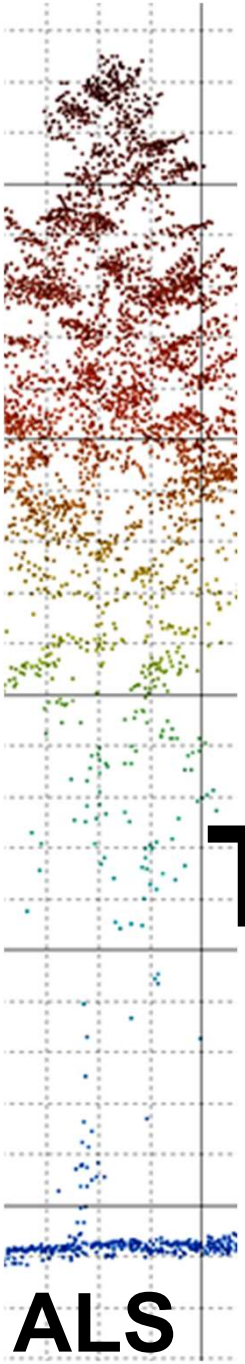


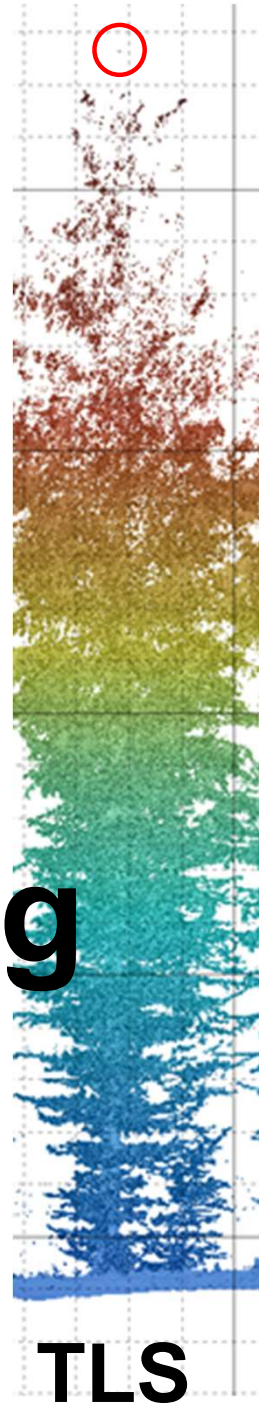
Forest Inventory

by the means of

Aerial Laserscanning

and

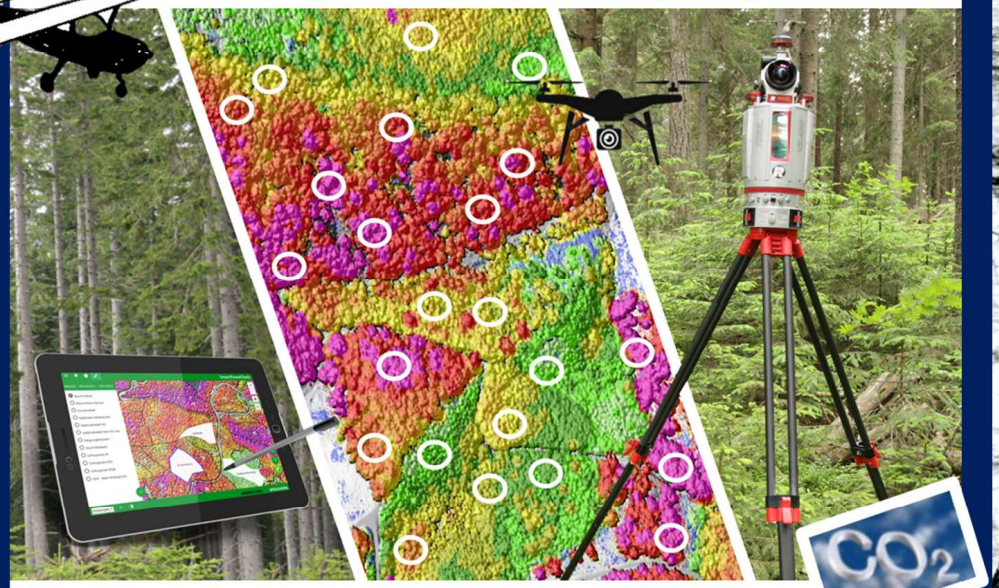
Terrestrial Laserscanning



umwelt data

digital forst

Sustainability : Monitoring : Mapping : Modelling : Management



FERNERKUNDUNGSBASIERTE FORSTINVENTUR
KOHLENSTOFF-MONITORING MIT LIDAR PRÄZISION

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Professional background and experiences

- **Austrian State Forest Agency, 1983-2000**
  ForestManagementPlanning, Inventory, GIS and Remote Sensing
- **Head of Umweltdata ltd. Since 2001**
  Forest Sustainability :Monitoring :Mapping :Modeling :Management
- **>150 Forest Inventory projects, >100,000 sample plots**
- **>200 Forest Management Planning projects >1000ha**
- **Operational usage of LIDAR data since 2006**
- **Rapid forest inventories for land acquisition due diligence**
- **Monitoring of wildlife influences and damages**
- **Growth models and monitoring**
- **Permanent Optimization of Forest Inventory based on RS**
- **Several R&D projects, ALS+ULS+TLS in Forest Inventory**
- **Silvilaser 2010,12,13,17,19,21(co-host); ForestSAT 2016,18,22**

Deep Digital Forest & ScanForest4Carbon

Operational Forest Inventory Workflow

ALS ▶ TLS ▶ Mapping ▶ Management

SME – Network funded by

FFG Promoting Innovation

umweltdata

E.C.O.

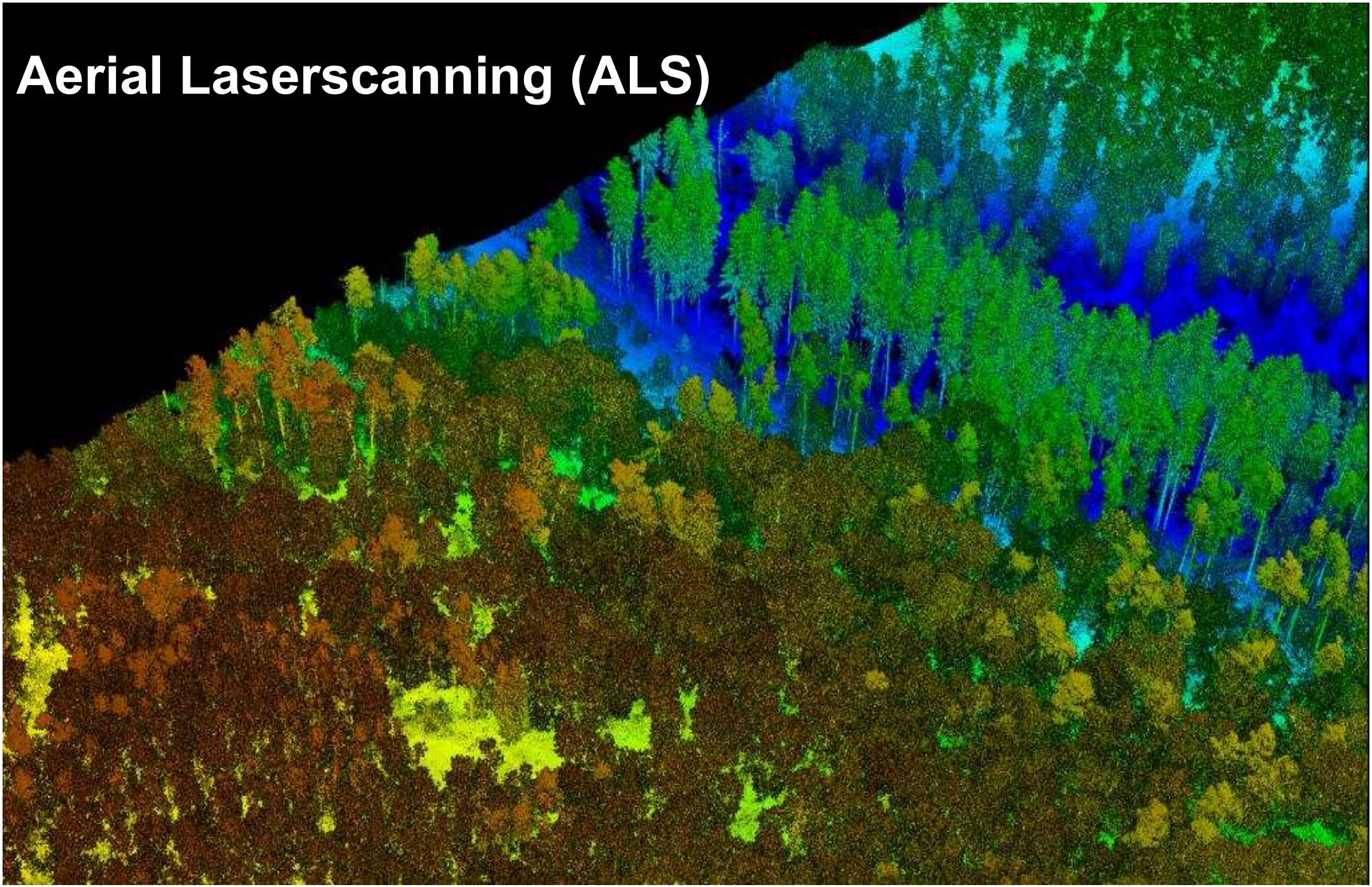
RIEGL® LASER MEASUREMENT SYSTEMS

JOANNEUM RESEARCH

aero map worldwide aerial mapping

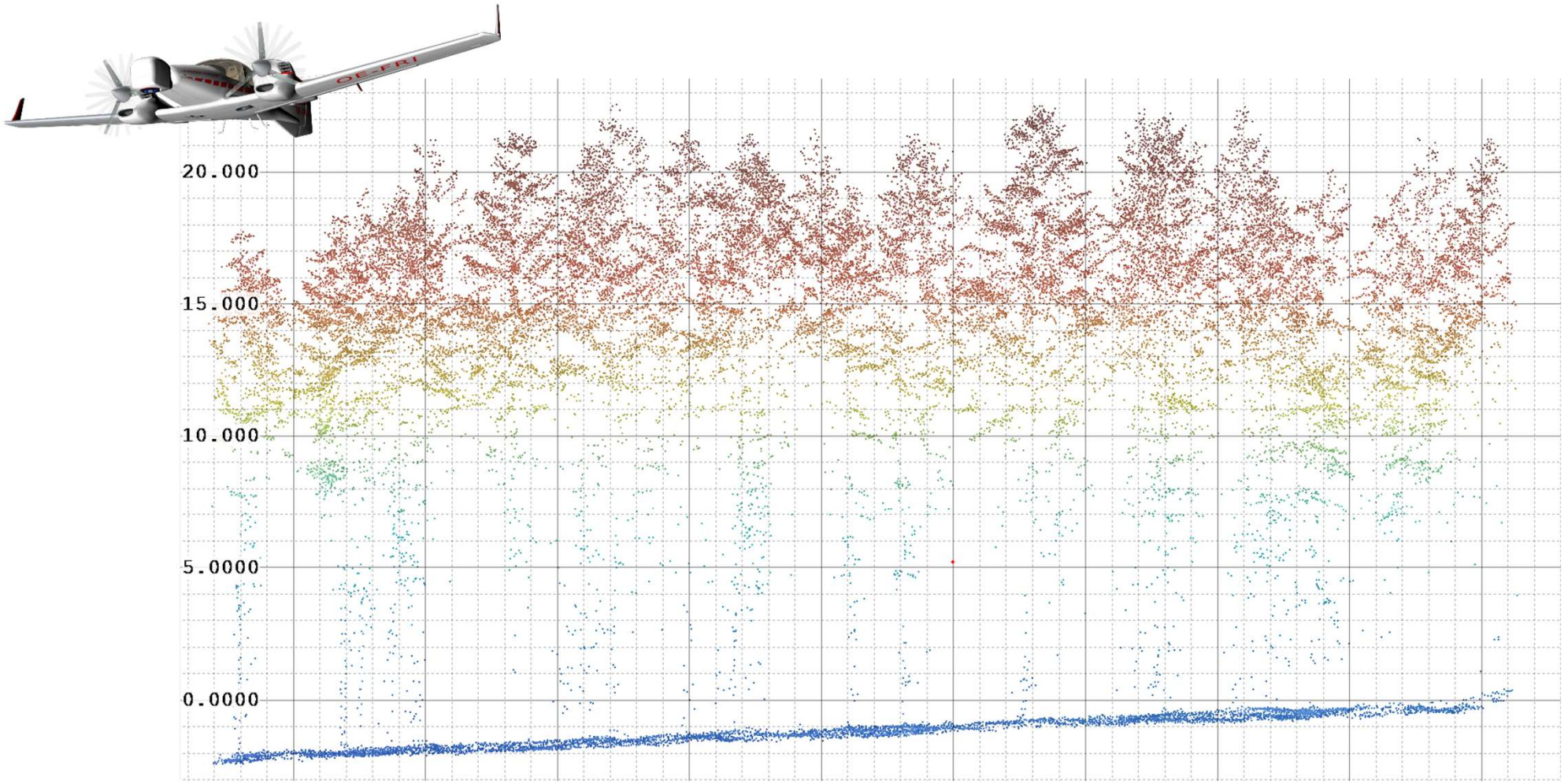
4DIT Consulting Service Software Development

Aerial Laserscanning (ALS)

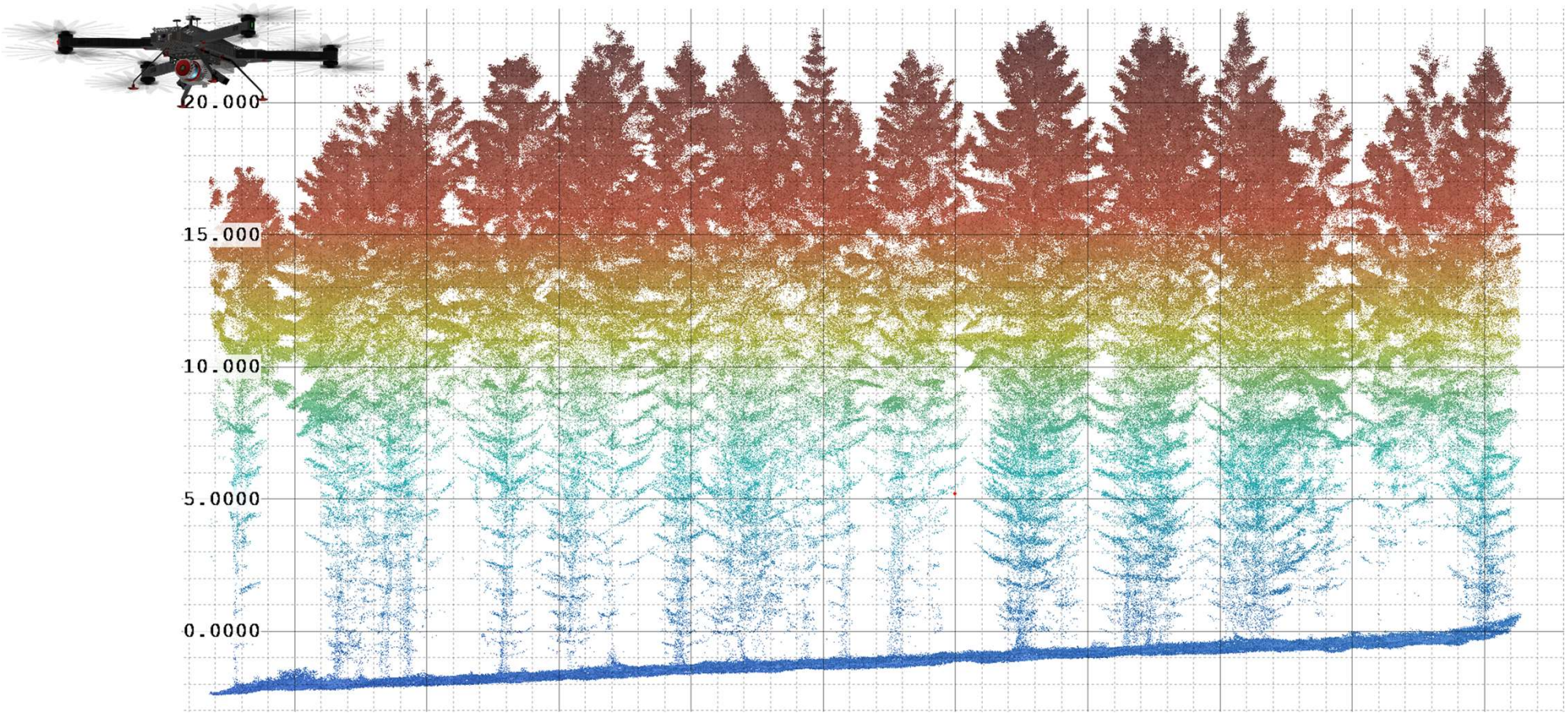


Terrestrial Laserscanning (TLS)

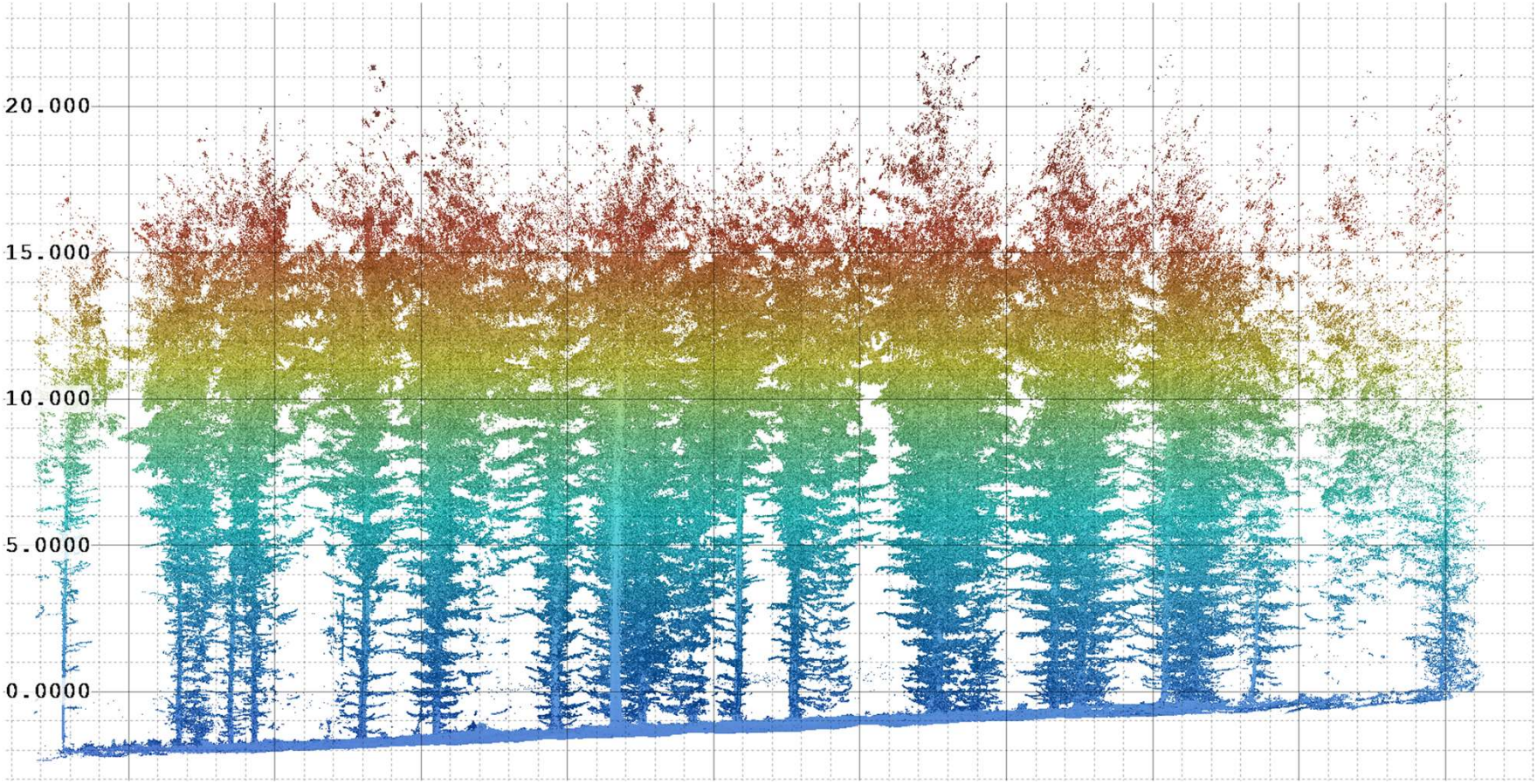
LiDAR collection methods: ALS



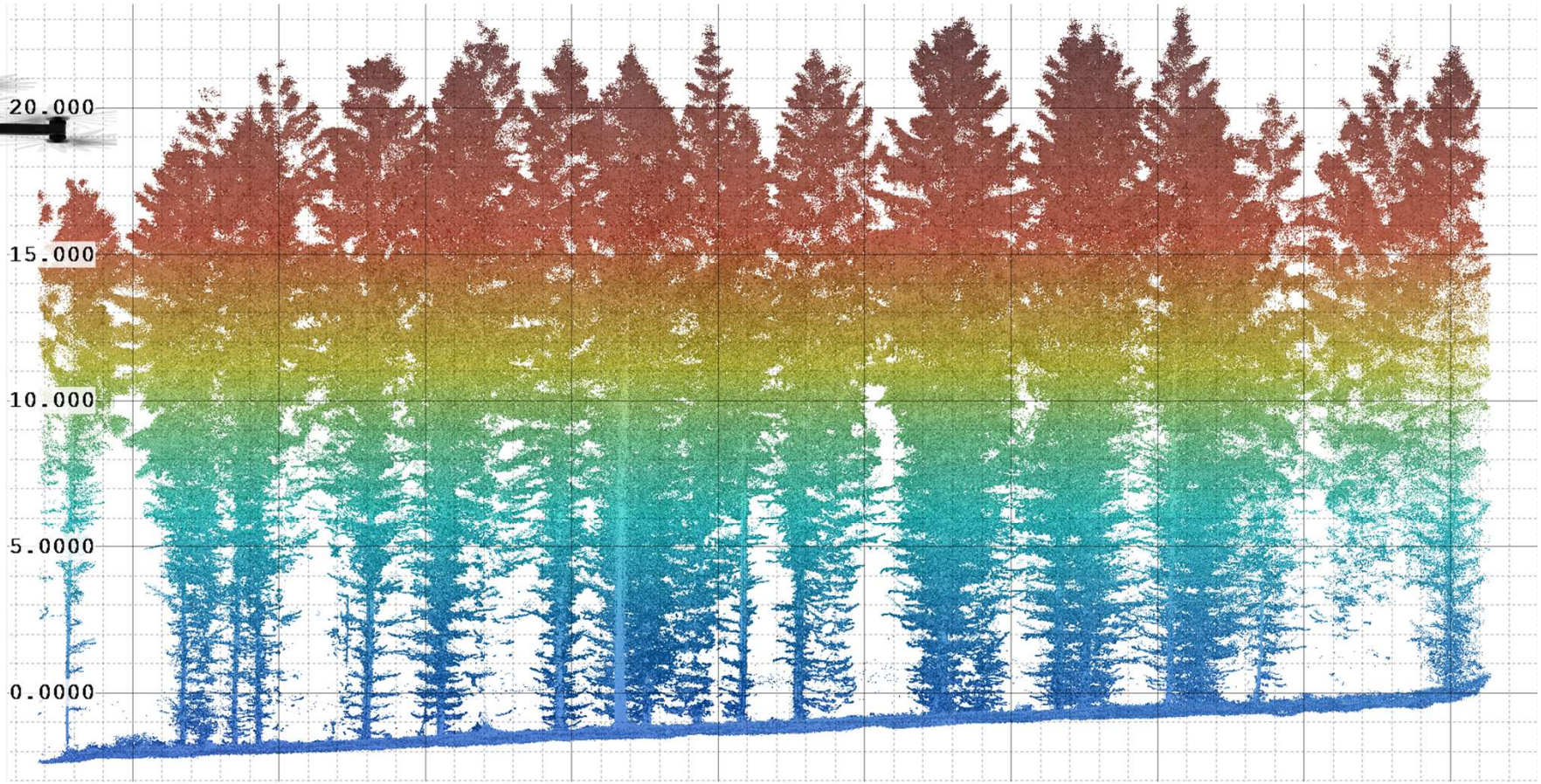
LiDAR collection methods: ULS

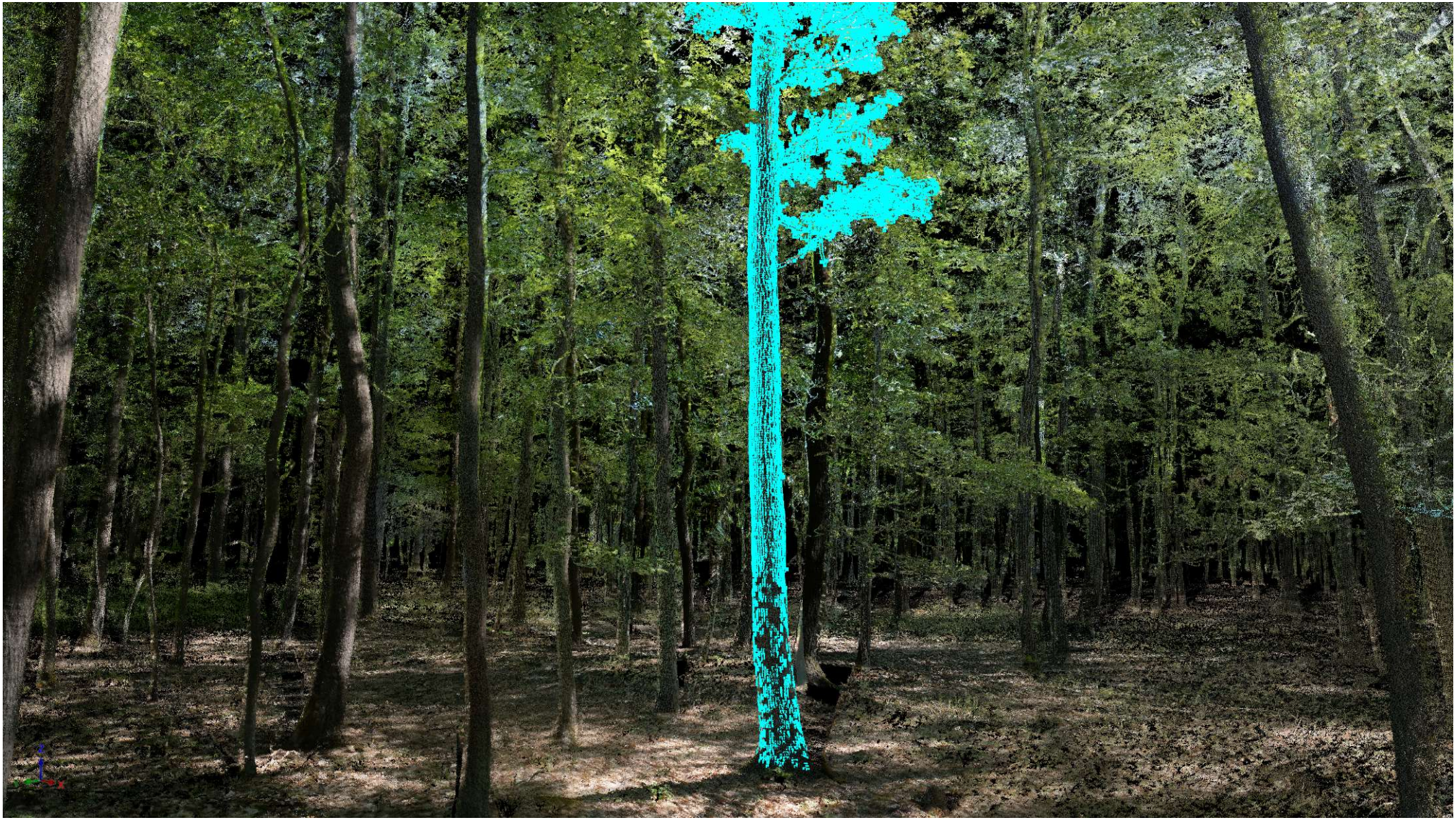


LiDAR collection methods: TLS



LiDAR collection methods: ULS+TLS





Extracting stem dimensions and crown dimensions

AUV-Laser-Scanning ready for diameter extraction

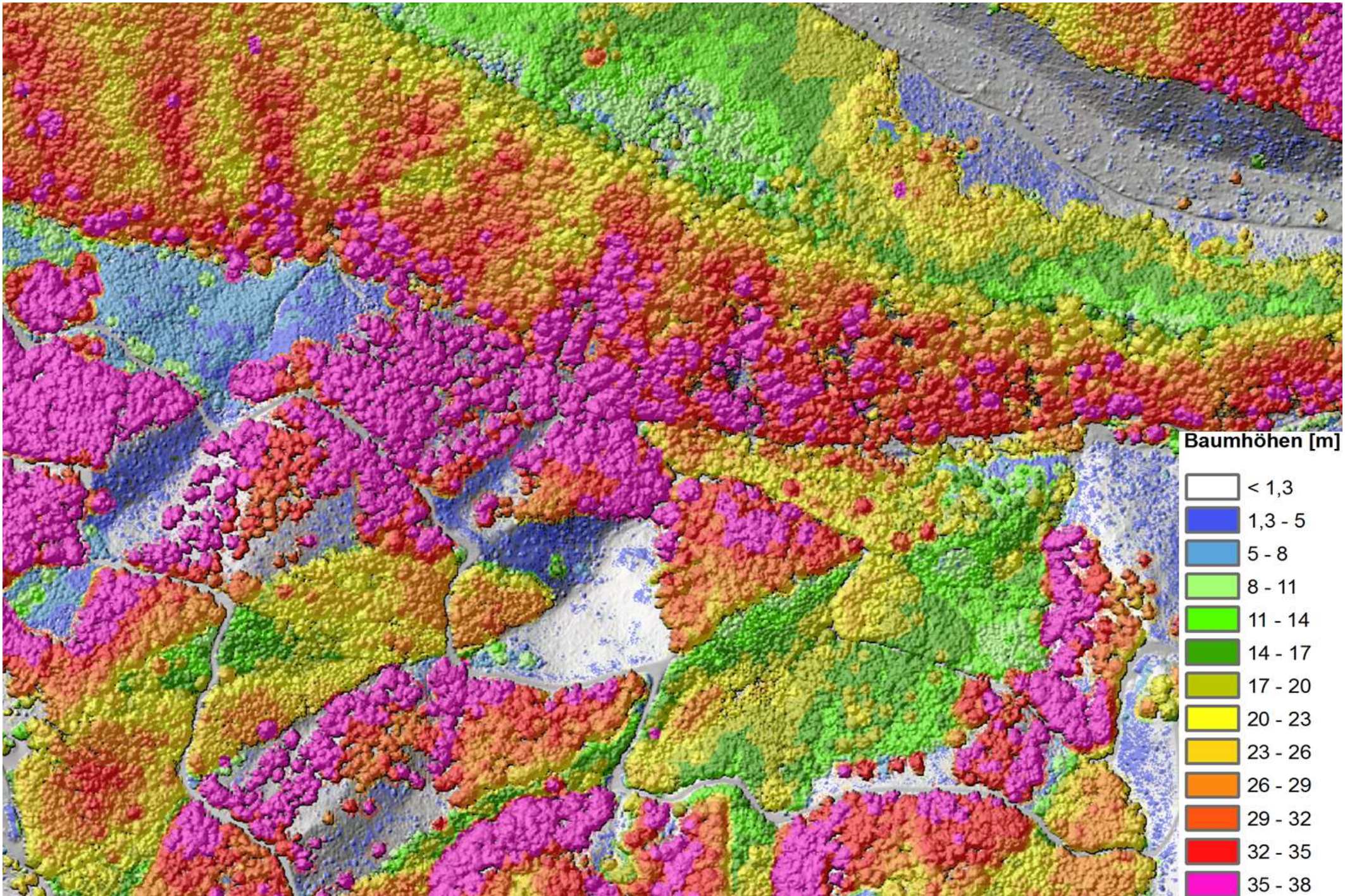

RIEGL
soleon

Aerial Laserscanning

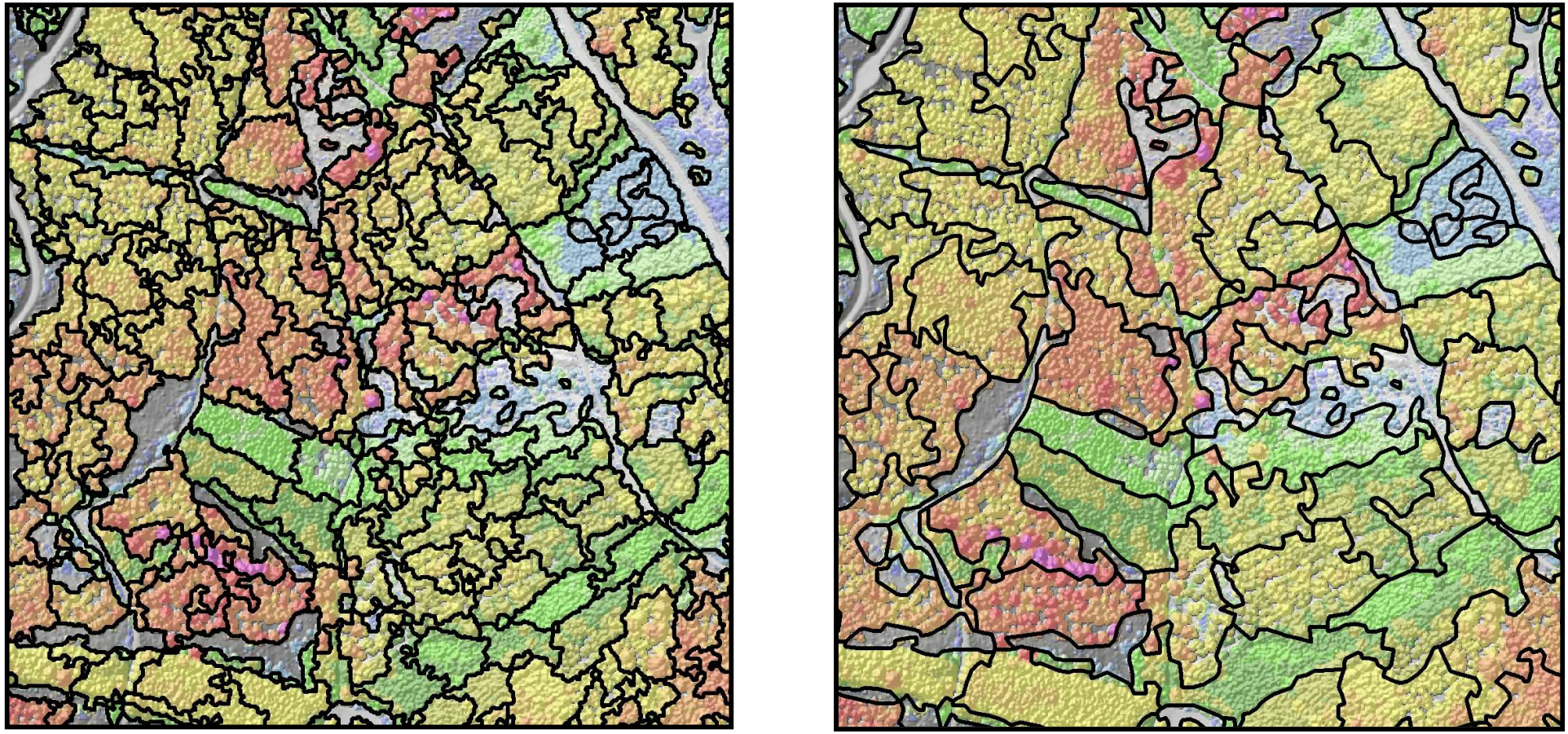
Calibration of Tree Properties (DBH)

Terrestrial Laserscanning

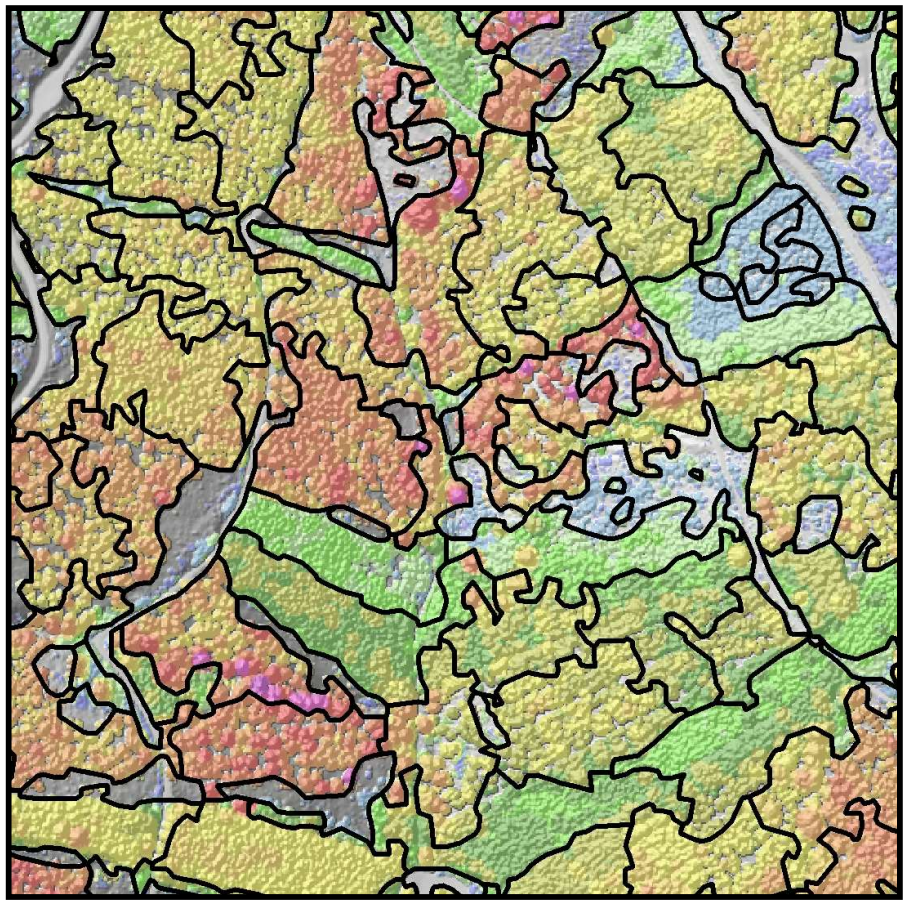
CHM Canopy Height Model

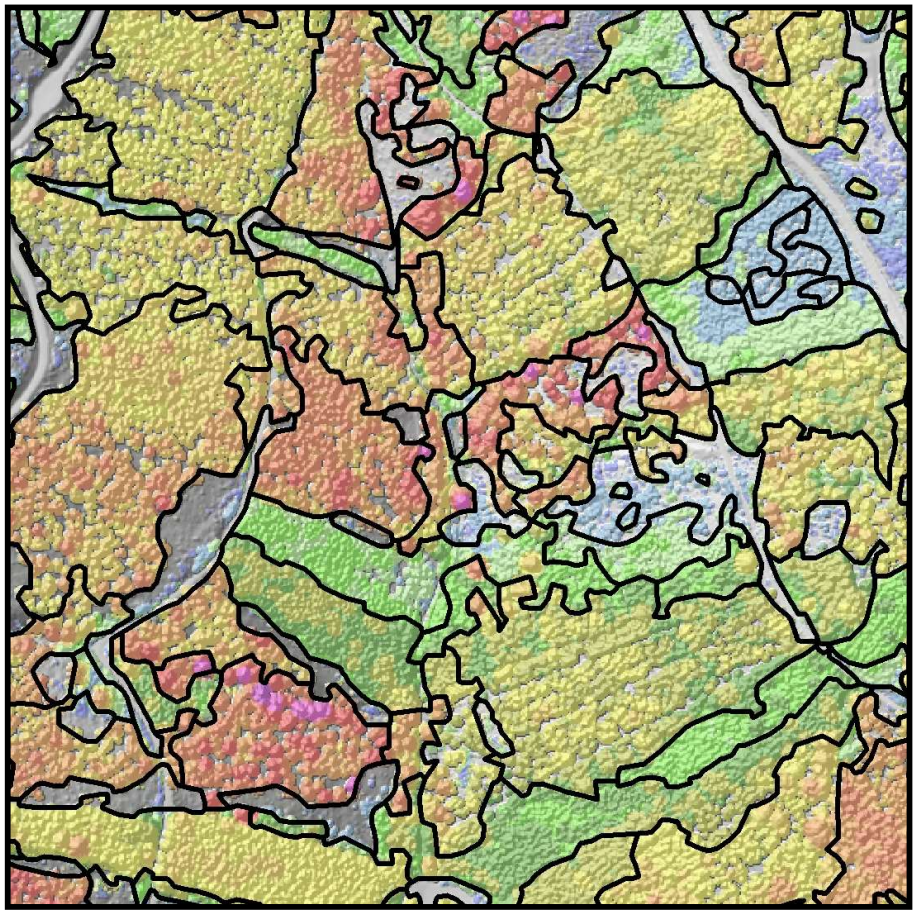


Automatic Segmentation of Canopy Height Models



Generation of management units from segments

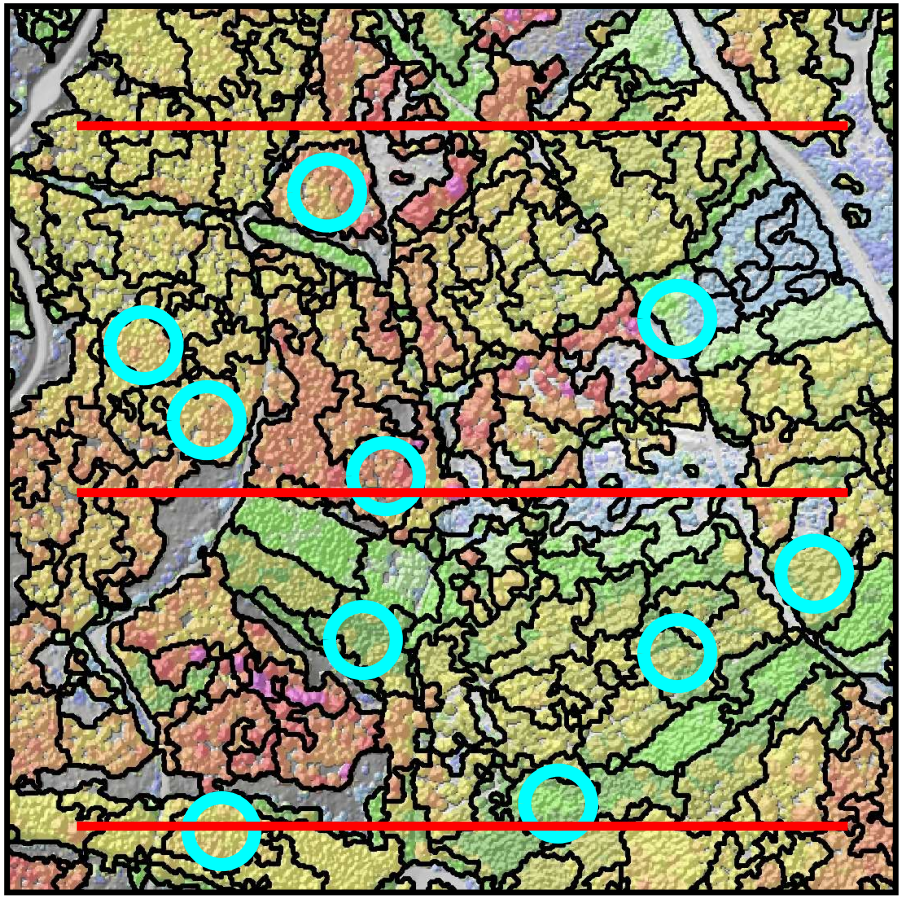




By step-wise region growing algorithms … until management units

Distribution of sample plots on segments

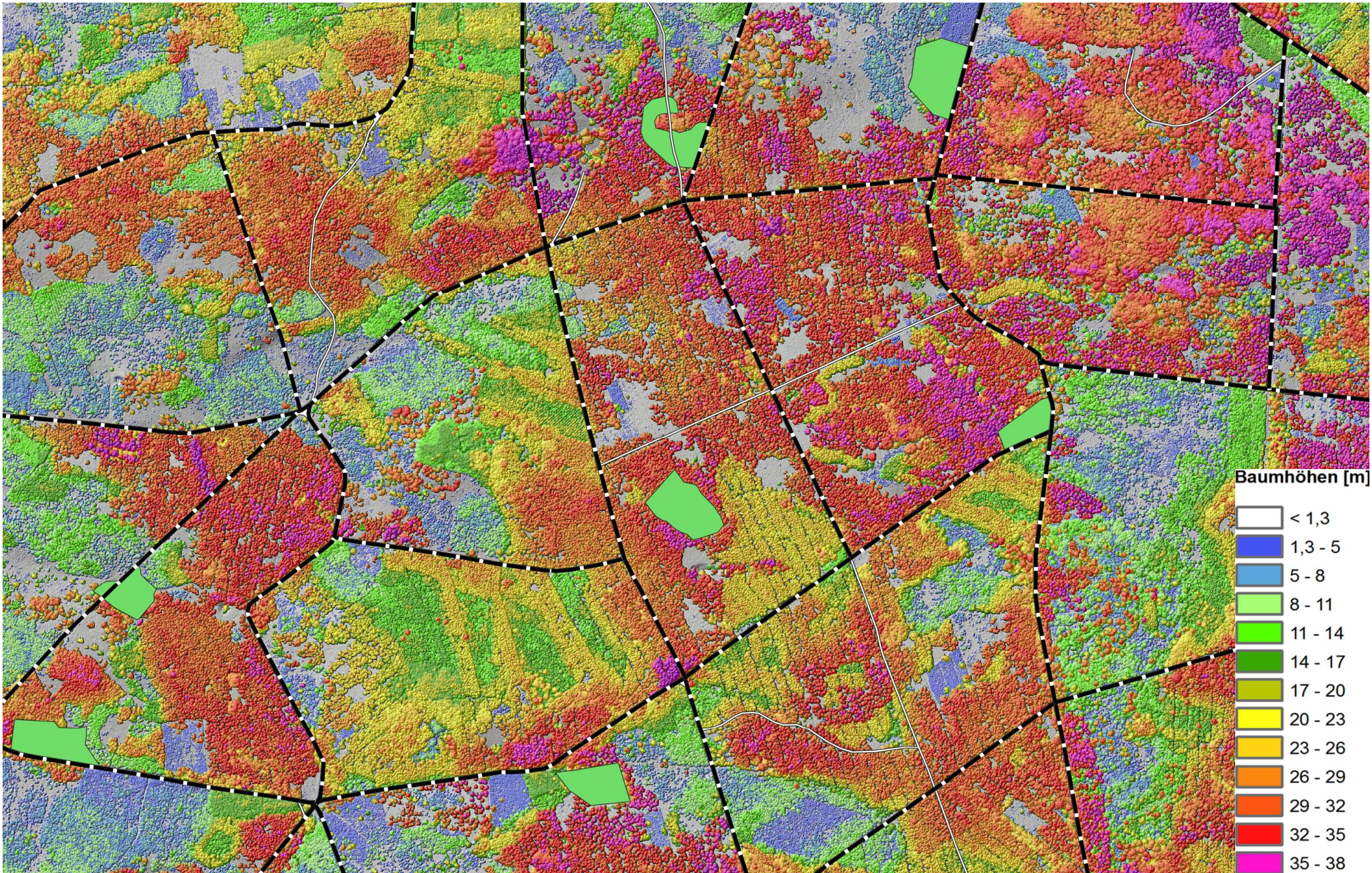
- Classification of segments
- Random positioning of sample plots on segments
- Definition of number of sample plots per stratum
- Distribution over total AOI per auxiliary lines and normal distance

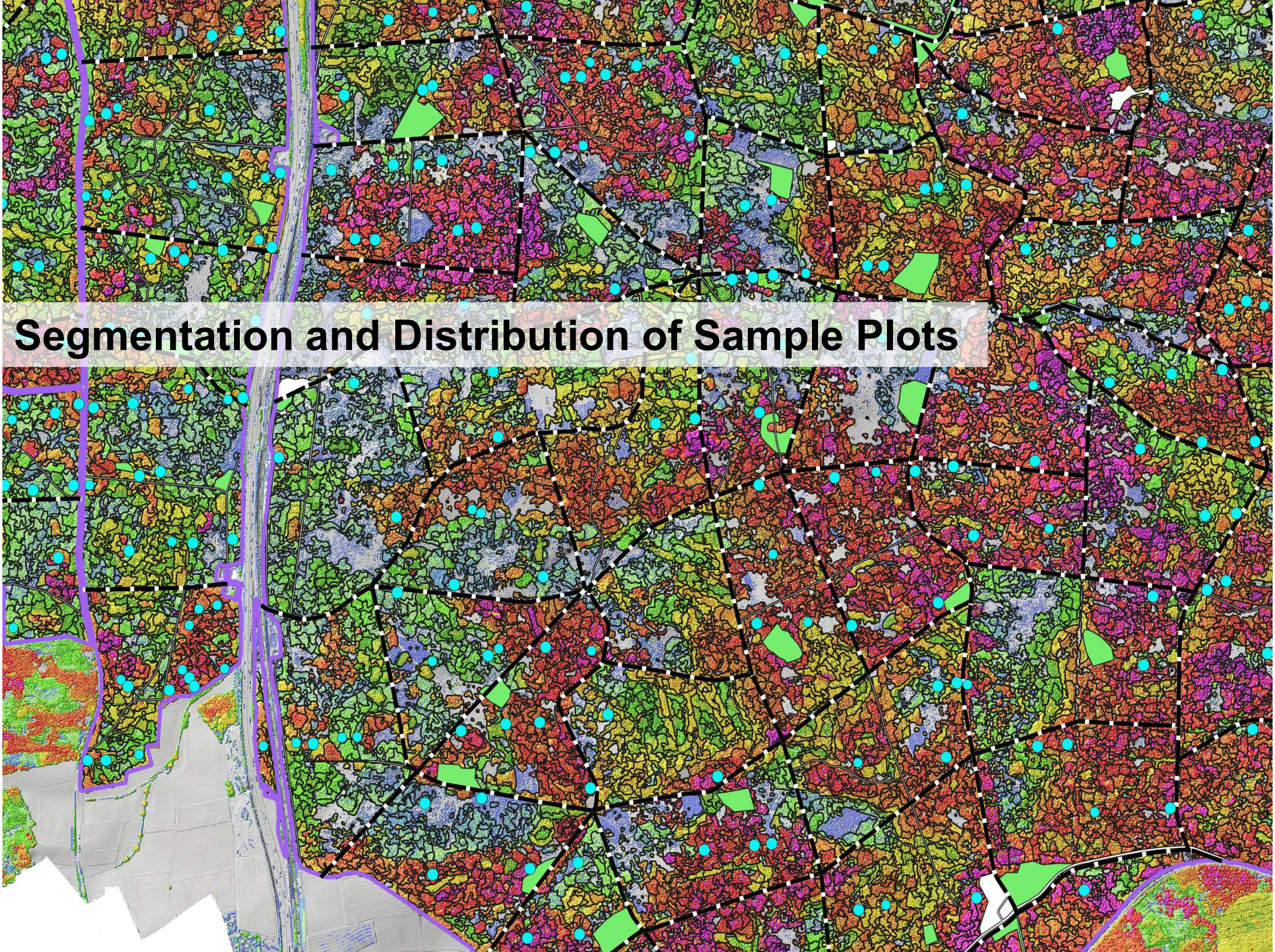


Motivation

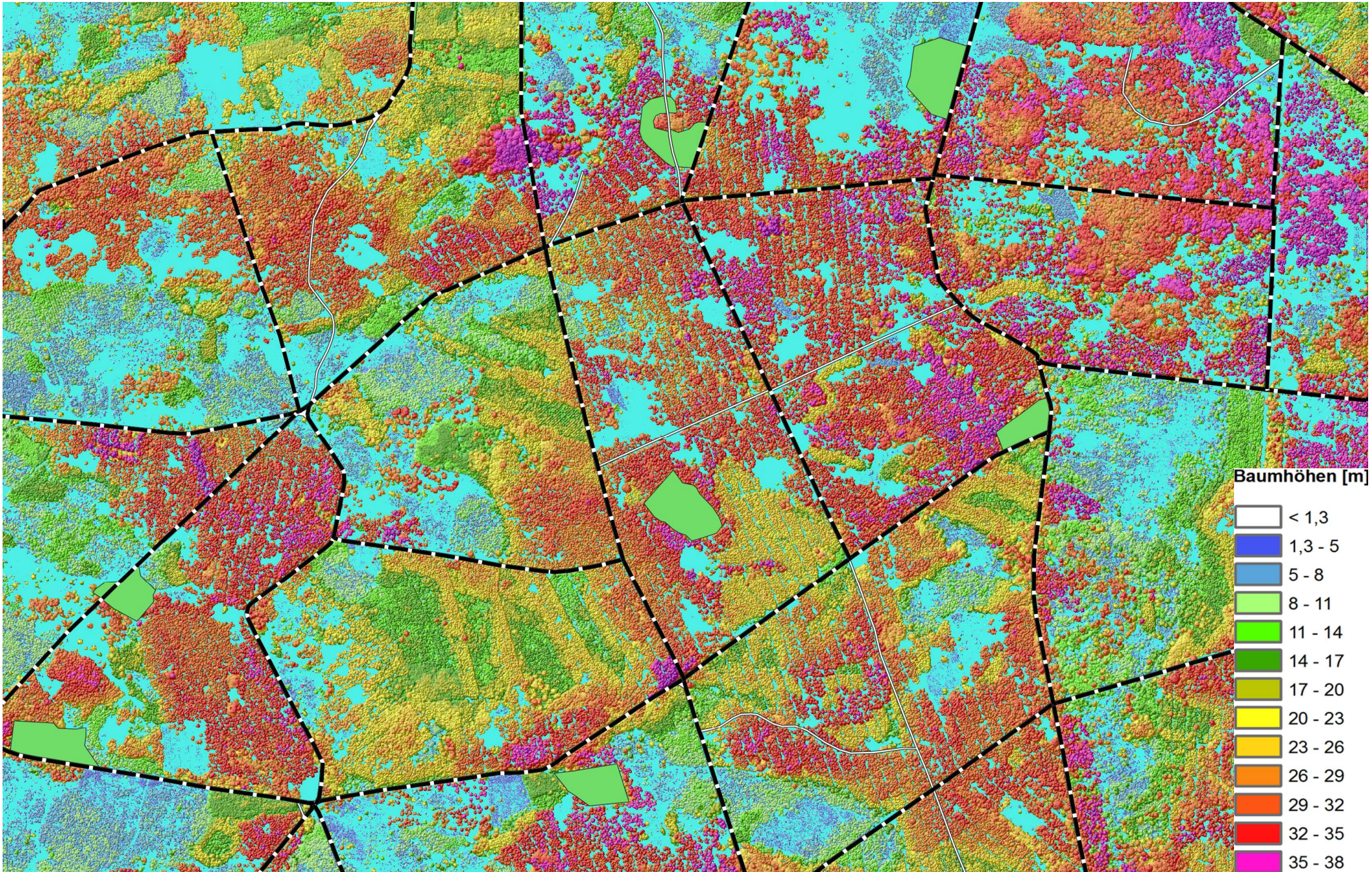
- Optimizing cost-benefit ratio of statistical forest inventory campaigns; reduction of sample plots from ~800 to ~200 to achieve +/-5% accuracy (stock volume)
- Step-by-step scalability of accuracy
- Avoiding and detecting errors of field measurements
- Linkage of forest inventory and forest mapping
- Automatic data updates by remote sensing
- Objective monitoring of sustainability criteria: biodiversity, habitat properties, above ground biomass, carbon segregation

Modelling unstocked area (1) CHM

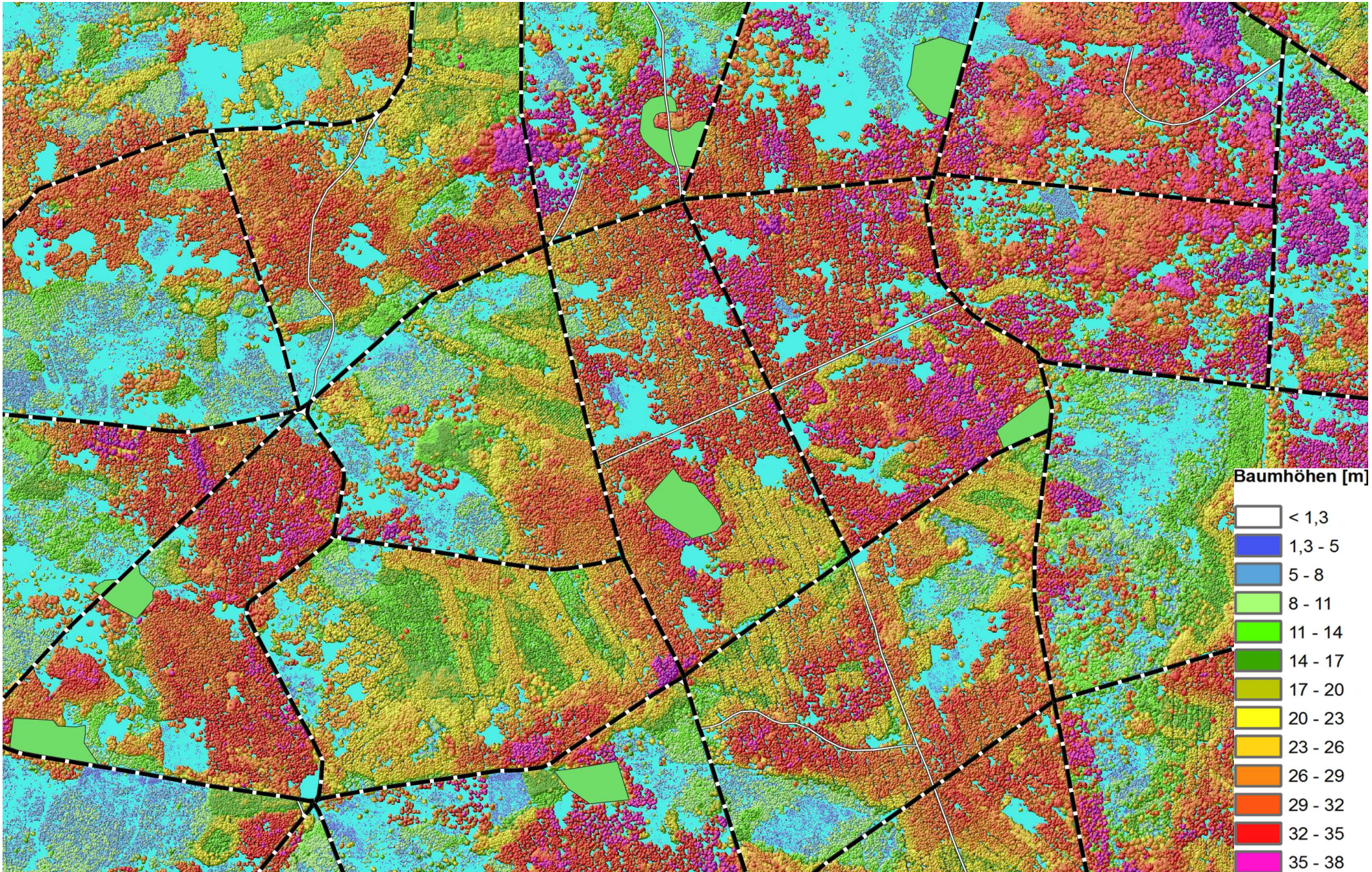



Segmentation and Distribution of Sample Plots

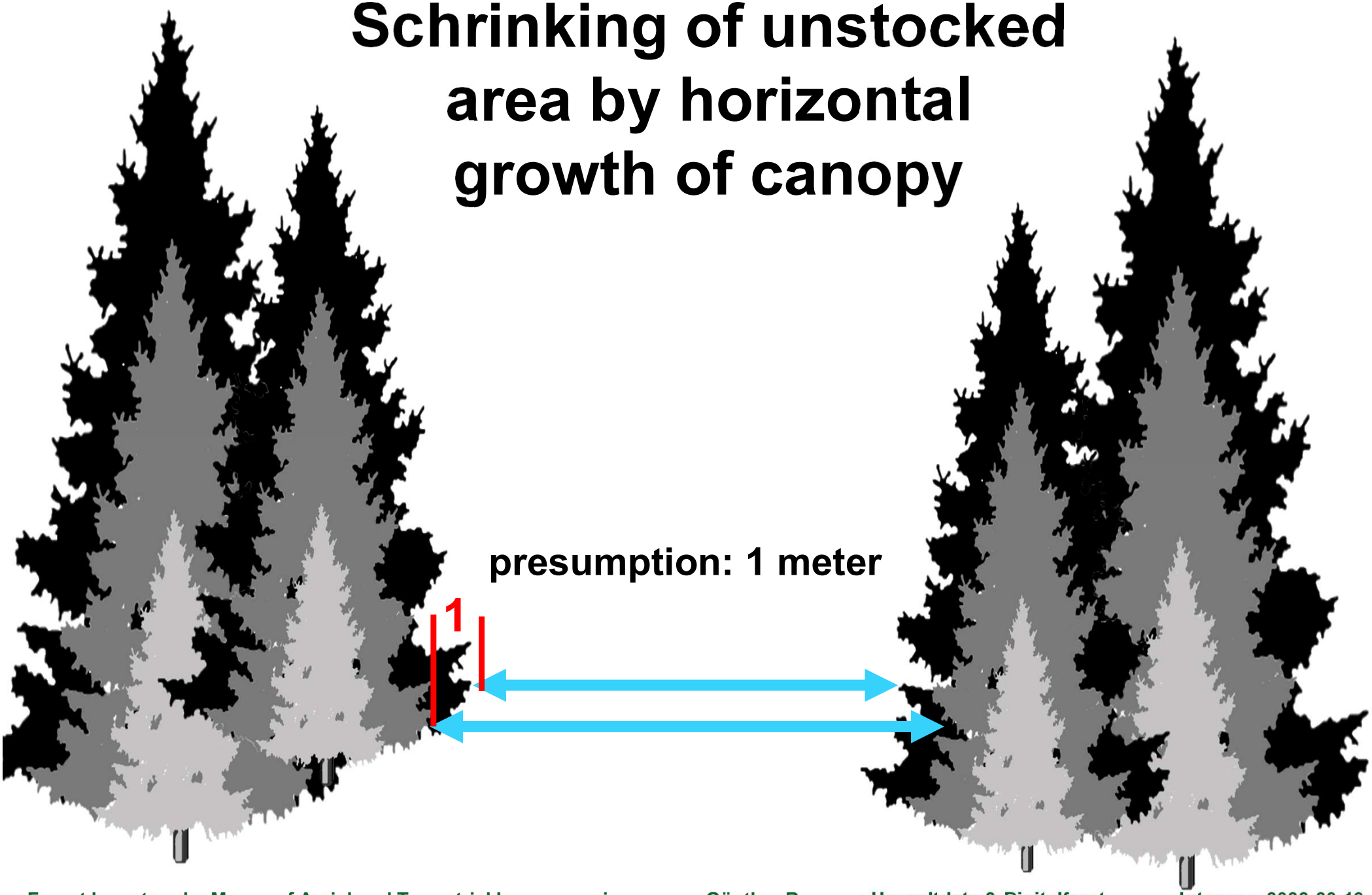
Modelling unstocked area (2)



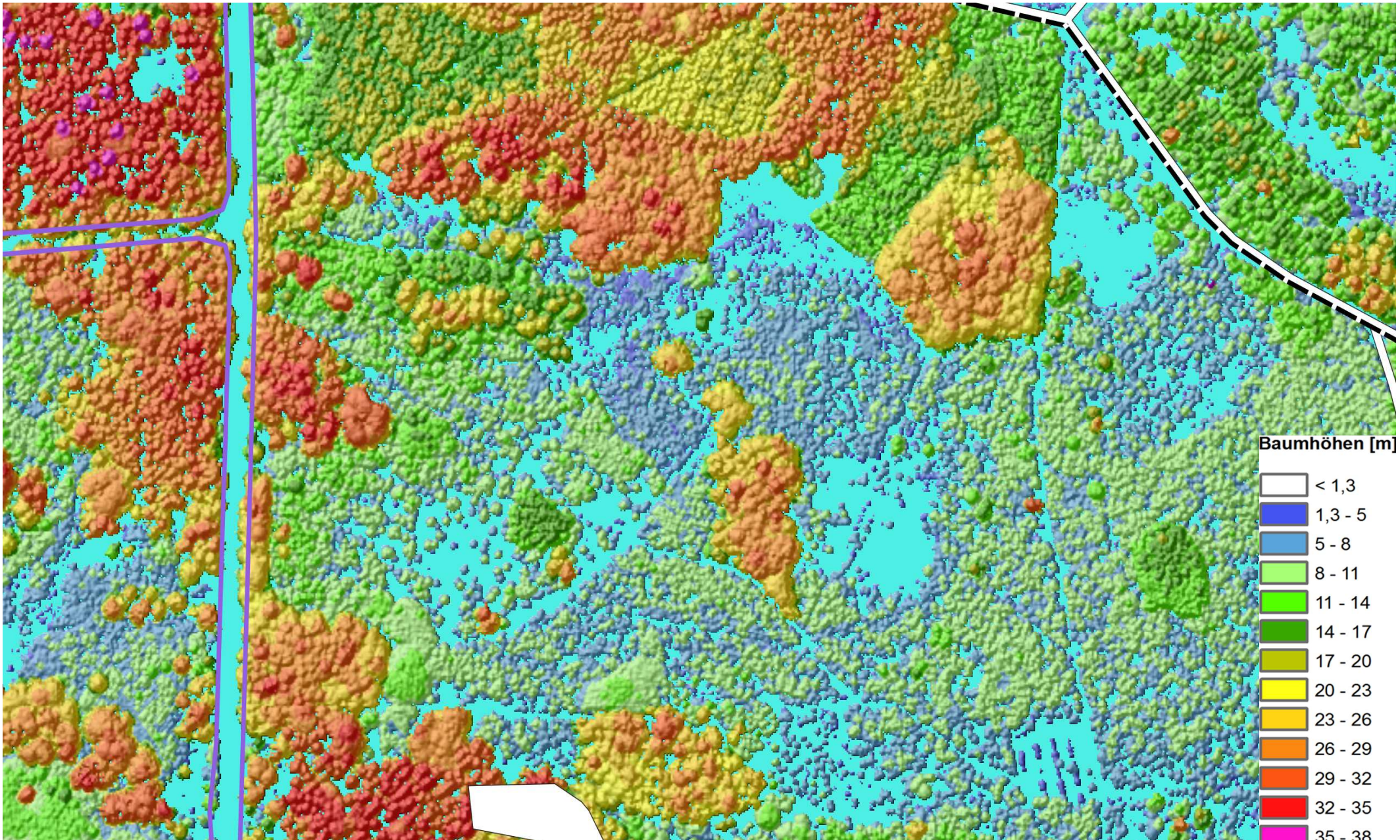
Modelling unstocked area (3)



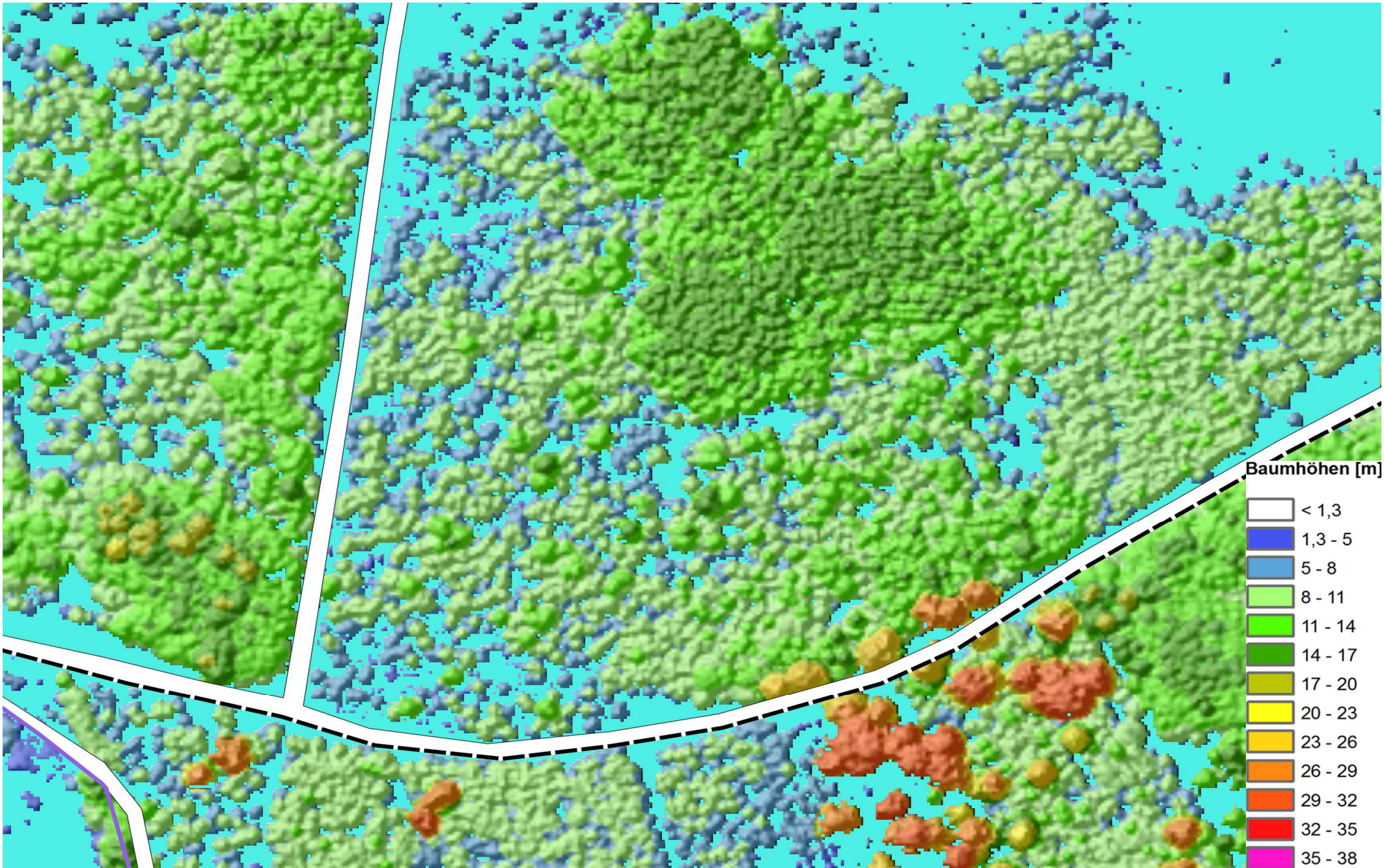
Schrinking of unstocked area by horizontal growth of canopy



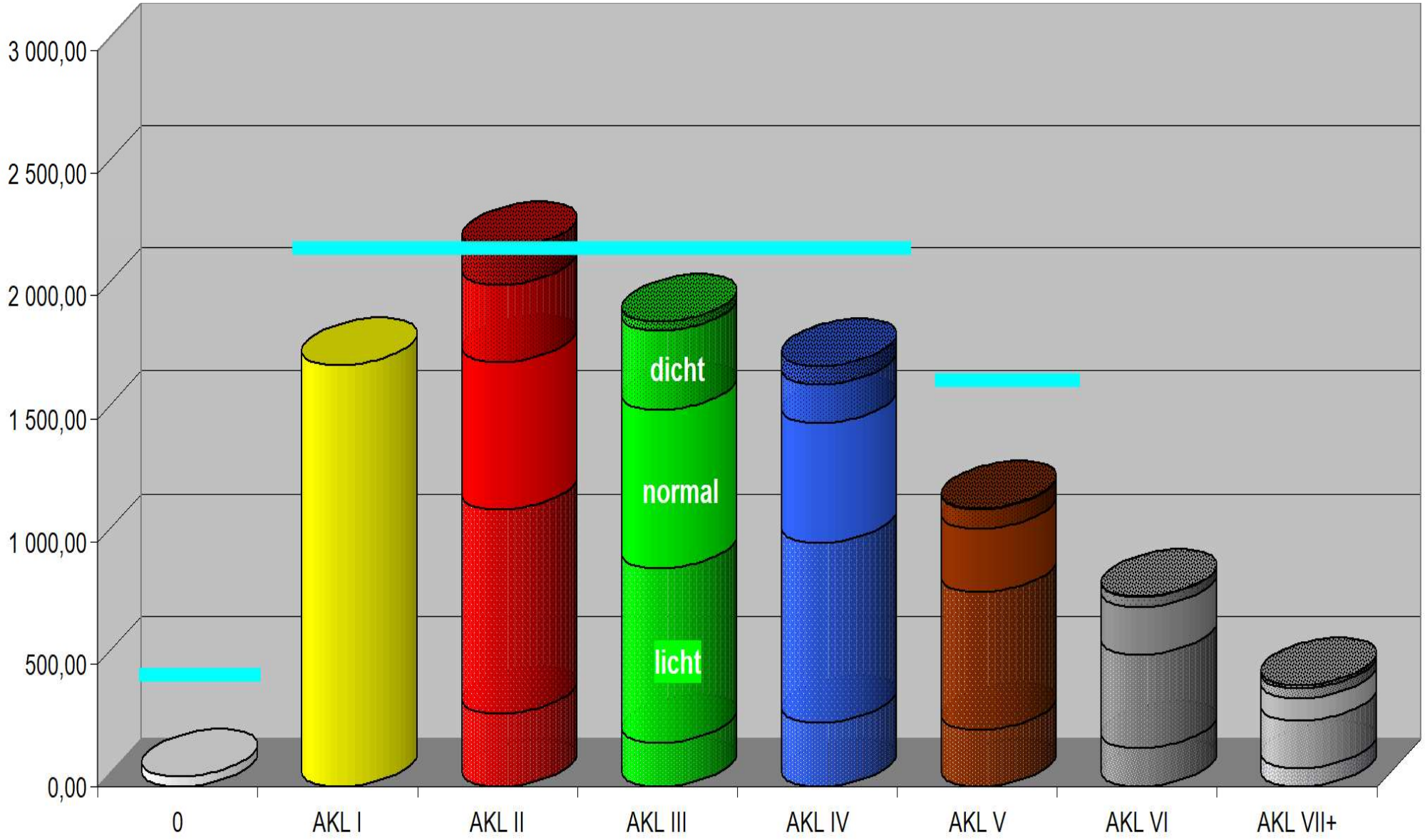
Modelling unstocked area (4)



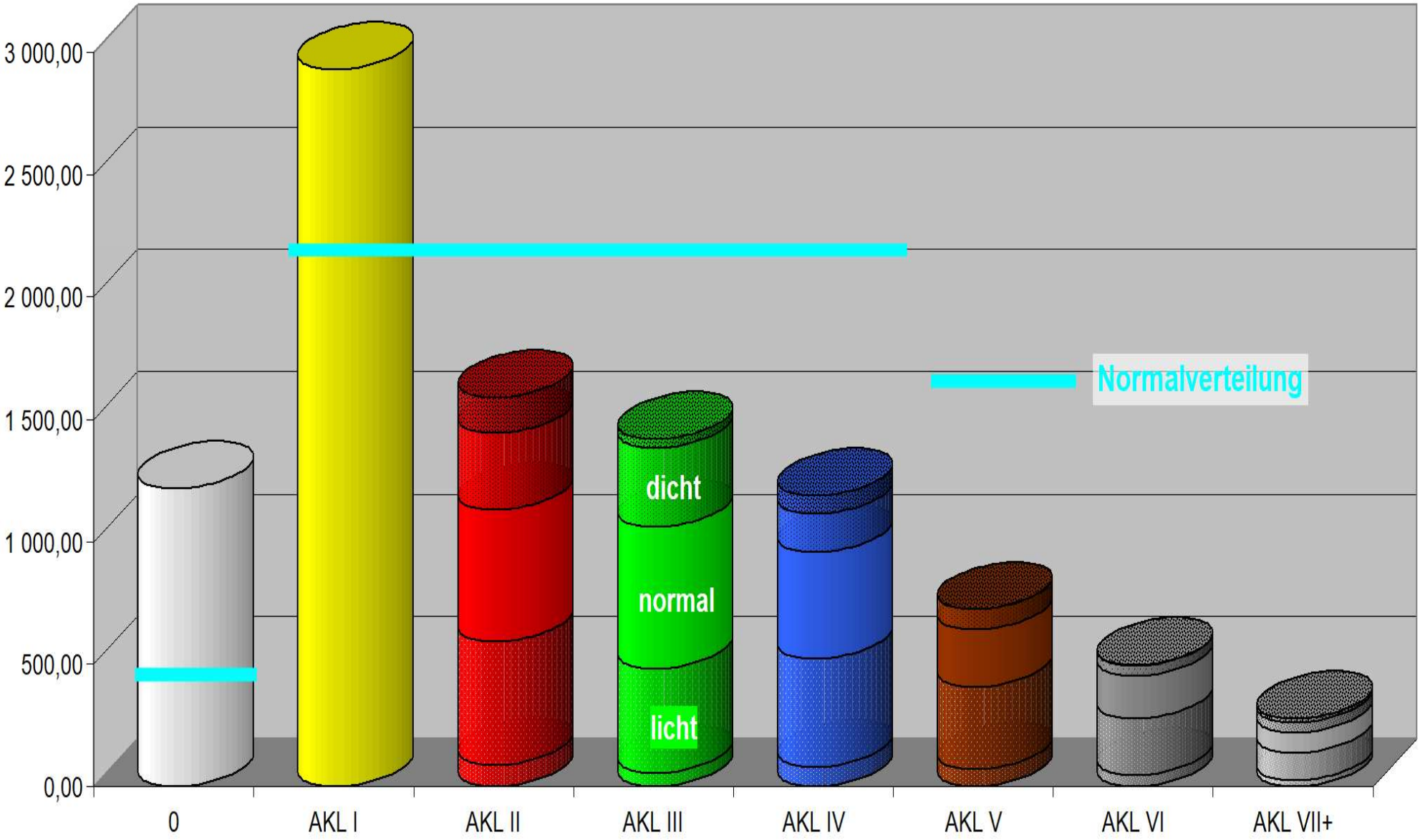
Modelling unstocked area (5)



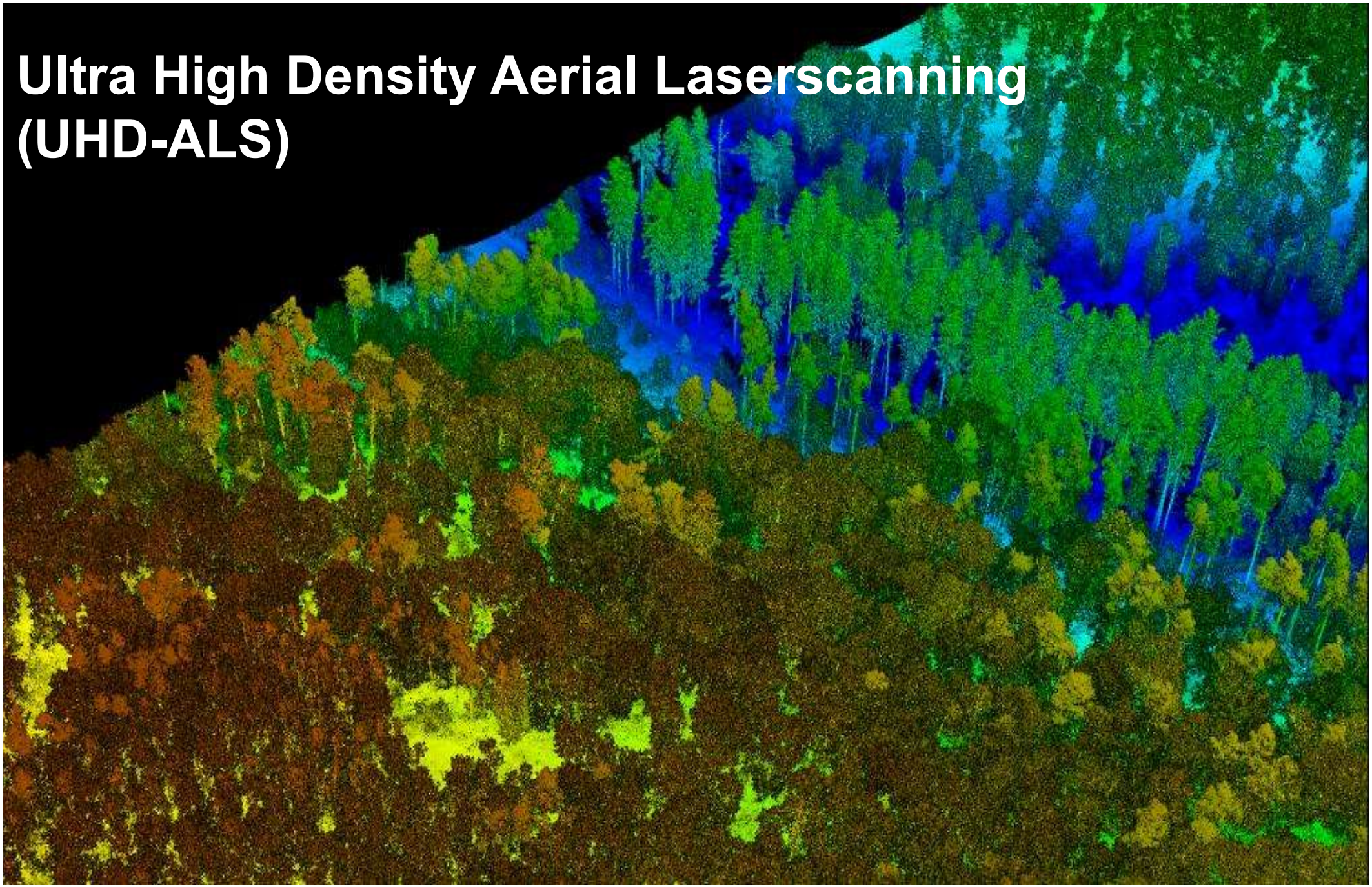
Age Class Distribution
before identification of small unstocked areas



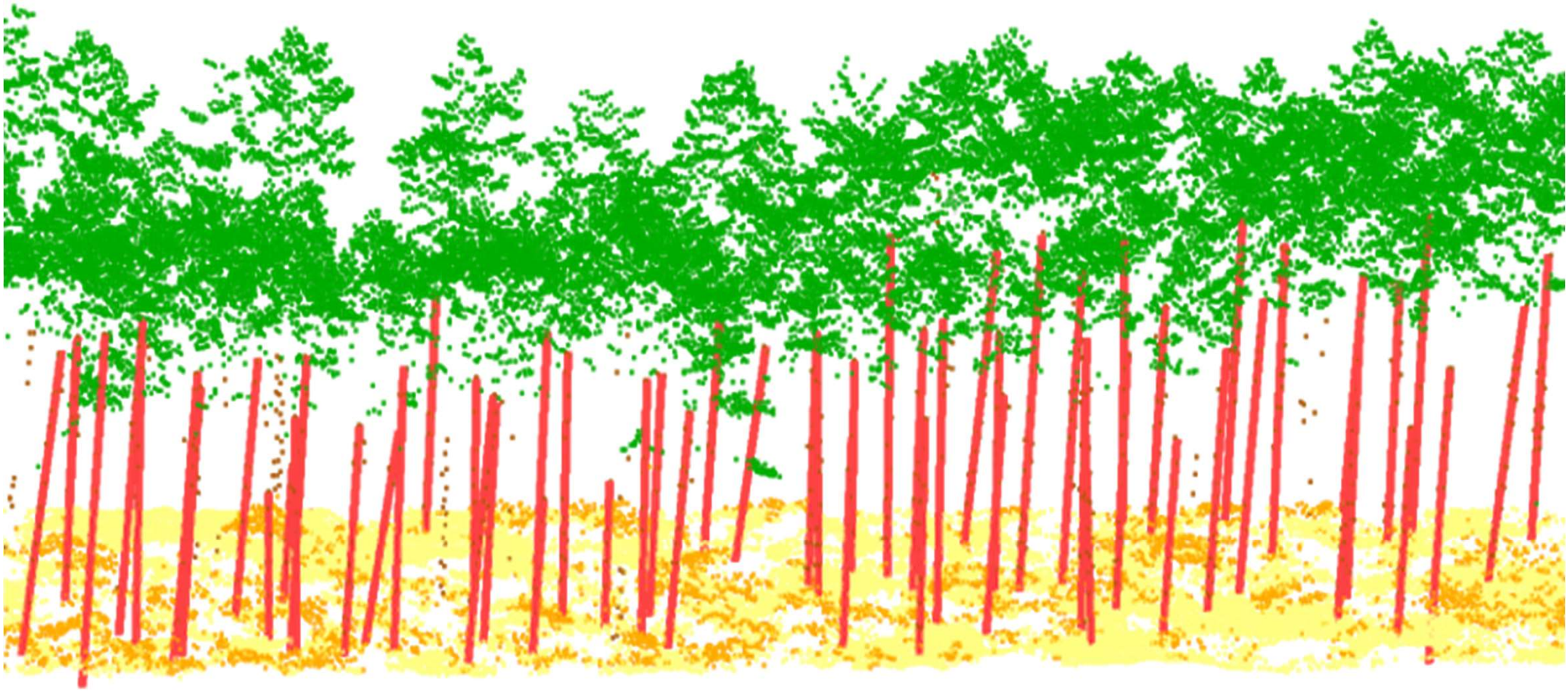
Age Class Distribution
after identification of small unstocked areas



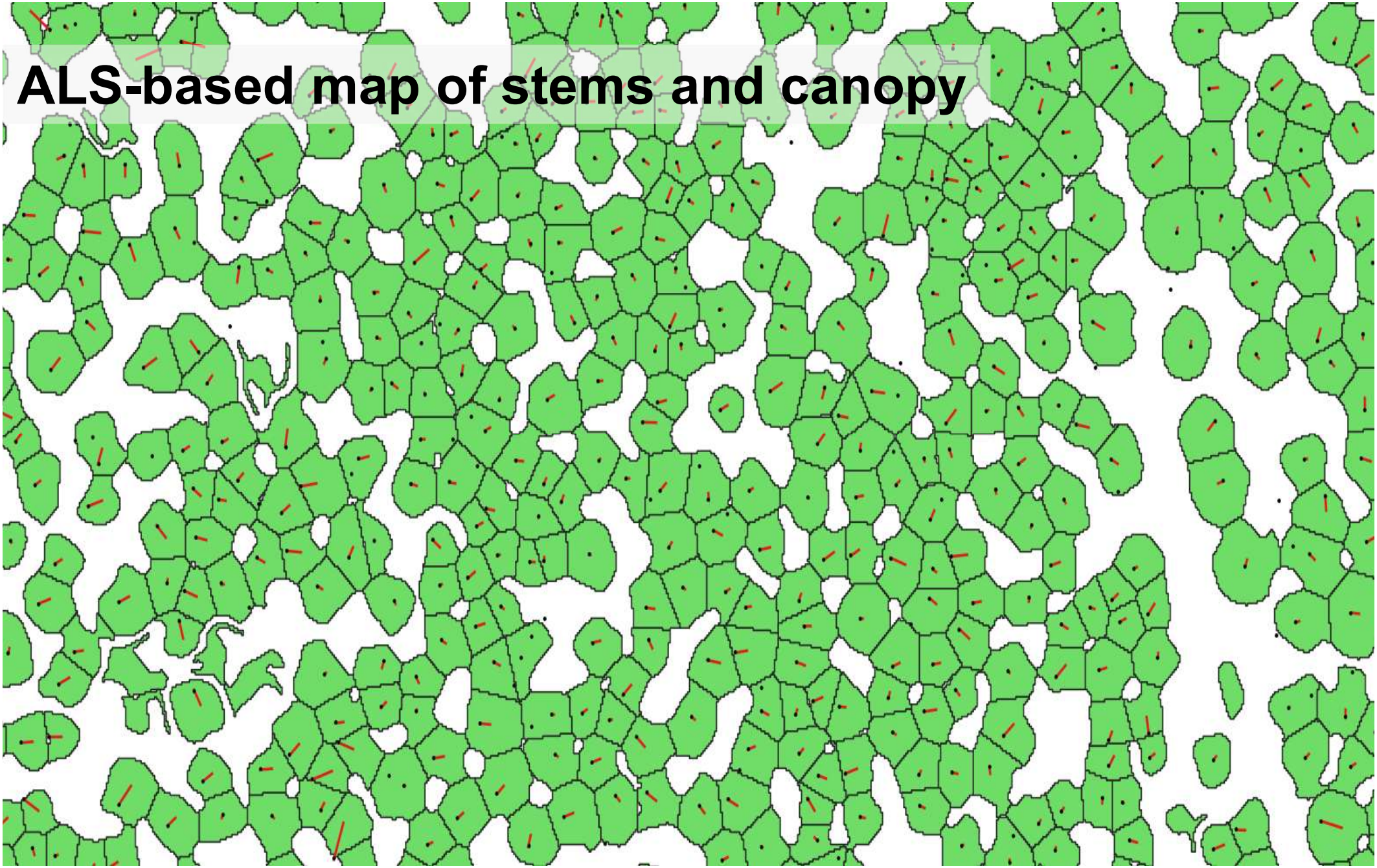
Ultra High Density Aerial Laserscanning (UHD-ALS)



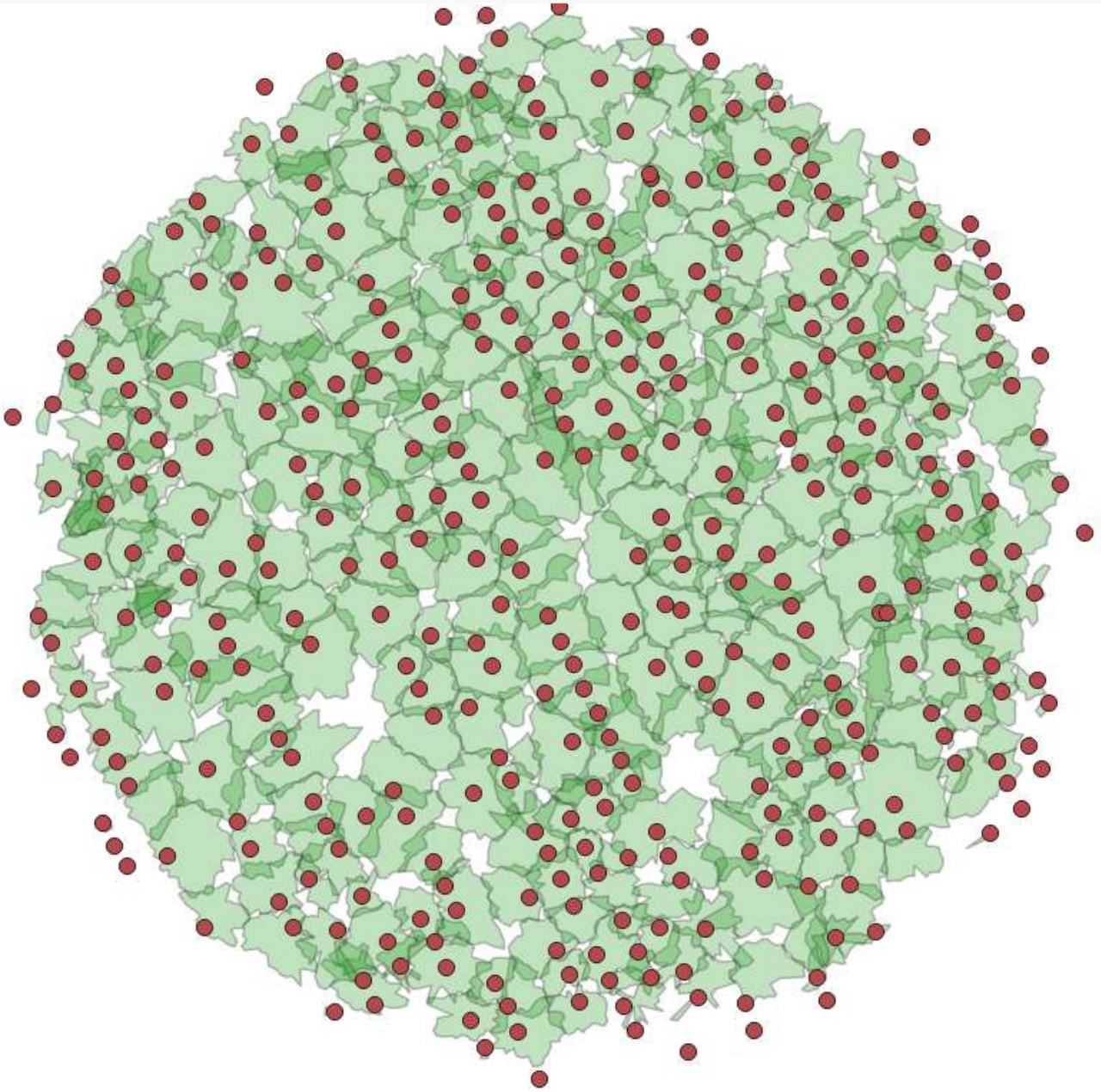
Stem Detection in UHD ALS Point Clouds



ALS-based map of stems and canopy



TLS-based map of stems and canopy

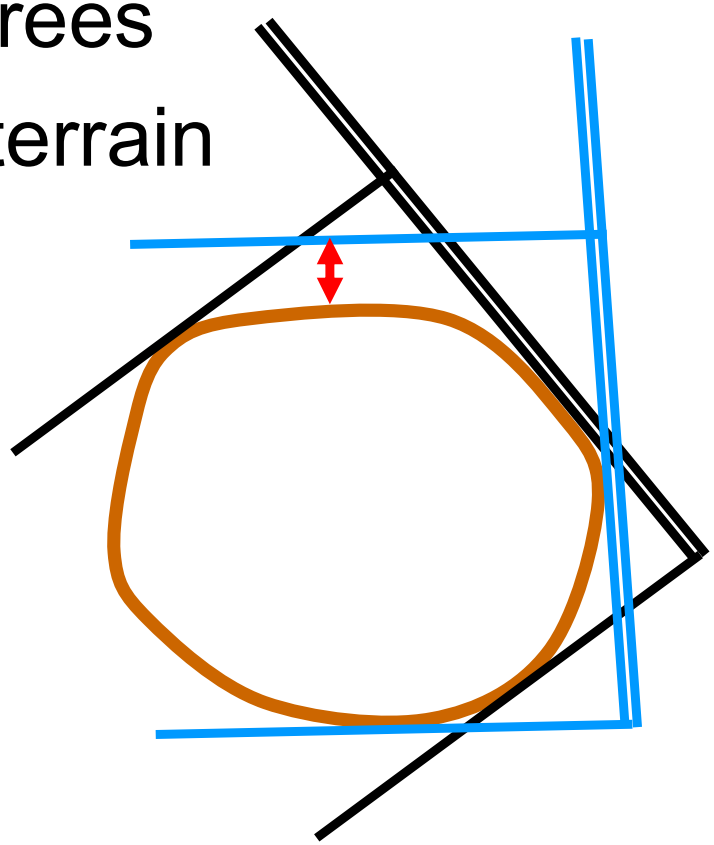


Terrestrial Laser-Scanning TLS

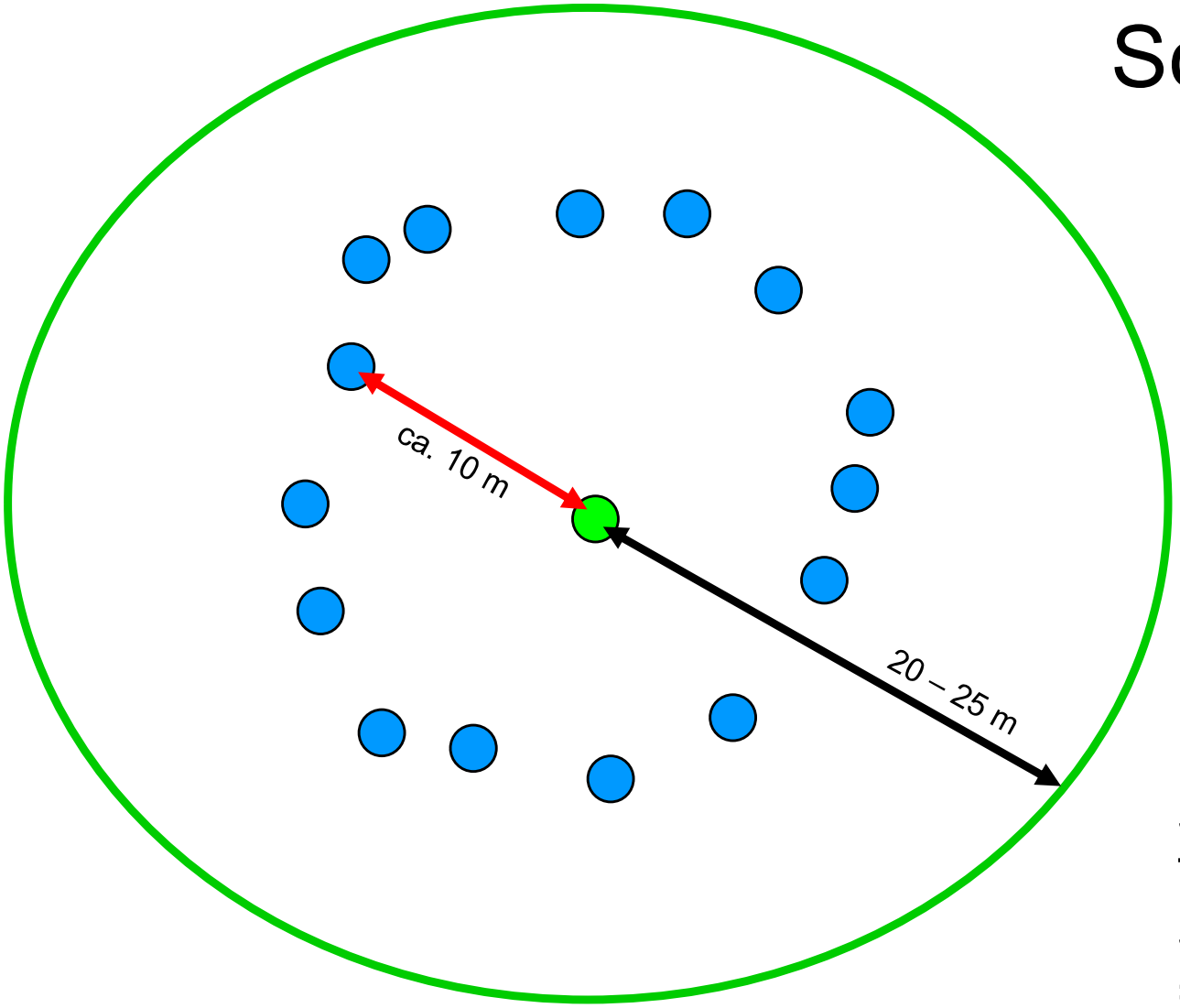
TLS Detail

DBH measurement on permanent sample plots

- Individual tree growth desired
- DBH time series of identical trees
- caliper position in relation to terrain
- direction of caliper
- growth < possible biases
- Implication for TLS
- NFI transition to TLS

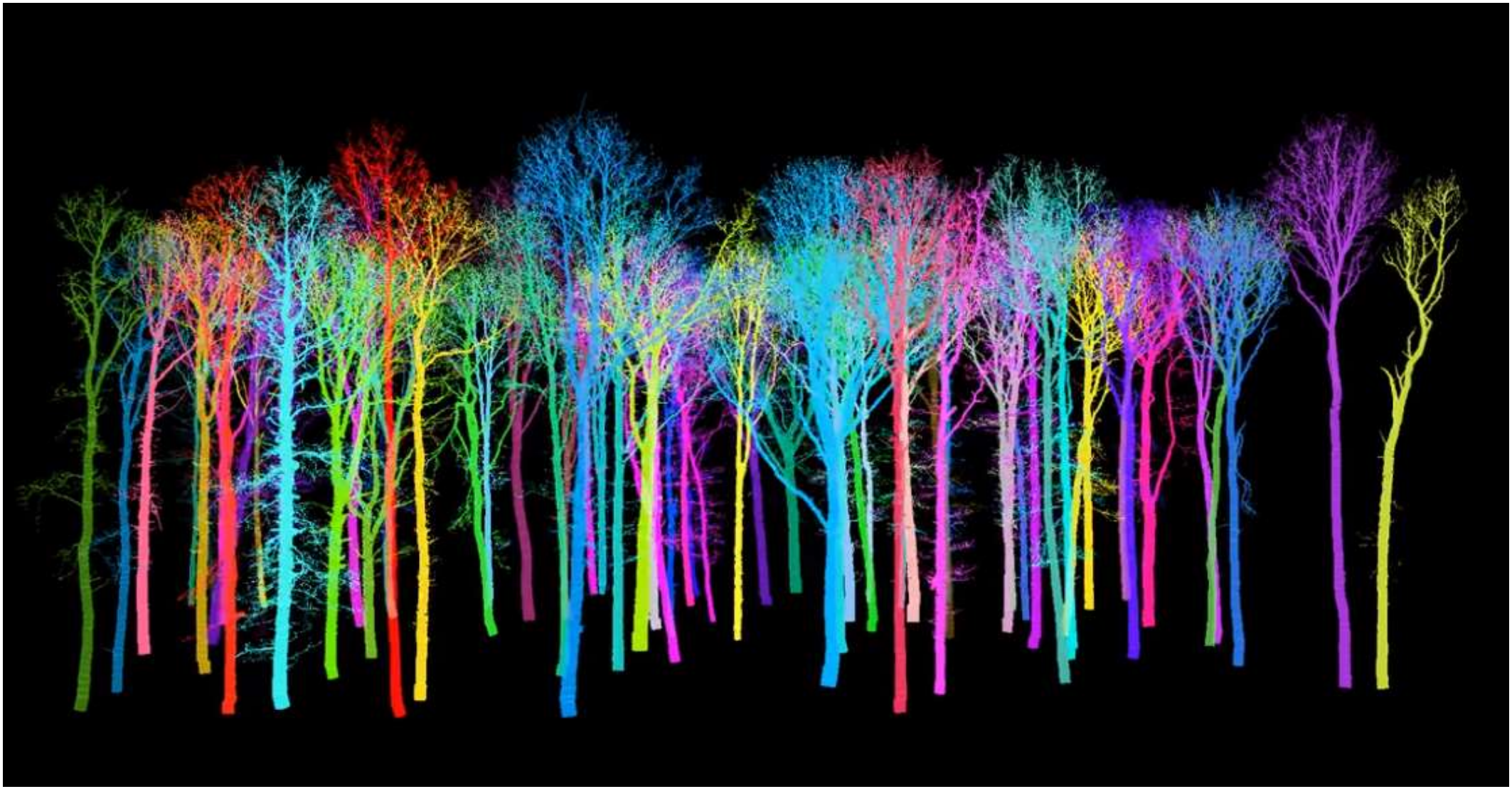


Scan Design on sample plots

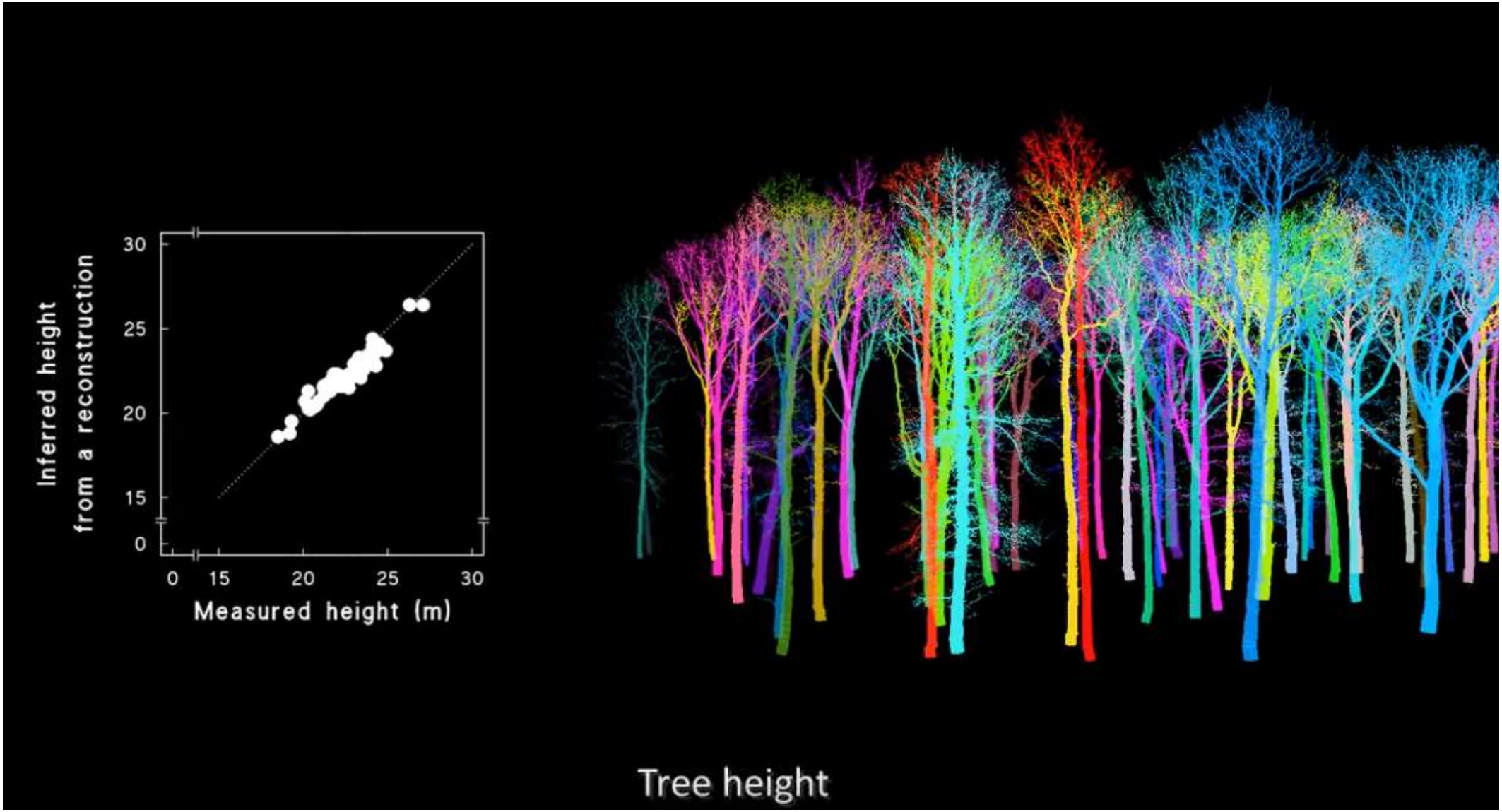


10-15 scan positions
Radius ~10m
Sample plot radius 20-25m
Total scanning time 15 min.
Scan resolution 50 milli-degree
= 9mm @ 10m distance

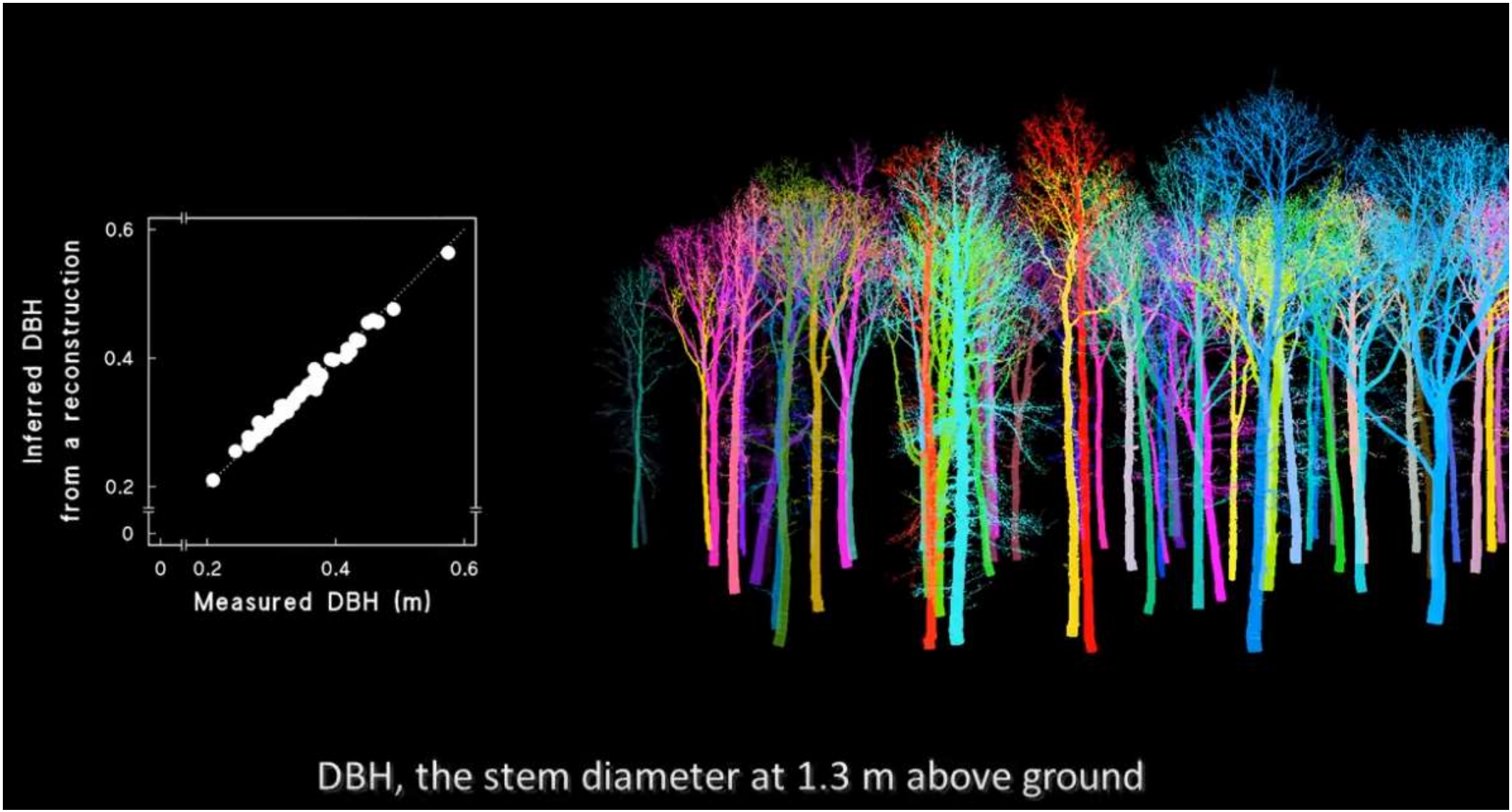
TLS point cloud after tree segmentation



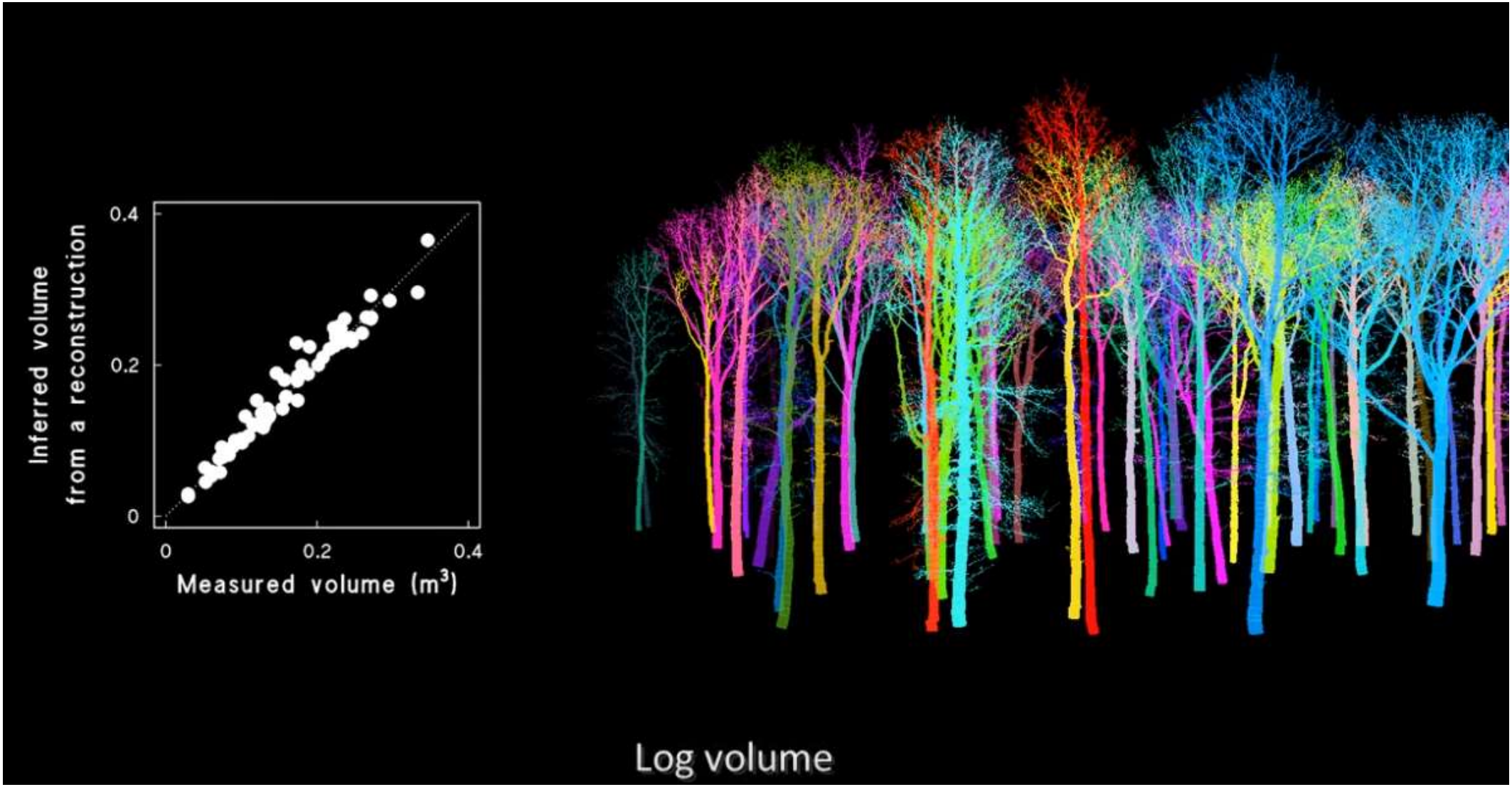
Tree height from TLS point clouds



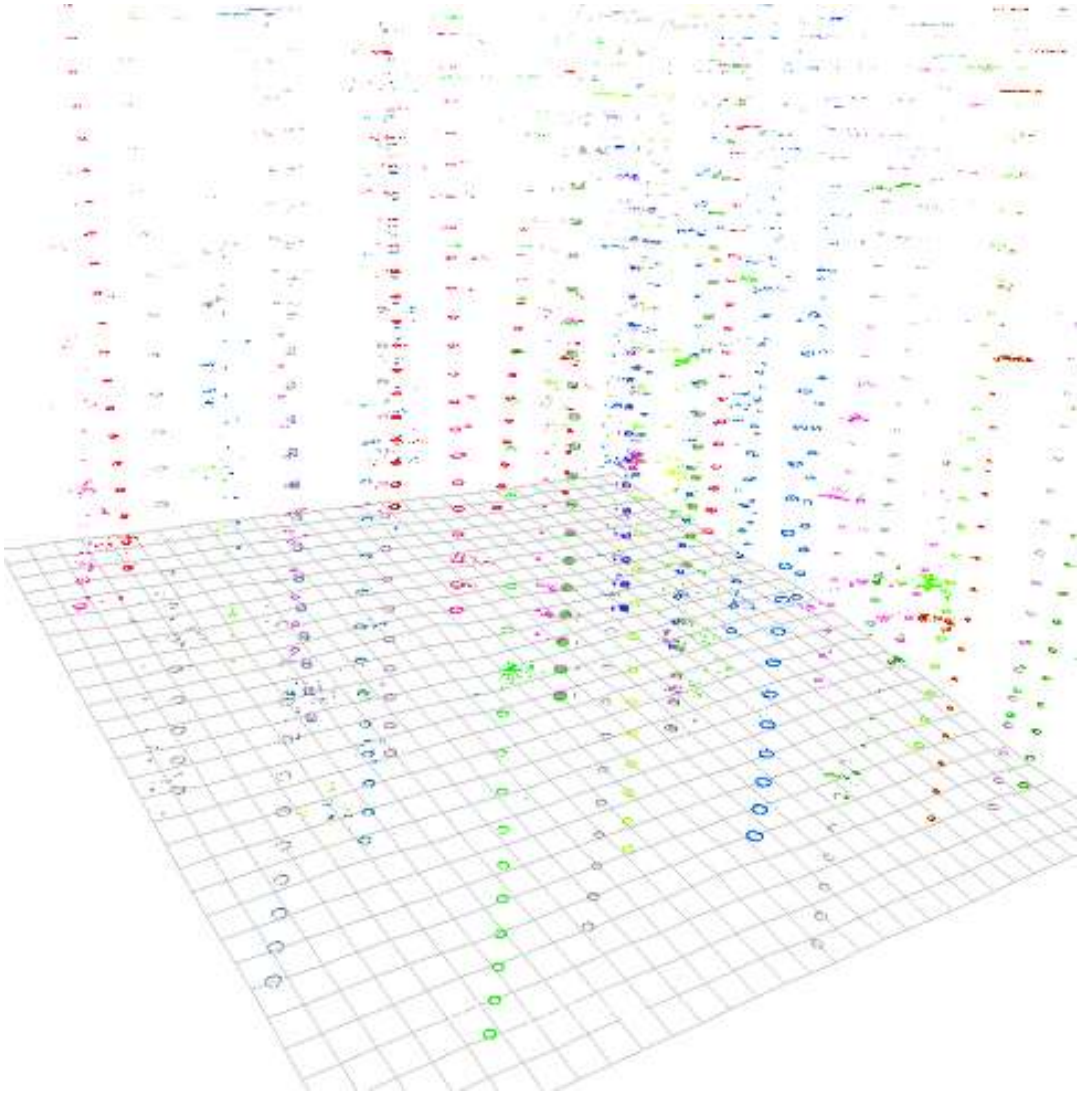
Tree diameters from TLS point clouds

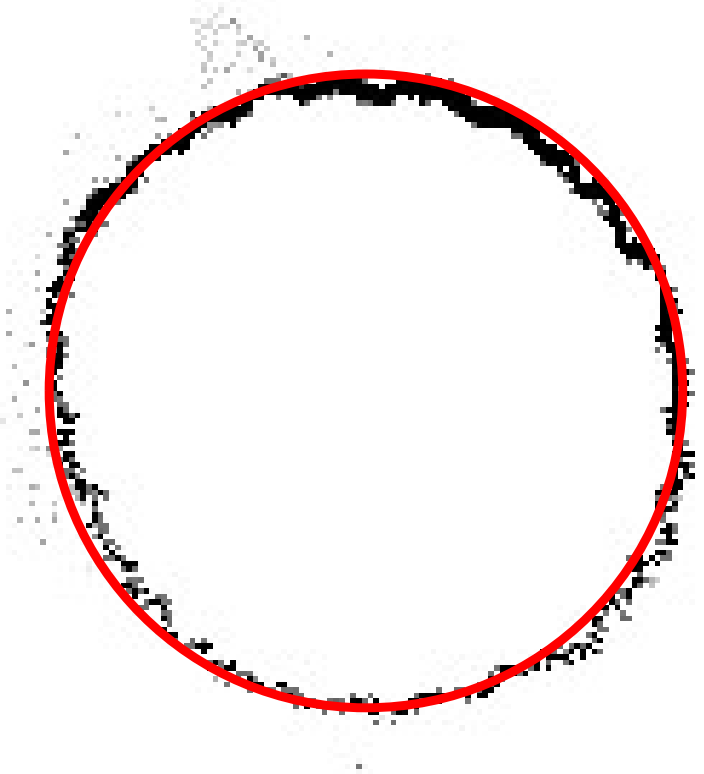


Tree volume from TLS point clouds

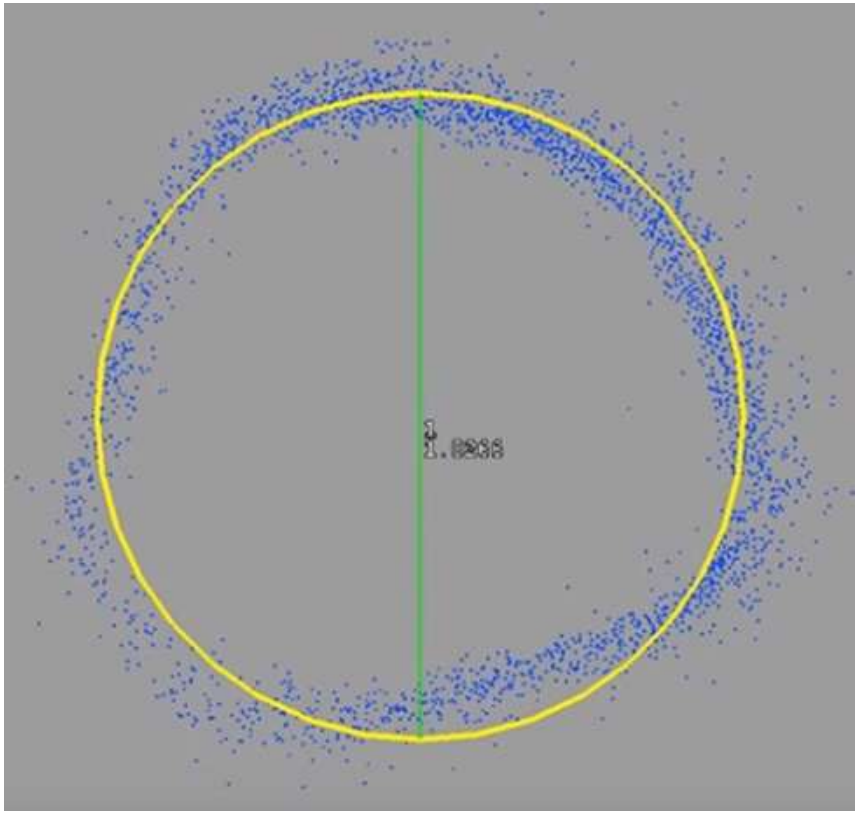


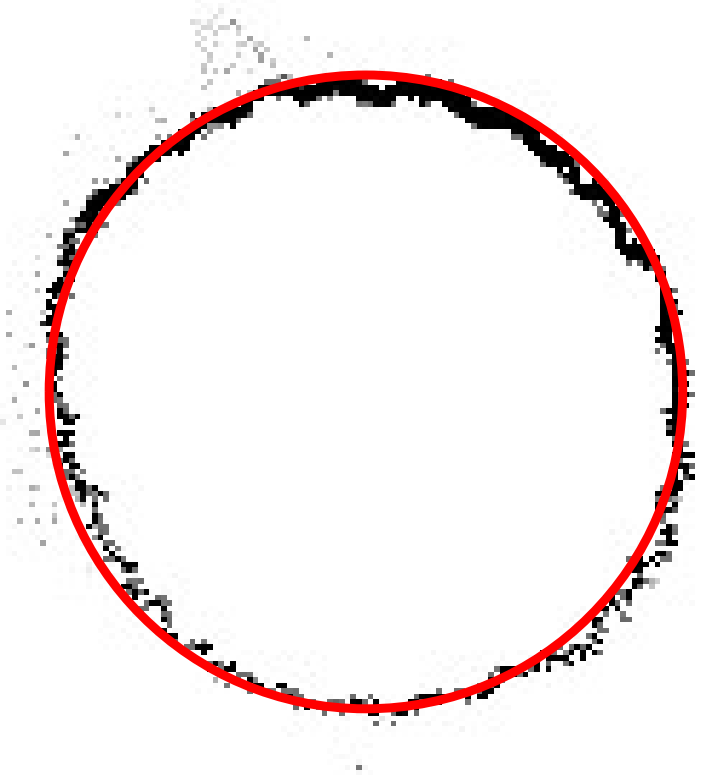
Diameter extraction from TLS point clouds



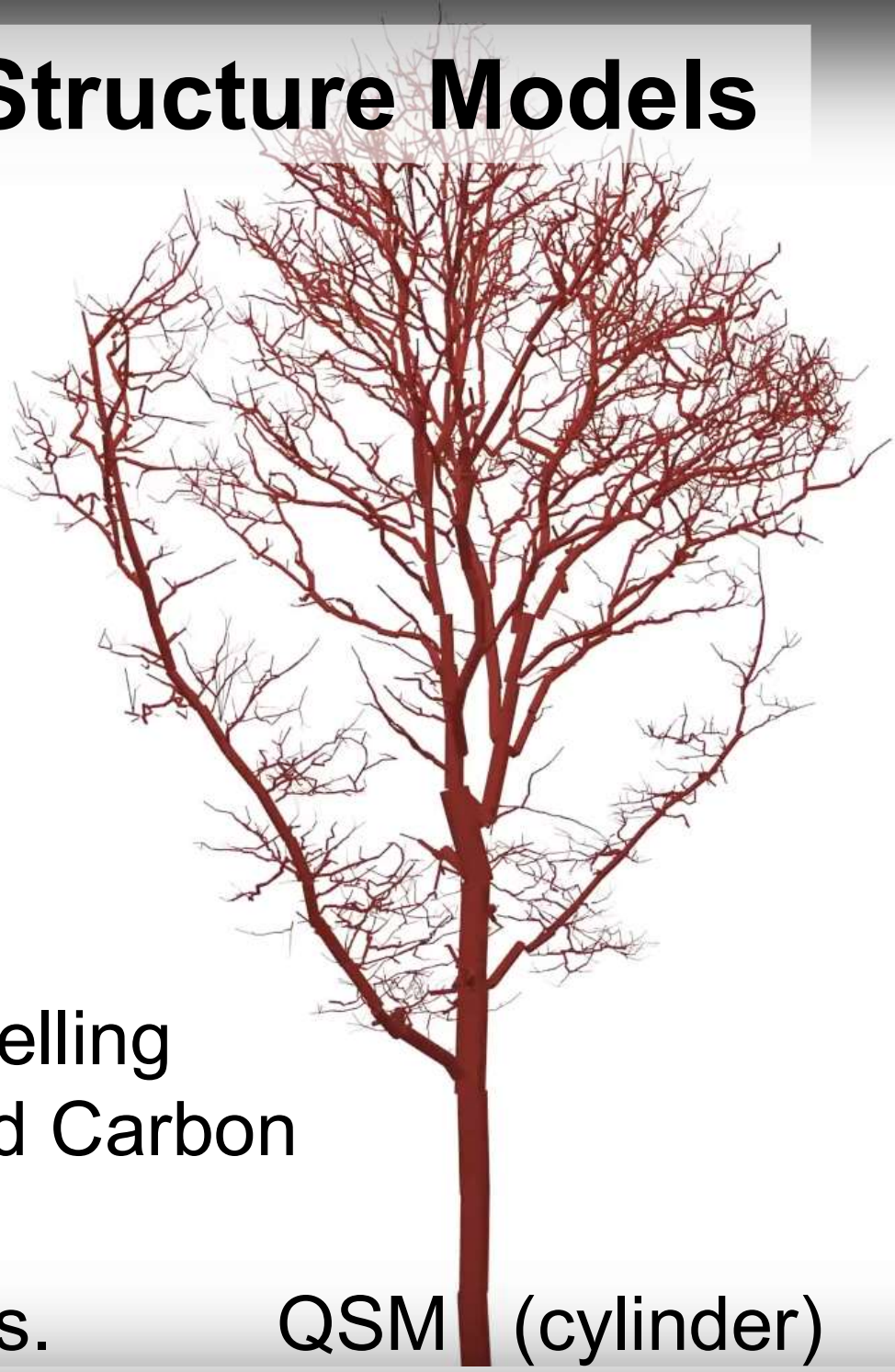


Different in Point Cloud Qualitys





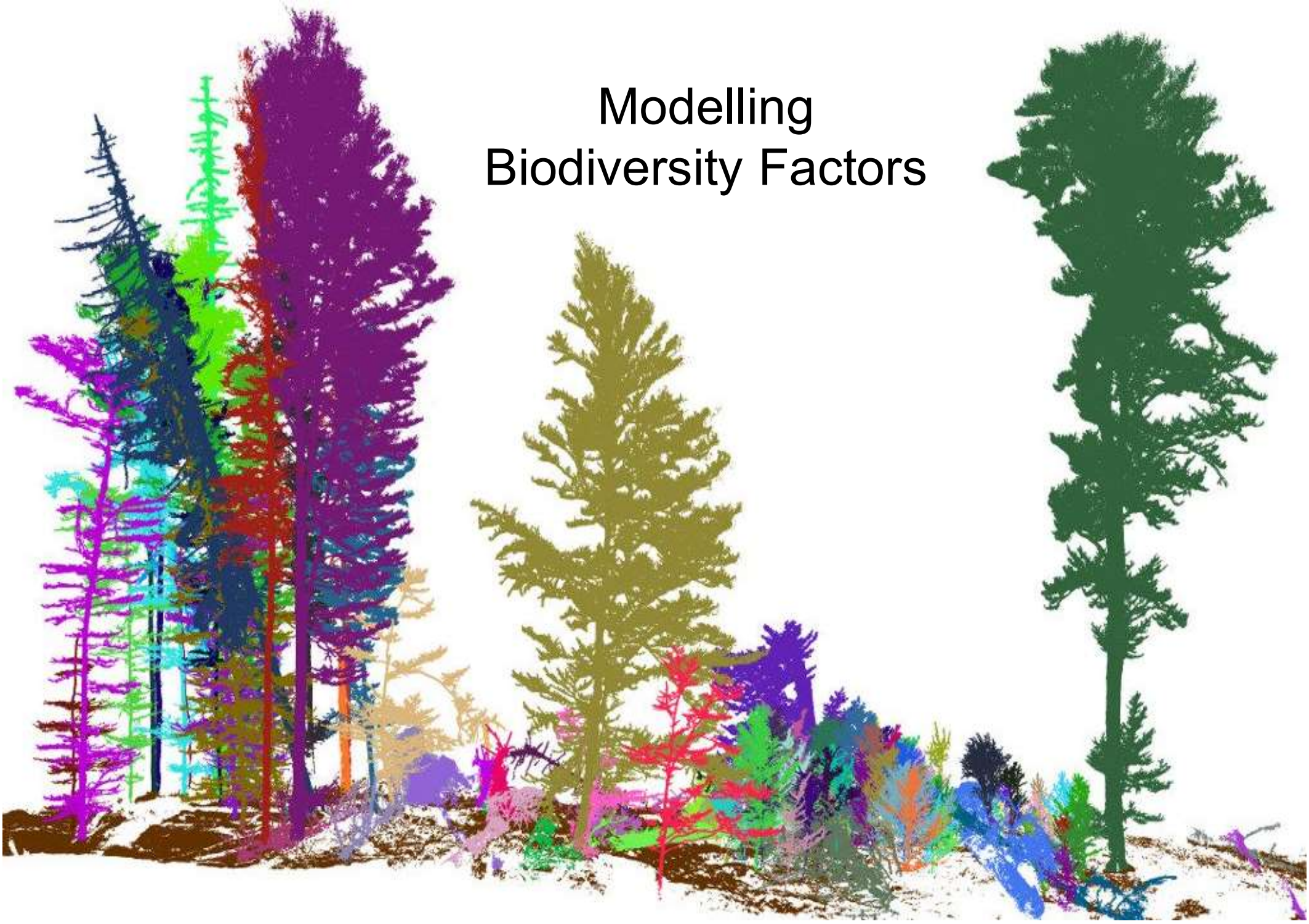
Quantitative Structure Models



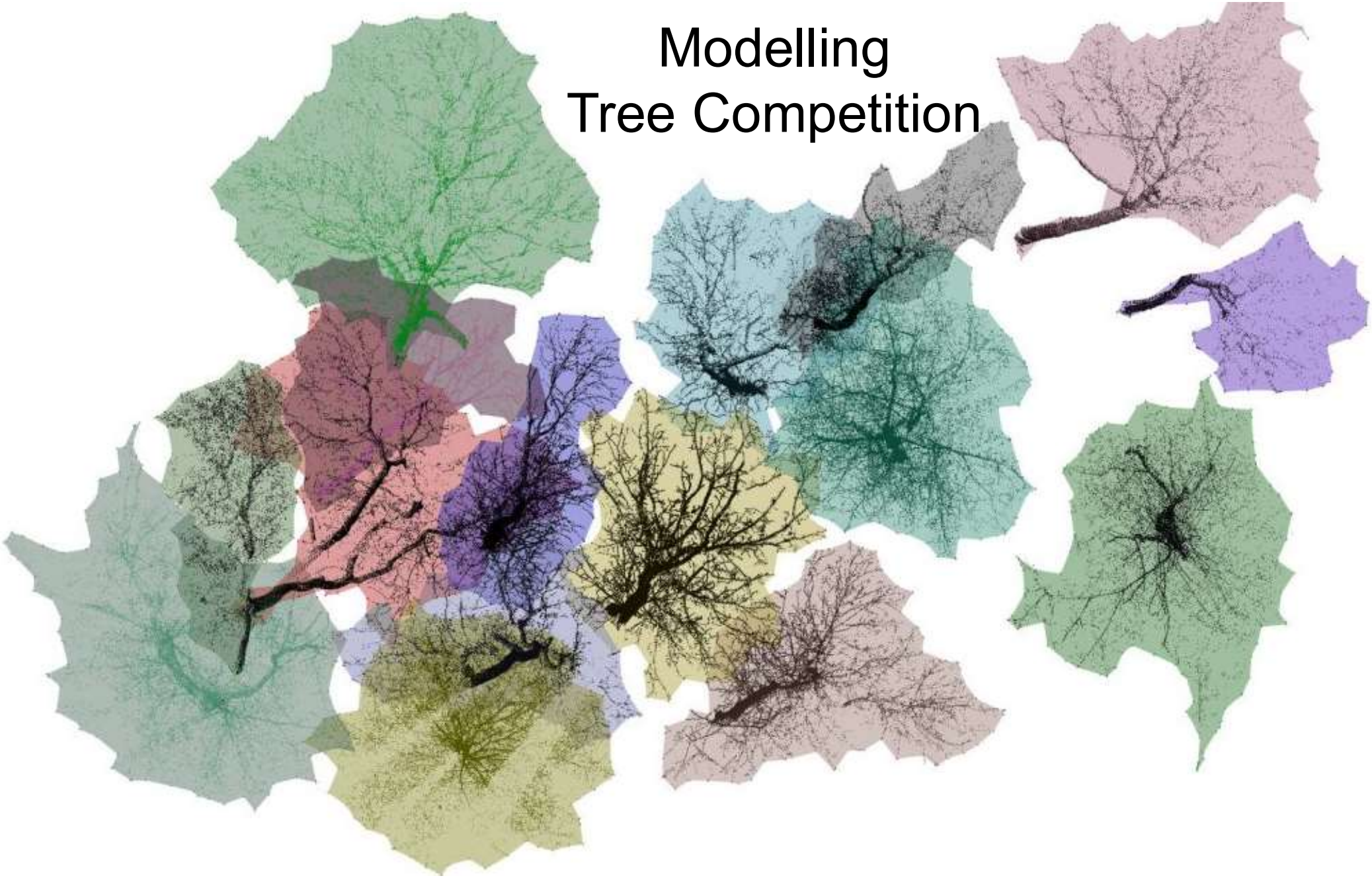
Modelling
AGB and Carbon

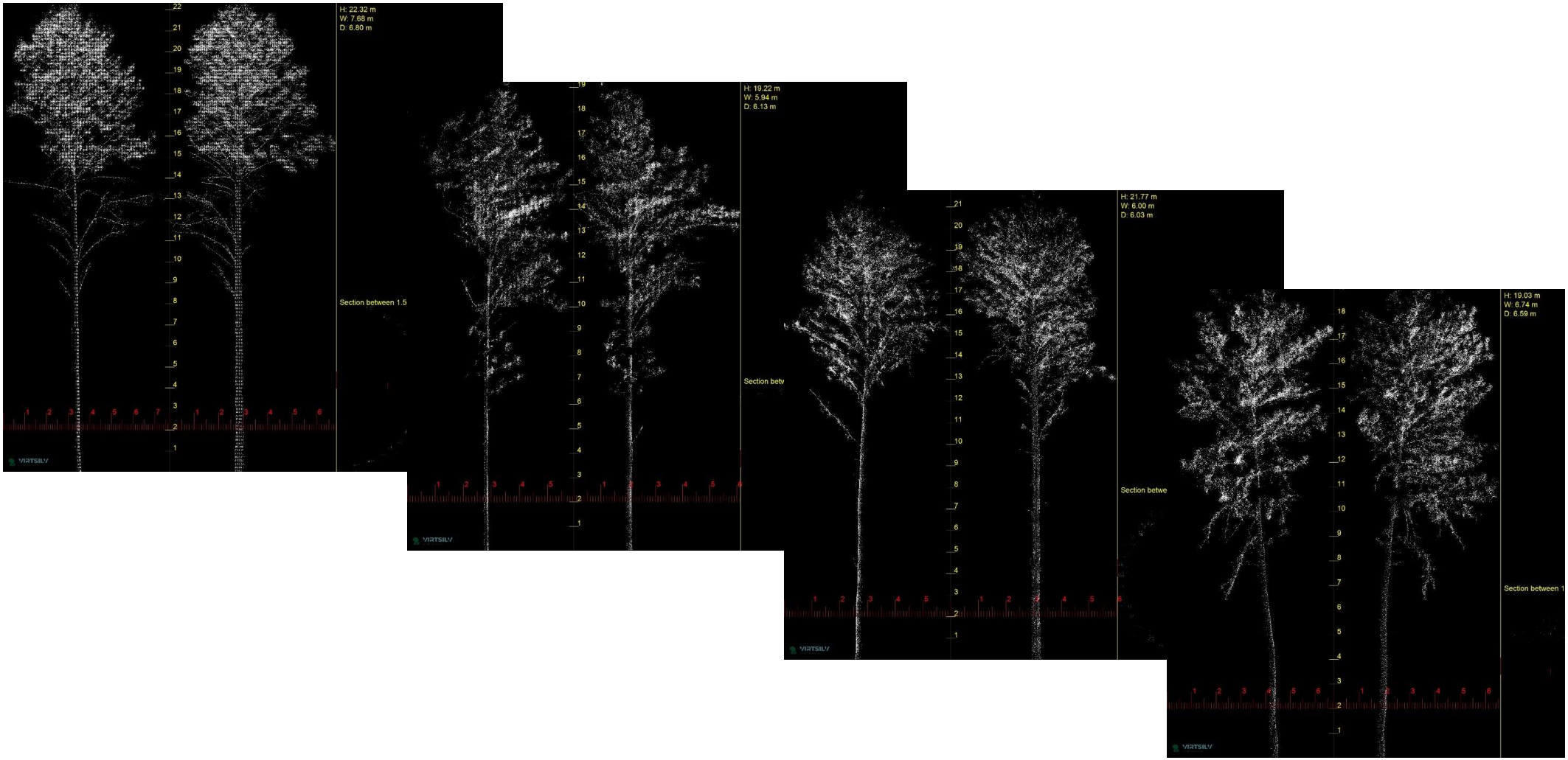
Point Clouds vs. QSM (cylinder)

Modelling Biodiversity Factors



Modelling
Tree Competition




H: 22.32 m
W: 7.68 m
D: 6.80 m
Section between 1.5
H: 19.22 m
W: 5.94 m
D: 6.13 m
Section betv
H: 21.77 m
W: 6.00 m
D: 6.03 m
Section betwe
H: 19.03 m
W: 6.74 m
D: 6.59 m
Section between 1
VIRTSILV


VIRTSILV
VIRTSILV
VIRTSILV
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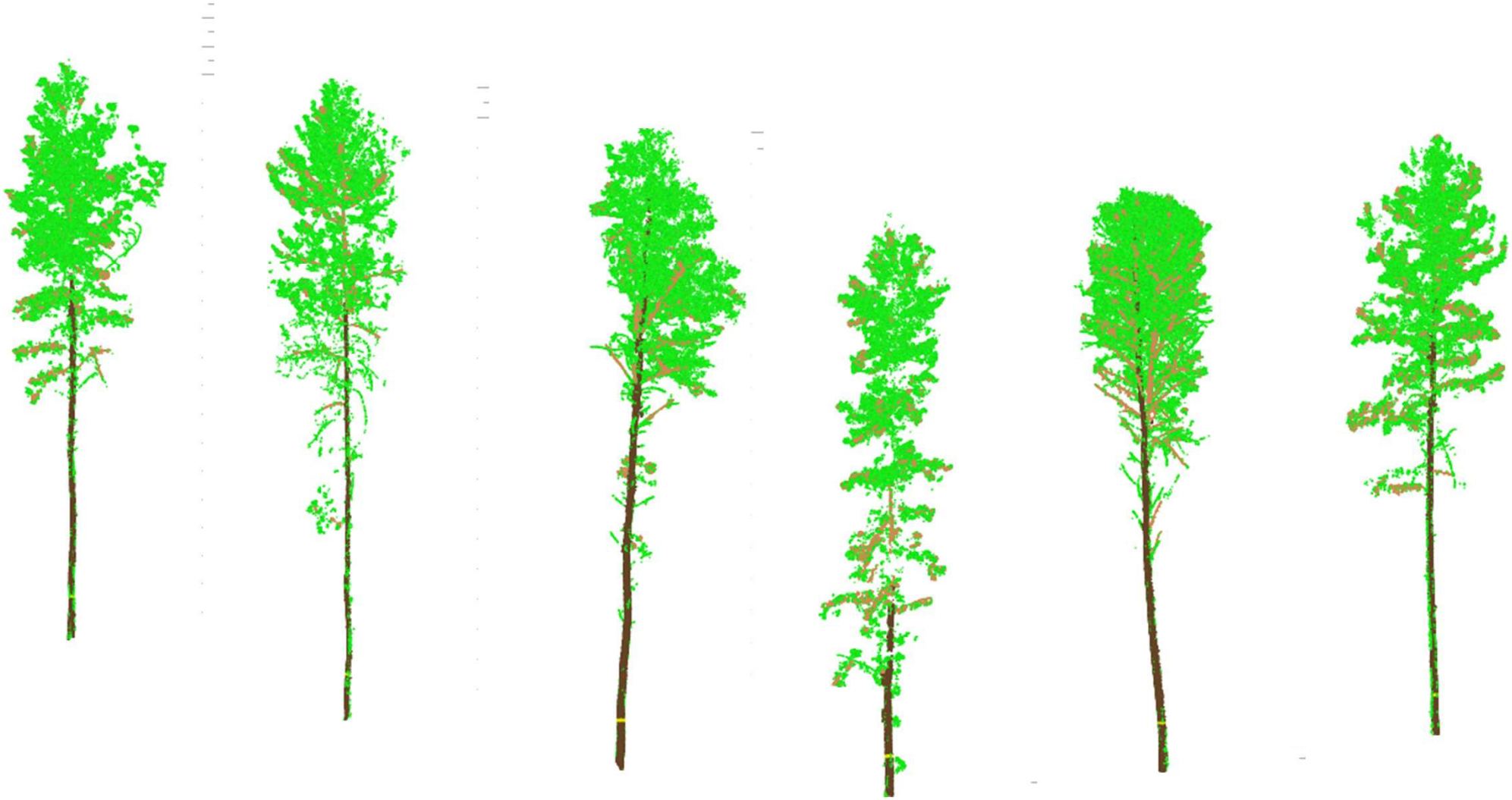
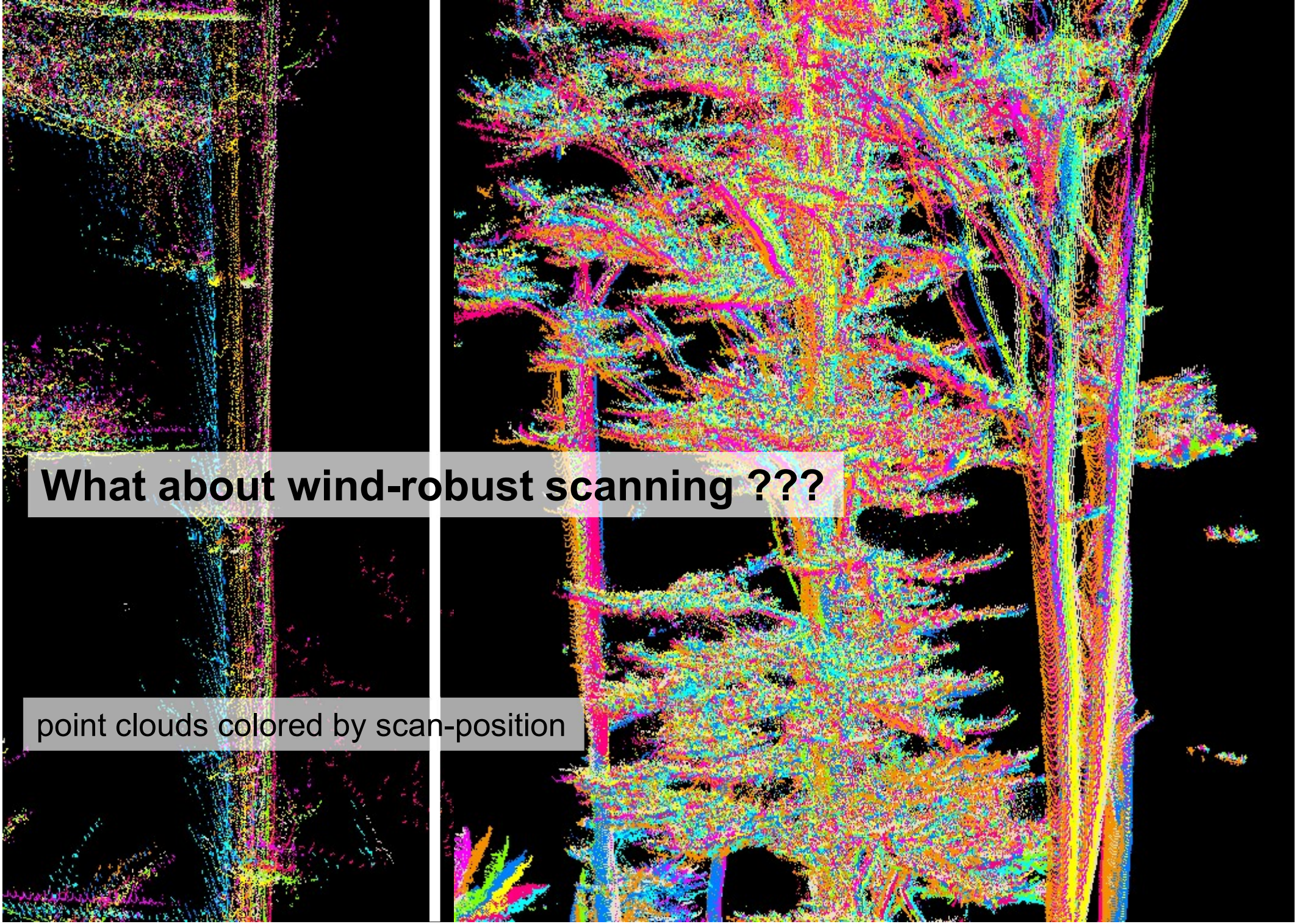
VIRTSILV



Benefits of Forest Digital Twins

- Freeze actual state of the forest in 3D-point-cloud
- Compare time series of digital forest twins for change monitoring
- Advanced feature extraction and change detection by machine learning and Neuronal Networks can be applied later on time series
- New methods can be applied to old datasets
- Visual classification by VR applications can be performed any time in mono-temporal and multi-temporal point clouds
- Method can be certified for Carbon Accounting
- Monitoring becomes transparent and objective

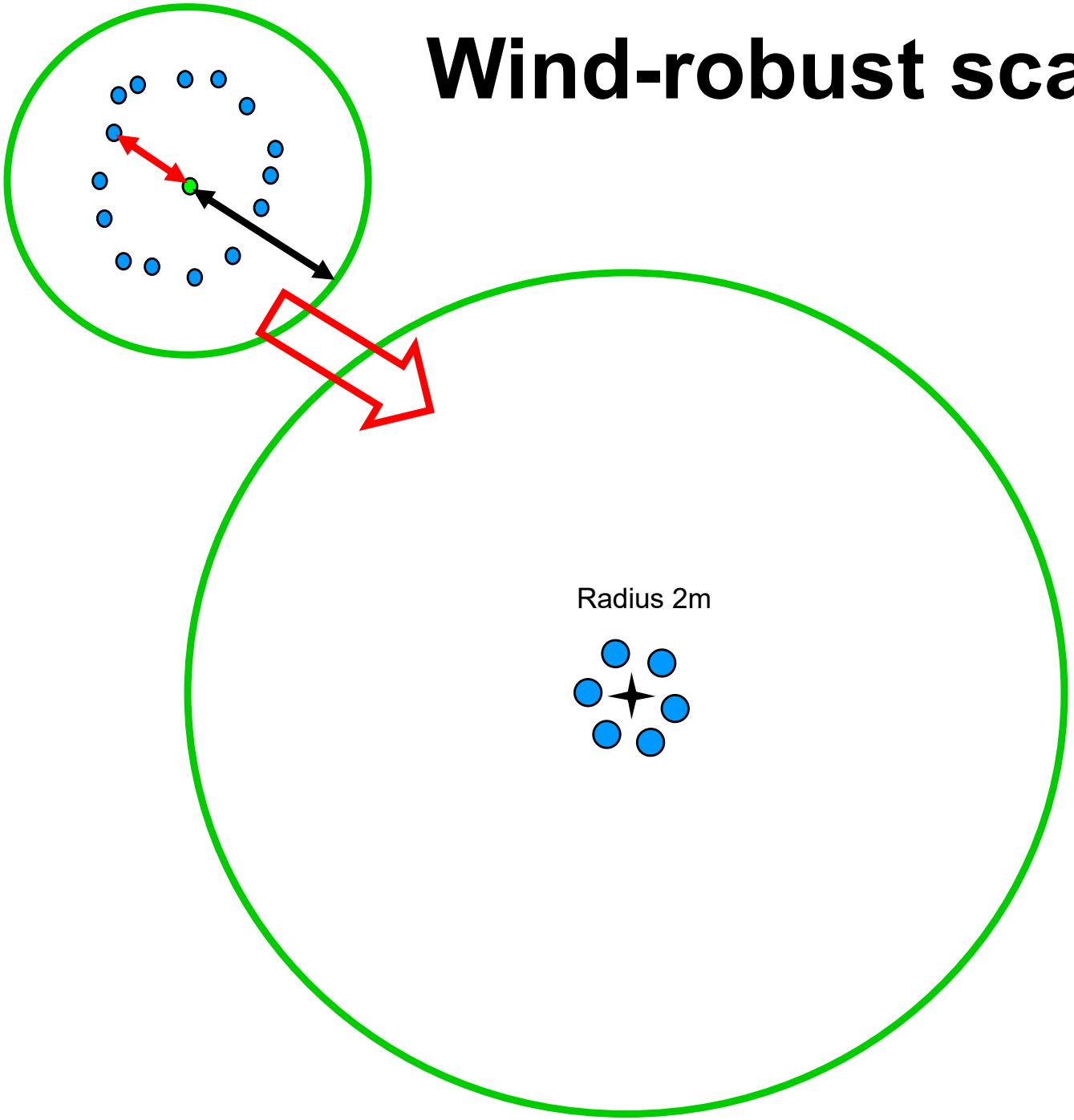

What about wind-robust scanning ???
point clouds colored by scan-position

Antero Kukko

BP-MLS-VUX1
Riegl VUX-1HA
NovAtel Flexpak6
LITEF UIMU-LCI

Riegl VZ400i tilted ~75° with scan pattern 100 x 10 mDeg

Wind-robust scan pattern:



6 scan-positions radius 2m

separated point clouds
from odd and even
scan positions

~horizontal scan-lines
resolution between lines:
100 milli-degree
resolution within lines:
10 milli-degree

scanning time
60 seconds per position

Eric Hyyppä et al 2020: Arc Detection on Stems

E. Hyyppä, et al. ISPRS Journal of Photogrammetry and Remote Sensing 161 (2020) 246–262

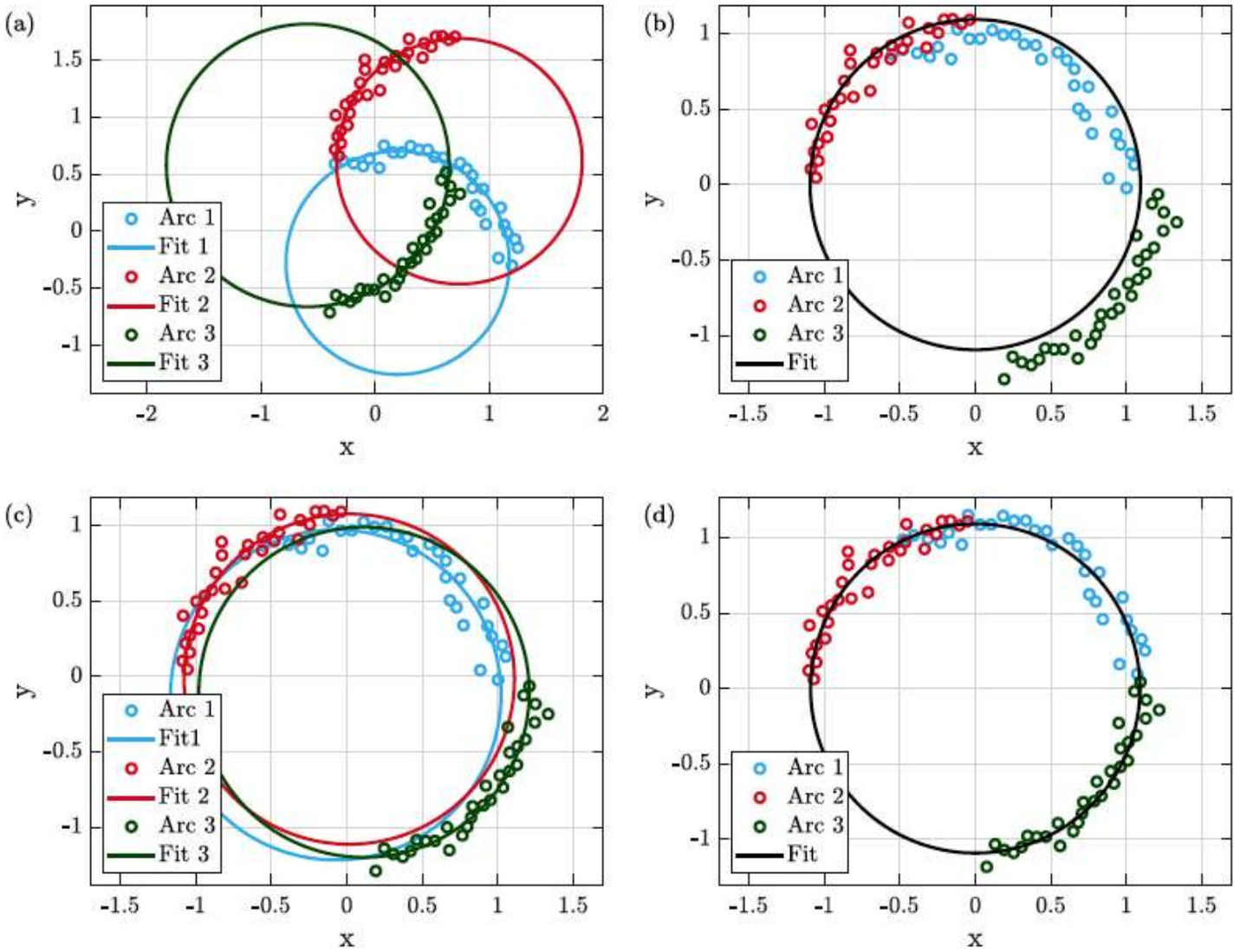
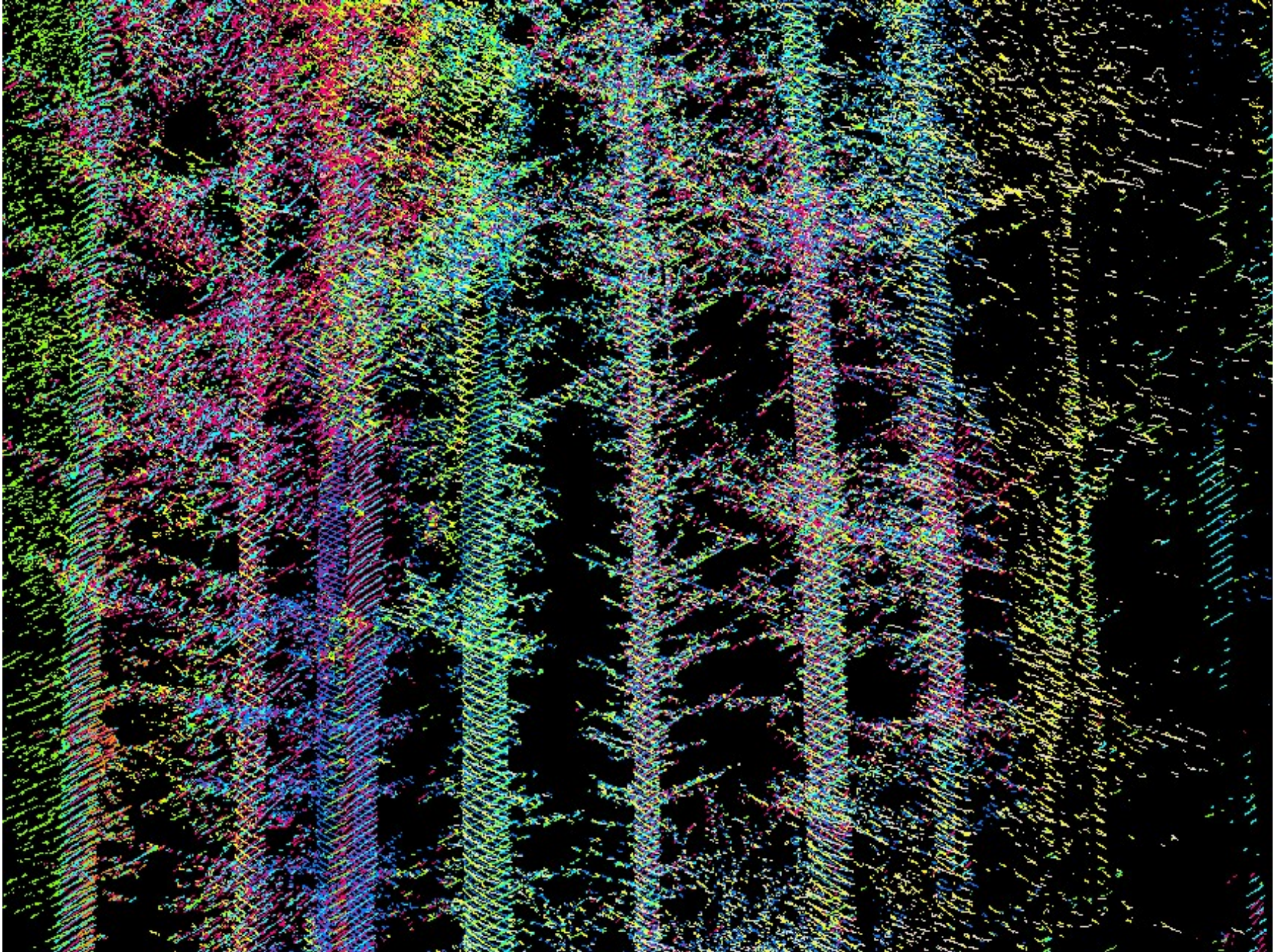


Fig. 7. Schematic of the arc matching algorithm. (a) Three simulated arcs of 30 points with normally distributed noise. The circles drawn with the solid line illustrate the hyperaccurate circle fit to each of the arcs. (b) The same arcs after shifting their coordinates such that the center of each fit coincides with the origin. The solid black line illustrates a circular fit with the center fixed at the origin. (c) Subsequently, we fit a circle to each of the arcs such that the radius of each fit is forced to equal the radius obtained in panel (b). (d) After iterating the process presented in panels (b) and (c), we obtain the final fit shown with the solid black line.

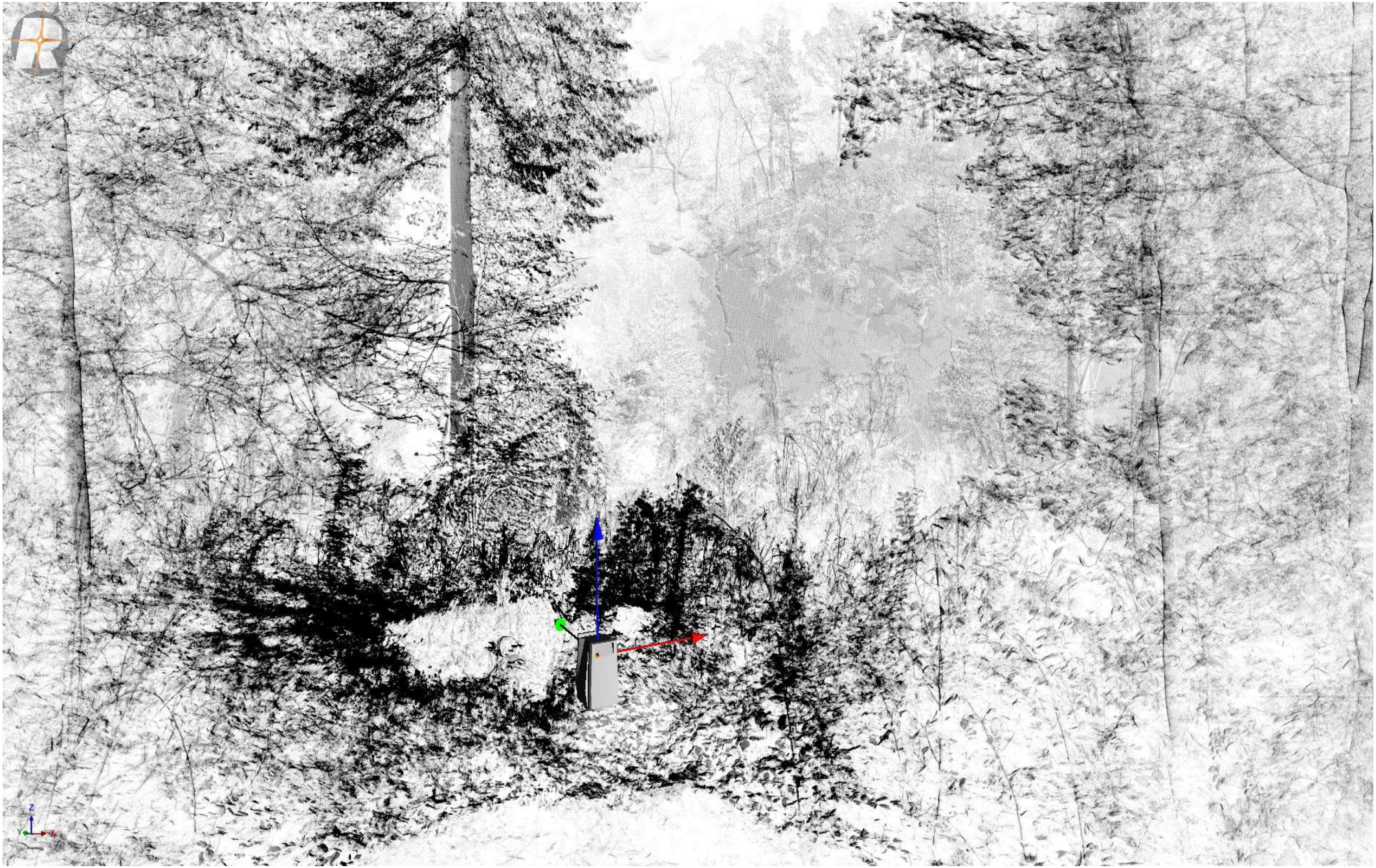


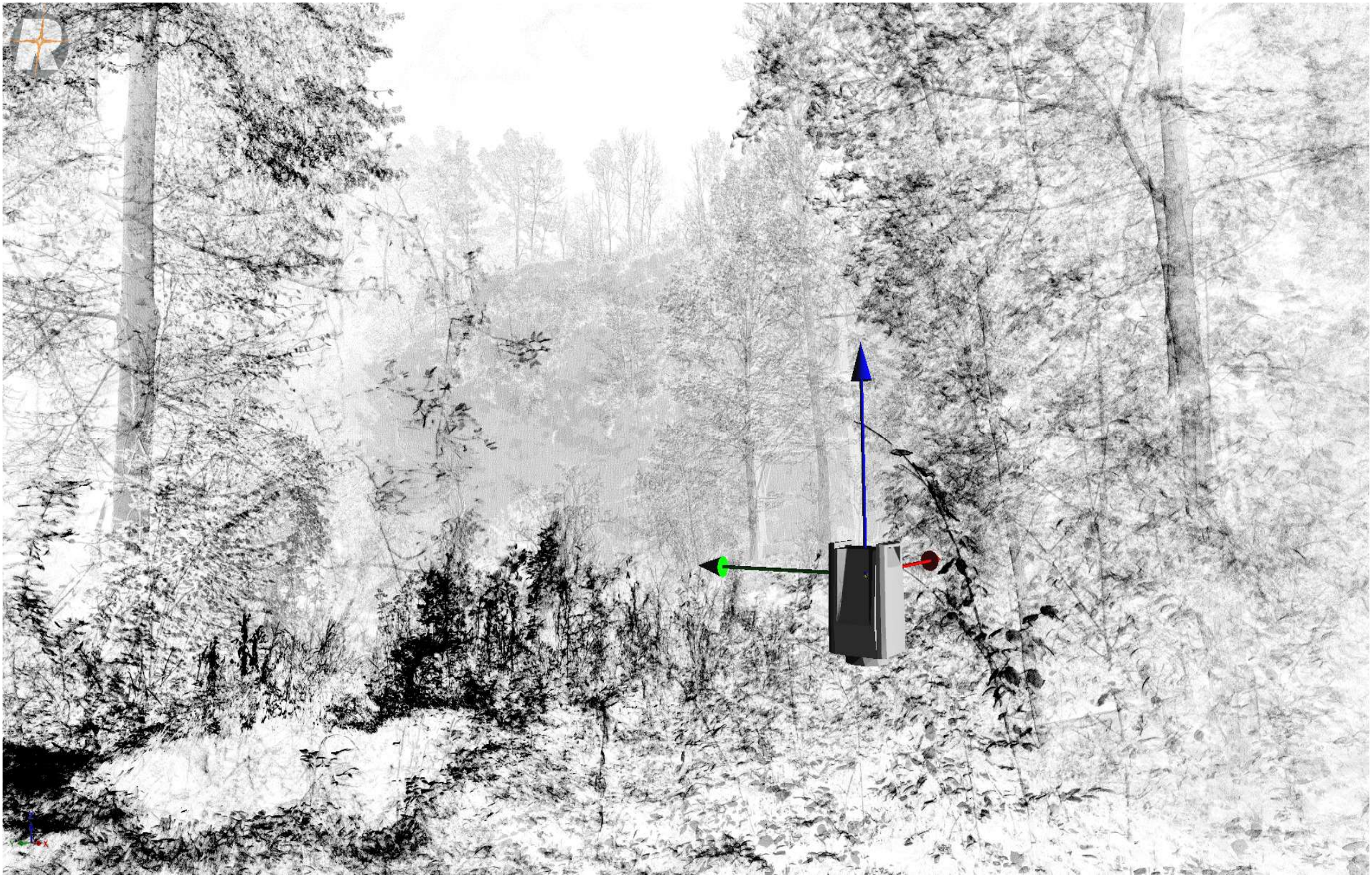

RIEGL

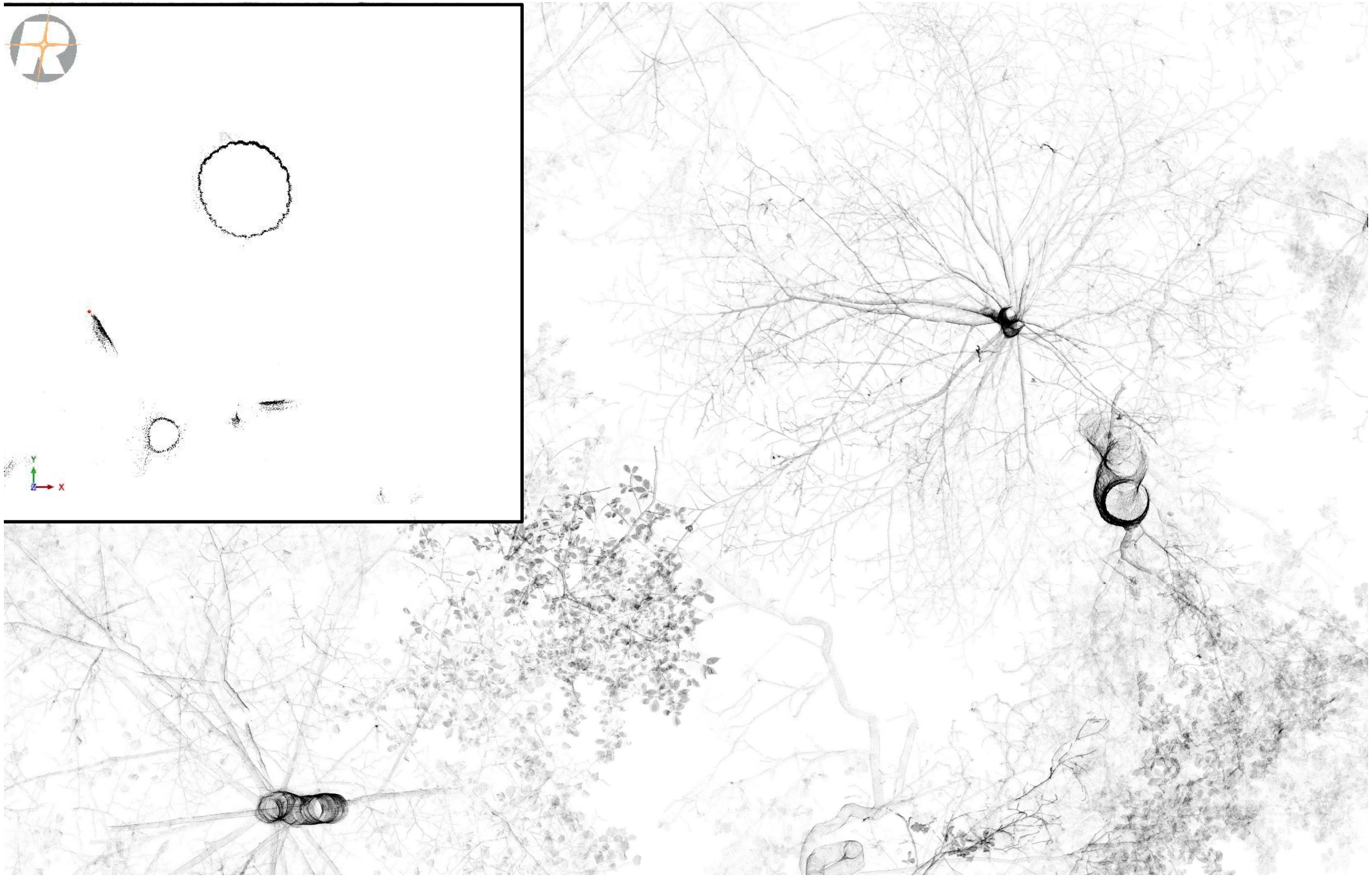
New TLS-Device by Riegl: VZ600i

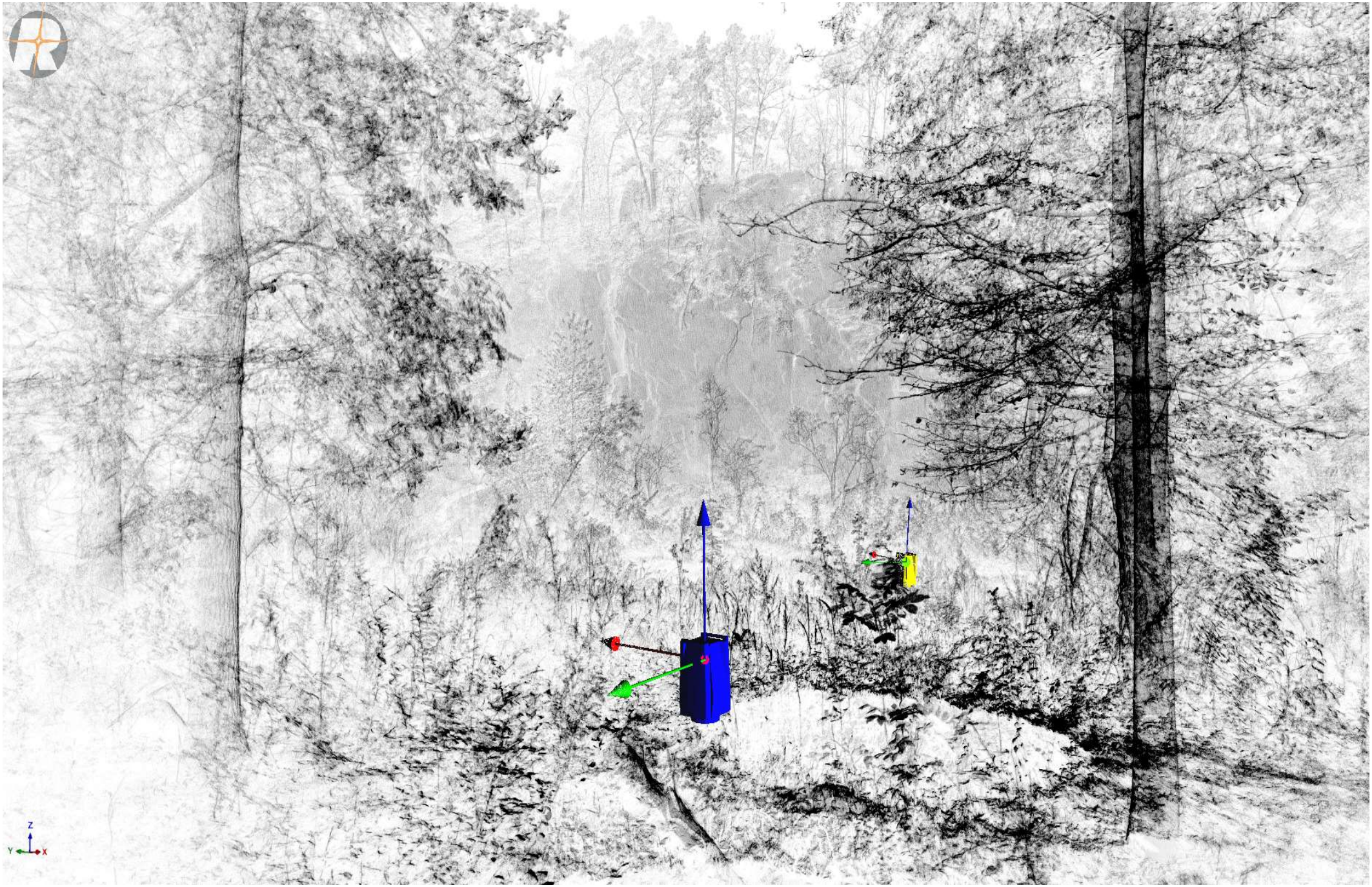
- <6kg weight (compared to 12kg VZ400i)
- 2,2 MHz pulse repetition rate (1,2MHz)
- 420 lines / sec (240)
- Max. distance 900m (800m)
- 17sec panorama scan 9mm point spacing (30sec)
- 30sec panorama scan 6mm point spacing (60sec)
- 3 built-in cameras 12 Mpixel each (no camera)
- Tree segmentation will be part of RiScan
- Diameter extraction will be part of RiScan


Data Acquisition Progress
Project
2022-10-13forest_horn
Scanposition
ScanPos012
Scanning
55%
00:00:12
Cancel
2022-10-13
11:25:03
RIEGL VZ-600i
RIEGL
PUSH





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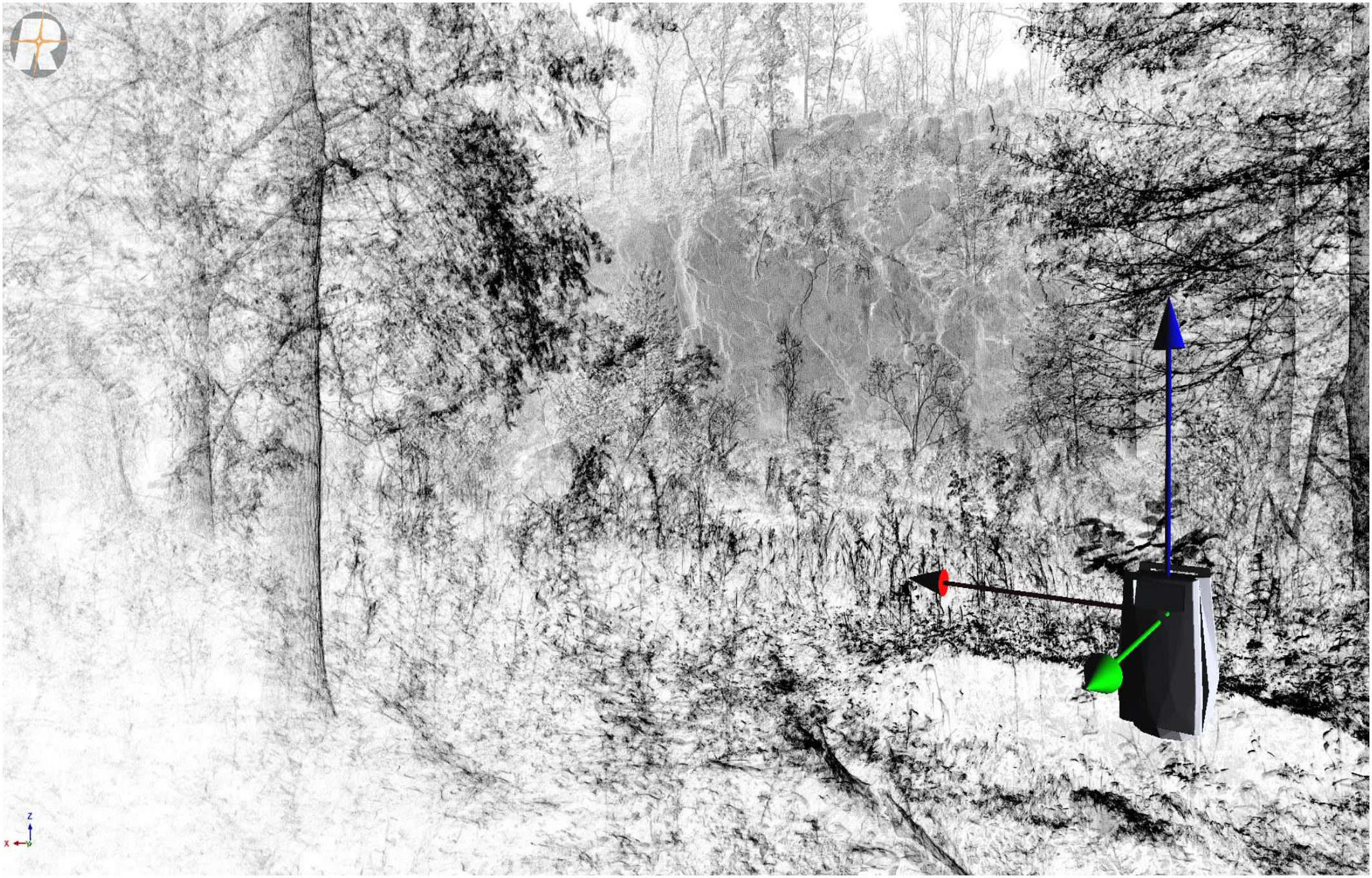

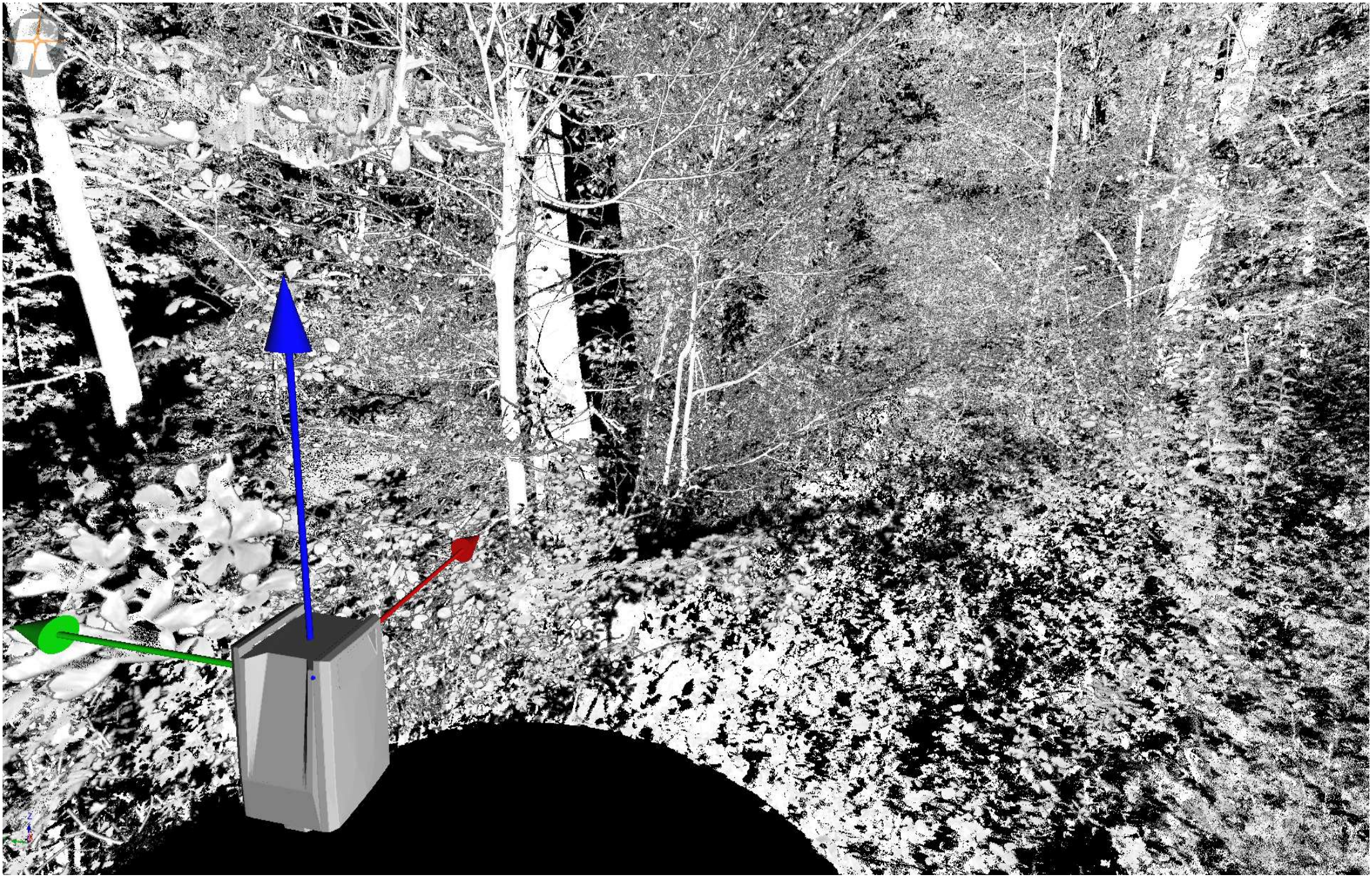

Digitize the Forest => Save the Planet !

- ALS-CHMs can protect against illegal logging by making the forest as transparent as possible
- TLS empowers single tree related growth modelling
- Growth modelling allows climate sensitive optimization of carbon segregation and timber value creation
- UHD-ALS perfectly links NFI assessment to wall-to-wall forest resource mapping
- Valid mapping enables good forest management

Digitize the Forest => Save the Planet !

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- TLS empowers single
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SmartForestTools

- Valid mapping enables good forest management

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