# Unmanned Aircraft Systems

# Forest Nursery Applications

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Modified by TPM
10 July 2017 SFNC Meeting
Myrtle Beach, SC

# Information drives agriculture and forestry

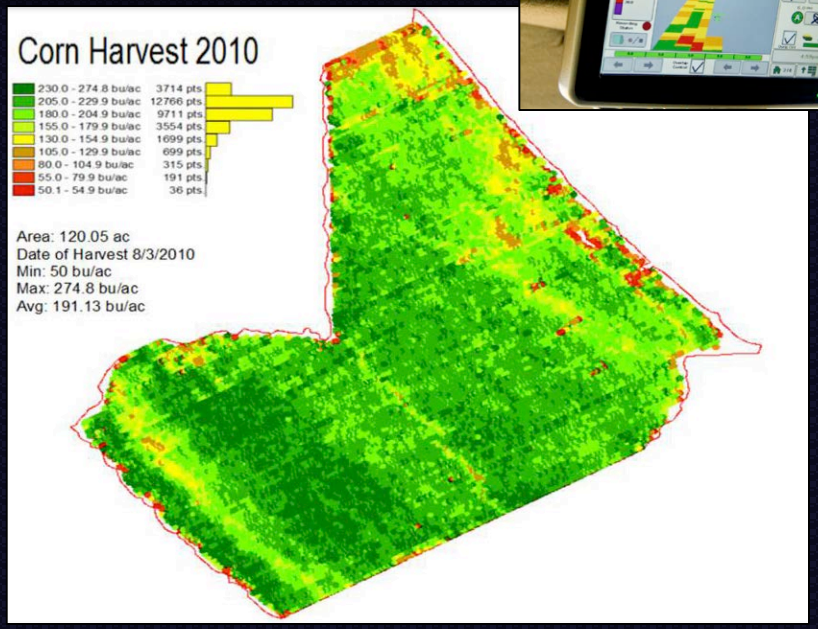
GPS sparked a geospatial data revolution in agriculture and forestry.

- Stand mapping
- Surveying
- Inventory
- Verification of services performed
- Guidance
- Yield mapping
- Variable rate control

# Precision Agriculture

- Yield monitors (with GPS) collect crop yield data during harvest.
- Yield maps reveal geospatial variability in crop yield.
- Yield maps are “after-the-fact” and only help prepare for next year
- Maximizing potential of soil, water, and genetics means maximizing profitability for the producer.

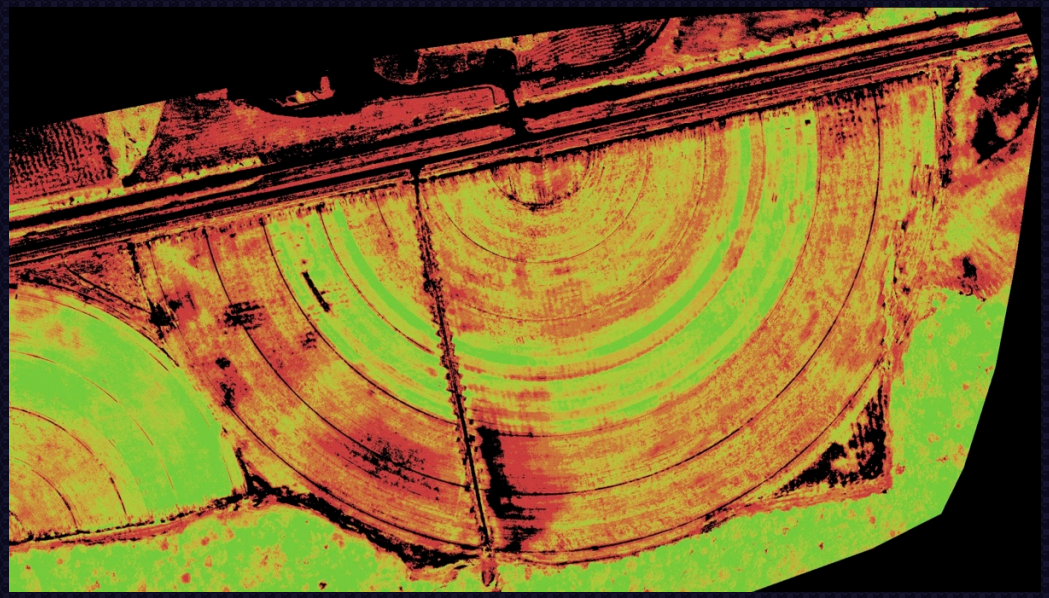




# Detecting variability and developing real-time “actionable information”

Unmanned Aerial Systems (UAS) allow rapid deployment of high resolution sensors to detect geospatial variability.

- Soil moisture
- Plant stress
  - Moisture
  - Nutrition
  - Diseases
  - Pests

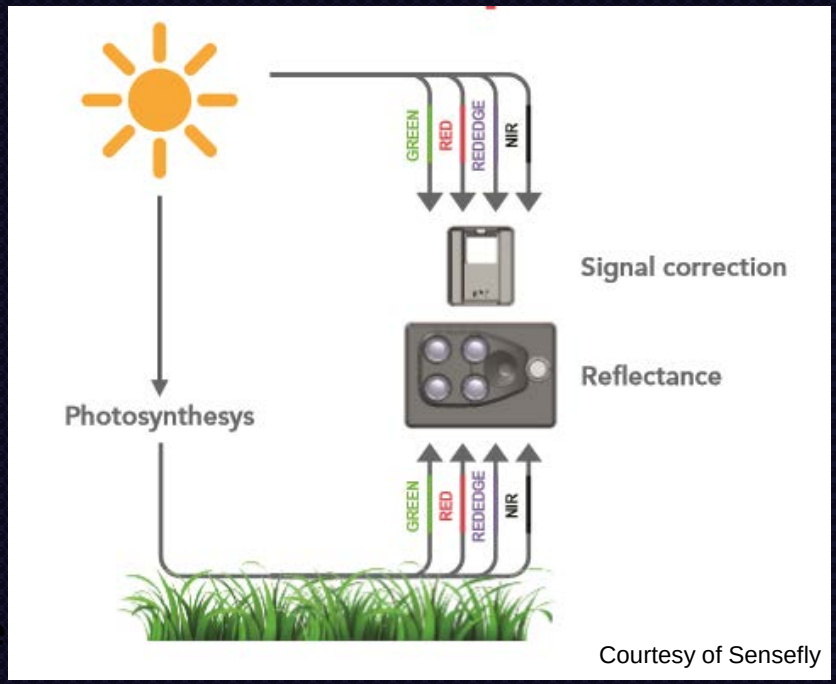


# UAS Sensors

- RGB
- Near-Infrared
- Multi-Spectral
- Thermal
- LiDAR
- Hyperspectral


Courtesy of Sensefly

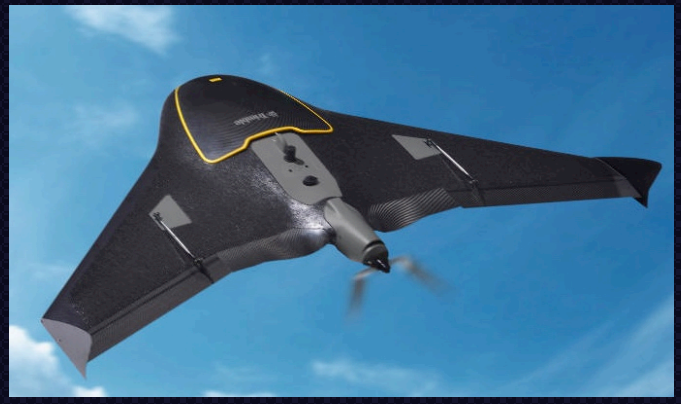
Trimble

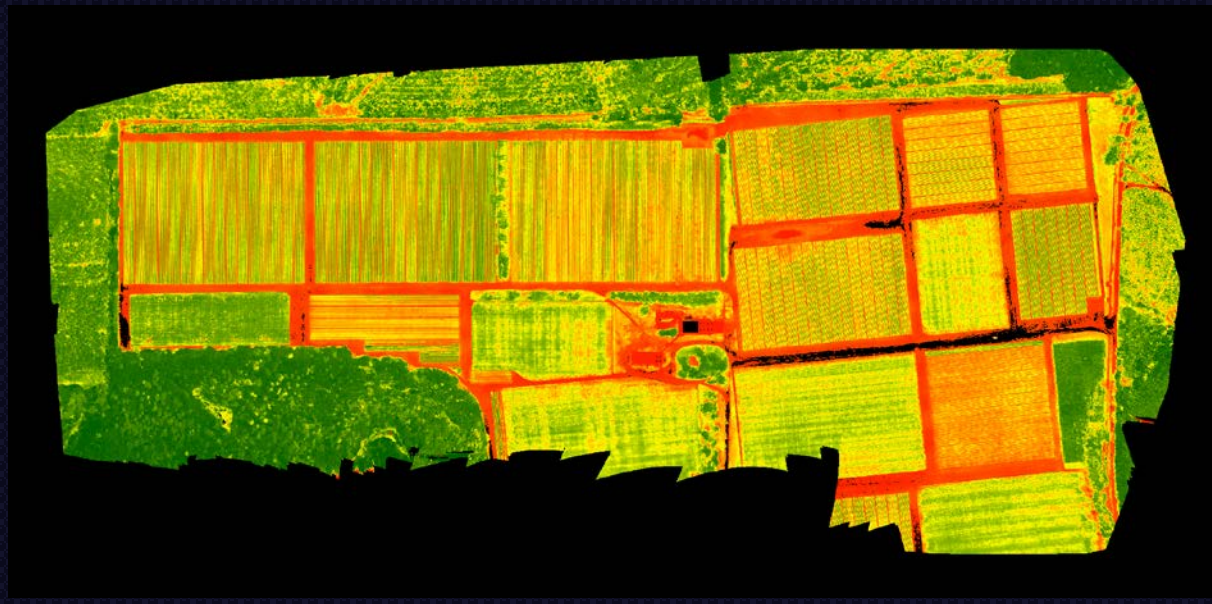


Courtesy of Sensefly

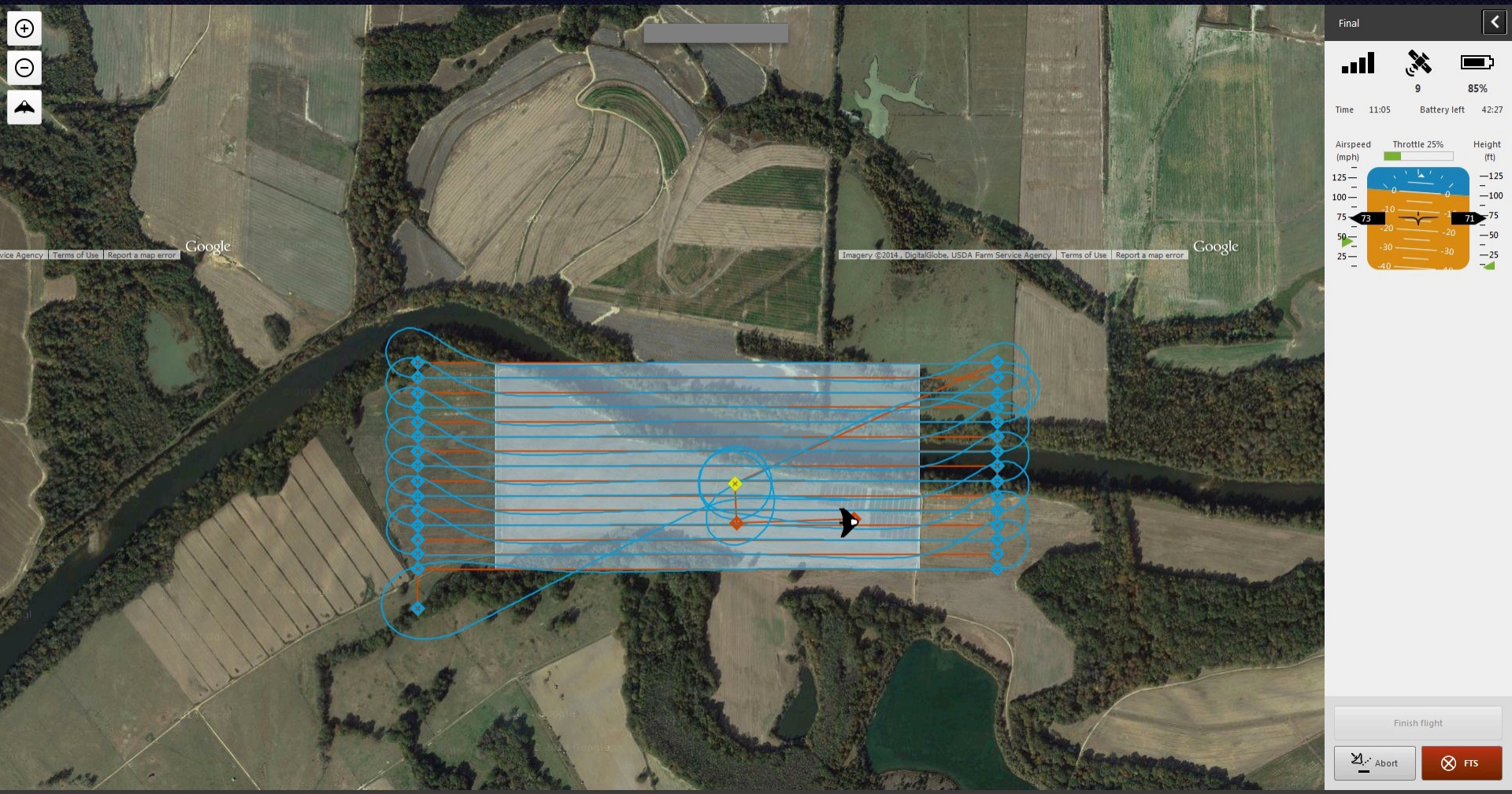
**Rotary wing aircraft are useful for visual observations of agricultural or forest operations or stand conditions**

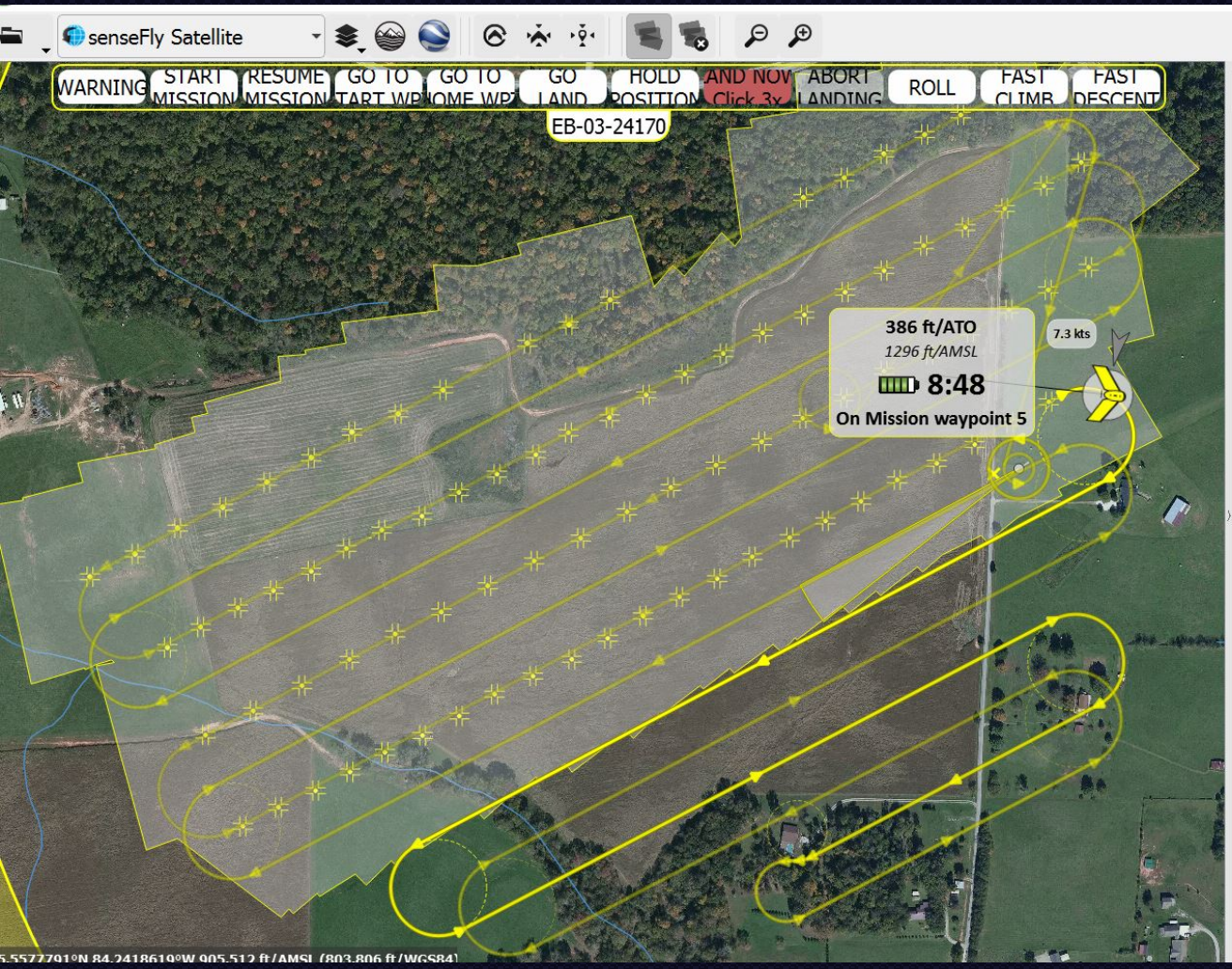
**Fixed wing aircraft are used for longer flights over larger areas allowing more in depth analysis and generation of prescription maps**





# Flight operations are pre-planned and automated






**Drone status**

**On Mission waypoint 5**

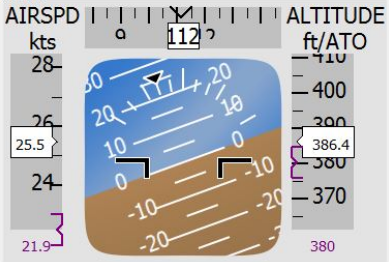
**Autonomy**

| Battery voltage | Time in flight |
|---|---|
| 87% (11.7 V) | 08:48 |
| Home distance | Estimated wind |
| 367 ft (00:08) | |
| Link quality | |
| 100 % | 7.3 kts |

**Flight data**

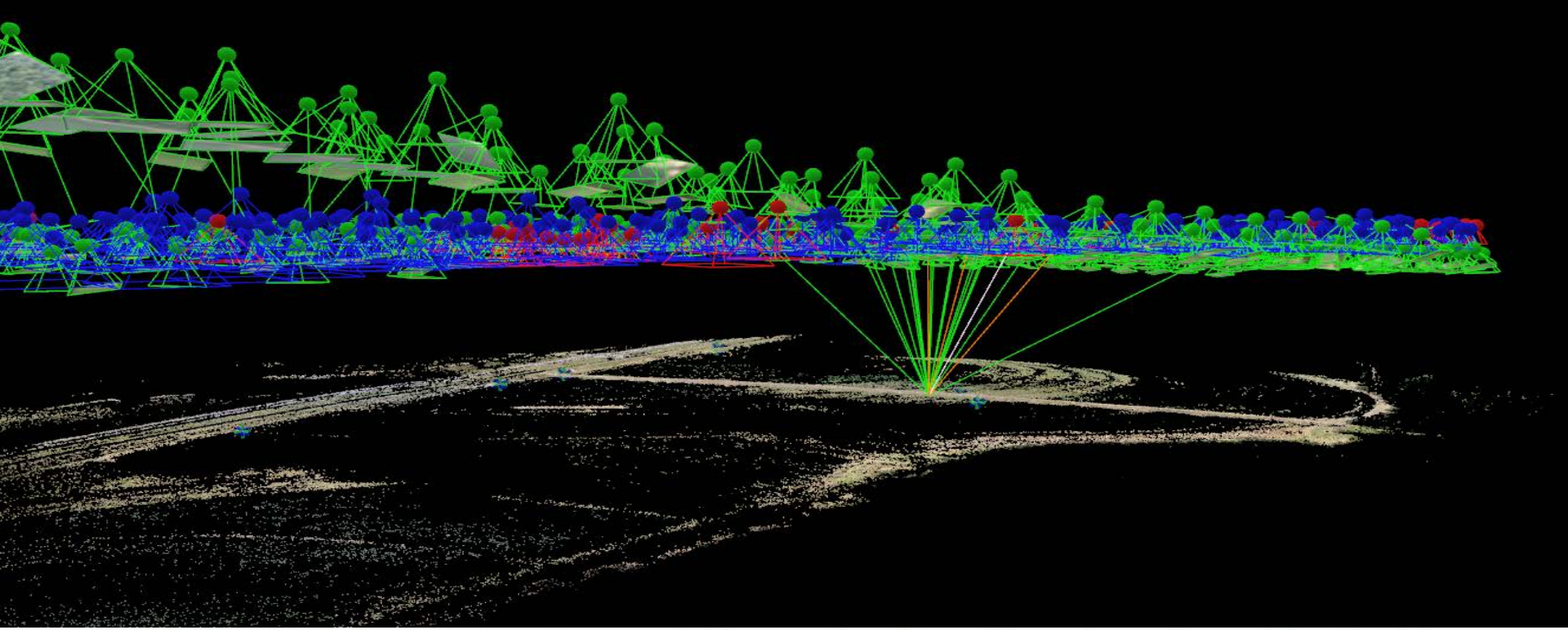
| | |
|---|---|
| Ground speed: | 25.6 kts |
| Altitude: | 1295.9 ft/AMSL<br>1191.2 ft/WGS84 |
| Ground sensor height: | - ft |
| Position: | N 35.5601165°<br>W 84.2429993° |

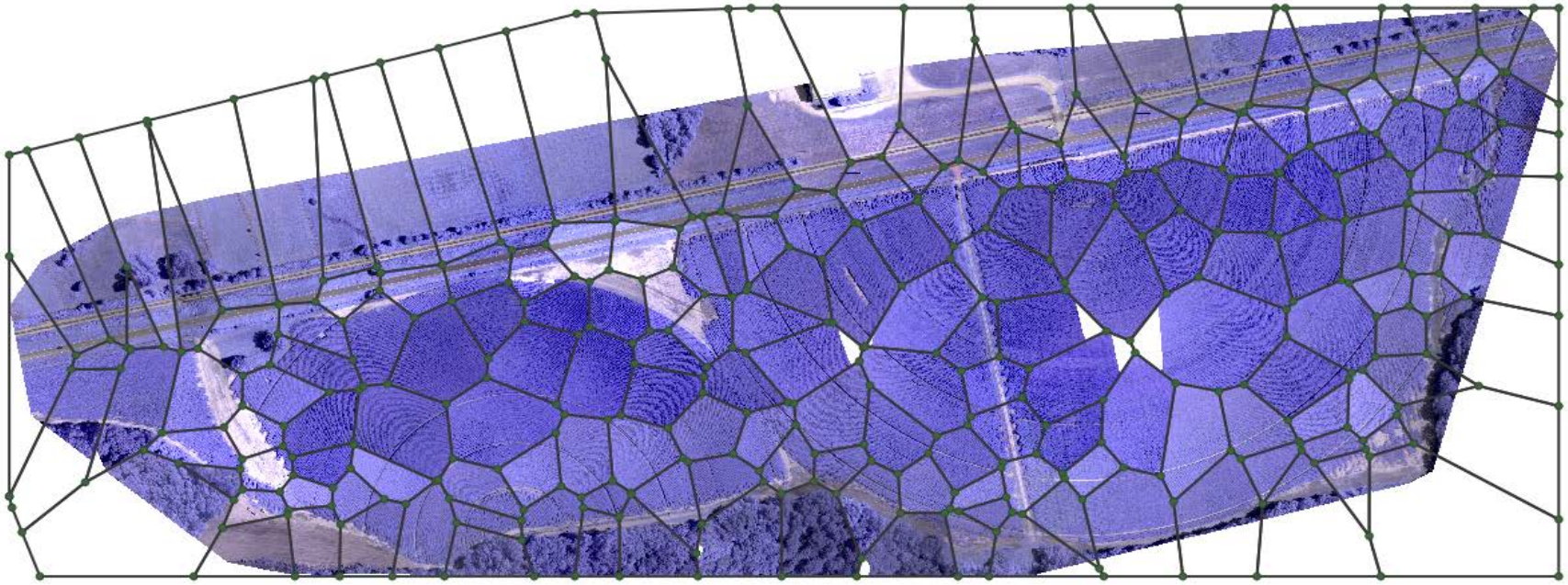
**Instruments**



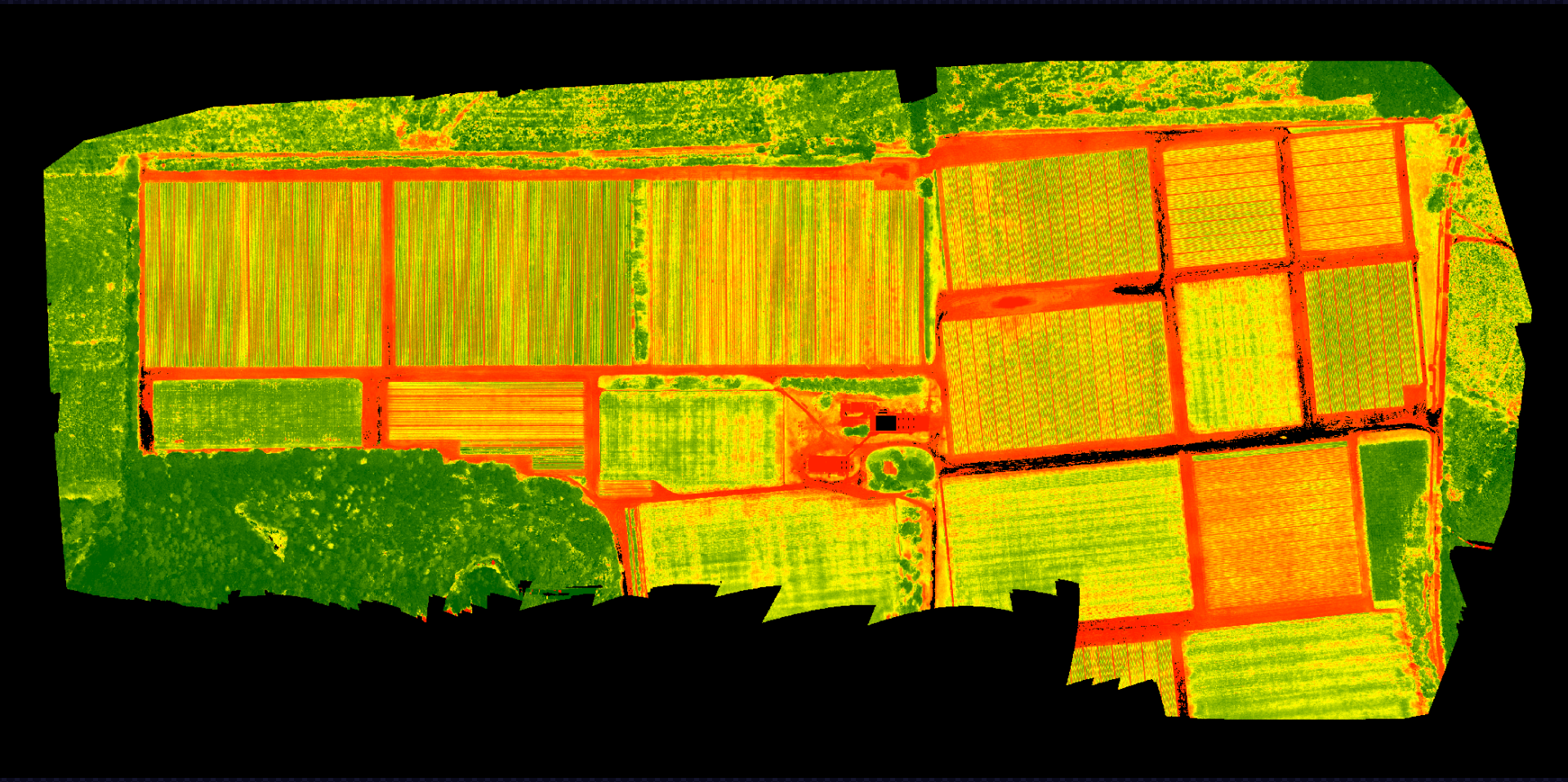

**Identification**

Name: **n/a (EB-03-24170)**

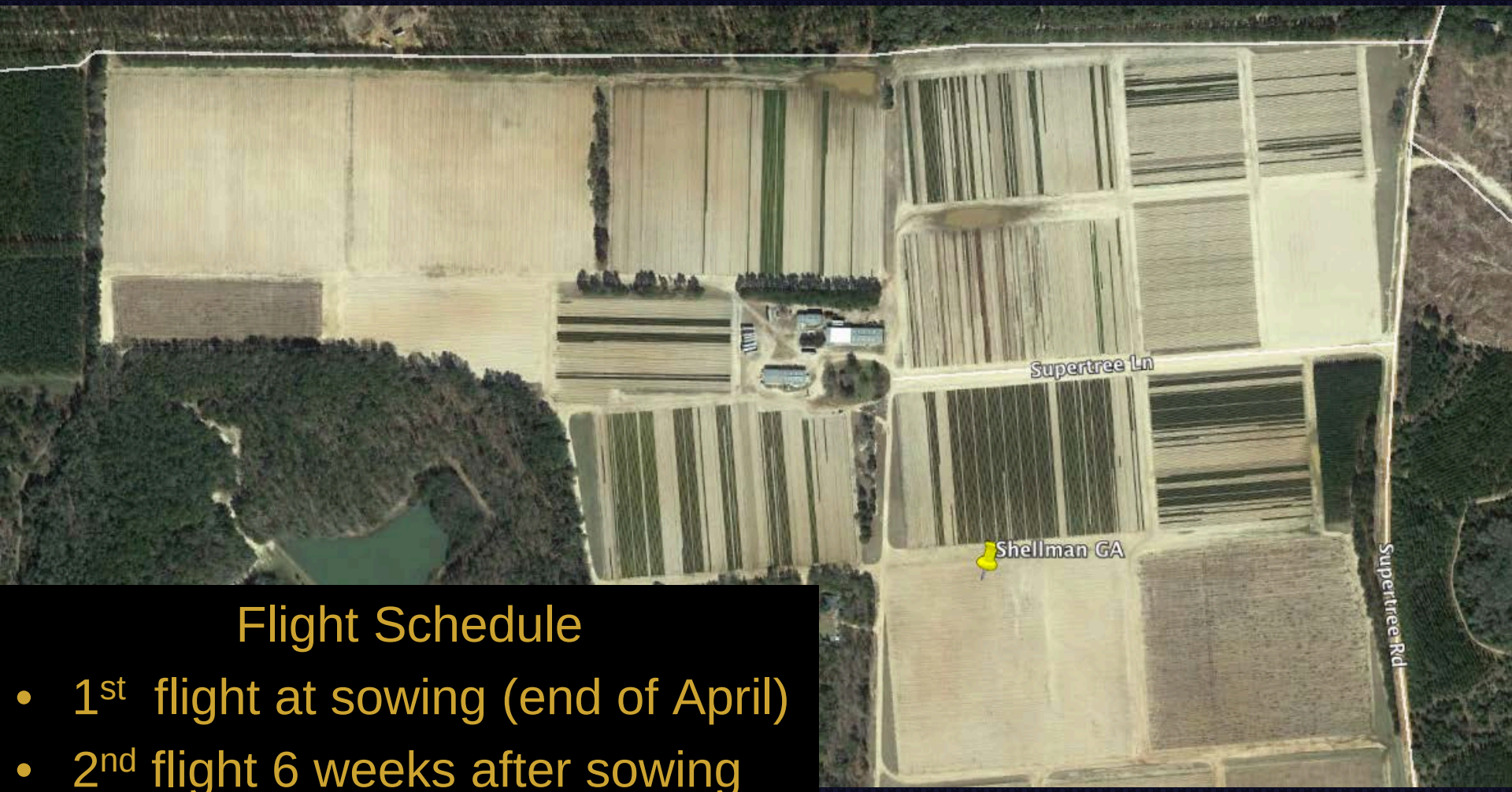




# UAS Imagery



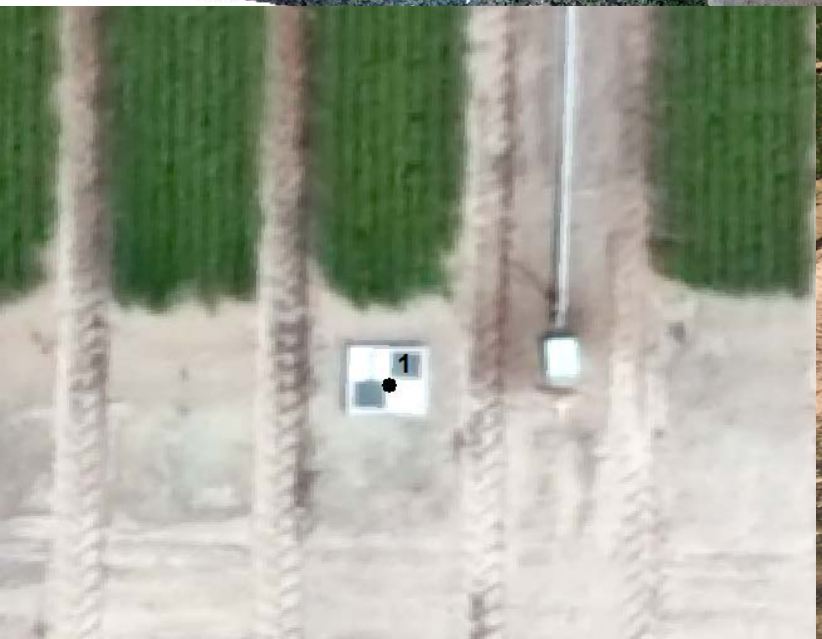
# Shellman Nursery Study Plan




## Flight Schedule

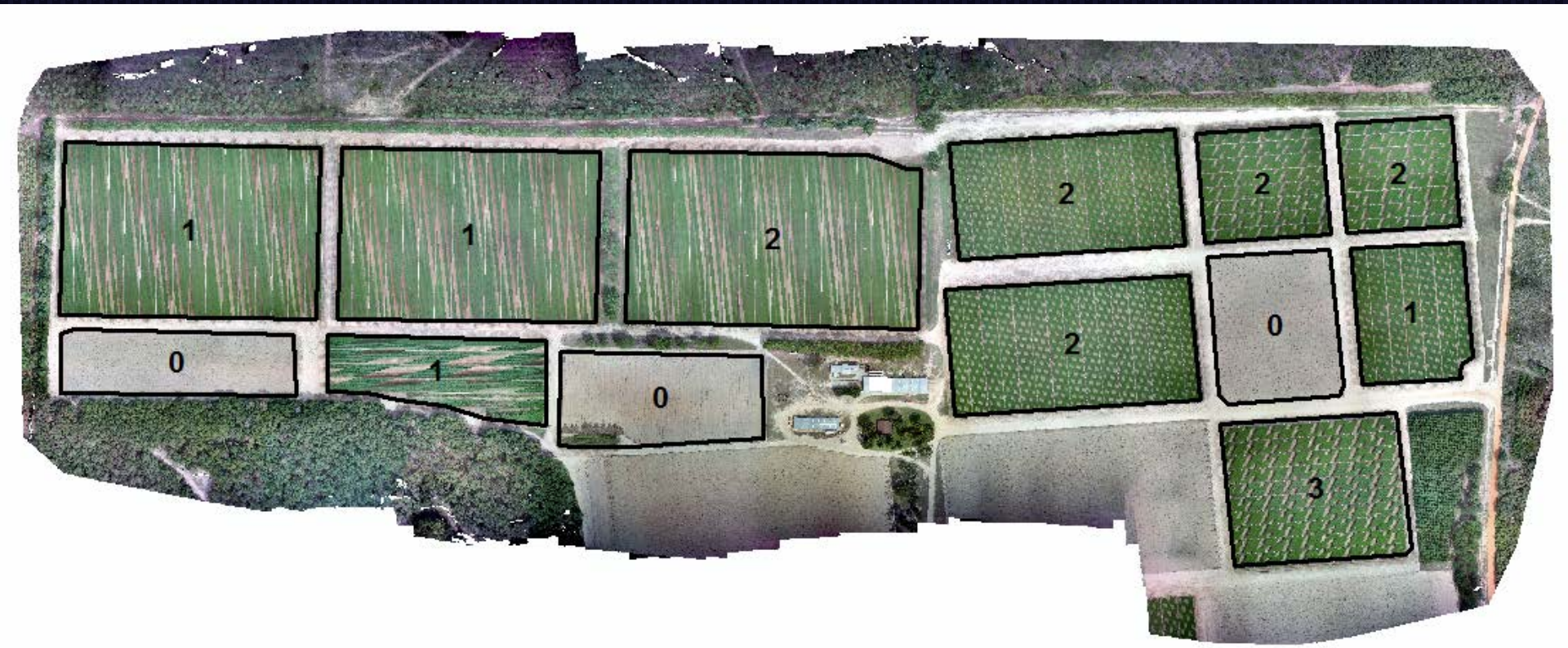
- 1st flight at sowing (end of April)
- 2nd flight 6 weeks after sowing
- Following flights would be about 4 weeks apart through October

# Ground Control Points


# Nursery Site Layout

## Years Since Fumigation



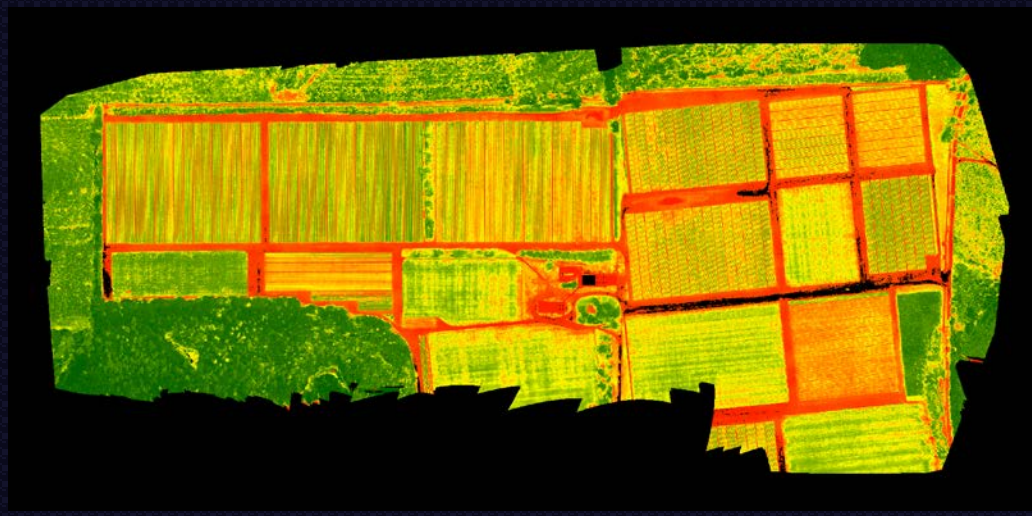
# Data Collection

Actual Flight Schedule

- Flight #1 – April 26
- Flight #2 – May 31
- Flight #3 – July 13
- Flight #4 – August 16
- Flight #5 – September 27
- Flight #6 – November 2

**RGB - Visual**

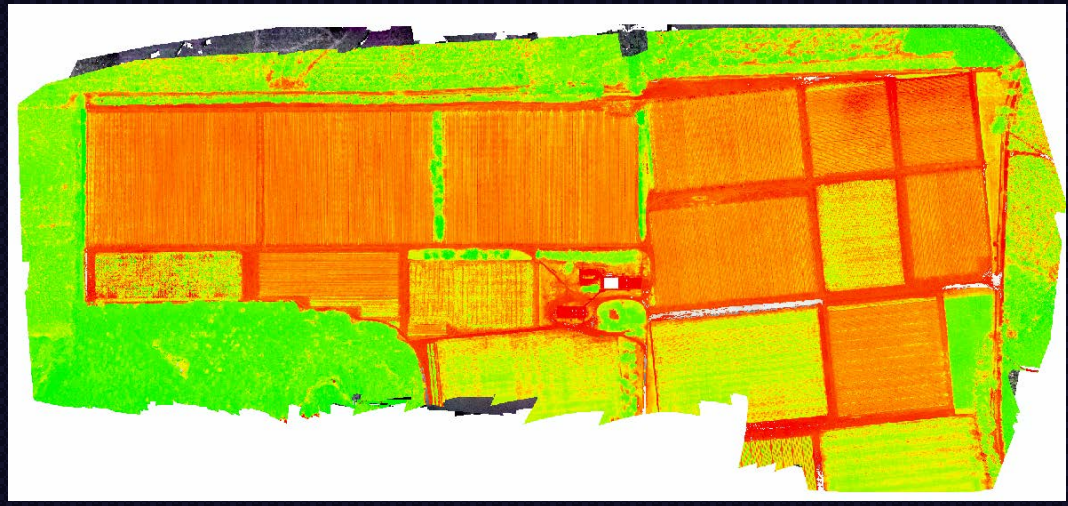
**Multispectral - NDVI**



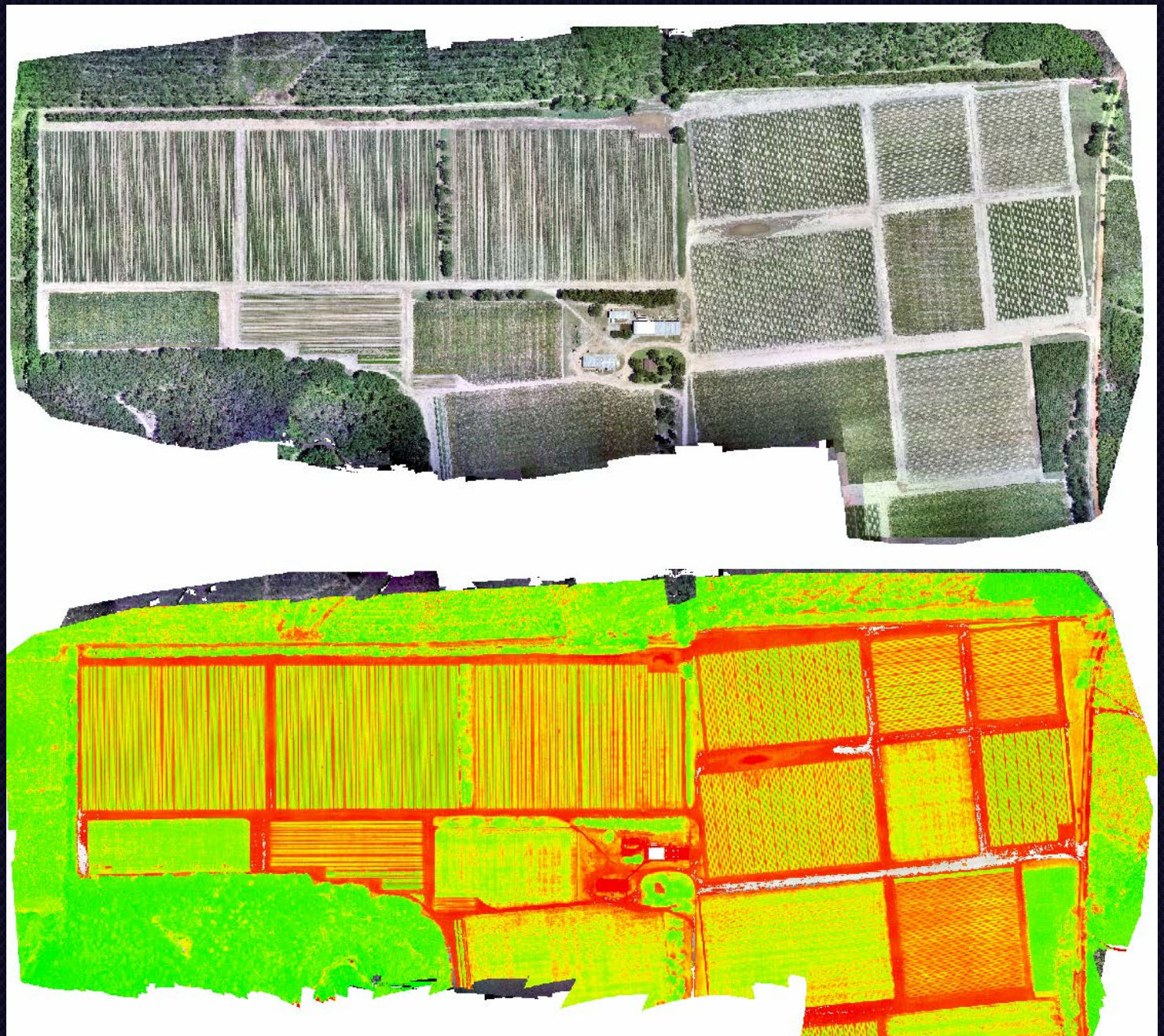
# Data Analysis

- Process data and generate visual imagery and NDVI imagery
- Look for and identify variability
- April and May flights showed very little variability
- Starting in July, some variability started to exist
- Needed to wait until seedling were large enough to be picked up by the imagery

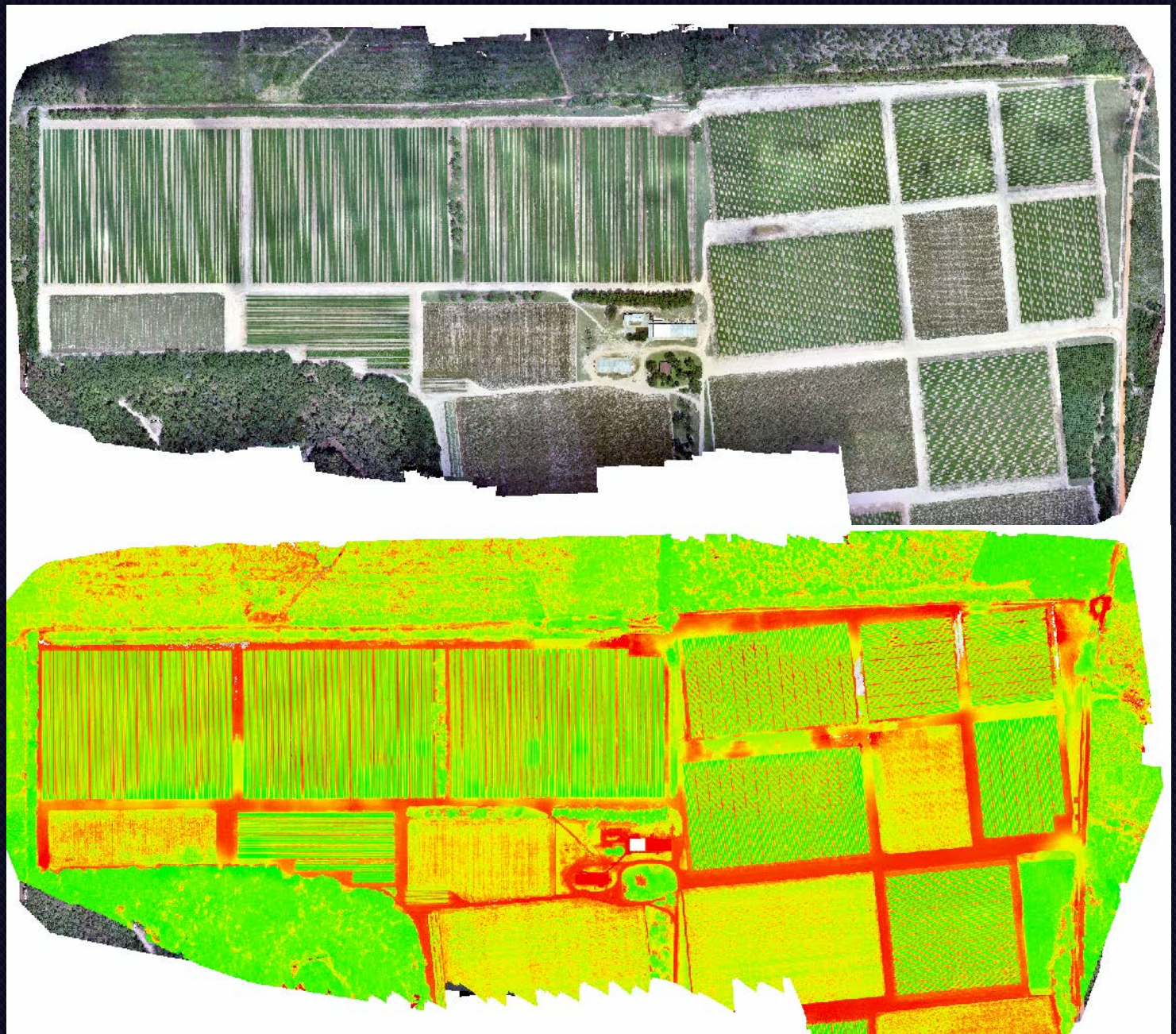
**May 31st Imagery**



# July 13, 2016



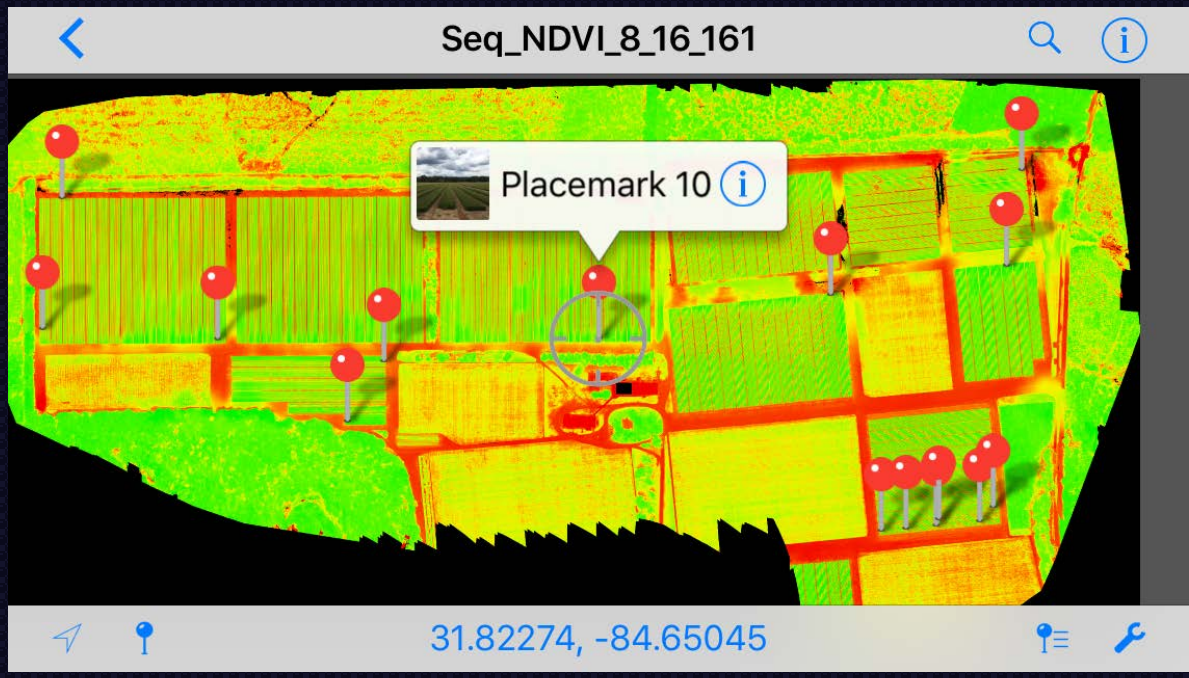
# August 16, 2016



# Field Scouting

- Using tablet or smartphone, load the NDVI imagery and use GPS to navigate to areas of the field that are of interest
- Determine if the variability identified in the imagery actually exists
- Document by mapping location and taking picture

**Screen Shot from iPad**



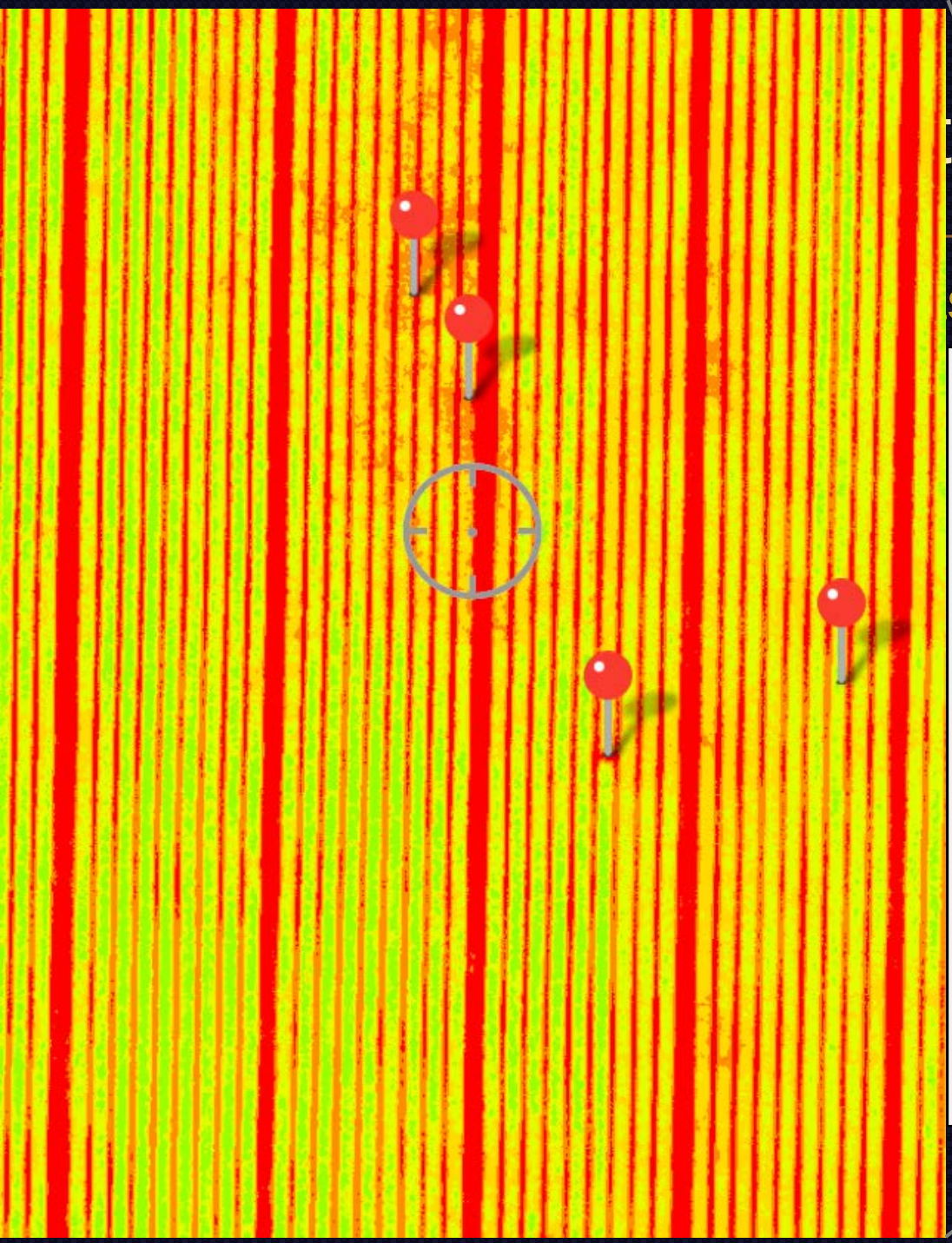
# Field Scouting

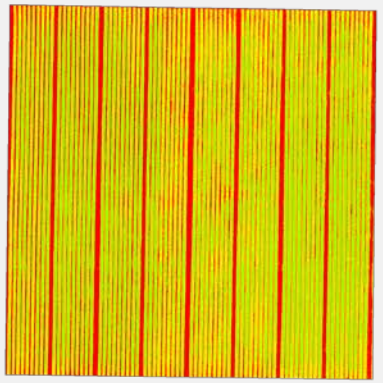
# Area of Optimal Growth

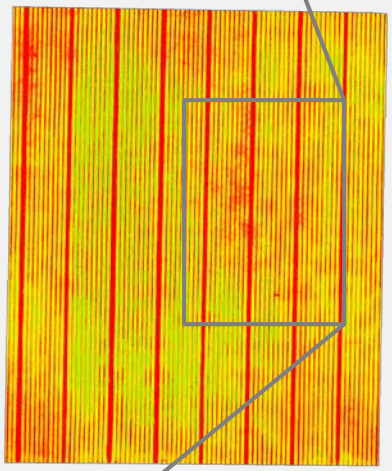
# Areas of Concern

# : Nursery Meeting

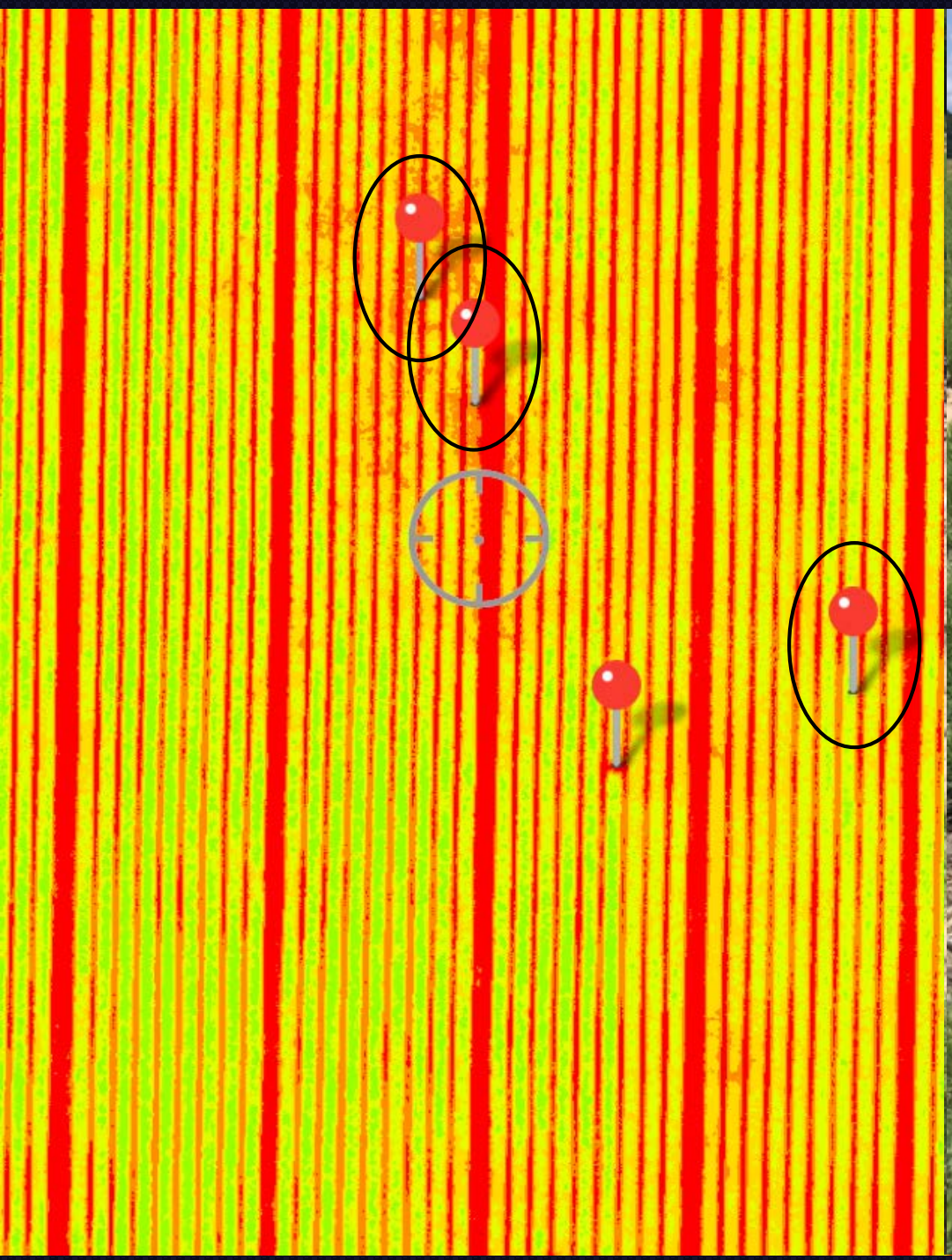
sper, TX





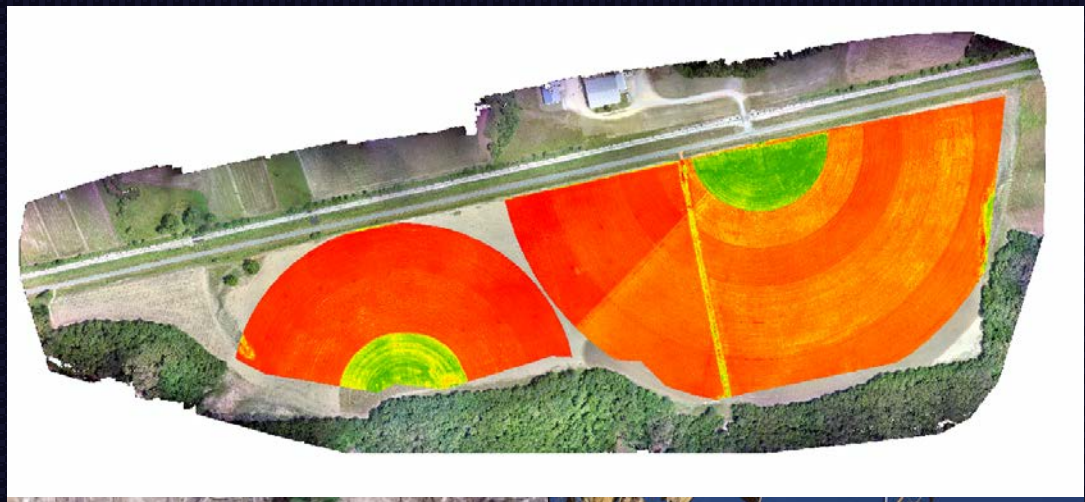


**Best Growth, Best Genetics**



# UAS Challenges

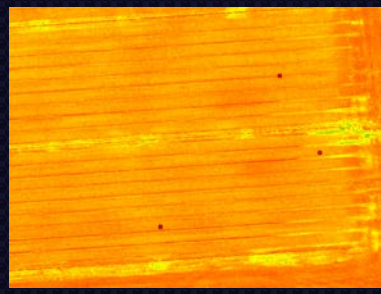
- Weather
  - Clouds, winds, irrigation
- Take-off/Landing
  - Suitable spot for landing
- Data handling
  - Large data sets, >10GB
  - Handling, storing, sharing
- Data Processing
  - Large data sets = large processing requirements
- Field Scouting
  - Need to scout close to time of flight
- Variability due to clipping
- Systems Failing



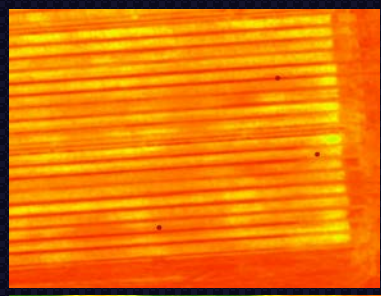

# UAS Conclusions

- Variability in nurseries can be mapped using UAS
- Takes about two months after sowing for variability to appear
- Variability seemed to be most evident three to four months after sowing
- NDVI algorithm is suitable, however there may be another more appropriate algorithm
- Field scouting will continue to be necessary
- UAS has potential as a management tool in forest nurseries

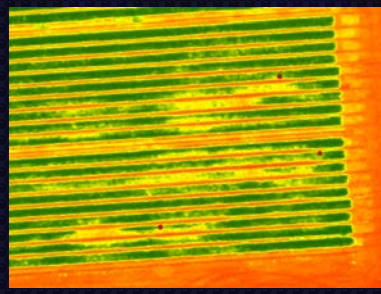
**May 31 NDVI**



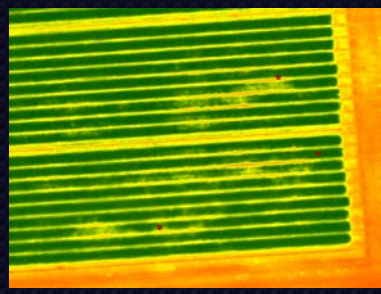
**July 13 NDVI**



**Aug. 16 NDVI**



**Sept. 27 NDVI**



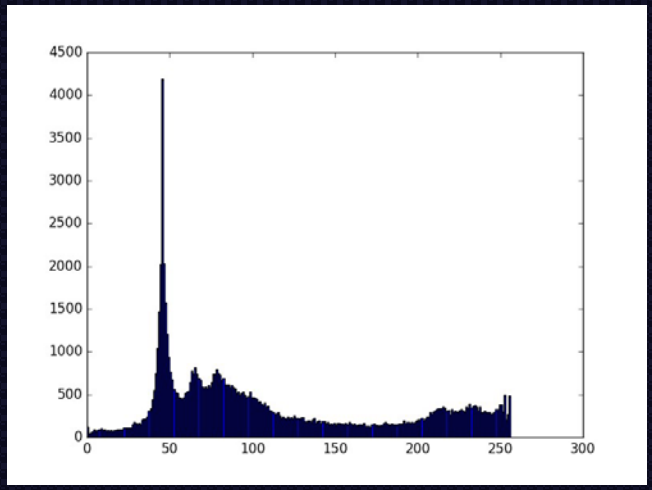
**Sept. 27 RGB**

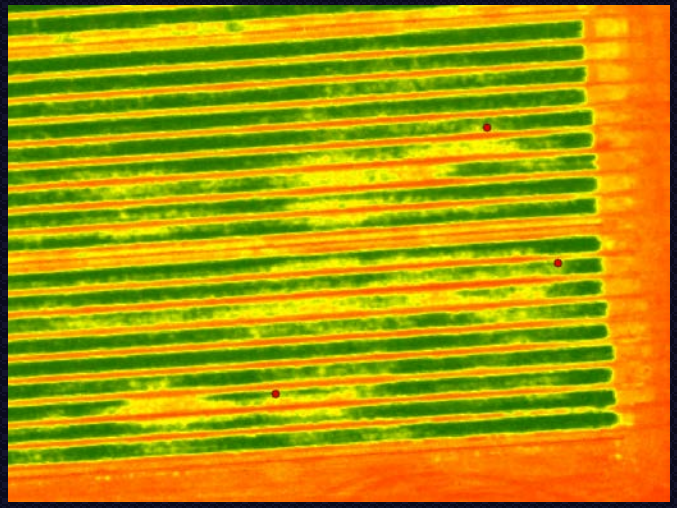
# Counting Trees

- Identified as an important issue
- Don’t have the scouting data to perform via UAS

# Image Processing

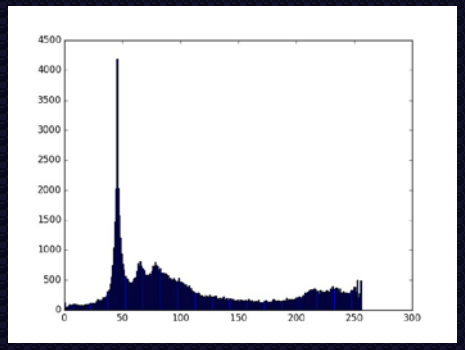
- Image is a matrix
  - Each number is a `pixel' and is associated with an intensity
  - Each pixel has an order, or location
- Can assign color to a value to help us interpret

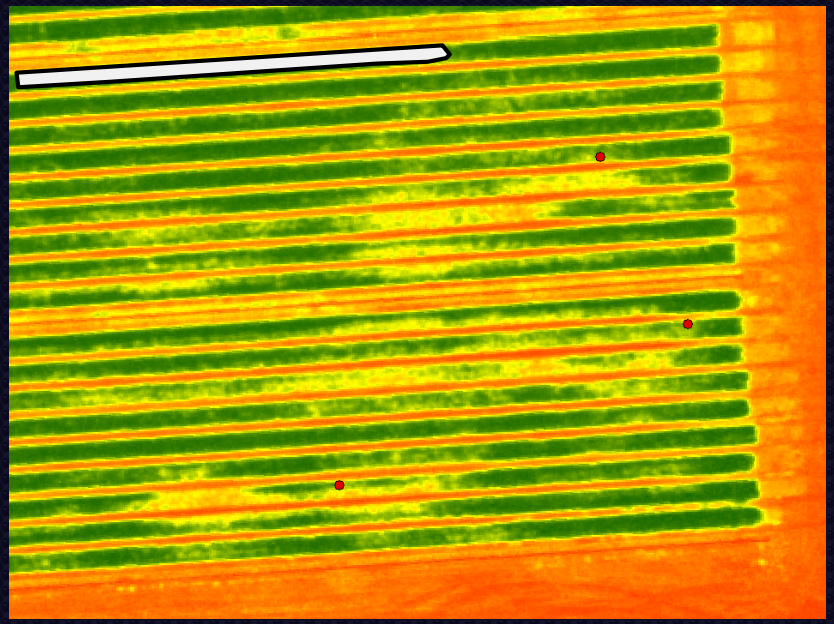


# How To Count Trees Via UAS

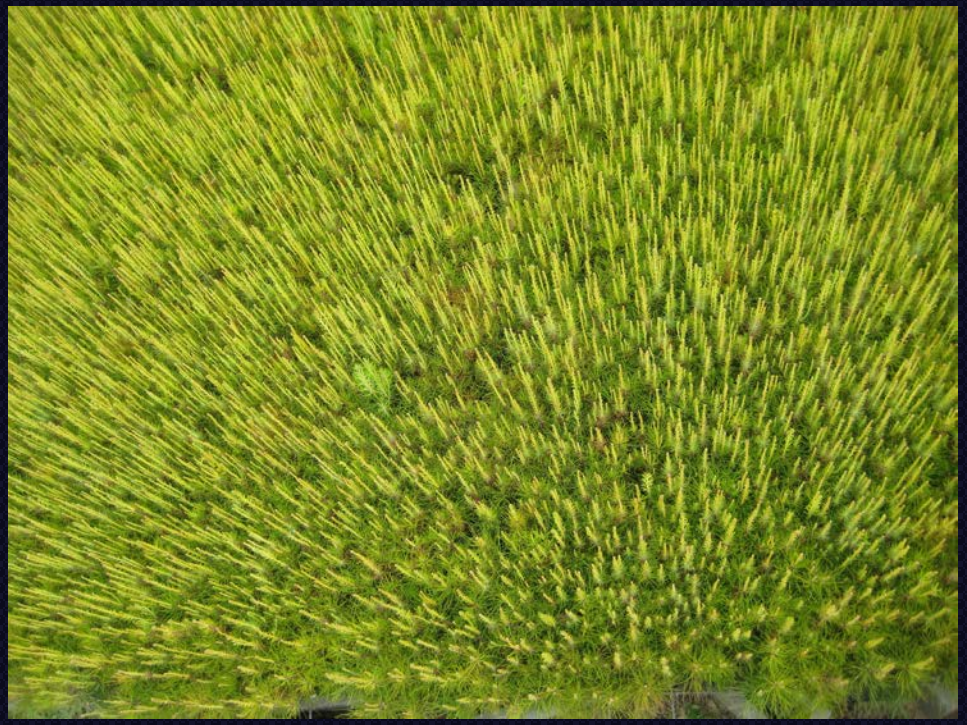
- Classification problem:
  - Identify regions of uniform intensity
  - Count the seedlings in those areas
  - Develop f(intensity) = seedling density



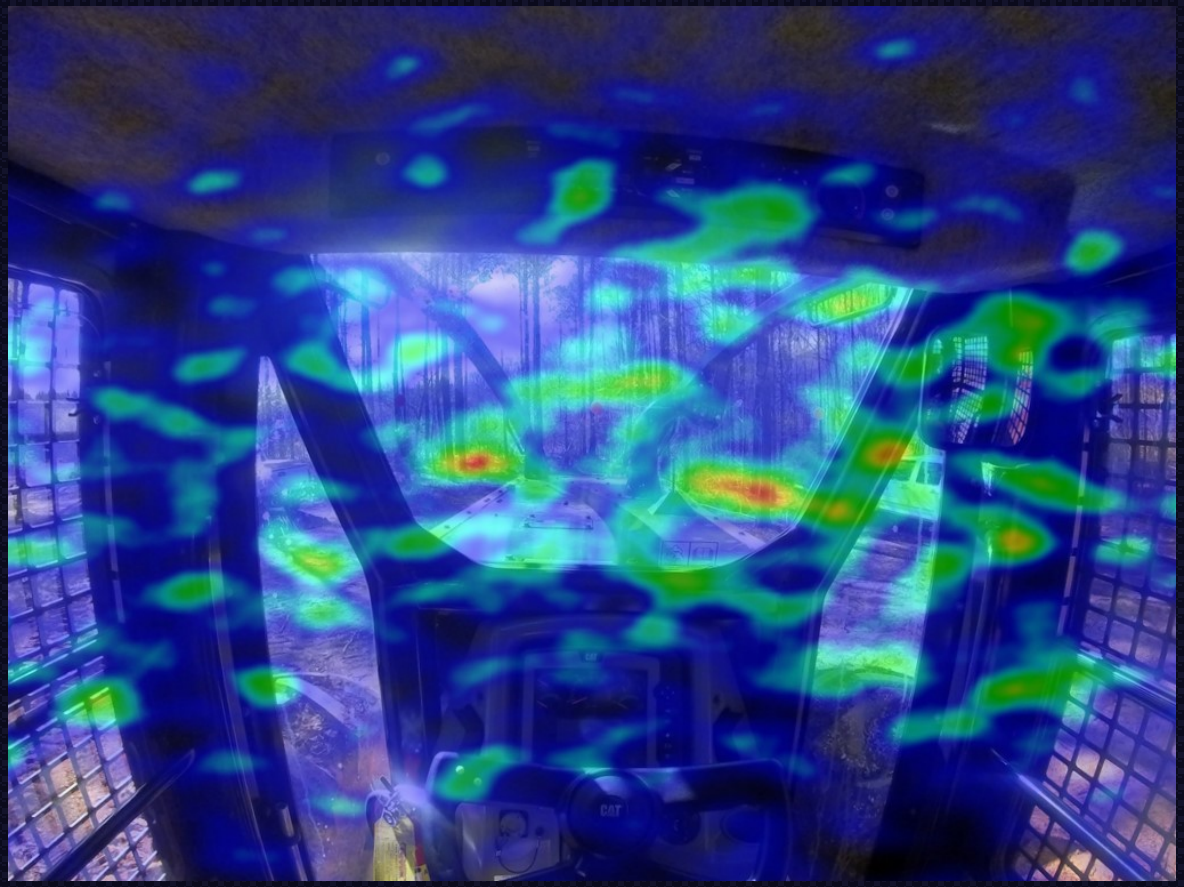
# Non-UAS Approach

- Still a classification problem
  - Intensity not the only classification criterion

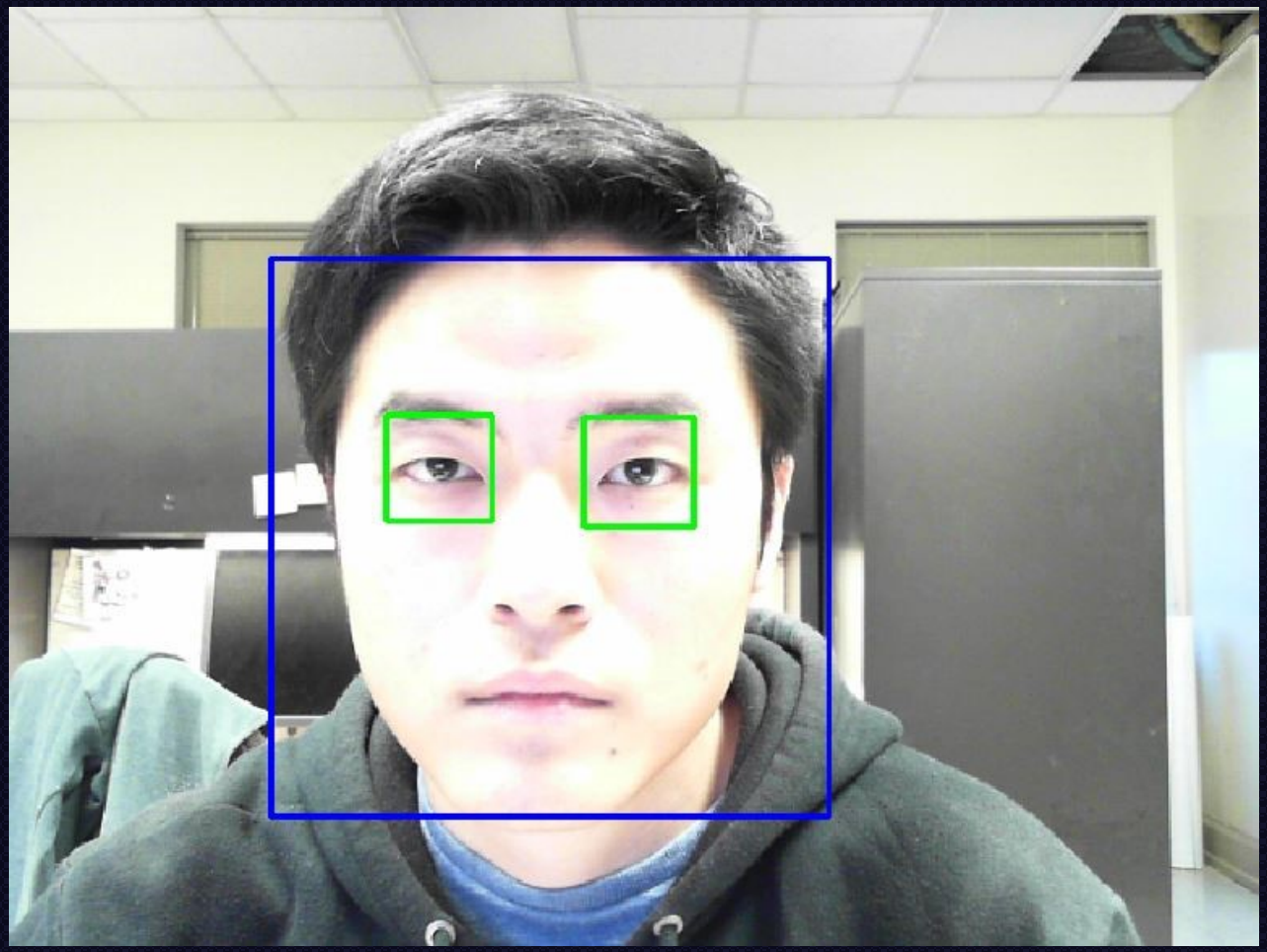


# Image Interpretation

- Similar Problem: Facial Recognition



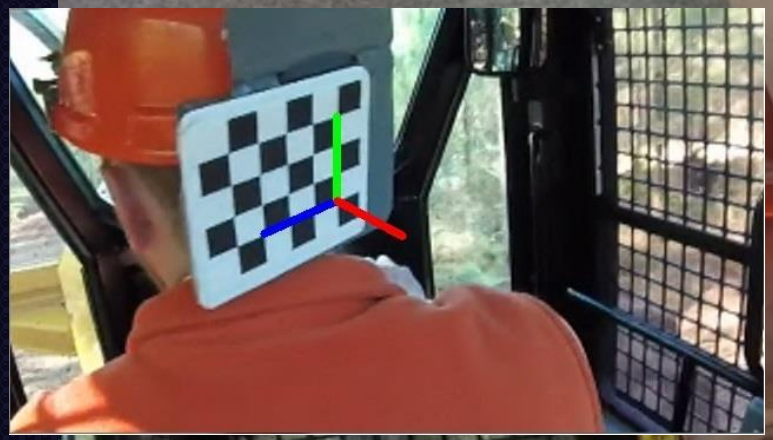
# Facial Recognition



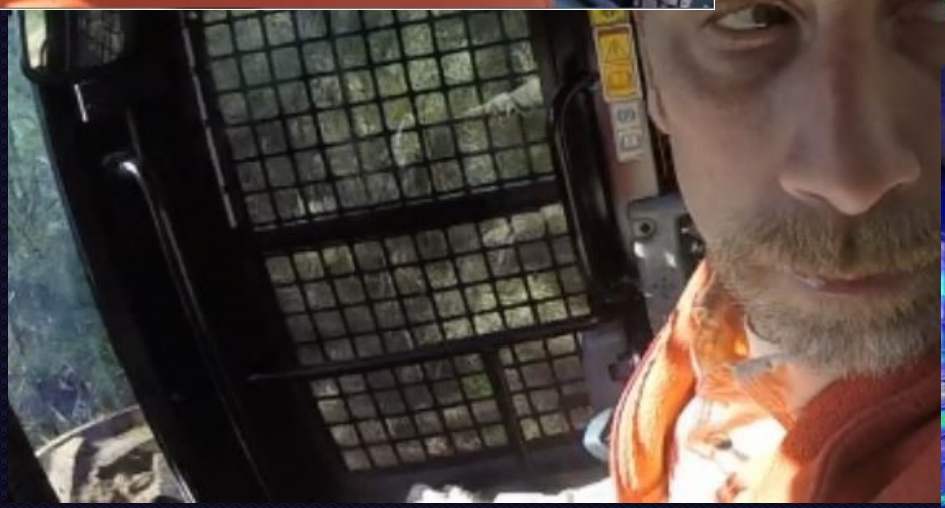
# Pupil Recognition

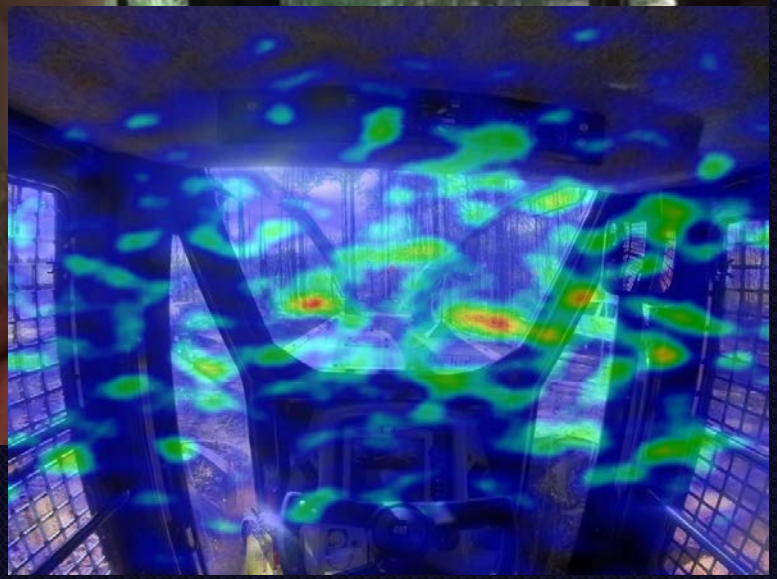
- Where is it relative to the eye `window’

# Operator Focus



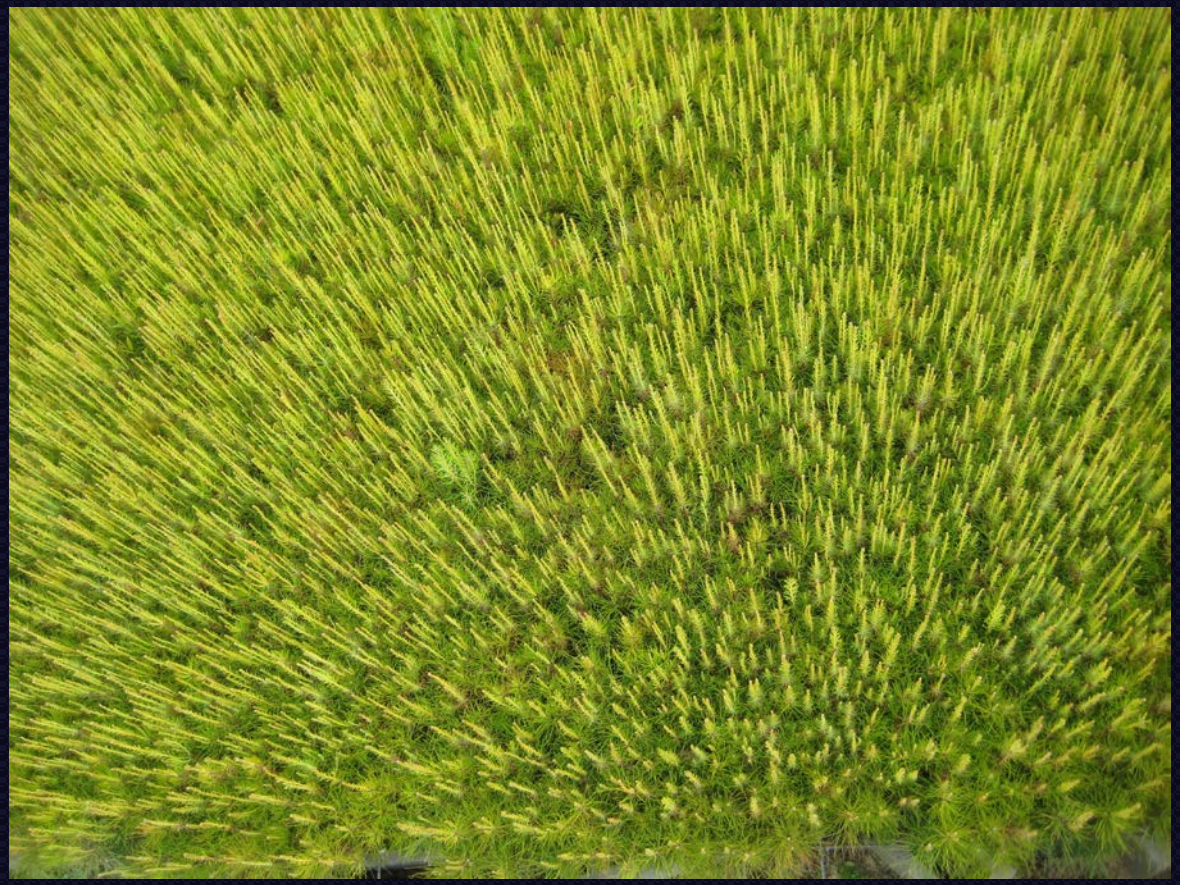






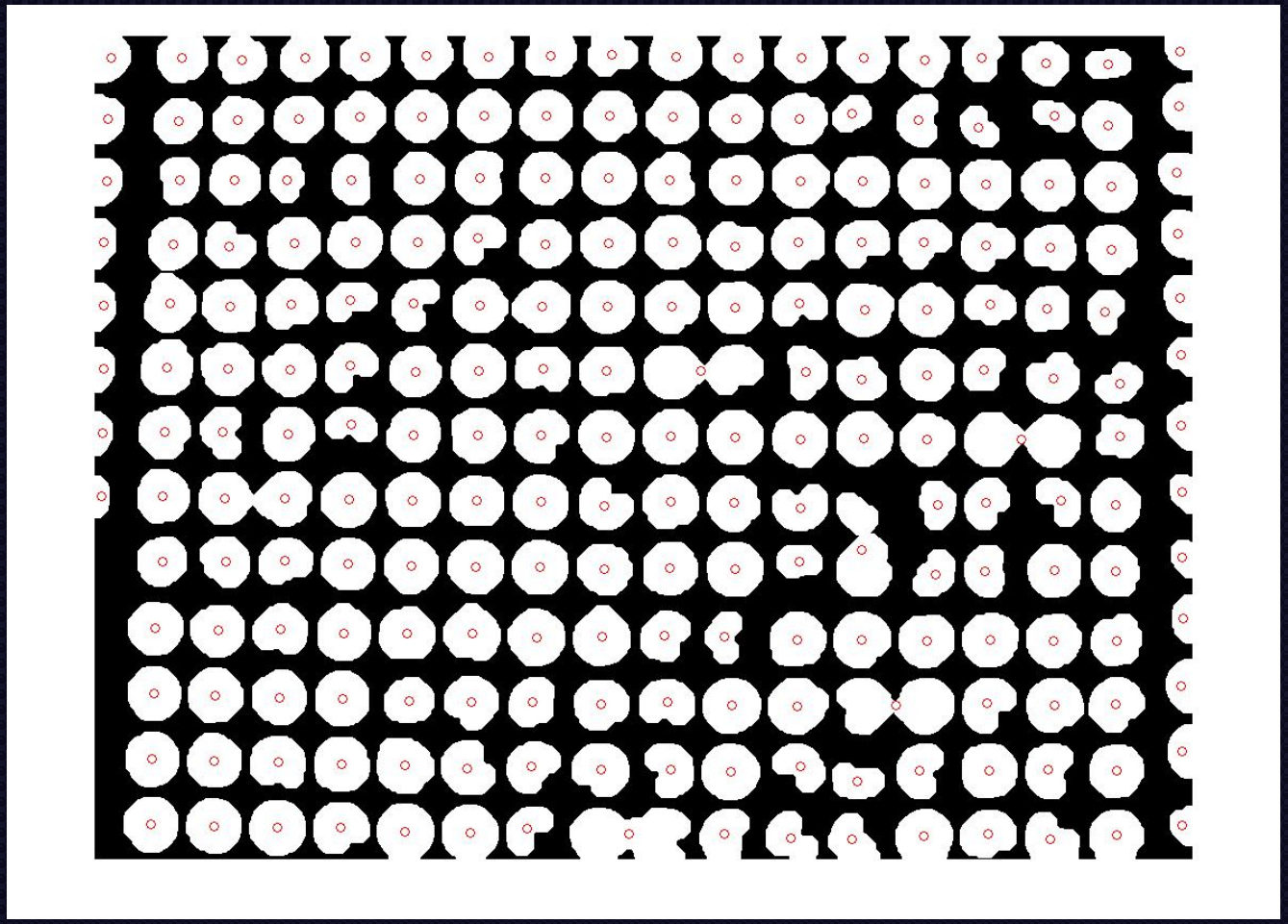
# Non-UAS Approach?

- Perhaps so

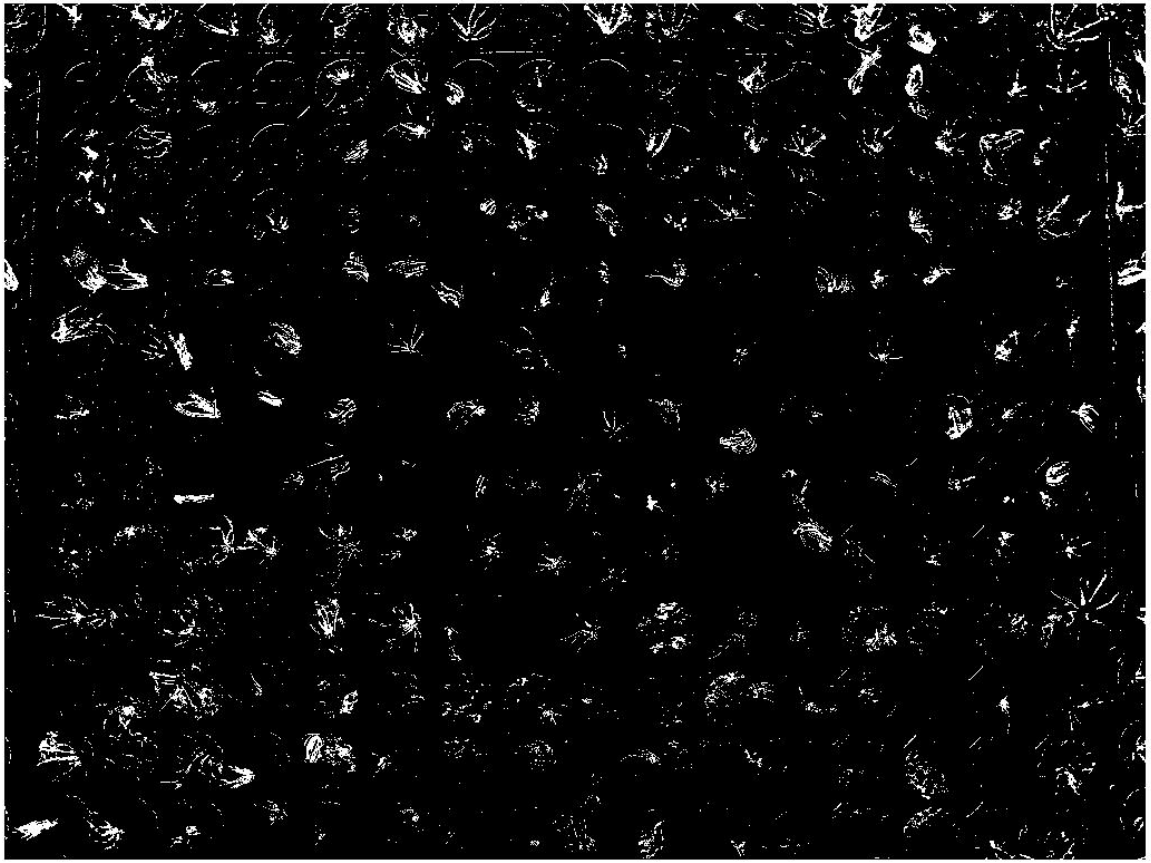


# Simple Counting Example

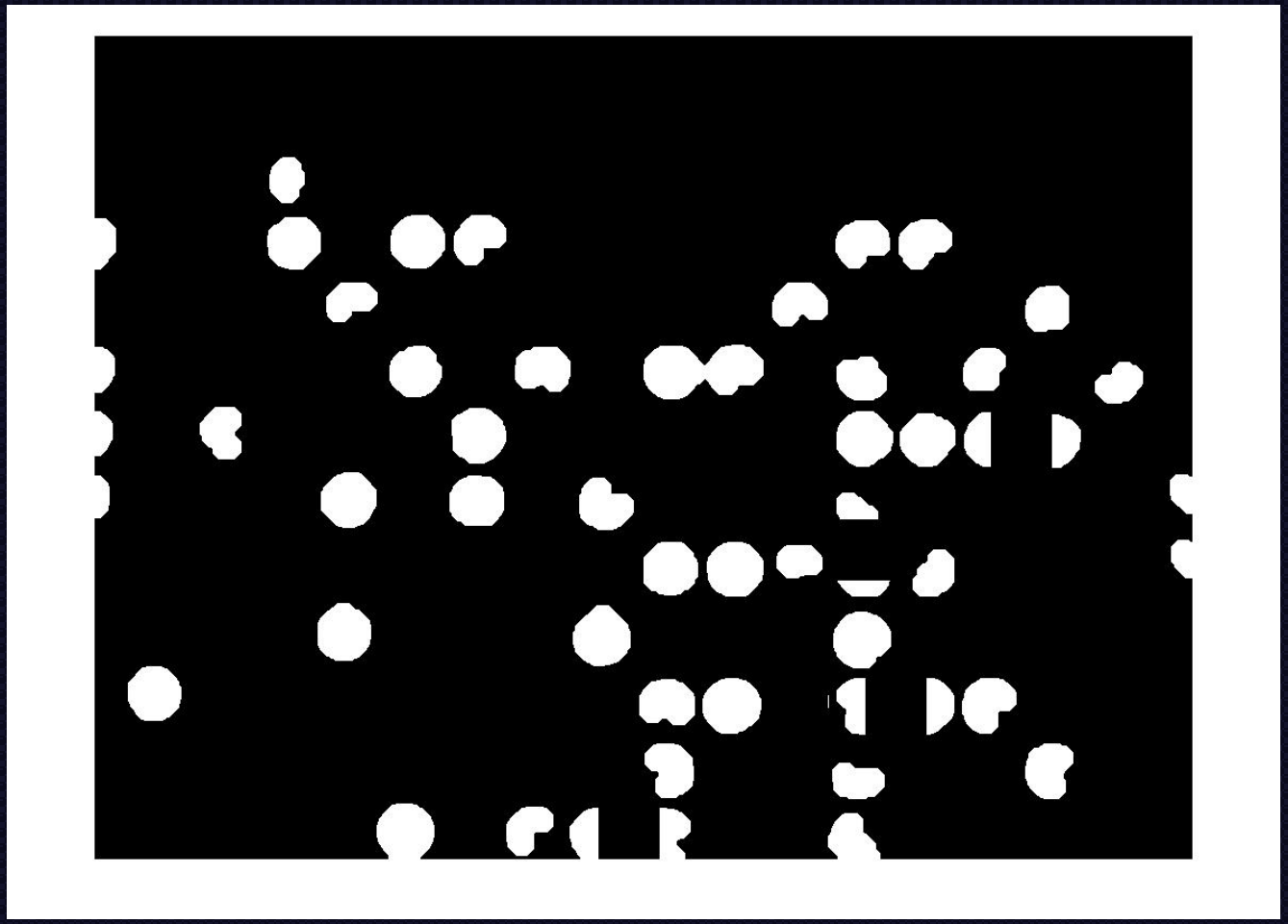
# Identify Where Seedlings Might Grow



# Find The Leaves



# Which Areas Have Less Than a `Small' Amount of Green?



# Thanks


**FAA Approved**

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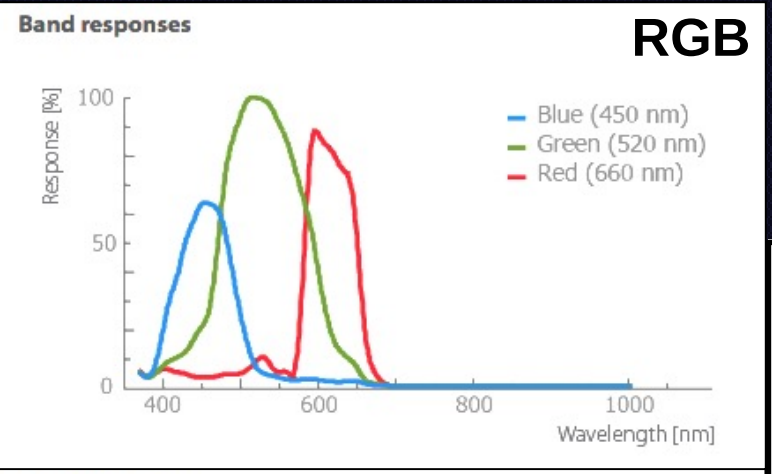
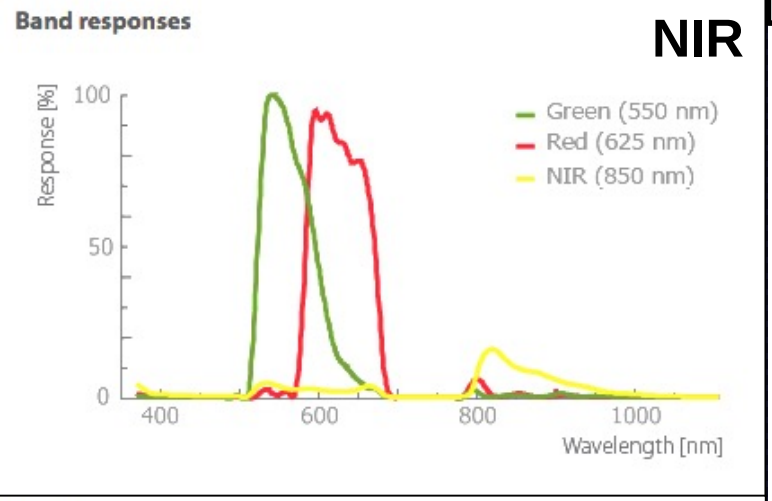
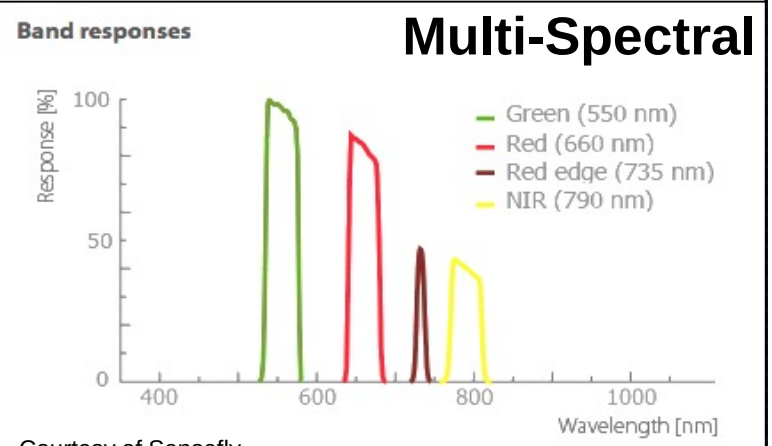
**brodbcj@auburn.edu**
**(334) 750-9375**

AUBURN UNIVERSITY

# RGB vs. NIR vs. Multi-spectral



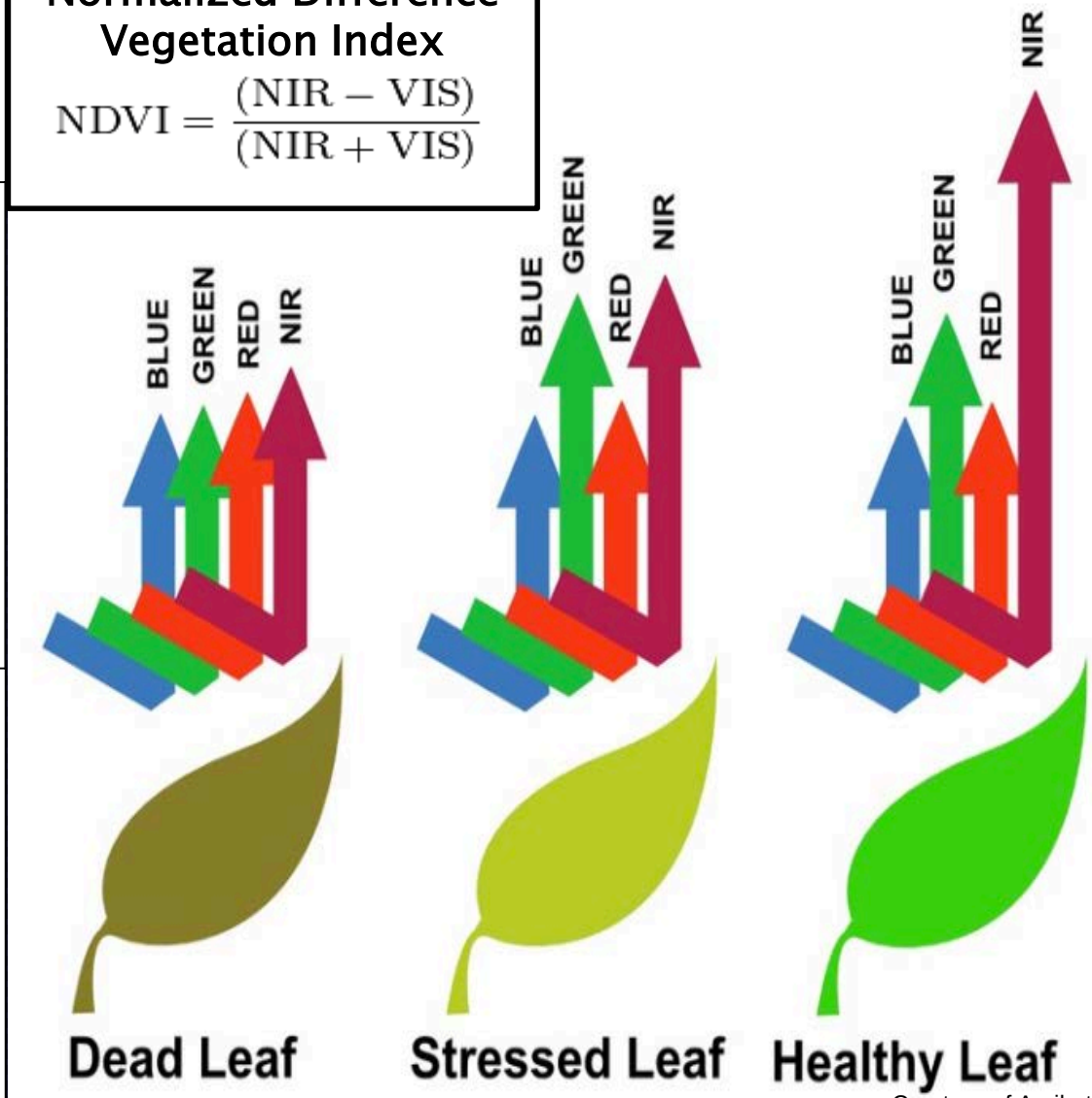




Courtesy of Sensefly

**Normalized Difference Vegetation Index**

$$\mathrm{NDVI} = \frac{(\mathrm{NIR} - \mathrm{VIS})}{(\mathrm{NIR} + \mathrm{VIS})}$$




Courtesy of Agribotix