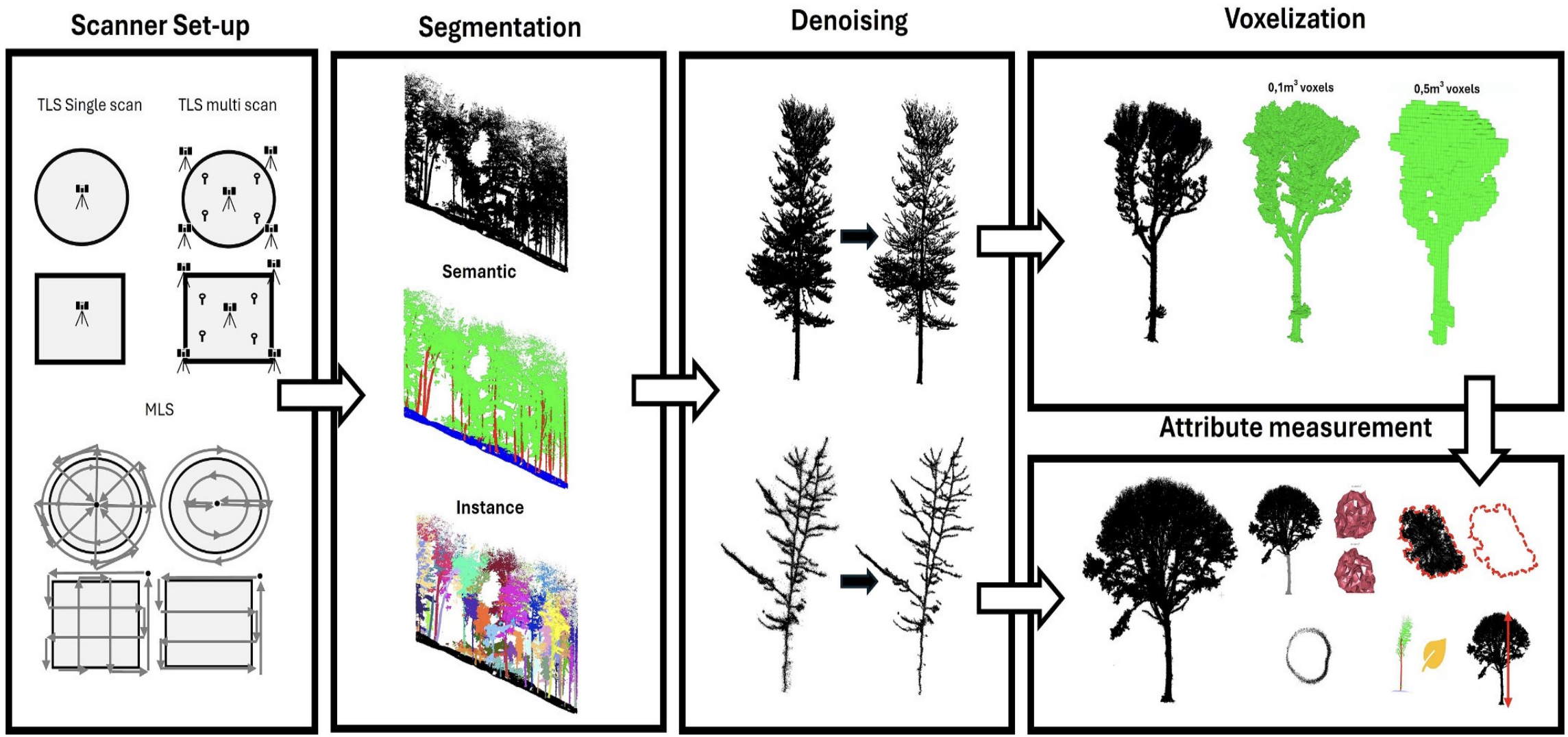
Možnosti využitia nízkonákladových mobilných 3D skenerov pri mapovaní a monitoringu vegetácie

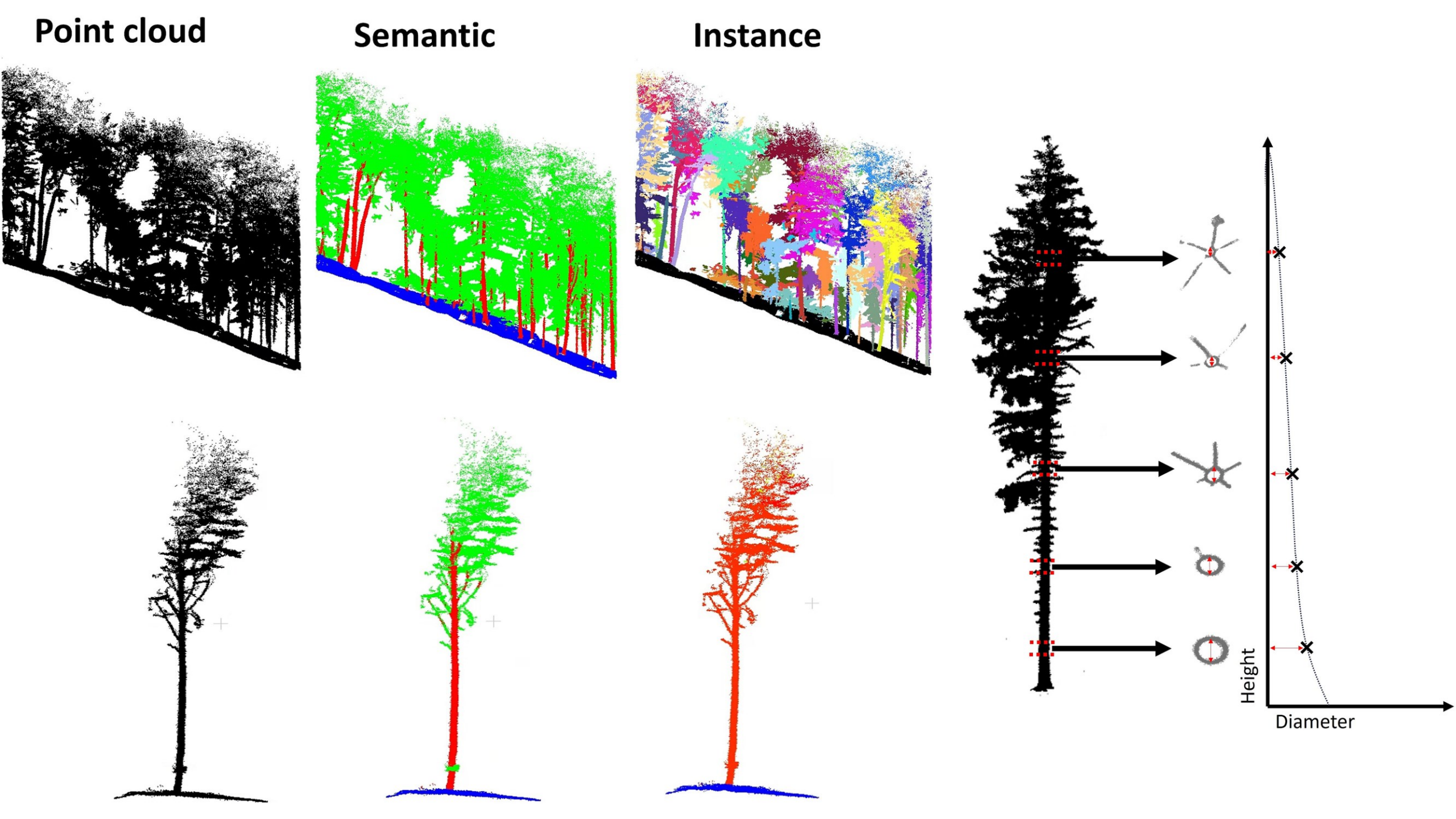
Ing. Jozef Výbošťok, PhD.

Katedra lesnej ťažby, logistiky a meliorácií
Lesnícka fakulta, Technická univerzita vo Zvolene

GeoKARTO 2026


Scanner Set-up
TLS Single scan
TLS multi scan
MLS
Segmentation
Semantic
Instance
Denoising
Voxelization
0,1m³ voxels
0,5m³ voxels
Attribute measurement



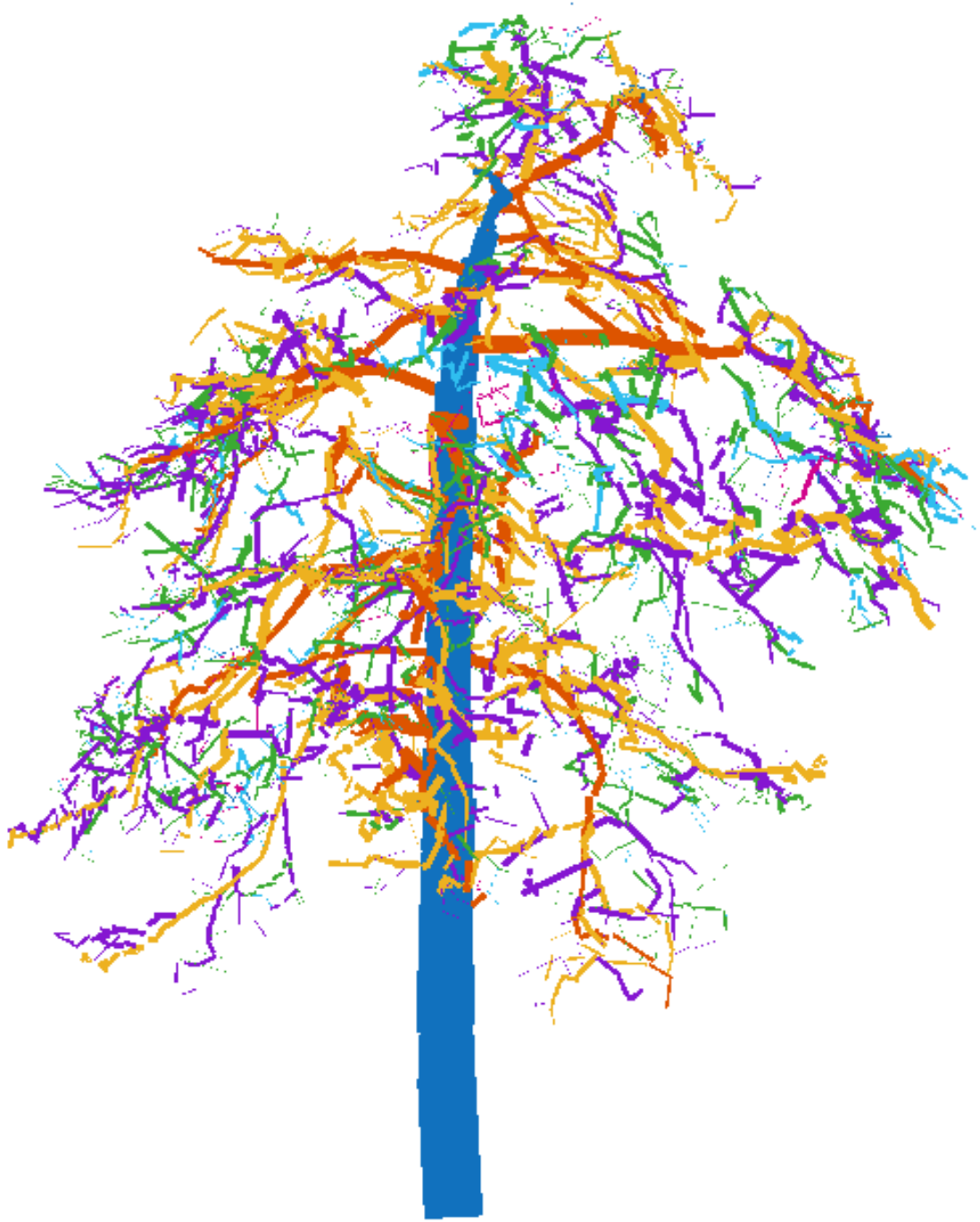

Point cloud
Semantic
Instance
Height
Diameter

Bodové mračno



3D Model





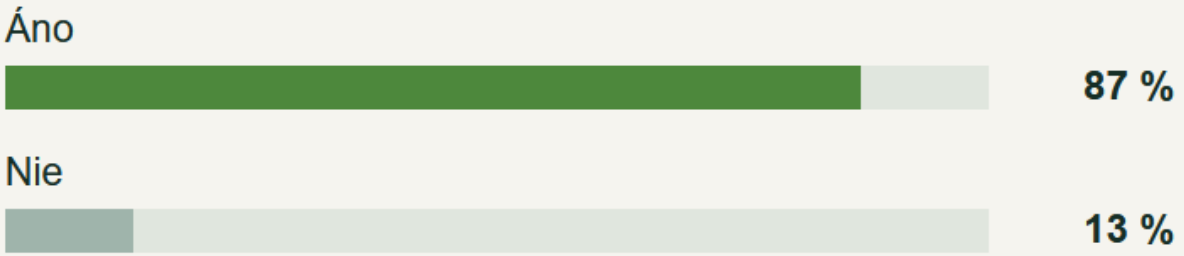
Metrika	Hodnota	Jednotka
Celkový objem	14 177,00	litre
Objem kmeňa	6 879,65	litre
Objem koruny (vetiev)	7 297,36	litre
Výška stromu	18,77	m
Priemer kmeňa vo výške 1.3 m nad terénom (QSM)	0,92	m
Priemer kmeňa vo výške 1.3 m nad terénom (valcový model)	0,93	m
Priemerný priemer koruny	12,23	m
Maximálny priemer koruny	15,15	m
Výška nasadenia koruny	3,03	m
Dĺžka koruny	15,73	m
Objem koruny (konvexný)	1 177,90	m^3

Záujem o implementáciu je vysoký

87 %

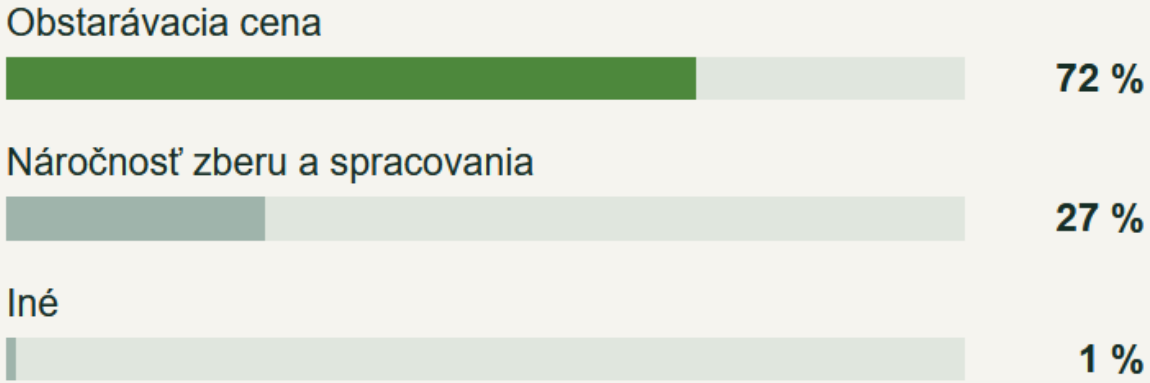
očakáva zavedenie technológií do monitoringu lesov

Otázka: Myslíte si, že sa technológie budú implementovať do monitoringu lesov?



Záujem existuje. Ďalším krokom je zníženie vstupnej ceny a náročnosti používania.

Čo najviac brzdí uplatnenie skenovania v praxi?



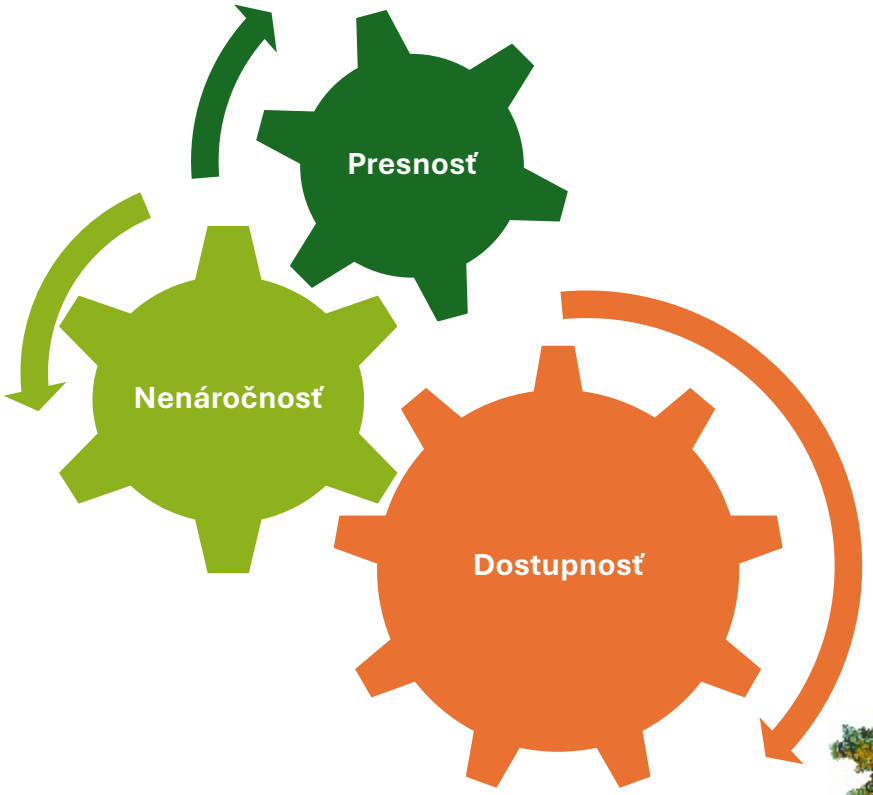
72 %

respondentov označilo cenu

Dotazník nasmeroval ďalší vývoj na dostupnejší hardvér.

> Druhou bariérou je pracovný postup. Lacnejšie zariadenie preto musí byť aj použiteľné.

Implementácia 3D technológií v praxi

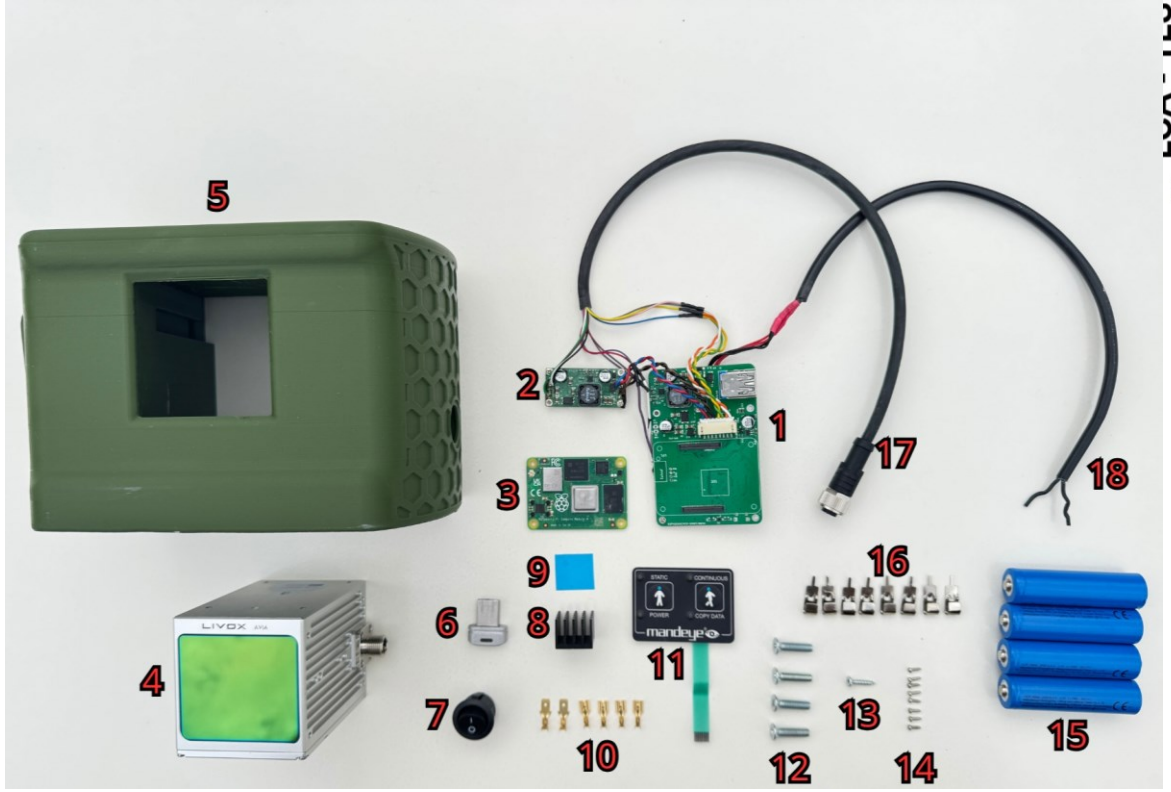


LCA TLS

LC HMLS



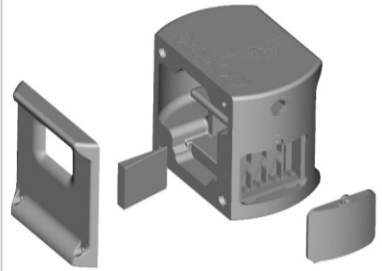
LCA TLS



LCA - TLS journey

DESIGN

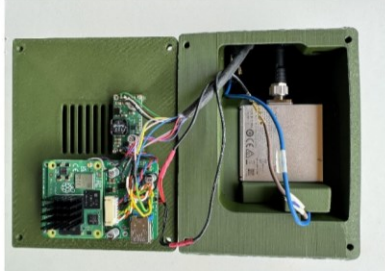
1 Compact and lightweight



2 Open-hardware



3 User-friendly setup



VISION

1 Fully open-source design

2 Clear documentation and workflows

3 Bridging the gap between cost and accuracy

4 User-friendly setup

COMMUNITY NEEDS

Affordable precision tools

Compact and lightweight design

Open-hardware approach

Breaking cost barriers in environmental monitoring

PRODUCT

LCA - TLS



Parameters

Range precision:	+/- 2cm (1σ @ 20m)
Poins per second:	240,000 based on the first/strongest return
Number of returns:	3
Weight:	1.5 kg

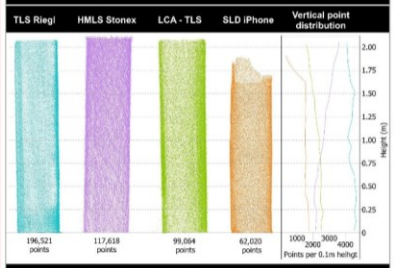
Accuracy

RMSE DBH	RMSE TH
1.503 cm	0.992 m

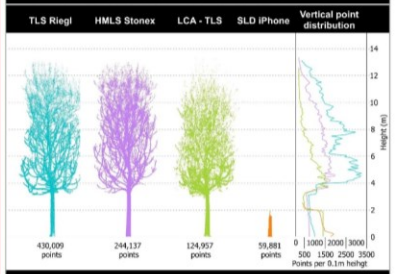
Price 2,050EUR

VALIDATION

1 Tested under lab conditions.



2 Tested under forest conditions.



3 Validated against commercial system and groud truth data.

COMMUNITY ACTION

Open design invites new ideas and improvements

Adaptable to local needs and research contexts

Platform for collective innovation and reuse

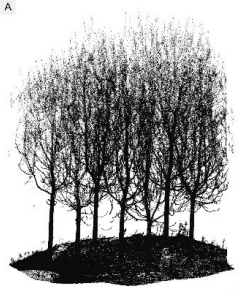
SHARE VISION

All design files are shared via Zenodo

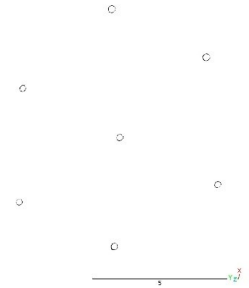
PRICE

TLS Riegl VZ-1000

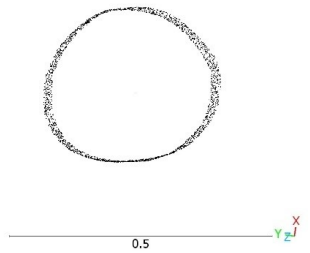
A



B

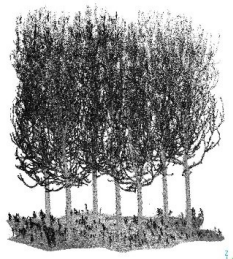


C

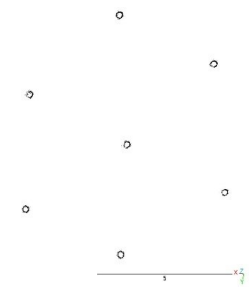


HMLS Stonex X120GO

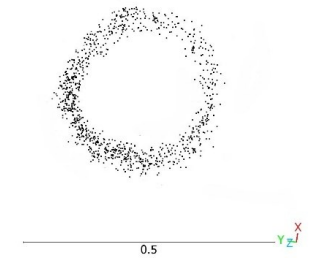
A



B

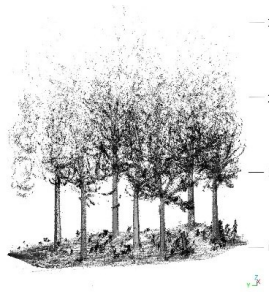


C

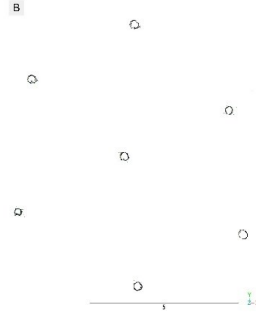


LCA - TLS

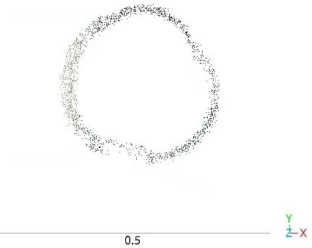
A



B



C

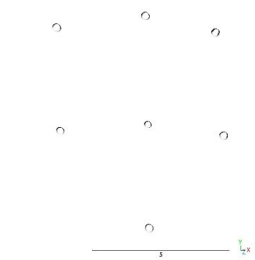


SLD iPhone 15 Pro Max

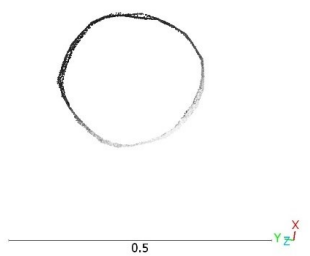
A



B



C

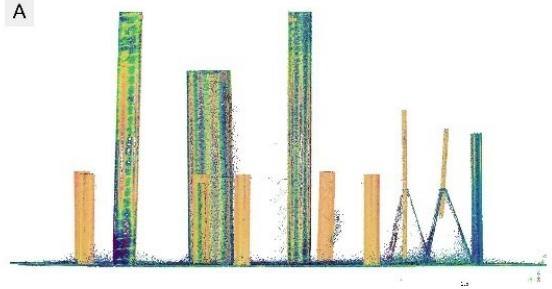


All scales in metres.

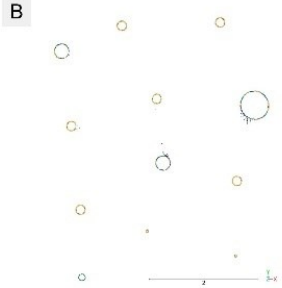
PRICE

TLS Riegl VZ-1000

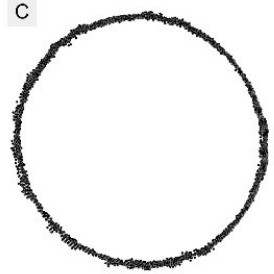
A



B

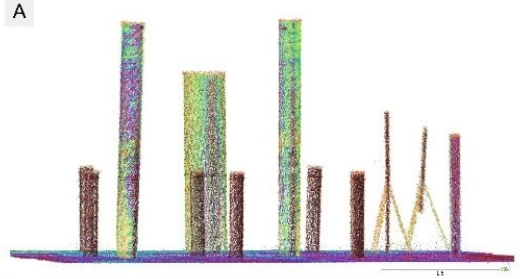


C

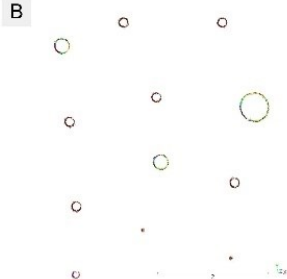


HMLS Stonex X120GO

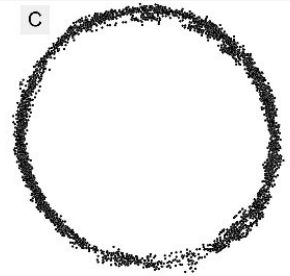
A



B

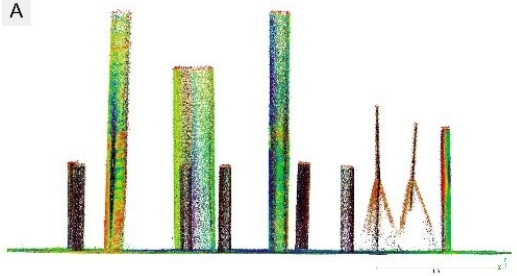


C

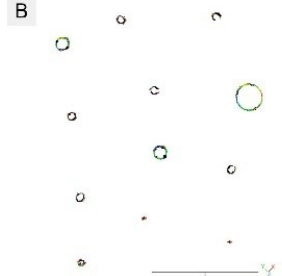


LCA - TLS

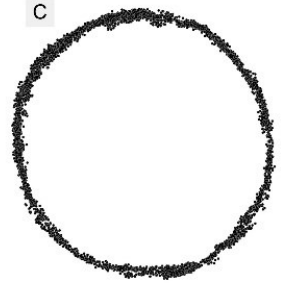
A



B



C

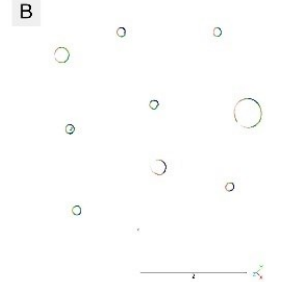


SLD Apple iPhone 15 PRO Max

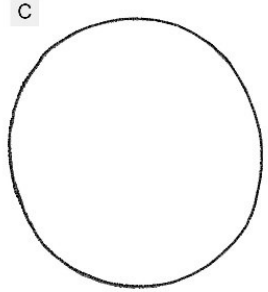
A



B



C

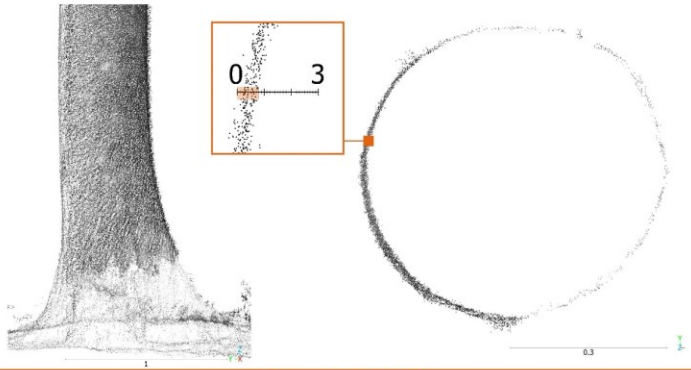


LC HMLS

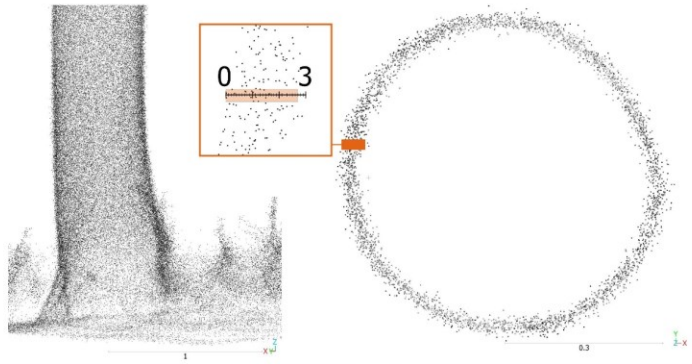




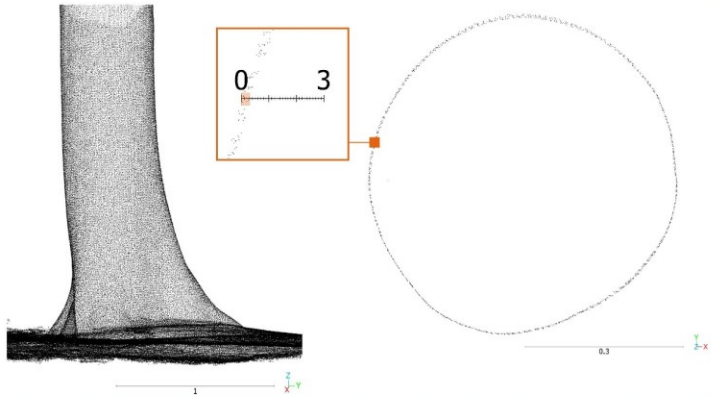
Stonex X120GO



Livox MID-360

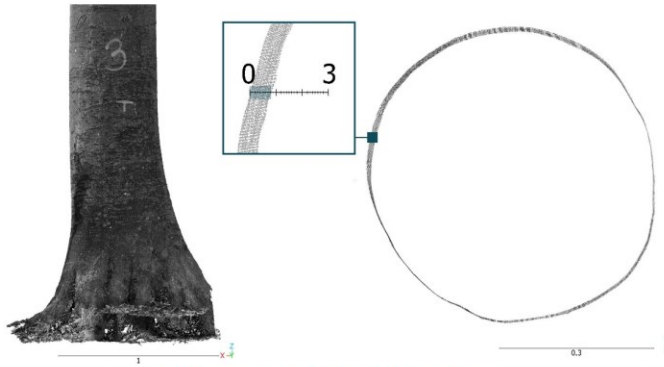


iPhone 15 PRO MAX - 3D Sacnner App

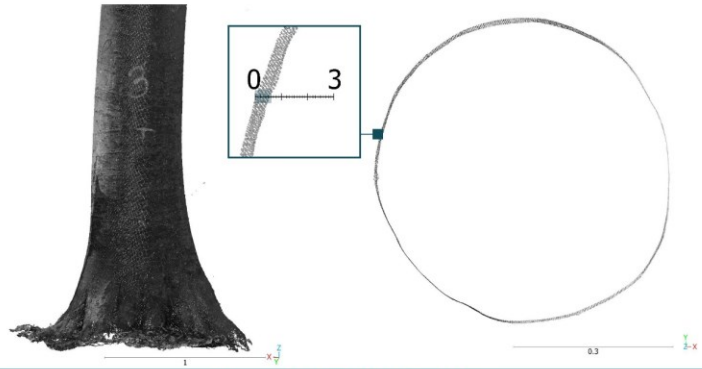


LiDAR based

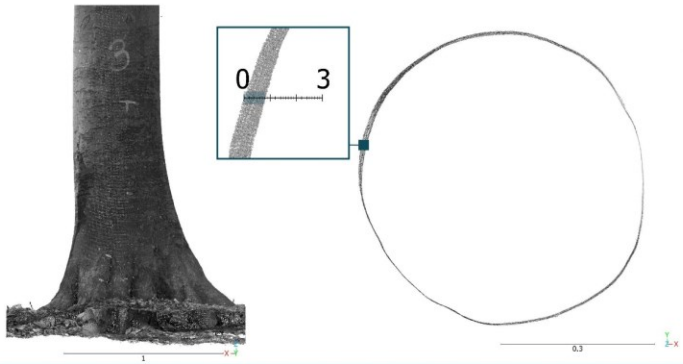
iPhone 15 PRO MAX - photo



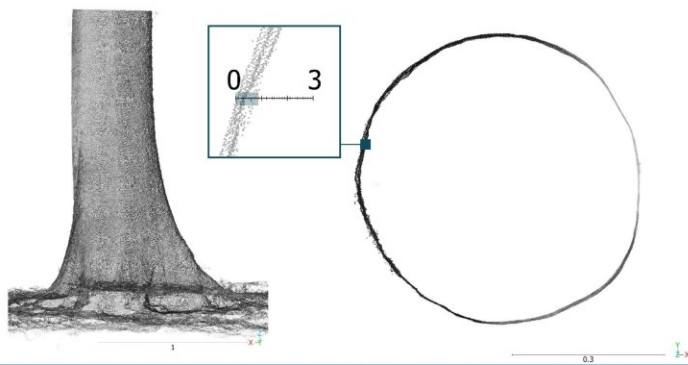
Sony Alpha 6300 - photo



iPhone 15 PRO MAX - video



Sony Alpha 6300 - video

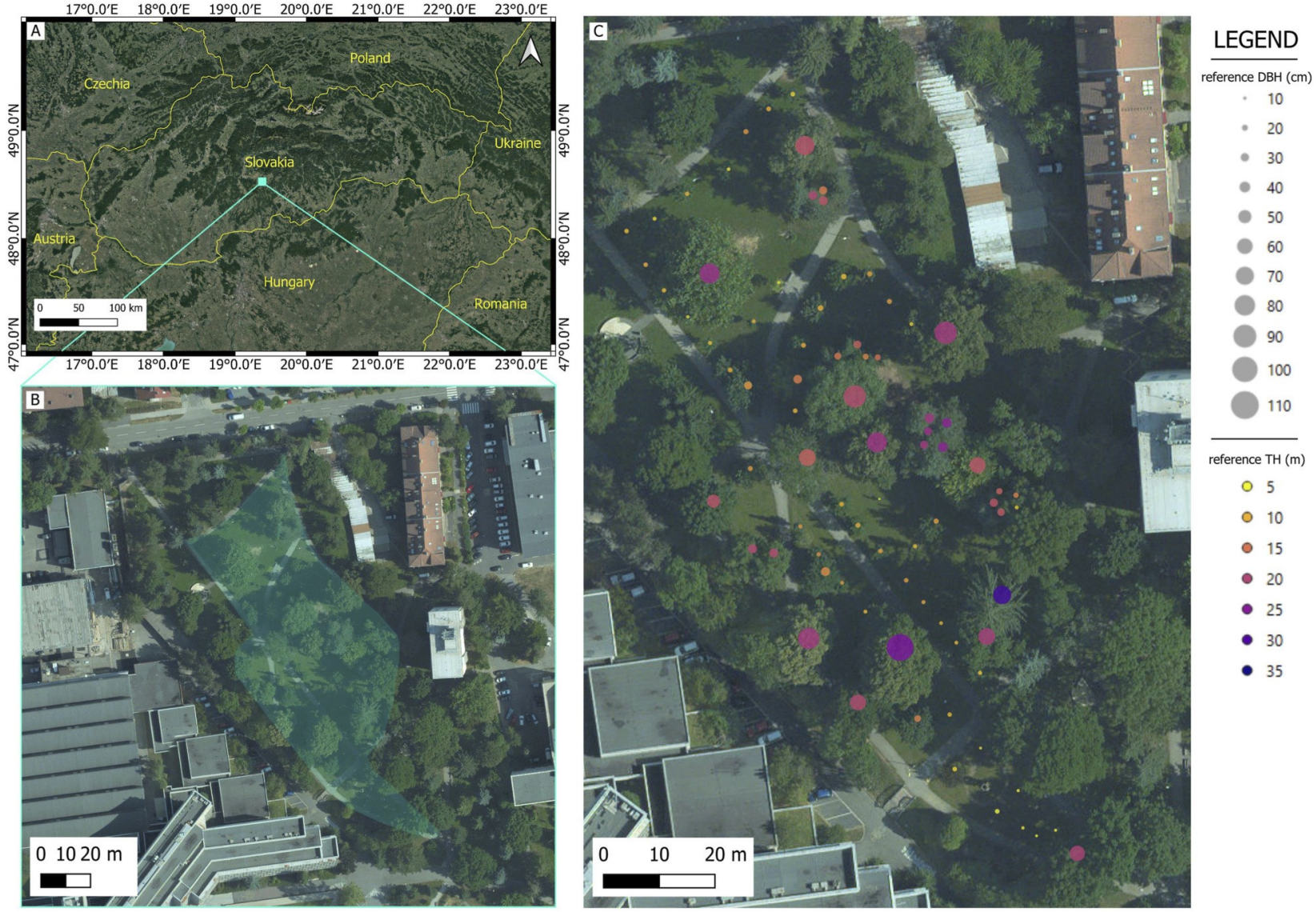


Photogrammetry based

Device	Number of points in 10cm cross-section (approx.)	RMSE (cm)
iPhone 15 PRO MAX - photo	135 000	0.533
iPhone 15 PRO MAX - video	87 600	0.358
Sony Alpha 6300 - photo	78 600	0.473
Sony Alpha 6300 - video	22 300	0.502
Stonex X120GO	6 300	1.445
Livox MID-360	4 000	1.553
iPhone 15 PROM MAX - 3D Scanner App in PC	2 000	4.517
iPhone 15 PROM MAX - 3D Scanner App	-	5.330
iPhone 15 PROM MAX - ForestScanner App	-	2.098
iPhone 15 PROM MAX - Arboreal App	-	1.653

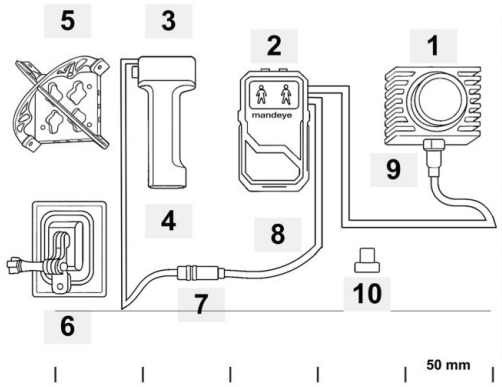
All pictures: Left - Tree point cloud detial; Right - Cross-section detail

Monitoring mestskej zelene



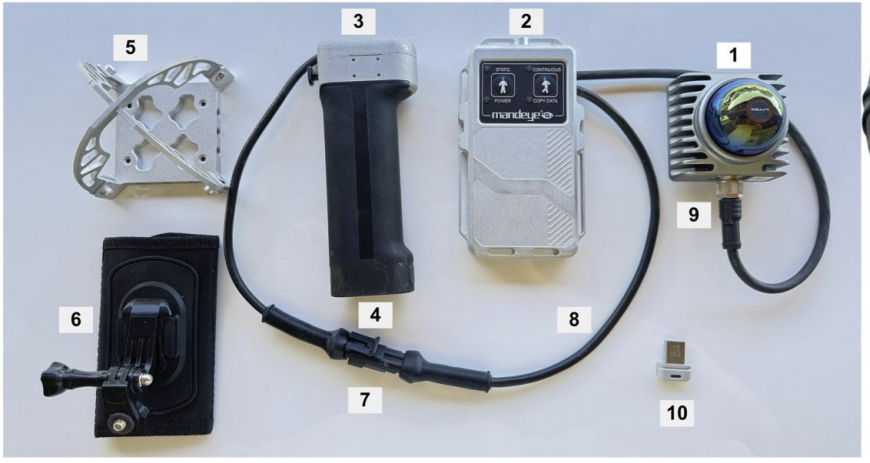
COMPONENTS OF THE ASSEMBLED PROTOTYPE

(A) Schematic view



1	LiDAR sensor Livox MID 360
2	Mandeye controller
3	Battery holder
4	Battery DJI Ronin BG30
5	Durable cover with 1/4 thread
6	Holder 1/4
7	AMP Waterproof connector
8	AWG 2wire cable
9	M12 Cable
10	USB3 Pendrive, FAT32

(B) Actual arrangement

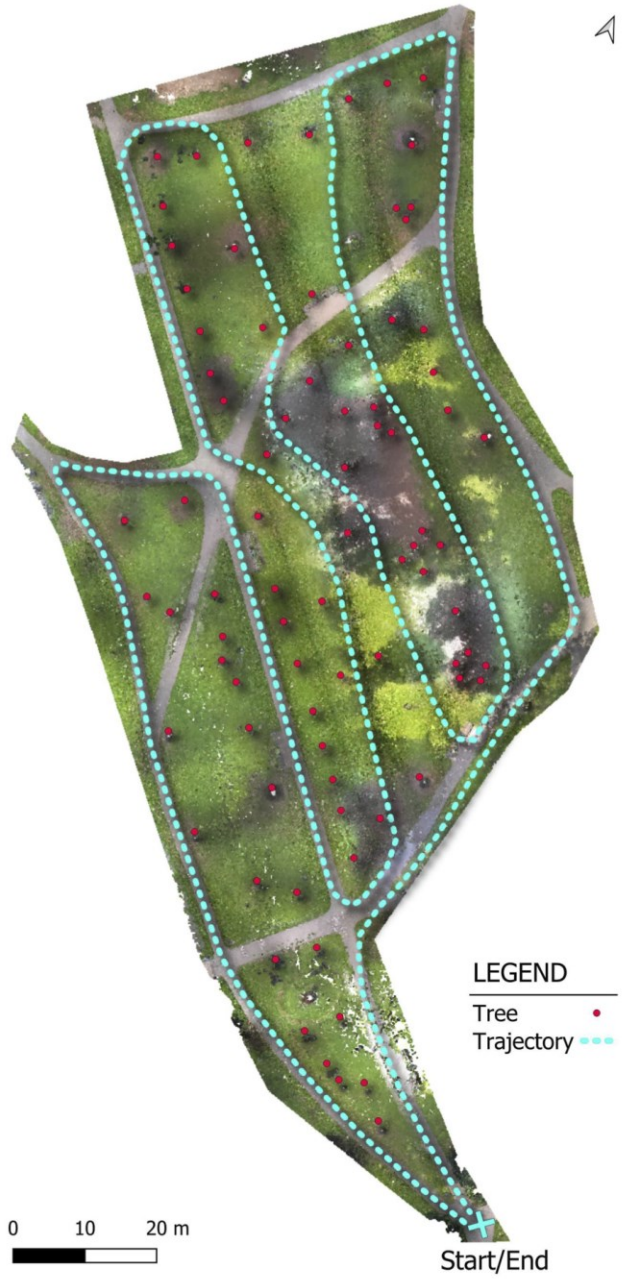


(C) On-body LiDAR prototype



Backpack operational configuration

TRAJECTORY OF DEVICES



USED DEVICES

PROTOTYPE

Points per second: 200,000

Range: up to 100 m

Return number: 1

Initialization: 30 seconds

Approx. Cost: 2,000 USD

Point Cloud: 83,675,923 points*



Stonex X120GO

Points per second: 320,000

Range: 120 m

Return number: 1

Initialization: 60 seconds

Approx. Cost: 30,000 USD

Point Cloud: 74,117,619 points*



Stonex X200GO

Points per second: from 640,000 to 1,920,000

Range: up to 300 m

Return number: 3

Initialization: 15 seconds

Approx. Cost: 45,000 USD

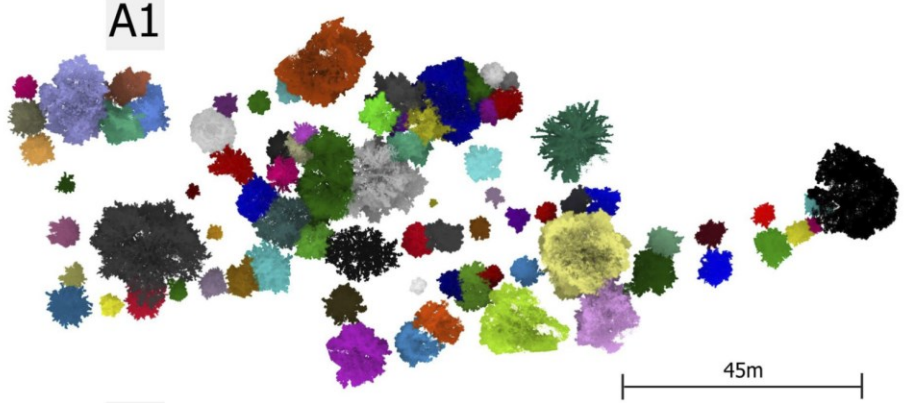
Point Cloud: 222,024,764 points*



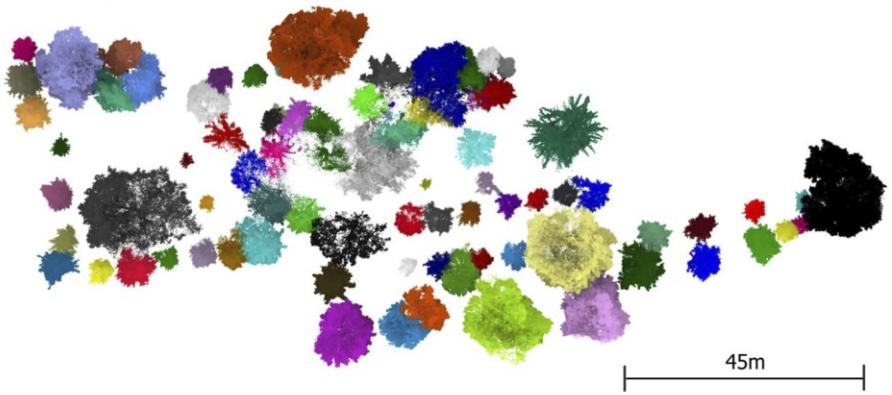
* Number of points in the initial point cloud of the research plot.

TOP VIEW

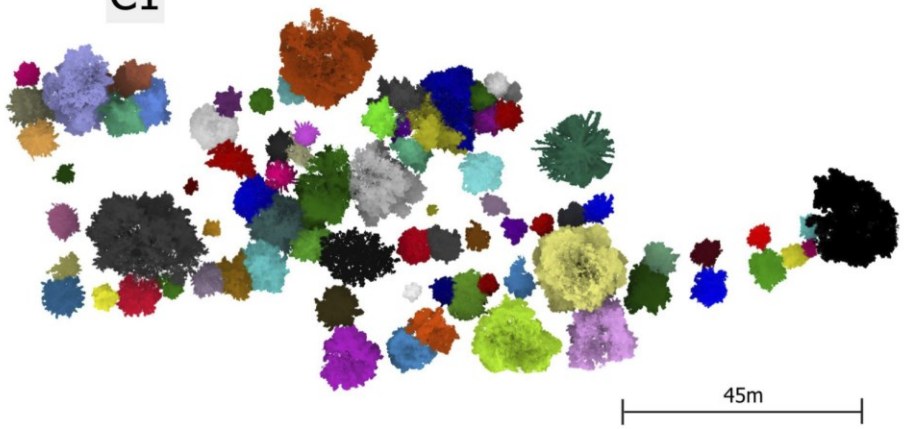
A1



B1

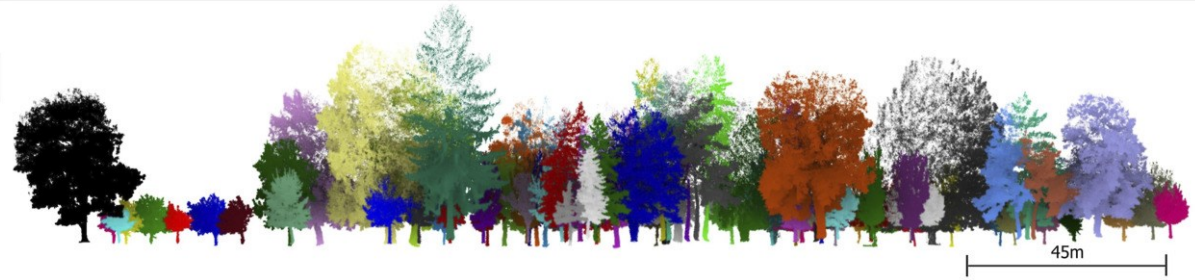


C1



SIDE VIEW

A2

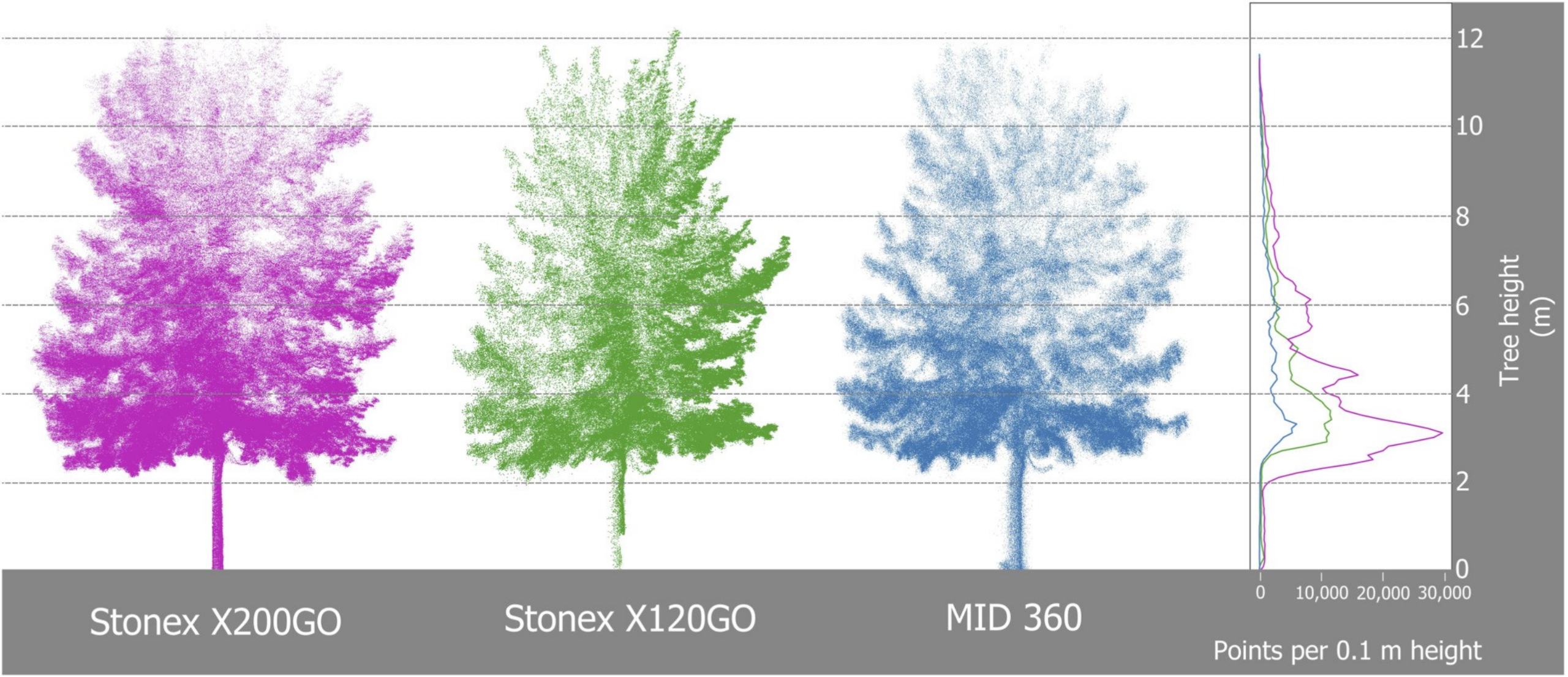


B2



C2

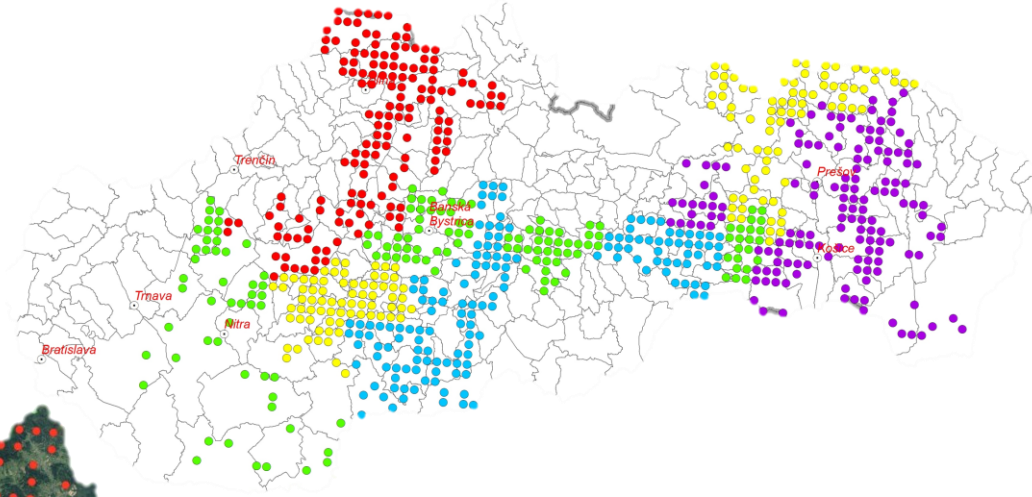


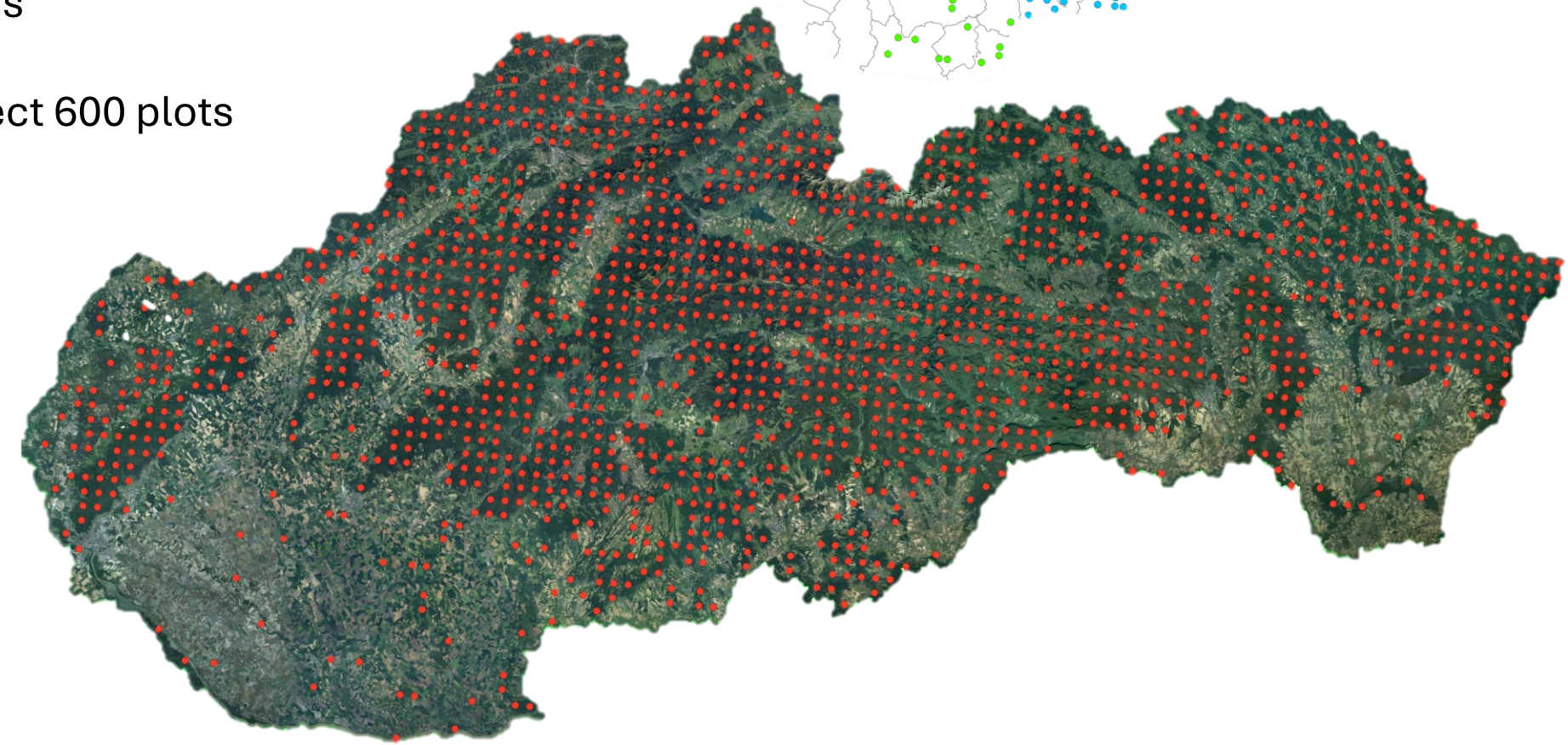

12
10
8
6
4
2
0
Tree height (m)
0
10,000
20,000
30,000
Points per 0.1 m height
Stonex X200GO
Stonex X120GO
MID 360

Device	Algorithm	R^2	RMSE (cm)	rRMSE (%)	$Error_{min}$ (cm)	$Error_{max}$ (cm)	$Error_{sd}$ (cm)	Bias (cm)	N (trees)
MID360	3DFin	0.995	3.16	11.27	−3.18	6.93	2.04	2.43	79
	FSCT	0.995	3.72	13.00	−3.40	6.20	2.12	3.07	77
	ITSMe	0.997	2.47	8.89	−2.58	6.54	1.39	2.05	80
Stonex x120	3DFin	0.995	3.30	11.65	−2.39	8.78	1.90	2.71	78
	FSCT	0.995	3.57	12.50	−0.80	8.22	1.85	3.06	77
	ITSMe	0.998	2.08	7.47	−0.17	6.70	1.17	1.73	80
Stonex x200	3DFin	0.996	2.42	8.63	−5.69	4.11	1.58	1.85	79
	FSCT	0.992	3.30	11.75	−7.70	6.60	2.24	2.44	79
	ITSMe	0.999	1.25	4.49	−0.96	3.68	0.69	1.05	80

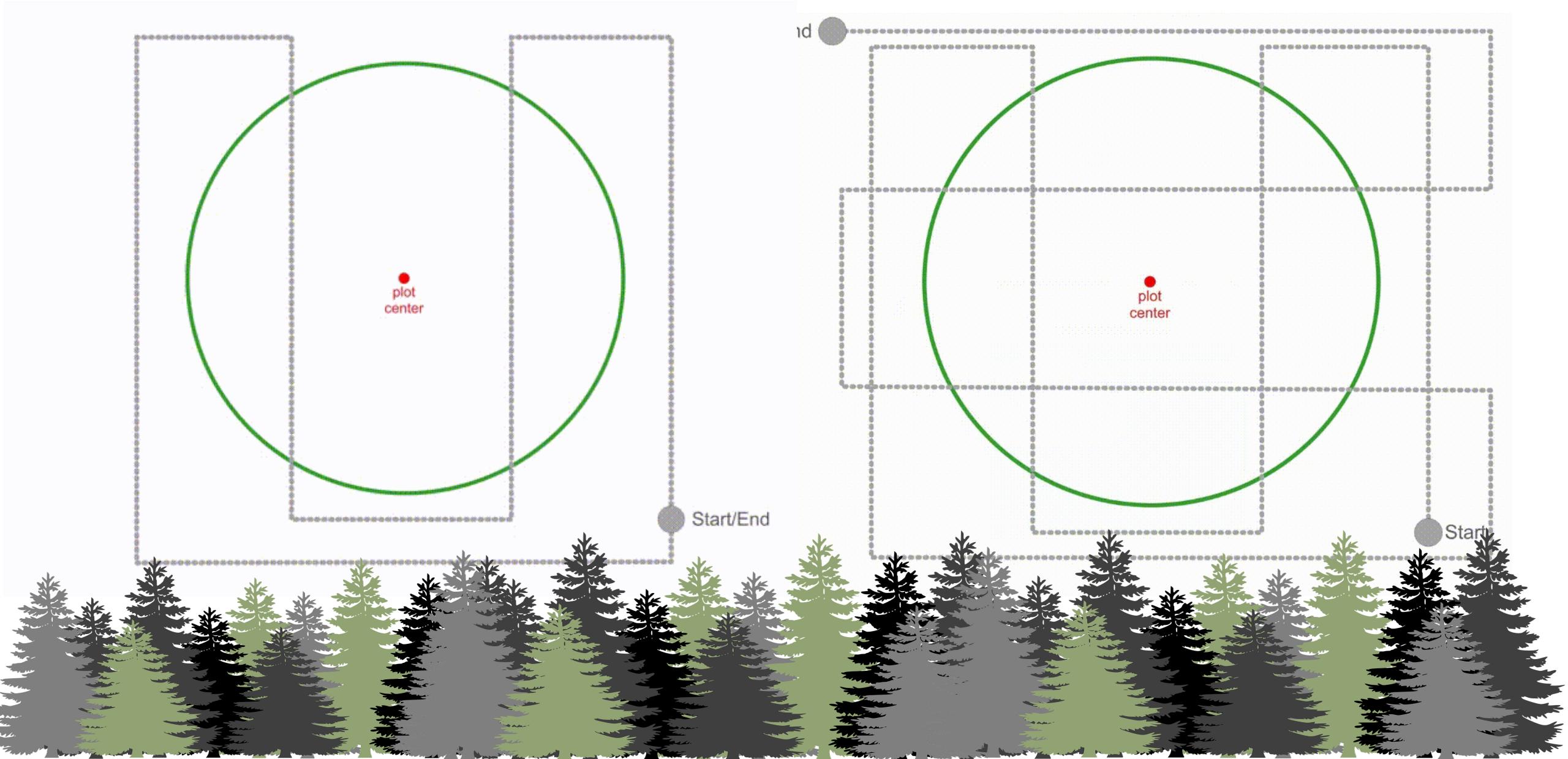
National forest inventory in Slovakia -characteristics

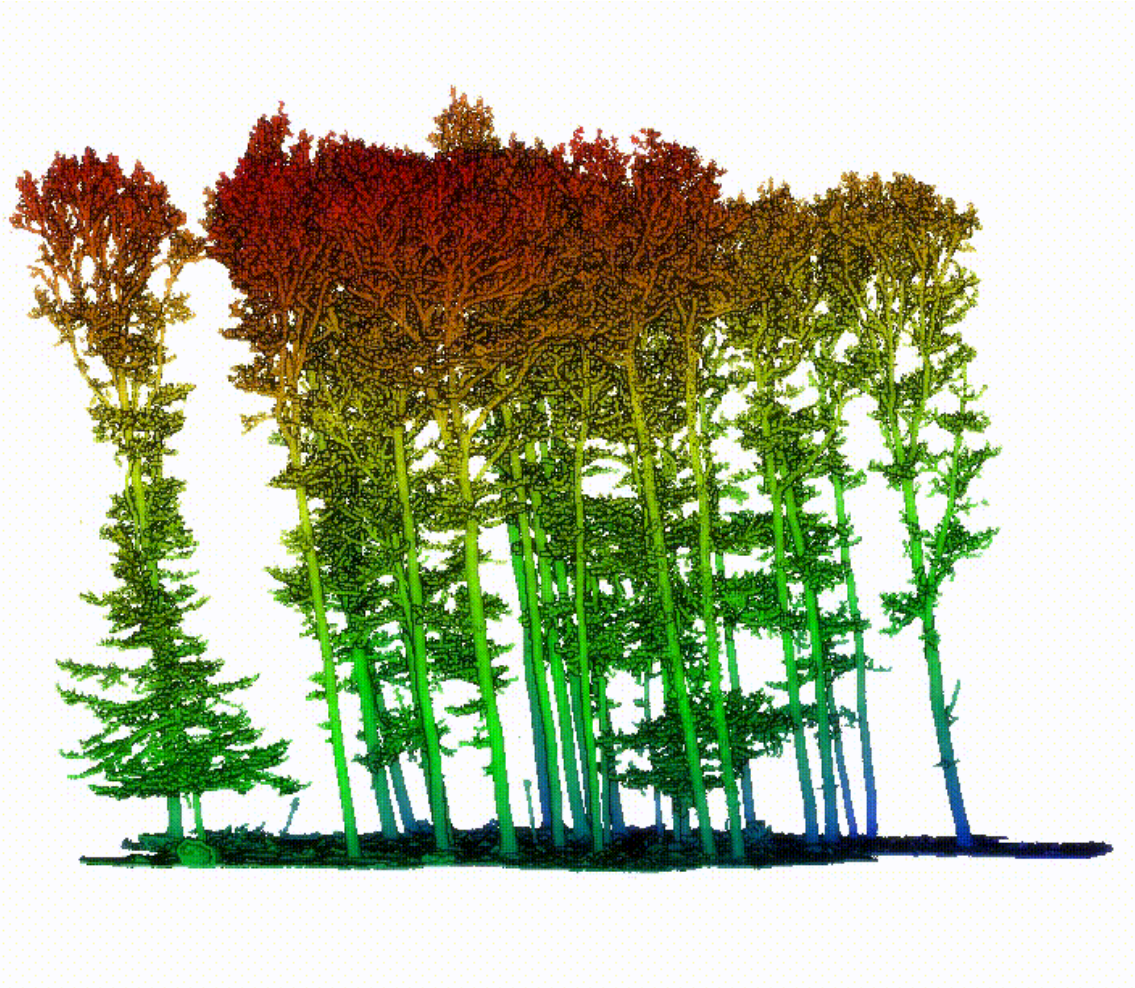
- Grid 4x4 km (selected only forest covered)
- All plots was stabilised in 2005 (iron pipe)
- Number of plots 1520
- 5 groups of surveyors
- Plans for 2025: collect 600 plots

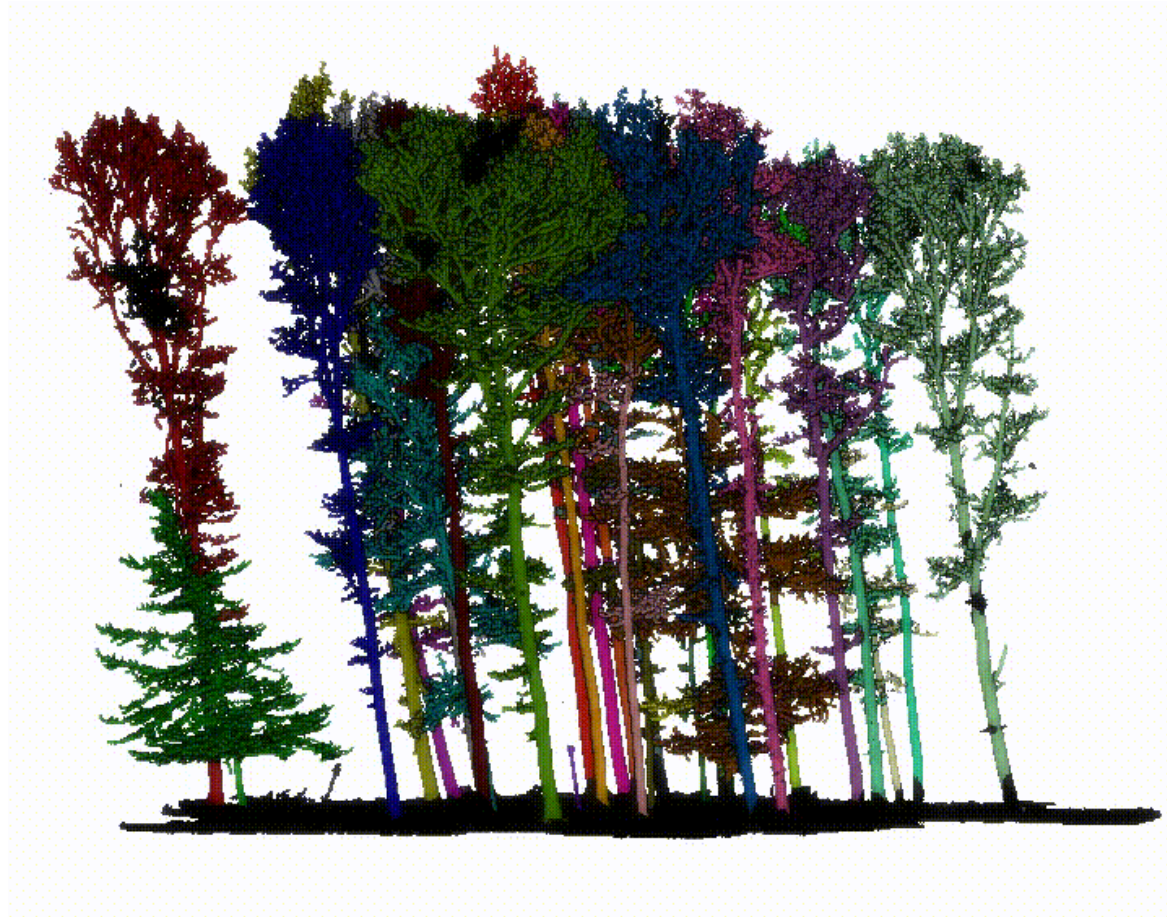




Národná inventarizácia a monitoring lesov







Za kratší čas získavame širší súbor parametrov

4–5 min

terénny zber jednej plochy HMLS

DBH + TH

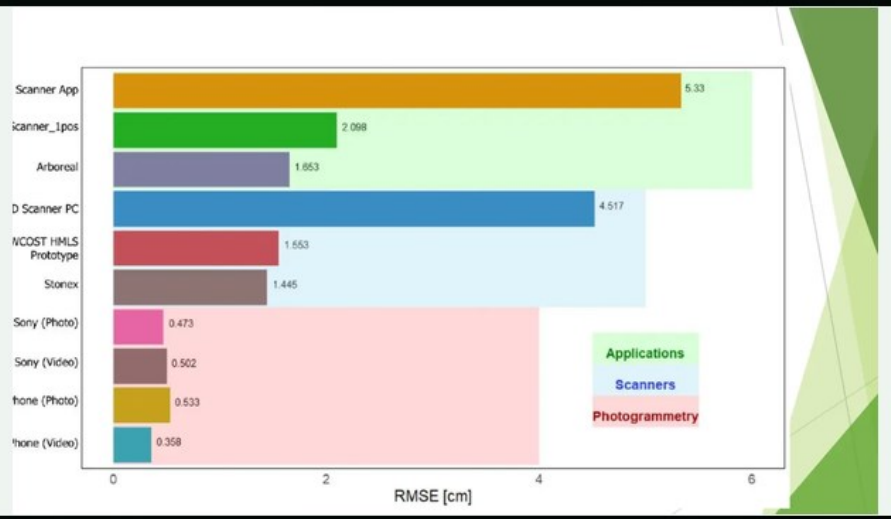
základné dendrometrické parametre

XYZ + koruna

poloha a priestorová štruktúra

archív 3D

nové parametre možno odvodiť aj neskôr



Porovnanie presnosti viacerých zariadení a aplikácií



Funded by the EU NextGenerationEU through the Recovery and Resilience Plan for Slovakia under the project No.09I03-03-V04-00341