



# Current Remote Sensing and Sprayer Drone Technologies in Agriculture

by

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# Summary:

- Current drone systems
- Examples of what you can do with drones
- Research at the LSU AgCenter
- Sprayer Drones

# Types of Drones in Agriculture:

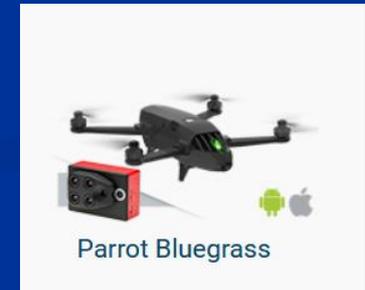
## Retail Store Drones:

- DJI Phantom; Mavic, etc.
- Low Cost (\$400 - \$1200)
  - RGB Visual Cameras
- Uses: Visual Observation and Mapping



## Commercial Mapping Drone Systems:

- Sentara, Ag Eagle, Parrot Bluegrass, Etc.
- Cost (\$8000 - \$15,000)
- NIR Camera / No Live View
- Uses: Mapping Only



## Sprayer Drones:

- T10, T20, T30, etc.
- \$10,000 to \$25,000
- For spraying fields



# Uses In Agriculture:

## ■ 3 Main Uses:

### ■ Live Aerial Views:

- Crop Scouting
- Checking cattle / Fences
- Etc.

### ■ Mapping:

- Visual / Numerical Analysis
- Prescription Maps

### ■ Crop Spraying

- Small area: 10 to 40 acres



# Drones I Recommend (Others Available):

## DJI Mavic Mini 2 - \$499

- Feels more like a toy, but powerful drone
- Disadvantages for use in Agriculture
  - License still required for commercial work in U.S. (not in many other countries)
- Not supported yet by agricultural flight software (drone deploy, Pix4D fields, etc., but close!)
- Advantages:
  - Low cost
  - Timed imagery capture function



## DJI Mavic Air 2 (\$599 to \$958)

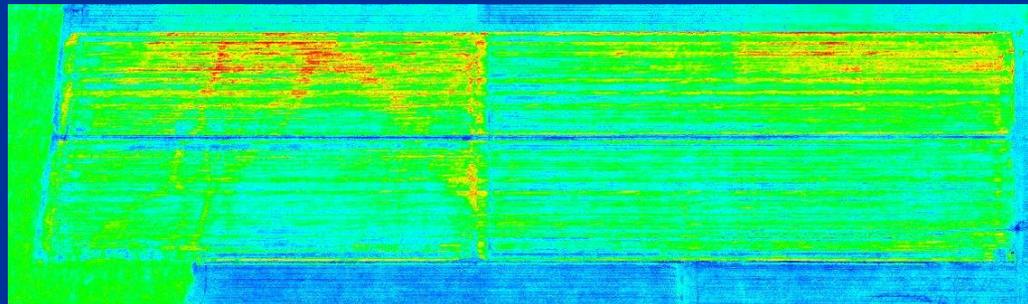
- Higher quality drone - heavier, more metal, etc.
- Longer flight times (30+ minutes)
- Operates in most winds (i.e. < 30 MPH)
- 48 Meg pixel camera
- Capable of very low crop scouting



# Production of a Precision Farming Map for Sprayer:



RGB/NIR Image -  
Value for each  
wavelength



Plant Index Map -  
Single Value Map



Shape File -  
File for Sprayers  
2 to 6 levels

# Different Plant Indices:

**Table.** Available indices in *FIELDImageR*. Any other index can be implemented using the option *myIndex* and the new formula (*FIELDImageR::fieldIndex*).

Description	Index	Formula	Related traits	References
Brightness Index	BI	$\sqrt{(R^2+G^2+B^2)/3}$	Vegetation coverage, water content	Richardson and Wiegand (1977)
Soil Color Index	SCI	$(R-G)/(R+G)$	Soil color	Mathieu et al. (1998)
Green Leaf Index	GLI	$(2*G-R-B)/(2*G+R+B)$	Chlorophyll	Louhaichi et al. (2001)
Primary Colors Hue Index	HI	$(2*R-G-B)/(G-B)$	Soil color	Escadafal et al. (1994)
Normalized Green Red Difference Index	NGRDI	$(G-R)/(G+R)$	Chlorophyll, biomass, water content	Tucker (1979)
Spectral Slope Saturation Index	SI	$(R-B)/(R+B)$	Soil color	Escadafal et al. (1994)
Visible Atmospherically Resistant Index	VARI	$(G-R)/(G+R-B)$	Canopy, biomass, chlorophyll	Gitelson et al. (2002)
Overall Hue Index <sup>#</sup>	HUE	$\text{atan}(2*(B-G-R)/30.5*(G-R))$	Soil color	Escadafal et al. (1994)
Blue Green Pigment Index	BGI	B/G	Chlorophyll, LAI	Zarco-Tejada et al. (2005)
Plant Senescence Reflectance Index	PSRI	$(R-G)/(RE)$	Chlorophyll, nitrogen, maturity	Merzlyak et al. (1999)
Normalized Difference Vegetation Index	NDVI	$(NIR-R)/(NIR+R)$	Chlorophyll, LAI, biomass, yield	Rouse et al. (1974)
Green Normalized Difference Vegetation Index	GNDVI	$(NIR-G)/(NIR+G)$	Chlorophyll, LAI, nitrogen, protein content, water content	Gitelson et al. (1996)
Ratio Vegetation Index	RVI	NIR/R	Biomass, water content, nitrogen	Pearson and Miller (1972)
Normalized Difference Red Edge Index	NDRE	$(NIR-RE)/(NIR+RE)$	Chlorophyll	Gitelson and Merzlyak (1994)
Triangular vegetation index	TVI	$0.5*(120*(NIR - G) - 200*(R - G))$	Green LAI, chlorophyll, canopy	Broge and Leblanc (2000)
Chlorophyll vegetation index	CVI	$(NIR*R)/(G^2)$	Chlorophyll	Vincini et al. (2008)
Enhanced vegetation index	EVI	$2.5*(NIR - R)/(NIR + 6*R - 7.5*B + 1)$	Chlorophyll, biomass, nitrogen	Huete et al. (2002)
Chlorophyll index – green	CIG	$(NIR/G) - 1$	Chlorophyll	Gitelson et al. (2003)
Chlorophyll index – red edge	CIRE	$(NIR/RE) - 1$	Chlorophyll	Gitelson et al. (2003)
Difference Vegetation Index	DVI	NIR-RE	Nitrogen, chlorophyll	Jordan (1969)

<sup>#</sup> Index HUE was modified to capture better the soil color. Original equation: “ $\text{atan}(2*(R-G-B)/30.5*(G-B))$ ” (Escadafal et al., 1994)

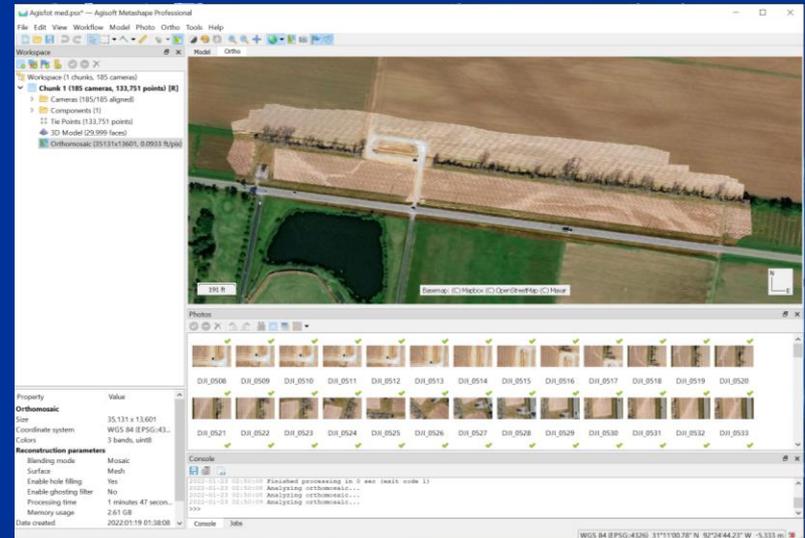
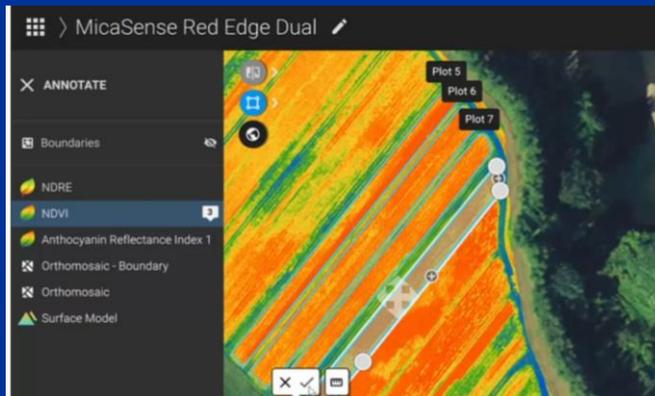
# Mapping and Layering Software:

## ■ Pix 4-D Suite:

- Mapper - Puts images together
  - \$5,000 / \$291 per month
- Fields - Ag. Functions in one package:
  - Automated flight guidance over field
  - Live mapping
  - Index calculations
  - Quick statistics (box area and see averages, etc.)
  - \$166 per month or \$3500 one time fee
- Capture – Flight Guidance
  - Free from App store

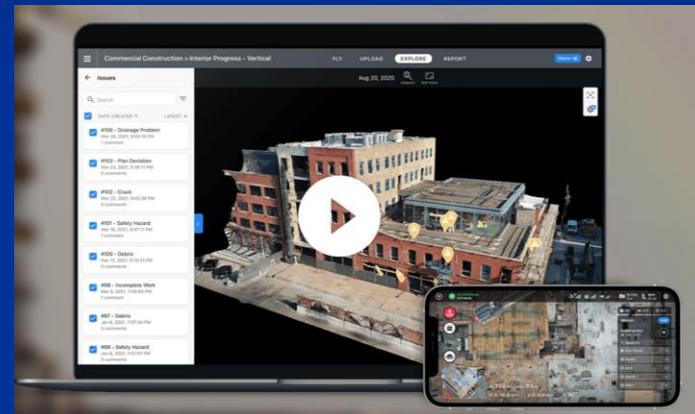
## ■ Agisoft:

- \$3,499
- Makes Orthomosaics
- Calculate indexes in equation format
- Can generate prescription maps (shape files)
- Get the Professional Version



# On-line and App Versions:

- Drone Deploy:
  - \$1200 per year and up
  - Share maps across internet
  - Moving into other things such as robotic control
- Mapware:
  - 2 cents per megapixel, etc.
- Etc.



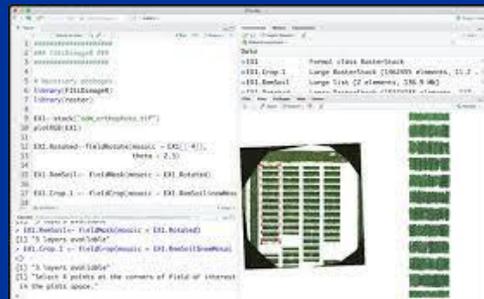
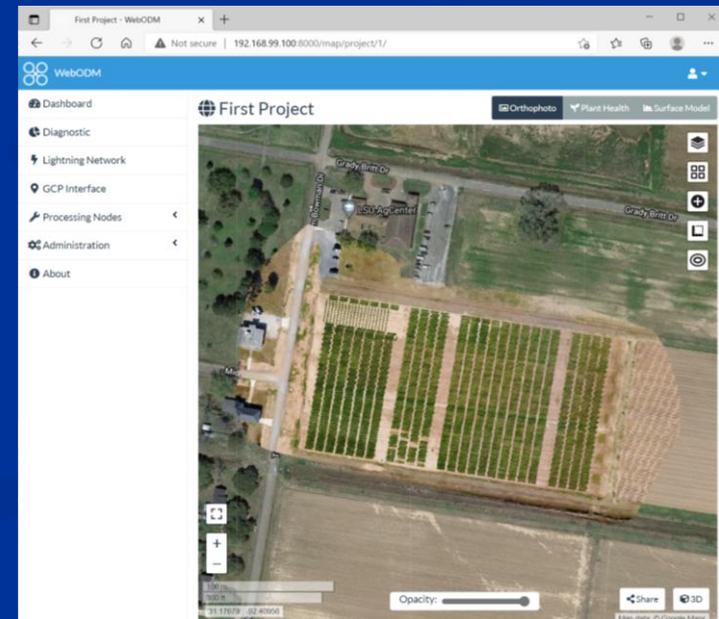
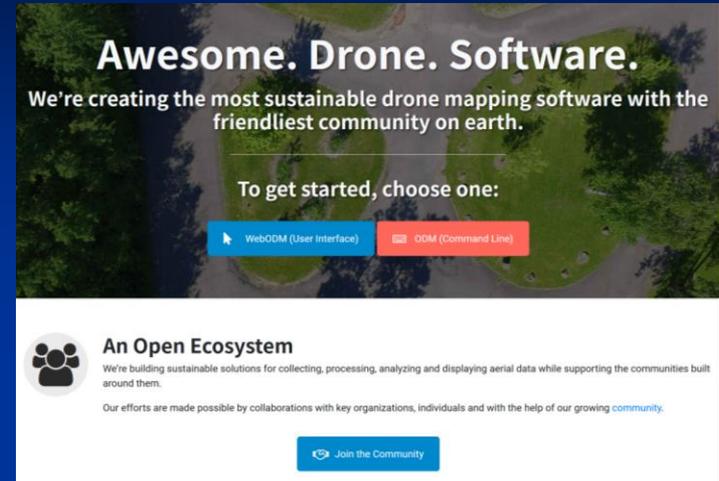
# Free Programs:

## ■ Web ODM (OpenDroneMap)

- 2-D Mapping / Orthomosaics
- Free
  - Free command line / \$57 for easy-to-use web version
  - Look as good as others
  - Took longer to process:
    - 45 minutes for field on left versus 10 minutes for Agisoft

## ■ FieldImageR:

- Analyzes plots for plant breeders



# What Can You Do with Remote Sensing Drones:

# Large Area Maps:

- DJI Mavic Air 2:
  - 30 to 35 minute flight time
  - 2 sec elapsed / 12M Images
  - Images taken slightly oblique
    - Fly down the rows (not across)
    - Good for getting rid of sunlight spots out of imagery
  - Used Average instead of Mesh Analysis in software
- Result: Mapped 250 to 300 acres with one battery.
- Airplanes: further
  - Probably 200 to 1200 acres per battery
  - A lot of photos – 1000 or more
  - Computer probably won't crunch that much data



# Oblique Shot of Field - Good Way to See Different Areas of Field

- 2-D maps may allow you to see proportional differences better

Oblique Image



2-D Image

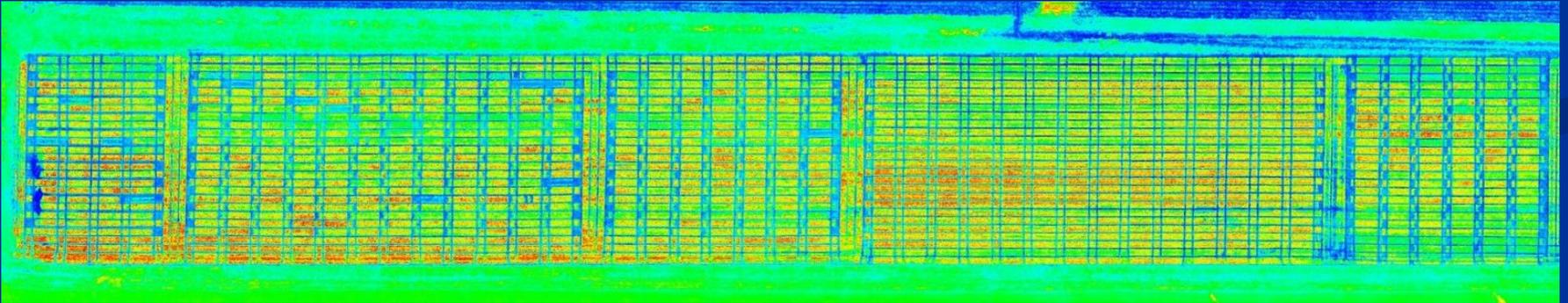


# Maps to Indicate Different Growing Areas:

RGB Image



Indices Image (Green - Red) – Note: Red Color Denotes Best Foliage



# Close Ups - Spot Checking: Wheat Field

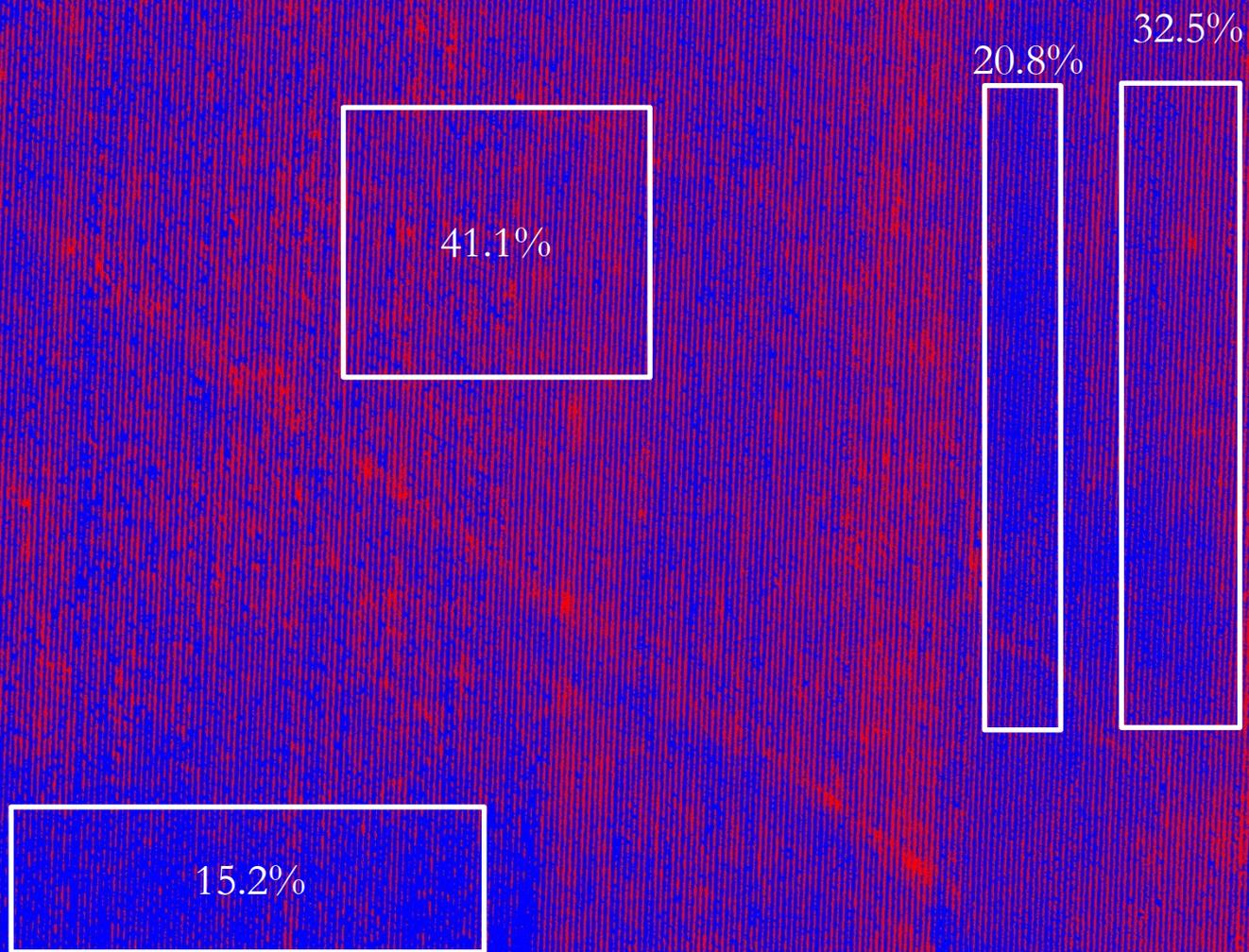


Mavic Mini  
- (\$399) 20  
Megapixel  
Camera

# Sugarcane Plant Growth - 2021:



# RGB Image of Field - Percent Foliage/Plants:



# Wire Worm Damage in Soybean Plots:



# Visual Wire Worms in Soybean Field:

## ■ Wire Worm Progression in Field with Time:

9/9/20



9/11/20



9/15/20



# Oblique Shot of Sugarcane Field:

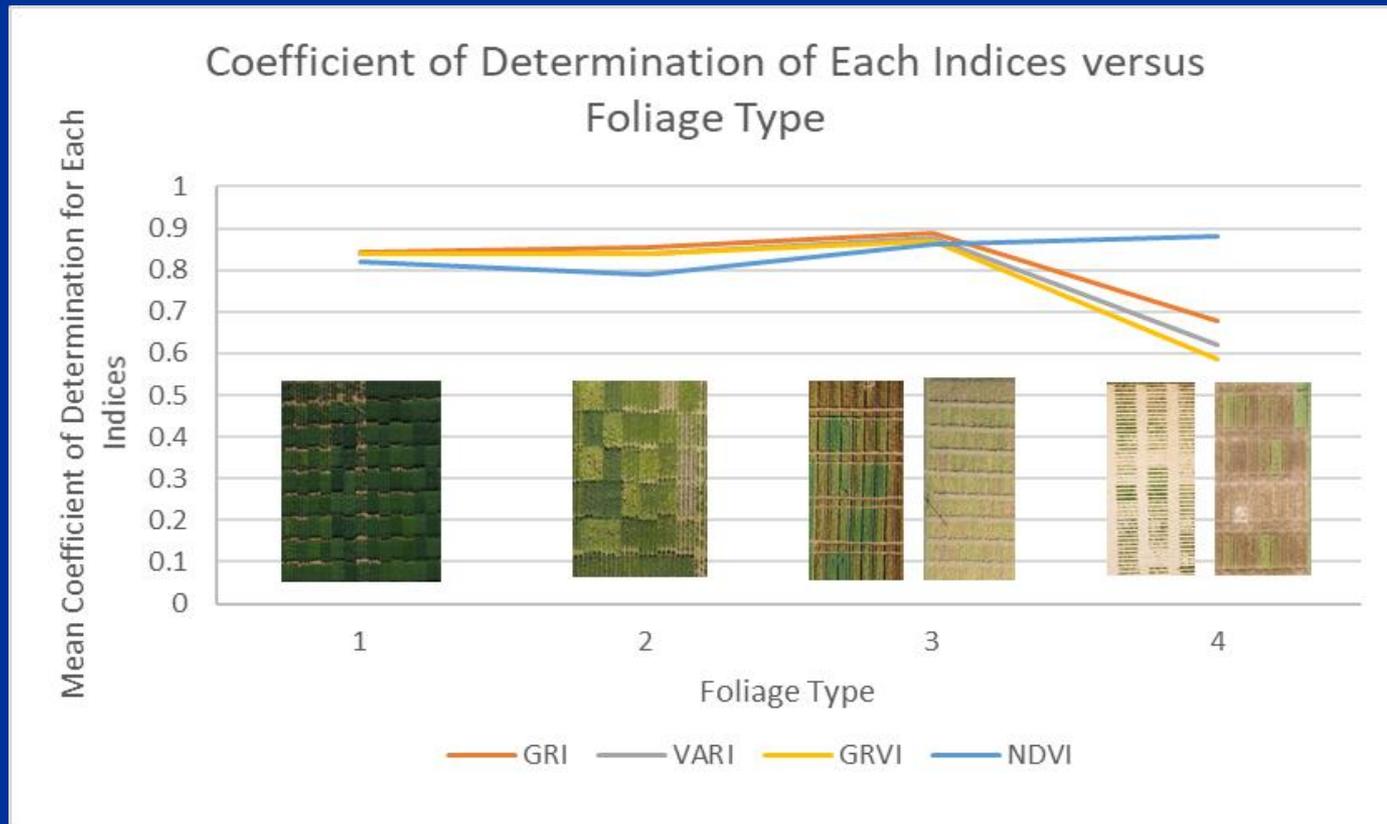


■ Mosaic Leaf Strip

# LSU AgCenter Research:

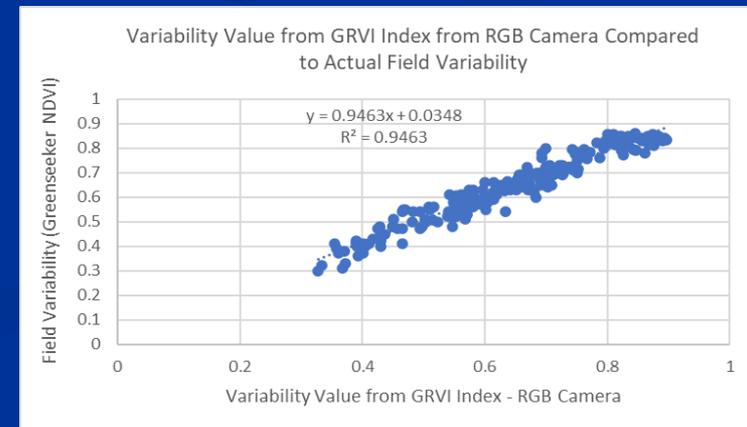
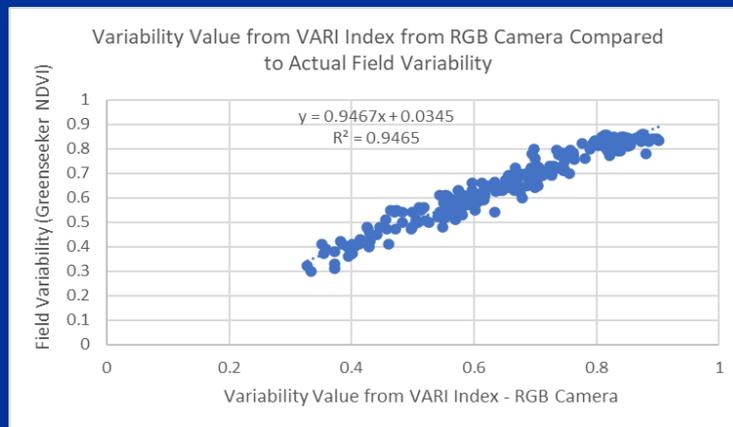
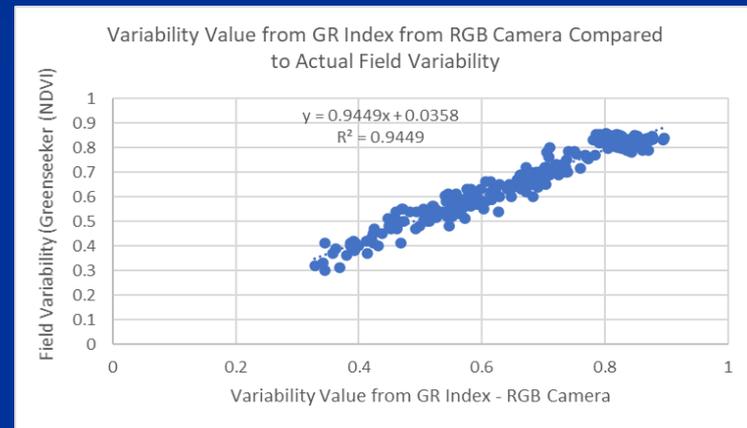
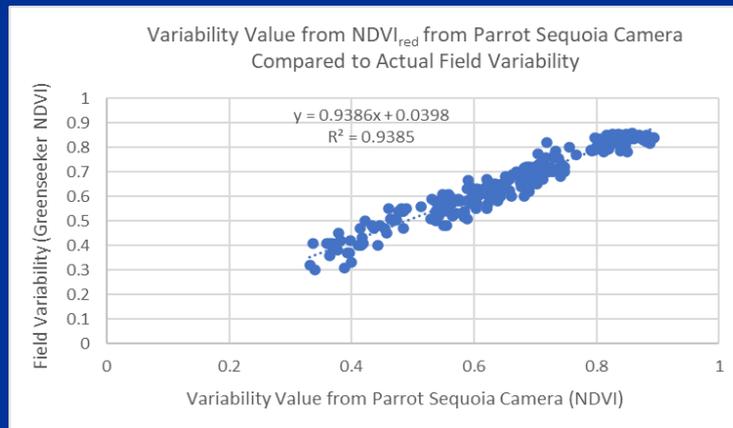
# RGB Camera compared to NIR for Detecting General Field Variability:

- In most situations, the RGB camera did better or as well as the NIR camera (NDVI) at indicating field variability.
- The NIR camera did perform better in fields with less foliage or higher amounts of soil background:



# Comparison of RGB Camera Indices to NDVI indices and the Greenseeker:

- RGB camera and indexes did slightly better than NDVI when only foliage fields included



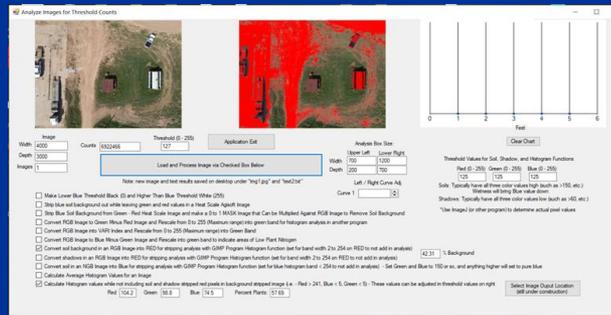
# Program for Multi-Plot Analysis and Background Stripping:

## ■ Software Makes it Easy to Perform Multiple Field or Plot Analysis:

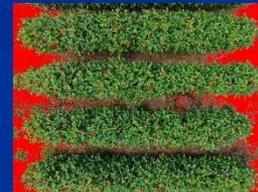
Original Images taken with Drone:



Software Can Analyze Multiple Images and Steps at Once:



Intermediate Images Stored in Separate Folder:



Text File Written with Results for Calculations in Excel

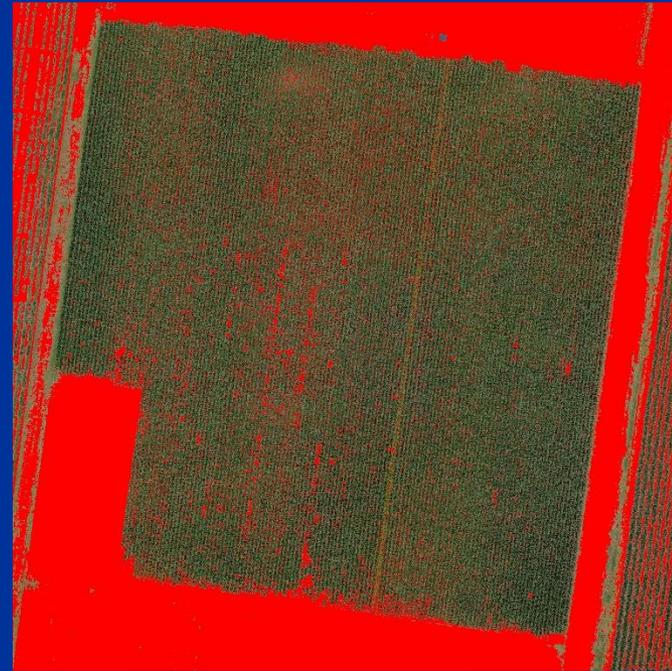
data2 - Notepad

Red	Green	Blue	%Plants
40.2	49.8	28.1	64.88
36.3	52.8	27.0	70.60
36.3	52.8	26.4	76.68
38.9	55.0	25.7	65.49
37.4	55.0	26.3	71.48
41.6	57.8	25.8	59.02
36.9	52.0	25.8	88.29
35.2	46.3	28.1	92.24
35.9	49.9	27.0	90.82
40.4	55.9	26.6	74.33
38.8	50.4	28.8	81.19
36.4	50.7	27.9	92.16
39.8	53.0	25.0	89.51
35.1	50.8	26.1	93.37
38.2	53.2	25.9	90.37
37.1	48.6	29.6	92.24
36.3	51.0	28.2	84.90
39.2	52.5	27.6	81.06
38.2	51.4	27.2	90.65
37.5	50.8	27.7	91.66
38.5	51.3	27.3	92.24
40.4	50.1	29.6	92.74
37.6	52.0	27.1	82.46
41.2	51.0	29.2	81.10
40.8	51.6	27.3	92.49
38.2	48.5	29.0	96.49
38.0	49.5	27.3	95.98
39.8	50.6	25.8	94.97
37.7	50.4	26.7	96.14
39.2	51.5	27.7	92.90
47.9	55.3	28.2	85.21

# Background Stripping

## Corn Test:

- Strip out unwanted background effects such as soil, water, or shadows in RGB imagery:
- Allows analysis to be applied to plants only without soil included
- Results:
  - Works well in some cases, but not in others:
    - Visual differences enhanced optical differences in fields
    - Plus: only evaluate foliage effects
    - Minus: Far away images tended to have “blended pixels” that contain both soil and plant colors combined



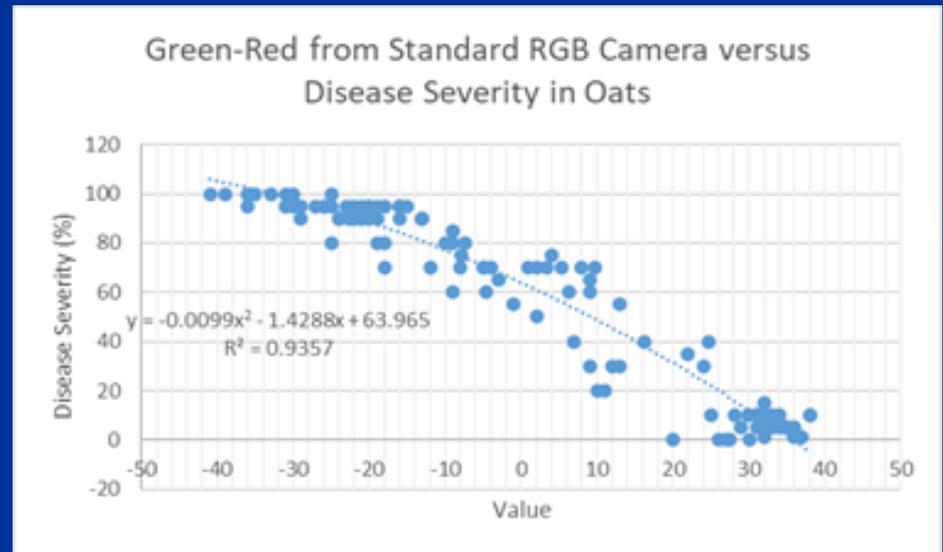
Corn field with soil  
background stripped to red

# Background Stripping in Rice:



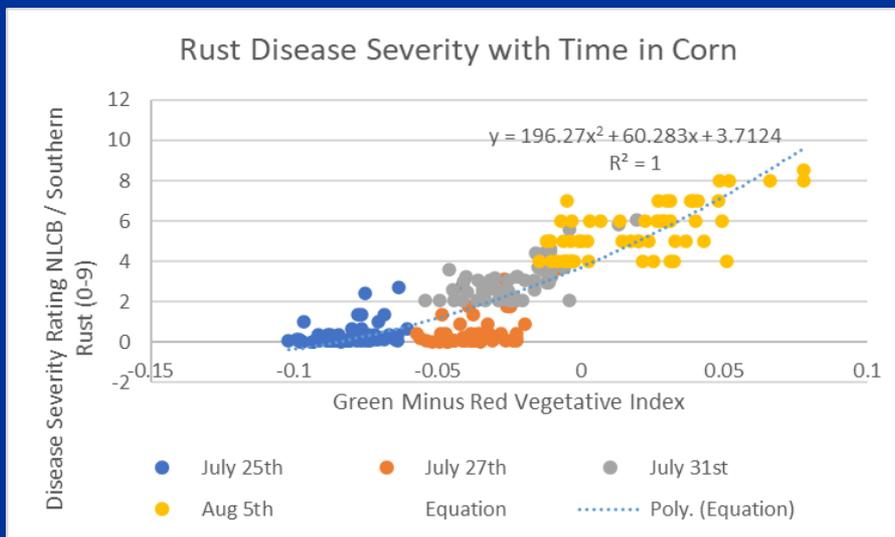
# Disease Severity in Oats and Wheat:

- Fungicide on Plots versus No Fungicide:



# Rust Severity in Corn:

- (NLCB) Northern Leaf Corn Blight and Rust: Damage areas very evident in maps and photos
  - Damage areas progressed very quickly through field - 3 to 5 days



# Sprayer “Agricultural” Drones:

# Sprayer Drones:

- Branded as “Agricultural” Drones
- Available from 10 to 30 Liter Sizes
  - 10 liter to stay under FAA weight limit
  - Rules not friendly to drones over 55 lbs. which includes most sprayer drones over 10 L
- Have radar and obstacle avoidance
- Select area to be sprayed on map or set AB line (built into controller)
- Most have:
  - Automatic return to work location
  - Automatic flowrate control
  - Radar height control
- 10 ft. to 20 ft. swath widths
- Flight 10 minutes
- Batteries- new Super LiPo
  - Higher voltages, faster charge times:
    - Old ones – 100 cycle charges / charge in approx. 45 minutes
    - New ones 300 cycles to 1000 cycle charges / charge in 15 minutes



# DJI T10:

- Professional Spray Drone
- Folds up compact
- PWM nozzle and anti-drip siphons
- Fly's 10 minutes
- 15-minute quick charge batteries
  - Supposedly rated to 1000 charging cycles

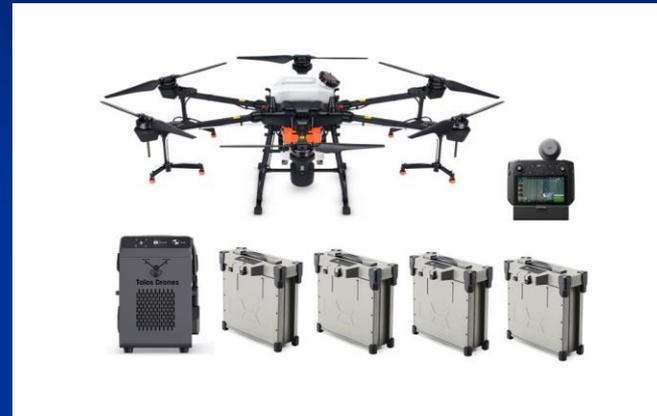


# Other Drones We Have:



# Equipment Needed for Sprayer Drone Operation:

- Agricultural Drone
- Batteries (6 to 10)
- Charger
- Generator
- Trailer and possibly upright floor section (sugarcane)
- Chemical containers
- Wash area



\$12,000 – \$25,000



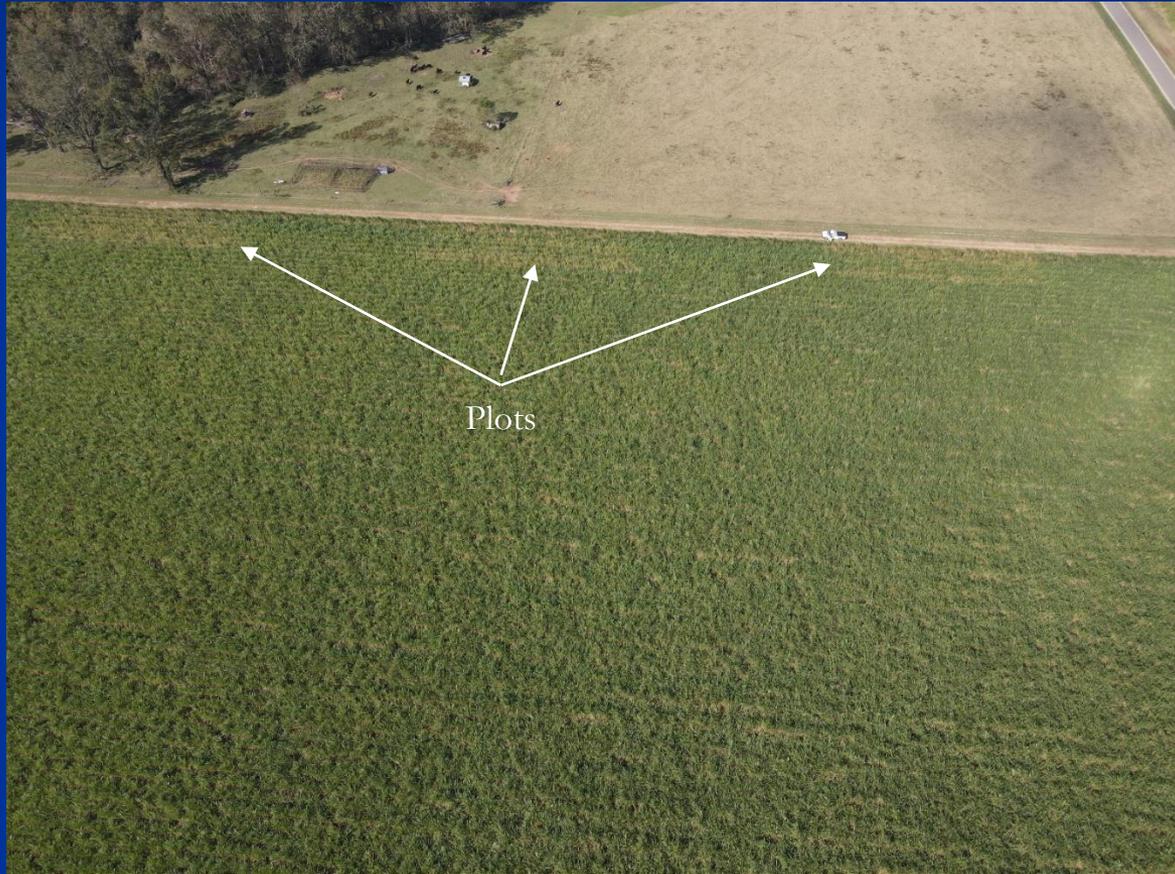
Trailer with Stand

# DIY Sprayer Drones:

- Most parts come “plug and play”:
- Dedicated flight controller
  - Already has programmed for pump operation, tank empty trigger, return to last spray point, etc.
- Motors, ESC, Prop in one unit



# Ripener in Sugarcane Field Applied with Sprayer Drone:



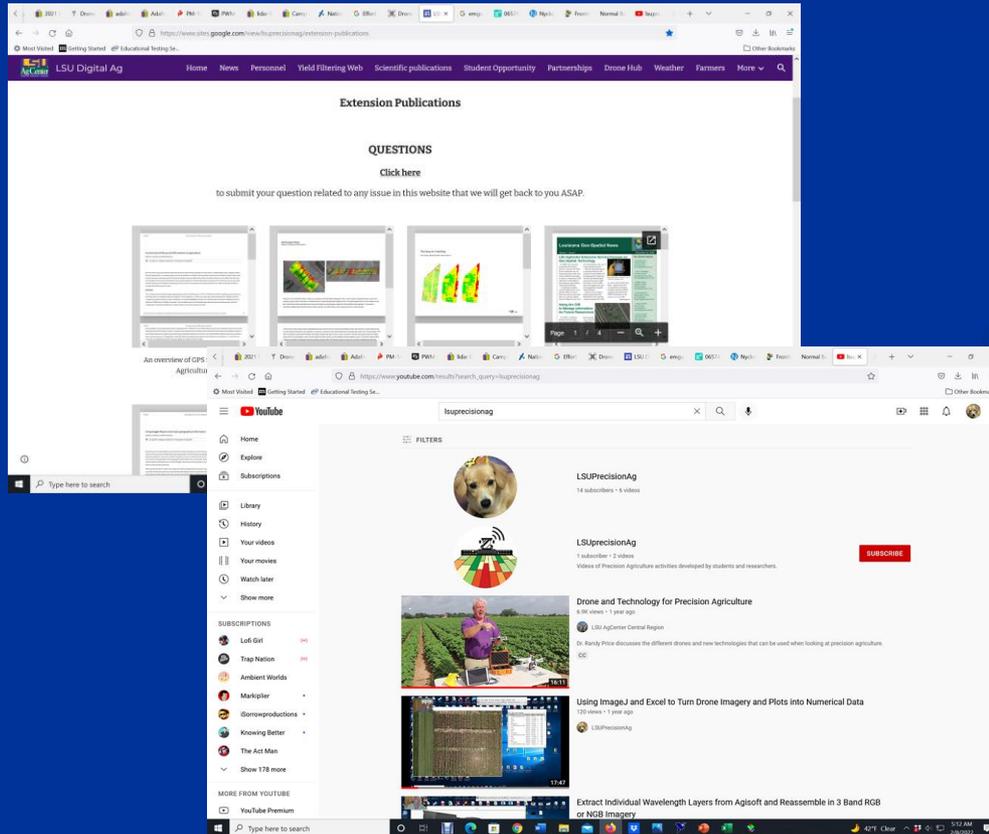
# Licensing:

- Any drone operator performing commercial operations needs a license:
  - Part 107
    - Commercial drone pilots license
- Sprayer drones under 55 lbs.:
  - Above requirement plus:
  - Part 137 (agricultural aviation commercial license)
  - Several small waivers
- Sprayer drones over 55 lbs.:
  - Above plus:
  - Experimental aircraft licensing
    - See a lawyer for this aspect
  - Other requirements:
    - Notice to everyone within 500 ft. of field and 48 hours before flight that you will be flying



# LSU Precision Ag Websites:

- Additional information on Main LSU AgCenter Page, Google, and YouTube under : LSUPrecisionAg and other keywords:



**drone facts** LSU AgCenter

### UAS and Drone Rules for Commercial, Recreational and Governmental Use

One of the most-asked questions we receive about drones is concerning the licensure and registration needed for flying in the United States. Although the flying rules are nearly the same for each group, different licensure procedures exist if you are flying for commercial, recreational or governmental use.

**Commercial**

Commercial use is defined as using an unmanned aircraft system, or drone, for any type of business purpose, such as providing images for compensation or hire or using the drone to enhance your business, like a roofing company using the drone to inspect roofs. For commercial use, you or one of your employees must hold a remote pilot certificate through the Federal Aviation Administration, and each drone must be registered through the FAA with those registration numbers displayed on the aircraft. Registration is easy and straightforward at <https://registermyfaa.gov>. The pilot in command (PIC) license is obtained by completing the ground school for a regular private pilot's license (given an approved FAA testing site) and then submitting a form to the FAA for your PIC license. This license must be renewed every two years. It is used to help equip the pilot with different flight zones and air spaces rules in the US, standard operating procedures of manned aircraft, and the effect of weather and wind patterns on the drone. The process also teaches pilots how to find out about NCAT's (noise to assess) and TRS (temporary flight restrictions). Many online courses are available, and licensure takes anywhere from 20 to 40 hours. The main flight rules for commercial use are:

1. Don't fly more than 400 feet high.
2. Keep the drone within your line of sight.
3. Yield to manned aircraft.

**drone facts** LSU AgCenter

### Low-Cost Drone Mapping System for Crop Scouting

Randy R. Price, LSU AgCenter Dean Lee Research and Extension Center, Alexandria, La.  
Jimmy Flanagan, Extension Agent, St. Mary Parish

If you have ever tried mapping a field with a drone, you will quickly find out that producing map-ready imagery of a farm field requires some amount of work and usually a trip back to the office. For this reason, drone systems have been fully realized for crop scouting. Still, several companies have recently introduced software or applications that can create a real-time mosaic by using live pictures sent back to the tablet and assembling them into a mapped image as you fly. This may have a lower resolution than the regular drone imagery, but it is still useful for most crop scouting purposes.

Two pieces of software that offer this feature are DroneDeploy and Pix 4-DEBS. We have tested DroneDeploy quite extensively, and its mapping quality are quite good (Figure 2) for crop scouting purposes; however, you may have to pay attention to camera setup and sunlight conditions for the best results. You will have to construct the system yourself because complete systems are not sold as a package. You will have to purchase a drone, a tablet, smartphone or laptop; and the correct software, such as DroneDeploy or Pix 4-DEBS. We have spent much time identifying the correct components with a total cost under \$2,000 that produce good results, and the best components we found for this purpose were a DJI Mavic Pro (or a similar model), an Apple iPad or iPhone with cellular capabilities and DroneDeploy software (Figure 1).

The DJI Mavic Pro is a small, easy-to-fly drone that is very powerful for its size. It can cover up to 100 acres of field area per flight at 400 feet. The Mavic Pro worked well for this because it has the radio components from the Inspire series that can provide high-quality uninterrupted DroneDeploy is a cloud-based software and tablet

also allowed easier viewing of the screen. Other drones may be substituted with good results for the Mavic Pro, such as the DJI Phantom 4, Phantom 3 Pro or Phantom 3 Advanced, etc., but the lower cost of the Mavic Pro is hard to beat. Note that some Mavic Pro drones have global problems, so use the global lock when not in use. The Mavic Air and similar drones may not be suitable for this operation because the radios do not have the range needed for mapping large fields. Also, you can use an extra long USB cable between the tablet and transmitter to allow you to stand outside the vehicle while flying if needed. Use the main USB port located on the bottom of the Mavic Pro's transmitter to transmit the video and make sure to completely unplug the side cable.

DroneDeploy is a cloud-based software and tablet

# The End

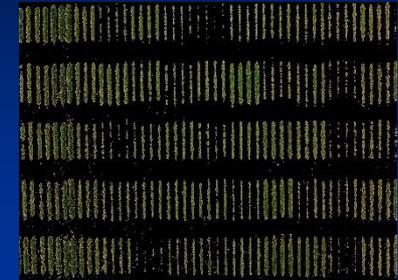
## Questions?

Special thanks to the Soybean & Grains Research and Promotion Board and the American Sugarcane League for provided funding and support for these projects

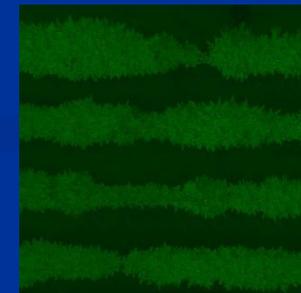


# Drone Imagery Toolbox:

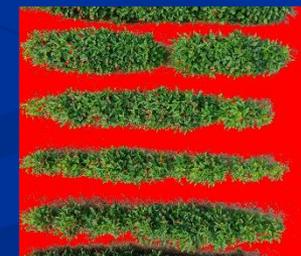
- Software will allow you to perform functions on RGB software:
  - Indices: GR, VARI, etc.
  - Background soil or shadow stripping:
  - Subtracting maps (images)
  - Histogram values on plots:
    - Soil background subtracting from histogram values



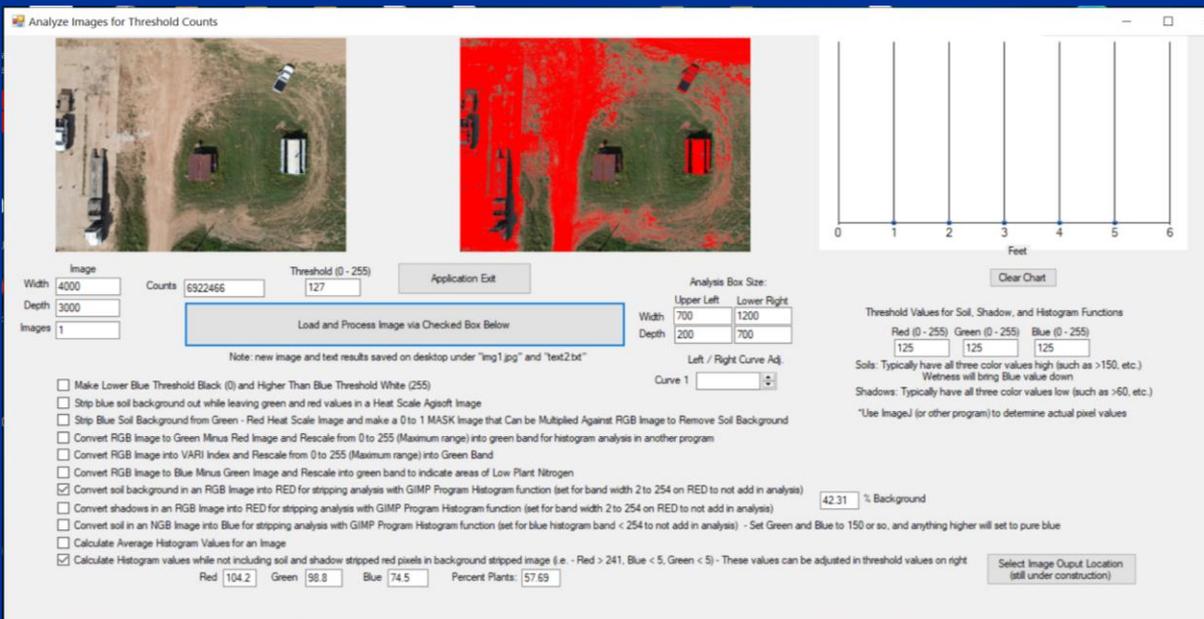
Background Stripping with Background Set to 0,0,0 (R,G,B)



VARI Ex.



Soil Stripping with Red Background Ex.



Analyze Images for Threshold Counts

Image: 4000 x 3000, Counts: 6922466, Threshold (0 - 255): 127

Analysis Box Size: Upper Left: 700, Lower Right: 1200, Depth: 200, 700

Threshold Values for Soil, Shadow, and Histogram Functions: Red (0 - 255): 125, Green (0 - 255): 125, Blue (0 - 255): 125

Soils: Typically have all three color values high (such as >150, etc.)  
Wetness will bring Blue value down  
Shadows: Typically have all three color values low (such as >60, etc.)  
\*Use ImageJ (or other program) to determine actual pixel values

Calculate Histogram values while not including soil and shadow stripped red pixels in background stripped image (i.e. - Red > 241, Blue < 5, Green < 5) - These values can be adjusted in threshold values on right

Red: 104.2, Green: 98.8, Blue: 74.5, Percent Plants: 57.63



34.6%

26.6%

13.7%

11.6%

35.8%

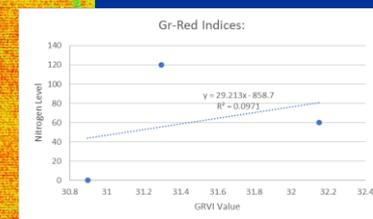
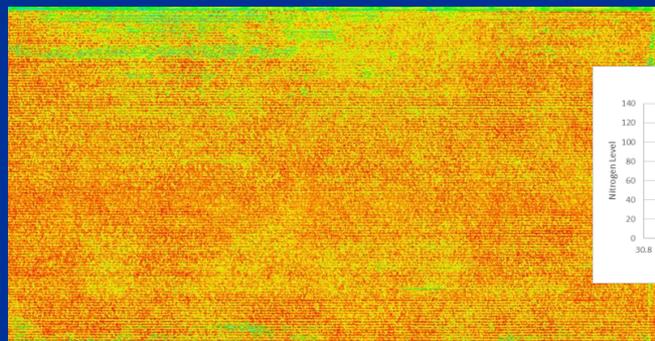
# Other Indices - Nitrogen Detection in Cotton:

- BGVI and GRVI Indices maybe used to discriminate between nitrogen deficiency and crop variability:

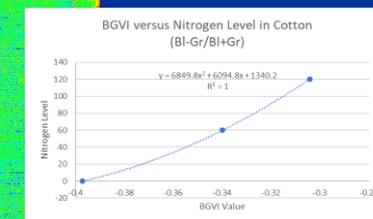
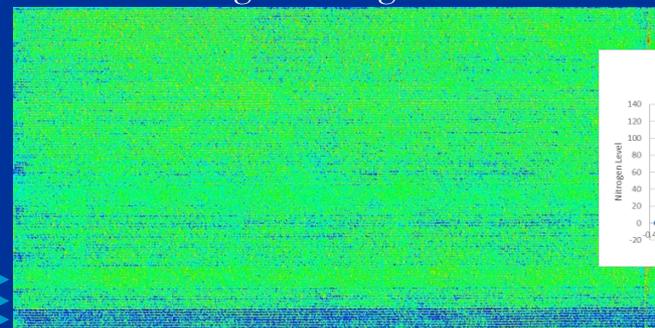
Raw RGB Image:



GR Image – General Crop Variability



BGVI Image - Nitrogen Detection:

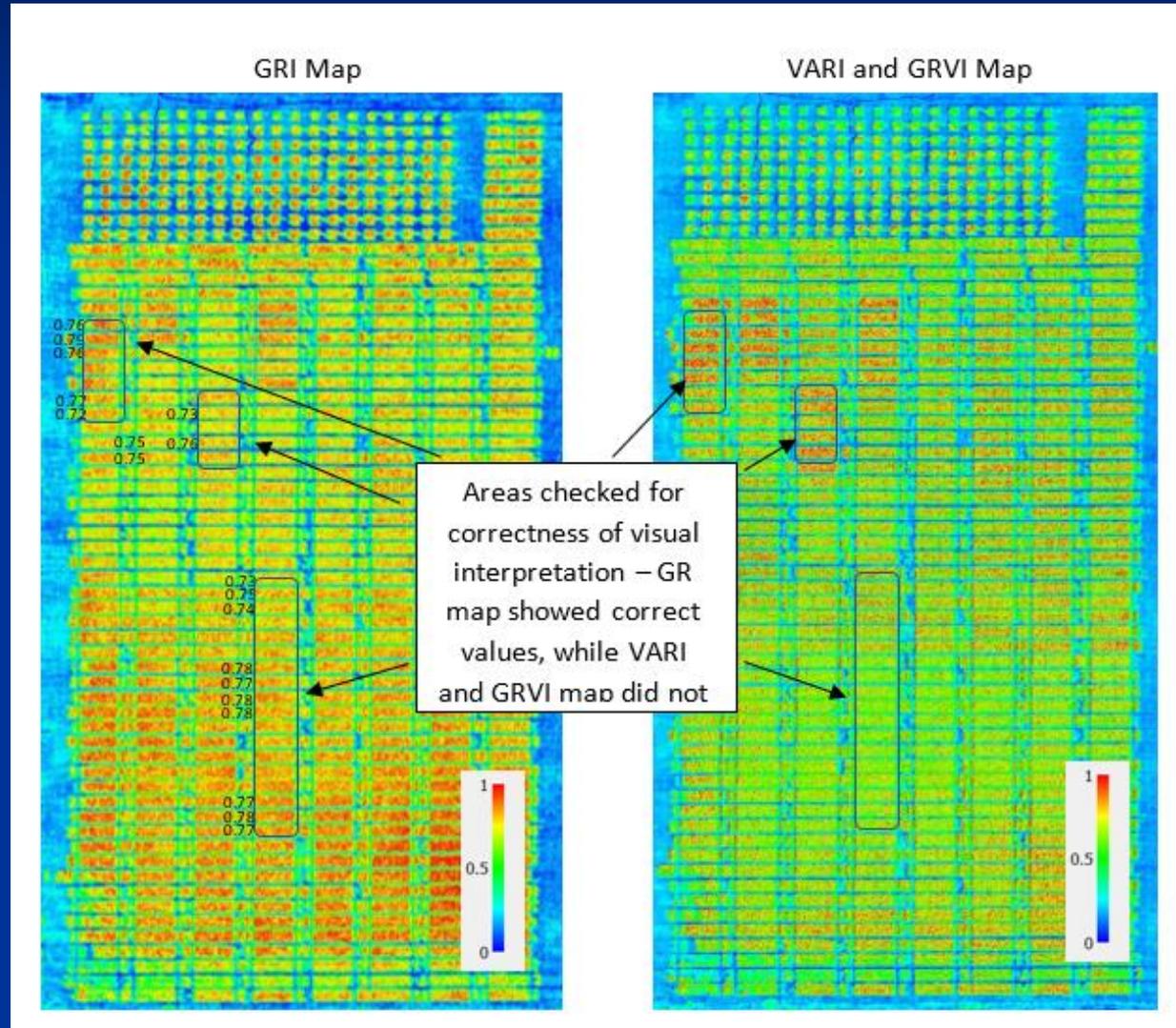


120 lbs./acre  
60 lbs./acre  
0 lbs./acre

120 lbs./acre  
60 lbs./acre  
0 lbs./acre

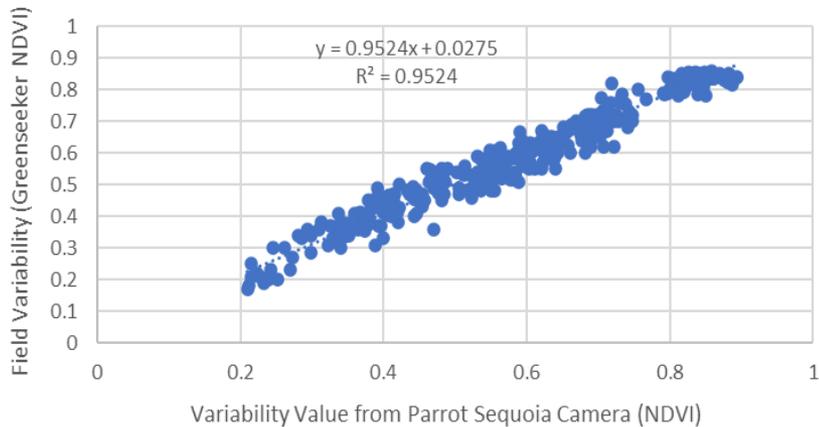
# Observational Checks:

- GR index performed better than other color indices (VARI or GRVI) for indicating general crop or field variance and health

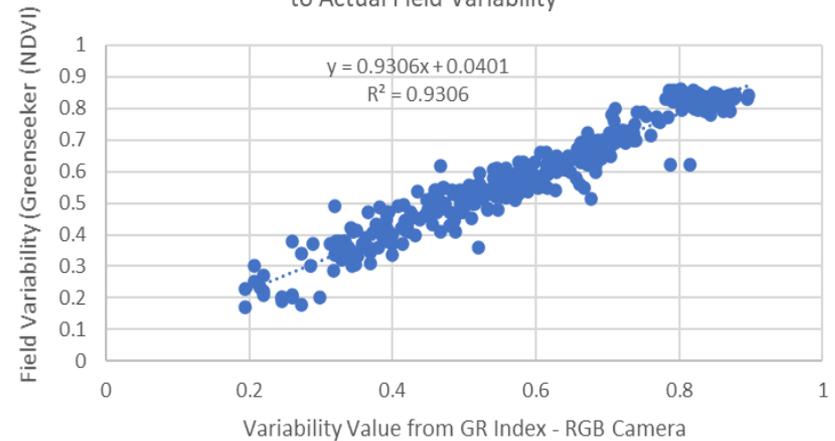


# Comparison of RGB to NDVI for Indicating General Field Variability:

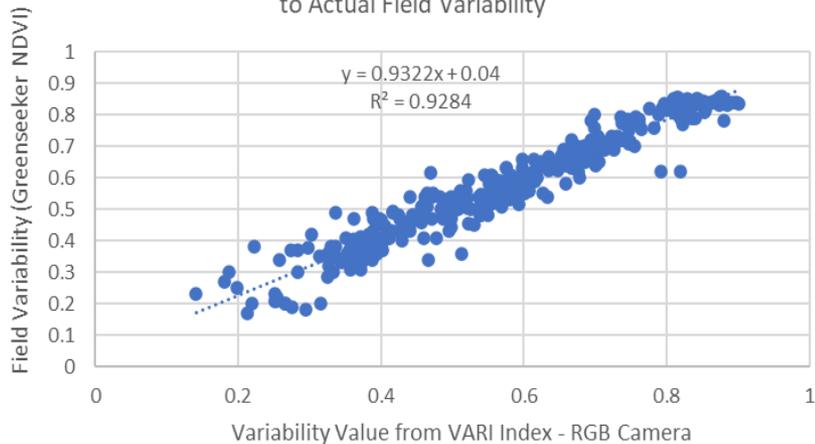
Variability Value from NDVI<sub>red</sub> from Parrot Sequoia Camera Compared to Actual Field Variability



Variability Value from GR Index from RGB Camera Compared to Actual Field Variability



Variability Value from VARI Index from RGB Camera Compared to Actual Field Variability



Variability Value from GRVI Index from RGB Camera Compared to Actual Field Variability

