From classified photo to LAI...
...the easy part, right..?

Will Woodgate
November 2015
From classified photo to LAI..

The three key components affecting canopy gaps

1. Leaf and Wood Angle Distribution
2. Clumping
3. Woody material proportion ($\alpha$)

$extinction\ coefficient\ 'k'$
The extinction coefficient ‘$k$’
The only thing between us and accurate LAI

$$\text{LAI} = - \log \left( P_{gap} \Theta_{image} \right) / k$$

Methods to estimate $k$:
Wood and leaf angle +
Clumping +
Woody proportion
or
Destructive with $P_{gap}$

Challenge: how accurate can we derive $k$ and LAI? Can we get ± 5% accuracy?
The virtual forest
Enabling precise benchmarking of indirect methods

(a) *E. tricarpa*
Height = 18.6 m, DBH = 28.3 cm

(b) *E. macrorhyncha*
Height = 9.6 m, DBH = 12.8 cm

(c) *E. microcarpa*
Height = 21.8 m, DBH = 27.2 cm

Whroo

11km

Balaclava
The virtual forest
Simulating the virtual scenes and measurements

Top down view (24 scenes, 90 m x 90 m +)

SLATS sampling design
From classified photo to LAI..

The three key components

1. Leaf and Wood Angle Distribution

2. Clumping

3. Woody material proportion
The leaf and wood angle distribution
From measurement to meaningful input value for ‘k’

What is the error if I don’t know my wood angle distribution?

1. Step 1: measure the angles and compile a frequency distribution

2. Step 2: characterise the projected area (G-function)
The magical angle
Accounting for the leaf and wood angle distribution

Take home message
Use the 57.5° viewing angle;
otherwise you must account for the leaf and wood angle distributions (see FEM article, 2015)
From classified photo to LAI..

The three key components

1. Leaf and Wood Angle Distribution
2. Clumping
3. Woody material proportion ($\alpha$)

Figure from: Leblanc et al. (2012) Trac manual
Clumping method evaluation
Which performed the best?

- **CC** = TRAC instrument
- **LX** = LAI-2000/2200* (with view cap)
- **CLX** = combined CC and LX
- **HP ref** = virtual reference

**Take home messages**
- Use the CLX method (at least for low Eucs)
- Do not use the LAI-2000/2200 for clumping
Clumping method evaluation
Where did most of the clumping occur?

Take home messages
- Clumping factors almost insensitive to stem distribution.
- The majority of clumping occurs within the crown envelope
From classified photo to LAI..

The three key components

1. Leaf and Wood Angle Distribution

2. Clumping

3. Woody material proportion ($\alpha$)
Aim:
Test a simple method based on the proportion of woody pixels to wood and leaf pixels
From PAI to LAI
Accounting for proportion of woody material

Take home messages
• A simple method classifying the entire image worked very well to get the proportion of woody material
• Photos taken close to very large stems were outliers – these images also adversely affected clumping estimates
From PAI to LAI
Does my field of view make a difference?

Take home messages
• Field-of-view does matter
• Either use it all of it or a narrow range around 57.5°
• Robustness of findings need to be tested in forests with different structure (extends to clumping as well)
From classified photo to LAI..

The road ahead

1. Best practise procedure: Unknowns remain

2. Room for improvement → scope for ‘disruptive’ monitoring technologies

3. Ongoing curation of LAI estimates: helping to differentiate actual canopy change from a method artefact
Thank you

Oceans & Atmosphere
Will Woodgate

e will.woodgate@csiro.au
The extinction coefficient ‘\(k\)’

The only thing between us and accurate LAI

\[
\text{LAI} = -\log \left( \frac{P_{\text{gap}} \theta_{\text{image}}}{k} \right)
\]
From classified photo to LAI..
The three key components and the road ahead

1. Leaf and Wood Angle Distribution
   - Use 57.5°, otherwise a big assumption is made or a lot of effort is required
   - TLS can be used to accurately reconstruct the tree structure → wood angle

2. Clumping
   - 2D gap size methods are challenged by highly clumped environments (Eucs)
   - Trade-off with view zenith angle and accuracy
   - 3D methods (using LiDAR) countering occlusion are probably the way forward

3. Woody material (α)
   - Promising simple method based on classification
   - The mutual shading effect and an even distribution assumption is must be noted
   - Further work required in other forest types with different structure (clumping too)