Three-dimensional plasticity in European forests

UNIVERSITY OF CAMBRIDGE

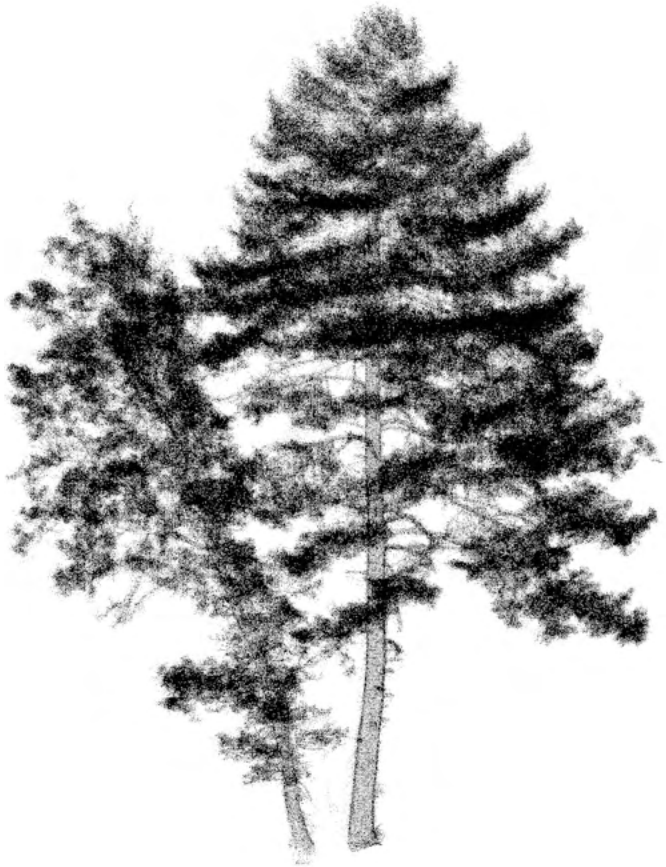
Harry Owen, Stuart Grieve and Emily Lines

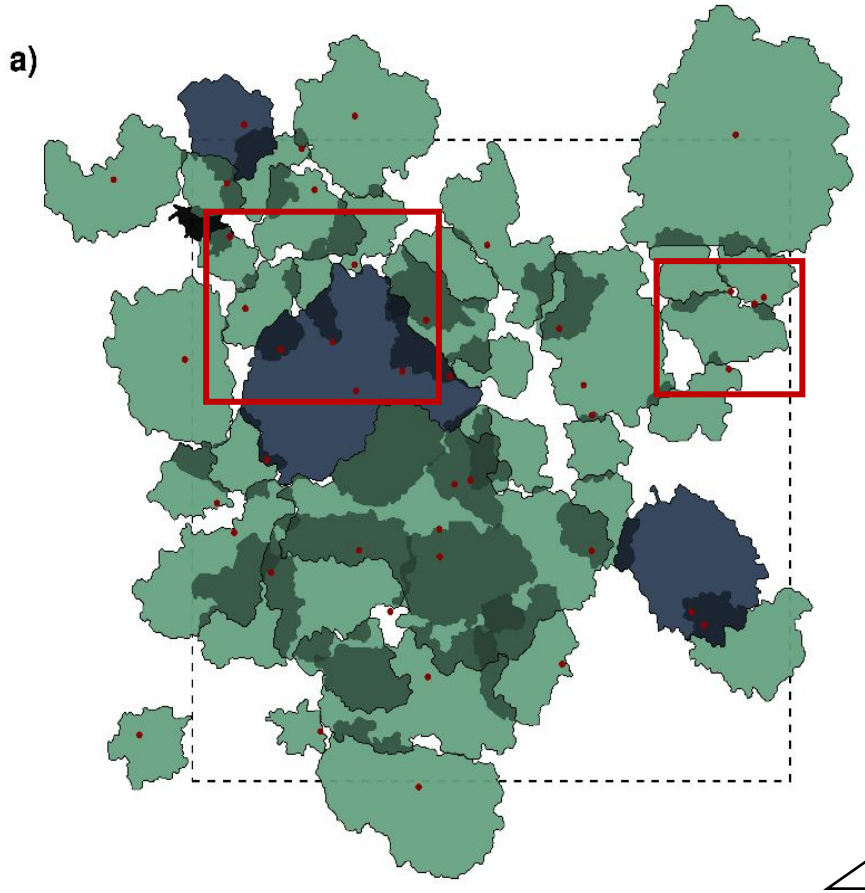
COST Action CA20118

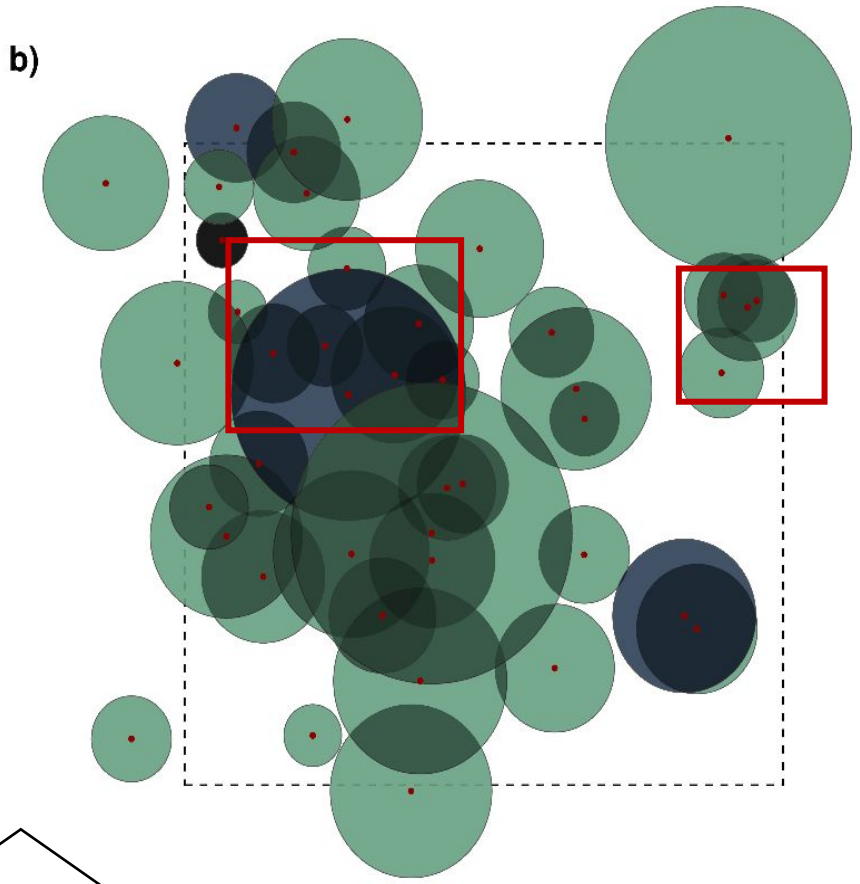
3DForEcoTech

Three-dimensional forest ecosystem monitoring & better understanding by terrestrial-based technologies

Forests show plasticity in their structure







Competition for light is key

Evidence for diversity-productivity links:

nature ecology & evolution

ARTICLES

PUBLISHED: 1 MARCH 2017 | VOLUME: 1 | ARTICLE NUMBER: 0063

Spatial complementarity in tree crowns explains overyielding in species mixtures

Laura J. Williams[1*], Alain Paquette[2], Jeannine Cavender-Bares[1], Christian Messier[2,3] and Peter B. Reich[4,5]

Functional Ecology

British Ecological Society

Functional Ecology 2015, **29**, 1078–1086 doi: 10.1111/1365-2435.12428

Crown plasticity enables trees to optimize canopy packing in mixed-species forests

Tommaso Jucker[1,*], Olivier Bouriaud[2] and David A. Coomes[1,*]

[1] *Forest Ecology and Conservation group, Department of Plant Sciences, University of Cambridge, Cambridge, UK; and*
[2] *Forestry Faculty, University Stefan cel Mare of Suceava, Suceava, Romania*

ECOLOGY

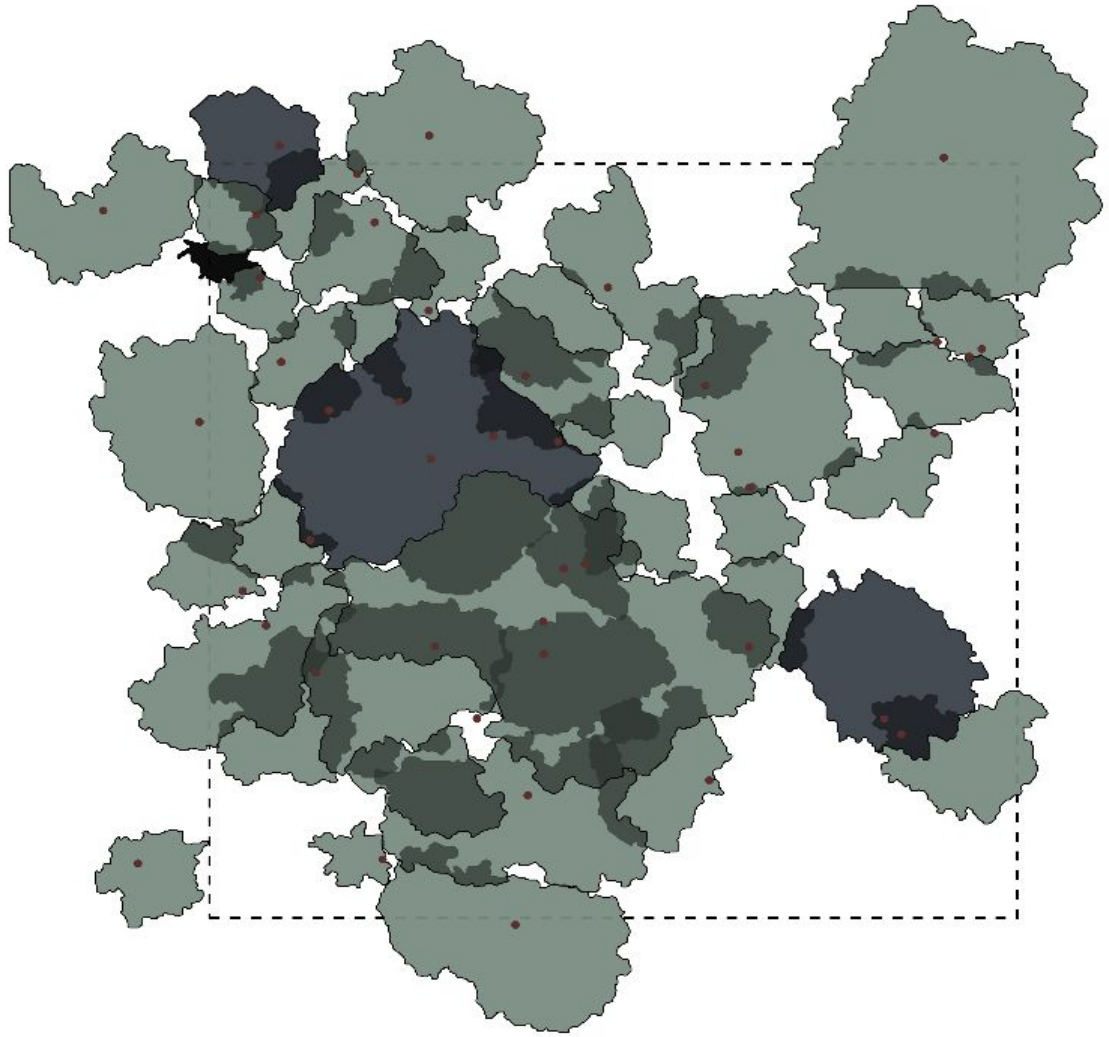
ECOLOGICAL SOCIETY OF AMERICA

Reports | Free Access

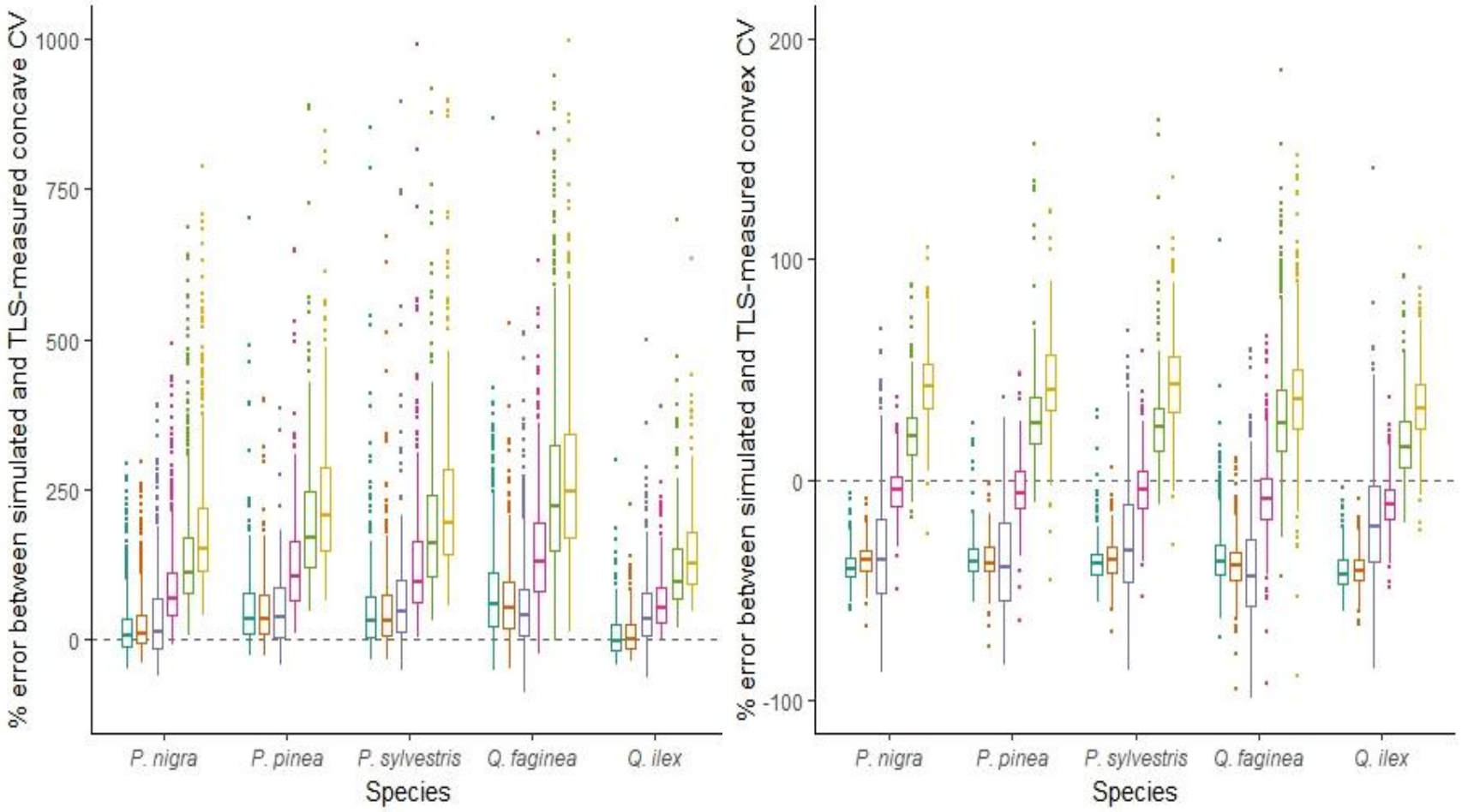
High rates of primary production in structurally complex forests

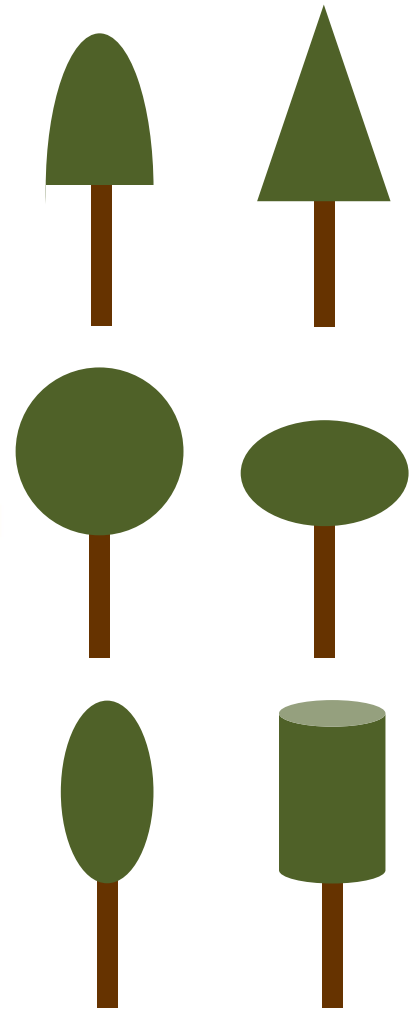
Christopher M. Gough, Jeff W. Atkins, Robert T. Fahey, Brady S. Hardiman

First published: 09 August 2019 | https://doi.org/10.1002/ecy.2864 | Citations: 29



Plasticity makes assumptions about shape difficult



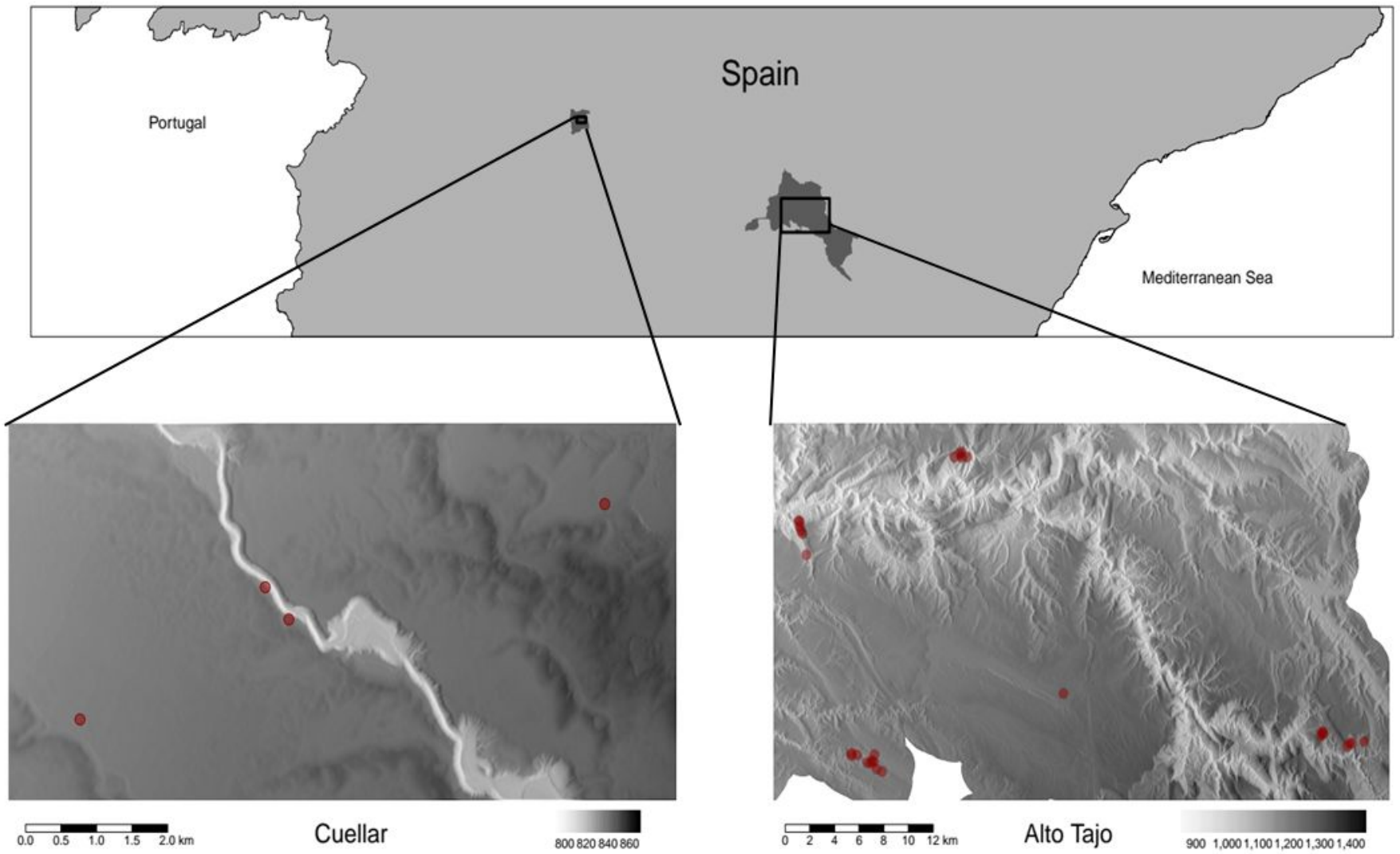


(Owen & Lines *in review*)

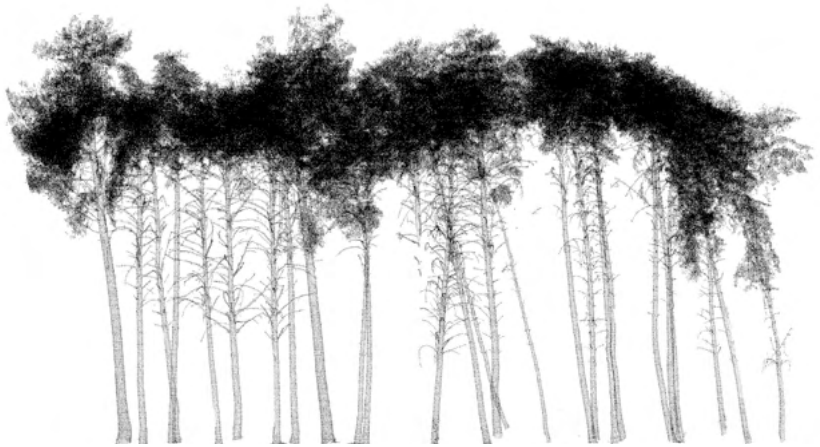
Q1) Do more diverse plots show higher crown volume packing and 3D space filling complexity?

Q2) Does increased individual size and complexity reflect higher plot structural packing and complexity

Study Site

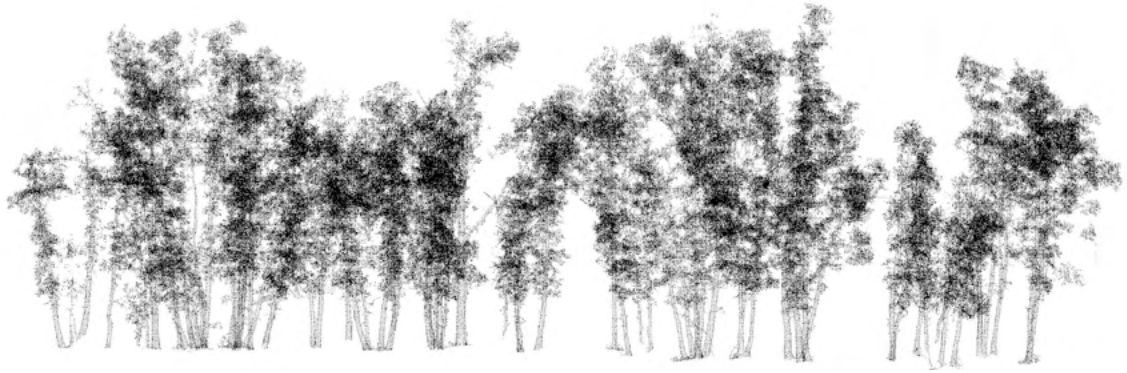

Spain
Portugal
Mediterranean Sea
0.0 0.5 1.0 1.5 2.0 km
Cuellar
800 820 840 860
0 2 4 6 8 10 12 km
Alto Tajo
900 1,000 1,100 1,200 1,300 1,400

TLS data from Mixed and Monoculture plots

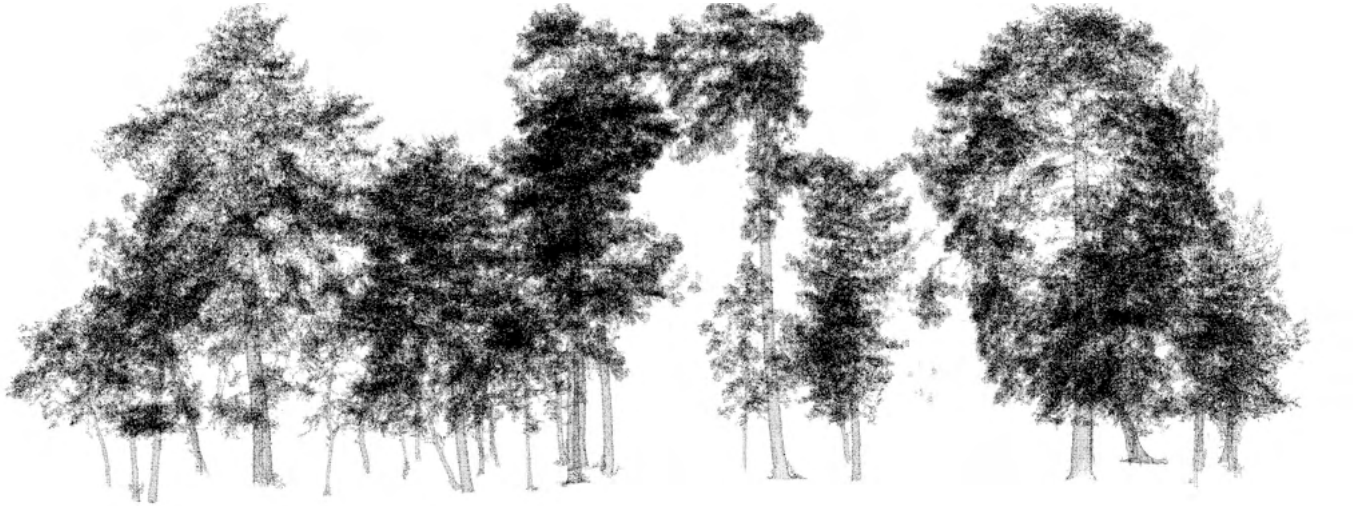


[*P. sylvestris only*]

Vs.



[*Q. Faginea only*]



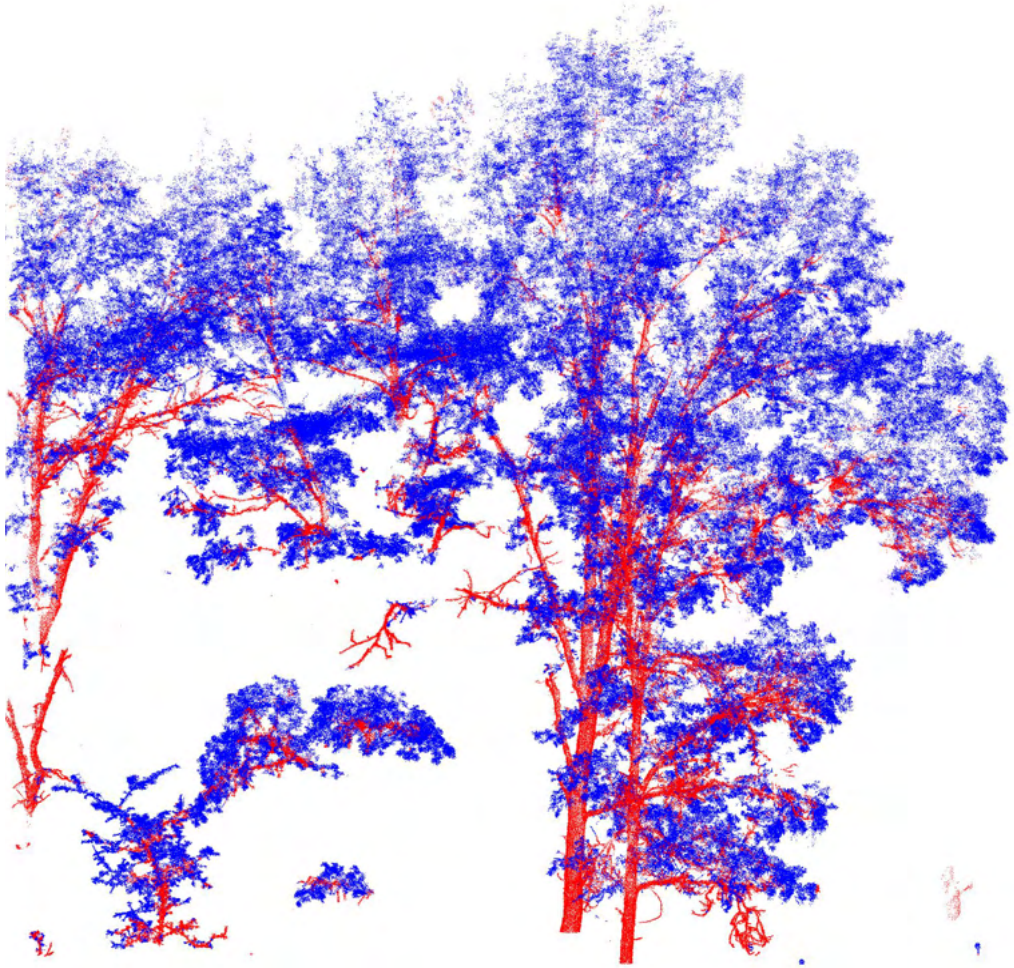
[*P. Sylvestris* + *P. nigra* + *Q. faginea* + *Q. ilex*]

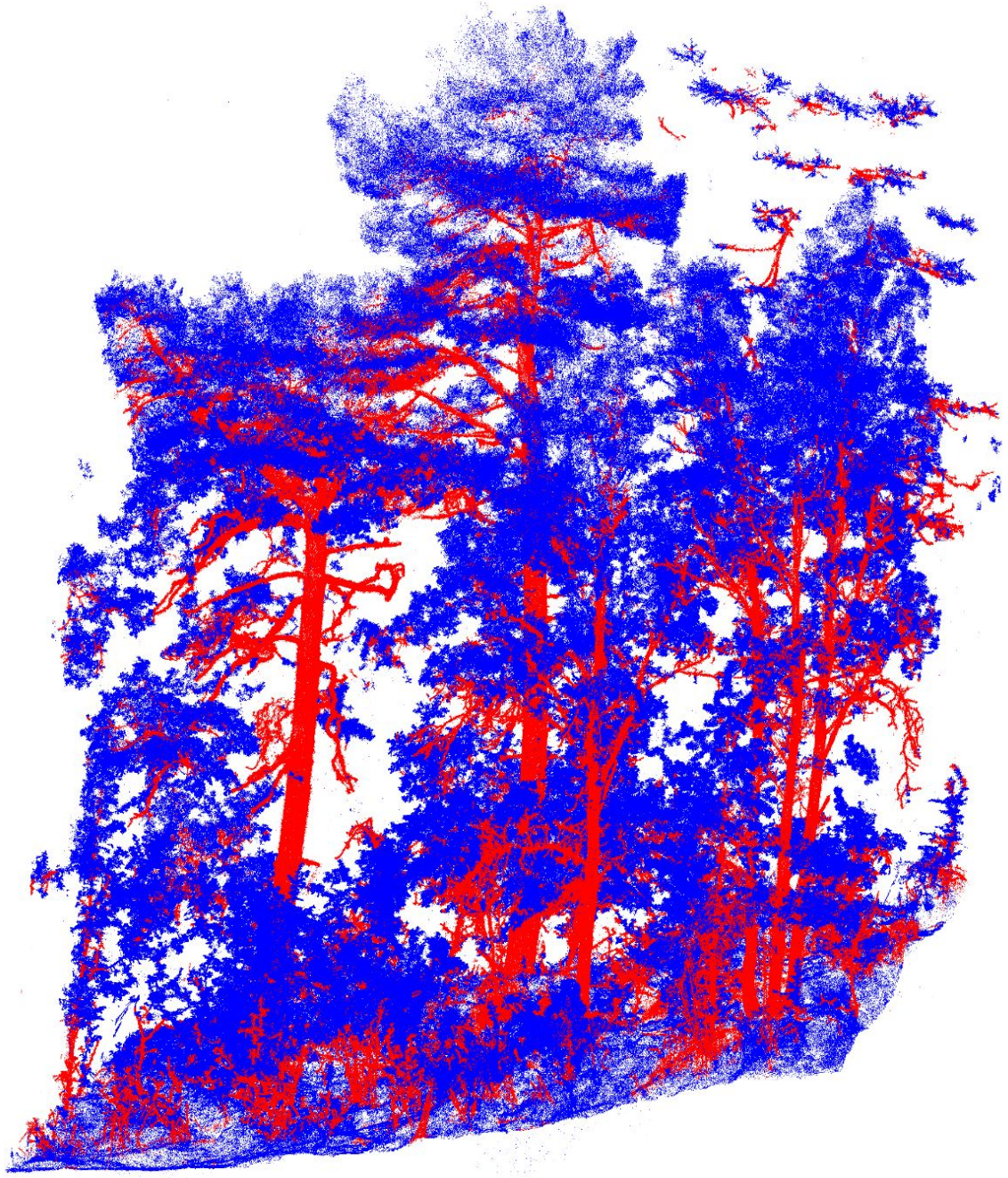
Plots from Alto Tajo, Central Spain:

Mixed: $N = 18$
Pine: $N = 9$
Oak: $N = 9$

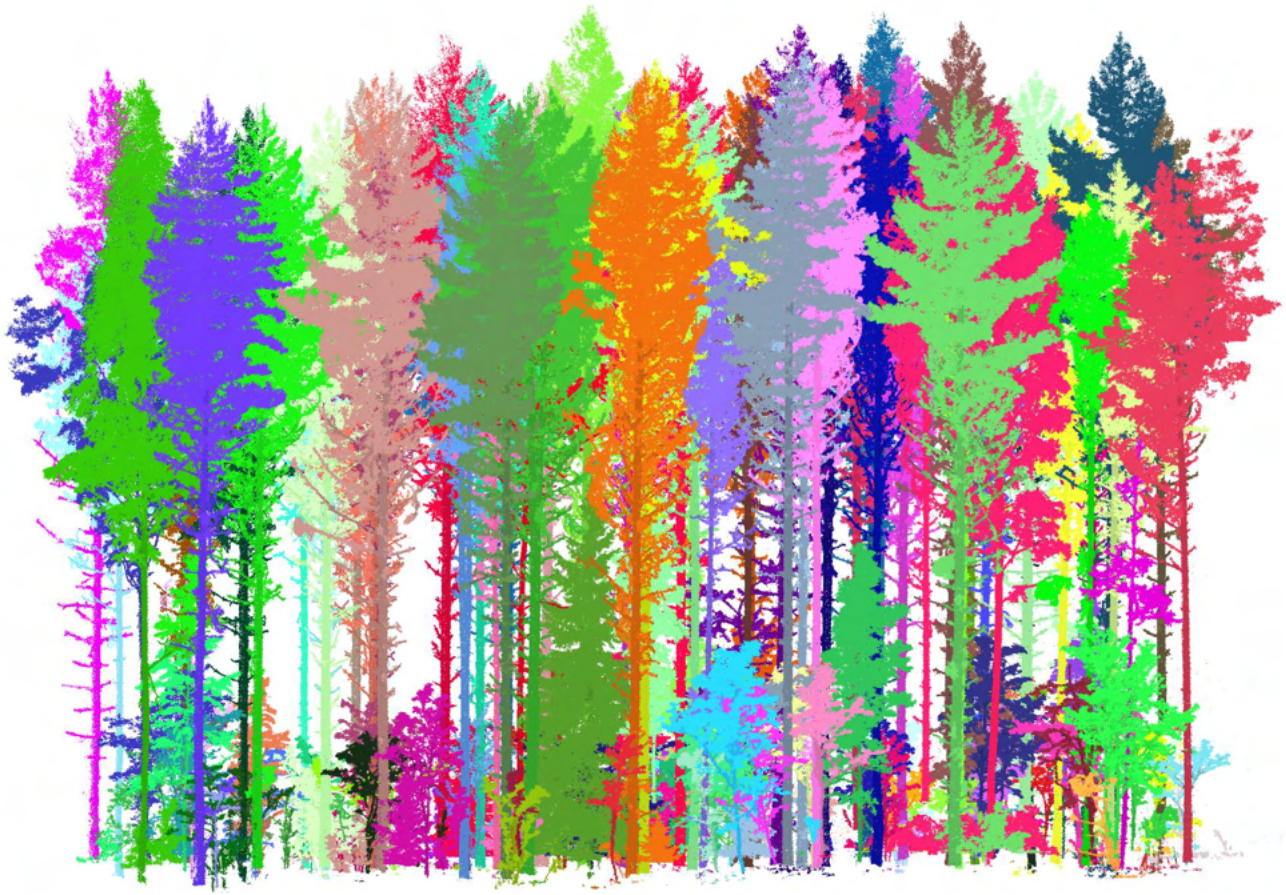
Getting at the individual is challenging

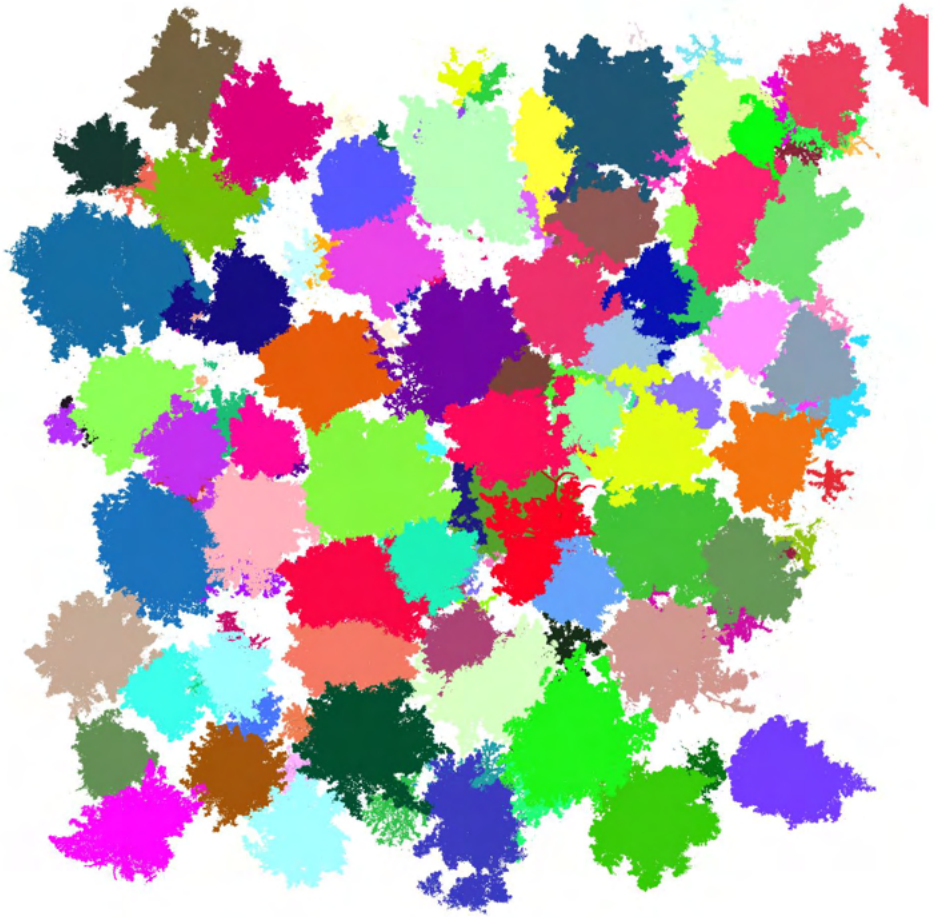
Built upon FSCT (Krisanski et al., 2021) for improved semantic labelling of wood in point clouds.





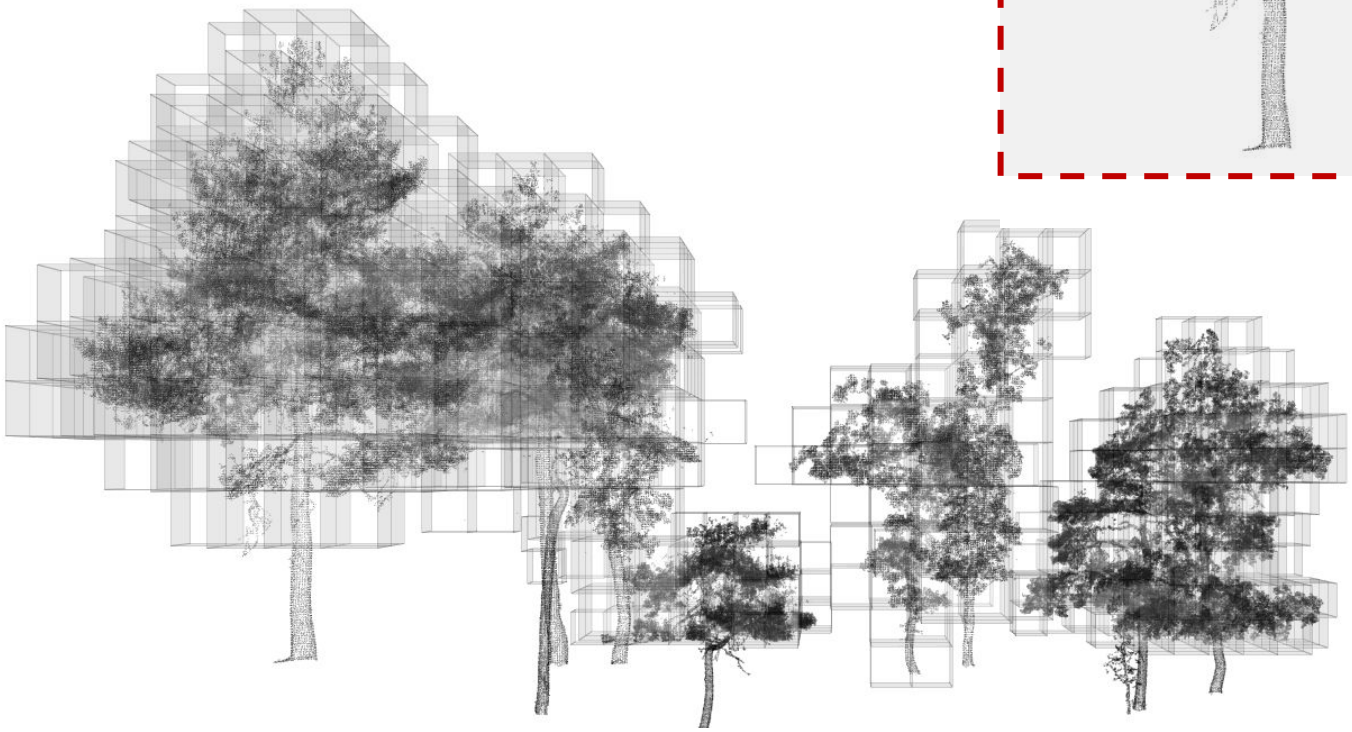
Which then feeds a novel instance tree segmentation pipeline by Wilkes et al., 2023 that leverages the semantic labels.

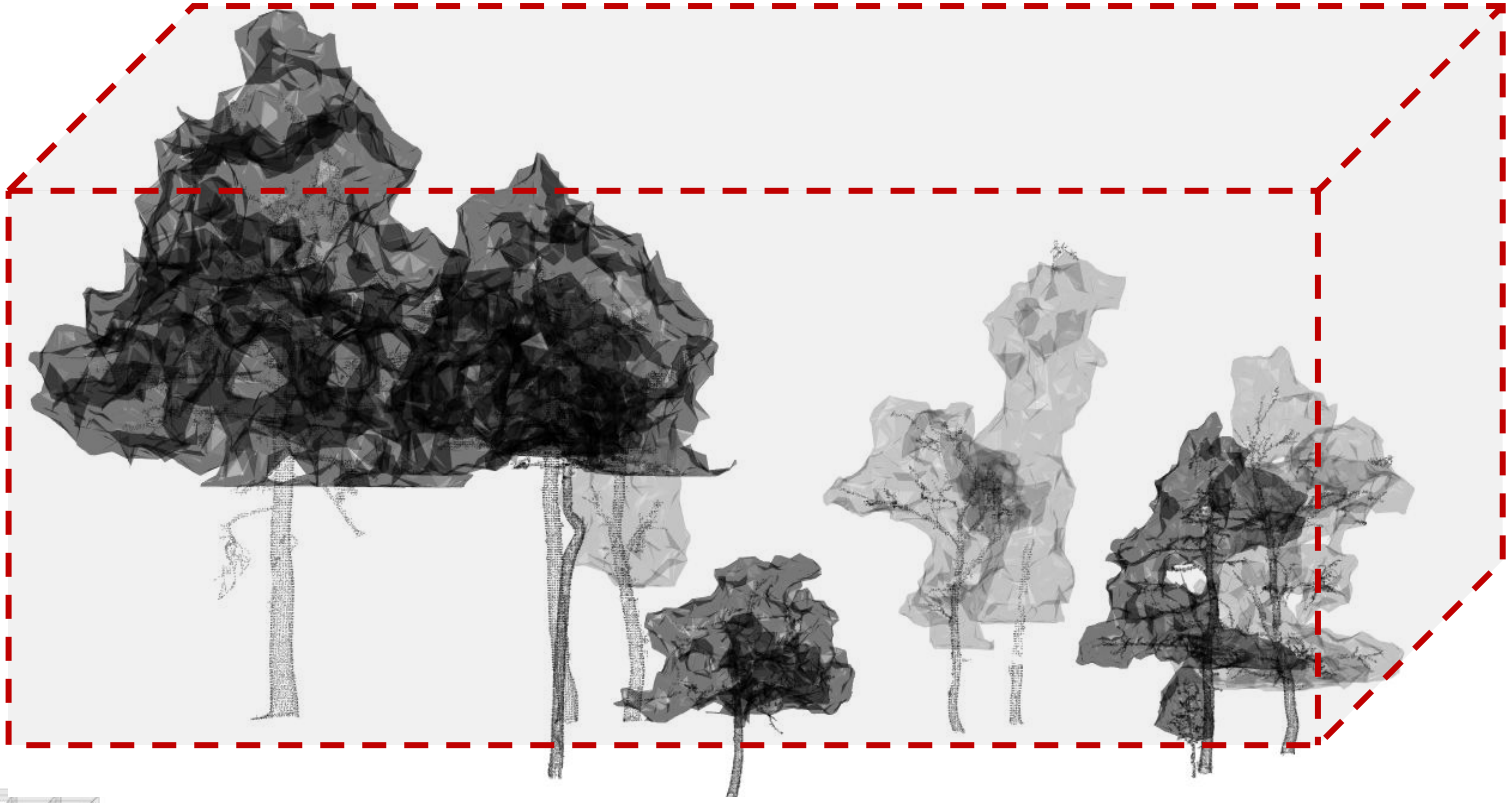




Wilkes, P., Disney, M.I., Armston, J., Bartholomeus, H., Bentley, L.P., Brede, B., Burt, A., Calders, K., Chavana-Bryant, C., Clewley, D. and Duncanson, L., 2022. TLS2trees: a scalable tree segmentation pipeline for TLS data.

Crown Volume Packing

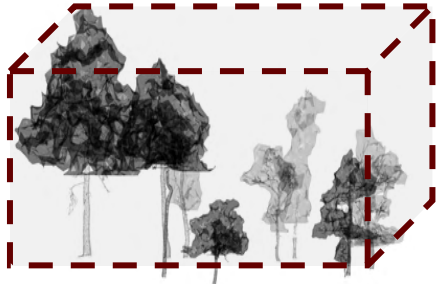


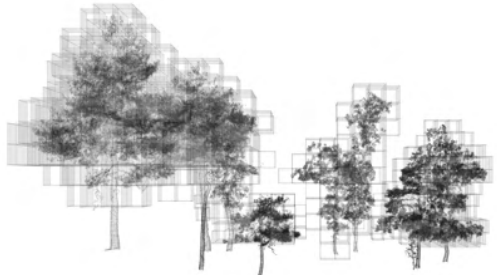


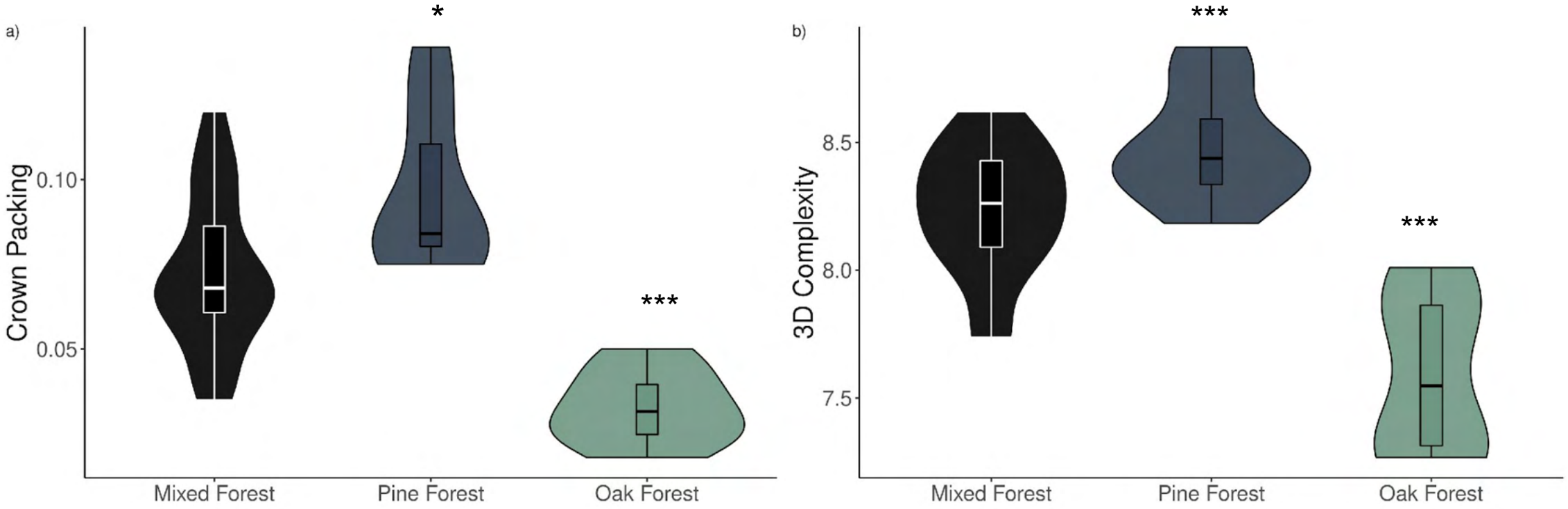
3D Space Filling (Complexity)

Guzmán Q, J.A., Sharp, I., Alencastro, F. and Sánchez-Azofeifa, G.A., 2020. **On the relationship of fractal geometry and tree–stand metrics on point clouds derived from terrestrial laser scanning**. *Methods in Ecology and Evolution*, *11*(10)

Oak plots have lowest packing and complexity

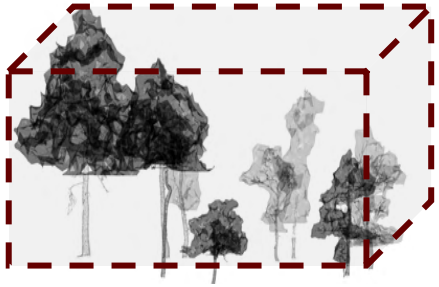


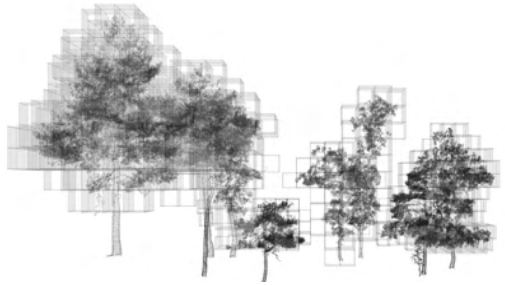


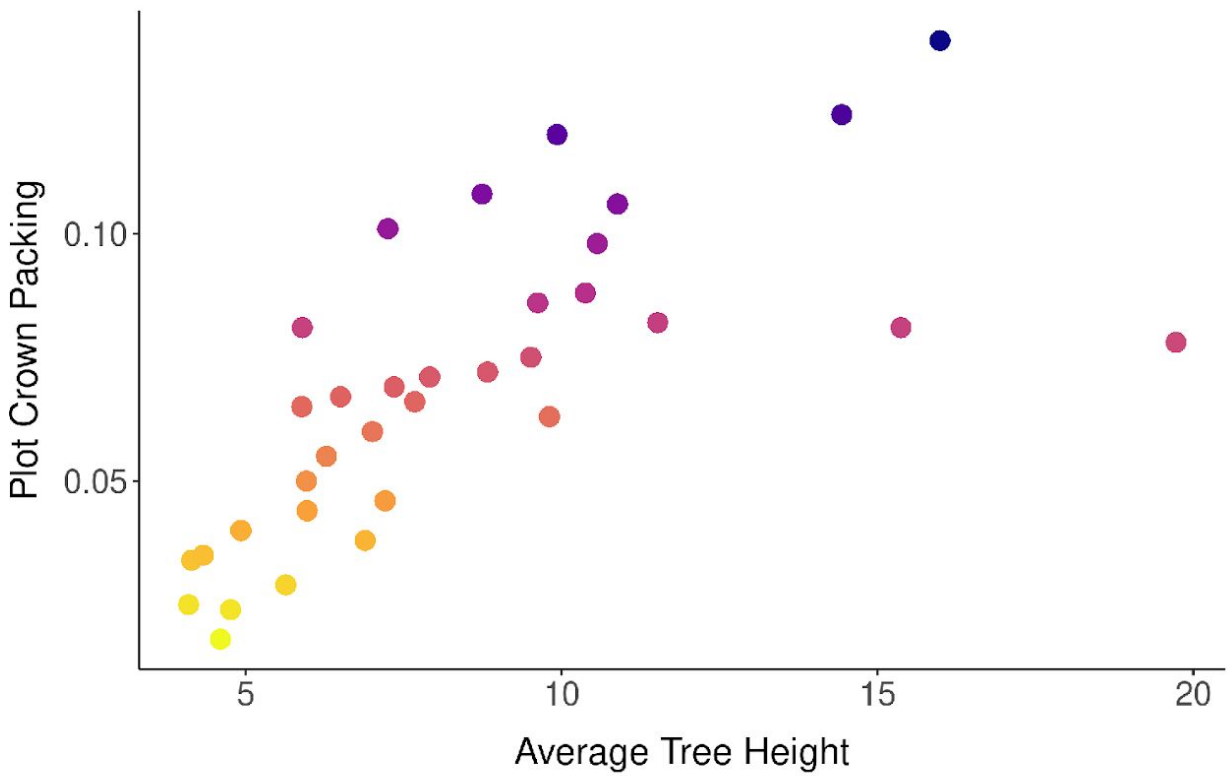


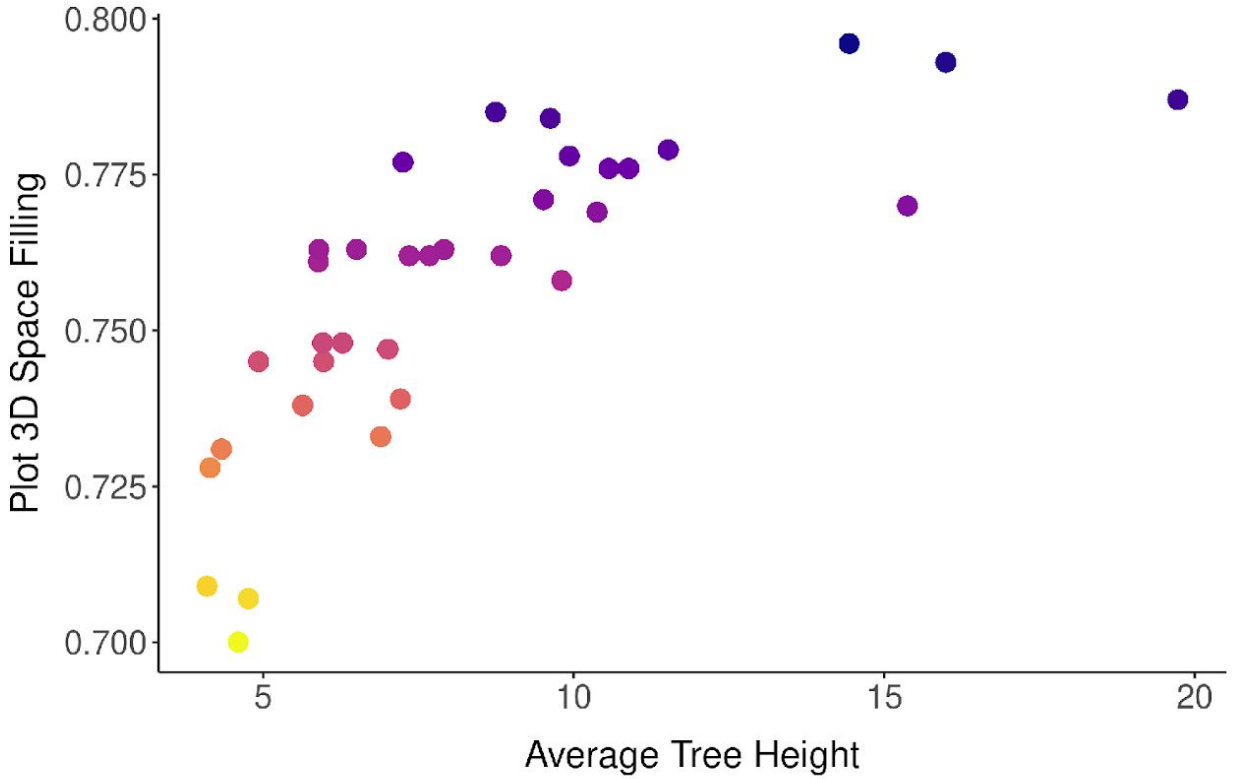
[Comparison accounts for differences in canopy density]

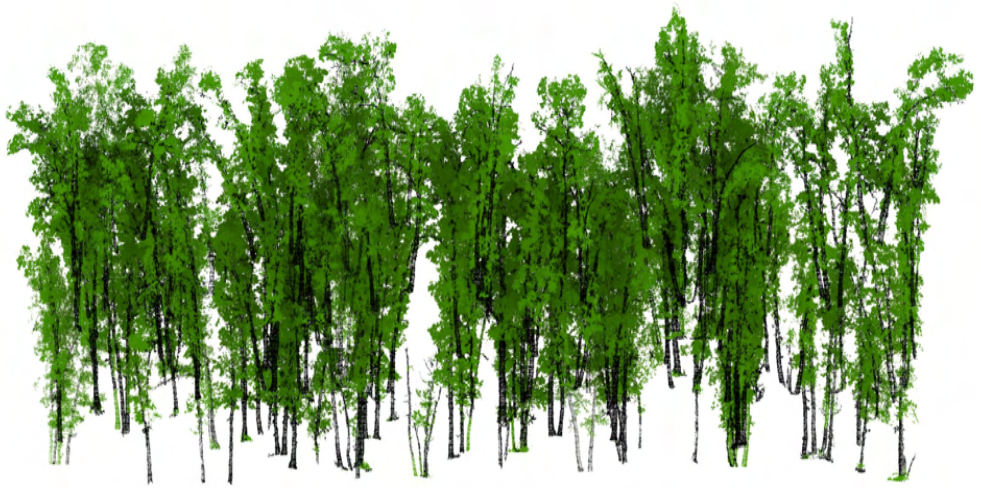
Effects of plot height on packing and complexity

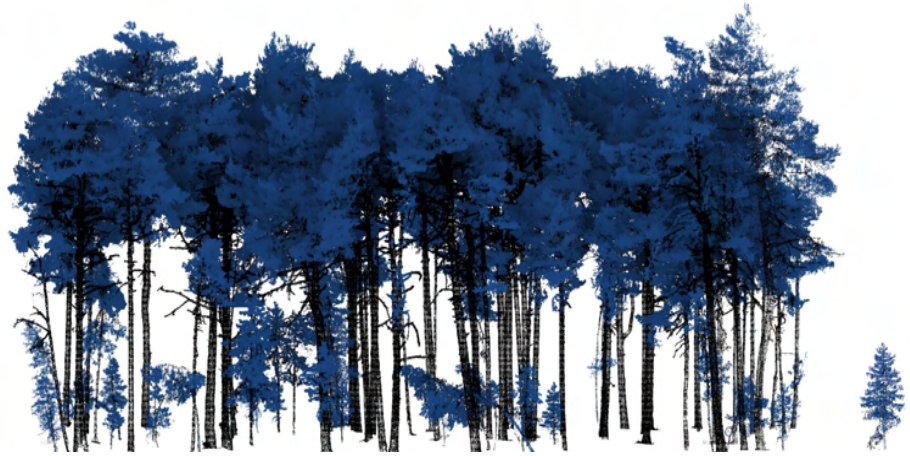












1) **Mixed more complex and packed compared to oak forests**

2) **Mixed equal in complexity and packing compared to pine forests**

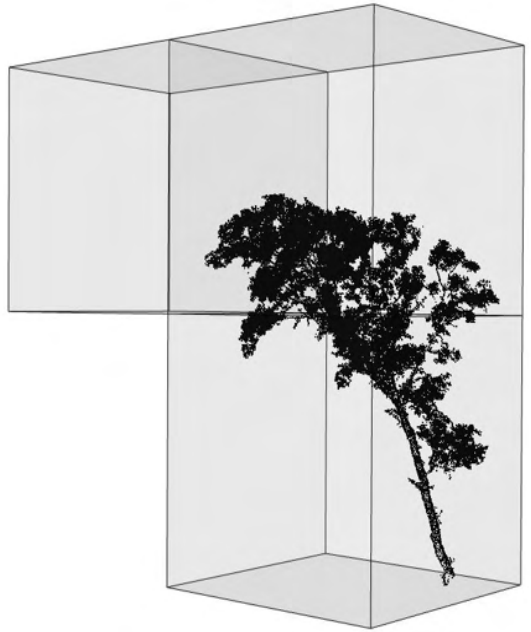
[Accounting for differences in canopy density and plot height]

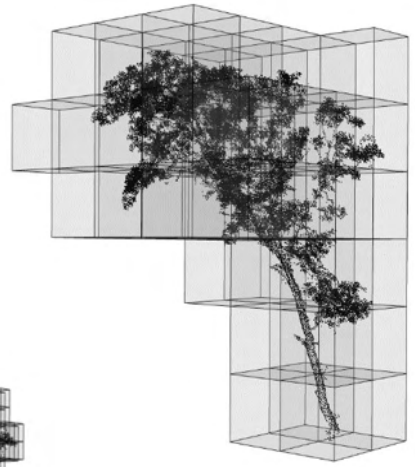
Q2) **Does increased individual size and complexity reflect higher plot structural packing and complexity?**

Individual metrics of crown plasticity

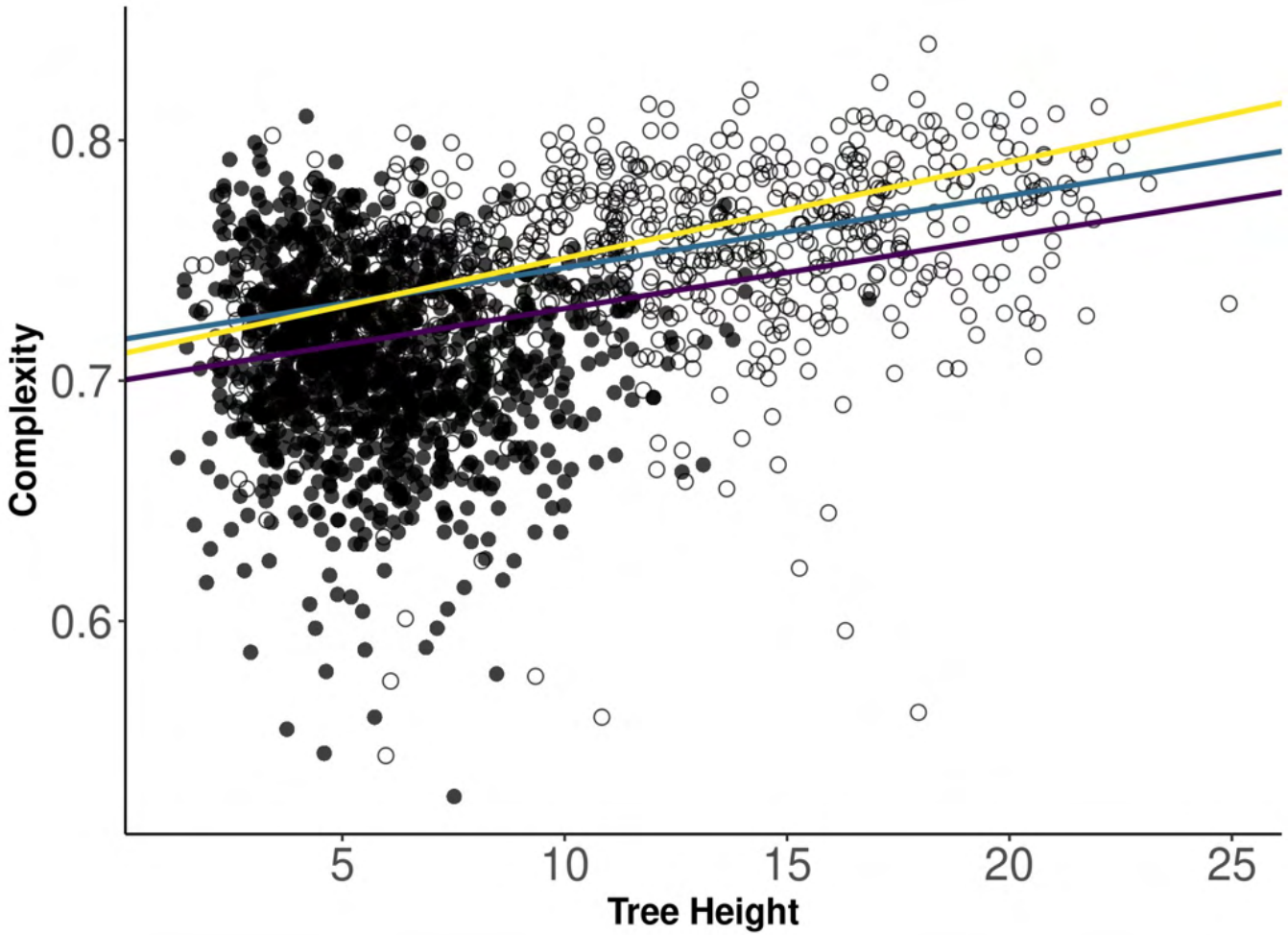
- Volume

- 3D Space Filling



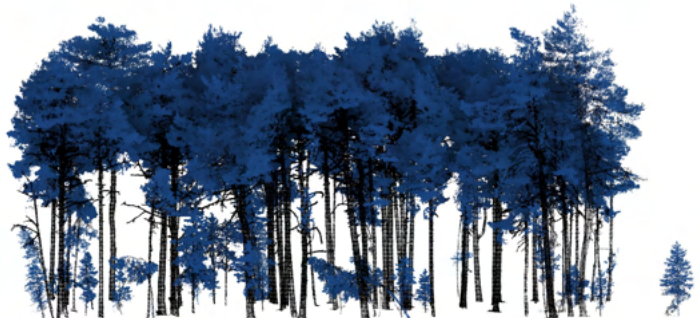


Height positively related to complexity in 3 of 4 species



No Diversity effect on individual volume or complexity

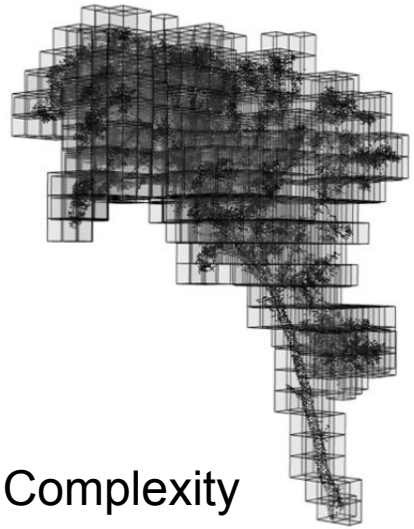
vs.



All species insignificant

Volume

All species insignificant



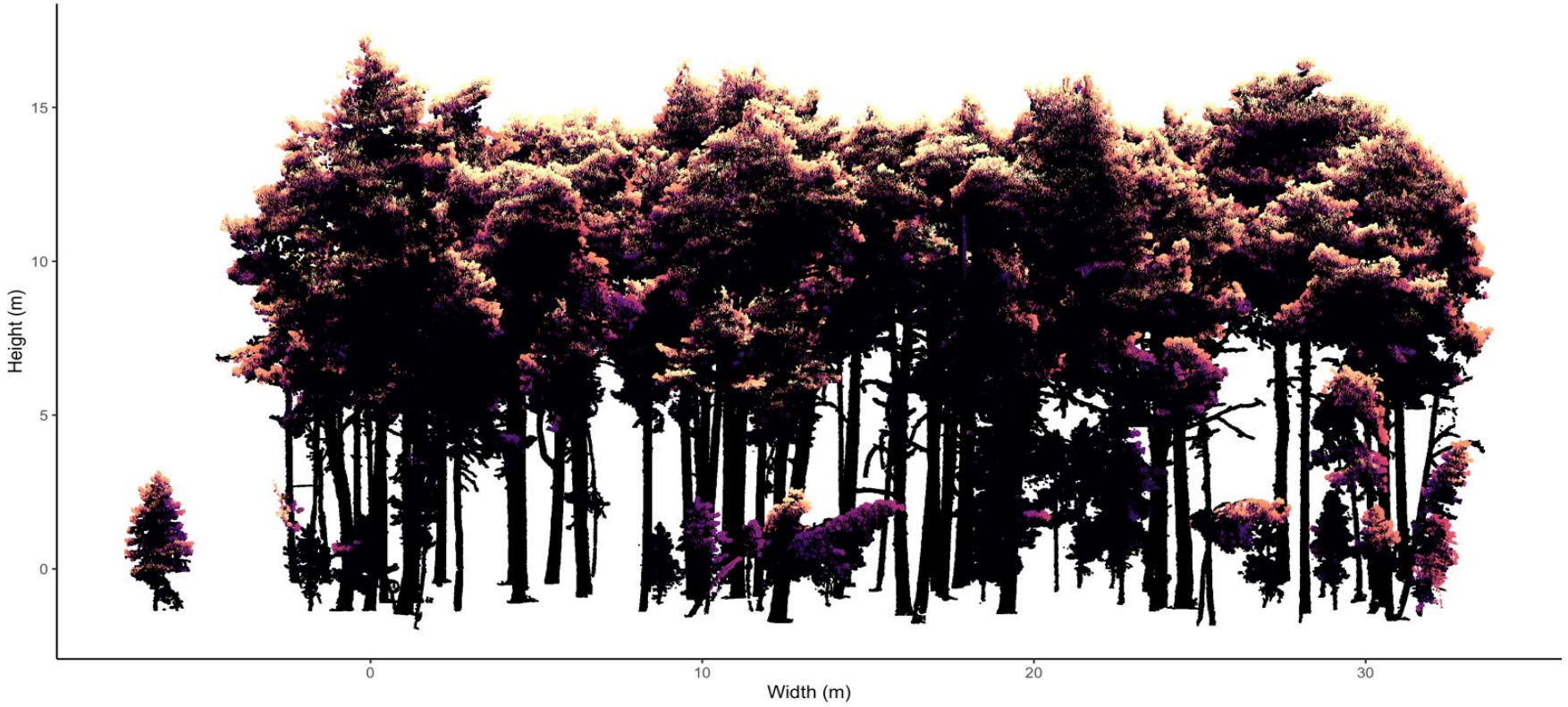
Complexity

Summary

1) Height is a strong predictor of individual complexity with no effect of diversity.

2) HOWEVER, diversity is having varying effects on height between pines and oaks.

3) Is complexity arising from indirect effects of diversity on height? Or through complex assemblage of all crowns independent of individual characteristics.



Derived from Bechtold, S. & Höfle, B. (2020): VOSTOK - The Voxel Octree Solar Toolkit. heiDATA, V1.

Yi et al., 2022 found negative relationship between complexity and productivity. Increased competition caused greater shading.

Derive more representative metrics of light/shading from TLS?

Acknowledgements

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Dr Stuart Grieve

William Flynn

Dr Paloma Ruiz-Benito and others at the University of Alcala, Spain

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