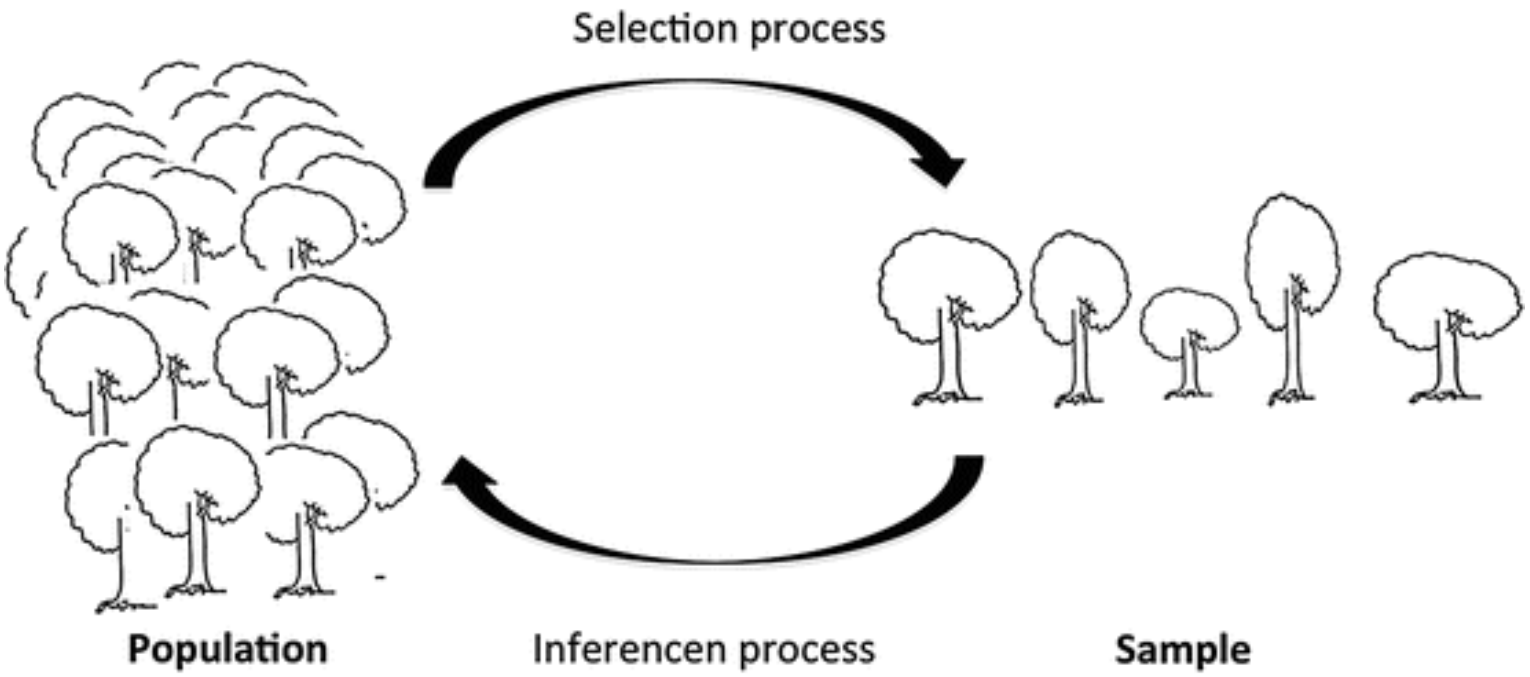
Low-Cost UAV  as a Tool for Aboveground Biomass Assessment in Teak Plantations : Pros and Cons

Ponthep Meunpong
Faculty of Forestry Kasetsart University

Estimation from a small plot

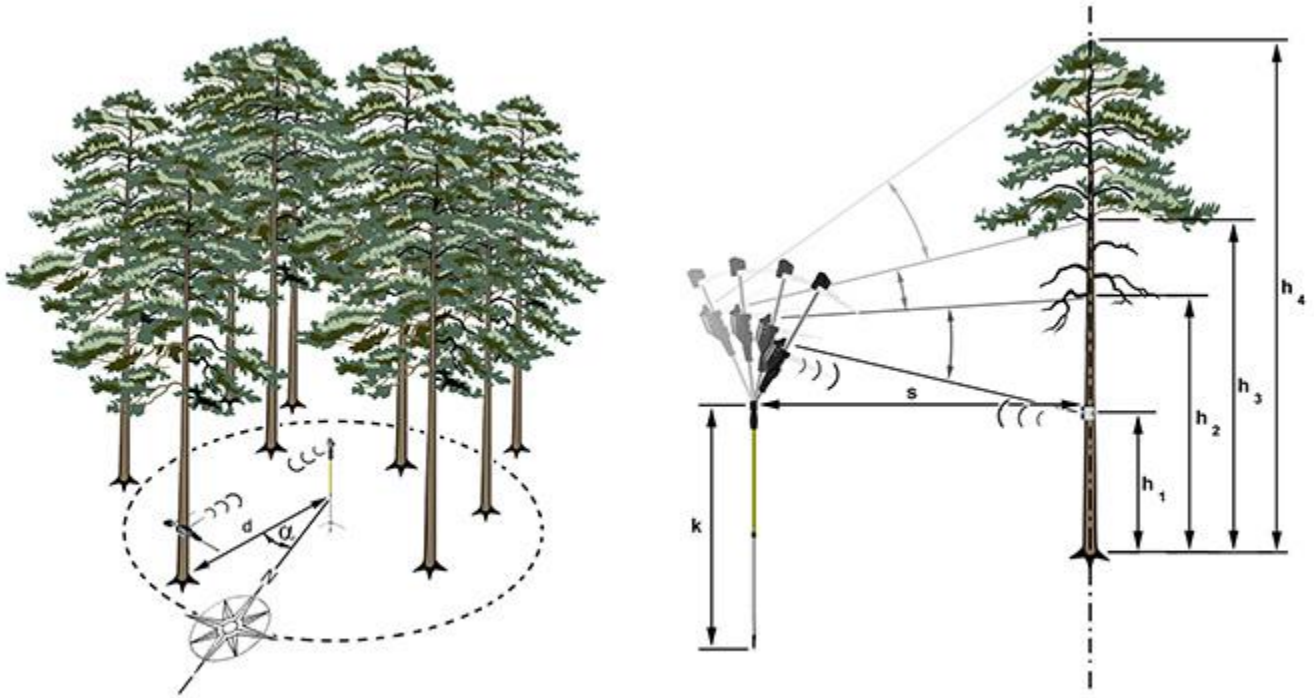
Any problems?



https://link.springer.com/referenceworkentry/10.1007/978-3-642-54601-3_72

1. Representation and Accuracy

- **Unrepresentative Sampling**
- **Edge Effects**



https://forestrypedia.com/what-is-forest-inventory/

2. Scaling Issues

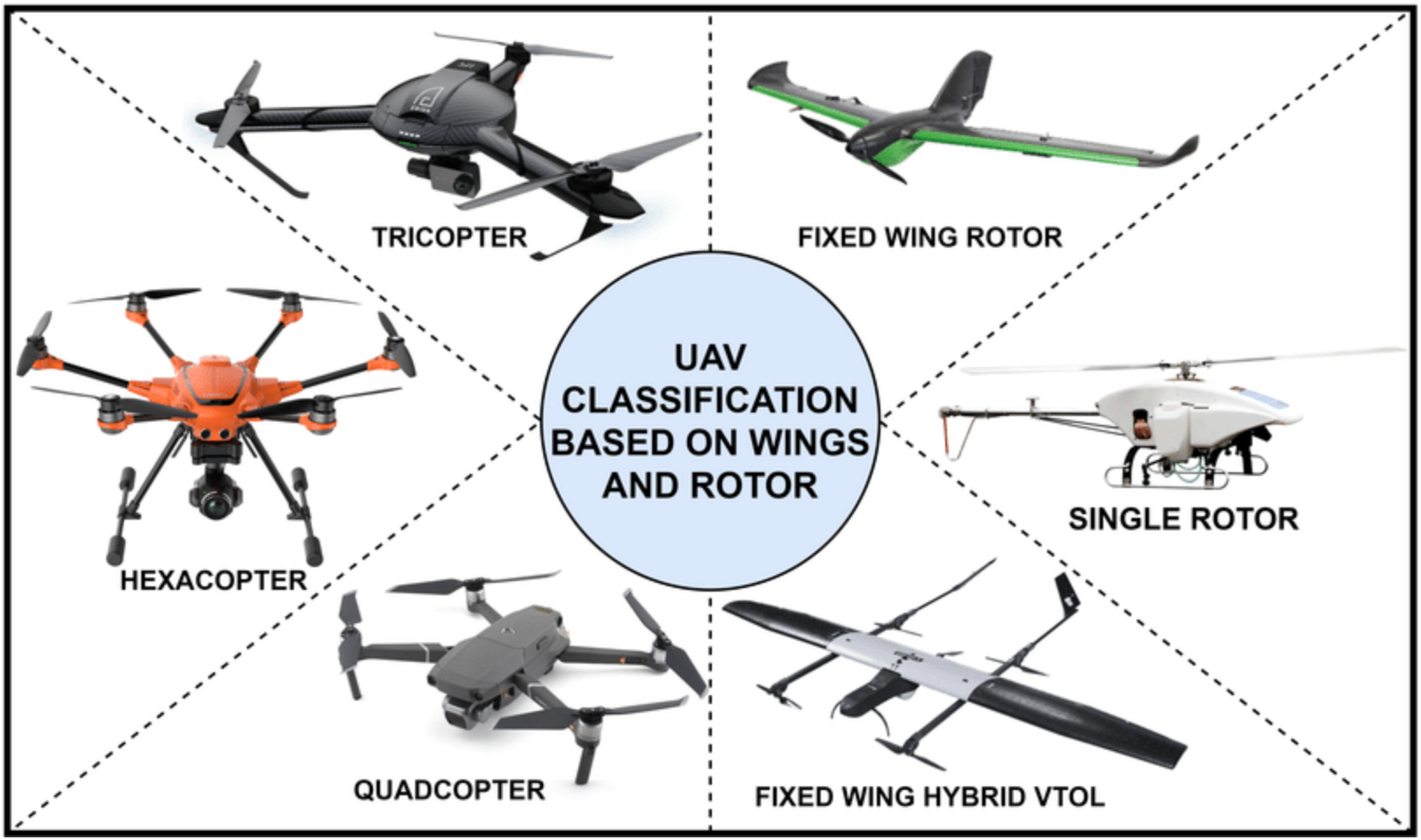
- **Extrapolation Error**
- **Nonlinear Growth Patterns**

3. Variability in Growth Rates

- **Species-Specific Growth**
- **Microclimatic Variations**
- **Disturbance Impact**
- **Uneven Terrain**

Traditional AGB Assessment Methods:
Ground-based measurements and allometric equations

UAV: Unmanned Aerial Vehicle



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Brand New

THB2,400.15

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from United States

Free returns

2 watchers

Low-Cost UAV

DJI Phantom 4 Pro V2.0 Drone Quadcopter UAV with 20MP Camera 1" CMOS Sensor 4K

Black Ant Official Store (234)
100% positive · Seller's other items · Contact seller

US $1,048.00

Approximately THB35,653.53

Condition: **Used**

"All functions are normal"

Quantity: 1 7 available · 33 sold

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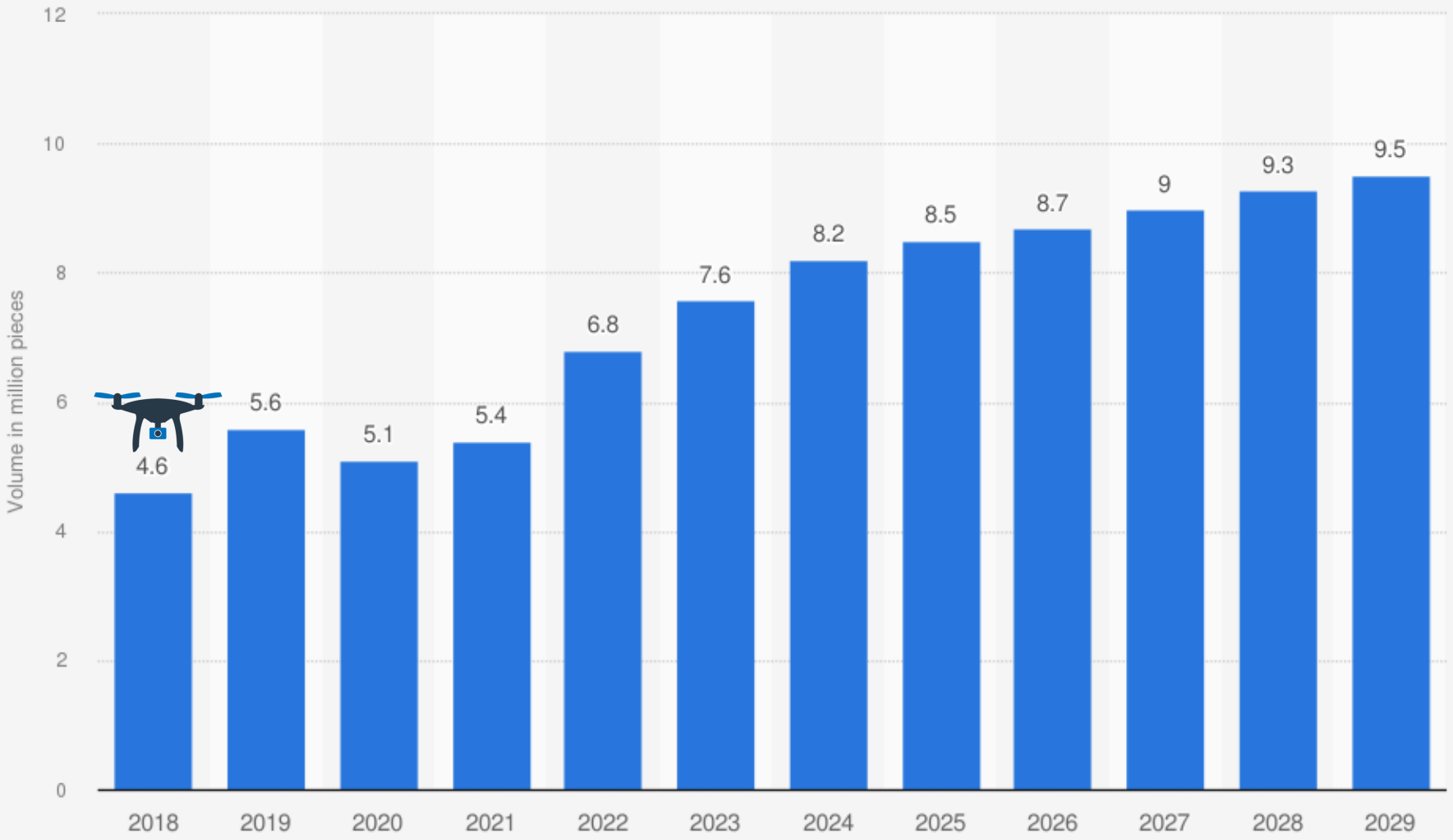
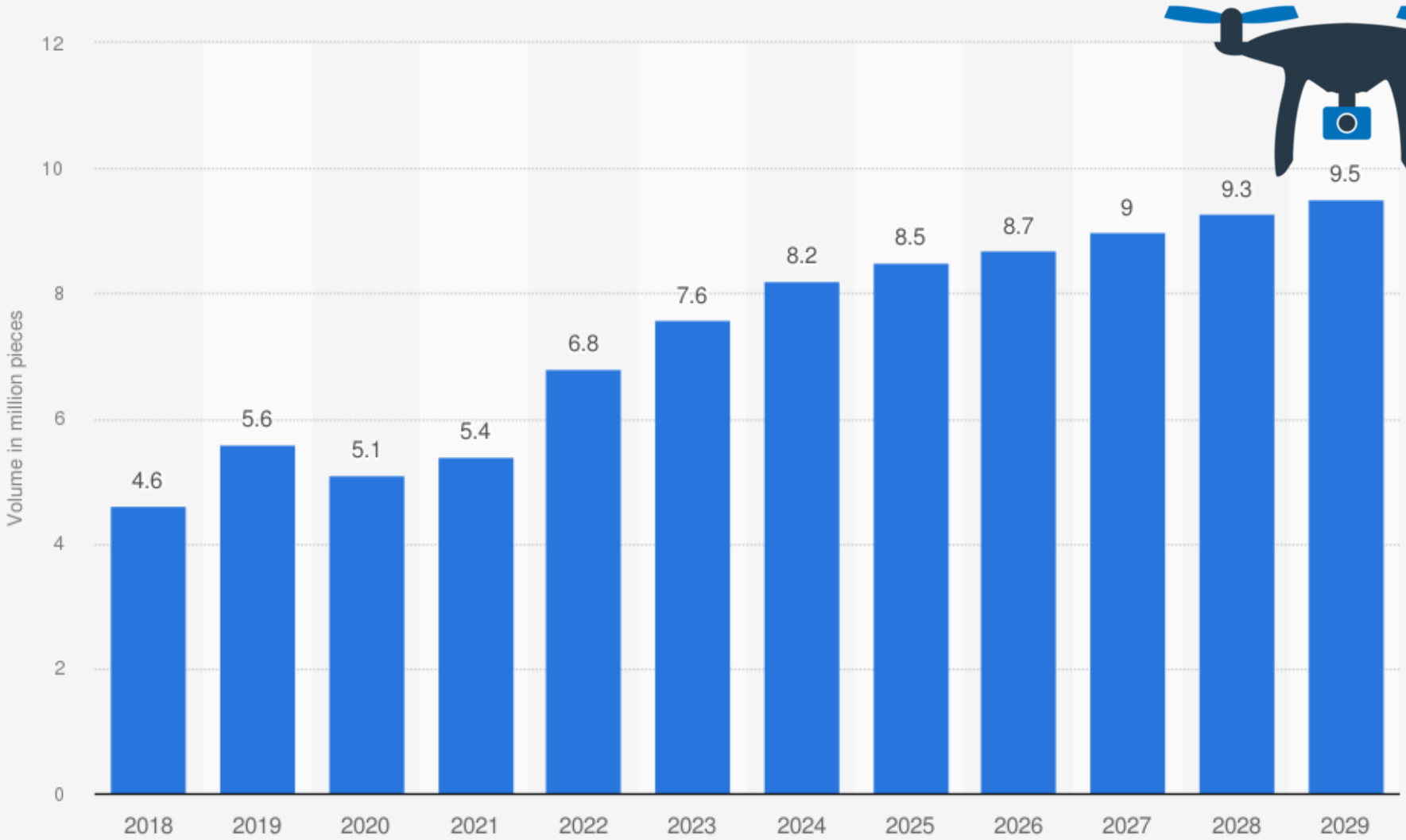
Volume of the global drone market from 2018 to 2029 (in million pieces)



Sources
Statista; Statista Consumer Market Insights

Additional Information:
Worldwide; Statista Consumer Market Insights; 2018 to 2024

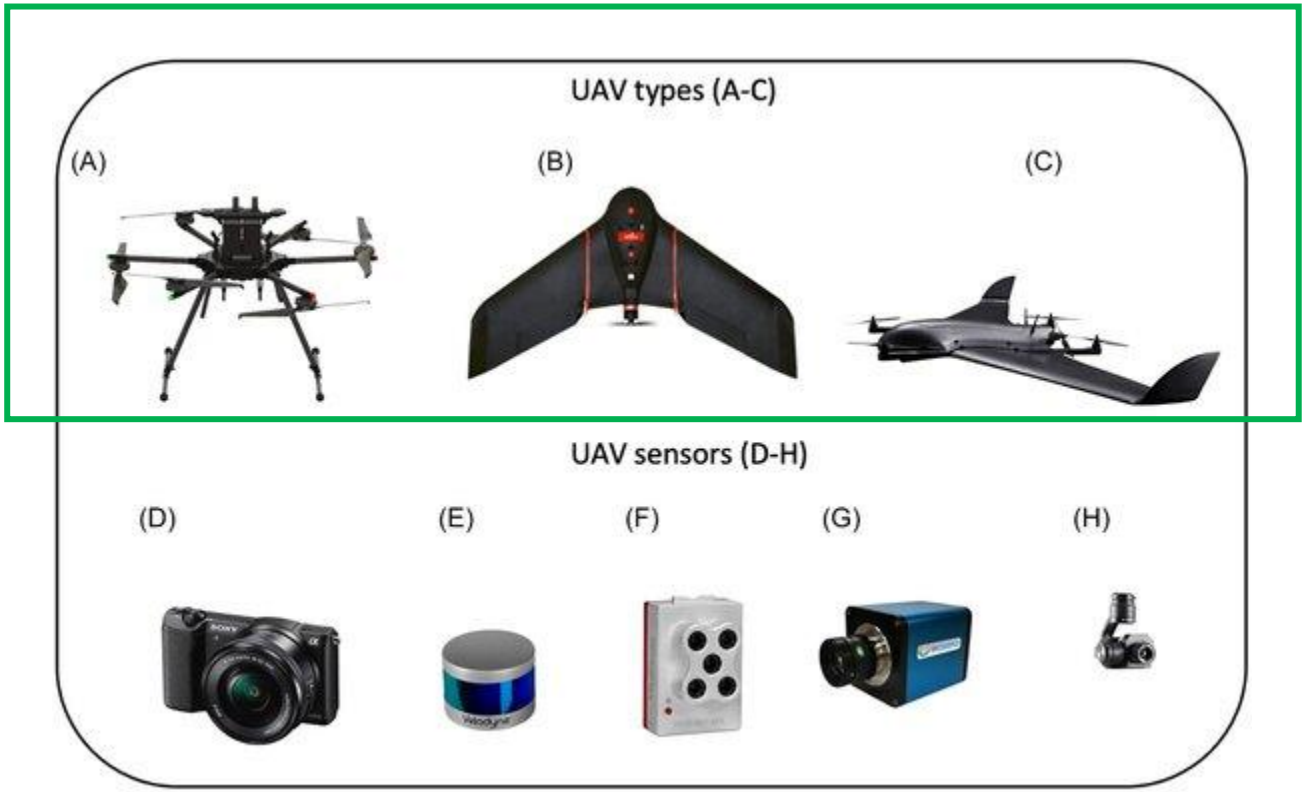
Volume of the global drone market from 2018 to 2029 (in million pieces)



Sources
Statista; Statista Consumer Market Insights

Additional Information:
Worldwide; Statista Consumer Market Insights; 2018 to 2024

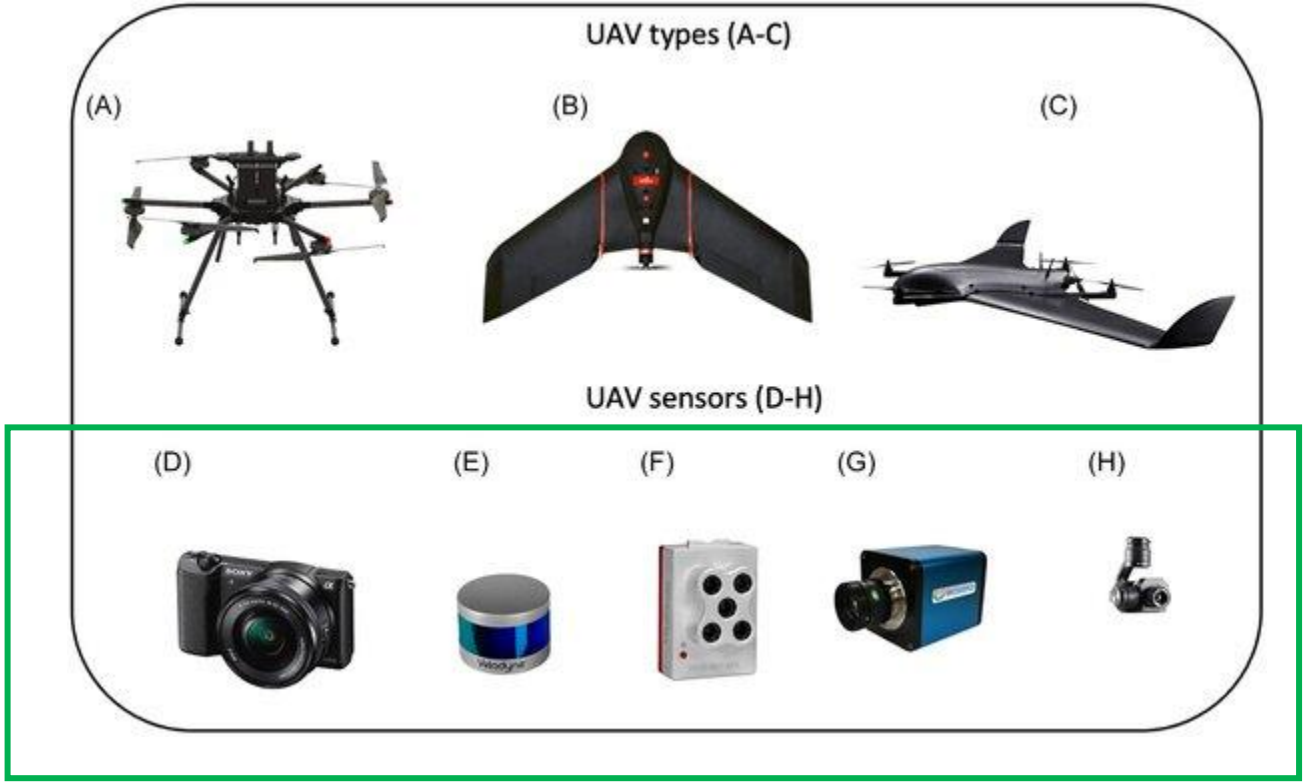
1. Selecting UAV



(A) rotary wings (Inspired flight IF1200A)
(B) fixed-wing (senseFly eBee SQ)
(C) hybrid, VTOL fixed-wing (DeltaQuad Evo);

https://acsess.onlinelibrary.wiley.com/doi/10.1002/ppj2.20100

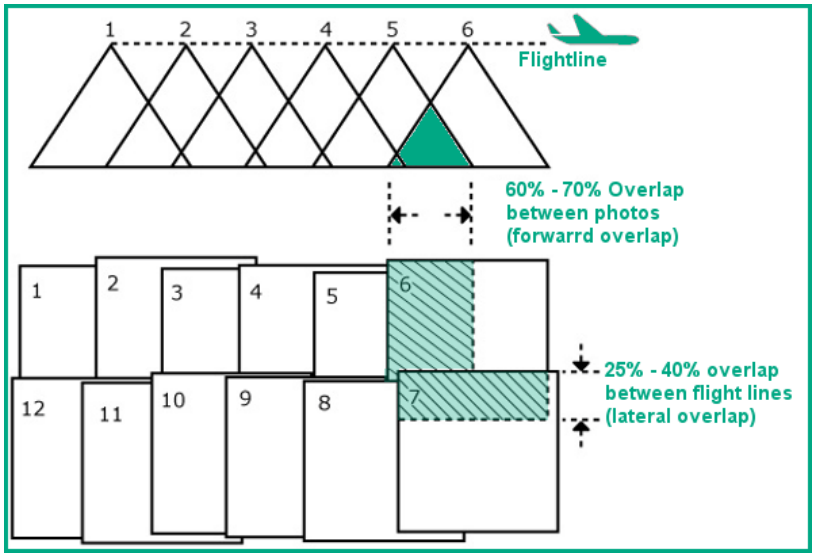
2. Selecting Sensors

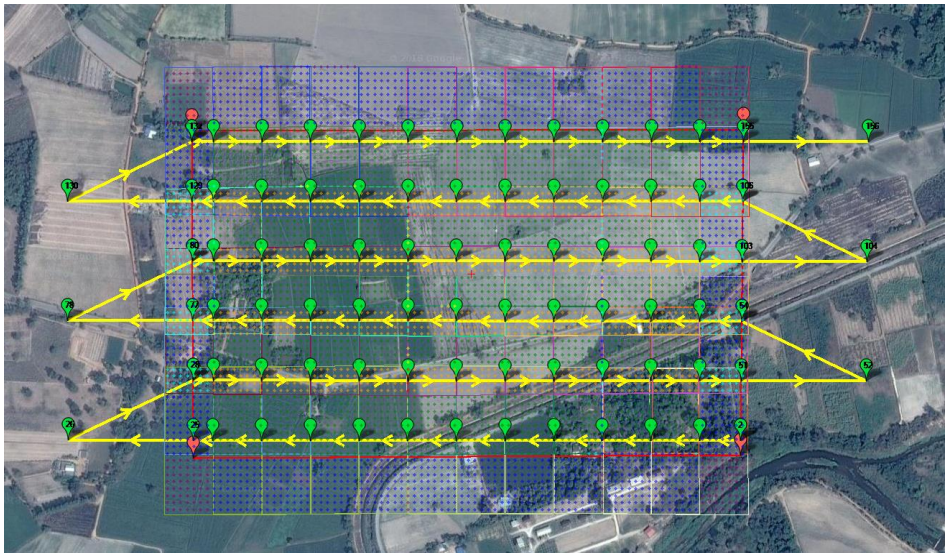


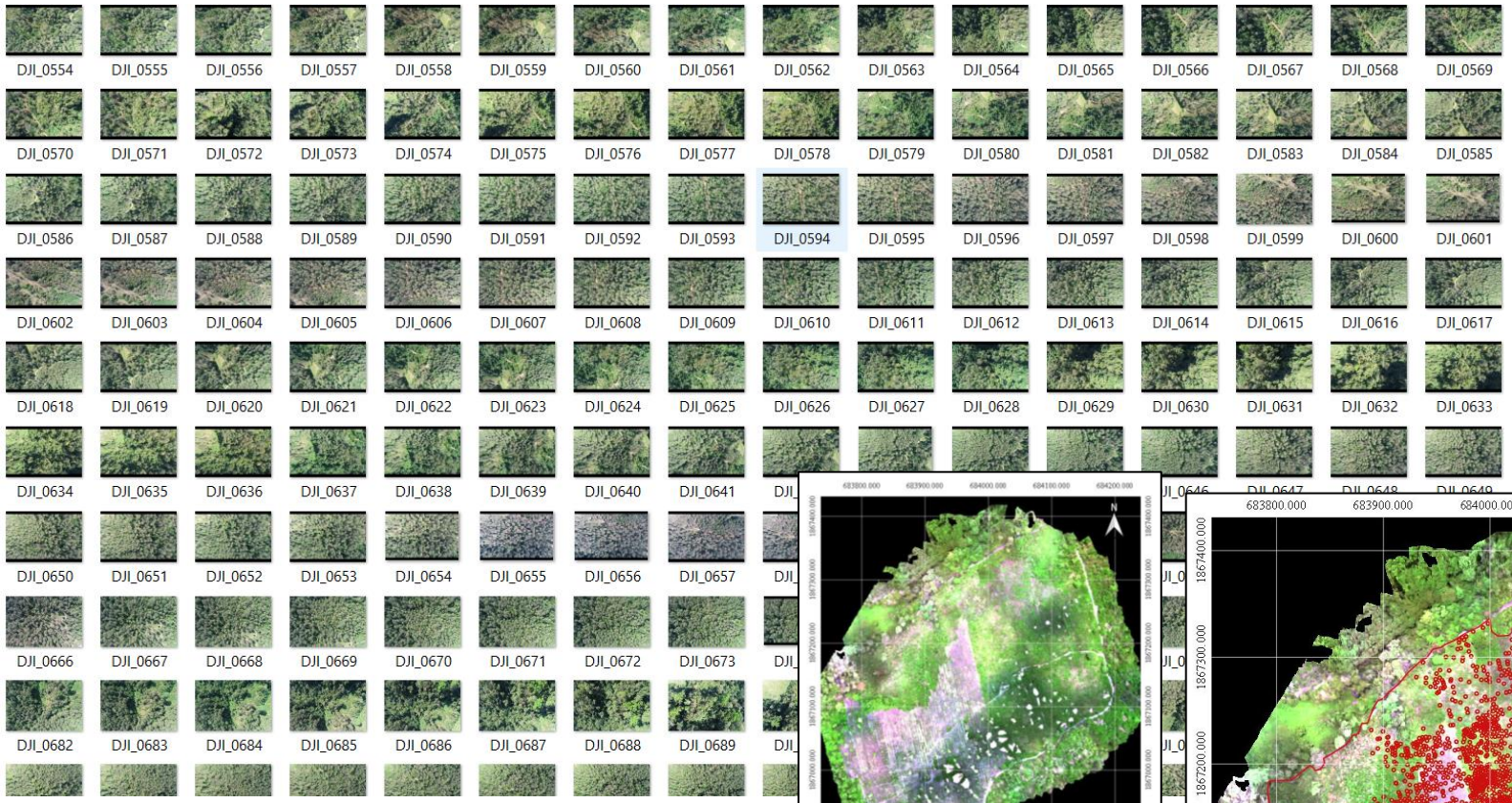
(D) RGB camera (Sony)
(E) Puck LITE LiDAR sensor (Velodyne)
(F) multispectral camera (Micasense)
(G) VIS-NIR hyperspectral camera (Optosky)
(H) DJI Zenmuse XT V2 640 thermal camera (DJI).

https://acsess.onlinelibrary.wiley.com/doi/10.1002/ppj2.20100

Data Collection Process



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DJI_0650 DJI_0651 DJI_0652 DJI_0653 DJI_0654 DJI_0655 DJI_0656 DJI_0657
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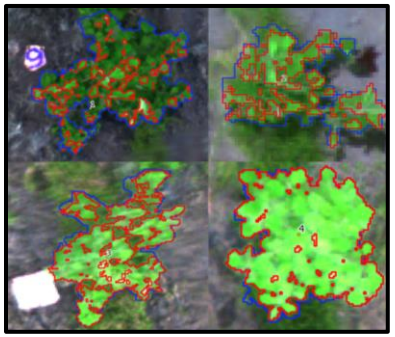

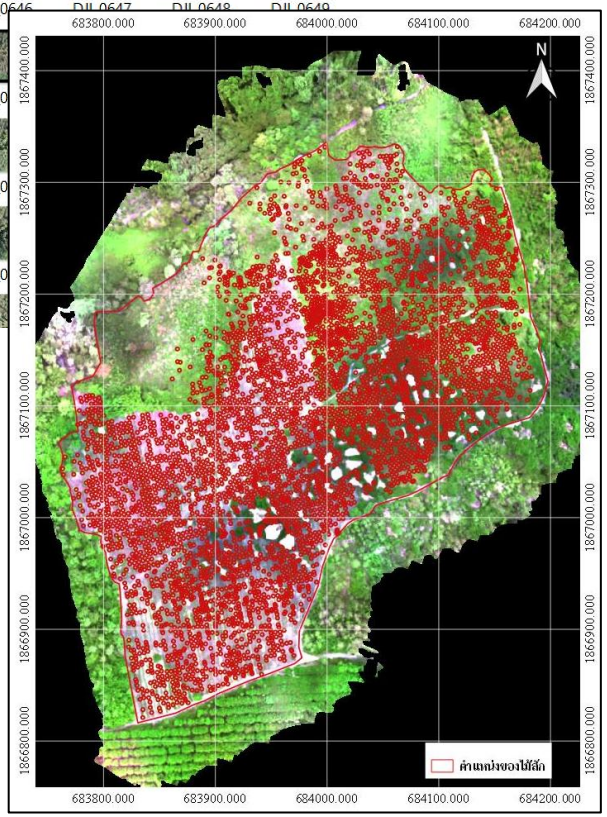
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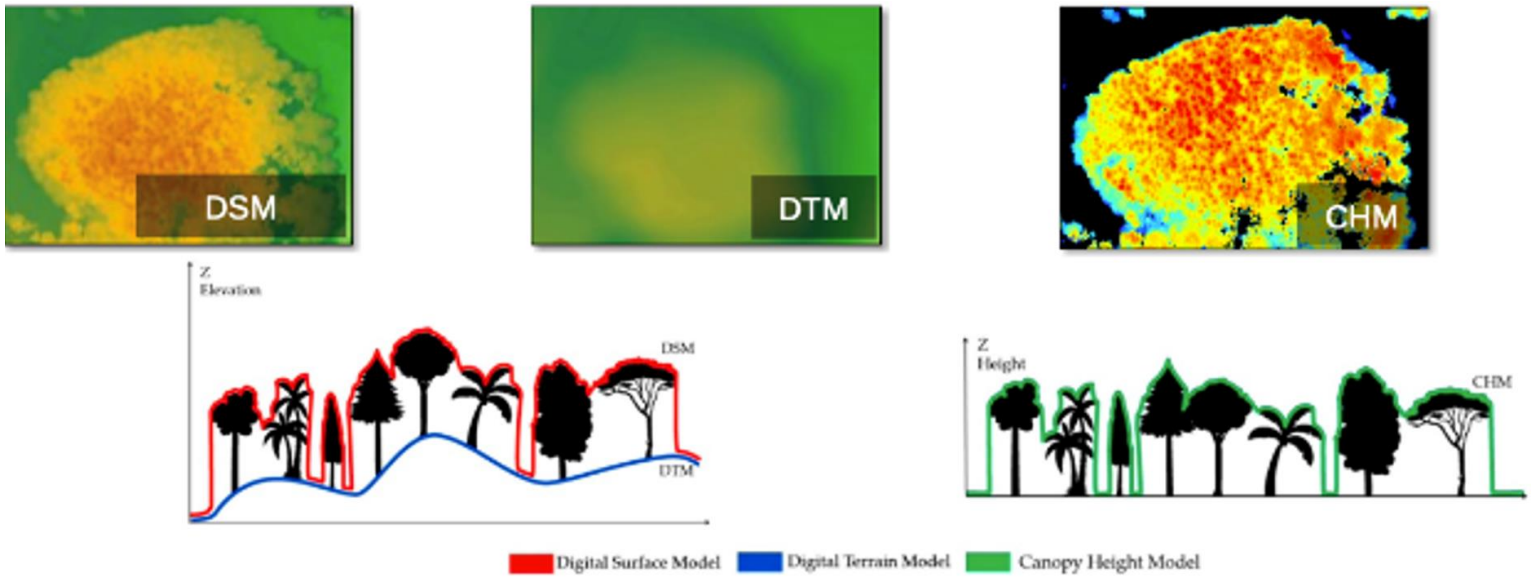
1866800.000
N
ค่าแหน่งของไม้สัก

PIX4D

Canopy Height Models (CHMs)



DSM – DTM = CHM

https://panorama.solutions/en/building-block/drone-data

Case Study: Application in Teak Plantations

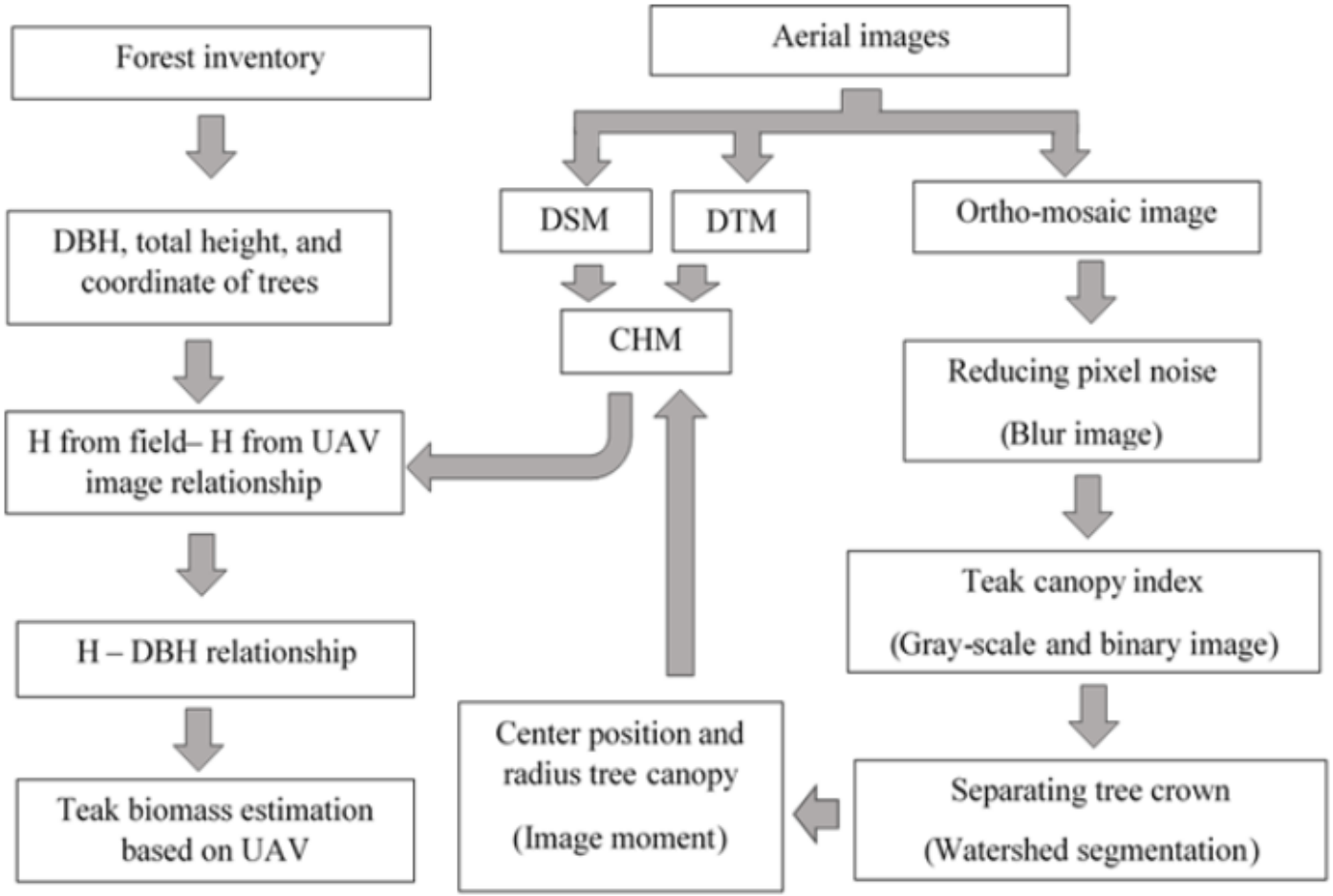
Estimation of aboveground biomass using aerial photogrammetry from unmanned aerial vehicle in teak (*Tectona grandis*) plantation in Thailand

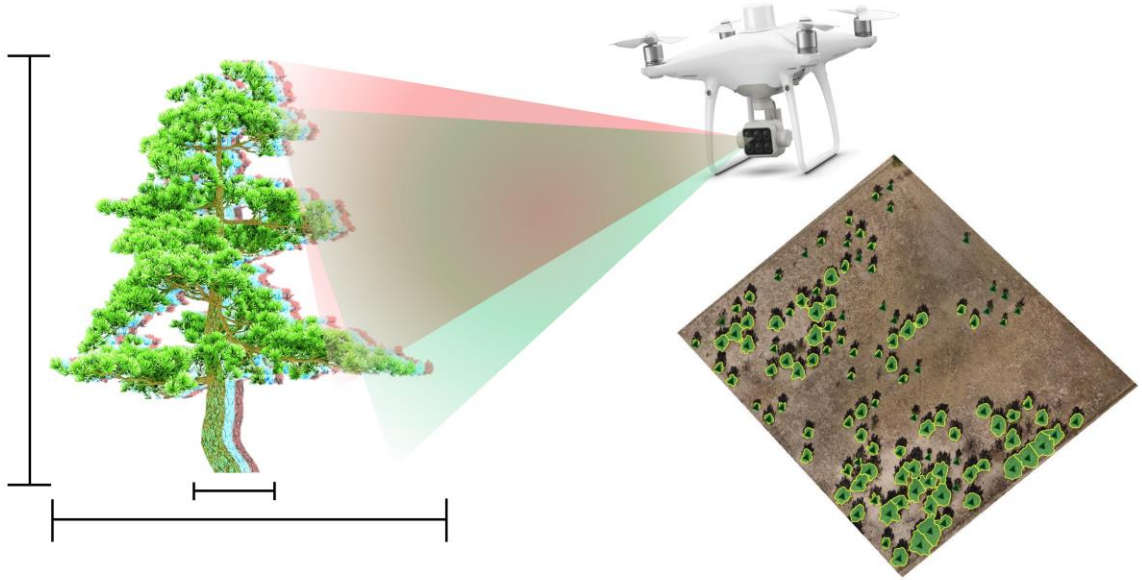
SASIWIMOL RINNAMANG[1], KAMPANART SIRIRUEANG[2], SORAVIS SUPAVETCH[3], PONTHEP MEUNPONG[1,♥]

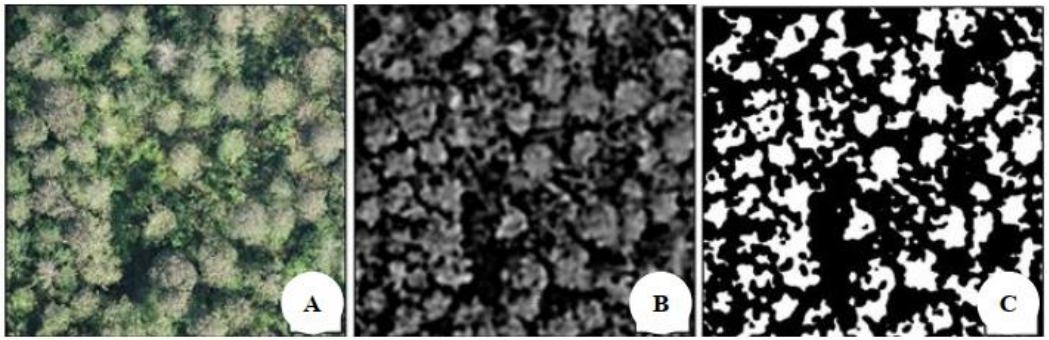
[1]Department of Silviculture, Faculty of Forestry, Kasetsart University. Bangkok 10900, Thailand. Tel./fax.: +6685-319-7912, ♥email: fforptm@ku.ac.th.
[2]World Wildlife Fund Thailand. Bangkok 10400, Thailand
[3]Department of Civil Engineering, Faculty of Engineering, Kasetsart University. Bangkok 10900, Thailand

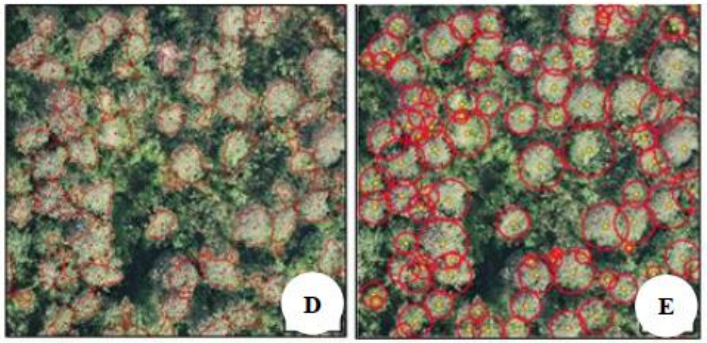
Manuscript received: 17 March 2020. Revision accepted: 6 May 2020.

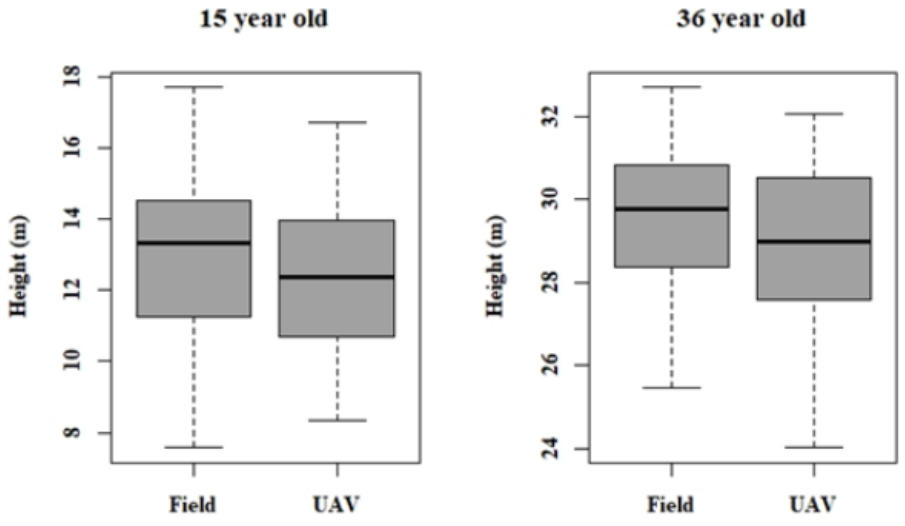
Workflow


Forest inventory
DBH, total height, and coordinate of trees
H from field– H from UAV image relationship
H – DBH relationship
Teak biomass estimation based on UAV
Aerial images
DSM
DTM
CHM
Ortho-mosaic image
Reducing pixel noise
(Blur image)
Teak canopy index
(Gray-scale and binary image)
Separating tree crown
(Watershed segmentation)
Center position and radius tree canopy
(Image moment)

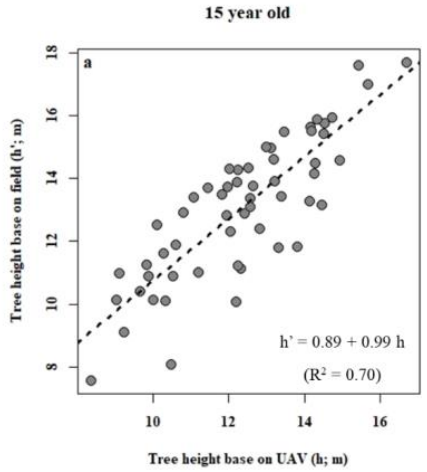


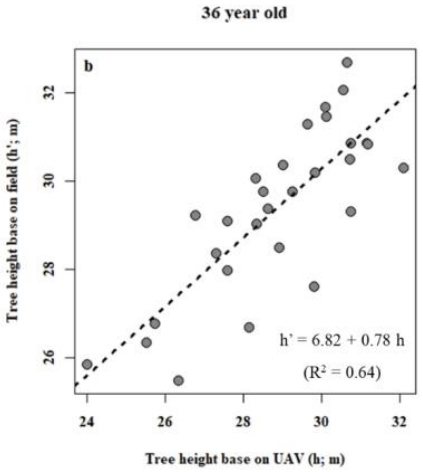

A
B
C

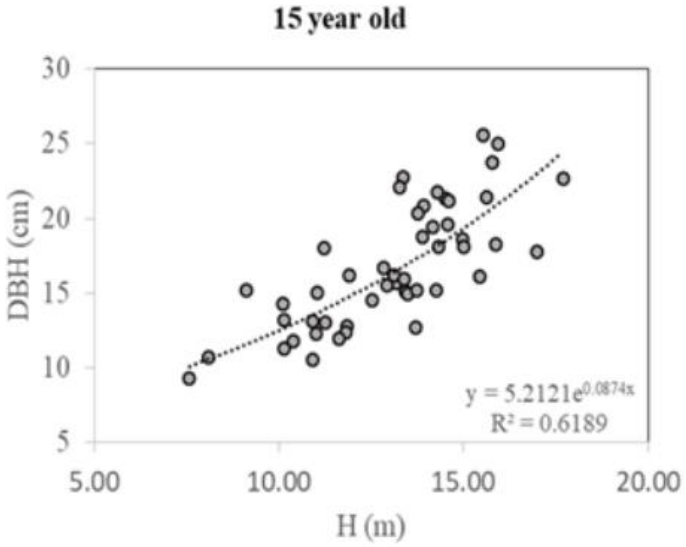

D
E


15 year old
Height (m)
Field
UAV

36 year old
Height (m)
Field
UAV


15 year old
a
Tree height base on field (h'; m)
Tree height base on UAV (h; m)
h' = 0.89 + 0.99 h
(R² = 0.70)


36 year old
b
Tree height base on field (h'; m)
Tree height base on UAV (h; m)
h' = 6.82 + 0.78 h
(R² = 0.64)


15 year old
DBH (cm)
H (m)
y = 5.2121e^0.0874x
R² = 0.6189

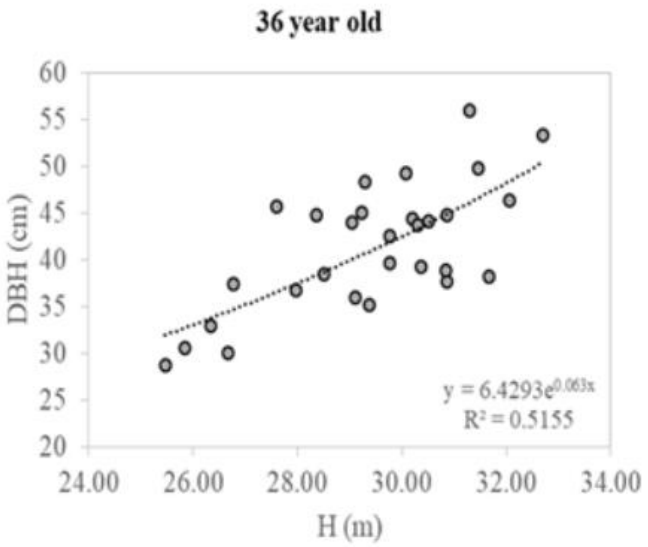
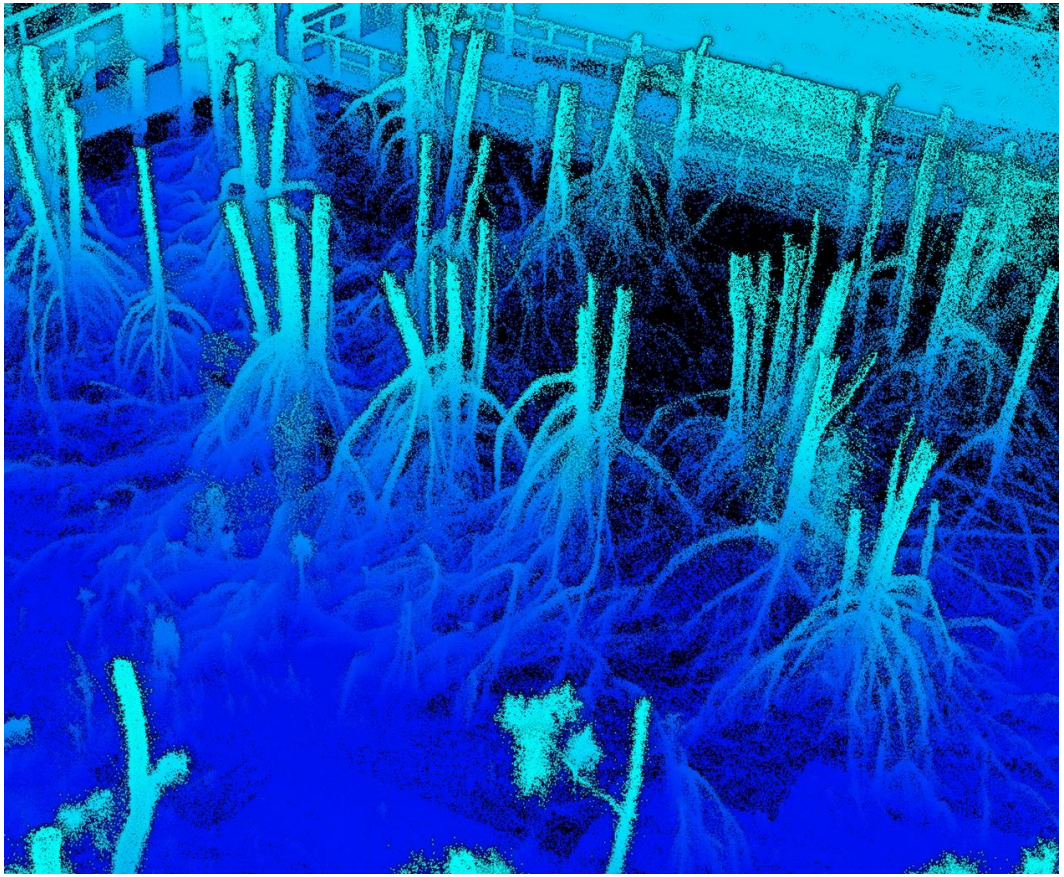

36 year old
DBH (cm)
H (m)
y = 6.4293e^0.063x
R² = 0.5155

Table 2. Tree density, tree height, DBH, basal area and teak biomass (t ha^{-1}) of 15 and 36 years stand in this study and other studies

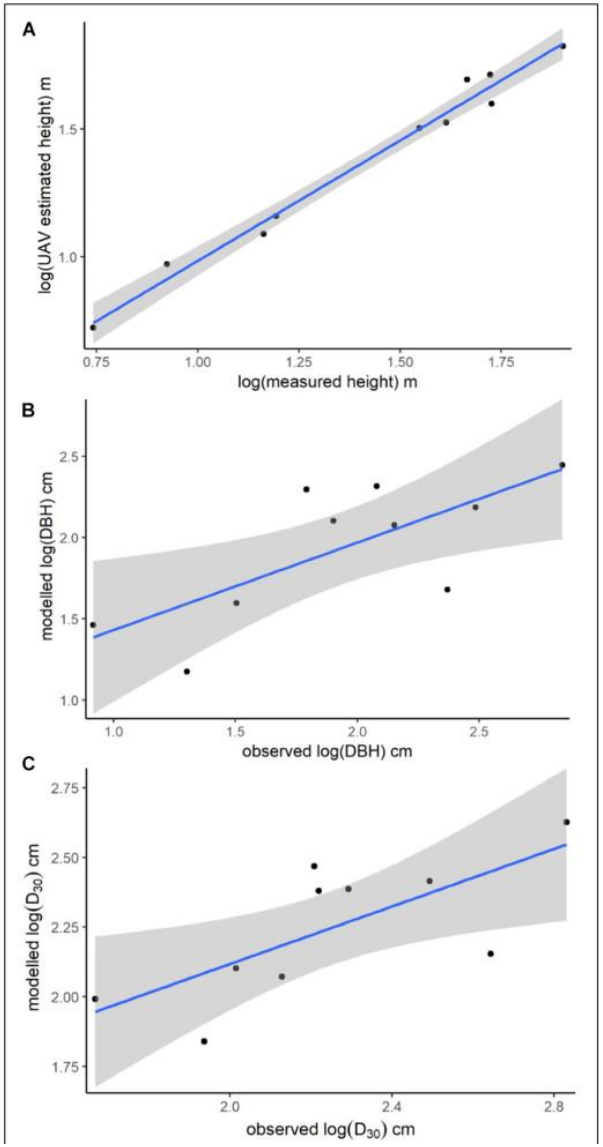
Stand age (year)	Ground truth data					Total biomass base on UAV data (t ha^{-1})	References
	Tree density (t ha^{-1})	Tree height (m)	DBH (cm)	Basal area (m^2 ha^{-1})	Total biomass (t ha^{-1})		
15	455	13.1 ± 0.3	17.2 ± 0.6	10.5	41.50	42.07	This study
	614	17.9	17.27	-	81.32	-	(Diloksumpun et al. 2011)
36	120	29.4 ± 0.4	41.4 ± 1.3	16.3	84.28	67.13	This study
	252	14.14 ± 1.68	28.42 ± 2.56	-	73.57	-	(Kongmeesup and Boonyanuphap 2019)

Advantages of Using Low-Cost UAVs

Accessibility and Coverage of Complex Areas

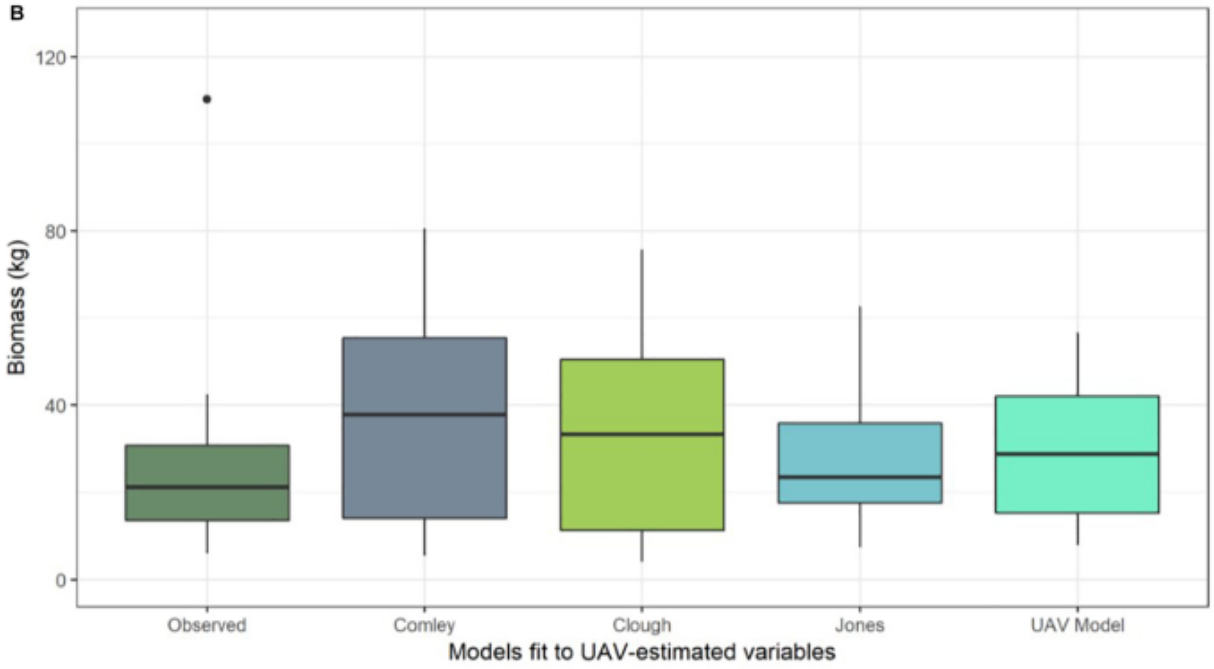


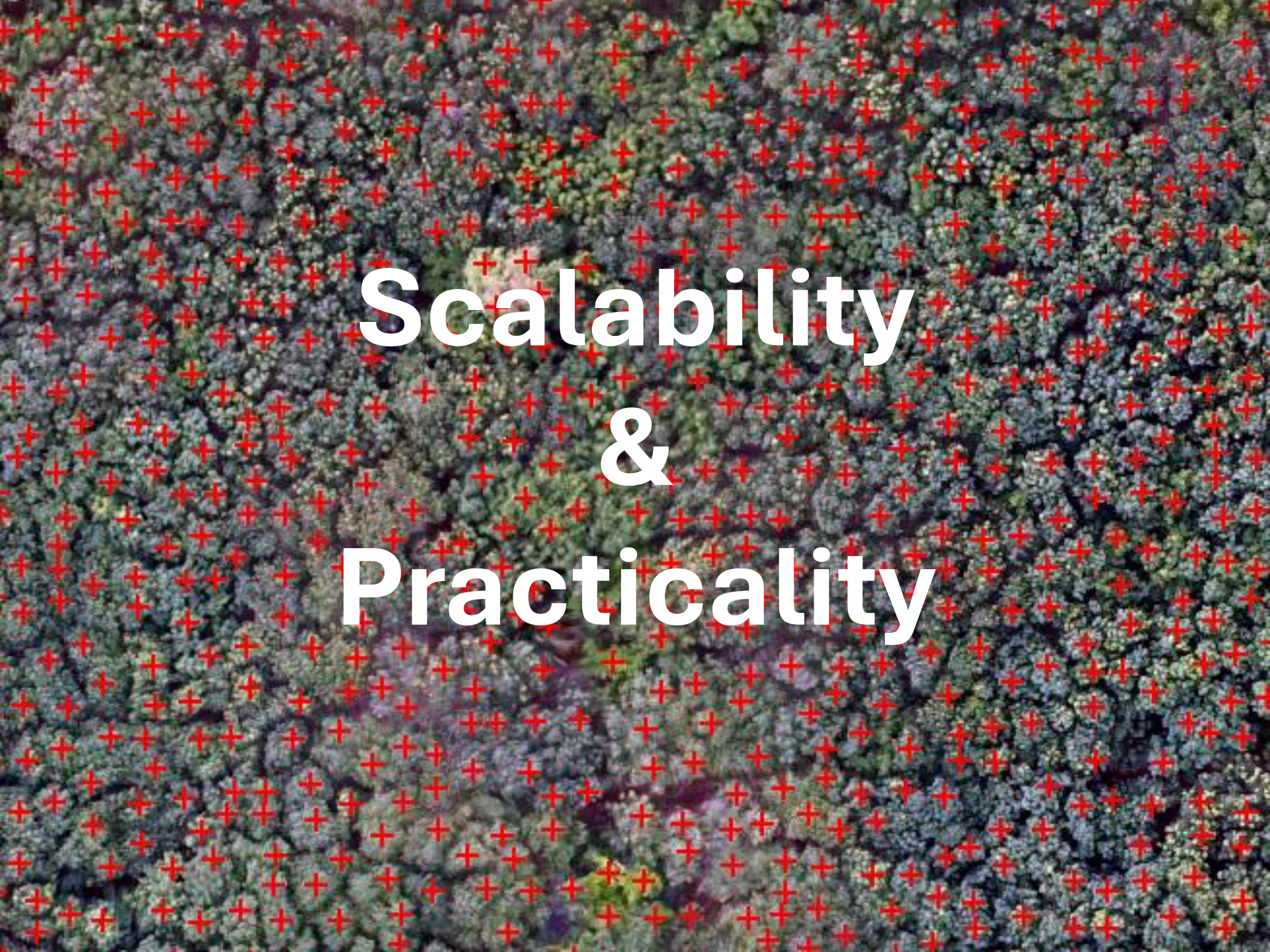
Accuracy and Data Quality



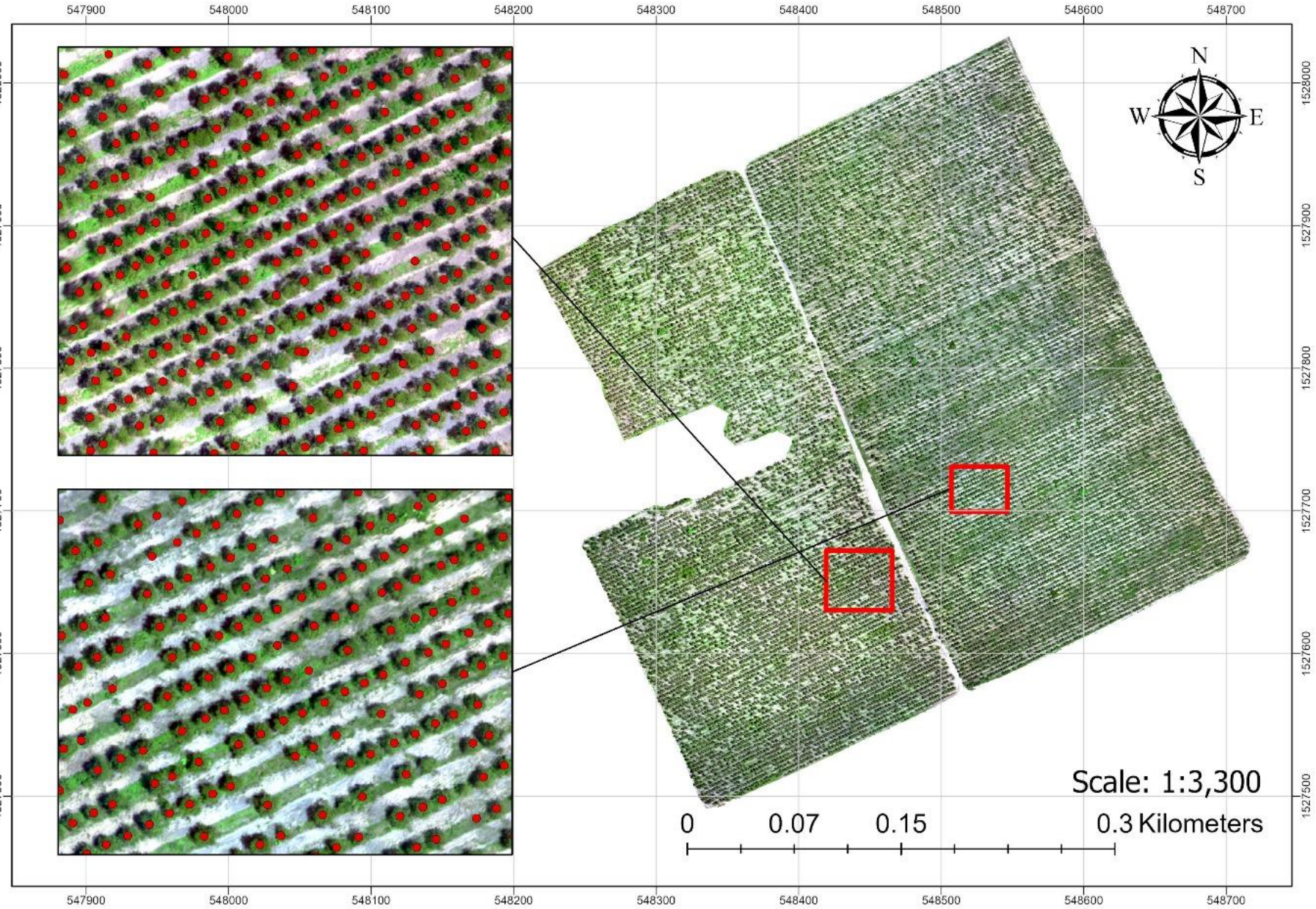
Estimating Mangrove Tree Biomass and Carbon Content: A Comparison of Forest Inventory Techniques and Drone Imagery

Alice R. Jones[1], Ramesh Raja Segaran[1], Kenneth D. Clarke[1], Michelle Waycott[1,2,3], William S. H. Goh[1] and Bronwyn M. Gillanders[1,2]*




Scalability
&
Practicality

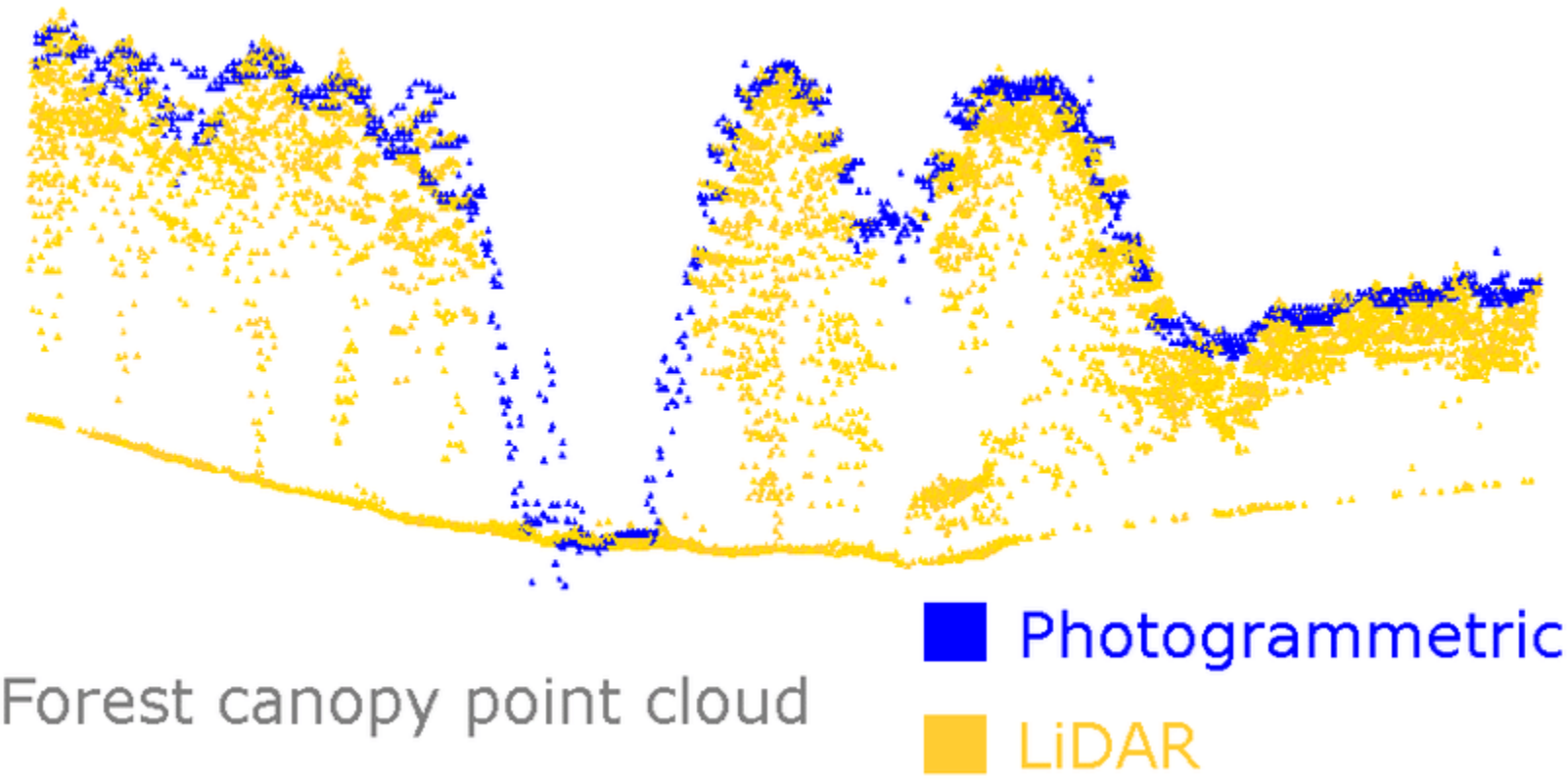
Scalability




Environmental Impact

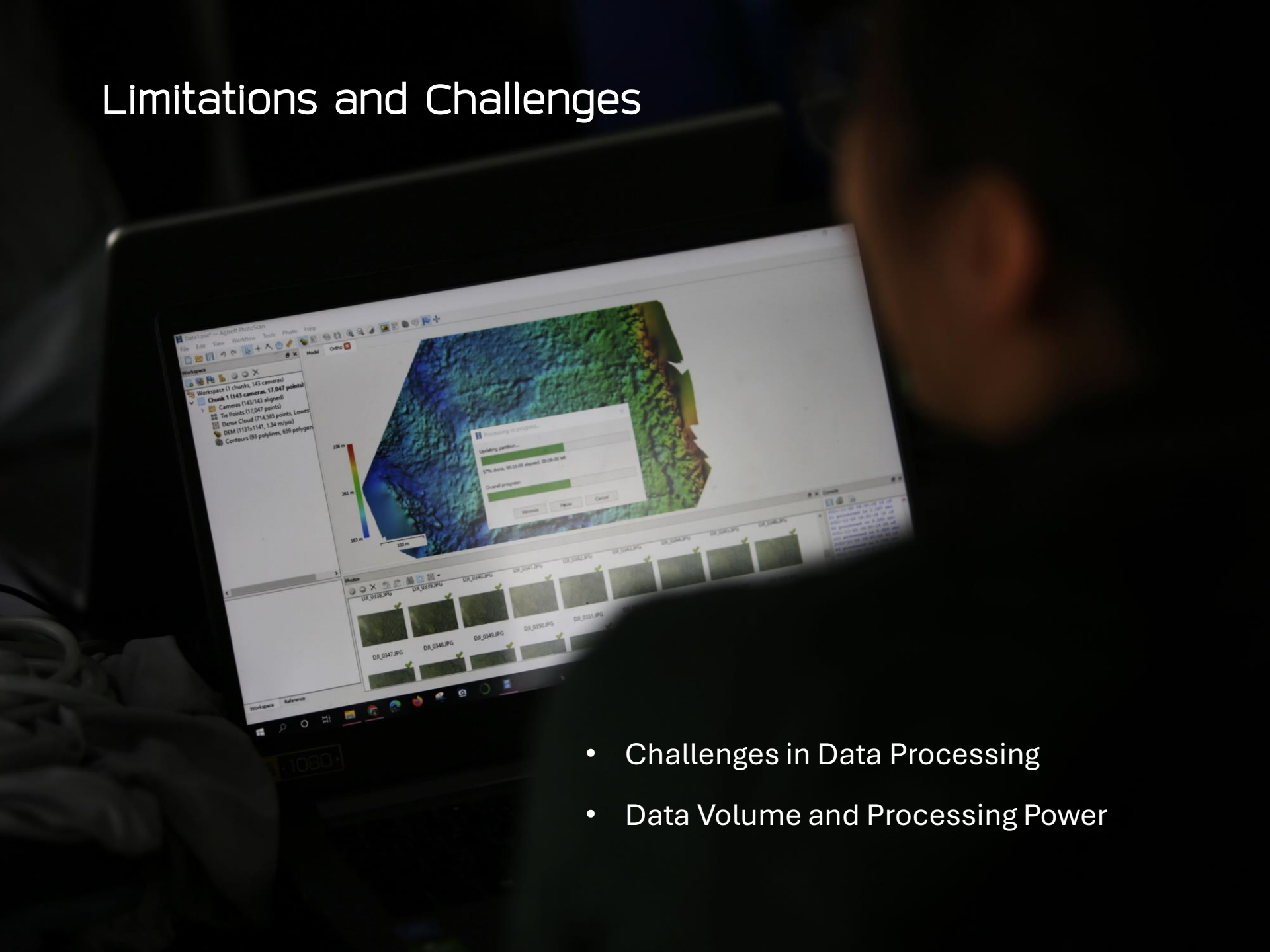
Limitations and Challenges

- Low-Resolution Sensors
- Inconsistent Altitude and Overlap
- Poor GPS Accuracy
- Weather Conditions



Forest canopy point cloud

Limitations and Challenges



- Challenges in Data Processing
- Data Volume and Processing Power

Conclusion

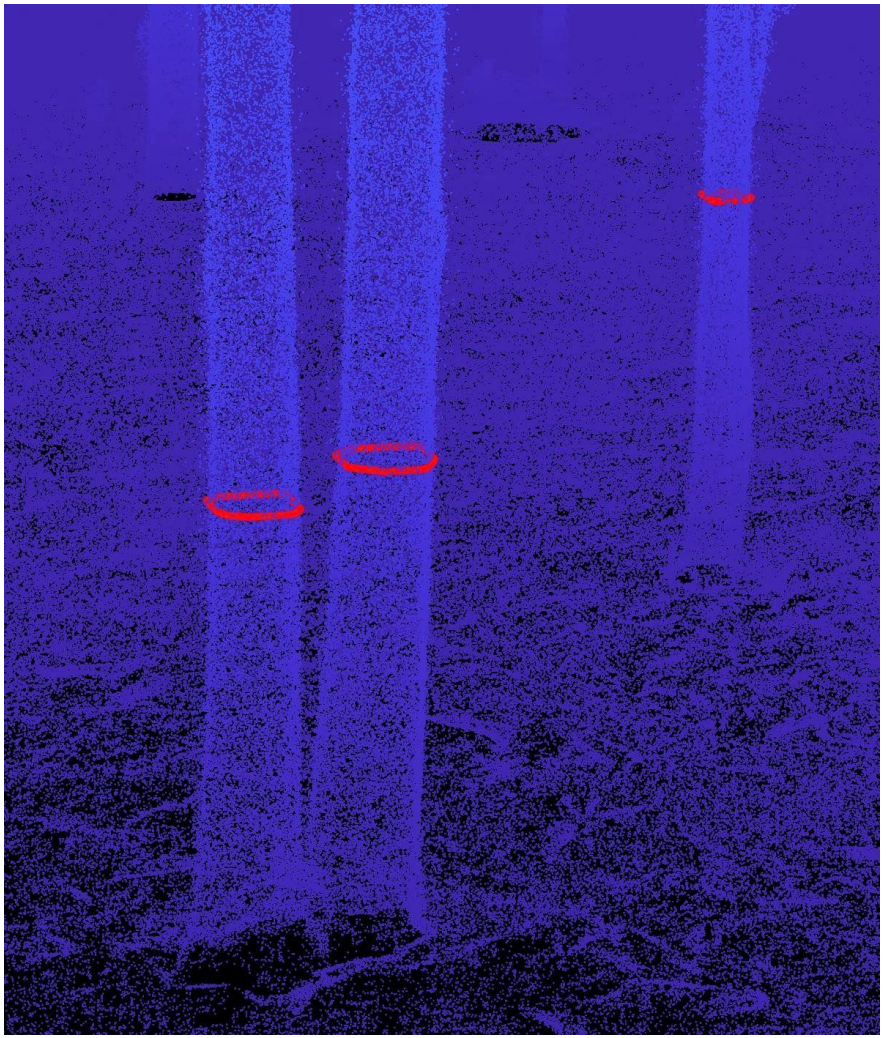
Data Accuracy

Factor	UAVs	Traditional Methods	Winner
Data Collection	Automated, sensor-based, highly accurate	Manual, prone to human error	**UAVs**
Spatial Resolution	High-resolution (sub-centimeter) coverage	Limited sample-based resolution	**UAVs**
Consistency	High (automated flights, GPS)	Inconsistent (manual measurements, human error)	**UAVs**
Coverage	Large areas, difficult terrain, full canopy	Limited to accessible terrain	**UAVs**
Data Processing	Automated, detailed, multi-layered analysis	Manual, slower, less data-rich	**UAVs**
Environmental Impact	Non-invasive, real-time data capture	Destructive (e.g., tree felling)	**UAVs** (non-destructive data)

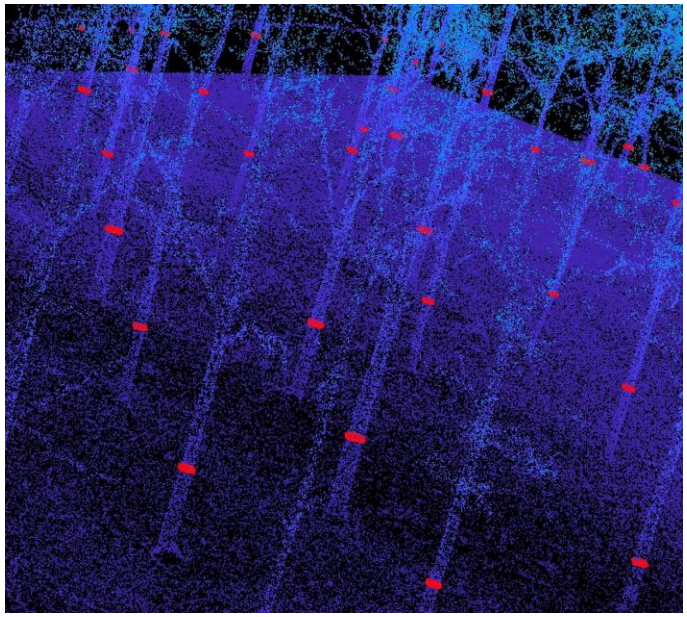
Cost- Benefit

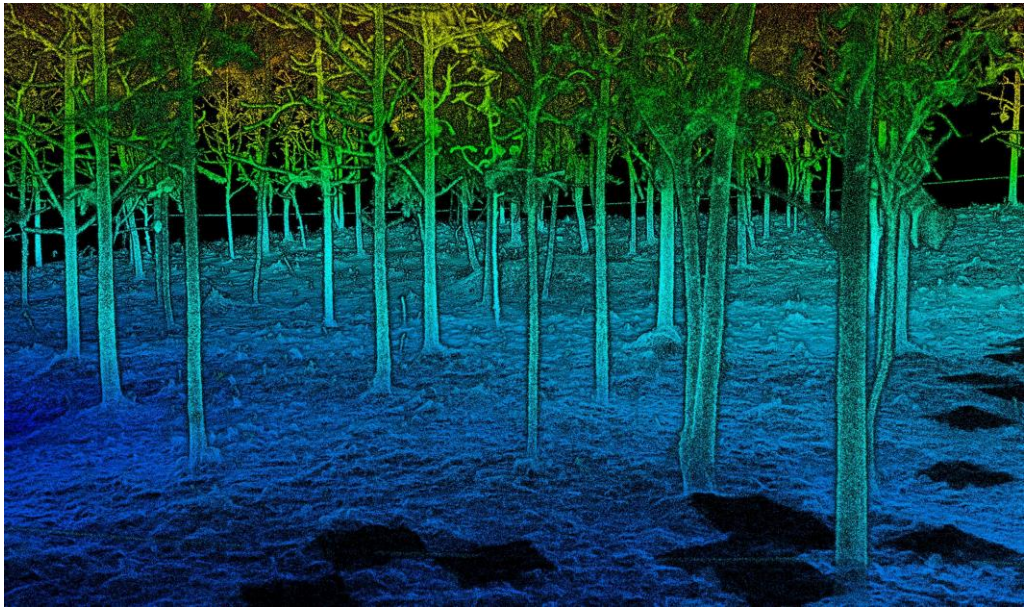
Factor	UAVs with Photogrammetry	Traditional Tree Felling Methods	Winner
Initial Cost	Moderate to High (technology cost)	Moderate (labor and equipment cost)	UAVs (long-term savings)
Operating Cost	Low (minimal labor, battery, software)	High (labor-intensive, fuel, equipment)	UAVs
Accuracy and Data Quality	High (non-invasive, precise models)	High (but limited to individual trees)	UAVs (scalable accuracy)
Time Efficiency	Very fast (covers large areas quickly)	Very slow (manual, time-consuming)	UAVs
Environmental Impact	Minimal (non-invasive)	Significant (destructive, disrupts ecosystem)	UAVs
Scalability	High (easy to scale for large forests)	Low (difficult to scale up manually)	UAVs

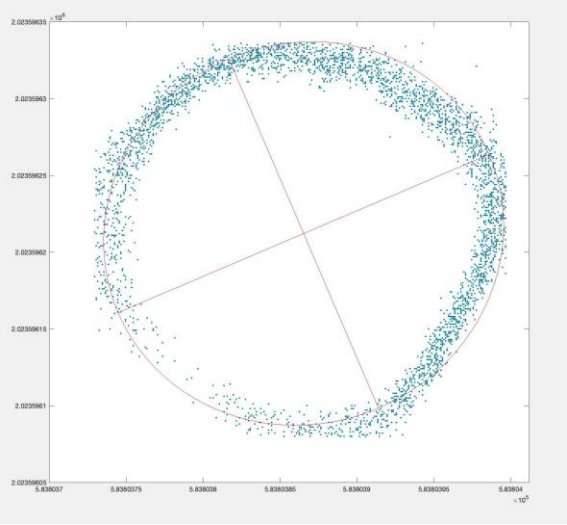
Future Outlook

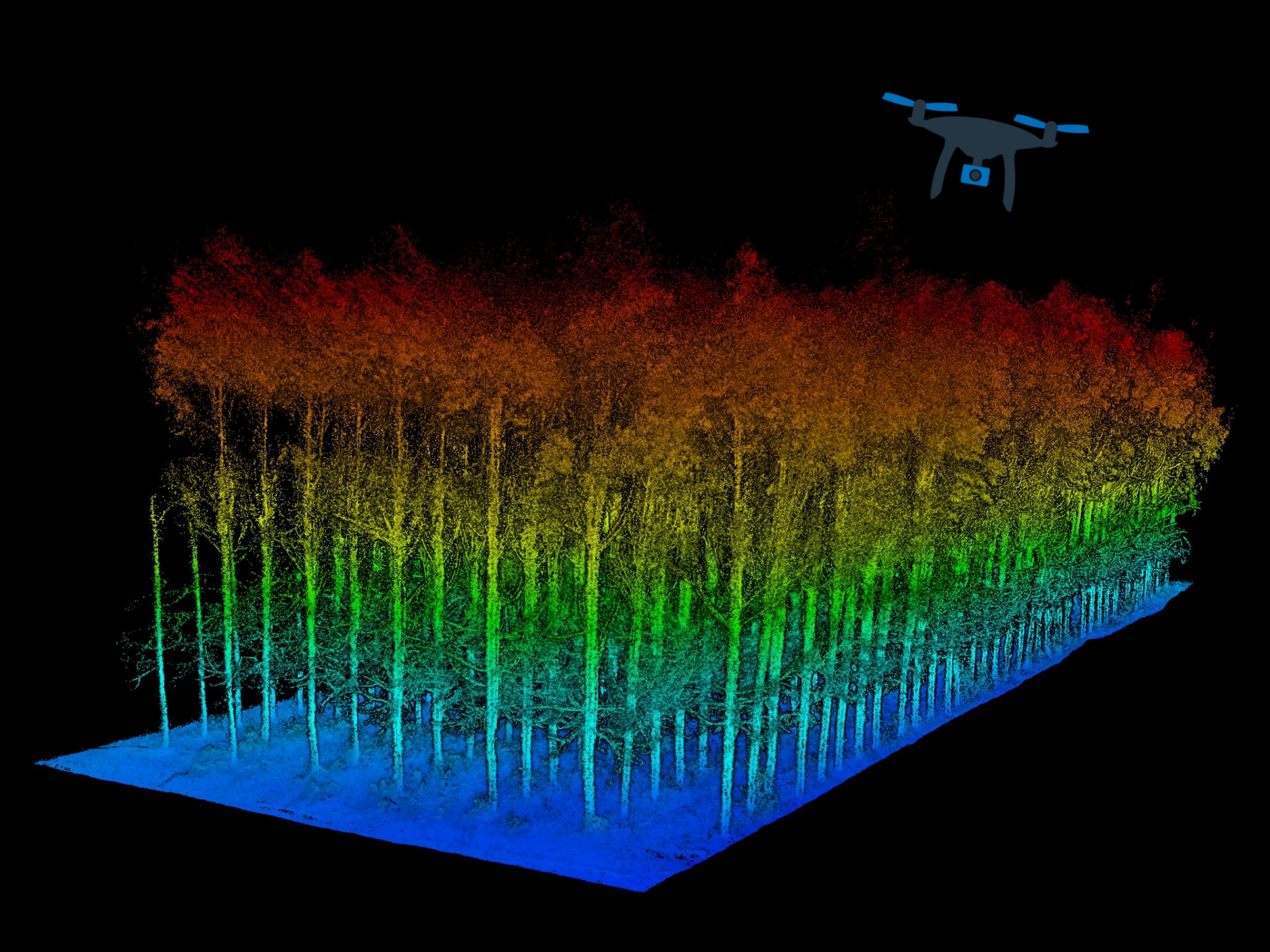


Integration of Advanced Sensors









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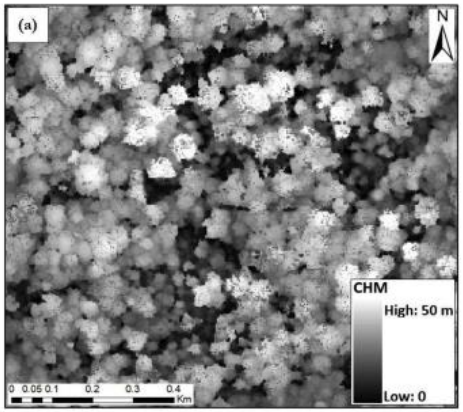
journal homepage: www.elsevier.com/locate/jag

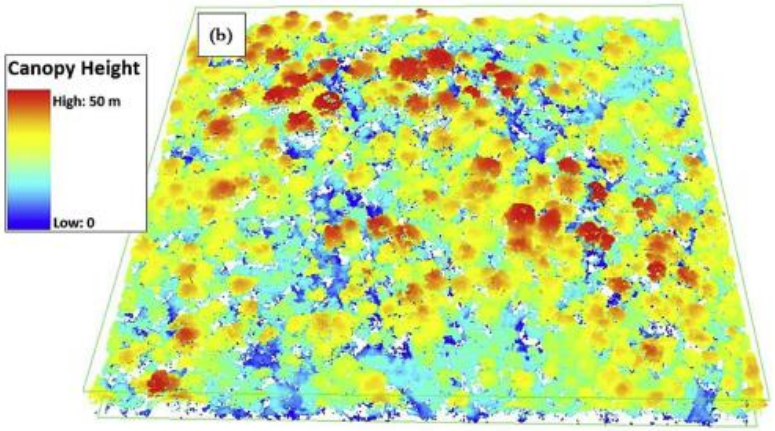
Higher accuracy

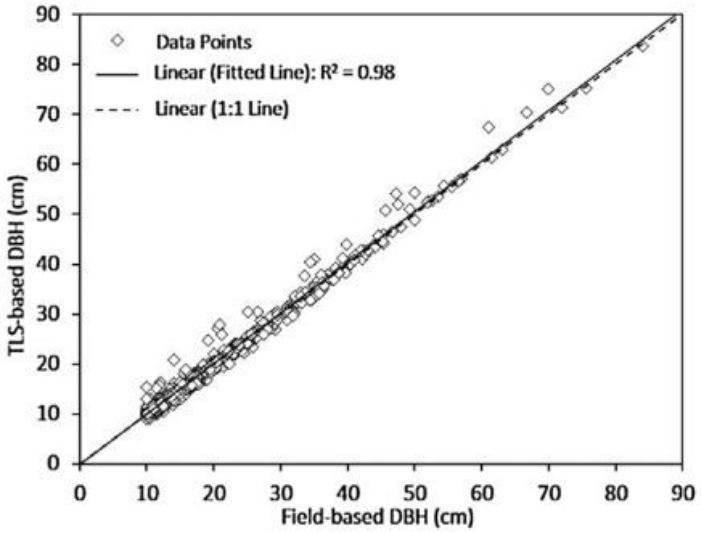
Integrating Airborne LiDAR and Terrestrial Laser Scanner forest parameters for accurate above-ground biomass/carbon estimation in Ayer Hitam tropical forest, Malaysia

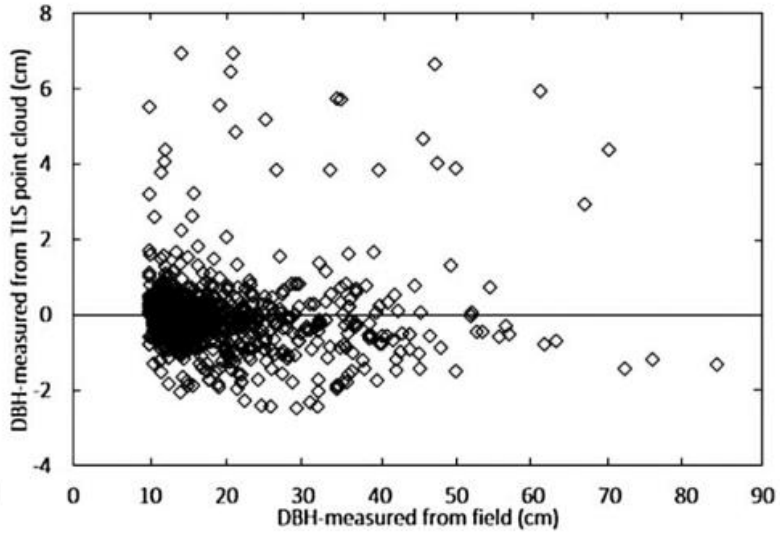
Muluken N. Bazezew[a,*], Yousif A. Hussin[b], E.H. Kloosterman[b]

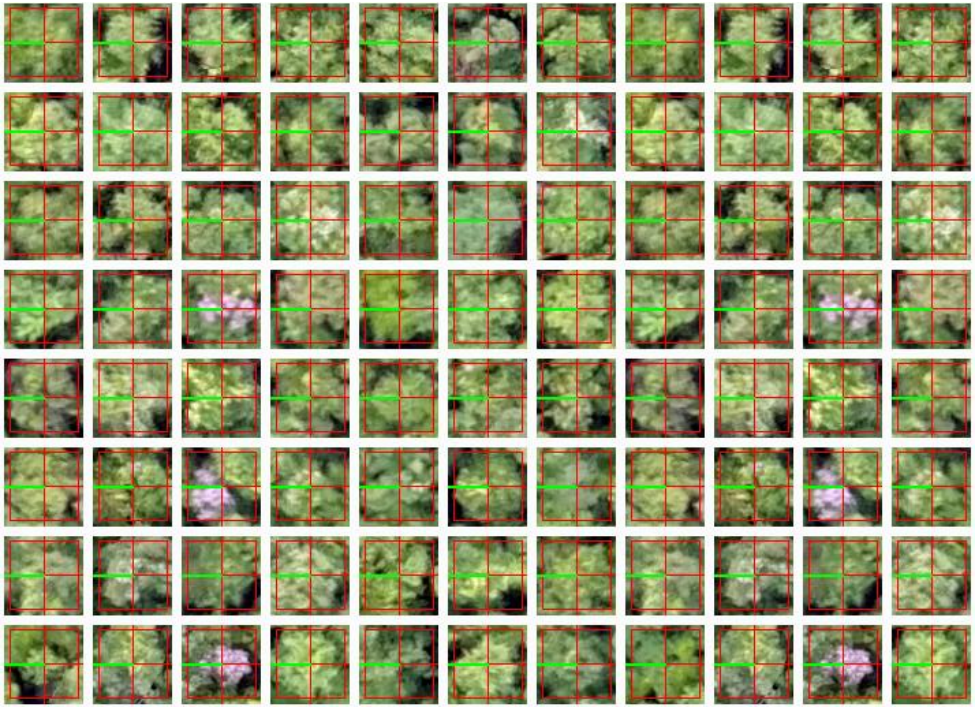
[a] Department of Natural Resources, College of Agriculture and Natural Resources, Dilla University, P.O. Box 419, SNNPE, Dilla, Ethiopia
[b] Department of Natural Resources, Faculty of Geo-information Science and Earth Observation (ITC), University of Twente, 7500 AE Enschede, The Netherlands











Artificial Intelligence (AI)
&
Machine Learning (ML)