Digitalisation of forest inventories with Smart Forestry TreeMaps

AFRY Smart Forestry

MAY 2024

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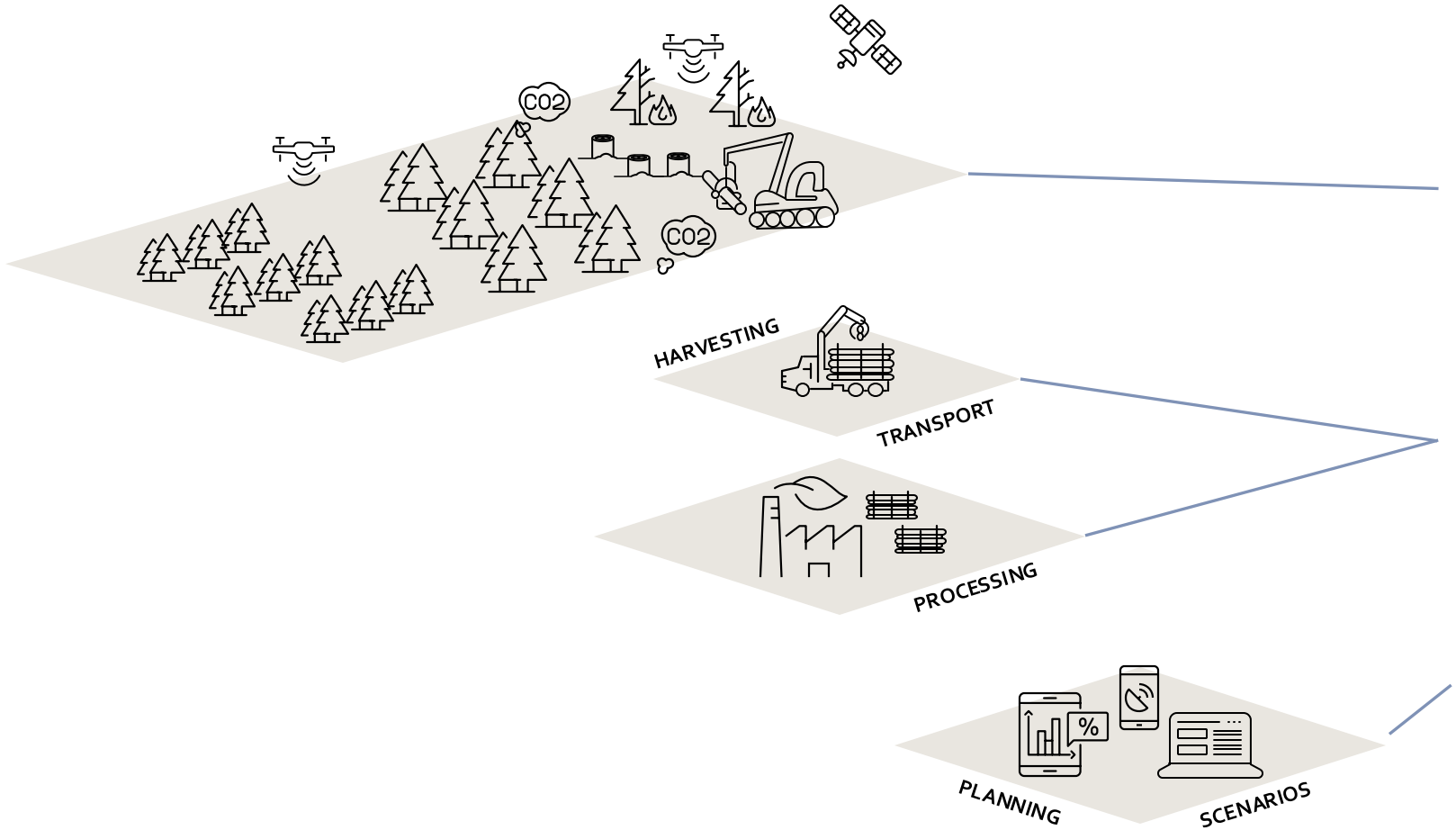
Requests for strategic digitalisation



Inventories

- Purpose: pre-harvest, health, R&D, survival, precision forestry
- Current practices vs. future set-up
- Ambition in digitalisation level
- Accuracy and level of details

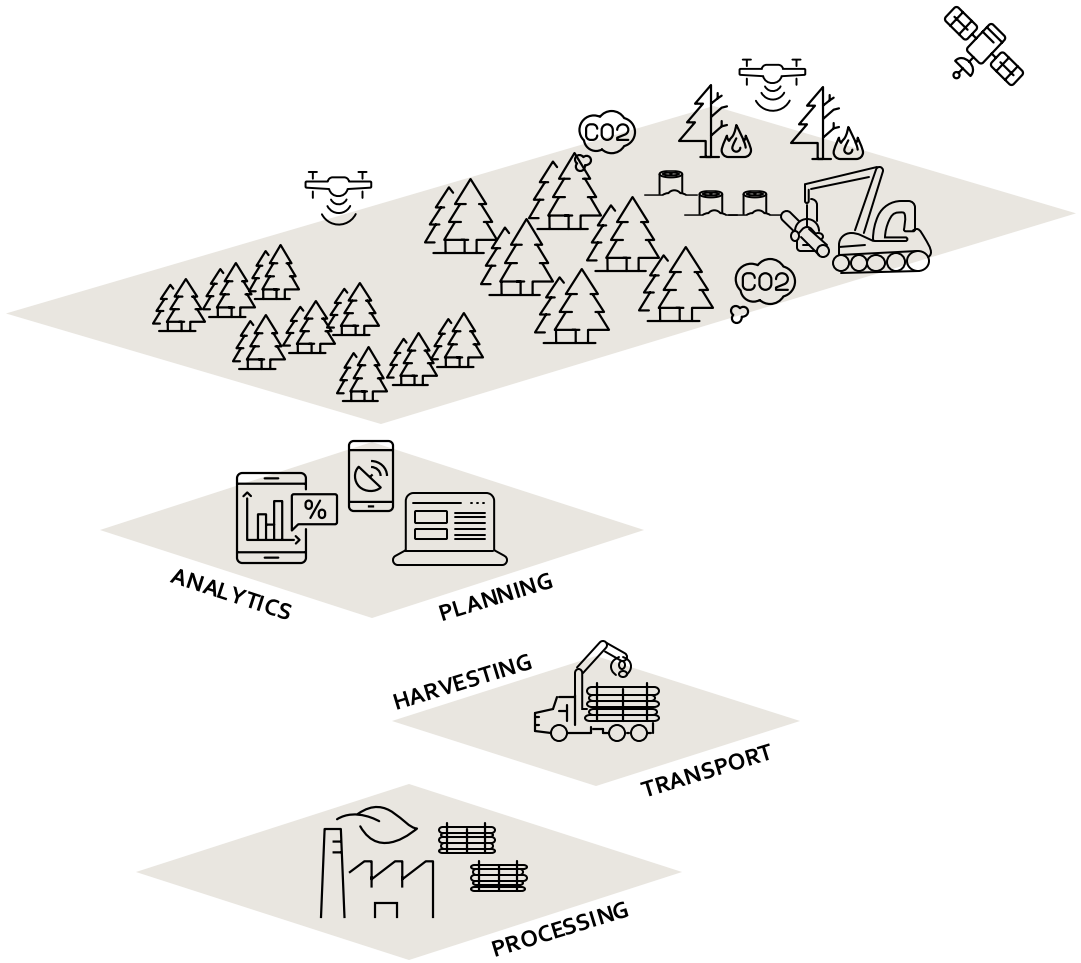
Operation management

- Inventory management
- Everyday management of operations
- Integration needs to other solutions, e.g. daily planning

Strategic and tactical planning

- Mill requirements
- Scenarios for future
- Optimising needs
- Wood cost analysis needs
- CO_2 analysis

Smart Forestry Suite



INVENTORIES

Smart Forestry TreeMaps – precision forestry data source

- Inventory solution based on drone
- Case-by-case optimised configuration based on desired inventory result accuracy, frequency and cost
- Integrate with any FMIS

OPERATION MANAGEMENT

Smart Forestry Manager – precision forestry data platform

- Inventory data management.
- Operational units separated from inventory units, but tightly integrated together; operational unit standing stock derived for inventory units.
- Full integration to planning and other system

STRATEGIC AND TACTICAL PLANNING

Smart Forestry Planner – digital twin of the forestry supply chain

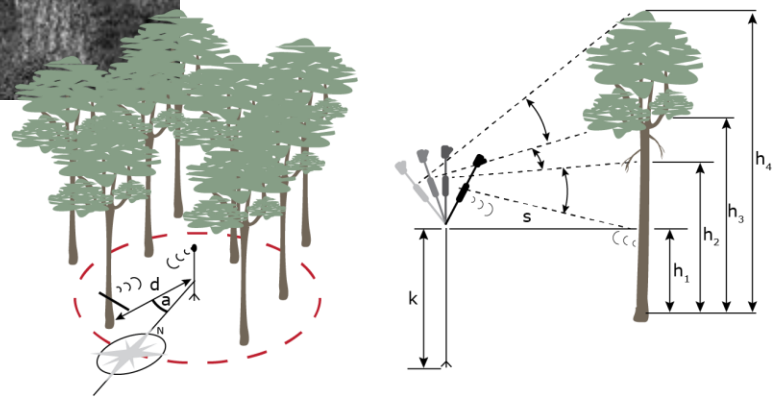
- Strategic planning – asset management over longer timeframes
- Tactical planning – automated creation of operational management units that minimise the operational costs of forestry, digital twin of the supply chain events
- Natively integrated to Manager, utilising the same user interface
- Possible to integrate to any FMIS

Digital approach for forest inventory

UNTIL 2010s

Measuring every tree in the field?
I don't think so.

Let's estimate the characteristics by taking a sample.



TODAY - Full digital twin with every tree measured.

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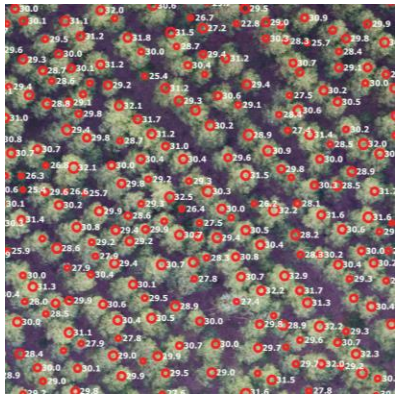
Selecting the right inventory system

DRONE INVENTORY

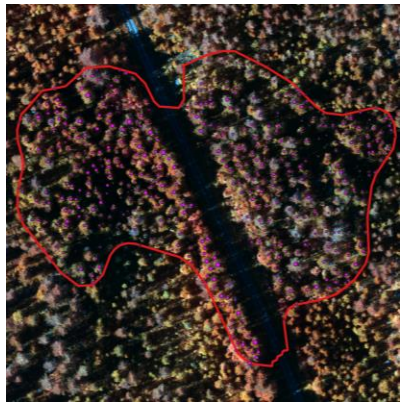
- <10 % error in stand volume
- Local scale, forest farms
- Low survey altitude (20 – 200 m)



- Tree level wall-to-wall inventory
- Survival mapping
- Health mapping, tree level
- **SAAS solution**

HYBRID INVENTORY

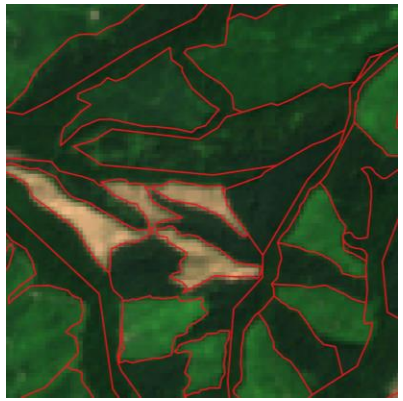
- ~10 % error in stand volume
- Asset scale (thousands km2)
- High survey altitude > 500 m



- Tree group and tree level wall-to-wall inventory of large areas with varying species and structure
- Health mapping
- **Service**

SATELLITE INVENTORY

- 30 % < error in stand volume
- National scale



- Management unit level wall-to-wall mapping of vast areas
- Forest cover change mapping
- **Service**

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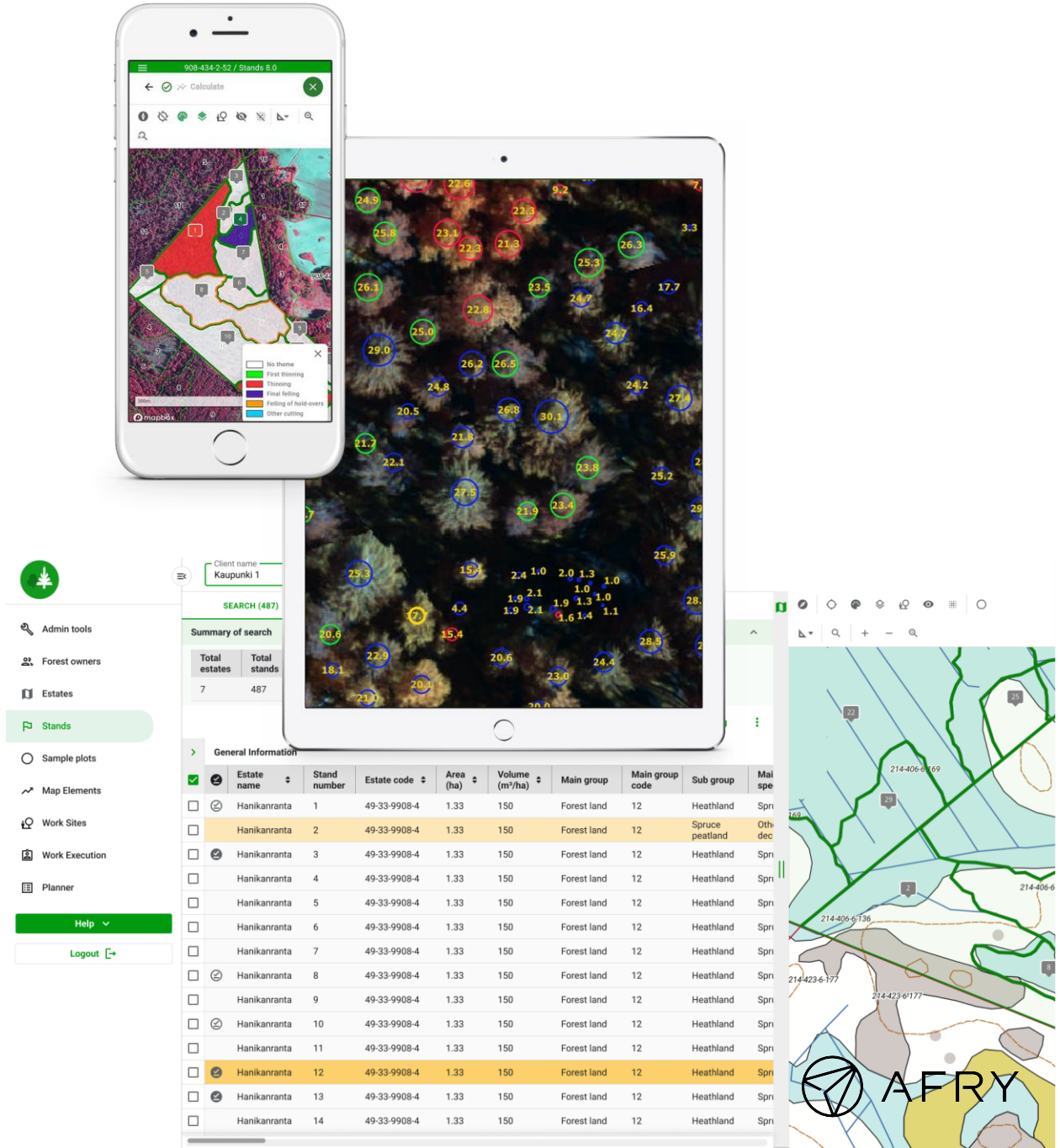
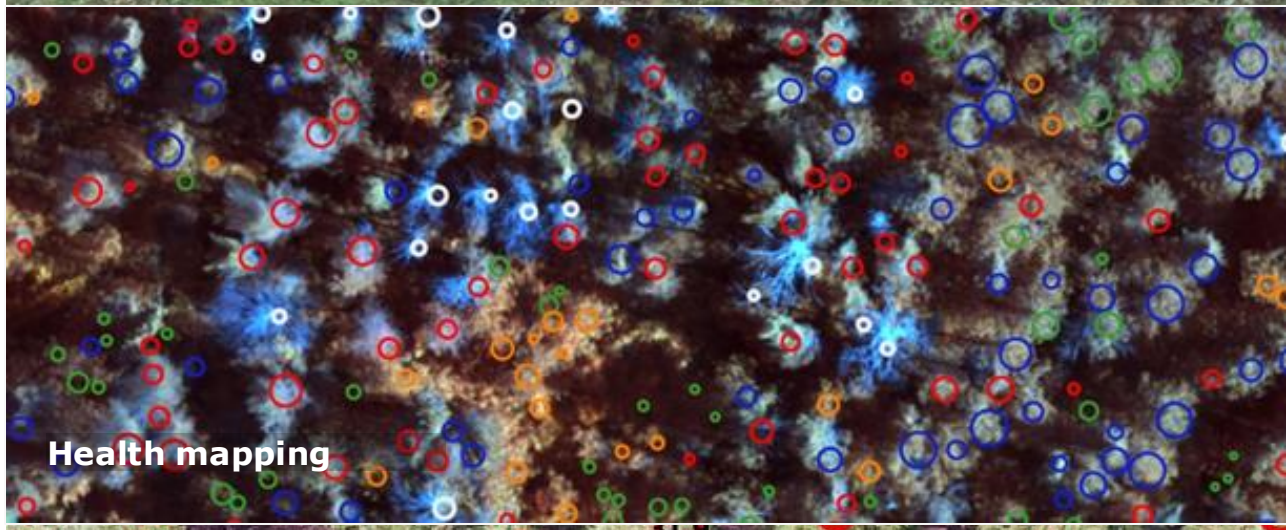
TreeMaps SaaS - Drone inventory

- 3D measurements – so **not** only tree count
- Every tree measured – stand internal variation fully covered
- Camera or LiDAR sensor measurements
- RGB sensor is used in plantations, health mapping requires Multispectral or Hyperspectral sensor
- Drone flights by client or third-party operator
- SAAS – enables independent process
- Can be integrated with any FMIS



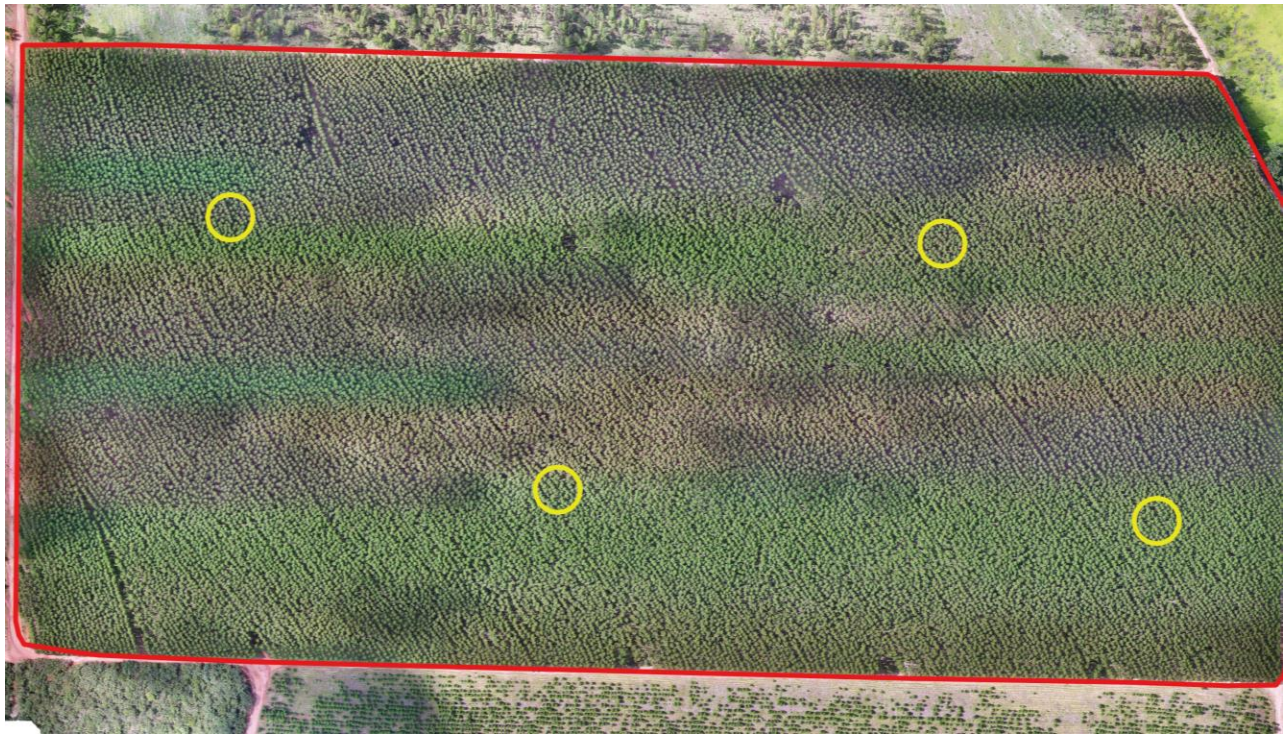
TreeMaps SaaS - Use cases

- Very detailed and accurate pre-harvest inventory - decrease traditional fieldwork (PSPs can be used for result calibration and modelling).
- Yield classification for improved wood supply estimates
- Areas without access for traditional inventory.
- Survival mapping – very limited time window for surveys.
- Healthiness and climate change related mapping.
- etc.



Inventory benefits - 100 % enumeration; example

- Sample plot inventory with 1% sampling intensity (yellow circles) resulted to 322 m3/ha
- Measurement of all trees with drone resulted to 274 m3/ha
- Sample plot average volume was 17% higher than volume summarised from all drone-measured trees
- Volume grid assessment reveals variation in standing stock and explains why sample plot approach typically contains more error than drone approach
- Drone measurement produces top accuracy assuming investment is made to create good quality models.
- Output as GIS compatible treemap and diameter distributions by stands/ inventory units

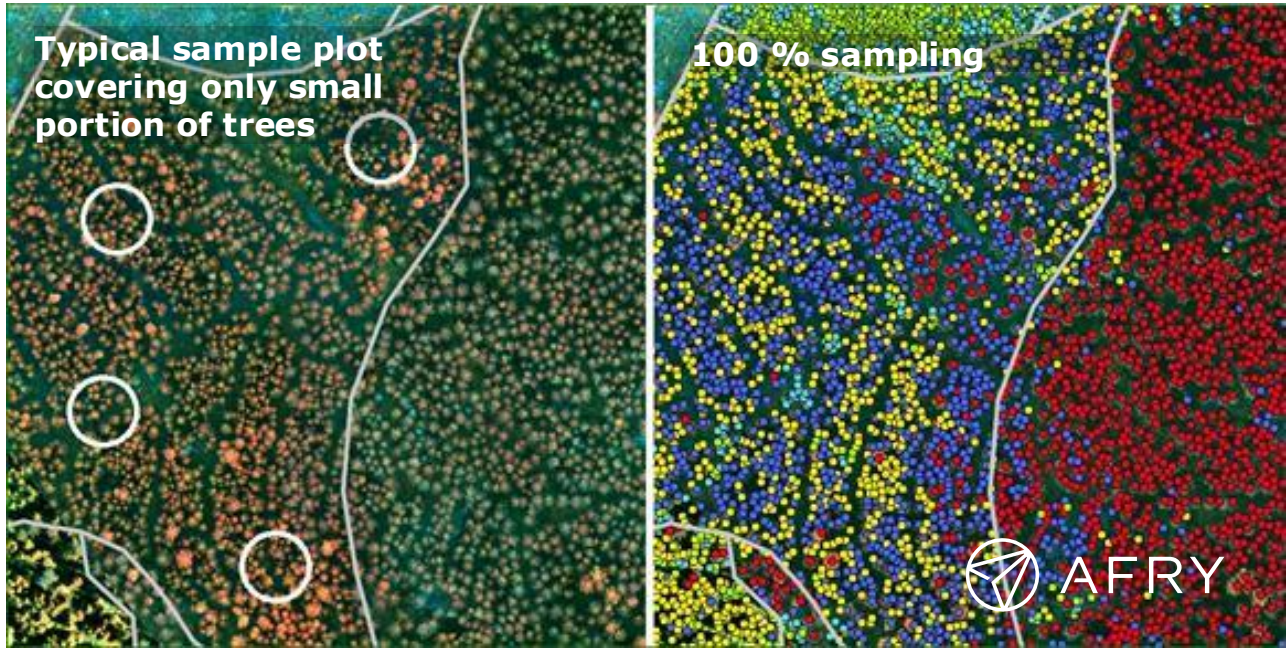


Inventory accuracy - Finland case

- Camera and LiDAR based drone inventories have very similar accuracy if data is of good quality, DTM should be available in camera based work as ground is not mapped. LiDAR is able to detect ground so external DTM is not required.
- Accuracy of camera based drone surveys was evaluated by field measurements in two different areas (7.1 ha and 3.1 ha) where all trees were measured, see tables above.
- Height measurement is very accurate, in practice better than field measurement.

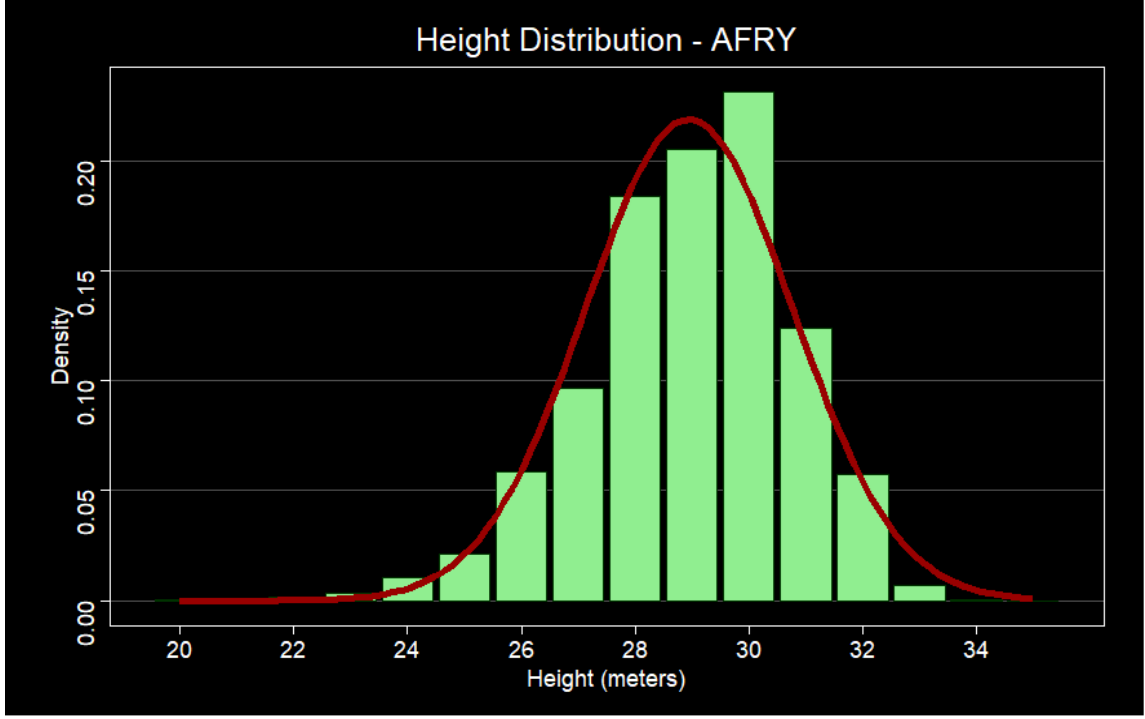
Variable	Drone	Ground	Diff. abs	Diff. %
Mean stem volume, m3/ha	285.5	279.0	6.9	2.5
Basal area, m2/ha	27.3	26.8	0.5	1.8
Mean height, m	21.4	21.8	-0.4	-1.7
Mean stem diameter, cm	26.6	25.5	1.1	4.3

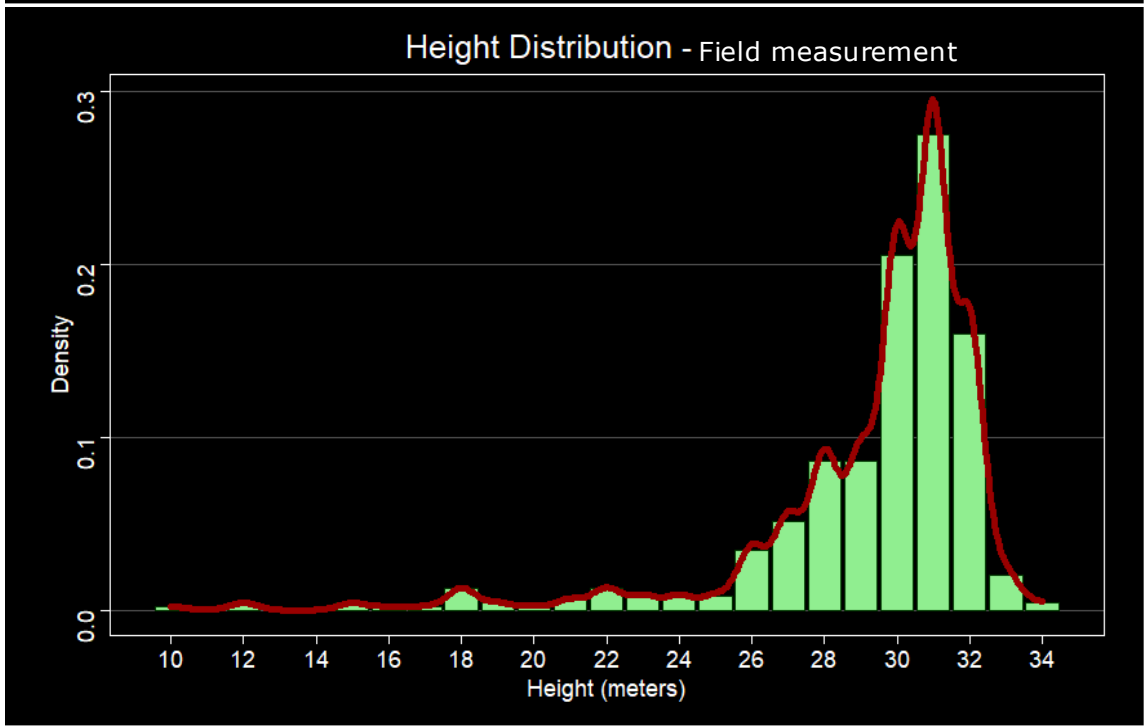
Variable	Drone	Ground	Diff. abs	Diff. %
Mean stem volume, m3/ha	202.9	199.5	3.5	1.7
Basal area, m2/ha	22.8	22.8	0.0	0.1
Mean height, m	17.8	18.1	-0.3	-1.8
Mean stem diameter, cm	21.2	20.4	0.7	3.6



Inventory accuracy Plantation case

- Tree heights were measured and average **height was 28.9 meters compared to field measurement average of 29.4 meters.**
- Height distribution of drone – field observations are quite similar
- In drone distribution shortest trees are lost due to fact that they are not well visible in drone data – missing trees are possible to add by modelling
- Heights greater than 26 meters the AFRY model estimated 46,522 trees, while our inventory estimated 48,980 trees (5% difference).





TreeMaps comparison to alternatives

	Field inventory	2D drone inventory services (*)	AFRY Smart Forestry TreeMaps
Required manpower	Several people / crew	Few	Few
Scope	Sample-based field measurements and update of stand database	• Mapping of trees from AOI • Possibly creating grid- or stand level density maps	• Mapping of trees from AOI/stands • Measuring and estimating tree attributes • Calculation of stand level inventory attributes
Measurement accuracy in stand level	Good	Incomparable, since contains tree count only	Good, Tree count and height of each tree
Stand level variation	Not possible	Only about stem count	Stem count, height, basal area, volume
Mosaics to use in FMIS	-	yes	yes
Dead or sick trees	Only in samples	Maybe	yes
Control of operators	-	no	Yes
Integration	Depending on FMIS	Maybe	Yes, to any FMIS
Survey in non-accessible areas	limited	yes	yes
Independent processing	Yes	Maybe	Yes
Can replace standwise sample plot inventory?		no	yes

(*) standard drone survey applied with low-end drone and GPS device

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CONTACT INFORMATION

AFRY Smart Forestry

Ismo Hippi
Head of Remote Sensing, Smart Forestry

Jaakonkatu 6, Vantaa
Finland
Ismo.hippi@afry.com
+358 40 5965322

