FIG Working Week 2023
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Protecting Our World, Conquering New Frontiers

The Use of Remote Sensing Technologies to Perform Tree Surveys

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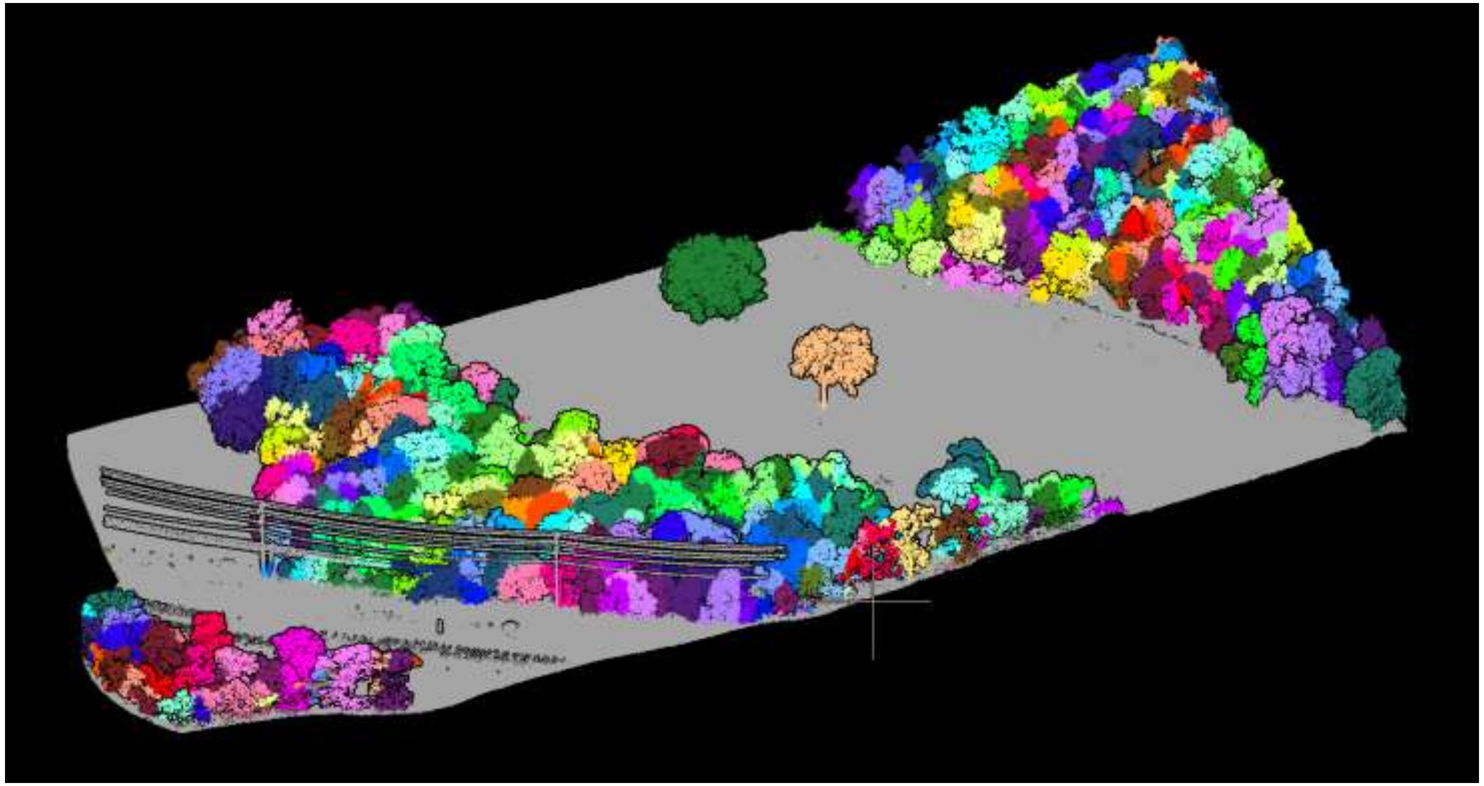
The Use of Remote Sensing Technologies to Perform Tree Surveys

Remote Sensing Technology:

- Aids urban forest management by providing valuable information about the distribution, health, and composition of vegetation
- Remote sensing data can be seamlessly integrated into GIS platforms, enabling spatial analysis and mapping of tree inventories
- Saves time & money!

The Use of Remote Sensing Technologies to Perform Tree Surveys

- **WHY:** Determine client goals – How can remote sensing technology be a solution for your client's project?
- **WHAT:** Determine remote system requirements: system accuracies, limitations, and cost.
- **WHERE**: Acquisition logistics, environmental site factors, and project airspace restrictions.



Solution

Determine which sensor technologies fit project expectations and budget

The TrueView 635 payload attached to a DJI Matrice 600 was selected and used for our representative project

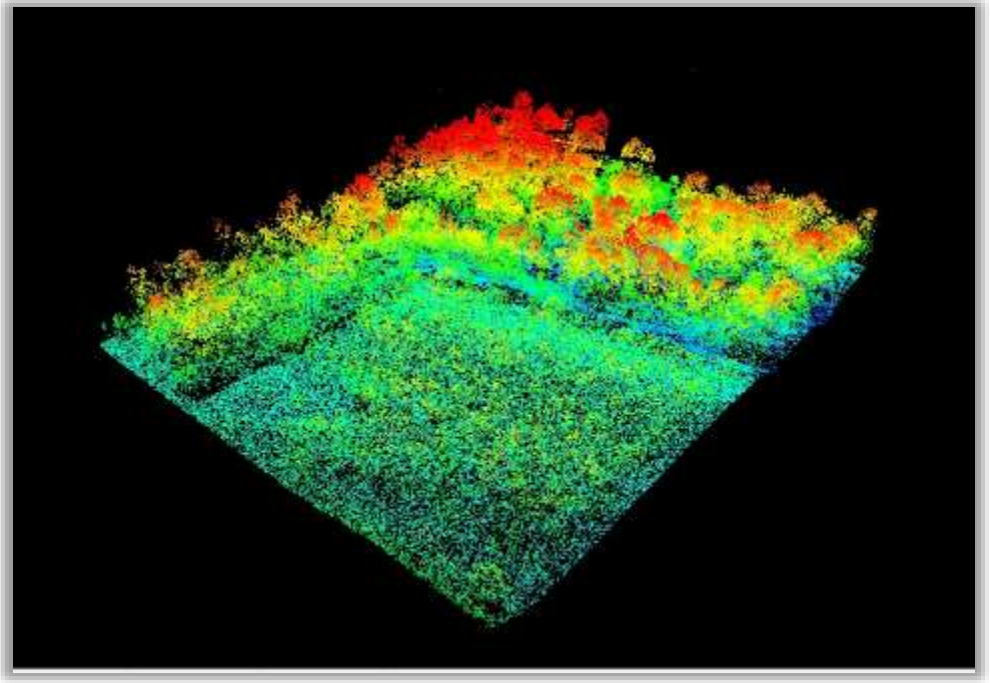
Flight Planning

- Validate flight plan covers the area of interest (AOI).
- Validate sensor settings to ensure point density meets project requirements.
- Validate flight plan design contains proper forward & side lap within the project area allowing proper target detection.

True View 635			
Flight Parameters	**Value**	**Units**	**Notes**
I plan to fly at this height (in meters)	60	m	Maximum effective altitude for True View 6xx is 100 m.
I plan to fly at this speed (in m/s)	5	m/s	Drone-dependent; recommend 5 m/s for typical projects.
I plan to have this total field-of-view (full angle, in degrees)	40	Degrees	Variable; recommend no greater then 90 degrees max, 80 degrees or less preferred.
I plan to have this %overlap (side)	50%	%	%overlap between adjacent flight lines.
I want to use this pulse repetion frequency (in KHz))	300	kHz	True View 6xx can be set to 100, 200, or 300 kHz.
I want to use this scan rate (Hz)	63.07	Hz	Scans 360 degrees. True View 6xx adjustable from 10 Hz - 100 Hz
... But the scan rate for uniform point spacing will be	*63.078*	Hz	See side note.
... I will need to set the angular step width to	*0.0757*	*degrees*	For uniform along/cross-track spacing.
... I will get this swath width on the ground	*100.69*	m	
... I will need to use this line-to-line spacing	50.35	m	See Line Spacing tab for Max Values
... I will get this average point density (single pass)	*152.64*	pts/m^2	Sampling rate only, does not consider multiple retruns per pulse.
... I will get this average point density (overlap)	*305.28*	pts/m^2	Sampling rate only, does not consider multiple retruns per pulse.
... I will get this point spacing (cross-track at nadir)	*7.93*	*cm*	Spacing at Nadir. Use the side note to calculate settings for uniform spacing.
... I will get this point spacing (along track at nadir)	*7.93*	*cm*	Spacing at Nadir. Use the side note to calculate settings for uniform spacing.
... I will have a spot size (cross-track at nadir)	*9.60*	*cm*	At Nadir
... I will have a spot size (along-track at nadir)	*3.0*	*cm*	At Nadir
System Parameters (From Manufacturer)	**Value**	**Units**	**Notes**
Pulse Repetition Frequency (PRF)	300.00	kHz	Sampling rate only, does not consider multiple returns per pulse.
Scan Rate	63.07	Hz	From above.
Beam Divergence (Cross-Track, full angle)	1.6	mrad	From manufacturer.
Beam Divergence (Along-Track, full angle)	0.5	mrad	From manufacturer.
#Channels	1	#	For multibeam/fan-type laser scanners
Operational Parameters (Calculated From Above Settings)	**Value**	**Units**	**Notes**
Altitude	60	m	From above.
Average Speed	5	m/s	From above.
Field of View (FOV) (Full)	40	Degrees	From above.
Effective Sampling Rate (ESR)	33.33	kHz	FOV/360*PRF
Swath Width	43.68	m	2*ALT*TAN(FOV/2)*PI/180
Swath Length	5	m	Average Speed
Swath Coverage	218.38	m^2/s	Product of Above 2 Parameters
Average Point Density	152.64	pts/m^2	ESR/Swath Coverage
Cross-Track Point Spacing	7.93	cm	Same as Per Channel calculation below.
Along-Track Line Spacing	7.93	cm	Same as All Channel calculation below.
Spot Size (Cross-Track)	9.60	cm	2*ALT*TAN((BD/2)/1000)*100
Spot Size (Along-Track)	3.00	cm	2*ALT*TAN((BD/2)/1000)*101
Per Channel Calculations			
PRF/Channel (kHz)	300.00	kHz	PRF/#Channels
Effective Sampling Rate (ESR) (kHz)(Per Channel)	33.33	kHz	FOV/360*(PRF Per Channel)
Average Point Density (pts/m^2)(Per Channel)	152.64	pts/m^2	(ESR Per Channel)/Swath Coverage
Angular Rate of Change Per Pulse (Per Channel)	0.076	deg/pulse	(360*SR)/(PRF/Channel)
Cross-Track Point Spacing (m)(Per Channel)	7.93	cm	ALT*TAN(ARC)*PI/180
Along-Track Line Spacing (m)(Per Channel)	7.93	cm	Speed/Scan Rate
Along-Track Line Spacing (m)(All Channels)	7.93	cm	Speed/Scan Rate/#Channels
Channel-To-Channel Seperation (m)	3.4	m	3.2 degree seperation on Ground from Altitude Specified
Scan Lag	42.28	#	#Scans Difference between Adjacent Channels Along-Track
Time Lag (s)	0.67	s	Time Difference between Adjacent Channels Along-Track

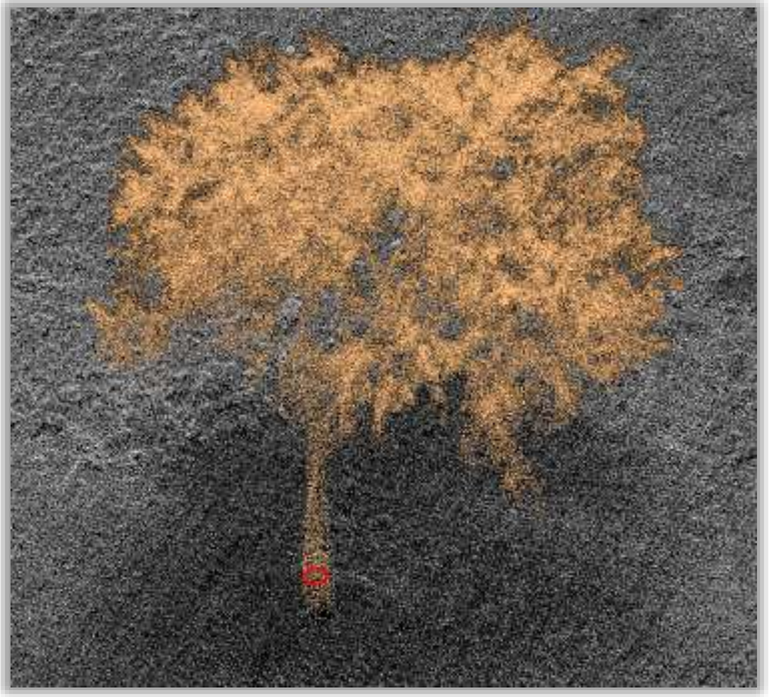
Post Processing – Initial Processing

- Airborne GPS processing
- Image georeferencing
- Point cloud geocoding
- Relative flight line adjustment & error debiasing
- **Data accuracy validation**



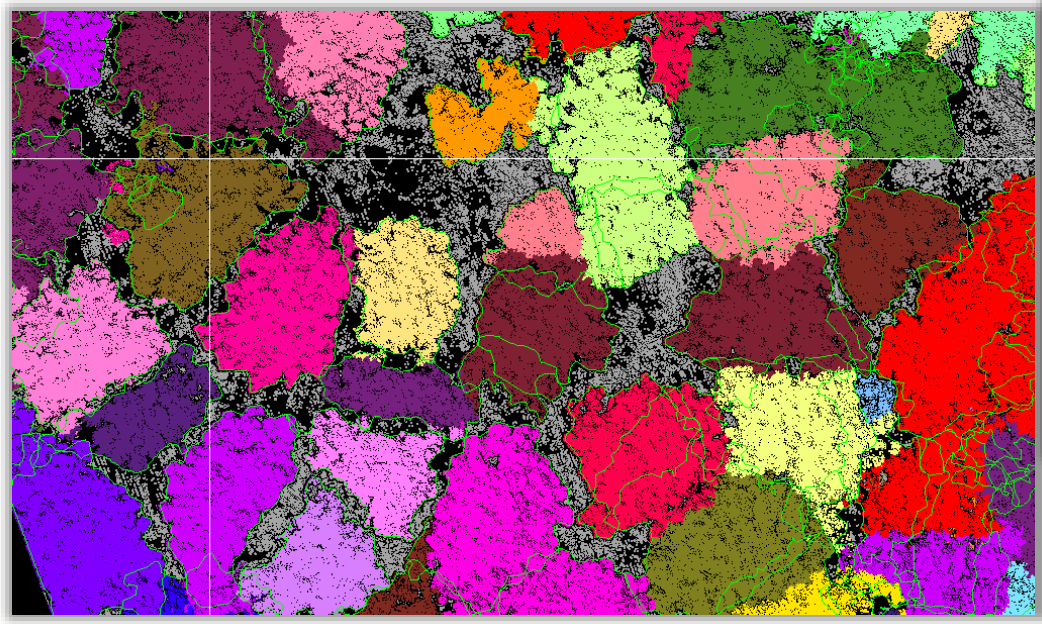
Tree Segmentation

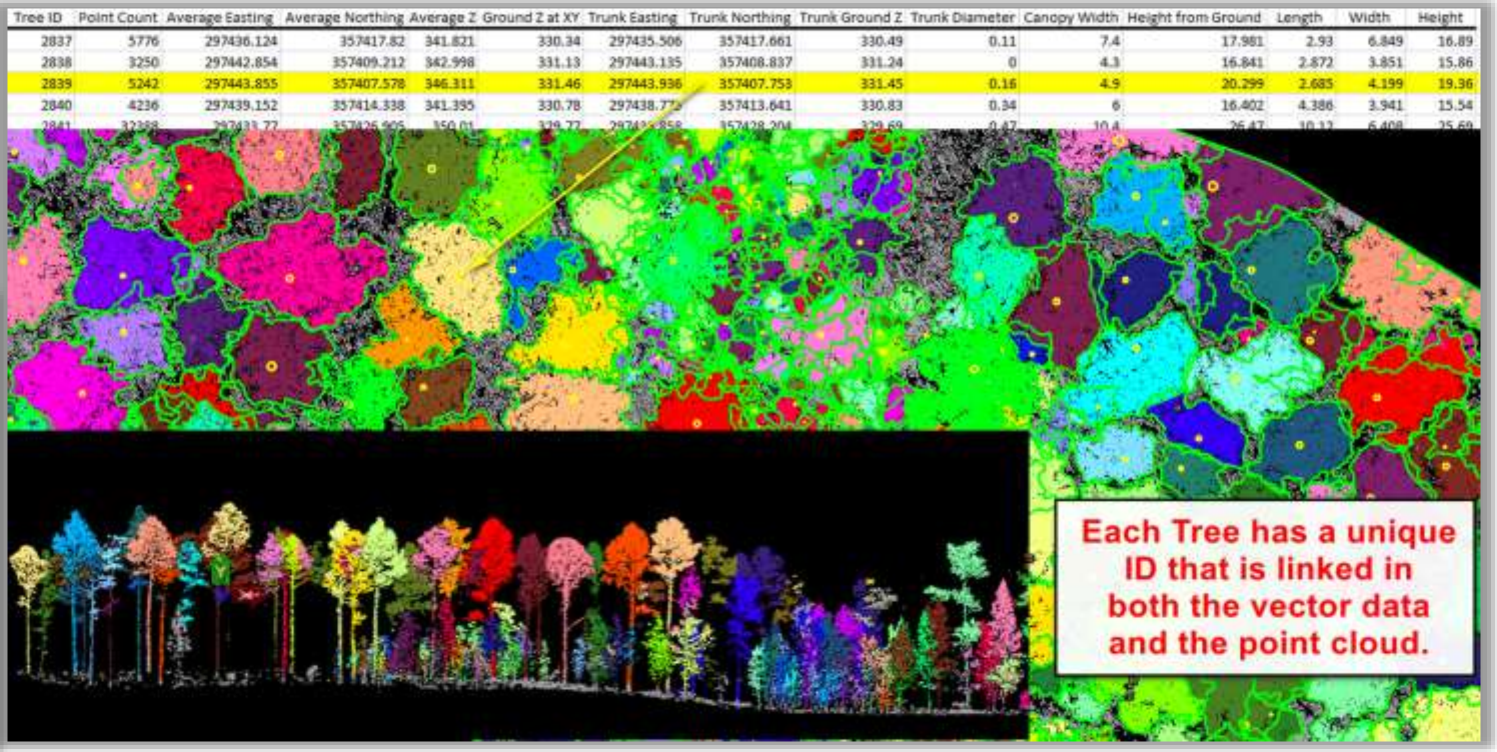
Machine Learning algorithm classifies, filters, and segments the point cloud data allowing for the discernment of individual trees. The dataset is then analyzed to generate a series of critical tree characteristics such as tree height, crown spread, crown height, and trunk diameter at breast height (DBH).



Extracted Deliverables

Tree canopy geometry along with computed tree analysis criteria is joined and extracted.



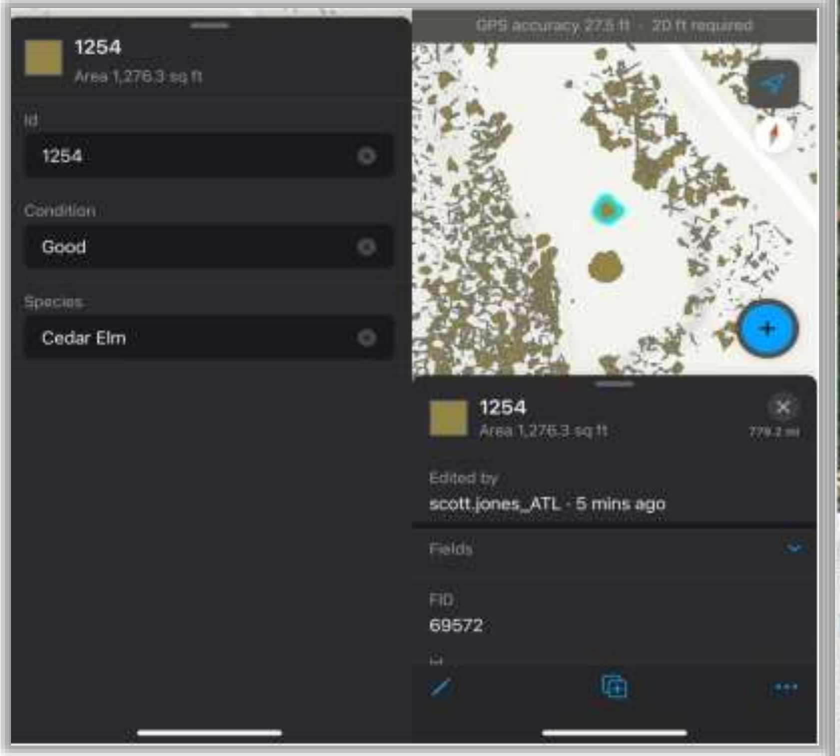


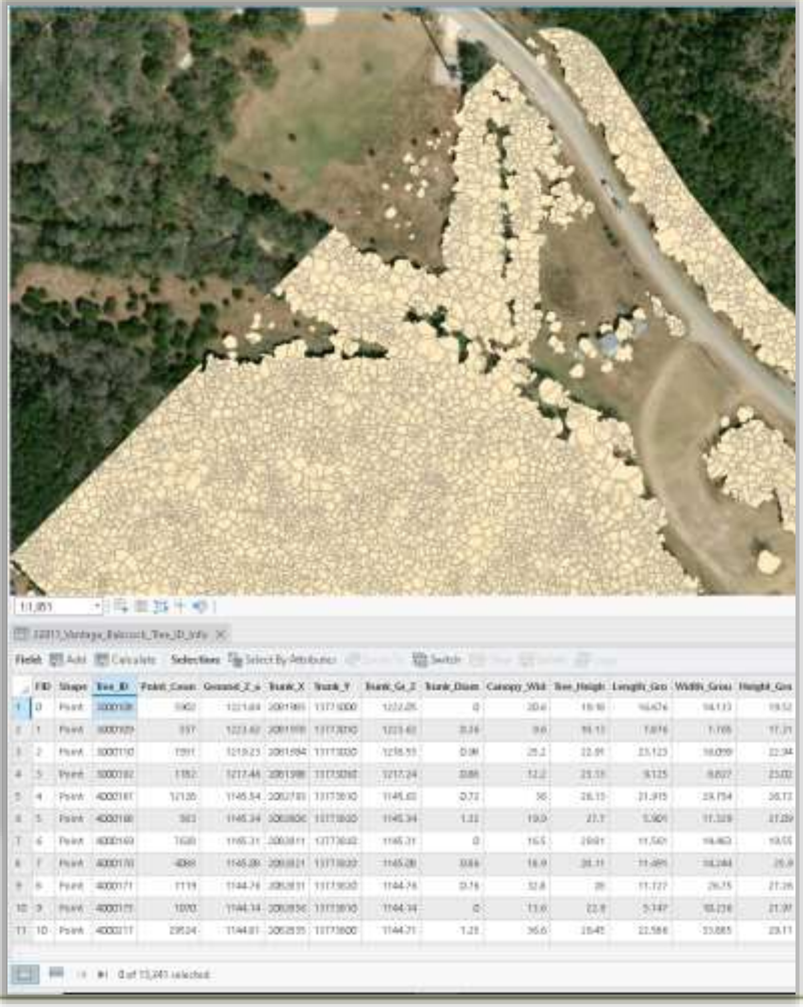
Tree ID	Point Count	Average Easting	Average Northing	Average Z	Ground Z at XY	Trunk Easting	Trunk Northing	Trunk Ground Z	Trunk Diameter	Canopy Width	Height from Ground	Length	Width	Height
2837	5776	297436.124	357417.82	341.821	330.34	297435.506	357417.661	330.49	0.11	7.4	17.981	2.93	6.849	16.89
2838	3250	297442.854	357409.212	342.998	331.13	297443.135	357408.837	331.24	0	4.3	16.841	2.872	3.851	15.86
2839	5242	297443.855	357407.578	346.311	331.46	297443.936	357407.753	331.45	0.16	4.9	20.299	2.685	4.199	19.36
2840	4236	297439.152	357414.338	341.395	330.78	297438.77[illegible]	357413.641	330.83	0.34	6	16.402	4.386	3.941	15.54
2841	32388	297433.77	357426.905	350.01	329.77	[illegible]	357428.204	329.69	0.47	10.4	26.47	10.12	6.408	25.69

Field Verification

Extracted canopy data is uploaded to an ESRI enterprise database for field validation. Field crews use ESRI's Field Maps application to update, edit and verify processing results in real-time.

All data is synchronized within the ArcGIS Online cloud for data integrity and viewing by both client and WGI associates.





What's next? Looking Forward

WGI has partnered with AKULAR to create an innovative approach to field validation using Virtual Reality (VR).

Collection methods such as diameter at breast height (DBH) measurements can now be collected within the safety of the office.