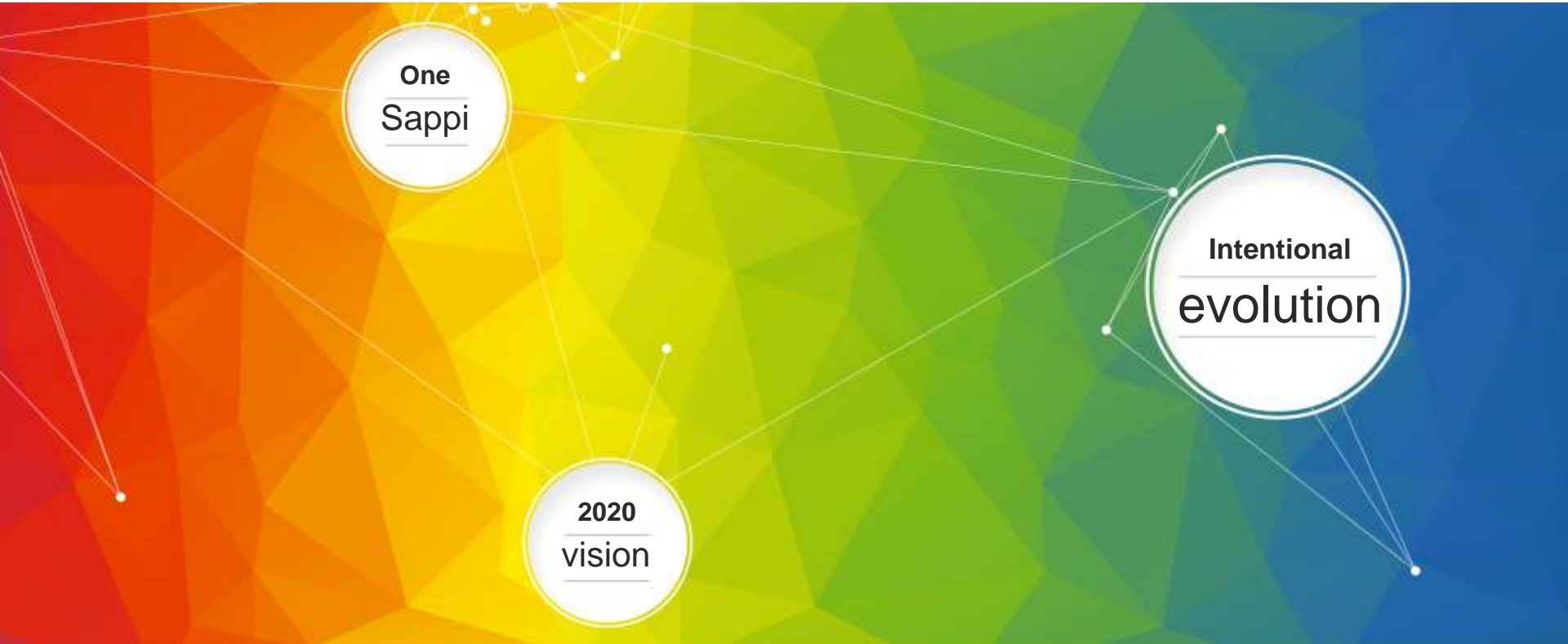


# Updating Sappi growing stock information at stand level using aerial LiDAR data

Precision Forestry Symposium 2017



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Mensurationist

Research, Planning and Nurseries

**sappi**  
Inspired by life

1. Stand level: Sampling (3%)
  - a) Traditional technology
  - b) Non-spatial
  
2. Stand level: Full census – Transition
  - a) Contemporary technology, traditional concepts
  - b) Semi spatial
  
3. Sub stand level: Full census
  - a) Contemporary technology, contemporary and traditional concepts
  - b) Fully spatial

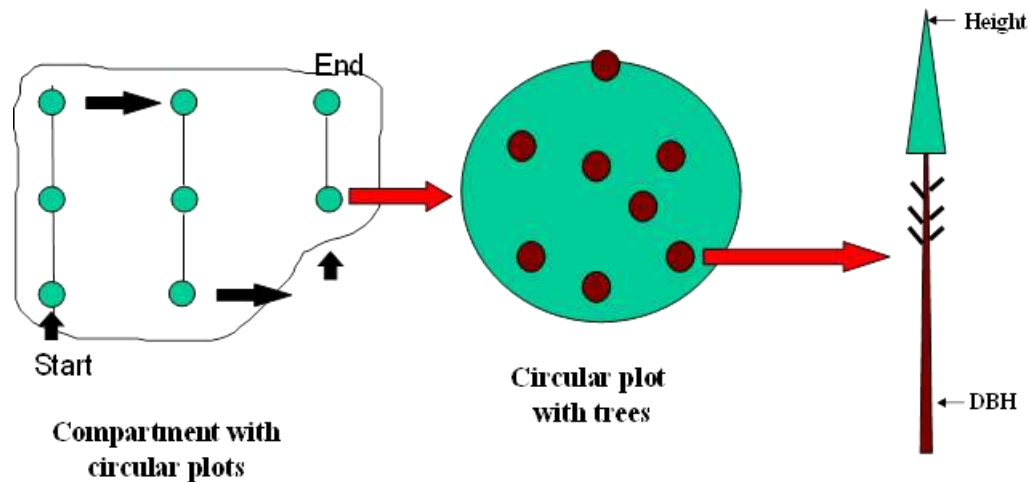
# Ground-based enumeration

Traditional forest measurement



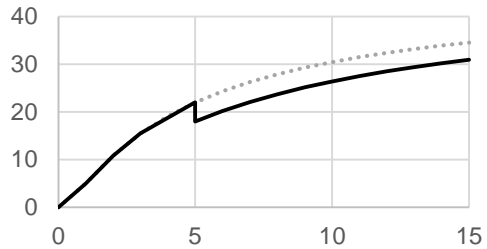
## Stand level: Sampling (3%)

- a) Traditional technology
- b) Non-spatial



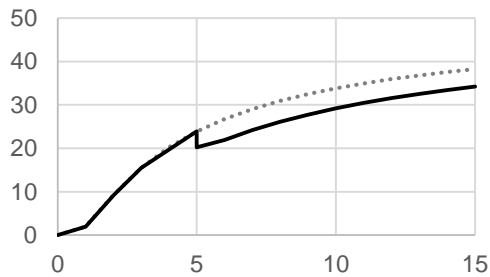
# Empirical growth modelling

### Height/SI

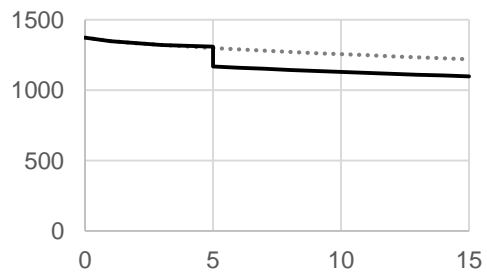


### DBH

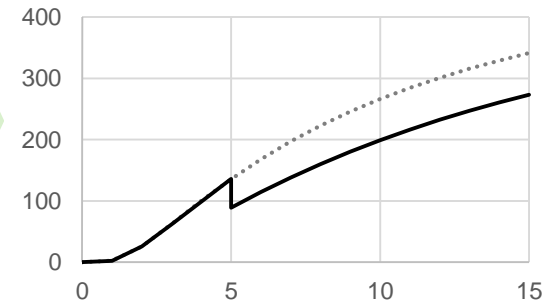
### BA



### TPH

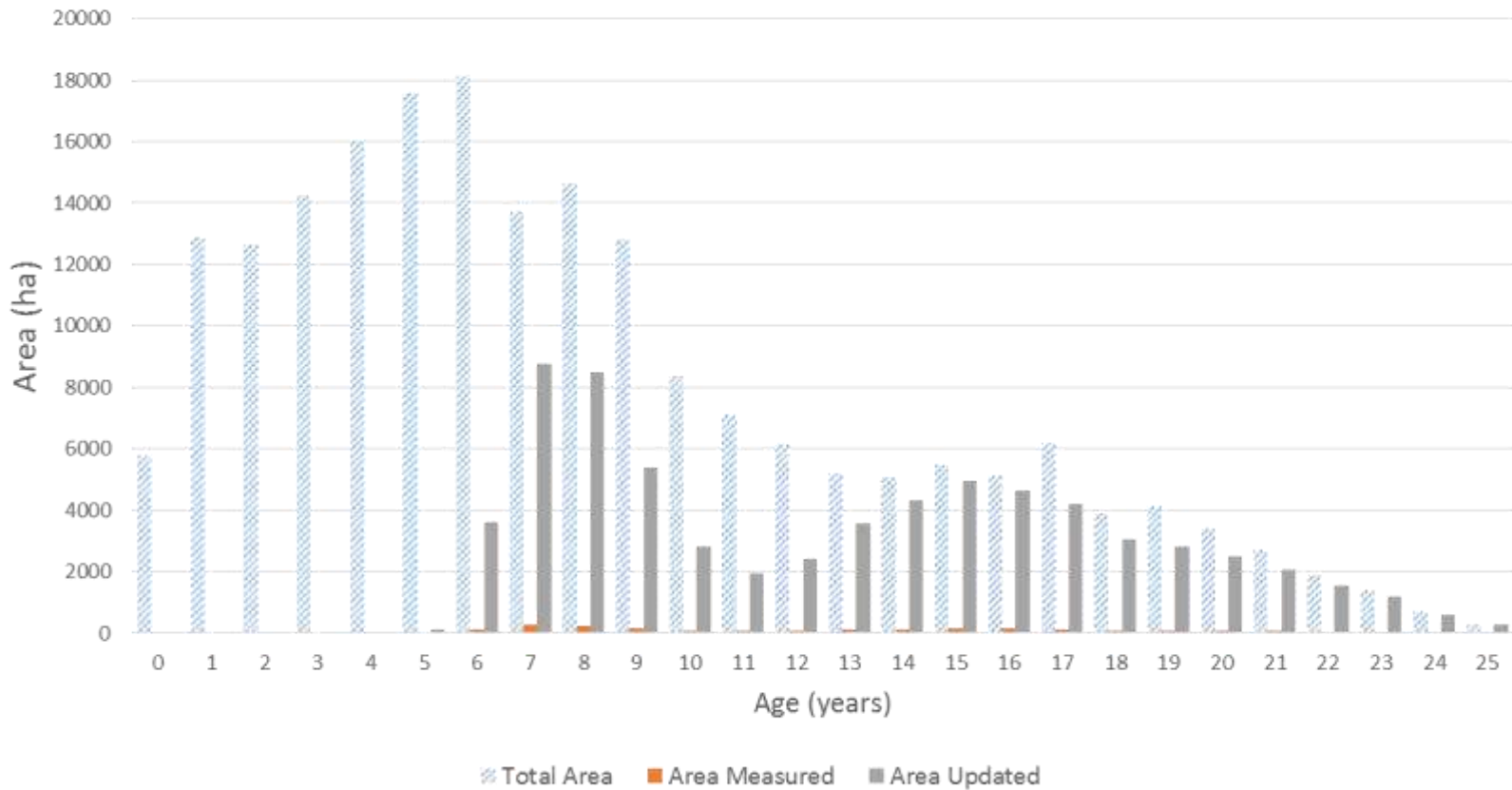


### Utilizable Tons



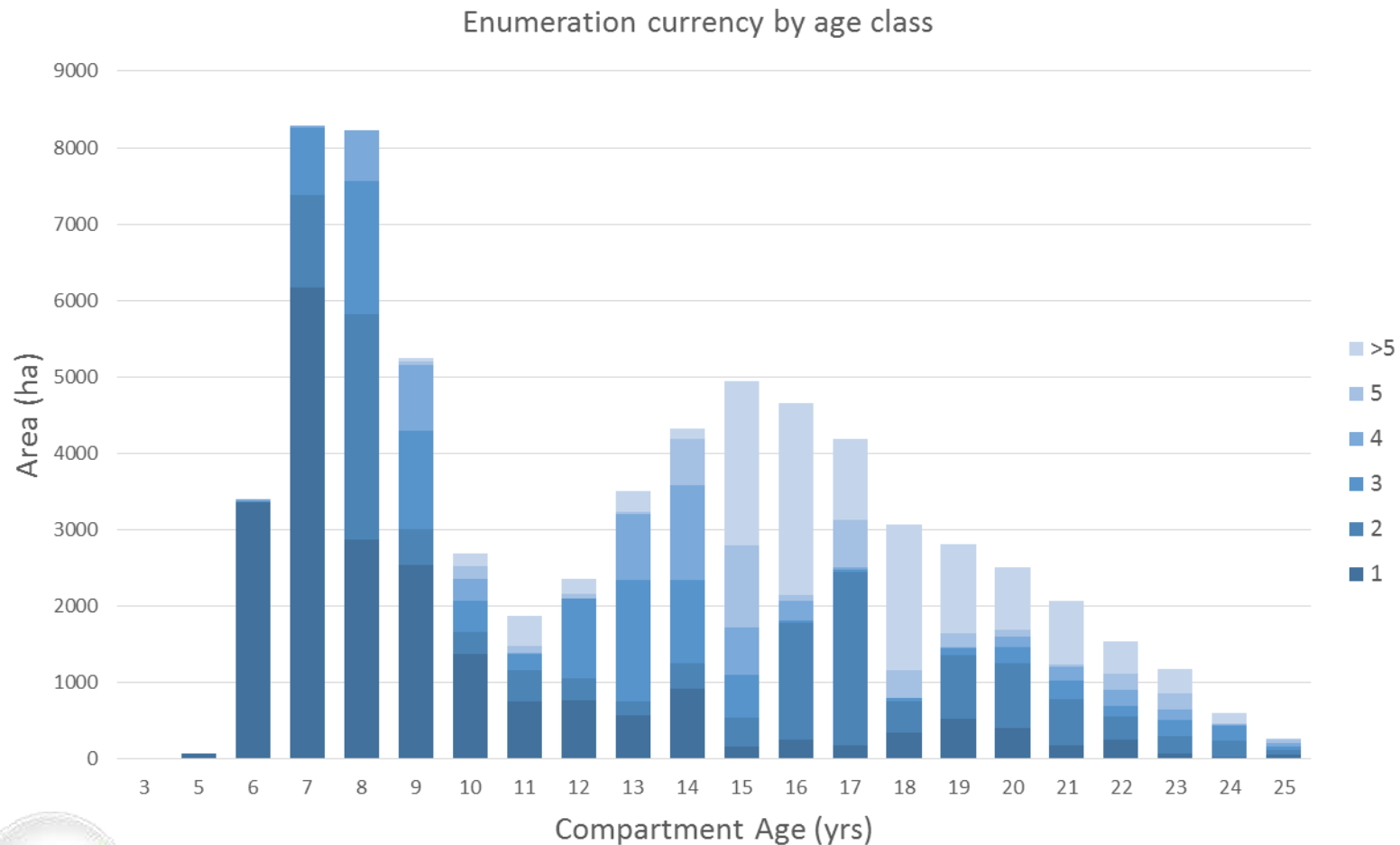
# Stand level: Sampling

Sappi area measured and updated by enumeration sampling



# Stand level: Enumeration sampling

## Age of enumeration data



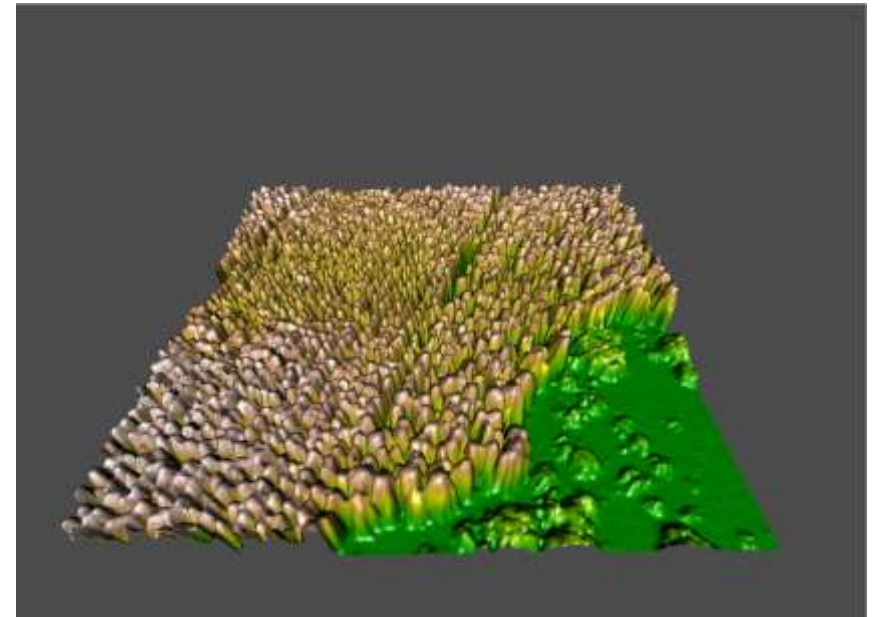
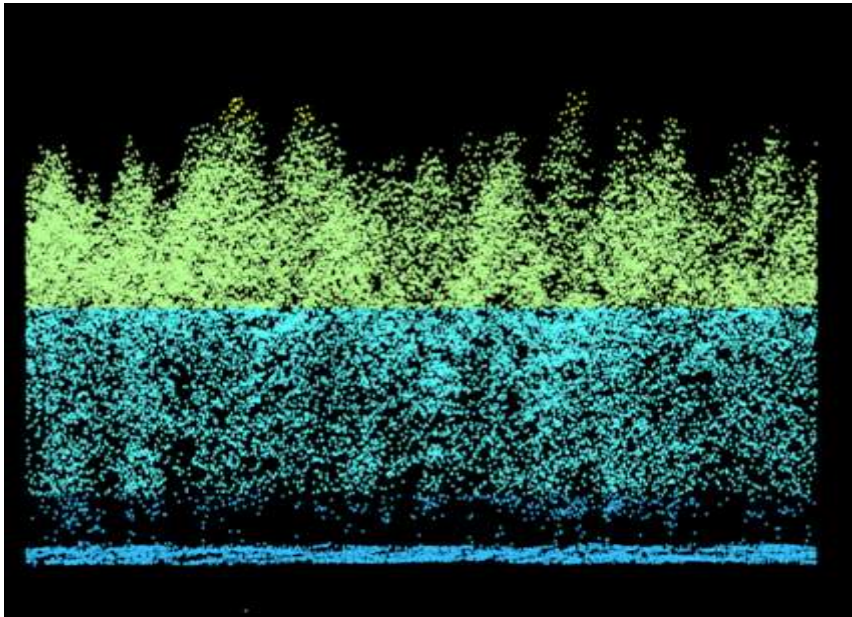
# Stand level LiDAR measurement





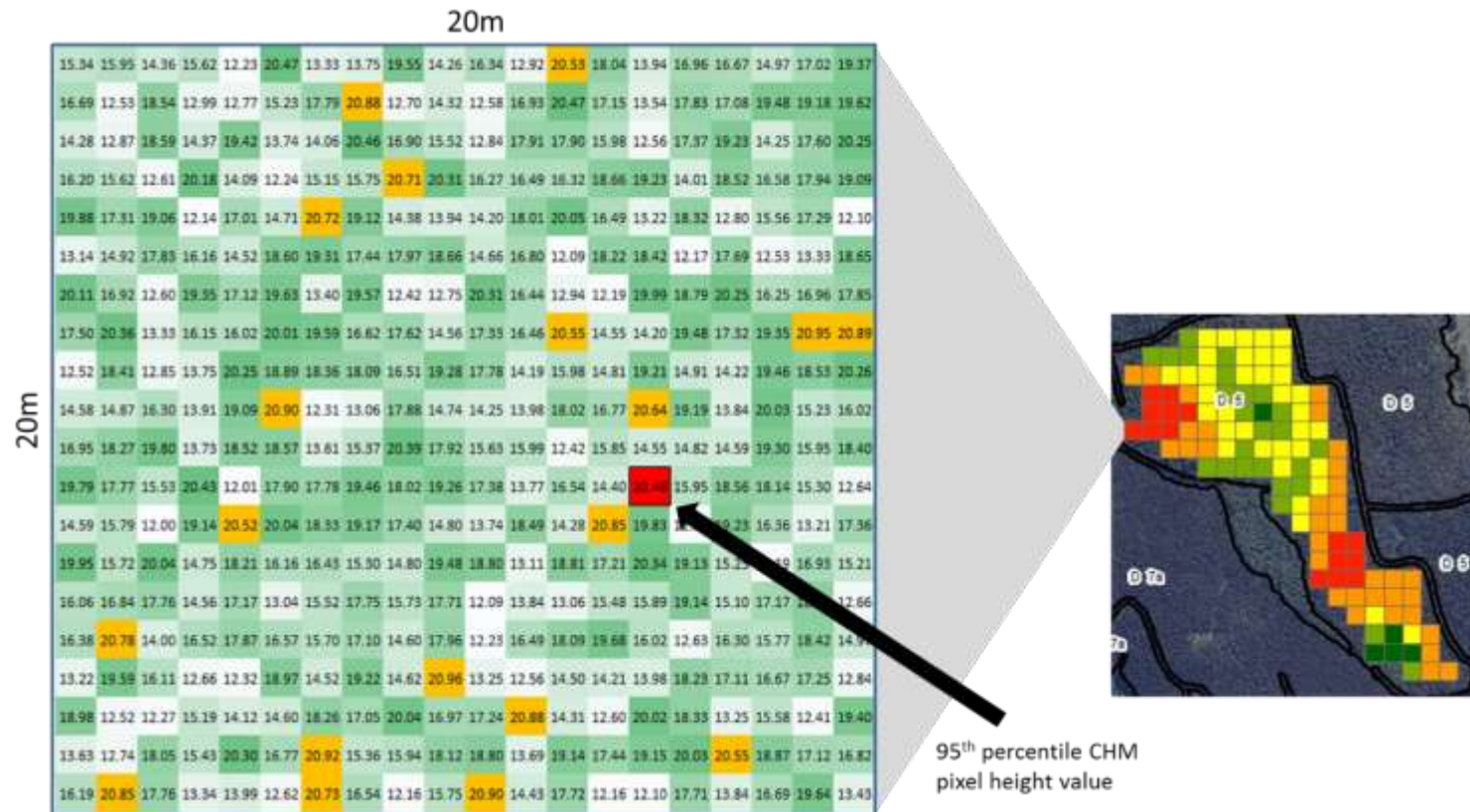
## Stand level: Full census – **Transition**

- a) Contemporary technology, traditional concepts
- b) Semi spatial



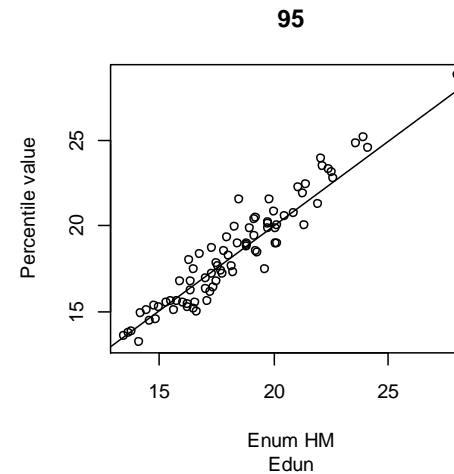
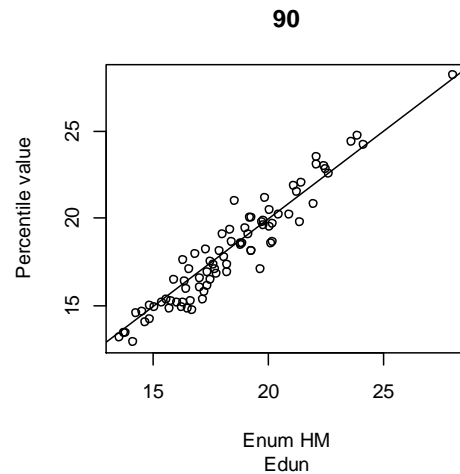
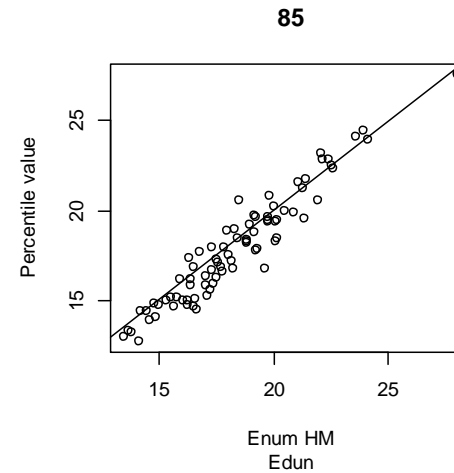
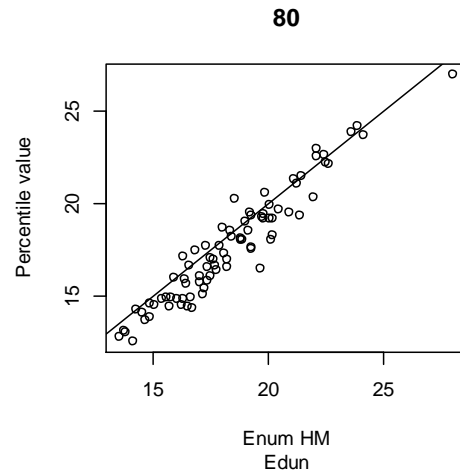
# Stand level LiDAR measurement

## Height percentile extraction



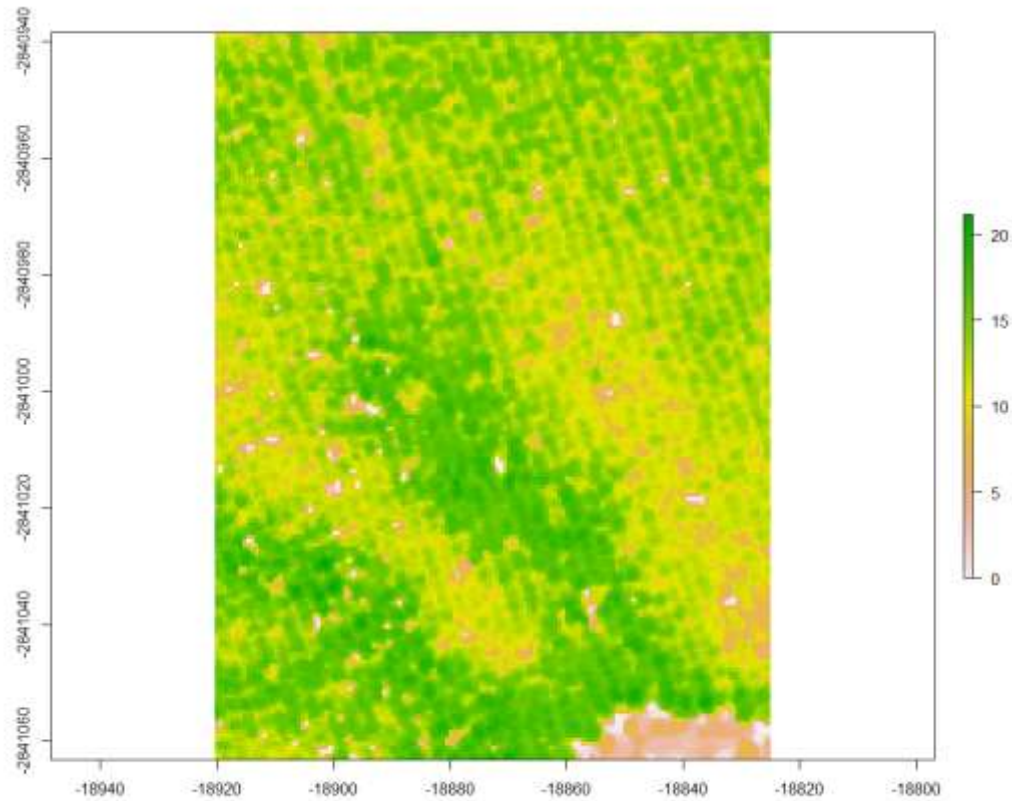
# Percentile selection

Example percentile fitting *E.dunnii*



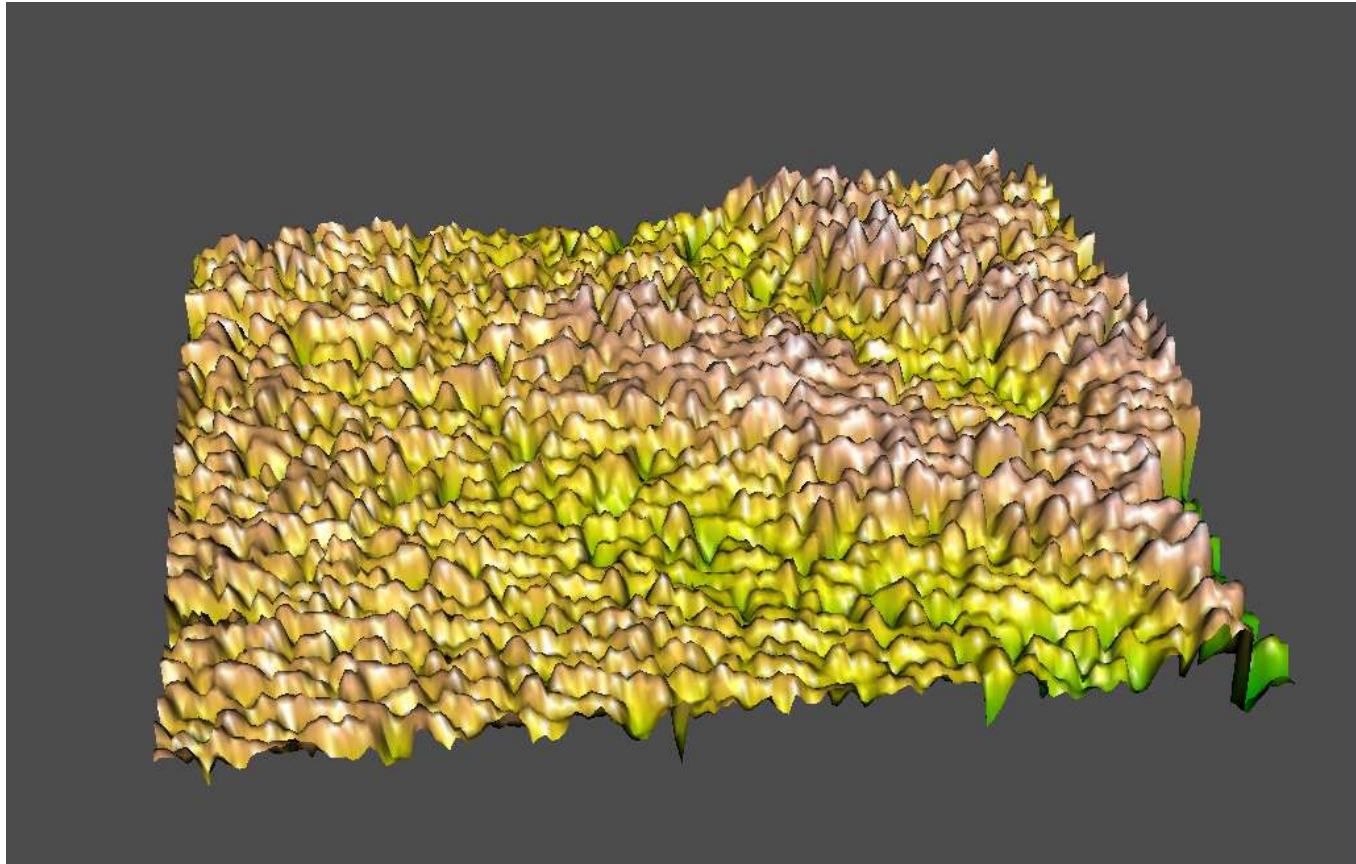
# Stand level LiDAR measurement

Canopy height model



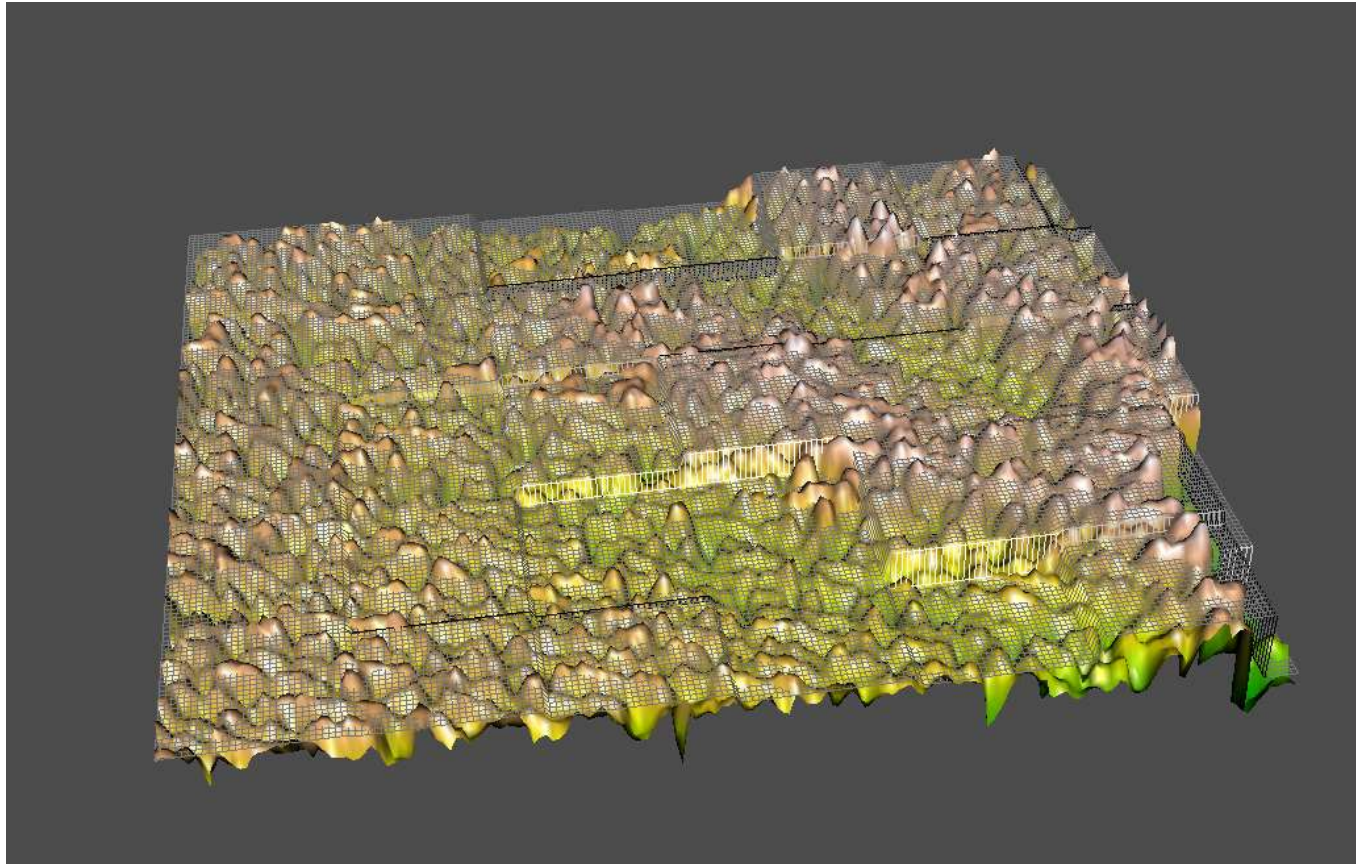
# Stand level LiDAR measurement

Canopy height model



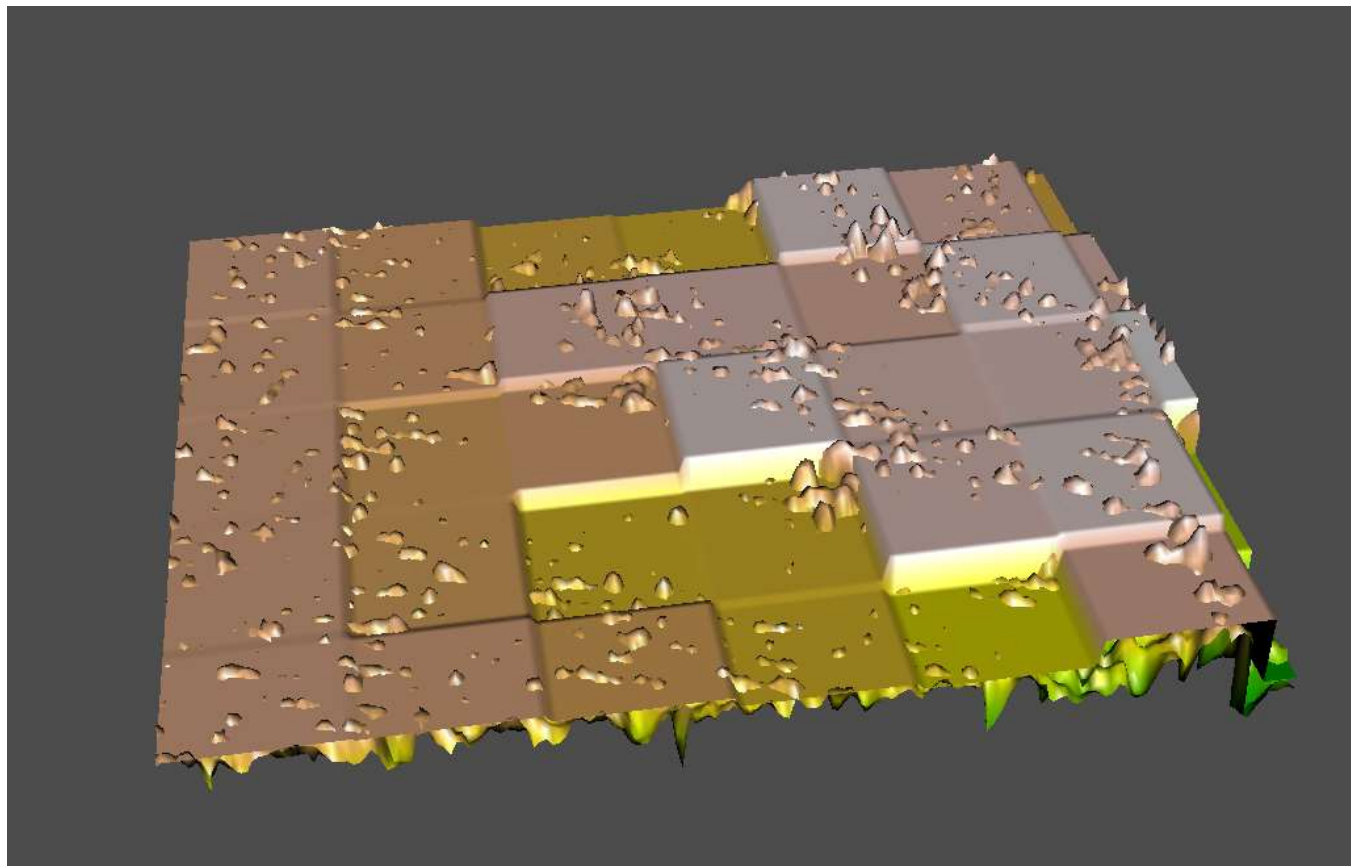
# Stand level LiDAR measurement

Pixel percentile value



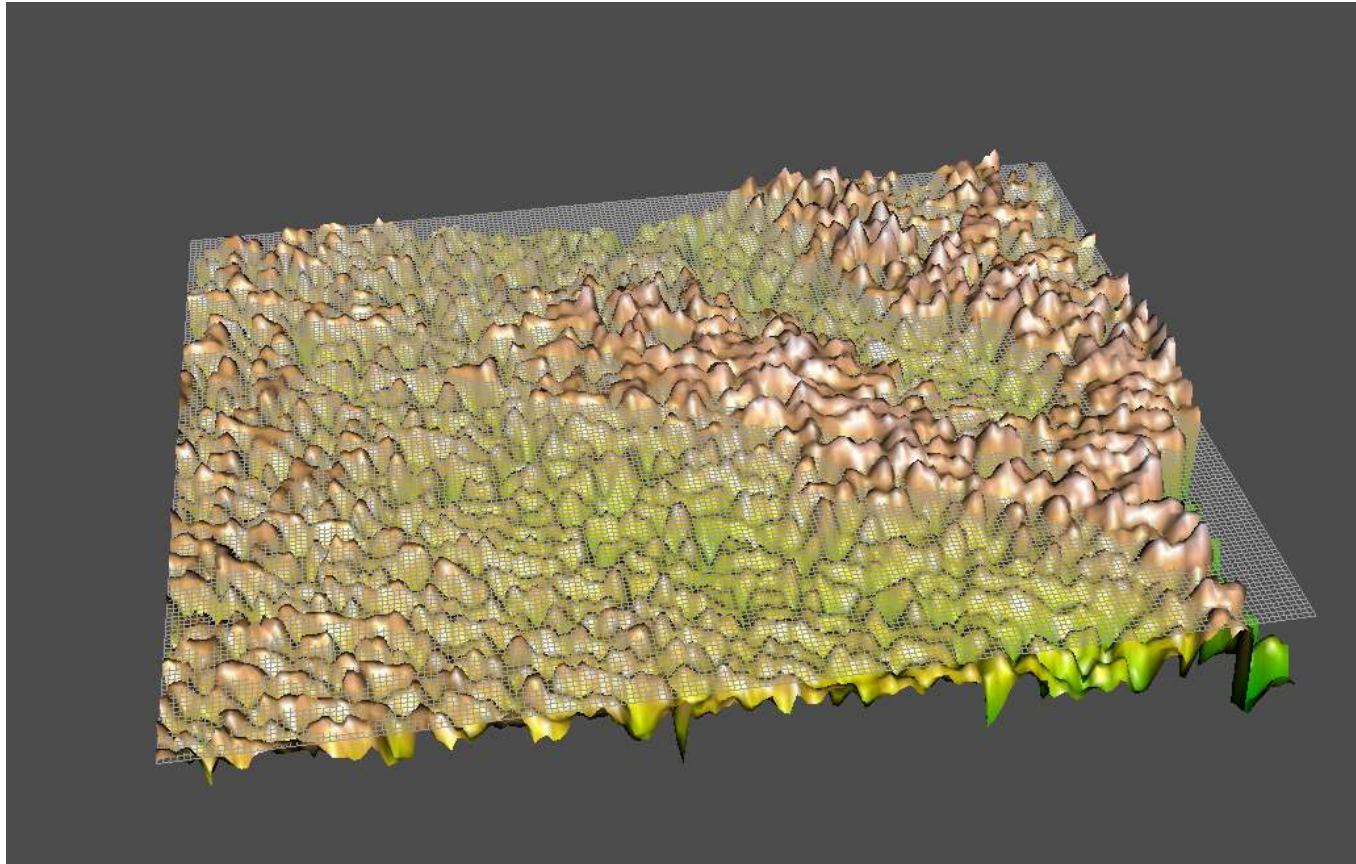
# Stand level LiDAR measurement

Pixel percentile value



# Stand level LiDAR measurement

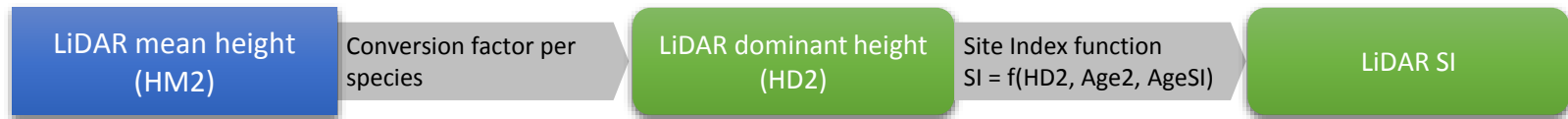
Mean stand height





## Update classes:

1. Young (Eucalyptus < 3, pine < 7 years)  
Site Index update from updated SI map
2. Previously enumerated  
Update of height from LiDAR
3. Older (Eucalyptus > 3, pine > 7 years), non-enumerated compartments  
Update of Site Index from LiDAR



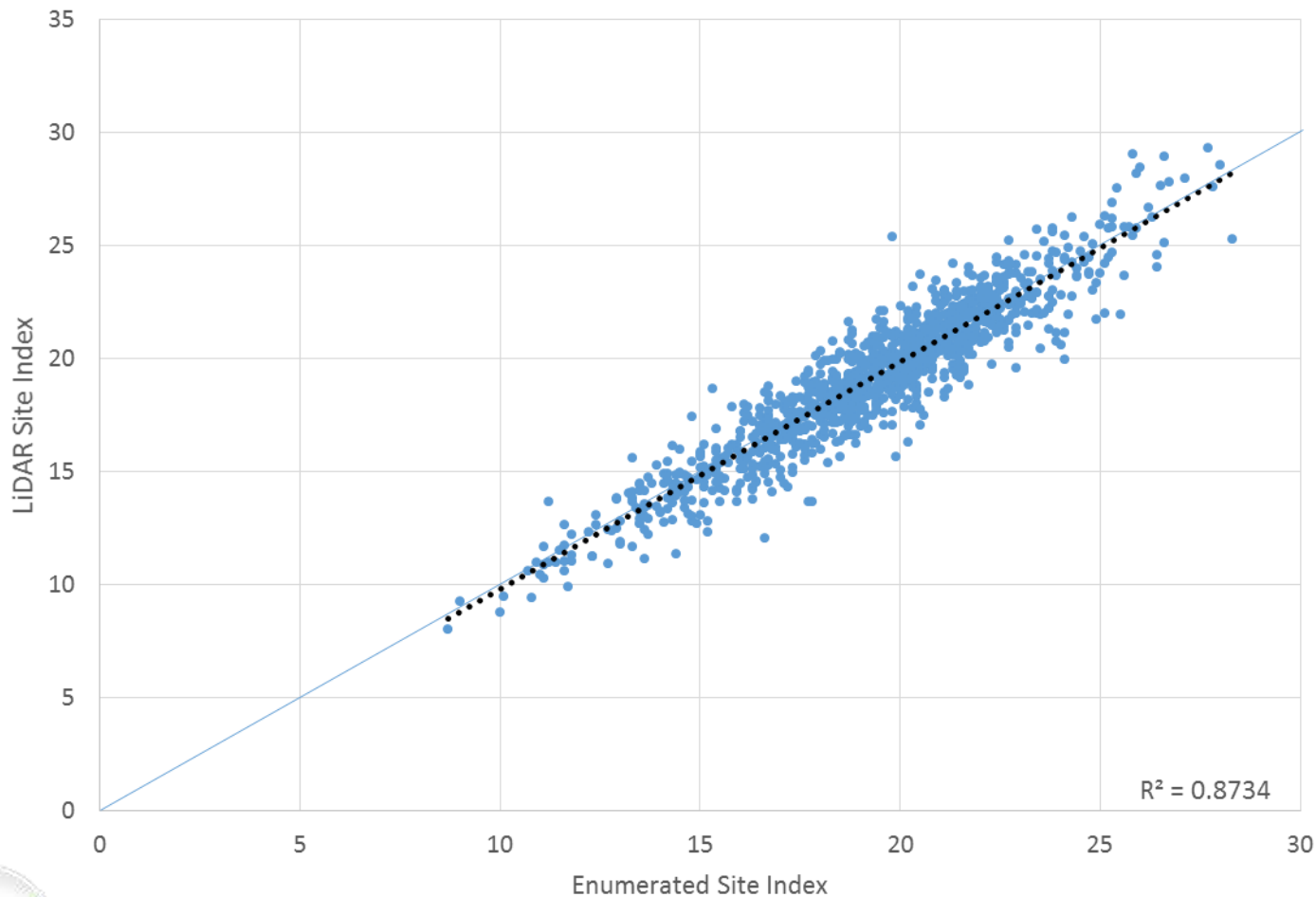
# Example of SI differences before and after update

Relative change in SI. Red shows decrease, green shows increase.

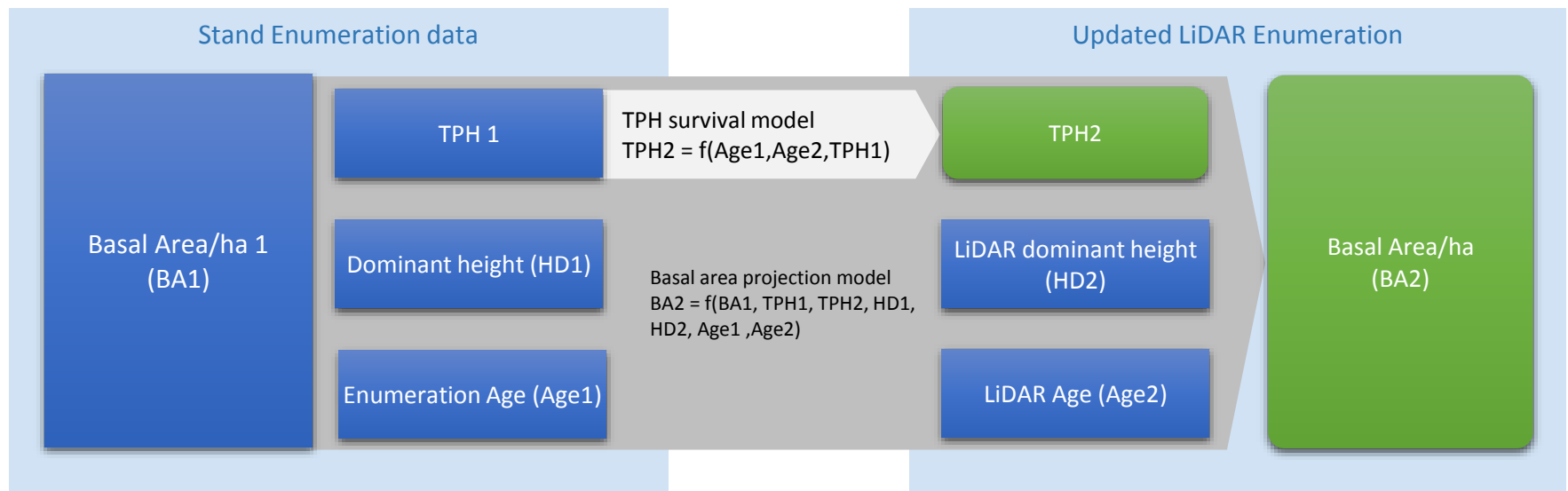


# Stand level SI comparison

All species, enumeration <5 years before LIDAR



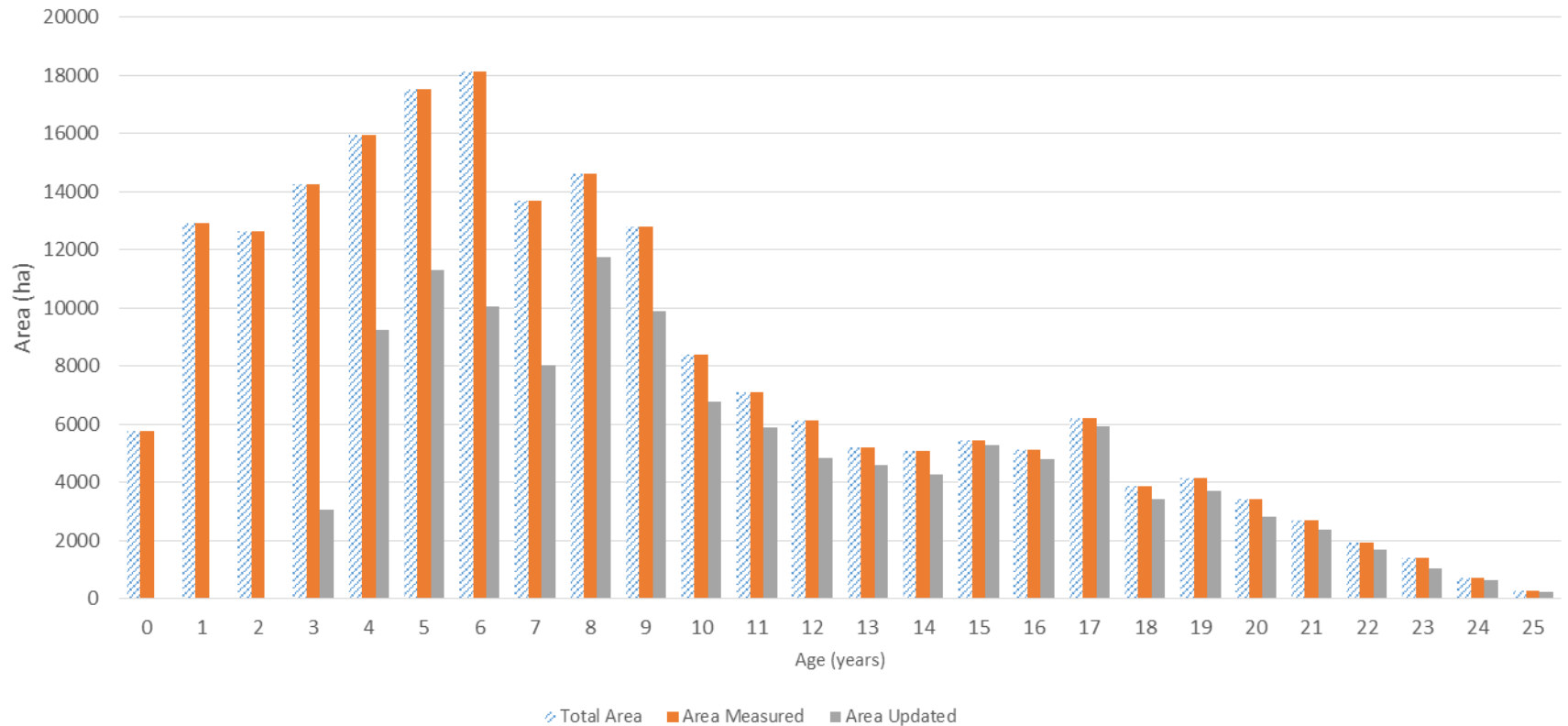
# Basal area update (Previously enumerated)



# Stand level LiDAR coverage

Data measured and updated in 2016

Area measured and updated by LiDAR census (2016)



# Sub stand level LiDAR measurement

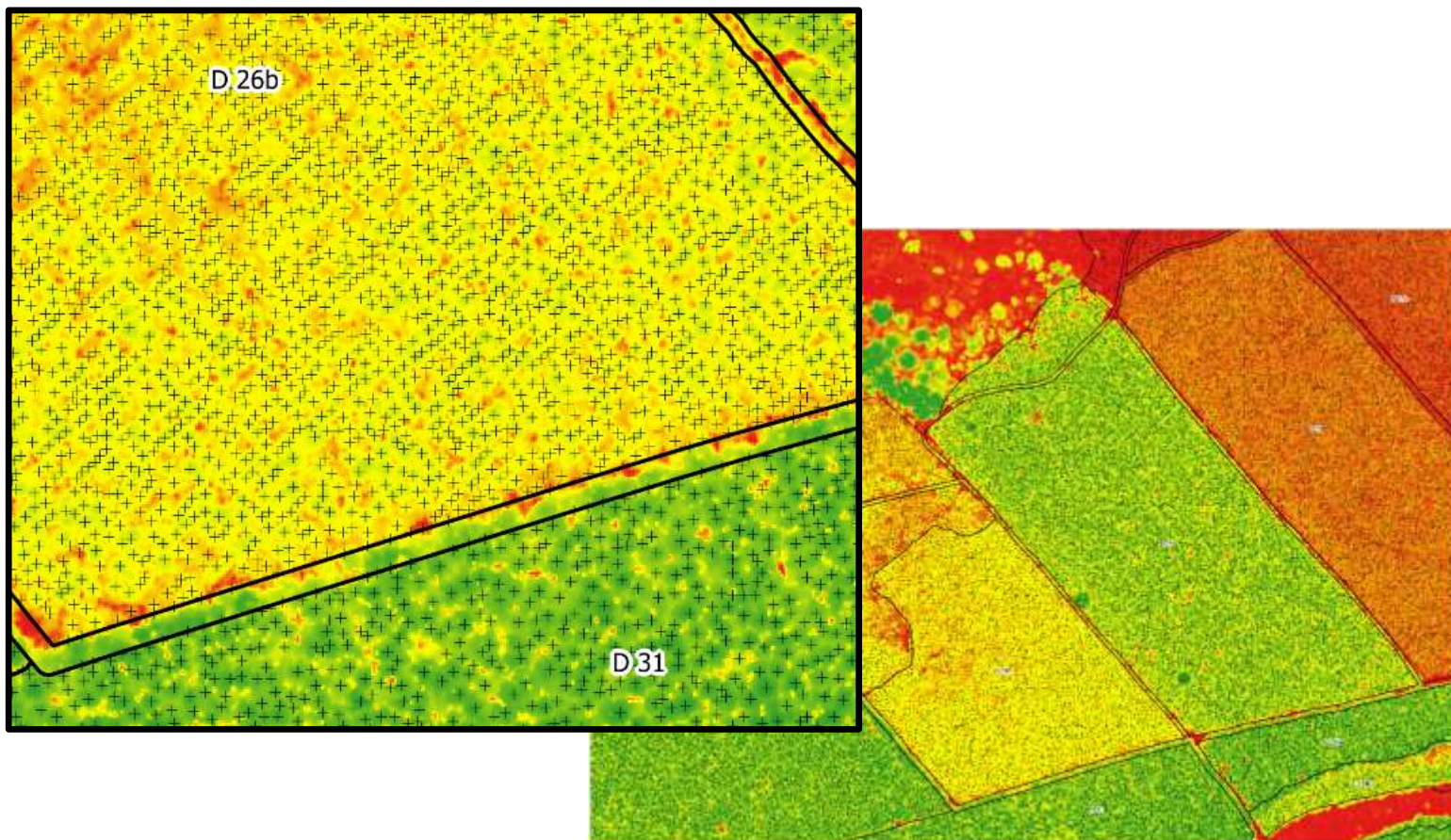


## Sub stand level: Full census

- a) Contemporary technology, contemporary and traditional concepts
- b) Fully spatial



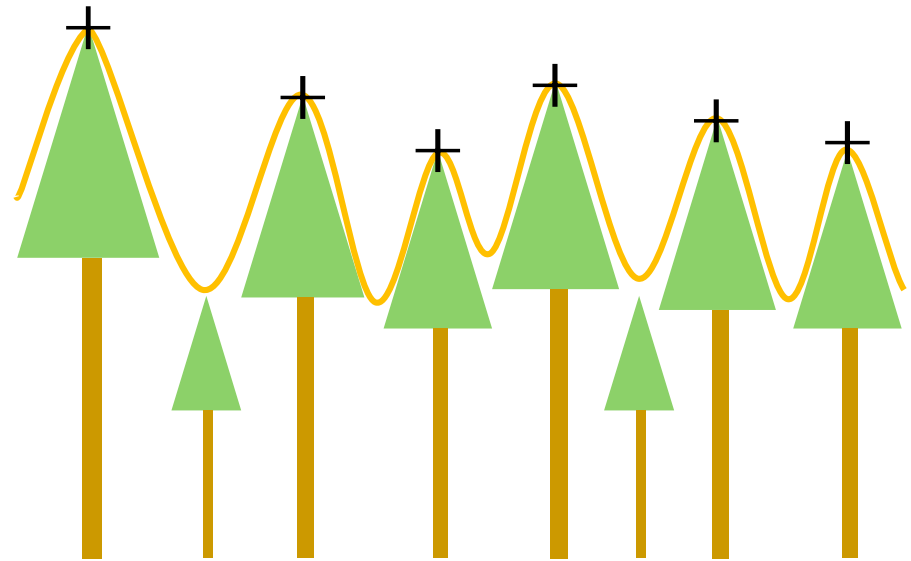
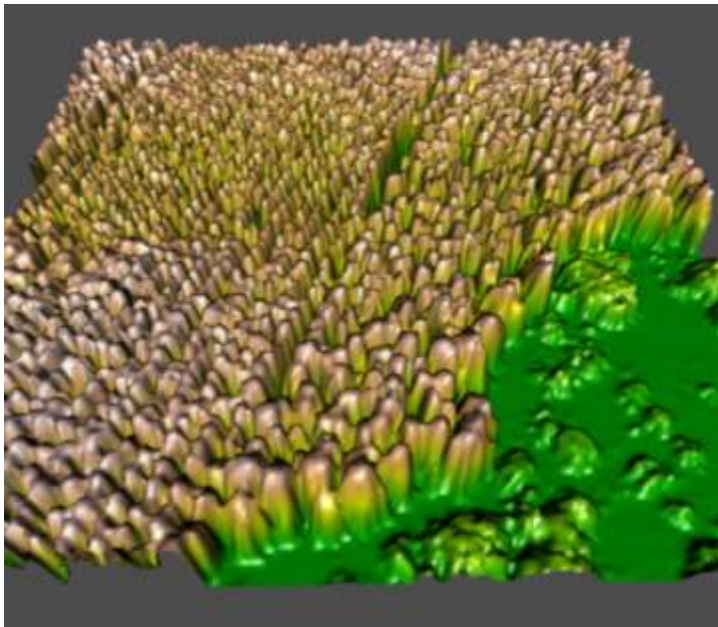
# LiDAR TPH





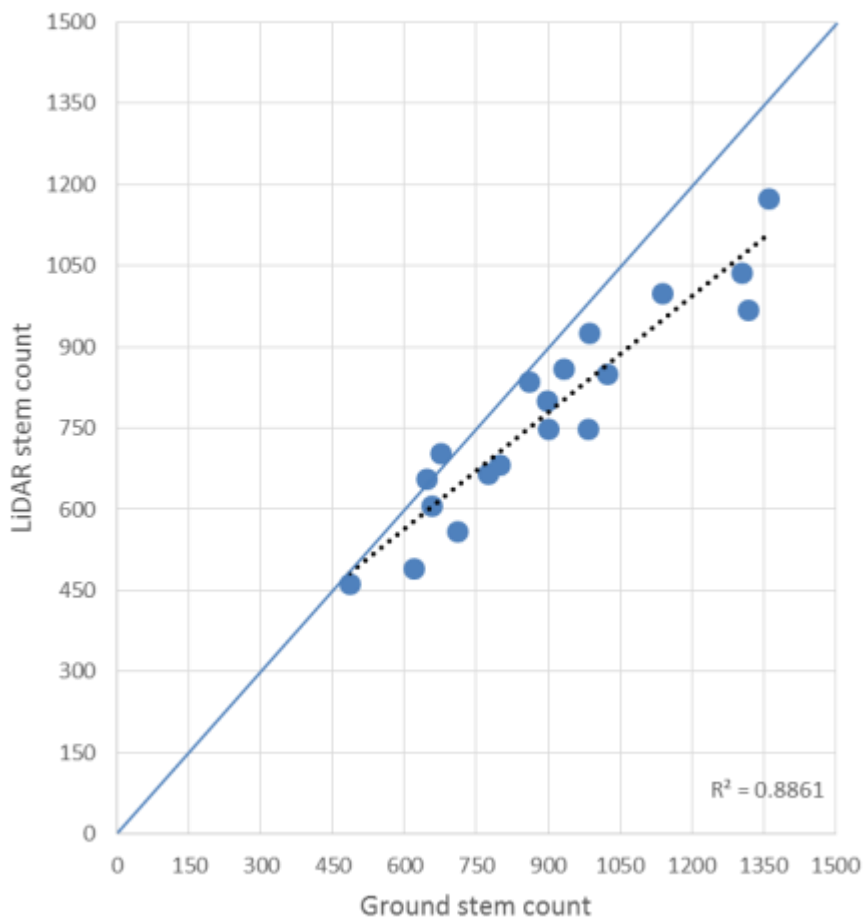
# LiDAR stem count adjustment

CHM Underestimate

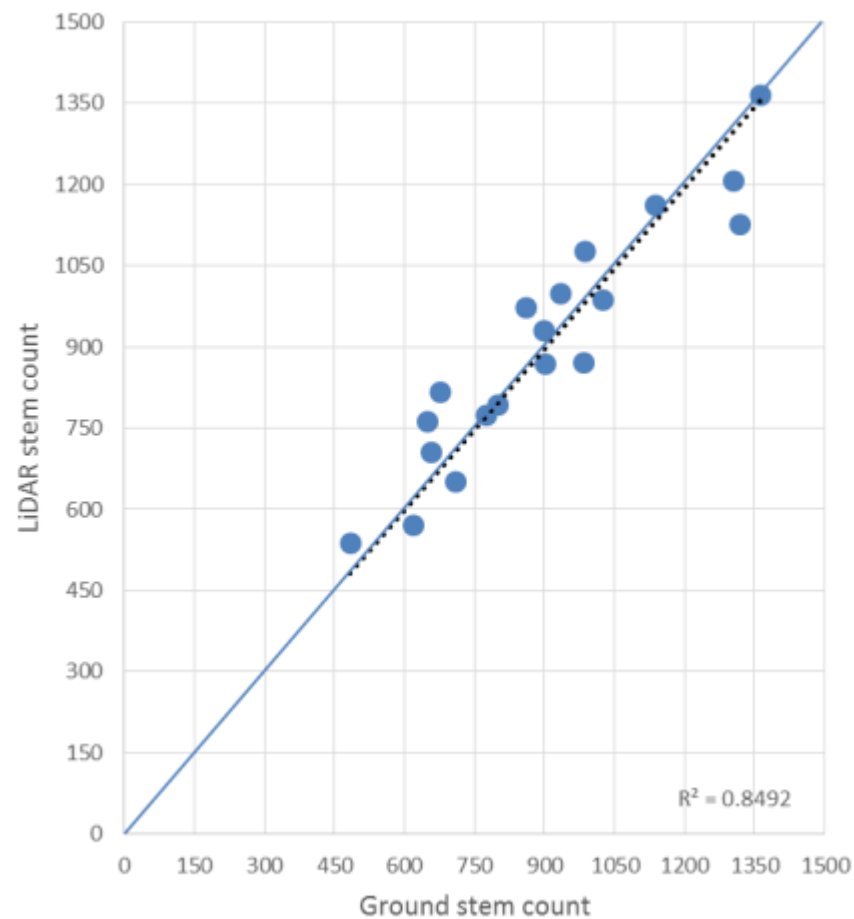


# LiDAR stem count Adjustment

Stem count before adjustment



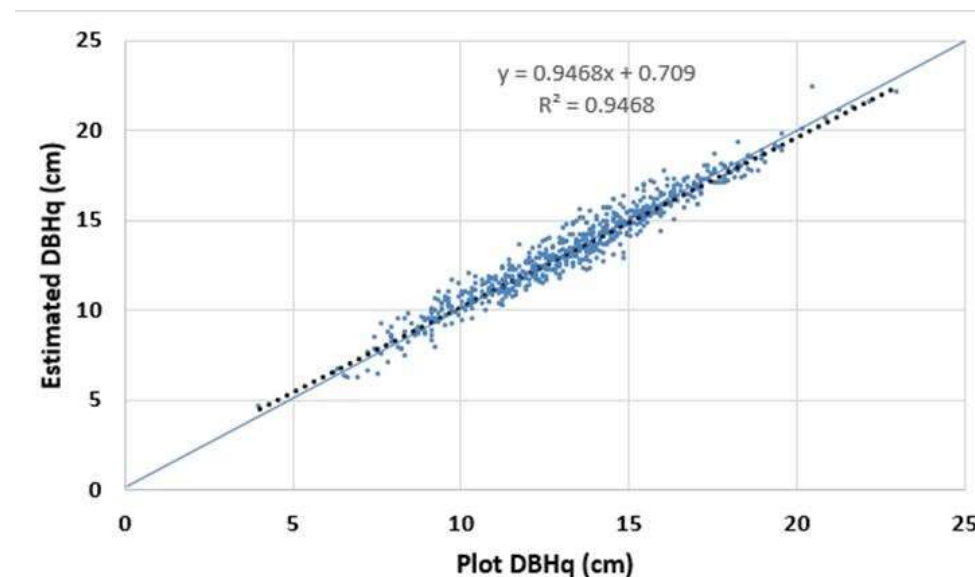
Stem count after adjustment



# LiDAR DBH estimate

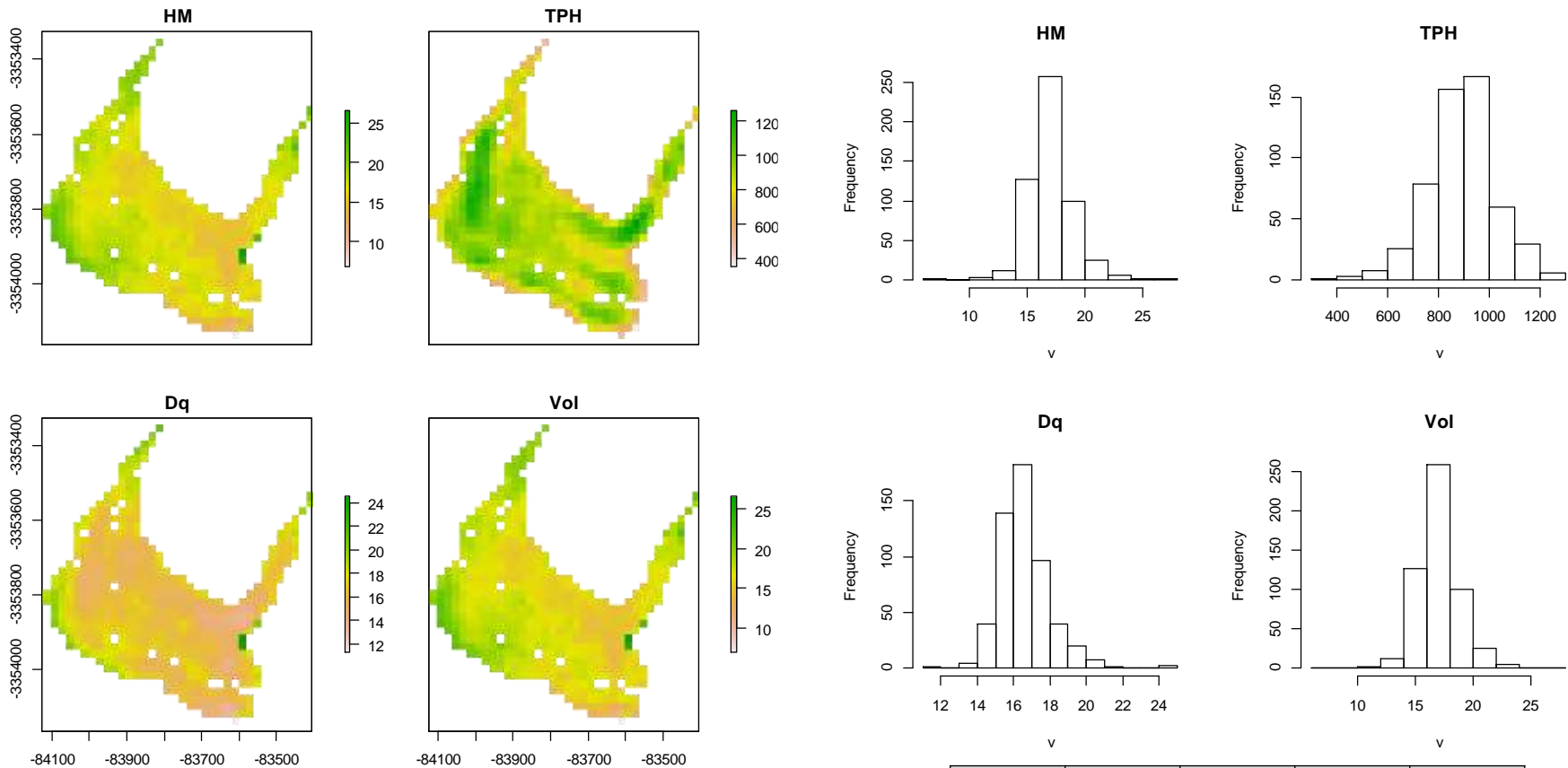
Output based on PSP data inputs (Not LiDAR measurements)

- Fitting of beta functions per species/region based on PSP and other enumeration data (include site variables).
  - $DBH = f(\text{LiDAR height, LiDAR TPH, Beta})$



# LiDAR measurement outputs

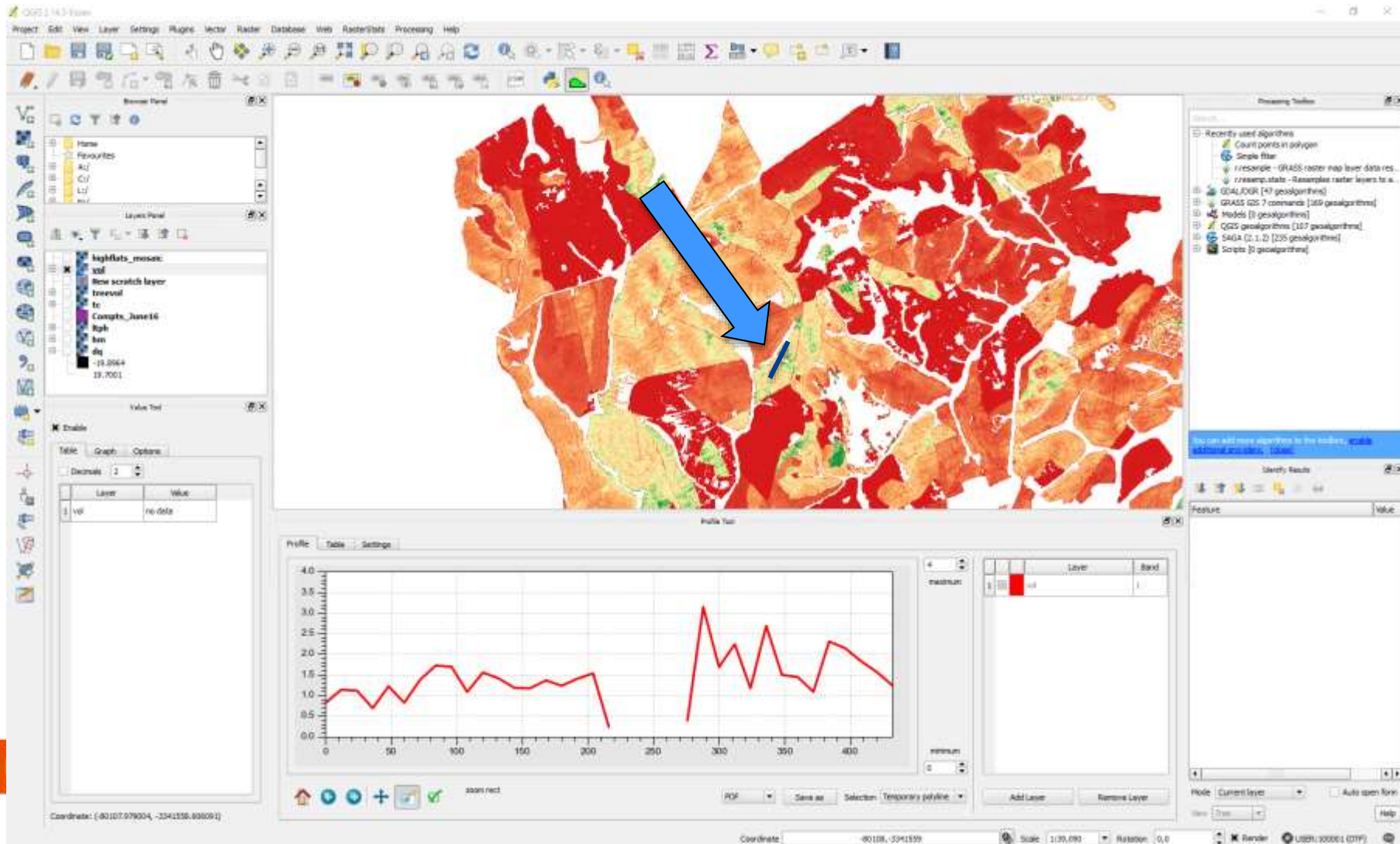
## Pixel level forest measurement



LID	HM	TPH	Dq	Vol
1097440	17.08	894	16.59	9084.89

# LiDAR measurement outputs

## Pixel-level forest measurement



# Conclusion



# Plantation growing stock variables



Full coverages

Variable	LiDAR		Enumeration	
Plantation level				
Coverage	100% (max 2 year old data)		30% (1-8 year old data)	
Compartment level				
	Sample % Area	Data source	Sample % Area	Data source
Height/SI	100%	Direct	<3%	Direct
TPH	100%	Adjusted	<3%	Direct
Diameter	100%	Derived	3%	Direct
Volume	100%	Derived	3%	Derived



# Acknowledgements



Dr. Horst Kassier

Dr. Riyad Ismail

Giovanni Sale

Nico Hattingh

Sappi Research Team

Sappi GIS Team