

# 2024 Iowa ASFMRA/RLI Spring Seminar

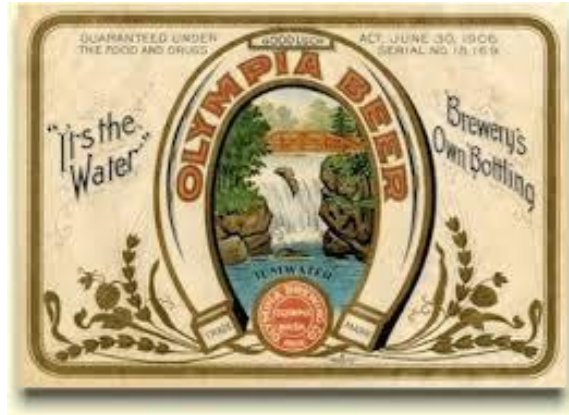
March 20, 2024  
Ankeny, IA

Leveraging Drones in  
Agriculture: Optimizing  
Farm Management in Iowa

**Illinois  
Extension**



# The Summer of 1979



# The Summer of 1979





**THE SUMMER OF 1979**



**Illinois Extension**

# Integration of Drones in Farm Management

1. Introduction
2. Drone Basics
3. Agricultural Applications
4. Case Studies/Examples
5. Challenges
6. Future trends



- Where do drones fit into farm management?

---

- Communication
- Precision Agriculture
- Crop Monitoring
- Pest Control
- Livestock Monitoring





faces: 10,702,383 vertices: 5,354,595

Basemap: (C) Sentinel-2 cloudless by EOX-IT Services GmbH (C) Mapzen



# Illinois Extension



# Communication



## Rotation

Continuous  
Corn



## 1876 Morrow Plots

Corn  
Soybean  
(<1968 corn/oats)

Corn  
Oats  
Alfalfa  
(<1901 corn/corn/oats/3x meadow)  
(<1953 corn/oats/clover)

Nafziger, E., Dunker, R., (2011) Soil Organic Carbon Trends Over 100 Years in the Morrow Plots, Agron. J. 103:261-267

## Rotation

Continuous  
Corn

Corn  
Soybean  
(<1968 corn/oats)

Corn  
Oats  
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(<1901 corn/corn/oats/3x meadow)  
(<1953 corn/oats/clover)



## 1876 Morrow Plots

**1876 No fert.**

**1904 Manure, Lime  
& Phosphorus**

**1955 Lime, Nitrogen  
P, K**

**1968 -1997  
L hi-N P & K**

**1997  
L N P & K**

Nafziger, E., Dunker, R., (2011) Soil Organic Carbon Trends Over 100 Years in the Morrow Plots, Agron. J. 103:261-267



**Illinois Extension**



## Terminology Disclaimer:

- Drone = UAV = UAS
  - Unmanned Aerial Vehicle (UAV)
  - Unmanned Aerial System (UAS)
  - SUAS, RPV, ROA
  - RPAAS
- Part 107 Pilot Certification for any “commercial” drone pilot
- Part 137 Certification for operation of aircraft for agricultural purposes

# UAV Types

- Copter style/Rotary Wing
  - Single rotor
  - Multi rotor
    - Twin, Quad, Hex, Oct, Dec
- Fixed Wing



# Rotary winged UAVs

- Benefits
  - Stable
  - Easy to learn
  - Versatile
- Drawbacks
  - Limited flight time
  - Limited payload









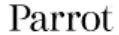













# Fixed wing UAVs

- Longer flight time
- Greater range
- Take-off and Landing?





### TOP 10 DRONE MANUFACTURERS' MARKET SHARES IN THE US

Rank	Manufacturer <sup>1</sup>	HQ Location	Founding Date	US Market Share <sup>2</sup>
1		Shenzhen, China	2006	 76,1% (-0,7%)
2		Santa Clara, USA	1968	 4,1% (+0,4%)
3		Hong Kong, China	1999	 2,6% (-0,5%)
4		Paris, France	1994	 2,5% (+0,3%)
5		Berkeley, USA	2009	 0,6% (-0,8%)
6		Bothell, USA	2014	 0,6% (-0,2%)
7		Redwood City, USA	2014	 0,3% (+0,1%)
8		Lausanne, Switzerland	2009	 0,2% (-0,1%)
9		Menlo Park, USA	2013	 0,1% (-0,2%)
10		Simi Valley, USA	1971	 0,1% (-)

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<sup>1</sup> 3D Robotics (Position 5) and Kespri (Position 9) no longer manufacture drones  
<sup>2</sup> The values in brackets indicate the change from the evaluation as of March 2019

Source: FAA drone registrations as of 30/06/2019, DRONEII.COM

Date: March 2<sup>nd</sup>, 2021

# Remote Pilot in Command

(FAA Part 107)

- <55 lbs
- Visual Line of sight
- Must yield right-of-way
- 3 mile weather visibility
- daylight-twilight 30min +/-
- Not over people, unless in protected structures
- <400 AGL, more if tall structure inspection
- ATC permission for access to Class B, C, D and E airspace
- Only 1 UAS per operator
- Waiver system

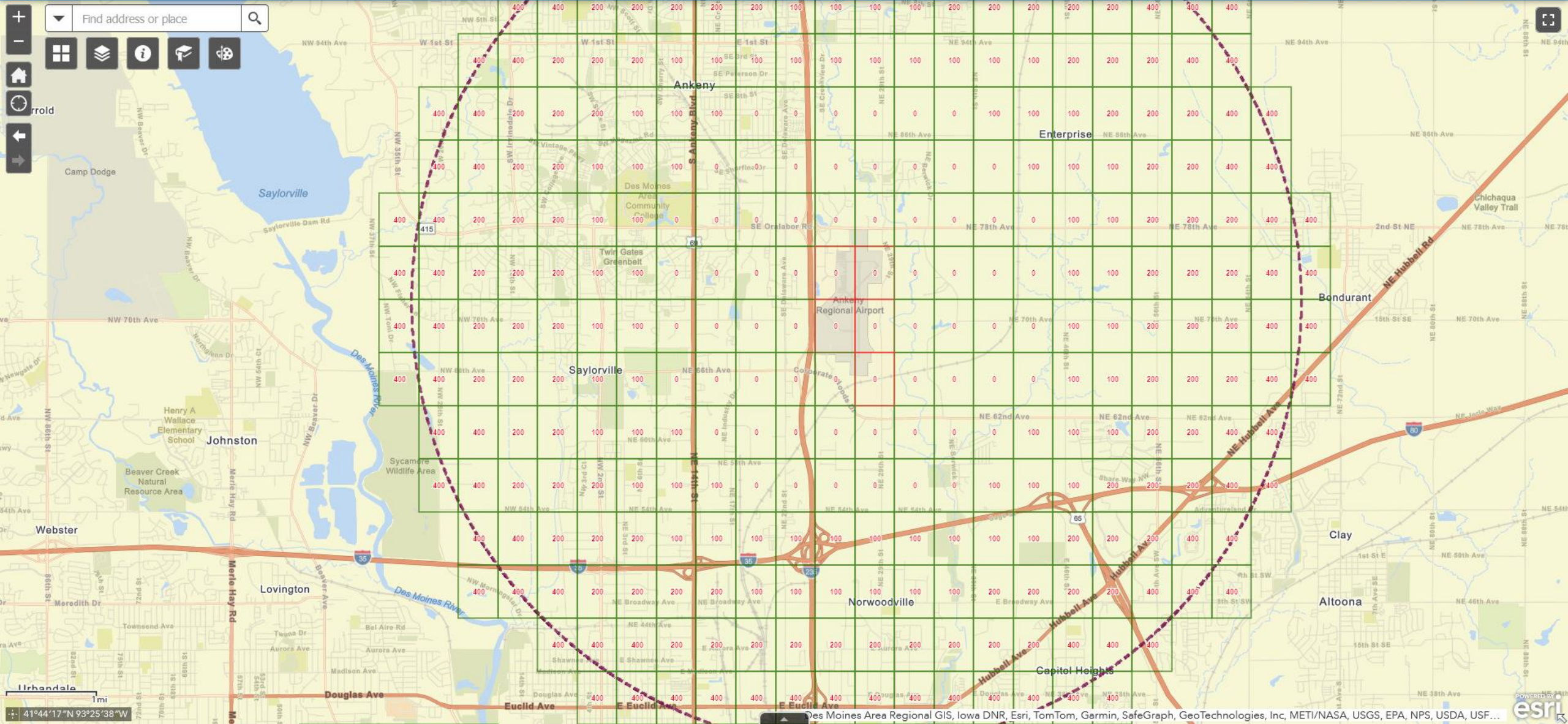


## Certification Requirements

- Existing Pilots take online test
- Pass knowledge test
- Recertify 2 years
- 16 years old
- Report accidents to FAA within 10 days, >\$500 or physical injury

# FAA >365,000 Licensed Drone Pilots





# Illinois Extension

# Drones are Transforming Aerial Agriculture Application

- Potential Advantages
  - Safety
  - Precision Application
  - Efficiency/Labor
  - Access to Challenging terrain





# Drones are Transforming Aerial Agriculture Application

- Potential Challenges
  - Initial Costs
  - Regulatory Hurdles
  - Weather Dependency
  - Technical Challenges

# PART 137: UAS Agricultural Aircraft Operations

- Exemptions from 14 CFR Part 137
  - Petition
  - Safety Manual
  - Training Manual
- TIME ...
- Aircraft Operating Certificate
  - PIC Certificate #
  - Aircraft Registration # (under 55# vs over 55#)
  - Class 3 medical (over 55#)



# Potential Advantages: Safety

- No on-board Pilot

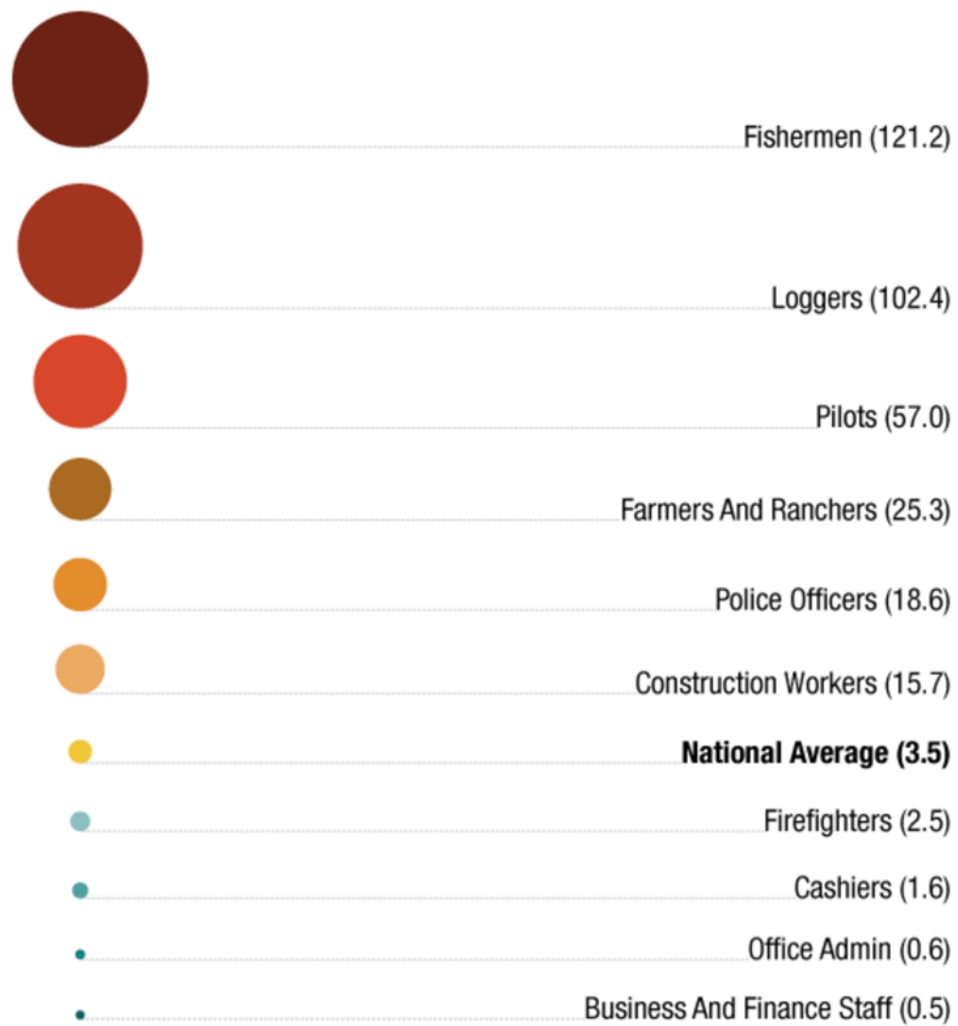






**NTSB: 2023 Ag Aviation 56 accidents (7 IA & IL) 12 fatal**

## Work-Related Deaths, 2011 (Per 100,000 Workers\*)



\* Full-time equivalent workers.

Source: Bureau Of Labor Statistics

Credit: Jess Jiang and Lam Thuy Vo /NPR





# Potential Advantages: Safety

- No Pilot
- No 254 gal aviation fuel\*
- No 800 gal pesticide\*
- Drone flights stay within field boundaries
- Drone safely operates at lower altitude
- vs. Backpack sprayers?

\*Air Tractor 802A \$2.5m



# Cameras/Sensors



\$300



\$900



~\$3500



\$600

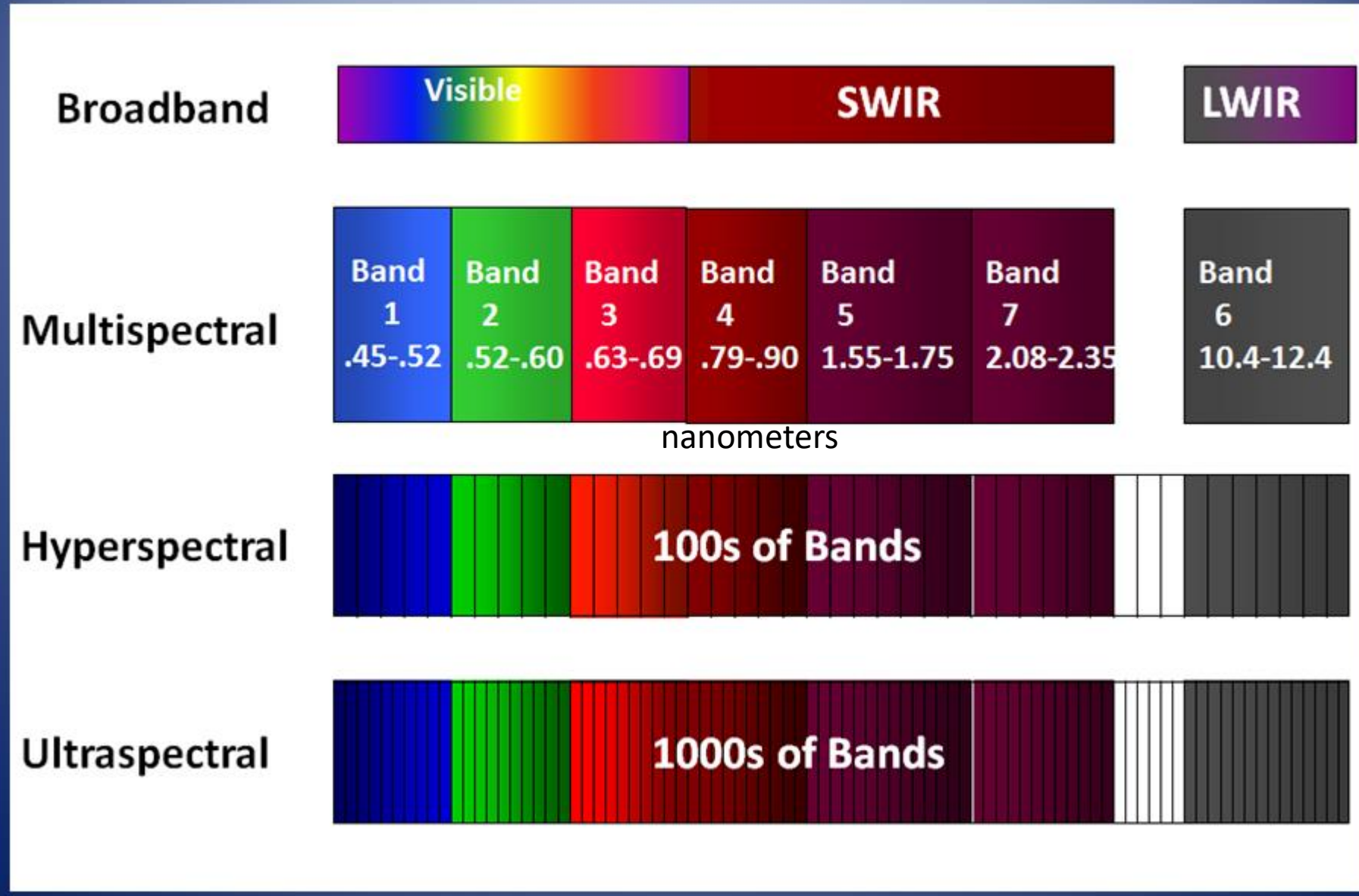


~\$8000



~\$10,000

# Difference Between Multispectral and Hyper-spectral Data



- Altum
- Blue: .475
  - Green: .56
  - Red: .668
  - Red Edge: .717
  - NIR: .842
  - LWIR: 8-14

## Drone Data:

Flight Date: 08/01/2019

Time: 2:35 pm

Drone Altitude: 254.59 m

Latitude: 40.08465

Longitude: -88.22635

Blue: 804

Green: 2343

Red: 1124

Red-edge: 8763

Near Infrared (NIR): 27060

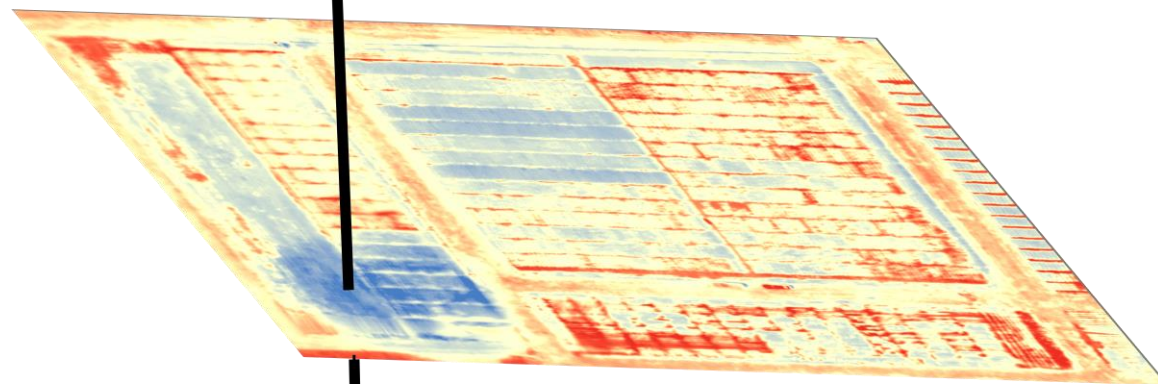
Thermal IR: 298.65K (77.95°F)

143 million pixels ~6A

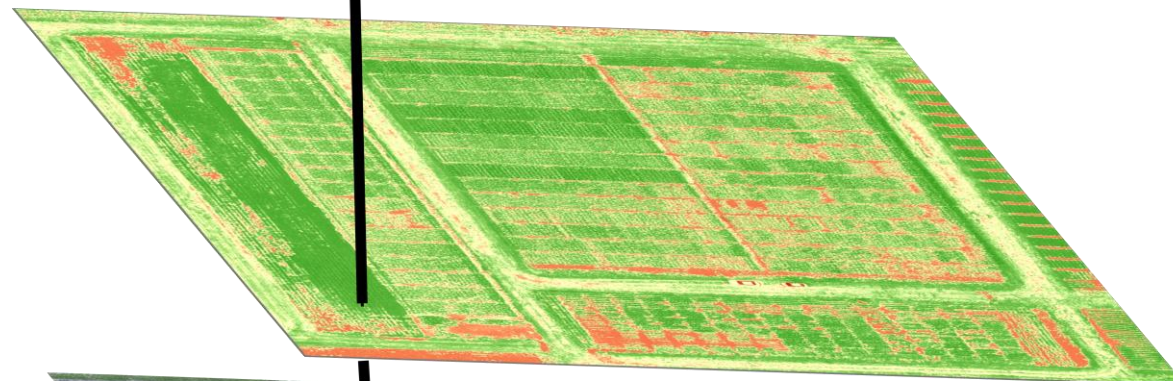
Elevation 715" 120" AGL



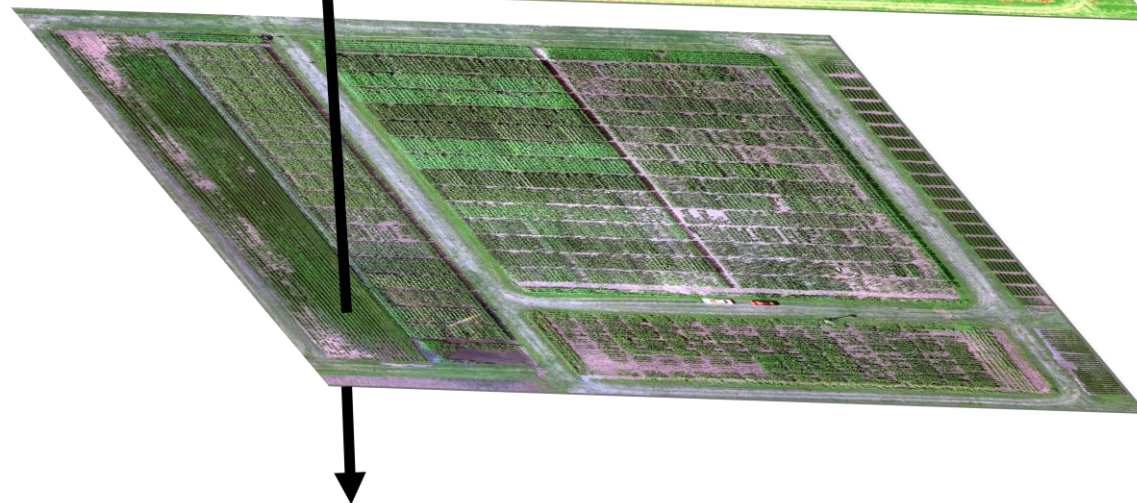
**Thermal IR**



**NDVI = (NIR - Red) / (NIR + Red)**



**Red-Green-Blue composite**



2013



2022



# Nitrogen Rate Trial with Variable Rate Sensor

MRTN plus	3.21	264
Base rate only	2.79	154
Control No N	2.09	91
MRTN	3.14	244
Greenseeker	3.23	228
MRTN minus	3.05	208
MRTN	3.07	244
Base rate only	2.81	162
Greenseeker	2.82	189
MRTN minus	3.04	213
Control No N	1.65	97
MRTN plus	2.88	242
Base rate only	2.65	155
MRTN	2.98	239
Control No N	1.77	60
MRTN minus	3.01	197
MRTN plus	3.01	221
Greenseeker	3.2	209
MRTN plus	3	214
Base rate only	2.45	121
MRTN	3.13	197
Greenseeker	3.1	167
Control No N	1.71	42
MRTN minus	3.2	215

# 2014

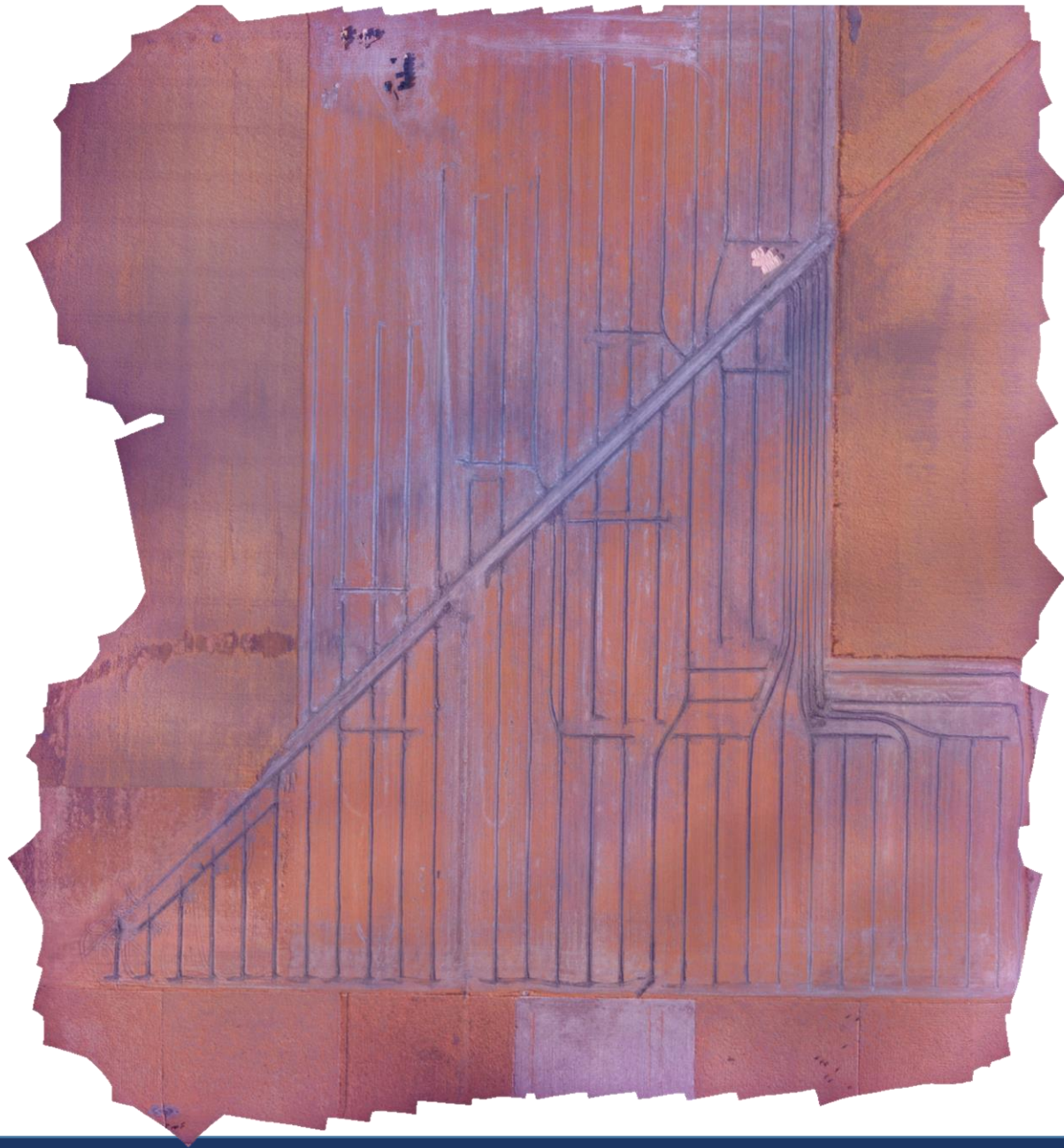


2015



PIX4D  
mapper

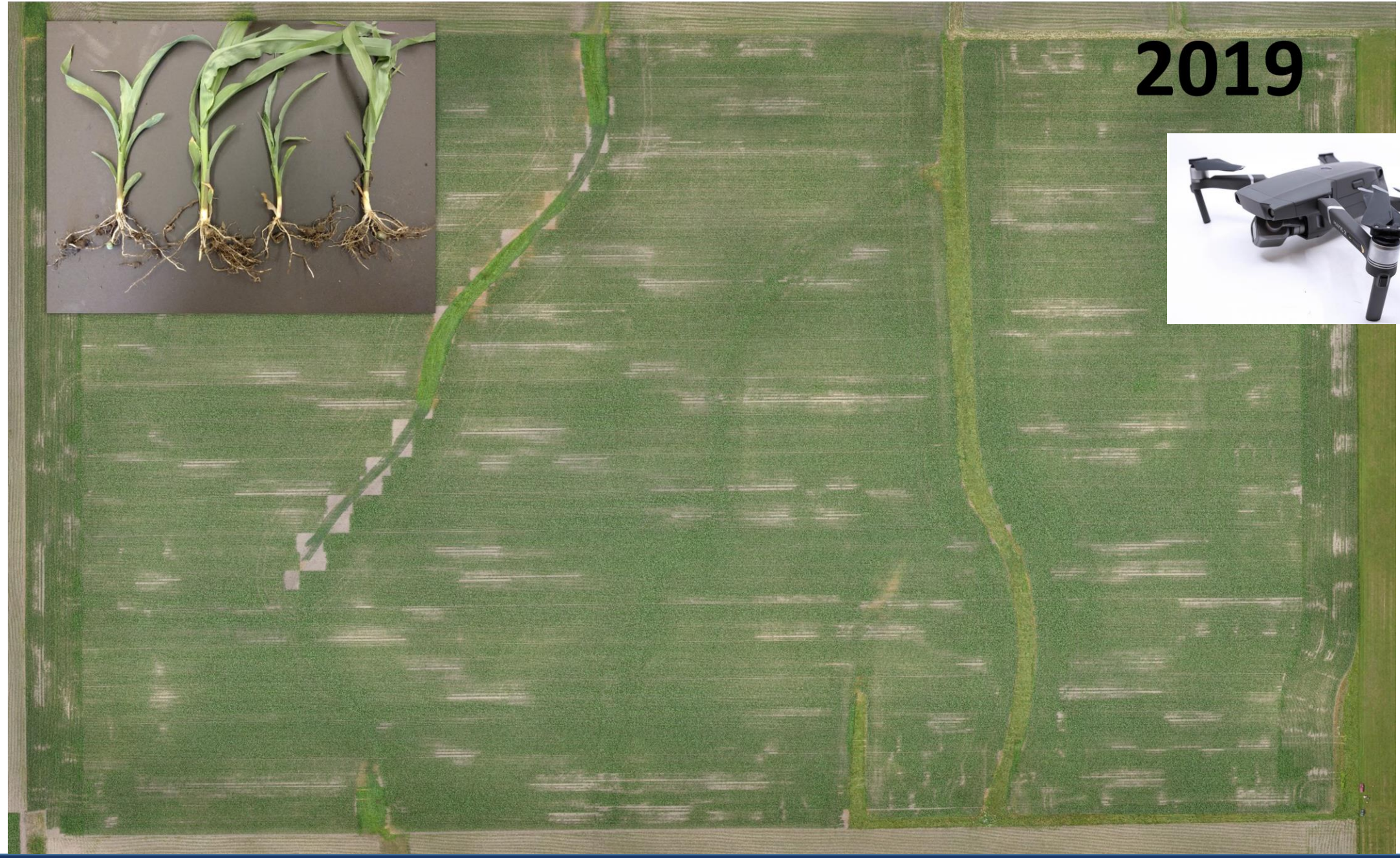
2016



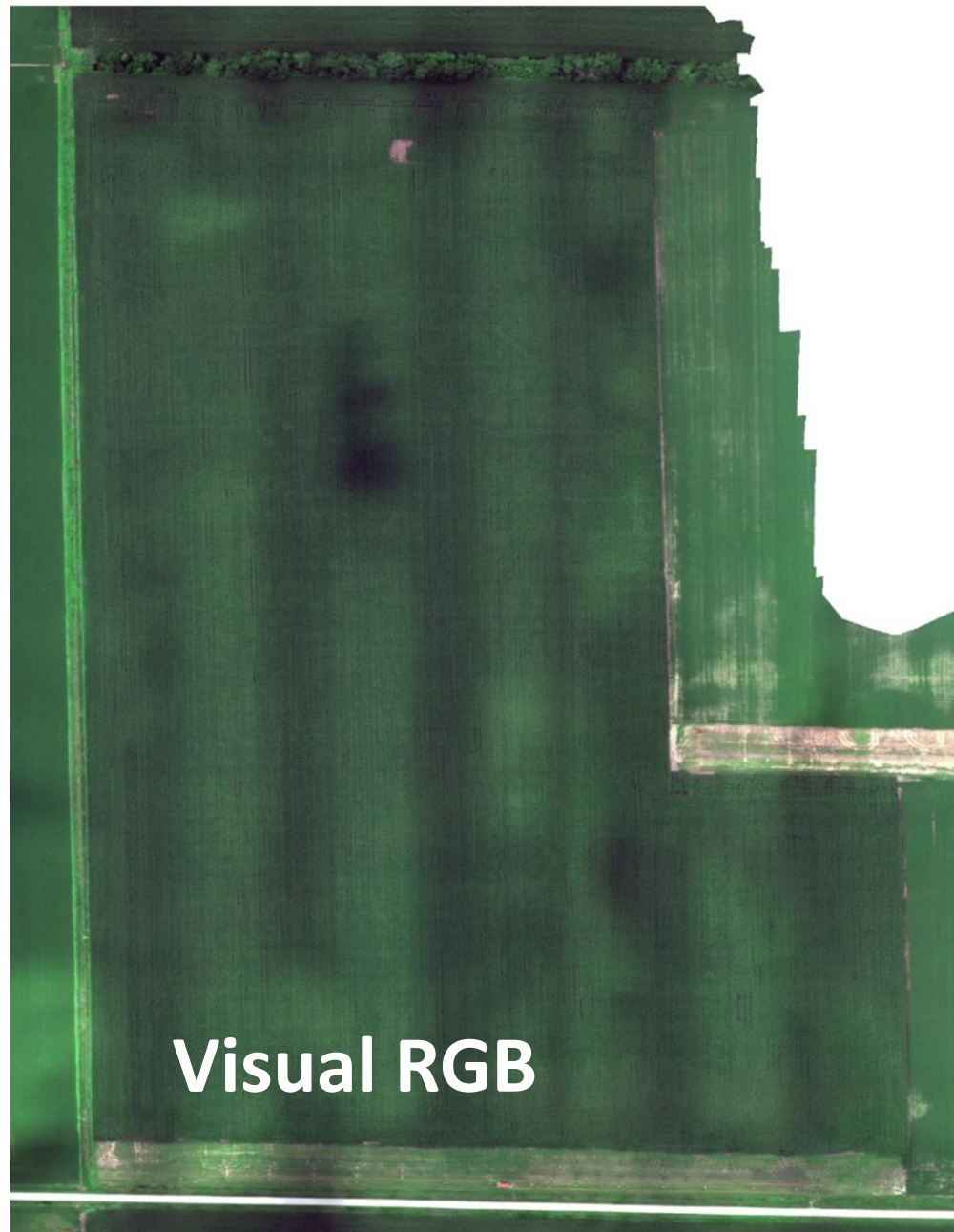
SDR  
SOLO



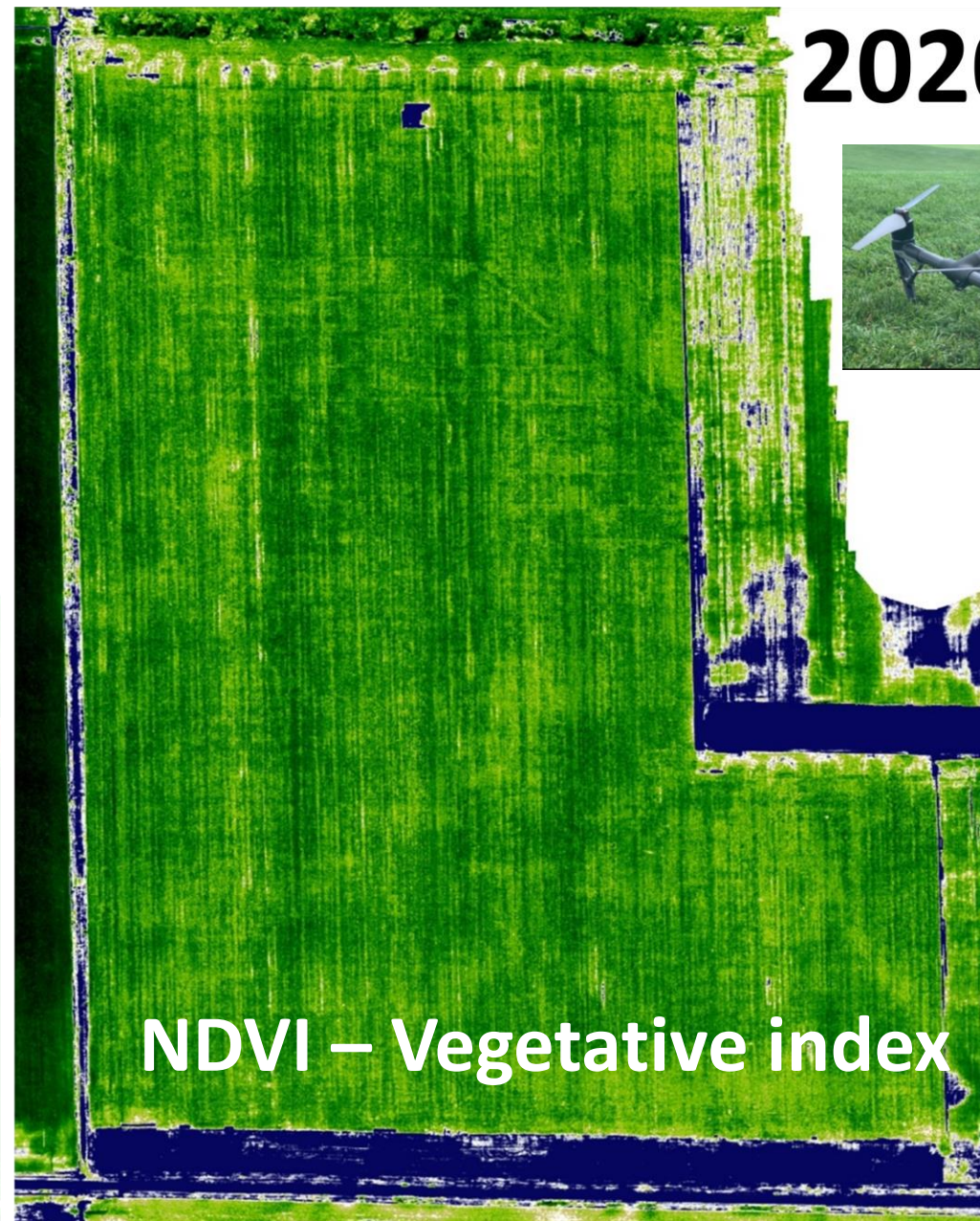
2019



**2020**

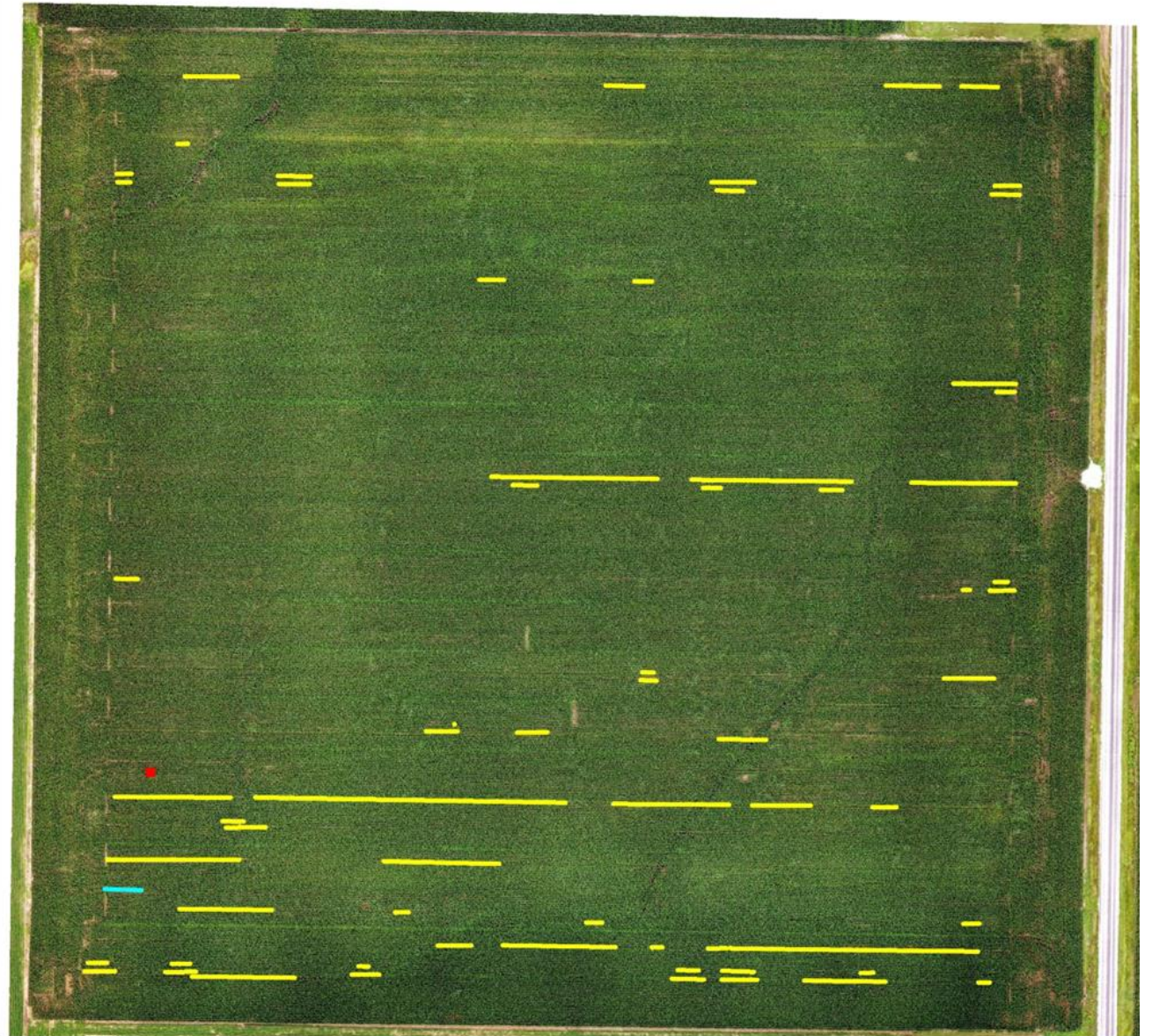


**Visual RGB**



**NDVI – Vegetative index**

# 2021



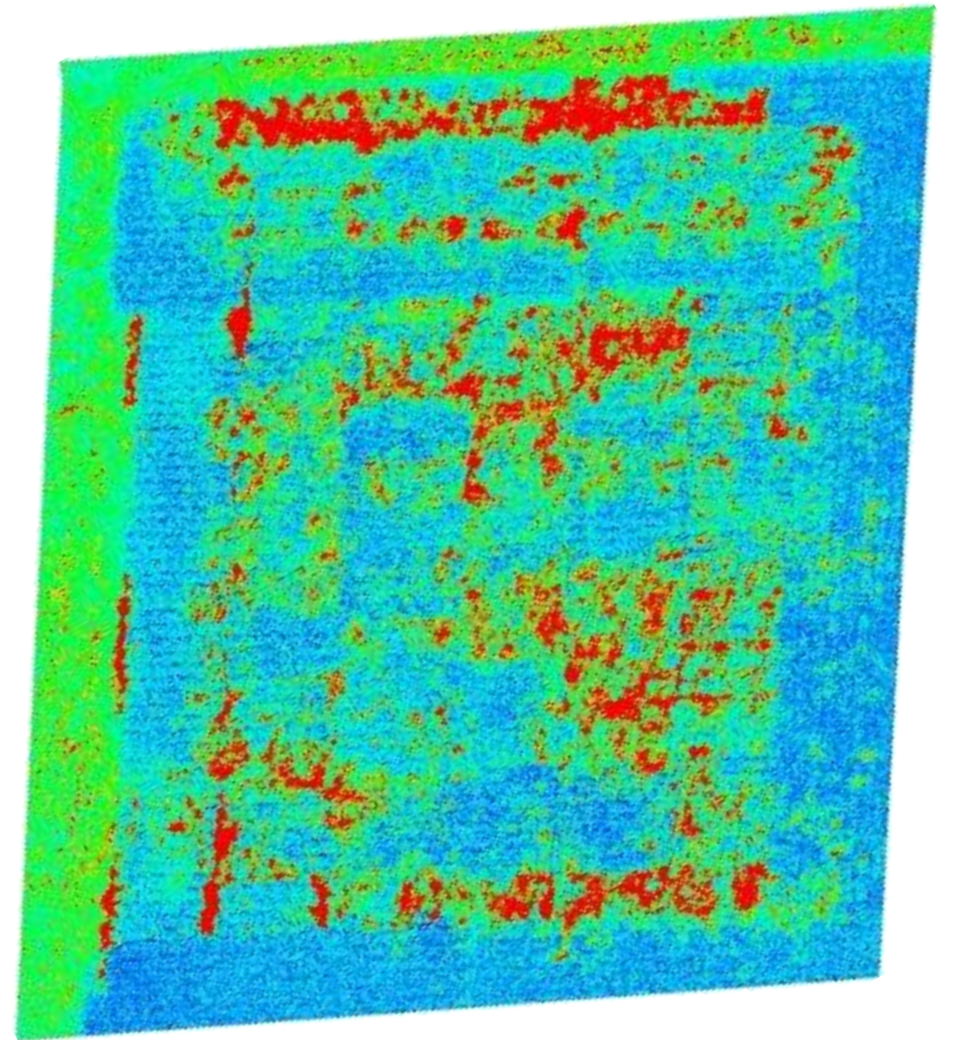
9500 ft of row lost

.55A corn lost

@225 bu/A= 123.5 bu lost

@ \$5.15/bu = \$637 lost

2022



New Soybean disease research – Red Crown Rot seed treatments

# 2023





# Data and Stories



**Discontinued-**  
**DJI Mavic 2 Pro + fly more kit: \$1800**

Photo courtesy DJI

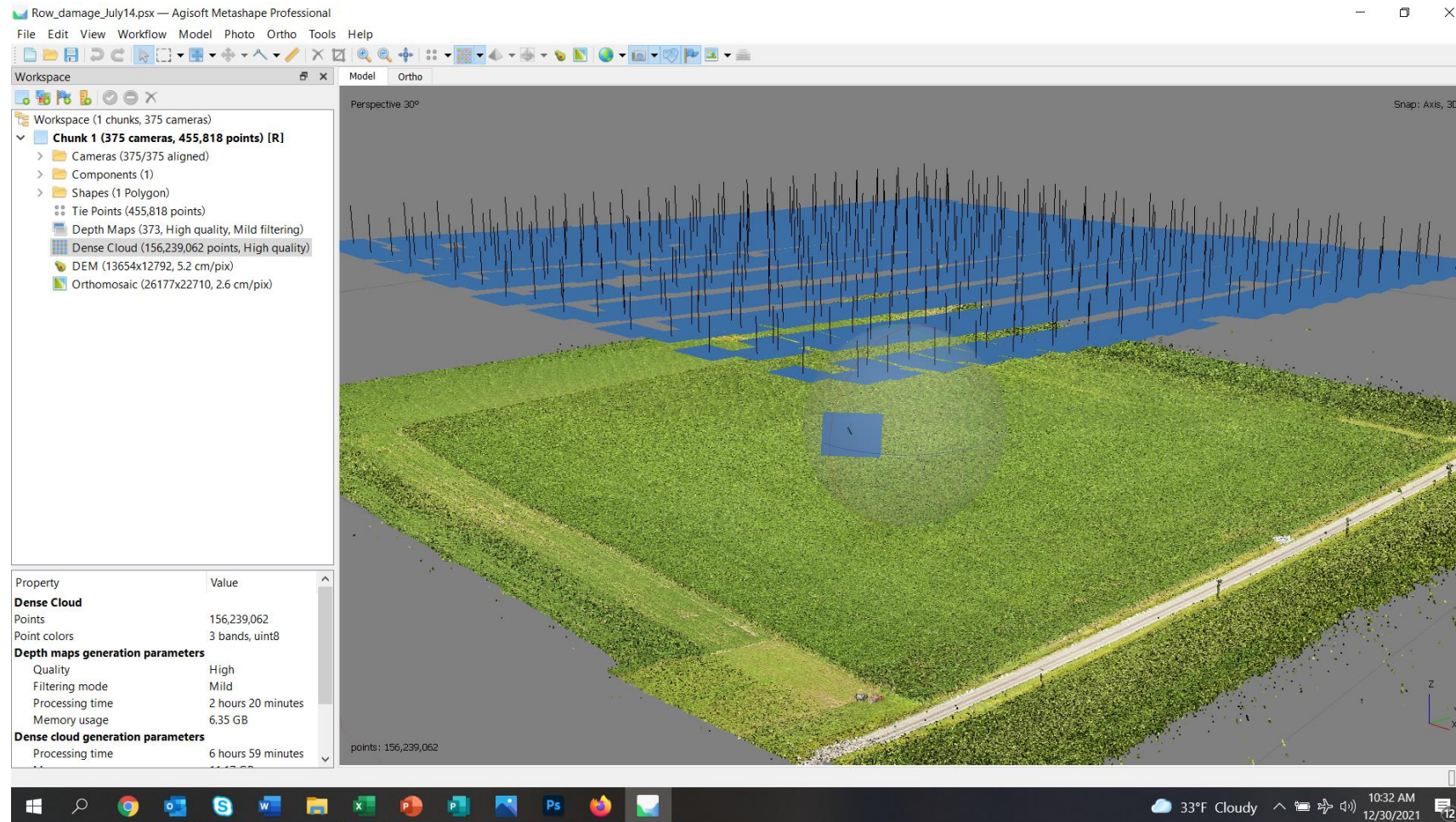
**Replacement-**  
**DJI Mavic 3 fly more: \$3000**

**Software:**  
**Pix4DCapture (free app)**

**iPad Mini 4**

# Photogrammetry: Agisoft Metashape Pro

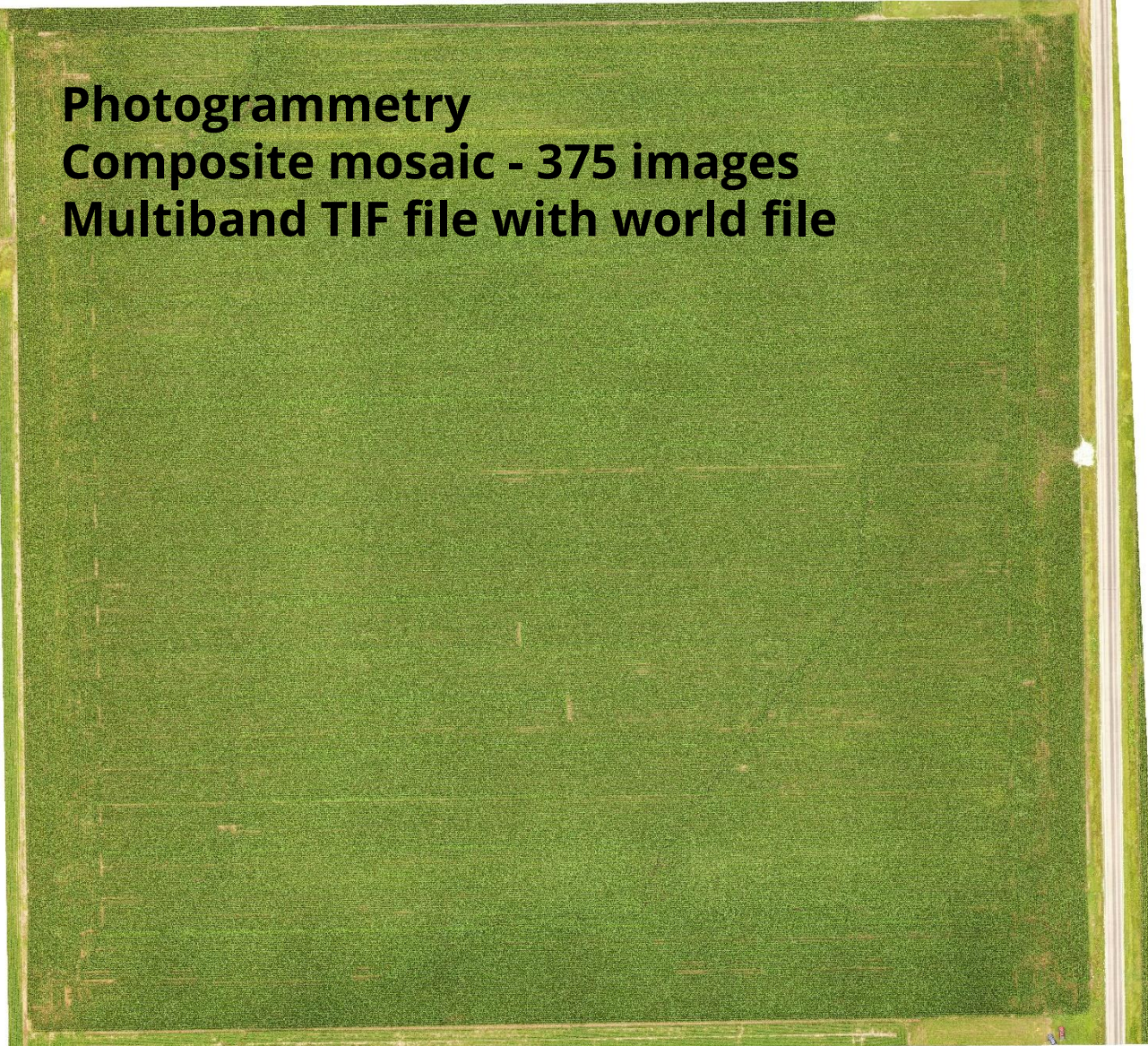
## Composite mosaic - 375 images



- Commercial license:
  - Standard ed. \$180
  - Professional ed. \$3,500
  - Educational \$550
  - (lifetime license)

# Data and Stories

Photogrammetry  
Composite mosaic - 375 images  
Multiband TIF file with world file

An aerial view of a large, rectangular green field, likely a crop field, created from a composite mosaic of 375 individual images. The field is surrounded by a thin white border, possibly a road or fence. The color is a uniform, vibrant green.

3D Surface model (DEM)

A 3D surface model (DEM) of the same green field shown in the left image. The model is rendered in a dark green color and shows the topography of the field, including subtle variations in elevation and the presence of small depressions or features. The field is surrounded by a thin white border.

Implementing a Digital Agriculture Program in Extension

# Data and Stories

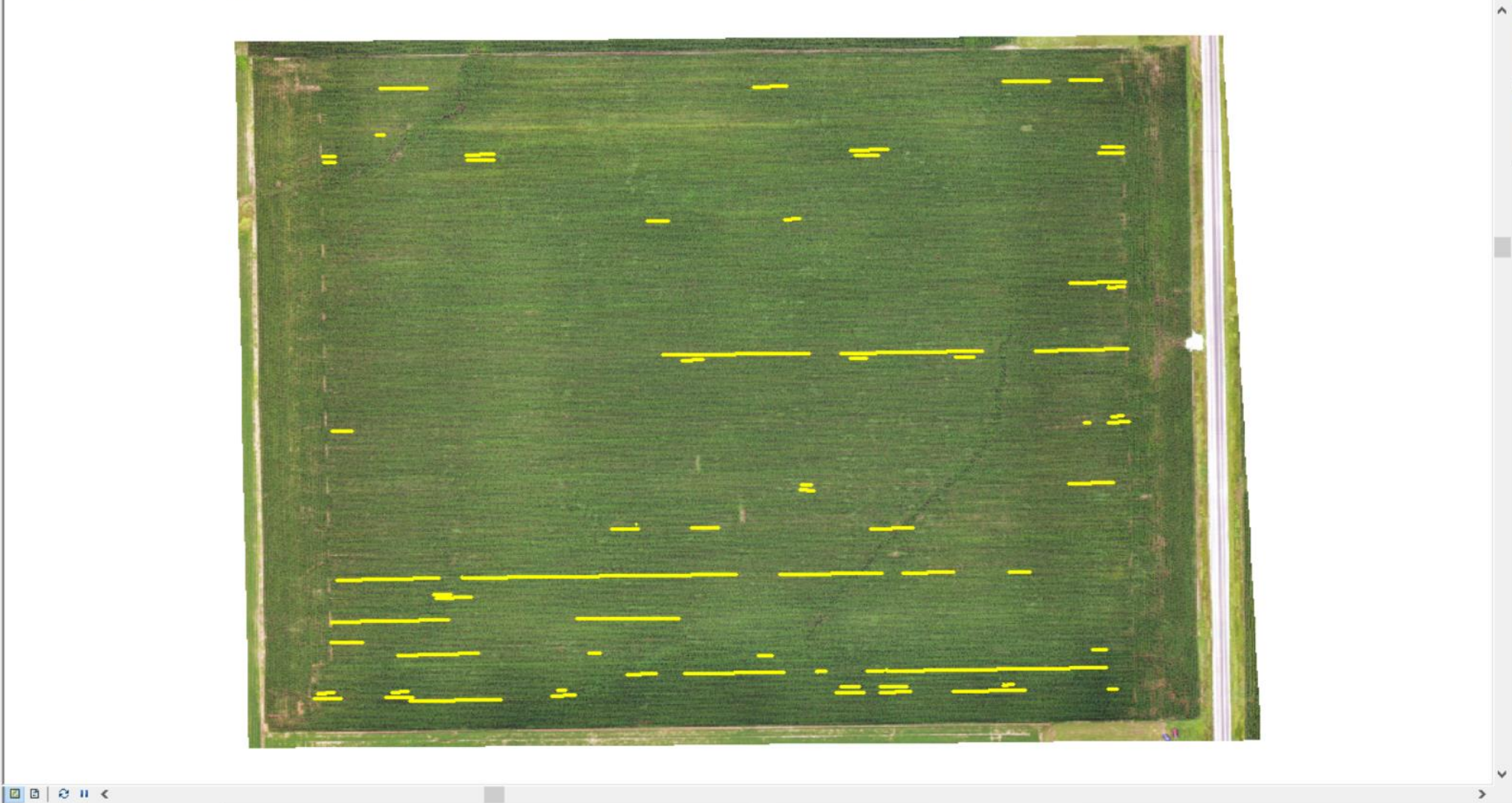


Implementing a Digital Agriculture Program in Extension



Table Of Contents

- Layers
  - Converted\_Graphics
    -
  - LuanJuly14.tif
    - RGB
      - Red: Band\_1
      - Green: Band\_2
      - Blue: Band\_3
  - rastercalc6
    - <VALUE>
      - 0 - 0.443963358
      - 0.443963358 - 0.541410295
      - 0.541410295 - 0.679593611
      - 0.679593611 - 4.186691284
  - BlockSt\_tif3
    - Value
      - High : 180.186
      - Low : 171.138
  - BlockSt\_tif2
    - Value
      - High : 180.186
      - Low : 170.923
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      - Low : 170.849
  - DEMBlockstats2
    - Value
      - High : 180.186



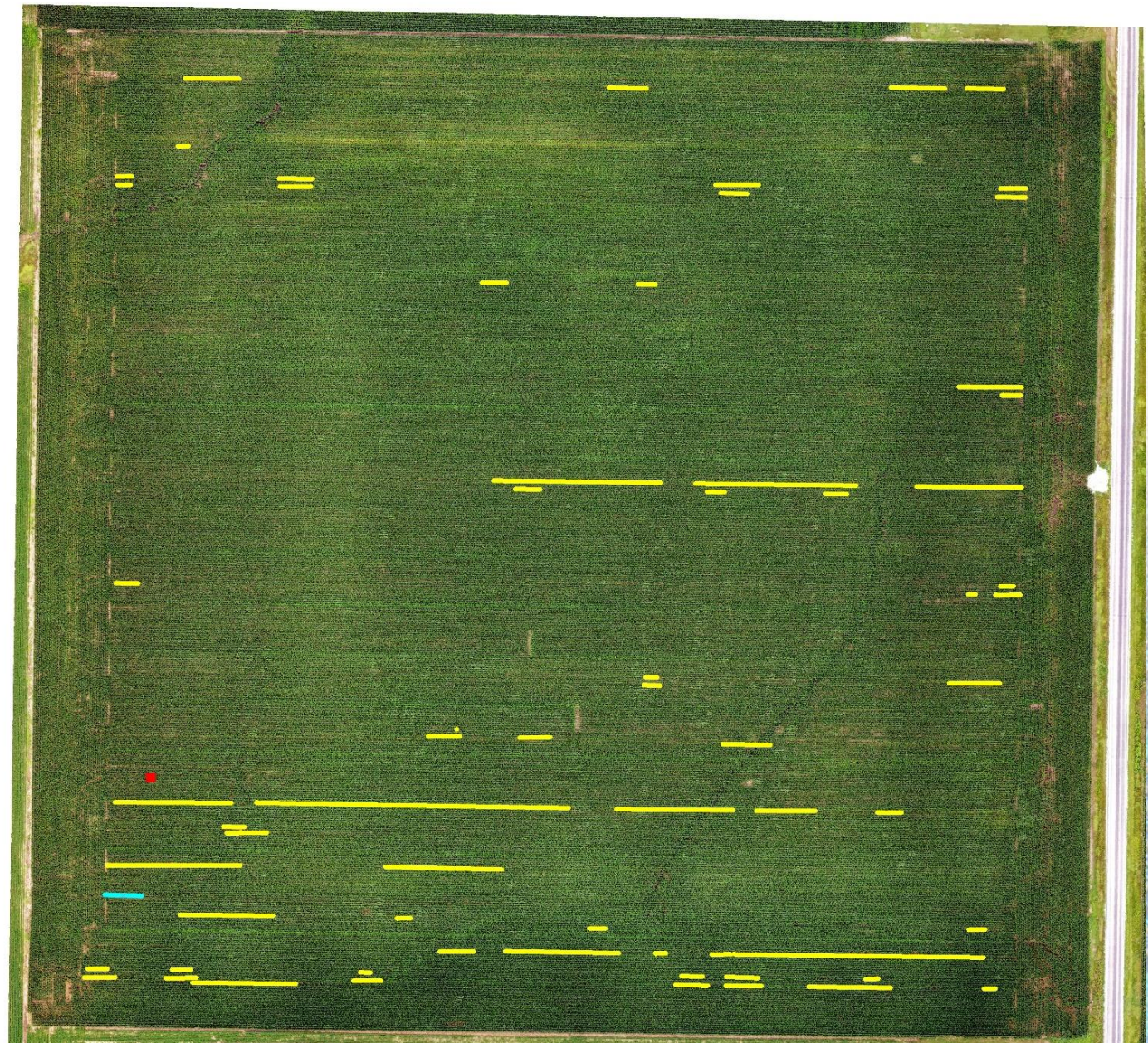
# Data and Stories

9500 ft of row lost

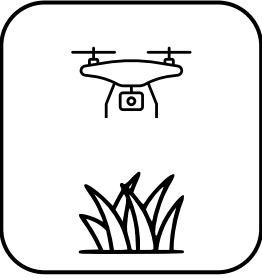
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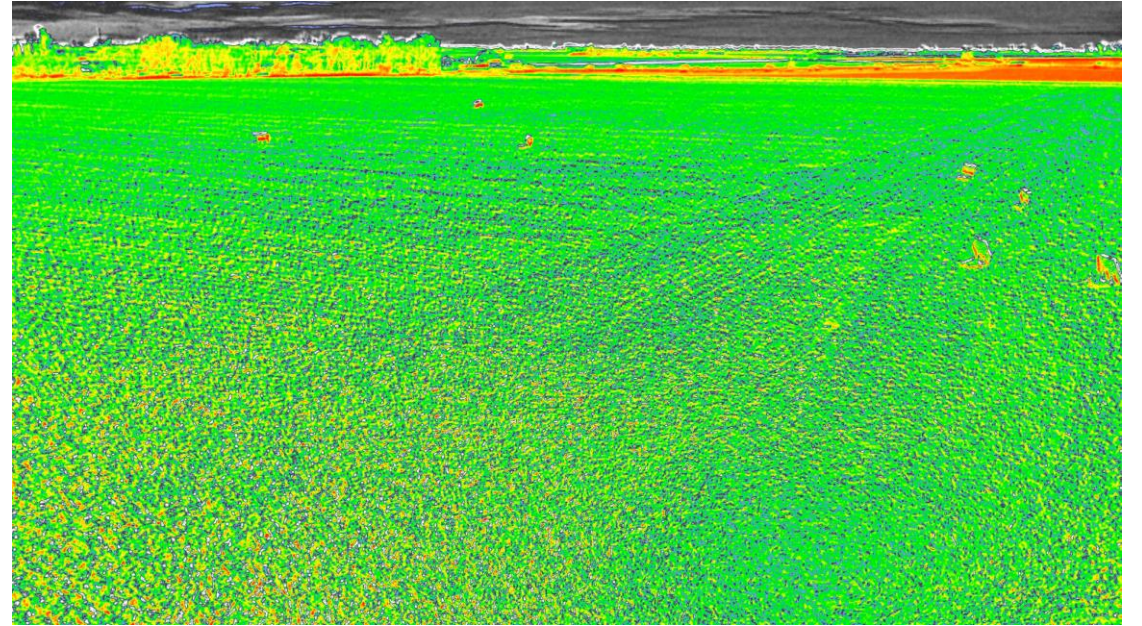
@ \$5.15/bu = \$637 lost







RGB



Multispectral



# Near Term Advancements

- Reduce the need for manual labor, as they can be programmed and operated remotely, saving time and labor expenses.
  - Drone Swarms
  - BVLOS
- Long Duration
- AI Directed Flights

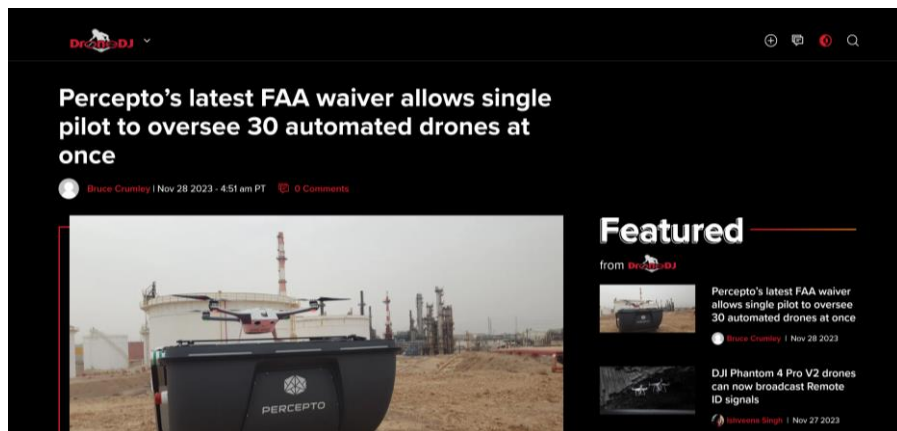
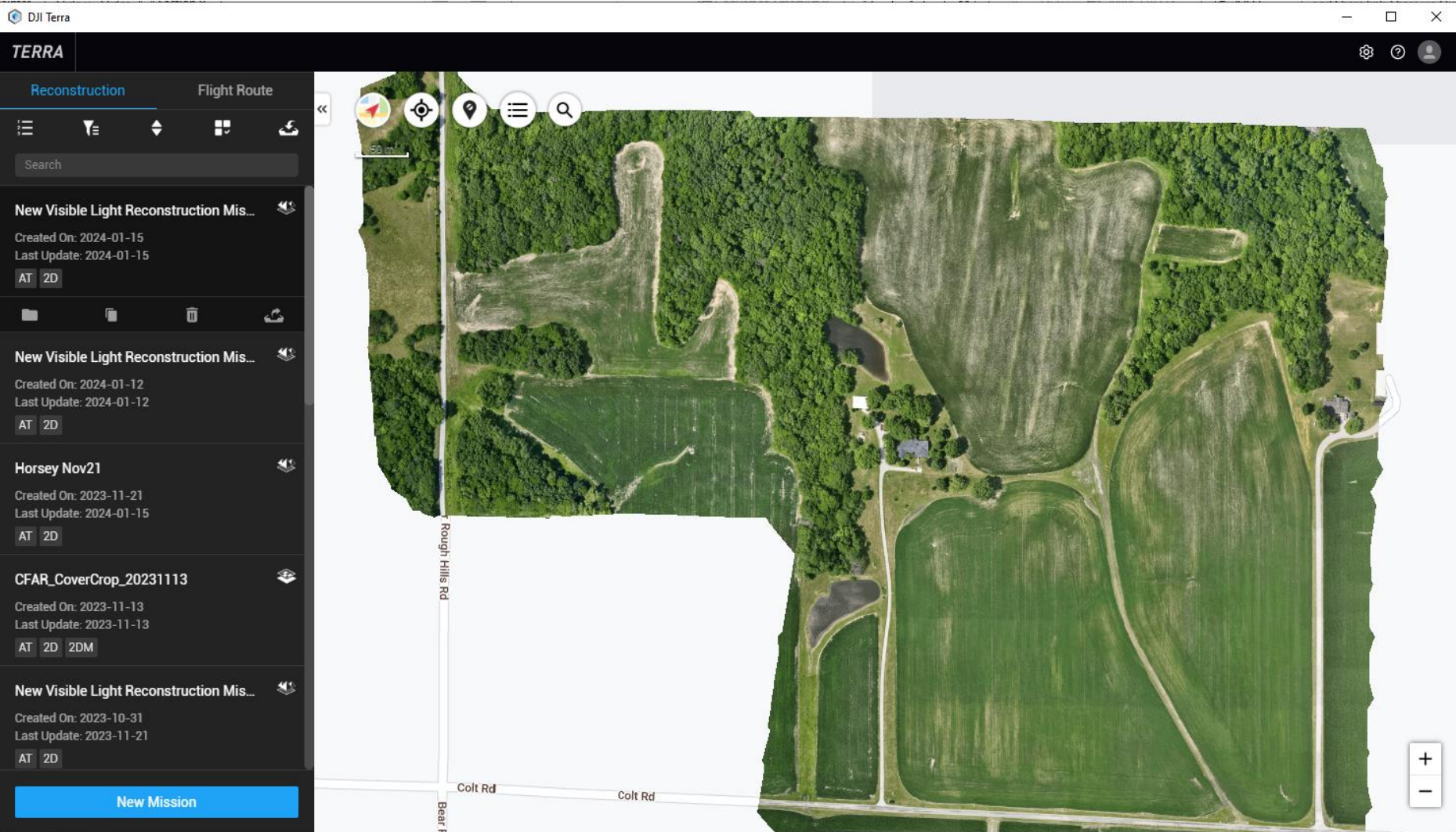


Image by DALL-E


# Orchard Mode





AT  
2D  
3D

+  
-

New Visible Light Reconstructio... 










Photos  2905 Photos 


Image POS Data   


Camera Info  


Aerotriangulation


Scene  
Normal 


Computation Method  
Standalone Computation 

Advanced 

2D Map 

Resolution  
High 

Scene  
Fruit Tree 

Computation Method  
Standalone Computation 

Start Reconstruction

# Orchard Mode



< New Visible Light Reconstru...

Spraying Type

Continuous Spraying

Flight Route Plan Type

Distance Interval (Auto)

Display Result

Force Set Calibration Point

Modify Result

Mission Area Planning

Tip:

1. Left-click to add boundary points for spraying area planning. Add at least one setpoint to complete planning.
2. Right-click to exit and continue making new field plans or flight routes

Generate 3D Flight Route

# Orchard Mode



20m

# Orchard Mode



&lt; New Visible Light Reconstru...



Spraying Type

Spot Spraying

Flight Route Plan Type

Tree Crown Center (Auto)

Display Result Force Set Calibration Point 

Modify Result

Mission Area Planning



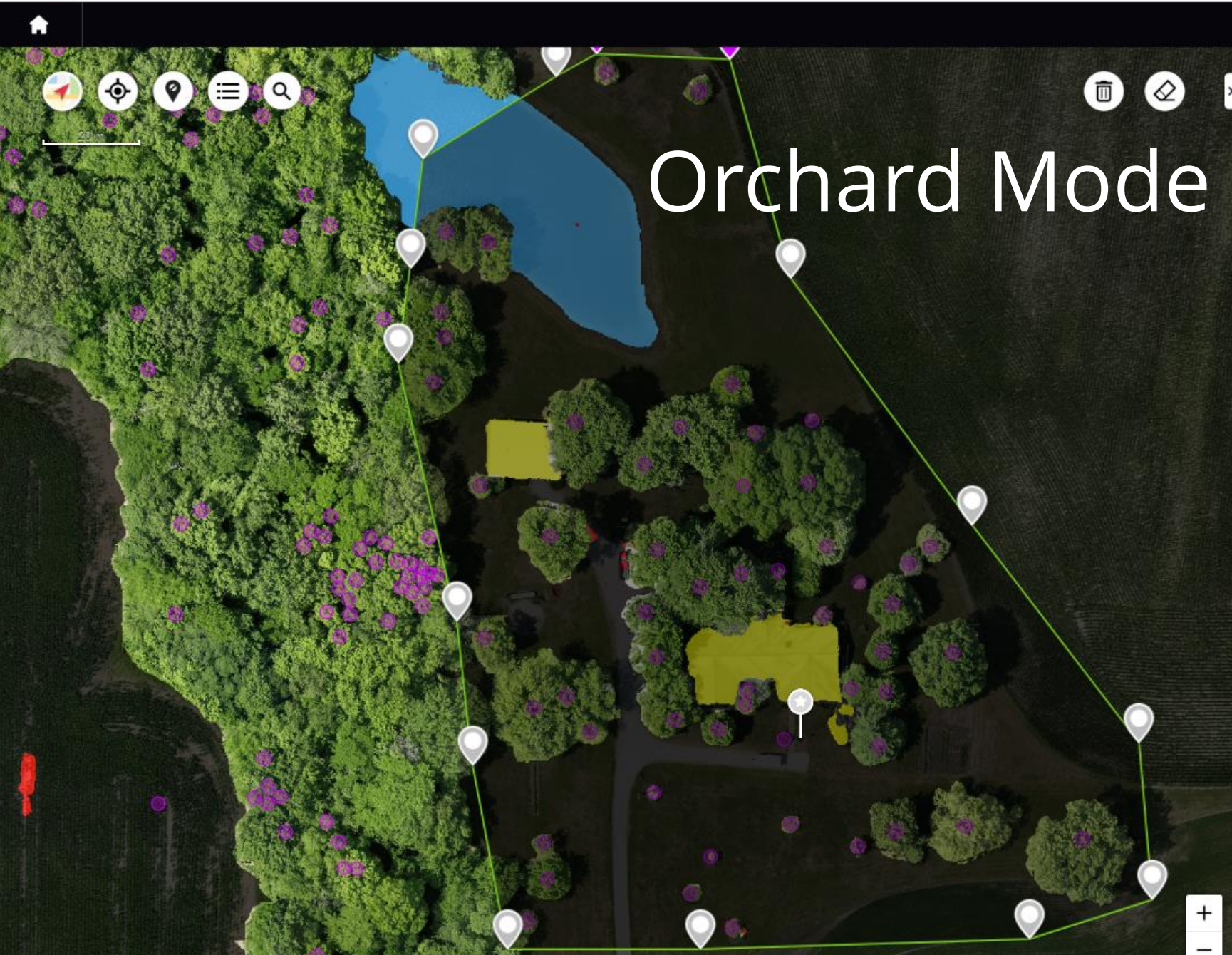
Tip:

1. Left-click to add boundary points for spraying area planning. Add at least one setpoint to complete planning.
2. Right-click to exit and continue making new field plans or flight routes



Others Fruit tree Building Pole Ground Water

Generate 3D Flight Route



20m



# Orchard Mode

< New Visible Light Reconstru...



Spraying Type

Spot Spraying

Flight Route Plan Type

Tree Crown Center (Auto)

Display Result

Force Set Calibration Point

Modify Result

Mission Area Planning



Farmland	Boundary Point
1	14

Area	Tree Count
200381.42 ft <sup>2</sup>	55

- Tip:
1. Left-click to add boundary points for spraying area planning. Add at least one setpoint to complete planning.
  2. Right-click to exit and continue making new field plans or flight routes

Legend for map features:

- Others
- Fruit tree
- Building
- Pole
- Ground
- Water



Generate 3D Flight Route



&lt; New Visible Light Reconstru... &gt;&gt;

Display Result Display Routes Enable Obstacle Sensing 

Route Altitude 6.56 ft

-  +

Flight Route Width 16.4 ft

-  +

Route Angle 0 °

-  +

Terrain Follow Accuracy 0.5

-  +

Tip:

1. Setting a lower value means higher terrain following accuracy, but less stability due to obstacle avoidance. A higher value means less accuracy, but more stable flight

Back to Edit

# Technology adoption

- First agricultural revolution: Move from hunter-gatherers to farmers, domestication of crops and livestock
- Second agricultural revolution: The adoption of mechanization and access to markets
- Third agricultural revolution: Hybridization, commercial fertilizers, pesticides
- Fourth agricultural revolution? Information, AI, robots/drones





SPEEDTENDER 375

J&M

3252-5071

# Questions?



Implementing a Digital Agriculture Program in Extension



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**217.244.0851**

**Illinois  
Extension**

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