Chrome File Edit View History Bookmarks People Window Help 89% Wed 8:10 AM Charles Peacock 2

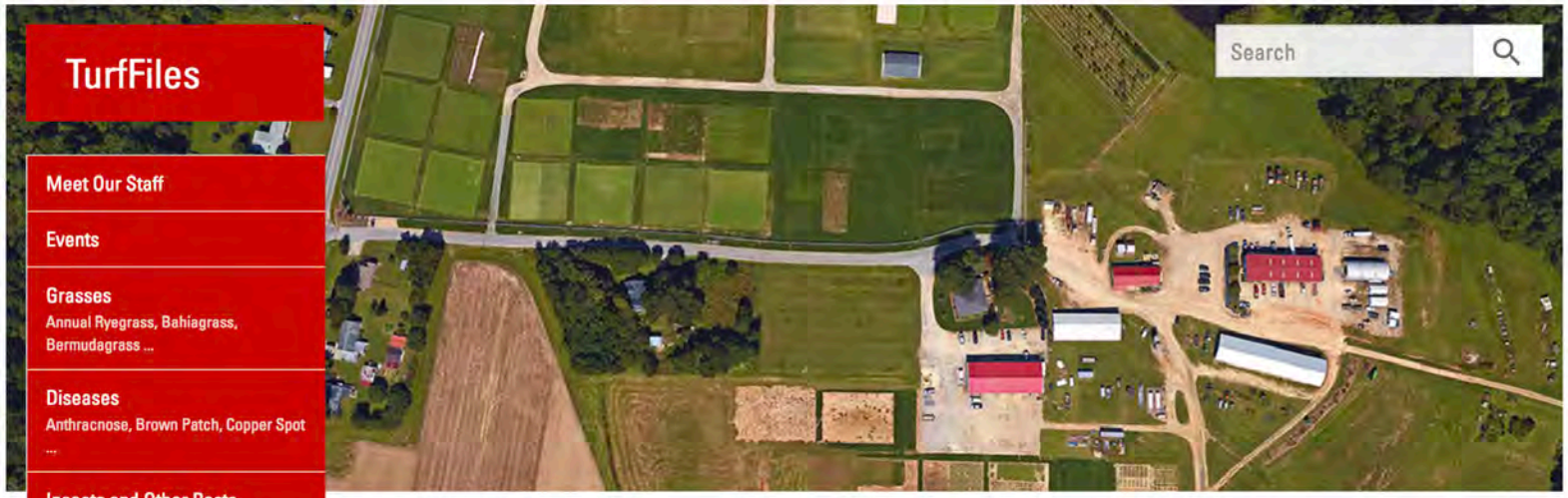
Inbox (3) - cpeacock | ETS Conference 201 | Visit Manchester - Tl | Mcr City Map 2017_1 | 2018 Wilmington Reg | 2018 Wilmington Rec | TurfFiles | NC State E | Charles

Secure https://www.turffiles.ncsu.edu

NC STATE EXTENSION

COUNTY CENTERS TOPICS GIVE NOW

TurfFiles



- Meet Our Staff
- Events
- Grasses
  Annual Ryegrass, Bahiagrass, Bermudagrass ...
- Diseases
  Anthracnose, Brown Patch, Copper Spot ...
- Insects and Other Pests
  Annual Bluegrass Weevil, Bees, Chinch Bug ...
- Weeds
  Annual Bluegrass, Annual Sedge, Barnyardgrass ...
- TIMS: Water Management Calculator
- Register for Email Alerts
- Turf Identification Tool

Events

ALL EVENTS

JAN 24 WED	JAN 26 FRI	FEB 2 FRI	FEB 19 MON
2018 Wilmington Regional Turfgrass Conference (TODAY)	2018 Raleigh Regional Turfgrass Conference	2018 Greensboro Regional Turfgrass Conference	2018 N Short C
TurfFiles	TurfFiles	TurfFiles	TurfFile
Wed 1/24 8am - 11:45am	Fri 1/26 8am - 11:45am	Fri 2/2 8am - 11:45am	Mon Fe
10 minutes ago	2 days away	1 week away	4 weeks a

News and Updates

Issues with ERDAS Im....docx | ERDASImagine_LWF_....docx | poster.pdf | UAV in turfgrass (1).pptx | image (3).png | image (2).png | Show All

Sign Up for Turf Alerts!

MONITORING FOR PEST PROBLEMS, A NEW UAV PERSPECTIVE

Charles H. Peacock

Crop & Soil Sciences Department

NC State University

* Intro

* SRS Data

* LP #15

* LW disease plots => Pythium plots, untreated

* Summary

7/6 & 7/20
supervised analysis
of spectral profile
& classification

Acknowledge

- Skyler Edenhart-Pepe, MS, Aerospace Engineering
- John Wall, PhD, Geographic Information Systems

DIGITAL IMAGE ANALYSIS

- Ability to take a digital image and analyze it for contrasts in color by using software to filter out certain wavelengths
- OR
- Taking a digital image with a camera that captures reflections for wavelengths other than in the visual spectrum
- Simply using light reflectance as an indirect way to detect differences

RESEARCH CONDUCTED

OVER THE LAST 20 YEARS

- Moisture stress
- Nitrogen and phosphorus stress
- Turf quality
- Disease activity

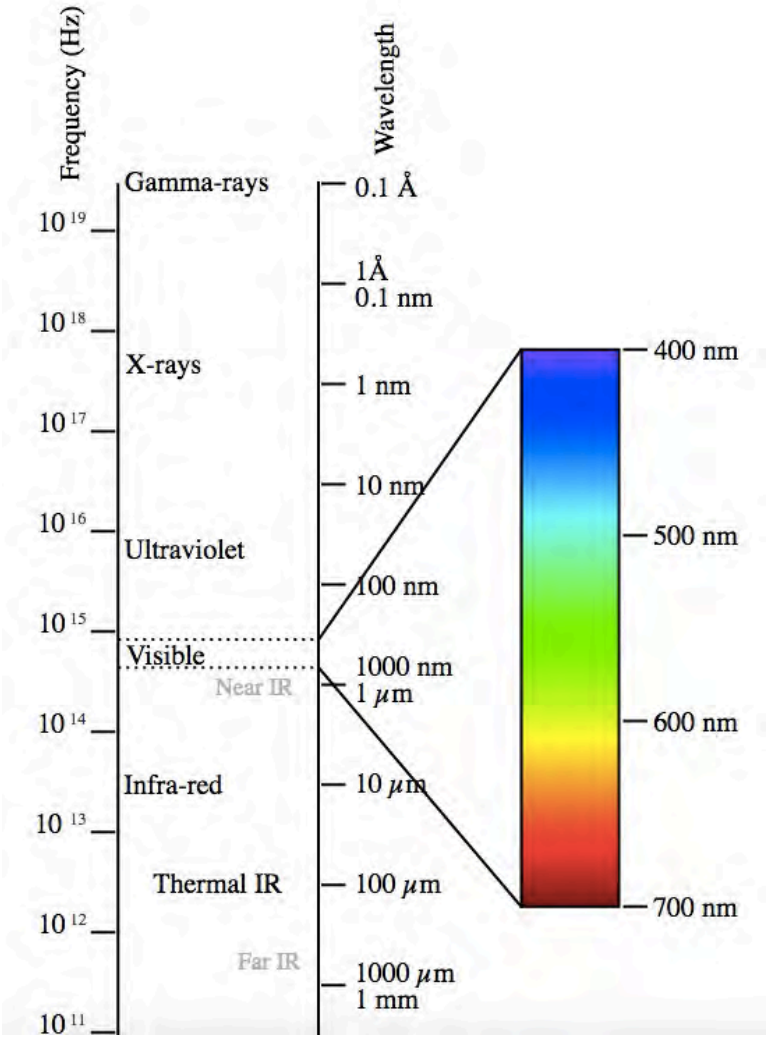
RESEARCH CITATIONS

- **Anderson and Fermanian (2009) found that brown patch could be detected using multispectral analysis 2.5 to 25 hours before visual symptoms leading them to state, "Direct sensing of the creeping bentgrass foliar canopy with the multispectral camera and the standard digital camera provide the means to detect the onset of *Pythium* blight and brown patch in creeping bentgrass, before significant changes in the appearance of turfgrass health were detected."**

RESEARCH CITATIONS

- Horvath and Vargas (2001) found that DIA was a useful tool to calculate the area under disease progress curve for dollar spot in measuring the severity of the disease

RESEARCH METHODS



RESEARCH METHODS

- Unmanned Aerial Vehicle
- Unmanned Aerial System
- Unmanned Aerial Platform

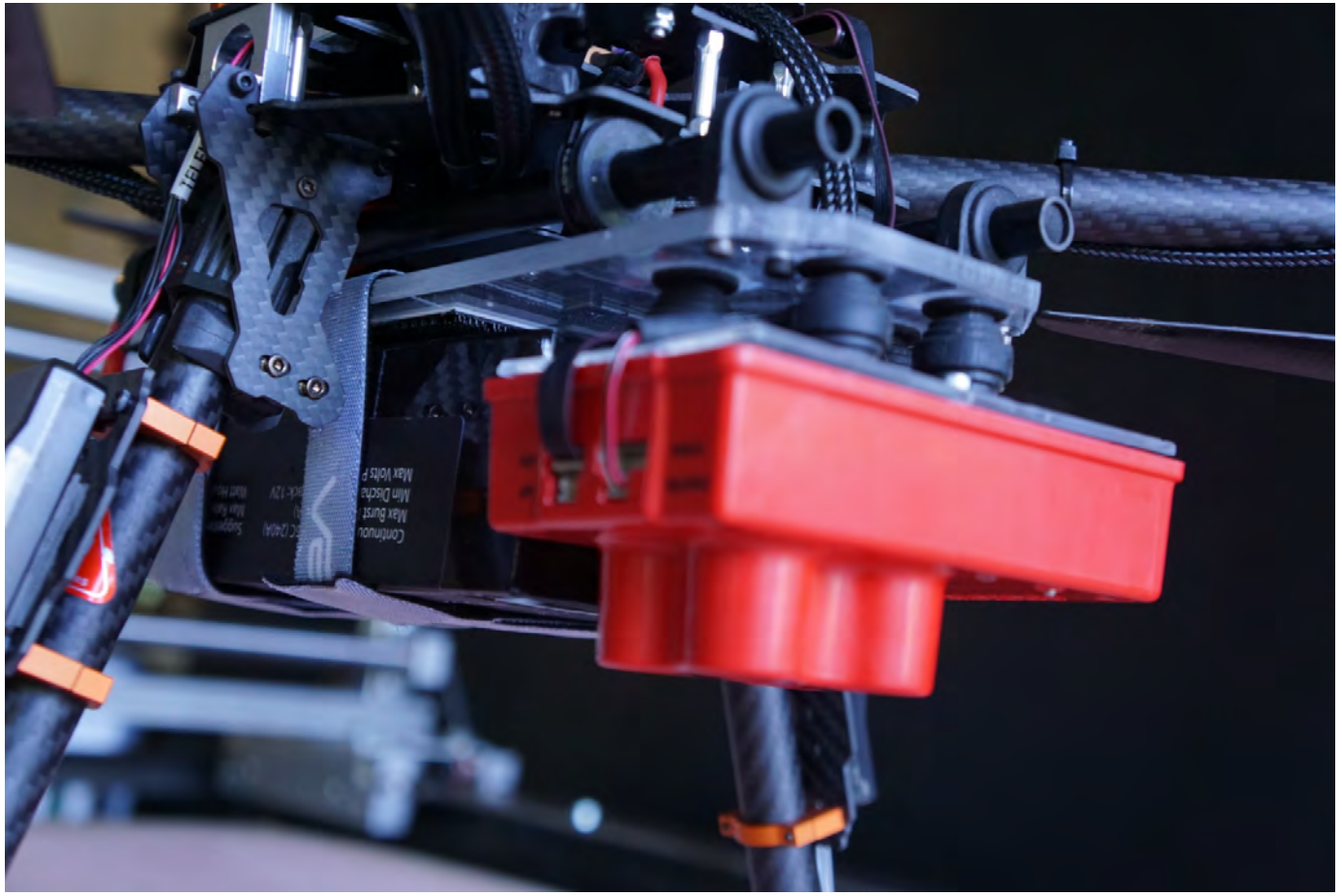
RESEARCH METHODS

- A UAS platform X-rotor UAV equipped with First Person View, temperature and humidity sensors, GPS, high definition camera and a MicaSense RedEdge multi-spectral camera is being used to collect digital information over a range of electromagnetic radiation wavelengths
- Computer flight controller allows for autonomous flight over an area that has been gridded

UAV=UAP=DRONE

UAV=UAP=DRONE

UAV=UAP=DRONE



WHY A COPTER DRONE?

- **Stability – each motor is individually computer controlled to adjust for changes in wind velocity and direction**
- **Power – can carry more weight**
- **Ability to hover**

RESEARCH METHODS

- Digital image data is being analyzed using sophisticated software to compute an array of
  - Simple Ratio Vegetation Indices
  - Normalized Difference Vegetation Indices
  - Disease monitoring
- Software is very expensive – site license for Pix4D is $10,000

VEGETATION INDICES

- Marco Volterrani – University of Pisa
- 17 different algorithms to calculate vegetative indices depending on which wavelengths of reflectance are used

RESEARCH CITATIONS

PLOS ONE

RESEARCH ARTICLE

Unmanned Aerial Vehicle to Estimate Nitrogen Status of Turfgrasses

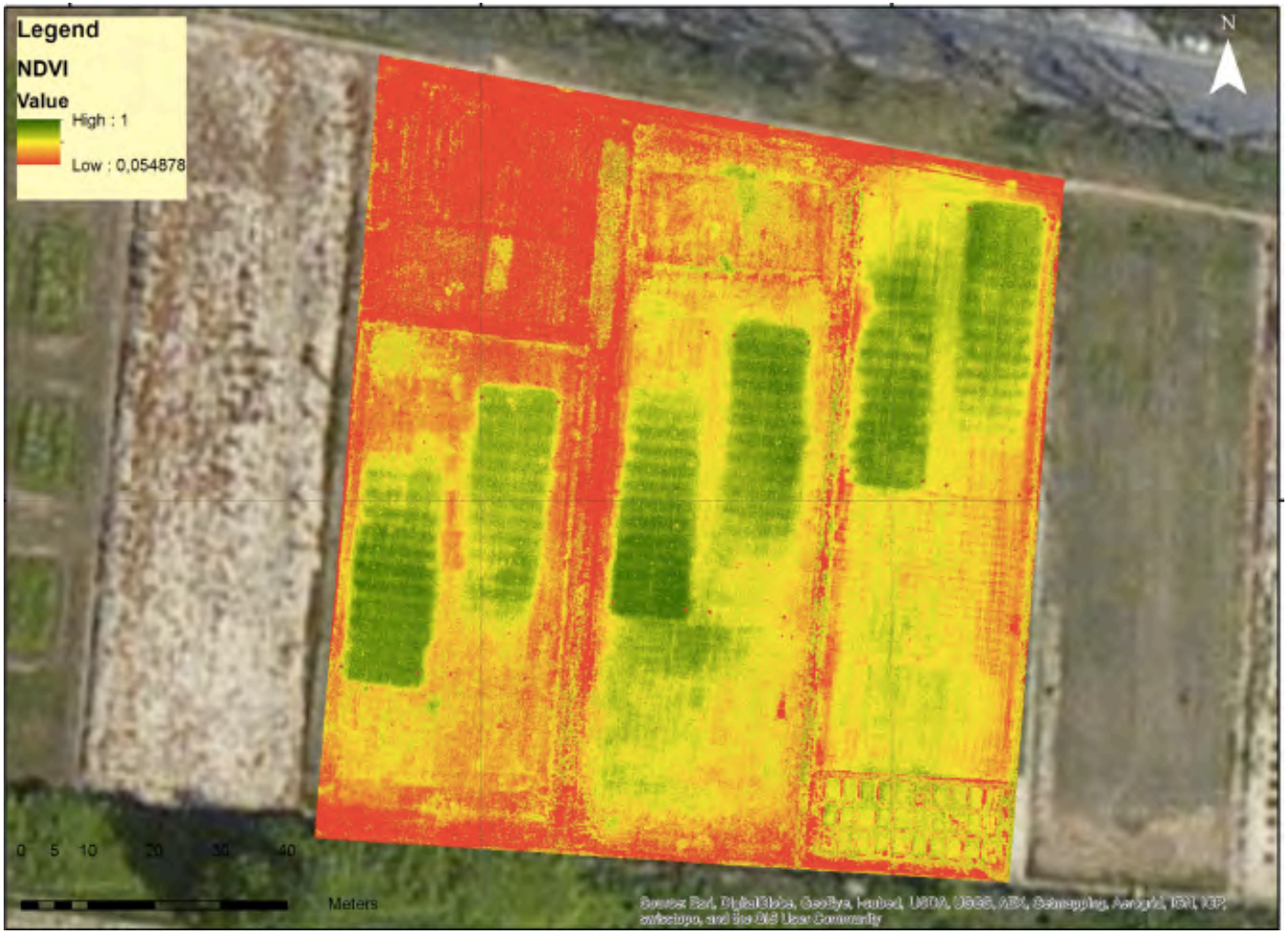
Lisa Caturegli[1]*, Matteo Corniglia[1], Monica Gaetani[1], Nicola Grossi[1], Simone Magni[1], Mauro Migliazzi[2], Luciana Angelini[1], Marco Mazzoncini[1], Nicola Silvestri[1], Marco Fontanelli[1], Michele Raffaelli[1], Andrea Peruzzi[1], Marco Volterrani[1]

1 Department of Agriculture, Food and Environment, University of Pisa, Pisa, Italy, 2 GLOBI Hi-Tech Srl, Genova, Italy

* lisa.caturegli@gmail.com

RESEARCH CITATIONS

RESEARCH CITATIONS



OUR WORK

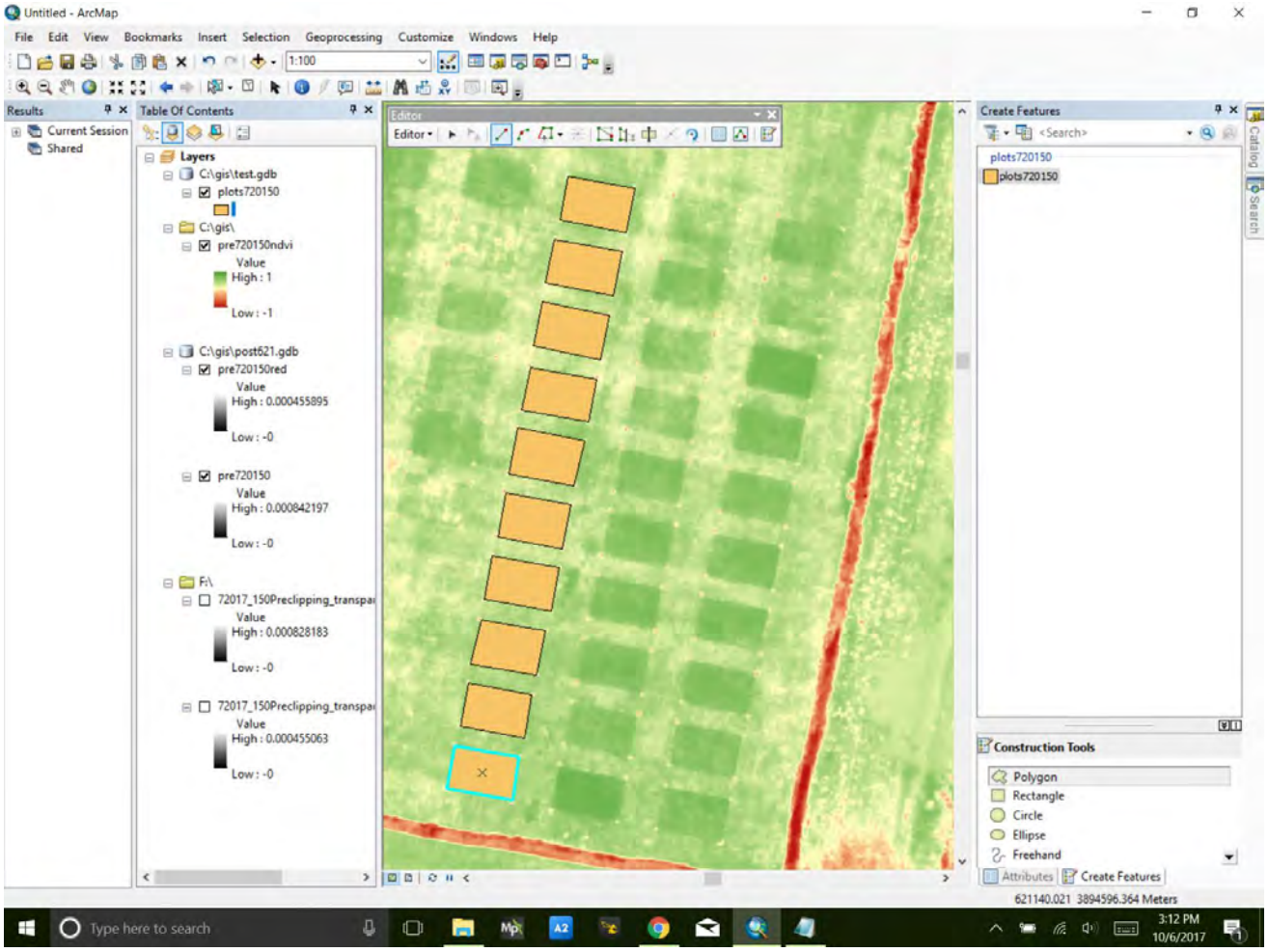
Objectives

1. Compare visual data with hand-held instrument data with data collected from a UAV
2. Compare data collected by our UAV with a commercial unit
3. Determine if data collected by our UAV on research plots can be used in monitoring for disease development

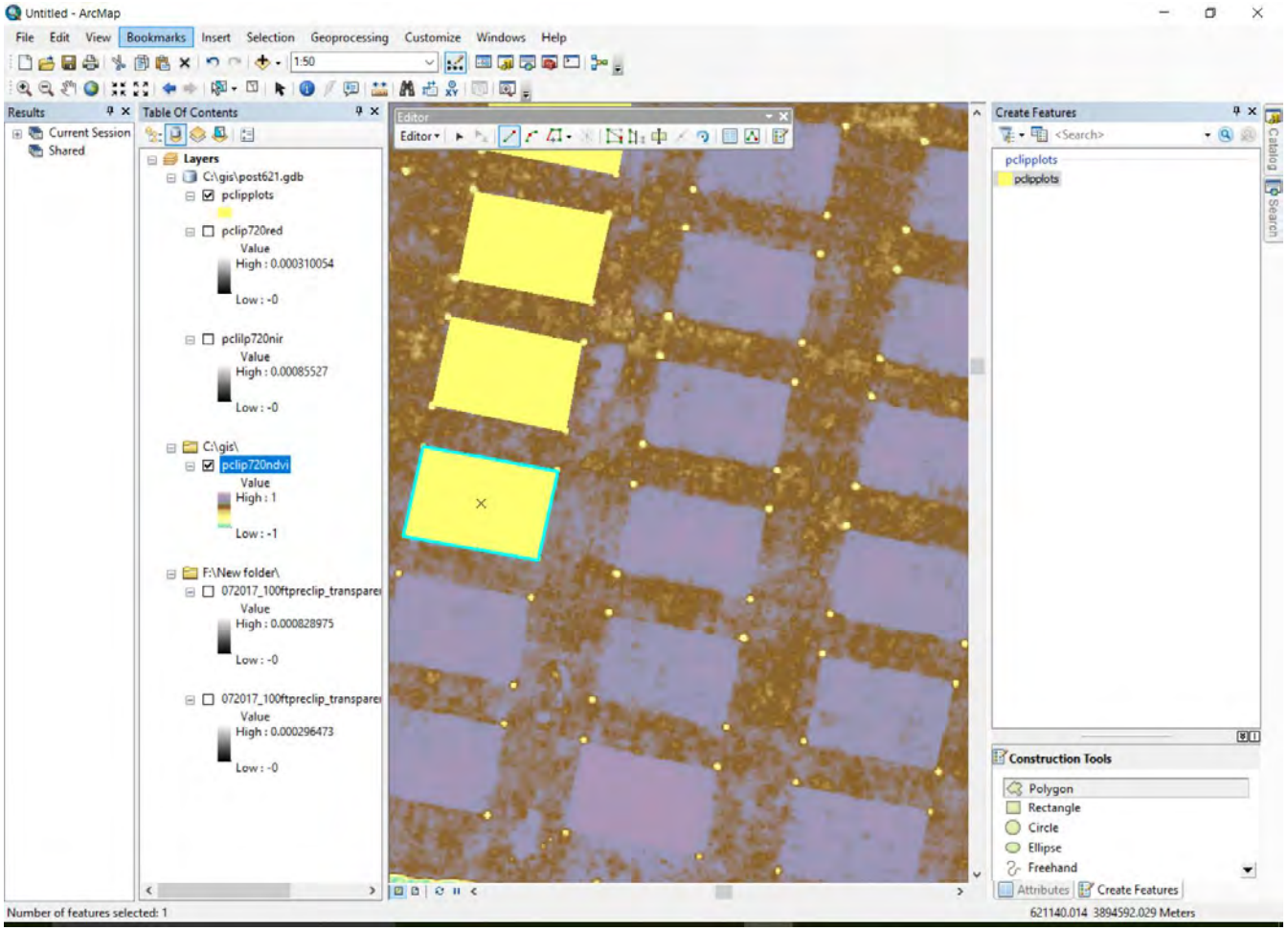
Our Work – Sandhills Research Station

- 'Tifway' bermudagrass
- Nine fertilization treatments and a control
- Data collected
  - Turf quality - visual
  - Turf color – visual
  - NDVI – aerial
  - NDVI – ground, hand held unit
  - Tissue samples for N

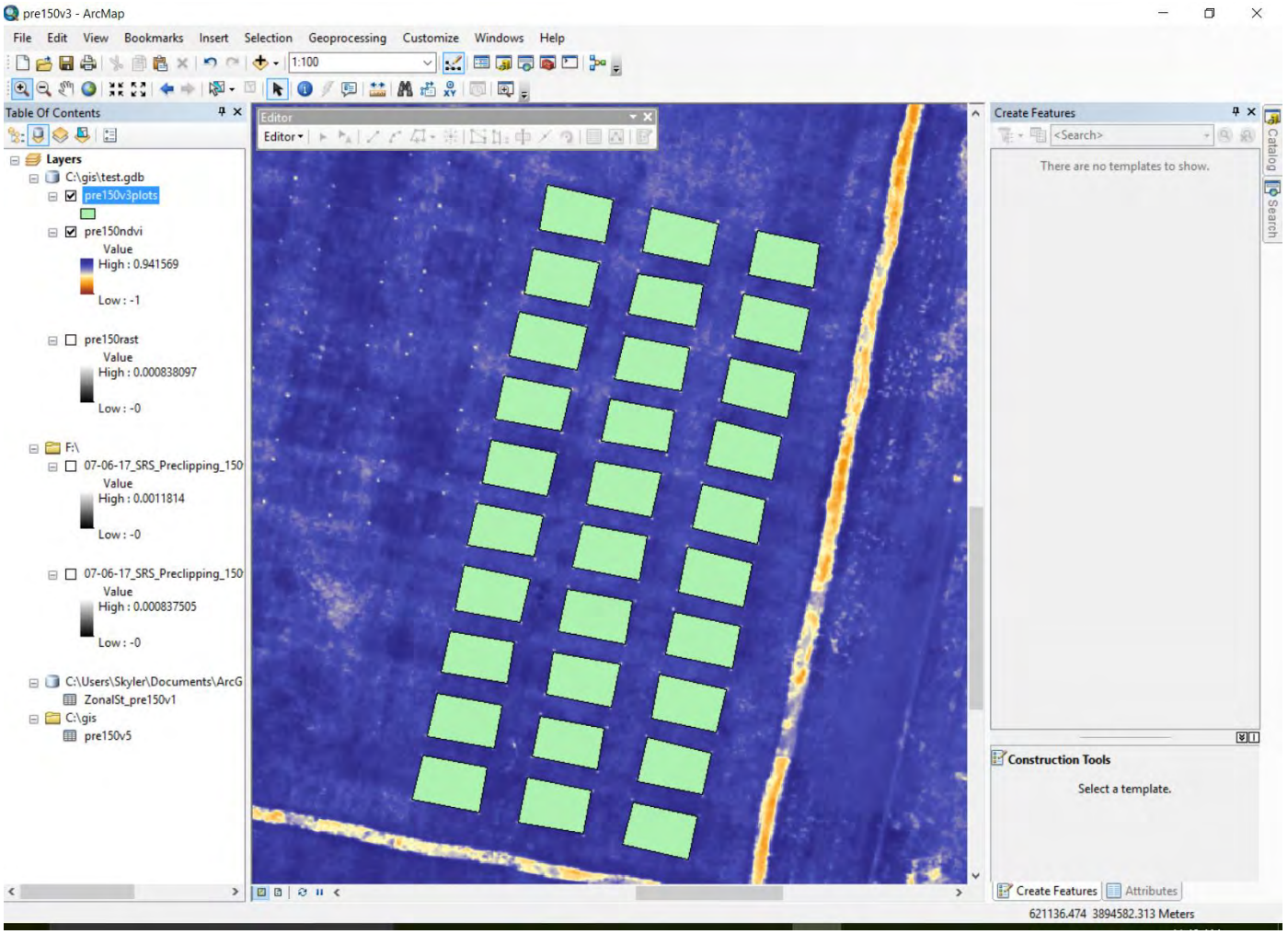
Results – Sandhills Research Station
Data collected July 6, 2017



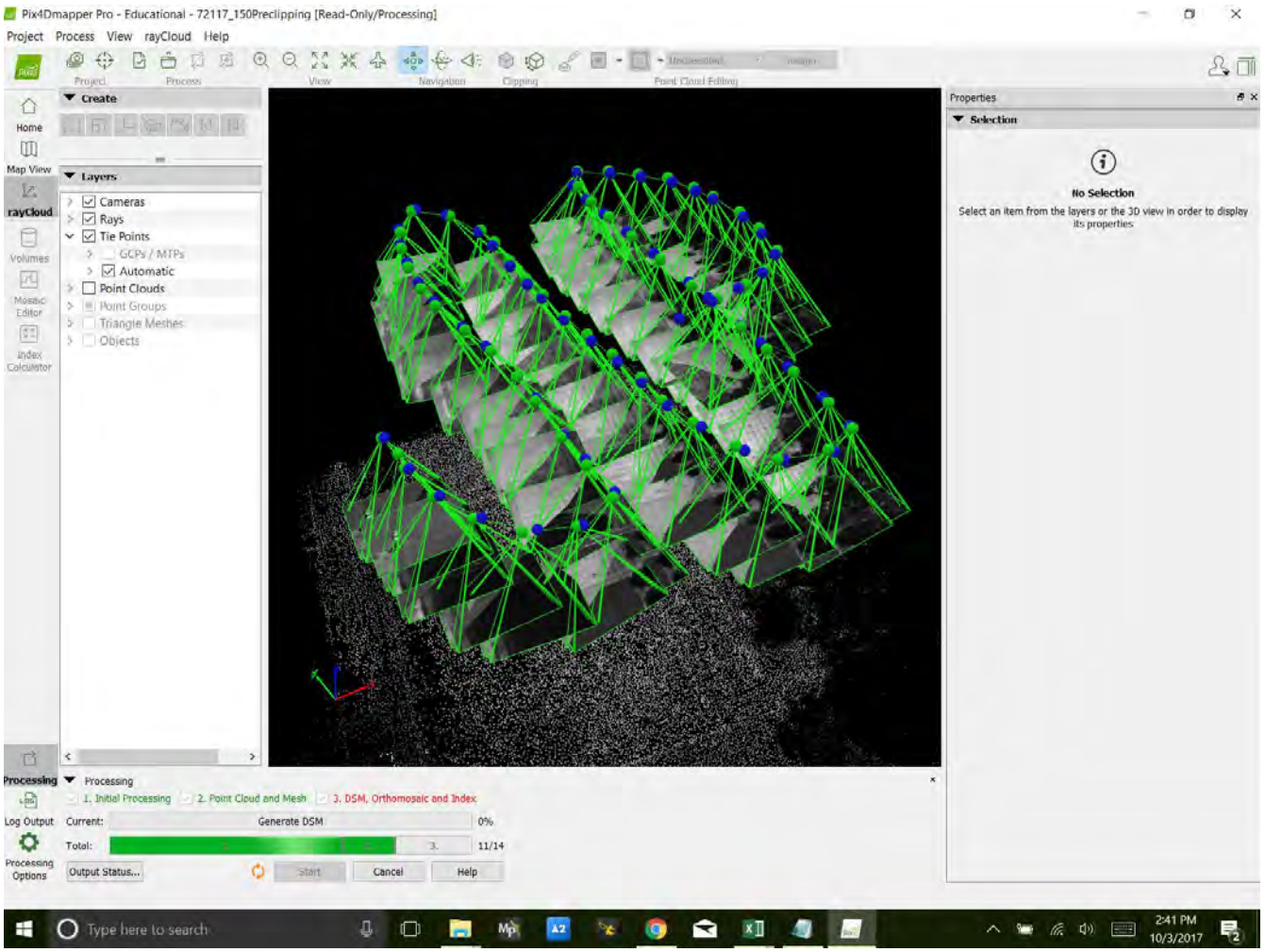
Results – Sandhills Research Station
Data collected July 6, 2017



Results – Sandhills Research Station Data collected July 6, 2017



Results – Sandhills Research Station Data collected July 6, 2017



Results – Sandhills Research Station
Data collected July 6, 2017

NDVI Measurements vs. Turf Health Metrics R^2

	Platform, Clipping Status, Altitude	*Color*	*Turf Quality*	*N*
Ground	*Pre-Clipping*	0.73	0.60	0.66
	Post-Clipping	0.67	0.44	0.54
UAV	*Pre-Clipping, 100 ft alt.*	0.84	0.65	0.49
	Post-Clipping, 100 ft alt.	0.70	0.39	0.48
	Pre-Clipping, 150 ft alt.	0.83	0.63	0.50
	Post-Clipping, 150 ft alt.	0.63	0.34	0.46

Results – Sandhills Research Station
Data collected July 6, 2017

Ground vs. UAV NDVI Measurements R^2

		Ground	
		Pre-Clipping	*Post-Clipping*
UAV	*Pre-Clipping, 100 ft alt.*	0.65	0.69
	Post-Clipping, 100 ft alt.	0.56	0.81
	Pre-Clipping, 150 ft alt.	0.67	0.69
	Post-Clipping, 150 ft alt.	0.51	0.77

Results – Sandhills Research Station
Data collected July 20, 2017

NDVI Measurements vs. Turf Health Metrics R^2

Platform, Clipping Status, Altitude		Color	Turf Quality	N
Ground	*Pre-Clipping*	0.79	0.65	0.58
	Post-Clipping	0.02	-0.11	-0.05
UAV	*Pre-Clipping, 100 ft alt.*	0.87	0.69	0.76
	Post-Clipping, 100 ft alt.	-	-	-
	Pre-Clipping, 150 ft alt.	0.87	0.70	0.72
	Post-Clipping, 150 ft alt.	0.87	0.69	0.73

Results – Sandhills Research Station
Data collected July 20, 2017

Ground vs. UAV NDVI Measurements R^2

		Ground	
		Pre-Clipping	*Post-Clipping*
UAV	*Pre-Clipping, 100 ft alt.*	0.75	0.15
	Post-Clipping, 100 ft alt.	-	-
	Pre-Clipping, 150 ft alt.	0.74	0.15
	Post-Clipping, 150 ft alt.	0.75	0.17

Results – Lonnie Poole Golf Course
Data collected October, 2017

- Overseeded bermudagrass
- Hole #15
- Compare data collected by our UAV with that of a commercial company – Precision Hawk

Our Work – Lonnie Poole Golf Course

Demo Flight at Lonnie Poole Gold Course, Hole #15

1.0 Technical Details

Survey Date: Tuesday, October 31, 2017
Survey Time: 14:32 EDT
Report Date: Tuesday, November 14, 2017
Location: Hole #15, Lonnie Poole Golf Course
Raleigh, North Carolina

Platform: X8 Multicopter
Sensor: MicaSense RedEdge
Altitude: 50 m
Pixel Resolution: 3.5 cm

2.0 Processing Details

Processing Software: Pix4D
Processing Method: Agriculture Multispectral

Post-Processing Software: ArcGIS 10.3.1
Raster Variant Processed: No Alpha
Bands Processed: Blue, Green, Red, Red Edge, Near-Infrared
Bit-depth: 16-bit, unsigned

Equations Used:

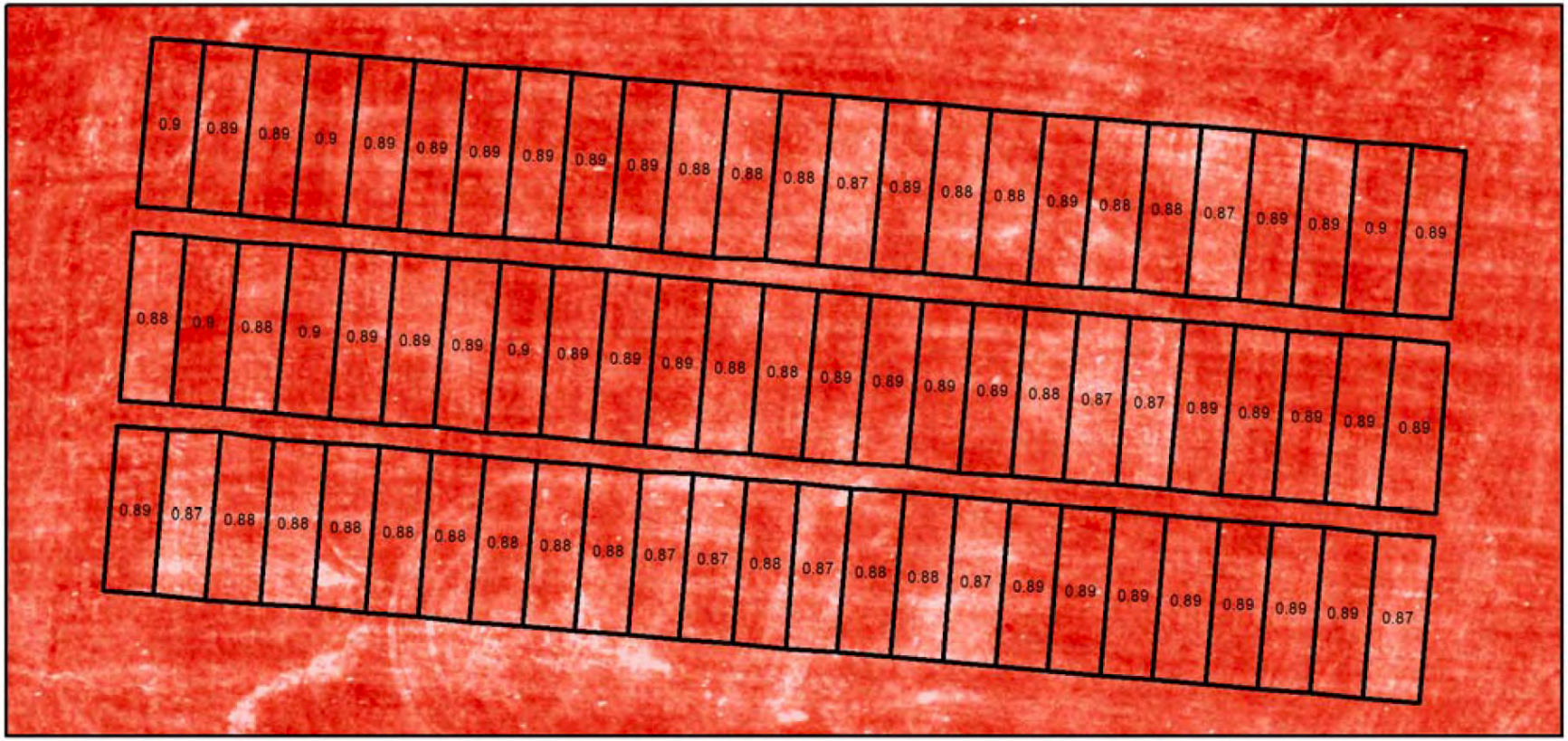
$$Normalized\ Difference\ Vegetation\ Index = \frac{Near\ Infrared - Red}{Near\ Infrared + Red}$$

Results – Lonnie Poole Golf Course
Data collected October, 2017

- NDVI – our UAV: range 0.87 to 0.90
  - average = 0.89
- NDVI – Precision Hawk: range 0.46 to 0.54
  - average = 0.51

NDVI

NDVI


0.9 0.89 0.89 0.9 0.89 0.89 0.89 0.89 0.89 0.89 0.88 0.88 0.88 0.87 0.89 0.88 0.88 0.89 0.88 0.88 0.87 0.89 0.89 0.9 0.89
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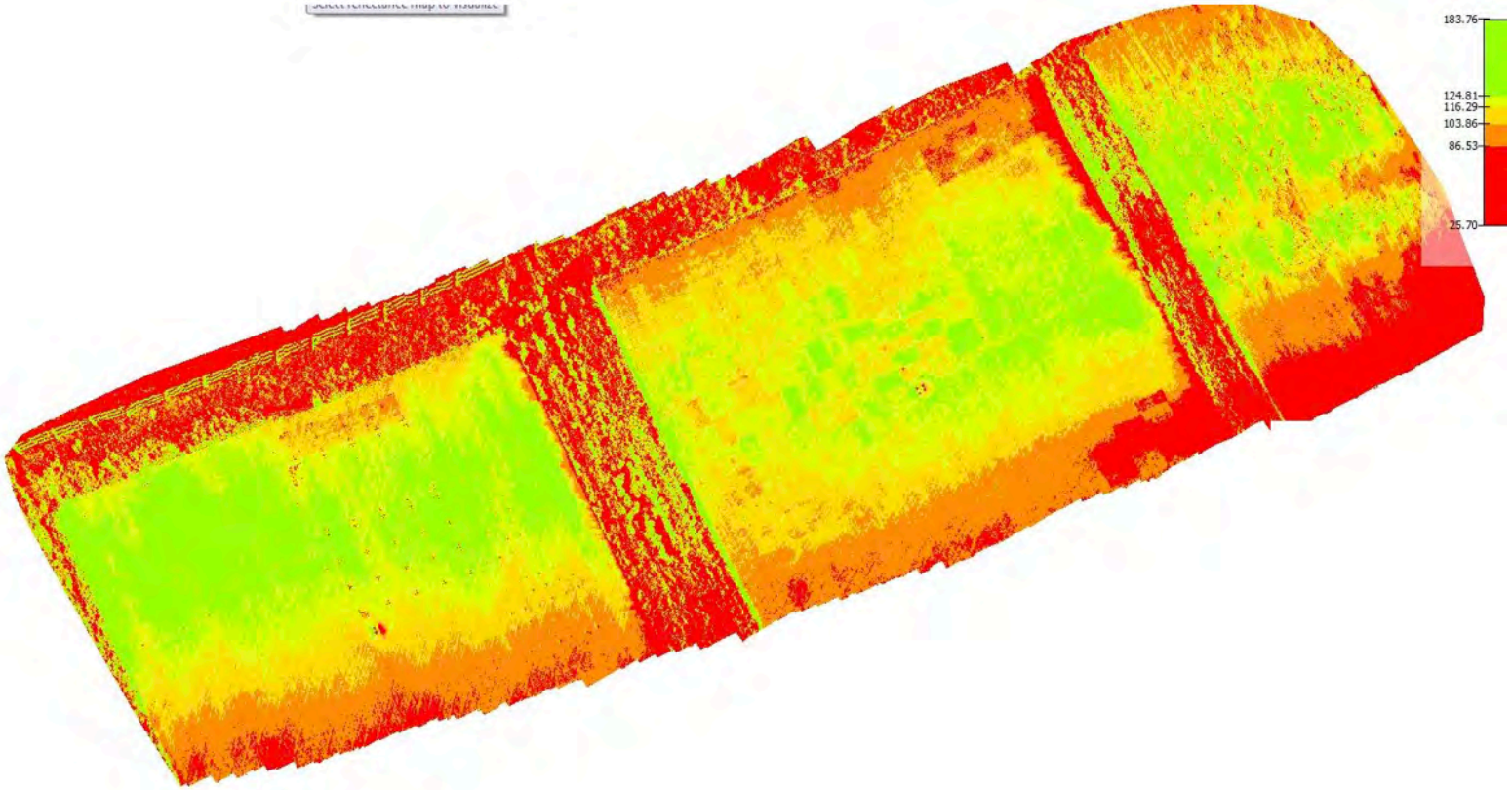
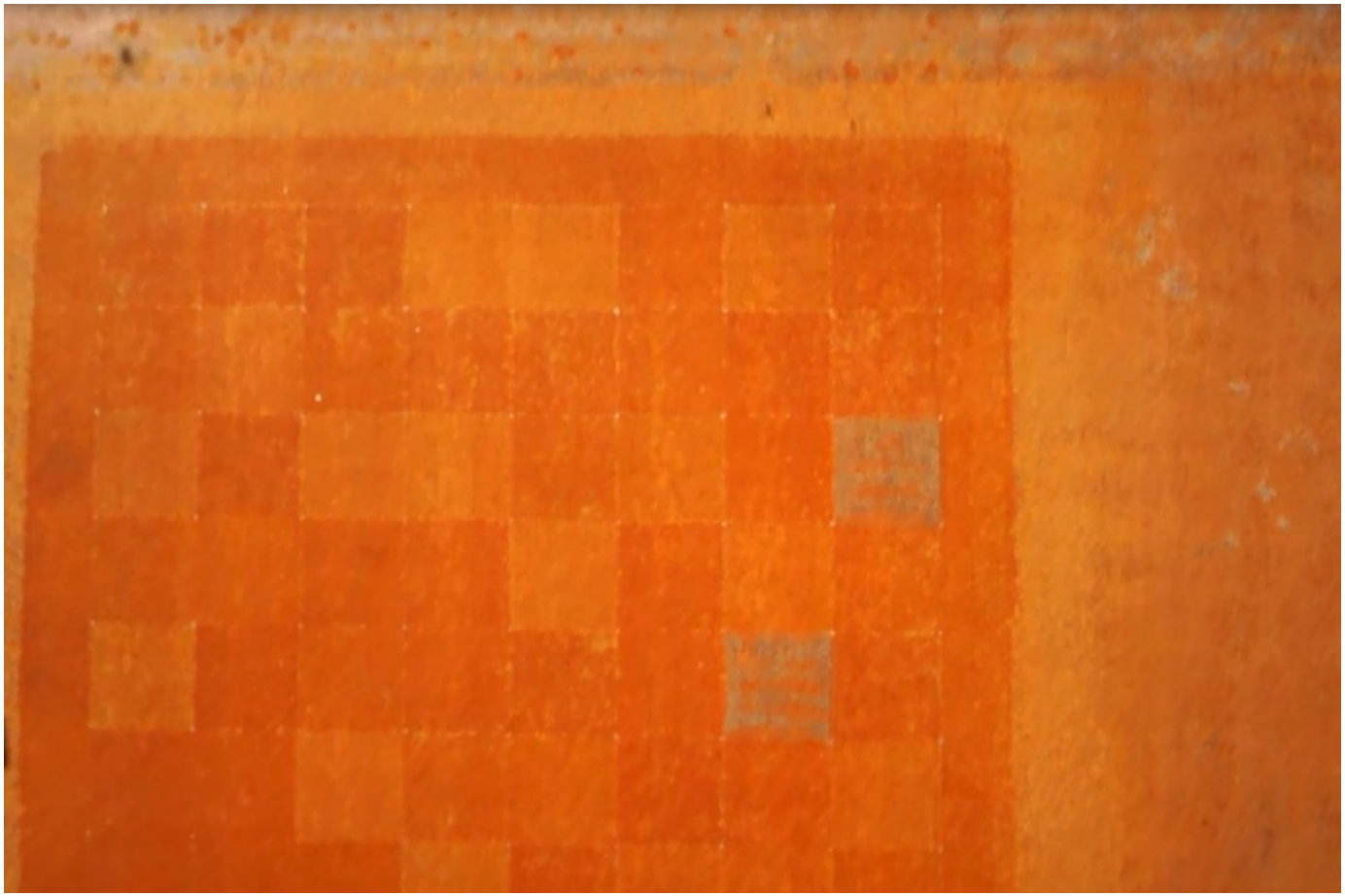
NDVI

NDVI



OUR WORK

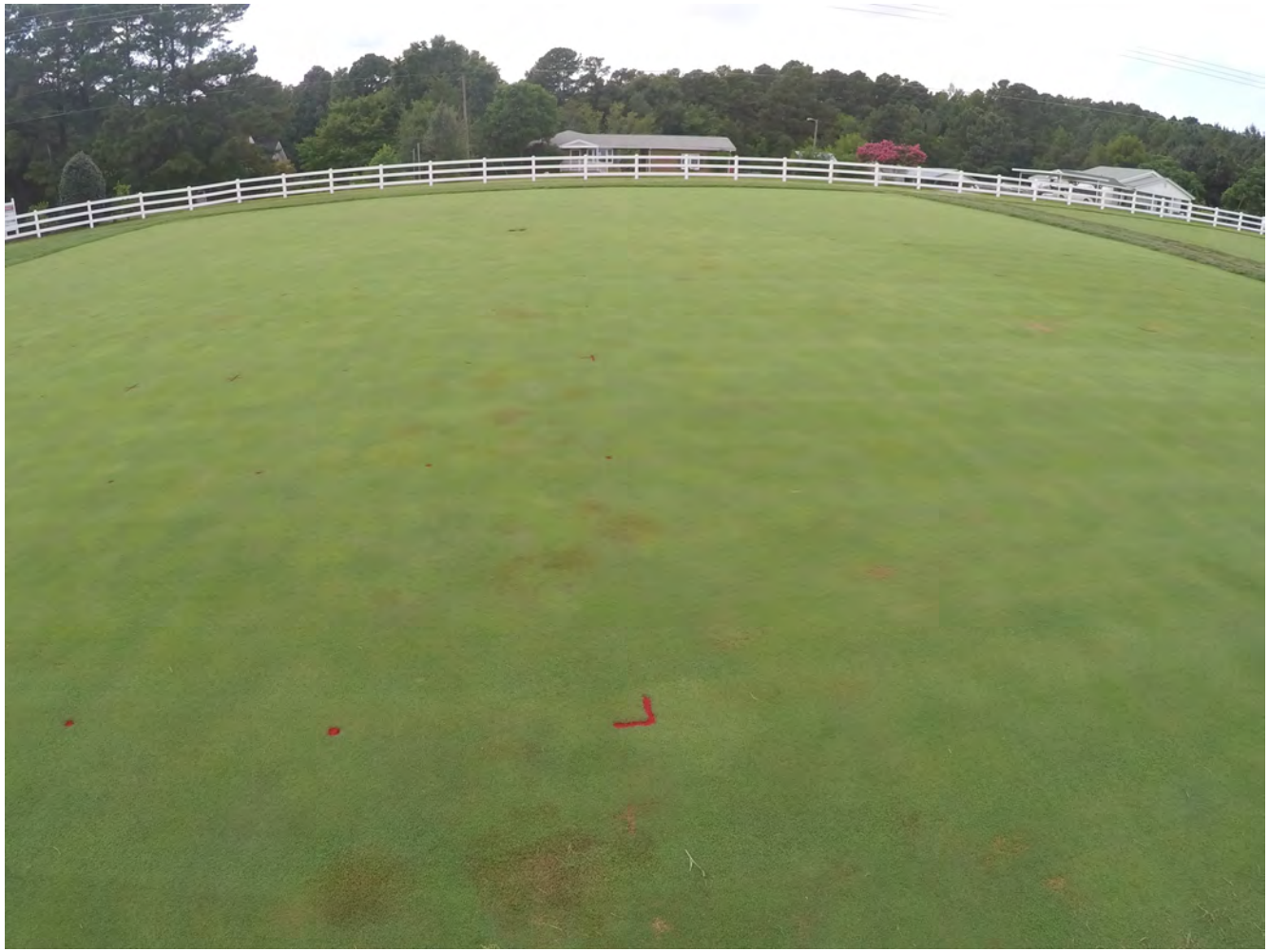


OUR WORK

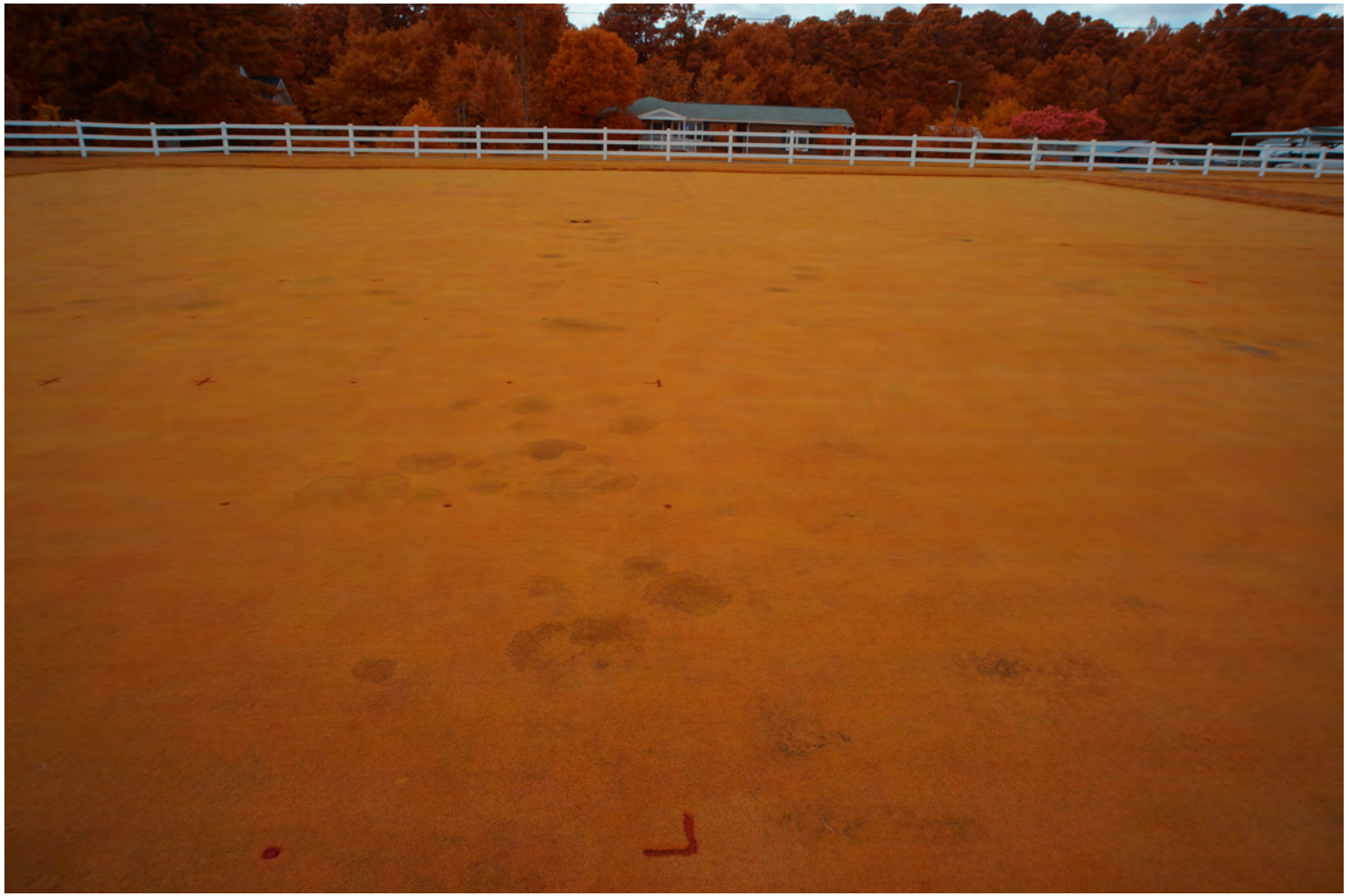
OUR WORK – Disease detection

OUR WORK

OUR WORK



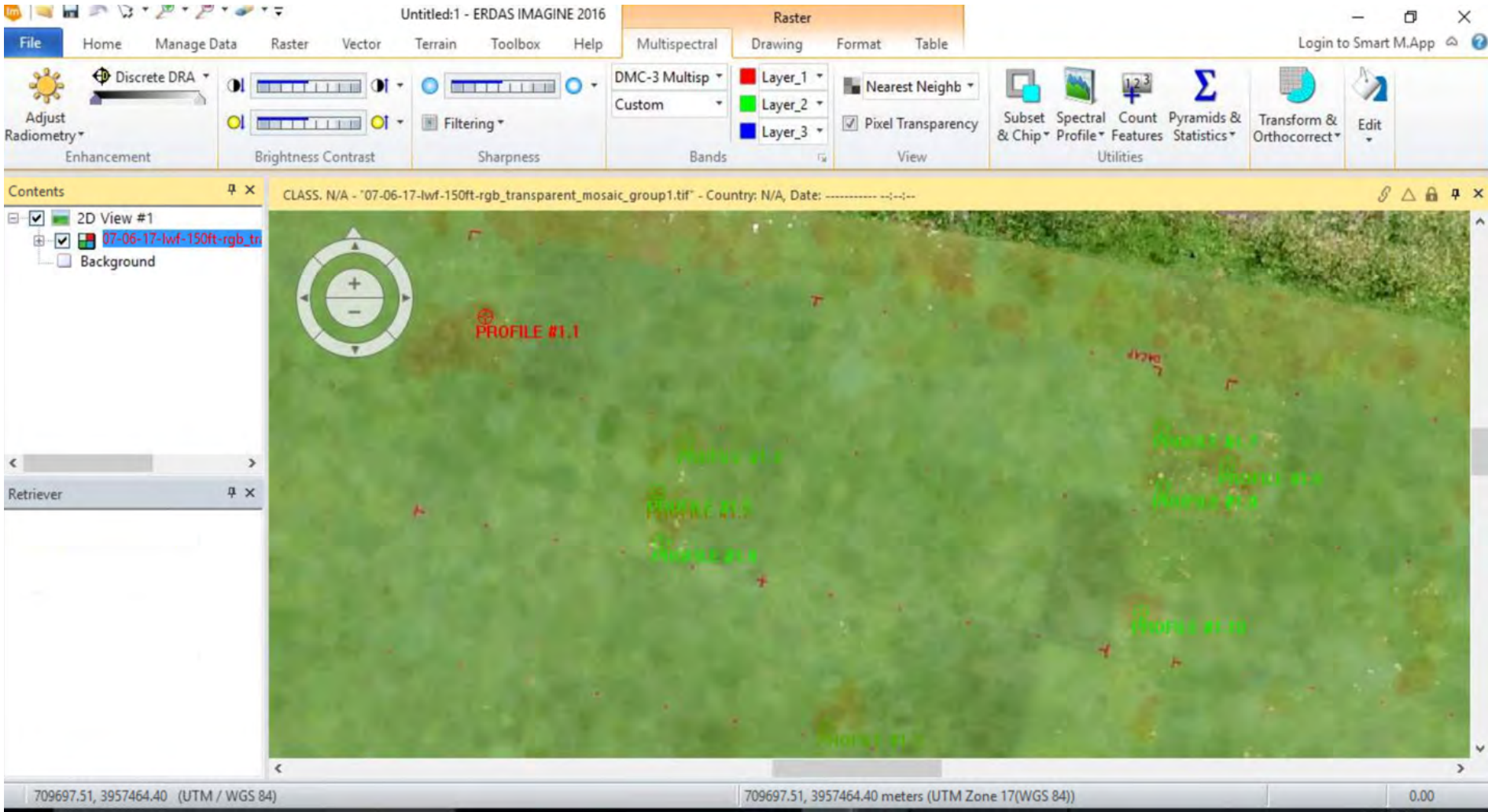
OUR WORK



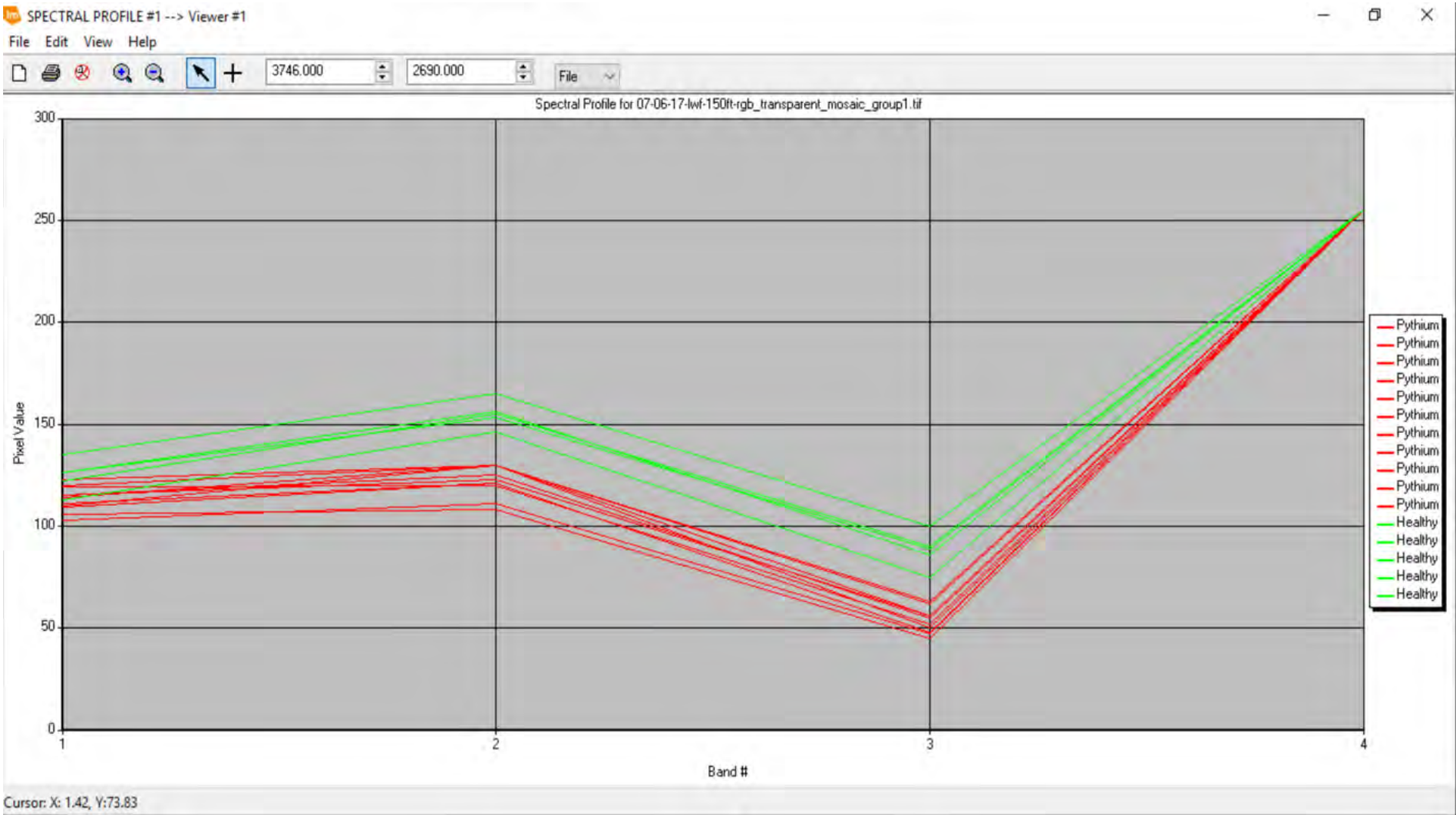
OUR WORK

OUR WORK

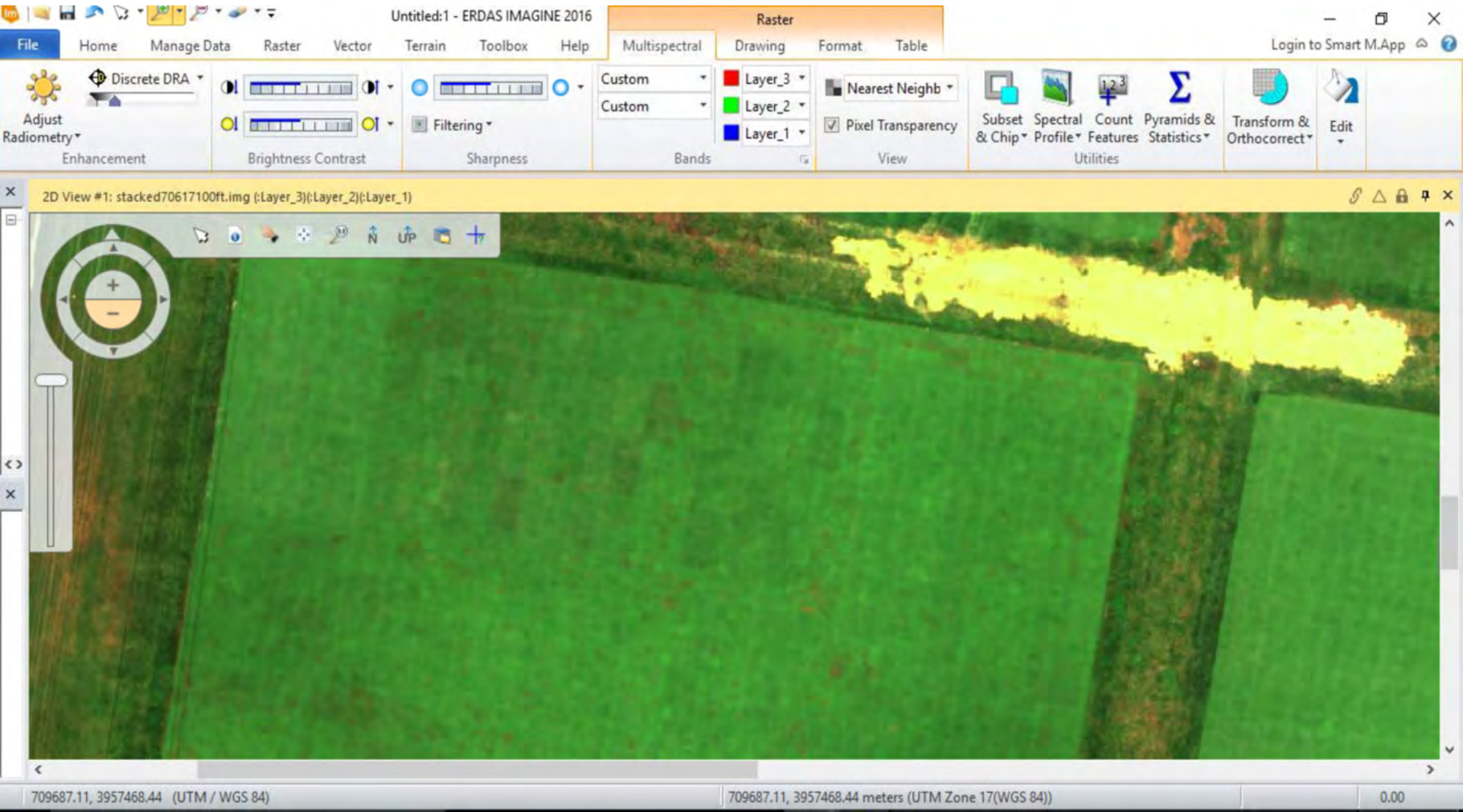
Disease Detection – RGB Natural Color Image



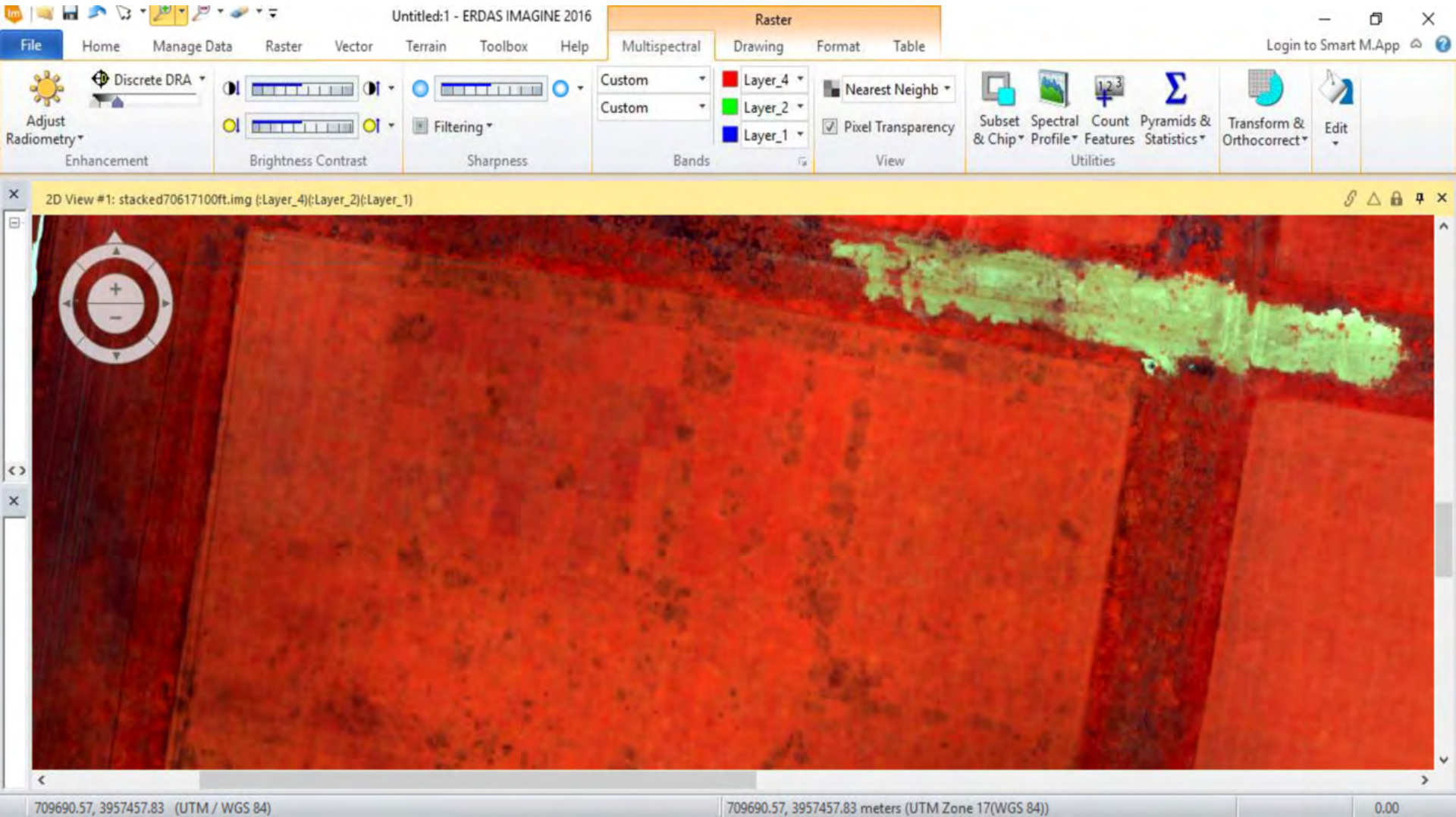
Disease Detection – Spectral Profile



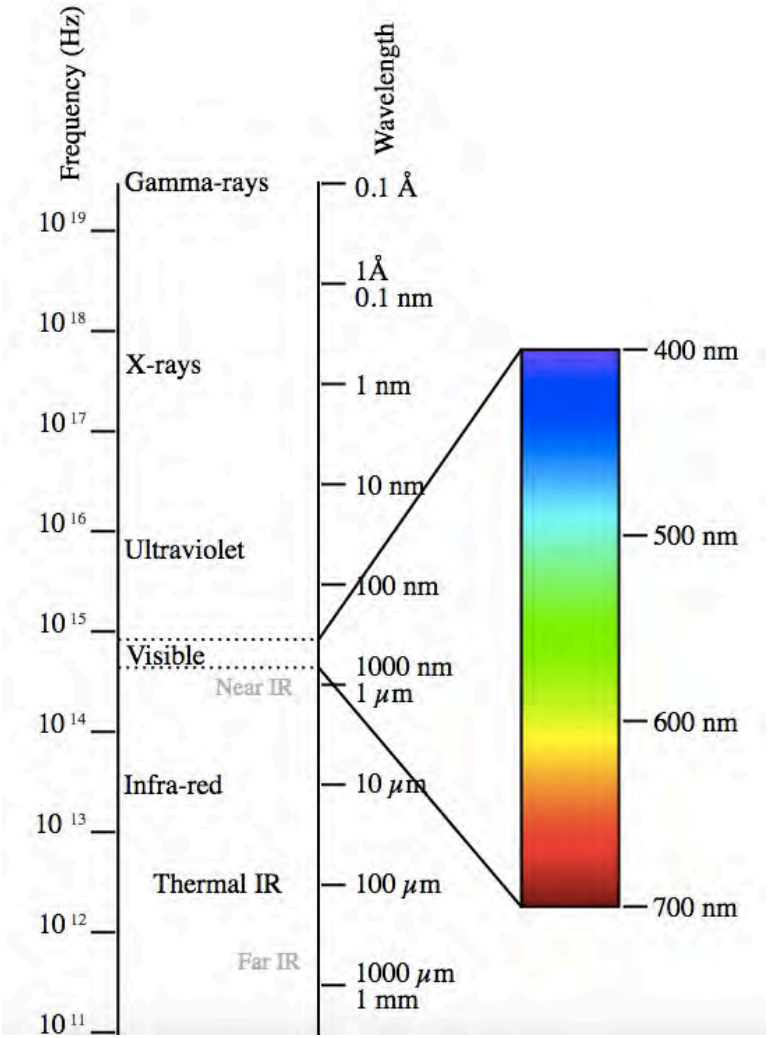
Disease Detection – Brightness Correction



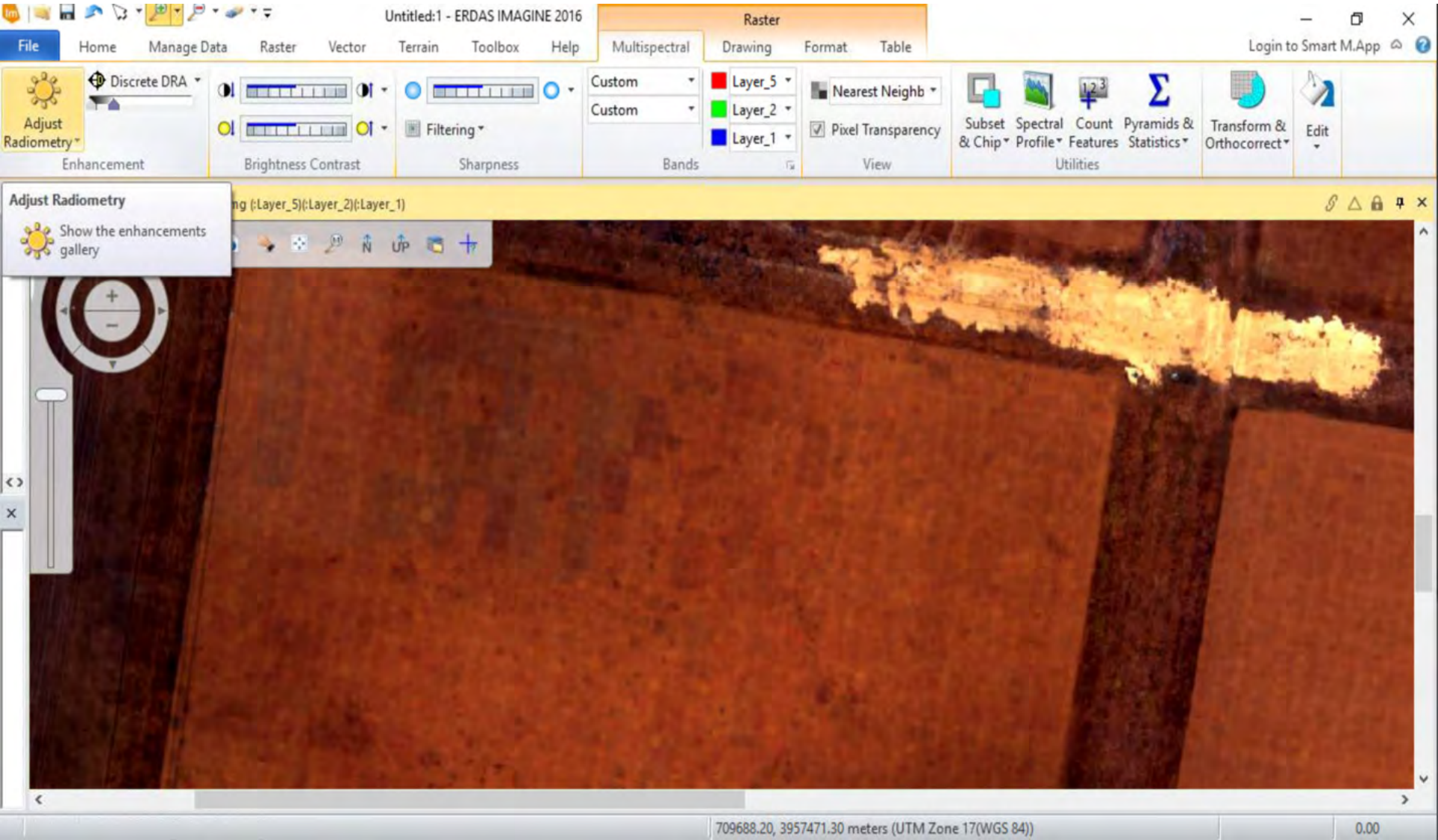
Disease Detection – Substituting NIR for Red



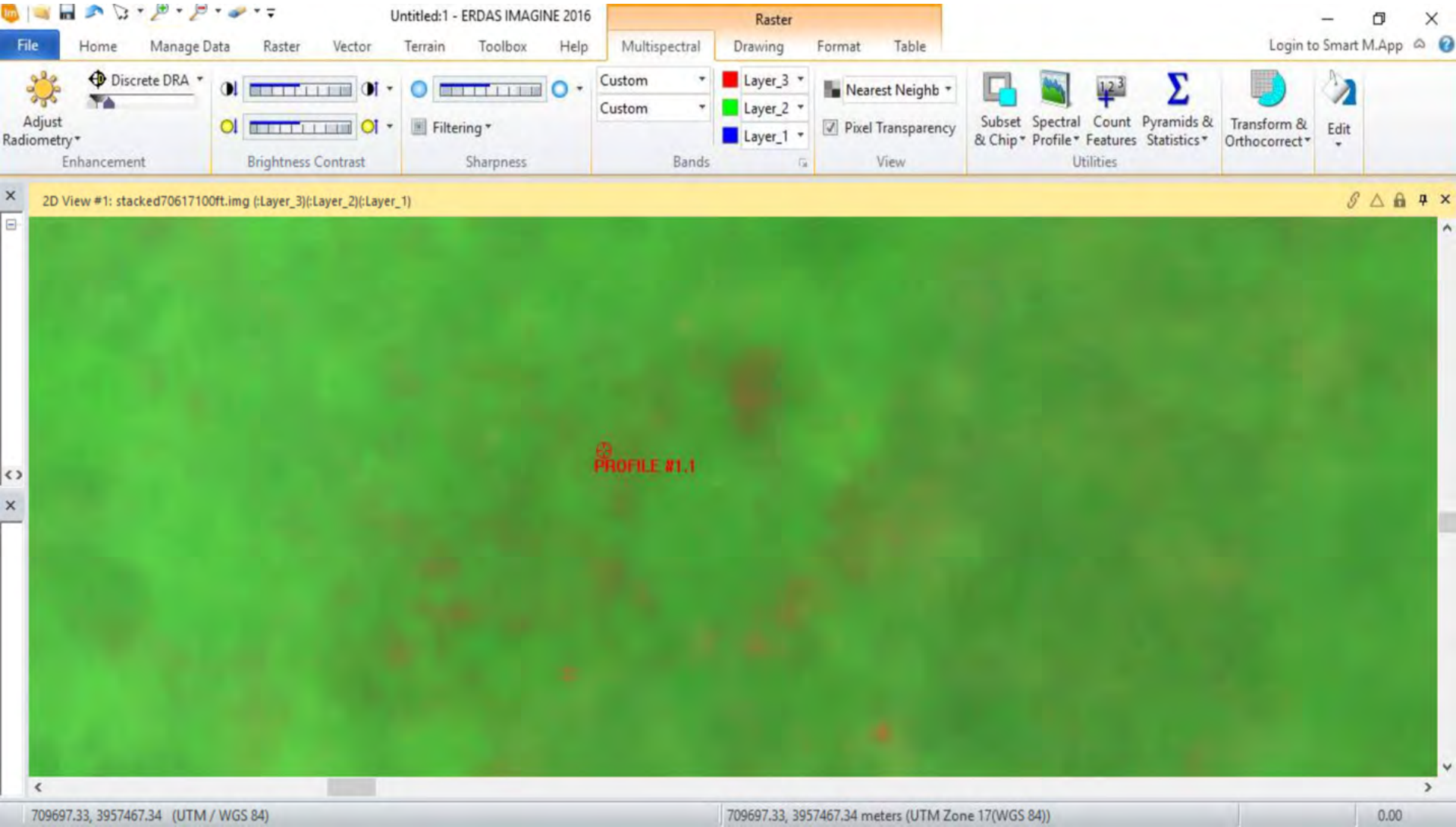
RESEARCH METHODS



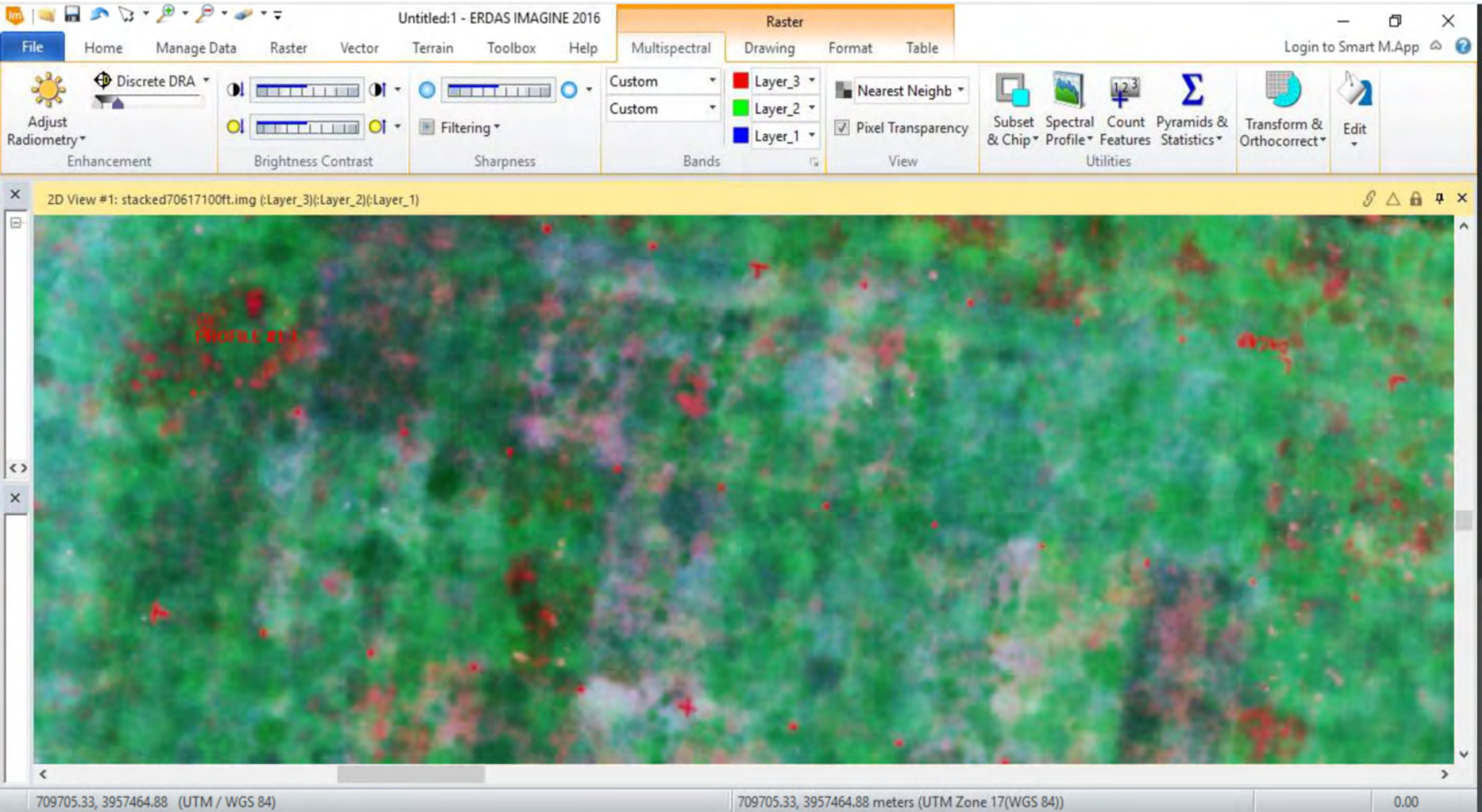
Disease Detection – Substituting Red Edge for Red



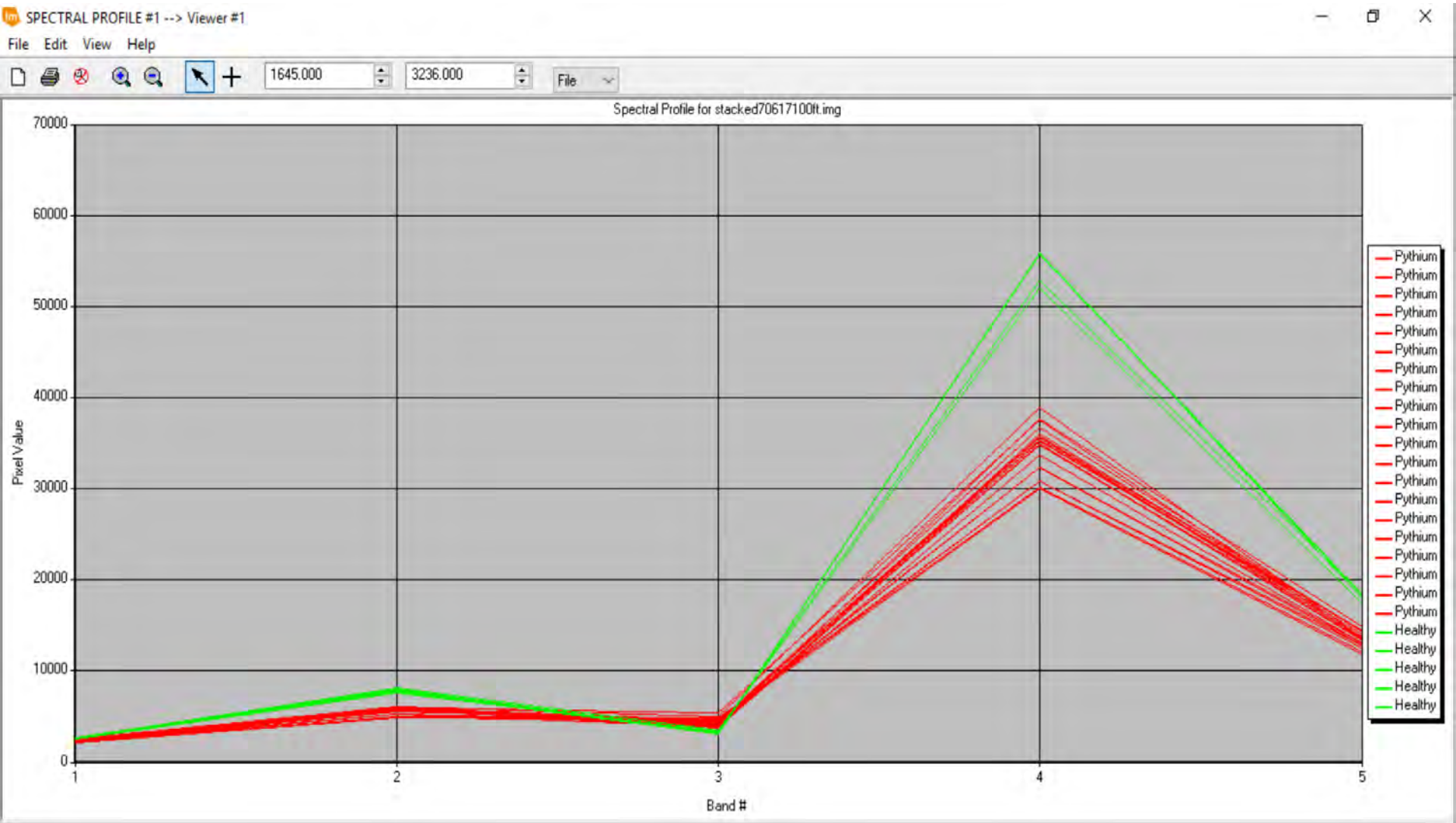
Disease Detection – Using Spectral Editor 5 Band Image



Disease Detection – Radiometric Enhancement



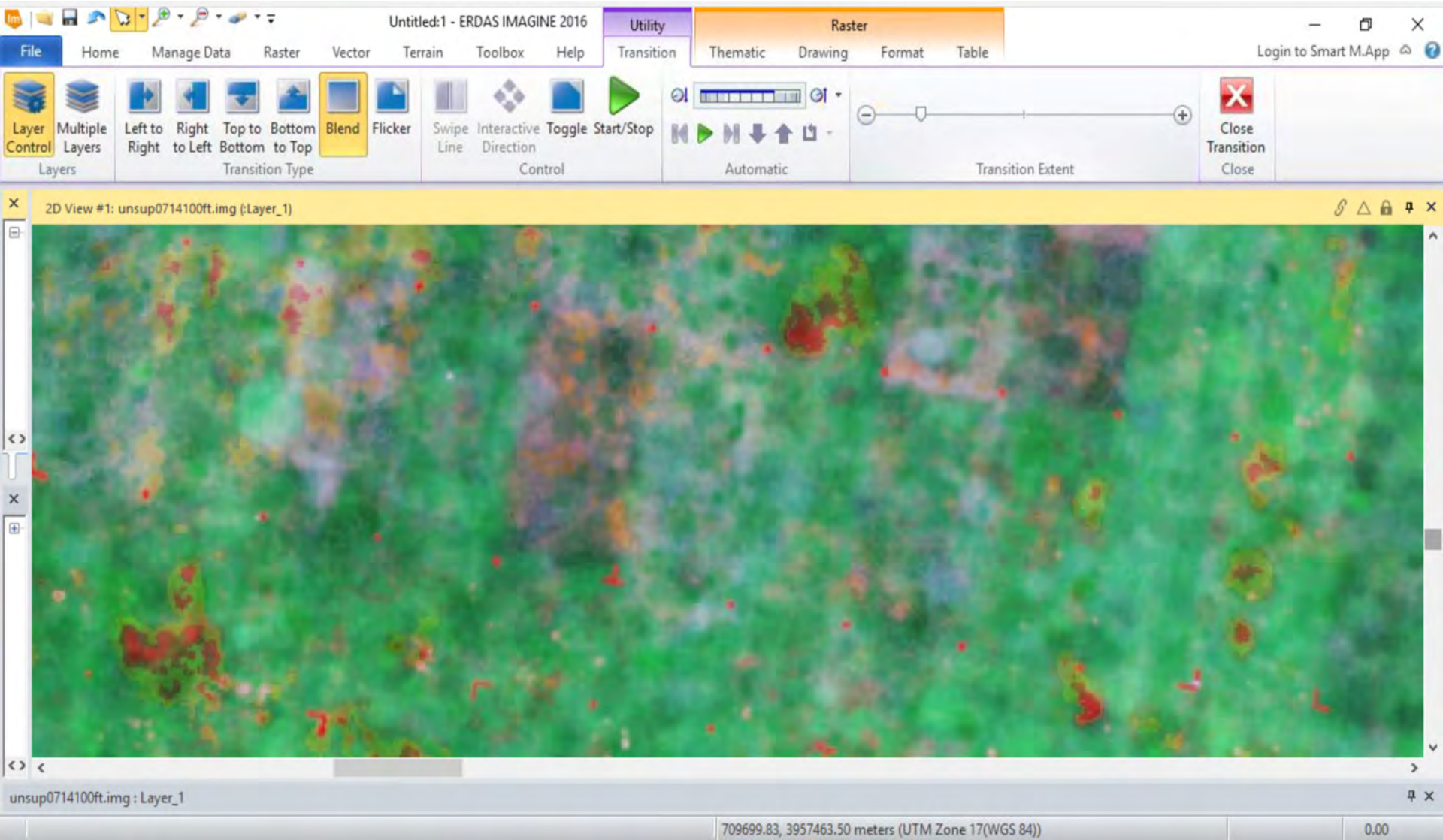
Disease Detection – NIR & RE Band Reflectance Differences



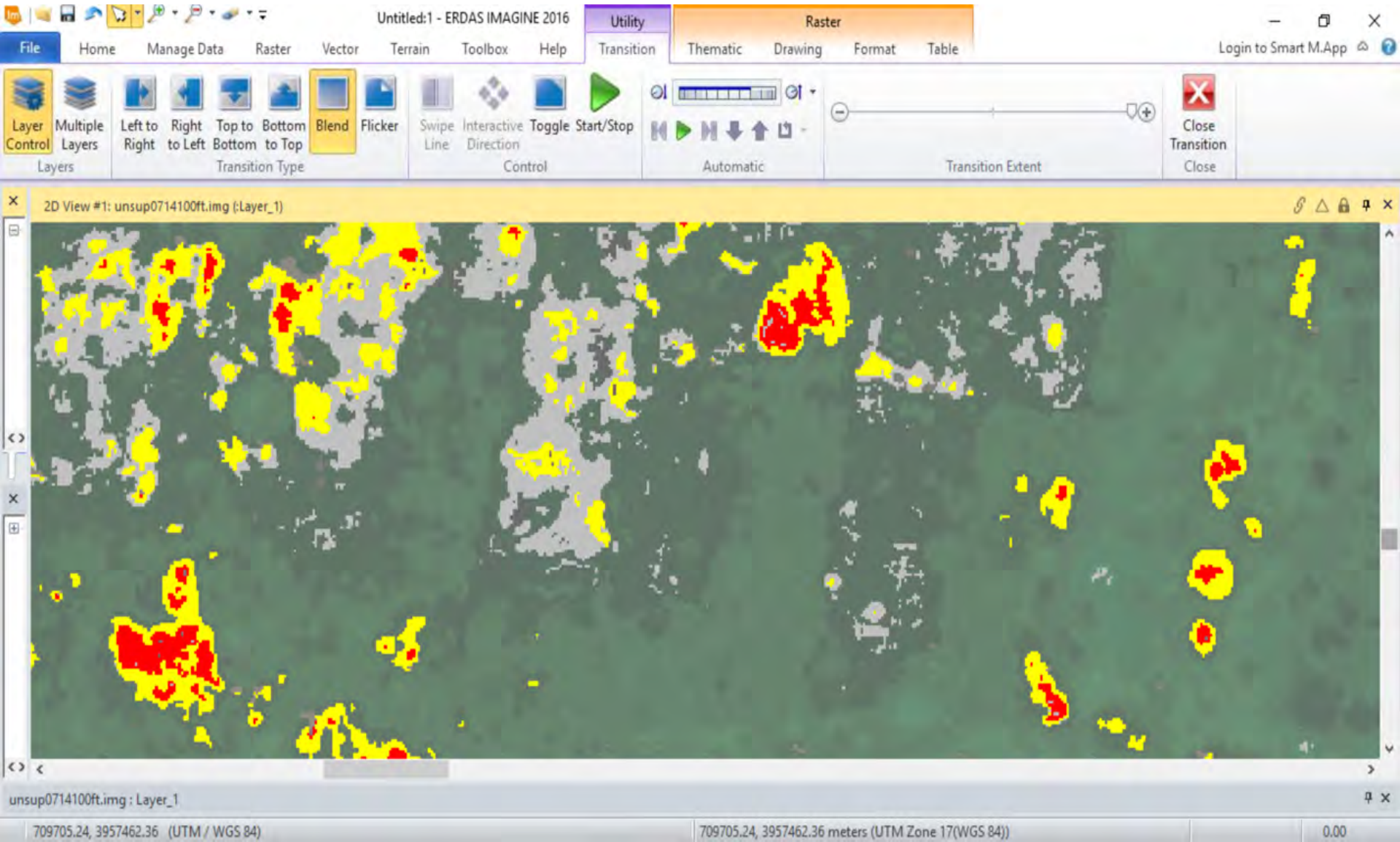
Disease Detection – ERDAS Imagine Software Unsupervised Classification

- Normal – Green
- Disease Under Pressure – Gray
- Disease Present – Yellow
- Disease severe – Red

Disease Detection – ERDAS Imagine Software



Disease Detection – ERDAS Imagine Software



Disease Detection – ERDAS Imagine Software

- Out of 200 classes, the clustering algorithm with 95% convergence threshold and 10 iterations made good distinction of Pythium in 39 classes, 4 severe

- Red – severe disease – Class 30 – 0.02196 acre
  Class 37 – 0.02313 acre
  Class 57 – 0.02462 acre
  Class 64 – 0.01993 acre

Why should you be at all interested in this?

OUR WORK

WHERE ARE WE HEADED?

- **NDVI – 19 WAYS TO CALCULATE THIS DEPENDING ON WHAT SPECTRAL REFLECTANCE WAVELENGTHS YOU USE!**

WHERE ARE WE HEADED?

- **CAN WE CORRELATE DIGITAL IMAGE ANALYSIS WITH…**
  - **Leaf chlorophyll?**
  - **Leaf nitrogen?**
  - **Leaf phosphorus?**
  - **Leaf moisture?**

WHERE ARE WE HEADED?

- **CAN WE CORRELATE DIGITAL IMAGE ANALYSIS WITH…**
  - **Leaf chlorophyll?**
  - **Leaf nitrogen?**
  - **Leaf phosphorus?**
  - **Leaf moisture?**
- **YES!**

WHERE ARE WE HEADED?

- **CAN WE CORRELATE DIGITAL IMAGE ANALYSIS WITH…**
  - **Leaf chlorophyll?**
  - **Leaf nitrogen?**
  - **Leaf phosphorus?**
  - **Leaf moisture?**
- **YES!**
- **EVERYTHING must be ground verified!!**

WHERE ARE WE HEADED?

- WHAT DON'T WE KNOW?
- WHAT CAN MAKE A DIFFERENCE IN DATA INTERPRETATION?
  - Species differences
  - Time of day
  - Light conditions
  - Leaf surface moisture
  - Drone height above turf
  - Drone speed of flight