

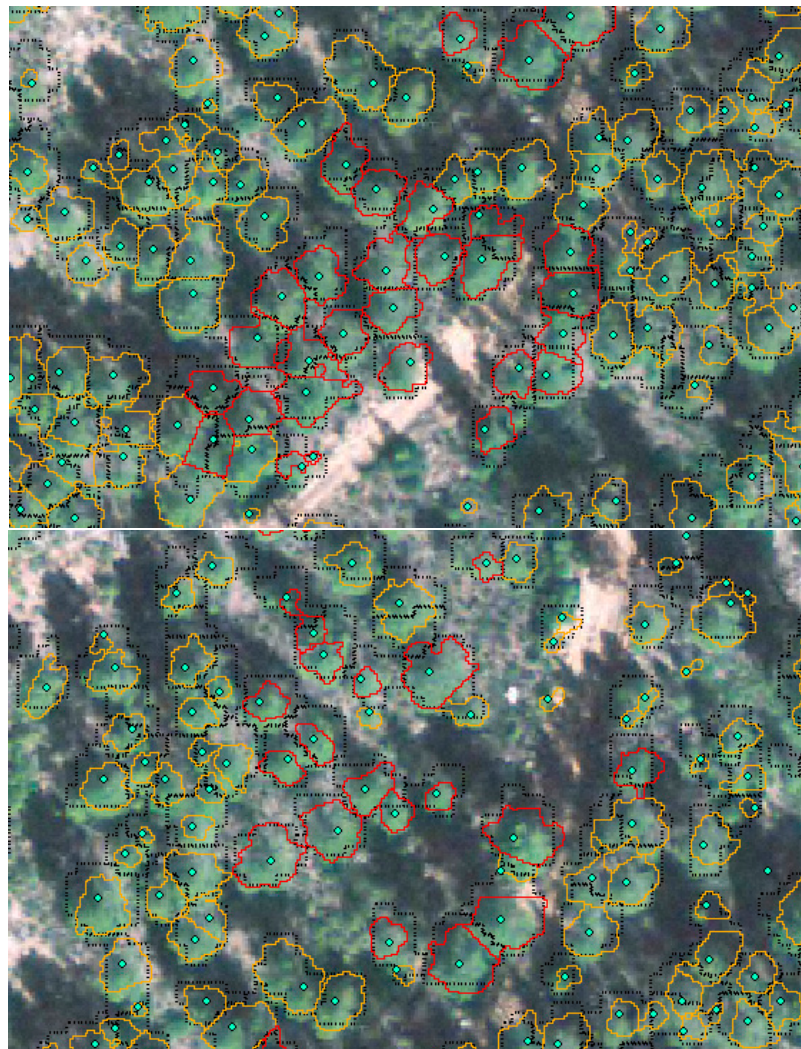
Postfire tree structure from high-resolution LiDAR and RBR Sentinel 2A fire severity metrics in a *Pinus halepensis*- dominated burned stand

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SUPPLEMENTARY MATERIAL

Figure S1. Snapshots of tree delineation validation in the field. In red, tree crowns measured both in the field and by post-fire high-density Lidar data (accuracy of 100 %); in orange, post-fire tree crowns measured by LiDAR but not validated in the field; and blue dots, the tree tops. For comparison it is shown in dotted black the tree crowns delineated by low-density pre-fire LiDAR data (Viedma et al. 2020). The background image corresponds to a pre-fire orthoimage (from 2016) downloaded from the Spanish Geographic Institute (SGI) (<http://centrodedescargas.cnig.es/CentroDescargas/index.jsp>).



0 0.01 0.02 0.04 0.06 0.08 Kilometers

Figure S2. Scatterplots relating tree top height (a) and crown area (b) derived from LiDAR data with diameter at breast height (DBH) of individual trees measured at ground-field.

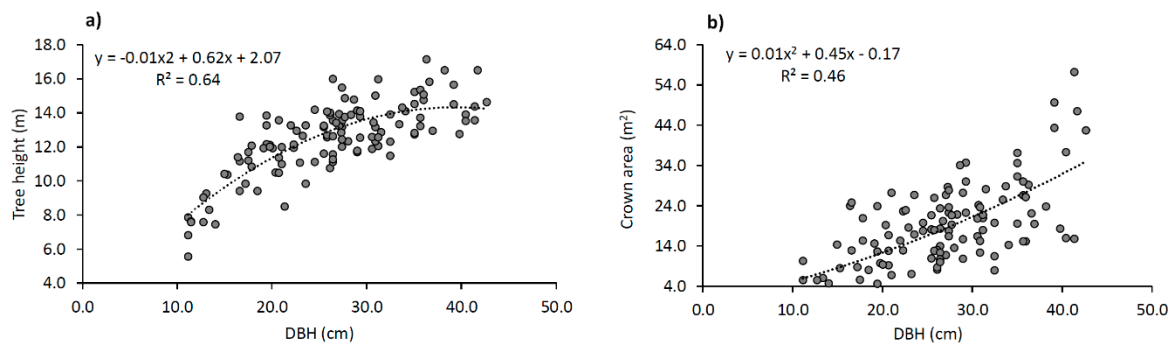
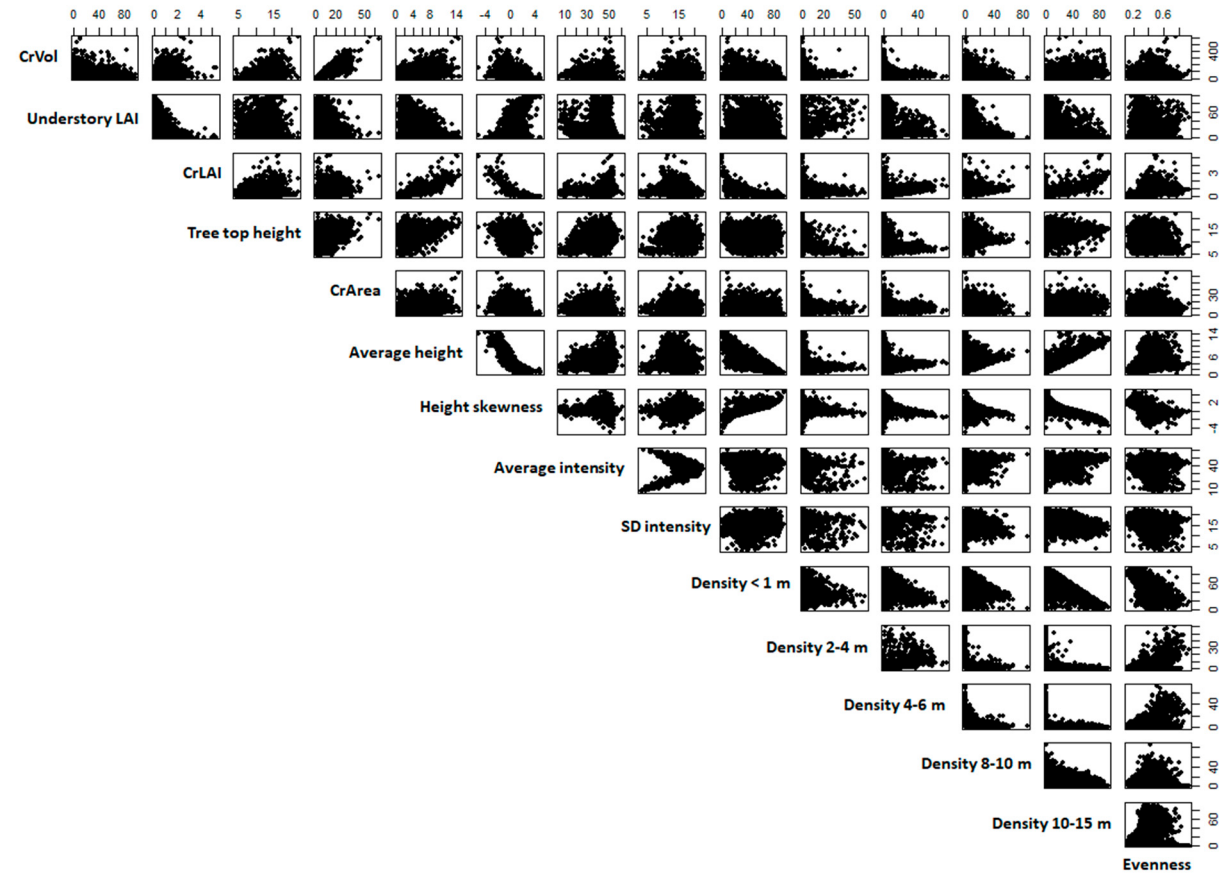


Figure S3. Scatterplots relating pairs of variables included in the Principal Component Analysis (PCA) and correlation matrix of the same set of variables.



	CrVol	underst	CrLAI	Tree.to	CrArea	Hmean	Hske	Int_avg	Int_std	d_1t1m	d2-4m	d4-6m	d8-10m	d10-15m	Evenness
CrVol	1.00														
understory_LAI	-0.18	1.00													
CrLAI	0.24	-0.17	1.00												
Tree top height	0.49	-0.44	-0.10	1.00											
CrArea	0.89	0.01	0.33	0.12	1.00										
Hmean	0.51	-0.39	0.60	0.51	0.35	1.00									
Hske	-0.19	0.07	-0.81	0.24	-0.34	-0.61	1.00								
Int_avg	0.10	-0.17	-0.05	0.32	-0.12	0.12	0.20	1.00							
Int_std	0.18	-0.08	-0.14	0.19	0.14	-0.04	0.19	0.02	1.00						
d_1t1m	-0.18	-0.30	-0.77	0.34	-0.38	-0.47	0.86	0.21	0.18	1.00					
d2-4m	-0.22	0.62	0.11	-0.69	0.08	-0.32	-0.35	-0.36	-0.16	-0.49	1.00				
d4-6m	-0.19	0.12	0.45	-0.56	0.04	-0.21	-0.35	-0.24	-0.09	-0.44	0.28	1.00			
d8-10m	0.18	-0.32	0.10	0.22	0.12	0.27	-0.09	0.13	0.01	0.10	-0.34	-0.34	1.00		
d10-15m	0.41	-0.38	0.24	0.62	0.20	0.82	-0.29	0.18	0.01	-0.13	-0.41	-0.45	0.09	1.00	
Evenness	0.05	0.35	0.47	-0.46	0.28	0.15	-0.57	-0.22	-0.14	-0.74	0.47	0.51	-0.09	-0.14	1.00

Table S1. Scores given by the v test derived from the PCA classification of individual trees and descriptive statistics. Here we show the most important variables (v test value > 10).

<i>V test</i>	C1	C2	C3	median	min	max
Tree top height	21.2	30.7		11.69	4.04	22.12
Crown area		25.7		11.25	0.81	64.69
Crown LAI		29.2	17.9	0.71	0.02	5.41
Relative understory LAI			33.7	11.23	0.00	98.56
Crown volume		37.72		52.24	1.10	242.72
Average height (all points)		55.7		4.02	0.49	15.48
Height skewness (all points)	51.6			-0.09	-5.08	4.92
Average intensity (all points)	15.8			40.00	6.00	61.00
SD intensity (all points)	13.3			16.38	3.16	24.60
Density < 1 m	56.3			35.10	0.00	96.10
Density 2 - 4 m			50.5	0.90	0.00	96.40
Density 4 - 6 m			51.2	1.80	0.00	90.10
Density 8 - 10 m		29.0		4.50	0.00	85.10
Density 10 - 15 m		48.6		7.90	0.00	93.40
Evenness			45.3	0.48	0.12	0.94

Table S2. Mean values of the most significant variables used to classify individual trees (C1-C3). Number in each entry shows the mean LiDAR metric value followed by letters indicating statistically distinguishable structural classes (Kruskal-Wallis $p < 0.05$).

	C1	C2	C3
Tree top height	12.4 a	13.5 b	6.8 c
Crown area	8.1 a	17.1 b	13.2 c
Crown LAI	0.3 a	1.3 b	1.1 c
Relative understory LAI	17.5 a	9.5 b	40.9 c
Crown volume	44.8 a	116.7 b	62.6 c
<i>Average tree height</i>	3.3 a	7.8 b	3.3 a
Height skewness	1.1 a	-0.8 b	-0.6 c
Average intensity	40.9 a	39.8 a	32.2 b
Standard deviation intensity	16.6 a	15.6 b	15.1 c
Density < 1m	62.8 a	25.5 b	18.7 c
Density 1 - 2 m	5.6 a	2.5 a	6.8 b
Density 2 - 4 m	1.1 a	1.4 b	35.7 c
Density 4 - 6 m	2.0 a	2.5 b	30.3 c
Density 8 - 10 m	8.9 a	15.7 b	0.9 c
Density 10 - 15 m	13.7 a	42.1 b	0.1 c
Evenness	0.3 a	0.5 b	0.7 c
RBR (Sentinel 2A)	0.4 a	0.3 b	0.2 c

Figure S4. Normalized height point clouds of individual trees classified by using LiDAR derived metrics (C1-C3) and stratified by RBR Sentinel 2 fire severity levels. UB: unburned; LS: low severity; MS: moderate severity and HS: high severity.

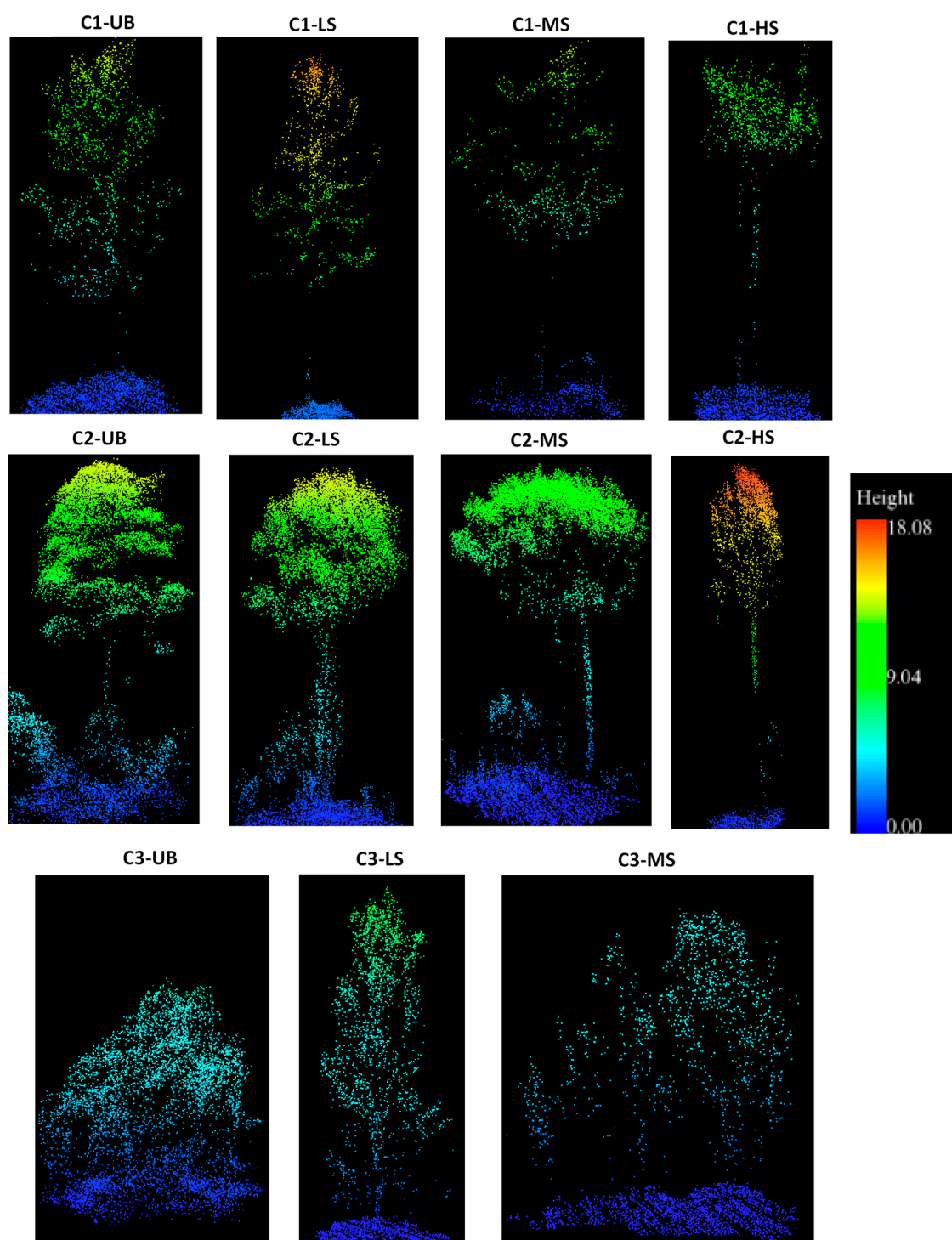


Table S3. Mean values of the most significant variables used to classify individual trees (C1-C3) grouped within each RBR fire severity levels to assess differences among tree groups (inter-cluster variability). Number in each entry shows the mean LiDAR metric value followed by letters indicating statistically distinguishable structural classes (Kruskal-Wallis $p < 0.05$).

RBR fire severity levels	Unburned			Low severity			Moderate severity			High severity	
Lidar metrics from VCPs	C1_UB	C2_UB	C3_UB	C1_LS	C2_LS	C3_LS	C1_MS	C2_MS	C3_MS	C1_HS	C2_HS
Tree top height	10.8 a	13.2 b	6.7 c	11.3 a	13.4 bd	7.1 c	12.4 e	14 d	6.4 c	13.1 b	14.4 d
Crown area	9.2 abc	21.5 d	13.9 e	8.4 a	15.3 e	10.2 b	8.7 a	12.2 b	5.8 ac	7.1 c	7.8 ac
Crown LAI	0.5 a	1.5 b	1.2 cd	0.4 a	1.2 c	0.8 e	0.3 f	0.9 de	0.4 afg	0.2 g	1 cde
Relative understory LAI	20.9 ab	12.4 ac	43.3 d	14.1 ce	8.3 f	30.1 b	15.5 ef	5.7 g	33.7 bd	21.6 ac	4.5 g
Crown volume	53.2 abc	149.1 d	65 a	46.1 bc	102.9 e	52.5 a	47.6 b	79.7 ae	34 abce	40 c	59.8 abc
Average tree height	3.5 abc	7.7 d	3.3 a	3.9 b	7.8 d	3.3 a	3.2 a	7.3 d	2.6 ac	2.9 c	8 d
Height skewness	0.4 ab	-0.9 c	-0.7 d	0.5 a	-0.8 cd	-0.3 ef	1.1 b	-0.3 ef	0.1 ae	1.4 g	-0.5 df
Average intensity	33.7 abc	33.6 a	32.6 a	42.2 d	45.5 e	31.6 a	40.5 fg	36.9 bf	19.5 c	41.1 g	42.8 deg
Standard deviation intensity	17 abc	17.2 a	15.3 d	15.2 d	14.2 e	14.4 bd	16.7 c	15.4 d	8.7 f	17.1 ac	15.6 bd
Density < 1m	49.6 a	19.9 b	15.8 c	53.8 a	27.4 d	30 de	63.8 f	35.5 e	45.1 ae	67.7 f	33.5 de
Density 1 - 2 m	5.7 ab	2.8 ac	7.1 b	4.2 cd	2.4 de	5.1 b	5 d	1.5 f	3.9 abcd	7.2 c	1.4 ef
Density 2 - 4 m	5.8 ab	2.3 a	39.4 c	2.2 ab	1.1 b	18.8 d	0.8 e	0.8 ef	17 cd	0.4 fg	0 g
Density 4 - 6 m	7.9 a	4 a	30.1 b	3.3 a	1.8 c	31.5 b	2.1 c	0.9 d	21.8 b	0.8 de	0 e
Density 8 - 10 m	13 abc	19.6 d	0.9 e	14.6 a	14.2 a	1.1 e	7.8 bc	10.2 ab	0.4 e	6.3 c	9.7 abc
Density 10 - 15 m	6.8 a	37.3 b	0.1 c	14.9 d	45.6 e	0.4 c	13.8 d	41.8 be	3.5 ac	13.4 d	44.6 be
Evenness	0.4 a	0.5 b	0.6 c	0.3 d	0.4 a	0.6 c	0.3 e	0.4 a	0.5 ab	0.3 e	0.6 bc
RBR (Sentinel 2A)	0.02 ab	0.02 a	0.03 b	0.25 c	0.21 d	0.17 d	0.41 e	0.39 e	0.34 ce	0.55 f	0.54 f

Table S4. Mean values of the most significant variables used to classify individual trees (C1-C3) stratified by RBR fire severity levels (UB: unburned; LS: low severity; MS: moderate severity and HS: high severity) to assess differences within groups (intra-cluster variability). Number in each entry shows the mean LiDAR metric value followed by letters indicating statistically distinguishable structural classes (Kruskal-Wallis $p < 0.05$).

Structure-derived tree groups	Cluster 1				Cluster 2				Cluster 3		
Lidar metrics from VCPs	C1_UB	C1_LS	C1_MS	C1_HS	C2_UB	C2_LS	C2_MS	C2_HS	C3_UB	C3_LS	C3_MS
Tree top height	10.8 a	11.3 a	12.4 e	13.1 b	13.2 b	13.4 bd	14 d	14.4 d	6.7 c	7.1 c	6.4 c
Crown area	9.2 abc	8.4 a	8.7 a	7.1 c	21.5 d	15.3 e	12.2 b	7.8 ac	13.9 e	10.2 b	5.8 ac
Crown LAI	0.5 a	0.4 a	0.3 f	0.2 g	1.5 b	1.2 c	0.9 de	1 cde	1.2 cd	0.8 e	0.4 afg
Relative understory LAI	20.9 ab	14.1 ce	15.5 ef	21.6 ac	12.4 ac	8.3 f	5.7 g	4.5 g	43.3 d	30.1 b	33.7 bd
Crown volume	53.2 abc	46.1 bc	47.6 b	40 c	149.1 d	102.9 e	79.7 ae	59.8 abc	65 a	52.5 a	34 abce
Average tree height	3.5 abc	3.9 b	3.2 a	2.9 c	7.7 d	7.8 d	7.3 d	8 d	3.3 a	3.3 a	2.6 ac
Height skewness	0.4 ab	0.5 a	1.1 b	1.4 g	-0.9 c	-0.8 cd	-0.3 ef	-0.5 df	-0.7 d	-0.3 ef	0.1 ae
Average intensity	33.7 abc	42.2 d	40.5 fg	41.1 g	33.6 a	45.5 e	36.9 bf	42.8 deg	32.6 a	31.6 a	19.5 c
Standard deviation intensity	17 abc	15.2 d	16.7 c	17.1 ac	17.2 a	14.2 e	15.4 d	15.6 bd	15.3 d	14.4 bd	8.7 f
Density < 1m	49.6 a	53.8 a	63.8 f	67.7 f	19.9 b	27.4 d	35.5 e	33.5 de	15.8 c	30 de	45.1 ae
Density 1 - 2 m	5.7 ab	4.2 cd	5 d	7.2 c	2.8 ac	2.4 de	1.5 f	1.4 ef	7.1 b	5.1 b	3.9 abcd
Density 2 - 4 m	5.8 ab	2.2 ab	0.8 e	0.4 fg	2.3 a	1.1 b	0.8 ef	0 g	39.4 c	18.8 d	17 cd
Density 4 - 6 m	7.9 a	3.3 a	2.1 c	0.8 de	4 a	1.8 c	0.9 d	0 e	30.1 b	31.5 b	21.8 b
Density 8 - 10 m	13 abc	14.6 a	7.8 bc	6.3 c	19.6 d	14.2 a	10.2 ab	9.7 abc	0.9 e	1.1 e	0.4 e
Density 10 - 15 m	6.8 a	14.9 d	13.8 d	13.4 d	37.3 b	45.6 e	41.8 be	44.6 be	0.1 c	0.4 c	3.5 ac
Evenness	0.4 a	0.3 d	0.3 e	0.3 e	0.5 b	0.4 a	0.4 a	0.6 bc	0.6 c	0.6 c	0.5 ab
RBR (Sentinel 2A)	0.02 ab	0.25 c	0.41 e	0.55 f	0.02 a	0.21 d	0.39 e	0.54 f	0.03 b	0.17 d	0.34 ce