Natural Resources and Mines
Managing Queensland's natural resources ... for today and tomorrow

Relationships between forest structure measurements

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Statewide Landcover and Trees Study

Queensland the Smart State

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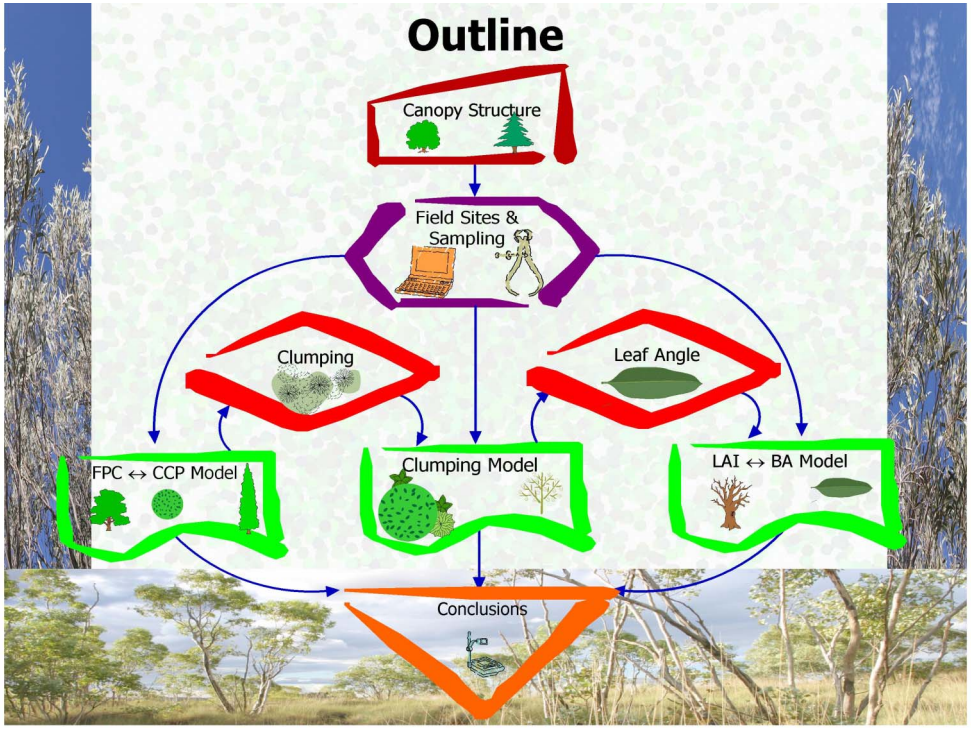
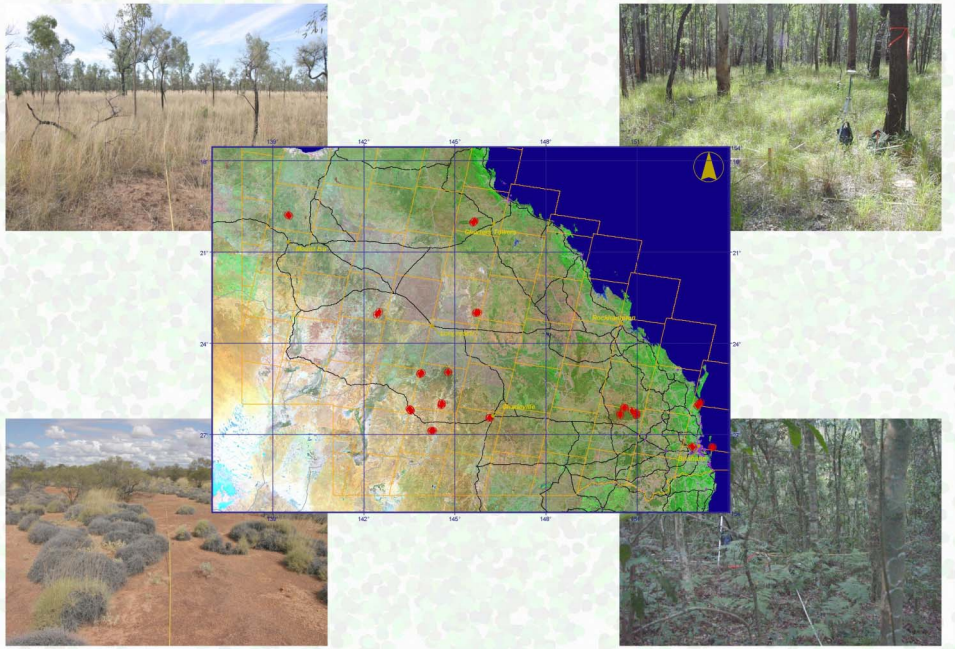
Primary canopy structural measurements

- Stand structure → 2 components
  - Structural **complexity**
  - Structural **attributes**
- Structural attributes
  - Projected Foliage Cover
  - Projected Canopy Cover
  - Basal Area
  - Foliage clumping - Ω
  - Leaf Area Index
    - LAI
    - LAIe → Leaf Angle & Ω

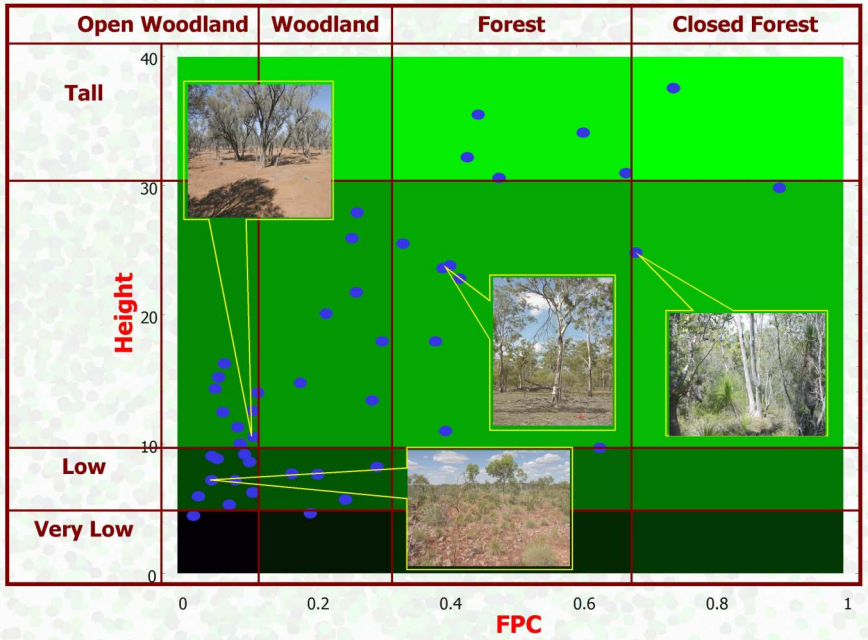
Outline



Measuring Canopies - Where

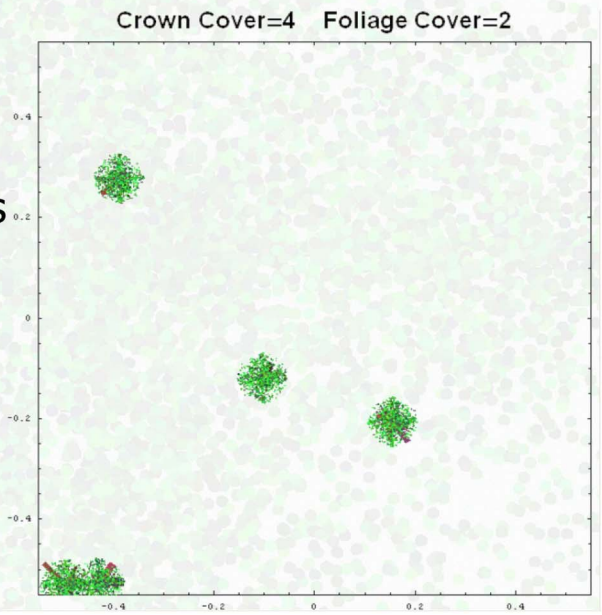


Measuring Canopies - Why



Introduction to CCP ↔ FPC Model

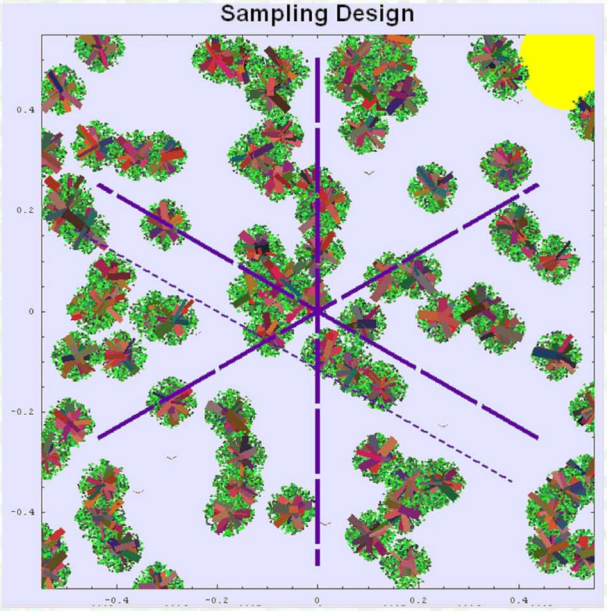
- Crowns ∈ Forest
  - P( )=ccp
  - $ccp = 1 - e^{-\lambda \pi r^2}$
- Leaves ∈ Crowns
  - P( )=fpc
  - $fpc = 1 - e^{-G\Omega L}$
- Leaves ∈ Forest
  - P( )=P( )×P( )
  - $ccp = \dfrac{fpc}{1-(1-fpc)^{\frac{\Psi}{\Omega}}}$



Measuring Canopies - Sampling Methods

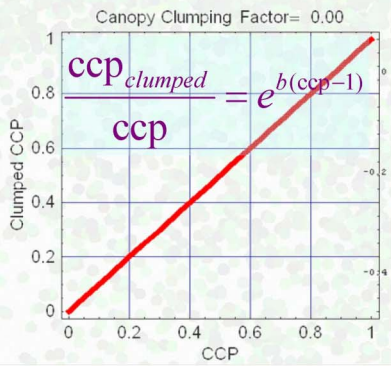
- Measurements
  - Cover
  - FPC
  - Basal Area
  - Clumping
- 3 × 100m + Trac

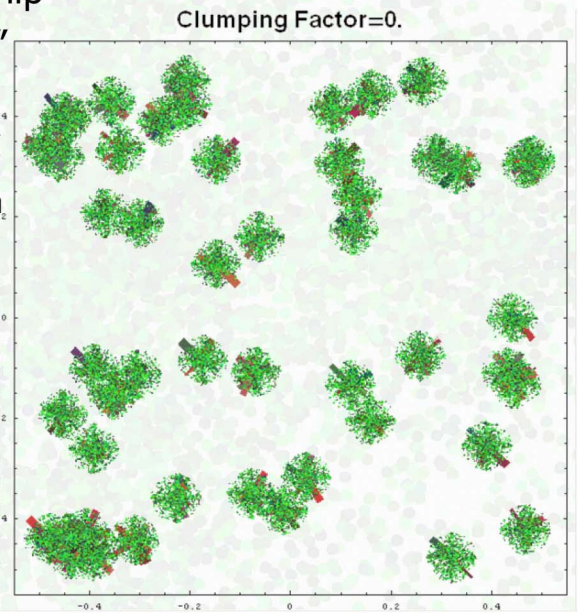
Distance	Crown	Green	Dead	Branch
1	1	1		
2	1	1		
3	1	1		
4	1	1		
5	1	1		
6	1			1
7	1	1		
8	1	1		
9	1	1		
10	1	1		



Clumping in Forests

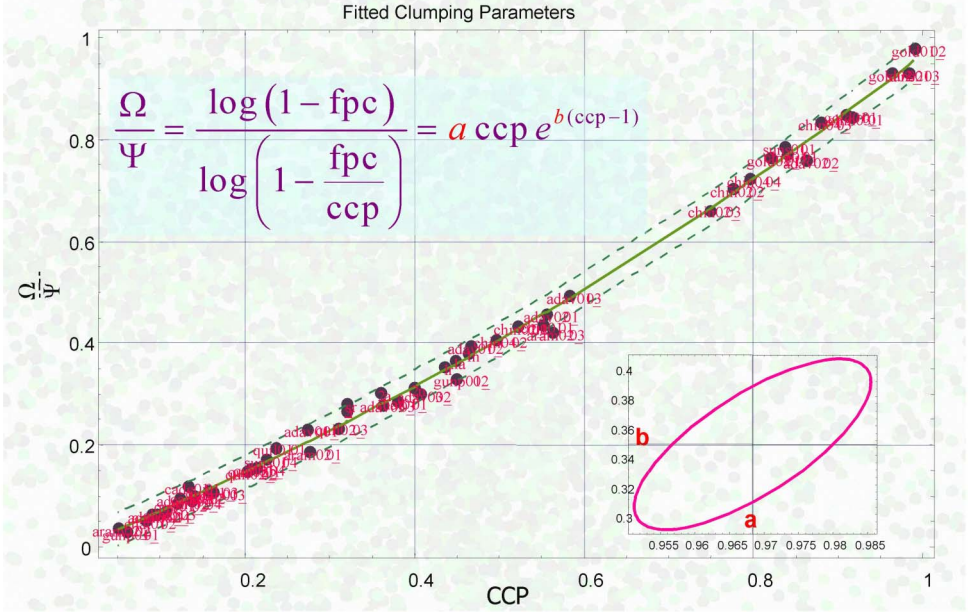
- CCP ↔ FPC relationship depends on "clumping"
  - Clumping (Ω,Ψ) is deviation from "Random"
  - Modelled using Neyman



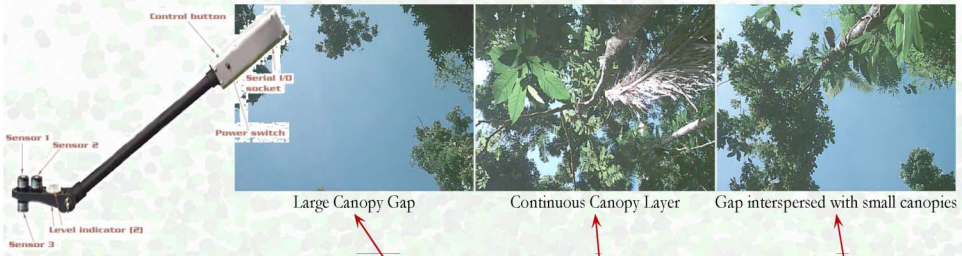


Fitting the Clumping Ratio Model

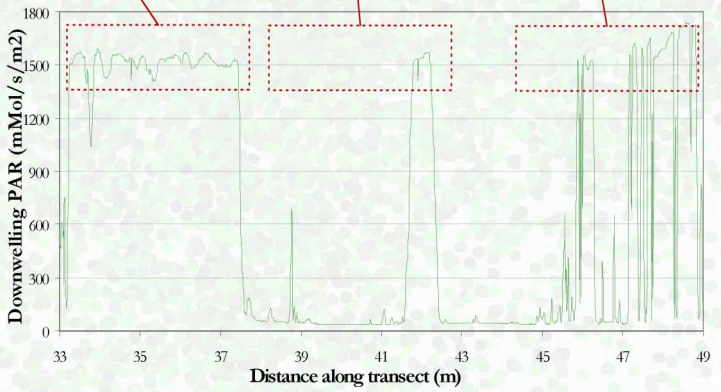
- Invert FPC↔CCP and fit – looks OK ☺



Measuring Clumping (Ω)

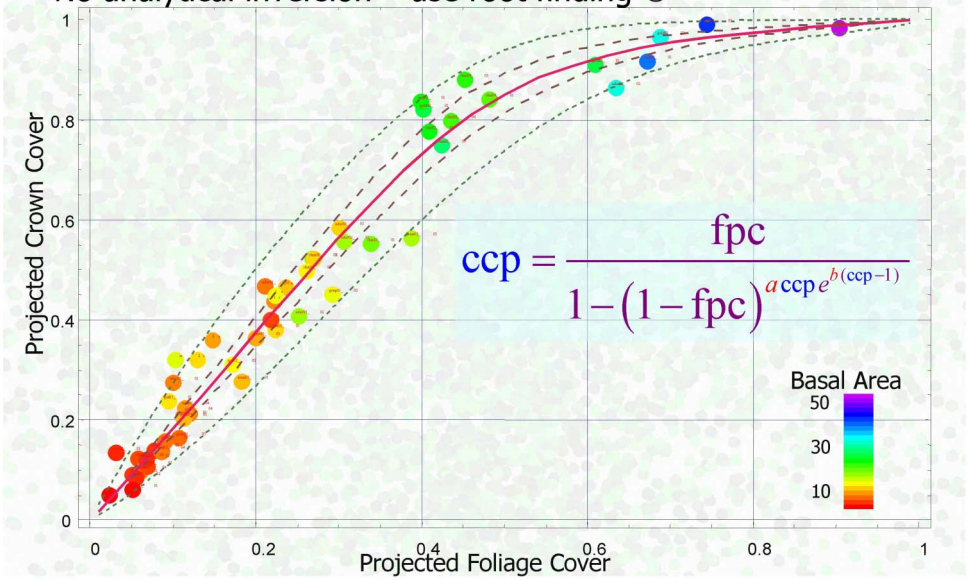


- Trac
  - Measures canopy "gaps"
  - Compares distribution to "Random"
  - Difference is clumping Ω

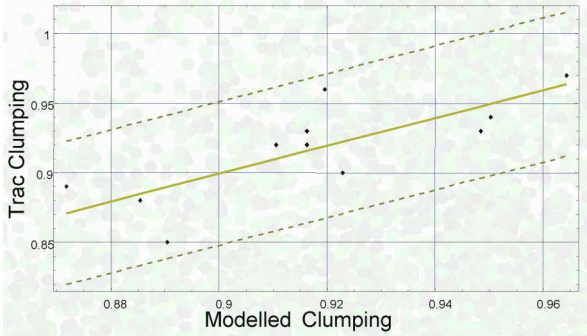


Fitted CCP ↔ FPC Model

- Apply clumping model to FPC↔CCP model
  - No analytical inversion – use root finding 😐



Fitting Trac Omega (Ω) ↔ Clumping Model

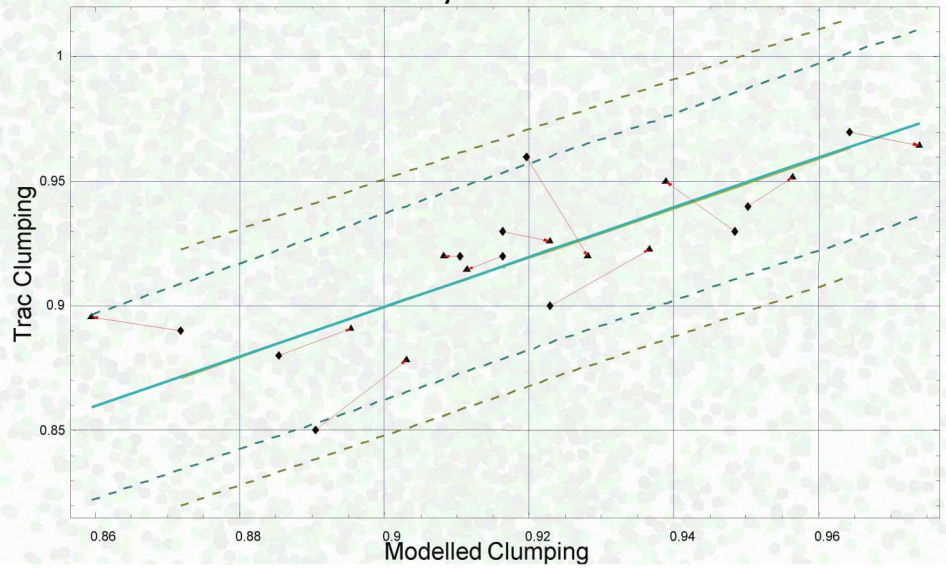


- Omega ↔ CCP modelled clumping
  - There is a fit but…
  - Omega is a function of Zenith!

- Correct for ☼ zenith
  - Zenith ↔ residuals
    - Try 1st to 4th order fits
    - 3rd is best (⇓ error σ^2)
    - Agrees with published work (Chen) ☺

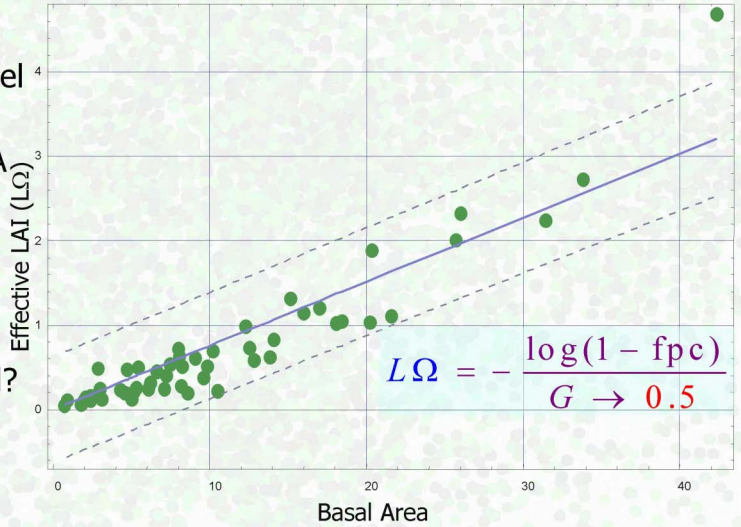
Improved Omega (Ω) ↔ Clumping Model

- Same Relationship but improved confidence ☺
  - But limited number & variety of sites ☹



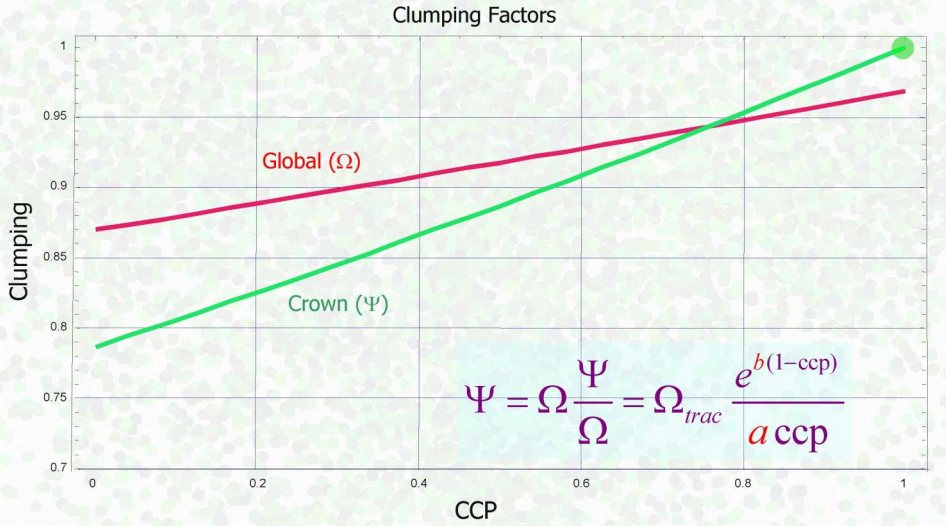
LAI ↔ Basal Area

- Theoretical models → more leaf ≈ more BA
  - Log(LAI) = a + b log(BA)
    - •As reported in literature
  - LAI = $a\,Ba^{b}$
  - Change Model
    - •b ⇒ 1
  - ∴ LAI = a BA
    - •Significant outliers ☹
  - Better model?

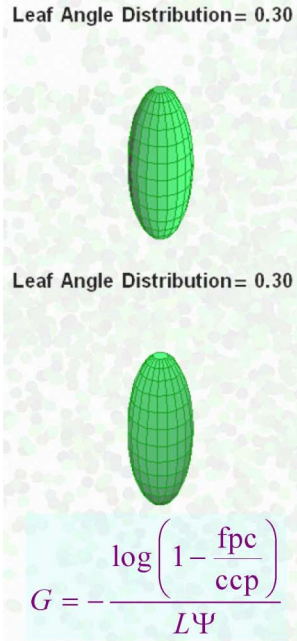


Clumping ↔ CCP Models

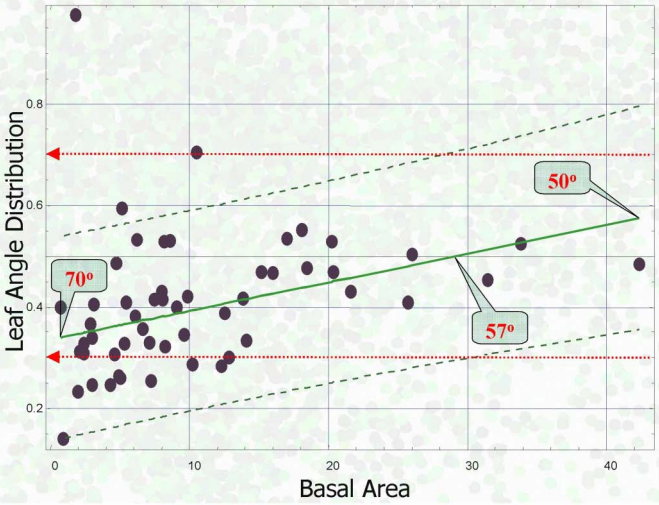
- Can recover within canopy clumping (Ψ)
  - Possible clumping > 1 implies "Regularity" (*overdispersion*)



Leaf Angle Distribution ↔ Basal Area



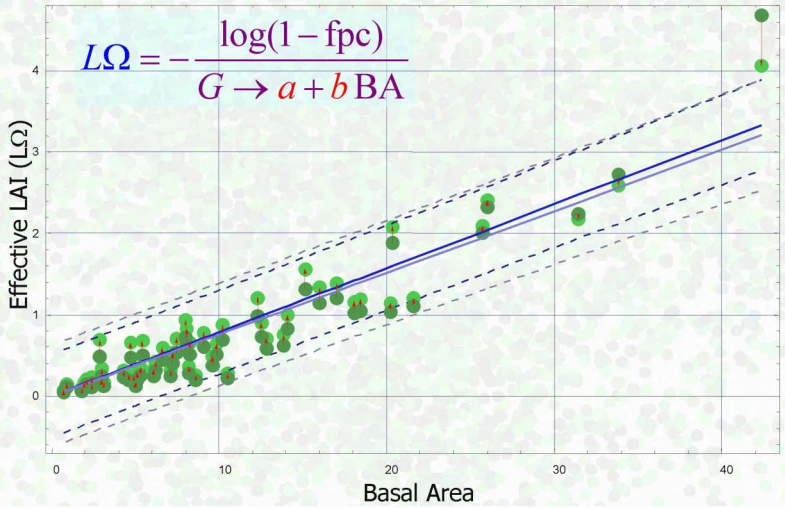
- Estimate **G** from Trac & Field Data
  - Pushing data to its limits 😐
  - Poor fit but sensible result



Leaf Angle Corrected LAI ↔ Basal Area

- Slightly different estimator
  - Improved confidence ☺
  - High BA site has "flatter" leaves

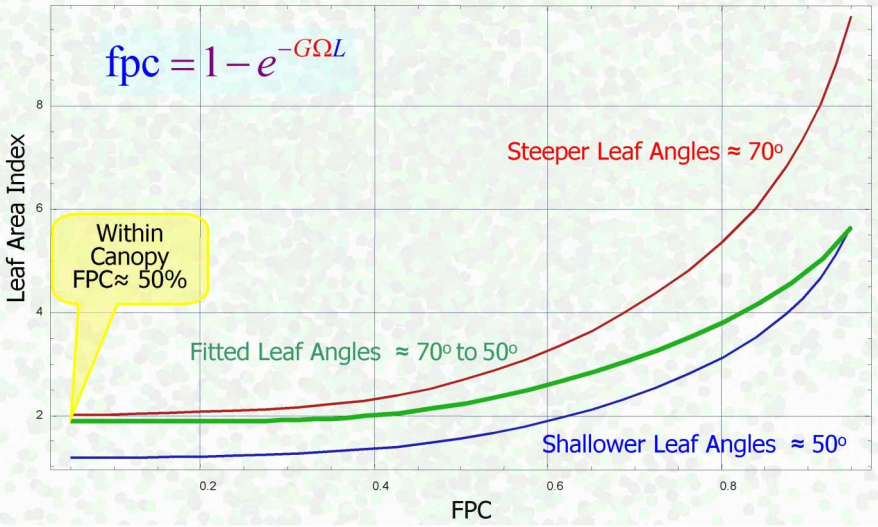
$$L\Omega = -\frac{\log(1-\text{fpc})}{G \to a + b\,\text{BA}}$$



FPC ↔ LAI Final Relationship

- We have estimated G and Ω
  - LAI ≈ 1.7 as FPC ⇒ 0 ∴ Mature trees have leaves ☺

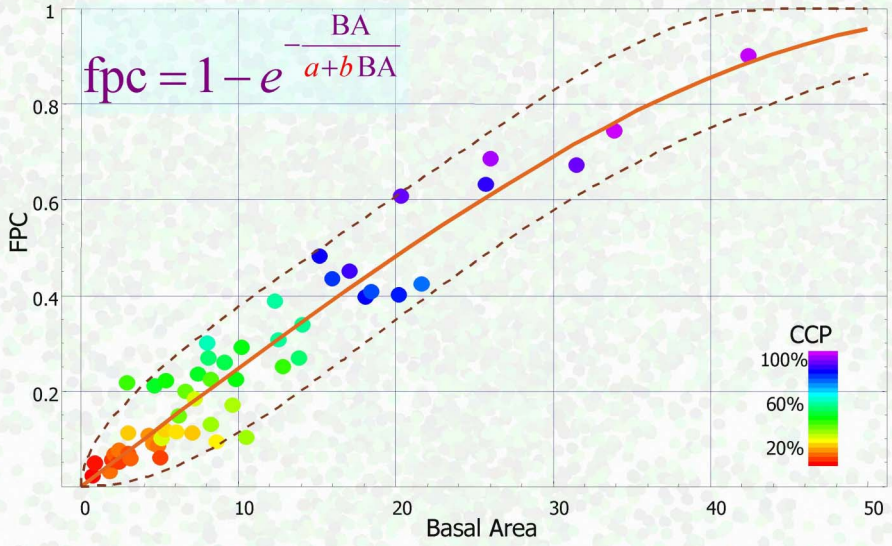
$$\text{fpc} = 1 - e^{-G\Omega L}$$



FPC ↔ Basal Area Nonlinear Fit

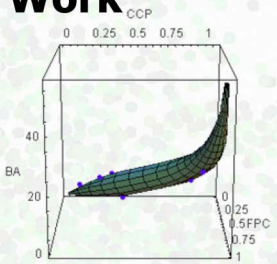
- Final model has simple form ☺
  - But still has wide confidence intervals on Statewide data ☹

$$\text{fpc} = 1 - e^{-\frac{\text{BA}}{a+b\,\text{BA}}}$$



Conclusions & Future Work

- Canopy parameters are interrelated
  - Probably different for regrowth – Sample?
- No single "best" structure measure
- Leaf scale parameters important
  - LAI & Leaf Angle
  - Clumping



Thanks to:

- *Rob Hasset*
  - *Site selection & photography*
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  - *Field campaign*
- *Slatters*
  - *Additional field sites*