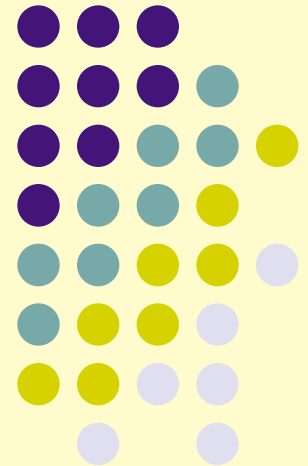
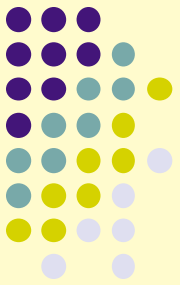


# Individual Tree Measurement: Key to Forest Assessment

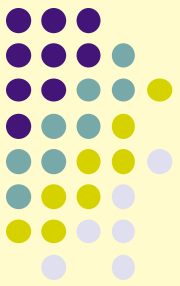
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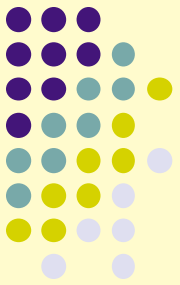
## Learning Objectives ...

- Know what basic tree & upper canopy (forest stand) attributes are important
- Know how to measure basic tree attributes
- Know how to record data on basic tree attributes



# Why Sample Forest Vegetation?

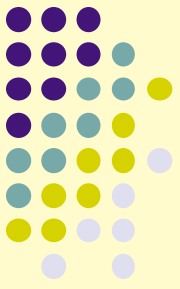
- Need information on forest vegetation for making sound decisions
  - What is the recreation potential?
  - What silvicultural treatment will result in best critical habitat enhancement?
  - What silvicultural treatment will result in best growth & regeneration of the trees?
  - What species is / are most suitable for reforestation?
  - What is the value of the timber and the land?
  - Is there sufficient value in timber to offset cost of silvicultural treatments?
  - What is the status of biodiversity on the area?
  - How is the forest currently storing carbon?



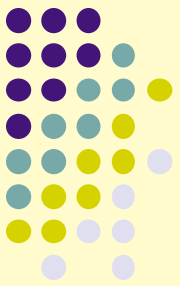
# Why Sample Forest Vegetation?

- ❖ Ultimate objective is to obtain quantifiable information about the resource that allows reasonable decisions on its destiny, management, and use

# Need to see the forest *through* the trees !



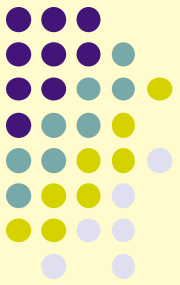
- Individual tree measurement forms the basis for all forest assessment / inventory
- Much information and many relationships can be derived from individual trees & their attributes
  - Quantity
  - Species
  - Age
  - Diameter
  - Height
- Direct measurement, sampling, prediction are all involved



# Stand Attributes

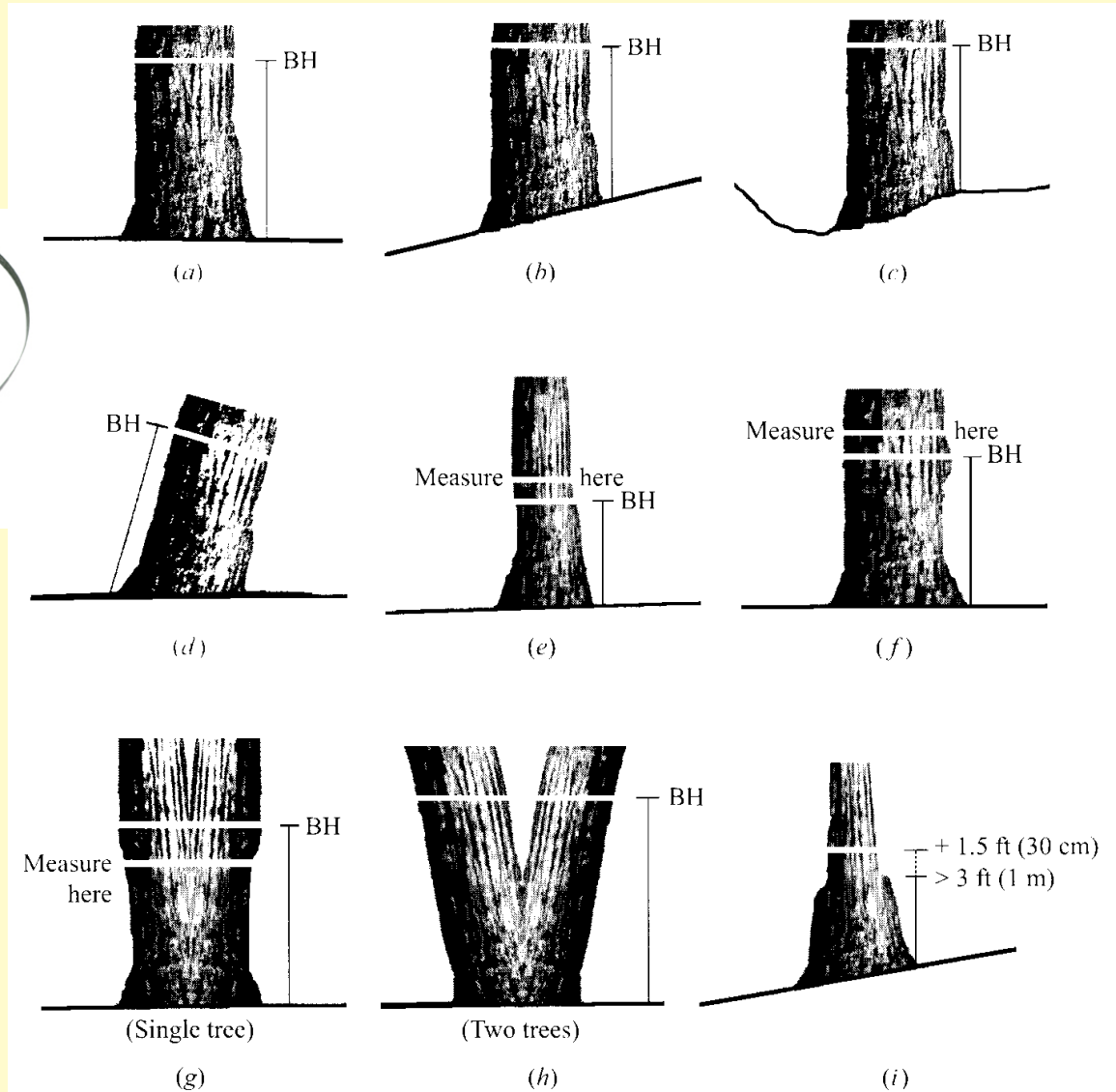
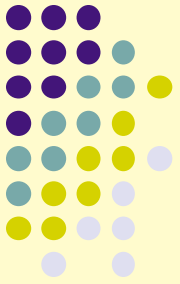
- Trees Per unit-Area (TPA)
  - Average number of live trees existing on a characteristic unit of area. The most basic measure of stand density. (In U.S.A., units are Trees Per Acre.)
- Species Composition – simple
  - Proportion of each species present in a stand – by Frequency of occurrence

# Individual Tree Measurement

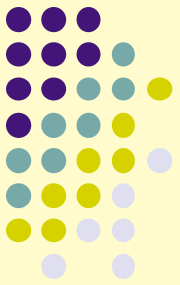


- Diameter
  - Most frequently measured diameter is Diameter Breast Height (DBH, or just D, for short)
  - DBH is average stem diameter (in inches!) outside bark of a tree measured at breast height above ground level
    - In U.S., breast height is taken to be 4.5 ft.
    - On steep slopes measure on the uphill side of tree
    - Leaning trees require measurement along the bole
    - Trees forking below breast height are treated as two
    - Trees forking above breast height – avoid swells
    - Other stem deformities – move above it
  - Most commonly used measurement device is the D-tape

# Tree Measurement: DBH







# Tree Measurement: basal area

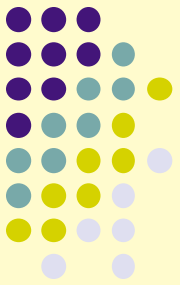
- Basal Area (ba)
  - ba (or g) is directly related to crown surface area
  - Cross sectional area of the tree at breast height – assuming stem circularity – always in square feet! (in U.S.)

$$a = \pi r^2$$

$$a = \pi \left( \frac{d}{2} \right)^2$$

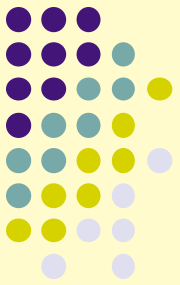
$$a = \pi \left( \frac{D}{2 \cdot 12} \right)^2 = 0.005454154 D^2$$

$$g = 0.005454154 DBH^2$$



## Stand Attributes ...

- Stand Basal Area (SBA, BA, or G)
  - sum of individual tree basal areas in a stand.
- Species Composition (more sophisticated)
  - Proportion of each species present in a stand – by Basal Area stocking

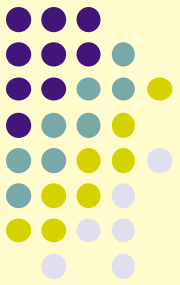


## Stand Attribute: Avg. DBH

- Average stand DBH is a useful statistic for silviculture, stewardship, management
  - Mean DBH (DBH) - The simple arithmetic mean DBH of all trees in the stand
  - Quadratic Mean DBH (DBHq, QMD, or sometimes  $D_g$ ) – the DBH of the tree with mean basal area

$$QMD = D_g = \sqrt{\frac{\bar{g}}{0.005454}}$$

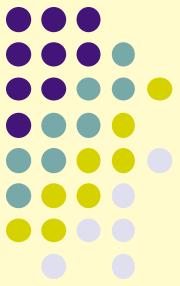
# Tree Measurement: Age



- Tree Age (in yr.)
  - Trees in temperate zones grow one distinctive layer of wood per year so age is found by counting these annual rings
    - Care is needed to avoid counting ‘false’ rings
  - Tree Age:
    - Total Age: Elapsed time since germination of a seed or time since budding of a sprout or cutting
    - Breast-height age: Elapsed time since tree height exceeded breast height
  - Instrument: Increment Borer

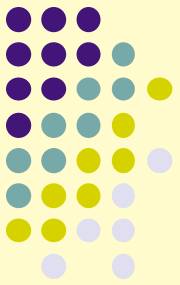


# Stand Attribute: Age



- Stand Age
  - Total Age
  - Breast Height Age
  - Plantation age: Elapsed time since planting – regardless of seedling age
- Even-aged vs. Uneven-aged
  - Even-aged: tree ages vary  $< 20\%$  of “rotation”
  - Uneven-aged: tree ages vary more, or there are 3 or more distinct ‘cohorts’

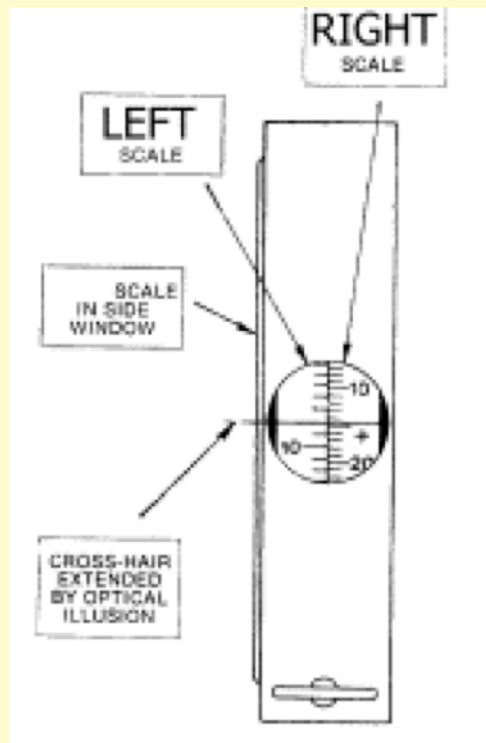
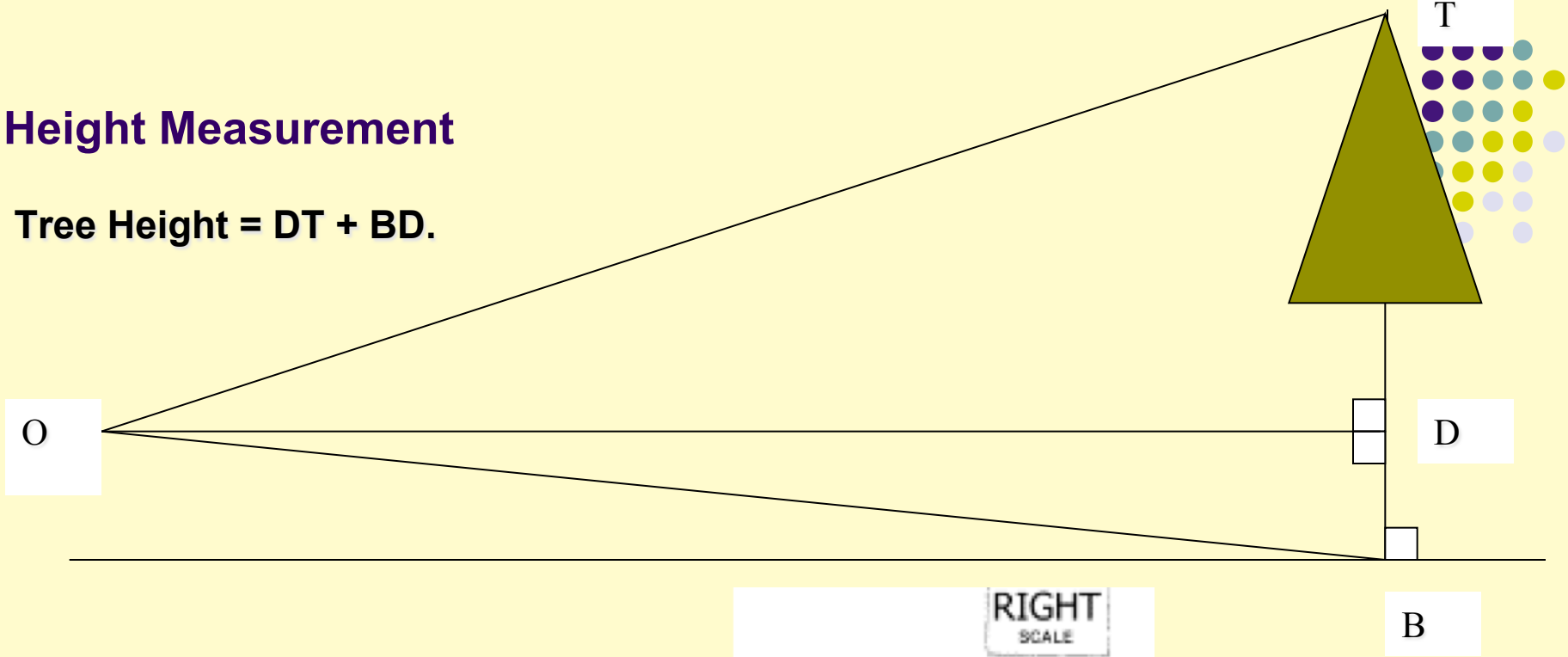
# Tree Measurement: Height



- Tree Height (ft., in U.S., m. elsewhere)
  - Total height (H) – distance from tree base to tip (volume, biomass, site quality)
  - Height-to-crown (HCB) – distance from tree base to base of live crown (enables derivation of LCR)
  - Merchantable height (Hm) – Height to a minimum top diameter, m
  - Instruments are called “hypsometers”
    - Direct measurement: Height poles
    - Indirect measurement
      - Similar triangles
      - Trigonometric principles (clinometer)

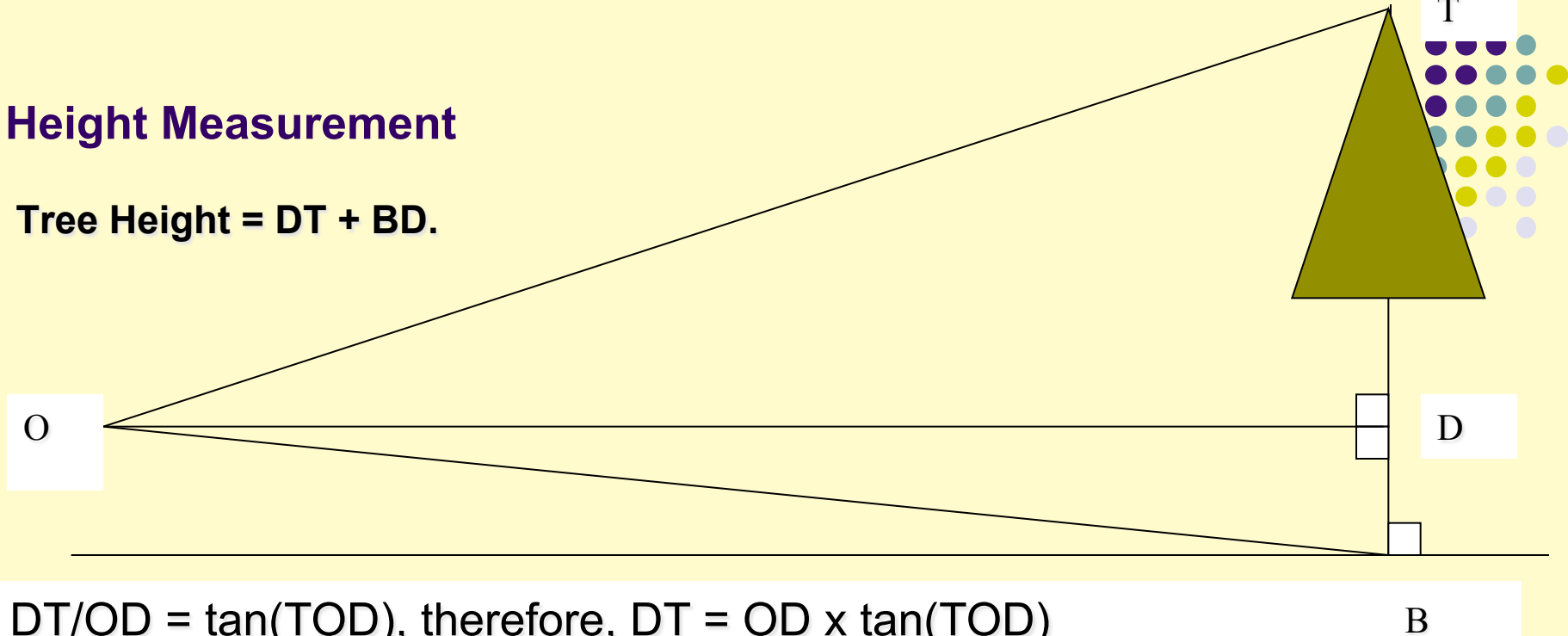
# Height Measurement

$$\text{Tree Height} = DT + BD.$$



## Height Measurement

Tree Height = DT + BD.



$DT/OD = \tan(TOD)$ , therefore,  $DT = OD \times \tan(TOD)$

$DB/OD = -\tan(DOB)$ , therefore,  $DB = -OD \times \tan(DOB)$ ,

Tree Height =  $OD \times \tan(TOD) + [-OD \times \tan(DOB)]$ , or,

Tree Height =  $OD \times [\tan(TOD) - \tan(DOB)]$ .

Horizontal distance OD is measured with a tape.

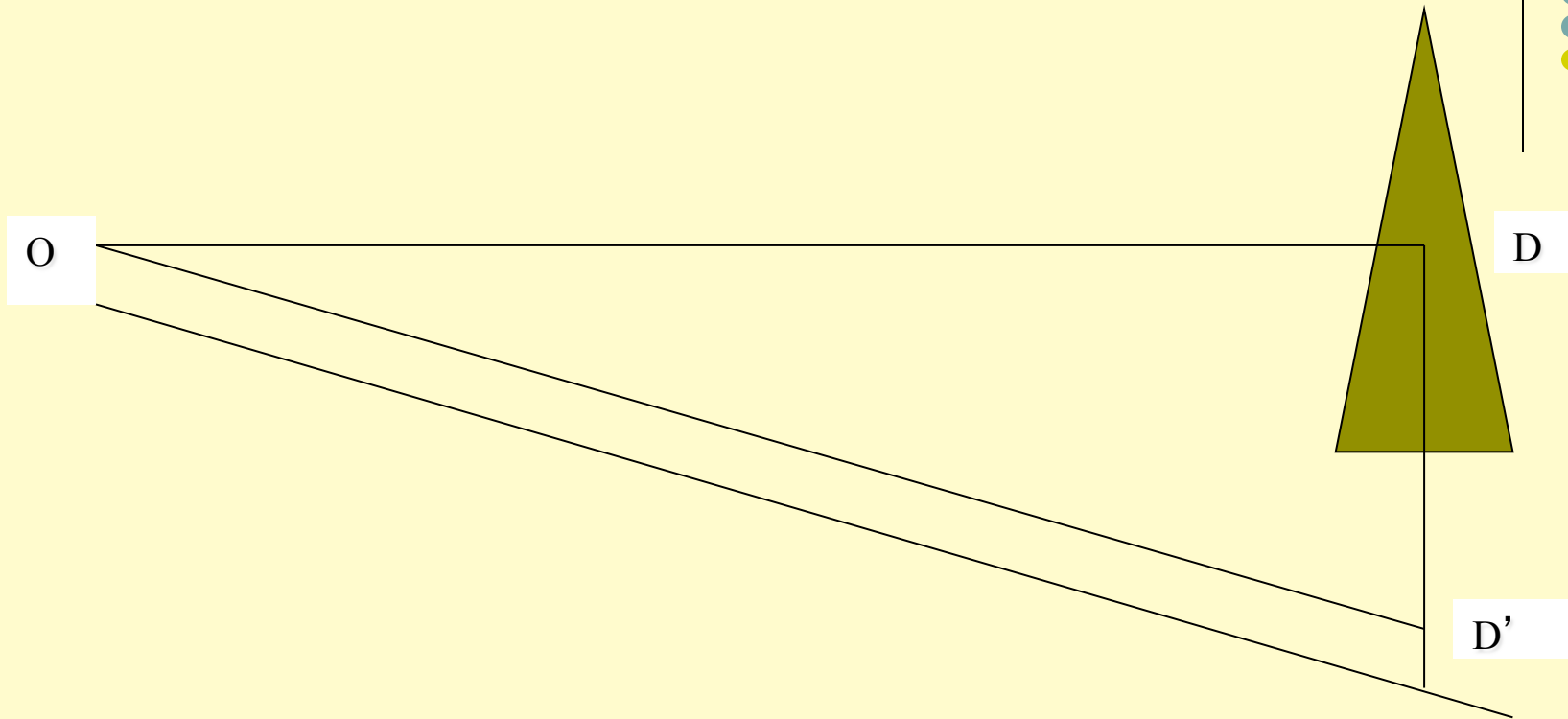
Climometer measures tangents of angles TOD, DOB in percent ( $100 \times \tan$ ), so

Tree Height =  $OD \times [TOD\% / 100 - DOB\% / 100]$ , or

Tree Height =  $OD \times [TOD\% - DOB\%] / 100$



## Slope correction for height measurement

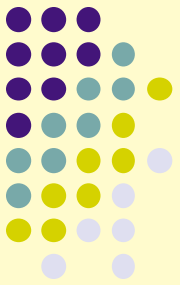


$$OD/OD' = \cos(DOD')$$

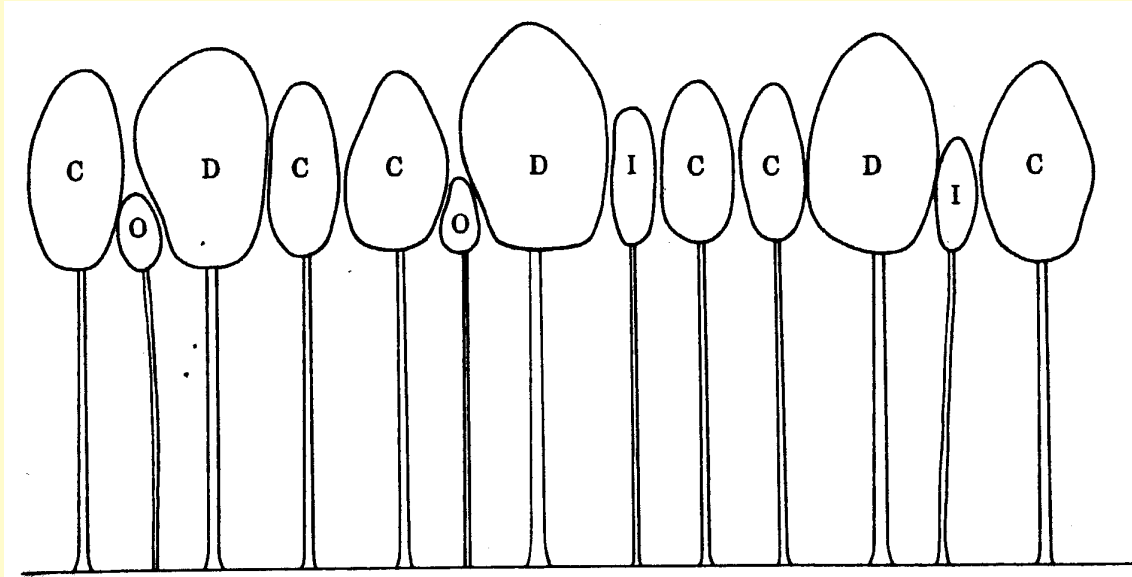
$$OD = OD' \times \cos(DOD')$$

Measure angle DOD' with clinometer in degrees & plug into height equation:

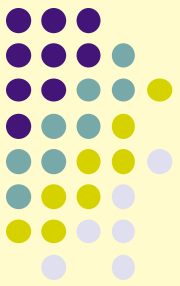
$$\text{Tree Height} = [OD' \times \cos(DOD')] \times [TOD\% - DOB\%] / 100$$



# Tree Crown Classes

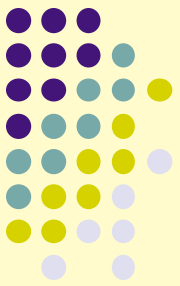


- D = Dominant:** Crowns extend above general level of canopy; receives light from above and substantially from sides,
- C = Codominant:** Crowns form general level of canopy; receives light from above, but comparatively little from sides,
- I = Intermediate:** Shorter than two preceding with crowns extending well into general level of canopy; receiving some light from above
- O = Overtopped:** Crowns entirely below general level of canopy; receives no direct sunlight



# Stand Attributes ...

- Height – (H, AveHt)
  - Arithmetic mean height of all trees in a stand
- Dominant Height
  - Definitions vary
    - Average height of just dominant trees (crowns extend above general level of canopy)
    - Average height of dominants and co-dominants (trees whose crowns form the general level of the canopy)
    - Predominant Height – average height of 100 tallest trees per hectare (40 per acre)
    - Top Height – average height of 100 largest diameter trees per hectare (40 per acre)

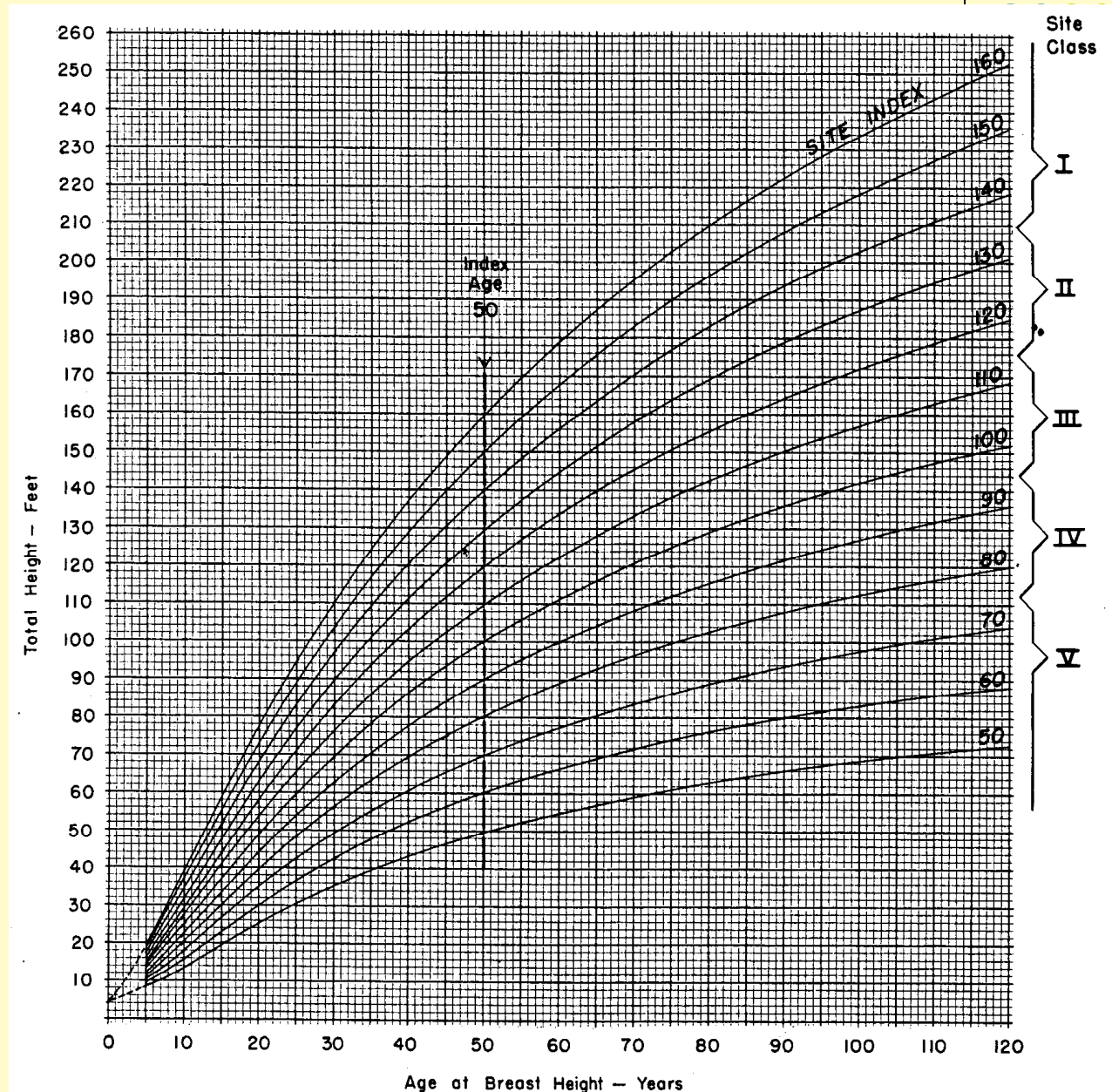


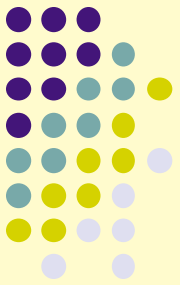
## Stand Attribute: Site Quality

- Dominant Height related to age – **Site Index**
  - Trees are resource integrators
  - Site Index: The average height of undamaged dominant trees at a reference age
  - Dominant tree height insensitive to crowding
  - Reference age (or base age, or index age) chosen appropriately
  - Species dependent
  - Sometimes dominant trees are unavailable; can be challenging esp. in mixed stands
  - Requires trees on the site

# Site Index

James King  
(1966)  
published  
site index  
curves for  
Douglas-fir  
in the  
Pacific  
Northwest





# Site Index & Basal Area - An application

## Bankfull width less than or equal to 10 feet

	River/Stream	Bankfull Width/Channel Migration Zone	Core Zone Width	Inner Zone Width	Outer Zone Width
<b>SITE CLASS I</b> 200' WIDE RMZ			50'	83'	67'
<b>SITE CLASS II</b> 170' WIDE RMZ			50'	63'	57'
<b>SITE CLASS III</b> 140' WIDE RMZ			50'	43'	47'
<b>SITE CLASS IV</b> 110' WIDE RMZ			50'	23'	37'
<b>SITE CLASS V</b> 90' WIDE RMZ			50'	30'	

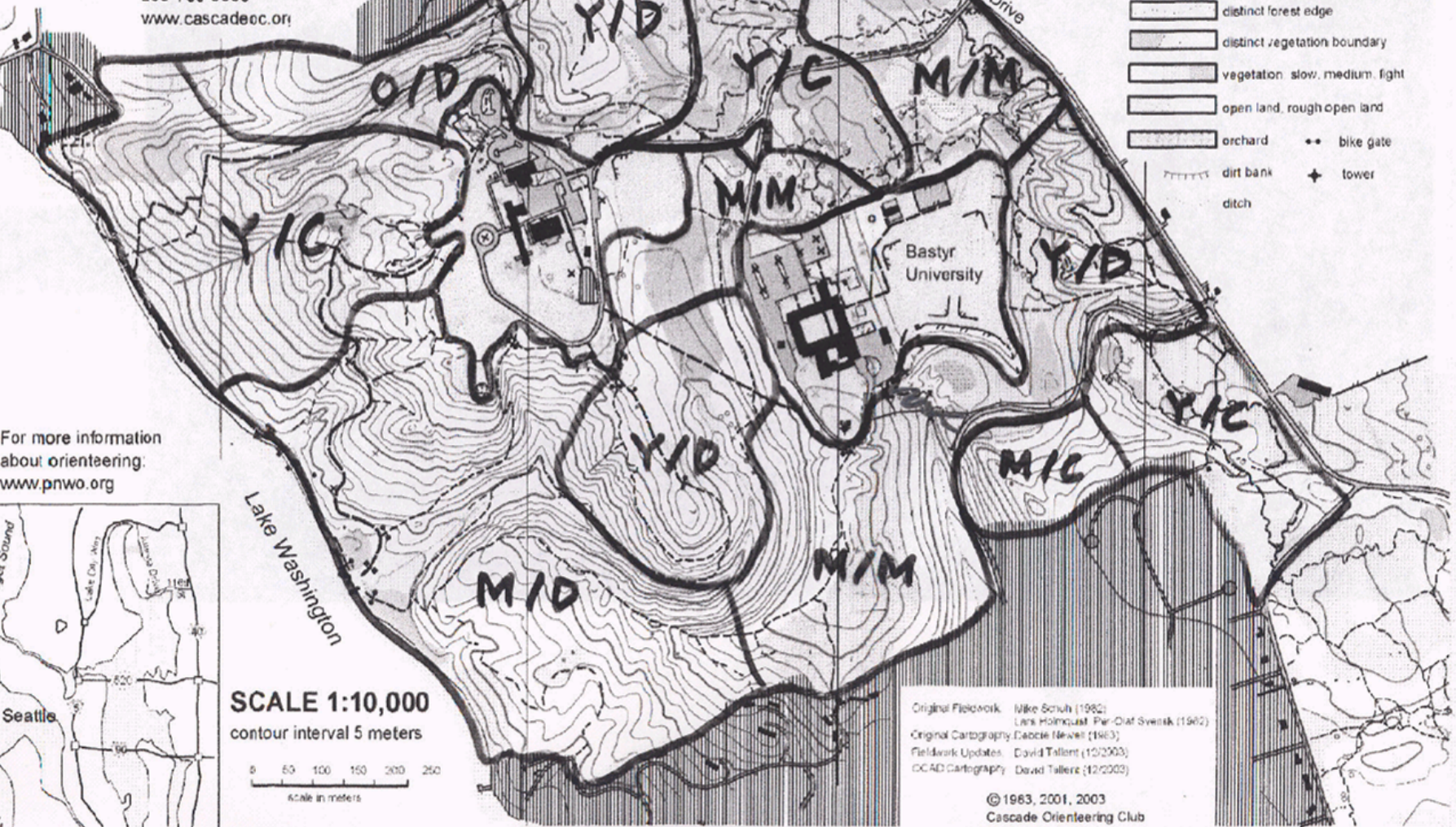
| No Harvest
| 10'

# St. Edward State Park and Bastyr University

## Forest Stand Type map Age / Spp.

**Cascade Orienteering Club**  
 PO Box 31375  
 Seattle, WA 98108  
 206-783-3866  
[www.cascadeoc.org](http://www.cascadeoc.org)

Age: Young / Middle / Old  
 Spp.: Deciduous / Conifers / Mixed



- stump, single tree
- distinct forest edge
- distinct vegetation boundary
- vegetation: slow, medium, fight
- open land, rough open land
- orchard
- dirt bank
- ditch
- bike gate
- tower

For more information  
about orienteering:  
[www.pnwo.org](http://www.pnwo.org)

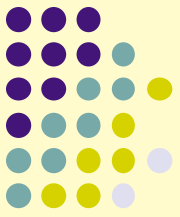


**SCALE 1:10,000**  
contour interval 5 meters

Scale in meters

Original Fieldwork: Mike Schult (1982)  
 Lars Holmquist, Per-Olaf Svensk (1982)  
 Original Cartography: Cecile Newell (1983)  
 Fieldwork Updates: David Tallent (12/2003)  
 OCAD Cartography: David Tallent (12/2003)

© 1983, 2001, 2003  
 Cascade Orienteering Club



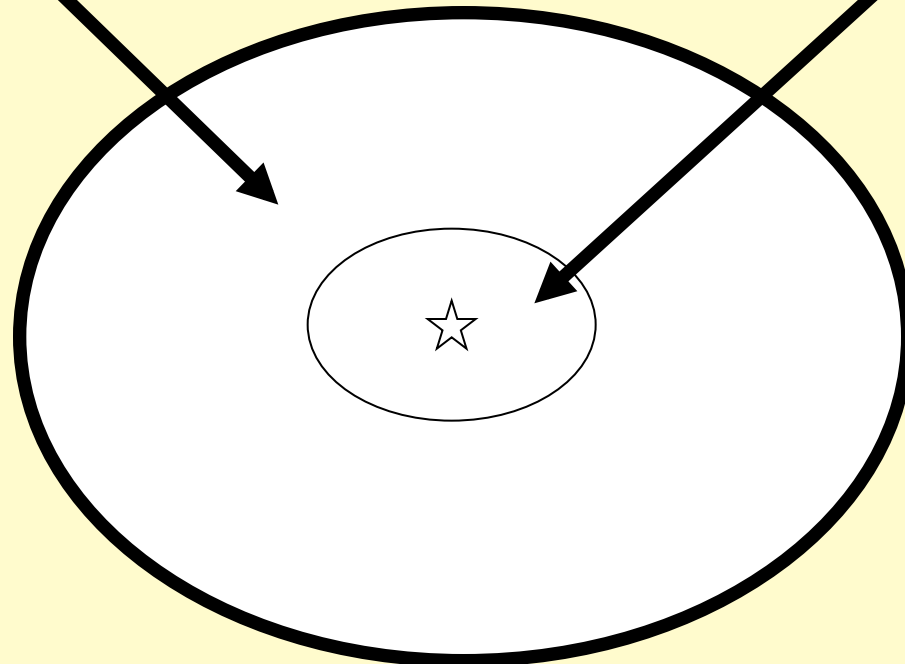
# Permanent Sample Plot Layout

## Large Tree measurement plot

- 0.1 acre plot → 37.2 foot radius
- white PVC pipe at plot center ☆; plot number written on it w/ indelible ink
- all trees within the plot have aluminum tags
- first tree on plot marked with pink flagging

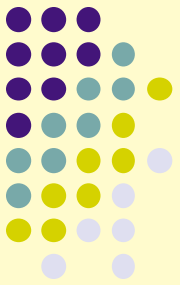
## Small Tree measurement plot

- 0.025 acre plot → 18.6 foot radius
- same plot center as large plot
- trees are not tagged
- perimeter is not marked









# Upper Canopy Surveys

- Field Trip to St. Edward State Park
- Tu & We 28 & 29 Month 2017
- Depart from behind Bloedel Hall (C-10 parking lot) promptly at 12:30 P.M.
- Dress appropriately: long pants, sturdy closed-toe footwear (preferably with ankle support), rain gear, etc.