Assessing Forestry Plantations with UAVs: A Comparative Study of Laser Scanning and Photogrammetry

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FORESTS ▪ PRODUCTS ▪ INNOVATION

Background

forests

MDPI

Article

Use of a Consumer-Grade UAV Laser Scanner to Identify Trees and Estimate Key Tree Attributes across a Point Density Range

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- **In our previous work:**
  - ➢ Developed and presented a workflow that uses UAV LiDAR to predict important tree characteristics
  - ➢ Initially tested in two recently thinned, mid-rotation (8-10 years) stands in Kaingaroa forest and shown to perform well
  - ➢ Efficiently provided individual tree information, accurately estimated key metrics such as DBH, height, and volume

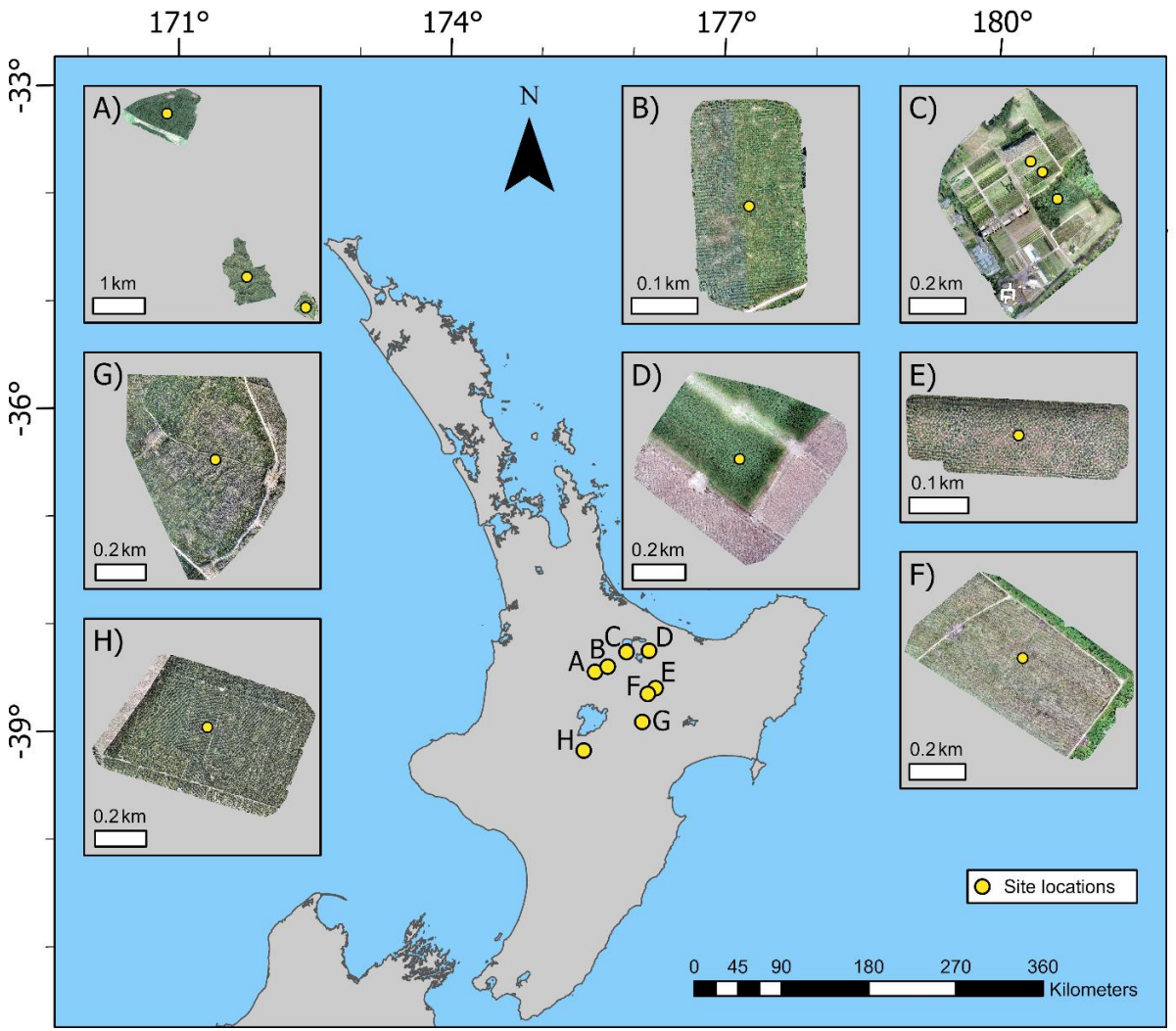
Objectives

- **To assess the accuracy** of DBH and tree height predictions at the individual tree level from a range of age classes and site conditions

- **To provide a detailed comparison** between the performance of UAV-LiDAR and UAV-SfM point clouds for individual tree level assessments

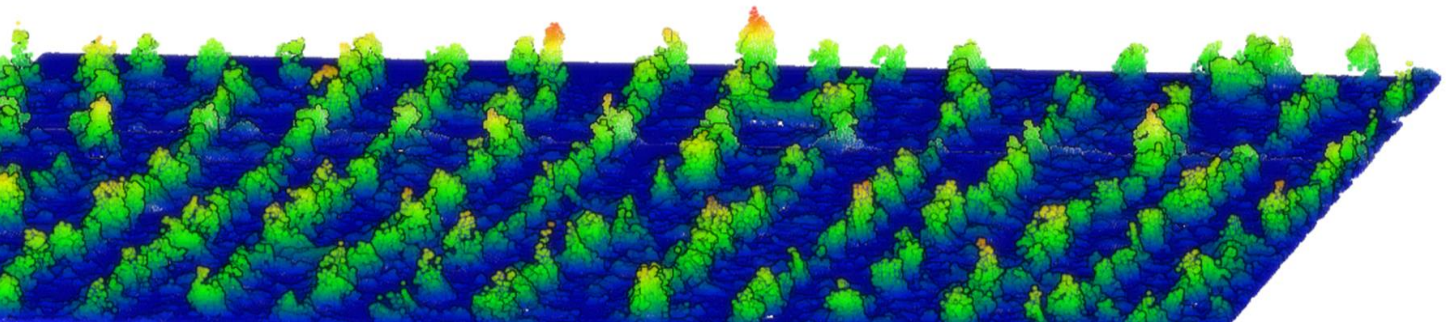
Test sites

- **8 Radiata Pine plantation stands**
- **Range of age classes**:
  - Recently established (<2 years)
  - Early establishment, prior to thinning (age 2-6)
  - Recently thinned, mid rotation (age 7-9)
  - Late rotation (age 17+)
- **Varying site conditions**:
  - Flat to steep terrain
  - Regularly mowed to significant weed cover
  - Minimal to significant amount of harvest debri



Data

- **Field data:**
  - Height
  - DBH
  - Stem map



- **16 UAV-LiDAR datasets:**
  - Riegl MiniVUX
  - DJI L1 LiDAR
  - HDL32E (Snoopy V Series)
- **14 UAV-SfM datasets:**
  - DJI P4 Pro
  - DJI P1
  - DJI L1 RGB

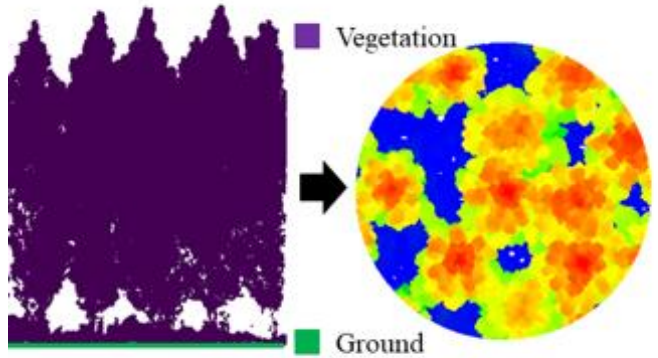
Method

Raw point cloud data

1 Homogenisation

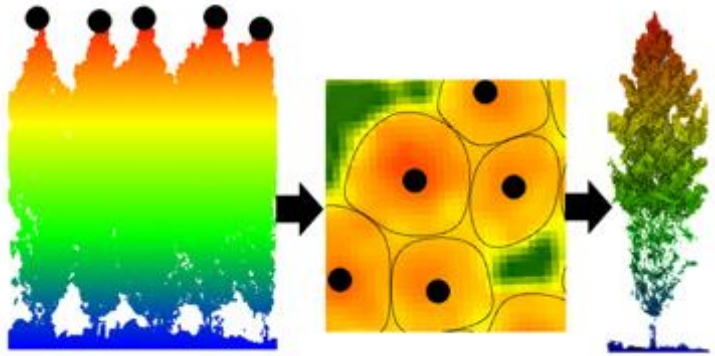
2 Standard preprocessing

3 CHM



4 Tree peak detection and crown delineation

5 Individual tree segmentation



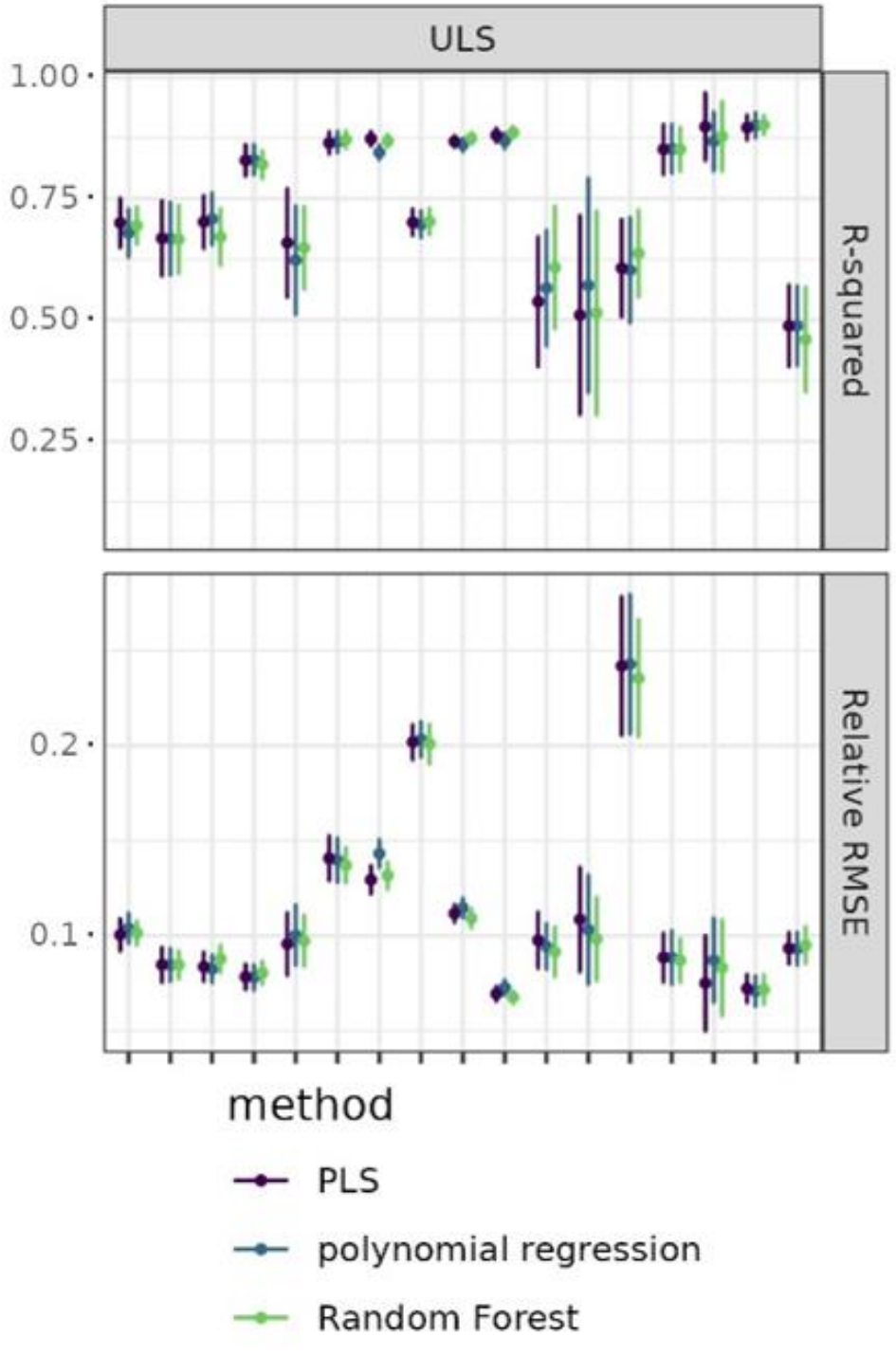
6 LiDAR metric extraction

Accuracy comparisons:
Site settings, Data sources

Tree attribute prediction:
Height, DBH

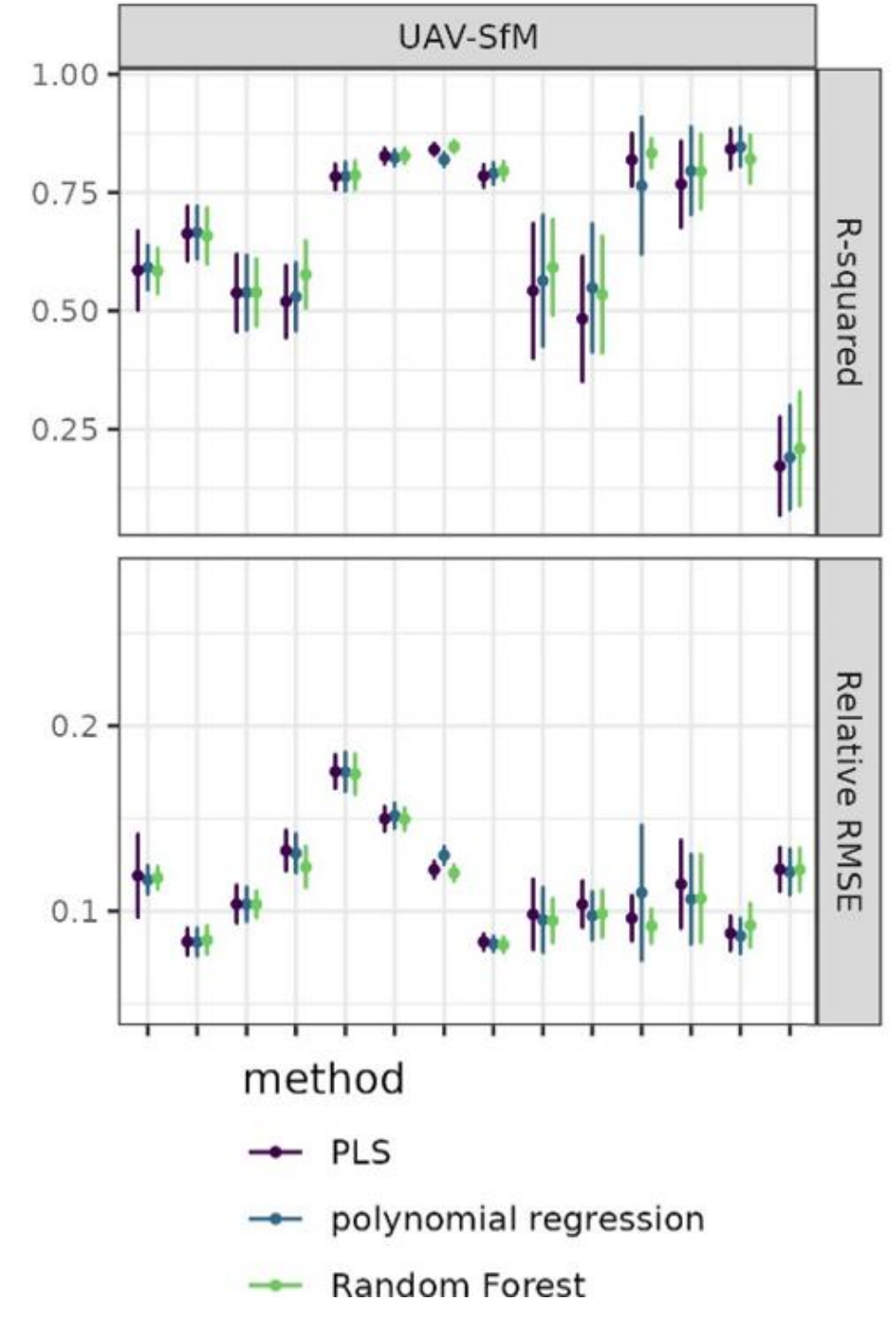
Results 1: DBH prediction from UAV-LiDAR

- **Model Performance:** Similar performance among models; Random Forest model was slightly better
- **Accuracy across sites:** Mean RMSE of 10% (7-20%); Mean R^2 of 0.75 (0.46-0.90)
- **Site performance trends:** Relatively poor performance in more mature sites with closed canopy



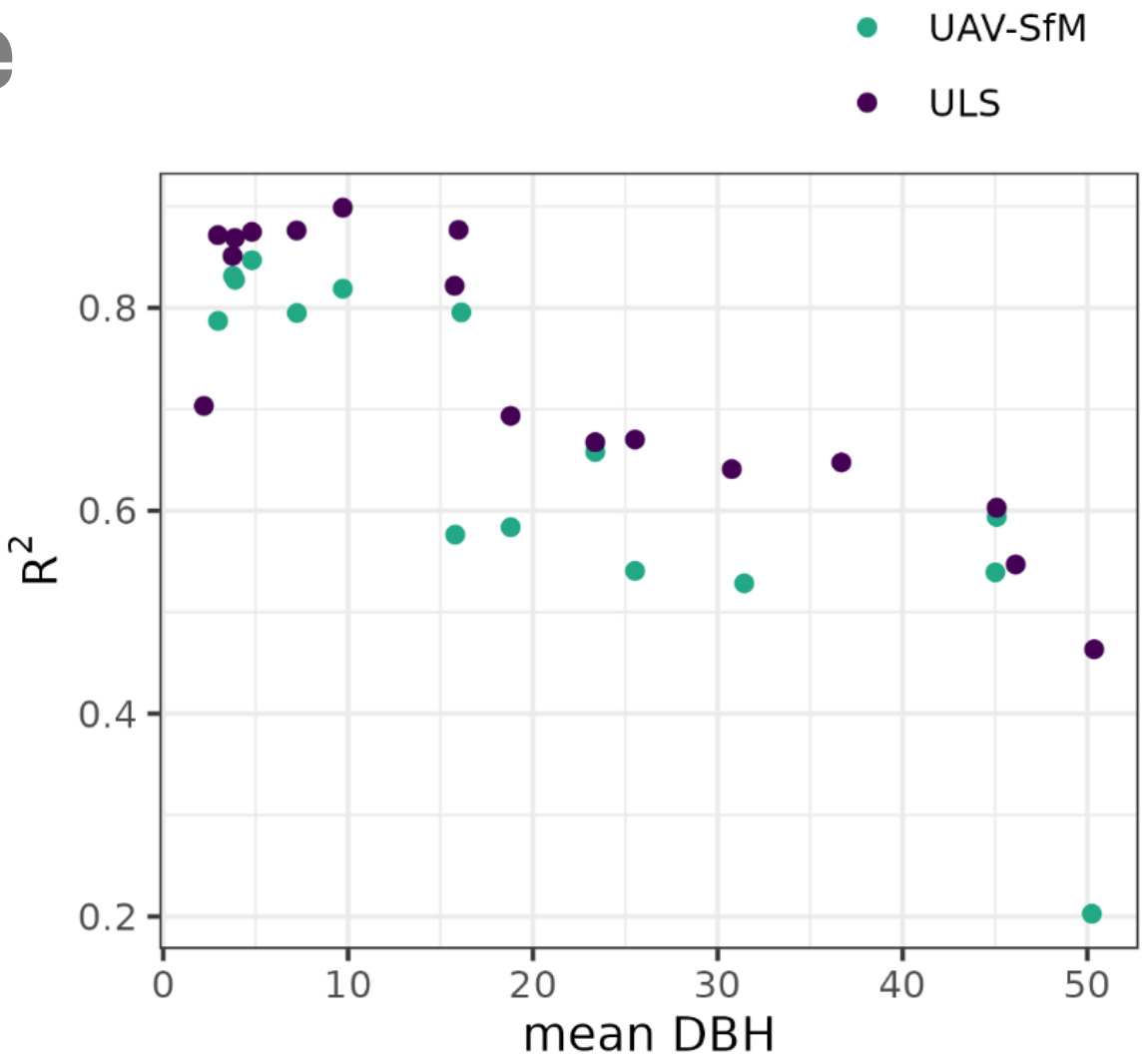
Results 2: DBH prediction from UAV-SfM

- **Model Performance:** Similar performance among models; Random Forest model was slightly better
- **Accuracy across sites:** Mean RMSE of 11% (8-17%); Mean R^2 of 0.67 (0.20-0.85)
- **Site performance trends:** Relatively poorer performance than UAV-LiDAR, particularly in mature sites with closed canopy



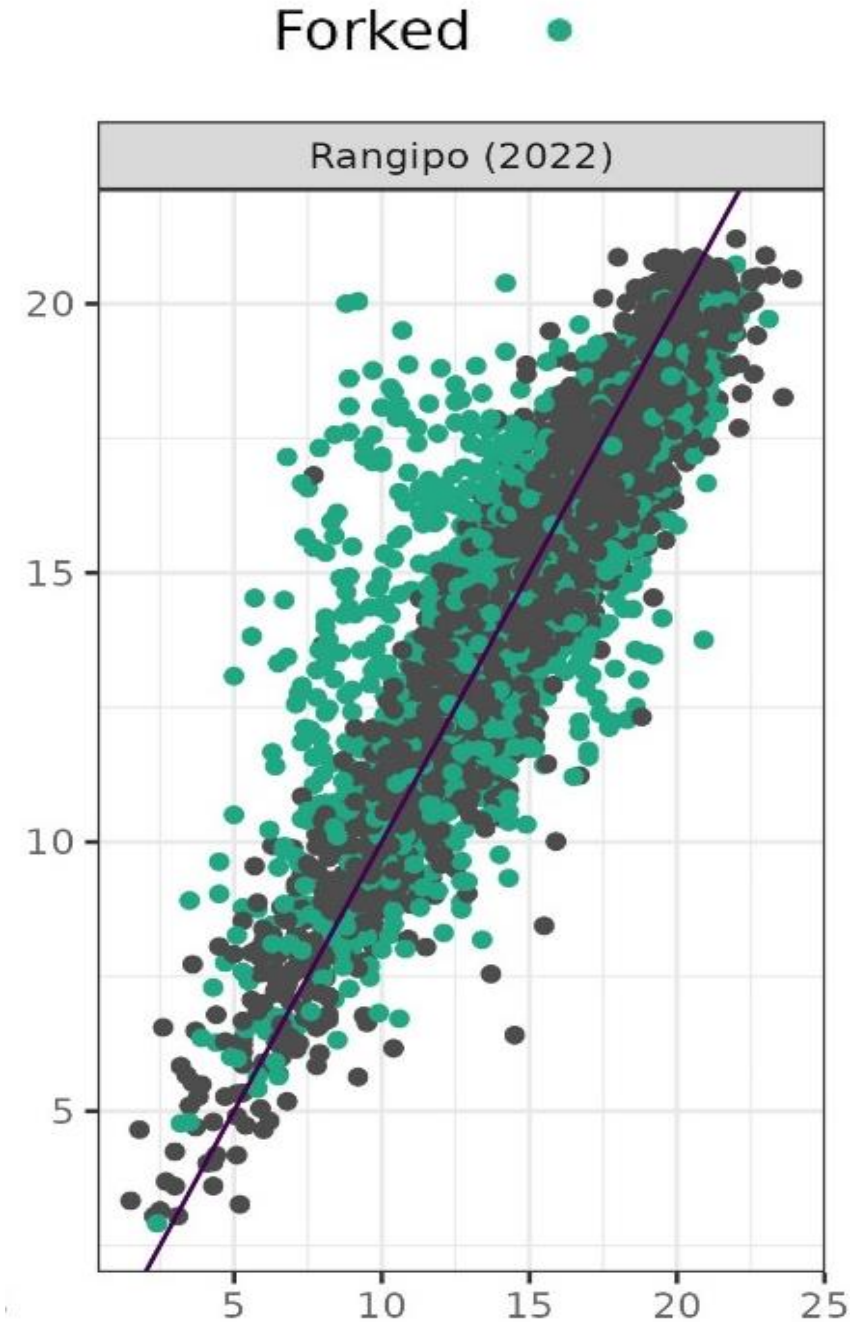
Results 3: Impact of tree size on model performance

- **DBH prediction accuracy decreased as tree size increased**
- Similar trends were observed with both UAV-LiDAR and UAV-SfM



Results 4: Impact of tree structure on model performance

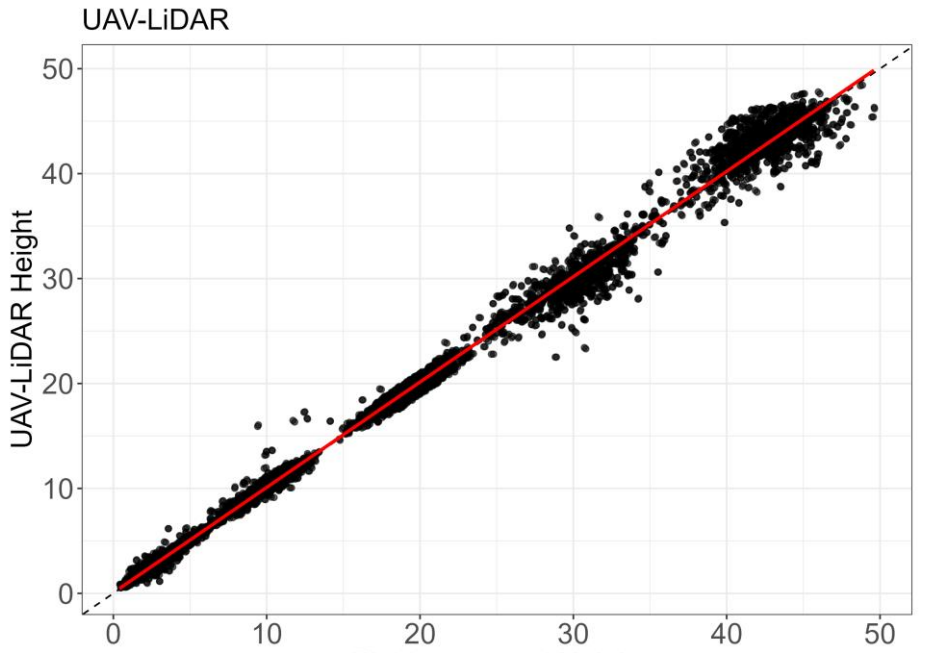
- **Including multi-leader trees in the analysis decreased model performance**
- This highlights the potential for automatic detection of multi-leader trees

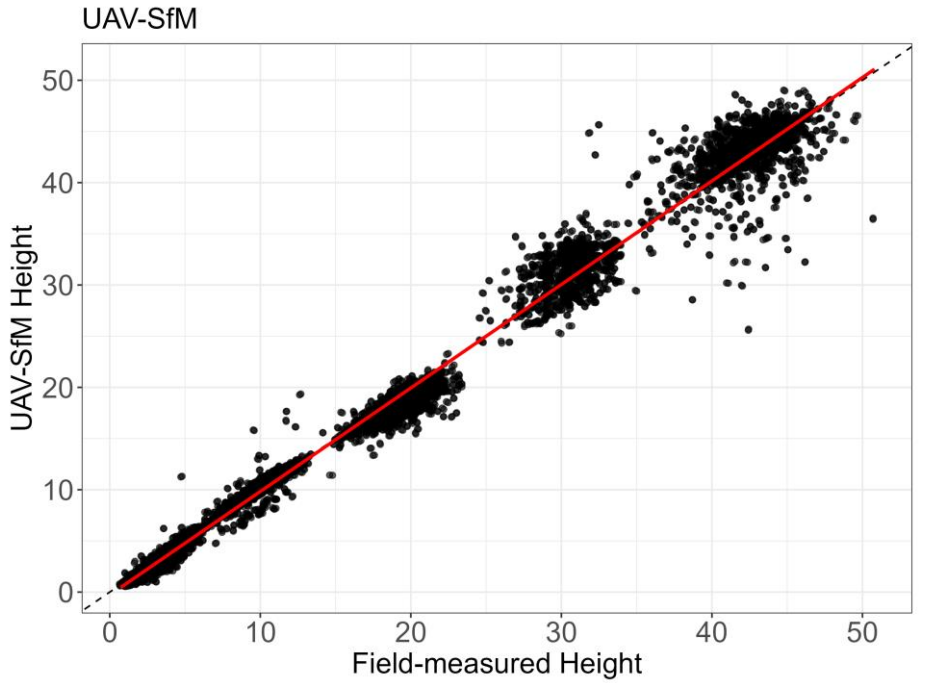


Results 6: Tree height measurements

- **UAV-LiDAR and UAV-SfM height estimates were comparable**

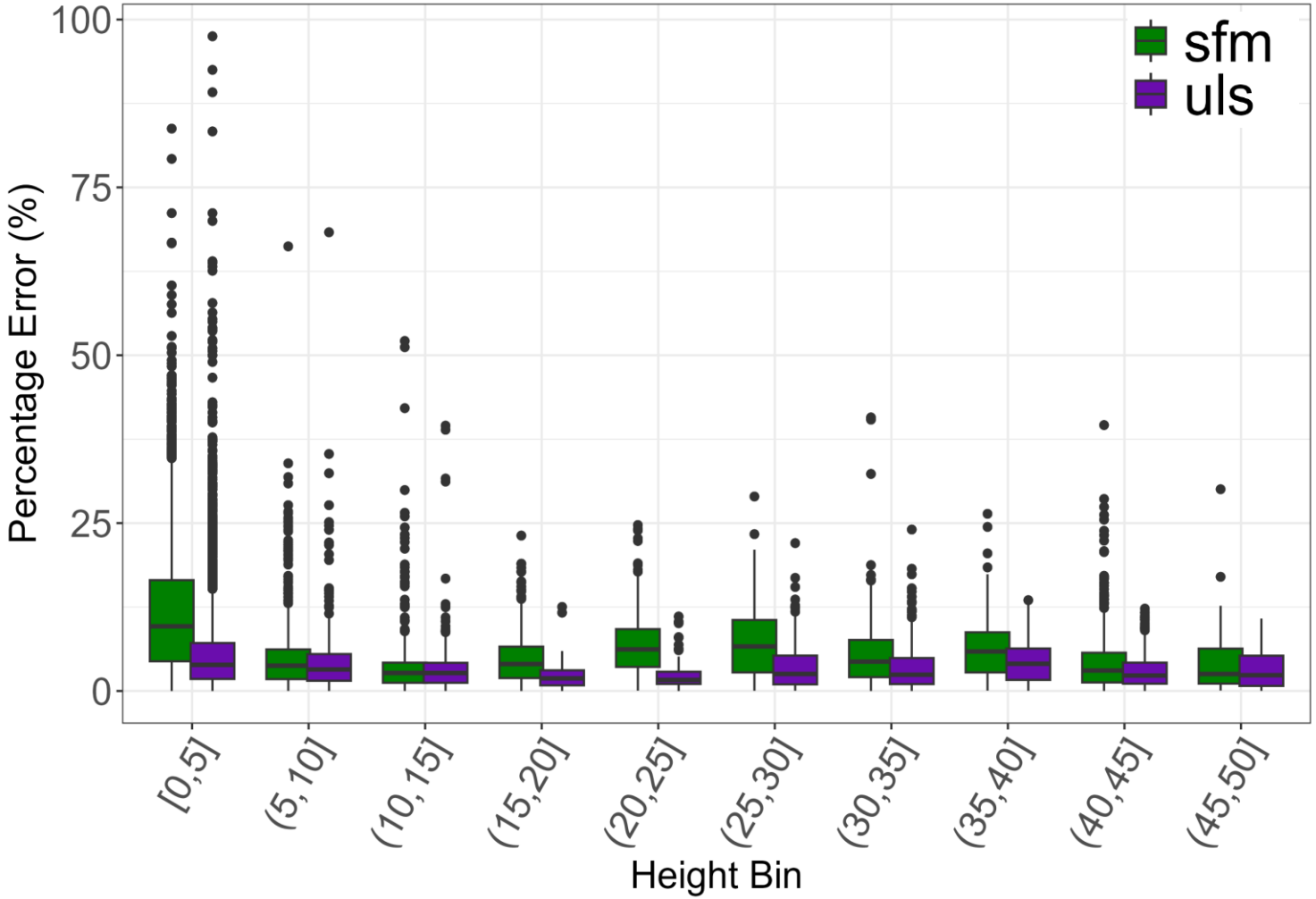
	UAV-LiDAR	UAV-SfM
R^2	0.99	0.98
RMSE (m)	0.55	1.16
%RMSE	7.22	10.41





Results 7: Height error variability

- In comparison to UAV-LiDAR height, UAV-SfM heights had higher error on average, showed more variability and produced more extreme errors
- Demonstrated both perform equally during “silviculture period”
- Neither works well for young trees (< age 5)



In conclusion

- While UAV-LiDAR was slightly more accurate in predicting DBH, both methods demonstrated comparable accuracy under ideal conditions. Model performance was affected by tree size, structure (e.g., multi-leader trees) and some site conditions (e.g., the amount of harvest debris present).

- Tree height estimations by both UAV-LiDAR and UAV-SfM were comparable across the range of site conditions. However, precise DTM co-registration is essential for accurate height estimations with UAV-SfM.

Our results highlighted that neither technology perform optimally on every site; therefore, the site conditions must be factored when selecting UAVs for forest inventory.

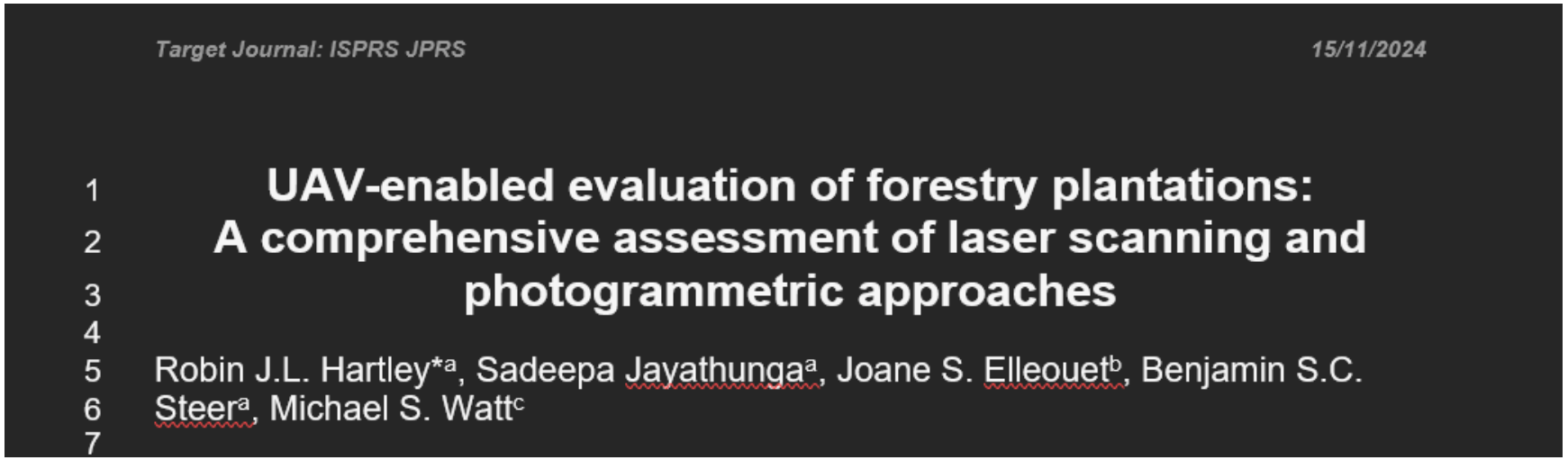
What's next?

- **Our findings demonstrated varied performance of site-specific models**, influenced by factors such as tree size and structure, sensor type, and presence of harvest debris.

- **Method Improvements**:
  - Further fine-tuning of the models using hyperparameter optimisation for better adaptation
  - Exploring SOTA deep learning models for improved accuracy
  - Extend this method to predict additional attributes like tree volume and Carbon

- **Exploring Generalisation**: Develop a generalised model using data from multiple sites. Test its versatility across sites to balance specificity and generalisation without compromising performance.

Stay tuned for our upcoming publication, where we'll provide more details, in-depth analysis, and comparisons.



We are also working on a R package, “TreenotypR - Tree Phenotyping in R”. This will include the method we used. We aim to publish it in December 2024.

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- **Scion team:**

Project team: Robin Hartley, Sadeepa Jayathunga, Joane Elleouet, Benjamin Steer and Michael Watt

Data collection and provision: Peter Massam, David Cajes, Honey Jane Estarija, Warren Yorston, Samuel Wong, John Henry, David Pont, Heather Flint, Stuart Fraser, David Lane, Liam Wright, Damien Sellier, Glen Thorlby, and Scion's Tree Biometrics team

Accelerator trials team: Simeon Smaill, and Lorretta Garret

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Interpine Innovation

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Transforming tree phenotyping

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Transforming tree phenotyping

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Thank You!

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