Measurement of Tree Basal Area & Volume

FOR 1001
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Today’s Objectives

- Tree → Stand → Forest
- Basic geometric calculations
- Measurement of tree diameter
- Measurement of tree height
- Determination of:
  - basal area
  - volume
  - biomass & carbon
  - $ value
What? Simply the *cross-sectional area* of a tree stem measured at *breast height* (1.4m)
Tree Basal Area

Why?

- Basal area closely relates to *volume*
- *Easy to* measure & calculate
- Useful measure of *site occupancy*
- Useful to *forecast* future development of stand
Tree Basal Area

How?

Area of a circle

Area = \pi \times (\text{radius})^2

Diameter is twice the radius

Radius = \text{diameter} / 2

Area of circle in terms of diameter is

area = \pi \times (\text{diameter}/2)^2

area = \pi \times \text{diameter}^2 / 4
How?

- Convert diameter of a circle to area of a circle

\[
\text{area} = \pi \times \text{diameter}^2 / 4
\]

\[
\text{Basal area} = \pi \times (\text{DBH})^2 / 4
\]

- But DBH is usually in cm & basal area is usually expressed in square metres

- 10000 cm per square metre

\[
\text{Basal area} = \pi \times (\text{DBH})^2 / (4\times10000)
\]

\[
\text{Basal area} = \pi \times \text{DBH}^2 / 40000
\]

Where: basal area in in m²
DBH is in cm
Tree Basal Area

How?

- Forestry naming & unit convention

  Basal area denoted by “BA”

  Basal area = in \( m^2 \)

  Diameter at breast height = DBH in cm

- Final form for basal area calculation

  \[ BA_{(m^2)} = \pi \times DBH_{(cm)}^2 / 40000 \]
Tree Volume Calculation

**What?**

- Volumetric content of tree
- Volume of different portions of tree (know which one you are talking about)
- *Total* volume (main stem from ground to tip)
- *Merchantable* volume (main stem excluding stump and tip defined to a minimum diameter)
Tree Volume Calculation

What?

Total volume

Merchantable volume

Tip

Stump
Tree Volume Calculation

Why?

- *Product content* and tree *value* are directly related to tree volume
- *Carbon* and *biomass* are directly related to tree volume
Tree Volume Calculation

How?

- Water displacement
- Geometry of solid shape approximating tree stem shape
- Cut stem into sections, measure & sum

Either physically cut or measure sections on uncut stem
Tree Volume Calculation

How?

Geometry of solid shape approximating tree stem shape

g = cross sectional area of base;  h = height;  v = volume

V =
- cylinder: $1 \times g \times h$
- parabola: $0.5 \times g \times h$
- cone: $0.33 \times g \times h$
- neloid: $0.25 \times g \times h$
Tree Volume Calculation

**How?**

- Tree form a mix of all these shapes
- Shape changes along tree stem
- So we calculate the form factor using stem analysis
Tree Volume Calculation

**How?**

- Section tree (either cut or mark)
- Measure each section to calculate volume
- Sum all sections to obtain tree total
- Perform for many trees across range of sizes
Relationship varies somewhat by tree, region and treatment

E.g. for Noonan (Kershaw)

\[ V = 0.42 \times BA \times H \]

Where:
- \( V \) = tree volume (m³)
- \( BA \) = tree basal area (m²)
- \( H \) = tree height (m)

Sometimes more complex equations are developed

\[ V = D^a \times \left[ \frac{H^2}{(H-1.4)} \right]^b \times e^c \]
### Tree Volume Calculation

#### How?

Sometimes tables are constructed that list volume by DBH & height.

<table>
<thead>
<tr>
<th>DBH</th>
<th>Spruce Height (m)</th>
<th>Spruce Volume (m^3)</th>
<th>Fir Height (m)</th>
<th>Fir Volume (m^3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>2.2</td>
<td>0.000</td>
<td>2.0</td>
<td>0.000</td>
</tr>
<tr>
<td>4</td>
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<td>0.009</td>
<td>5.6</td>
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<td>0.090</td>
<td>11.2</td>
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<td>0.355</td>
<td>16.1</td>
<td>0.318</td>
</tr>
</tbody>
</table>
Volume equations allow you to calculate tree *volume* from tree *diameter* and *height*

They can be *complex* and very *accurate*

Rough-and-ready *approximation*

\[ V = 0.42 \times g \times h \]

*Volume tables* allow you to “look up” tree volume from tree diameter and height