Stand structure characterization from TLS data to assess forest management effects in protected areas

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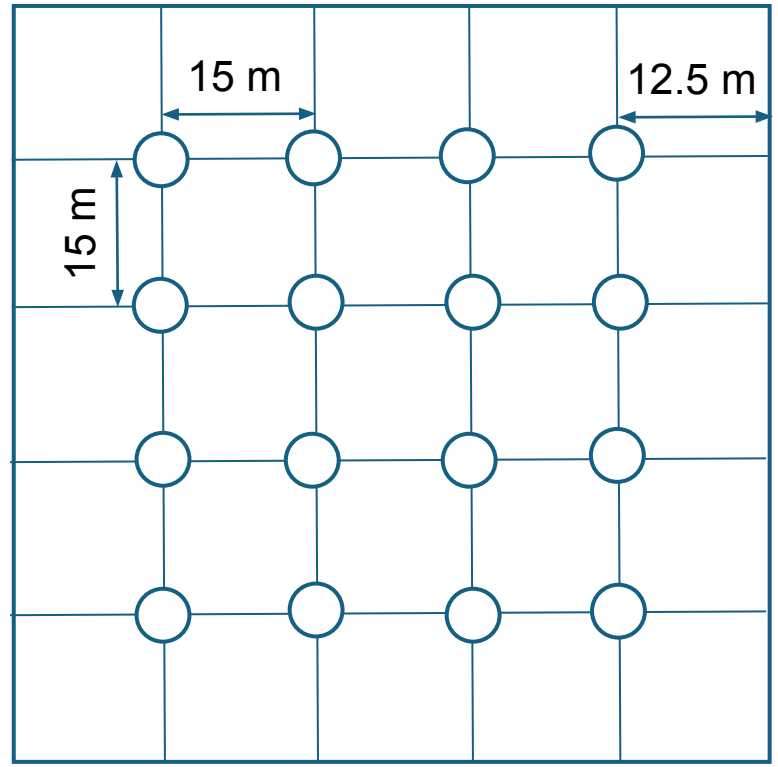
Symposium on Ecosystem Services, Forest Management and Decision Making

2 plots:

Managed & unmanaged

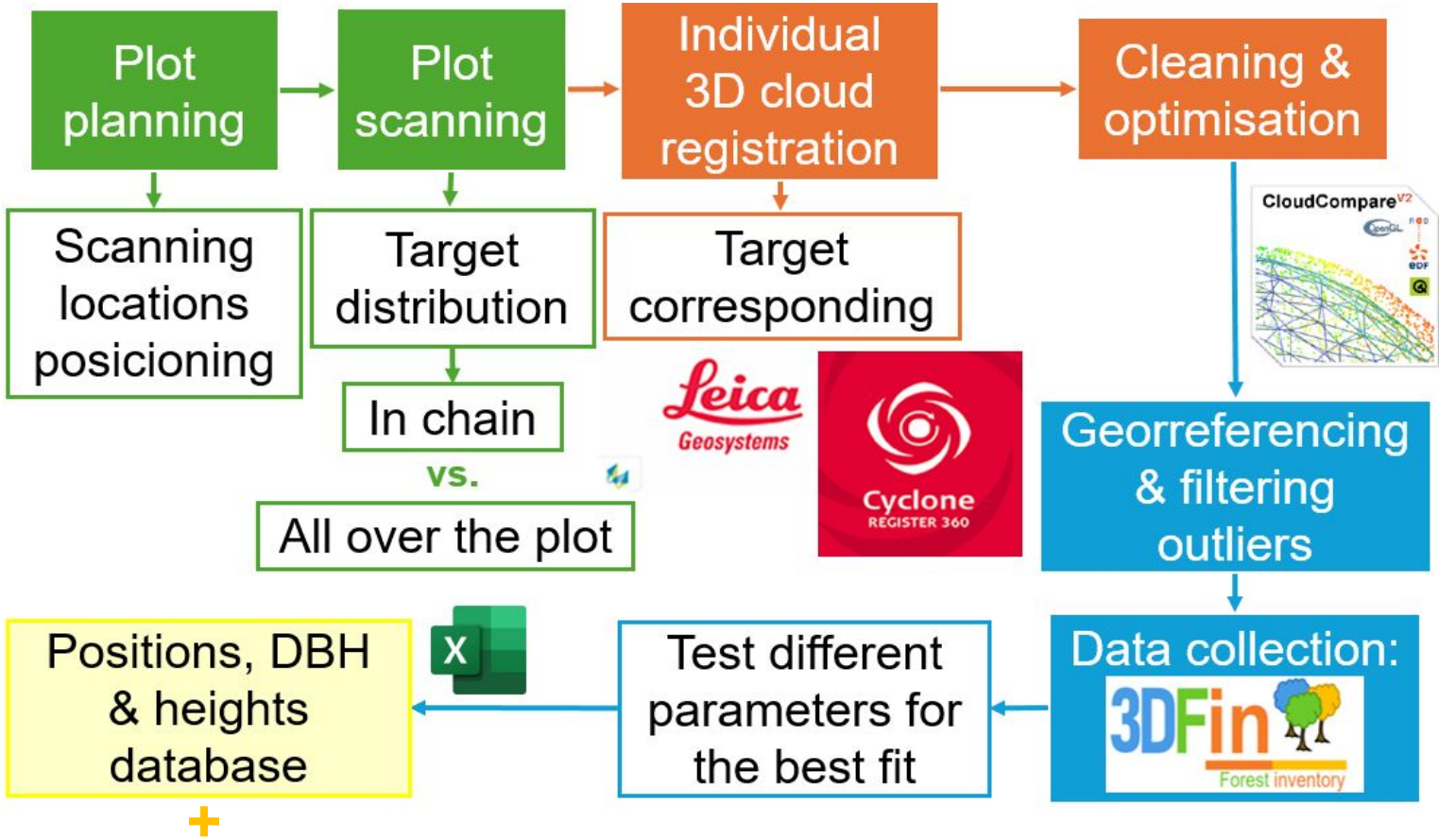

Picos de Europa
Aigüestortes and Sant Maurici Lake
Atlantic islands
Ordesa y Monte Perdido
Guadarrama mountains
Cabañeros
Sierra de las Nieves
Sierra Nevada


15 m
12.5 m
15 m

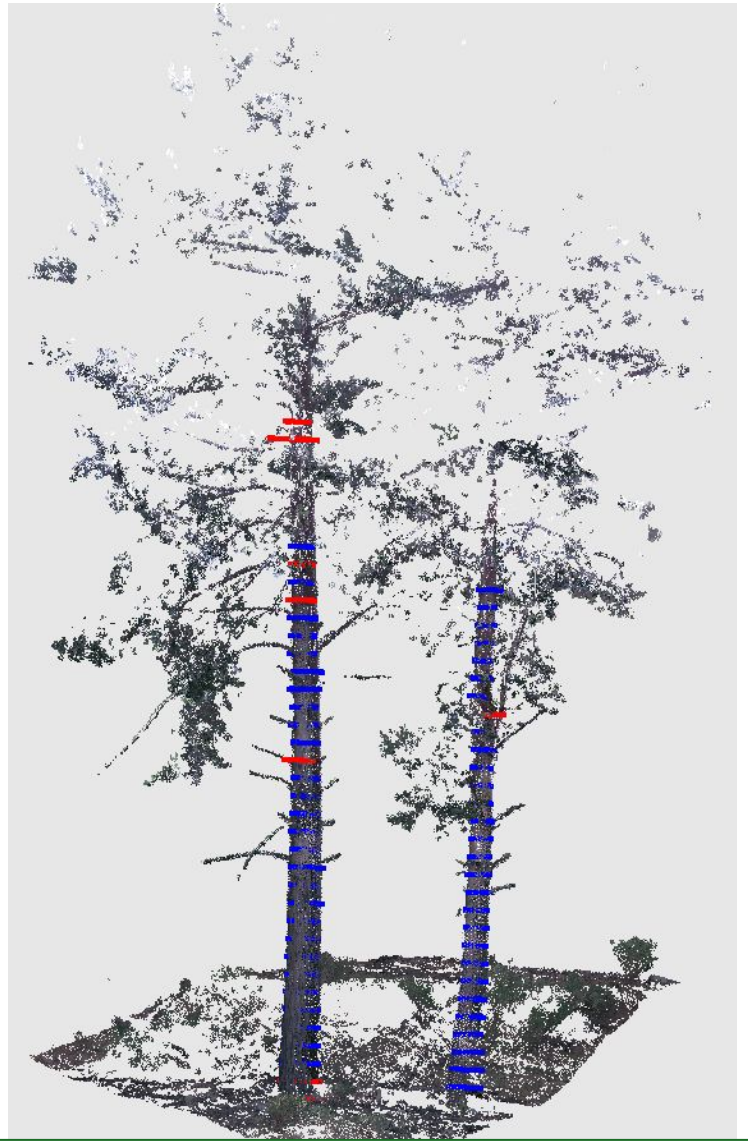
70m x 70m

TLS METHODOLOGY

WORKFLOW

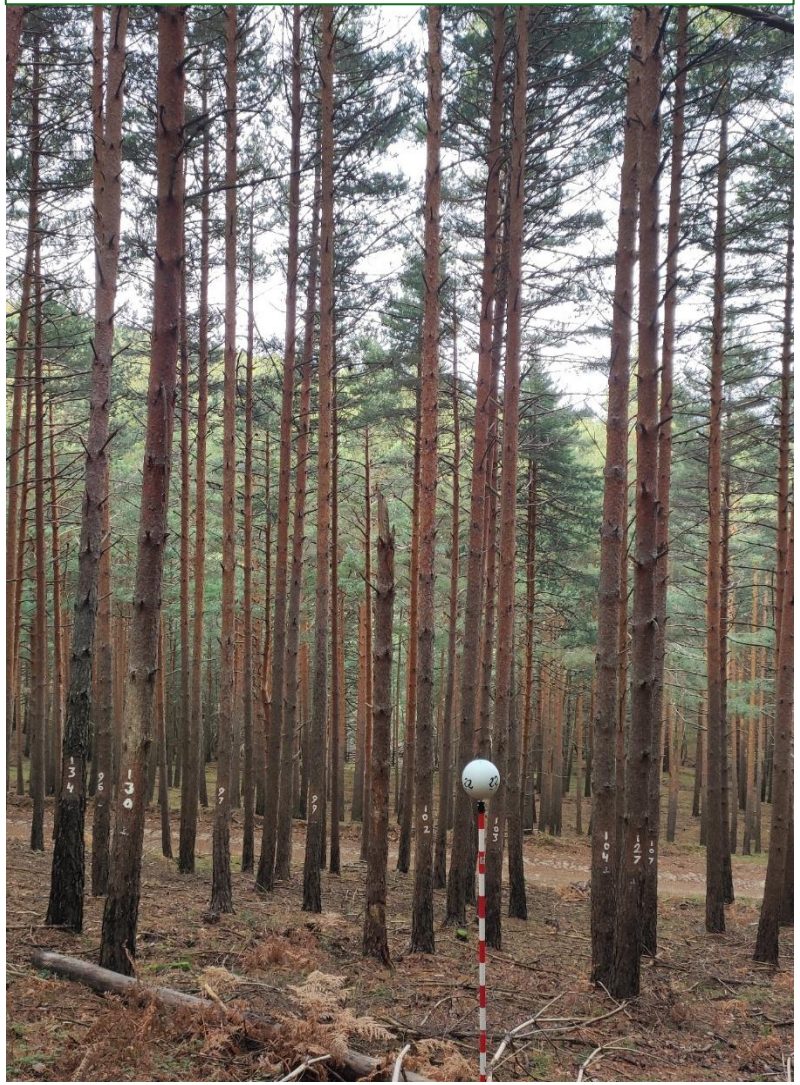


- Diameters along the stem sections
- Section overall quality : sector occupancy, outlier probability & inner circle points



Overall quality of computed sections

Natural managed *Pinus sylvestris* forest for timber harvesting



RESULTS

OBJECTIVE:
Evaluate the accuracy of TLS for stand structure characterization

9 plots in two forests: Valsaín and Navafría

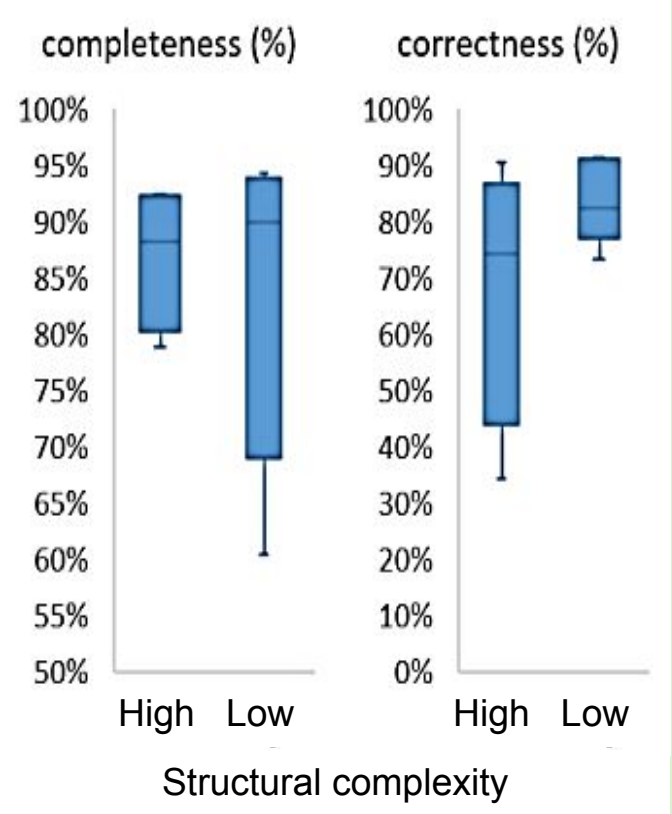
Different forest management approaches
&
Different stages of development

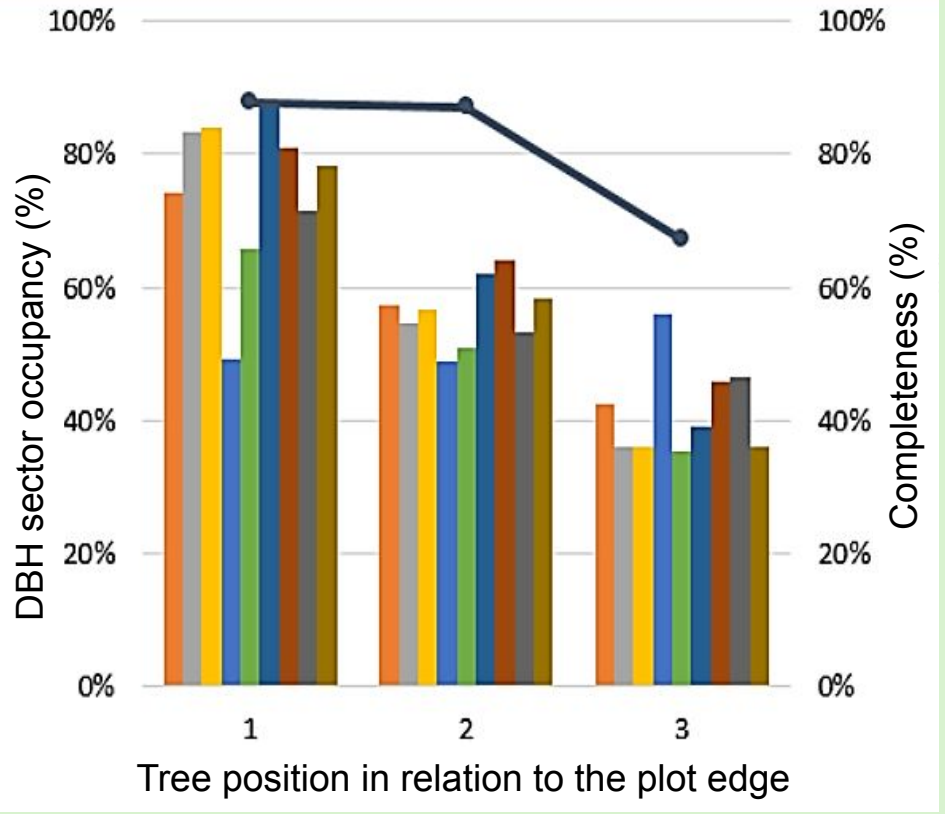
Structural complexity:

High & Low

DETECTION

❖Mean detection: 84,78%





completeness (%) = $(n_{mat}/n_{ref})*100$

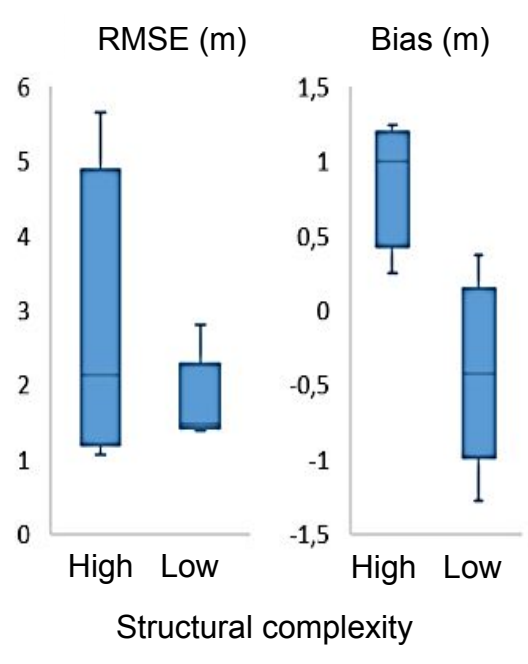
correctness (%) = $(n_{mat}/n_{det})*100$

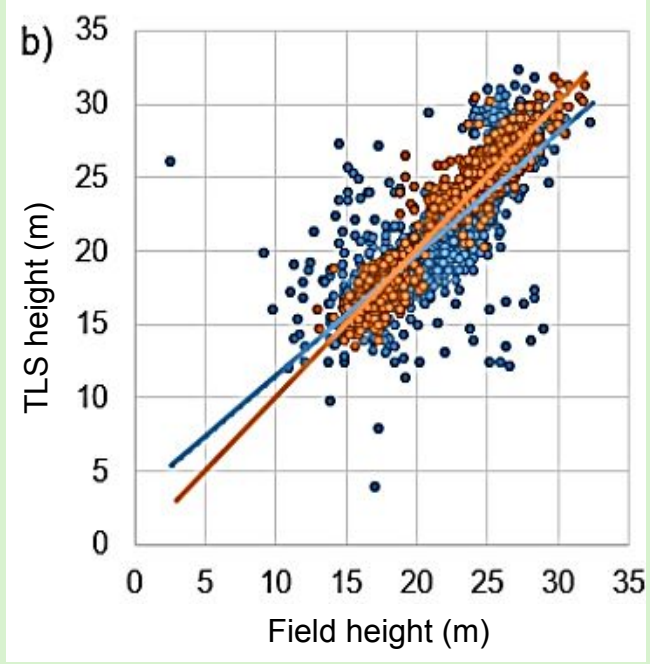
1. Between scans
2. 0 - 7,5 m band to the edge
3. 7,5 - 12 m band to the edge

RESULTS

Height

R^2 : 0.91 Valsaín y 0.58 Navafría

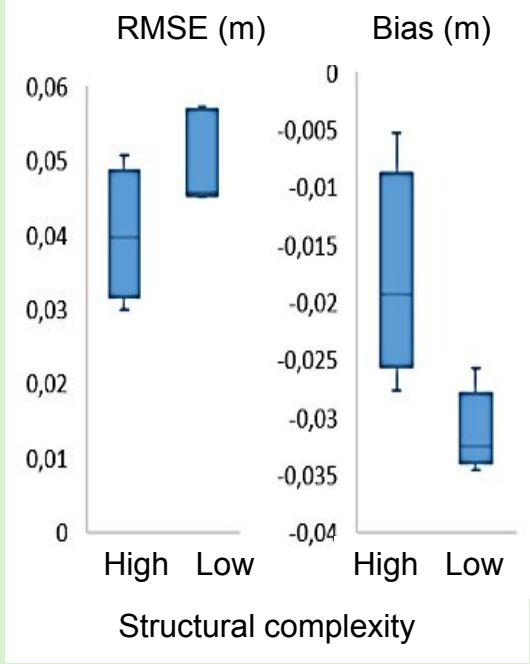


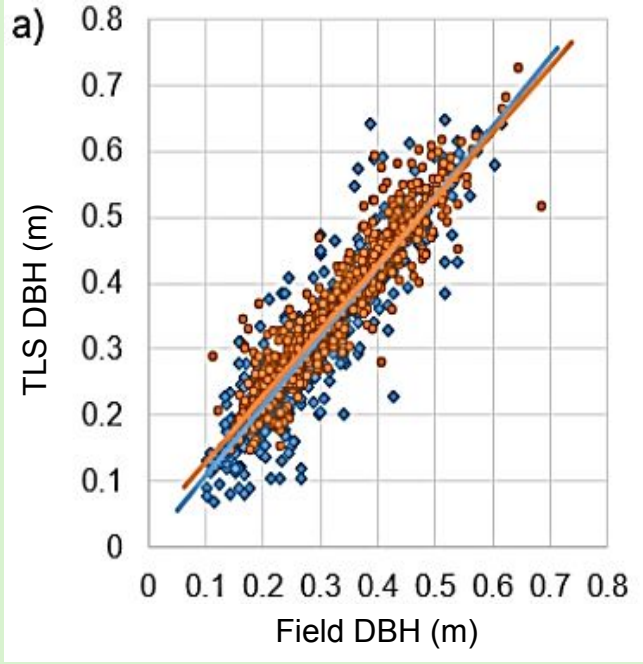


❖ Accuracy < 10% RMSE

DBH

R^2 : 0.9 Valsaín y 0.88 Navafría





❖ Accuracy ≈ 15% RMSE

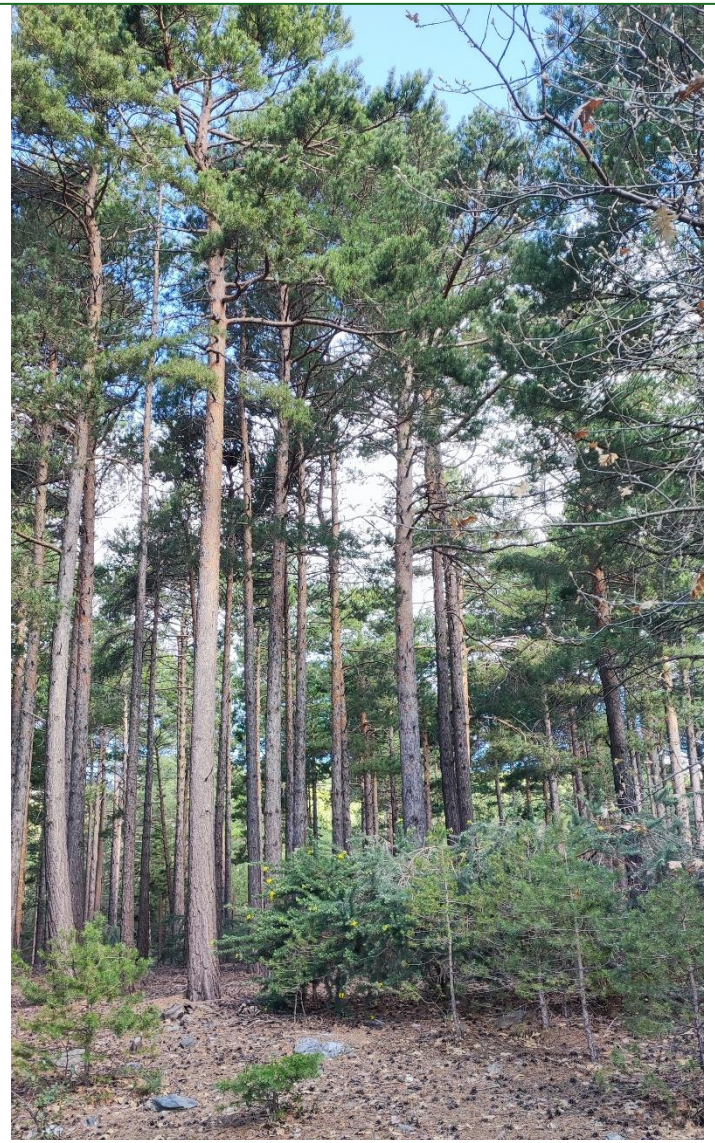
Reforested *Pinus sylvestris* forest managed for benefit biodiversity

SAN JERÓNIMO

Quercus pyrenaica


Picos de Europa
Aigüestortes and Sant Maurici Lake
Atlantic islands
Ordesa y Monte Perdido
Guadarrama mountains
Cabañeros
Sierra de las Nieves
Sierra Nevada

PUENTE PALO



GEOSTAT

MATLAB®

Ecology spatial pattern analysis

OBJECTIVE

Management effect on the forest

+

Wildfire risk

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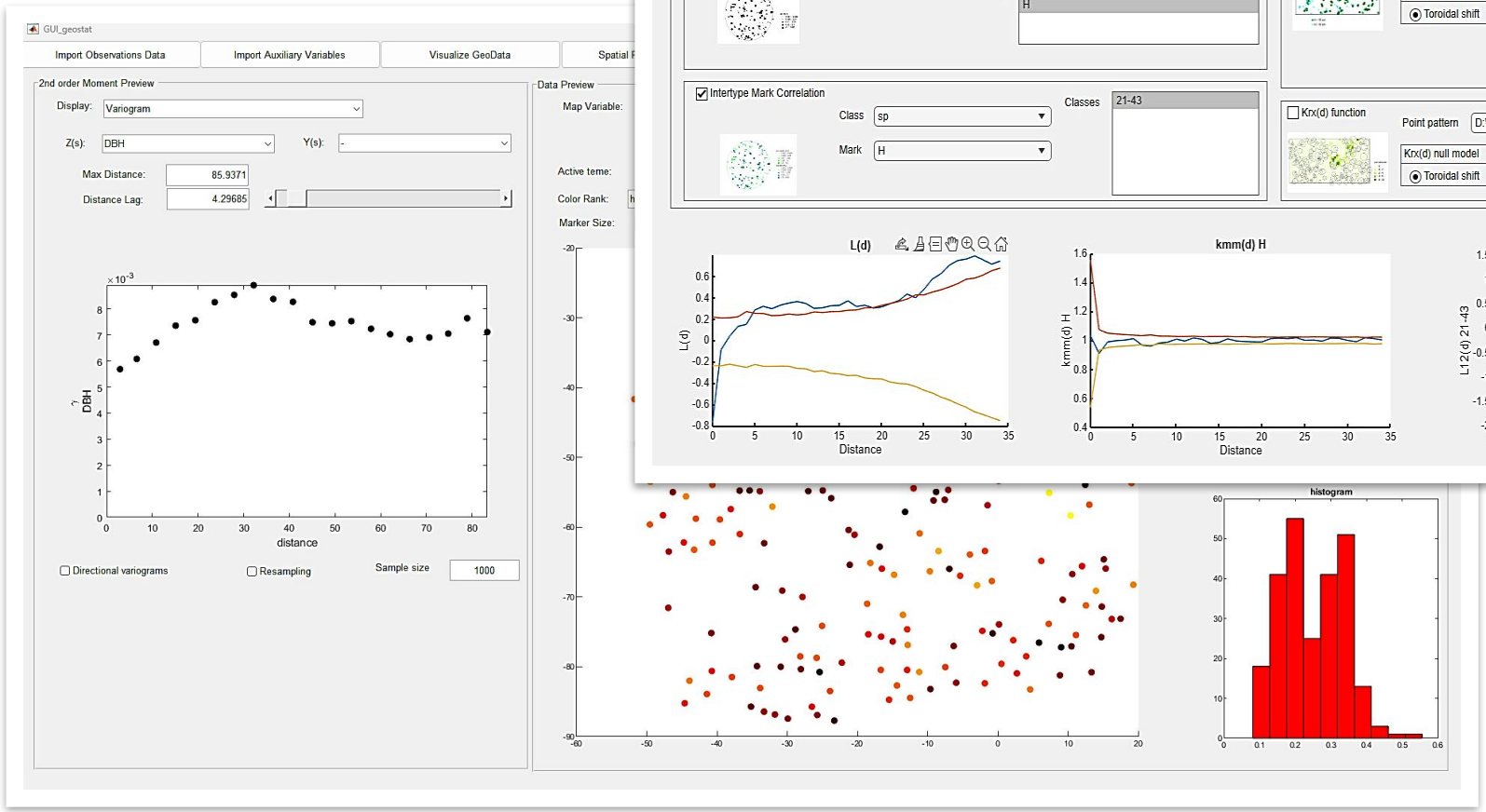

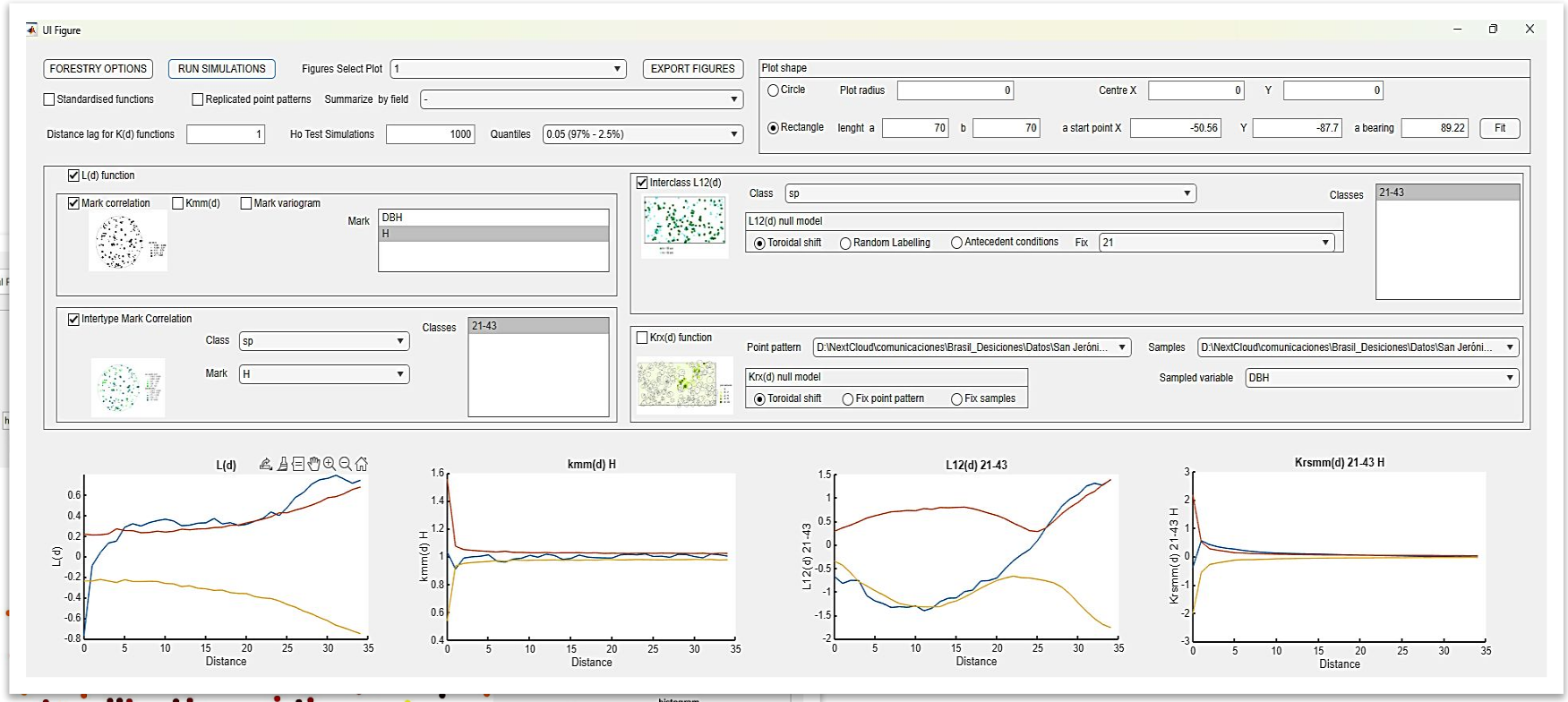

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Ecology spatial pattern analysis

OBJECTIVE

Management effect on the forest

+

Wildfire risk

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Spatial pattern functions	Measurement	Interpretation
L(d)	Spatial distribution of the trees	< 0 □ uniform distribution > 0 □ aggregated distribution
Intertclass L12 (d)	Spatial distribution and interaction of the class: species	< 0 □ species repulsion > 0 □ species attraction
Mark Correlation kmm (d)	Correlation between spatial distribution and the tree mark: DBH and height	< 1 □ + correlation □ similar values > 1 □ - correlation □ different values
Intertype Mark Correlation krsmm (d)	Correlation between spatial distribution of the species and the tree mark	< 0 □ + correlation □ similar values x sp. > 0 □ - correlation □ different values x sp.

GEOSTAT

MATLAB

Ecology spatial pattern analysis

OBJECTIVE

Management effect on the forest + Wildfire risk

DecisionES 2025 Porto Seguro Jun 30th to Jul 4th BR

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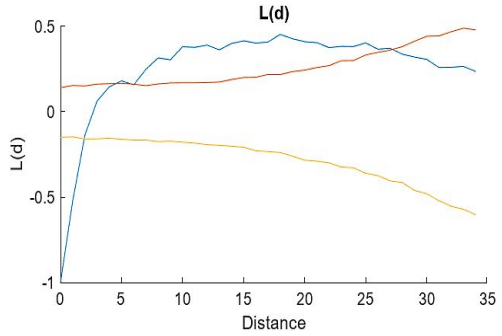
Statistical significance → Montecarlo's Test



97.5% quantil

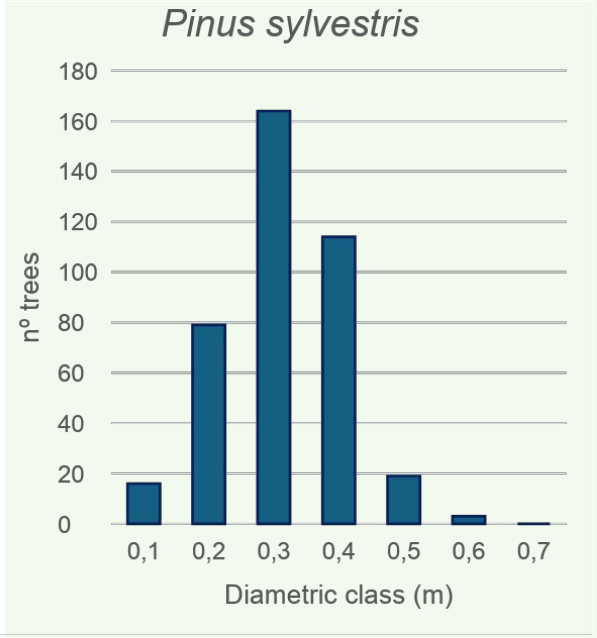
Function

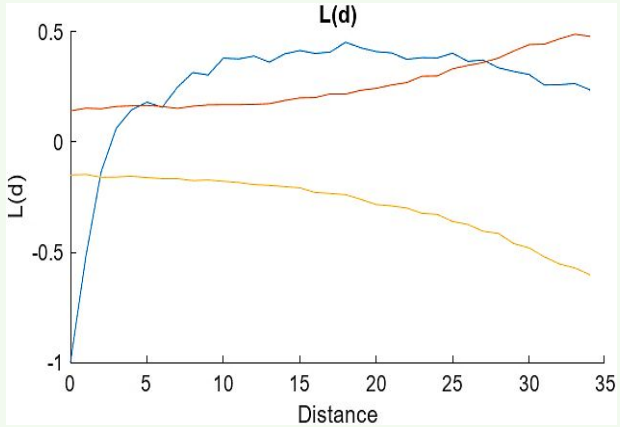
2.5% quantil

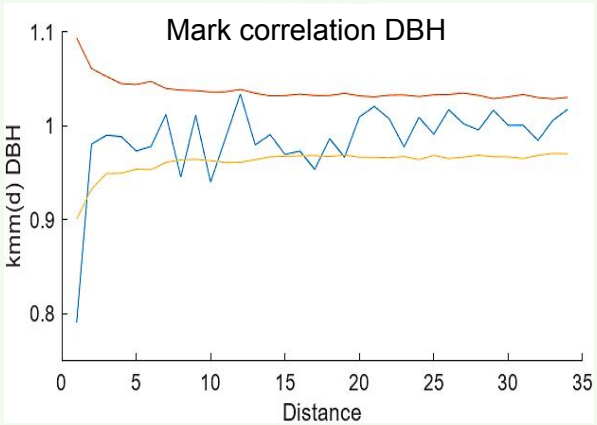
RESULTS

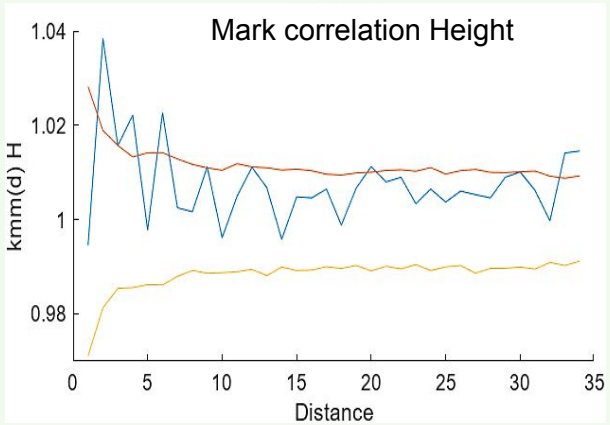
PUENTE PALO

unmanaged

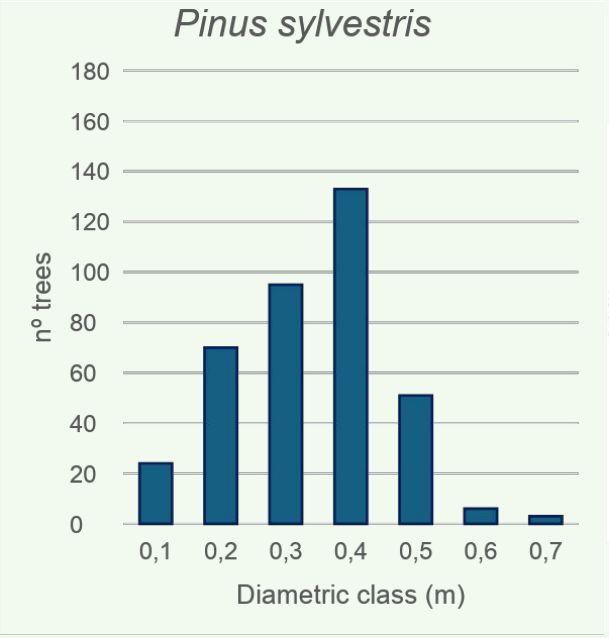


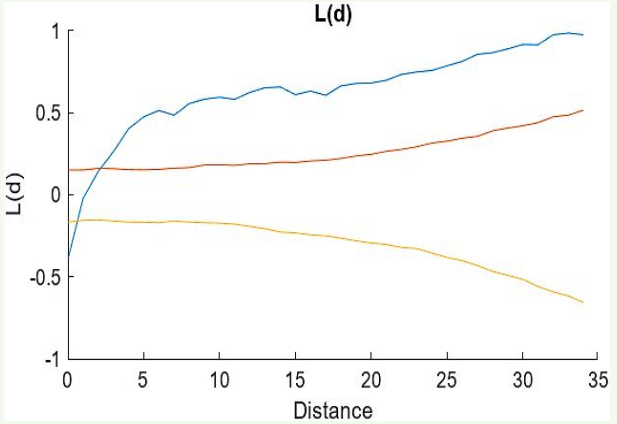


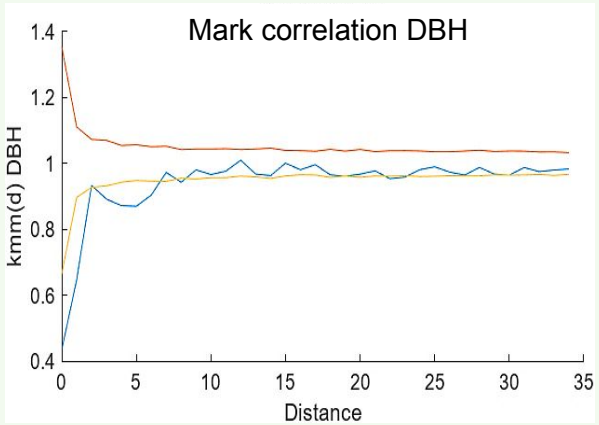


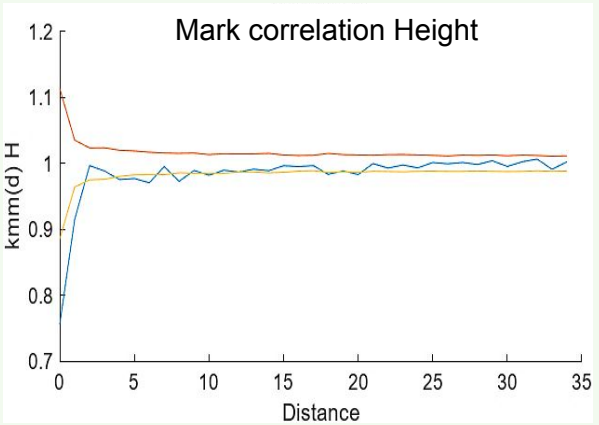


managed



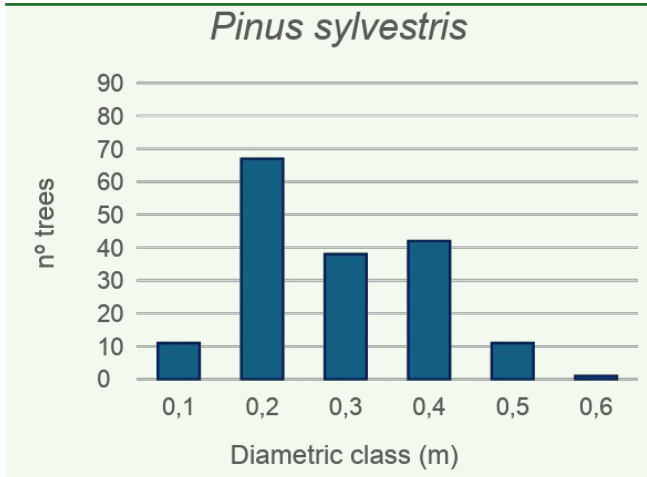


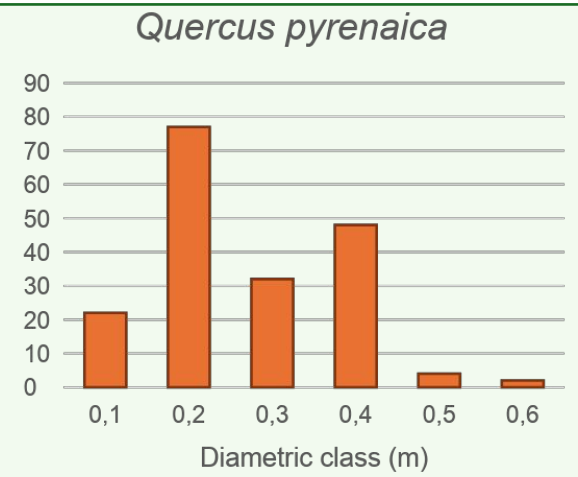


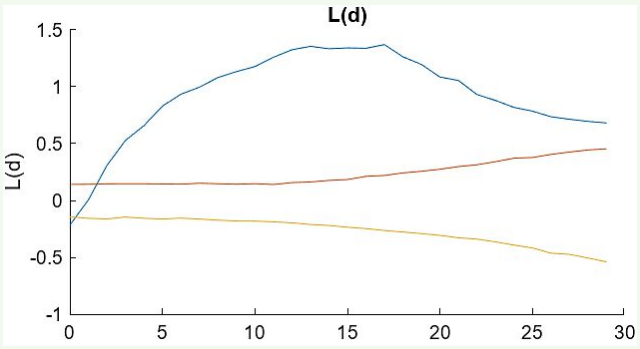


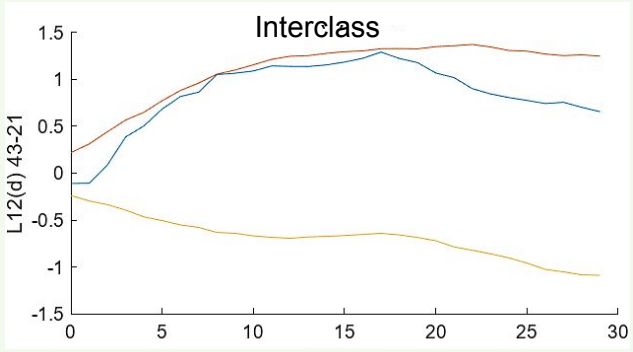
SAN JERÓNIMO

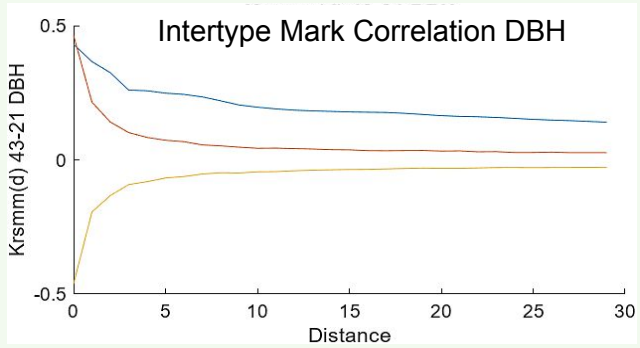
unmanaged

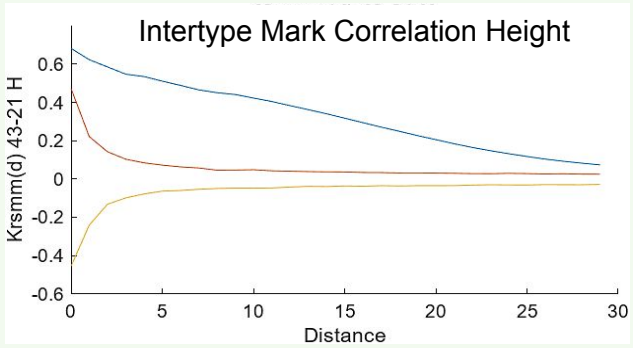




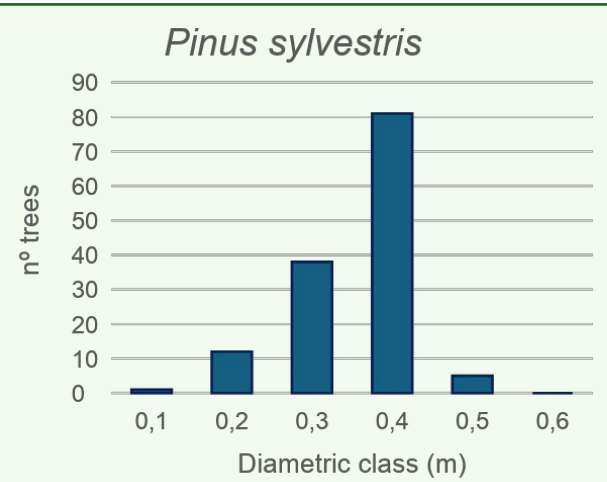


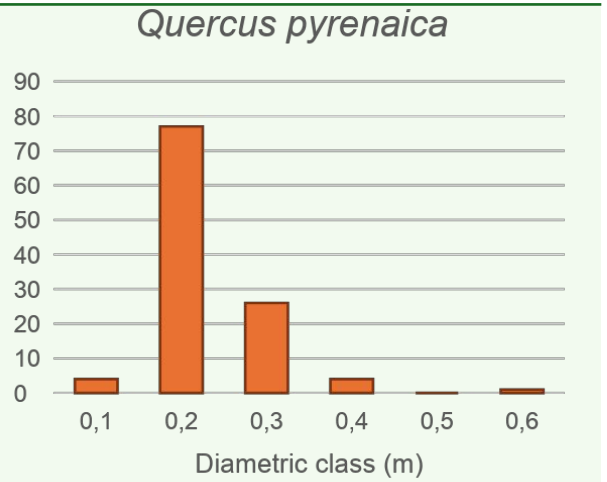


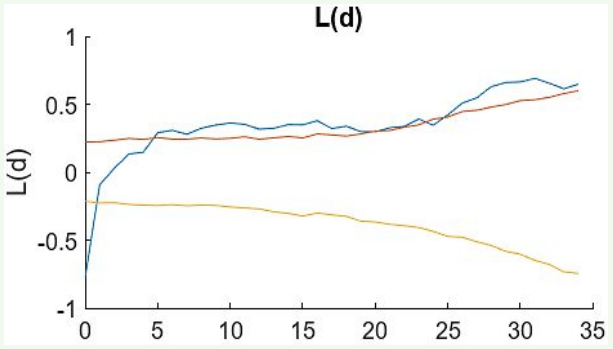


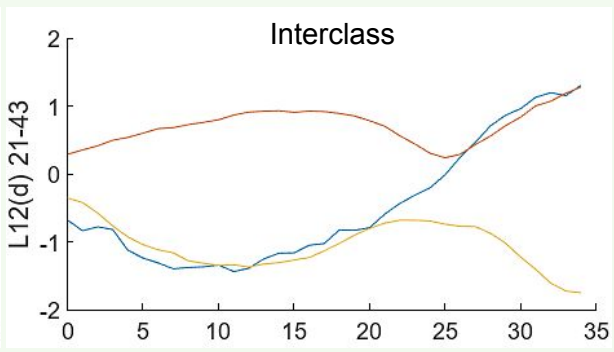


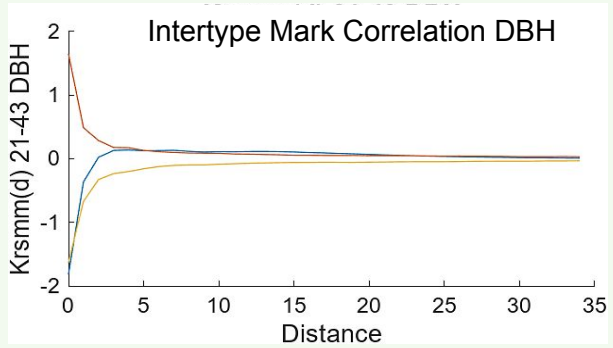
managed

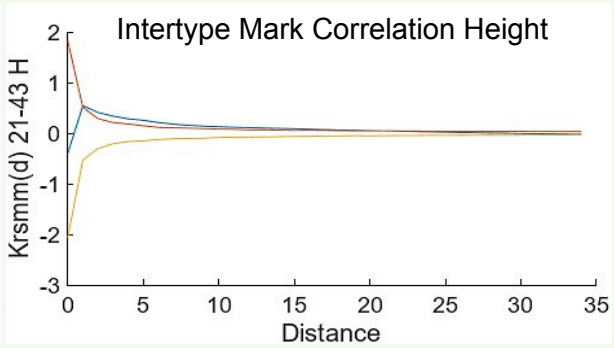




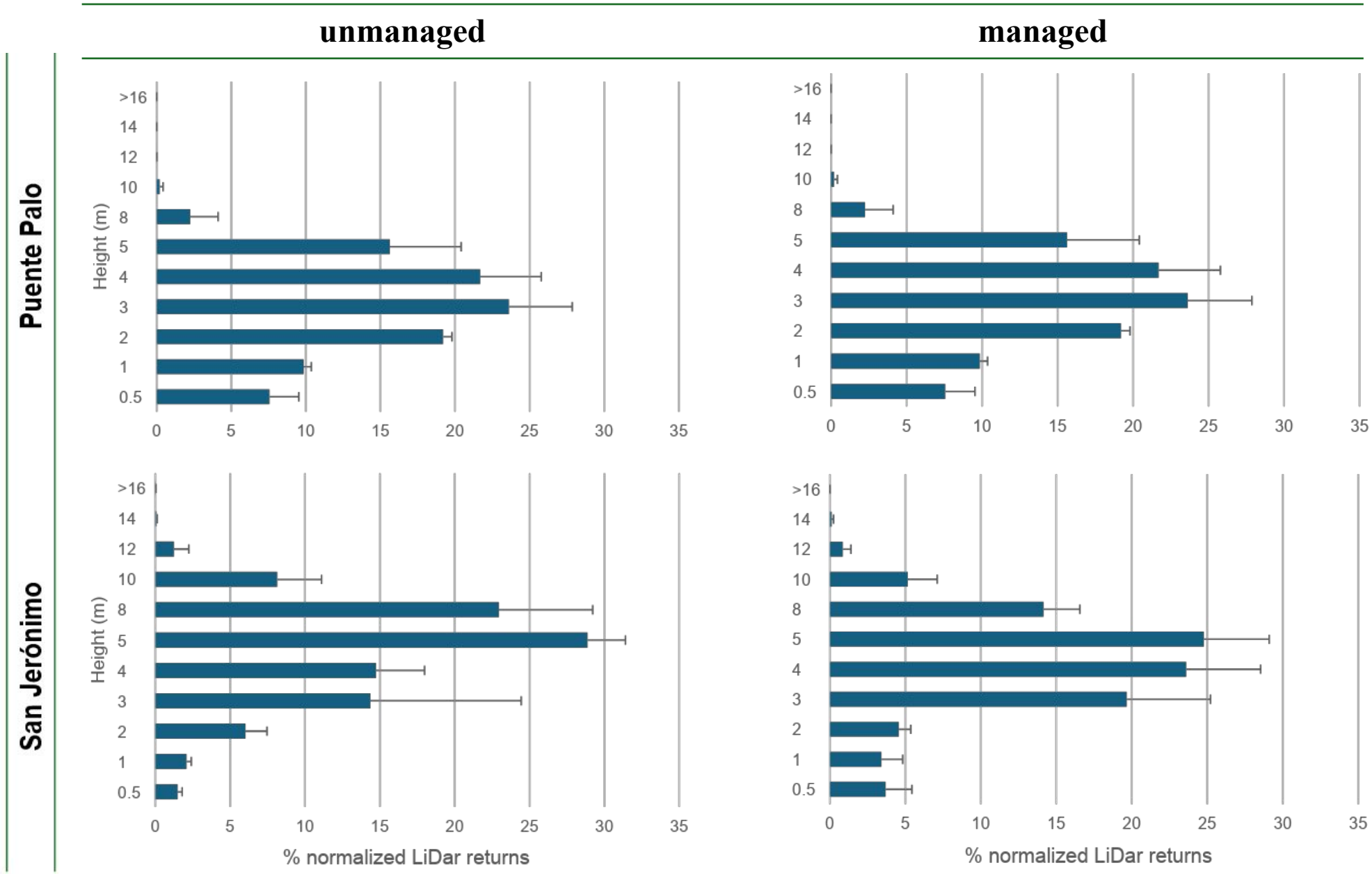








Vertical structure profile



CONCLUSION

- TLS provides accurate information of forest structure, independently of the stand structure complexity and without scanning outside the plots
- The spatial pattern analysis shows the effect of the management on the forest: actually, it does not seem to benefit the *Quercus pyrenaica* trees.
- Trade off between close to nature management could and wildfire risk
- This results highlighting the benefits of this technology compared to field forest monitoring, but in need to be improved.
- The importance of open software as 3DFin and Geostat for implementing LiDAR technology at large scale.

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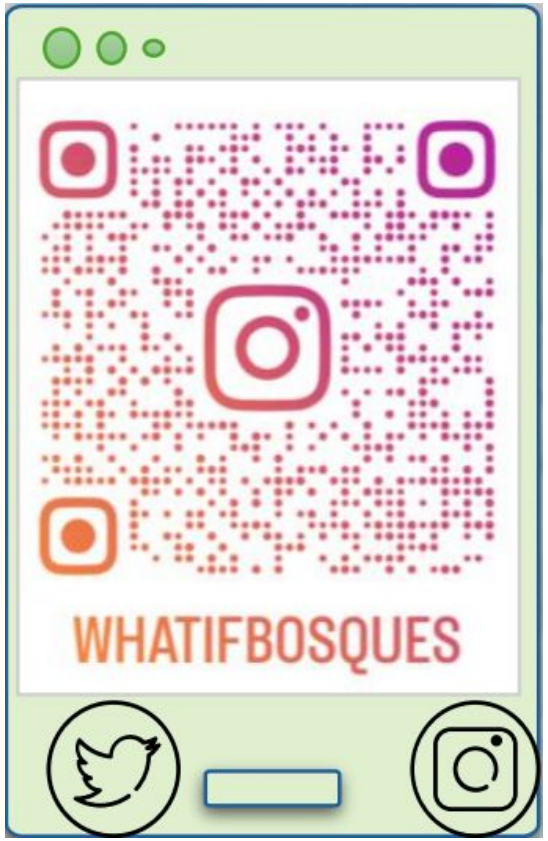

WHAT IF

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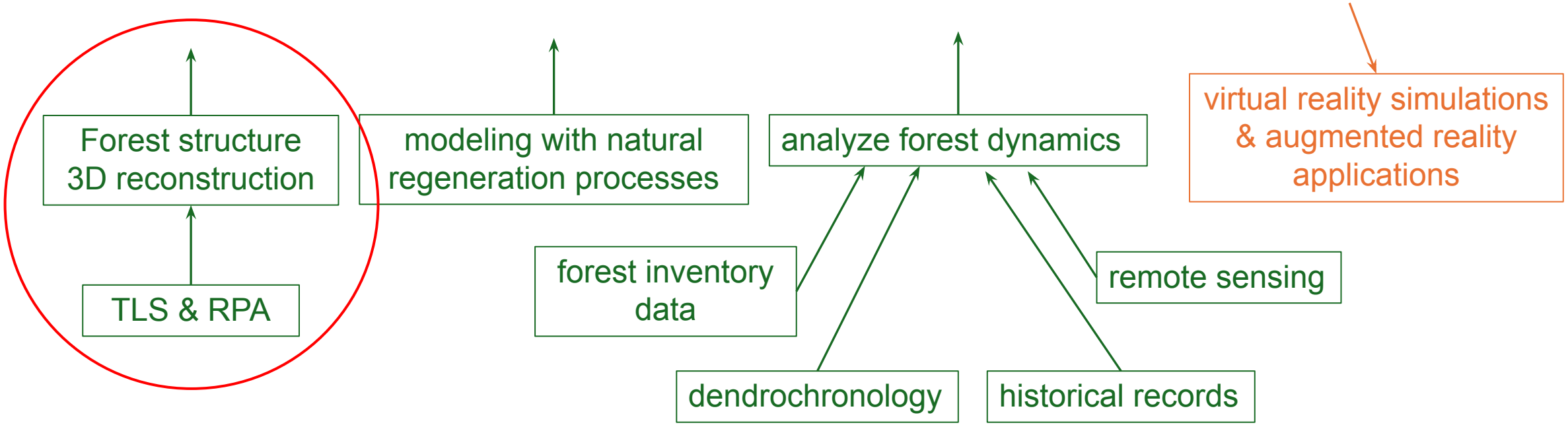
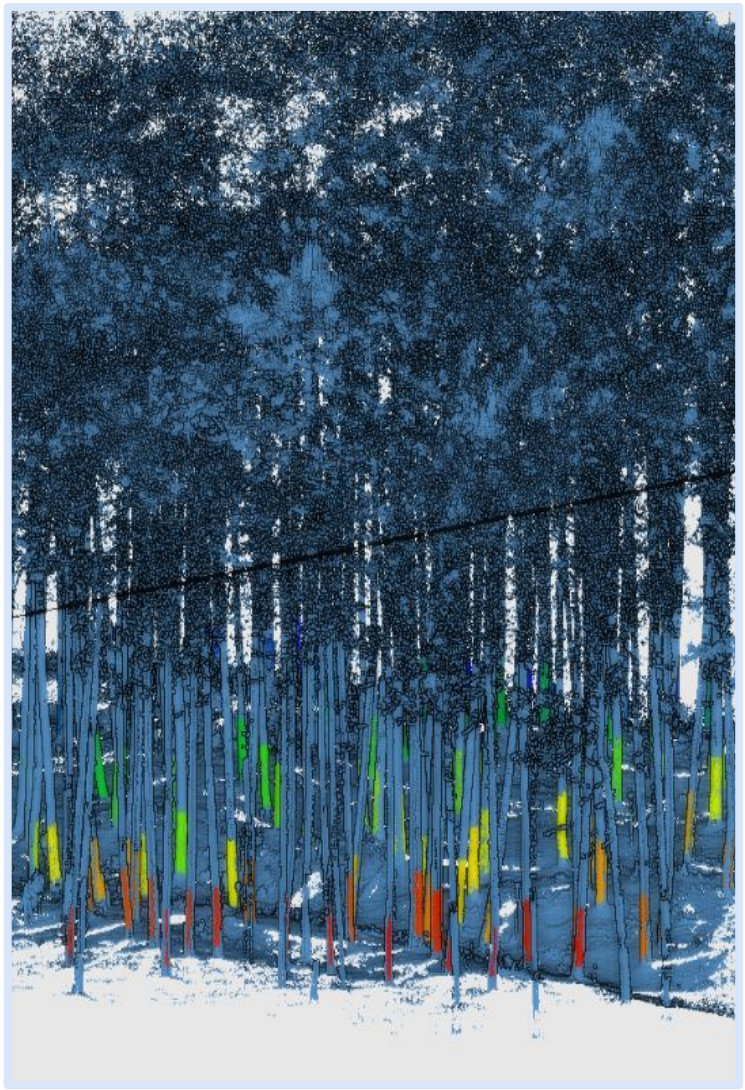
VICEPRESIDENCIA TERCERA DEL GOBIERNO
MINISTERIO PARA LA TRANSICIÓN ECOLÓGICA Y EL RETO DEMOGRÁFICO
Fundación Biodiversidad
Plan de Recuperación, Transformación y Resiliencia
Financiado por la Unión Europea NextGenerationEU
CSIC Consejo Superior de Investigaciones Científicas
INIA Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria
ICIFOR Instituto de Ciencias Forestales

Forest management pathways and their effect on forest vulnerability and resilience to global change

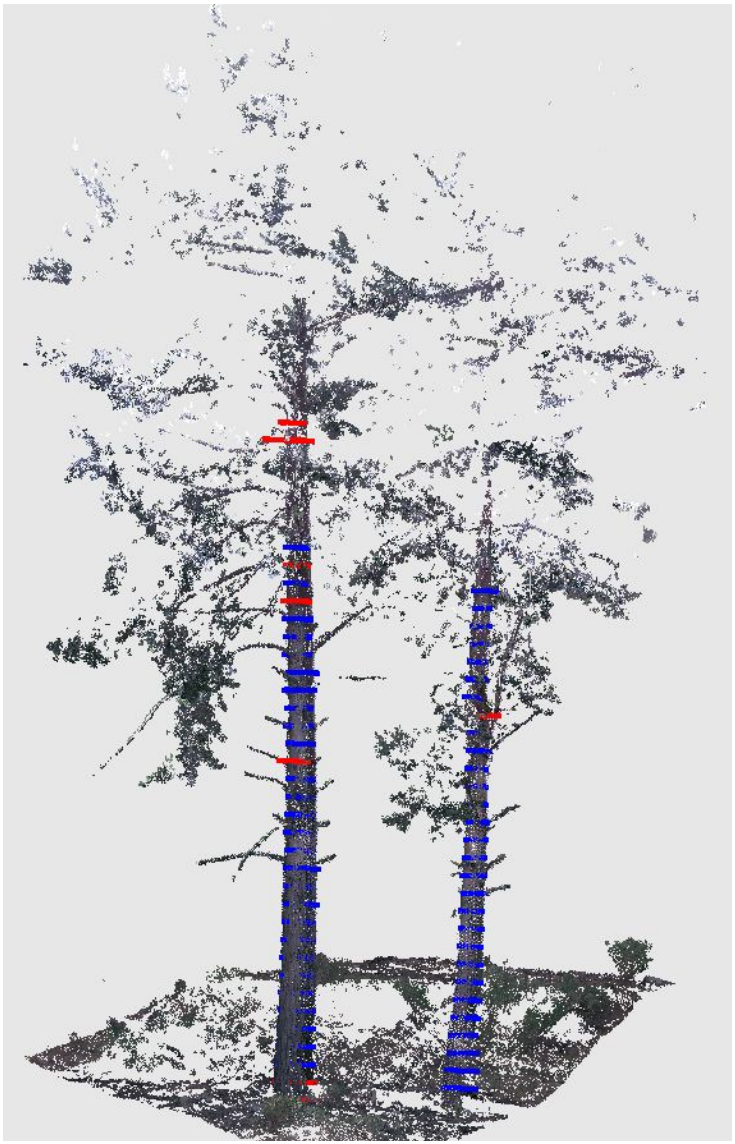
Objective: To project forest evolution and its response to global change under different forest management alternatives, addressing processes such as species decline or expansion, structural shifts affecting biodiversity, and increased fire risk.



3DFin outputs

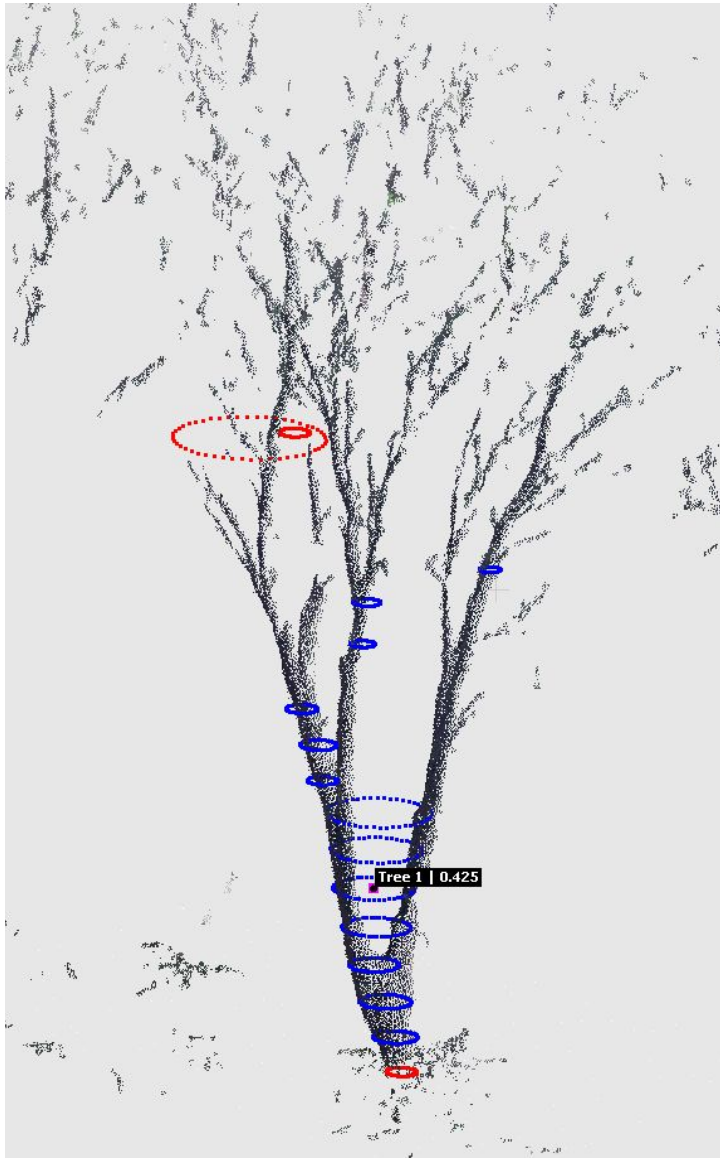


Stem’s stripe for identification



Overall quality of computed sections

Point distance to tree axis



Low bifurcated trees

Low ground representation

RESULTS: Spatial pattern analysis

SPATIAL & STRUCTURAL INDEX	SAN JERÓNIMO		PUENTE PALO		Function equivalence
	unmanaged	managed	unmanaged	managed	
Clark & Evans aggregation index (Z test)	1.129 (4.106)	1.087 (2.418)	1.192 (6.671)	1.136 (4.639)	
DBH Shannon diversity index	1.953	1.865	2.024	2.214	
H Shannon diversity index	0.693	0.751	0.686	0.771	
DBH Differentiation index (qntl 2.5% - qntl 97.5%)	0.314 (0.366-0.405)	0.250 (0.296-0.335)	0.272 (0.314-0.346)	0.288 (0.349-0.38	
H Differentiation index (qntl 2.5% - qntl 97.5%)	0.116 (0.157-0.175)	0.165 (0.173-0.195)	0.066 (0.111-0.124)	0.075 (0.132-0.14	
Mingling index	0.461	0.268	-	-	

Uniform distribution

Equilibrate DBH class distribution

Predominant of some height class

Low local differentiation of DBH and height

Higher mingling in unmanaged plot