Stand prediction

in

Un-Even aged or mixed species stand

Stand prediction

in

Even aged single species stand

Yield table…

Yield Table

Definition

Tabular statement

- Summarizes on unit area basis
  - all the essential data relating to the development **at periodic intervals**

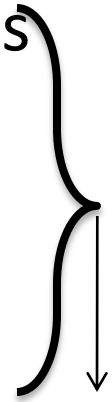
    of a **fully-stocked** and **regularly thinned , even aged crop**
- Not applicable to uneven aged forest (Natural Forests)

Purpose :

a) Determination of volume and increment of woods

b) Determination of the qualities of locality

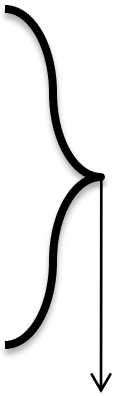
c) Forecasting of yield of forests



Volume yield table

a) Deciding the most profitable species ,

b) Determination of value of growing stock



Money yield table

TABLE 12

Shorea robusta, SQ I Top Height 40-30 m at 80 years

crop age	Main Crop									Thinning			Final Yield			Accumulated yield of thinnings			Total yield			m.a.i.		c.a.i.		crop age
	Average dia	Average height	Total BA	No of trees	Stem Timber Form Factor	Total small wood form factor	Standing volume stem timber	Standing volume total small wood	Total standing volume	Stem Timber Volume	Total small wood volume	Total volume stem timber and small wood	Stem Timber Volume	Total small wood volume	Total volume stem timber and small wood	Stem Timber Volume	Total small wood volume	Total volume stem timber and small wood	Stem Timber Volume	Total small wood volume	Total volume stem timber and small wood	Stem Timber Volume	Total volume stem timber and small wood	Stem Timber Volume	Total volume stem timber and small wood	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
10	8.1	8.8	6.2	118	0.000	0.485	0.0	26.6	26.6	0.0	1.4	1.4	0.0	28.0	28.0	0.0	1.4	1.4	0.0	28.0	28.0	0.0	2.8	0.0	0.0	10
15	11.4	12.2	8.7	855	0.000	0.480	0.0	51.1	51.1	0.0	4.9	4.9	0.0	56.0	56.0	0.0	6.3	6.3	0.0	57.4	57.4	0.0	3.8	0.0	5.9	15
20	14.2	14.9	11.2	712	0.008	0.425	1.4	71.4	72.8	0.0	9.8	9.8	1.4	81.2	82.6	0.0	16.1	16.1	1.4	87.5	88.9	0.1	4.4	0.3	6.3	20
25	16.8	17.4	13.5	610	0.054	0.360	12.6	84.7	97.3	0.0	14.7	14.7	12.6	99.4	112.0	0.0	30.8	30.8	12.6	115.5	128.0	0.5	5.1	2.2	7.8	25
30	19.6	19.5	15.8	531	0.097	0.306	30.1	94.5	124.6	1.4	18.9	20.3	31.5	113.4	144.8	1.4	49.7	51.1	31.5	144.1	175.6	1.0	5.9	3.8	9.5	30
35	22.1	21.0	18.1	472	0.139	0.257	53.2	98.0	151.1	3.5	23.1	26.6	56.7	121.1	177.7	4.9	72.8	77.7	58.1	170.7	228.8	1.7	6.5	5.3	10.6	35
40	24.6	22.9	20.0	420	0.178	0.218	81.2	99.4	180.5	6.3	25.9	32.2	87.5	125.3	212.7	11.2	98.7	109.9	92.4	198.0	290.4	2.3	7.3	6.9	12.3	40
45	26.9	24.4	21.6	378	0.211	0.188	111.3	98.7	209.9	10.5	28.7	39.2	121.8	127.3	249.1	21.7	127.3	149.0	132.9	226.0	359.0	3.0	8.0	8.1	13.7	45
50	29.2	25.9	23.2	346	0.235	0.161	141.3	96.6	237.9	14.7	30.1	44.8	156.0	126.6	282.7	36.4	157.4	193.8	177.7	254.0	431.7	3.6	8.6	9.0	14.6	50

Contents of Yield Table

- Main crop
- Thinning
- Final Yield
- Accumulated Yield of Thinning
- Total Yield
- M.A.I.
- C.A.I.

Site quality wise,

Per unit area basis

At intervals of 5 or 10 years

MAIN CROP

i. Average diameter

ii. Average height

iii. Total basal area

iv. Number of trees

v. Stem timber form factor

vi. Standing volume stem timber

vii. Standing volume total small wood

viii. Total standing volume, i.e. stem and small wood

THINNING

i. Volume stem timber

ii. Volume total small wood

iii. Total volume

How to read from Yield Table…

- **Main crop**

8) Standing volume stem timber

9) Standing volume total small wood

10) Total standing volume = (8) + (9)

- **Thinning**

11) Stem timber volume

12) Total small wood volume

13) Total volume(stem timber + small wood) = (11) + (12)

- ***FINAL YIELD***
  i. Volume stem timber
  ii. Volume total small wood
  iii. Total volume
- ***ACCUMULATED YIELD OF THINNING***
  i. Volume stem timber
  ii. Volume total small wood
  iii. Total volume
- ***TOTAL YIELD (final yield of that yr + accumulated thinning yield till previous yr)***
  i. Volume stem timber
  ii. Volume total small wood
  iii. Total volume

How to read from Yield Table…

- **Final yield**

  14) Stem timber volume = (8) + (11)

  15) Small wood volume = (9) + (12)

In a particular year,

Final Yield from forest = (14) + (15)

- **Total yield** = (20, 21, 22)

  final yield of a particular year

  +

  accumulated thinning yield till previous year

- ***MEAN ANNUAL INCREMENT***

  i. Volume stem timber

  ii. Total volume

- ***CURRENT ANNUAL INCREMENT***

  i. Volume stem timber

  ii. Total volume

M.A.I. = total yield / age

- **Primary data**
  - All volumes (yield)
- **Secondary data**
  - Crop averages for dia, ht,
  - no. of stems per unit area
  - crop basal area
  - form factor
  - M.A.I. and C.A.I.
- **Additional information**
  - Top ht by site quality and age

Types of Yield tables

1. Based on thinning

   a) Single Yield Table

      - for one grade of thinning,
      - usually C - Grade

   b) Multiple Yield Table

      - for different grades of thinning

2. Based on out put

a) Volume Yield Table

- Out turn expressed in terms of vol.

b) Money Yield Table

- Out turn expressed in terms of money
- Prepared from Vol Yield Table

Applications and Uses of Yield Table

- Prior knowledge of following is required to use the yield table:-
  - **Site Quality**
  - **Crop Age or Crop Dia**
  - **Stand density** : From Basal area
    - Comparing it with the B.A. given in the Yield Table for the age and quality of the stand

Applications and Uses of Yield Table

1. Determination of site quality or Fractional site quality
2. Estimation of Total Yield or Growing Stock

   at present age
3. Determination of increment of the stand
4. Determination of rotation
5. Guide to Silvicultural Thinning

1. Determination of site quality or Fractional site quality

Method 1 (Top height method) :

i. Ht of some dominant trees measured (Top ht)

ii. Age is obtained either from records or from field methods

iii. Table of top ht by site quality and age is referred

If table is not given then:-

i. Site quality curves (Age ~ Top ht) available for different site quality classes

ii. The point corresponding to the top ht and age as measured is located and quality class within which it falls is determined.

iii. Site quality or fractional site quality can also be determined from the table directly instead of plotting site quality curves

Method 2 - (By Plotting Dia vs Height Curve) :

- Steps
  - Lay a Representative Sample plot
  - Get data for plotting **ht vs dia** curve
  - If data for all dia class is not available go out side the sample plot to get the data
  - Plot **ht vs dia** curves for various site qualities
  - Overlay the field data curve with the site quality curves (yield table) to see the site quality

2. Estimation of Total Yield or Growing Stock at present age

- **Age** of the stand, site quality determined.
- Growing stock or total yield read against the age from the yield table.
- For ages not exactly decade or half decade, yield is worked out by simple rule of proportion.
- In absence of information on age, the **crop dia** is considered for reference.

Total yield of the stand

= (yield as calculated from yield table)
X
(area of the stand)

- then corrected for density of stand

3. Determination of increment of the stand

- Age and site quality determined.
- Increment = (C.A.I. for the age)

$\times$ (Area of the stand)

$\times$ (stand density)

$\times$ (period of years for which increment required)

➢ Stand density 0.8, area 10 ha, age 40-45 years, increment ?

– CAI is 12.3 m^3

⟶ Increment = 12.3 x 10 x 5 x 0.8 = 492 m^3

Increment in under-stocked stand

$$I \propto \text{stand density}$$

$$I_r = I \times d$$

I_r : Increment of under-stocked stand

I : Increment of normal stand.

d : Ratio of actual basal area to normal basal area

In understocked forests –

- growth is faster due to availability of more space
  - increment is not proportional to density

Increment = (i) normal rate of growth

+

(ii) additional growth because of additional growing space available

i. Normal growth element $\longrightarrow$ $\mathbf{I_{r1}} = I \cdot d$

ii. Additional growth :

$$\mathbf{I_{r2}} = (1 - \text{stand density}) \times I_{r1}$$

$$= (\text{equivalent to deficiency in stocking}) \times I_{r1}$$

$\Rightarrow$ $\mathbf{I_r = I_{r1} + I_{r2}}$ (For tolerant or shade bearing species)

- For light demanding species

  -- gain in density is less

  -- Additional growth is 70% of that for shade bearing species

So $\mathbf{I}_r = I.d + (1- d).I.d.\mathbf{k}$

where,

I : Increment of normal stand

d : density of under stocked stand

k : constant depending on shade tolerance of the species

4. Determination of rotation

Rotation : maximum volume production:

- Age at which M.A.I. culminates

Q. Stand density of Sal forest at Timali block is 0.8. Considering this as even aged forest of SQ I, Calculate the increment per ha for the age between 30 yrs & 40 yrs.

From YT :

Total yield at 30 yrs = 175.6 cu m

Total yield at 40 yrs = 290.4 cu m

Increment = 114.8 cu m

For forest in Timali :

Increment, $\mathbf{I_{r1}}$ = I . d = 114.8 * 0.8 = 91.84 cu m

$\mathbf{I_{r2}}$ = (1 - stand density) x I_{r1} = (1 - 0.8) x 91.84 = 18.36

Total increment = $\mathbf{I_{r1} + I_{r2}}$ = 91.84 + 18.36 = 110.2 cu m

5. Guide to Silvicultural Thinning

Figures in Yield Table

- rough guide to check marking of thinning in field

- For Thinning :
  - Stocking is important
    - Basal Area per ha
  - Thinning starts when a stand reaches full stocking

Steps :

i. Lay sample plots
ii. Measure dia of all trees and prepare a dia- class frequency table
iii. Calculate basal area & Crop diameter
iv. Overstock or Understock ?
v. Thinning if Overstock
vi. Remove excess stems

Methods of removing excess stems :

a) Silviculturally

b) Spacement table

c) Stand table

(b) Spacement Table

- by crop age and site qualities (p.no. 127)
- by crop dia and site qualities (p.no. 128)
  - ✓ Silvicultural thinning marked according to table of spacement

– For a check - no. of trees/ha and av. crop dia left after marking the thinning determined for a representative area and compared with yield table main crop no. of trees/ha for same av. dia and quality.

c) STAND TABLE

- Distribution of stems by dia classes for each of the series of crop diameter
- Trees per unit area under different dia class

Given in following form:

- % of trees in a given dia limit of various crop dia

(p.no.-130)

TABLE 22

Shorea robusta

Stand Table (Main Crop) Showing the percentage of trees in a given diameter limit in crops of various diameters

Diameter limit cm	Average crop diameter in inches																							Diameter limit cm
	5	8	10	13	15	18	20	23	25	28	30	33	36	38	41	43	46	48	51	53	56	58	61	64	
	Percentage																								
2.5	5.0	1.0																							2.5
5.0	56.0	23.0	8.0	2.0	1.0																				5
7.5	35.5	46.0	30.0	15.0	5.0	2.0	1.0																		7.5
10.0		25.0	35.0	27.0	17.0	8.0	3.0	2.0	1.0																10
12.5		4.0	20.0	30.0	24.0	18.0	10.0	5.0	2.0	2.0	1.0														13
15.0			5.5	17.0	24.0	20.0	16.0	10.0	6.0	2.0	1.0	1.0													15
17.5			1.0	6.5	17.0	22.0	18.0	15.0	11.0	7.0	3.0	2.0	1.0	1.0											18
20.0				1.5	8.0	15.0	19.0	16.0	14.0	11.0	8.0	4.0	3.0	1.0	1.0										20
22.5					2.5	9.0	15.0	17.0	14.0	13.0	10.0	7.0	4.0	3.0	2.0	1.0	1.0								23
25.0					1.0	3.5	9.0	14.0	16.0	14.0	13.0	11.0	8.0	5.0	3.0	2.0	1.0	1.0							25
27.5						1.5	5.0	9.0	13.0	14.0	13.0	12.0	10.0	8.0	5.0	3.0	2.0	1.0	1.0	1.0					28
30.0						0.5	2.0	6.0	9.0	12.0	13.0	12.0	11.0	10.0	9.0	6.0	3.0	2.0	1.0	1.0	1.0				30
32.5							1.0	3.0	6.0	10.0	12.0	13.0	12.0	10.0	9.0	8.0	6.0	4.0	3.0	1.0	1.0	1.0	1.0		33
35.0							0.5	1.5	4.0	6.0	9.0	11.0	12.0	12.0	10.0	10.0	8.0	6.0	4.0	3.0	1.0	1.0	1.0	1.0	35
37.5								0.5	2.0	4.0	6.0	9.0	11.0	11.0	11.0	9.0	10.0	7.0	7.0	4.0	3.0	2.0	1.0	1.0	38
40.0								0.5	1.0	2.0	5.0	6.0	9.0	10.0	11.0	11.0	9.0	10.0	7.0	6.0	5.0	3.0	2.0	1.0	40
42.5									0.5	1.5	2.5	5.0	6.0	9.0	10.0	11.0	11.0	9.0	9.0	8.0	6.0	5.0	3.0	2.0	43
45.0										0.5	1.5	3.0	5.0	7.0	9.0	10.0	10.0	10.0	10.0	9.0	8.0	7.0	5.0	4.0	45

Contd…

Dia meter limit cm	Average crop diameter in inches (Percentage)																							Dia meter limit cm
	5	8	10	13	15	18	20	23	25	28	30	33	36	38	41	43	46	48	51	53	56	58	61	64	
47.5										0.5	1.0	1.5	3.5	5.0	7.0	8.0	10.0	11.0	10.0	9.0	9.0	8.0	7.0	5.0	48
50.0											0.5	1.0	1.5	3.0	4.0	7.0	8.0	8.0	9.0	9.0	9.0	8.0	7.0	7.0	50
52.5												0.5	1.5	2.0	4.0	5.0	7.0	9.0	10.0	11.0	10.0	10.0	9.0	8.0	53
55.0												0.5	0.5	1.0	2.0	3.0	5.0	7.0	8.0	9.0	10.0	9.0	9.0	8.0	55
57.5													0.5	1.0	1.0	2.5	3.0	5.0	7.0	8.0	9.0	10.0	10.0	9.	58
60.0														0.5	1.0	1.5	2.5	4.0	5.0	7.0	8.0	9.0	10.0	10.	60
62.5															0.5	0.5	1.5	2.5	3.0	5.0	6.0	8.0	9.0	10.	63
65.0																0.5	0.5	1.0	2.5	3.0	5.0	6.0	8.0	8.0	65
67.5																0.5	0.5	1.0	1.0	2.5	3.0	4.0	5.0	8.0	68
70.0																	0.5	0.5	1.0	1.0	2.5	3.0	4.0	5.0	70
72.5																		0.5	0.5	1.0	1.0	2.5	3.0	4.0	73
75.0																			0.5	0.5	1.0	1.0	2.0	3.0	75
77.5																				0.5	0.5	1.0	1.5	2.0	78
80.0																					0.5	0.5	1.0	1.5	80
82.5																						0.5	0.5	0.5	83
85.0																							0.5	0.5	85
87.5																								0.5	88
90.0																								0.5	90

Note Figures below 5% have been read correct to 0.5 %

Extract of Stand Table

Extract of Stand Table

(Yield and Stand Table for plantation teak)

(Main crop)

Showing the percentage of trees above given diameter limit in crops of various diameters

Diameter limit in inches	Average crop diameters in inches															
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	73	96	99.5	100												
2	21	67	94	99	100	100										
3	2.0	22	63	90	98	99.5	100	100								
4		3	24	59	87	96	99	99.5	100							
5		0.5	5.0	26	59	85	94	98	99	100	100					
6			1.0	6	30	60	81	92	96	98.5	99.5	100				
7				1.5	9	34	58	77	90	95	98	99	100	100		
8				0.5	2.5	12	34	56	74	88	94	97	99	99.5		
9					0.5	4.5	13	33	54	72	87	93	96	98.5	100	100

Uses :

i. Mainly for thinning

ii. Determination of financial values of crop

iii. Preparation of Money Yield Table.

Money Yield Table

Objective : To determine the financial rotation

- Vol yield of Yield Table is converted to money yield
- Money yield values divided by age give net value increment per ha

➢ These values plotted over age –

⟶ Culmination point of this curve

↓

Rotation of max. net income

Point Sampling

Point Sampling

- Sampling unit can be of 2 types :
  1. Plot sampling
  2. Point sampling
     i. Horizontal sampling
     ii. Vertical sampling

Point sampling

- Basal area expressed in – m^2
- Land area expressed in – Ha

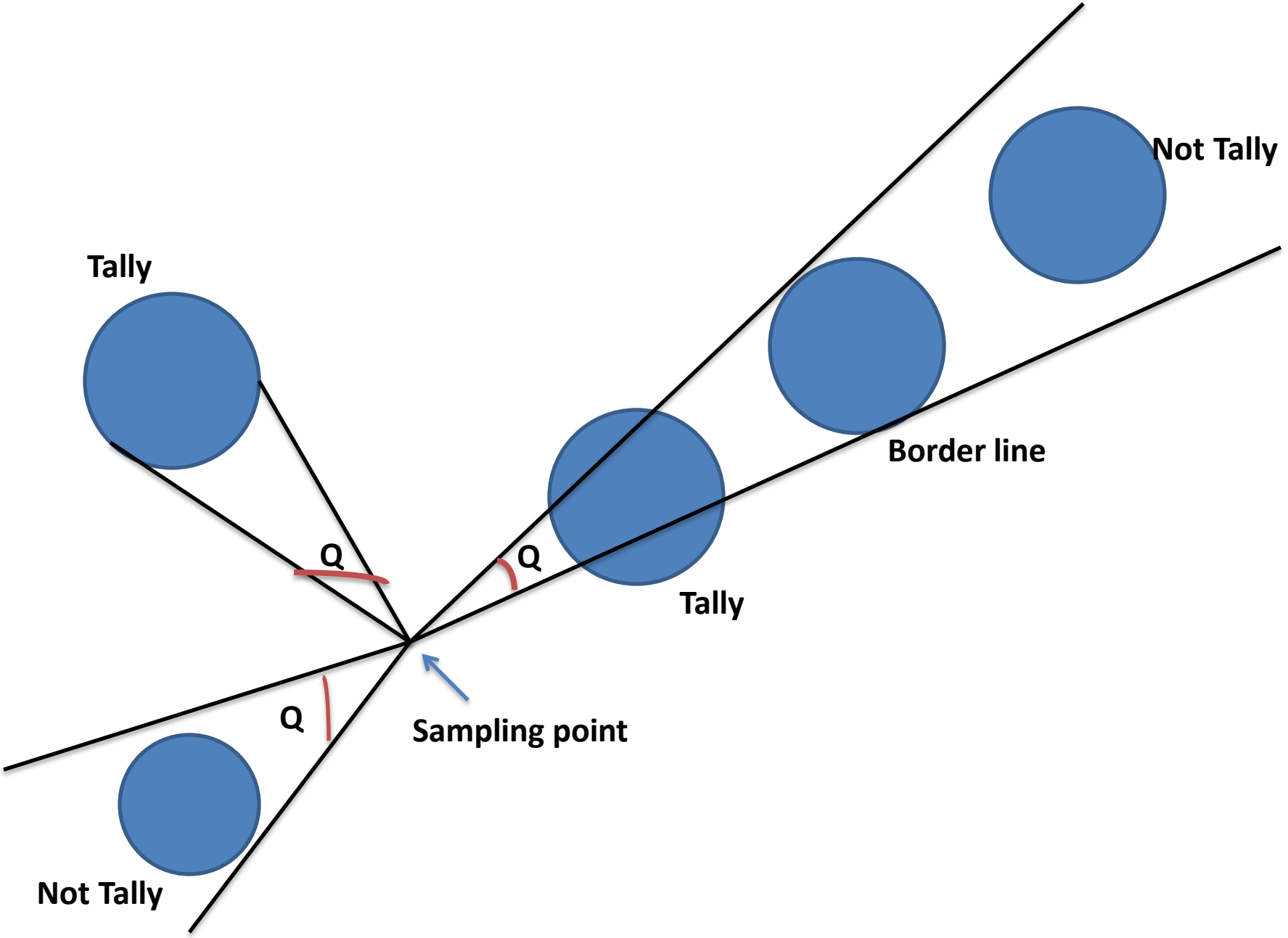
  (1 Ha = 10000 m^2)

(Basal area / land area) is dimensionless quantity

- Known as **Basal Area Factor (BAF)**
- **Counting from random point, the no of trees whose breast height X-section exceeds a certain critical angle, when multiplied by a constant factor(BAF) gives an unbiased estimates of basal area per Ha**

Horizontal point sampling

- Series of sampling points are selected either randomly or systematically
- Sampling points distributed over entire area
- Trees around this point are viewed at breast height through any angle gauge
- All trees forming an angle bigger than the critical angle of the instrument are counted


Not Tally
Tally
Border line
Q
Q
Tally
Q
Sampling point
Not Tally

- Inclusion of trees in tally depends upon
  - sizes of trees
  - Distance from the observer or sampling point
- Number of trees counted multiplied by a constant factor which is dependent only on the size of angle, gives basal area per Ha
- It can be used to compute the basal areas, volumes and number of trees per unit area

- Basal area per Ha = no of trees tallied X BAF

  (BAF : Basal Area Factor)

- Volume per Ha = Basal area X stand Height

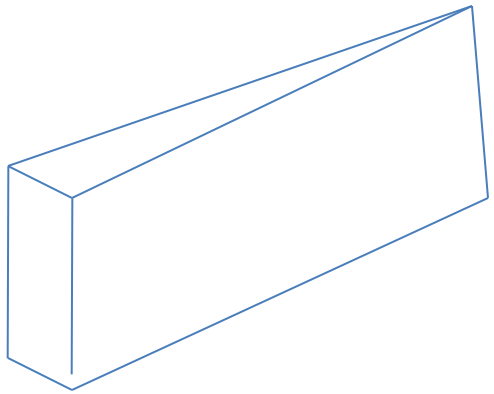
- No of trees per Ha

  = BAF / (total basal area of Tally trees)

Instrument used in Horizontal Point Sampling

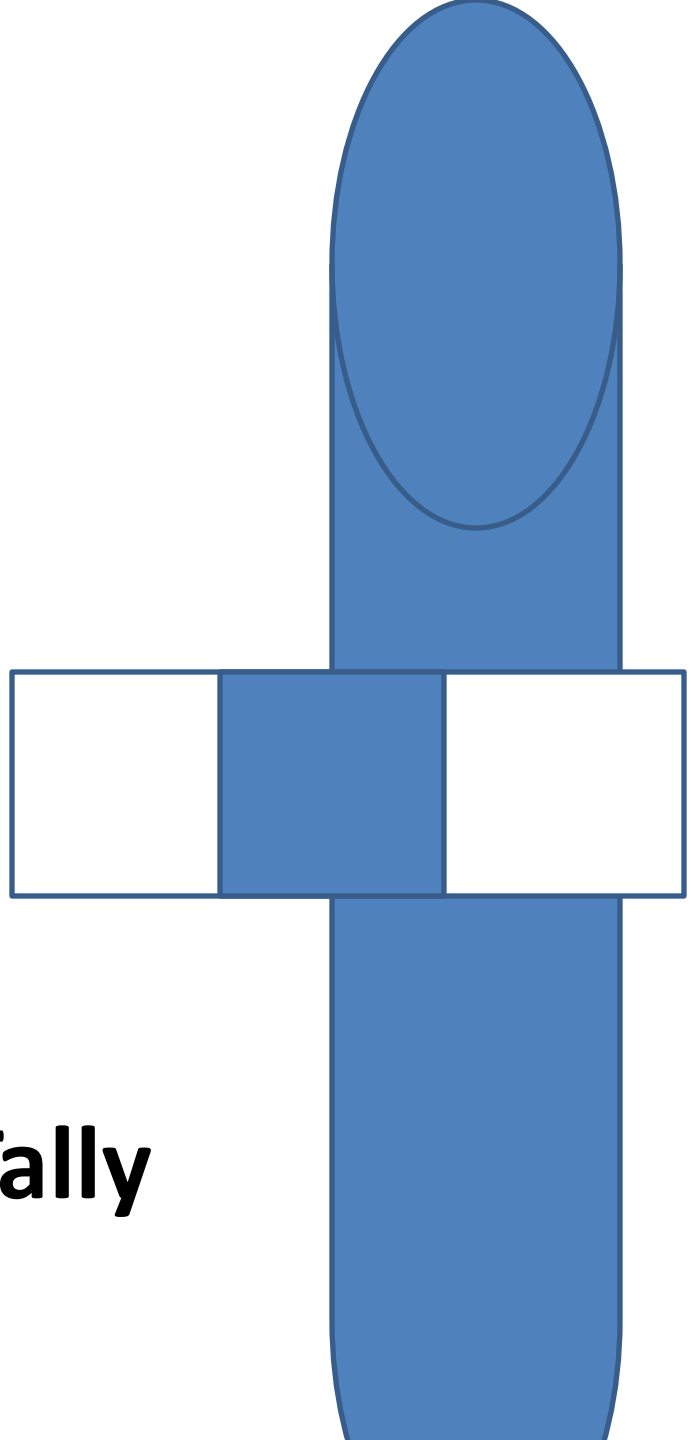
- Wedge Prism
  - Wedge shaped piece of glass
  - Rays of light passing through prism bent depending upon their critical angle
  - while standing , Trees are viewed holding the wedge prism in hand
  - Prism to be kept in vertical position
    - Right angle to the line of sight
  - Breast height is then viewed through prism and directly from above it
  - Distance between the eye and the prism is immaterial

WEDGE PRISM

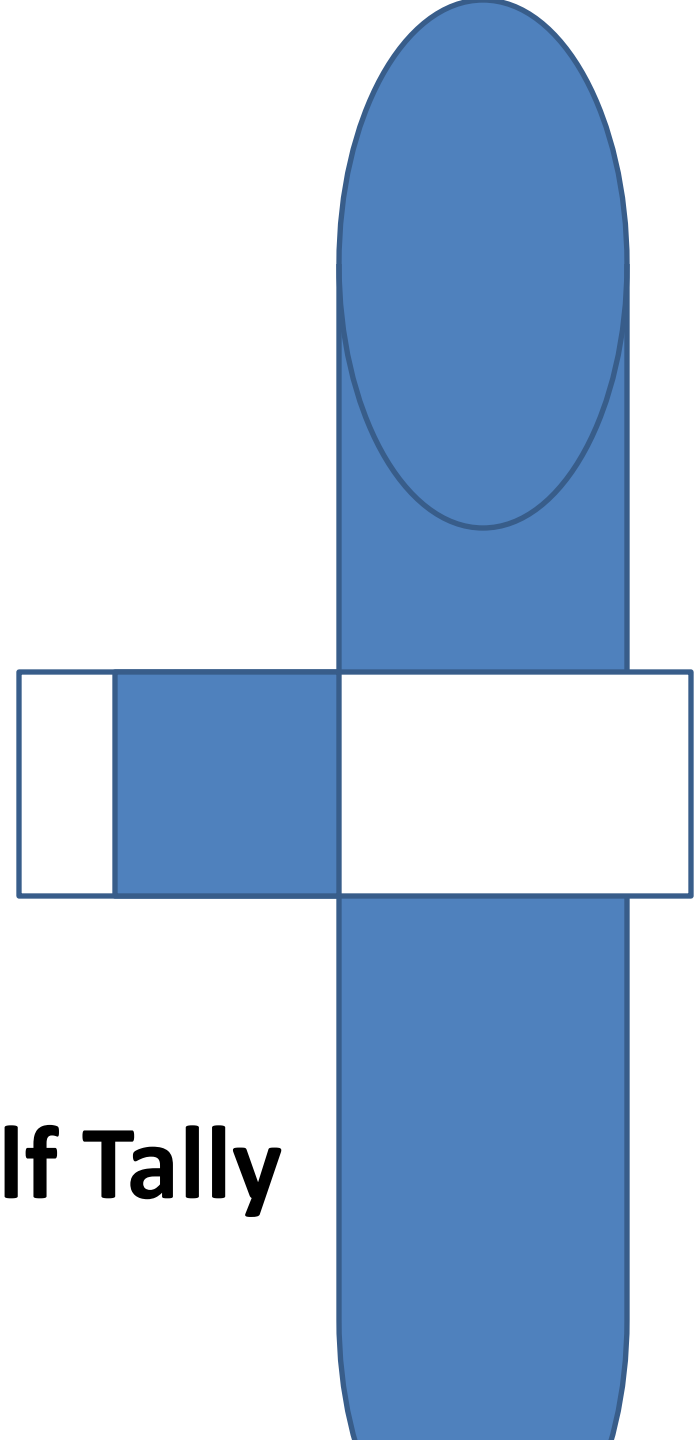


- Image of trees follow following 3 conditions:

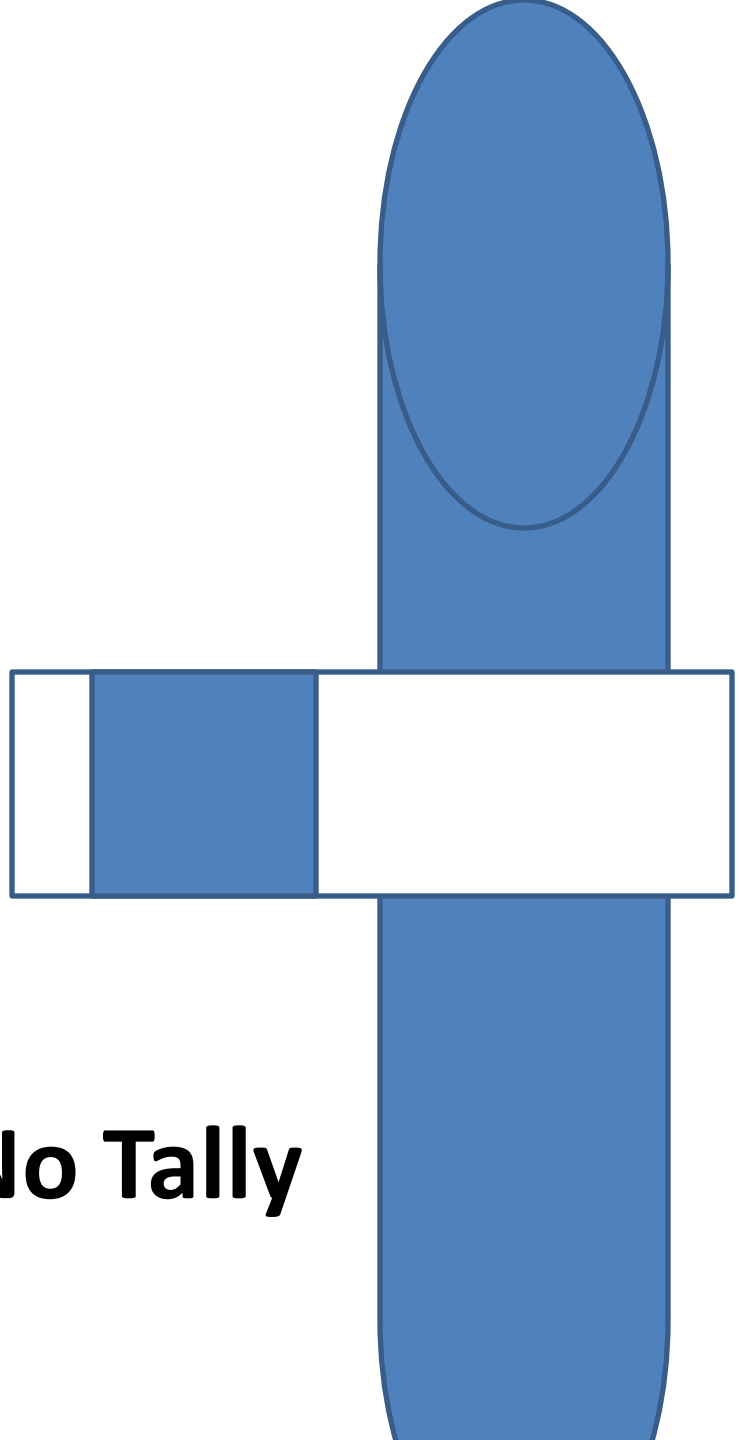
1. Overlap - Full Tally
2. Just touch - Half Tally
3. Separated from tree stem - No Tally



Tally



Half Tally



No Tally

- Full sweep of 360˚is taken
- Note all full and half Tallies
- Take reading at 2 -3 sample points
- Full tallies then counted as - 1
- Half tallies counted as - 0.5
- Total tallies multiplied with BAF to get BA per Ha

CAUTION

- Prism to be held vertically above the sample point
- Each tree is sighted at the b.h. through the prism
- Line of sight should be perpendicular to the prism
- The distance between the prism and the eye should be convenient
- If the prism is not perpendicular to the line of sight it results in fewer tallies.
- If the prism is tilted in the vertical plane - too many tallies

Factors Affecting Accuracy

- Dense stands
  - Difficult sighting - a place higher than the breast height can be sighted - if it tallies then the tree is taken as tallied.
- Slope correction
  - Up to 15% not necessary
- Trees leaning to left or right - The Wedge Prism should be rotated so that the vertical axis of the prism is parallel to the axis of the leaning tree

DOUBTFUL TREES

- Missing (hidden) trees - The cruiser can sway from side to side.
- Double counting trees - Double counting to be avoided.

Computations from point sampling

1. Basal Area per ha / acre

   – No. of full tallying trees = n_1

   – No. of half tallying trees = n_2

   Therefore no. of tallies, **$n = n_1 + (n_2/2)$**

   → **B.A. per ha = ($n \times$ B.A.F.)**

2. No. of trees per ha

a) No of trees (stems) per ha

$$N = BAF \times (1/ \Sigma(BA)_i)$$

=(BAF of the prism / Total basal area of tally trees)

b) No. of trees per ha in a particular dia class

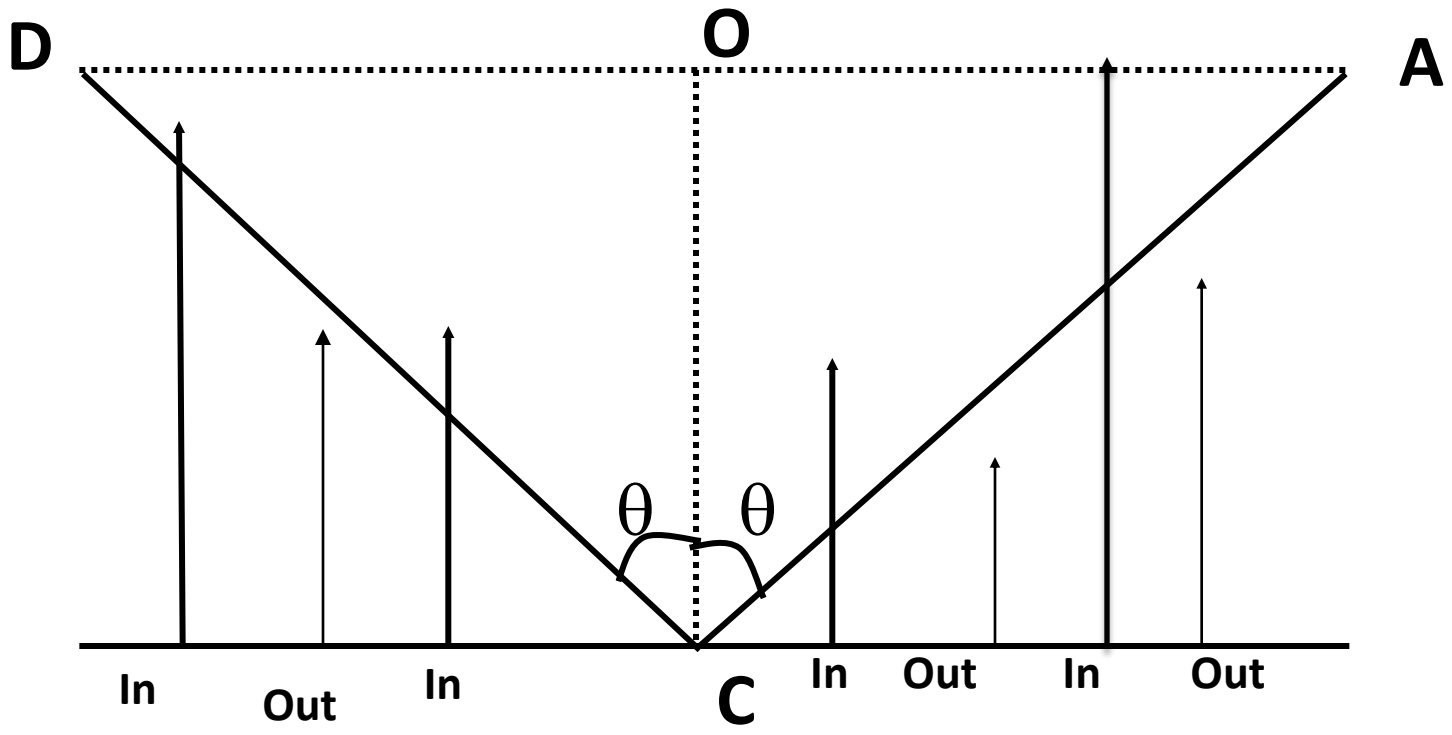
$$= \left[\textbf{BAF x } \frac{\textbf{1}}{\textbf{(no of trees) x(Basal area of the mid point of the dia class)}} \right]$$

Volume per ha / acre

V = (B.A. per ha / acre) $\times$ (Stand Form Height)

Vertical Point Sampling

- Developed by Hirata (Japanese Forester)
- Helps determining the mean stand height



θ : critical angle

n : no of trees tallying

N : no of trees per ha

Contd.

- The instrument is called as the **Conimeter**

$$h = 56.4 \sqrt{n/N}$$

  - Eye level height is added to the h to get mean stand height

Advantages of Point Sampling

- No need to lay fixed area plots ⟶ time saved
- High value trees sampled in greater proportions
- Basal area and volume per unit area derived without direct measurement of dia.
- Volume determination made in quick time - ideal for reconnaissance survey

Limitations of Point Sampling

- Difficult to compute sampling intensity
- Heavy undergrowth reduces visibility - unsuitable for dense tropical rain forests
- Skilled crew is required
- Small error in tallying gets magnified
- Slope compensation, edge effect, hidden trees, boundary over lap etc. have to be taken care of

!! Thank You !!