# SAMPLING WITH A ROPE—A WORKED EXAMPLE

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## Introduction

A survey party consisting seven members of Statistical Branch visited compartment number 2 in Lachiwala Range, East Dehra Dun Division from 20th to 30th of November, 1978. The said compartment consists of 101.2 hectares of mixed forest. A portion in the centre is blank. The rest of the area is well stocked with Kokat and occasional Sal and Sain trees. The trees have good growth. The entire area was surveyed systematically by considering points at five chain by five chain apart. At each point data was collected by two methods. One is by the method of rope sampling (please refer to the paper 'Sampling with a Rope—A novel and useful method' for theoretical details) and the second one is by laying down a circular plot of 400 m² area centered at each of the systematically selected points of 5×5 chains. Basal area estimated from these two methods are presented. A theoretical forest as in Figure 4 was used to check the sampling method's accuracy.

## Material and method

In order to understand the working procedure of the sampling with a rope, let me explain the procedure in some detail. First we should understand when to tally a tree. Figure 1, shows the area in which we tally the tree having circular stem denoted by shaded area. Here $C_i$ is the critical distance from the tree within which if one stands then the tree is tallied. Let, $C_i = k L_i$ for any tree where k is a fixed constant. In the Figure 2, the trees which are tallied when k=1 from random point P are marked with 'X' in the centre of the tree. Note that the distance from P to the tree's trunk is less than the circumference value for tallied trees. Thus we are going to use only the distance from random selected point P to the tree and the circumference measurement of the tree. Let $M_i$ be the distance from P to the $i^{th}$ tree whose circumference is $L_i$. For k=1, we tally the $i^{th}$ tree if $M_i \leqslant L_i$. For any general k, we tally the $i^{th}$ tree if

$$(1/k)\ M_i \leqslant L_i \quad \text{.........................................(1)}$$

It is easy to see that (1) implies that P is within the distance ($k L_i$) from the tree. Normally we take $k = 2^m$ for any integer 'm'. By this we can halve again and again (see Fig. 3) to get the length ($M_i/k$) easily. [If m is negative then double the length again and again to get ($M_i/k$)].

Key words :—Rope sampling, Basal area enumeration, Practical hints for Rope sampling.

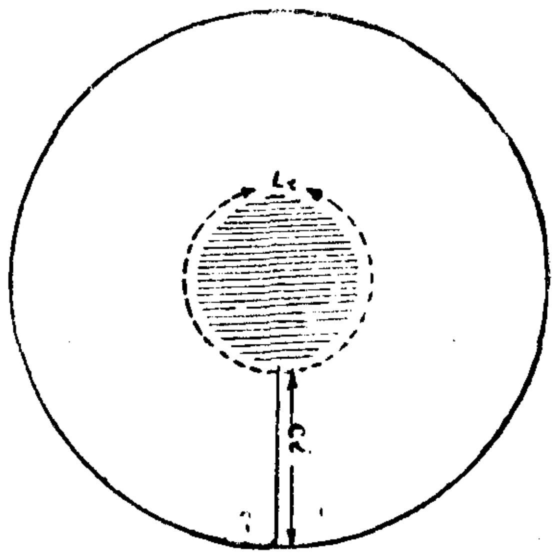

Fig. 1

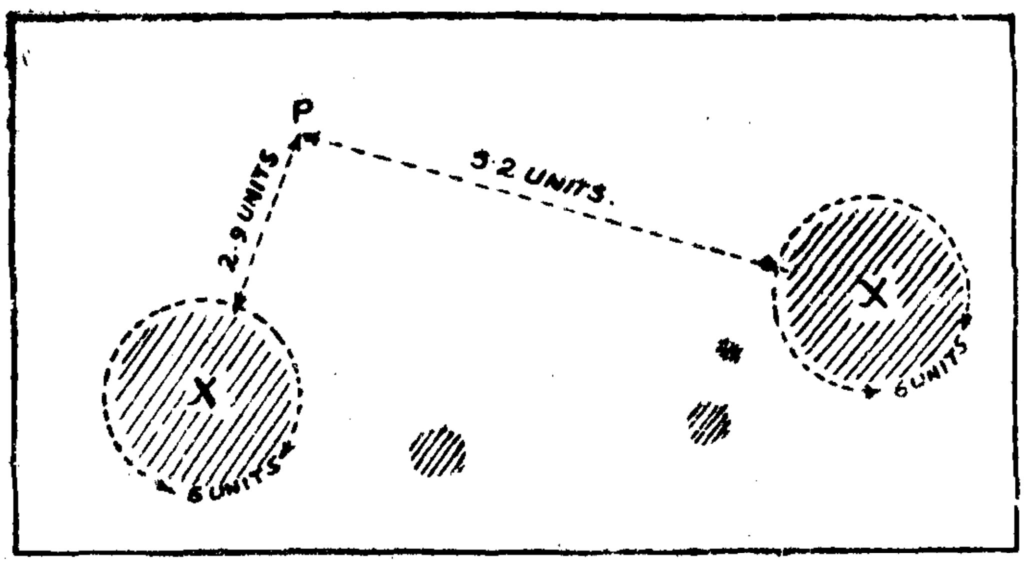


Fig. 2

In practice it is very easy to say whether a tree is tallied or not from P for a given $k = 2^m$. After some experience it is seen that tallying at P by making 360° sweep is just checking a few daubtful trees while most of the trees can be had as obviously not tallied or obviously tallied. After reaching P we have tallies for different 'm' values just like using different basal area factor wedge prisms.

The sampling with a rope survey results are presented in Table 1.

**Table 1**

*Table giving the total number of tallies for different $2^m$ values*

| Number of points | $(M_i/2^m)$ | | | |
|---|---|---|---|---|
| | $M_i$ | $M_i/2$ | $M_i/2^2$ | $M_i/2^3$ |
| 1-22 | 3 | 7 | 28 | 84 |
| 23-44 | 5 | 11 | 38 | 157 |
| 45-66 | 6 | 19 | 47 | 160 |
| 67-88 | 0 | 9 | 29 | 122 |
| 1-88 | 14 | 46 | 142 | 523 |
| Average ($\bar{n}_m$) | 0.159 | 0.523 | 1.602 | 5.898 |

For any m the equation to be solved is :—

$$\bar{n}_m = \frac{\Sigma BA_i}{A} + \frac{\Sigma L^2_i}{A}\,(2^m + 2^{2m}\pi) \qquad \text{.........} \quad (2)$$

(Please refer to equation 4 of the paper by Satyamurthi in *Indian Forester*, 1979 January, issue, Vol. 105, No. 1).

The upper limit for basal area per unit area is

$$\left(\frac{\Sigma BA_i}{A}\right) \leqslant \left[\bar{n}_m \Big/ \left(1 + 4\pi\,(2^m + 2^{2m}\pi)\right)\right] \qquad \text{.........} \quad (3)$$

The exact basal area per unit area is estimated by

$$\left(\frac{\Sigma BA_i}{A}\right) = \left[\bar{n}_m \Big/ \left(1 + \frac{4\pi}{f}\,(2^m + 2^{2m}\pi)\right)\right] \qquad \text{.........} \quad (4)$$

Here 'f' value which is the ratio of correction is $f = \frac{4\Sigma ab}{\Sigma(a+b)^2}$ where a, b are diameters at two vertical directions for the tallied trees is 0.9692.

From Table 1 we get by using equations (3) and (4) the following Table 2 results.

**Table 2**

| $k=2^m$ | Upper limit of $(\Sigma BA_i / A)$ | $\bar{n}_m$ | Estimate of $(\Sigma BA_i / A)$ |
|---|---|---|---|
| $2^0=1$ | 0.0030 | 0.159 | 0.002907 |
| 2 | 0.0028 | 0.523 | 0.002713 |
| $2^2$ | 0.0023 | 1.602 | 0.002229 |
| $2^3$ | 0.0022 | 5.898 | 0.002132 |

By interpolating basal area for $\bar{n}=1$ from Table 2 we get the best estimate of basal area to be 25.0 $m^2$ per ha. (The logic of this will be clear after reading the theoretical example that follows in next para). For plot sampling the same 88 points were visited and from each point the basal area of trees on a 400 $m^2$ circle with the centre as the said point (for rope sampling) is considered. The mean basal area per unit is 0.001447 and the 95% confidence limits is from 0.00123 to .00158 which in other words gives 12.3 $m^2$ to 15.8 $m^2$ per ha. In a previous survey conducted by the branch during 1972 in the same area by using strip sampling procedure after enumerating 300 plots in 8 strips showed the 95% confidence limits to be 15 $m^2$ to 17.1 $m^2$ per ha. Thus the results obtained are not much different. To have an exact known basal area on which we can use the rope sampling method and compare its estimate with actual we proceed as follows :

Let us consider a theoretical forest with basal area of the shapes given in Figure 4. The systematically selected points of size 4, 9, 16, 25 were used for analysis. The real basal area is 0.088 square inches per one square inch of forest area.

| Number of points | Table showing values of $\bar{n}_m$ for different $2^m$ given as $(M_i / 2^m)$ | | | | | |
|---|---|---|---|---|---|---|
| | $4M_i$ | $2M_i$ | $M_i$ | $M_i/2$ | $M_i/2^2$ | $M_i/2^3$ |
| 4 | .7500 | 1.7500 | 4.0000 | 6.00 | 6.00 | 6.00 |
| 9 | .7775 | 1.6667 | 4.222 | 6.00 | 6.00 | 6.00 |
| 16 | .7500 | 1.8125 | 4.00 | 6.00 | 6.00 | 6.00 |
| 25 | .6400 | 1.7600 | 4.44 | 5.96 | 6.00 | 6.00 |

The figure we considered is having only six trees and hence for m having values more than 1 we have 6 to be the average number of tallies. This arises because when we consider the Figure 4 it is kept in a rectangle. The imaginary circles which will be formed for m values greater than 1 will be lying out-side the rectangle, and there by reducing the precision of $\bar{n}$ (Please refer to the previous paper of the author in January, 1979 issue of

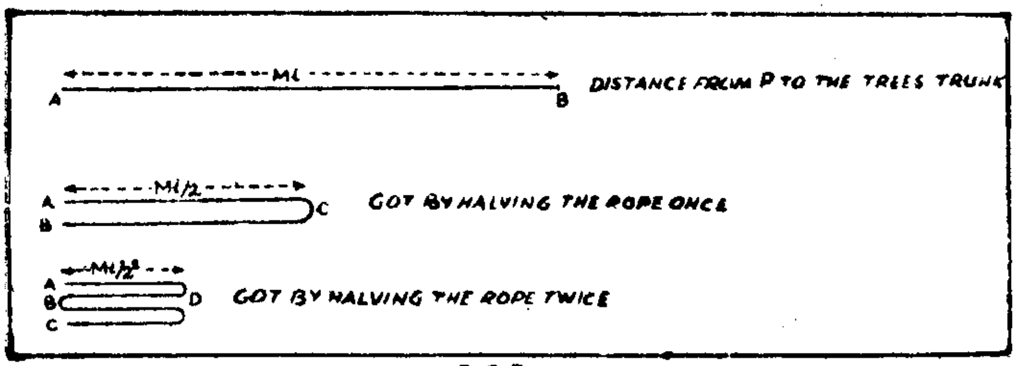
Ml
A
B
DISTANCE FROM P TO THE TREES TRUNK
Ml/2
A
B
C
GOT BY HALVING THE ROPE ONCE
Ml/2²
A
B
C
D
GOT BY HALVING THE ROPE TWICE

FIG. 3

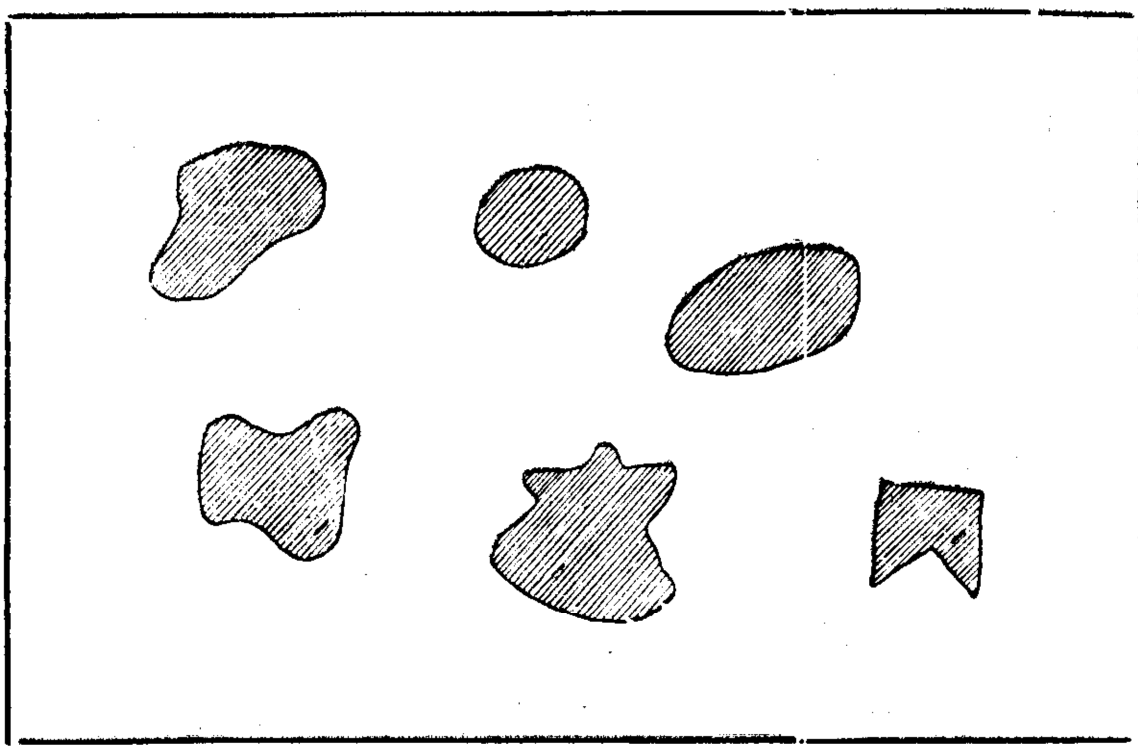

Fig. 4

of *Indian Forester*, Vol. 105 No. 1. Hcene we arrive at the following conclusion namely the basal area calculation using rope method is precise when the $\bar{n}$ values are closer to one

| Size | $\bar{n}$ value | Estimated upper limit of basal area in sq. inches per one square inch. |
|---|---|---|
| 4 | 0.75 | 0.0928 |
| | 1.75 | 0.1083 |
| | | Interpolated for $\bar{n}=1$ is 0.0966 |
| 9 | 0.78 | 0 0963 |
| | 1.67 | 0.1031 |
| | | Interpolated for $\bar{n}=1$ is 0.0980 |
| 16 | 0.75 | 0 0928 |
| | 1.81 | 0.1022 |
| | | Interpolated for $\bar{n}=1$ is 0.0974 |
| 25 | 0.64 | 0.0843 |
| | 1.76 | 0.1089 |
| | | Interpolated for $\bar{n}=1$ is 0.0908 |

Using the exact 'f' value for this figure is 0.9691 we get for 25 samples the best estimate of basal area corresponding to $\bar{n}=1$ is 0.0878. Hence we see that our estimate is very satisfactory. Obviously it proves the salient point that rope sampling method gives good estimates of the basal area. The Table 3 gives $k=2^m$ values which when used we get near unity value for $\bar{n}$, while $(\Sigma BA_i / A)$ is approximately known

**Table 3**

***The approximate basal area when known, the value of 'm' which will give $\bar{n}_m$ near one is as follows***

| Aprox. $\left(\frac{\Sigma BA_i}{A}\right)$ | k* | 'm' |
|---|---|---|
| 0.0001 | 15.75 | 4 |
| 0.0010 | 4.87 | 2 |
| 0.0050 | 2.09 | 1 |
| 0 0100 | 1.43 | 0 |
| 0.0500 | 0.55 | -1 |
| 0 1000 | 0.34 | -2 |
| 0.5000 | 0.065 | -3 |

*—found from equation (3)

**Conclusions**

(1) The rope sampling method is easy to apply.

(2) It provides good estimates for basal area when large samples are taken.

(3) The basal area should be calculated for values of $\bar{\bar{n}}$ which are near unity.

**Acknowledgements**

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**SUMMARY**

**The author in a previous paper "Sampling with a rope—a novel and useful method" published in January, 1979, *Indian Forester* Vol. 105, No. 1 has described a new method of conducting surveys for estimating basal area of a stand of trees. Here the practical verification of the above said theory is done. For this purpose both a real forest stand at Lachhiwala Range, East Dehra Dun Division, Compartment Number 2 and a theoretical basal area of the shapes given in Figure 4 (Text) were considered. This study proves the validity of the Sampling with a Rope Theory.**

रस्सी से न्यादर्शन करना—करके दिखाया उदाहरण

लेखक के०आर० सत्यमूर्ति

## सारांश

प्रस्तुत लेखक ने अपने पिछले अभिपत्र "रस्सी से न्यादर्शन करने की नई और उपयोगी रीति" प्रकाशित जनवरी 1979, इण्डियन फॉरेस्टर में वृक्ष समूह के आधारिक क्षेत्रफल के प्राकलन का सर्वेक्षण करने की एक रीति का वर्णन किया था। यहां पर उपर्युक्त सिद्धान्त का व्यावहारिक सत्यापन करके दिखाया गया है। इस प्रयोजन के लिए लच्छीवाला वन परिक्षेत्र, पूर्व देहरादून मंडल, उपखण्ड 2 वाला वास्तविक वन क्षेत्र तथा रेखाचित्र 4 (पाठ) में दी हुई आकृतियों वाला सैद्धांतिक क्षेत्र दोनों पर विचार किया गया है। इस अध्ययन से रस्सी से न्यादर्शन करने वाले सिद्धान्त की उपयुक्तता सिद्ध हो जाती है।

Probung mit einem Seil-eines gewirkte Beispiel

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**ZUSAMMENFASSUNG**

Der Verfasser, in eine vorige Artikel, "Probung mit einen Seil-Eine neue und nützliche Methode", im Januar 1979, Indian Forester, herausgegeben hat eine Methode der Besichtigung beschrieben, die Stammgrundfläche eines Bäumebestands zu abschätzen. Hier ist die praktische Bestätigung der obengesagte Theorie getan. Um diesen Zweck, werden einer wirkliche Forstbestand auf Lachchiwala Bezirk, Ost Dehradun Distrikt, Bestandabteilung 2 und eine theoritische Stammgrundfläche der Formen, in Figur 4 (der Text) gegeben, betrachtet. Diese Studie beweist die Gültigkeit der Probung mit einem Seil Theorie.

Echantillonnage par Corde— Mis à l'épreuve de la technique

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**Résumé**

Dans une publication antérieure "Echantillonnage par corde—un procédé nouveau et utile" parue dans l'*Indian Forester* de Janvier 1979, l'auteur a décrit une méthode toute nouvelle pour faive un relevé dans le butd'estimer la surface terrière totale d'un peuplement. La publication actuelle a pour objet, de mettre à l'épreuve la théorie du procédé. Pour ce but on a choisi d'une part un peuplement réel dans le triage forestier de Lachhiwala, de la section de l'est de Dehra Dun et d'autre part une surface terrière dont la figure 4 (Texte) représente le profil. Cette étude démontre la validité de l'échantillonnage par corde.

**References**

1. Satyamurthi, K.R. (1979).—"Sampling with a rope—a novel and useful method," *Indian Forester*, Vol. 105, No. 1.