# Multi-temporal LIDAR data for forestry – an approach to investigate timber yield changes

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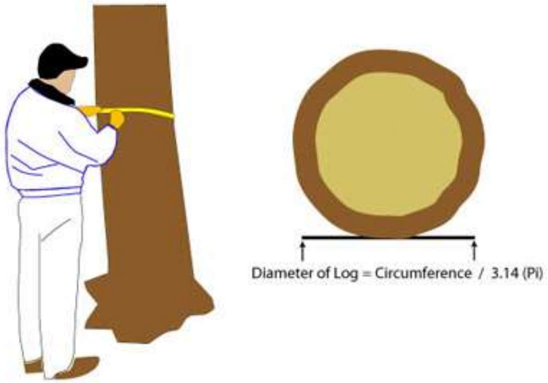
# Why investigating Multi-Temporal LIDAR data ?

- Use of existing ALS datasets
- Model and predict the 'change'

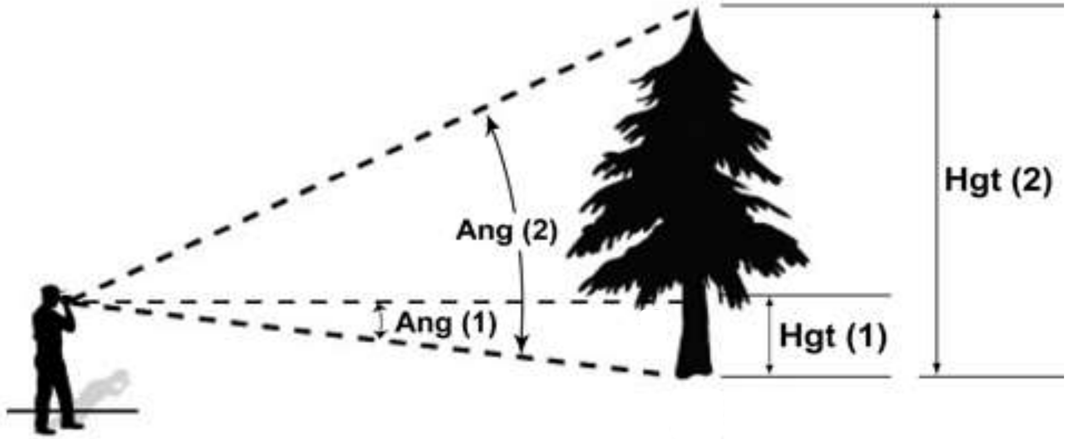
# Determining Timber Yield

$$Pine\ tree\ Wood\ Volume = \left(\frac{DBH}{200}\right)^2 * 3.142 * tree\_height * 0.35$$

$$DBH = Diameter\ at\ breast\ height\ (at\ 1.37m)$$




Measuring circumference ➔ DBH

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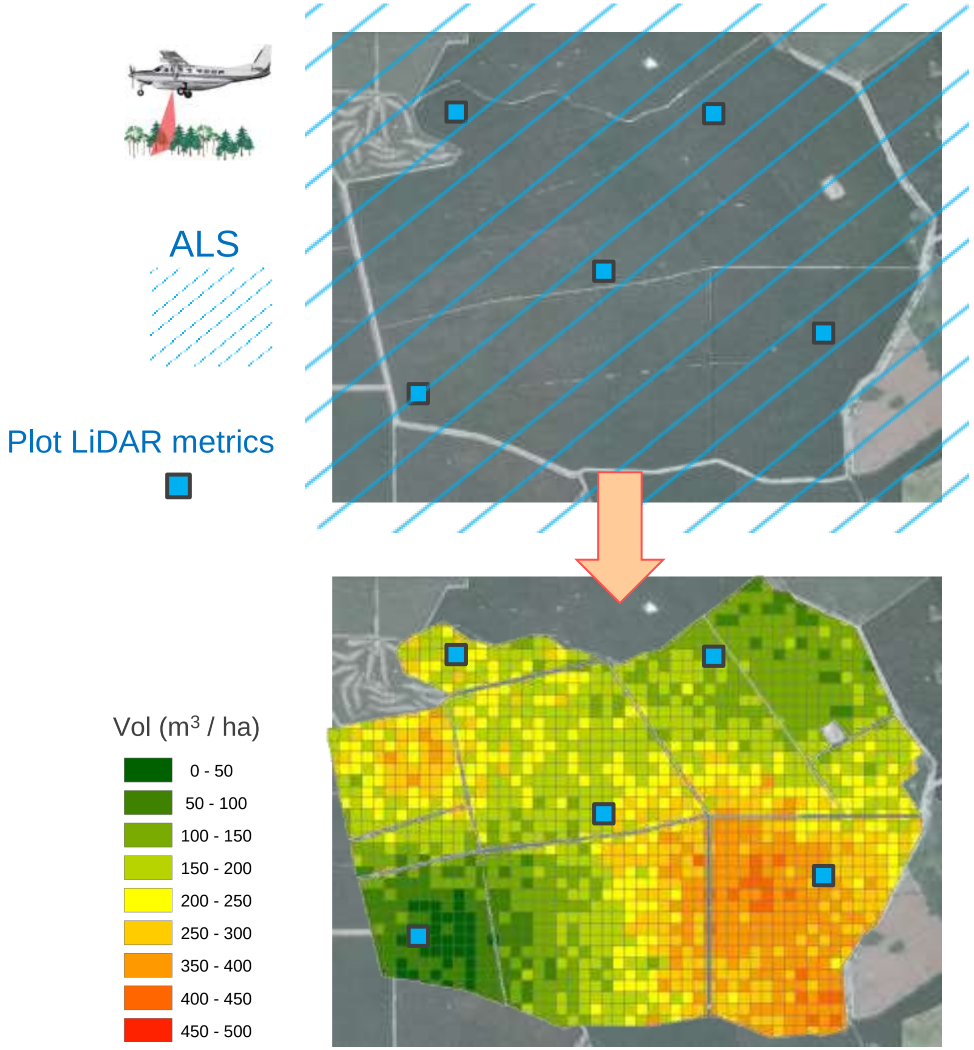
Measuring tree height

# Wood Volume from LiDAR metrics



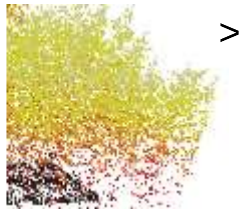

**1) Forest plots:**

- *ground truthing*

  wood volume derived from measured DBH and tree heights

**2) ALS over the entire area**

→ metrics



> 100 descriptors of the cloud

Point density, return intensity, height (std dev, skewness, avg, percentiles…)

**3) Cut plots out of entire ALS**

→ metrics

**4) Build model**

WoodVolume = $f$ [ plot_LiDARmetrics ]

**5) Impute plot-level Wood Volume to a stand level target grid**

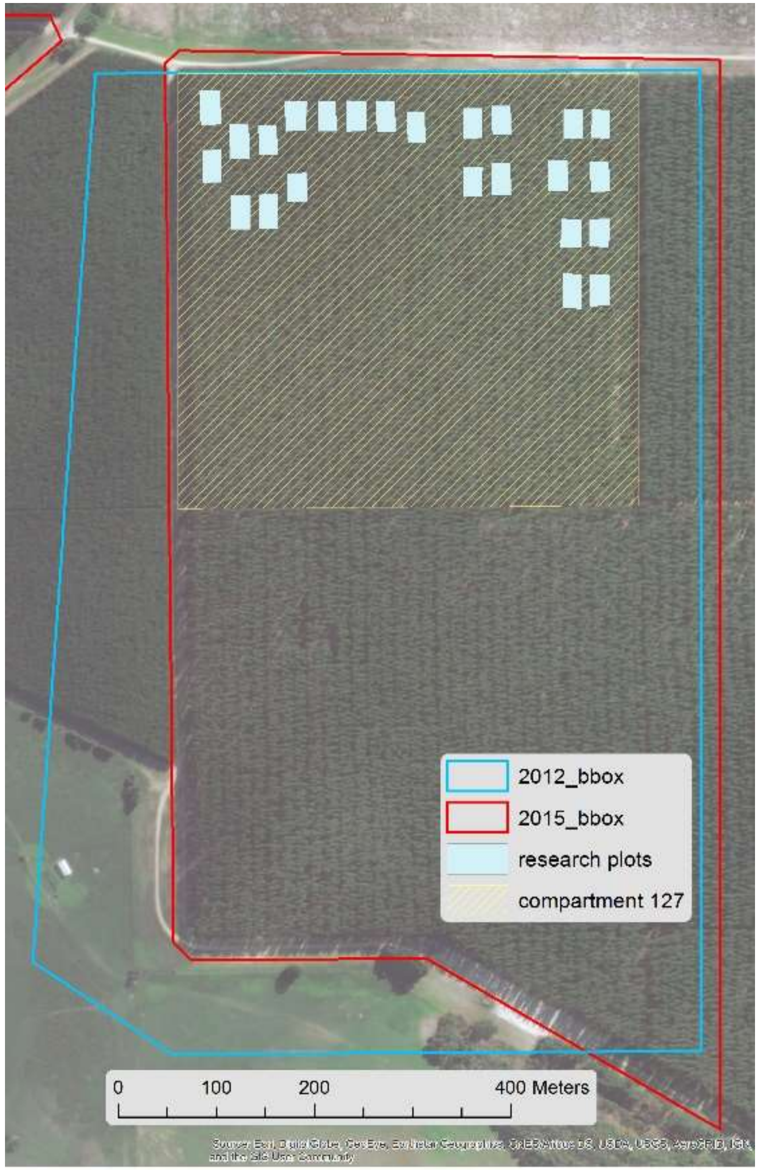
Intro

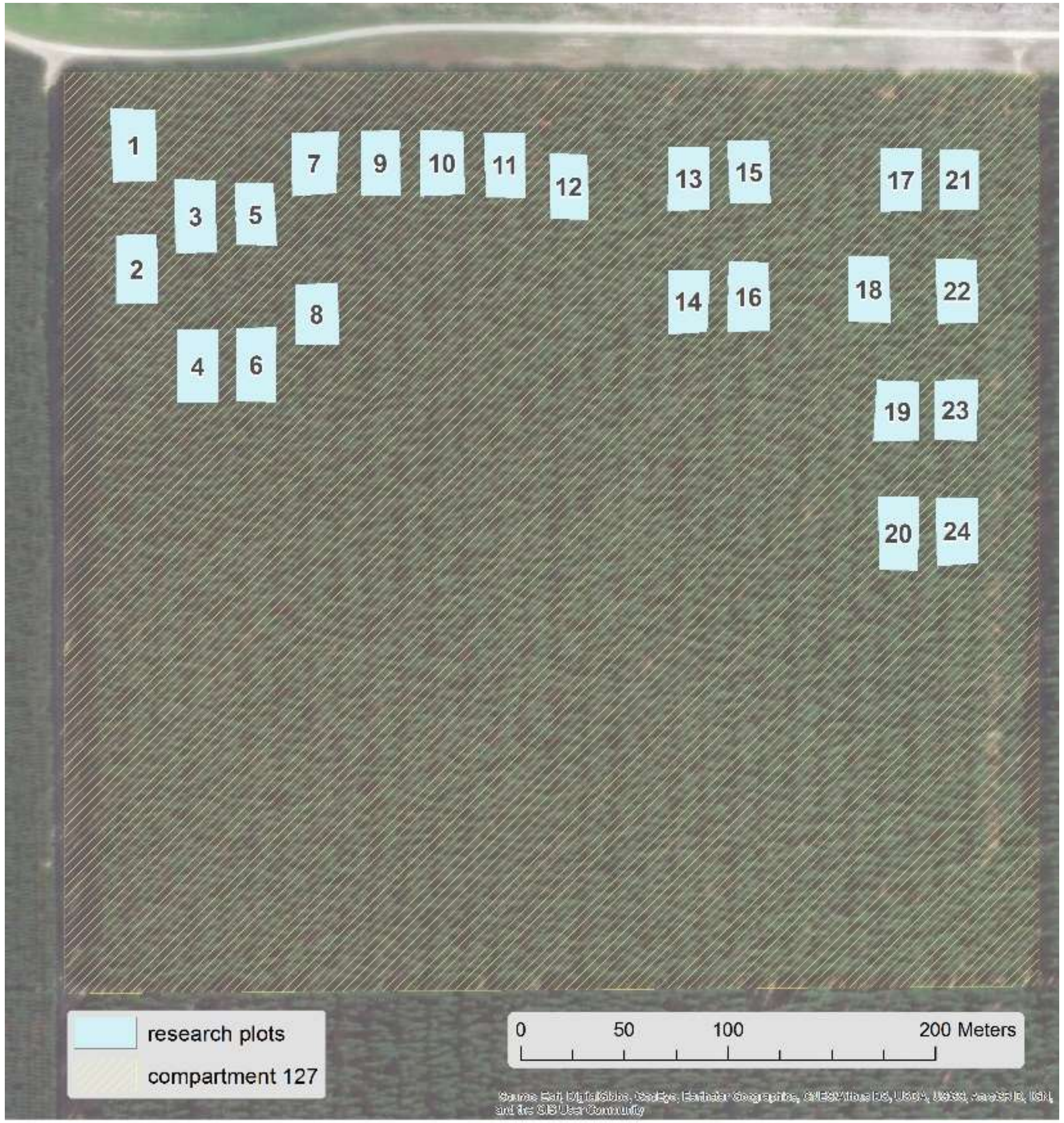
**Study area**

Data-processing

Modeling

Conclusion



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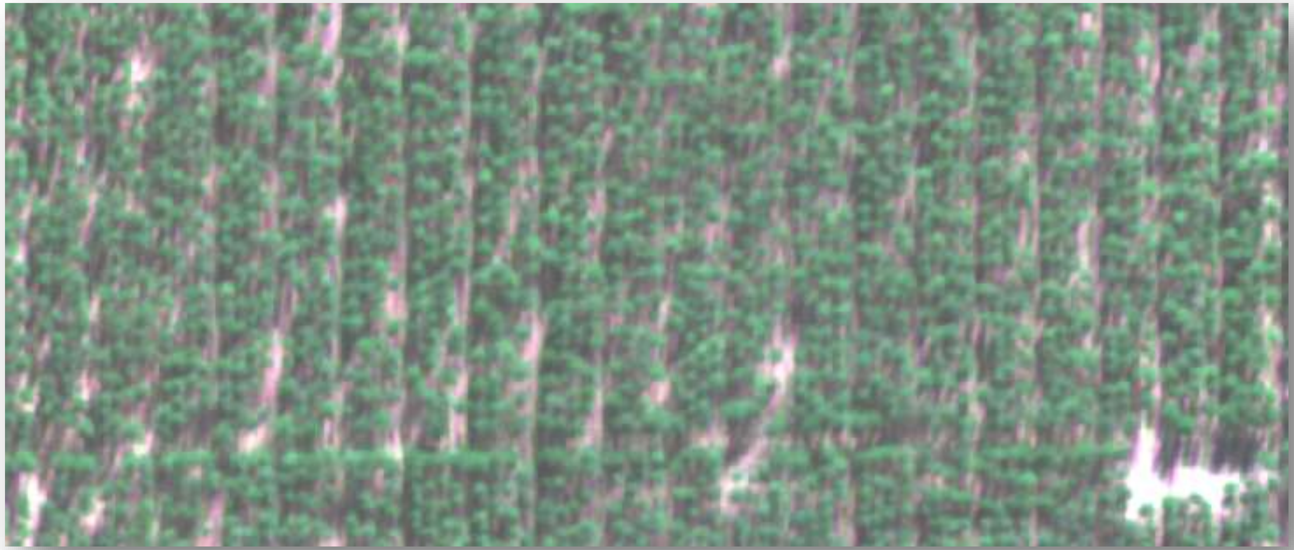
## Forest features

- Single tree type: Radiata Pine
- Planted in 1997
- ~ evenly distributed



# Discrete multi-return Airborne Lidar Scanning (ALS)

| Flight / data characteristics | 2012 ALS flight | 2015 ALS flight |
|---|---|---|
| Data supplier | De Bruin Spatial Technologies | AAM |
| **Date of acquisition** | **15.01.2012** | **01.04.2015** |
| Data format | LAS 1.2 | LAZ 1.4 |
| Flying altitude (m ASL) | 800 | 1300 |
| Scan Angle (°) | 15 | 28 |
| Scan overlap (%) | 25 | 15 |
| Mean footprint diameter (cm) | 19 | 25 |
| **Mean point density** | **8.9** | **8** |
| Point density range inside inventory plots ($m^{-2}$) | 3.4 - 9.2 | 4 - 8 |
| Horizontal / Vertical accuracy | 0.5 m / 0.25 m RMS (1 Sigma) | 0.5 m / 0.25 m RMS (1 Sigma) |
| Datum and projection | GDA 1994 / MGA Zone 54 | GDA 1994 / MGA Zone 54 |

*ALS metadata*

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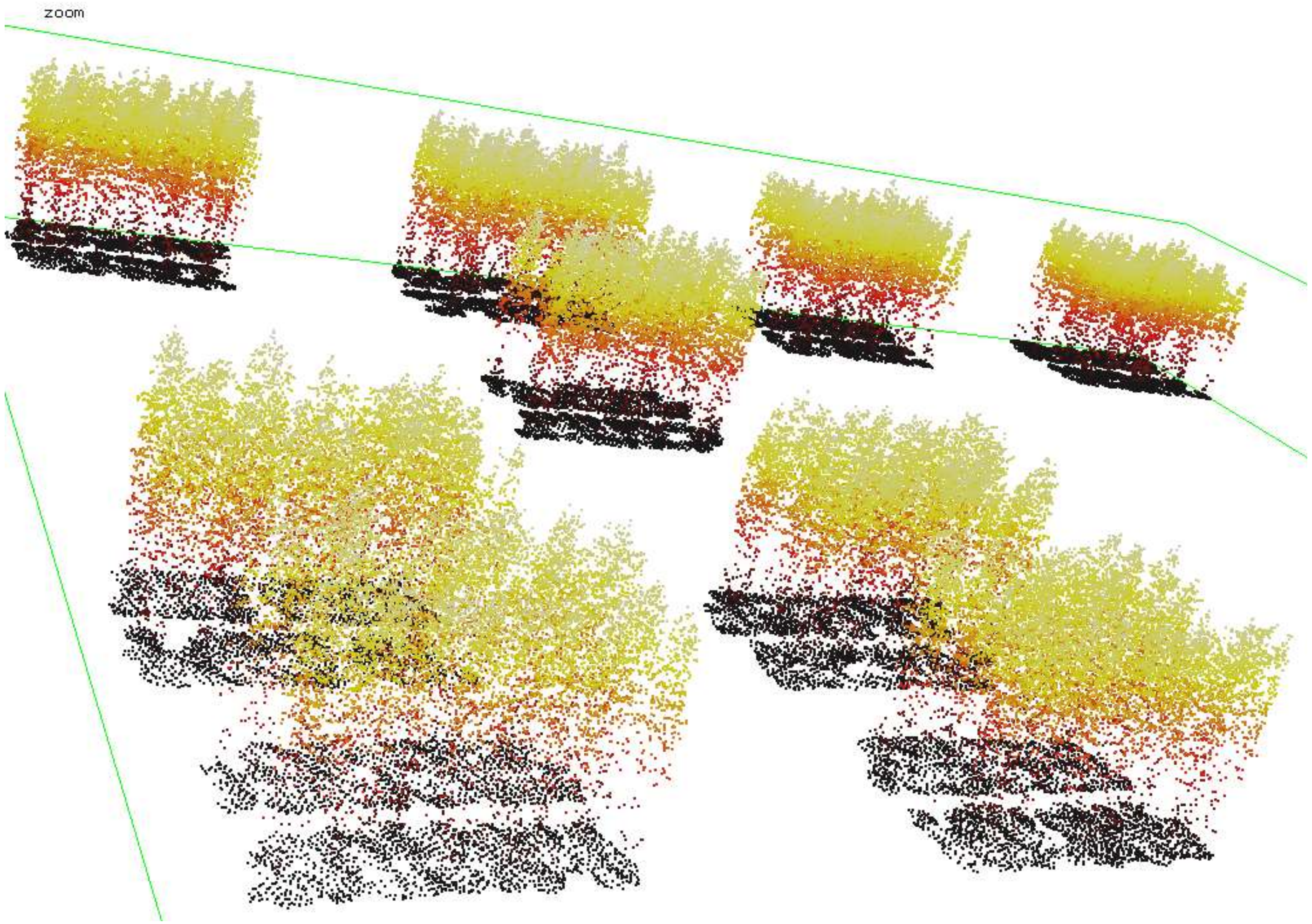
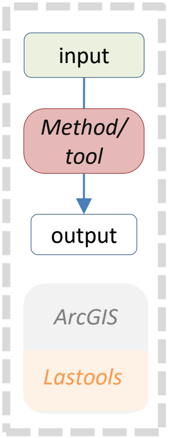
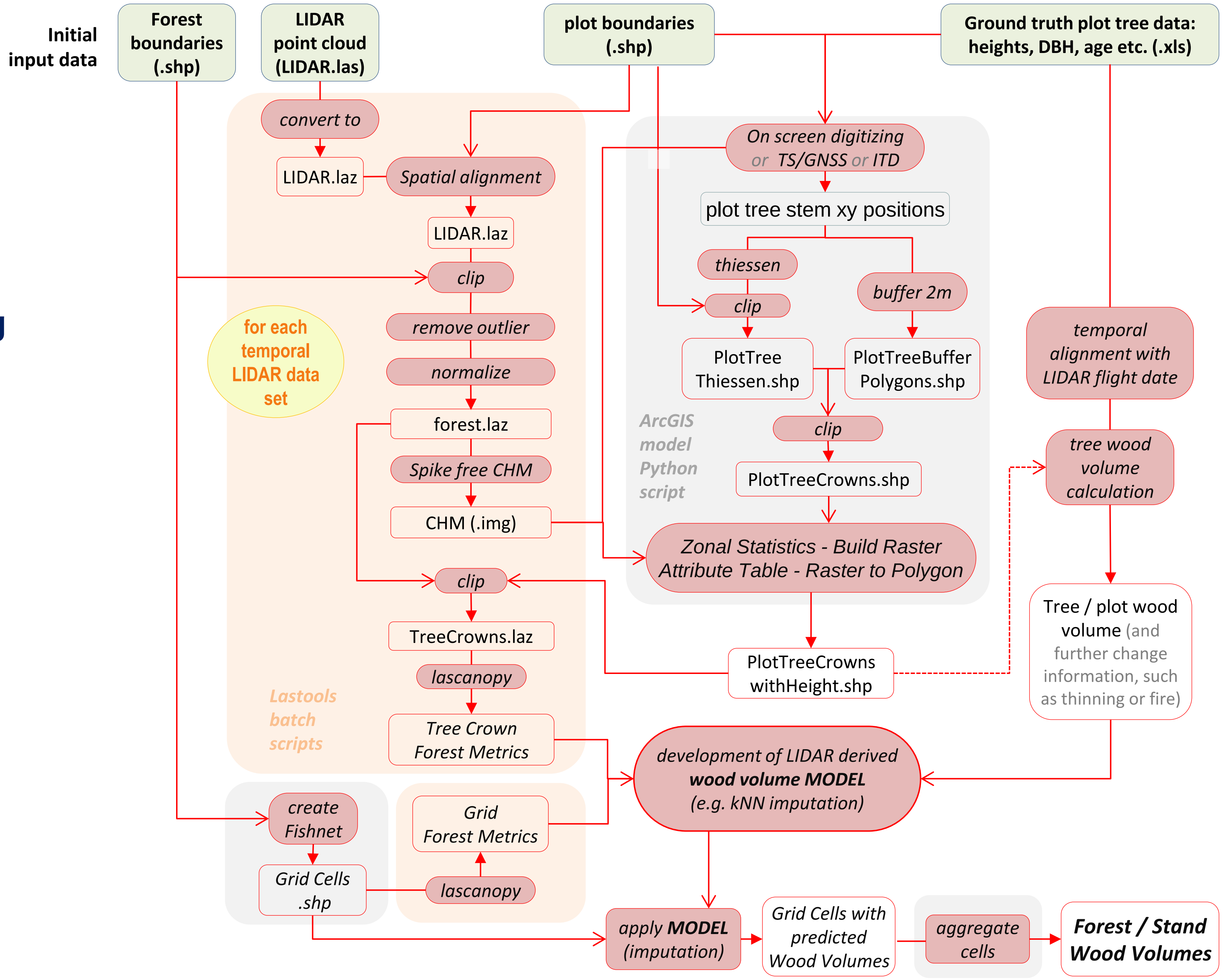
# **LiDAR point cloud (2015)** – clipped plots



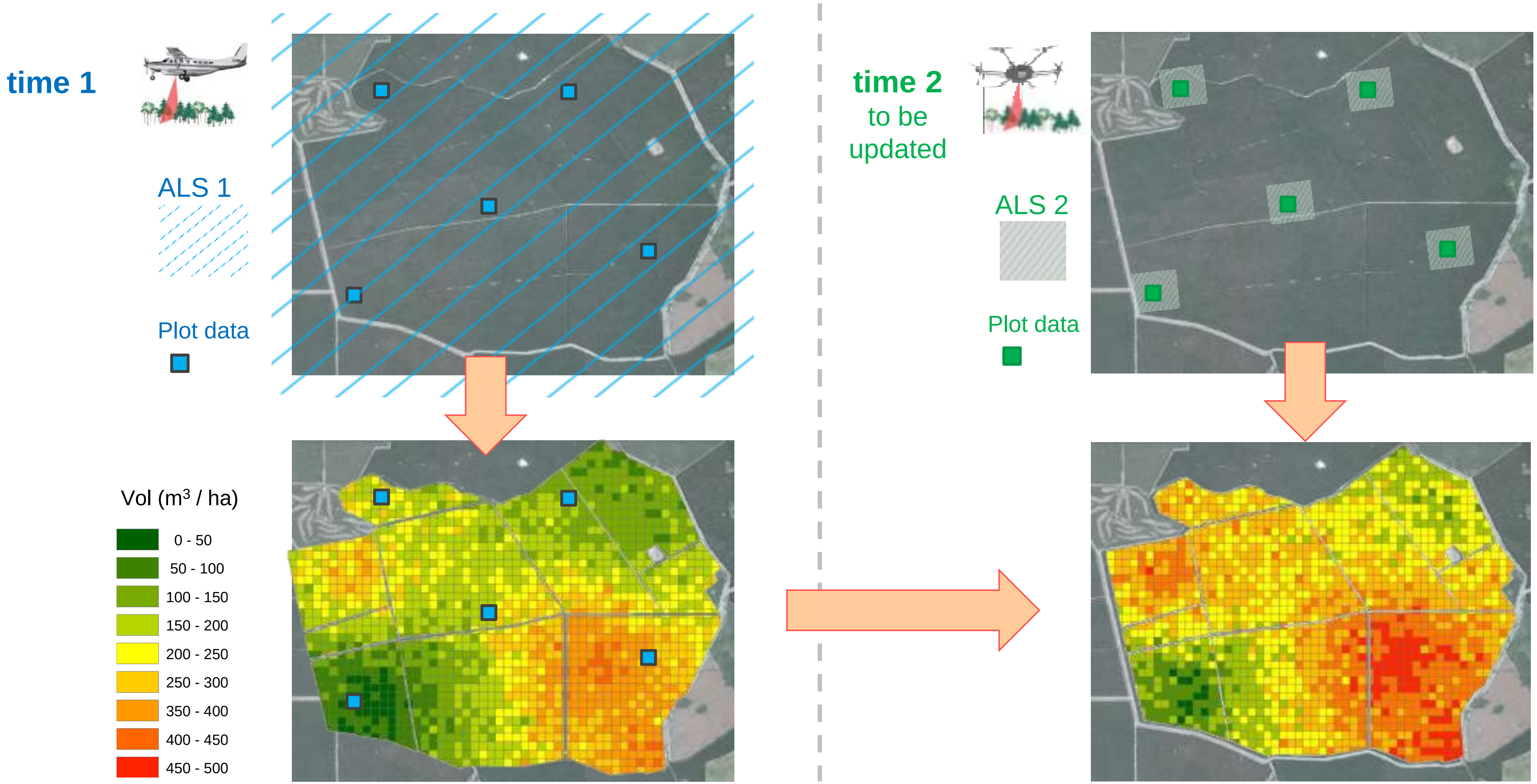
# LiDAR and GIS data processing flowchart



# Timber yield modelling: Cost effective **update** of **timber yield estimates**

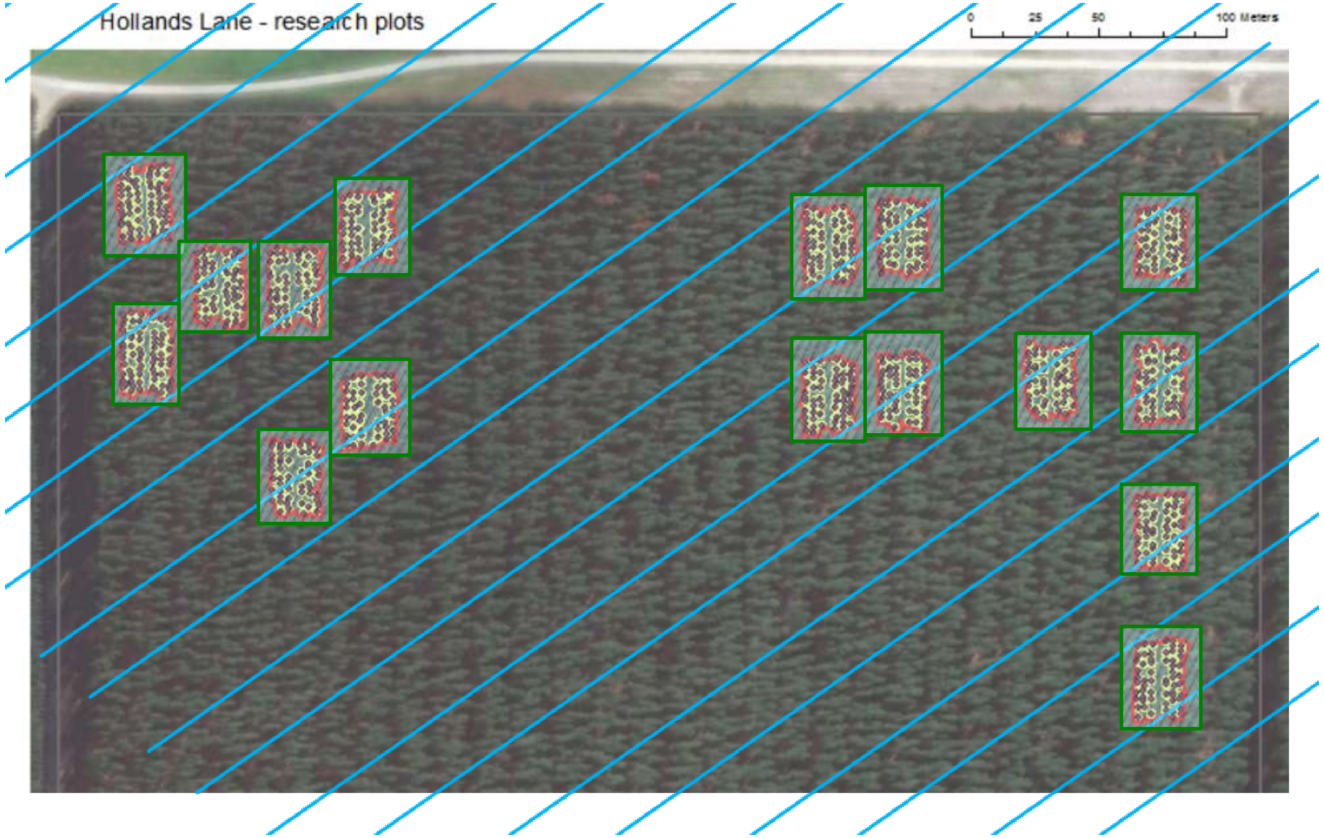




# Timber yield modelling: II) Cost effective update of timber yield estimates

- Intro
- Study area
- Data-processing
- **Modeling**
- Conclusion

…first test at our study area




time 1
ALS 2012

**time 2**
to be updated
**ALS 2015**

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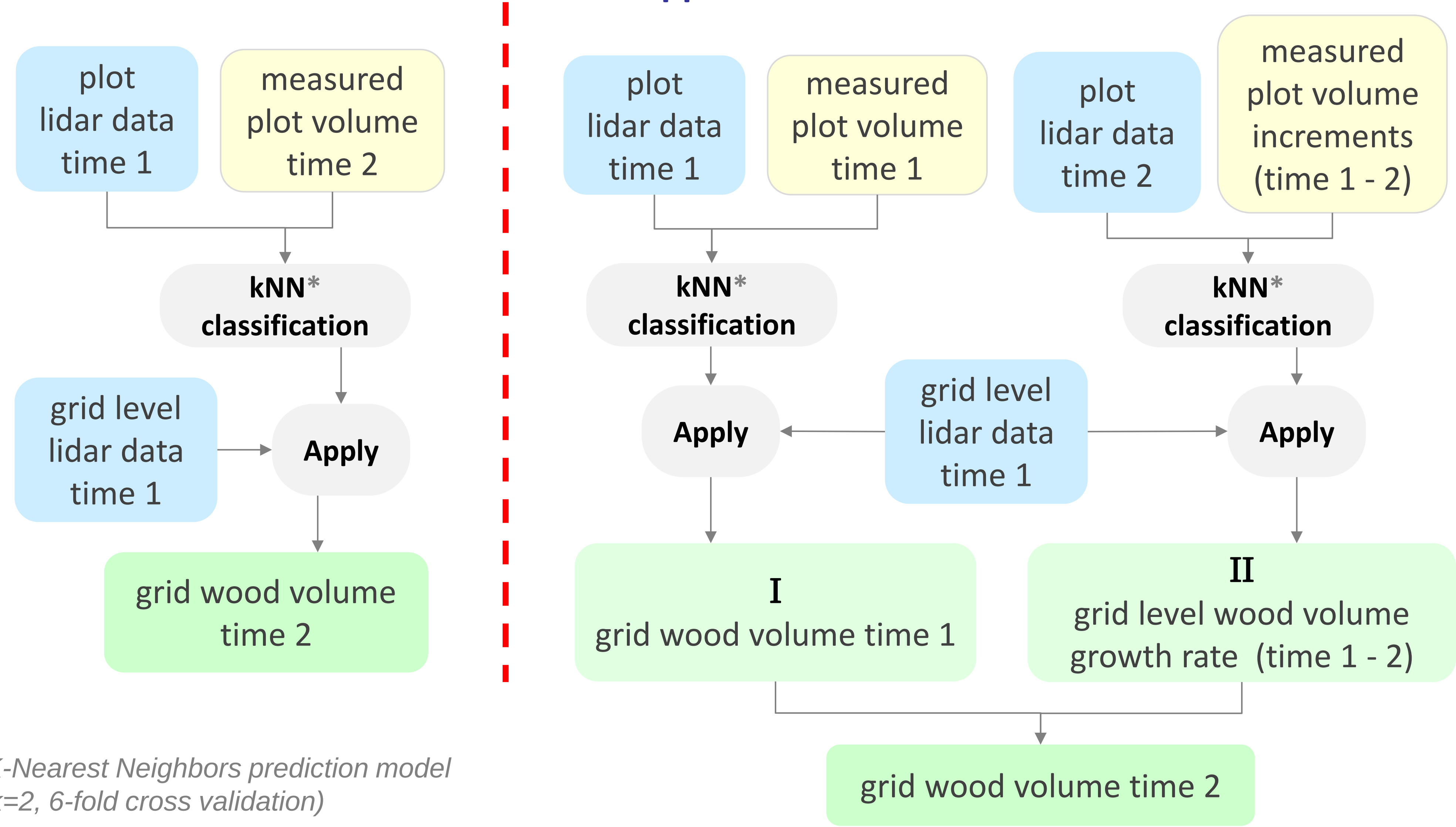
## Approach A:

## Approach B:




** K-Nearest Neighbors prediction model (k=2, 6-fold cross validation)*

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# Models A and B applied to predict grid-level wood volumes

## Approach A and B grid prediction: relative difference: 1%

*Approach A*

| GridID | Pred Vol 2015 |
|---|---|
| 1 | 24.23 |
| 2 | 22.46 |
| 3 | 22.46 |
| … | … |
| 263 | 24.12 |
| 264 | 24.12 |

**Vol total:** **5751.41**

**RMSE (plots):** **1.51**

*Approach B*

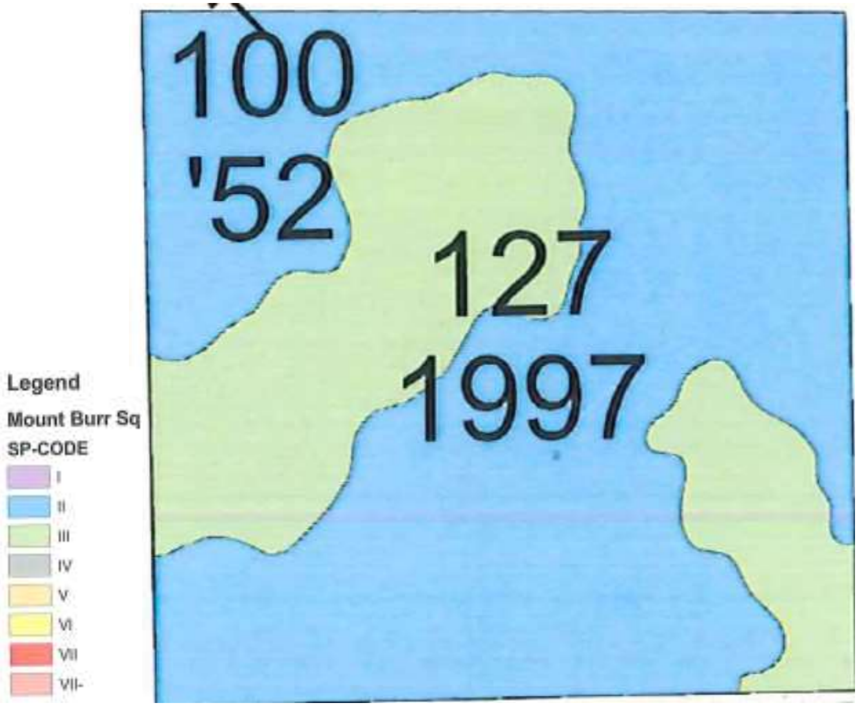
| GridID | Pred Vol 2012 | Pred Vol Rate | Calc Vol 2015 |
|---|---|---|---|
| 25 | 17.805 | 0.379597 | 24.5637 |
| 26 | 17.805 | 0.381722 | 24.6016 |
| 27 | 17.58 | 0.381722 | 24.2907 |
| … | … | … | … |
| 263 | 16.395 | 0.381722 | 22.6533 |
| 264 | 15.7 | 0.423105 | 22.3427 |

**Vol total:** **5783.8**

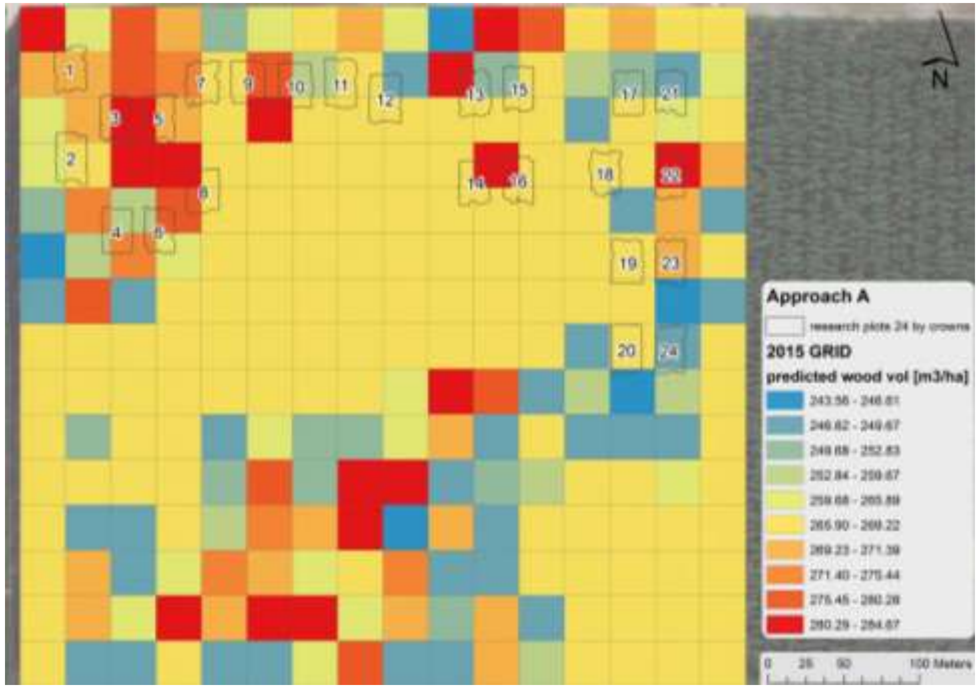
**RMSE (plots):** **1.70**

*all wood volumes in $m^3$*

# Resulting Grid map compared with Site Quality map (2007)




Site Quality map (Manual assessment) of wood volume at age 10 (2007)




2015 LiDAR based volume prediction

# Conclusion

*Proof of concepts:*

- Multi-temporal LiDAR data → added values
  - Model, estimate, predict change of timber yield
  - ALS + UAV-LiDAR for cost efficient update of yield estimates

…potentially applied to other applications
(agriculture, vegetation monitoring…)

# Outlook

- **Enhance wood volume change model and future prediction**
  - Larger test area
  - 3+ multitemporal LiDAR scans
  - Higher point density (30 ppm$^2$)
- **Investigate change in more detail**
  - Change of basal area, biomass, …
  - Thinning, Harvested trees, gap dynamics, damaged crowns

# Many thanks

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