Growing confidence in forestry's future Research Programme

SCION
FORESTS | PRODUCTS | INNOVATION

What's under the canopy

Using airborne and terrestrial laser scanning to characterise forest structure

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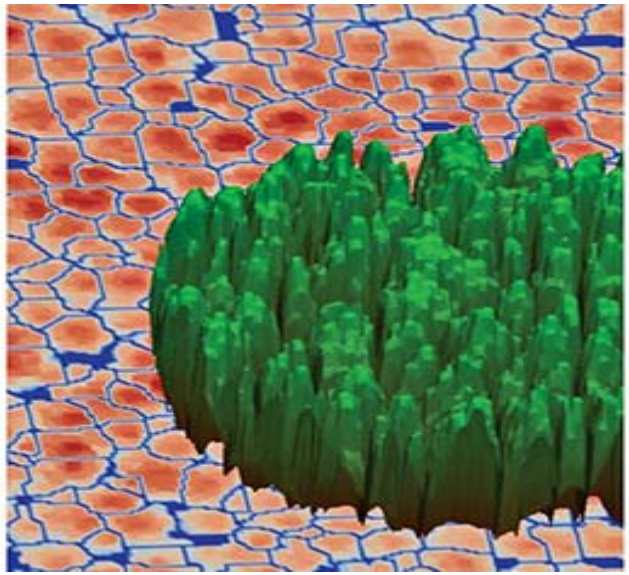

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FOREST GROWERS RESEARCH

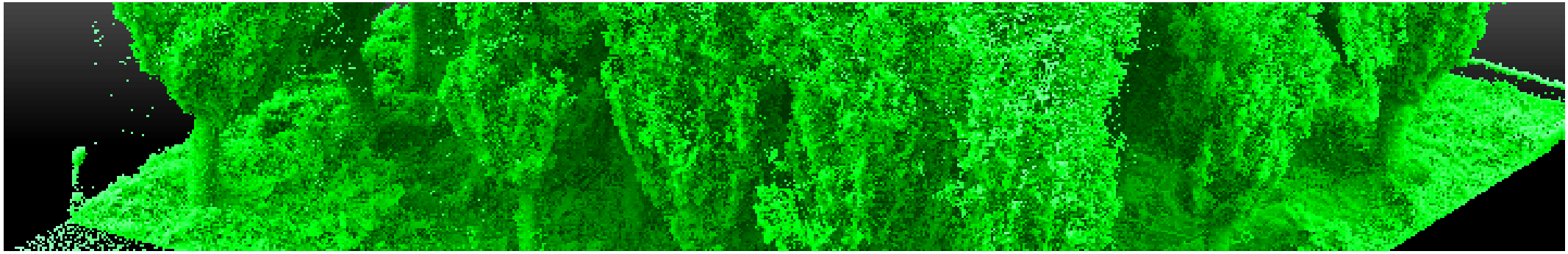
Tree-based Phenotyping - Outline

Objectives

Projects

Research Highlights

Key Outcomes



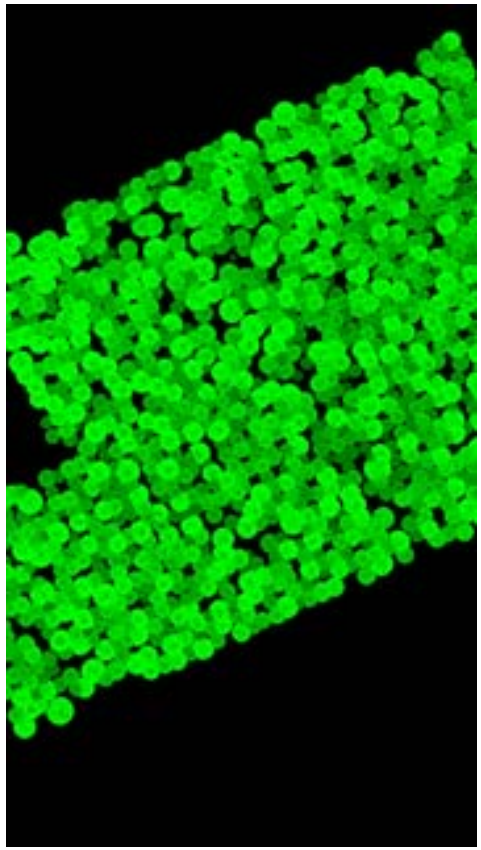
Tree-based Phenotyping - Objectives

Understanding the drivers of tree growth by teasing apart the interactions of
Genetics, Environment, and Silviculture

Remote Sensing - Sensors and Platforms to capture data
(**LiDAR, RGB**, multi- and hyper- spectral imagery)
(**UAV, hand-held**, mobile, manned aircraft, satellite)

Image analysis to identify and to phenotype (characterise) individual trees

Models to quantify and elucidate **G**x**E**x**S**
Development of elite tree breeds
Decision support tools to optimise management objectives



Tree-based Phenotyping - Projects

Tree-based Phenotyping Extension

Spatial analysis methods to take account of environmental variation.

ALS + ULS + RGB

Compare assessment of individual trees using conventional and UAV airborne laser scanning.

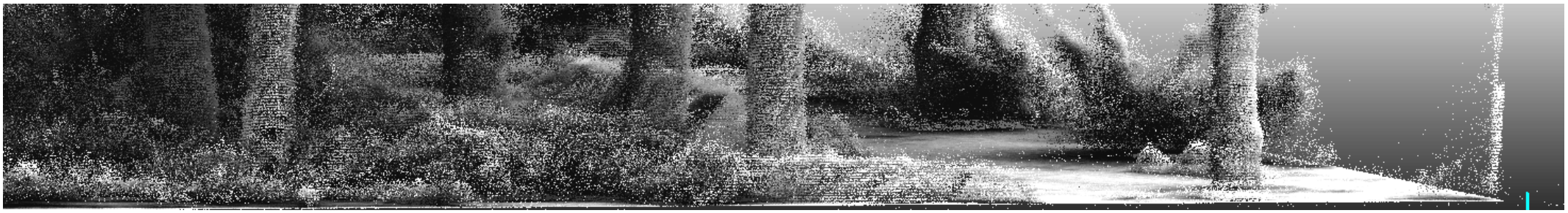
Also evaluate point cloud from RGB imagery.

ULS + TLS

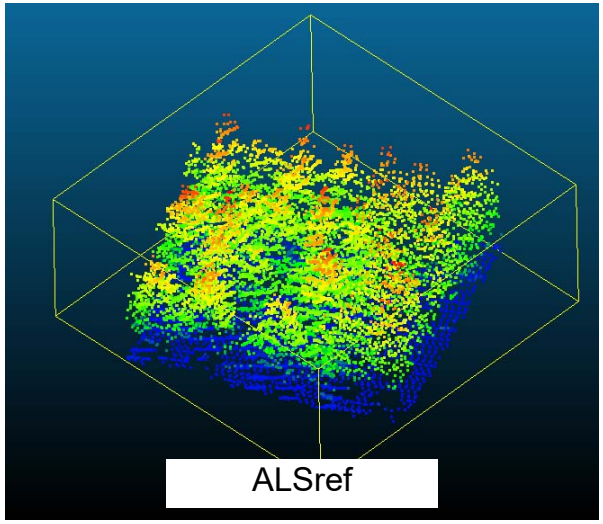
Match trees detected in LiDAR point clouds from TLS and a UAV.

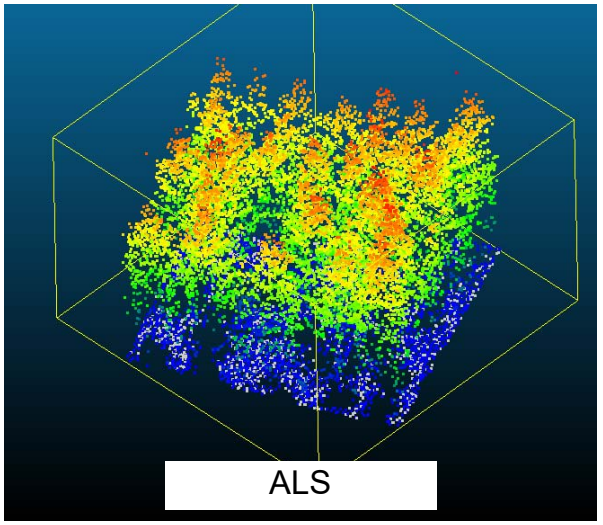
Exceptional trees

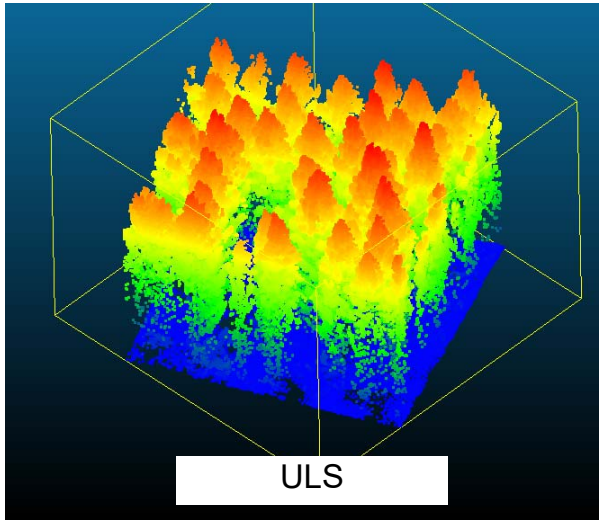
Identify a cohort of elite trees, by applying the “Phenotyping Platform” to a case study area.

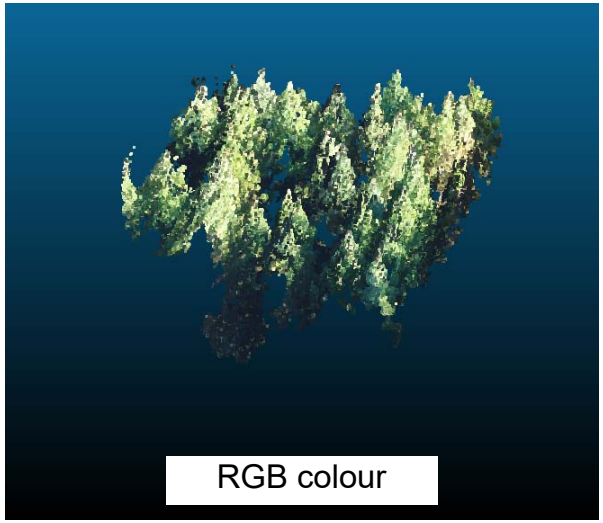


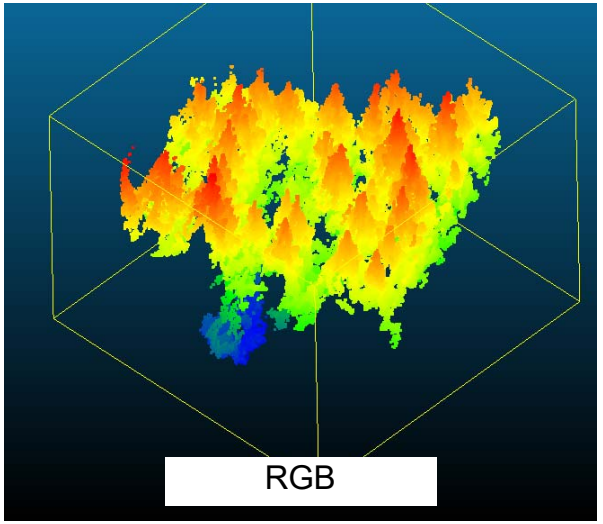
ALS + ULS + RGB - Point cloud data





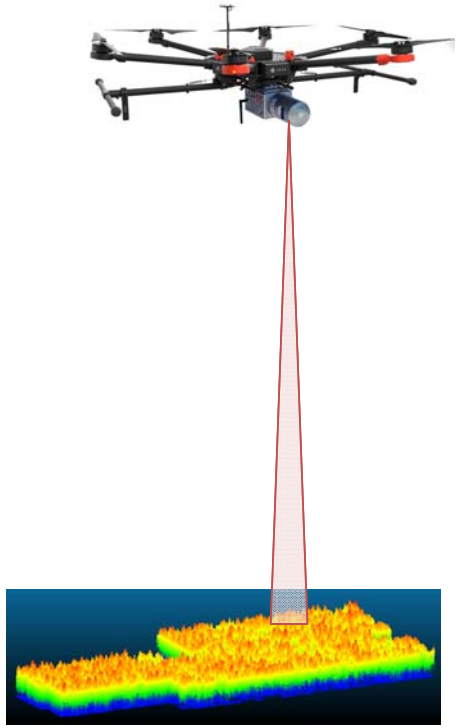






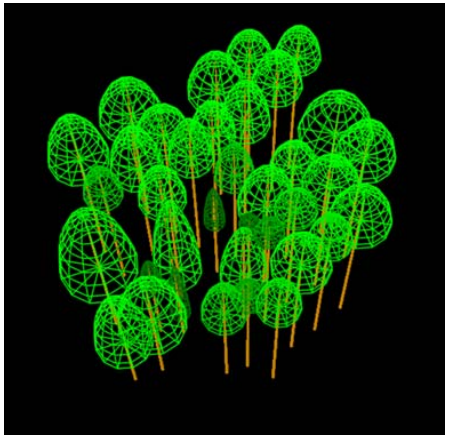
ALS + ULS + RGB - Key results

Key results	ALSref	ALS	ULS	RGB
Last returns density	10	19	1299	1518
Ground returns %	3.7	5.3	4.4	(0.5)
Tree detection %	90	83	84	78
DBH estimation (r)	0.82	0.68	0.68	0.55
Height estimation (r)	0.92	0.84	0.82	0.61

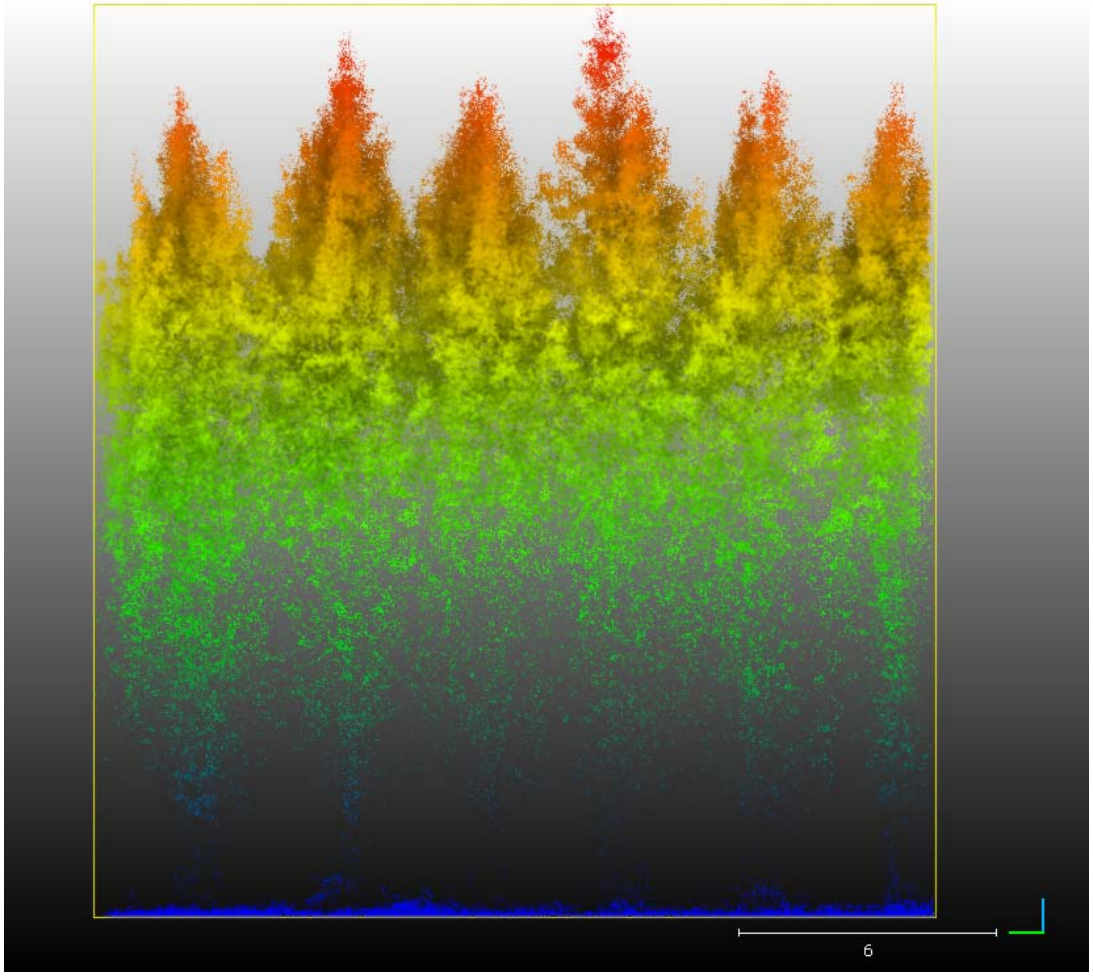


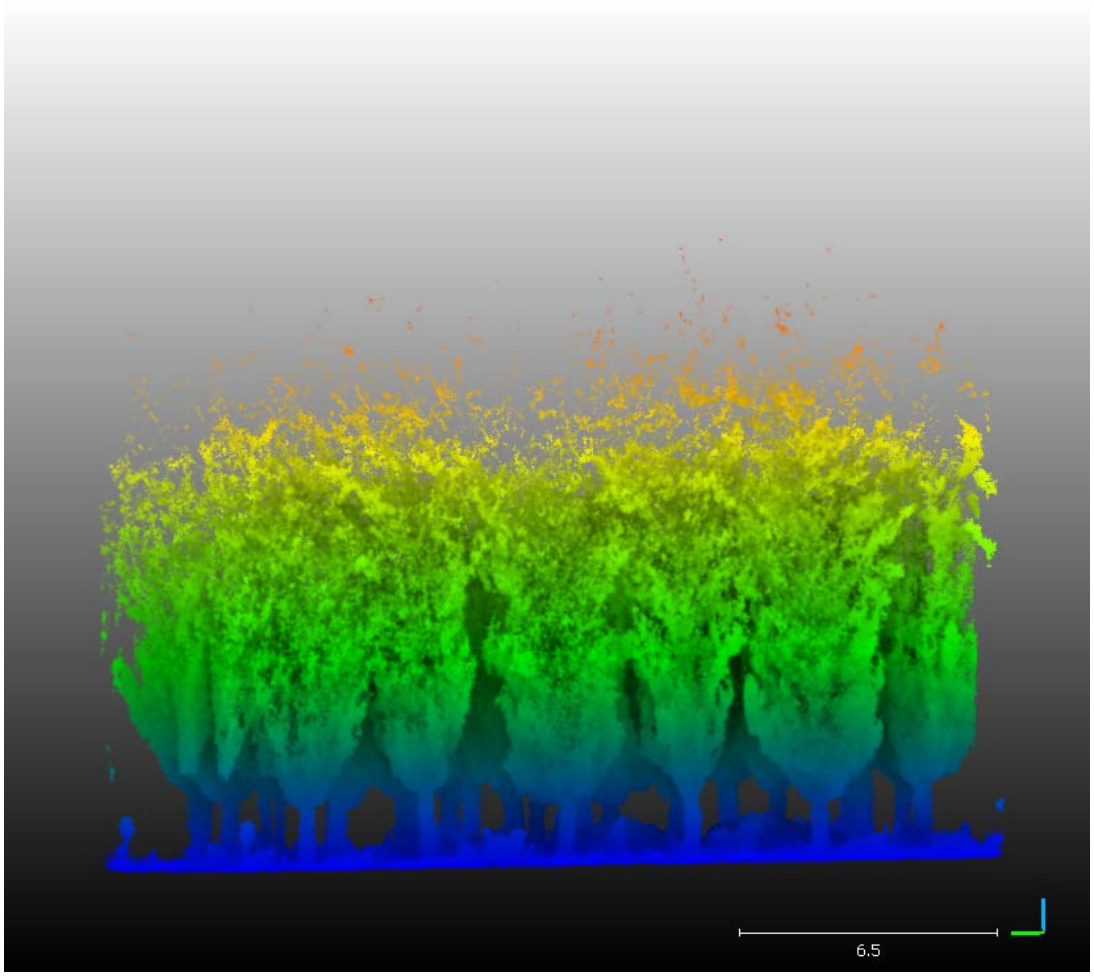
Key conclusions

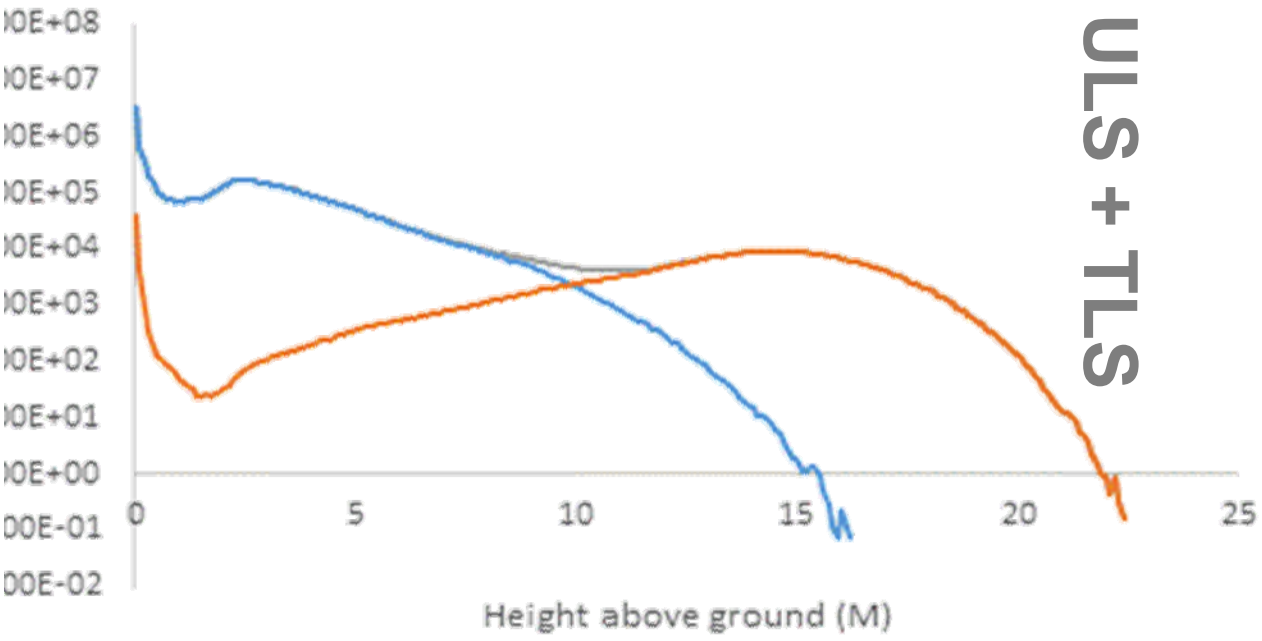
- ULS is a viable alternative to ALS
- High point density of ULS (RGB) offer potential to extract more information
- RGB shows promise, lacking ground, solutions developed
- UAV is a useful platform for tree-based phenotyping

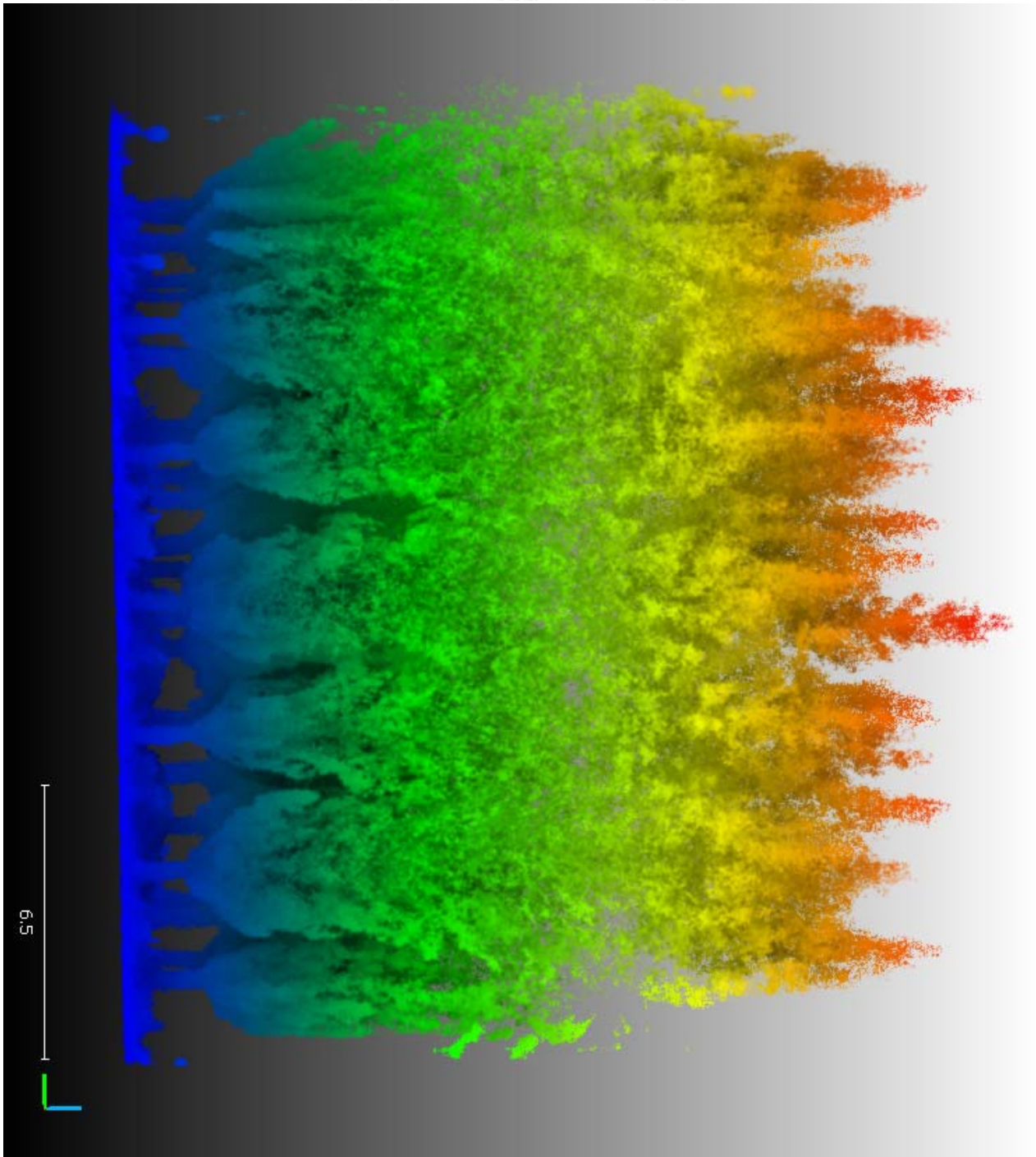


ULS + TLS - Point cloud data






0E+08
0E+07
0E+06
0E+05
0E+04
0E+03
0E+02
0E+01
0E+00
00E-01
00E-02
0
5
10
15
20
25
Height above ground (M)
CMB
ZEB
ULS
ULS + TLS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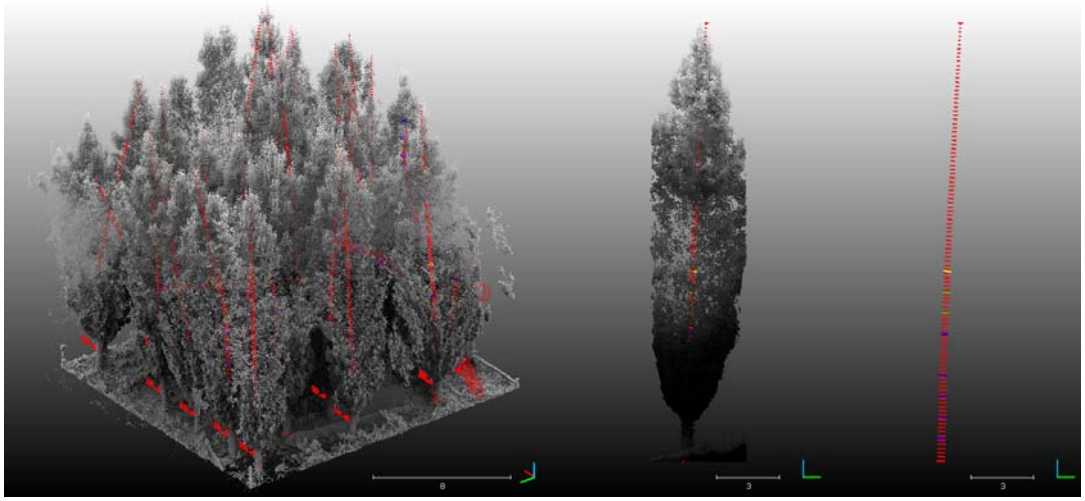
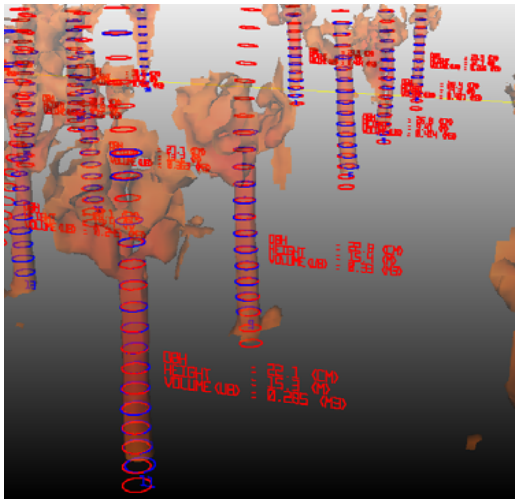
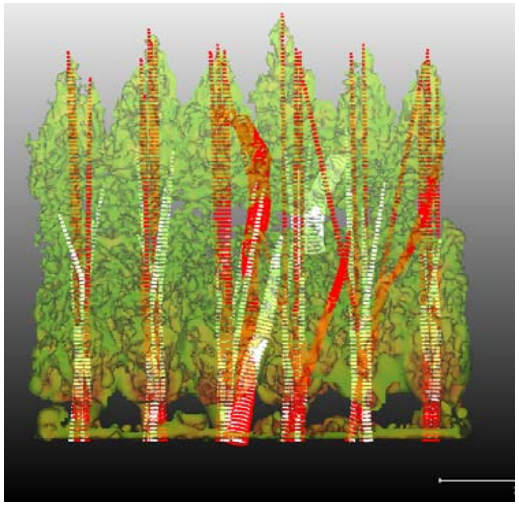
ULS + TLS - Key results

Key conclusions

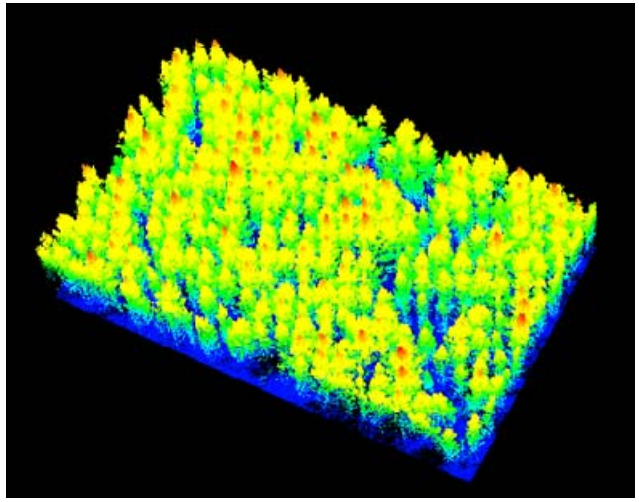
- Methods established to fuse ULS and TLS
- TLS data provides stem detection, DBH, and stem diameters
  - Recent international research showing ZEB superior to tripod units for DBH
- Fused TLS-ULS data enable height, taper and volume estimates

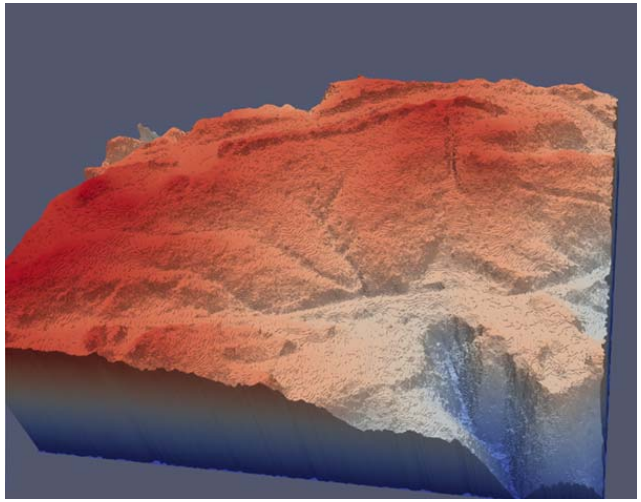


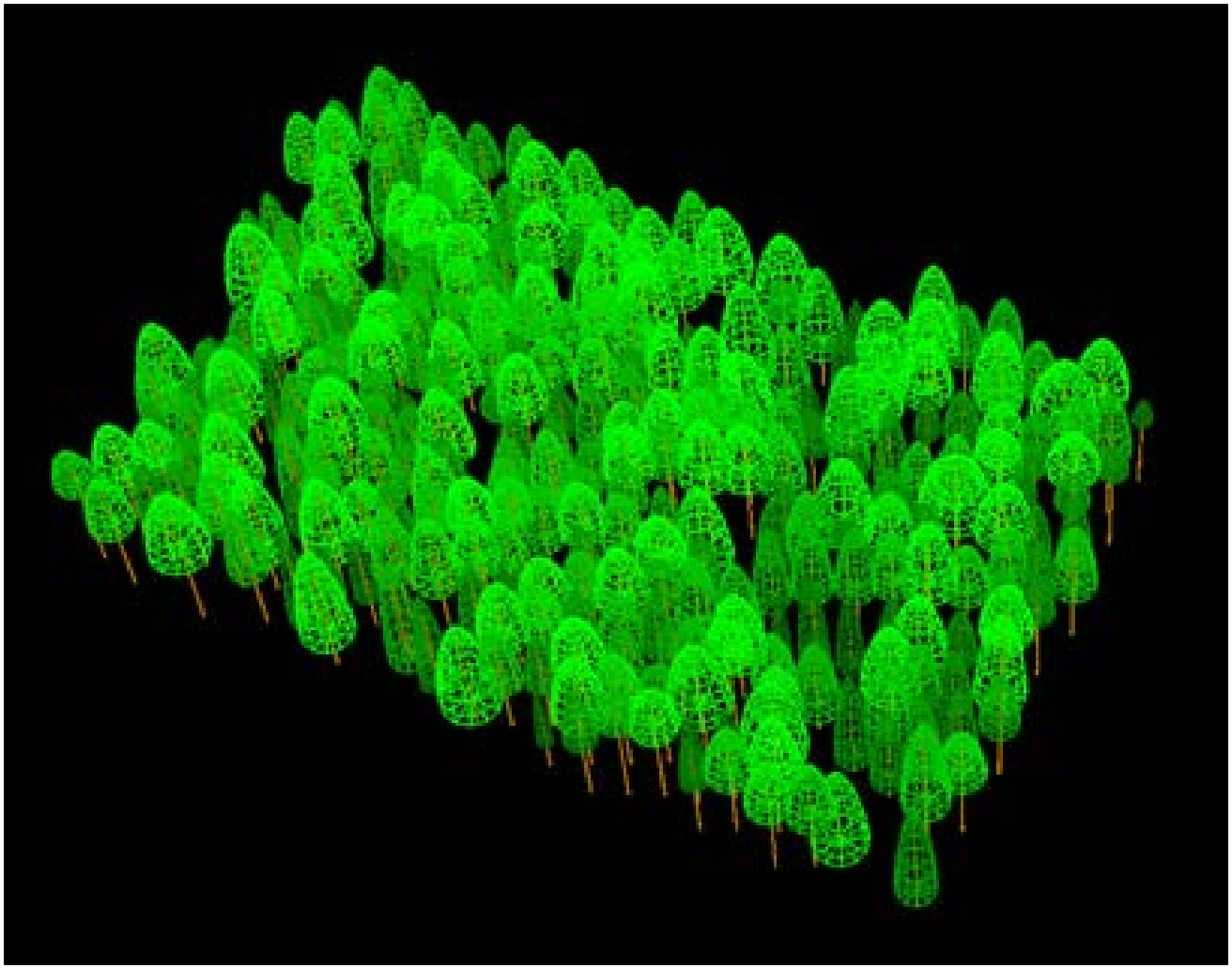




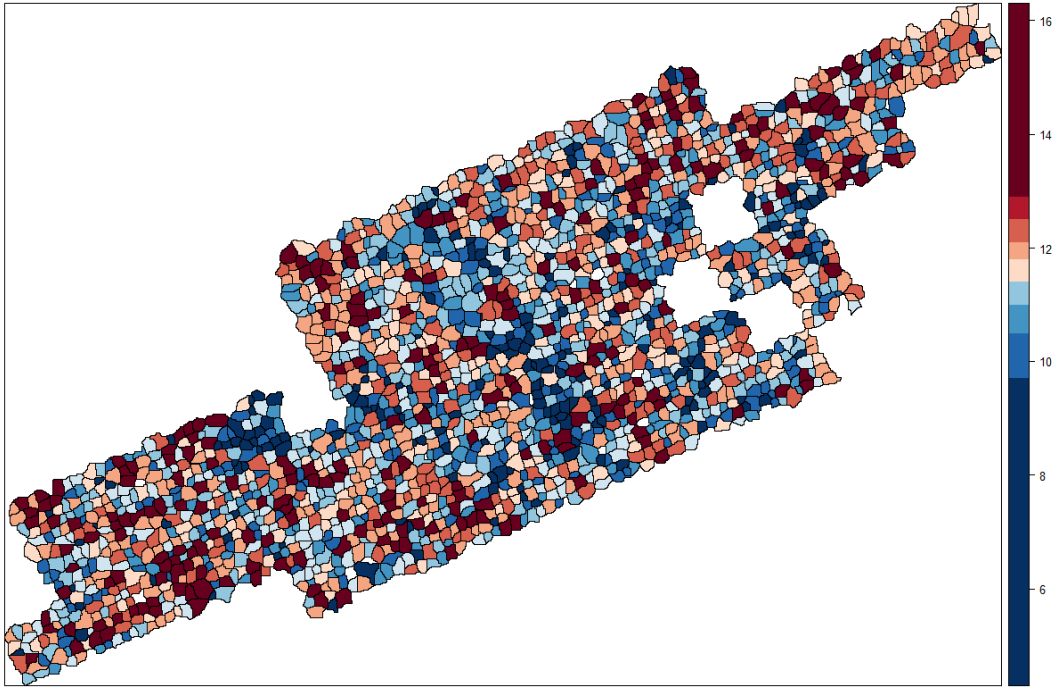
Exceptional Trees - Environment mapping, phenotyping







Exceptional Trees - Removing environmental effects



Exceptional Trees - Progress highlights

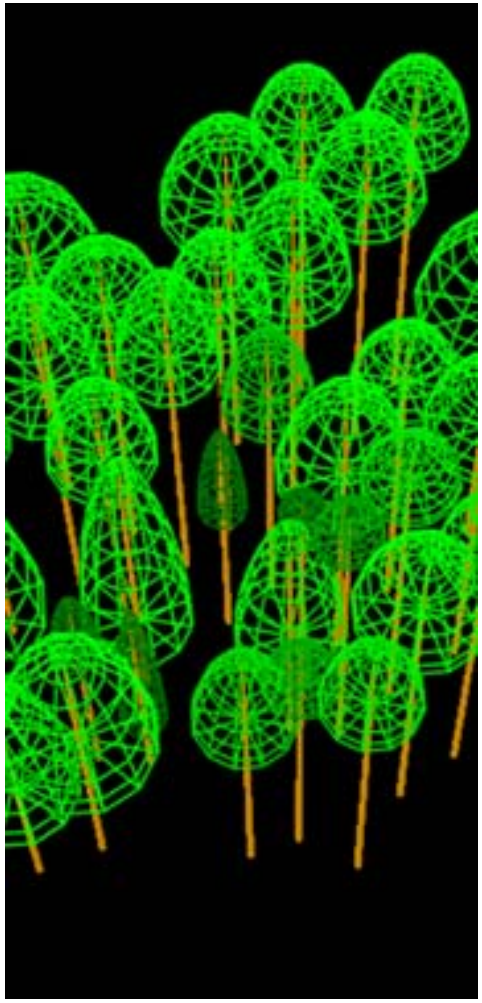
Spatial analyses

- Evaluated a range of terrain metrics (aspect, slope, wetness …)
- Evaluated a range of competition metrics and neighbourhood definitions
- Spatial models found to be essential to explain environmental effects on tree growth

Phenotyping methods

- Prototype spatial GxExS models being developed

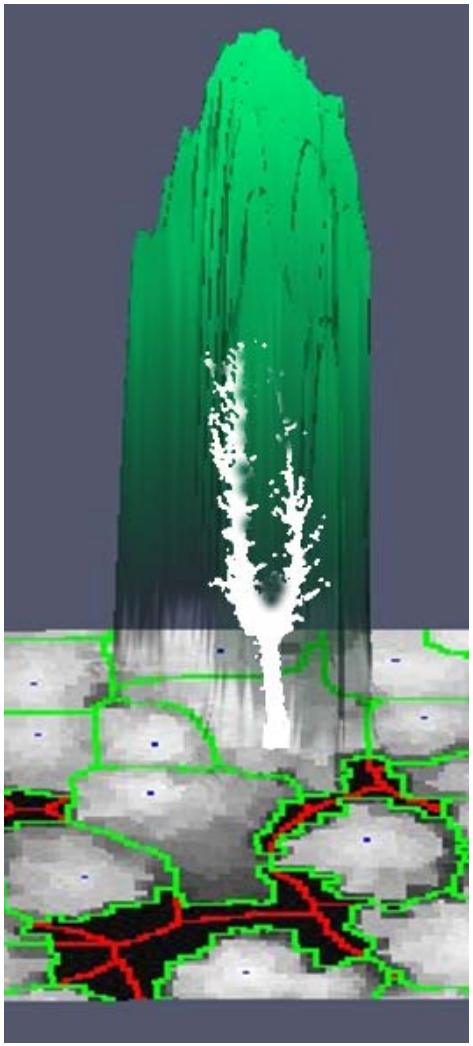
- Next step is to apply to sample areas to identify elite trees



Key Outcomes

Remote sensing to characterise individual trees, aided by Tree-level Phenotyping Extension.

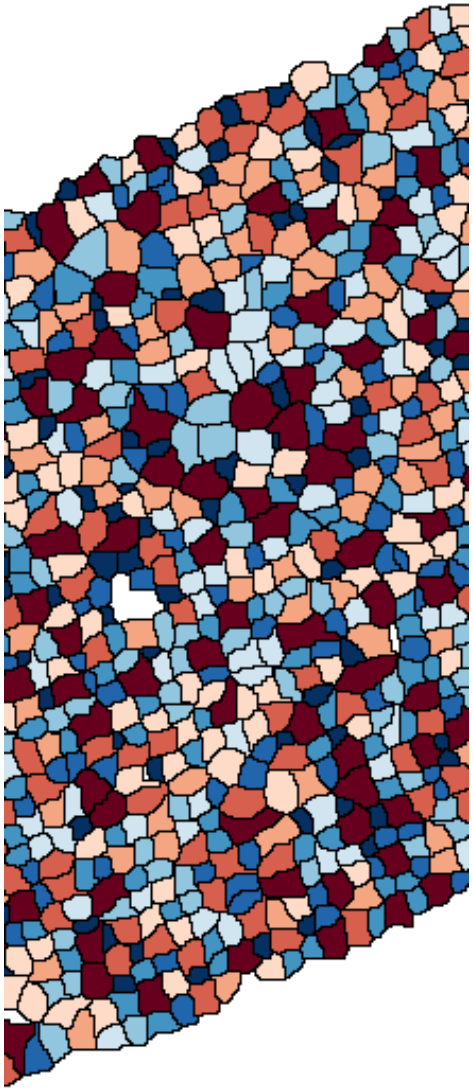
- A PhD on ALS to characterise individual trees for size, form, disease, and wood quality traits. Strong correlations established between crown metrics and tree size measures (Height, DBH, and TSV).
- Extension of individual tree characterisation methods to ULS data, and potential to use point clouds generated from RGB images.
- Methods to extract tree locations and DBH estimates from TLS.
- ULS + TLS fusion to estimate of tree taper and volume.
- Ongoing research into extraction of stem form (sweep, lean, taper) from high density points clouds (TLS and ULS).



Key Outcomes

- World-leading research utilising remote sensing to quantify environmental, silvicultural, and genetic effects on individual tree growth.
- Being applied to identify exceptional trees, for the development of superior breeds for future forests.

The research is developing innovative methods to phenotype individual trees, for tree growth, breeding, forest health, and precision forest management applications, to give confidence in future forests.



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