Stand Form Factor Measurement by Application of the Angle Method

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I. Preface

The definition of the stand form factor of breast height is shown by the equation (1).

$$F=\frac{V}{G\times H}\cdots\cdots\cdots\cdots(1)$$

Where F : stand form factor of breast height

G : basal area per ha. (m^2)

H: average tree height (m)

V : stand volume per ha. (m^3)

An advanced method of forest mensuration has simplified the methods of G and $\bar{H}$ measurement. Since they are chiefly objective to the stand volume estimation, the methods of the V estimation by these elements have been researched in various kinds.

i. e.,

$$V=\phi\,(G)\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots(2)$$

or

$$V=\psi\,(G,\ H)\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots(3)$$

Therefore, these functions are decided generally by calculation of the regression coefficients and constants, but it is always necessary to correct the estimated error and bias. If F can be measured by directly, V could be easily calculated as the following simplified equation.

$$V=F\times G\times \bar{H}\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots(4)$$

In the equation (4), if all the elements are directly measurable, the corrections for bias as in the regression estimation are entirely unnecessary.

From the point of view mentioned above, a necessary condition to be obtained is to induce the corresponding method for the time, cost and the precision for the measurement of the stand form factor against the advanced methods of the measurement of G and $\bar{H}$.

This report is an attempt to measure the stand form factor briefly by some modelling methods.

II. Principle and method

A fundamental principle of this report is that of the Bitterlich's Angle Method.

If the Angle Method was to be carried out at each height from the ground, stand volume per ha. might be calculated similarly with the simple stand stem analysis but, practically, it is a very prodigal method and almost always may be impossible.

1. A modified method of simple stem analysis by the Angle Method

In Fig. 1, A_1, A_2, $A_3, \cdots A_n$, are heights from the ground respectively, and A_0 indicates the breast height.

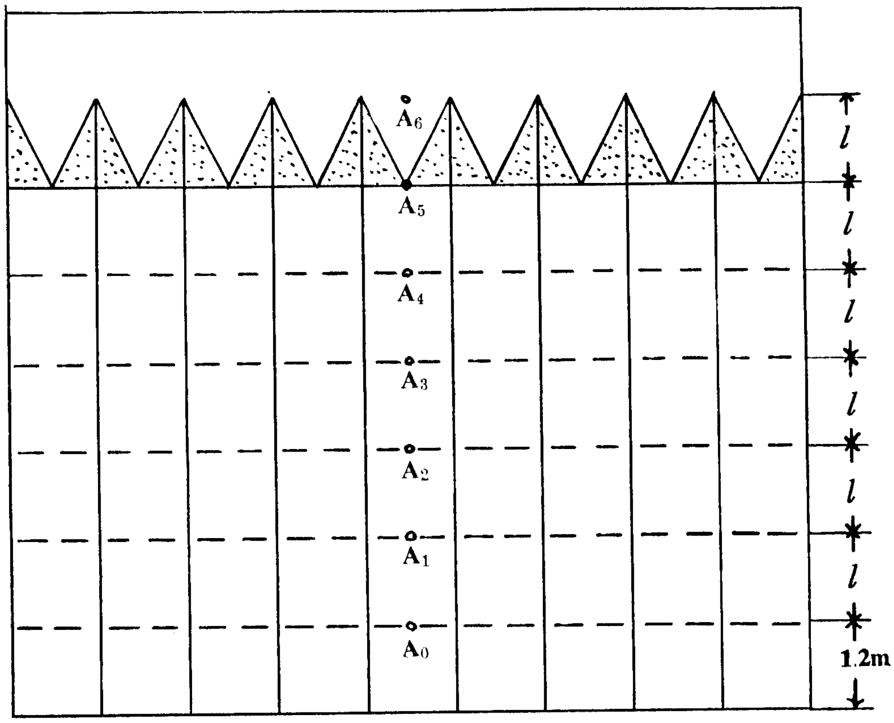

Fig. 1. Figure Showing the Angle Method at each height.

Now we assume that the Angle Method practised at the height of A_0, A_1, $A_2, \cdots A_n$ by a technique in which the Bitterlich's factors were changed at each height and the count numbers were equally fixed at them. If the individual tree shows a similar type in a stand, the trees counted at A_0 are ought to count in each height. Consequently, the cross section area per ha. (G_i) at the height A_i is shown in the equation (5).

$$G_i = K_i \times N (\mathrm{m}^2) \quad \cdots\cdots\cdots\cdots\cdots (5)$$

Where, K_i: factor at the height A_i
N : equally fixed count number

2. Multi-elevation angle method

Multi-elevation angle count methods which I have lectured in this report are practised as the following procedures.

In Fig. 2, the Angle Method, in the first place, is practised at the breast height (count number=N), and in the next, the arm is supported toward upper direction in angle α_1 and in that condition, the Angle Method is practised as the same count as N (slit wide decreases).

If we repeat these proceduses to the angle α_2, $\alpha_3 \cdots \alpha_n$, the counting boundary tree is as the same as in the case of A_0, A_1, $A_2, \cdots A_n$. Consequently, G_i of the $1.2 + i \times l$ meter high can be calculated.

In these procedures, the absolute length of l cannot be decided, but it does not impede

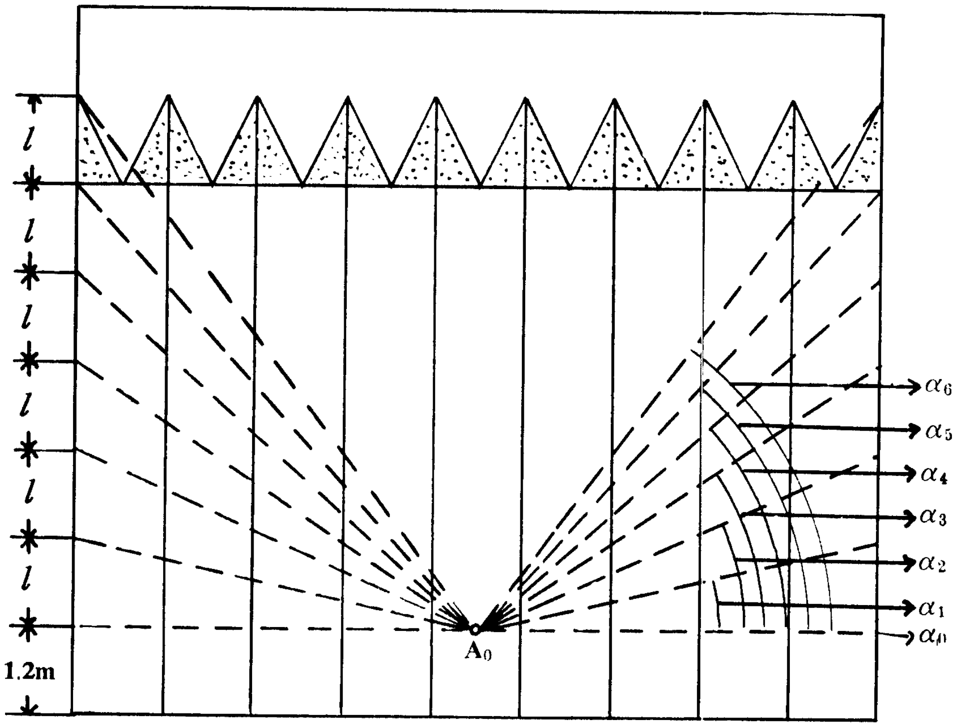

Fig. 2. Figure showing the Multi-angle Method.

the calculation of the stand form factor. By these methods the absolute stand form factor upper from the breast height come into calculation as the following equation.

$$F' = \frac{l[(G_0+G_1)/2+(G_1+G_2)/2+\cdots+(G_{n-1}+G_n)/2]}{n\times l\times G_0}$$

$$= \frac{[G_0+2(G_1+G_2+\cdots+G_{n-1})+G_n]}{2\times n\times G_0}$$

With these reasoning, it is possible to apply the Angle Method to the stand form factor measurement.

III. Application to the photographical measurement

It is able to apply the method to the photographical measurement.

The plane with elevation α_i is expressed by a straight line in a photograph, and if the camera optical axis is vertical to the tree stems, the intervals between the lines ($\alpha_i-\alpha_{i-1}$) are equal with themselves (refer to the Fig. 3).

On the occasion of taking a photograph, the camera is set horizontally at 1.2 meter high and a pole (L meter long) is supported horizontally at a point of C meter beyond from the camera. C and L are necessary to determine the photo-scale.

1. Measurement by photograph must be carried out by aid of a lantern slide. The methods are as the following order.

(1). Fix the lantern enlargement scale by the scale of L.

(2). Decide the count number N.

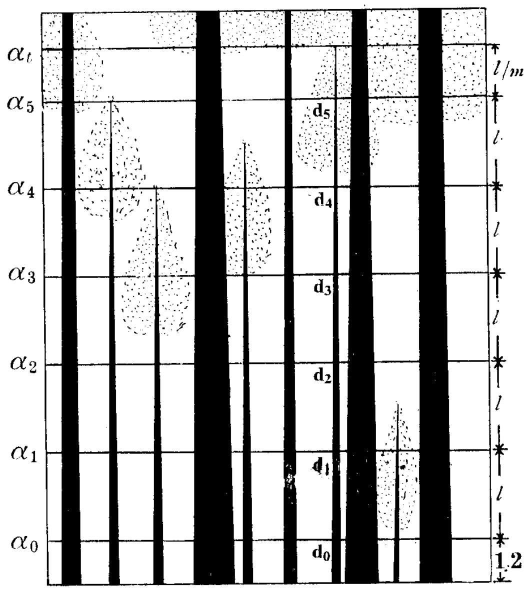

Fig. 3. Figure showing the lines in photograph in which the Angle Method performed by angle α_1, $\alpha_2, \cdots\cdots \alpha_n$.

(3). The measurement of α_0 line :— Count the individuals according to their diameter size order on the α_0 line, and the diameter of the number N tree (d_0) is measured by centimeter scale (refer to the Fig. 3).

(4). The measurements of α_1, $\alpha_2 \cdots \alpha_n$ are performed as in the same way mentioned above (d_1, $d_2, \cdots d_n$).

(5). The line of angle α_t which indicates the top of the number N tree shows the comparative top ($d=0$).

Practical measurements are closed with these procedures.

2. The decision of the Bitterlich's factor

If the measured diameter d_i is equla to p_i centimeter of the scale of the supported pole, the factor K is shown by the equation (7).

$$K=\left(\frac{p_i}{2C}\right) \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots (7)$$

As the number N tree must be counted as 1/2 count, it is desirable that the count number is treated as $(N-0.5)$.

In case the included angle of the photograph is γ°, the sum of the cross area per ha. is presented in the equation (8).

$$G_i=K_i(N-0.5)\frac{360}{\gamma} \cdots\cdots\cdots\cdots\cdots\cdots\cdots (8)$$

3. Calculation of F'

Additional procedure to the calculation of F' which is shown in the section II, 2 is a tree top measurement. The comparative top length l/m must be measured in the lantern slide and the top value is calculated by l/m and G_n (refer to the Fig. 3).

IV. Some of the correction about the photo-measurement

1. Equal tree diameter at equal distance from the camera cannot be photographed with equal diameter.

As the form of the cross section of a tree trunk is a circle and as the film in camera is set in flat, equal diameter at equal distance from the camera cannot be photographed with equal diameter.

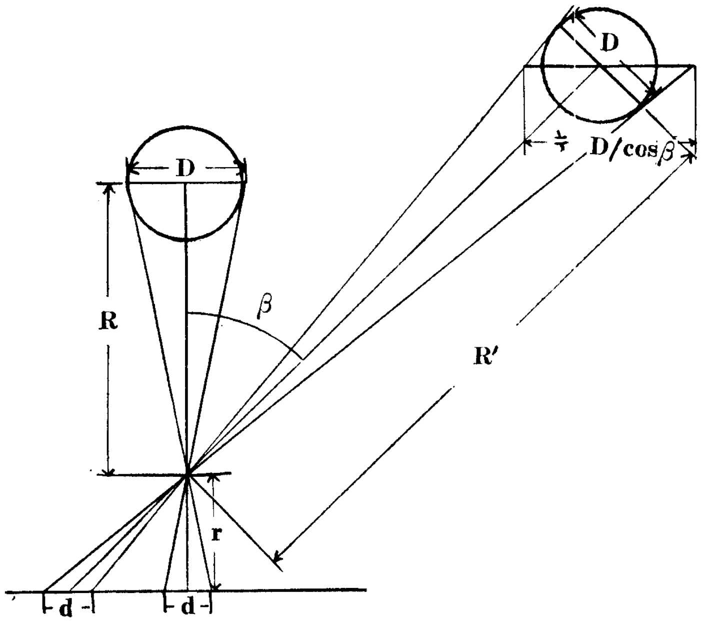

Fig. 4. Figure showing the locations of trees which show equal diameter in photograph.

As shown in the Fig. 4, equal tree diameters in the photograph are situated at the distance of R' from the camera.

Thus,

$$\frac{D}{\cos\beta} : R' = d : \frac{r}{\cos\beta}$$

$$R' \times d = \frac{D \times r}{\cos^2\beta}$$

$$R' = \frac{D \times r}{d \times \cos^2\beta}$$

$$= \frac{R \times r}{r \times \cos^2\beta}$$

$$= \frac{R}{\cos^2\beta}$$

The drawing area S by the R and β was presented in the equation (9).

$$S = \frac{R^2}{2}\int_{-\beta}^{+\beta} \frac{1}{\mathrm{eos}^2\beta} d\beta$$

$$=\frac{R^2}{2}\left[\frac{\sin\beta}{3\times\cos^3\beta}+\frac{2}{3}\tan\beta\right]_{-\beta}^{+\beta}\cdots\cdots\cdots\cdots\cdots(9)$$

The ratio t with the fan shape (radial$=R$) is shown as

$$t=\frac{\frac{2\beta}{R360}R^2\pi}{S}$$

if we decide $\beta=\frac{\pi}{8}$, calculated t is equal to 0.895.

2. The inclination of the camers optical axis

In the case of the stand photographing, it is more successful to have any elevation in camera optical axis than that is perfectly parallel to the ground. In these occasion, as shown in Fig. 5, Intervals between the measuring lines in a photograph are not equal.

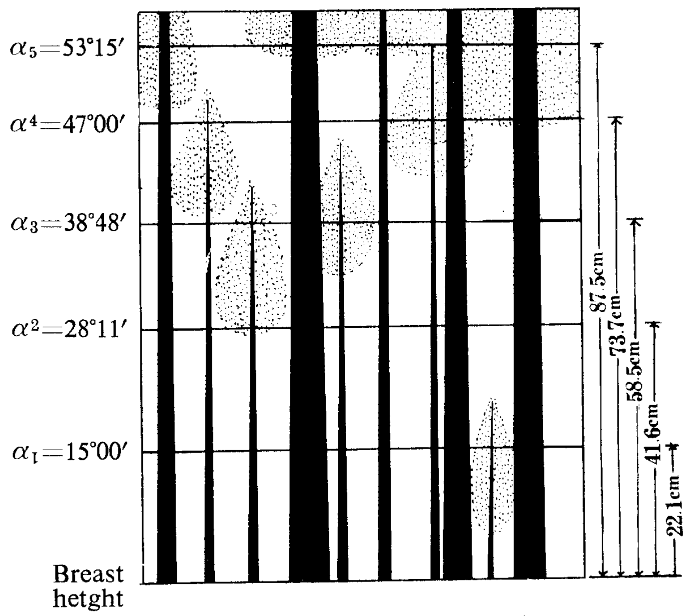

Fig. 5. Measuring lines in lantern slide when the camera angle is 15 and the reducting ratio is 1/5.

In the Fig. 6, if we assume that

$$\alpha_1=\text{camera angle},$$
$$\tan\alpha_2=2\tan\alpha_1$$
$$\tan\alpha_3=3\tan\alpha_2$$
$$\vdots$$
$$\text{and}\quad \tan\alpha_n=n\tan\alpha_1,$$

the line $\overline{A_0\ A_4}$ is photographed as the line $\overline{a_0\ a_4}$.

Hence

$$\overline{a_0\ a_1}=\frac{C}{\cos\alpha_1}\tan\alpha_1$$

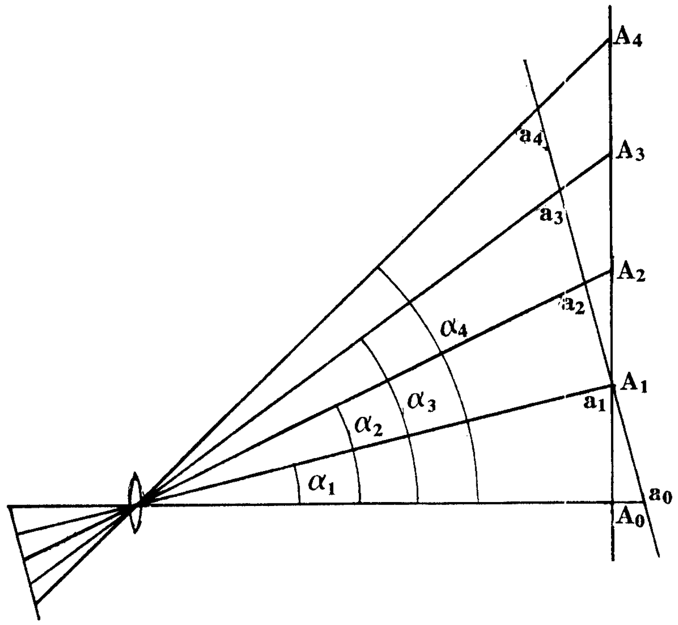

Fig. 6. Figure showing the relationship between actual vertical length and the length in photograph.

$$\overline{a_1 \ a_2} = \frac{C}{\cos \alpha_1} \tan(\alpha_2 - \alpha_1)$$

$$\overline{a_1 \ a_3} = \frac{C}{\cos \alpha_1} \tan(\alpha_3 - \alpha_1)$$

$$\vdots \qquad \vdots$$

$$a_1 \ a_n = \frac{C}{\cos \alpha_1} \tan(\alpha_n - \alpha_1).$$

Namely, on the photograph the increasing of the elevation α_i causes of decreas of the interval $a_i - a_{i-1}$.

3. The correction of the measured diameter by the inclination of the camera optical axis

The inclination of the camera axis causes the tendeucious bias in the photograph.

Supposing that the reducted ratio between actual diameter and the photograph at each levels of α_0, α_1, $\alpha_2 \cdots\cdots \alpha_n$ is equal to q_0, q_1, $q_2, \cdots\cdots q_n$, the relationship between q_0 and q_1, $q_2, \cdots\cdots q_n$ is obtained as follows :—

$$q_1 = q_0(\cos^2 \alpha_1)$$

$$q_2 = q_0 \frac{\cos \alpha_1 \cos \alpha_2}{\cos(\alpha_2 - \alpha_1)}$$

$$q_3 = q_0 \frac{\cos \alpha_1 \cos \alpha_3}{\cos(\alpha_3 - \alpha_1)}$$

$$\vdots \qquad \vdots$$

$$q_n = q_0 \frac{\cos \alpha_1 \cos \alpha_n}{\cos(\alpha_n - \alpha_1)}$$

Accordingly, the measured diameters on the photograph at each level must be corrected as equal reducted ratio.

i. e., $(d_0, d_1, d_2, \cdots d_n) \longrightarrow$

$$\left(d_0,\ d_1 \frac{1}{\cos^2\alpha_1},\ d_2 \frac{\cos(\alpha_2-\alpha_1)}{\cos\alpha_1 \cos\alpha_2}, \cdots\cdots,\ d_n \frac{\cos(\alpha_n-\alpha_1)}{\cos\alpha_1 \cos\alpha_n}\right).$$

V. Measurement and Calculation

1. The data were taken from the Takakuma University Forest.

(1). Stand condition

1). Surveyed stand area = 0.11 ha.
2). Number of trees = 115
3). Stand age = 38 years
4). Tree species = Sugi (*Cryptomeria japonica* D. Don.)
5). Average diameter = 21.8 centimeter
6). Average tree height = 12.8 meter

All the trees were numbered and the stems were analysed under standing condition.

(2). Calculation of the F' from the field data

Absolute stand form factors F' were calculated under the groups of the following tree numbers and its results are presented in Table 1.

1～ 5, 6～10, …… 111～115,
1～10, 11～20, …… 101～110,
1～15, 16～30, …… 91～105,
1～20, 21～40, …… 81～100,

Table 1. Calculation table of F′ of grouped trees.

	Tree No.	V	V'	H'	G	F'
group of 5 trees	1～ 5	1.3860	1.0215	12.5	0.2171	0.3764
	6～ 10	1.2850	0.9415	12.0	0.2037	0.3852
	11～ 15	1.4157	1.0637	12.5	0.2090	0.4072
	16～ 20	0.9660	0.7145	11.8	0.1453	0.4167
	21～ 25	1.2037	0.8887	12.4	0.1857	0.3859
	26～ 30	1.1513	0.8303	10.5	0.1897	0.4168
	31～ 35	2.4100	1.8280	13.4	0.3545	0.3848
	36～ 40	0.8708	0.6193	10.6	0.1453	0.4021
	41～ 45	1.5595	1.1500	12.1	0.2457	0.3868
	46～ 50	1.2135	0.8315	9.8	0.2281	0.3720
	51～ 55	1.6004	1.1764	11.7	0.2546	0.3949
	56～ 60	1.2839	0.9399	11.5	0.2040	0.4006
	61～ 65	0.5969	0.4139	10.6	0.1022	0.3821
	66～ 70	1.0505	0.7625	11.2	0.1685	0.4040
	71～ 75	0.7285	0.5040	9.9	0.1284	0.3965
	76～ 80	1.3582	0.9977	12.1	0.2143	0.3848
	81～ 85	1.0440	0.7425	11.1	0.1770	0.3779
	86～ 90	0.9178	0.6613	11.4	0.1487	0.3901
	91～ 95	1.3232	0.9752	12.2	0.2065	0.3871
	96～100	1.3035	0.9365	11.3	0.2184	0.3795
	101～105	1.3897	1.0307	11.8	0.2136	0.4089
	106～110	0.7886	0.5971	11.2	0.1265	0.4003
	111～115	2.3606	1.7871	12.9	0.3490	0.3969

grup of 10 trees	1~ 10	2.6710	1.9620	12.3	0.4208	0.3791
	11~ 20	2.3817	1.7787	12.2	0.3543	0.4115
	21~ 30	2.3550	1.7190	11.4	0.3754	0.4017
	31~ 40	3.2808	2.4468	12.0	0.4998	0.4080
	41~ 50	2.7730	1.9810	11.0	0.4738	0.3801
	51~ 60	2.8843	2.1153	11.6	0.4586	0.3976
	61~ 70	1.6474	1.1764	10.9	0.2707	0.3987
	71~ 80	2.0867	1.5017	11.0	0.3427	0.3984
	81~ 90	1.9618	1.4038	11.3	0.3257	0.3814
	91~100	2.6267	1.9117	11.8	0.4249	0.3813
	101~110	2.1783	1.5973	11.5	0.3401	0.4084
group of 15 trees	1~ 15	4.0867	3.0262	12.4	0.6298	0.3875
	16~ 30	3.3210	2.4330	11.6	0.5207	0.4028
	31~ 45	4.8403	3.5968	12.1	0.7455	0.3987
	46~ 60	4.0978	2.6473	11.0	0.6867	0.3902
	61~ 75	2.3759	1.6799	10.6	0.3991	0.3971
	76~ 90	3.3200	2.4020	11.6	0.5400	0.3835
	91~105	4.0164	2.9409	11.8	0.6385	0.3903
group of 20 trees	1~ 20	5.0527	3.7407	12.2	0.7751	0.3956
	21~ 40	5.6358	4.1638	11.7	0.8752	0.4066
	41~ 60	5.6573	4.0973	11.3	0.9324	0.3889
	61~ 80	3.7341	2.6781	10.9	0.6134	0.4005
	81~100	4.5885	3.3165	11.5	0.7506	0.3842
	115 trees	29.2073	21.3838	11.6	4.6358	0.3977

Note: V ; Sum of volume.
V' ; Sum of volume upper from breast height.
H′: Average tree length upper from breast height.
G : Sum of basal area.
$F' = V'/(G \times H')$

(3). The variances and standard deviations of F' were calculated to compare with the photographical measurements (Table 2).

Table 2. Statistical values of F′ from the field data.

Crouped tree No.	n	Variance	Standard deviation	Average	Coefficent of variation (%)
5	23	0.001378	0.0371	0.3853	9.63
10	11	0.000154	0.0124	0.3951	3.13
15	7	0.000046	0.0068	0.3929	2.83
20	5	0.000079	0.0089	0.3952	2.25

2. Several terms for photographing
   (1). The ground condition was perfectly horizontal.
   (2). The elevation of the camera optical axis was kept as 15° canstantly.
   (3). Two poles of 2 meter long were supported at the point of 4 meter beyond from the camera (refer to the Fig. 7).
   (4). The camera with a 28 millimeter focus lens was used.
   (5). 8 points were sampled at random to photograph.
3. Measurement in photograph
   All the measurements were practised in lantern slide.
   (1). Enlargement scale in lantern slide was set in 1/5, consequently, the length of the

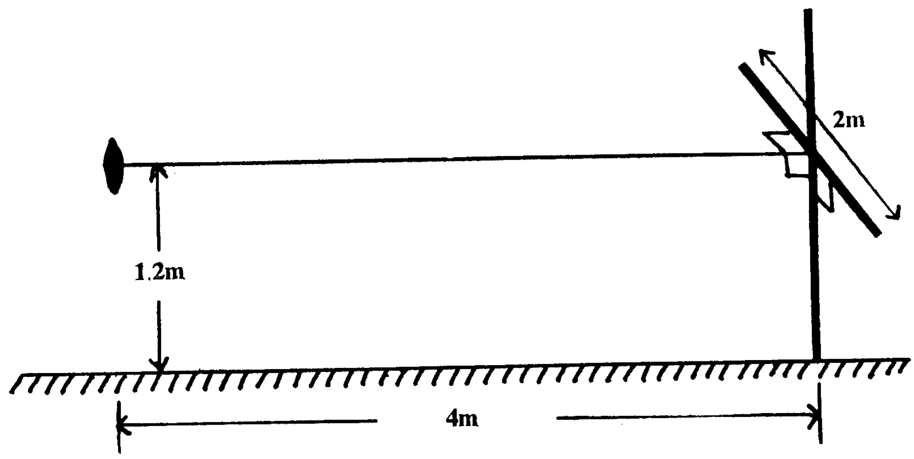

Fig. 7. Figure shawing the situation and condition of the camera and poles.

crossed 2 meter poles indicated 40 centimeter length.

(2). Included angle of the photograph was set in 45°.

(3). Multi-elevation angles were arranged as follows:—

$$\alpha_1 = 15°00' \cdots\cdots \text{camera elevation angle}$$
$$\alpha_2 = 28°11' \cdots\cdots \tan\alpha_2 = 2\tan\alpha_1$$
$$\alpha_3 = 38°48' \cdots\cdots \tan\alpha_3 = 3\tan\alpha_1$$
$$\alpha_4 = 47°00' \cdots\cdots \tan\alpha_3 = 4\tan\alpha_1$$

(4). The situations of the measurement lines in lantern were determined under above mentioned condition (refer to IV, 2).

$$l_1 = \frac{400}{5} \times \frac{\tan 15°00'}{\cos 15°00'} = 22.1\text{cm}$$

$$l_2 = \frac{400}{5} \times \frac{\tan 15°00' + \tan(28°11' - 15°00')}{\cos 15°00'} = 41.6\text{cm}$$

$$l_3 = \frac{400}{5} \times \frac{\tan 15°00' + \tan(38°48' - 15°00')}{\cos 15°00'} = 58.5\text{cm}$$

$$l_4 = \frac{400}{5} \times \frac{\tan 15°00' + \tan(47°00' - 15°00')}{\cos 15°00'} = 73.7\text{cm}$$

(5). Tables for the evaluated values and calculations

Measured data in photographs and calculating procedures of cross area per ha. in each level were presented in Table 3. Finally derived values of F' were shown in Table 4, and the calculated statistical values were presented as follwos:—

Variance = 0.00062607

Standard deviation = 0.0250

Average form factor = 0.3977

Coefficient of variation = 6.29%.

Table 3. Cross area per ha. in each level

Point 1

$N=9$ $N'=7.608$ $N''=60.86$ $l_t=\frac{3}{5}l$

Angle	h	d	p	p'	K	G
α_0	1.2	1.3	6.5	6.50	0.6602	40.18
α_1	$1.2+l$	1.0	5.0	5.36	0.4489	27.32
α_2	$1.2+2l$	0.6	3.0	3.43	0.1839	11.19
α_3	$1.2+3l$	0.3	1.5	1.82	0.0518	3.15
α_4	$1.2+4l$					

Point 2

$N=9$ $N'=7.608$ $N''=60.86$ $l_t=\frac{2}{3}l$

	h	d	p	p'	K	G
α_0	1.2	1.3	6.5	6.50	0.6602	40.18
α_1	$1.2+l$	1.0	5.0	5.36	0.4489	27.32
α_2	$1.2+2l$	0.5	2.5	2.86	0.1278	7.78
α_3	$1.2+3l$	0.3	1.5	1.82	0.0518	3.15
α_4	$1.2+4l$					

Point 3

$N=9$ $N'=7.608$ $N''=60.86$ $l_t=\frac{1}{4}l$

	h	d	p	p'	K	G
α_0	1.2	0.8	4.0	4.00	0.2500	15.22
α_1	$1.2+l$	0.6	3.0	3.22	0.1620	9.86
α_2	$1.2+2l$	0.5	2.5	2.86	0.1406	8.56
α_3	$1.2+3l$	0.3	1.5	1.82	0.0518	3.15
α_4	$1.2+4l$	0.1	0.5	0.64	0.0064	0.39

Point 4

$N=9$ $N'=7.608$ $N''=60.86$ $l_t=\frac{1}{5}l$

	h	d	p	p'	K	G
α_0	1.2	1.4	7.0	7.00	0.7656	46.59
α_1	$1.2+l$	1.1	5.5	5.90	0.5439	33.10
α_2	$1.2+2l$	0.7	3.5	4.00	0.2500	15.22
α_3	$1.2+3l$	0.4	2.0	2.43	0.0923	5.63
α_4	$1.2+4l$	0.1	0.5	0.64	0.0064	0.39

Point 5

$N=9$ $N'=7.608$ $N''=60.86$ $l_t=\frac{1}{2}l$

	h	d	p	p'	K	G
α_0	1.2	1.2	6.0	6.00	0.5625	34.23
α_1	$1.2+l$	0.8	4.0	4.29	0.2876	17.50
α_2	$1.2+2l$	0.5	2.5	2.86	0.1278	7.78
α_3	$1.2+3l$	0.3	1.5	1.82	0.0518	3.15
α_4	$1.2+4l$					

Point 6

$N=7 \quad N'=5.818 \quad N''=46.54 \quad l_t=\frac{1}{2}l$

	h	d	p	p'	K	G
α_0	1.2	1.3	6.5	6.50	0.6602	30.73
α_1	$1.2+l$	0.8	4.0	4.29	0.2876	13.38
α_2	$1.2+2l$	0.6	3.0	3.43	0.1839	8.56
α_3	$1.2+3l$	0.3	1.5	1.82	0.0518	2.41
α_4	$1.2+4l$					

Point 7

$N=12 \quad N'=10.293 \quad N''=82.34 \quad l_t=\frac{1}{4}l$

	h	d	p	p'	K	G
α_0	1.2	1.3	6.5	6.50	0.6602	54.36
α_1	$1.2+l$	1.1	5.5	5.90	0.5439	44.78
α_2	$1.2+2l$	0.7	3.5	4.00	0.2500	20.59
α_3	$1.2+3l$	0.3	1.5	1.82	0.0518	4.27
α_4	$1.2+4l$	0.1	0.5	0.64	0.0064	0.53

Point 8

$N=9 \quad N'=7.608 \quad N''=60.86 \quad l_t=\frac{4}{5}l$

	h	d	p	p'	K	G
α_0	1.2	1.2	6.0	6.00	0.5625	34.23
α_1	$1.2+l$	0.9	4.5	4.82	0.3630	22.09
α_2	$1.2+2l$	0.6	3.0	3.43	0.1839	11.19
α_3	$1.2+3l$	0.2	1.0	1.22	0.0233	1.42
α_4	$1.2+4l$					

Note: d = Measured diameter in lantern (cm)
p = d × 5 (cm)
p' = p corrected by the elevation of camera angle (cm) (refer to IV, (3))
K = The Bitterlich's factor
G = Cross area per ha. (m^2)
N = Count number
N' = (N − 0.5) × 0.895 (refer to IV, (1))
N'' = N' × 360/45 = 8 × N'
l_t = Comparative top length (refer to III, (3))

Table 4. F' calculation table

Point	Procednre	F'
1	$\dfrac{\frac{l}{2}\{[40.18+3.15]+2[27.32+11.19]\}+\frac{3}{5}l\times3.15\times\frac{1}{3}}{\left(3+\frac{3}{5}\right)l\times40.18}$	0.4204
2	$\dfrac{\frac{l}{2}\{[40.18+3.15]+2[27.32+7.78]\}+\frac{2}{3}l\times3.15\times\frac{1}{3}}{\left(3+\frac{2}{3}\right)l\times40.18}$	0.3901

3	$\dfrac{\frac{l}{2}\{[15.22+0.39]+2[9.86+8.56+3.15]\}+\frac{1}{4}l\times0.39\times\frac{1}{3}}{\left(4+\frac{1}{4}\right)l\times15.22}$	0.4289
4	$\dfrac{\frac{l}{2}\{[46.56+0.39]+2[33.10+15.22+5.63]\}+\frac{1}{5}l\times0.39\times\frac{1}{3}}{\left(4+\frac{1}{5}\right)l\times46.59}$	0.3958
5	$\dfrac{\frac{l}{2}\{[34.23+3.15]+2[17.50+7.78]\}+\frac{1}{2}l\times3.15\times\frac{1}{3}}{\left(3+\frac{1}{2}\right)l\times34.23}$	0.3714
6	$\dfrac{\frac{l}{2}\{[30.78+2.41]+2[13.38+8.56]\}+\frac{1}{2}l\times2.41\times\frac{1}{3}}{\left(3+\frac{1}{2}\right)l\times30.73}$	0.3580
7	$\dfrac{\frac{l}{2}\{[54.36+0.53]+2[44.78+20.59+4.27]\}+\frac{1}{4}l\times0.53\times\frac{1}{3}}{\left(4+\frac{1}{4}\right)l\times54.36}$	0.4214
8	$\dfrac{\frac{l}{2}\{[34.23+1.42]+2[22.09+11.19]\}+\frac{4}{5}l\times1.42\times\frac{1}{3}}{\left(3+\frac{4}{5}\right)l\times34.23}$	0.3958

VI. Conclusion

It may be given as a conclusion that the stand form factor is able to be measured with the photographical methods. In this study, the average stand form factor with photograph was in accordance with the total stand form factor, and the degree of variation was corresponded with the actual measurement of grouped 5～10 trees.

According to these conclusion, it is considered that the stand form factor upper from the breast height can be easily and acculately measured, but, as these measurements were accomplished under very suitable conditions, it seems difficult to draw a hasty conclusion to apply this method to actual field works.

Some point at issue for this problem was supposed as the following clauses.

(1). The relationship between the effect of this method and the variation of individual trees in a stand.

(2). Photographical technique in stand of high density.

(3). The relationship between the precision and the uumber of the sample point.

(4). The relationship between the precision and the number of multi-elevation angles.

(5). The relationship between the precision and the count number.

(6). Conceptions to the construction of camera.

(7). Discussion for the application to the broad leaves forests.

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