The Estimation of the Standing Crop of the Forest in Northeastern Thailand

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INTRODUCTION

An accurete and detailed knowledge of the standing crop of a plant community is the necessary biological basis of any attempt to control the productivity of that plant community. However, available information about standing crops of forests is not very detailed so far.

Recently Japanese ecologists have used allometric relations in estimating standing crops of plant communities. Several attempts in this direction have been made in Thailand by the Osaka City University Biological Expedition 1957-58 and the Thai-Japanse Biological Expedition 1961-62.

Our present work is also an attempt along these same lines, that is to say, to examine the possibility of using allometric relations in estimating standing crops in tropical areas.

A BRIEF DESCRIPTION OF THE STAND

Field work was carried out from the 22nd of October to the 11th of December, 1962 at Wangnamkhiow, Pakthongchai, Nakornrachasima. This area is situated about 60 km south of the town of Korat in northeastern Thailand.

The season in which the work was done was around the end of the rainy season and the beginning of the cool season in the area. It was getting cooler day by day. The average minimum and maximum temperatures during the first week when the work was carried out were 20.1°C (68.2°F) and 28.5°C (83.3°F). The temperature continued to drop so that it reached a minimum of 11.7°C (53.1°F) and a maximum of 20.8°C (69.4°F). Nevertheless leaffall did not occur in those stands during the period of our work.

In that area we can see two types of forest: Dry Dipterocarp Forest and Dry Evergreen Forest. As to the notation of the forest types, we think another discussion would be necessary from the point of view of the plant sociologist; however, in the present work we will take tentatively the practical nomenclature which was devised by the Royal Thai Forest Department.

As is already well known, Dry Dipterocarp Forest has a rather sparse forest crown of about 15m in height, is a scarcely stocked stand and consists mainly of *Shorea obtusa*, *Shorea floribunda*, *Pentacme siamensis* and other kinds of Dipterocarpaceae. The open forest floor is covered with abundant grasses. Occasionally younger trees, dwarf shrubs and cycads are scattered around. A soil survey shows very shallow dry sandy soil with much gravel and many pebbles.

On the other hand, Dry Evergreen Forest which is adjacent to the Dry Dipterocarp Forest is taller and has a much denser forest crown. The stand is packed with five stratified tree layers. Lofty gigantic trees more than

20m in height make up the prominent arboreal layer. The tall arboreal layer 15-20m in height forms a continuous forest crown. The short arboreal layer 5-15m in height comes next to it. The tall shrubbery layer is 1-5m in height. The short shrubbery layer is less than 1m in height. Many kinds of climbers grow up and down, in and out these stratified layers.

The number of species which constitute the stands is large. More than 90 species were counted, including trees, shrubs, climbers and grasses. Soil observation shows that the soil is deeper than that of a Dry Dipterocarp Forest stand and holds more organic matter.

THE METHOD ADOPTED FOR THE SURVEY

As mentioned above two types of forest were found in the area. Two sample plots of 10×50 m in size were placed in each forest type after a preliminary look around so that the plot would represent each forest type.

In order to know the floristic composition of the forest, the local name of every tree which occurred in the plot was recorded, using the names as given by a local worker who came from a neighbouring village. The manuals of Royal Forest Department was used for further checking.

The diameters at breast height, height and life form of all trees higher than 1m were measured and recorded.

Other measurements were taken of subordinate species and these measurements were kept separate from those of the dominant species. Ten subplots of 5×5m were taken in sample plots for this purpose. The subordinate species were gathered according to their life form into several groups, seedlings of the dominant trees, climbers, herbs, grasses and cycads. The local names, leaf weight and stem weight of each group were recorded.

25 sample trees in Dry Dipterocarp Forest and 37 sample trees in Dry Evergreen Forest were cut for individual tree measurements. These sample trees were selected carefully so that every species which occurred in the plot would be included. More sample trees were cut of those species which occurred more frequently. The trees which had a better tree form were selected. Sample trees were taken from a wide range of the diameter distribution in order to reduce the error of interpretation as far as possible. The following items of each sample tree were measured:

H : height of the tree

H_b : height of the trunk up to the lowest living branch

$D_{0.0}$: diameter at ground level

$D_{0.3}$: diameter at 0.3m in height

$D_{1.3}$: diameter at 1.3m in height, which is analogous to diameter at breast height (DBH)

$D_{3.3}$: diameter at 3.3m in height, from 3.3m in height upward diameter at the height of every 2m

$D_{0.1H}$: diameter at the height of one-tenth of the tree height

D_b : diameter at the height of the lowest living branch

R : crown diameter

W_s : stem weight

W_b : branch weight

W_l : leaf weight

If the sample tree was too big to weigh, a sample part or sometimes several parts were taken, and the ratio of weight to volume was calculated. Exploiting the weight to volume ratio, the weight of the remaining part of the tree was calculated.

RESULTS AND DISCUSSIONS

The results of a census survey of the stands are summarized in Table 1.

As is easily understood, the figures for stand

Table 1. Summarized Figures of the Census Survey of the Stands

	Dry Dipterocarp Forest		Dry Evergreen Forest	
Sample plot	P-1	PP-1	P-2	PP-2
Nos. of trees in the plot	57	68	135	114
Stand density tree nos./ha	1140	1360	2700	2280
Basal area m^2/ha	11.18	19.34	26.34	42.55

density, numbers of species of dominant trees and basal area of Dry Evergreen Forest are larger than those of Dry Dipterocarp Forest. In permanent plot No. 1 (PP-1) and permanent plot No. 2 (PP-2), some trees bigger than average happened to occur in the plot so that the size of the basal area was affected.

The allometric relations: The allometric relations was first foumulated by J.S. Huxley (1932), Teissier (1934) as

$$y=Ax^h \quad (1)$$

$$\text{or} \quad \log y=\log A+h\log x \quad (2)$$

where y, x are any quantity of two parts of an individual, A, h are specific constants.

Although the allometric relation was found in the study of relative growth of animals, it also seems to fit plant growth satisfactorily.

Equation (2) shows a linear regression between log x and log y. The linearity of these two variables enables us to compute the specific constants A and h easily, and to verify whether the two variables follow the allometric relation or not.

If we take a diameter as the independent variable and volume or weight for the dependent variable of the equation (2), the equation will be written as follows:

$$\log V_i=\log A_{vi}+h_{vi} \log D_j \quad (3)$$

$$\log W_i=\log A_{wi}+h_{wi} \log D_j \quad (4)$$

where V_i and W_i stands for a volume or weight of any kind, log A_{vi}, log A_{wi}, h_{vi} and h_{wi} for the specific constants for V_i, W_i and D_j concerned, and D_j for diameter of any kind which is taken into account. Usually for the sake of convenience of utilization of these equations, the value of the diameter is preferably taken for x, the value of volume or weight for y.

Checking of allometric relations: The data of stem weight, branch weight and leaf weight were plotted on logarithmic paper, in order to examine their linearity. For instance stem weight was taken for y, and DBH for x. As shown in Fig. 1 these plotted dots seem to follow the linear regression, the regression equation of stem weight on diameter at breast height (DBH) was decided by means of the least square method.

We were primarily interested in finding out which of a large number of variables were more closer related to a given dependent variable, e.g. stem weight. The coefficients of determinations were computed in order to know the strength of the relationship. The 95% confidence intervals were also calculated. The calculated values of the specific constants h and log A, the 95% confidence intervals, the coefficients of determinations r^2, are shown in Tables 2,3 and 4.

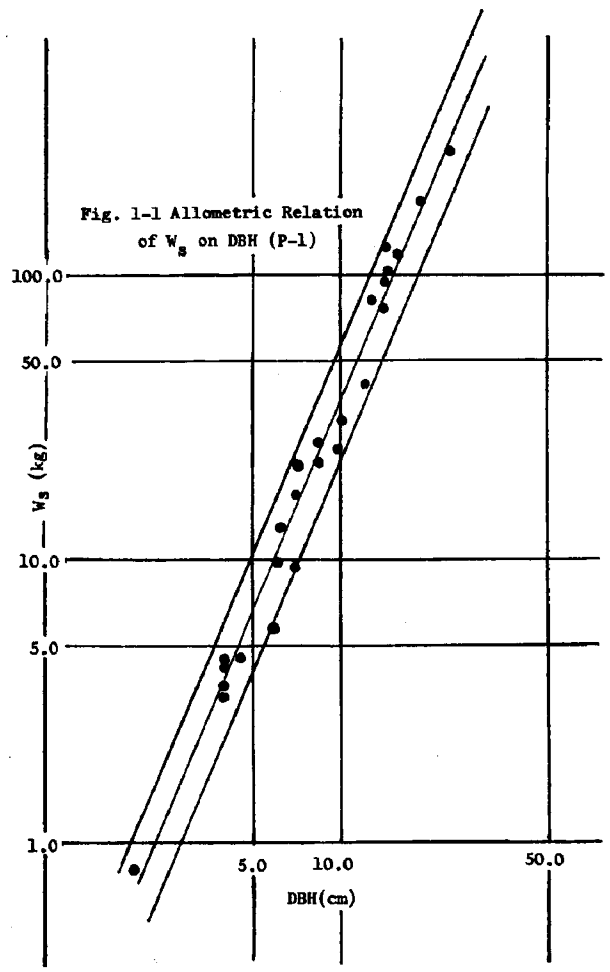
'h' shows the slope of the regression line and log A shows the y interception of the line, in other words the value of y when x=1. Needless to say, log A is not an ordinary numerical

Table 2. Allometric relations of stem weight on several kinds of diameter (Data based on those from Dry Dipterocarp Forest)

	$D_{0.0}$	$D_{0.1H}$	DBH	D_b
h	2.95448	2.93538	2.50913	2.34410
log A	−1.76246	−1.48659	−0.94402	−0.60247
c. i.	0.30288	0.28416	0.21228	0.45071
r^2	0.949	0.955	0.974	0.874

Table 3. Allometric relations of stem weight on several kinds of square of diameter (Data based on those from Dry Dipterocarp Forest)

	$D_{0.0}^2$	$D_{0.1H}^2$	DBH^2	D_b^2
h	1.46547	1.46457	1.25235	1.14886
log A	4.12497	4.37840	4.06969	4.02945
c. i.	0.31627	0.28538	0.21267	0.48331
r^2	0.943	0.954	0.974	0.867



value but a logarithmic value.

The value of r^2 shows that the variables of all regression equations based on the product of the square of diameter and height of the tree have thebest relationship. We can explain this fact easily. Weight is a three demensional quantity; therefore if we take a three dimensional value for x, the slope of the regression line becomes nearly 1, and consequently various error of the interpretation would be minimized.

Comparion between the kinds of diameter resulted in the conclusion that whatever the dimension of x happens to be, that based on the diameter at breast height is better than other.

If we can find a proper way to measure the tree height, the use of the product of the square of the diameter at breast height and height of the tree as an independent variable would give most reliable estimation of the stem weight. However, apart from the cut sample trees the measurement of tree height is

Table 4. Allometric relations of stem weight on the products of several kinds of diameters squared and the tree height (Data based on those from Dry Dipterocarp Forest)

	$D_{0.0}{}^2H$	$D_{0.1H}{}^2H$	DBH^2H	$D_b{}^2H$
h	0.98623	1.01892	0.90084	0.86822
log A	2.40513	2.62185	2.57108	2.66352
c. i.	0.33594	0.15317	0.13289	0.35161
r^2	0.969	0.987	0.990	0.929

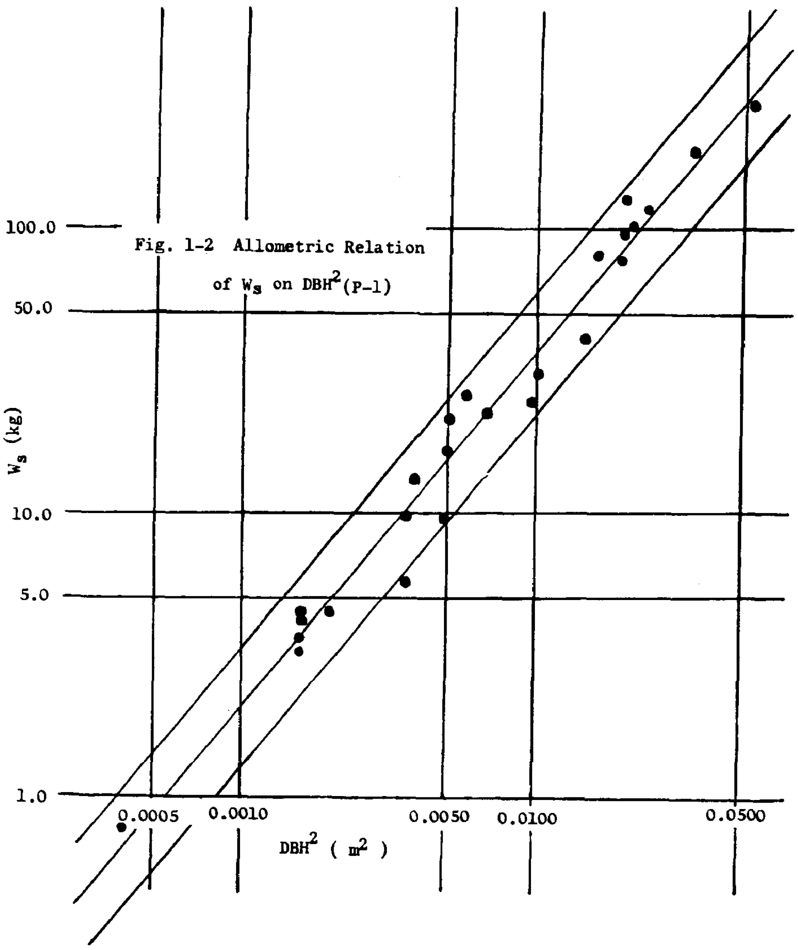


Fig. 1-2 Allometric Relation of W_s on DBH^2(P-1)

still quite difficult, especially in such a forest stand where the top of the trees can hardly be seen. So we have to use the next best, that is to use the diameter at breast height as the independent variables.

The values of the constants, the 95% confidence intervals and the coefficients of determinations of the regression equation for the estimation of stem weight, branch weight and leaf weight on the diameter of breast height are shown in Tables 5 and 6.

Estimation of standing crop: Using the regression equation the specific constants of which have just decided, we can compute the average value of the standing crops in terms of weight. The calculation procedures of the estimation of stem weight are as follows:

Table 5. Allometric relations used for the estimation of standing crops of Dry Dipterocarp Forest

	W_s	W_b	W_l
h	2.50913	2.93168	1.81022
log A	−0.94402	−1.98034	−1.41128
c. i.	0.21228	0.29938	0.41922
r^2	0.974	0.963	0.835

Table 6. Allometric relations used for the estimation of standing crops of Dry Evergreen Forest

	W_s	W_b	W_l
h	2.21604	2.32660	1.33842
log A	−0.57729	−1.34271	−0.83584
c. i.	0.19661	0.51804	0.58151
r^2	0.965	0.816	0.537

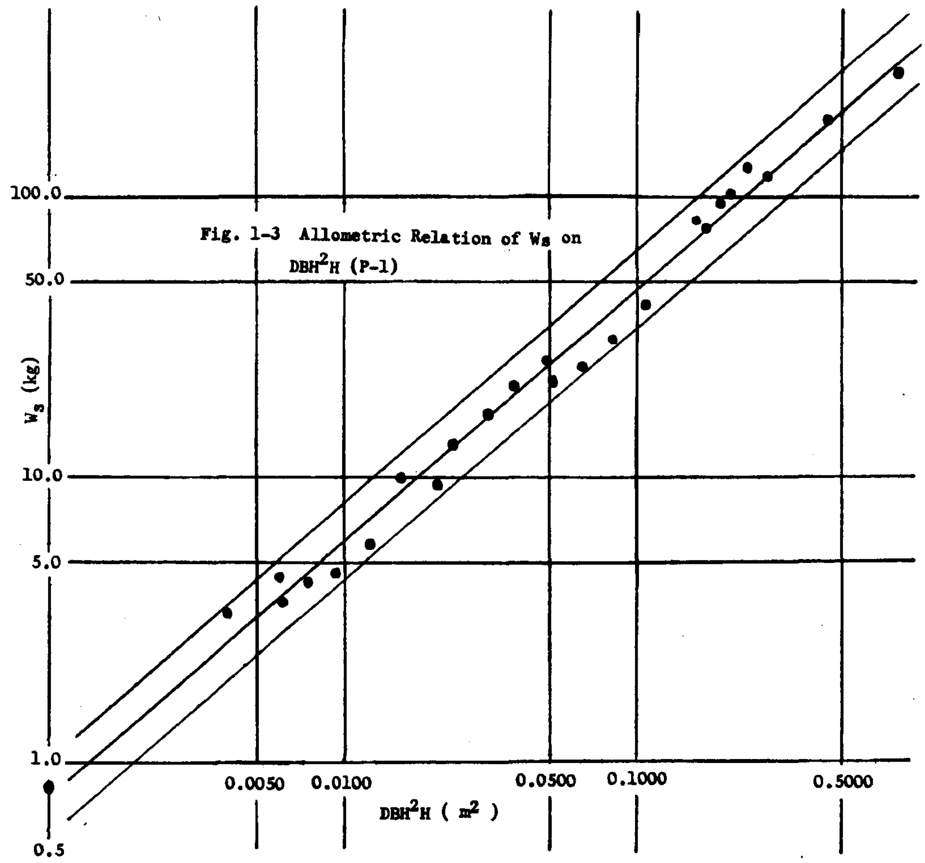


Fig. 1-3 Allometric Relation of W_s on DBH^2H (P-1)

First we prepare the diameter frequency table. The measurements of the diameter at breast height are grouped into diameter steps using the round number of every 2 cm. Next we compute the average stem weight of every diameter step substituting the value of the diameter for x. The stem weight of each diameter step is easily calculated by multiplication of the average stem weight by the number of trees. The total of these values is the stem weight of the sample plot. The branch weight and the leaf weight are similary calculated. Thus we have the estimation of the standing crop of the dominant trees of the stand in terms of weight.

For the standing crops of the subordinate species another measurement was carried out. The results were converted into the value for hectare, which are shown in Tables 7 and 8.

The permanent plot No.1 in Dry Dipterocarp Forest and the permanent plot No.2 in Dry Evergreen Forest are kept undisturbed; therefore figures for the standing crops of subordinate species of the plots are not available. However, the amount of the subordinate species is comparatively so small that the standing crops of the dominant trees would give approximate values for the plots.

We noticed that the magnitude of the standing crops varies from plot to plot even in the same stand. In Dry Dipterocarp Forest the value of W_t for PP-1 250.48 ton/ha is more than 2 times the value for P-1 91.37 ton/ha. In Dry Evergreen Forest the value of W_t for PP-2 403.77 ton/ha is a little less than 2 times the value for P-2 220.94 ton/ha. Such a variability of the magnitude of the estimates may be caused by unusually big sized trees which

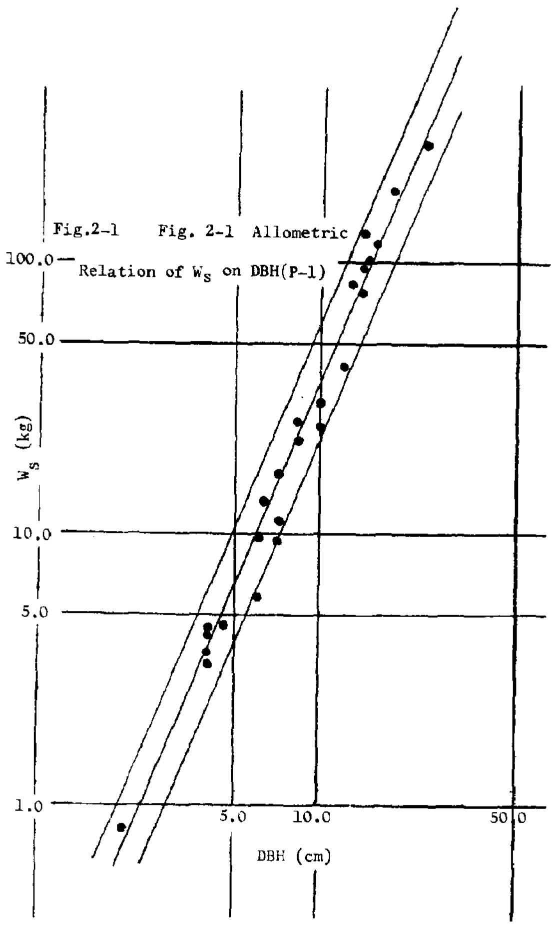


Fig. 2-1 Allometric Relation of W_s on DBH(P-1)

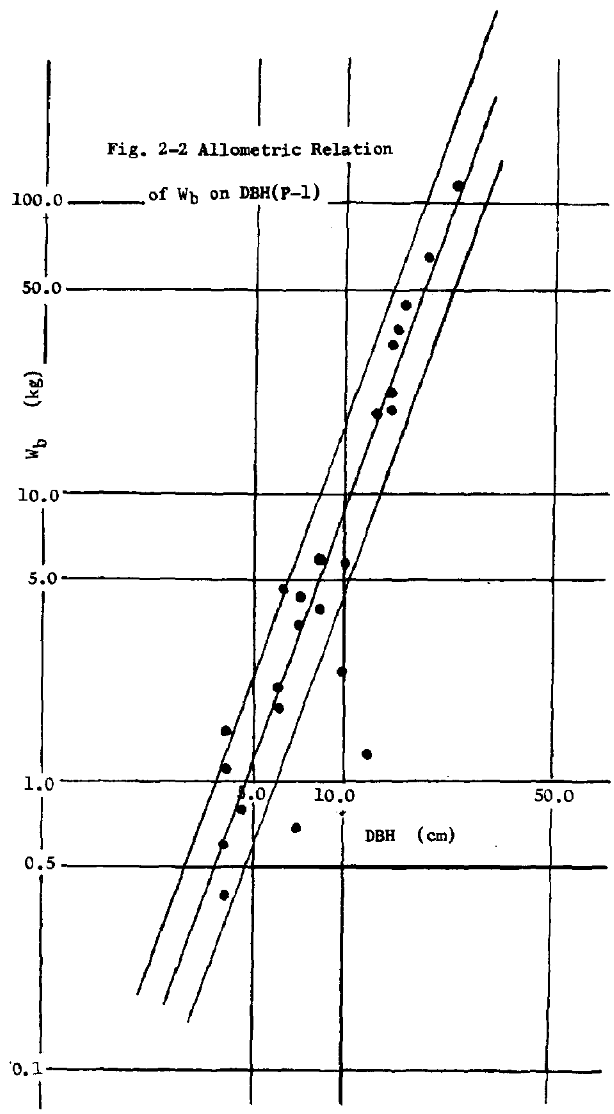


Fig. 2-2 Allometric Relation of W_b on DBH(P-1)

Table 7. The estimates of the standing crops of Dry Dipterocarp Forest

		W_s	W_b	W_c	W_l	W_t
P-1	Dominant tree	65.78	18.62	84.40	3.41	87.81
	Subordinate spp.	2.07	0	2.07	1.49	3.56
	Total	67.85	18.62	86.47	4.90	91.37
PP-1	Dominant tree	176.34	67.70	244.04	6.44	250.48
	Subordinate spp.	—	—	—	—	—
	Total	176.34	67.70	244.0	6.44	250.48

Table 8. The estimates of the standing crops of Dry Evergreen Forest

		W_s	W_b	W_c	W_l	W_t
P-2	Dominant tree	151.95	45.75	197.70	8.26	205.96
	Subordinate spp.	10.10	1.33	11.43	3.55	14.98
	Total	162.05	47.08	209.13	11.81	220.94
PP-2	Dominant tree	313.34	81.50	394.84	8.93	403.77
	Subordinate spp.	—	—	—	—	—
	Total	313.34	81.50	394.84	8.93	403.77

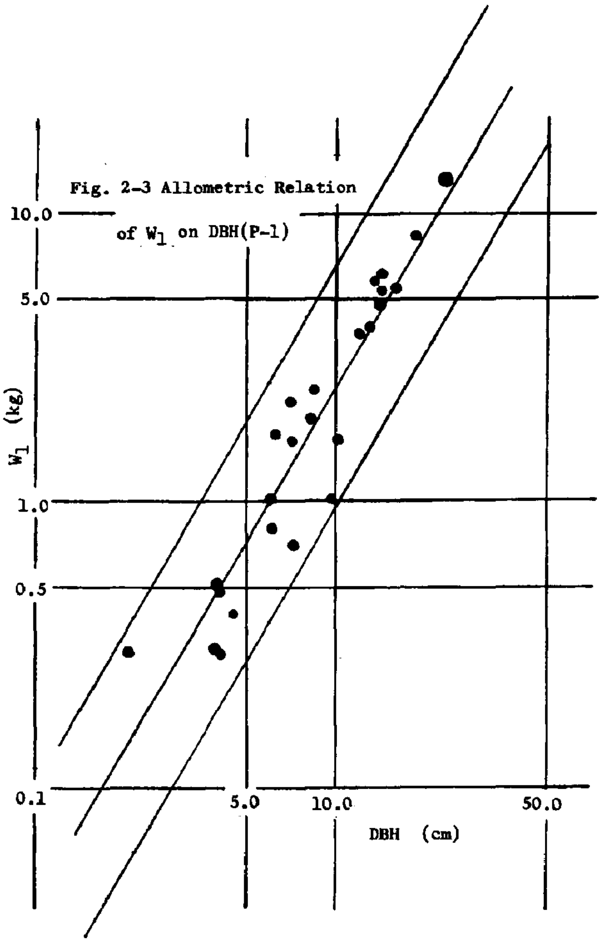


Fig. 2-3 Allometric Relation of W_l on DBH(P-1)

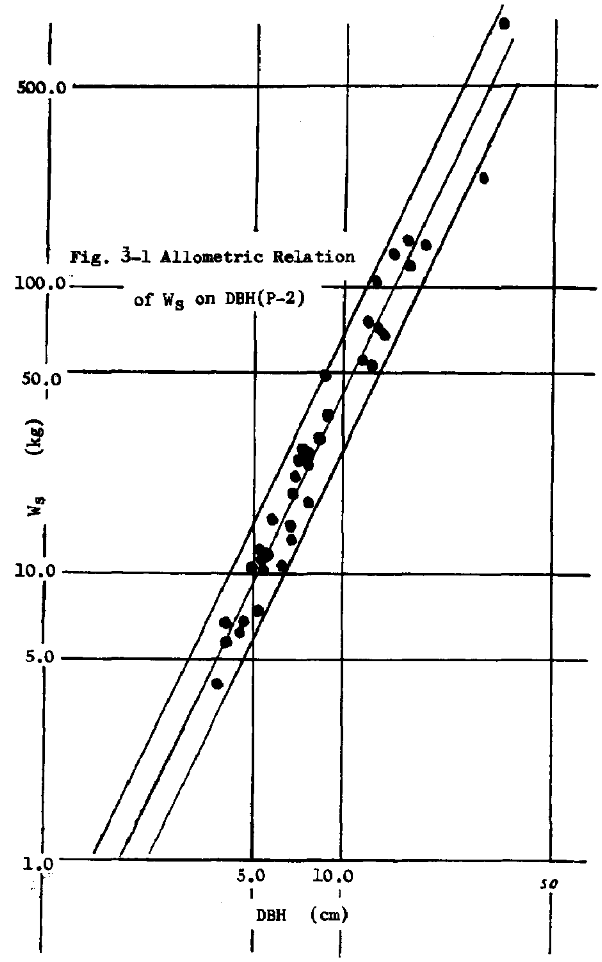


Fig. 3-1 Allometric Relation of W_s on DBH(P-2)

happened to occur in the sample plot. This fact may imply that the size of the sample plot is still smaller than necessary. In other words, if the size of the sample plot is large enough to cover the diversity of the stand, the variability of any quantity of the stand will be minimized. The bigger the individual, the more critically they will affect the value of the quantity estimated. However, as yet we do not know the suitable size (or minimum area) of a sample plot for this purpose. But the suitable size have to be fairly accurately determined, if we were to make a reliable quantitative study.

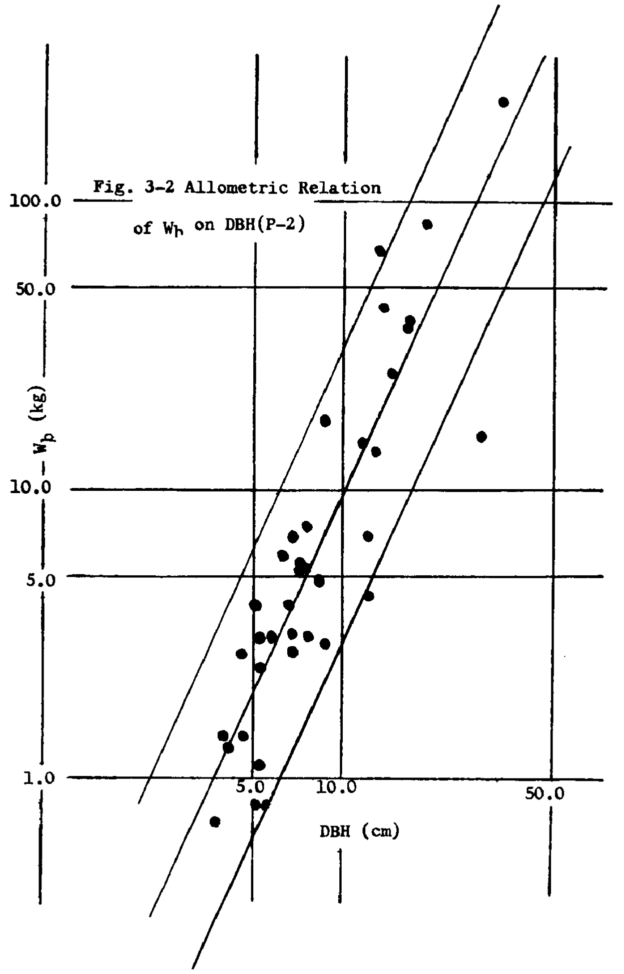


Fig. 3-2 Allometric Relation of W_b on DBH(P-2)

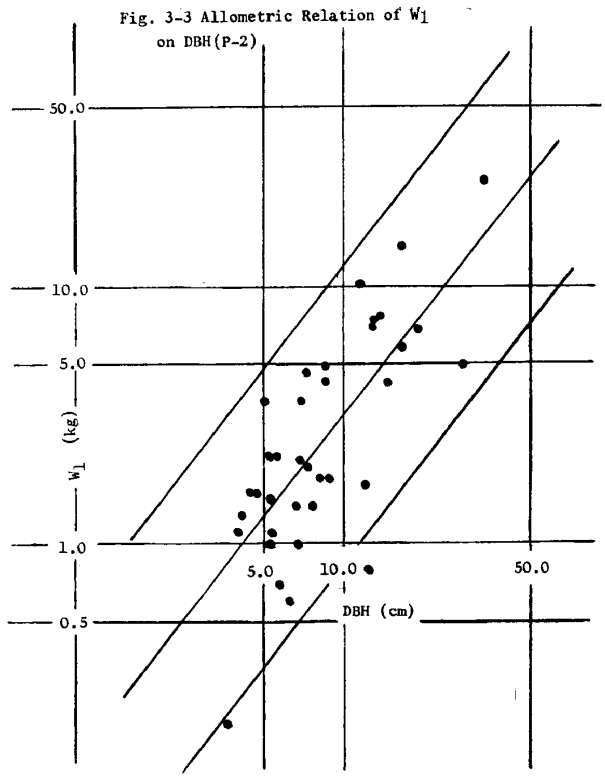


Fig. 3-3 Allometric Relation of W_l on DBH(P-2)

In 1957 a group of Japanese ecologists studied the estimation of standing crops in northern Thailand. They estimated the total weight of trees for the Dipterocarp savanna forest at 49.6 ton/ha, and for the temperate ever green-forest at 177.9 ton/ha. They worked out their estimation thoroughly on the dry weight basis; therefore direct comparison of our results with theirs would have no meaning. We have to take the difference of bases into account in the comparison. If we do so, it seems that their results and ours agree with each other approximately.

Thus we see a possibility of using allometric relation in estimating standing crops of a forest stand. Though, the estimates of standing crops by using regression equation of allometric relation have a little variability even in the same forest stand, they approximately agree with those made in different localities in a similar stand of forest type.

Recently T. Kira et al. read a paper at the 11th Congress of Japanese Ecological Society, in which they treated the relationship of leaf amount to the other elements of the individual tree on the reciprocal expression base. The leaf amount would reach at the saturation value sooner or later. The regressions presented here would have to be examined again on the reciprocal expression base.

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