

Field Report on Quantix UAV



MECHANICAL ENGINEERING
TEXAS A&M UNIVERSITY

OVERVIEW

Through a generous donation from AeroVironment, the MEEN UAS team operated a Quantix UAV to conduct aerial surveys at the Texas A&M University Farms in Burleson County for the 2019 growing season. Most of the surveys were in support of a research project being conducted by Dr. Seth Murray titled "Aerial and Ground Phenotyping Analytical Tool Development for Plant Breeders using the Maize G2F Project". Additional surveys were conducted over larger research fields in order to evaluate the operating limitations of the UAV.

Equipment Used

The Quantix UAV, shown in Figure 1, was used to collect both visual and multispectral imagery data. This UAV features an innovative VTOL (vertical takeoff and landing) hybrid design. Quantix is purpose-built for crop scouting, and can survey up to 400 acres in just 45 minutes.



Figure 1. AeroVironment Quantix

During flight, integrated sensors capture high-resolution color (i.e. RGB) and multispectral imagery via dual 18MP cameras. The spectrum range for the RGB camera is 425 – 675nm with the following peak values:

- Blue: 455nm peak
- Green: 535nm peak
- Red: 600nm peak

The spectral bands for the Multispectral camera are:

- Green: 538-589nm, 550nm peak
- Red: 583-676nm, 610nm peak
- Near-infrared: 798-891nm, 829nm peak

On-board processing delivers true color and NDVI imagery on the included operating tablet as soon as the drone lands, allowing growers to ground-truth issues while still in the field. For more detailed analysis, Quantix seamlessly integrates with AV DSS to perform advanced image processing and data analytics including True Color, NDVI, GNDVI, canopy coverage, anomaly detection and more. These analytics provide users with deeper insights into plant emergence, vegetative health, inputs and resource management.

Aerial Survey Data

Dates	05/05/2019 to 07/31/2019
Location	Texas A&M University Farm
Fields	Corn, Cotton, Sorghum
Altitudes	150ft and 360ft
Quantix RGB/NIR Survey:	
Ground Sample Distance (i.e. Resolution)	RGB: 1cm/px @ 150ft 2.5cm/px @ 360ft NIR: 2cm/px @ 150ft 5cm/px @ 360 ft

Available Files:

- Quantix – True Color
- Quantix – Multispectral
- NDVI
- Canopy Coverage
- Anomaly Layer

Point of Contact:

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Aerial Surveys Completed with Quantix UAV

As of July 31, the MEEN UAS Team completed 50 surveys of a corn field with the Quantix over 27 separate flight days during an 88-day calendar period. It proved to be an exceptional UAV for conducting the crop surveys, performing flawlessly for each and every flight we conducted with it. It also greatly simplified flight operations. With its automated generation of flight plans, the UAV only requires the pilot to select the desired survey area on the operating tablet, as shown in Figure 2. Also, with its dual cameras, the UAV conducts both a visual and multispectral survey in one flight.



Figure 2. Selection of Survey Area for Quantix

Once a series of pre-flight checks are completed on the Quantix, the pilot launches the UAV vertically and monitors its flight. Once it completes the survey, the UAV returns to the launch location, landing vertically. Then, the operating tablet provides a “Quick Look” of the survey, allowing the pilot to address any issues while still in the field.

Processing of Quantix Imagery Data

The imagery data from the Quantix was uploaded to the AeroVironment Decision Support System (AV DSS) to perform advanced image processing and data analytics including True Color, NDVI, GNDVI, canopy coverage, and anomaly detection. These orthomosaic maps and charts can be viewed in the AV DSS using the email address and password provided on the overview page. Under the location in the DSS Dashboard, one can view details in four tabs – Information, Data Collections, Charts, and Alerts.

Information – Shown in Figure 3, the Information tab includes the Geo Location, Crop, Acreage, Season Start Date, and Season End Date. When viewing details under this tab, a separate window shows an orthomosaic map of the survey area.



Figure 3. Information Tab in AV DSS

In this viewing window, shown in Figure 4, one can select the collection date, the imagery (True Color, Enhanced Color, NDVI, or GNDVI), canopy coverage, anomaly detection, and other options to view on the map. The team typically conducted two flights, one at an altitude of 150 feet and another at 360 feet (default altitude), on most collection dates for the research field. If two flights were conducted on the same date, the imagery option will show the time of the flight, which the user can select.

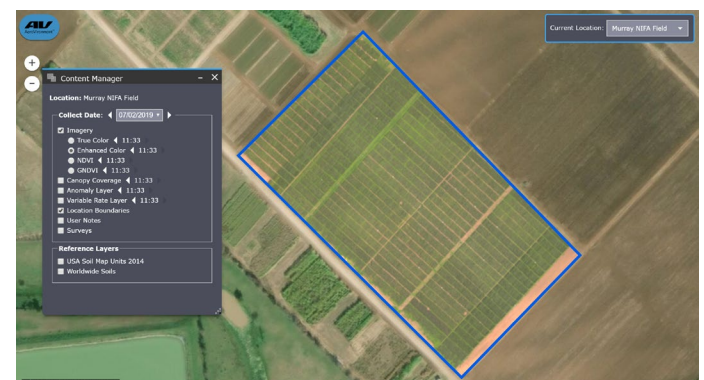


Figure 4. Orthomosaic Map of Research Field

Data Collections – The Data Collections tab, shown in Figure 5, provides a table listing collections dates with options for selecting products or reports.

Collect Date	Products	Reports	Resolution
07/31/19 10:42 AM CDT	[Download]	[Download]	Standard
07/31/19 10:31 AM CDT	[Download]	[Download]	Standard
07/26/19 10:54 AM CDT	[Download]	[Download]	Standard
07/26/19 10:46 AM CDT	[Download]	[Download]	Standard
07/24/19 12:38 PM CDT	[Download]	[Download]	Standard
07/24/19 12:28 PM CDT	[Download]	[Download]	Standard

Figure 5. Data Collections Tab in AV DSS

The download icon under the Products column allows the user to download an image or zip file to a local folder.

- Quantix - True Color (TIF image)
- Quantix - Multispectral (TIF image)
- NDVI (TIF image)
- Canopy Coverage (zip file)
- Anomaly Layer (zip file)

The icon under the Reports column opens another window with a PDF of the DSS Field Report produced for each survey completed. This report includes information such as location, date/time, and flight altitude, along with maps for the True Color, NDVI, GNDVI, Canopy Coverage, and Anomaly. A sample DSS Field Report is included in the appendix.

Charts – The Charts tab, shown in Figure 6, provides charts of the Canopy Coverage and Anomaly Coverage over time for the location.

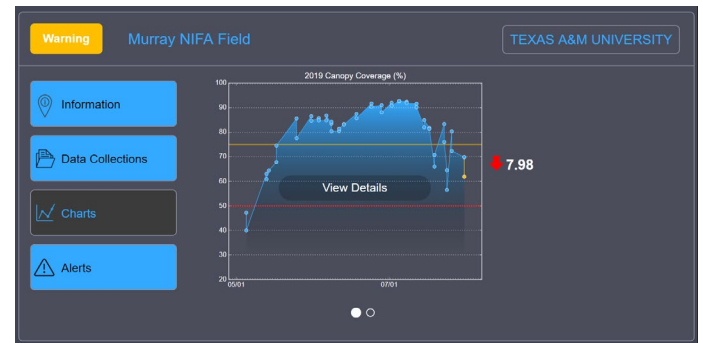


Figure 6. Charts Tab in AV DSS

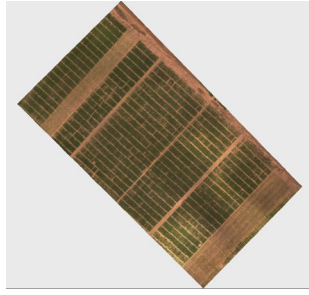
Every time a Canopy Coverage layer is created for a data collection, an average analytic value is calculated for the entire location. This analytic value represents the percentage of the location area that is covered by vegetation. This value is added to the Canopy Coverage chart showing the rise and fall of canopy coverage over time for the location. A similar chart is generated for each time an Anomaly Layer is created. This chart represents the percentage of the location area that may have anomalies as well as the rise and fall of potential anomalies over time for the location.

Preliminary Review of Quantix Surveys

Preliminary review of the aerial surveys completed with the Quantix show several distinct advantages for using this UAV for crop surveys. First, the reliability and performance of the Quantix allowed the MEEN UAS team to conduct surveys on a frequent basis, typically once or twice a week. Figures 7 and 8 provide thumbnail images of the True Color and NDVI surveys conducted over a research field from May 5 to July 31. The images clearly show the progression of plant growth in the research field during the growing season. The plants were emerging in early May, and they had rapid growth in the month of May. By mid-June, the plants had reached the tasseling stage. The plants reached maturity by mid-July, and the growing season was officially ended on July 31.



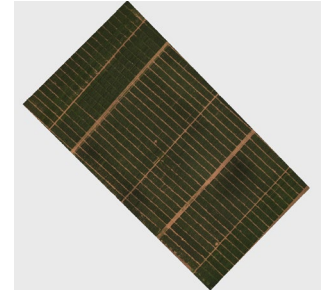
a) May 5



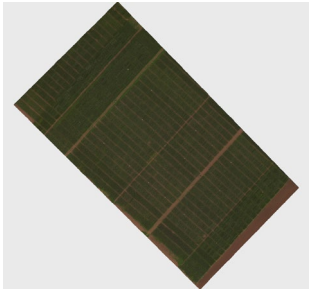
b) May 14



c) May 25



d) June 8



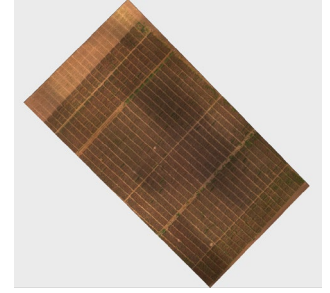
e) June 24



f) July 5

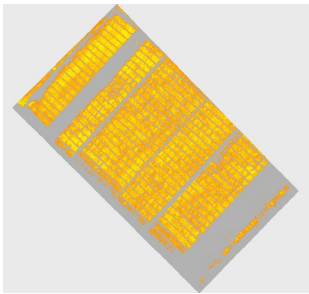


g) July 17

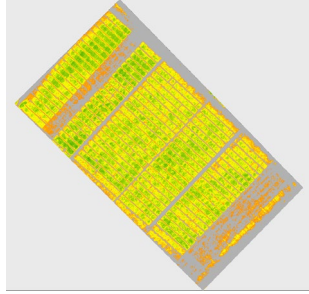


h) July 31

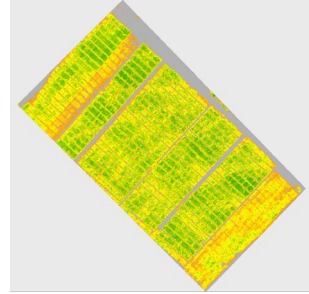
Figure 7. Temporal Comparison of True Color Surveys



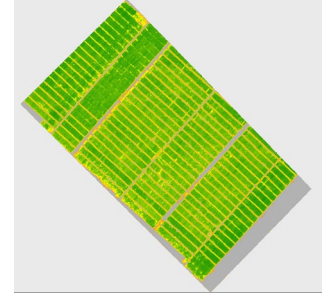
a) May 5



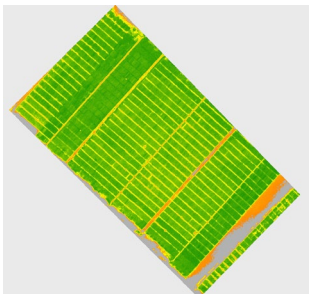
b) May 14



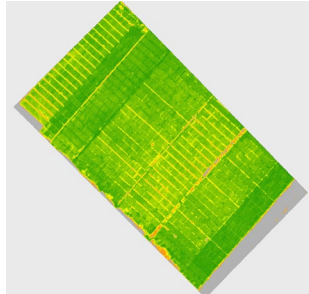
c) May 25



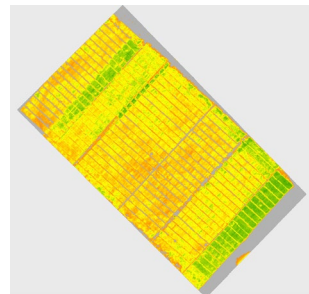
d) June 8



e) June 24



f) July 5



g) July 17



h) July 31

Figure 8. Temporal Comparison of NDVI Surveys

Another distinct advantage of the Quantix is the high resolution of the images and orthomosaic maps. Figure 9 shows the screenshots of two orthomosaic maps created from surveys conducted at altitudes of 360 ft and 150 ft. Each screenshot contains the same Ground Control Point (GCP) to accurately compare the resolution of the 18MP visual camera at different altitudes.



(a) Visual Resolution at Flight Altitude of 360 ft

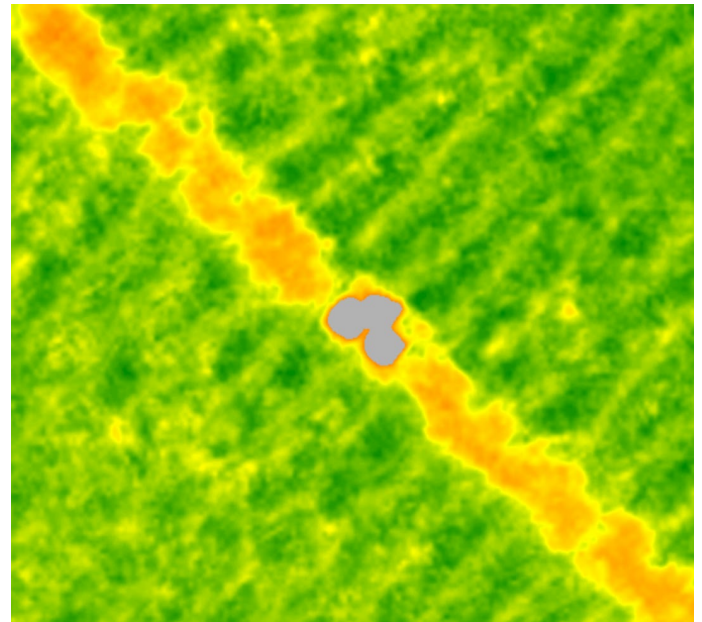


(b) Visual Resolution at Flight Altitude of 150 ft

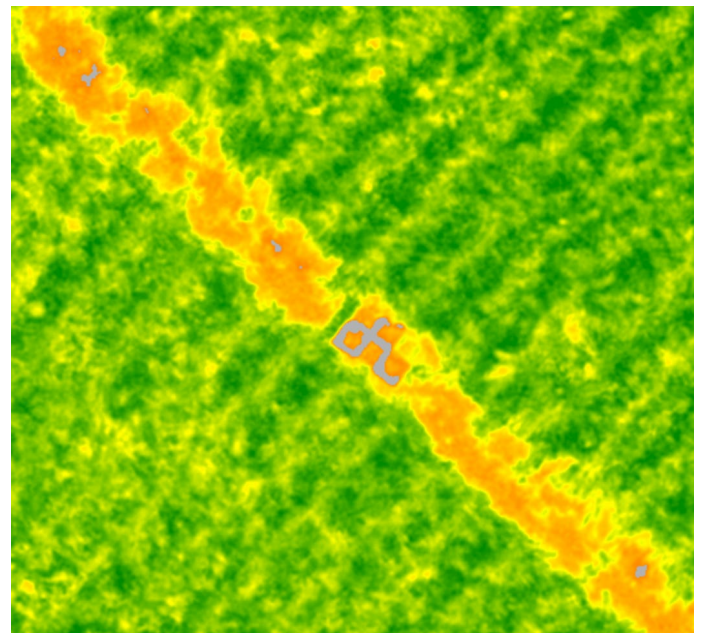
Figure 9. Resolution of Quantix Visual Camera

The camera produces a resolution of 1-in per pixel at 360 ft and 0.4-in per pixel at 150 ft. At 360 ft, the letter C on the blue tile of the GCP is difficult to distinguish, but at 150 ft, one can read the letter C.

As shown in Figure 10, the improved resolution at the lower altitude is also evident in the 18MP multispectral camera. It has a resolution of 2-in per pixel at 360 ft and 0.8-in per pixel at 150 ft.



(a) Multispectral Resolution at Flight Altitude of 360 ft

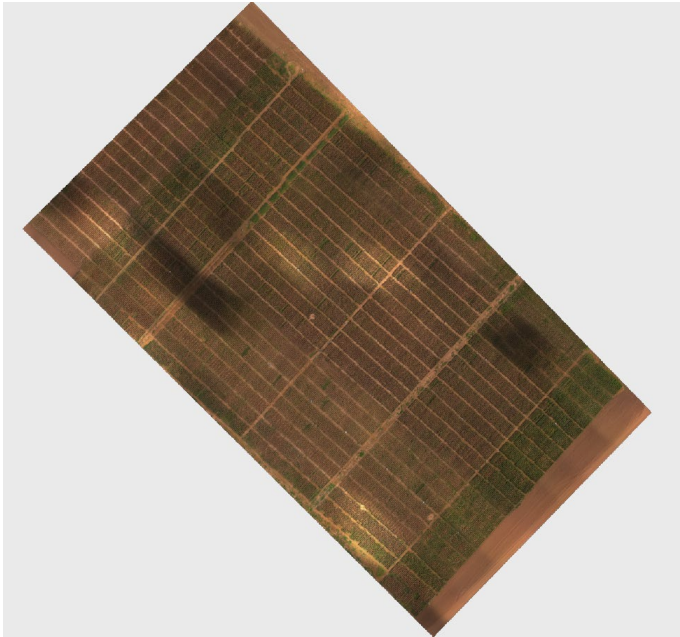


(b) Multispectral Resolution at Flight Altitude of 150 ft

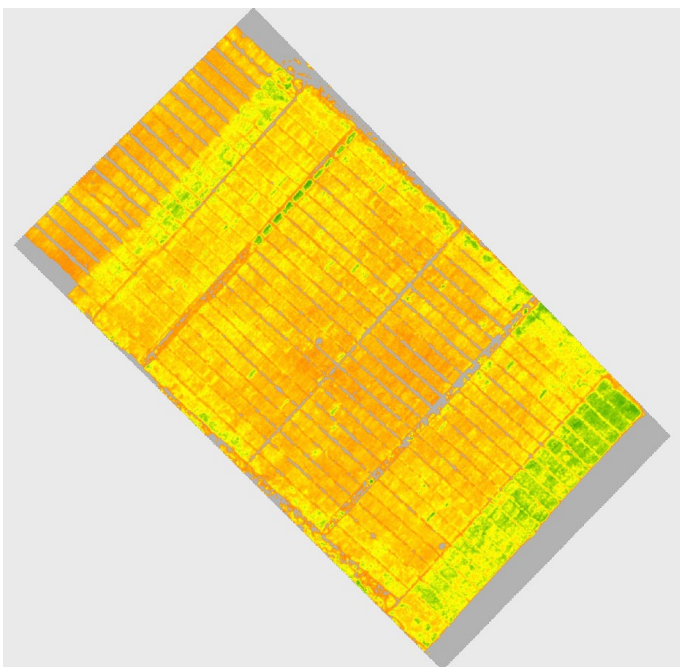
Figure 10. Resolution of Quantix Multispectral Camera

At 360 ft, the GCP is a blurred gray rectangular area, but at 150 ft, the individual black/white tiles are outlined on the GCP.

A third advantage of the Quantix UAV is the ILS Solar Sensor incorporated into the multispectral camera. While cloud cover adversely affects crop surveys, this sensor helps to mitigate cloud shadows in the multispectral surveys. Figures 11 and 12 illustrate this advantage. Surveys were conducted on two consecutive days when cloud cover varied significantly. On Day 1, the cloud conditions during the survey were partly cloudy, and on Day 2, they were fair. The True Color survey in Figure 11(a) shows the cloud shadows that appeared in the survey on Day 1 while the NDVI survey in Figure 11(b) is relatively uniform.



(a) True Color Survey on Day 1 at 150 ft



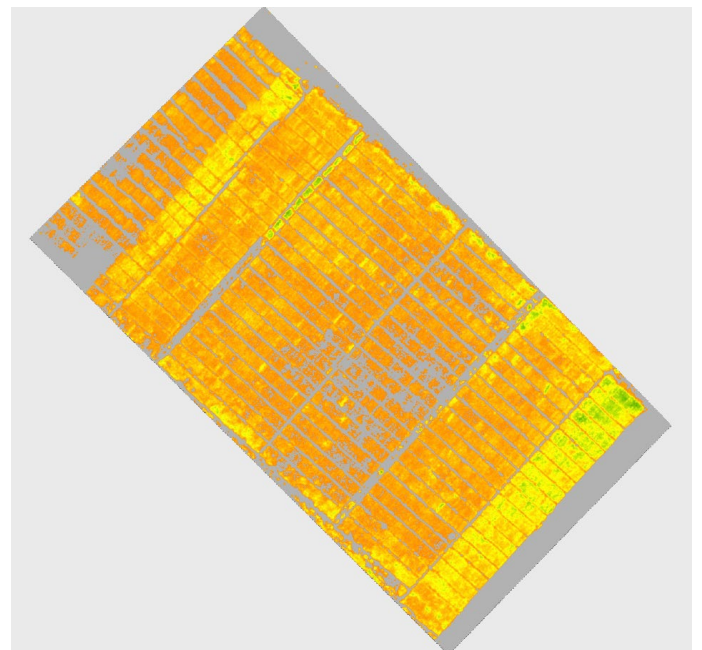
(b) NDVI Survey on Day 1 at 150 ft

Figure 11. True Color and NDVI Surveys on Day 1

The True Color survey in Figure 12(a) shows the fair cloud conditions (i.e. no shadows) for the survey on Day 2 while the NDVI survey in Figure 12(b) has similar uniform results as the survey on Day 1.



(a) True Color Survey on Day 2 at 150 ft



(b) NDVI Survey on Day 2 at 150 ft

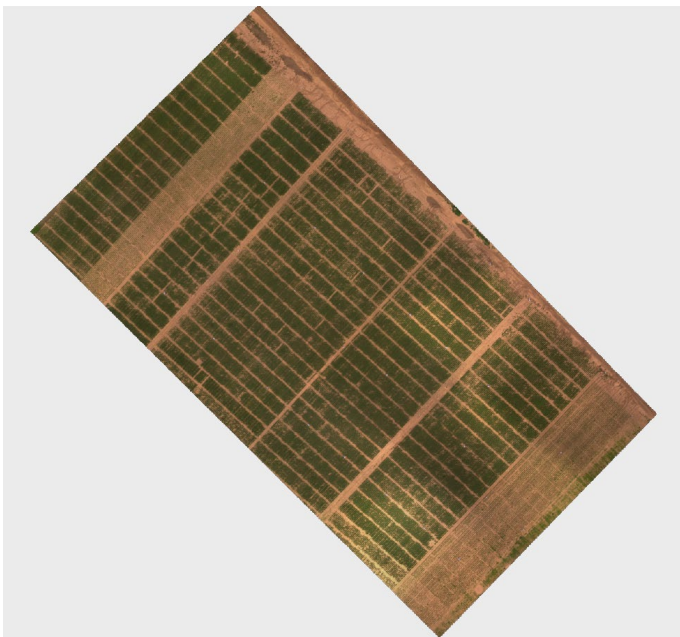
Figure 12. True Color and NDVI Surveys on Day 2

Suggested Improvements for Quantix Surveys

One item that needs to be addressed with the Quantix surveys is the use of GCPs. While the AV DSS produces high quality orthomosaic maps, it does not use GCPs to overlay those maps onto a base map. This issue causes orthomosaic maps to be misaligned with the boundaries of the survey, as shown in Figure 13 for surveys conducted on two consecutive days.



(a) Map Alignment within Boundary on Day 1



(b) Map Alignment within Boundary on Day 2

Figure 13. Alignment of Orthomosaic Maps within Survey Boundary

Survey on Day 1 shows the farm road and edge of the field on the left, but the survey on Day 2 has a portion of the left edge cut off by the survey boundary.

It would also be beneficial if digital surface models (DSMs), otherwise known as 3D point clouds, were added to the data analytics in AV DSS. Agricultural research scientists use DSMs and 3D point clouds extensively for estimating plant height and biomass in an agricultural field. Currently, the raw imagery data has to be processed with other third-party photogrammetry software in order to generate these DSMs and 3D point clouds.

Summary

For the 2019 growing season, the MEEN UAS team conducted 50 aerial surveys of a corn fields over 27 flight days during an 88-day calendar period. The team used a Quantix UAV to complete these surveys in support of the research project “Aerial and Ground Phenotyping Analytical Tool Development for Plant Breeders using the Maize G2F Project” being conducted by Dr. Seth Murray. Imagery data from the Quantix was processed on the AV DSS, providing both visual and NDVI orthomosaic maps of the fields throughout the growing season along with charts on Canopy Coverage and Anomaly coverage. The Quantix UAV provided three distinct advantages for conducting crop surveys.

- 1) Quantix’s high reliability allowed the team to complete surveys on a frequent basis, typically once or twice a week, throughout the season.
- 2) With the capability of conducting surveys at 150 ft, the Quantix provided high resolution images and orthomosaic maps of the crop to the detail of 0.4-in per pixel for the visual camera and 0.8-in per pixel for the multispectral camera.
- 3) Quantix’s ILS Solar Sensor incorporated into the multispectral camera helps to mitigate cloud shadows in the multispectral surveys.

Two items could improve the quality and usefulness of the Quantix UAV.

- 1) Use of GCPs to align orthomosaic maps at same location within survey boundaries
- 2) Addition of DSMs and 3D point clouds to analytics available from the surveys

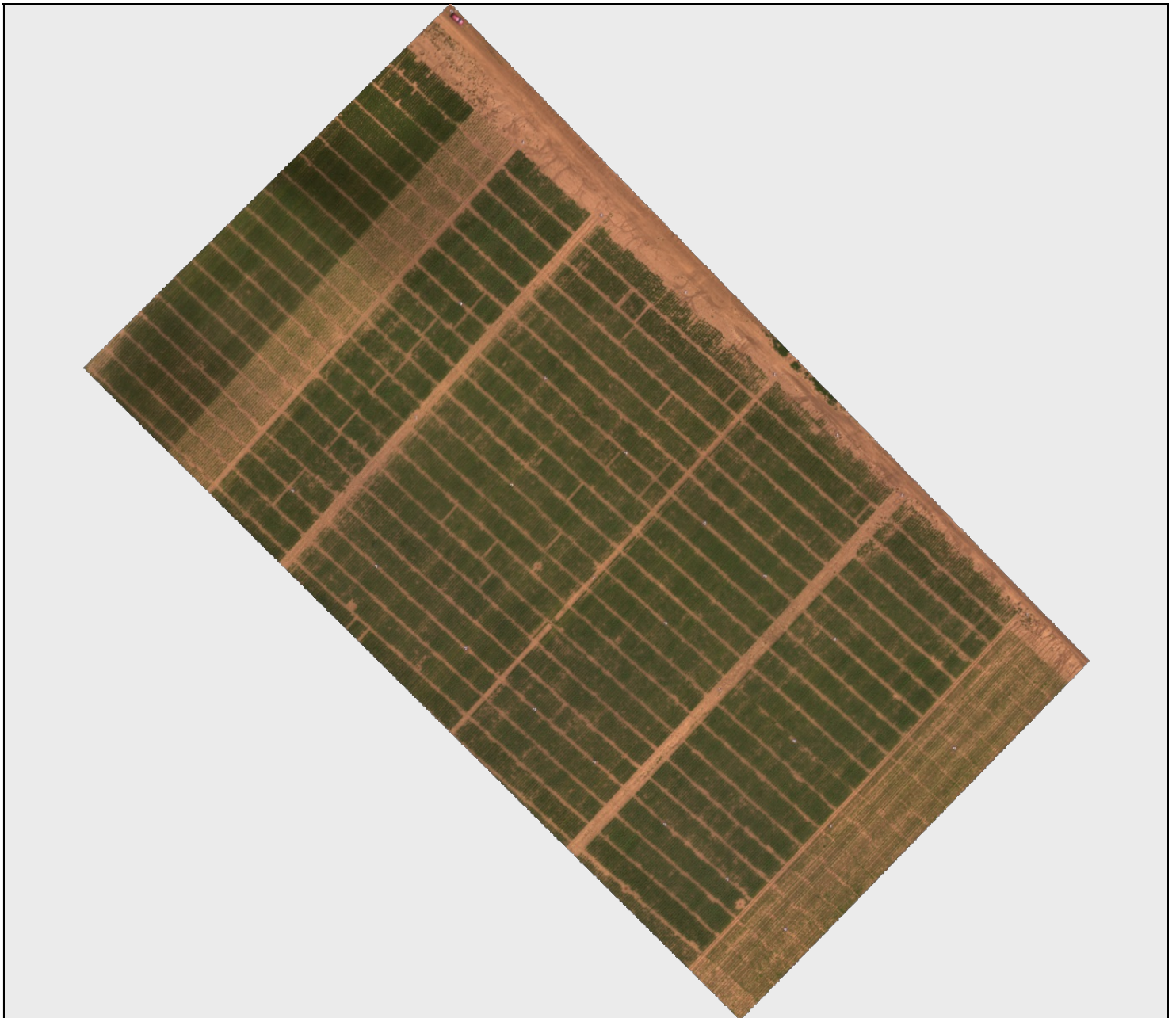
Appendix – DSS Field Report

The attached DSS Field Report is a sample report produced by the AV DSS for each survey completed. This report includes information such as location, date/time, and flight altitude, along with maps for the True Color, NDVI, GNDVI, Canopy Coverage, and Anomaly.

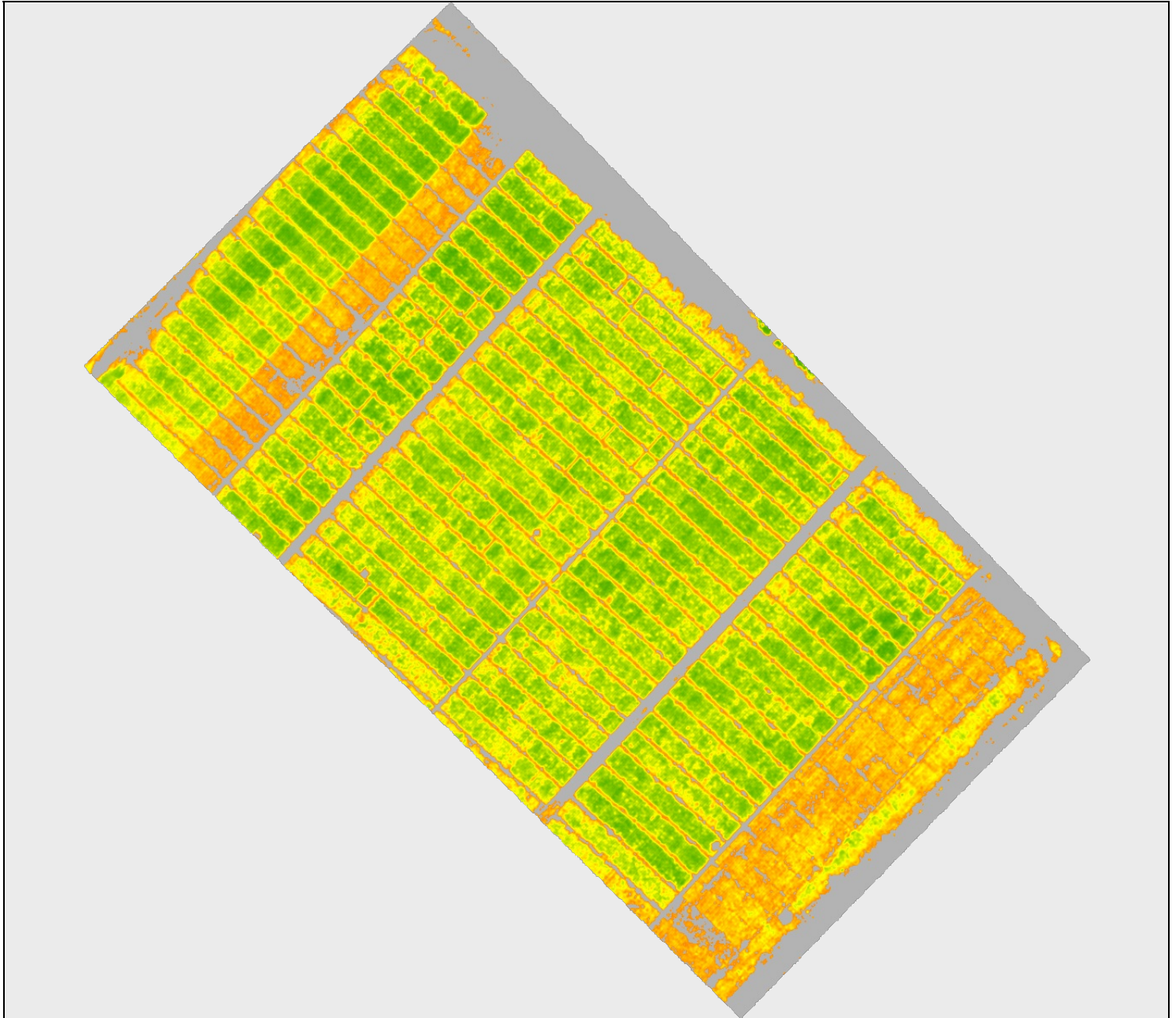
Information

Customer Name:	TEXAS A&M UNIVERSITY	Collection Date:	05/17/19 12:15 PM CDT
Location Name:	Murray NIFA Field	Upload ID:	112b2-2019-05-17_11-15-28.592
Geo Location:	30.546, -96.433	Area Covered:	100%
Crop:	Corn		
Acreage:	13.42 acres		








True Color

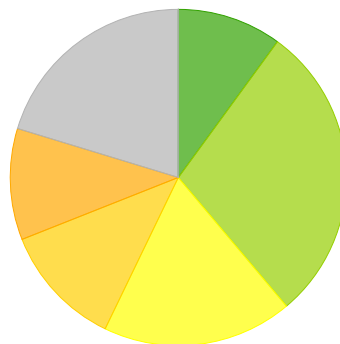


NDVI

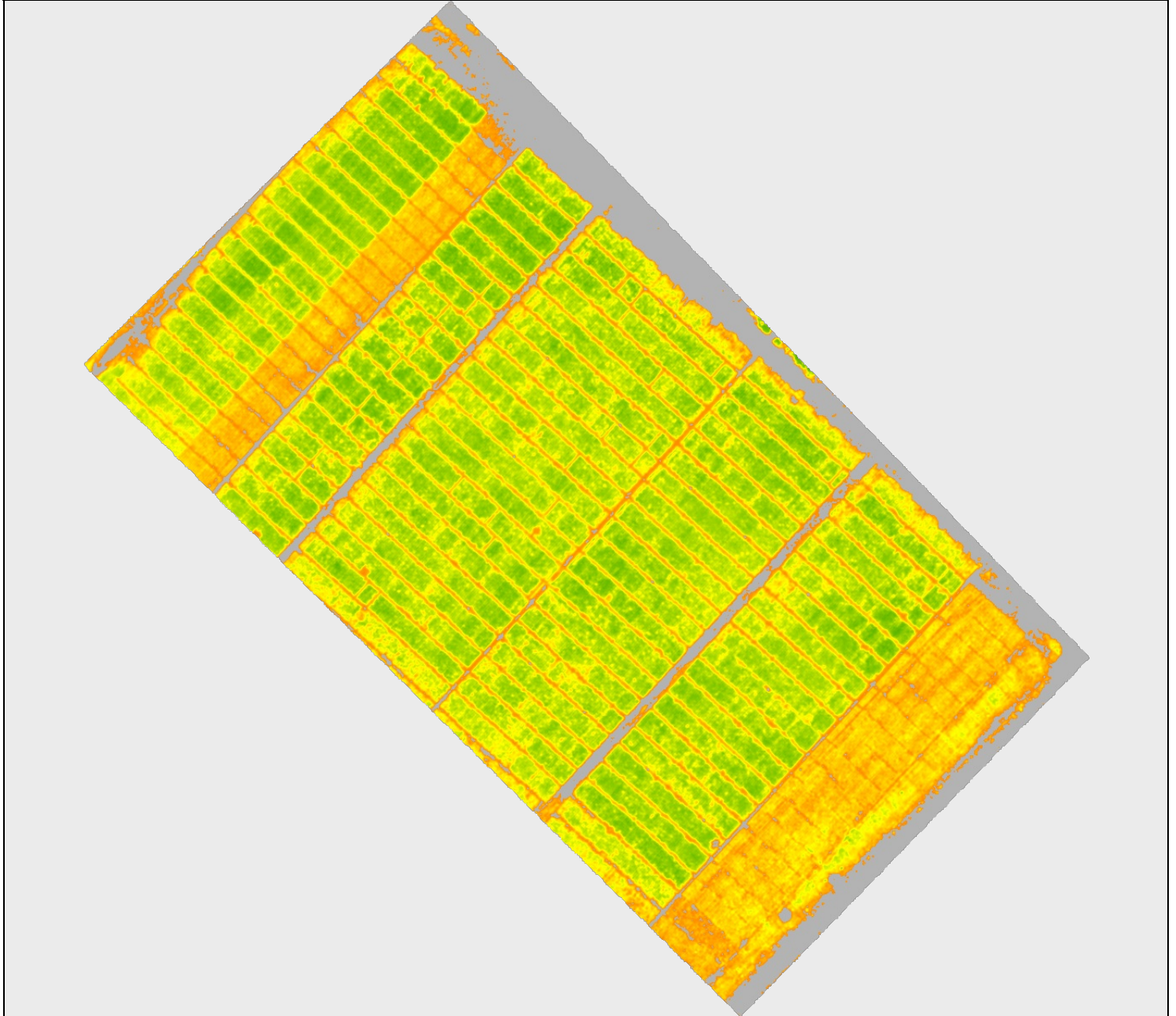


Statistics







	Min - Max	Acres	Percent
	0.90 - 1.00	0.00	0.00 %
	0.80 - 0.90	1.35	10.03 %
	0.70 - 0.80	3.87	28.84 %
	0.60 - 0.70	2.46	18.30 %
	0.50 - 0.60	1.59	11.83 %
	0.40 - 0.50	1.44	10.71 %
	-1.00 - 0.40	2.72	20.30 %

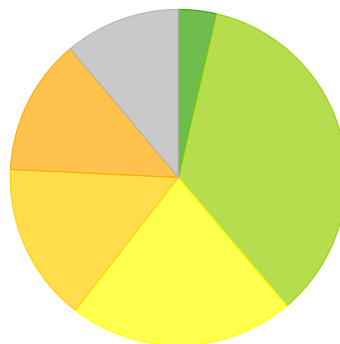


GNDVI

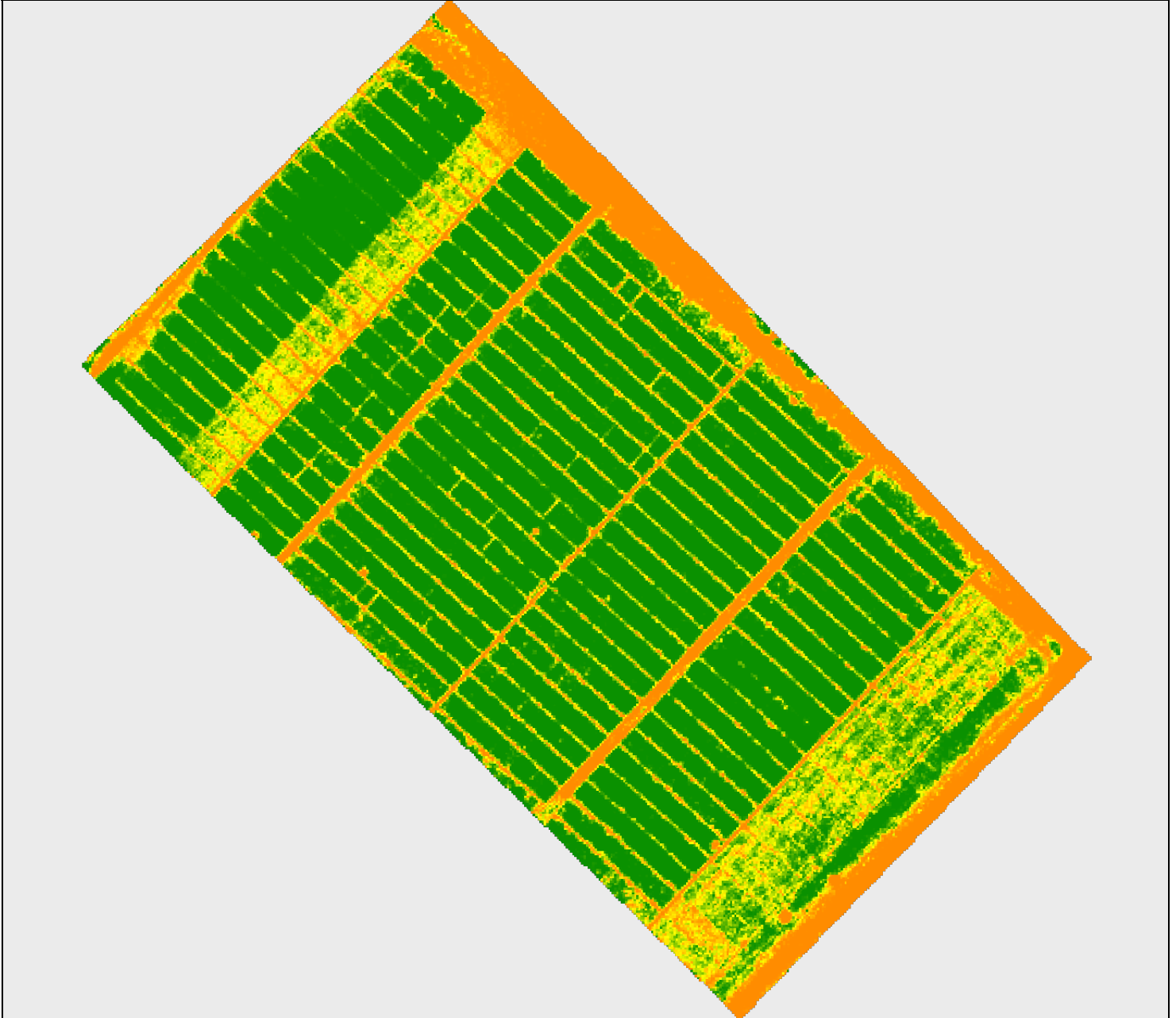


Statistics






	Min - Max	Acres	Percent
	0.80 - 0.90	0.49	3.64 %
	0.70 - 0.80	4.72	35.19 %
	0.60 - 0.70	2.91	21.67 %
	0.50 - 0.60	2.05	15.27 %
	0.40 - 0.50	1.76	13.10 %
	-1.00 - 0.40	1.49	11.13 %

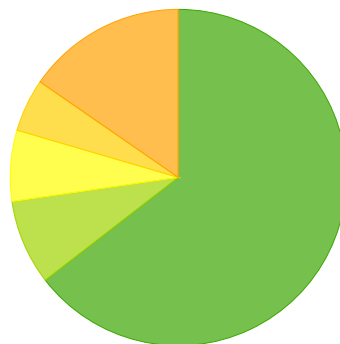


Canopy Coverage

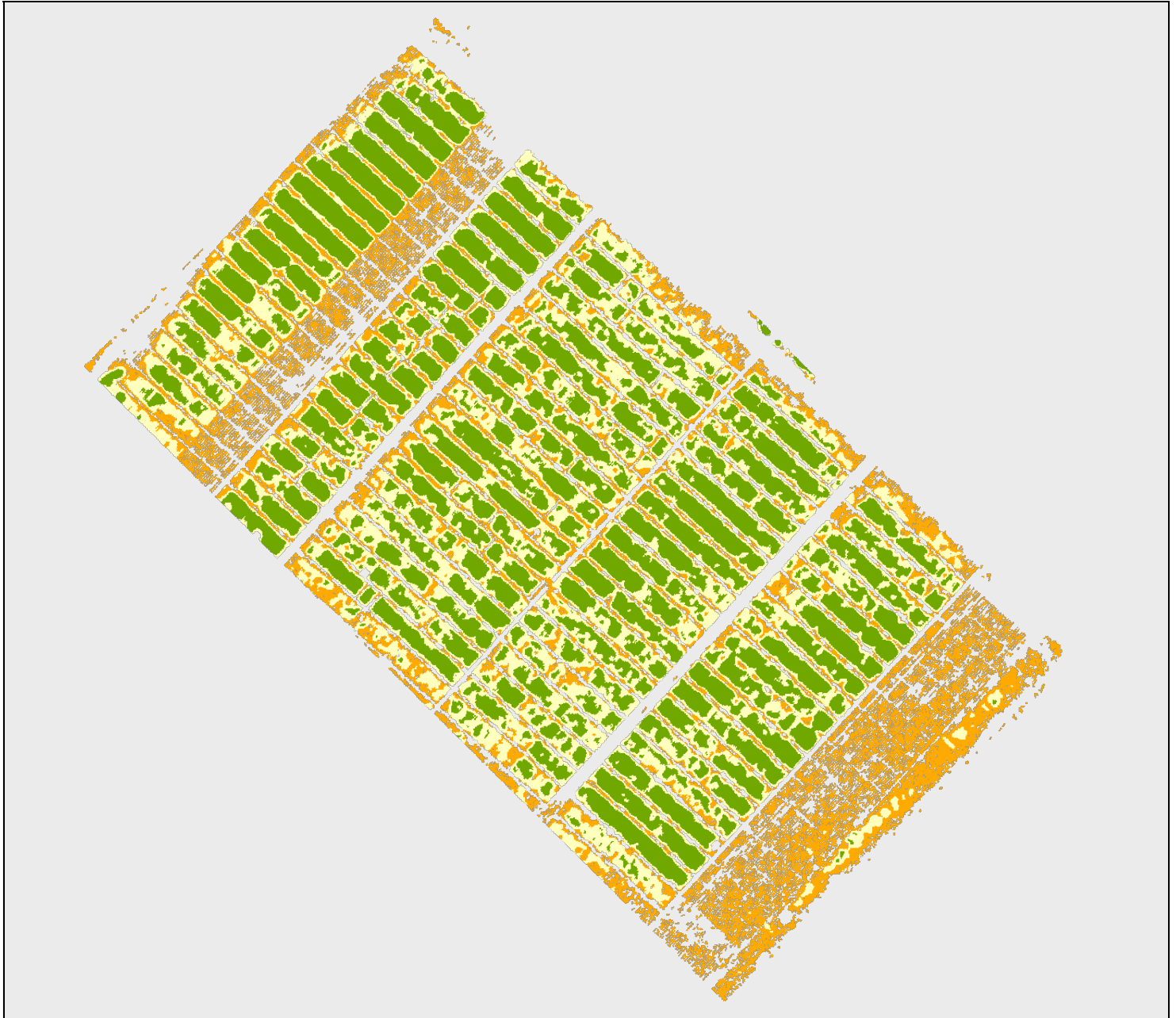


Statistics




	Min - Max	Acres	Percent
	80.00 - 100.00	8.66	64.53 %
	60.00 - 80.00	1.10	8.18 %
	40.00 - 60.00	0.92	6.83 %
	20.00 - 40.00	0.68	5.09 %
	0.00 - 20.00	2.06	15.37 %



Anomaly



Statistics

	Min - Max	Acres	Percent
	3.00 - 3.00	5.59	41.64 %
	2.00 - 2.00	4.19	31.24 %
	1.00 - 1.00	3.64	27.12 %

