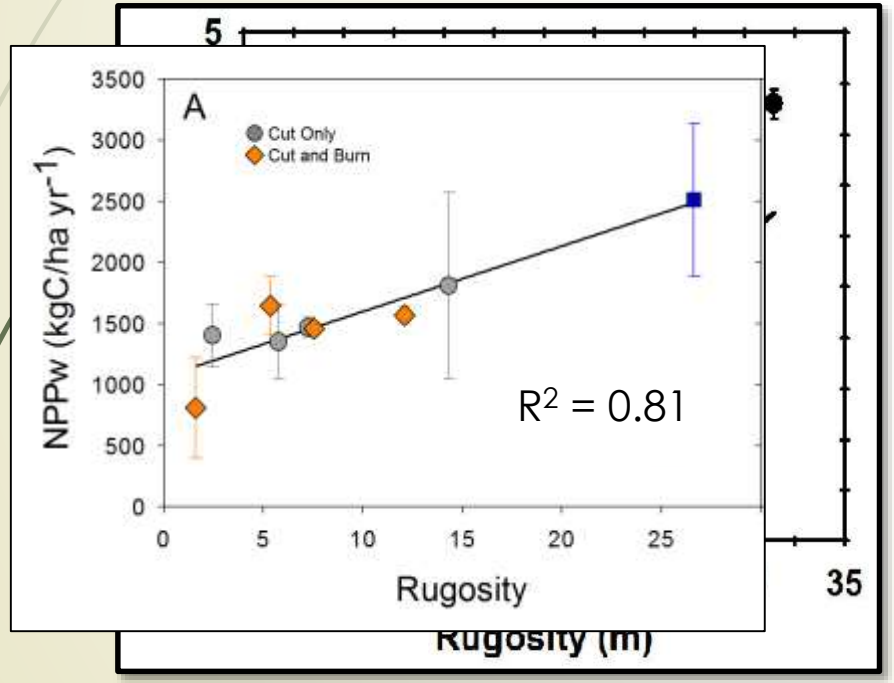
Methods and metrics for quantifying forest canopy complexity

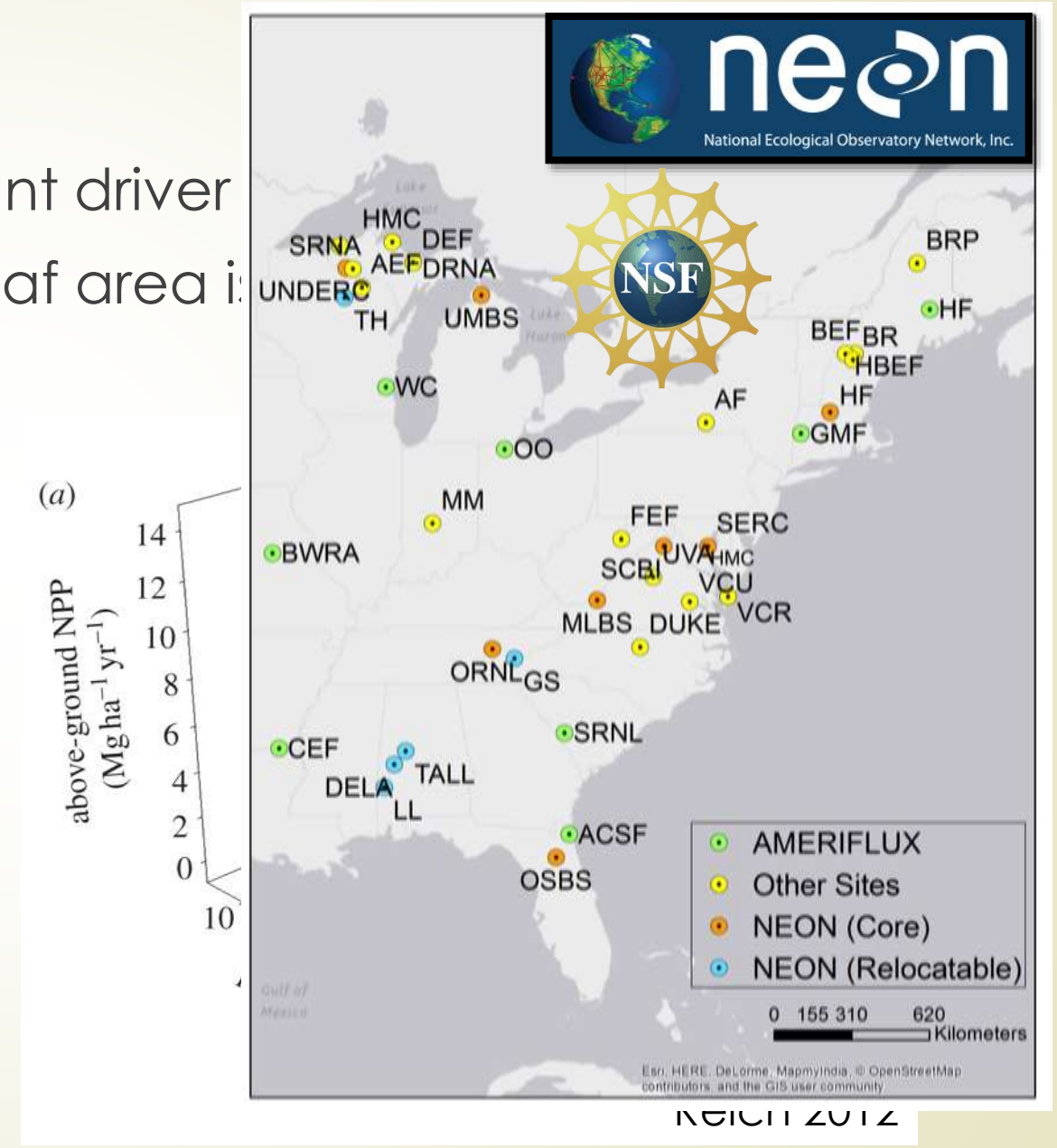
Robert Fahey, Jason Tallant, Jeff Atkins, Chris Gough, Brady Hardiman, Cynthia Scheuermann

Background

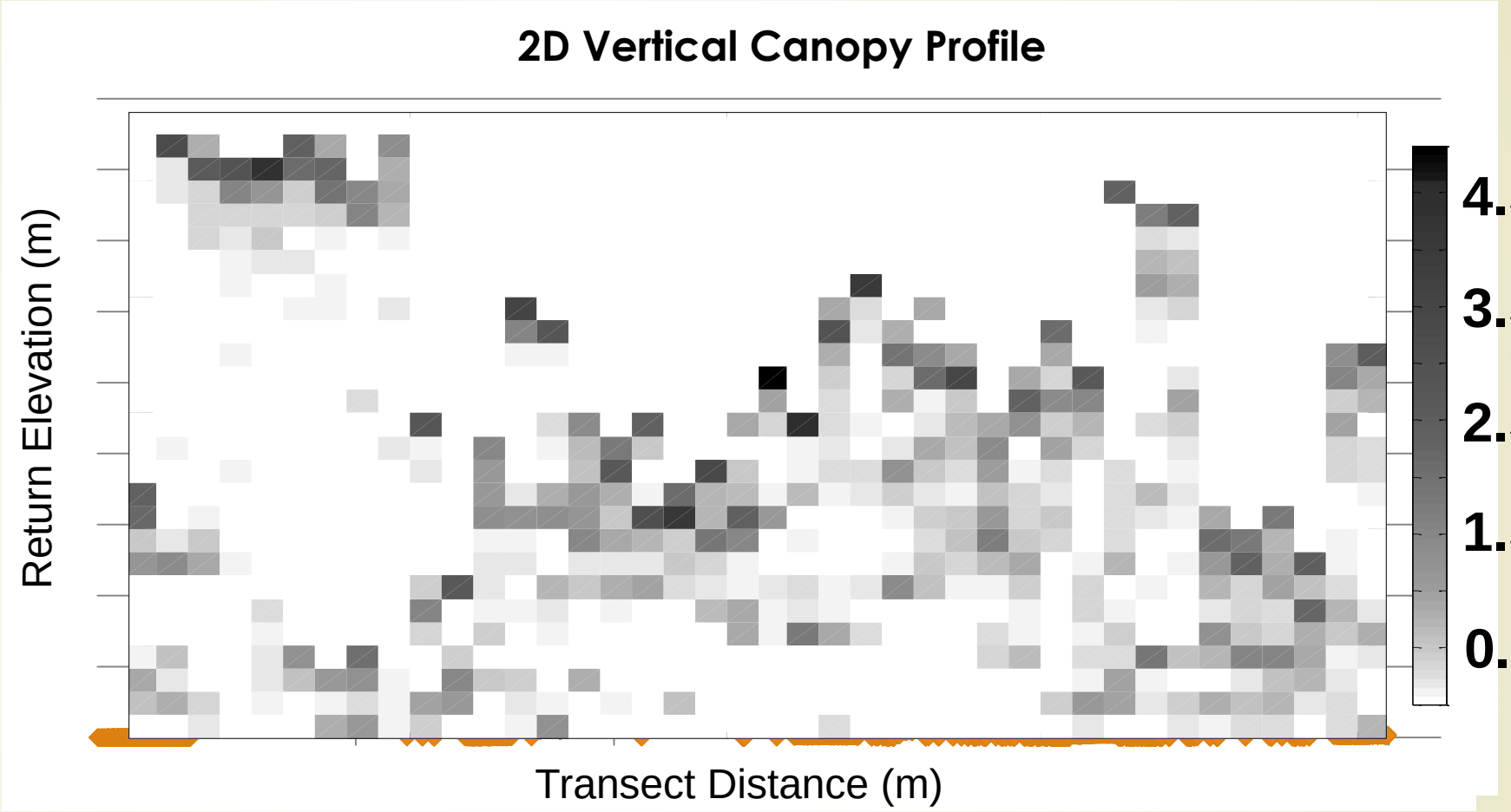
- Leaf quantity is an important driver
- But arrangement of that leaf area i



Hardiman et al. 2011

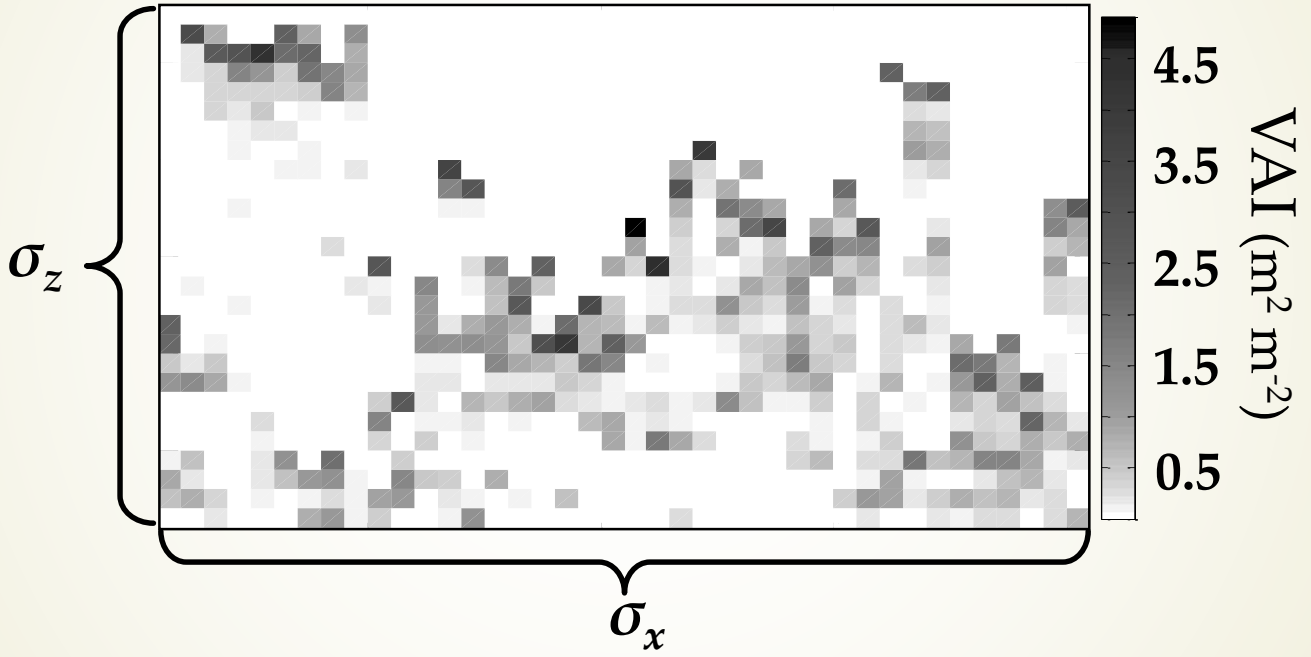


Reich 2012



- **LiDAR returns to vegetation distribution:**
  - Density - VAI
  - Distribution & Variability
  - Presence/absence - porosity

- Canopy rugosity (R_c): horizontal variation in vegetation height variability (i.e. canopy structural complexity)

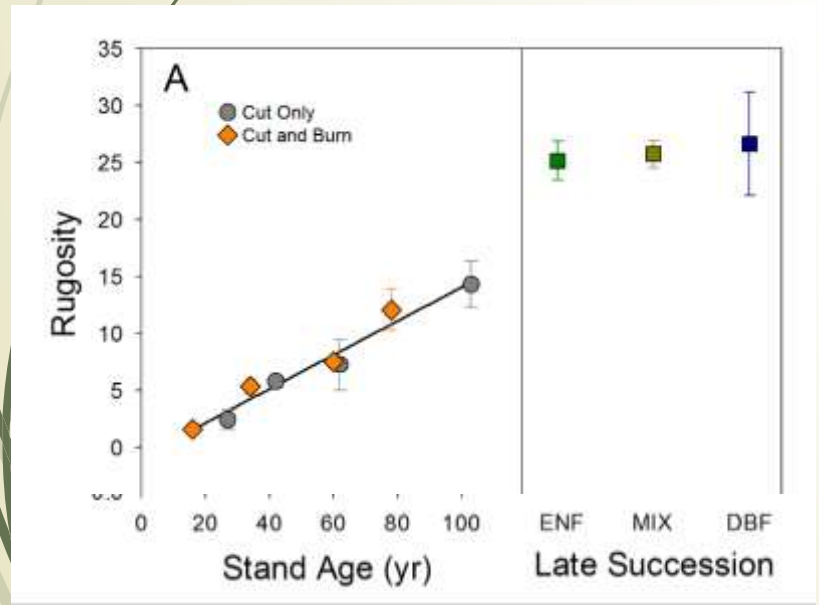


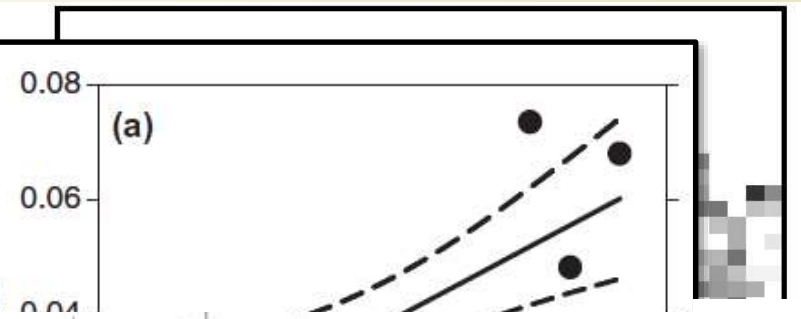
$$R_c = \sigma[\sigma(\mathrm{VAI})_z]_x$$

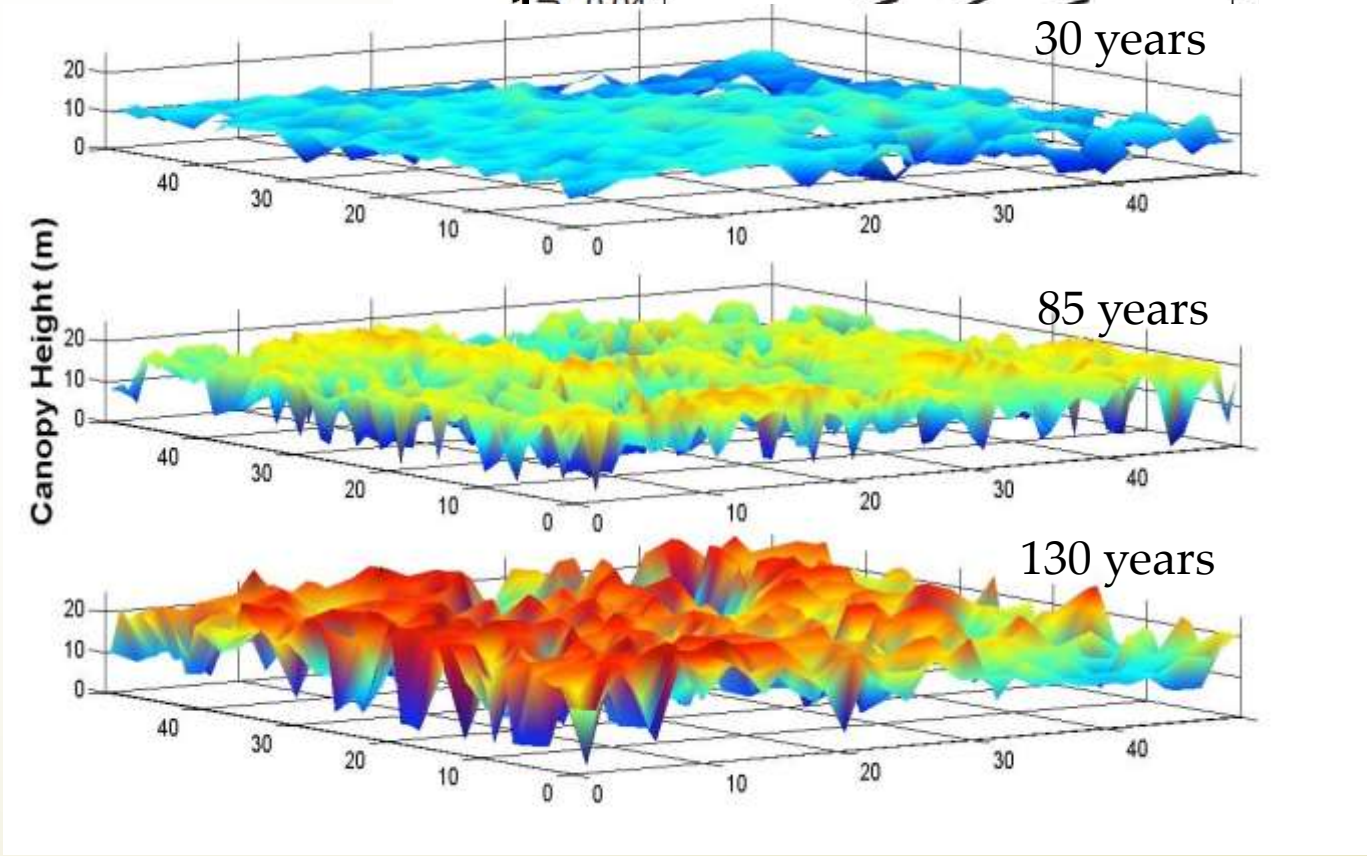
VAI: Vegetation Area Index

Background

- Complexity (i.e., Canopy rugosity) can be somewhat independent of LAI
- Drives resource use efficiency
- Varies strongly through stand development





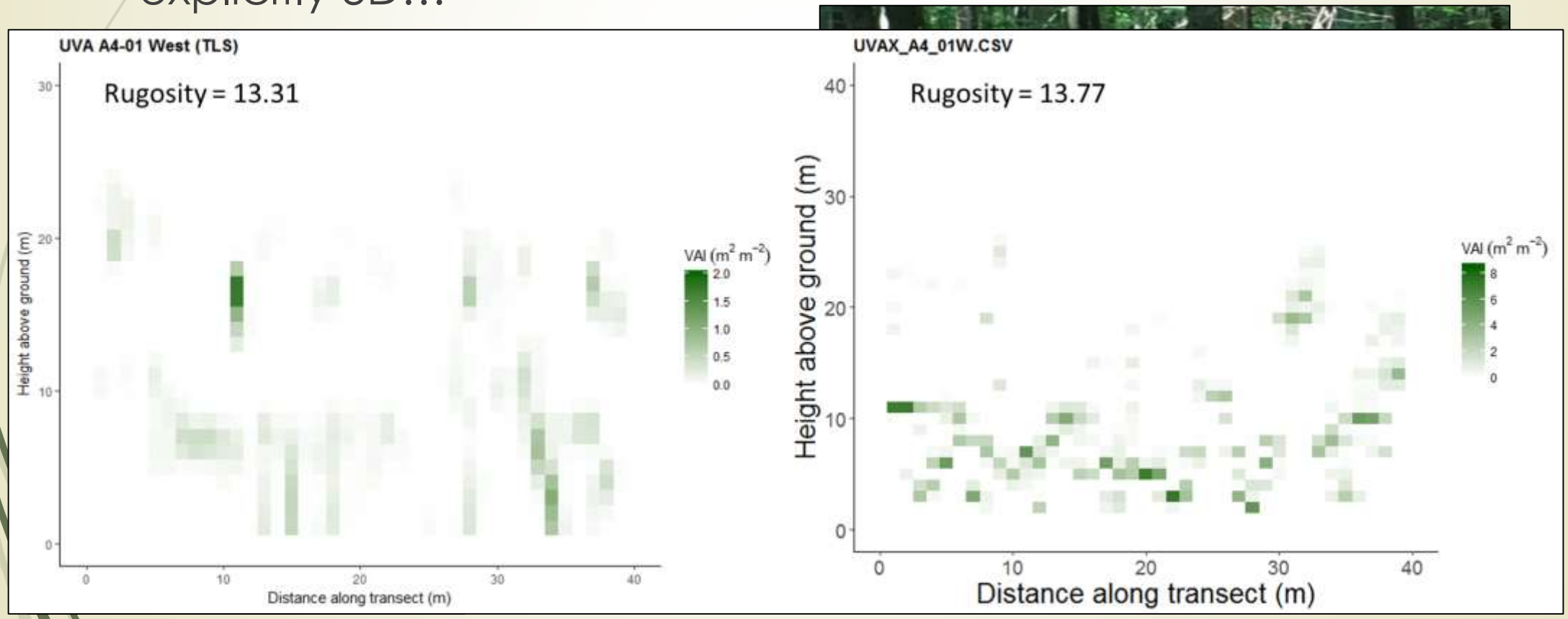


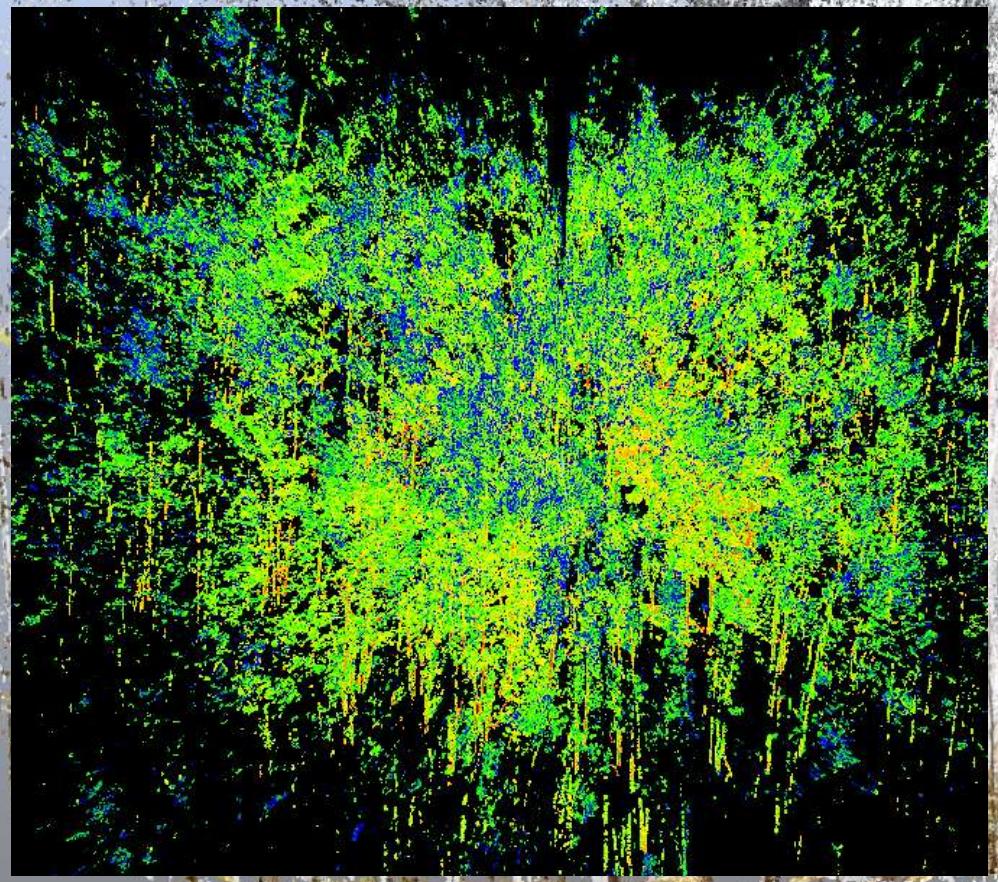
Outline

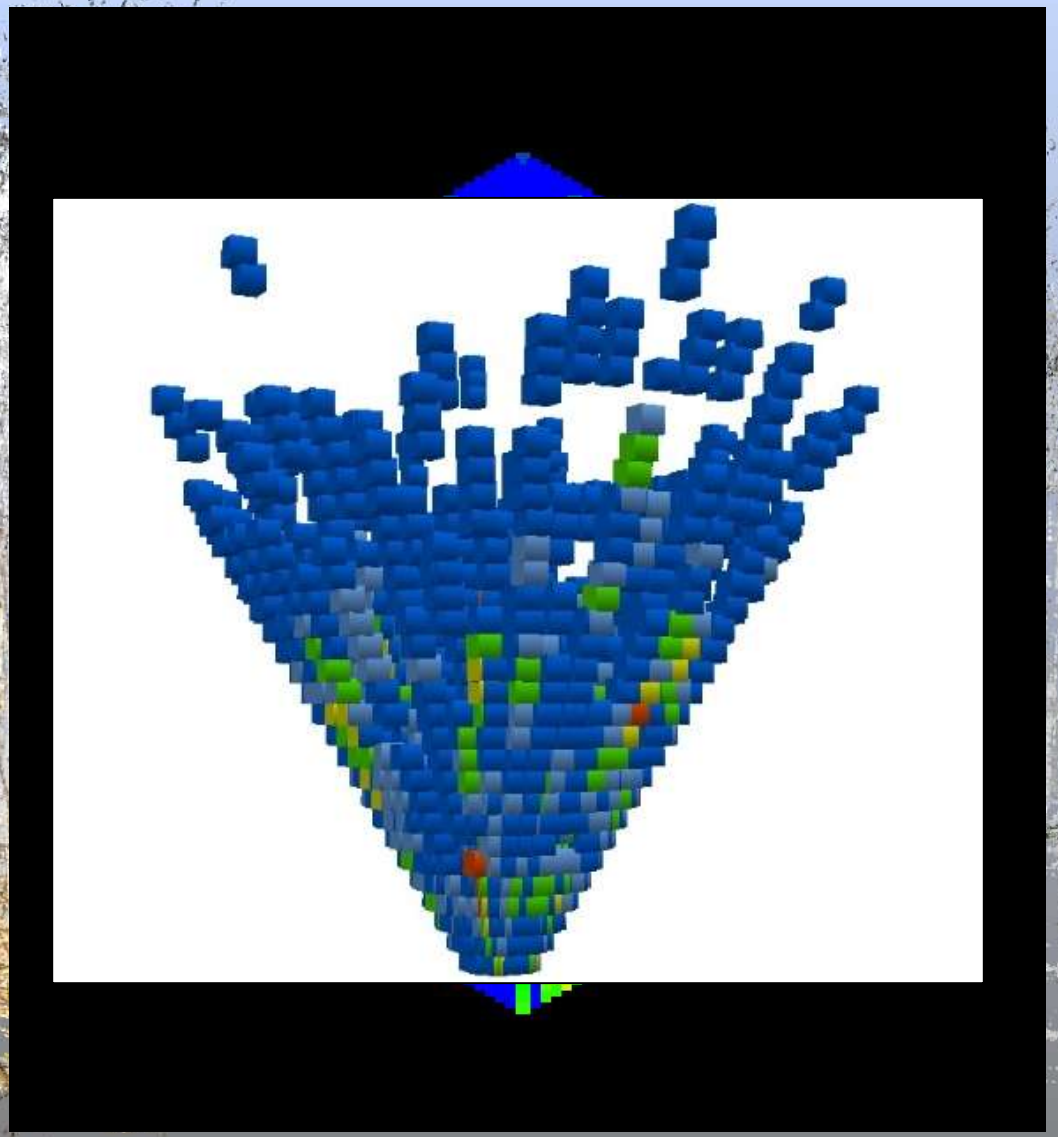
1. Alternative Methods?
2. New Structural Metrics?
3. Beyond Physical Structure?

1. Methods

- Comparison of PCL with TLS
- Orders of magnitude greater information density and explicitly 3D…

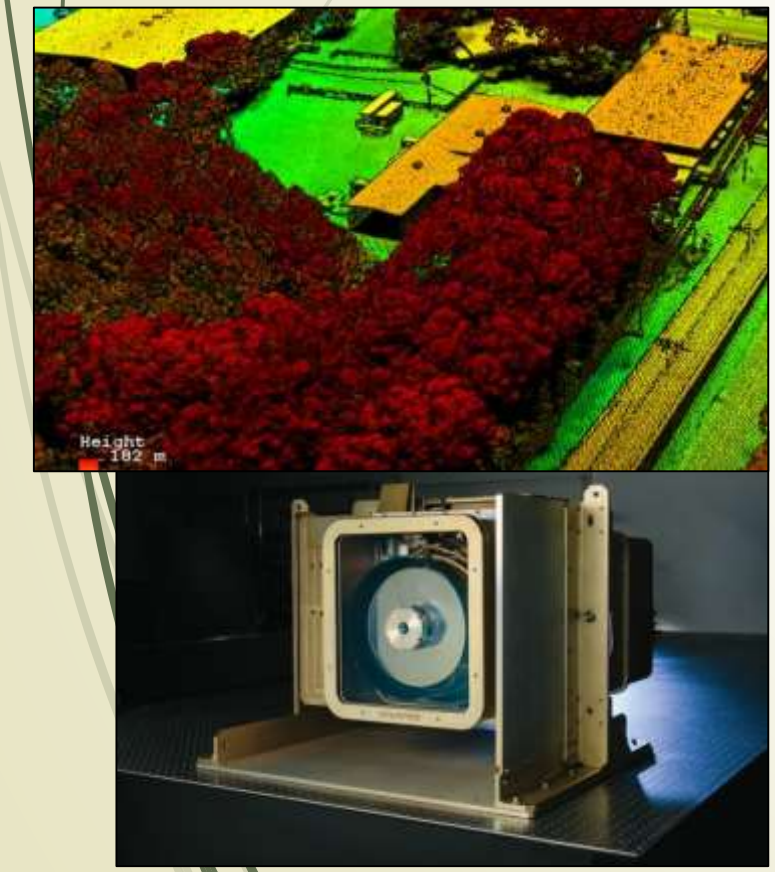






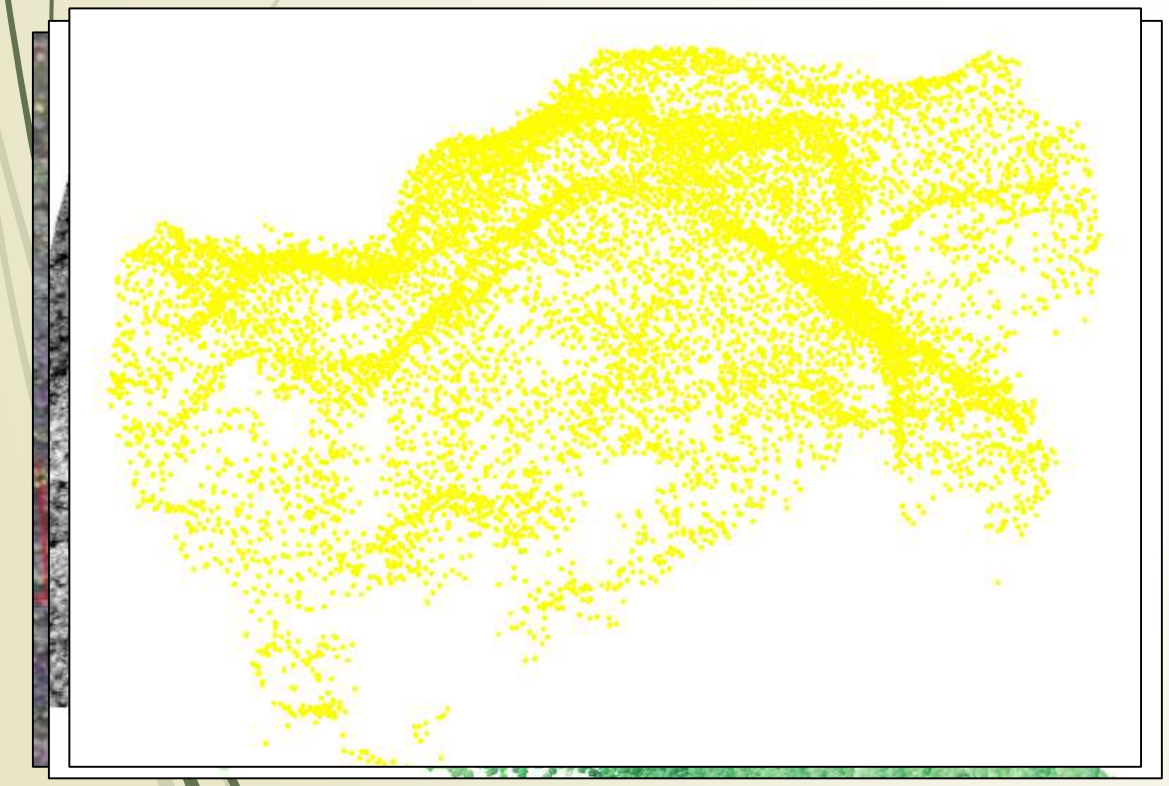
1. Methods

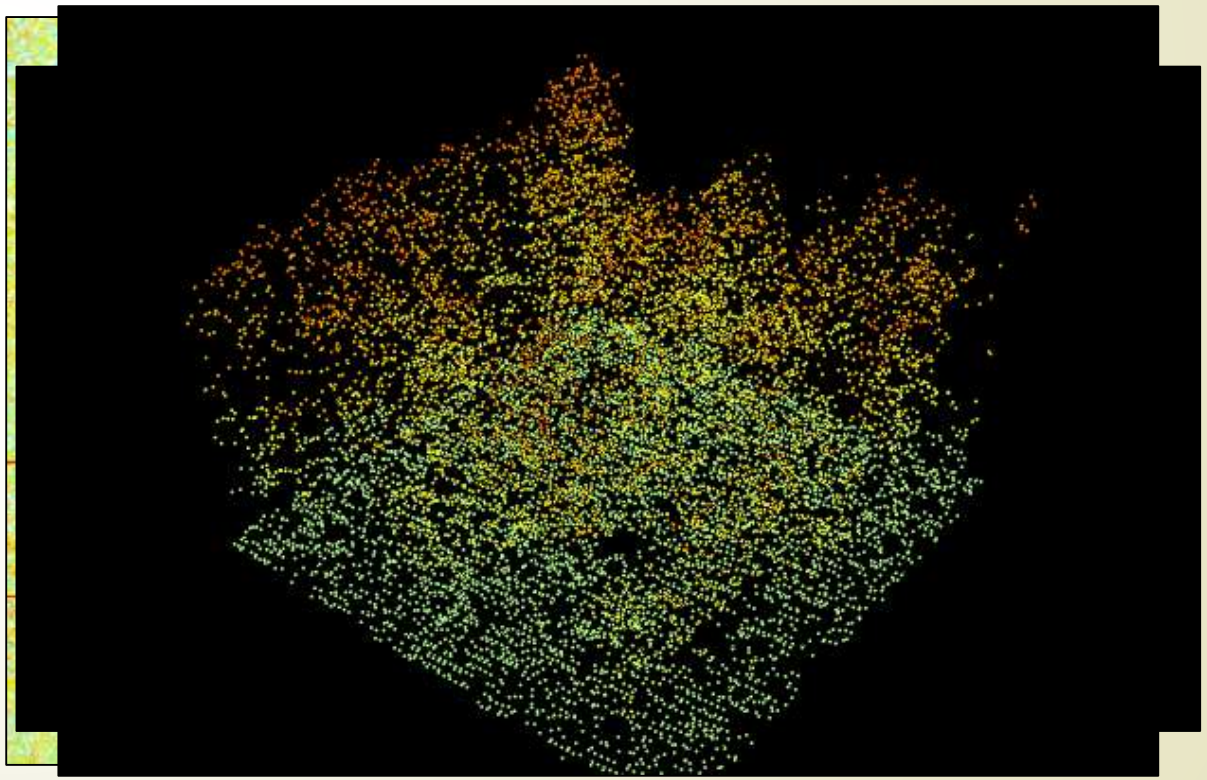
- Aerial remote sensing options
- Much greater spatial extent



1. Methods

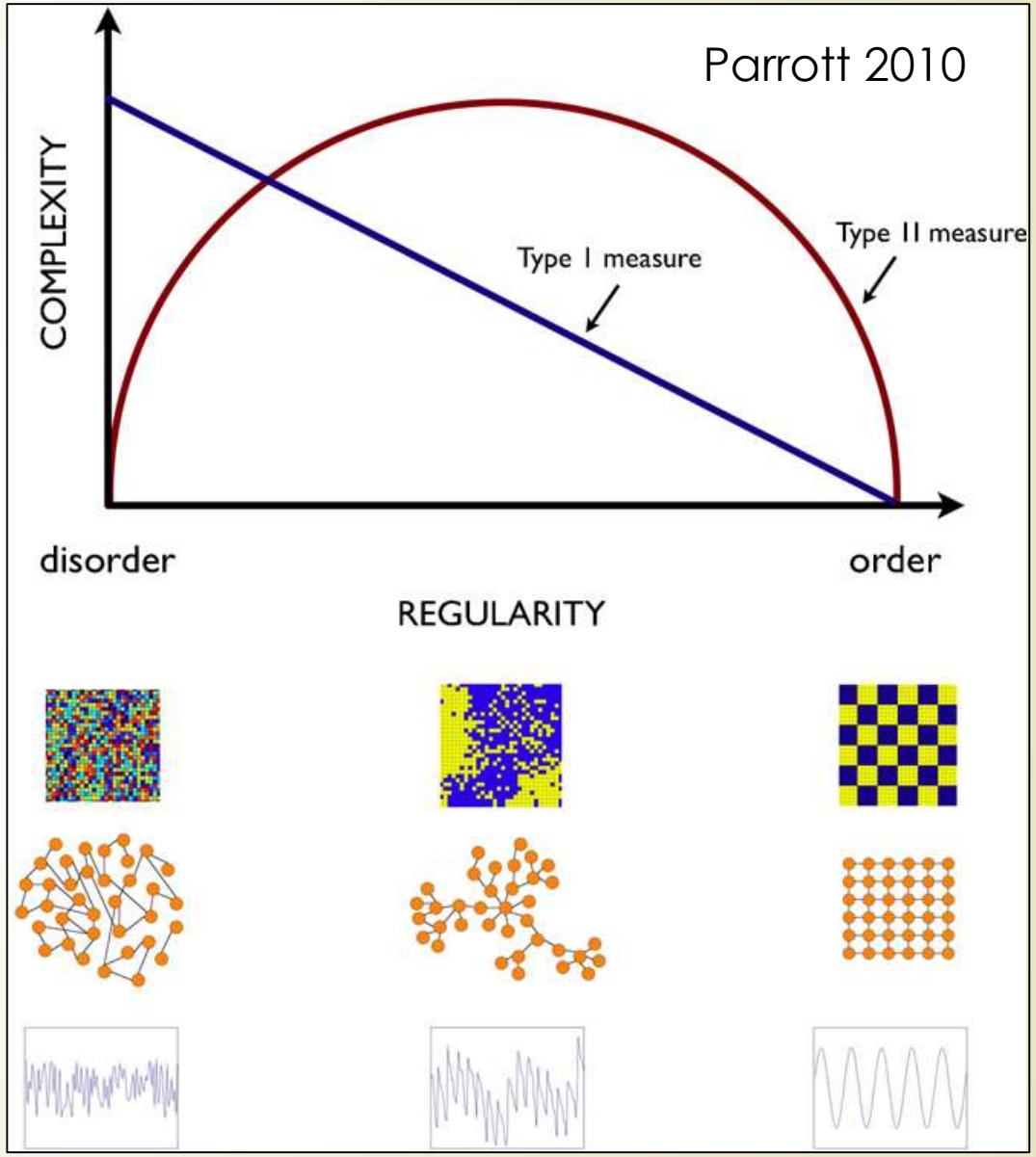
- Comparable data possible through common aerial remote sensing products?
- For example drone image point clouds – combined with leaf-off aerial lidar?





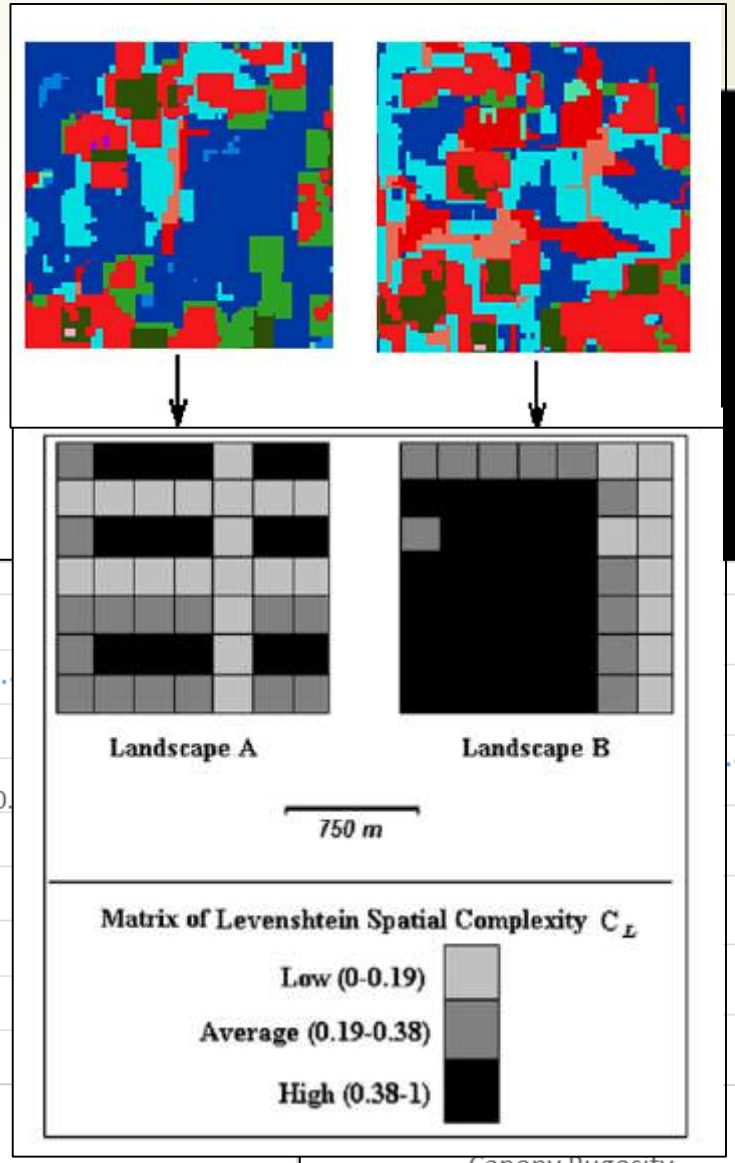
2. Metrics

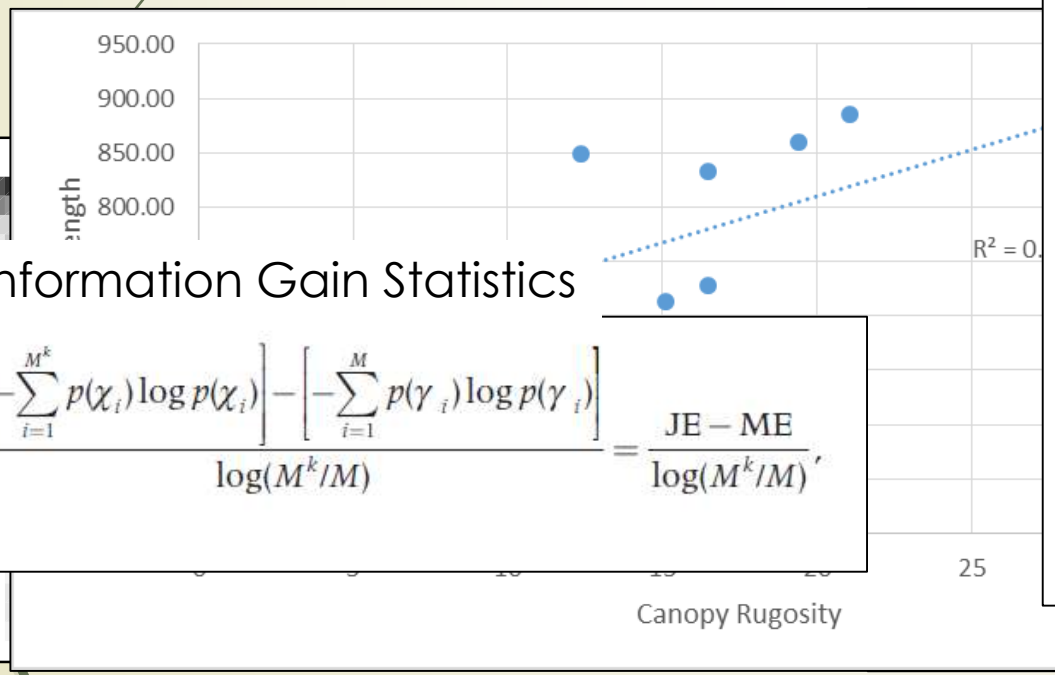
- How best to quantify canopy structural complexity?
- In 2D, 3D, 4D?
- Type 1 vs Type 2 complexity metrics
- Zonal analysis?
- Which equates best to complexity in arrangement of canopy elements that drive productivity?

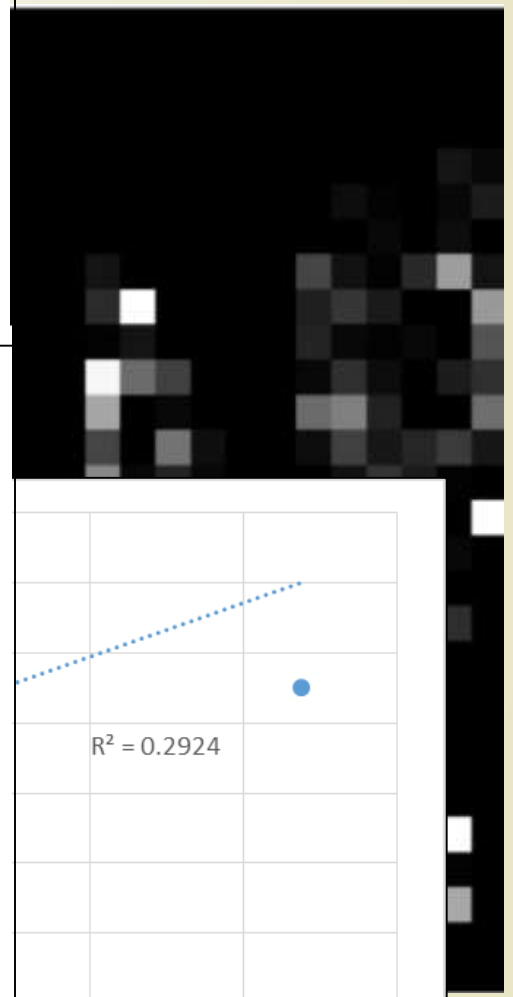


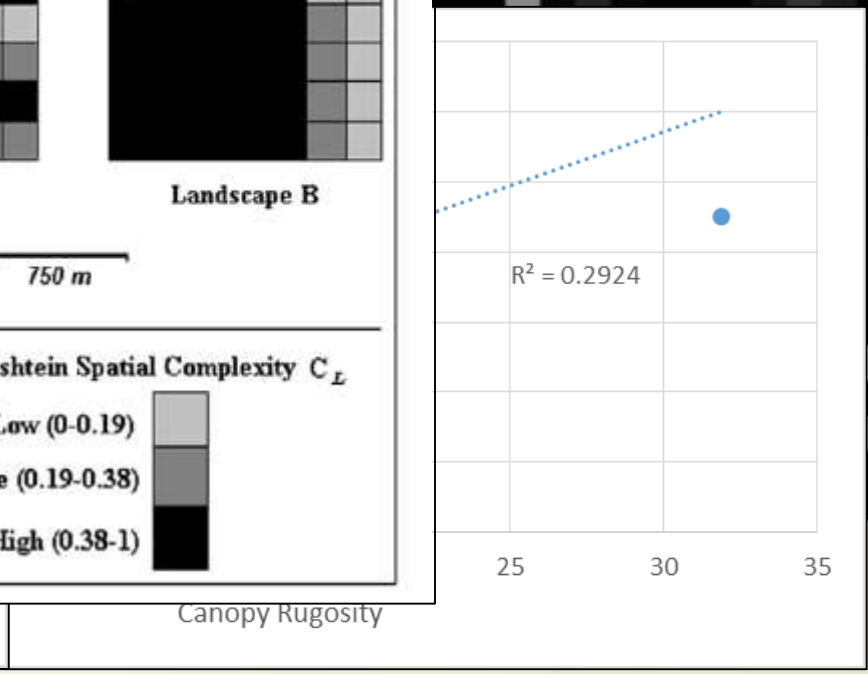
2. Metrics

- Landscape patch metrics – for example, contagion, fractal dimension, clumping index
- Shape complexity metrics – boundary/edge complexity







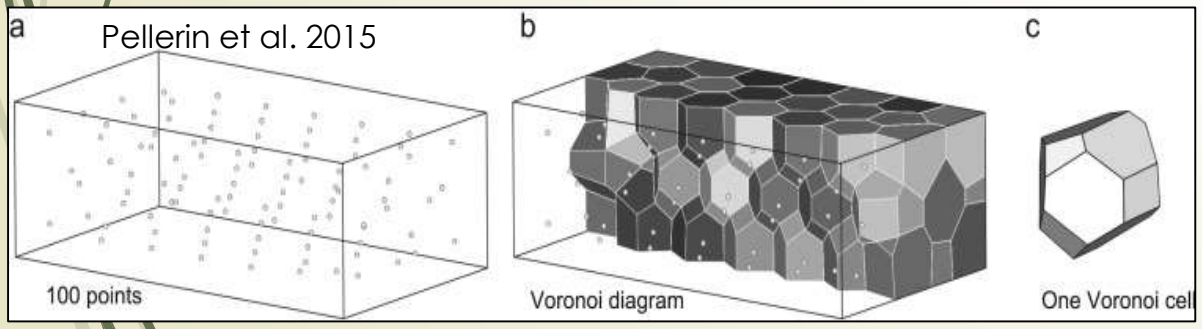


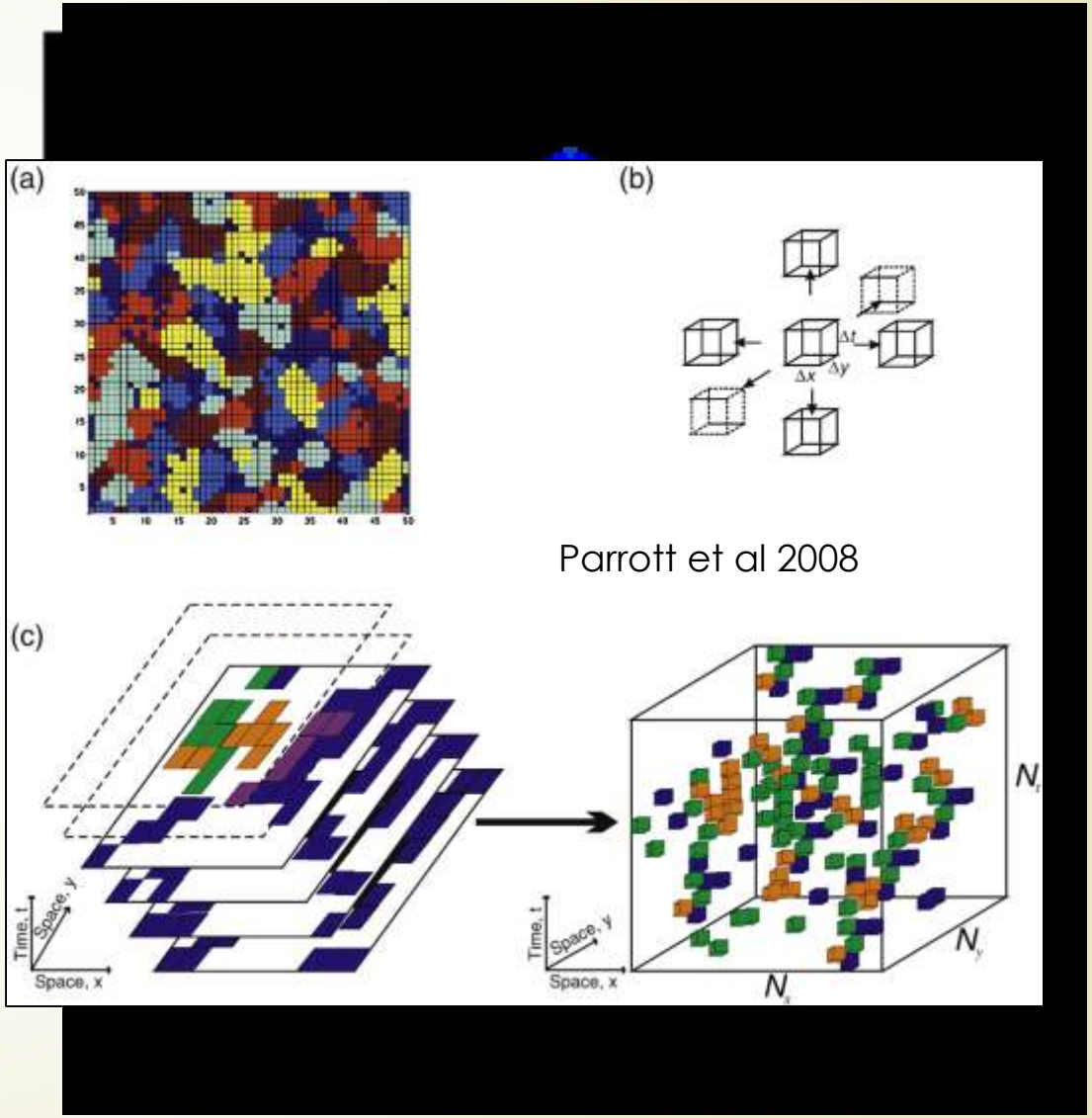
Information Gain Statistics

$$MIG = \frac{\left[-\sum_{i=1}^{M^k} p(\chi_i)\log p(\chi_i)\right] - \left[-\sum_{i=1}^{M} p(\gamma_i)\log p(\gamma_i)\right]}{\log(M^k/M)} = \frac{JE - ME}{\log(M^k/M)},$$

2. Metrics

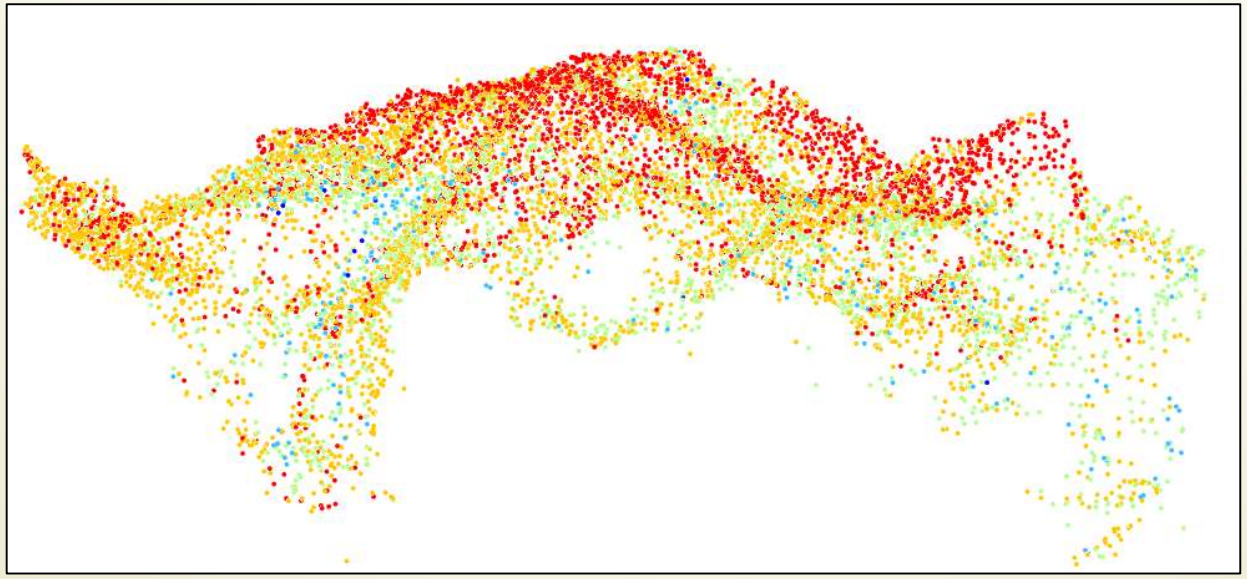
- New methods could require new techniques?
- How to extend to 3D data?
- Analysis of image stacks – "Blob analysis" of voxels – Parrott
- Neural network analysis techniques, geology techniques





3. Beyond physical structure

- Quantify complexity of species, function/trait arrangement
- For example: NDVI rugosity? N rugosity?
- Adds an additional dimension to analysis – non binary –> as multiple patch types
- Continuous data analysis in 3d – e.g. 3D variograms



Questions?

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