FIRMWOOD SCALING PROCEDURES 1

1.0 Introduction to Metric Scale

Scaling plays a critical role in fulfilling the financial responsibility of the Forest Management Branch, Energy, Mines and Resources, in a systematic and equitable manner. Scaling must also serve the needs of the clients, including timber and manufacturing industries, stakeholders, and the public in assessing the Yukon timber harvesting activities.

Many parties are dependent upon an accurate and meaningful scale. To give this assurance and ensure scale results mean the same thing to all users, all scaling must conform to standard measurement methods and conventions.

Scale results in the Yukon are reported in terms of the net firmwood volume in cubic metres. A cubic metre (m^3) of timber can be viewed as a cubic metre of solid wood, free of any rot, hole, char or missing wood; hence the expression "net firmwood volume".

1.1 Introduction to Smalian's Formula

In the Yukon, the formula that is used to calculate the volume of a log that is piece scaled is Smalian's formula, which states that: *the volume of a log can be closely estimated by multiplying the average of the areas of the two log ends by the log's length*. The units used for the areas and the length must be the same, (e.g., square metres and metres in the Yukon Territory), in order to arrive at the volume in cubic metres.

Smalian's formula is commonly expressed as follows:

$$V = \left(\frac{A_1 + A_2}{2}\right) L$$

Where:

V = The volume of the log in cubic metres (m^3),

A_1 = The area of the small end in square metres (m^2),

A_2 = The area of the large end in square metres (m^2), and

L = The length of the log in metres (m).

1.2 Smalian's Formula in Detail

Smalian's formula uses the formula for the area of a circle to find A_1 (area of the top end in m^2) and A_2 (area of the butt end in m^2):

$$A_1 = \frac{\pi T^2}{10\,000}$$

$$A_2 = \frac{\pi B^2}{10\,000}$$

Fully expressed, Smalian's formula becomes:

$$V = \left(\frac{\frac{\pi T^2}{10\,000} + \frac{\pi B^2}{10\,000}}{2} \right) L$$

Where:

V = volume of the log in cubic metres,

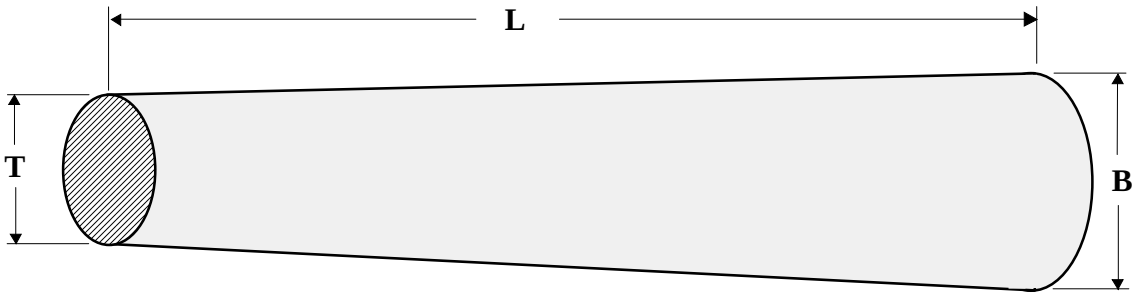
π = 3.141 592 (to 7 significant figures or 6 decimal places),

T = radius of the small end in centimetres (or the diameter in rads),

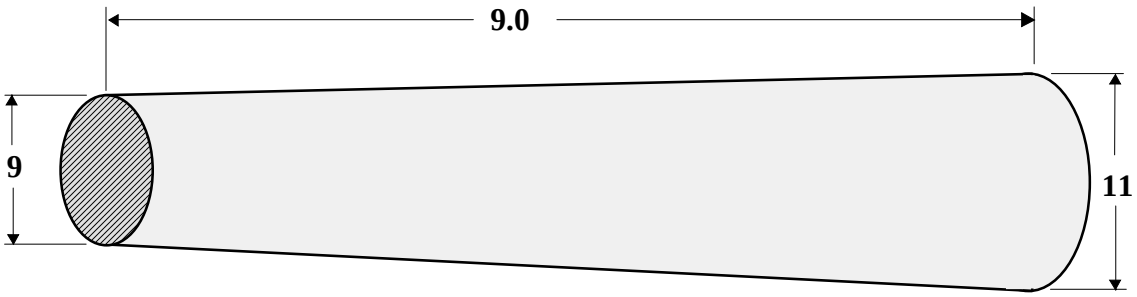
B = radius of the large end in centimetres (or the diameter in rads), and

L = length of the log in metres.

(Division of the top and butt areas by 10,000 converts square centimetres to square metres. Division of the sum of the top and butt areas by 2 determines the average end area)



The location of the variables T, B, and L.



Substitution of the variables with measured values.

Figure 1.1 Measurements for finding the values "T", "B", and "L" in Smalian's formula

If a log is measured across its diameter in rads, using a scale stick, the recorded measurement will also represent the radius of the log in centimetres. (I.e. 1rad = 2cm).

1.3 Smalian's Formula - Example Calculation

If the log illustrated is given a top radius "T" of 9 cm (9 rads in diameter), a butt radius "B" of 11 cm (11 rads in diameter), and a length "L" of 9 m.

Fully expressed, Smalian's formula states:

$$V = \left(\frac{\frac{\pi T^2}{10\,000} + \frac{\pi B^2}{10\,000}}{2} \right) L$$

Substitute the variables "T", "B" and "L" with the logs dimensions:

$$V = \left(\frac{\frac{\pi 9^2}{10\,000} + \frac{\pi 11^2}{10\,000}}{2} \right) 9.0$$

Calculate the area of the two ends in square centimetres:

$$V = \left(\frac{\frac{254.468\,952}{10\,000} + \frac{380.132\,632}{10\,000}}{2} \right) 9.0$$

Divide each area by 10,000 to change square centimetres to square metres:

$$V = \left(\frac{0.025\,446\,895\,2 + 0.038\,013\,263\,2}{2} \right) 9.0$$

Sum the areas of the two ends and divide by two to average the areas:

$$V = 0.031\,730\,079\,2 \times 9.0$$

Multiply the average end area by the length in metres to yield the volume:

$$V = 0.285\,570\,712\,8\ m^3,$$

Round the volume of the log to 3 decimal places:

$$\text{Volume} = 0.286\ m^3$$

1.4 Smalian's Formula - Simplified

The fully expressed Smalian's formula described contains three constants: "π", 10,000, and "2". The formula may be simplified by reducing these constants to one constant, expressed as "C" Smalian's formula is:

$$V = \left(\frac{\frac{\pi T^2}{10\,000} + \frac{\pi B^2}{10\,000}}{2} \right) L$$

By rearranging the terms to consolidate the constants, the formula becomes:

$$V = \left(T^2 + B^2\right) L \left(\frac{\pi}{20\,000} \right)$$

The value of "C" is therefore:

$$C = \frac{\pi}{20000}$$

$$C = 0.000\,157\,079\,6$$

Using the constant "C" provides for Smalian's simplified formula:

$$V = \left(T^2 + B^2\right) \text{ x } L \text{ x } C$$

Where:
- V = the volume of the log in cubic metres,
- T = the top radius in centimetres (or the diameter in rads),
- B = the butt radius in centimetres (or the diameter in rads),
- L = the length in metres, and
- C = 0.000 157 079 6 (the constant).

1.4.1 Smalian's Formula Simplified - Example Calculation

Using the simplified Smalian's formula and substituting the log dimensions into the formula, the volume of the log may be calculated in fewer steps than with the long formula demonstrated previously.

$$V = \left(T^2 + B^2\right) \times L \times C$$
$$V = \left(09^2 + 11^2\right) \times 9.0 \times 0.000\,157\,079\,6$$
$$V = \left(81 + 121\right) \times 9.0 \times 0.000\,157\,079\,6$$
$$V = 202 \times 9.0 \times 0.000\,157\,079\,6$$
$$V = 1\,818 \times 0.000\,157\,079\,6$$
$$V = 0.285\,570\,71$$

Round the volume of the log to 3 decimal places:

$$\text{Volume} = 0.286\ m^3$$

1.5 The Application of Smalian's Formula

Log volumes can be derived from the metric scale stick, from the *Table of the Half Volume of Cylinders in Cubic Decimetres* or from computer software. These methods, while still based upon Smalian's formula, save unnecessary arithmetic, but scalers must be able to use the formula in situations where these tools are not available.

Scalers must be able to demonstrate their knowledge and comprehension of the principles underlying scaling by stating the full version of Smalian's formula and by calculating volumes with either the full or simplified version on the written portion of the licensed Scaler's exam.

All persons designing software for scaling purposes must employ Smalian's formula and have the software approved by Yukon Forest Management Branch. Additional information on volume calculation and compilation standards can be found in the computer software section of this manual (Chapter 12)**.**

1.6 Scaling Tools

All scaling computation software and measuring devices must comply with Yukon Forest Management Branch and/or CSA standards for accuracy (CSA CAN3-0302.1-M86-12.x). It is the responsibility of scalers to ensure the accuracy of their equipment.

1.6.1 Tally Sheets

Tally sheets are used to record scale data. The data is then key-punched into computers which use Smalian's formula to calculate volumes, or hand-compiled from the scale stick or *Table of the Half Volume of Cylinders in Cubic Decimetres.* The summarized information is then submitted on Yukon Forest Management Branch approved forms. Chapter 15 details the selection and use of the approved forms to be used in different types of scales.

1.6.2 Hand-held Computers

Hand-held computers and data capture units, using Yukon Forest Management Branch approved scaling software are now preferred over the tally sheet and summary sheet system. After entering the data, the machine generates a detailed log listing and a summary report including volumes by species and grades automatically. These computer generated forms may be submitted in lieu of the above tally sheet system, thereby substantially reducing the time required to manually determine volumes and complete the forms.

1.6.3 Volume Tables

The *Table of the Half Volume of Cylinders in Cubic Decimetres* contains half volumes of cylinders with lengths from 2 m to 29.9 m and radii from 1 cm to 100 cm (diameters from 1 rad to 100 rad). It is often used to assist in hand compiling log volumes.

1.6.4 Measuring Tapes

The metric steel loggers' tape, calibrated to 0.05 m (0.5 dm) increments, is used to measure log lengths.

1.7 Species Identification and Codes

The wood of each species has unique properties that affect its value and in many cases, the grade applied to it. Each species commercial value is tied to its suitability for the manufacture of specific products.

As part of the scaling process, the scaler must be able to identify species so that volumes may be calculated by category, as well as grade. This section of the manual deals not only with identifying the various species found in the Yukon, but to some degree, the defects commonly associated with each one. The purpose is to provide guidance to help scaler’s identify species through such indicators as bark form, heartwood colour, and hardness of wood.

Note that the species symbols used in this manual are unique to the function of scaling. Other disciplines such as cruising and silviculture use different codes to designate the various species.

Relative Hardness Table of Heartwoods

Soft	Medium	Hard
Cottonwood	Lodgepole pine	Larch
Aspen	Spruce	Birch
	Balsam	

Many species have bark that is somewhat similar in appearance. If in doubt, be sure to check all indicators before classifying any log by species (i.e., appearance of bark, colour and hardness of wood, sapwood/heartwood contrast (if any), form and shape of logs and type of needles if available).

ASPEN SPECIES CODE	**AS**
BIRCH SPECIES CODE	**BI**
BALSAM SPECIES CODE	**BA**
PINE SPECIES CODE	**LO**
SPRUCE SPECIES CODE	**SP**

1.7.1 Trembling Aspen (Deciduous) – *Populus tremuloides* Michx.

Aspen is recorded as **AS.**

Logs	Logs tend to be long and cylindrical with minimal taper rapidly. While aspen has been known to get as large as 130 cm in diameter, logs in general do not exceed 60 cm. Branching is irregular and logs are generally not very straight.
Bark	Trembling aspen bark is smooth, with a waxy appearance, pale green to almost white. Bark of older trees is grey and furrowed into long, flat ridges, separated by deep, V-shaped crevices.
Wood	Relatively light and moderately low in strength. Heartwood of trembling aspen is greyish white and not clearly defined. Sapwood is nearly white.
Common defects and identifiers	Butt rot, white trunk rot, and crooked logs.
Common uses	For the manufacture of veneer, strand board, pallet stock, furniture stock, aspenite board, and pulp.

1.7.2 Birch (Deciduous) - White Birch *Betula papyrifera* Marsh, and Alaskan Birch *Betula neoalaskana* Sarg.

Birch is recorded as **BI.**

Logs	Small, rarely exceeding 60 cm in diameter, and tend to be crooked if cut in lengths over 3 m.
Bark	Very distinctive. Thin and smooth, reddish brown on young trunks, it becomes creamy white and peels off in large sheets from more mature stems. Peeling exposes a reddish-orange inner bark that oxidizes in time to black.
Wood	Hard, heavy, relatively strong, but not durable when in contact with the soil. Heartwood is pale brown in colour with a whitish sapwood.
Common defects and identifiers	Butt rot, white heart rot, and crooked logs.
Common uses	For the manufacture of finishing veneer, furniture, flooring, and panelling.

1.7.3 Balsam (Coniferous) – Alpine Fir, *Abies lasiocarpa* Hook.

Balsam is recorded as **BA.**

Logs	Normally long and cylindrical in form, can reach diameters of over 70 cm.
Inner bark	Soft and mushy and thicker than the outer bark. The outer bark takes three main forms: ▪ Young trees and the top logs of older trees, it is a light-to-dark ash grey with greyish white flecks. The bark is smooth and shows pitch blisters, or scars of pitch blisters. ▪ The bark of the lower stem on older trees is also light-to-dark ash grey with greyish flecks. However, as the tree ages, the smooth bark of the lower stem begins to break into longitudinal and some transverse cracks. The cracks are dark, even black in colour. Bark at the edges of the cracks tends to peel. Scars of pitch blisters may be visible. ▪ The bark of still older trees breaks into dark grey flat ridges and develops a scaly appearance.
Wood	Light, soft, and of relatively low strength. It has little odour and is white to a pale, yellowish brown colour. There is no contrast between heartwood and sapwood. Cut ends usually pitch.
Needles	Amabilis fir (balsam)–needles are a shiny greyish to bluish green on upper surface and white banded underneath. Needles grow 2 to 3 cm in length, and typically have a notched tip
Common defects and identifiers	Butt rot, pocket rot, ring rot, heart rot, pin rot, sap rot, ambrosia, butt (water) shake, frost checks, checks.
Common uses	For the manufacture of veneer, structural and fine quality export lumber. Poor quality balsam is usually used for pulp.

1.7.4 Lodgepole Pine (Coniferous) *Pinus contorta* Dougl.

Pine is recorded as **LO.**

Logs	Small, rarely exceeding 60 cm in diameter. They have little taper and butt ends of logs frequently show catface. Branches grow in whorls, with recessed and usually small knots.
Bark	Lodgepole pine has thin bark, finely scaled, dark brown to orange brown to grey in colour, orange brown colour under-bark between the scales. Bark usually is only about 1 cm thick.
Wood	Relatively light and soft, sometimes spiral-grained. Where free of bark, its surface is often prominently dimpled. Heartwood is light yellow to yellowish brown. Sapwood is almost white. Cut ends tend to pitch.
Needles	Grow in twos, are 2.5 to 7.5 cm long and are stiff and spirally twisted. They are very sharply pointed and dark green to yellowish green, with sharply toothed edges.
Common defects and identifiers	Butt rot, catface at butt, conk, red heart rot, spiral and straight checks in dry stems, blue stain in sapwood, and galleries under the bark in beetle attacked stems.
Common uses	For the manufacture of structural lumber, veneer, round wood products such as fence posts and fence rails, house logs and some limited use for shakes and shingles. Poor quality pine is usually used for pulp.

1.7.5 Spruce (Coniferous) - White Spruce *Picea glauca* (Moench), and Black Spruce *Picea mariana* (Mill.)

Spruce is recorded as **SP.**

Logs	Tend to be quite cylindrical and straight, with a pronounced flare, even fluting in some cases, on butt ends of logs. Branches grow in whorls and when dead are very brittle. May attain heights of 70 metres and diameters as great as 120 cm.
Bark	Thin and scaly. White spruce scales are light greyish brown, with silvery inner bark; Black spruce dark greyish brown, with deep olive green inner bark.
Wood	Soft, light in weight, resilient, relatively strong, and straight-grained. The wood is white in colour with little contrast between heartwood and sapwood. Cut ends usually exude pitch.
Needles	White spruce needles are broad, needle shaped, about 2 cm long. They are straight, 4-sided, with blunt ends. Needles are green to bluish-green, aromatic when crushed. Black spruce needles are broad, about 1.5 cm long, stiff, blunt and four- sided. Colour is dark bluish green without lustre.
Common defects and identifiers	Butt rot, pocket rot, conk, checks, frost cracks, spiral grain, oversize knots, wavy grain and burls.
Common uses	For the manufacture of veneer, structural lumber, fine quality finishing material and house logs. Poor quality spruce usually sells for pulp.