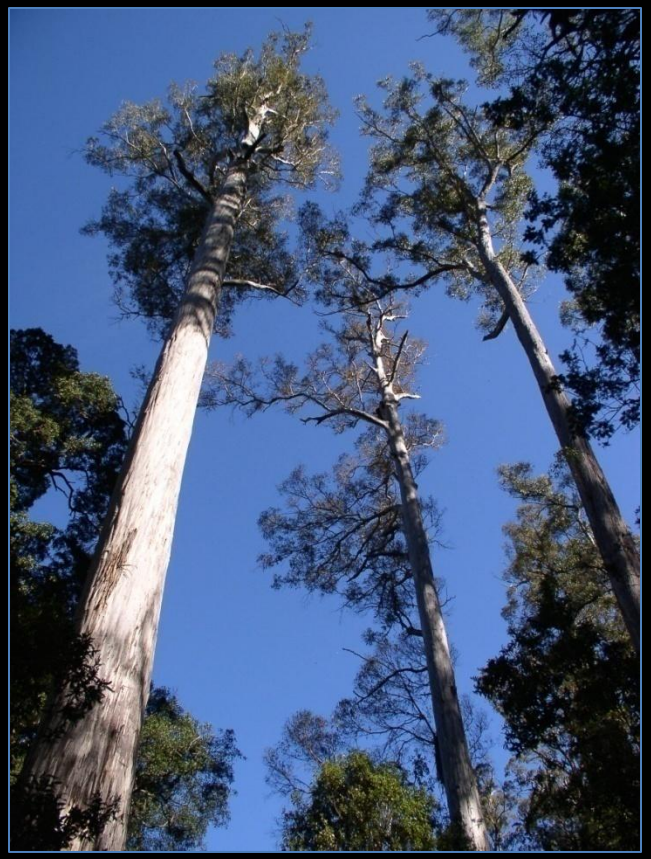
Measurement of Tree Diameter & Height



FOR 1001

Dr. Thom Erdle

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

Tree → Stand→ Forest

- We need ***information*** about forests to manage them
- But forest can be ***large*** (many hectares to many millions of hectares)
- How can we ever get ***adequate information*** about such large & complex areas?
- Viewing the forest in terms of ***nested scales***

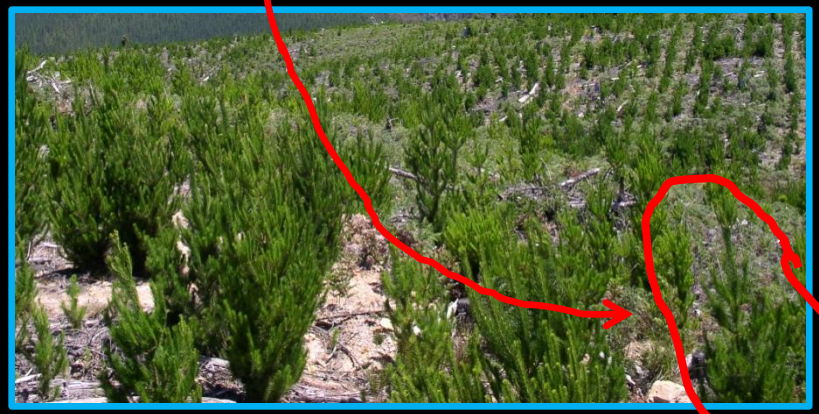
Tree → Stand→ Forest

Trees

Stands

Forest

Stands



Tree → Stand→ Forest

- Forest is made up many stands
- Stands are made of many trees
- How determine a characteristic of interest for a forest?

  Volume
  $ Value
  Tonnes Carbon
  Habitat

- ∑ tree volumes in stand = stand volume
- ∑ stand volumes in forest = forest volume

Basic building block is the tree

Basic Geometric Calculations

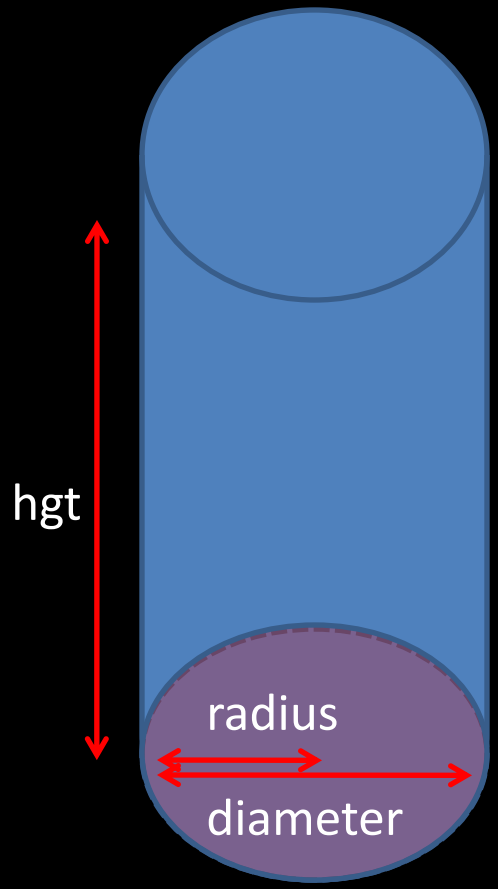
- What might you want to know about this tree?

Volume of wood in main stem

- What if we assumed the main stem (bole) shape approximated:
  - a cylinder?
  - a cone?

Basic Geometric Calculations

- How would you calculate the volume of this cylinder?



Volume = area of base * height

Area of base = pi * radius^2

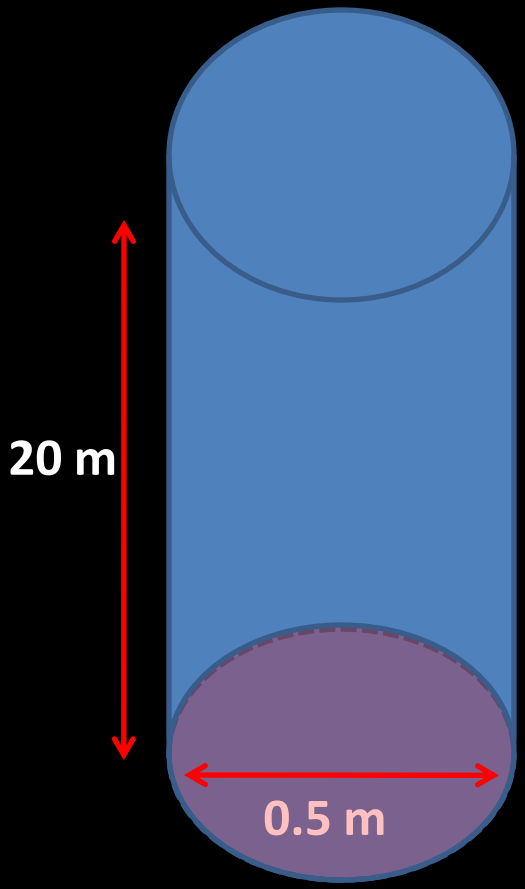
Radius = diameter/2

Area of base = pi * (diameter/2)^2

Volume = pi * (diameter/2)^2 * height

Basic Geometric Calculations

- How would you calculate the volume of this cylinder?



Volume = area of base * height

Volume = pi * (diameter/2)^2 * height

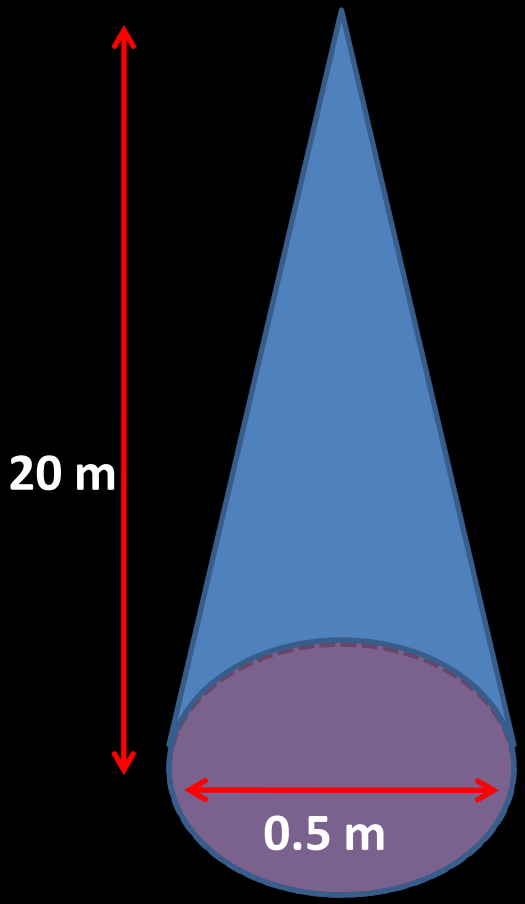
Volume = pi * (0.5m/2)^2 * 20m

Volume = 3.14 * 0.0625m^2 * 20m

Volume = 3.93m^3

Basic Geometric Calculations

- How would you calculate the volume of this cone?



Volume = 1/3 * area of base * height

Volume = 1/3 * pi * (diameter/2)^2 * height

Volume = 1/3 * pi * (0.5m/2)^2 * 20m

Volume = 1/3 * 3.14 * 0.0625m^2 * 20m

Volume = 1.31m^3

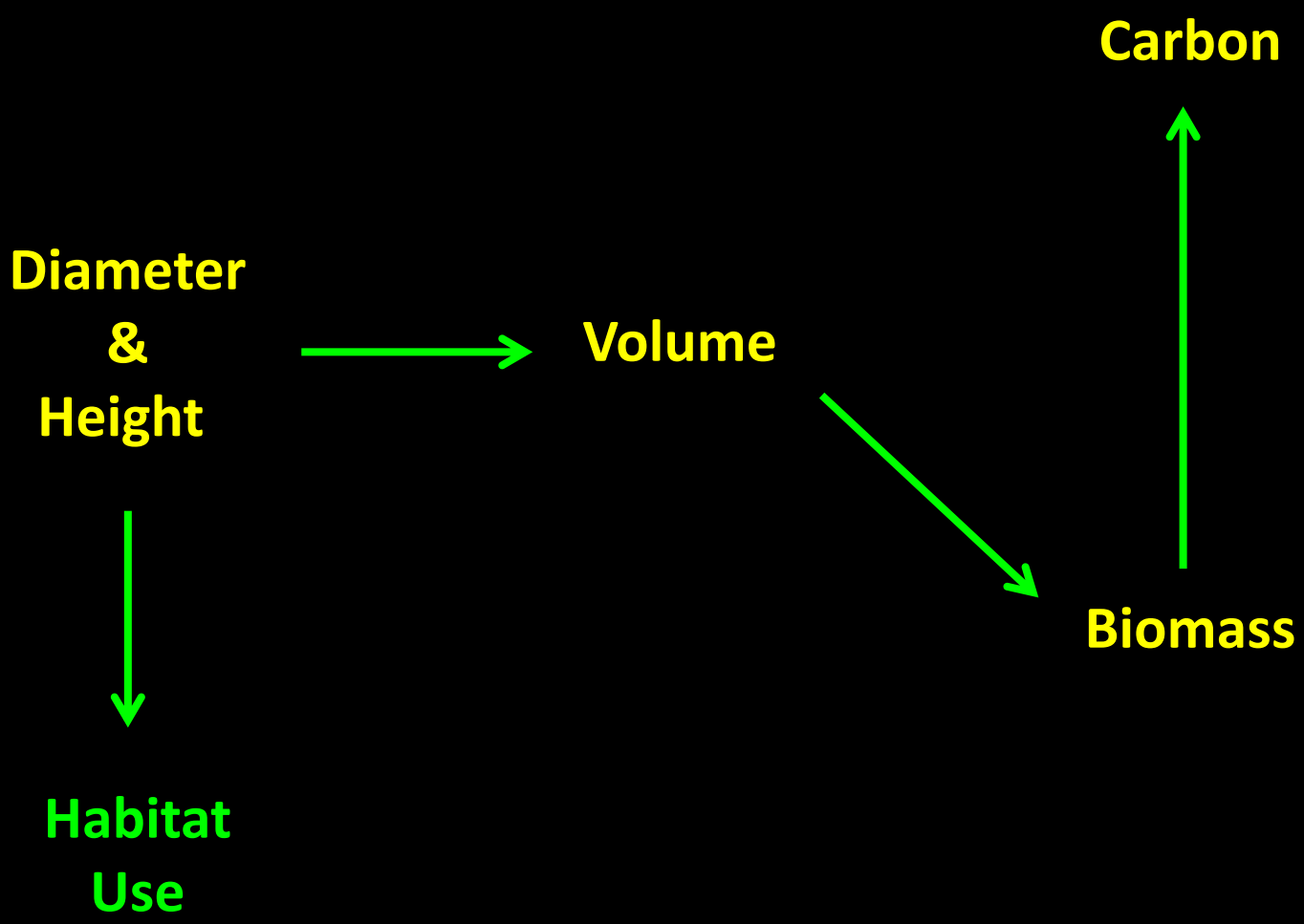
Diameter & Height Measurement

Why?

- Shape of tree stem (or bole) is somewhere between a cylinder and a cone
- Volume of cylinder & cone are functions of diameter and height
- Therefore estimate tree volume using diameter & height
- Carbon, biomass & other characteristics also relate to volume (thus diameter & height)

Diameter & Height Measurement

Why?



Diameter Measurement

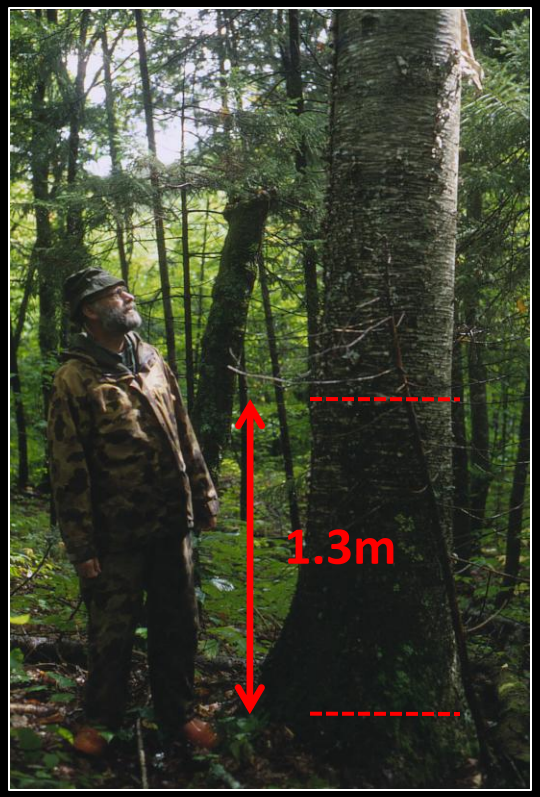
What?

- Diameter through the stem (bole) perpendicular to stem long axis

  (usually in cm to nearest mm; e.g. 43.7cm)

Diameter Measurement

Where?



- Easy
- Consistent
- Closely related to stem volume

- Standard:
  Diameter at Breast Height
  (DBH or dbh)

- Canada 1.3 metres above ground

- Avoids butt flare (swelling a base)

Diameter Measurement

Where?

- Easy
- Consistent
- Closely related to stem volume

- Avoids butt flare (swelling a base)

Diameter Measurement

How?

Dendrometer:

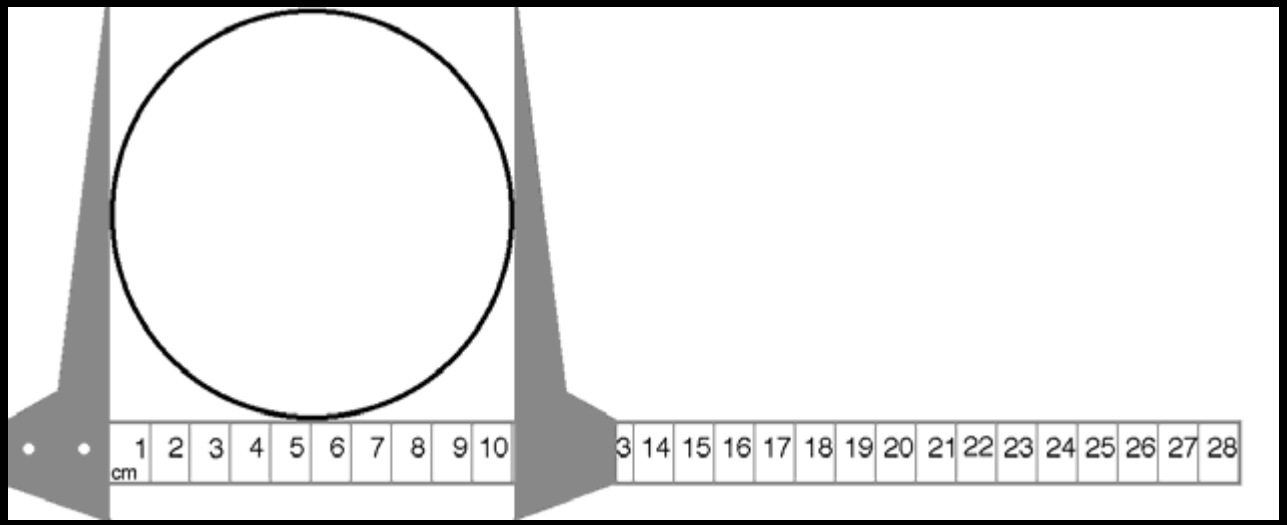
general term used for instruments designed to measure diameter

- Ocular (eye-balled estimate)
- Calipers
- Diameter Tape
- Optical Instrument

Diameter Measurement

How?

Calipers



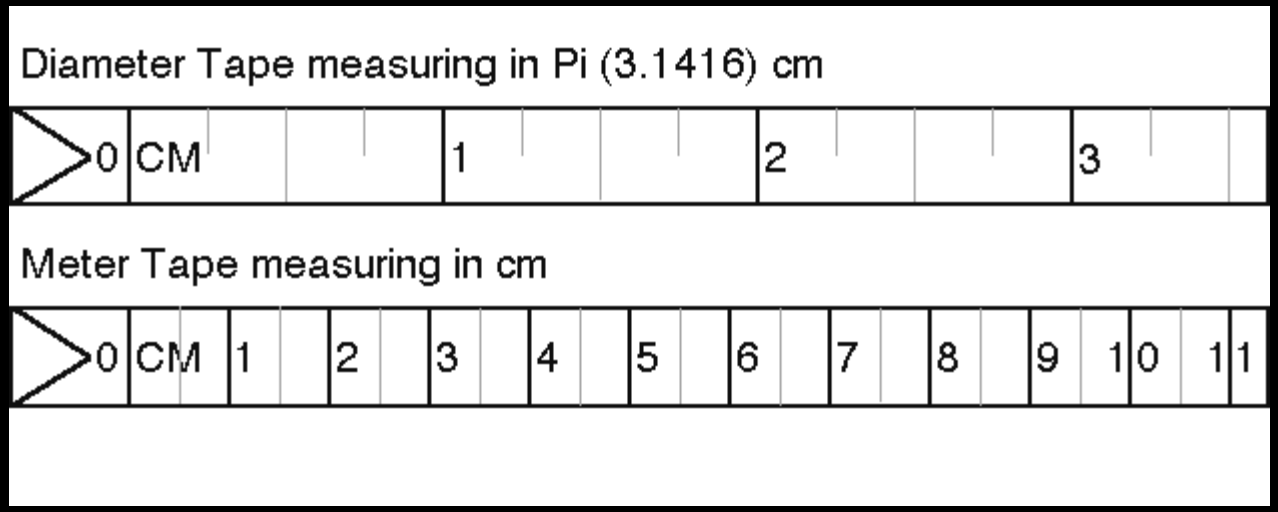
- average of two measurements taken at right angles
- useful if stem non-circular

Diameter Measurement

How?

Diameter Tape

- measures circumference, but tape calibrated in diameter



Diameter Measurement

How?

Diameter Tape

- place tape flat, tight, & level at 1.3 m above ground

Diameter Measurement

Note

- methods show measure diameter **outside bark** (DBH $_{ob}$)
- if **inside bark** diameter is needed (DBH $_{ib}$) measure two bark thicknesses and subtract from DBH $_{ob}$

Diameter Measurement

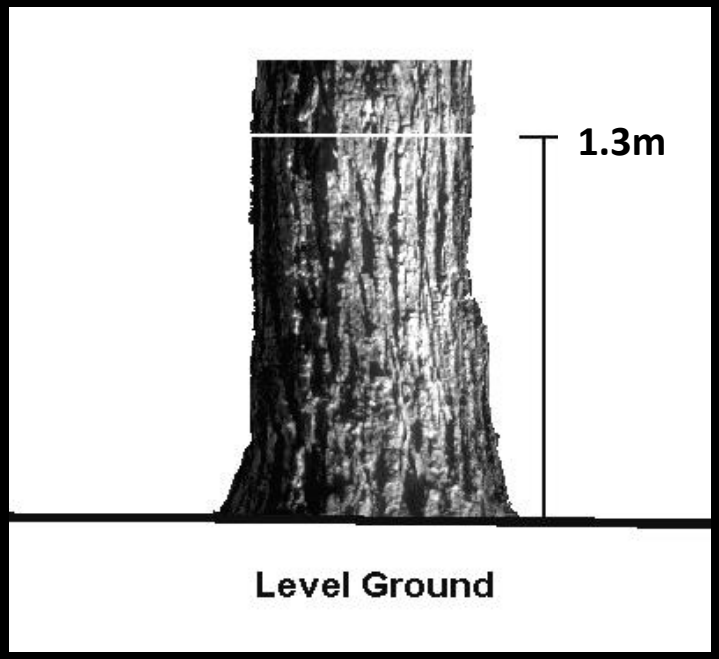
How?

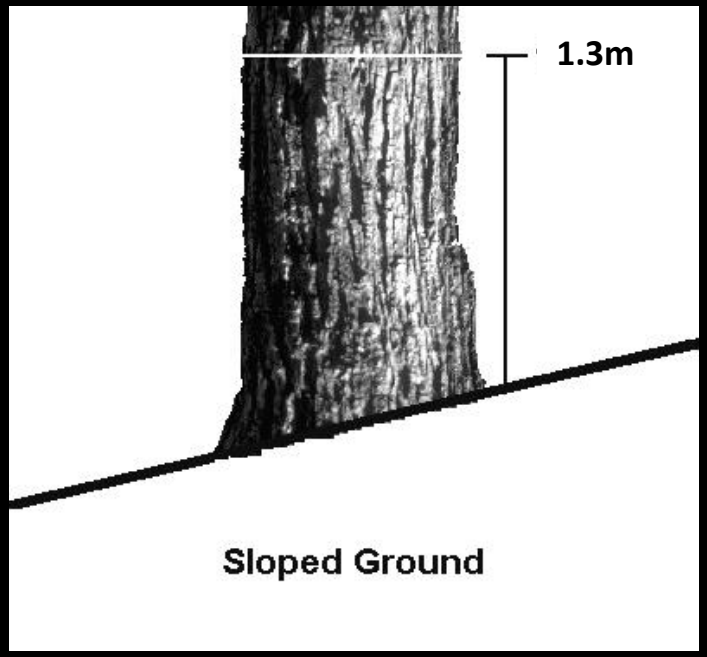
Special Cases (see website material)

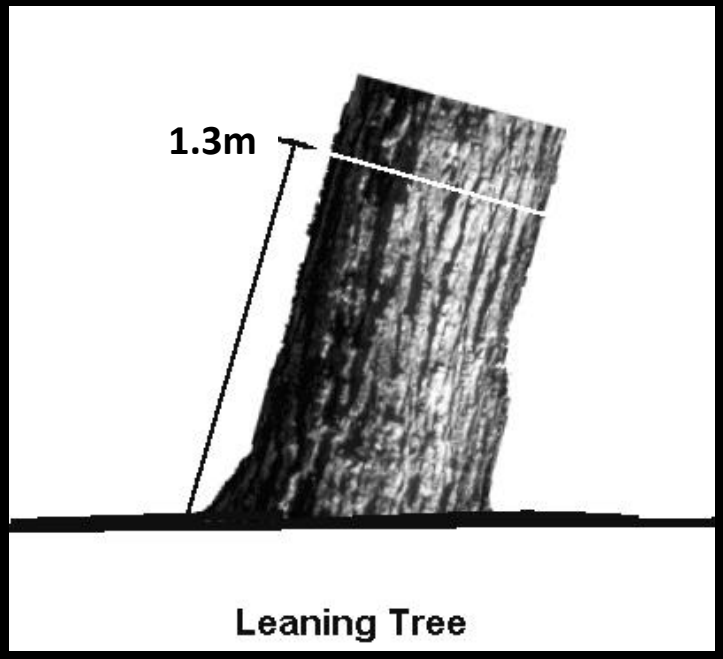
- **Slope:**
  "ground level" is on uphill side of tree

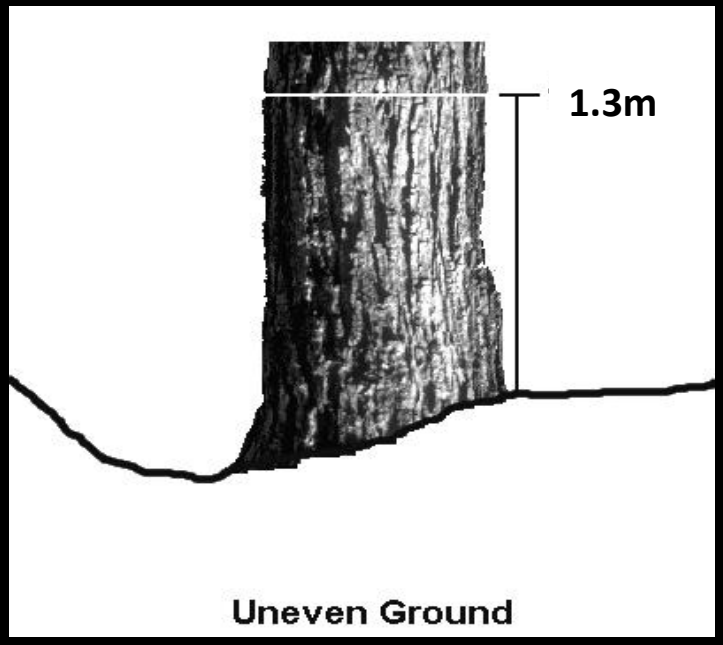
- **Deformity at 1.3m:**
  (a) shift to nearest normal position on tree
  (b) if shift >15cm, average two measures (one above & one below)

DBH Measurement – Special Cases



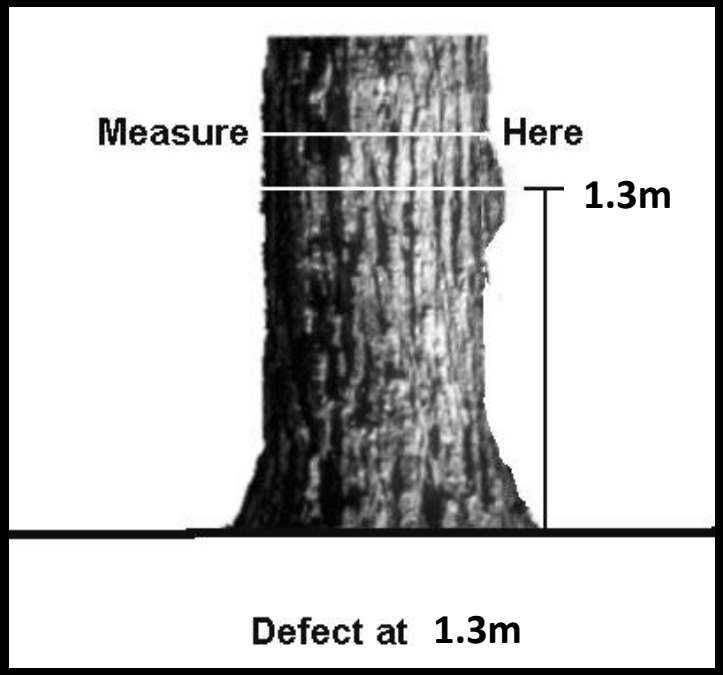


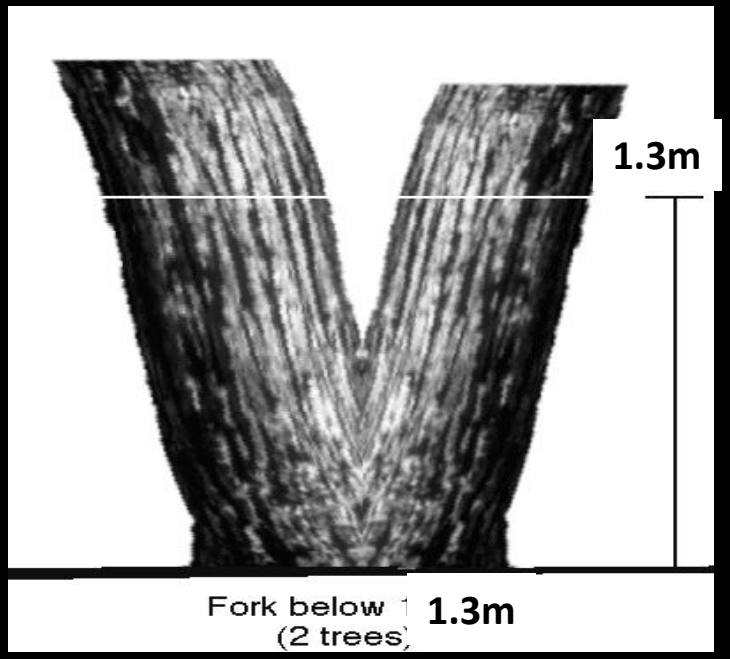


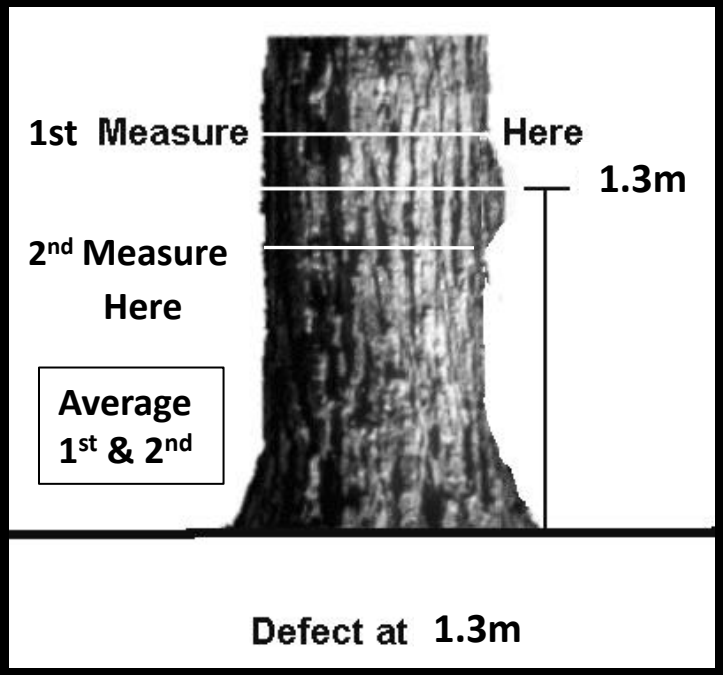


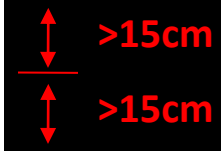
Figures courtesy John Kershaw (UNB Forestry)

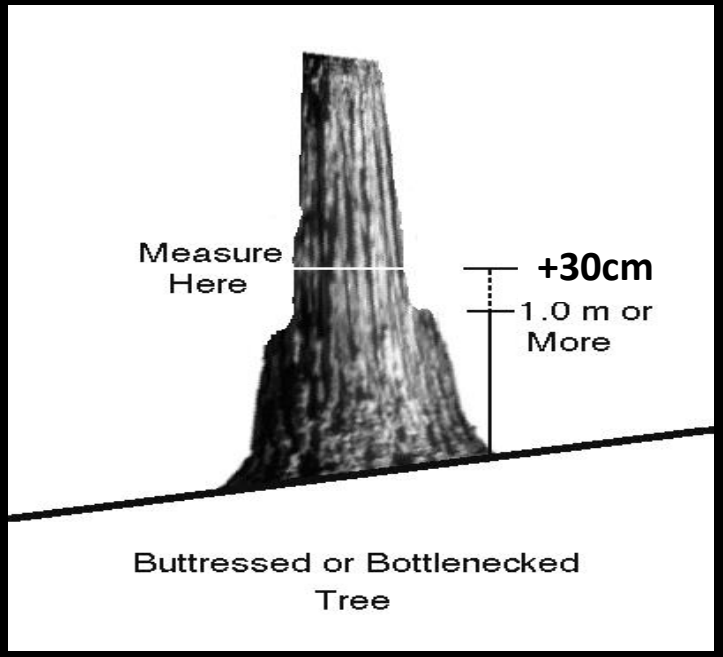
DBH Measurement – Special Cases











Figures courtesy John Kershaw (UNB Forestry)

Height Measurement

What?

- Vertical distance from ground level to tip of tree

  (usually to nearest 10th m; e.g. 20.3m)

- Other measures may be of interest

  (e.g. height where branches start)

  Height to base of live crown

Diameter Measurement

How?

Hypsometer:

general term used for instruments designed to determine tree height

- Ocular
  -eye ball estimate
- Poles
  -direct measure
- Trigonometry
  -angles & distances
- Ultrasonic or laser instrument
  -direct measure

Diameter Measurement

How?

- **Poles**

  -direct measure

Diameter Measurement

How?

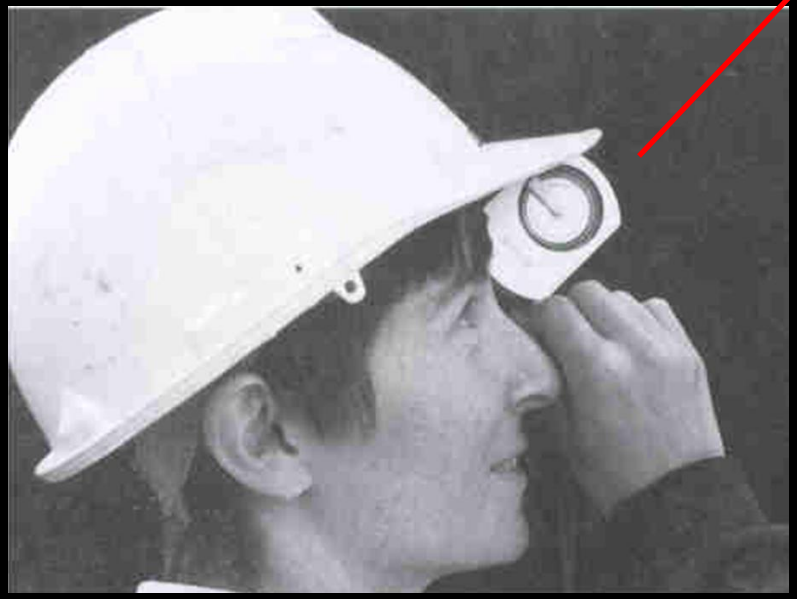
- Trigonometry
  -angles & distances

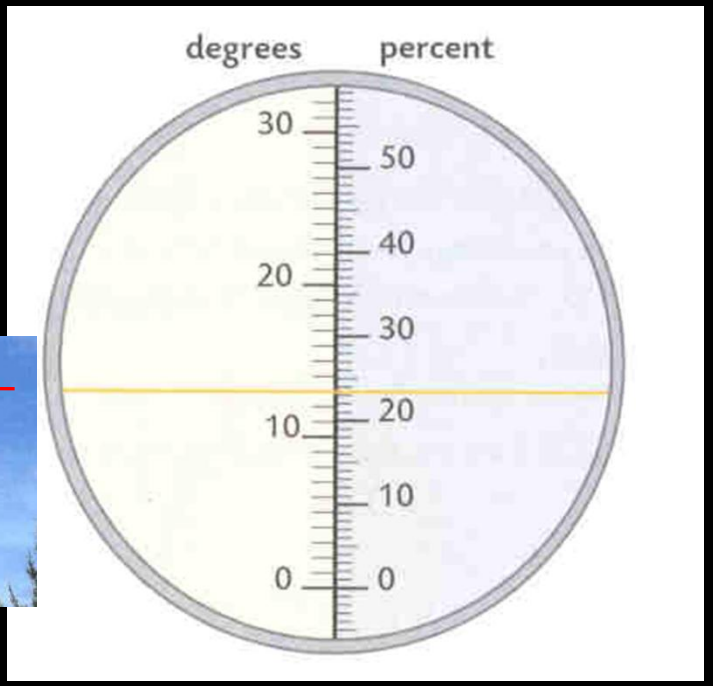
- Suunto
  -device to measure angles

Diameter Measurement

How?

- Suunto

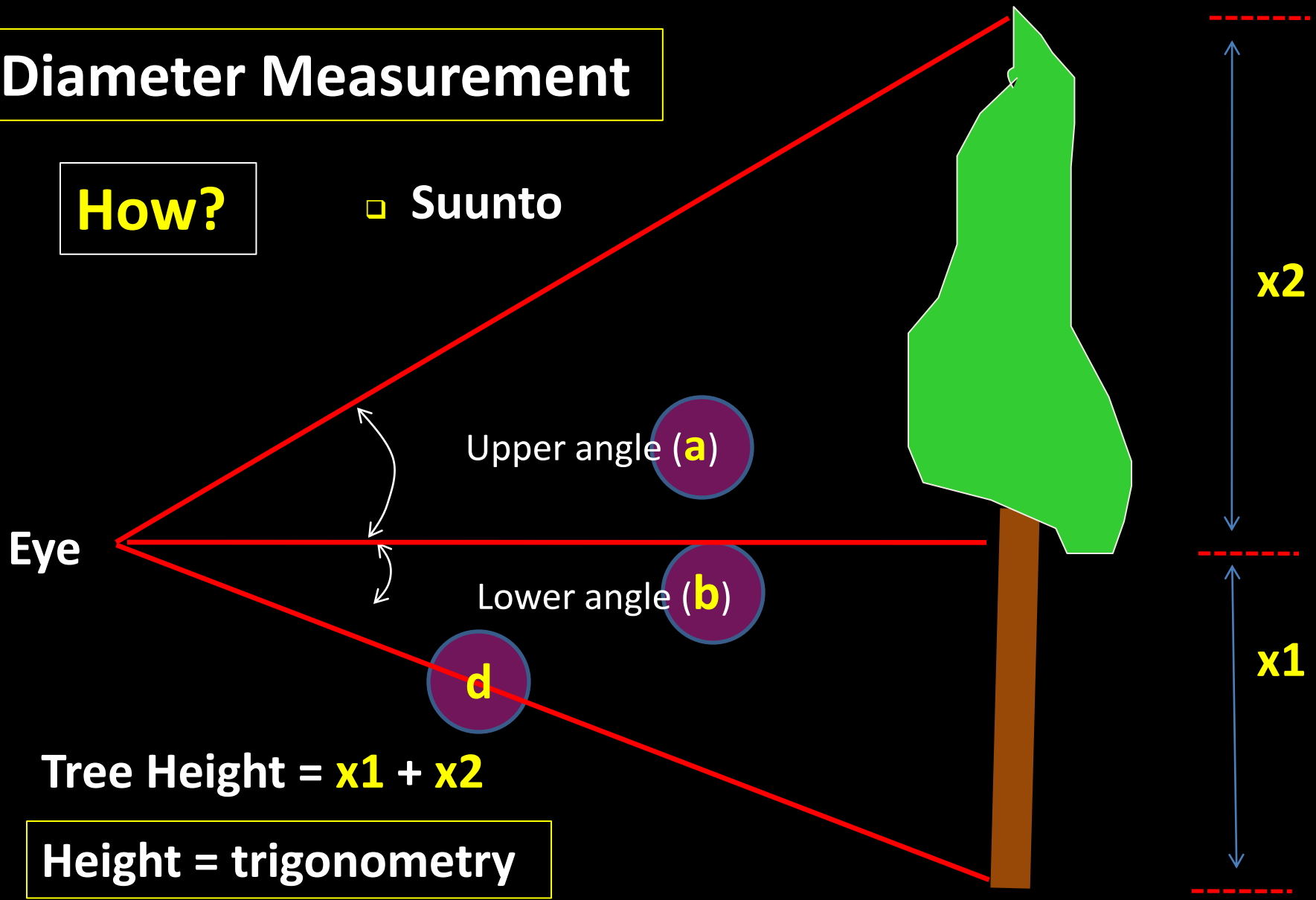




Diameter Measurement

How?

- Suunto



Tree Height = x1 + x2

Height = trigonometry

d = eye to tree (m)

a = upper angle (degrees)

b = lower angle (degrees)

Height Measurement

How?

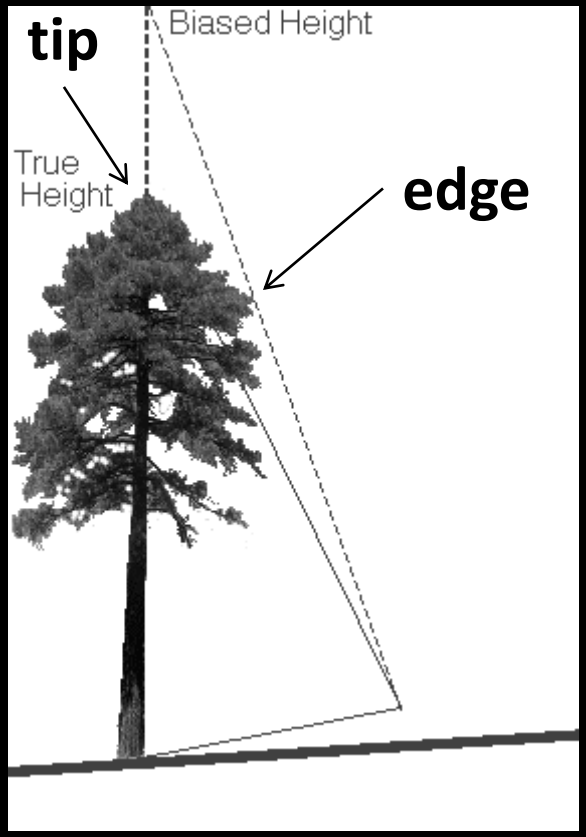
Special Cases (see handouts)

- Leaning Trees:
  "ground level" is on uphill side of tree
- Visibility Obscured
- Base Visible

Height Measurement – Special Cases

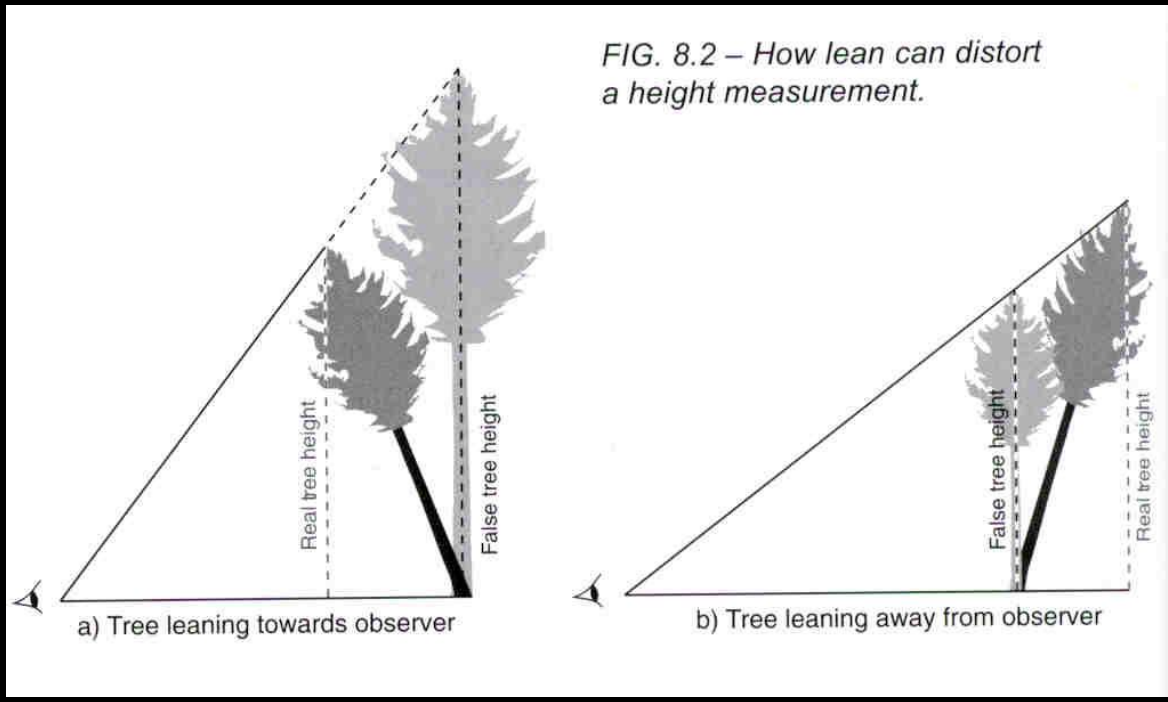
Tip Vs Edge of Crown

- Measure to the tip of the crown
- Measurement to the edge produces error



Leaning Tree

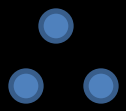
- Measure at right angles to lean
- Otherwise measurement is in error



Diameter & Height Measurement

Summary

- tree volume tells us about many important characteristics & is thus highly important
- we can build up from trees to stands to forest levels
- diameter & height relate closely with tree volume
- diameter & height are relatively easy to measure



Diameter & height measurement are *fundamental* in forestry and must be performed *accurately*

Measurement of Height & Diameter

Noteworthy messages from last lab?

- **Height measurement *less accurate***
- **Height measurement more *time consuming***
- **Height and diameter are *positively related***

What do these messages suggest?

Height & Diameter Relationships

What?

- **Reveals pattern of tree height as it varies with dbh**

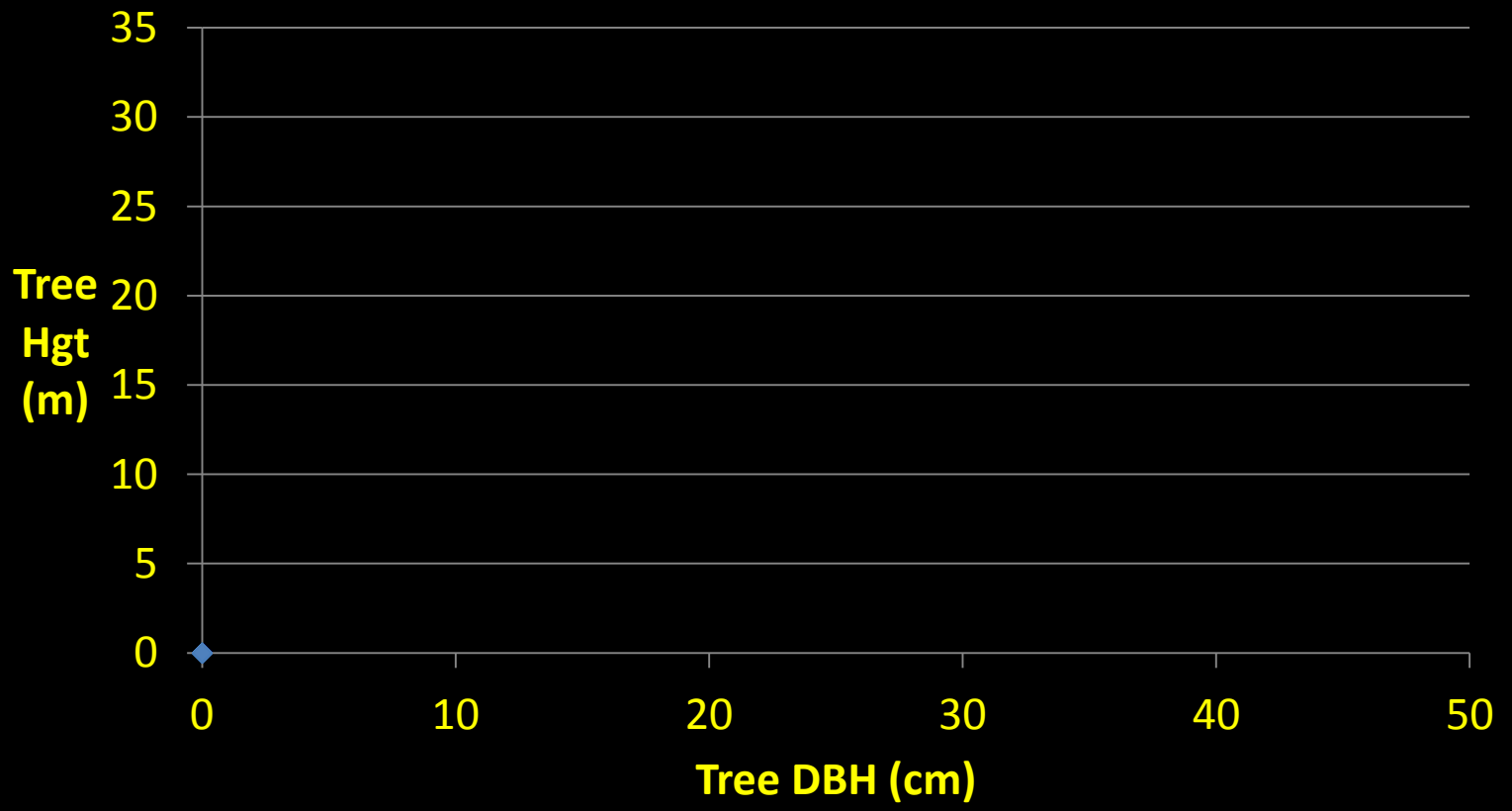


Figure 1. Height vs Diameter for Trees in Bottle Forest

Height & Diameter Relationships

What?

- **Reveals pattern of tree height as it varies with dbh**

Example Data

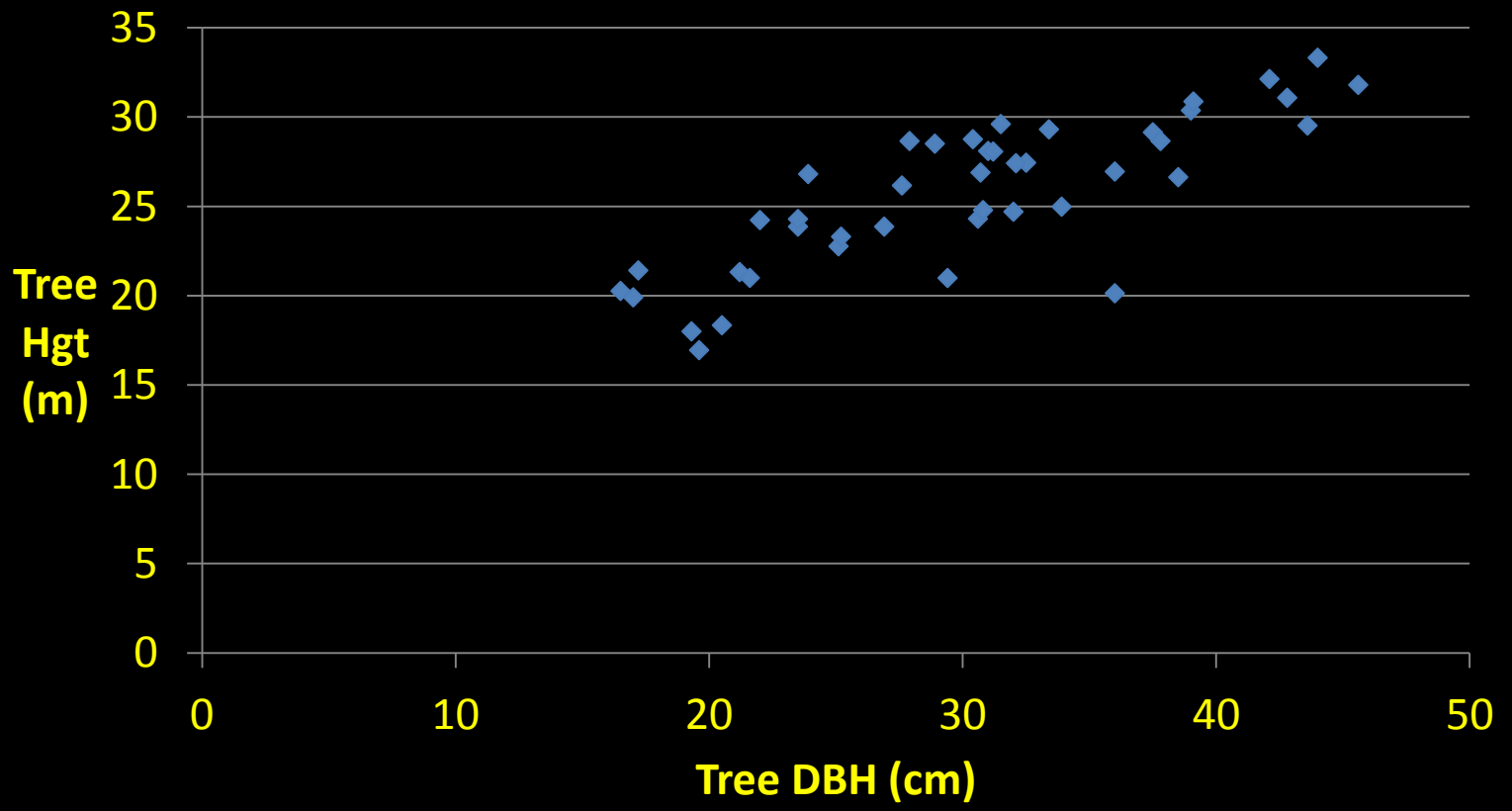


Figure 1. Height vs Diameter for Trees in Bottle Forest

Height & Diameter Relationships

Why?

- **Height measurement is *time consuming***
- **Height and diameter are *positively related***
- **Build a *mathematical relationship* between diameter and height**
- **Use it *estimate height* for trees where we have *dbh*, but do not have *height***

Height & Diameter Relationships

How to Use?

- **What is the avg height of trees @ 30 cm dbh?**
- **We can mathematically fit an equation to describe the pattern & use that to solve for height**

Example Data

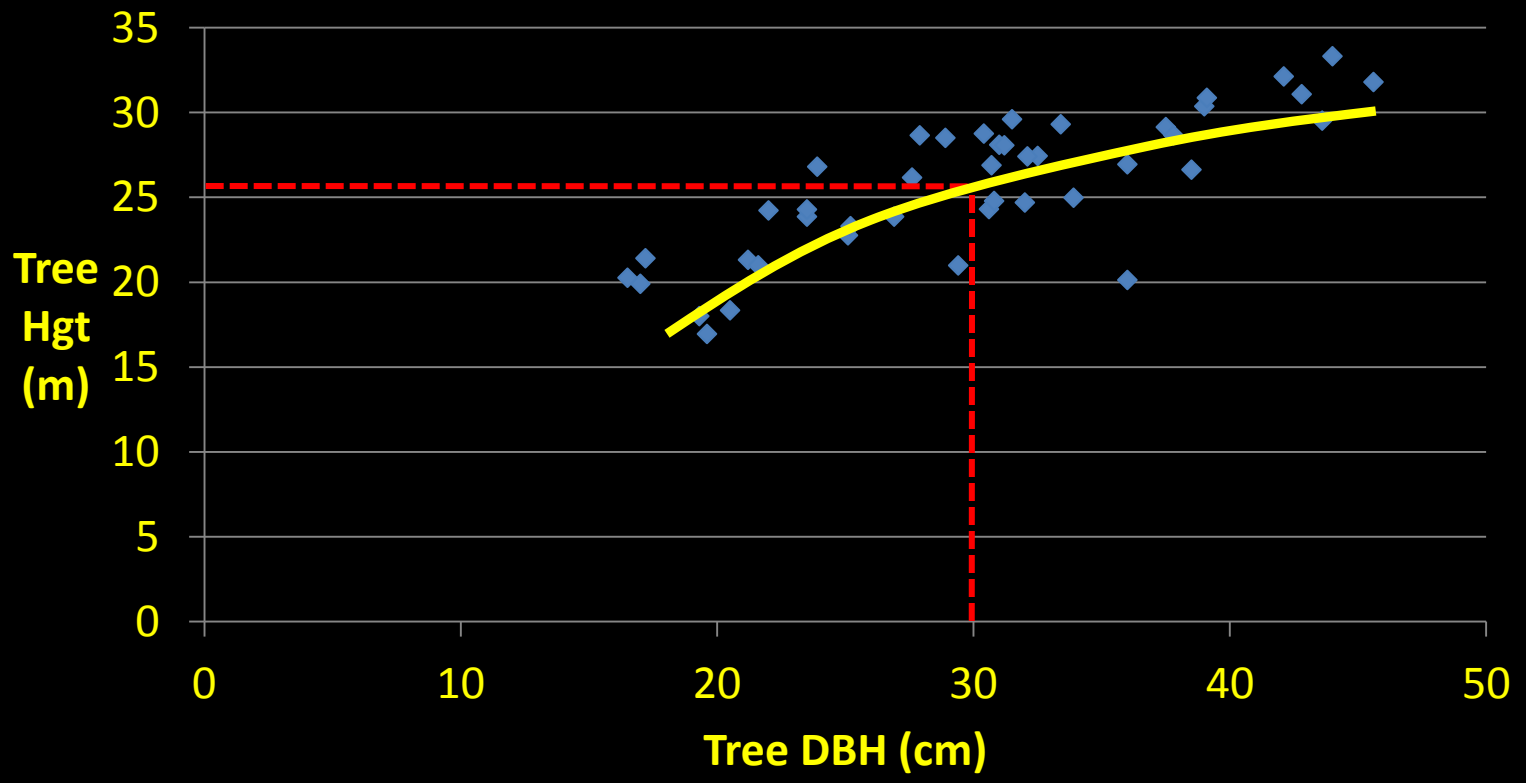
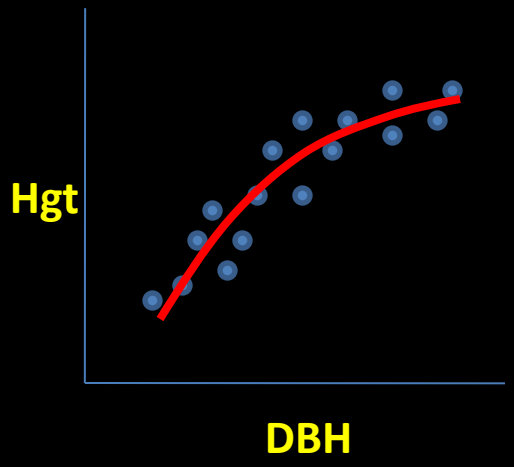


Figure 1. Height vs Diameter for Trees in Bottle Forest

Height & Diameter Relationships

How to Build?

- General shape is usually non-linear (tree height flattens out with increasing diameter)



- Specific ***shape varies*** from stand to stand
- So we ***sample trees*** & fit equation for stand of interest (separate by species)
- ***Standard equation***

$$Hgt = 1.4 + (b + a / DBH)^{-2.5}$$

- Coefficients "a" and "b" are estimated by ***regression*** methods