



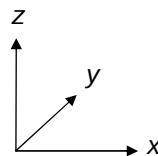
Analysis of Airborne LIDAR for Validation of SLATS FPC Products

John Armston
Robert Denham
Tim Danaher
Peter Scarth
Trevor Moffiet
Rob Hassett

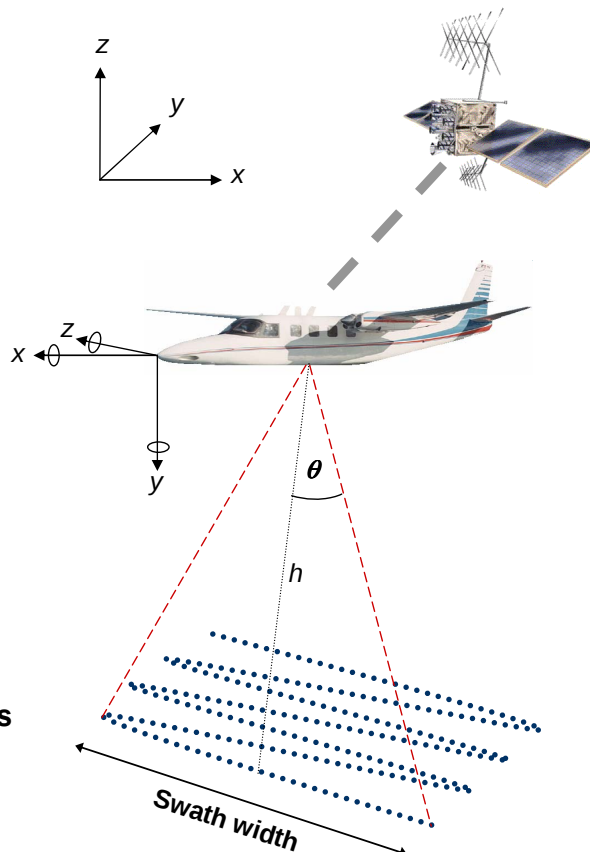
Statewide Landcover and Trees Study

Light Detection and Ranging (LIDAR)

Global
Positioning
System



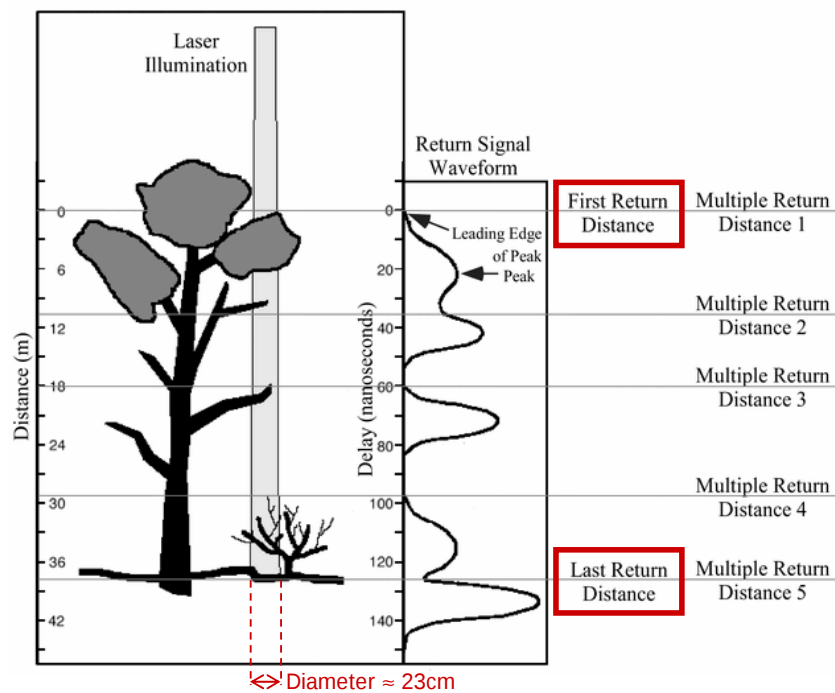
Inertial
Measurement
Unit



$$\text{Range} = c \frac{\Delta t}{2}$$

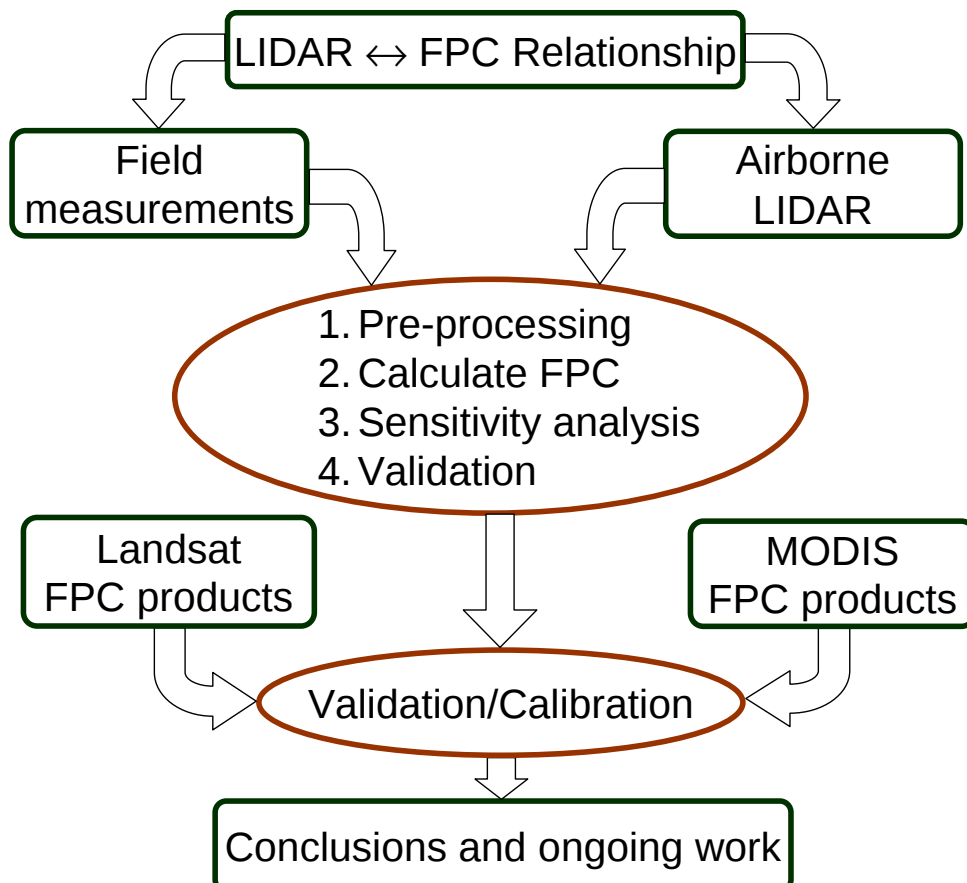
SLATS acquisitions
 $h \approx 1000\text{m}$
Swath width $\approx 300\text{m}$
 $\theta \approx 10^\circ$

What does LIDAR measure?

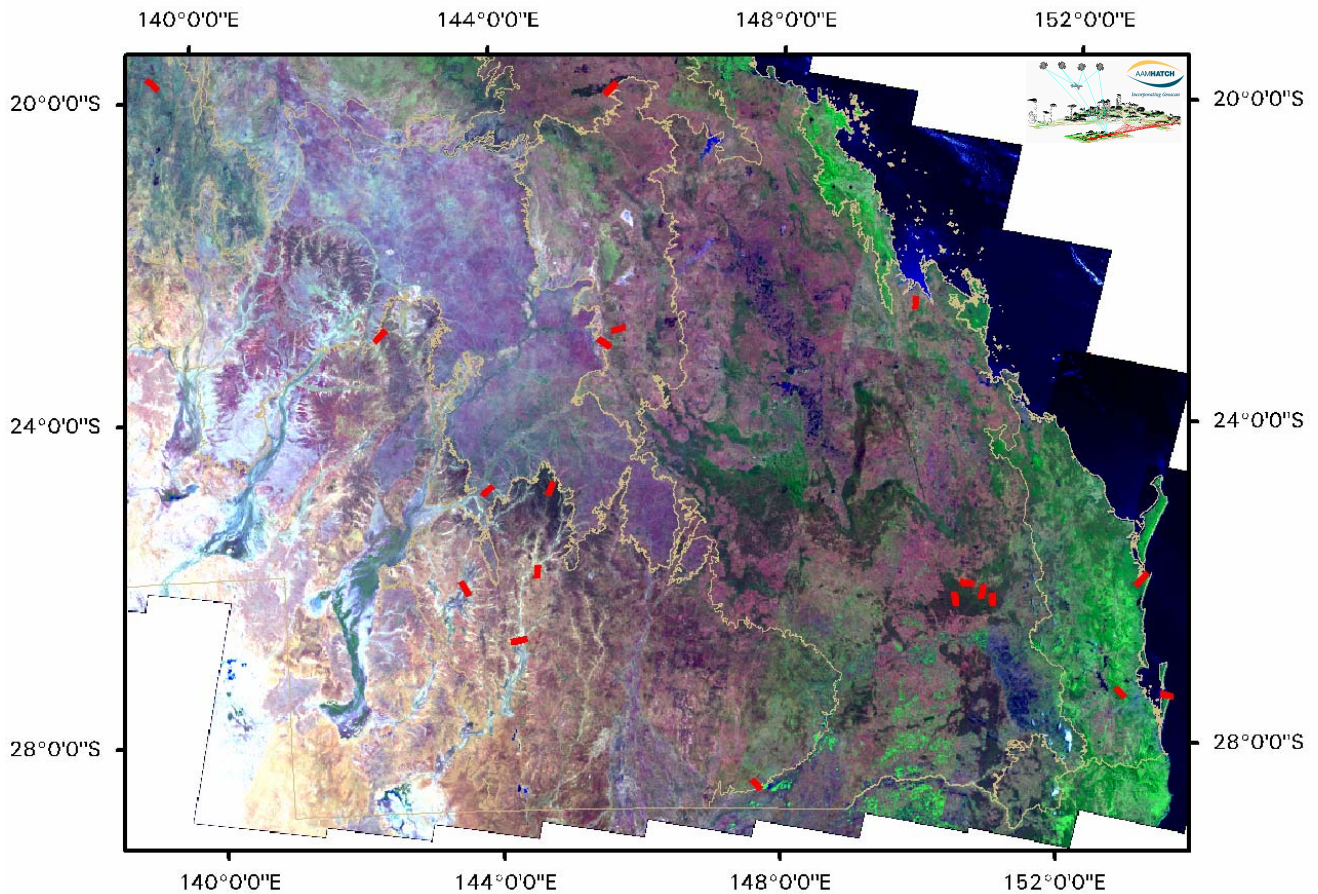


Source: Lefsky *et al.* (2002). Lidar Remote Sensing for Ecosystem Studies. *Bioscience*.

Outline



SLATS LIDAR transects



Field measurements

● Dot-count transects

● CCP

$$\text{● FPC} = \frac{N_{GL}}{N_{Total} - N_{Br}}$$

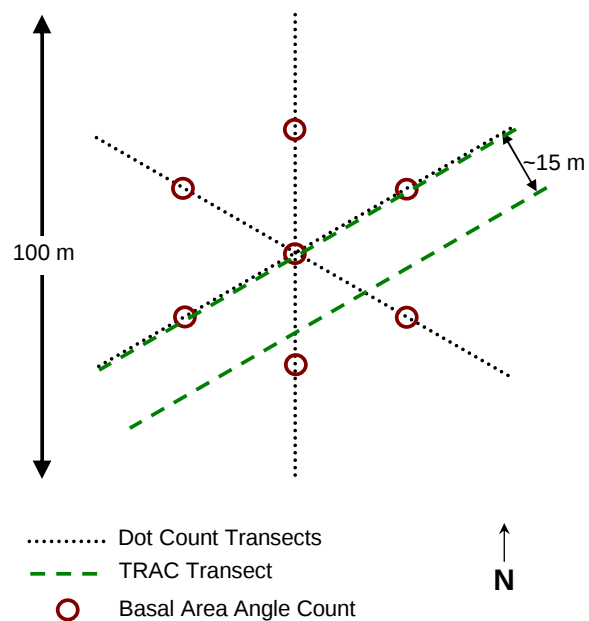
● Other measures

● Basal area

● Clumping (TRAC)

● Stem density

● LAI (indirect)



Field measurements

- Dot-count transects

- CCP

$$\bullet \text{ FPC} = \frac{N_{\text{GL}}}{N_{\text{Total}} - N_{\text{Br}}}$$

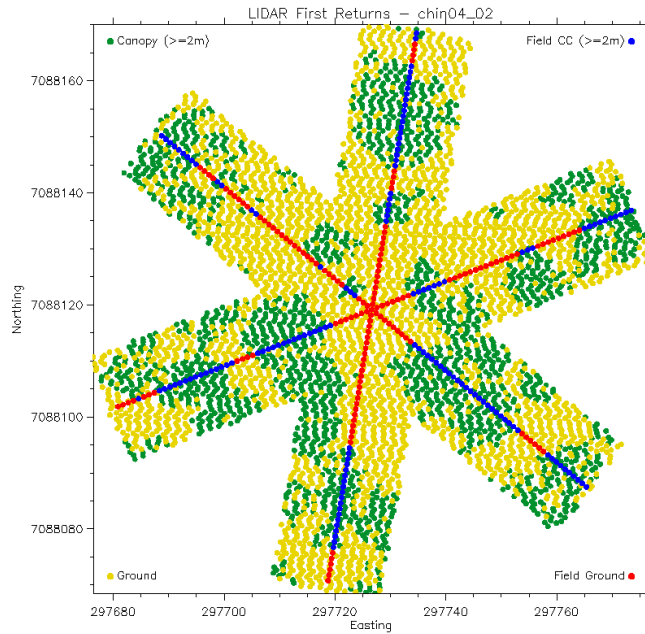
- Other measures

- Basal area

- Clumping (TRAC)

- Stem density

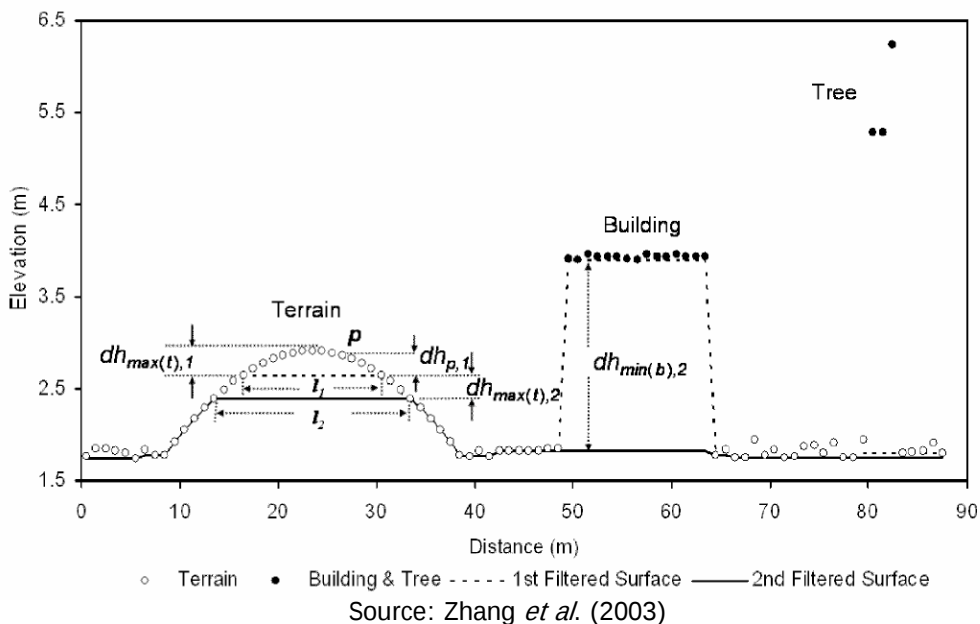
- LAI (indirect)



LIDAR pre-processing

- Automated ground classification

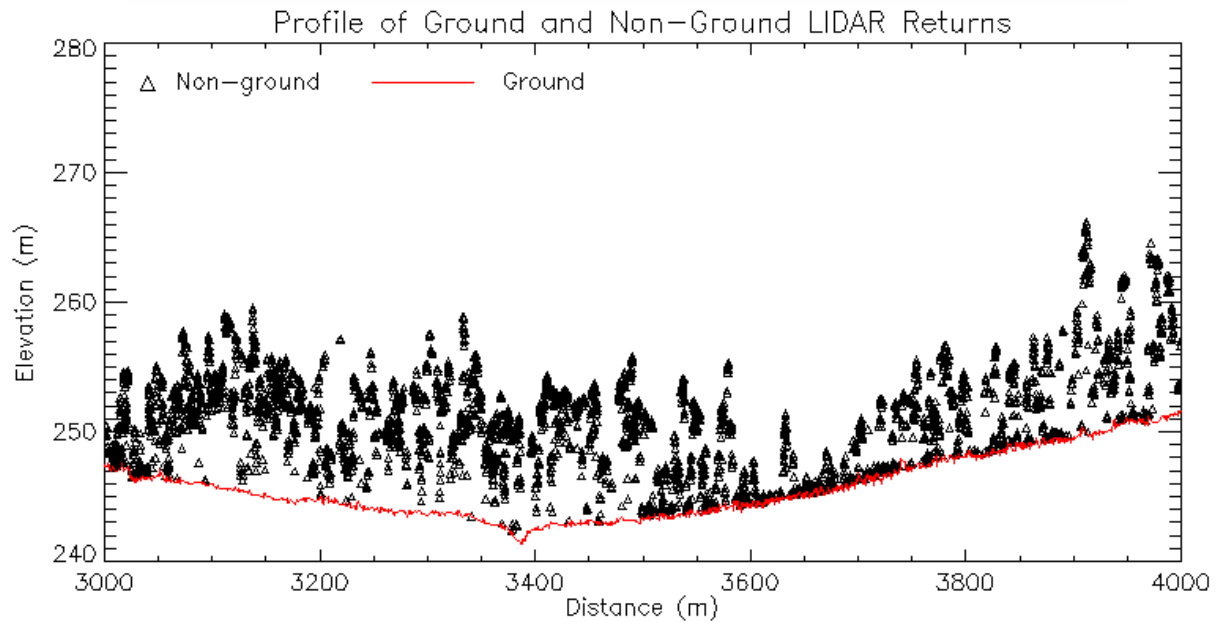
- Progressive morphological filter of last returns



Source: Zhang *et al.* (2003)

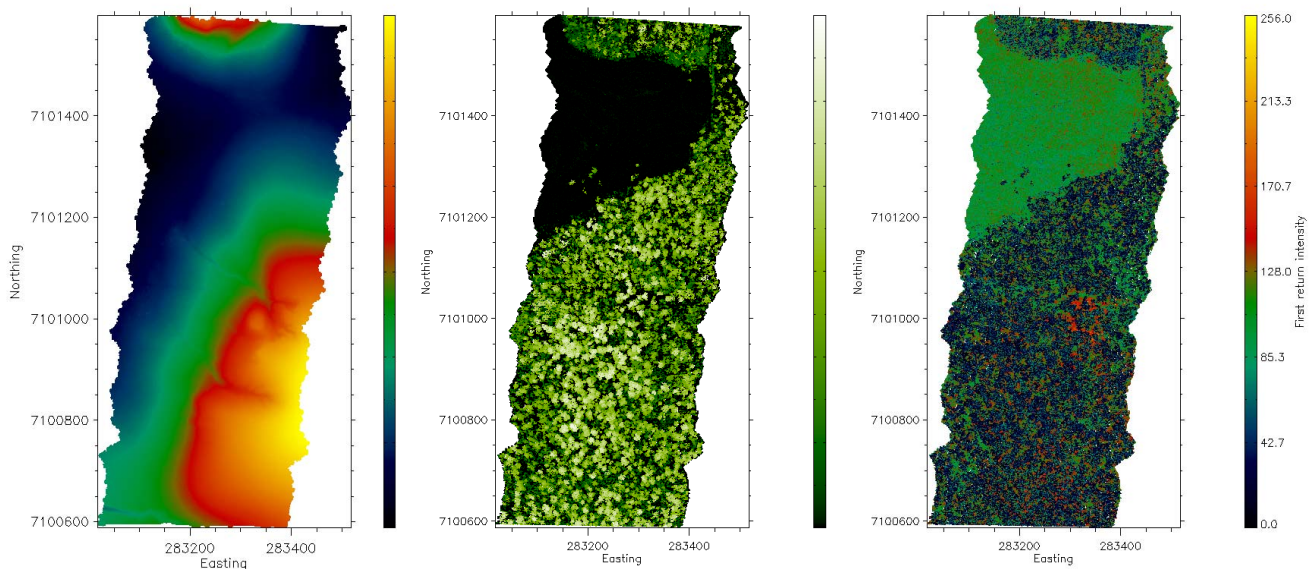
LIDAR pre-processing

- Automated ground classification
 - Progressive morphological filter of last returns

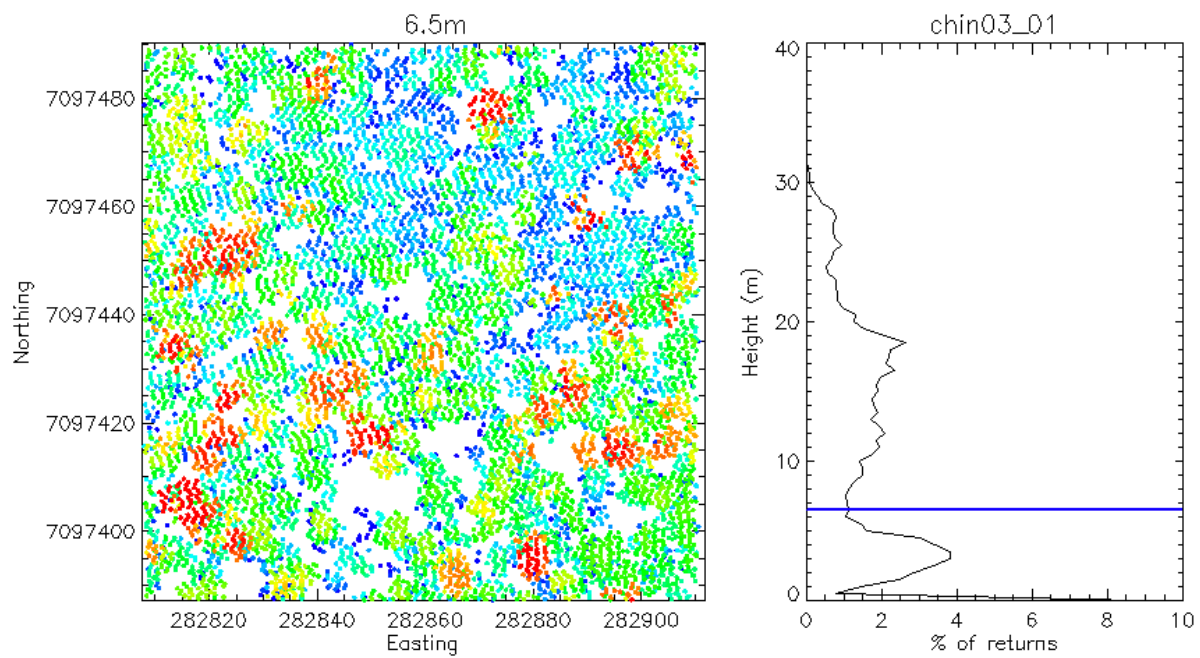


LIDAR pre-processing

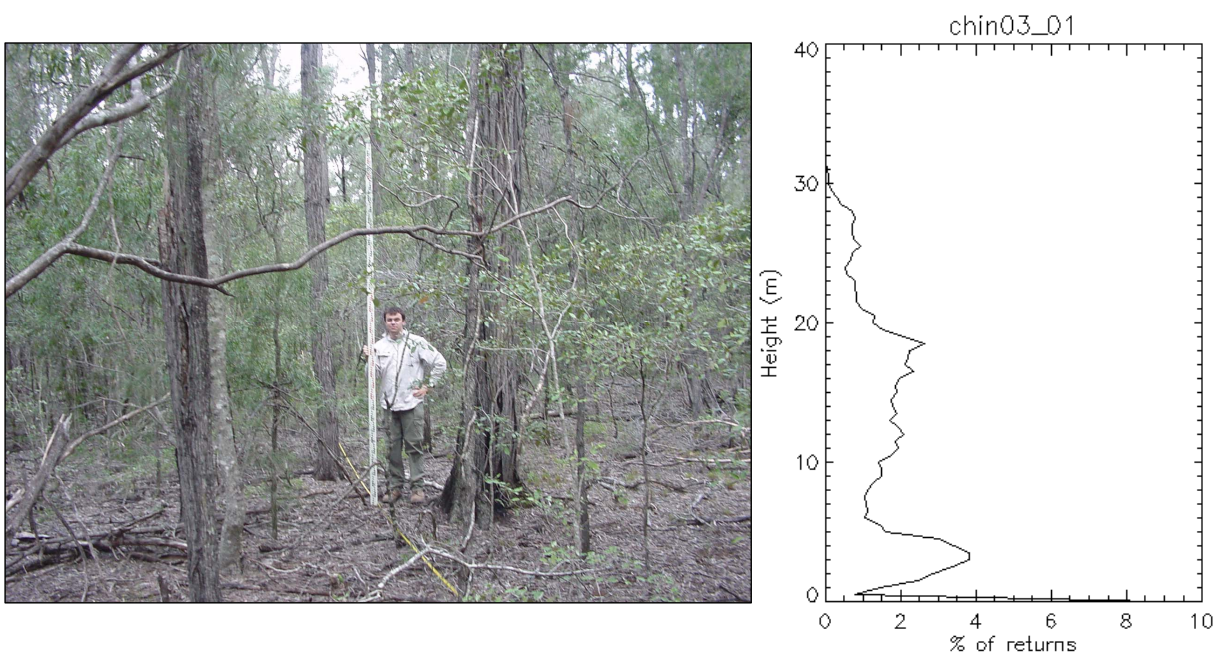
- Creation of Digital Elevation Model (DEM)
 - Inverse distance weighted interpolation
- Return height = return elevation – DEM



*LIDAR maps the **distribution** of foliage*



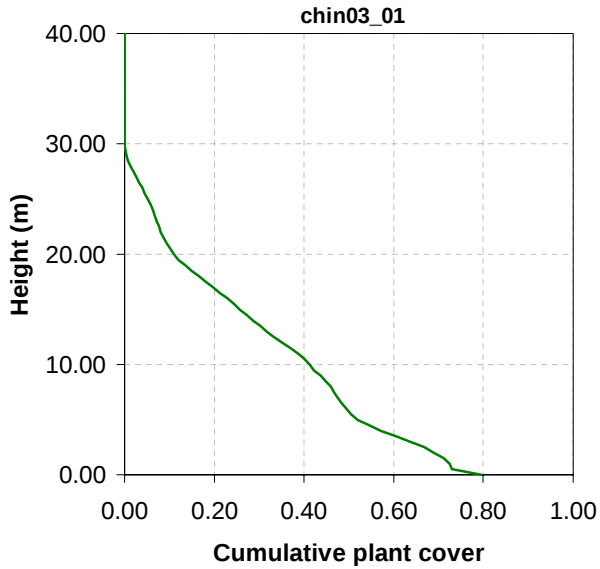
*LIDAR maps the **distribution** of foliage*



Calculation of LIDAR FPC

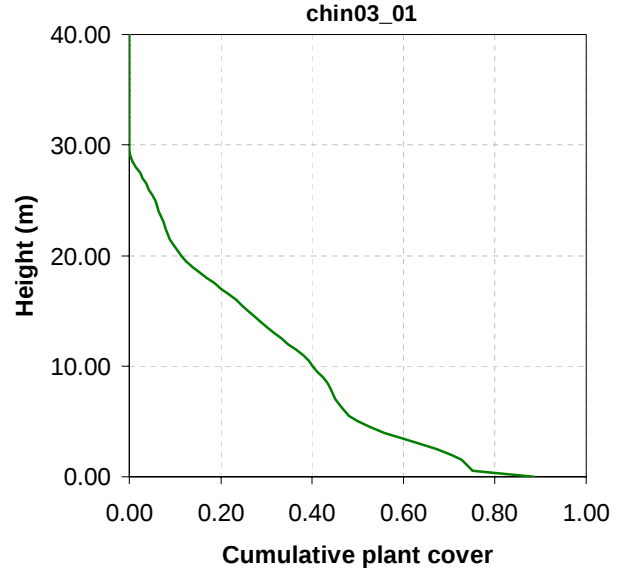
Proportion of **returns**

$$1 - P_{gap}(z) = \frac{N_V(z)}{N_V(0) + N_G}$$



Proportion of **energy**

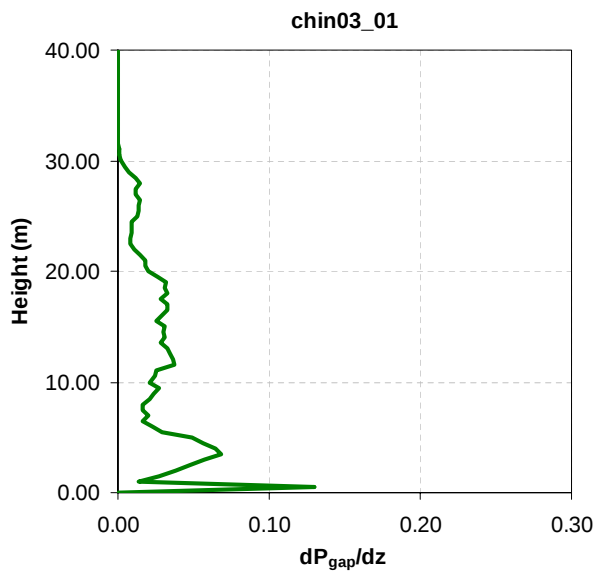
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Calculation of LIDAR FPC

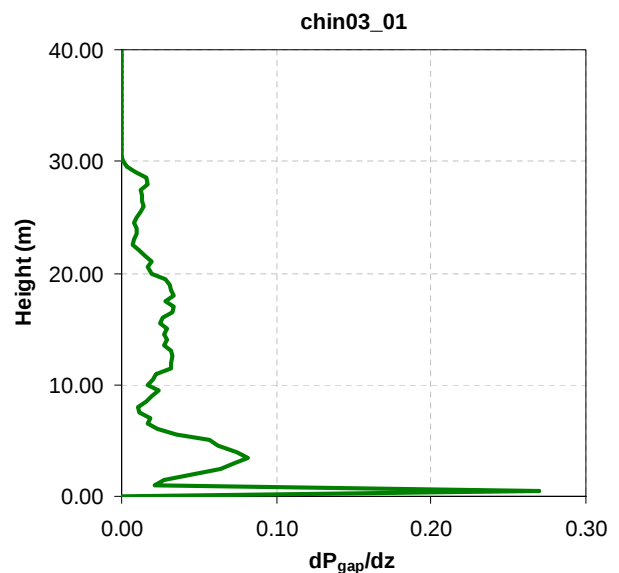
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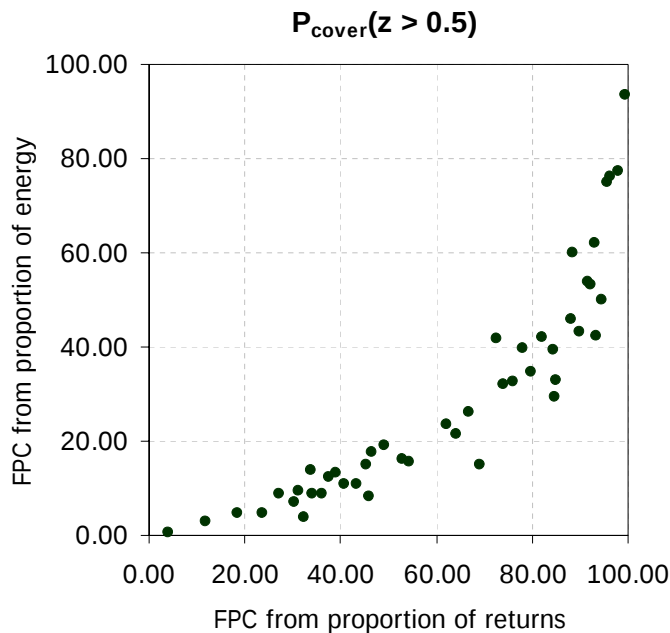
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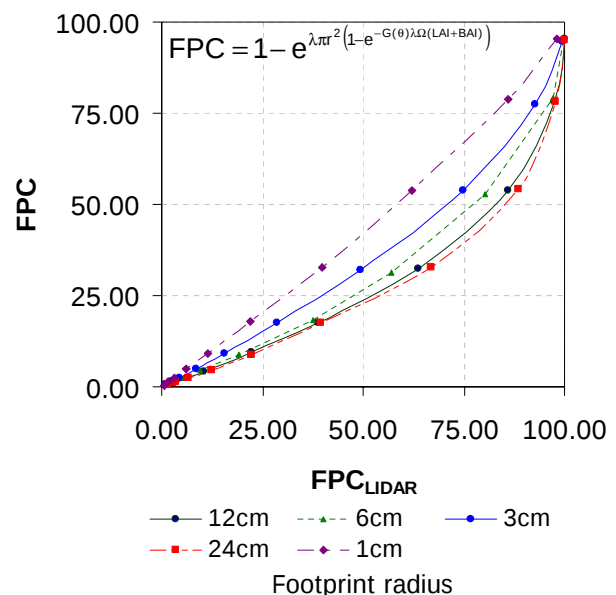
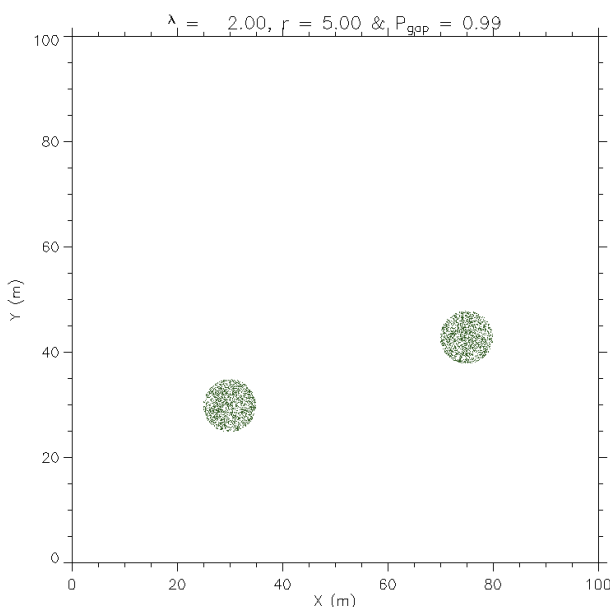
Linking LIDAR and FPC

- Different methods are measuring different things!
 - Effect of “footprint” size
 - Effect of plant structural and optical properties



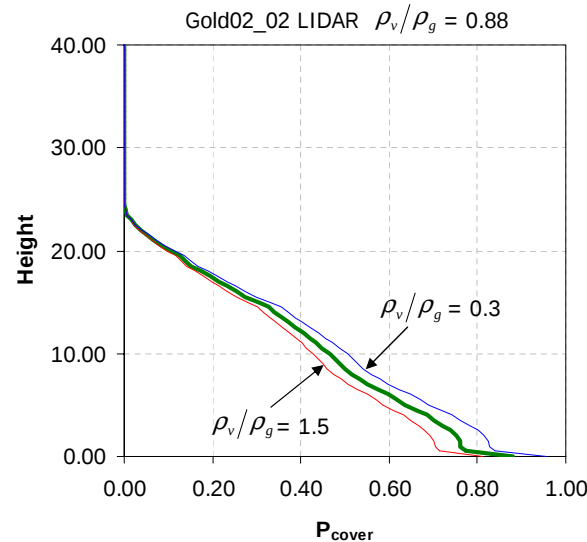
Effect of footprint size

- Simulation of LIDAR returns from a simple 2D canopy
 - Interaction with disk size, clumping and leaf angle
 - Usual solution is to calibrate to field data



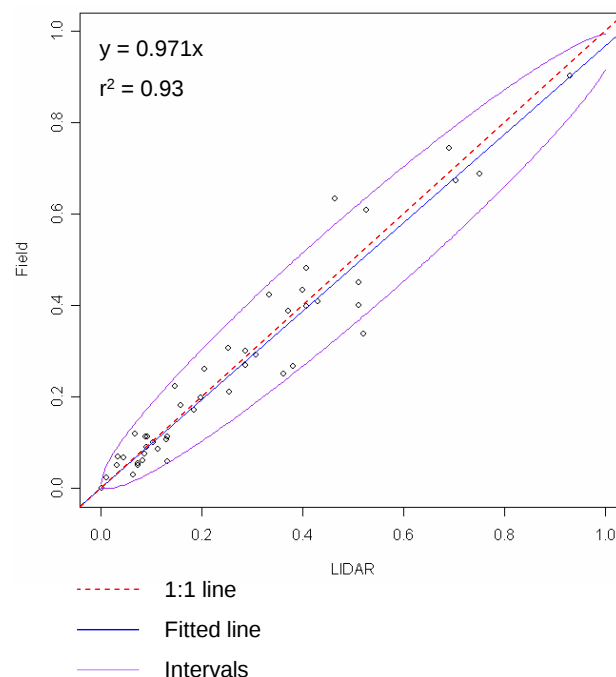
Effect of plant/ground reflectivity

- Can recover sub-footprint information using intensity
 - Requires an estimate of ρ_v/ρ_g
 - Spectrometer measurements ✗
 - Determine optimum constant ?
 - Derive from intensity data itself ?



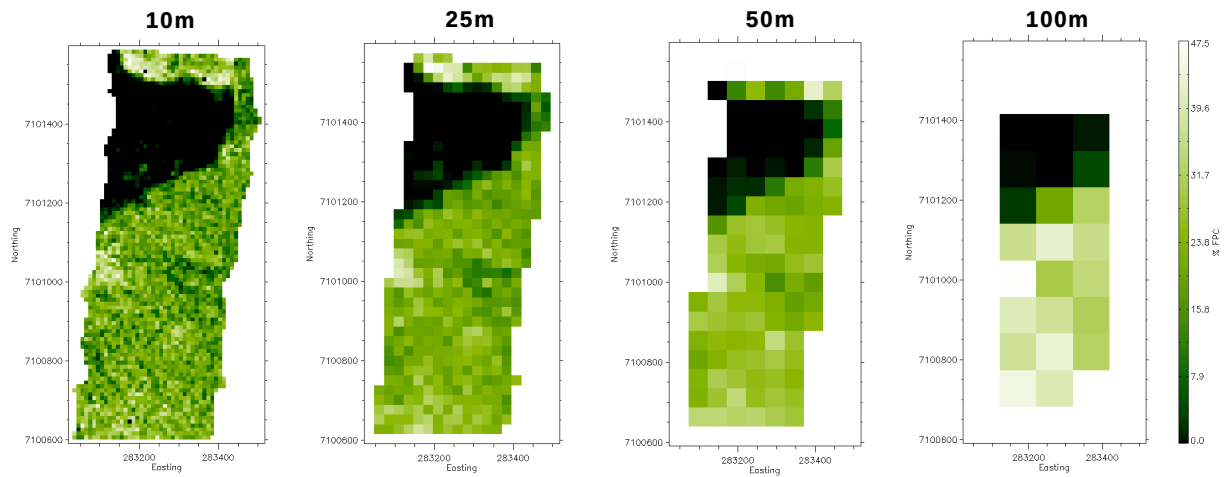
Validation of LIDAR $\leftrightarrow$ FPC relationship

- Error consistent with binomial sampling distribution



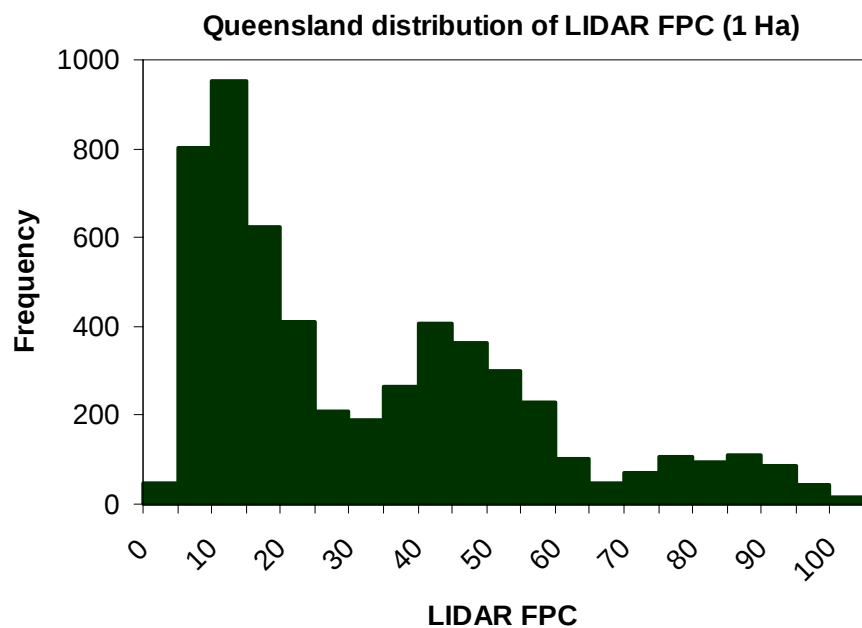
SLATS LIDAR FPC Products

- Aggregate returns into “data bins”



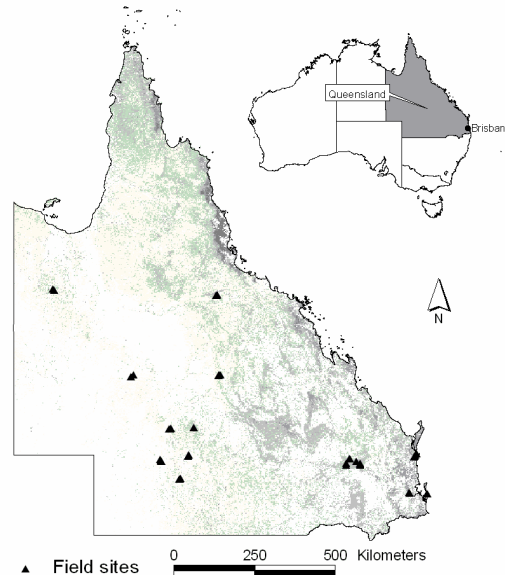
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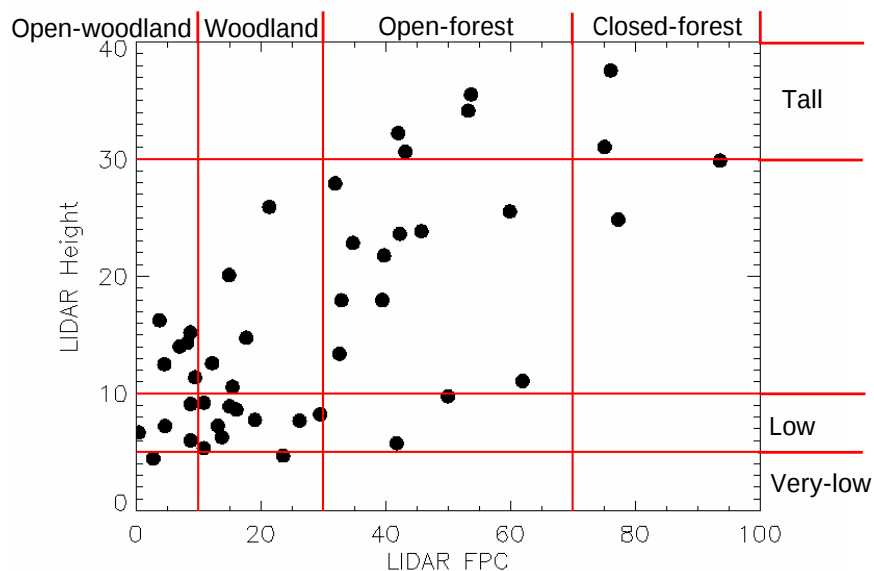
Comparison of Landsat and LIDAR FPC

- LIDAR suitable for multi-scale validation (in progress)
- **Preliminary** Landsat FPC validation
 - Calibration sites (1 Ha) $\Rightarrow$ LIDAR FPC $> 0.5\text{m}$
 - Assumed no change in FPC between acquisition dates



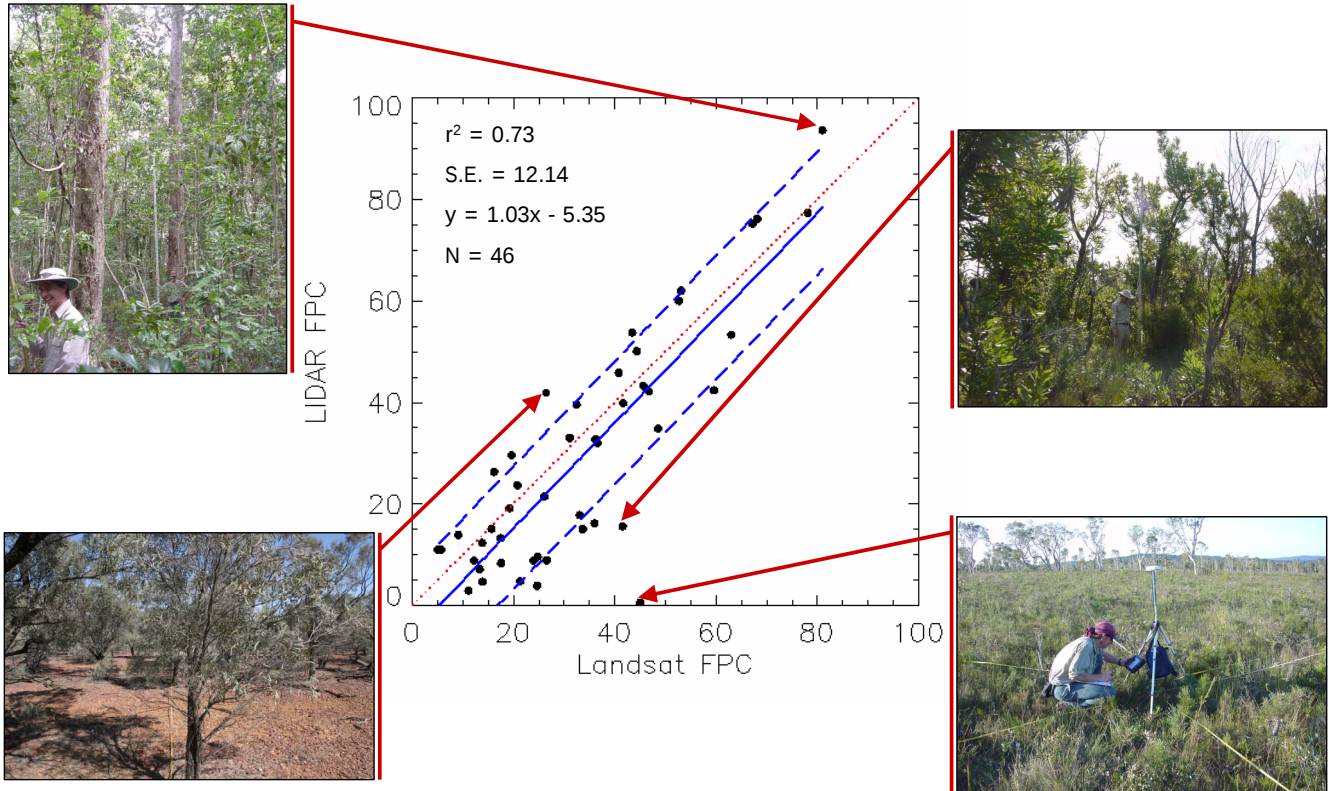
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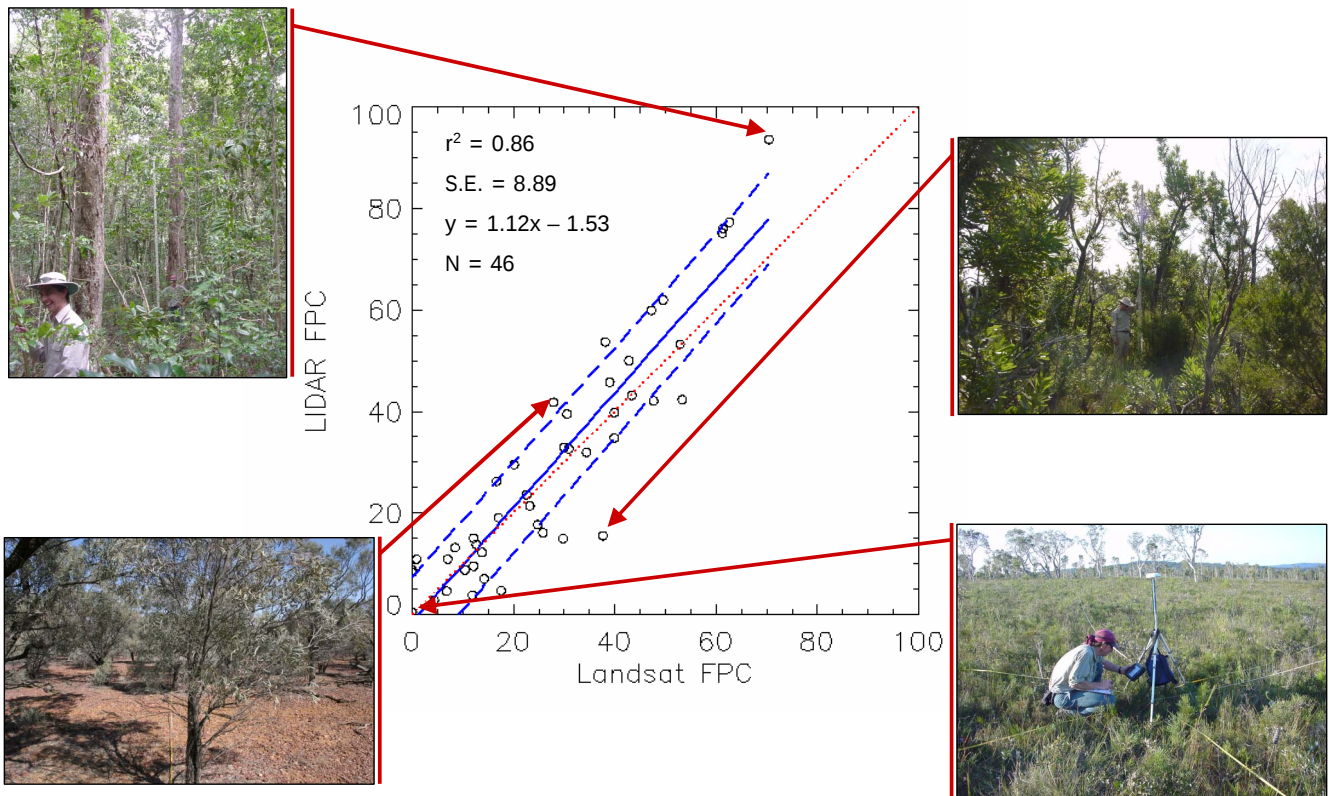
Comparison of Landsat and LIDAR FPC

● Predictions from Landsat regression models



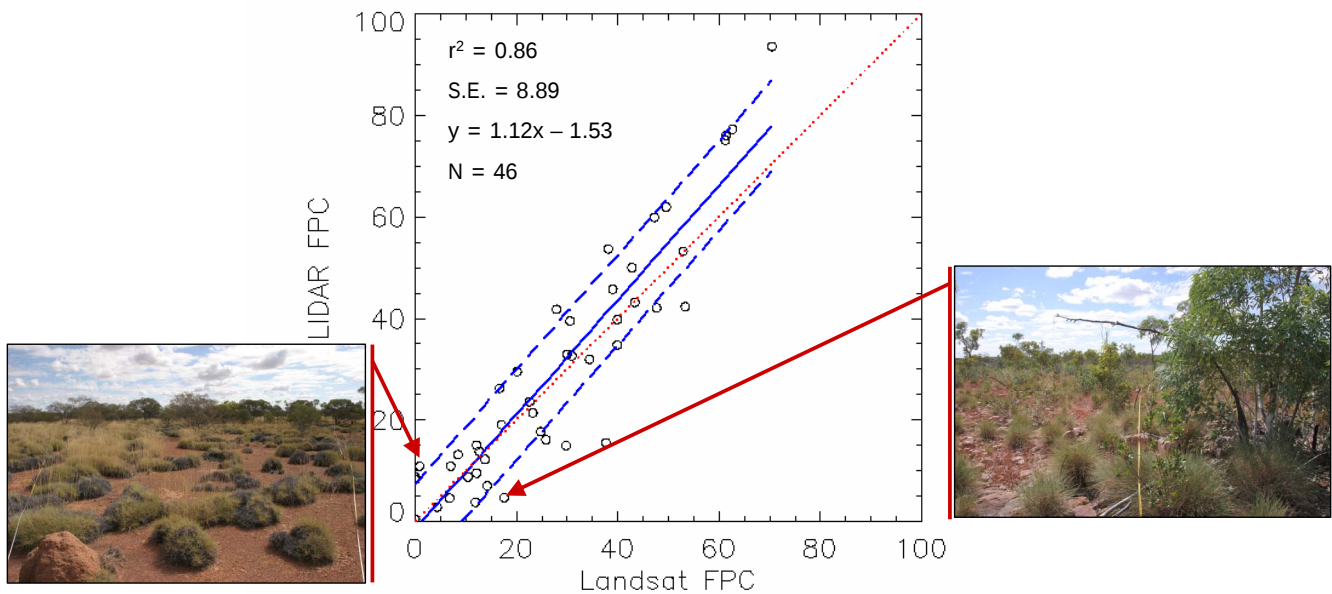
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● Predictions from Landsat trend analysis



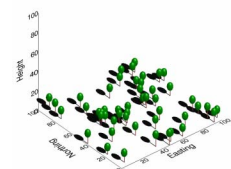
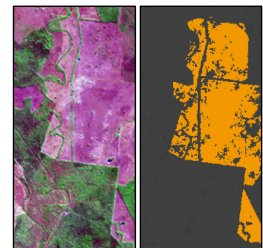
Comparison of Landsat and LIDAR FPC

- Predictions from Landsat trend analysis



Conclusions

- LIDAR analysis
 - Validated retrieval of FPC (effect of branches?)
 - Use of intensity measurement providing good results
- SLATS FPC validation is in progress
 - Precise but biased in some areas
 - Suitable for monitoring applications
- Future work
 - Integration of LIDAR with broad scale remote sensing
 - Landsat & PALSAR $\Rightarrow$ FPC and woody regrowth
 - Inversion of LIDAR return model
 - Retrieve stand-scale structural parameters



Questions?



Left to right: Sel Counter, Robert Denham, Tim Danaher and John Armston

Other fieldworkers: Rob Hasset, Peter Scarth, John Carter, Tony Gill, Jo Shaw, Craig Shephard and Sam Gillingham