

Monitoring tree water use in the field: training template

By

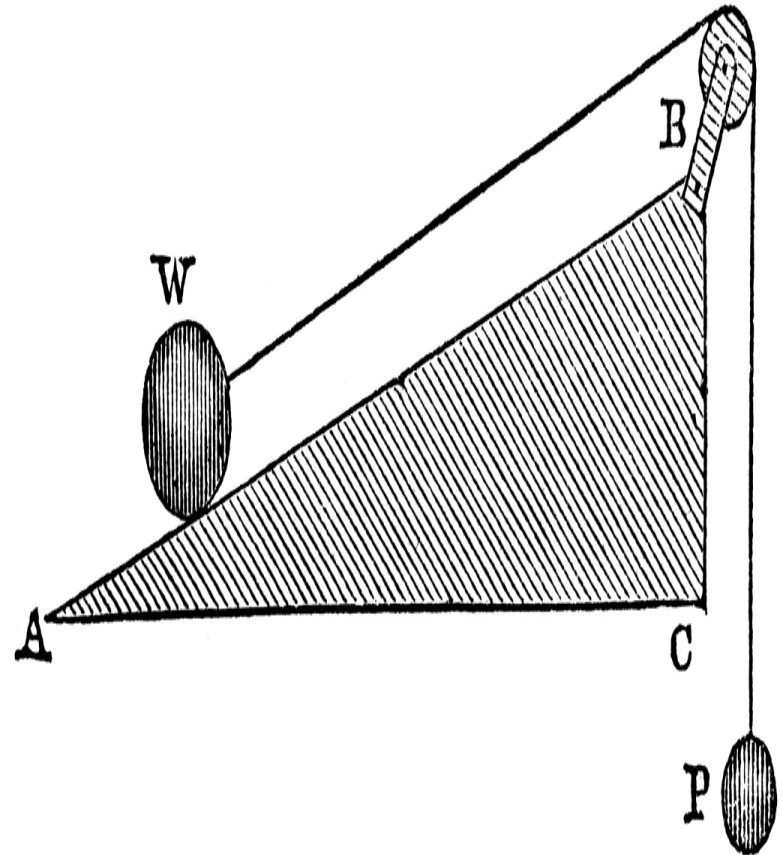
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Why tree water use/ transpiration?

- Water is a limiting factor to crop / tree growth
- Transpiration and water uptake have a direct effect on systems productivity and hence food security
- Limited knowledge on water use of different tree species
- Quantify productivity of different components in a system to help advice the right tree for the right place
- Information on this critical to inform policy (irrigation requirements, limits of species range AEZ)

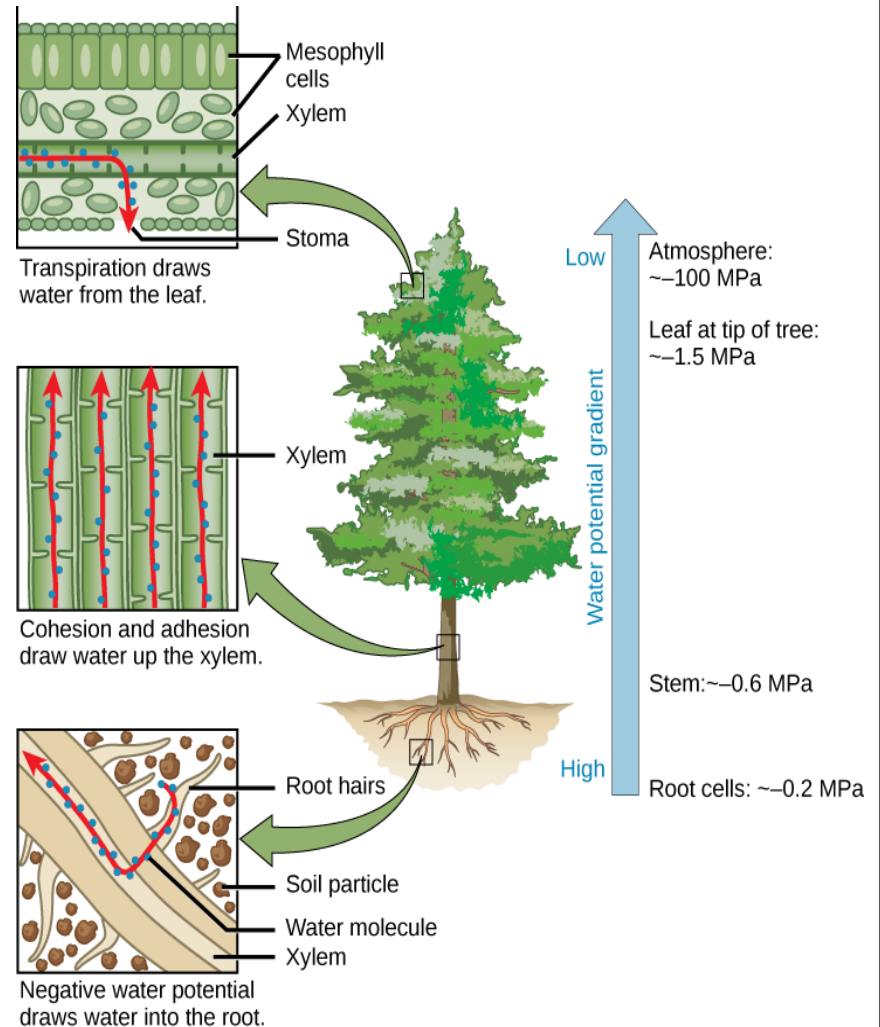
What is Sap Flow?

- Sap is simply a fluid transported in xylem cells (tracheids or vessel elements)
- Movement of water in plants is based purely on principles of physics
- A gradient in water potential is the physical mechanism that drives water movement in plants
- Water potential is the ability of water to do work
- Plants can have some influence over the passage of water by closing stomata during periods of moisture deficit



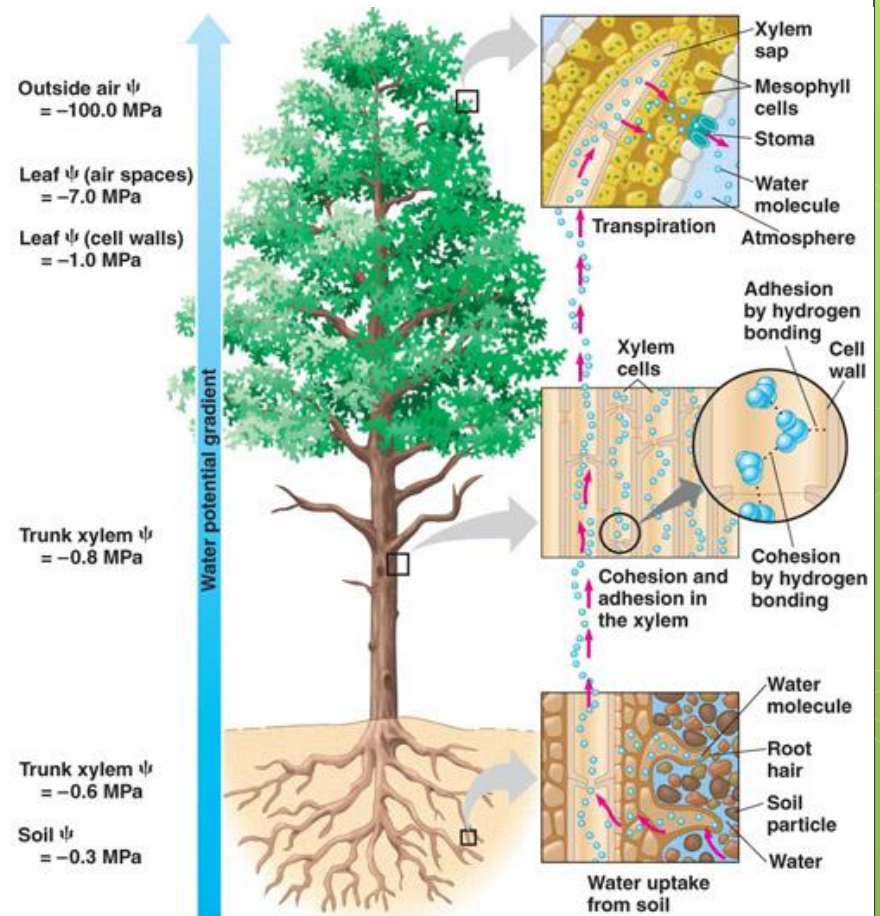
What is sap flow cont.

- Water moves from a region of high potential to a region of low potential
- Pure water has the largest potential and is given value 0 (SI unit for water potential is Pascal (Pa); so water at its reference point has a value of 0Pa)
- The gradient of water potential becomes more negative from the reference point of 0Pa



Understanding Sap Flow cont....

- There is a strong water potential gradient through the Soil-Plant-Atmosphere Continuum ranging from -1.5MPa to -3.0MPa to -100MPa for very dry conditions
- This is the physical principle that allows water movement thru plants and ultimately for transpiration to occur
- Water potential gradient allow moisture to move from soil to the atmosphere, but it allows water to move from any part of the plant to any other part of the plant (hydraulic redistribution)



Importance of sap flow

<http://youtube.com/user/ictintl>

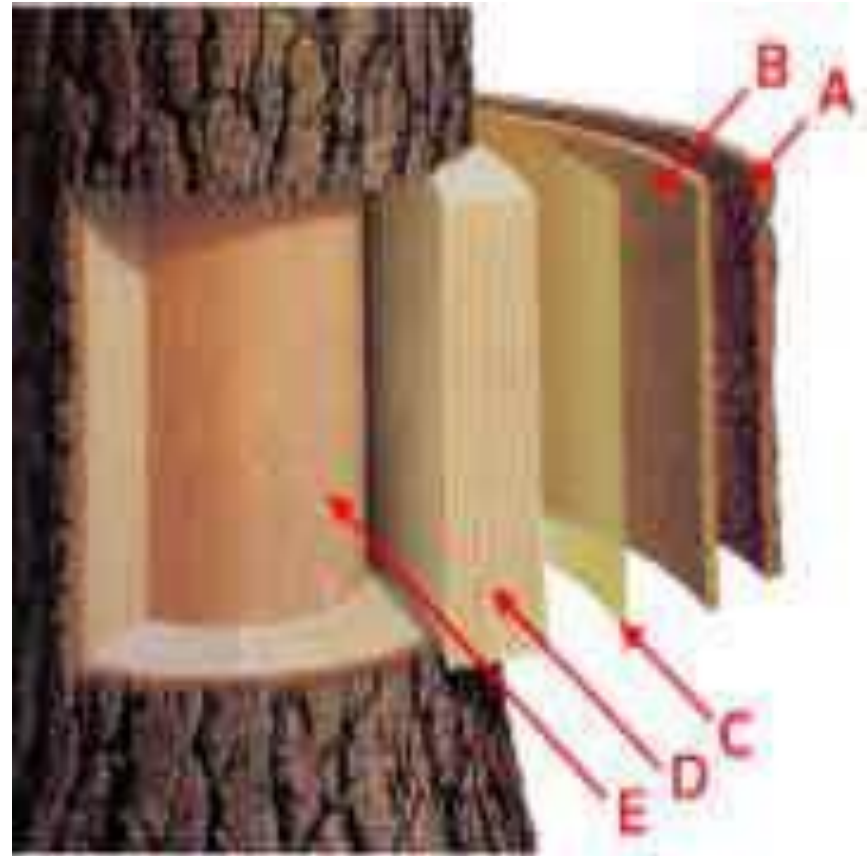
Tree Anatomy

E.G Pine (*Pinus pinaster*)

- (A) Outer Bark
- (B) Inner Bark
- (C) Cambium Layer
- (D) Sapwood
- (E) Heartwood

Note

- Only the Sapwood conducts water
- Only the sapwood needs to be measured
- Sapwood thickness = 40-80mm



Methods of measuring sap flow

- Weighing of potted plant or a leafy shoot (no roots in it) and pouring some oil on the surface to prevent loss of water by evaporation
- Potometer
- Lysimeter –weighing method
- Heat balance method
- **Heat ratio method**

Why Heat ratio Technique

- Direct, non-destructive measurements of transpiration
- Measures intact plants
- Provides daily and seasonal water use over extended periods
- Sap flow techniques offer the major benefit of allowing transpiration by each component of agroforestry systems to be followed continuously and reliably
- Non labor intensive

Considerations for use

Advantages

- Measure Flow Volume & Orientation
 - Low flow
 - Zero flow
 - Reverse flow
- Suitable for any size stem > 10 mm
- Suitable for roots
- Low power usage
- No Cables
- Standalone Logging Operation
- Ease of use and configuration

Disadvantages

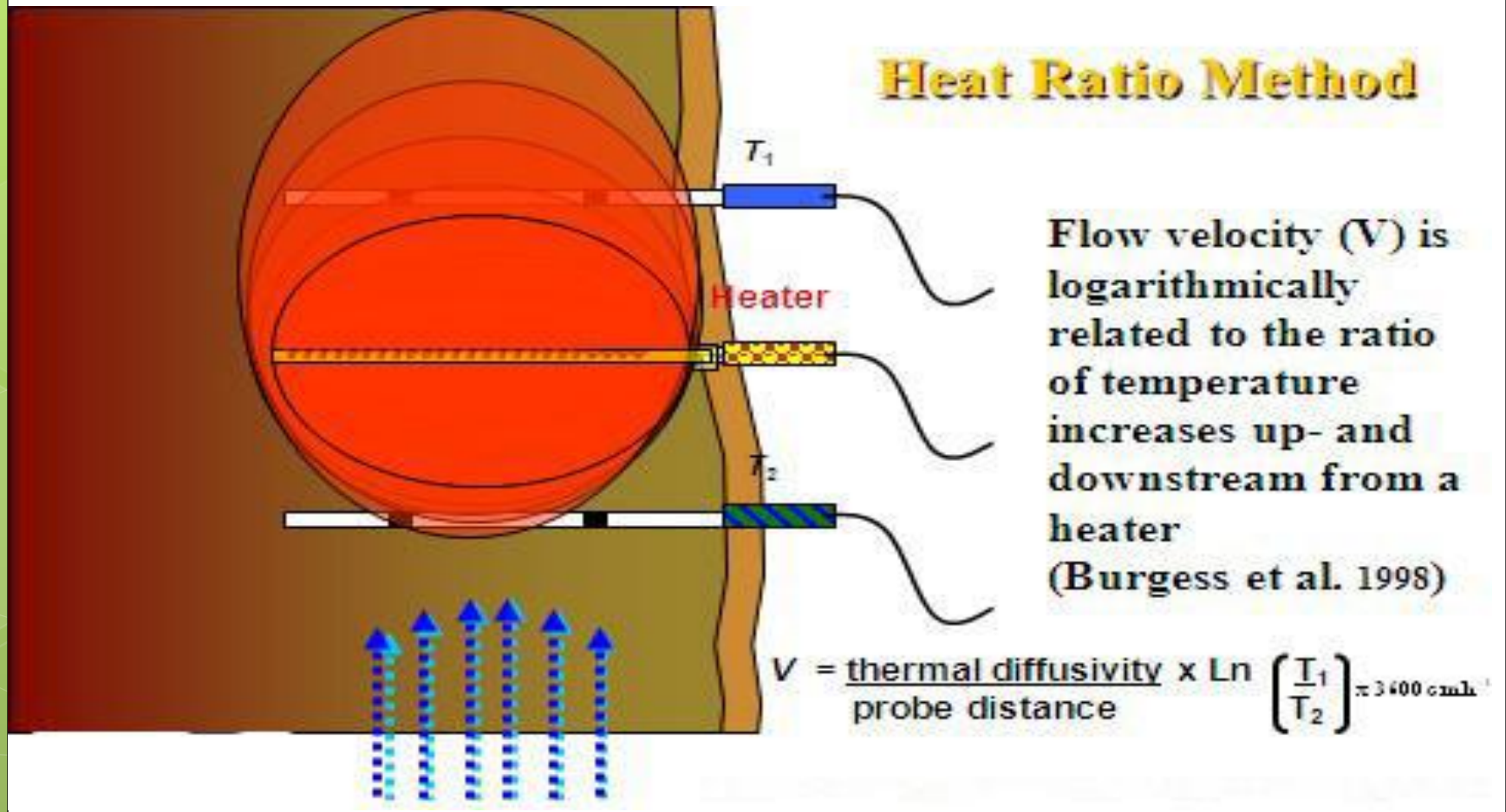
- Invasive
- Not suitable for herbaceous stems

Heat ratio method (HRM)

- Heat Ratio method developed by Burgess et al., (2001) consists of 3 needles; one central heater needle and 2 sampling needles inserted upstream and downstream of the heater
- The needles are 35mm in length and the 2 sampling needles contain thermistors located at 12.5mm and 27.5mm; called the outer and inner measuring points respectively
- By measuring the ratio of heat transported between two symmetrically placed temperature sensors, the magnitude and direction of water flux can be calculated
- The HRM measures the ratio of the increase in temperature, following the release of a pulse of heat, at points *equidistant* downstream and upstream from a line heater



Heat ratio method (HRM) cont..



Determining Sap Flow

- The ratio of increase in temperature between measurement points indicate sap velocity as well as sap direction
- It is possible to determine direction of the flow due to polarization of the heat flux; positive values indicate upward sap flow while negative values indicate reverse sap flow
- A low ratio indicates little to no movement in sap (i.e. little or no transpiration) whereas a large ratio indicates rapid sap flow (its hot/sunny day)
- Sap Flow or the water movement within a tree can be expressed as a volumetric measurement by multiplying the corrected sap velocity (V_s) by the cross-sectional area of conducting sapwood
- The sapwood area is calculated by the cross-sectional area under-bark after discounting the heartwood area

Sap flow installation: preparations

- Selecting a suitable measurement tree (healthy, straight trunk, representative of the site)
- Measure stem diameter (DBHOB)
- Measure bark depth
- Measure sapwood thickness (optional)
- Attach installation guide
- Begin drilling
- Check for hole symmetry (parallelism)
- Grease needles
- Attach needles to measurement tree



Installation preparation video

<http://youtube.com/user/ictintl/videos>