Supplementary S3

Tree Height and DBH Measurement

1. Statistical Analysis

For matched UAS and field trees (i.e. True Positive trees) we calculated the mean error of the UAS tree height and DBH compared to field measurements to represent measurement bias and the RMSE to represent precision. Mean error can take on continuous positive (UAS > field measurement) or negative (UAS < field measurement) values with values close to zero indicating low measurement bias. RMSE is strictly positive with a lower-bound of zero representing cases where UAS values perfectly match field measurements. We modeled the mean error and the RMSE for height and DBH of the True Positive trees with a Gaussian likelihood implemented with the Bayesian modeling package brms [36] in the R statistical program [26]. Models were run using four chains with 20,000 iterations each with a warmup of 10,000 samples and 40,000 total post-warmup samples. We describe the mathematical details of these models, the computational procedures we used to fit them, and methods for model checking in Supplementary 4.

2. Overall Tree Height and DBH Accuracy

Across all SfM processing software and algorithm parameterizations tested, UAS height values were generally within 1 m of field measured heights. As the dense point cloud generation quality increased the UAS values shifted from either a slight underestimation or no bias to a consistent overestimation in height (Figure S3A; Table S17). However, UAS height precision (RMSE) improved with increasing quality (Figure S3B; Table S18). UAS-derived DBH values were generally larger than field measured values by approximately 1 cm across the SfM processing software and algorithm parameterizations tested with variability in the DBH estimation bias (mean error) ranging between -3.5 and 5.5 cm (Figure S4A; Table S24). The precision of UAS DBH values as quantified by RMSE was near 6 cm for all software and SfM parametrization settings tested with variability in the estimates generally ranging between 3 and 10 cm (Figure S4B; Table S25). Within each software the dense point cloud filtering mode setting had limited impact on both height and DBH bias and precision (Figure S3 and S4).

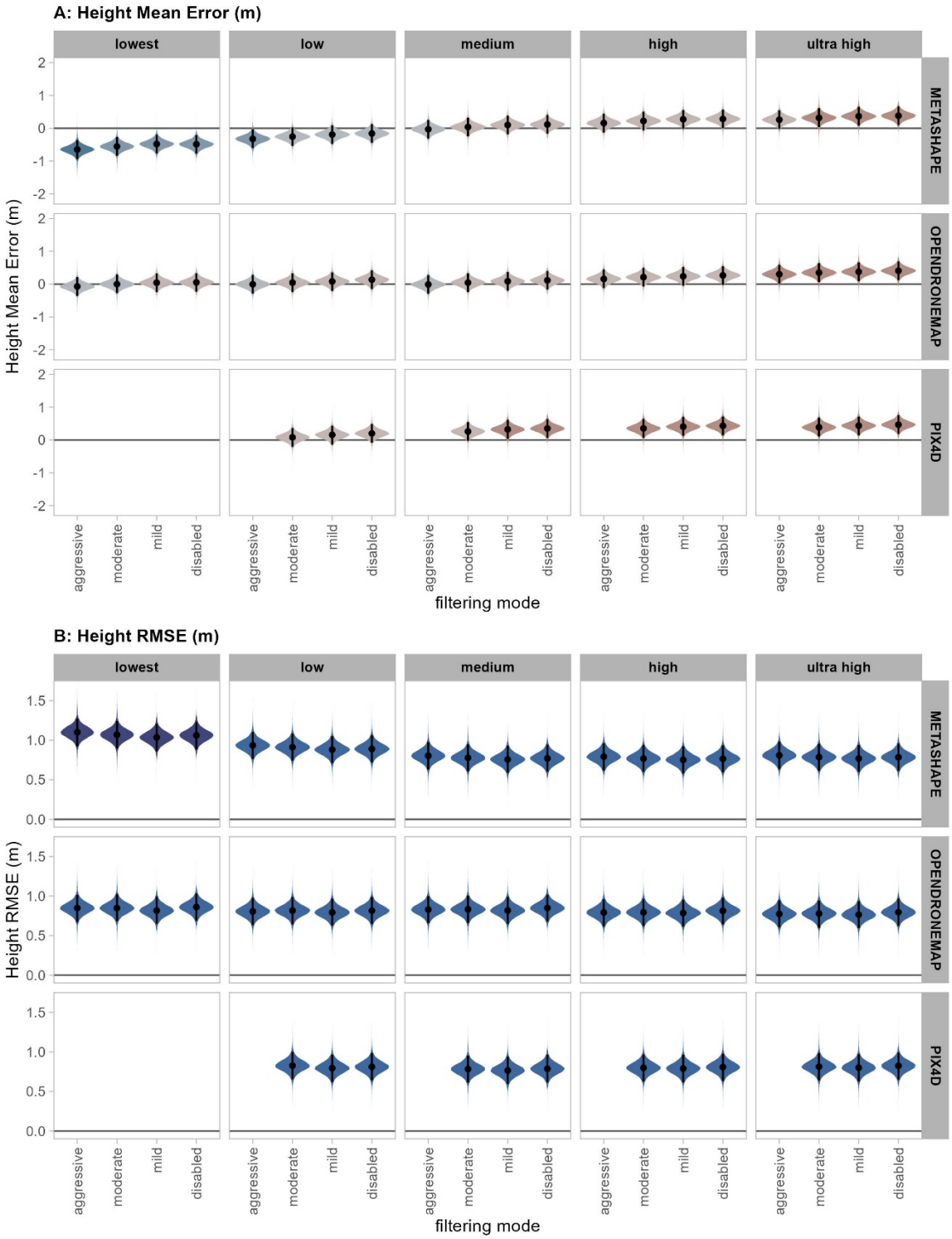


Figure S3. UAS-detected tree height bias (mean error; top panel [A]) and precision (RMSE; bottom panel [B]) by software platforms (rows), dense point cloud quality (columns), and filtering mode (x-axis) settings of the SfM algorithms. (A) Positive bias values (red) indicate UAS values greater than field measurements and negative bias values (blue) represent UAS values less than field values. (B) RMSE is strictly positive with higher values (darker blue) implying less precise UAS values and a lower-bound of zero representing cases where UAS values perfectly match field measurements. Each cell represents the posterior predictive distribution where the dot is the median posterior predicted value and vertical segment indicates the 95% highest density interval (HDI).

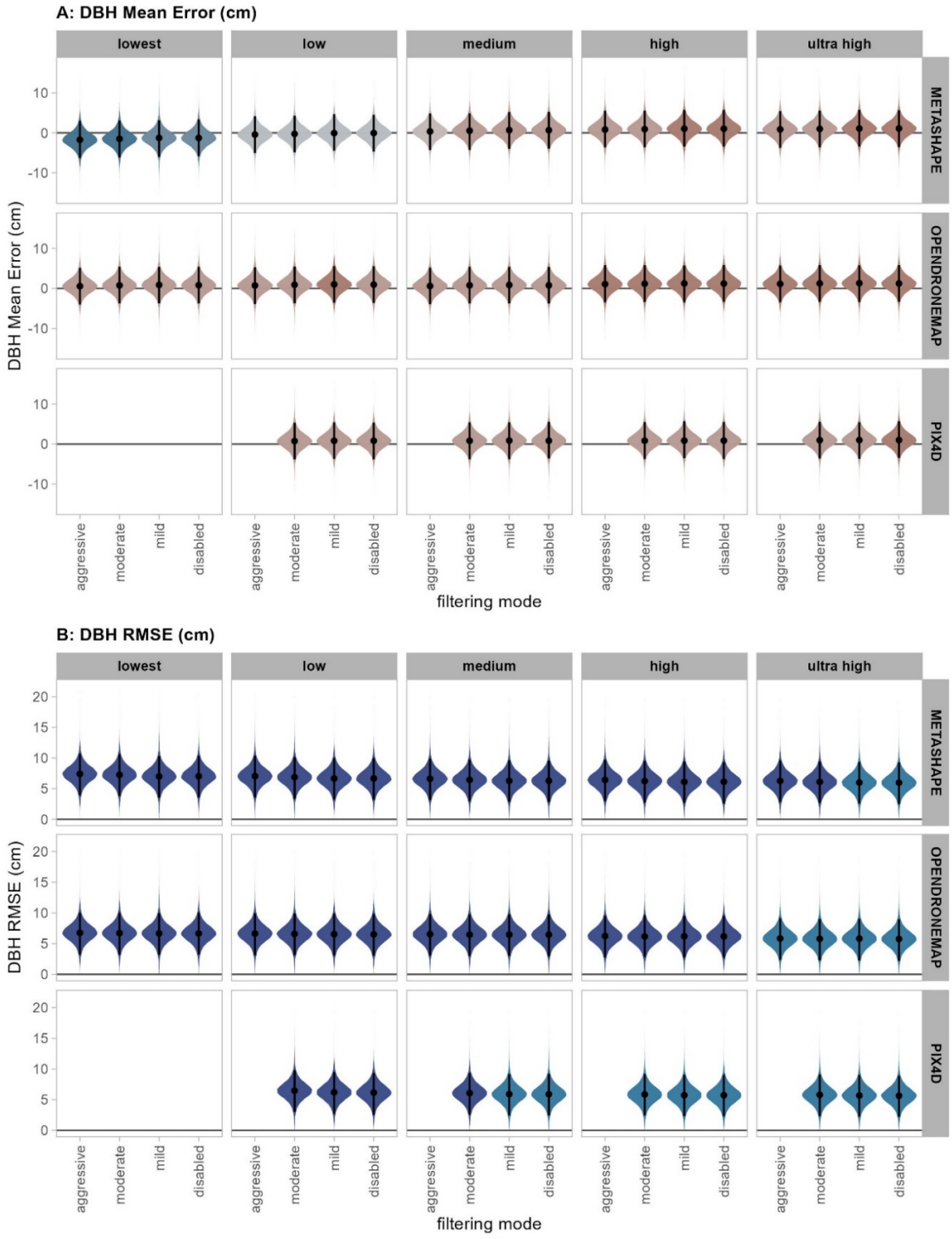


Figure S4. UAS-detected tree DBH bias (mean error; top panel [A]) and precision (RMSE; bottom panel [B]) for software platforms (rows), dense point cloud quality (columns), and filtering mode (x-axis) settings of the SfM algorithms. (A) Positive bias values (red) indicate UAS values greater than field measurements and negative bias values (blue) represent UAS values less than field values. (B) RMSE is strictly positive with higher values (darker blue) implying less precise UAS values and a lower-bound of zero representing cases where UAS values perfectly match field measurements. Each cell represents the posterior predictive distribution where the dot is the median posterior predicted value and the vertical segment indicates the 95% highest density interval (HDI).

2.1 Dense Point Cloud Generation Quality Setting

After collapsing across the filtering mode setting to compare the dense cloud quality setting effect on UAS-derived height and DBH precision (RMSE) within each software, there was a clear improvement in tree height precision (Pr. ≥ 99%; Figure S5A; Table S24) by increasing quality using Metashape in successive quality steps from lower quality to medium (RMSE: 0.78 m [0.60, 0.96]; Table S19) but there was no evidence that increasing quality beyond the medium setting improved height precision (Figure S5A; Table S24). Similarly within Metashape, UAS-derived DBH precision (RMSE) improved by increasing dense cloud quality from lower quality to medium (Pr. 96%; Figure S6A; Table S29) where an RMSE of 6.4 cm ([3.0, 9.9]; Table S26) was achieved with results suggesting slightly improved DBH accuracy (Pr. 91%; Figure S6A) of 6.1 cm ([2.5, 9.5]; Table S26) at the ultra high quality setting. Using OpenDroneMap it was not clear that increasing dense cloud quality improved UAS-derived height precision (RMSE) with evidence pointing to the optimal height precision (RMSE: 0.80 m [0.62, 0.97]; Table S19) achieved using high quality (Pr. 61-86%; Figure S5A; Table S24). However, there was strong evidence of a positive relationship between DBH precision and dense cloud quality using OpenDroneMap with the lowest RMSE (Pr. 94%; Figure S6A; Table S29) of 5.8 cm ([2.3, 9.2]; Table S26) achieved using the ultra high quality setting. Using Pix4D there was no clear effect of dense cloud generation quality on tree height precision (Figure S5A) and some evidence (Pr. 78%; Figure S6A; Table S29) suggesting that the high quality setting resulted in the best DBH precision performance with an RMSE of 5.8 cm ([2.3, 9.2]; Table S26).

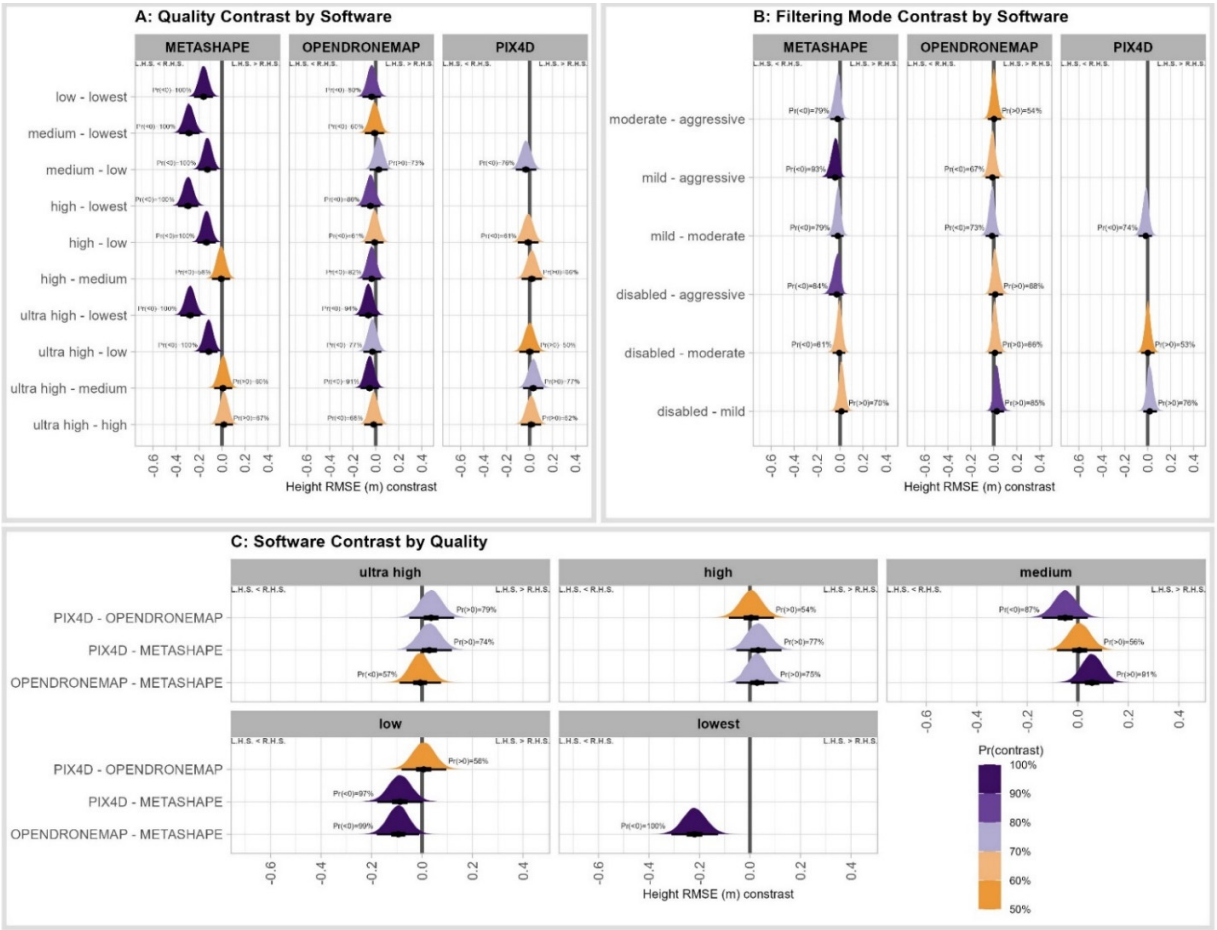


Figure S5. Change in UAS-derived tree height precision (RMSE) as influenced by (A) dense point cloud generation quality setting within each software, (B) dense point cloud filtering mode within each software, and (C) software within each dense point cloud generation quality setting. Each contrast shows the posterior predictive distribution of the

difference in tree height RMSE (i.e. contrast) where the dot is the median posterior predicted value and the horizontal segment indicates the 95% highest density interval (HDI). Colors represent the probability of one setting or software outperforming another. Lower RMSE values mean that UAS values better match field measurements and, as such, a contrast (i.e. difference) in RMSE that is negative indicates that the left hand side (L.H.S.) setting is more accurate than the right hand side (R.H.S.) setting of the contrast and vice versa.

2.2 Dense Point Cloud Filtering Mode Setting

After collapsing across the dense point cloud generation quality setting to compare the dense cloud filtering mode effect within each software, the model and data suggest that the dense point cloud filtering mode setting had limited impact on both height and DBH precision (Figure S5B and S6B) within all three software packages tested. In each software package, the results weakly suggest that optimal height precision was achieved using the mild filtering setting (Pr. 73-79%) but precision improvements were small (<0.05 m; Figure S5B; Table S23). There was some evidence that the best DBH accuracy was achieved using mild filtering in both Metashape and Pix4D (Pr. 80%; Table S30) with no indication that adjusting the filtering mode improved DBH accuracy using OpenDroneMap (Figure S6B).

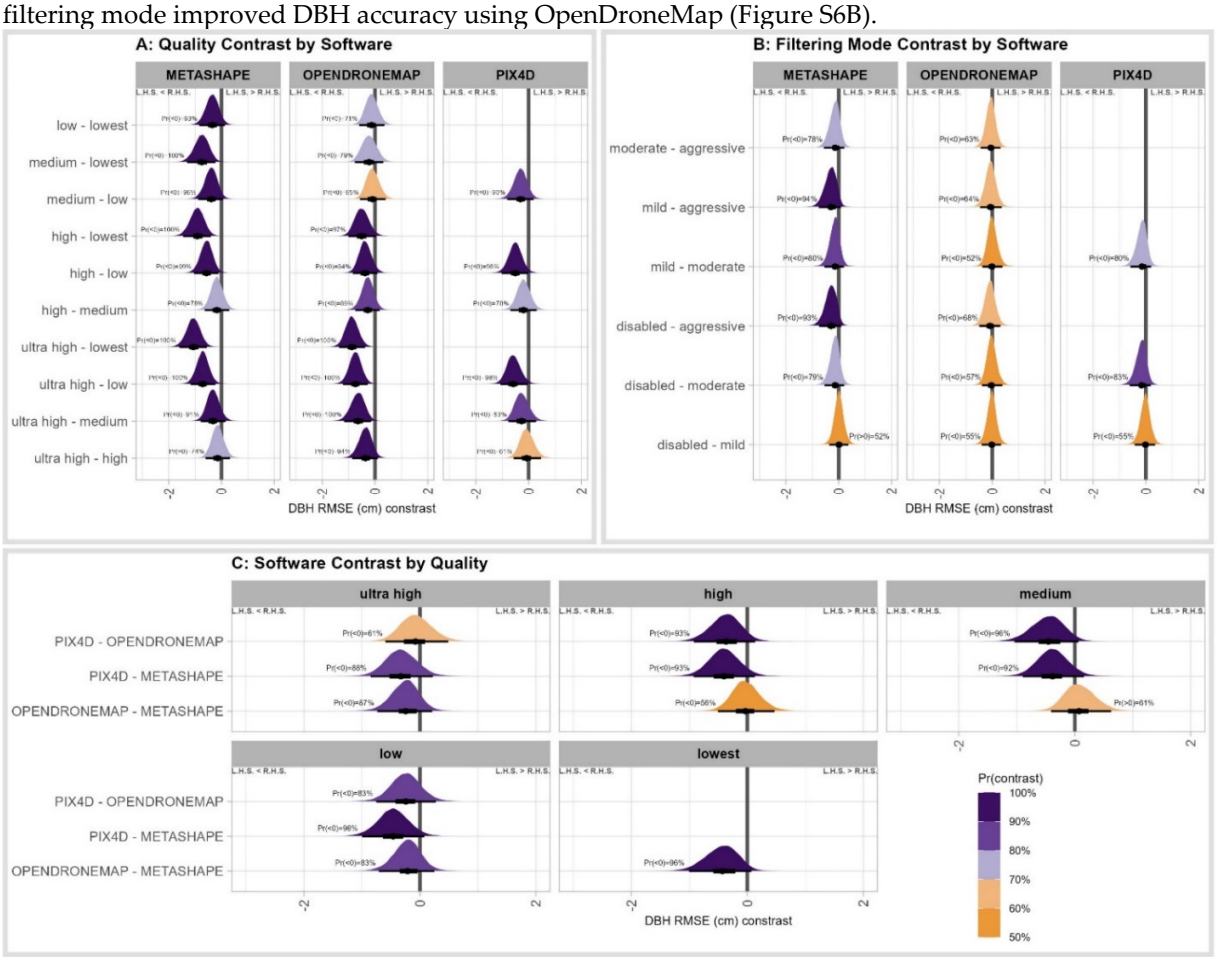


Figure S6. Change in UAS-derived tree DBH precision (RMSE) as influenced by (A) dense point cloud generation quality setting within each software, (B) dense point cloud filtering mode within each software, and (C) software within each dense point cloud generation quality setting. Each contrast shows the posterior predictive distribution of the difference in tree height RMSE (i.e. contrast) where the dot plots the median posterior predicted value and the horizontal segment indicates the 95% highest density interval (HDI). Colors represent the probability of one setting or software outperforming another. Lower RMSE values mean that UAS values better match field measurements and, as such, a contrast (i.e. difference) in RMSE that is negative indicates that the left hand side (L.H.S.) setting is more accurate than the right hand side (R.H.S.) setting of the contrast and vice versa.

2.3 Software

We compared UAS-derived tree height and DBH accuracy between software by collapsing across the filtering mode setting to compare the effect of software within each dense point cloud quality level (Figure S5C and S6C). Across all levels of dense point cloud quality, there was little difference in height precision (~0.05 m; Figure S5C; Table S21) between the software tested. At all levels of dense point cloud generation quality there was evidence (Pr. 88-96%; Table S28) that DBH values obtained using Pix4D were more precise (i.e. lower RMSE) than values obtained using Metashape but precision improvements were small ranging between 0.3 and 0.5 cm (Figure S6C; Table S28). Pix4D also produced slightly (0.2-0.5 cm) more precise DBH estimates compared to OpenDroneMap with the exception of point clouds generated using the ultra high quality setting (Figure S6C; Table S28). At the highest levels of dense point cloud generation quality (i.e. medium to ultra high) DBH precision was nearly identical between OpenDroneMap and Metashape (Figure S6C; Table S20).

3. Discussion of Tree Height and DBH Accuracy

Each software provided tree height mean errors and RMSE of < 1 m for nearly all algorithm combinations. The transition from slight negative mean height errors to slight positive errors is attributed to two things. First, the point clouds generated using the low and lowest point cloud quality settings likely fail to capture the true apex of each individual tree due to the coarsening of image resolution resulting in less dense point clouds. For the settings that maintain closer to the original image resolution (i.e. high and ultra high) the UAS overestimation bias of tree heights could be explained by the known underestimation bias of field measured tree heights [53], potentially indicating that the UAS-SfM tree heights have a bias close to zero.

The DBH RMSE for each software decreased from the lower quality settings toward the higher quality settings, improving by 1.0 to 1.5 cm (Table S25). The best DBH RMSE values ranged from 5.6 to 6.1 cm at the ultra high quality setting, which is slightly greater than has been reported in other studies using either regional or locally derived allometries for modeling DBH values [50,52]. Further testing should be completed to evaluate if regionally informed relationships of height to DBH modeling can substitute for direct local observations. Similar theories of DBH modeling have been proposed in studies of both UAS-SfM and aerial-LiDAR individual tree detection [51,52]. Being able to use regional allometries to model DBH values in remotely sensed individual tree data sets would save substantial data processing time as DBH extraction accounted for 50% to 62% of all tree extraction data processing time in this study across the different depth map quality settings (unreported data).

Table S17. Posterior predicted tree height (m) mean error (bias) and 95% HDI by dense point cloud generation quality, filtering mode, and software after collapsing across other model factors.

Software	Quality	Filtering Mode	Height Mean Error (m) Median	HDI Low	HDI High
METASHAPE	lowest	aggressive	-0.65	-0.94	-0.36
		moderate	-0.55	-0.84	-0.27
		mild	-0.48	-0.77	-0.20
		disabled	-0.49	-0.77	-0.20
	low	aggressive	-0.32	-0.60	-0.03
		moderate	-0.26	-0.54	0.03
		mild	-0.19	-0.48	0.09
		disabled	-0.16	-0.45	0.13
	medium	aggressive	-0.03	-0.32	0.26
		moderate	0.04	-0.25	0.32

		mild	0.10	-0.19	0.38
		disabled	0.12	-0.16	0.41
	high	aggressive	0.16	-0.13	0.44
		moderate	0.22	-0.06	0.51
		mild	0.27	-0.02	0.56
		disabled	0.28	0.00	0.57
	ultra high	aggressive	0.26	-0.02	0.55
		moderate	0.32	0.04	0.61
		mild	0.37	0.08	0.65
		disabled	0.38	0.09	0.67
OPENDRONEMAP	lowest	aggressive	-0.07	-0.36	0.21
		moderate	0.00	-0.27	0.30
		mild	0.04	-0.24	0.33
		disabled	0.05	-0.23	0.33
	low	aggressive	0.00	-0.29	0.28
		moderate	0.05	-0.24	0.33
		mild	0.08	-0.21	0.36
		disabled	0.14	-0.15	0.42
	medium	aggressive	-0.01	-0.30	0.28
		moderate	0.04	-0.24	0.33
		mild	0.09	-0.20	0.37
		disabled	0.12	-0.17	0.40
	high	aggressive	0.16	-0.12	0.45
		moderate	0.21	-0.08	0.50
		mild	0.24	-0.05	0.52
		disabled	0.27	-0.02	0.55
	ultra high	aggressive	0.30	0.01	0.58
		moderate	0.35	0.06	0.63
		mild	0.38	0.09	0.66
		disabled	0.41	0.12	0.69
PIX4D	low	moderate	0.08	-0.21	0.37
		mild	0.16	-0.14	0.43
		disabled	0.20	-0.09	0.49
	medium	moderate	0.26	-0.03	0.55
		mild	0.32	0.04	0.61
		disabled	0.35	0.06	0.64
	high	moderate	0.35	0.07	0.64
		mild	0.40	0.13	0.70
		disabled	0.43	0.14	0.72

	ultra high	moderate	0.39	0.10	0.68
		mild	0.44	0.14	0.71
		disabled	0.47	0.18	0.76

Table S18. Posterior predicted tree height (m) RMSE (precision) and 95% HDI by dense point cloud generation quality, filtering mode, and software after collapsing across other model factors.

Software	Quality	Filtering Mode	Height RMSE (m) Median	HDI Low	HDI High
METASHAPE	lowest	aggressive	1.10	0.92	1.27
		moderate	1.07	0.90	1.24
		mild	1.04	0.86	1.21
		disabled	1.06	0.88	1.23
	low	aggressive	0.94	0.76	1.11
		moderate	0.91	0.74	1.08
		mild	0.88	0.71	1.05
		disabled	0.89	0.72	1.06
	medium	aggressive	0.80	0.63	0.98
		moderate	0.78	0.61	0.95
		mild	0.76	0.59	0.93
		disabled	0.77	0.60	0.94
	high	aggressive	0.79	0.62	0.96
		moderate	0.77	0.60	0.94
		mild	0.75	0.58	0.92
		disabled	0.77	0.59	0.94
	ultra high	aggressive	0.81	0.64	0.98
		moderate	0.79	0.61	0.96
		mild	0.77	0.60	0.94
		disabled	0.78	0.61	0.96
OPENDRONEMAP	lowest	aggressive	0.85	0.67	1.02
		moderate	0.85	0.68	1.03
		mild	0.82	0.65	0.99
		disabled	0.86	0.69	1.03
	low	aggressive	0.81	0.63	0.98
		moderate	0.82	0.64	0.99
		mild	0.79	0.63	0.97
		disabled	0.82	0.65	0.99
	medium	aggressive	0.83	0.66	1.00
		moderate	0.83	0.66	1.00
		mild	0.82	0.65	0.99
		disabled	0.85	0.68	1.02

	high	aggressive	0.79	0.62	0.96
		moderate	0.79	0.62	0.96
		mild	0.79	0.61	0.95
		disabled	0.81	0.64	0.98
	ultra high	aggressive	0.77	0.60	0.95
		moderate	0.78	0.60	0.94
		mild	0.77	0.59	0.94
		disabled	0.80	0.62	0.97
PIX4D	low	moderate	0.83	0.65	1.00
		mild	0.79	0.62	0.97
		disabled	0.81	0.64	0.99
	medium	moderate	0.78	0.61	0.95
		mild	0.77	0.59	0.94
		disabled	0.79	0.62	0.96
	high	moderate	0.80	0.63	0.97
		mild	0.79	0.62	0.96
		disabled	0.81	0.63	0.98
	ultra high	moderate	0.81	0.64	0.98
		mild	0.80	0.63	0.97
		disabled	0.82	0.65	0.99

Table S19. Posterior predicted tree height (m) RMSE (precision) and 95% HDI by dense point cloud generation quality and software after collapsing across other model factors.

Software	Quality	Height RMSE (m) Median	HDI Low	HDI High
METASHAPE	ultra high	0.79	0.60	0.96
	high	0.77	0.59	0.94
	medium	0.78	0.60	0.96
	low	0.90	0.73	1.08
	lowest	1.06	0.88	1.24
OPENDRONEMAP	ultra high	0.78	0.60	0.96
	high	0.80	0.62	0.97
	medium	0.83	0.66	1.01
	low	0.81	0.63	0.98
	lowest	0.84	0.66	1.02
PIX4D	ultra high	0.82	0.64	0.99
	high	0.80	0.62	0.98
	medium	0.78	0.60	0.96
	low	0.81	0.64	1.00

Table S20. Posterior predicted tree height (m) RMSE (precision) and 95% HDI by dense point cloud filtering mode and software after collapsing across other model factors.

Software	Filtering Mode	Height RMSE (m) Median	HDI Low	HDI High
METASHAPE	aggressive	0.88	0.68	1.07
	moderate	0.85	0.66	1.05
	mild	0.83	0.64	1.03
	disabled	0.84	0.65	1.04
OPENDRONEMAP	aggressive	0.82	0.62	1.01
	moderate	0.82	0.62	1.01
	mild	0.80	0.61	0.99
	disabled	0.83	0.64	1.02
PIX4D	aggressive	0.83	0.63	1.04
	moderate	0.83	0.63	1.02
	mild	0.81	0.61	1.01
	disabled	0.83	0.63	1.02

Table S21. Posterior predicted difference in tree height (m) RMSE (i.e. contrast) and 95% HDI between software by dense point cloud generation quality after collapsing across other model factors. Lower RMSE values mean that UAS values better match field measurements and, as such, a contrast (i.e. difference) in RMSE that is negative (difference<0) indicates that the left hand side (L.H.S.) setting is more accurate than the right hand side (R.H.S.) setting of the contrast and vice versa. The probability (Pr) that the contrast is negative was calculated from the posterior predictive distribution as the proportion of the posterior distribution where the contrast was less than zero.

Quality	Median Difference Height RMSE (m)	HDI Low	HDI High	Pr(diff<0)
OPENDRONEMAP - METASHAPE				
ultra high	-0.01	-0.09	0.08	57%
high	0.03	-0.05	0.11	25%
medium	0.06	-0.03	0.14	9%
low	-0.09	-0.18	-0.01	99%
lowest	-0.22	-0.31	-0.13	100%
PIX4D - METASHAPE				
ultra high	0.03	-0.06	0.12	26%
high	0.03	-0.05	0.13	23%
medium	0.01	-0.08	0.10	44%
low	-0.09	-0.18	0.00	97%
PIX4D - OPENDRONEMAP				
ultra high	0.04	-0.05	0.13	21%
high	0.00	-0.08	0.10	46%
medium	-0.05	-0.14	0.04	87%

low	0.01	-0.08	0.10	44%

Table S22. Posterior predicted difference in tree height (m) RMSE (i.e. contrast) and 95% HDI between dense point cloud generation quality by software after collapsing across other model factors. Lower RMSE values mean that UAS values better match field measurements and, as such, a contrast (i.e. difference) in RMSE that is negative (difference<0) indicates that the left hand side (L.H.S.) setting is more accurate than the right hand side (R.H.S.) setting of the contrast and vice versa. The probability (Pr) that the contrast is negative was calculated from the posterior predictive distribution as the proportion of the posterior distribution where the contrast was less than zero.

Software	Quality Contrast	Median Difference Height RMSE (m)	HDI Low	HDI High	Pr(diff<0)
METASHAPE	ultra high - high	0.02	-0.06	0.10	33%
	ultra high - medium	0.01	-0.07	0.09	40%
	ultra high - low	-0.12	-0.20	-0.04	100%
	ultra high - lowest	-0.28	-0.36	-0.19	100%
	high - medium	-0.01	-0.09	0.07	58%
	high - low	-0.13	-0.21	-0.05	100%
	high - lowest	-0.29	-0.38	-0.21	100%
	medium - low	-0.13	-0.21	-0.05	100%
	medium - lowest	-0.29	-0.37	-0.20	100%
	low - lowest	-0.16	-0.24	-0.08	100%
OPENDRONEMAP	ultra high - high	-0.02	-0.10	0.06	68%
	ultra high - medium	-0.05	-0.13	0.03	91%
	ultra high - low	-0.03	-0.11	0.05	77%
	ultra high - lowest	-0.06	-0.15	0.02	94%
	high - medium	-0.04	-0.11	0.04	82%
	high - low	-0.01	-0.09	0.07	61%
	high - lowest	-0.05	-0.13	0.04	86%
	medium - low	0.02	-0.05	0.10	27%
	medium - lowest	-0.01	-0.10	0.07	60%
	low - lowest	-0.04	-0.12	0.04	80%
PIX4D	ultra high - high	0.01	-0.08	0.10	38%
	ultra high - medium	0.03	-0.06	0.12	23%
	ultra high - low	0.00	-0.09	0.09	50%
	high - medium	0.02	-0.07	0.11	34%
	high - low	-0.01	-0.10	0.08	61%
	medium - low	-0.03	-0.12	0.06	76%

Table S23. Posterior predicted difference in tree height (m) RMSE (i.e. contrast) and 95% HDI between dense point cloud filtering mode by software after collapsing across other model factors. Lower RMSE values mean that UAS values better match field measurements and, as such, a contrast (i.e. difference) in RMSE that is negative (difference<0) indicates that the left hand side (L.H.S.) setting is more accurate than the right hand side (R.H.S.) setting of the contrast and vice versa. The probability (Pr) that the contrast is negative was calculated from the posterior predictive distribution as the proportion of the posterior distribution where the contrast was less than zero.

Software	Filtering Contrast	Median Difference Height RMSE (m)	HDI Low	HDI High	Pr(diff<0)
METASHAPE	disabled - mild	0.01	-0.04	0.07	30%
	disabled - moderate	-0.01	-0.06	0.05	61%
	disabled - aggressive	-0.03	-0.10	0.03	84%
	mild - moderate	-0.02	-0.08	0.03	79%
	mild - aggressive	-0.04	-0.11	0.01	93%
	moderate - aggressive	-0.02	-0.09	0.03	79%
OPENDRONEMAP	disabled - mild	0.03	-0.02	0.09	15%
	disabled - moderate	0.01	-0.04	0.07	34%
	disabled - aggressive	0.01	-0.04	0.08	32%
	mild - moderate	-0.02	-0.07	0.04	73%
	mild - aggressive	-0.01	-0.07	0.05	67%
	moderate - aggressive	0.00	-0.05	0.06	46%
PIX4D	disabled - mild	0.02	-0.04	0.08	24%
	disabled - moderate	0.00	-0.06	0.06	47%
	mild - moderate	-0.02	-0.08	0.04	74%

Table S24. Posterior predicted tree DBH (cm) mean error (bias) and 95% HDI by dense point cloud generation quality, filtering mode, and software after collapsing across other model factors.

Software	Quality	Filtering Mode	DBH Mean Error (cm) Median	HDI Low	HDI High
METASHAPE	lowest	aggressive	-1.7	-6.2	3.0
		moderate	-1.5	-6.1	3.1
		mild	-1.3	-6.0	3.2
		disabled	-1.3	-5.9	3.4
	low	aggressive	-0.4	-5.0	4.2
		moderate	-0.3	-4.9	4.3
		mild	-0.1	-4.5	4.7
		disabled	-0.1	-4.7	4.5
	medium	aggressive	0.4	-4.3	4.9
		moderate	0.5	-4.3	4.9
		mild	0.7	-4.0	5.2
		disabled	0.7	-3.9	5.2

	high	aggressive	0.8	-3.7	5.5
		moderate	0.9	-3.6	5.6
		mild	1.0	-3.4	5.7
		disabled	1.0	-3.4	5.7
	ultra high	aggressive	0.9	-3.7	5.4
		moderate	1.0	-3.6	5.6
		mild	1.1	-3.4	5.8
		disabled	1.1	-3.6	5.7
OPENDRONEMAP	lowest	aggressive	0.6	-4.0	5.2
		moderate	0.8	-3.7	5.5
		mild	0.9	-3.7	5.4
		disabled	0.8	-3.8	5.4
	low	aggressive	0.7	-3.9	5.3
		moderate	0.9	-3.7	5.5
		mild	1.0	-3.6	5.6
		disabled	1.0	-3.6	5.5
	medium	aggressive	0.6	-4.0	5.2
		moderate	0.8	-3.8	5.4
		mild	0.9	-3.8	5.4
		disabled	0.8	-3.8	5.4
	high	aggressive	1.1	-3.5	5.8
		moderate	1.2	-3.4	5.8
		mild	1.2	-3.5	5.7
		disabled	1.2	-3.3	5.9
	ultra high	aggressive	1.1	-3.5	5.7
		moderate	1.3	-3.4	5.8
		mild	1.3	-3.4	5.8
		disabled	1.2	-3.3	5.9
PIX4D	low	moderate	0.8	-3.8	5.3
		mild	0.8	-3.7	5.4
		disabled	0.8	-3.8	5.4
	medium	moderate	0.8	-3.8	5.4
		mild	0.9	-3.8	5.4
		disabled	0.8	-3.6	5.6
	high	moderate	0.8	-3.8	5.5
		mild	0.9	-3.5	5.7
		disabled	0.9	-3.7	5.5
	ultra high	moderate	1.0	-3.6	5.6
		mild	1.0	-3.7	5.5

		disabled	1.0	-3.5	5.7

Table S25. Posterior predicted tree DBH (cm) RMSE (precision) and 95% HDI by dense point cloud generation quality, filtering mode, and software after collapsing across other model factors.

Software	Quality	Filtering Mode	DBH RMSE (cm) Median	HDI Low	HDI High
METASHAPE	lowest	aggressive	7.4	3.9	10.7
		moderate	7.3	3.8	10.7
		mild	7.0	3.5	10.4
		disabled	7.0	3.6	10.4
	low	aggressive	7.0	3.5	10.4
		moderate	6.9	3.3	10.3
		mild	6.7	3.1	10.0
		disabled	6.7	3.2	10.0
	medium	aggressive	6.6	3.1	10.0
		moderate	6.4	2.9	9.8
		mild	6.3	2.8	9.7
		disabled	6.3	2.8	9.7
	high	aggressive	6.4	2.9	9.8
		moderate	6.2	2.7	9.6
		mild	6.1	2.6	9.5
		disabled	6.1	2.6	9.5
	ultra high	aggressive	6.3	2.7	9.6
		moderate	6.1	2.6	9.5
		mild	6.0	2.5	9.4
		disabled	6.0	2.5	9.4
OPENDRONEMAP	lowest	aggressive	6.8	3.2	10.1
		moderate	6.7	3.1	10.0
		mild	6.7	3.2	10.1
		disabled	6.7	3.1	10.1
	low	aggressive	6.7	3.1	10.0
		moderate	6.6	3.1	10.0
		mild	6.5	3.0	9.9
		disabled	6.5	3.0	9.9
	medium	aggressive	6.5	3.0	9.9
		moderate	6.5	3.0	9.9
		mild	6.5	3.0	9.9
		disabled	6.5	3.0	9.9
	high	aggressive	6.2	2.7	9.6
		moderate	6.2	2.7	9.6

		mild	6.2	2.7	9.6
		disabled	6.2	2.7	9.6
	ultra high	aggressive	5.9	2.3	9.2
		moderate	5.8	2.3	9.2
		mild	5.8	2.3	9.2
		disabled	5.8	2.2	9.1
PIX4D	low	moderate	6.5	3.0	9.9
		mild	6.2	2.6	9.5
		disabled	6.2	2.6	9.6
	medium	moderate	6.1	2.6	9.5
		mild	5.9	2.4	9.3
		disabled	5.9	2.4	9.3
	high	moderate	5.8	2.3	9.2
		mild	5.7	2.3	9.2
		disabled	5.7	2.3	9.2
	ultra high	moderate	5.8	2.2	9.1
		mild	5.7	2.1	9.0
		disabled	5.6	2.1	9.0

Table S26. Posterior predicted tree DBH (cm) RMSE (precision) and 95% HDI by dense point cloud generation quality and software after collapsing across other model factors.

Software	Quality	DBH RMSE (cm) Median	HDI Low	HDI High
METASHAPE	ultra high	6.1	2.5	9.5
	high	6.2	2.6	9.5
	medium	6.4	3.0	9.9
	low	6.8	3.3	10.2
	lowest	7.1	3.7	10.6
OPENDRONEMAP	ultra high	5.8	2.3	9.2
	high	6.2	2.6	9.6
	medium	6.5	2.9	9.9
	low	6.6	3.0	10.0
	lowest	6.7	3.2	10.1
PIX4D	ultra high	5.7	2.3	9.3
	high	5.8	2.3	9.2
	medium	6.0	2.4	9.4
	low	6.3	2.8	9.7

Table 27. Posterior predicted tree DBH (cm) RMSE (precision) and 95% HDI by dense point cloud filtering mode and software after collapsing across other model factors.

Software	Filtering mode	DBH RMSE (cm) Median	HDI Low	HDI High
METASHAPE	aggressive	6.7	3.1	10.1
	moderate	6.6	3.0	10.0
	mild	6.4	2.9	9.8
	disabled	6.4	2.9	9.9
OPENDRONEMAP	aggressive	6.4	2.9	9.8
	moderate	6.3	2.8	9.7
	mild	6.3	2.8	9.8
	disabled	6.3	2.8	9.8
PIX4D	aggressive	6.2	2.7	9.7
	moderate	6.2	2.6	9.6
	mild	6.0	2.5	9.5
	disabled	6.0	2.4	9.4

Table S28. Posterior predicted difference in tree DBH (cm) RMSE (i.e. contrast) and 95% HDI between software by dense point cloud generation quality after collapsing across other model factors. Lower RMSE values mean that UAS values better match field measurements and, as such, a contrast (i.e. difference) in RMSE that is negative (difference<0) indicates that the left hand side (L.H.S.) setting is more accurate than the right hand side (R.H.S.) setting of the contrast and vice versa. The probability (Pr) that the contrast is negative was calculated from the posterior predictive distribution as the proportion of the posterior distribution where the contrast was less than zero.

Quality	Median Difference DBH RMSE (cm)	HDI Low	HDI How	Pr(diff<0)
OPENDRONEMAP - METASHAPE				
ultra high	-0.2	-0.7	0.2	87%
high	0.0	-0.5	0.5	56%
medium	0.1	-0.4	0.6	39%
low	-0.2	-0.7	0.2	83%
lowest	-0.4	-1.0	0.1	96%
PIX4D - METASHAPE				
ultra high	-0.3	-0.9	0.2	88%
high	-0.4	-0.9	0.1	93%
medium	-0.4	-0.9	0.2	92%
low	-0.5	-1.0	0.1	96%
PIX4D - OPENDRONEMAP				
ultra high	-0.1	-0.6	0.5	61%
high	-0.4	-0.9	0.1	93%
medium	-0.5	-1.0	0.1	96%

low	-0.2	-0.8	0.3	83%

Table S29. Posterior predicted difference in tree DBH (cm) RMSE (i.e. contrast) and 95% HDI between dense point cloud generation quality by software after collapsing across other model factors. Lower RMSE values mean that UAS values better match field measurements and, as such, a contrast (i.e. difference) in RMSE that is negative (difference<0) indicates that the left hand side (L.H.S.) setting is more accurate than the right hand side (R.H.S.) setting of the contrast and vice versa. The probability (Pr) that the contrast is negative was calculated from the posterior predictive distribution as the proportion of the posterior distribution where the contrast was less than zero.

Software	Quality Contrast	Median Difference DBH RMSE (cm)	HDI Low	HDI High	Pr(diff<0)
METASHAPE	ultra high - high	-0.1	-0.6	0.3	74%
	ultra high - medium	-0.3	-0.8	0.2	91%
	ultra high - low	-0.7	-1.2	-0.2	100%
	ultra high - lowest	-1.1	-1.6	-0.6	100%
	high - medium	-0.2	-0.6	0.3	78%
	high - low	-0.6	-1.0	-0.1	99%
	high - lowest	-0.9	-1.5	-0.4	100%
	medium - low	-0.4	-0.9	0.1	96%
	medium - lowest	-0.7	-1.3	-0.2	100%
	low - lowest	-0.4	-0.8	0.1	93%
OPENDRONEMAP	ultra high - high	-0.4	-0.9	0.1	94%
	ultra high - medium	-0.6	-1.2	-0.2	100%
	ultra high - low	-0.7	-1.2	-0.3	100%
	ultra high - lowest	-0.9	-1.4	-0.4	100%
	high - medium	-0.3	-0.8	0.2	89%
	high - low	-0.4	-0.8	0.1	94%
	high - lowest	-0.5	-1.0	0.0	97%
	medium - low	-0.1	-0.6	0.4	65%
	medium - lowest	-0.2	-0.8	0.3	79%
	low - lowest	-0.1	-0.6	0.4	71%
PIX4D	ultra high - high	-0.1	-0.6	0.5	61%
	ultra high - medium	-0.3	-0.8	0.3	83%
	ultra high - low	-0.6	-1.1	0.0	98%
	high - medium	-0.2	-0.7	0.3	78%
	high - low	-0.5	-1.0	0.0	98%
	medium - low	-0.3	-0.8	0.2	90%

Table S30. Posterior predicted difference in tree DBH (cm) RMSE (i.e. contrast) and 95% HDI between dense point cloud filtering mode by software after collapsing across other model factors. Lower RMSE values mean that UAS values better match field measurements and, as such, a contrast (i.e. difference) in RMSE that is negative (difference<0) indicates that the left hand side (L.H.S.) setting is more accurate than the right hand side (R.H.S.) setting of the contrast and vice versa. The probability (Pr) that the contrast is negative was calculated from the posterior predictive distribution as the proportion of the posterior distribution where the contrast was less than zero.

Software	Filtering Contrast	Median Difference DBH RMSE (cm)	HDI Low	HDI High	Pr(diff<0)
METASHAPE	disabled - mild	0.0	-0.4	0.4	48%
	disabled - moderate	-0.1	-0.5	0.2	79%
	disabled - aggressive	-0.3	-0.7	0.1	93%
	mild - moderate	-0.1	-0.5	0.2	80%
	mild - aggressive	-0.3	-0.8	0.1	94%
	moderate - aggressive	-0.1	-0.6	0.2	78%
OPENDRONEMAP	disabled - mild	0.0	-0.4	0.3	55%
	disabled - moderate	0.0	-0.4	0.4	57%
	disabled - aggressive	-0.1	-0.5	0.3	68%
	mild - moderate	0.0	-0.4	0.4	52%
	mild - aggressive	-0.1	-0.5	0.4	64%
	moderate - aggressive	-0.1	-0.4	0.3	63%
PIX4D	disabled - mild	0.0	-0.4	0.3	55%
	disabled - moderate	-0.2	-0.6	0.2	83%
	mild - moderate	-0.1	-0.6	0.2	80%