THE LINE INTERSECT METHOD IN FOREST FUEL SAMPLING

From C.E. Van Wagner (1968).

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The tallying rules for the method are given and its limitations and sources of error are discussed.

1. Lay a line of known length across the area to be studied.

2. Record the diameter (into diameter classes) of every piece of wood intersected.

3. If the sample line crosses the end of a piece, tally only if the central axis is crossed.

4. If the sample line passes exactly through the end of a piece's central axis tally every second such piece.

5. Ignore any piece whose central axis coincides with the sample line.

6. If the sample line crosses a curved piece more than once, tally each crossing.

Formulae:

The basic formula, when all factors are in the same units, is;

$$V = \frac{\pi^2 \sum d^2}{8L}$$

where: V = Volume of wood per unit area

d = piece diameter (mid-point of diameter class).

L = Length of sample line.

To find weight of wood, then multiply the volume estimate by the specific gravity of the wood. That is;

$$W = \pi^2 S \sum d^2$$

This formula can be modified to any set of units. For example, if d is in millimetres, L is in metres, the desired answer in tonnes/ha. is;

$$W = \frac{(0.013 S \sum d^2)}{L}$$

THEORY.

Suppose that a sample line of length L crosses an area containing many horizontal cylinders of various length, diameters and orientations. The sample line will cross at various angles making a series of vertical elliptical cross sections, that if summed, would provide the required volume estimate. To visualize this, imagine the line to have infinitesimal width, which then cancels out in the division of total volume by total sampled ground area. The volume per unit area can thus be stated in terms of cross-sectional area per unit length of line; the net dimension, length, is the same in both expressions.

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Sources of Error.

The method depends on three basic assumptions;

1. The pieces are cylindrical. However, the presence of taper probably introduces error.

2. All pieces are horizontal. However, a vertical angle can be quite large before the error is serious.

3. The pieces are randonly orientated.

Provided the basic assumptions are met, the method gives an unbiased estimate of wood volume along the sample line. Field errors are discussed;

a) Taper - The volume of a tapered piece is the sum of all its right circular cross sections of infinitesimal thickness. Since the measurement of any one diameter should be an unbiased sample of the piece, the presence of taper consequently ought not to affect the volume estimate.

b) Axial asymmetry. If some pieces are not symmetrical about their central axes, it is reasonable to suppose that, on the average, representative diameter will be tallied.

c) Tilt. If the pieces were tilted at an angle h, their chances of being crossed would be reduced by the factor 1 - cos h, and the volume estimate would be low by that amount. Minor tilt can thus be safely ignored.

d) Sloped Surfaces. When the sampled area lies on a slope, the volume V per unit area can be readily converted to the horizontal basis. Multiply V by the ratio of slope area to equivalent horizontal area.

Van Wagners line intersect method gives accurate weight per unit area of stem wood fuels. His technqiue can be used to give accurate weights of aerial needles and other fire fuel components. To achieve this, a relationship between stem diameter, or wood weight, and biomass of other materials was established.

Following is the procedure of sampling for stem wood weight, areial needle weight and light (branch) wood weight.
Each top intersected by the line is entred into one of the following diameter classes; 0-4cm, 6-8cm, 8-10cm, 10-12cm, 12-14cm. For each diameter class, the formula developed earlier is applied using the midpoint of the diameter class.

$$W = \frac{(0.013\ S\ Ti\ di^2)}{L}$$

where Ti = the total number of tops in a i^{th} diameter class,
di = the midpoint of the i^{th} diameter class.

This will yield the weight/unit area of stemwood along this sample line.

The next step is to determine how many tops there are in each diameter class, per hectare. Using a wood density figure of $357Kg/m^3$ and a stem taper of 1.2cm diameter decrease per one metre increase in lenght, an average wood weight can be caluclated (using the class midpoint diameter) for each diameter class.

diameter class (cm)	0-4	4-6	6-8	8-10	10-12	12-14
Stem wood weight (Kg)	0.79	6.14	21.86	42.19	64.11	107.7

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Knowing the average weight of a top in each diameter class, simple division will then give the number of tops per hectare in each diameter class.

Needle weight then becomes;

$$TNW = T_iW_i$$

where TNW = total needle weight (tonnes/ha)

T_i = number of tops in i diameter class

W_i = average top needle weight in the i diameter (which we know from the developed relationship between top diameter and biomass)

To enable the calculation of light wood fuel (branch material - both pruned and in residual tops) a strong relationship between branch diameter and branch wood weight was developed ($Y = 27.8X^{2.6}$; - Y = branch wood weight, X = butt diameter). A strong relationship between residual top butt diameter and average branch diameter and number of branches on the top was also developed. From these it was then possible to determine the branch weight in a top of particular diameter.

The whole process has been calculated and simplified on Table 2. These figures are for a line 100 metres long.

To map fuels, the area to be mapped must be stripped into a number of sampling areas. The intensity of stripping will depend on accuracy required and on available funds.

In essence, the total area to be mapped is divided into a number of sub plots - even as small as 10m x 20m. A line transect is run through these sub-plots and the fuel weight in tonnes per hectare of each sub-plot is determined - see figure 1, and mapped. Obviously, it will be a rough guide to fuel build-up areas and likely hot spots. Depending on the grid dimensions, this form of fuel assessment may be economically impractical over large areas.

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