Sap Flow Installation Scenarios

ICT International
Golden Rule

Install your sensors according to your hypotheses!
Arbitrary Sampling

- User arbitrarily chooses which species to sample where to install on a tree

- Typical scenario:
  - Only on north facing stems in southern hemisphere
  - Only on south facing stems in northern hemisphere

- Assuming sap flow is constant around the circumference of the tree

- Good choice if you have a limited number of sensors or you have a general hypothesis
Random Sampling

- Randomly select species and then trees within species
- Randomly select a location around the circumference to install sensor
- Not a common approach
- Not recommended unless you have a very large number of sensors
Stratified Sampling

• Definition: sample each subpopulation of an overall population independently
  
  • For example: you have 12 SFM1 units to install into 12 trees:
    
    • 12 trees of Species A are all the same diameter
      
      • Subdivide the circumference of the tree into 4 quadrants (e.g. north, south, east, west faces)
        
        • Randomly select 3 trees and install 3 units on the north face
        • Randomly select 3 trees and install 3 units on the south face
        • Randomly select 3 trees and install 3 units on the east face
        • Randomly select 3 trees and install 3 units on the west face
Comprehensive Sampling

• Install as many sensors at as many locations around circumference and at different depths as possible

• Typical scenario:
  • At start of study, comprehensively sample select trees to understand their sap physiology. Then arbitrarily sample a larger selection of trees.
  • A study may comprehensively sample only a single tree

• If you have the resources, definitely choose this option!
How to Measure Forest Water Use

- Sample trees according to:
  - Number of species
  - Diameter at Breast Height (DBH)
  - Sapwood diameter
  - Leaf Area Index (LAI)
  - Crown extent

- Cermak et al. (2004):
  - Dominant trees (1/3) = 66% water use
  - Medium trees = 25% water use
  - Suppressed trees = ~10% water use
How to Measure Forest Water Use

Quantiles of Total Technique (Cermak et al., 2004)

• Definitions:
  • $B =$ Biometric Parameter (e.g. DBH, LAI, sapwood area)
  • Stand (e.g. 100x100m plot)
  • Tree (free standing stem, multiple stems???)
  • $k =$ number of sample stems (chosen by number of sensors)

• Method:
  • Measure $B$ for all trees in stand
  • Sort $B$ from smallest to largest
  • Calculate cumulative $B$ for stand to give total = $B_{\text{stand}}$
  • Divide $B_{\text{stand}}$ by $k$ to give $B_{\text{port}}$
  • Sample tree = $B_{\text{port}} \times (\text{Sample}_i - 0.5)$
How to Measure Forest Water Use

Quantiles of Total Technique (Cermak et al., 2004)

- Example calculation:
  - 12 trees in a 20x20m plot
  - 3 x SFM1 instruments available
  - $B = \text{stem area based on DBH}$
  - $B = \pi (\text{DBH}/2)^2$
  - $B_{\text{stand}} = 2065.4135$
  - $B_{\text{port}} = B_{\text{stand}} / k = 688.471$
  - Sample = $B_{\text{port}} \times (\text{Sample}_i - 0.5)$
  - Sample 1 = 688.471 * (1-0.5)
  - Sample 1 = 344.236
  - Sample 2 = 688.471 * (2-0.5)
  - Sample 2 = 1032.707
  - Sample 3 = 688.471 * (3-0.5)
  - Sample 3 = 1721.178

<table>
<thead>
<tr>
<th>Tree No.</th>
<th>DBH (cm)</th>
<th>Stem Area (cm$^2$)</th>
<th>Cumul. Area (cm$^2$)</th>
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<tbody>
<tr>
<td>1</td>
<td>3.5</td>
<td>9.61625</td>
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<td>5</td>
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How to Measure Forest Water Use

Quantiles of Total Technique (Cermak et al., 2004)

• Sample 1 = 344.236
• Sample 2 = 1032.707
• Sample 3 = 1721.178

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How to Measure Forest Water Use

**Diameter Class Technique** (Cermak et al., 2004)

- Method:
  - Measure DBH of all trees in plot or area of interest
  - Divide trees into DBH classes (e.g. 0 – 2cm; 2.1 – 4cm; 4.1 – 6cm etc)
  - Number of classes may depend on number of available sensors
  - Generate a scaling curve between $Q$ and a Biometric Parameter
How to Measure Forest Water Use

• **Scaling Curves:**
  - Basal area
  - Sapwood area
  - Leaf Area Index

• **Stand Transpiration:**
  - Find mean transpiration in each sampling class
  - Multiply this by number of trees (or stems) in sampling class

Source: Fig 7. Cermak et al. (2004)
How to Measure Massive Trees

• Large tree with many branches, multiple stems, or a large tree with no dominant trunk:
  • Use same methodology as though you were sampling a forest, in this case individual branches or trunks are equivalent to stems in a forest

• Large tree with a dominant trunk:
  • Comprehensive sample
How to Measure Hydraulic Redistribution

Source: Burgess et al. (2000)
How to Measure Hydraulic Redistribution

Reference: Ambrose et al. (2010)
How to Measure Stem Refilling

SFM1 Sap Flow Meter
SFM1 at Crown Height
SFM1 at Breast Height

Stem Refilling & Sap Flow

Sap Velocity (cm/hr)

Midday  Midnight  Midday

Stem Refilling
How to Measure Stem Refilling

DBL60 Dendrometer

SFM1 Sap Flow Meter
Dendrometer V Sap Flow

DBL60 Dendrometer

SFM1 Sap Flow Meter

Tree Circumference (mm)

Sap Flow (cm/hr)
Stem Refilling & Dendrometers

DBL60 Dendrometer

SFM1 Sap Flow Meter
How to Measure Nocturnal Transpiration

SFM1 Sap Flow Meter

Enabling better global research outcomes in soil, plant & environmental monitoring
Nocturnal Transpiration & SFM1

SFM1 at Crown Height
SFM1 at Breast Height

Nocturnal Transpiration
How to Measure Nocturnal Transpiration

Linear correlation is needed between sap flow and VPD

Sugar Gum (*Eucalyptus cladocalyx*)

Yellow Box (*Eucalyptus melliodora*)

Blue-leaved Mallee (*Eucalyptus polybractea*)

Positive correlation between transpiration and VPD

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