

Supplementary Materials:

Elaboration of how automated and manual crowns were paired:

We wrote our tuning/accuracy assessment R script so that, during each iteration, the automated crown polygons (A_{ITC}) were intersected with the manual crown polygons (M_{ITC}). For each M_{ITC} , we calculated I_M , the ratio of $A_{ITC}:M_{ITC}$ intersection area to M_{ITC} area. For each A_{ITC} , we calculated I_A , the ratio of $A_{ITC}:M_{ITC}$ intersection area to A_{ITC} area. I_A and I_M describe the percent area of each respective crown that overlapped with its counterpart. We used I_A and I_M to categorize each M_{ITC} delineation by type of error based on the four rules outlined in section 2.4. For example, if $I_A = 0.7$ (70% intersection overlap with automated crown) and $I_M = 0.8$ (80% intersection overlap with manual crown), then the M_{ITC} would be considered correctly delineated. Given that any M_{ITC} could only be linked to one A_{ITC} , in the case where multiple A_{ITC} crowns fell within a single M_{ITC} (as is the case with over-segmentation), the M_{ITC} was assigned to the A_{ITC} that best overlapped with the particular M_{ITC} identified based on the A_{ITC} that maximized the sum of I_A and I_M .

Figures:

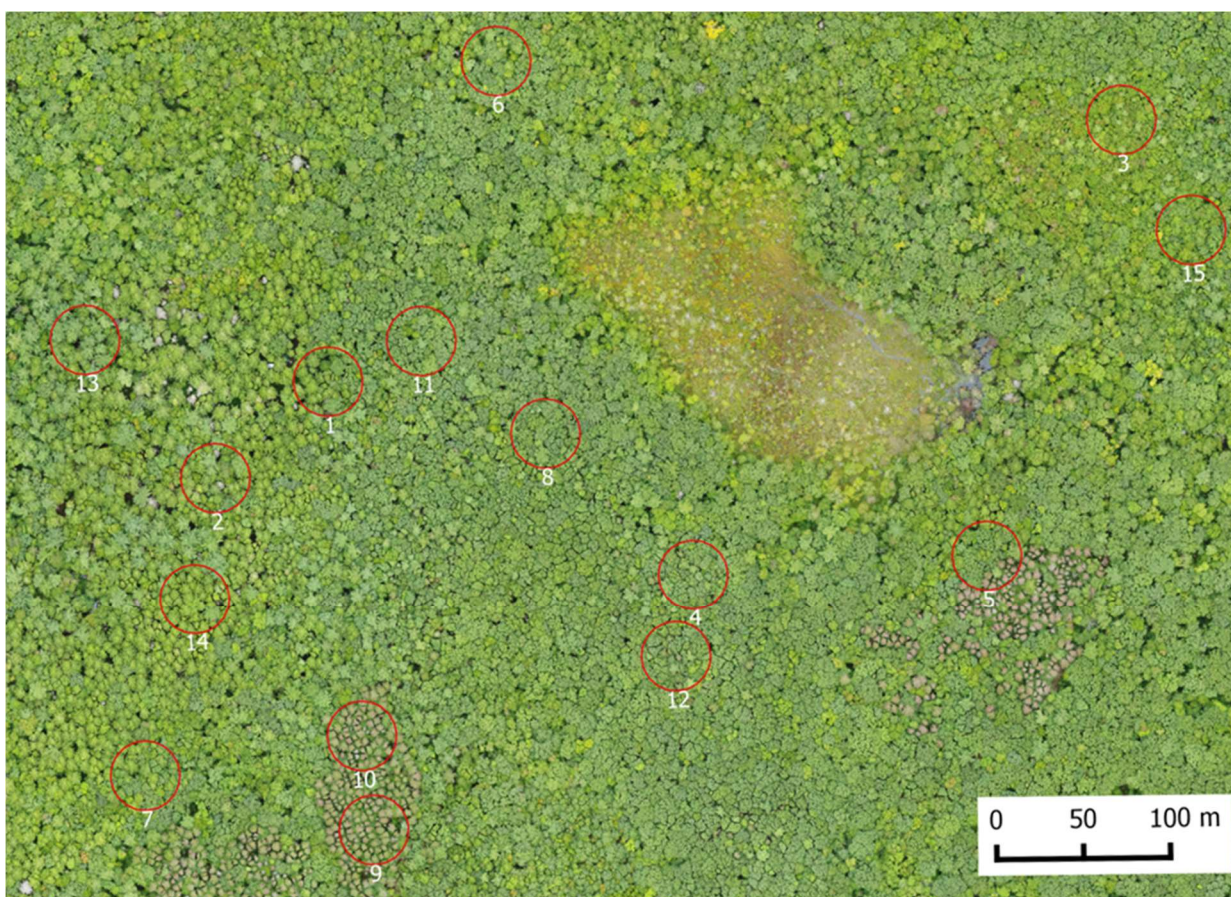


Figure S1: September 2018 UAV image collected over the MegaPlot showing the location of the fifteen plots used in this study.

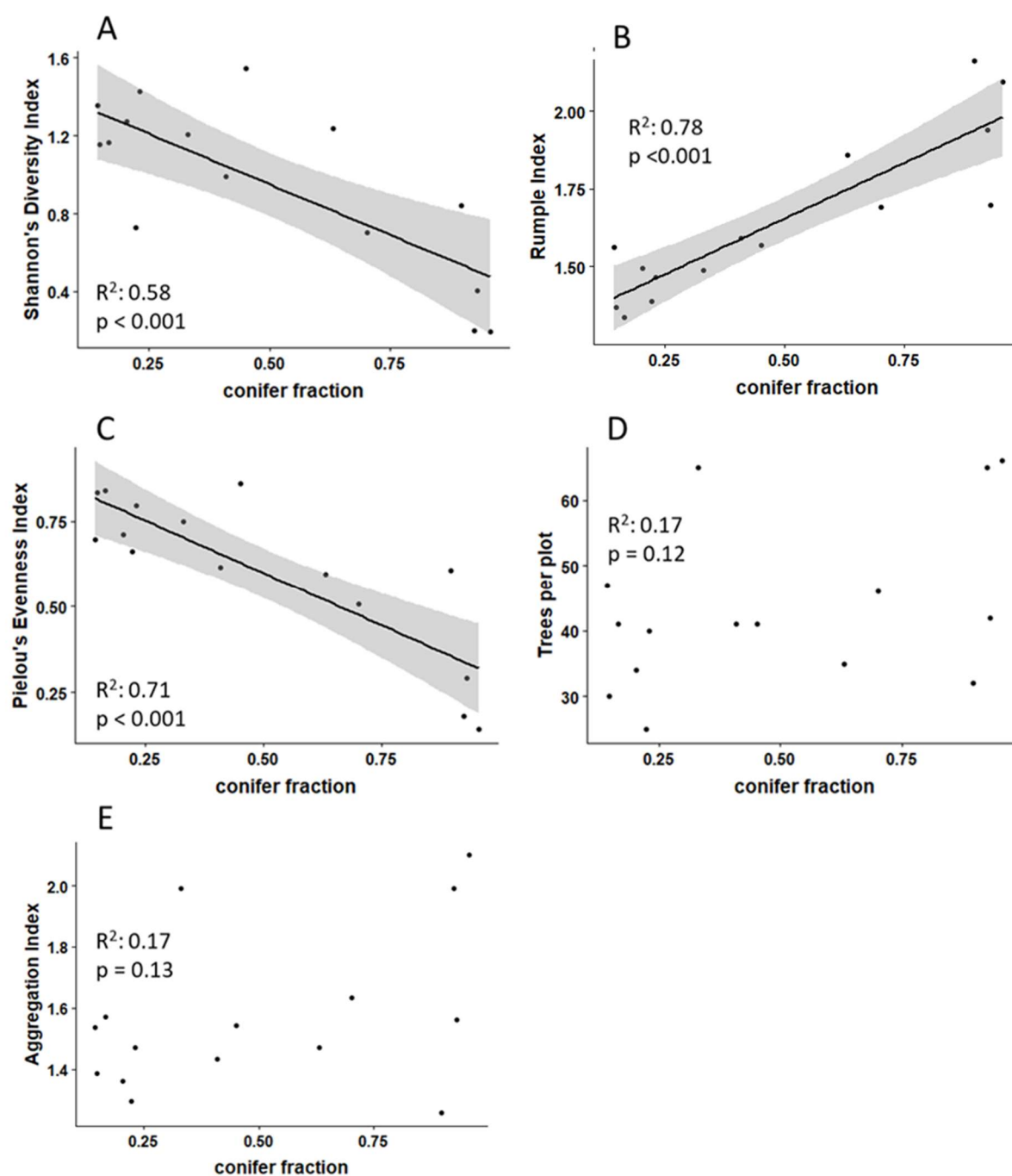


Figure S2: Relationships between the fraction of conifer crown area per plot (conifer fraction) and Shannon's diversity index (A), Rumple index (B), Pielou's evenness index (C), trees per plot (D), and aggregation index (E).

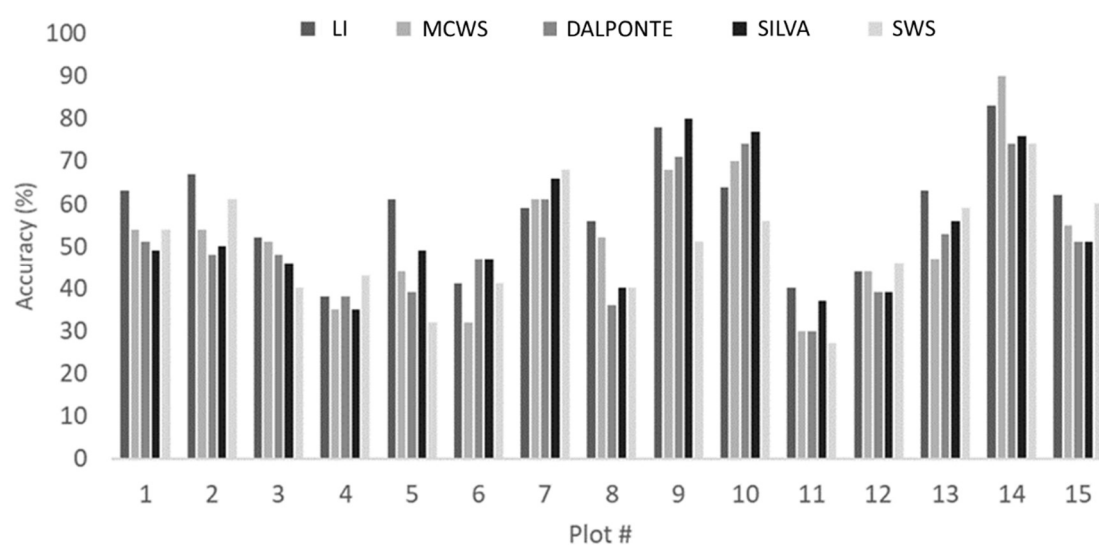


Figure S3: Following parameter tuning, plot-level accuracy varied similarly by methods across plot, indicating that accuracy is largely controlled by the structure and composition of the plots rather than methodological differences.

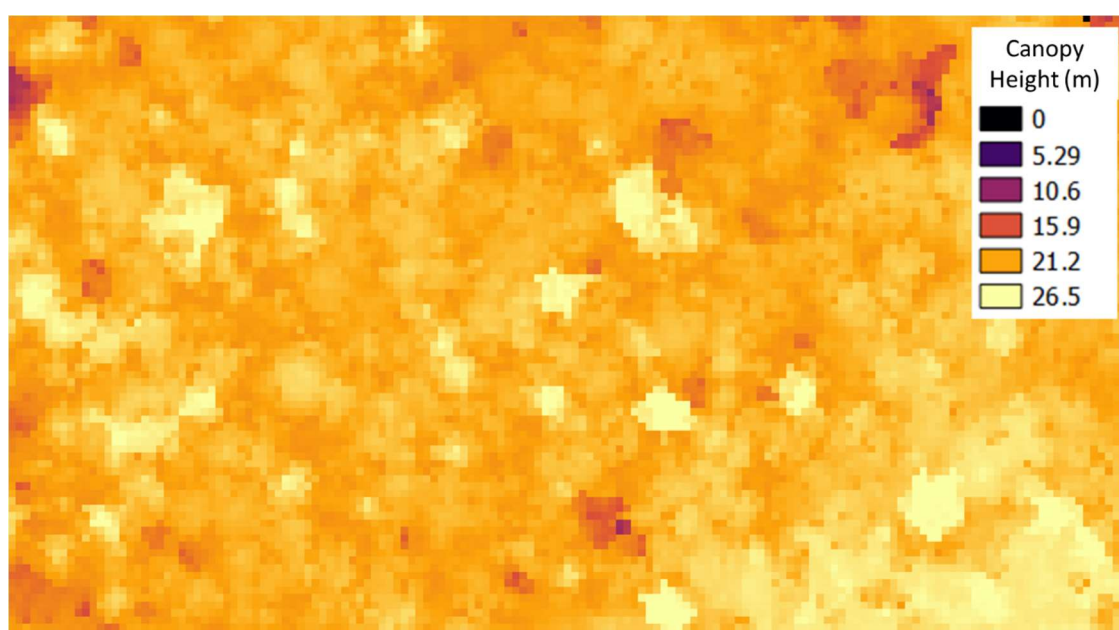


Figure S4: Emergent white pine crowns stand out as bright yellow hotspots on a canopy height model. Low density wood allows white pine to grow taller than all other species in the Harvard Forest. They can often stand five or more meters above the continuous canopy.



Figure S5: Red pine often exhibit crown shyness when grown in monoculture. Panel A shows a below and above view of a broadleaf stand, and panel B shows a below and above view of a conifer (red pine) stand.

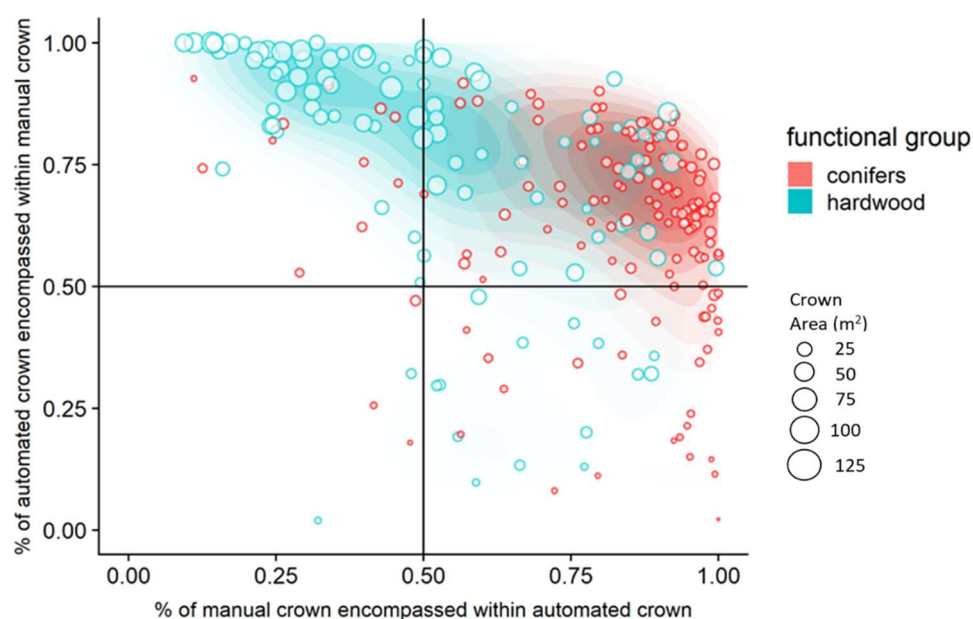


Figure S6: Two-dimensional density plot showing different patterns of crown delineation accuracy between conifer and broadleaf functional groups. The circles provide crown size comparison for two end member species: red pine (shown in red circles) and red oak (shown in blue circles). This figure corresponds with delineation categories described in **Error! Reference source not found.**: the top right quadrant signifies true delineations, the top left signifies over-segmentation, the bottom right signifies under-segmentation, and the bottom left signifies false positive. This figure shows data generated using the LI method.

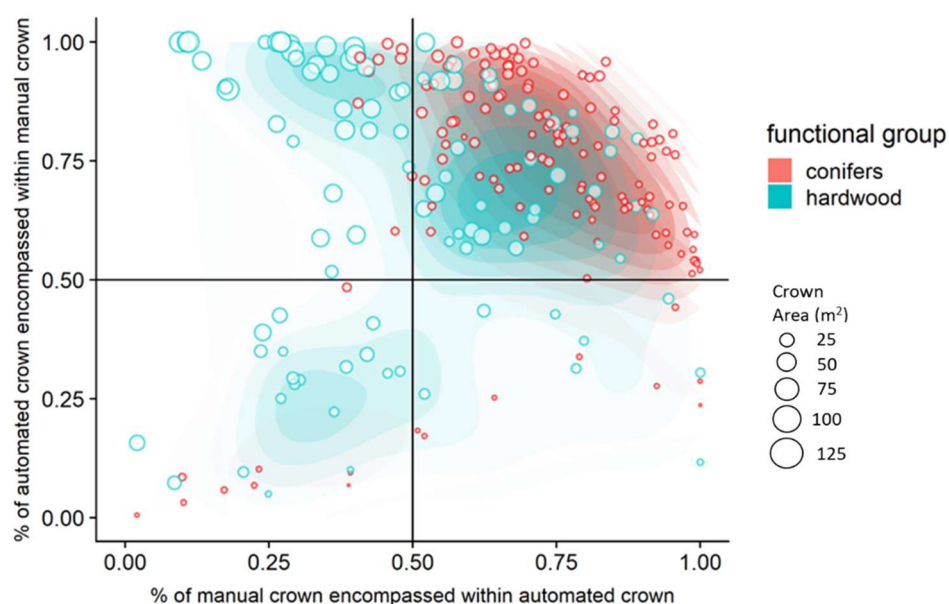


Figure S7: Two-dimensional density plot showing different patterns of crown delineation accuracy between conifer and broadleaf functional groups. The circles provide crown size comparison for two end member species: red pine (shown in red circles) and red oak (shown in blue circles). This figure corresponds with delineation categories described in **Error! Reference source not found.**: the top right quadrant signifies true delineations, the top left signifies over-segmentation, the bottom right signifies under-segmentation, and the

bottom left signifies false positive. This figure shows data generated using the SILVA method.

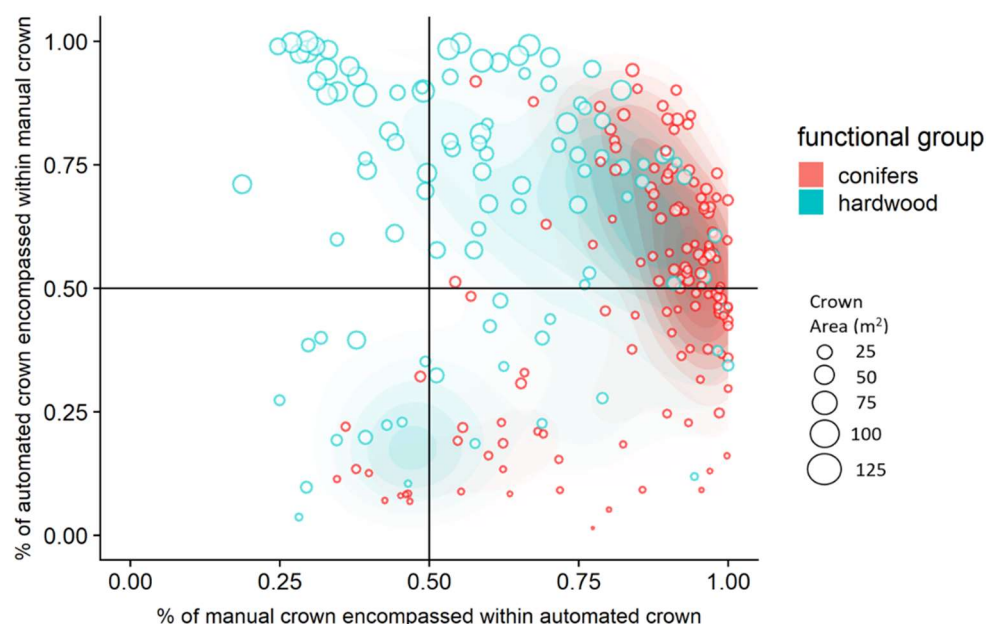


Figure S8: Two-dimensional density plot showing different patterns of crown delineation accuracy between conifer and broadleaf functional groups. The circles provide crown size comparison for two end member species: red pine (shown in red circles) and red oak (shown in blue circles). This figure corresponds with delineation categories described in **Error! Reference source not found.**: the top right quadrant signifies true delineations, the top left signifies over-segmentation, the bottom right signifies under-segmentation, and the bottom left signifies false positive. This figure shows data generated using the SWS method.

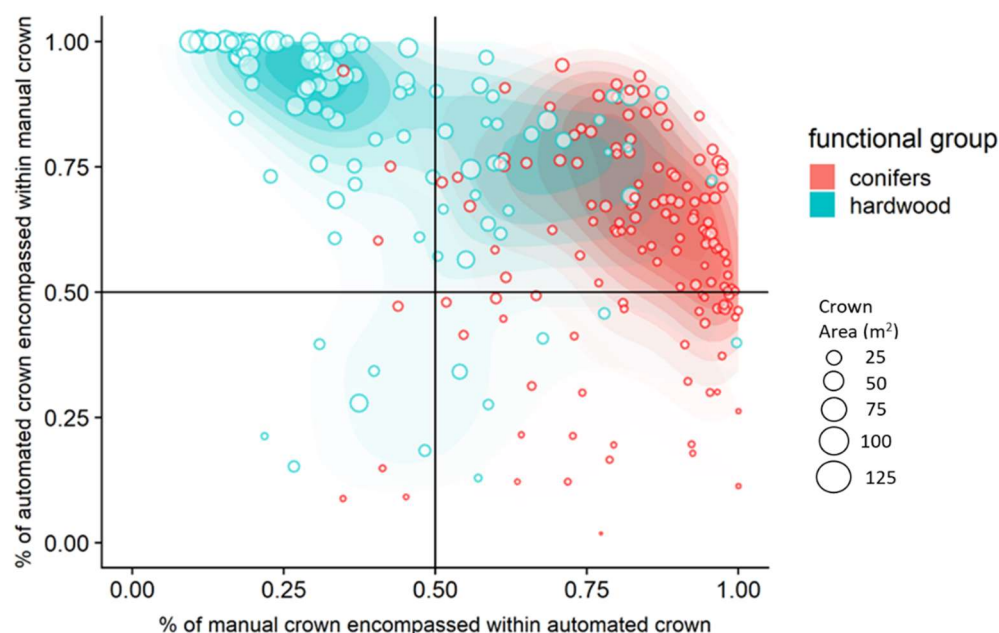


Figure S9: Two-dimensional density plot showing different patterns of crown delineation accuracy between conifer and broadleaf functional groups. The circles provide crown size comparison for two end member species: red pine (shown in red circles) and red oak (shown in blue circles). This figure corresponds with delineation categories described in

Error! Reference source not found.: the top right quadrant signifies true delineations, the top left signifies over-segmentation, the bottom right signifies under-segmentation, and the bottom left signifies false positive. This figure shows data generated using the MCWS method.

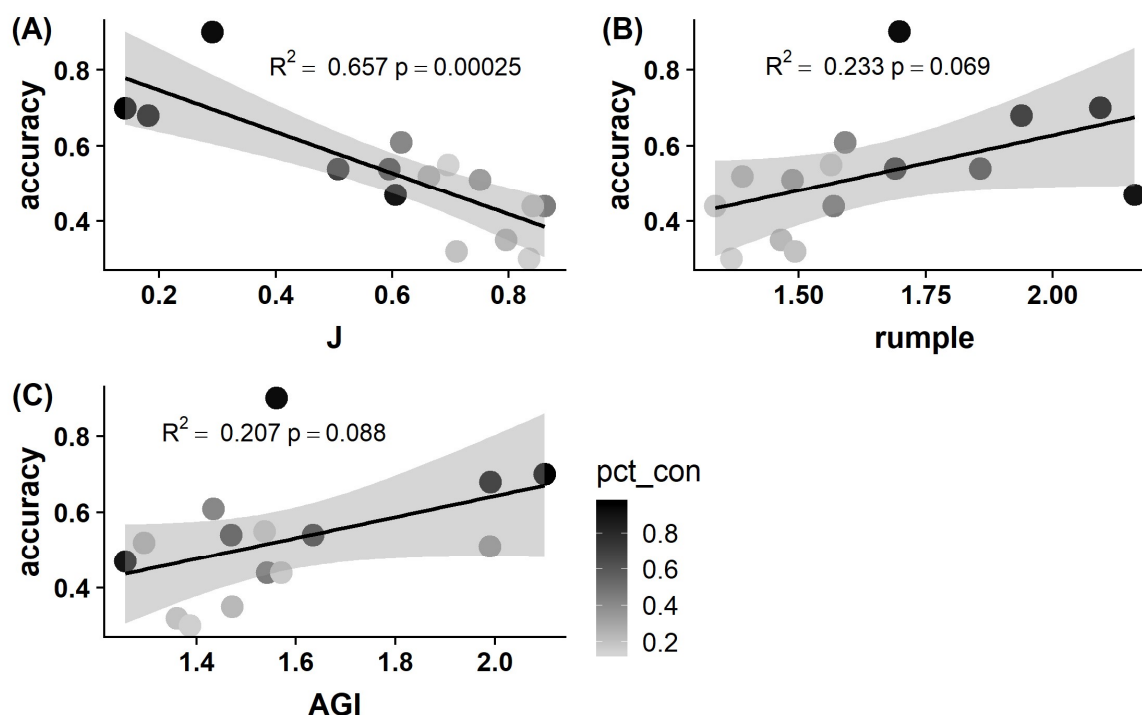


Figure S10: Prediction accuracy in relation to plot-level (a) evenness, (b) rumple index, and (c) aggregation index for one crown delineation method (MCWS). Points are colored to show fraction of conifer crown area per plot (conifer fraction).

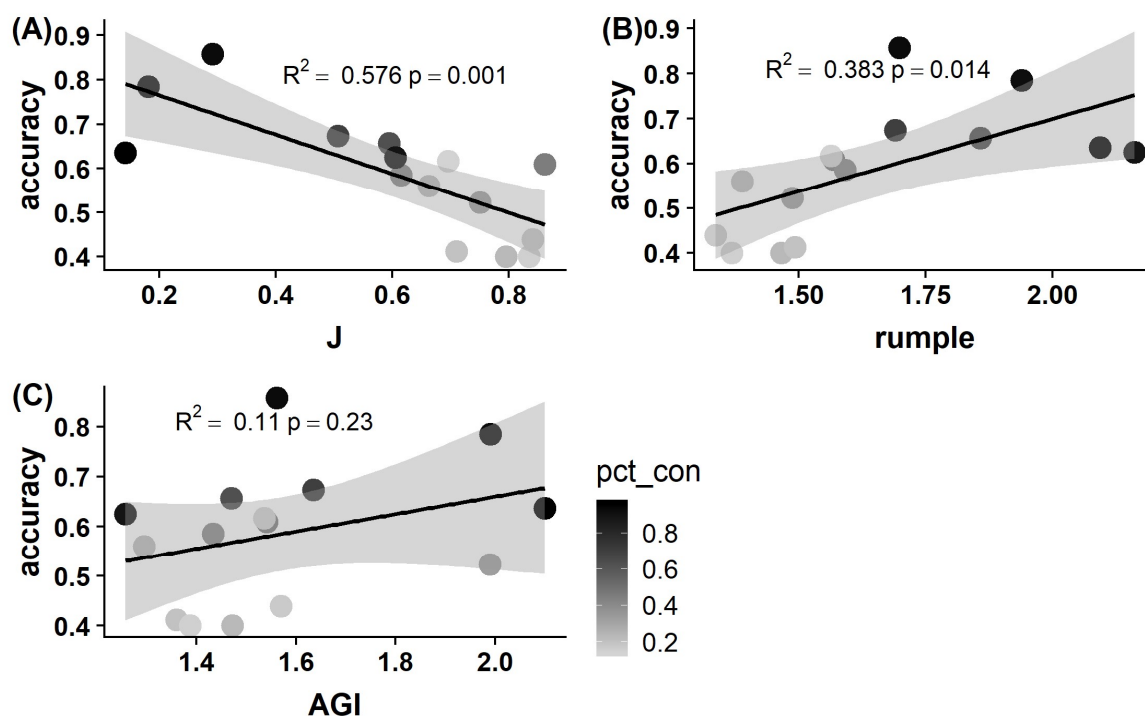


Figure S11: Prediction accuracy in relation to plot-level (a) evenness, (b) rumple index, and (c) aggregation index for one crown delineation method (LI). Points are colored to show fraction of conifer crown area per plot (conifer fraction).

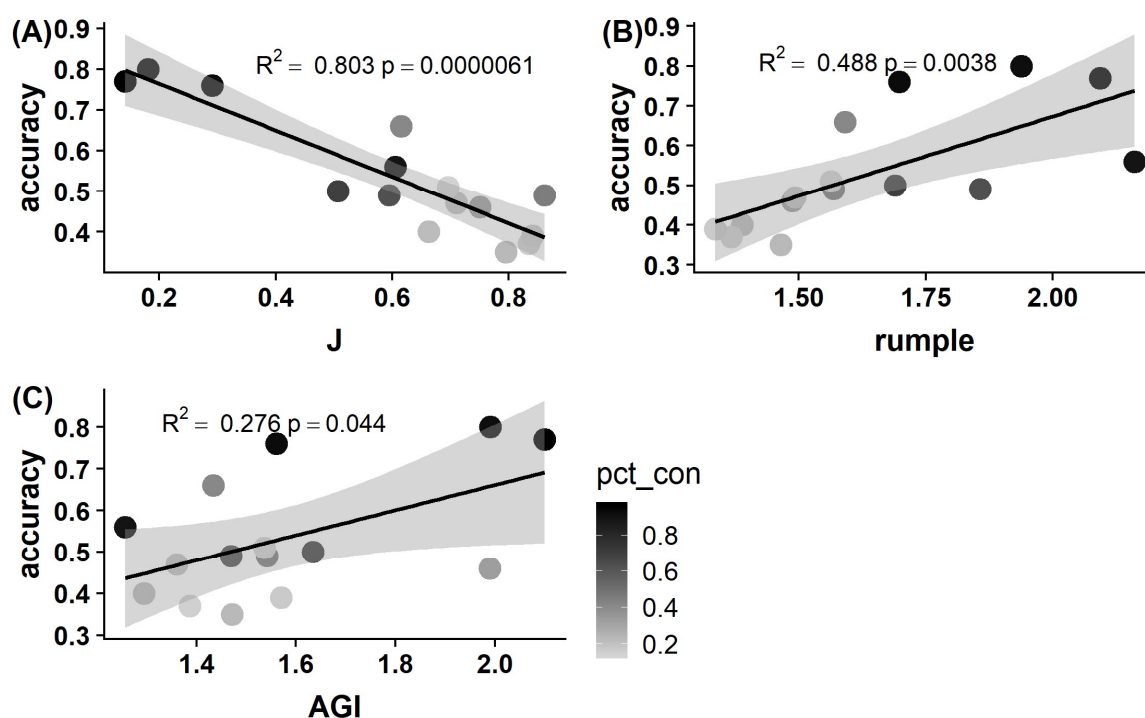


Figure S12: Prediction accuracy in relation to plot-level (a) evenness, (b) rumple index, and (c) aggregation index for one crown delineation method (SILVA). Points are colored to show fraction of conifer crown area per plot (conifer fraction).

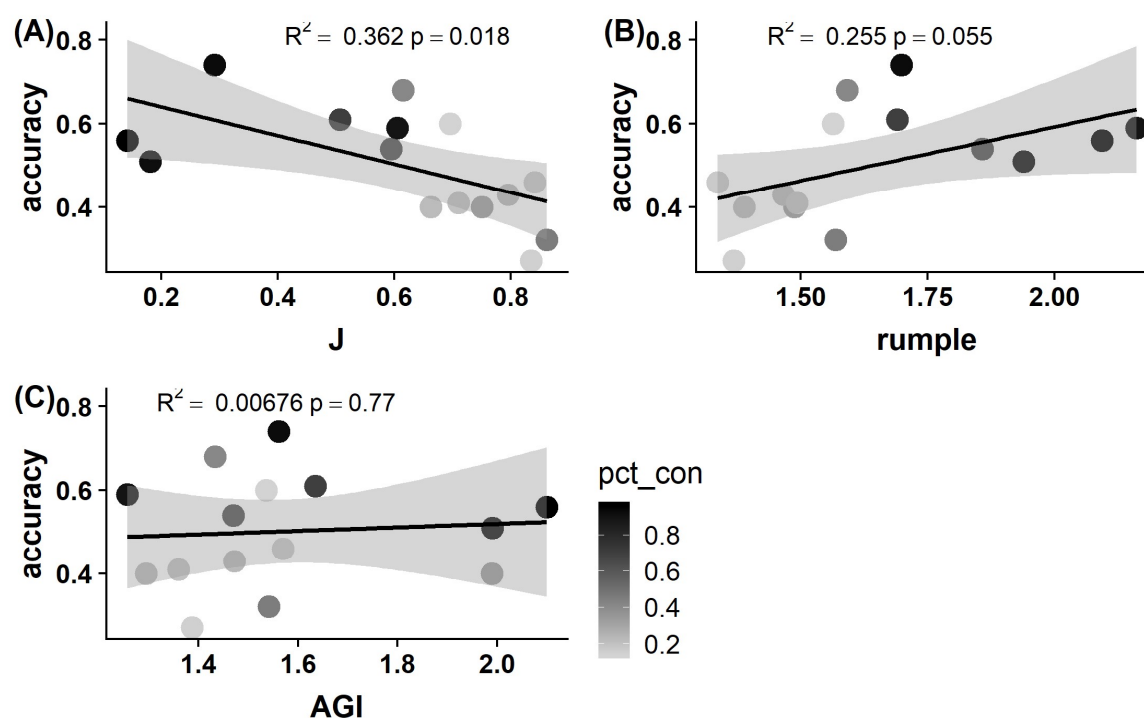


Figure S13: Prediction accuracy in relation to plot-level (a) evenness, (b) rumple index, and (c) aggregation index for one crown delineation method (SWS). Points are colored to show fraction of conifer crown area per plot (conifer fraction).

Tables

Table S1: Automated tree crown delineation parameter and sample ranges used in parameter optimization. Values in parentheses are default values. † Local maxima tree detection algorithm used for SILVA, DALPONTE, and MCWS. *Odd values only

Routine	Parameter	Sampled Range
<i>SILVA</i>	ws [†]	3 – 7* (3)
	hmin [†]	2 – 10 (2)
	max_cr_factor	0.01 – 0.99 (0.6)
	exclusion	0.01 – 0.99 (0.3)
<i>MCWS</i>	ws [†]	3 – 7* (3)
	hmin [†]	2 – 10 (2)
	th_tree	2 – 10 (2)
<i>SWS</i>	th_tree	2 – 10 (2)
	ext	1 – 3 (1)
	tol	0.001 – 1.00 (1)
<i>DALPONTE</i>	ws [†]	3 – 7* (3)
	hmin [†]	2 – 10 (2)
	th_tree	2 – 15 (2)
	th_seed	0.01 – 0.99 (0.45)

LI	th_cr	0.01 – 0.99 (0.55)
	maxCR	2 – 25 (10)
	dt1	0.1 – 4 (1.5)
	dt2	0.1 – 2.5 (2)
	R	1 – 4 (2)
	Zu	10 – 20 (15)
	hmin	2 – 10 (2)
	speed_up	10 – 25 (10)

Table S2: Generalized and plot-tuned parameter values generated from parameter optimization model iterations.

Li	Generaliz					
	ed	1	2	3	4	5
th tree	5.94	5.94	5.94	5.94	5.9	5.94
hmin [†]	5.86	5.86	5.86	5.86	5.9	5.86
ws [†]	3	3	3	3	3	3
tol	0.04	0.24	0.01	0.03	0.1	0.06
ext	1	1	1	1	1	1
th tree	3.17	2.44	9.73	6.65	4.4	4.41
maxCR	16.6	16.8	11.7	15.8	3.4	15.8
th_cr	0.65	0.31	0.23	0.66	0.9	0.66
th seed	0.66	0.72	0.68	0.53	0.9	0.53
th tree	9.17	10	9.44	6.33	7.6	6.33
hmin [†]	5.6	5.21	6	5.06	4.4	5.06
ws [†]	3	3	3	3	5	3
exclusion	0.69	0.57	0.63	0.16	0.9	0.41
max cr factor	0.23	0.22	0.17	0.25	0.4	0.09
hmin [†]	9.45	7.38	4.5	7.81	9	8.63
ws [†]	3	5	5	3	5	3
speed up	25	25	25	20	20	25
hmin	2	2	2	7	3	9
Zu	18	18	18	19	18	11
R	1	1	1	2	4	3
dt2	1.32	1.32	1.32	0.84	0.9	0.37
dt1	1.5	1.5	1.5	1.58	0.6	0.28

	8	9	10	11	12	13	14	15
7	8	9	10	11	12	13	14	15
5.94	4.2	5.94	5.94	5.94	5.94	4.18	5.9	5.94
5.86	5.2	5.86	5.86	5.86	5.86	5.24	5.9	5.86
3	5	3	3	3	3	5	3	3
0.03	0.1	0.01	0.01	0.08	0.06	0.08	0.1	0.08
1	1	1	1	1	1	1	1	1
6.65	10	4.32	4.32	9.95	4.41	9.95	10	9.95
15.8	4.4	3.64	7.19	4.75	17.9	12.3	2.7	15.8
0.66	0.8	0.94	0.52	0.11	0.92	0.76	0.9	0.66
0.53	0.8	0.6	0.89	0.78	0.49	0.19	0.8	0.53
6.33	6.9	12.4	14.3	12.3	13.2	7.23	6.3	6.33
5.06	9.6	9.5	9.26	8.62	4.66	5.54	2.6	5.06
3	5	3	3	5	3	5	3	3
0.28	0.6	0.31	0.12	0.81	0.89	0.75	0.3	0.27
0.14	0.2	0.08	0.08	0.78	0.46	0.32	0.9	0.89
5.14	7.4	2.85	8.31	4.24	7.02	5.01	8.2	8.23
5	5	3	3	5	5	5	3	3
25	21	21	25	18	18	23	25	20
2	2	9	2	9	9	4	2	7
18	11	20	18	13	13	10	18	19
1	1	1	1	1	1	1	1	2
1.32	2.4	1.29	1.32	1.8	1.8	1.67	1.3	0.84
1.5	1.7	0.58	1.5	2.33	2.33	2.18	1.5	1.58

Table S3: Results from accuracy assessment (0–1 range) from five different automated crown delineation method at the plot level. The table includes plot-tuned, generalized, and default parameter accuracy.

	Plot	1	2	3	4	5	6	7
LI	Plot-tuned	0.5	0.5	0.5	0.4	0.4	0.3	0.6
	Generalized	0.5	0.5	0.5	0.4	0.3	0.3	0.6
	Default	0.5	0.5	0.5	0.3	0.4	0.3	0.6
	Plot-tuned	0.5	0.6	0.4	0.4	0.3	0.4	0.7
MCWS	Generalized	0.5	0.6	0.4	0.4	0.3	0.4	0.7
	Default	0.5	0.5	0.5	0.3	0.4	0.3	0.6
	Plot-tuned	0.5	0.5	0.5	0.4	0.4	0.3	0.6
	Generalized	0.5	0.5	0.5	0.4	0.4	0.3	0.6
SWS	Plot-tuned	0.5	0.5	0.5	0.4	0.4	0.5	0.6
	Generalized	0.5	0.5	0.5	0.3	0.4	0.3	0.6
	Default	0.5	0.5	0.5	0.2	0.4	0.3	0.6
	Plot-tuned	0.5	0.5	0.5	0.4	0.4	0.5	0.7
DALPONTE	Generalized	0.5	0.5	0.5	0.3	0.4	0.3	0.6
	Default	0.5	0.5	0.5	0.2	0.4	0.3	0.6
	Plot-tuned	0.5	0.5	0.5	0.4	0.4	0.5	0.7
	Generalized	0.5	0.5	0.5	0.3	0.4	0.3	0.6
Silva	Plot-tuned	0.5	0.5	0.5	0.4	0.5	0.5	0.6
	Generalized	0.5	0.5	0.5	0.3	0.4	0.3	0.6
	Default	0.5	0.5	0.5	0.2	0.4	0.3	0.5
	Plot-tuned	0.5	0.5	0.5	0.4	0.6	0.4	0.6
LI	Generalized	0.5	0.5	0.5	0.3	0.6	0.4	0.6
	Default	0.5	0.5	0.5	0.3	0.3	0.3	0.5
	Plot-tuned	0.5	0.5	0.5	0.4	0.6	0.4	0.6
	Generalized	0.5	0.5	0.5	0.3	0.6	0.4	0.6

	Intercept	0.53	0.02	30.16	0.0000	***
	J	-0.13	0.02	-7.29	0.0000	***
<i>LI</i>						
	Intercept	0.53	0.02	30.16	0.0000	***
	J	-0.13	0.02	-7.29	0.0000	***