - Basic object of management is sustained yield
  - Middle aged and younger age classes are well represented
  - Sustained Yield is safeguarded if number felled = number recruited

Calculation of yield

- Determine felling cycle
- FS is divided into annual coupes
- Determine exploitable size
- Enumeration to find out trees in different dia classes
- Determine the % of pre exploitable class that reaches exploitable size

Increment

- The recruitment from Class II to Class I per ha = X = f/t (II – Z% of II)
    - f is the felling cycle
    - t is the time taken by Class II trees to pass into Class I
    - Z% is the % of Class II trees that do not pass into Class I
- Number of trees to be removed (Yield) should be less than ‘X’

Annual Yield

- Annual Yield = X (Area of annual coupe)
- Yield is prescribed in percentage of trees of Class I (N)
- N = I + (X/2)
- Annual yield = (X /N) 100

  = [X/(I + (X/2)] . 100

- With this another factor “A” is included
- $AY = [X/(I + (X/2)] . 100 + A$

Value of the factor ‘A’

- Class II trees in small number and Class I large and deteriorating, then A is +
- Calculated % may not be available, then A is –
- Proportion of Class I is too low, then – value is given to A
- Class III and IV may not be well represented and a likely drop in Class I in future, A is –

Limitations

- Determination of ‘t’ and ‘z’ is difficult
- Factor ‘A’ is arbitrary
- Yield is bound to vary with the number of trees that move into Class I
- If Class I is 0, then yield is 200 % of N.
- If Class I is too large, then yield will be very small and large number of trees would deteriorate
- If Class I = x/2, then yield will be 100 % of N, a impractical situation
- Applicable only when I > x/2

Calculate annual yield if exploitable dia is 50cm, FC is 25 years

- No of Class I trees = 7804
- No of Class II trees = 16677
- t is 50 years
- Z is 33.33 %

Annual Yield

X = 25/50 (16677 – 33.33% of 16677)

= 5559

Y = 5559/[7804+(5559/2)] . 100 + A % of N

= 52 + A % of N

= 50% of N

One in two trees above exploitable dia will be marked for regeneration felling

WP-2012-2022 Yavatmal FD- Sh GRK Rao IFS

Class	Girth class (cm)	No of trees/ha	Years in Class	Survival % to Class I	Net Harvestable Trees
I	> 76	29.41	-	-	29.41
II	61-75	26.68	20	65	17.34
III	46-60	36.91	14	47	17.35
IV	31-45	42.19	12	41	17.30
V	16-30	39.59	10	44	17.42
	Total	174.78			69.41

Annual Yield

Recruitment into Class I = 69.41 in 56 years

Annual Recruitment = 1.24 trees per ha

Working Stock = 1.24x 20/2= 12.4 trees

Surplus = 27 trees

Yield = 1.24 + 27

= 28.24 trees

WP Chakrata Forest Division Fir and Spruce WC- 2007-2017

Class	IV 40-50	III 50-60	II 60-70	I > 70 cm
No of Trees	35236	31329	18796	14907

Age	Dia
180	70
170	66
160	61.5
150	57

- From the data t = 23 years
- Felling Cycle= 10 years
- II- 18796 trees, I- 14907 trees
- Z was assessed as 1% each year- or 23 % for class II
- X= 10/23 x 18796 (1-0.23) = 6293
- Y = 6293 / (14907 + 6293/2) = 34.8 % +- A
- A was decided by WPO as -1.8 so Y = 33%
- One in three of Selection Trees

Working of Bamboos

- Bamboo working Circle may be an overlapping working circle or specific one.
- To assess the resource the sample plots 0.1 ha are laid out in forest blocks at random with pre determined sampling intensity.
- Two way sampling- (i) No of clumps per ha are calculated. (ii) Select the representative clumps and count the culms in each

- After calculating the number of culms per ha convert this figure to Weight
- Either the thumb rule in the state can be used or FSI figures or Experimental weighing and determination of weight per bamboo
- Culm Selection System or selectively thinning of culms
- Felling cycle – 3 to 4 years
- Yield is regulated by area

Sal Irregular Shelterwood System

- Ram Nagar Forest Division- WP- 2008-2018 by A. K. Mahar, SFS
- 3 Periodic blocks-
- PBI- Mature trees:- PB 1A- Advanced regeneration present; PB 1B- ANR
- PB II- Middle Aged trees and all areas exept in PB1 and PB 3
- PB 3- Younger Trees – 3 A- Naturally regenerated areas and 3 B Artificially regenerated

Ram Nagar WP

- No equalisation of area was attempted
- The area is having large proportion of higher age classes
- Rotation- 150 years,
- The trees having more than 50 cm dia only to be felled.
- Total area of FS= 9216 ha PB 1= 1464 ha then period = (1464/9216)x 150 = 23.83
- Yield by Cotta's formula ignoring the increment

Ram Nagar WP

- Total GS in PB 1 223245 CMT for trees more than 50 cm dia then the annual yield will be 223245/23.83= 9368 CMT
- The trees will only be felled if the regeneration is fully established.

Teak and Sal Selection cum Improvement WC

- East Mandla Forest Division 1999- 2009 M. K. Sinha, IFS
- Exploitable girth for Teak- 120 cm
- Teak

Girth Class	Trees /ha	Time in class	Mortality	Class
61-90	13.41	30	40	III
90-120	12.47	60	35	II
> 120	9.76	-	-	I

East Mandla

- X2= 30/30(1-0.4)x 13.4 = 8 trees per ha
- X1= 30/60(1-0.35) x 12.5 = 4 trees per ha
- Y1= 34% and Y2= 48 %
- So the marking rule is one in three trees

East Mandla

- Sal Rotation – 150 years
- Felling Cycle- 20 years
- Exploitable girth- 120 cm

Girth Class	Trees /ha	Time in class	Mortality	Class
61-90	59.06	30	40	III
90-120	12.47	60	35	II
> 120	9.76	-	-	I

East Mandla

- X2= 20/30 x (1-0.6)x 59.06 = 24
- X1= 20/60 x (1-0.35) x 44.12 = 9.6
- Y1= 51.69 %
- Y2= 42.16 %
- Since attacked by Sal borer the WPO fixes as 100 % subjected to Von Mantel's yield regulation formula.