

Supplementary Material

1 ALS data characteristics for each study area

Study area	ALS acquisition period	Mean point density (pts m ⁻²)	Spatial coverage
Avio	2014–2018	~19	Full area
Dro	2014–2018	~18	Full area
Ledro	2014–2018	~30	Full area
Rumo	2014–2018	~13	Full area
Vermiglio	2014–2018	~11	Full area

Table 1: Summary of ALS data characteristics for the five study areas.

2 Spatial Autocorrelation Analysis of Plot Selection: Moran's I

Table 2 presents the results of the Moran's I test for each study area.

Study Area	Moran's I	p-value	Interpretation
Rumo	-0.0051	0.5582	No spatial autocorrelation
Avio	-0.0336	0.9606	No spatial autocorrelation
Dro	-0.0263	0.9112	No spatial autocorrelation
Ledro	0.0172	0.1326	No spatial autocorrelation
Vermiglio	0.0067	0.3016	No spatial autocorrelation

Table 2: Results of Moran's I test for spatial autocorrelation across study areas. None of the areas exhibit significant spatial autocorrelation (all p-values > 0.05), suggesting spatial randomness in the distribution of the plots.

3 Breusch-Pagan

Table 3 presents the results of the Breusch-Pagan test for each study area.

Study Area	Mean CHM	Max CHM	Min CHM	Number of Trees	Canopy Cover
Rumo	1.324e-06	0.7285	0.927	<2.2e-16	0.1155
Avio	1.698e-07	0.001821	0.8539	0.1532	0.09684
Ledro	0.3909	0.05170	0.8307	1.964e-09	5.746e-10
Dro	0.002526	0.05013	0.6699	6.2e-11	4.756e-16
Vermiglio	6.604e-06	0.7261	0.8905	0.070104	0.4388

Table 3: Breusch-Pagan test results (p-values) for heteroscedasticity across study areas and models. Significant p-values (<0.05) indicating heteroscedasticity are in **bold**.

4 Tree count and crown size estimate analysis

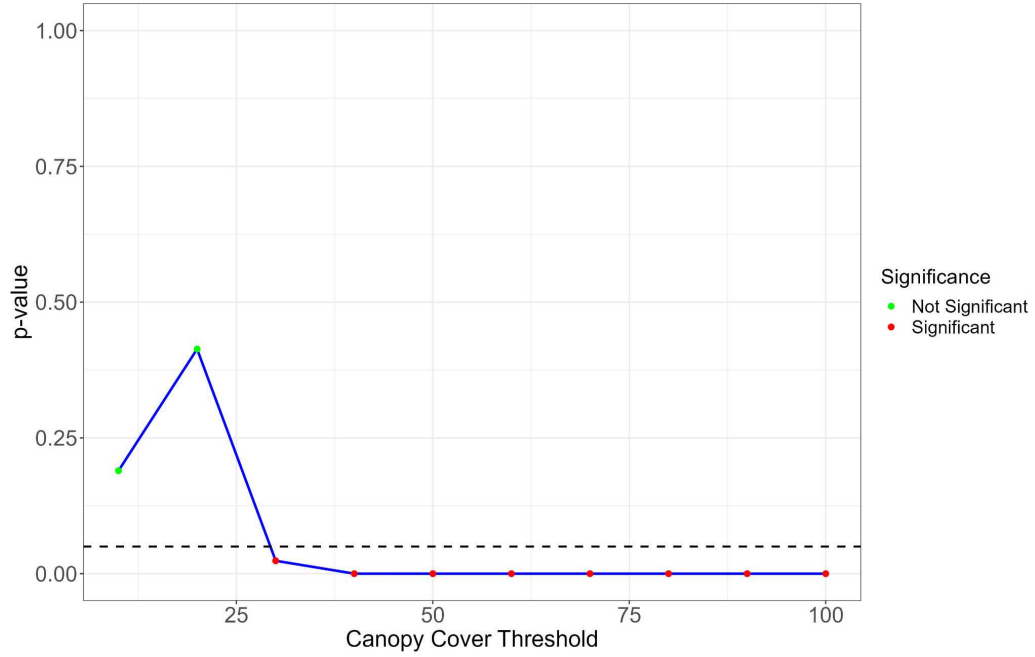


Figure 1S: p-values from t-tests comparing tree count estimates between ALS and Meta/WRI CHM datasets across all study areas together. The figure shows that for all the canopy cover threshold (except a canopy cover of 10% and 20%), the difference in number of trees identified by the ALS CHM and Meta/WRI CHM is significantly different.

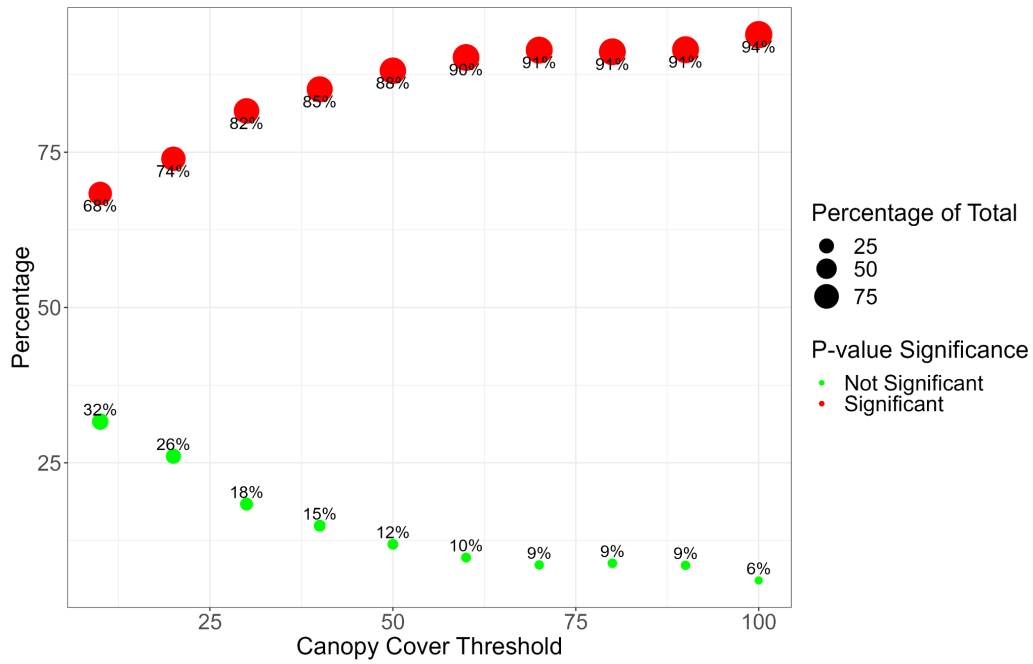


Figure 2S: Comparison of crown size estimates between ALS and Meta/WRI CHM datasets across all study areas together under varying canopy cover thresholds. The y-axis shows the percentage of p-values, and the size of the points reflects the percentage of tests where crown size estimates were either significantly different (red) or not significantly different (green) between ALS and Meta/WRI.

5 Analysis of relative RMSE across topographic gradients

2*Gradient	2*Bin	Canopy cover		Mean CHM		Max CHM		Tree count	
		RMSE (%)	rRMSE (%)	RMSE (m)	rRMSE (%)	RMSE (m)	rRMSE (%)	RMSE (n)	rRMSE (%)
Slope	10–20°	9.0	19.9	2.8	39.8	10.0	38.8	332.7	217.1
	20–30°	8.6	12.2	3.0	25.5	8.7	29.8	427.5	200.6
	30–40°	11.8	15.2	2.8	23.7	9.0	29.8	578.5	221.0
	40–50°	14.0	18.5	3.2	32.9	13.3	43.6	811.6	252.9
Aspect	0–90°	11.4	16.2	3.2	28.0	9.7	32.7	606.6	249.0
	90–180°	14.2	20.6	3.3	32.5	12.6	41.4	669.1	257.7
	180–270°	10.1	14.1	2.8	25.4	10.0	33.5	542.3	221.2
	270–360°	8.9	11.1	2.8	22.7	7.3	26.0	523.9	203.0
Altitude	200–600 m	21.2	31.2	3.2	45.7	11.9	48.9	884.8	204.4
	600–1000 m	10.2	11.5	3.5	26.6	10.8	36.4	830.9	259.4
	1000–1400 m	8.8	11.0	3.2	24.2	11.7	36.0	651.7	281.4
	1400–1800 m	12.0	17.8	2.8	26.7	9.8	31.7	369.6	166.9
	1800–2200 m	14.1	27.3	2.5	35.3	7.9	32.0	307.2	129.4
	2200–2600 m	9.6	52.0	1.2	67.8	8.4	51.2	106.0	83.1

Table 4: Absolute and relative RMSE of Meta/WRI CHM-derived forest structural metrics against ALS-derived reference metrics across topographic bins. Absolute RMSE is reported in the original unit of each metric; relative RMSE (rRMSE) was calculated as RMSE divided by the mean ALS-derived reference value within each bin and expressed as a percentage.