FIXATION OF THE YIELD OF AN IRREGULAR FOREST ON THE BASIS OF ITS CURRENT ANNUAL INCREMENT

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1. A few minutes after I had formally presented the papers on 'Forest Management' submitted to the IX Silvicultural Conference, including my papers (*i*) Brandis' Method of Yield Regulation and (*ii*) Smythies' Safeguarding Formula* I was given a copy of R. Sahai's Paper, 'Use of Enumeration Data and Yield Tables to calculate the increment of a forest with a view to fix its yield'*.

2. In my first Paper I have given a method of determining the *highest sustained yield* and in the second Paper I have shown the shortcomings of the Smythies' formula, namely that

(*i*) the yield derived from this formula is merely the annual recruitment of trees from class II to Class I in the first cycle ;

(*ii*) it does not take into consideration either the stock-in-hand of harvestable trees or the rate of recruitment in subsequent cycles ; and

(*iii*) the formula is inapplicable when the felling cycle is longer than the time taken by trees to pass through Class II.

3. Sahai has come to the same conclusion regarding Smythies' formula but he derives the correct yield by using the C.A.I. of the 'fit' trees.

4. This article deals with the comparative merits of my and Sahai's methods. I have used the data cited in Sahai's paper.

5. The basic data are :—

(*a*) *From enumerations* :

Dia. Class	Over 20″	16″–20″	12″–16″
Trees per acre	5·891	3·615	1·787

(*b*) *From Yield Tables* (*Sal Q. III*) :

Dia.	8″	12″	16″	20″
Age	43	71	104	44
Trees per acre	201	117	68	43

6. Yield calculation by my method.

Class	Years in class	Survivals %	†Trees per acre		‡Annual increment in class period
			Enumerated	Harvestable	
I Over 20″	...	100	1·787	1·787 (S_1)	...
II 16″–20″	40 (Y_2)	63	3·615	2·280 (S_2)	·057
III 12″–16″	33 (Y_3)	37	5·891	2·180 (S_3)	·066
IV 8″–12″	28 (Y_4)	21	...	...	...

* Published in this issue.

† The correct figures of *average* survival percentage in class periods as shown in para 5 are (100+63)/2=81·5, (63+37)/2=50 and (37+21)/2=29, but for comparison I have taken the figures used by Sahai.

‡ $S_2/Y_2 = R_2$ etc.

The accruing recruitment in successive cycles of 10 years will be :

Cycles 1 to 4 10 × ·057 = ·57 per cycle.
5 to 7 10 × ·066 = ·66 per cycle.
8 (3 × ·066) + (7R4) per cycle.

Therefore, the realizable and accumulating recruitments in successive cycles will be :

CYCLE	a. REALIZABLE b. ACCUMULATING		HENCE AVAILABLE IN CYCLE
1	a.	·285	·285 in cycle 1
	b.	·285	·57 „ 2
2	a.	·285	
	b.	·285	·57 „ 3
3	a.	·285	
	b.	·285	·57 „ 4
4	a.	·285	
	b.	·285	·615 „ 5
5	a.	·33	
	b.	·33	·66 „ 6
6	a.	·33	
	b.	·33	etc.

Therefore—

When the stock-in-hand is liquidated in	The annual available yield will be, in cycle					
	1	2	3	4	5	6
1 Cycle* ...	·2072	·057	·057	·057	·066	·066
2 Cycles ...	·1321	·1321	·057	·057	·066	·066
3 Cycles ...	·107	·107	·107	·057	·066	·066
4 Cycles ...	·095	·095	·095	·095	·066	·066
5 Cycles ...	·088	·088	·088	·088	·088	·066
6 Cycles ...	·085	·084	·084	·084	·084	·084

* (1·787 + ·285)/10 = ·2072
(1·787 + ·285 + ·57)/20 = ·1321, etc.

In other words the *maximum sustained yield* is ·084 tree per acre which will be realizable for at least 60 years, whereafter, it will be higher if the tendency for the recruitment to increase is maintained, whereas Smythies' formula gives it as ·057 tree only.

In the first cycle the total realizable trees are ·2072 per acre and if the yield is fixed at ·057 tree per acre, the percentable of callipered harvestable trees under number-control, when fellings proceed from one end of the forest to the other, is—

100 × 0·057/0·2072 or 27% according to Smythies' formula and,
100 × 0·084/0·2072 or 40% according to my method.

7. Yield calculation by Sahai's method – Besides the basic data cited in para 5, Sahai uses the following :—

Class	Trees per acre	Vol. of mean tree	Current Annual Increment	
			per tree	whole class
1	2	3	4	5
I	1·787	...	...	...
II	3·615	71·50	0·8918	3·224
III	5·891	32·15	0·8450	4·978
				8·202

The figures in columns 3, 4 and 5 are obtained in a round about way as under :—

The number of 'fit' sal trees per acre for even-aged crops is taken (source not mentioned) as :—

Dia. Class	Over 20″	16″–20″	12″–10″	8″–12″
Trees per acre	2·01	4·94	9·81	x

and the value of x determined by using Smythies' formula viz. :—

$$\frac{IV}{III} = \frac{iv\ t\ iii}{iii\ t\ ii} \times \frac{I}{1-Z_{iv}}$$

∴ By substitution—

IV = 14·35.

8. This done, smooth curves are drawn for *crop-diameter/volume of mean trees* and for *crop-diameter/C.A.I. of mean tree*, to read volume (Col. 3 of para 7) and C.A.I. (Col. 4 of para 7) for mid-diameter of classes and the latter multiplied by number of fit trees of para 7 to get the C.A.I. for each diameter class (Col. 5 of para 7).

9. Thereafter, it is assumed that the C.A.I. of the 20 inches and up diameter trees is negligible and therefore, the C.A.I. of trees of over 12 inches is 8·202 (Col. 5 of para 7) which is equivalent to 32·15/8·202 or 0·2551 trees of class III. It is then stated that as volume of class I trees is 3 times that of class III, the C.A.I. of the forest corresponds to 0·2551/3 = 0·0850 trees of class I and as the felling cycle is 10 years the C.A.I. of 10 acres can be removed annually from each acre, i.e., in all 0·0850 × 10 = 0 850 trees per acre. As the average number of these trees per acre is—

$I + \frac{x}{2}$ where x is the yield by Smythies' formula viz., II (I$-Z_{ii}$).

that is $1{\cdot}787 + \frac{1}{2}\left\{\frac{10}{40} \times 3{\cdot}615\ (1-0{\cdot}37)\right\} = 2{\cdot}0716$ or say, 2·072.

The percentage of removable class I trees is $\frac{0{\cdot}850}{2{\cdot}0716} \times 100$ or 40%.

10. It should be seen that this is exactly the figure arrived at by my method (q.v., para 6 *supra*) namely $100 \times \frac{\cdot 084}{\cdot 2072}$, where the numerator is the maximum sustained yield in numbers and the denominator is the number of *realizable* class I trees in the first cycle.

I leave it to the reader to decide for himself which is the more logical and simpler method, mine or Sahai's.