

Diagnosing Macadamia Nut Tree Health: A Case Study Using Multispectral Analysis

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Orchard Technologist



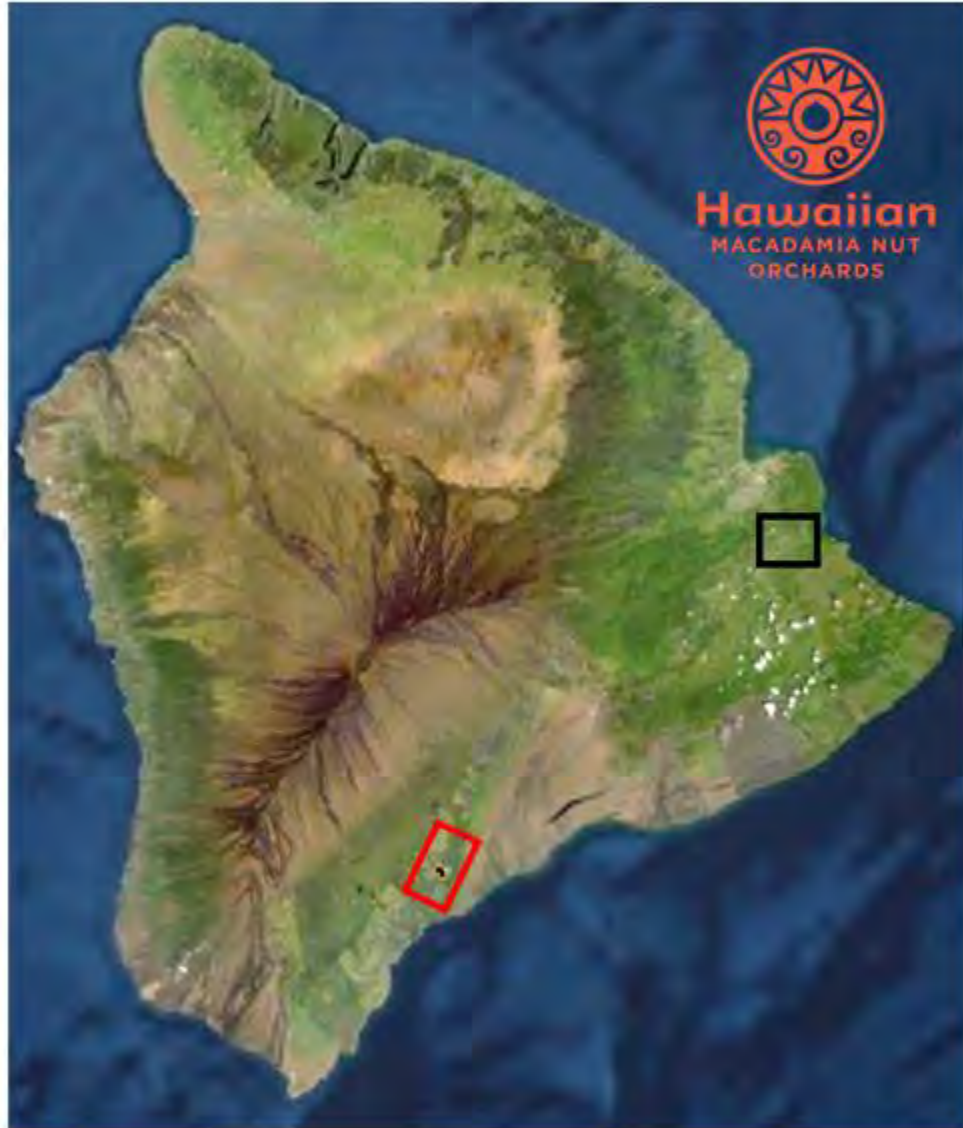
Hawaiian
MACADAMIA NUT
ORCHARDS



LON: -155° 28' 58.73"
LAT: 19° 11' 51.62"



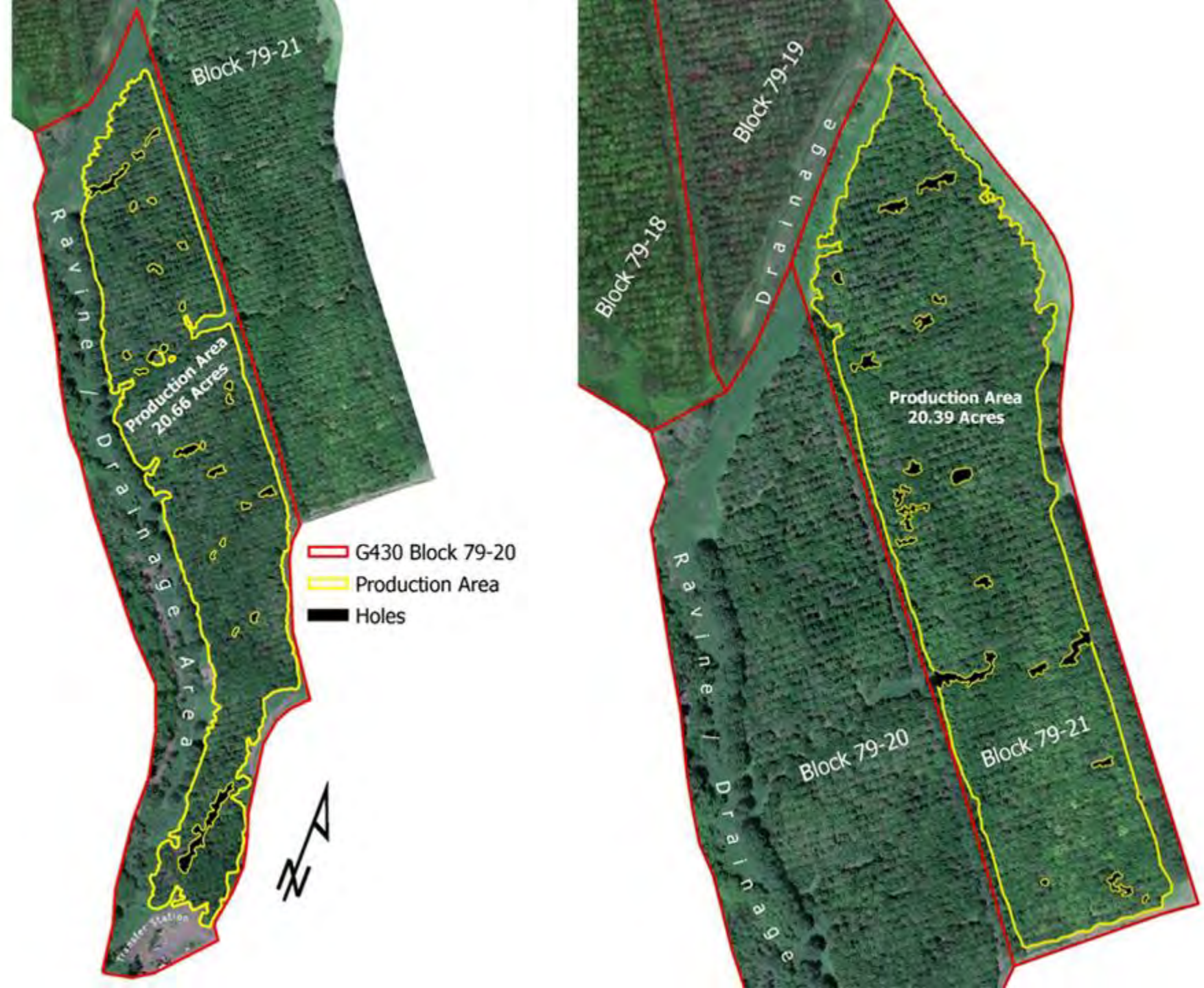
Study Area Pahala, Hawaii Island



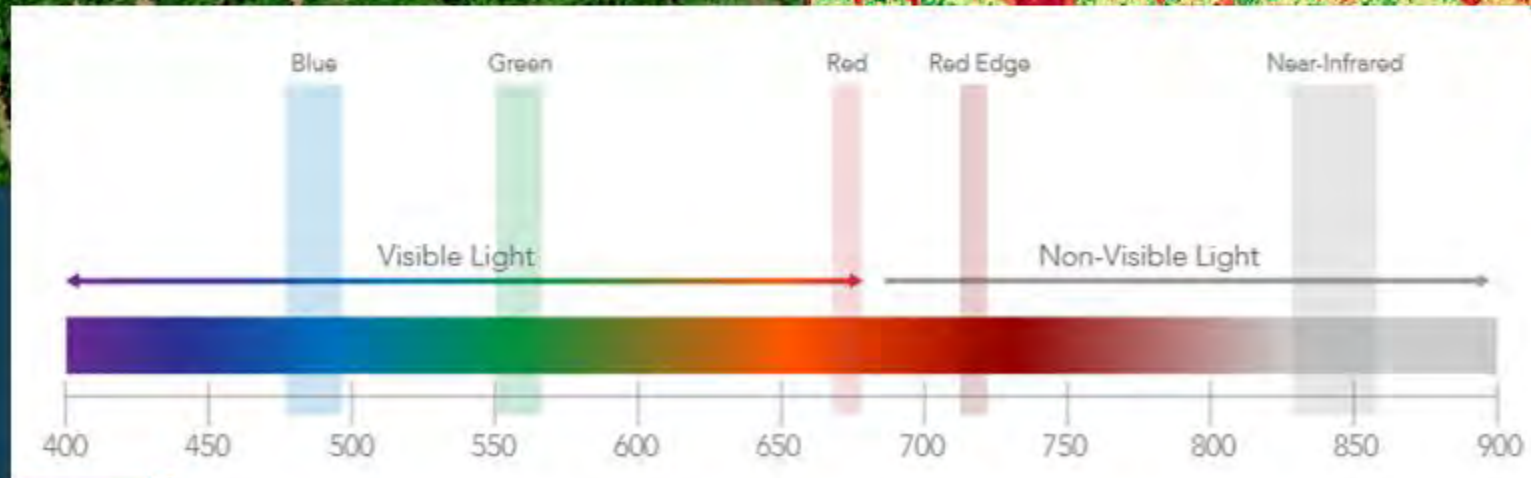
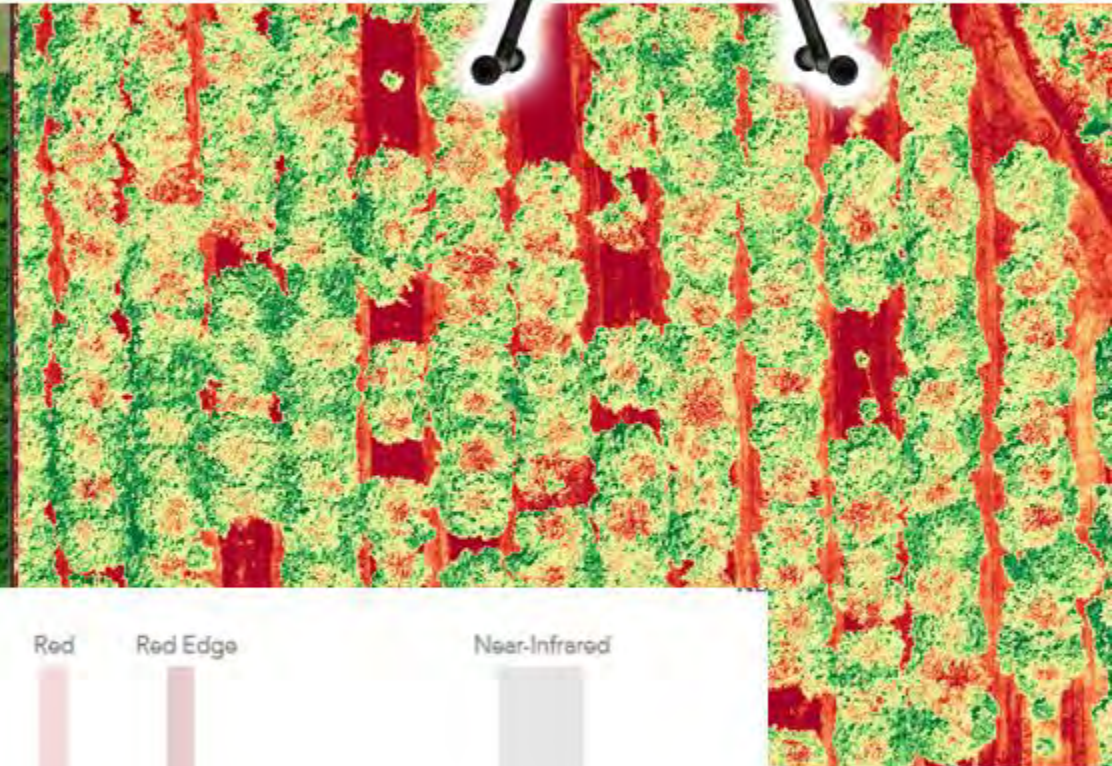
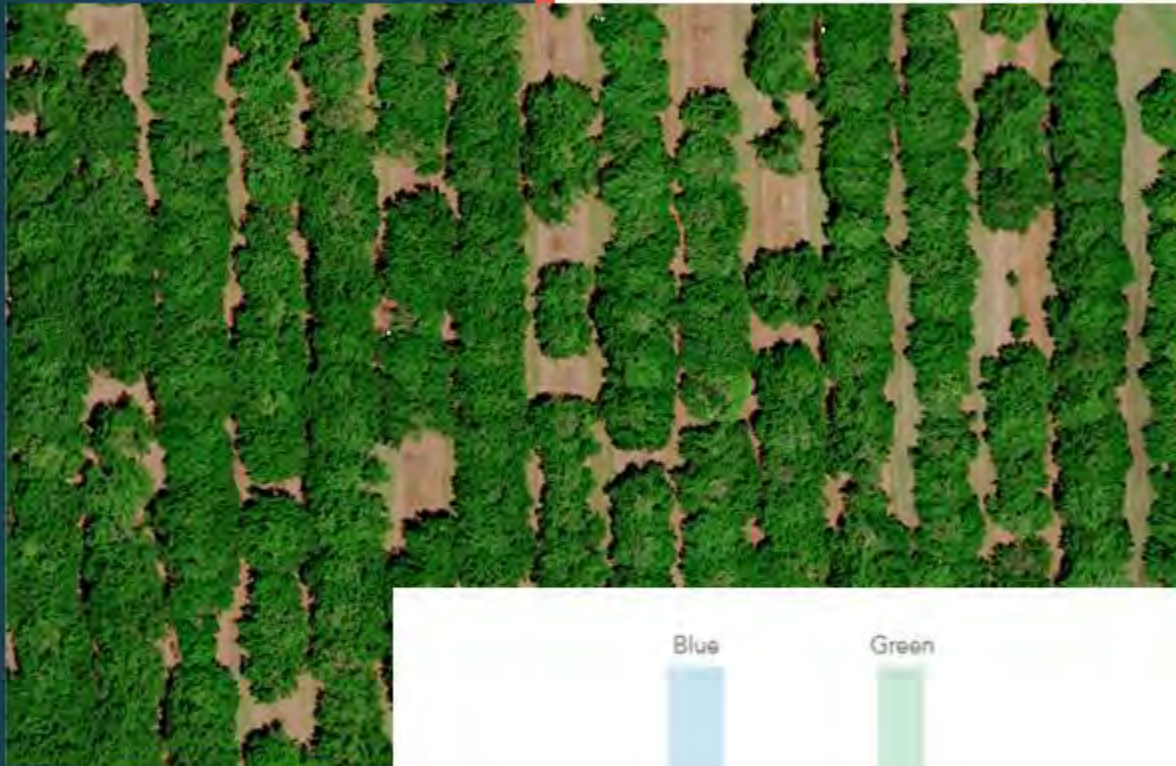
Study Area Delineation

accurate
calculations

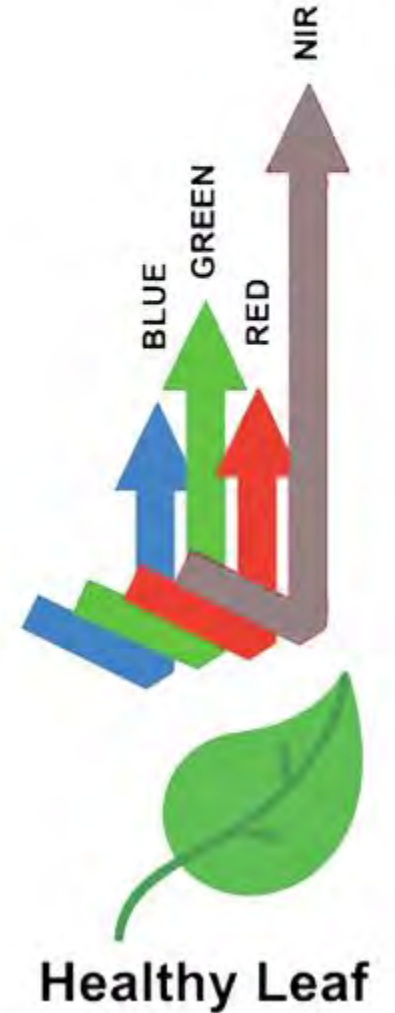
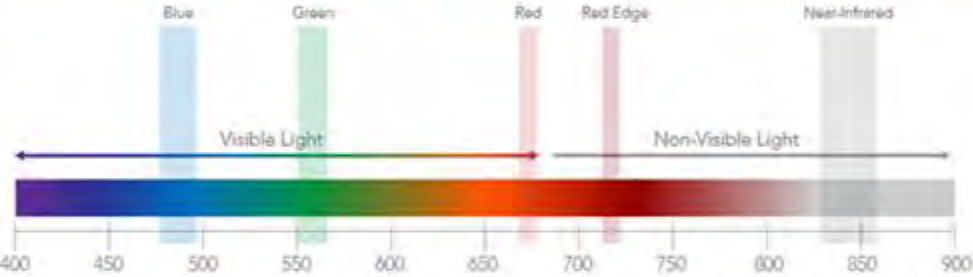
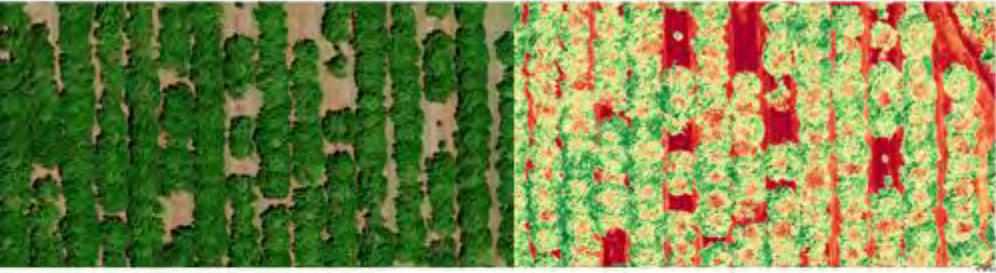
trees/acre
yield
fertilizer
fuel utilization
taxes, etc.



Multispectral Imagery



Data from Non-Visable (IR) Light



Non-Visible (IR) Light & Vegetation Indices

Dozens of Vegetation Indices

How do you choose?

Literature?

Compare indices for consistency

Crop Type: Row vs Orchard

Age/Seasonality

Structure: Closed Canopy vs Pruned

Environmental Characteristics



Common Vegetation Indices

NDVI Normalized Diff Veg
Difference near-IR (veg reflects) & red light (veg absorbs)



NDVire/NDRE

Red Edge
Use when high
chlorophyll, to
detect nitrogen
variability

GNDVI

Green
H₂O & nitrogen
uptake, chlorophyll
content
to detect wilt/aging
& nitrogen content

CLRE

Chlorophyll Red Edge
Chlorophyll content
Photosynthetic
activity
Use when actively
growing, not harvest

Vegetation Indices General Measurement

dead, bare ground,
not vegetation

dense green leaves
healthy, mature, ripe

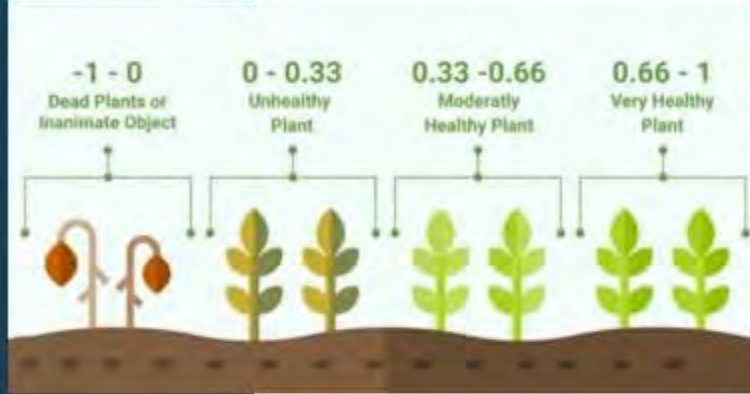
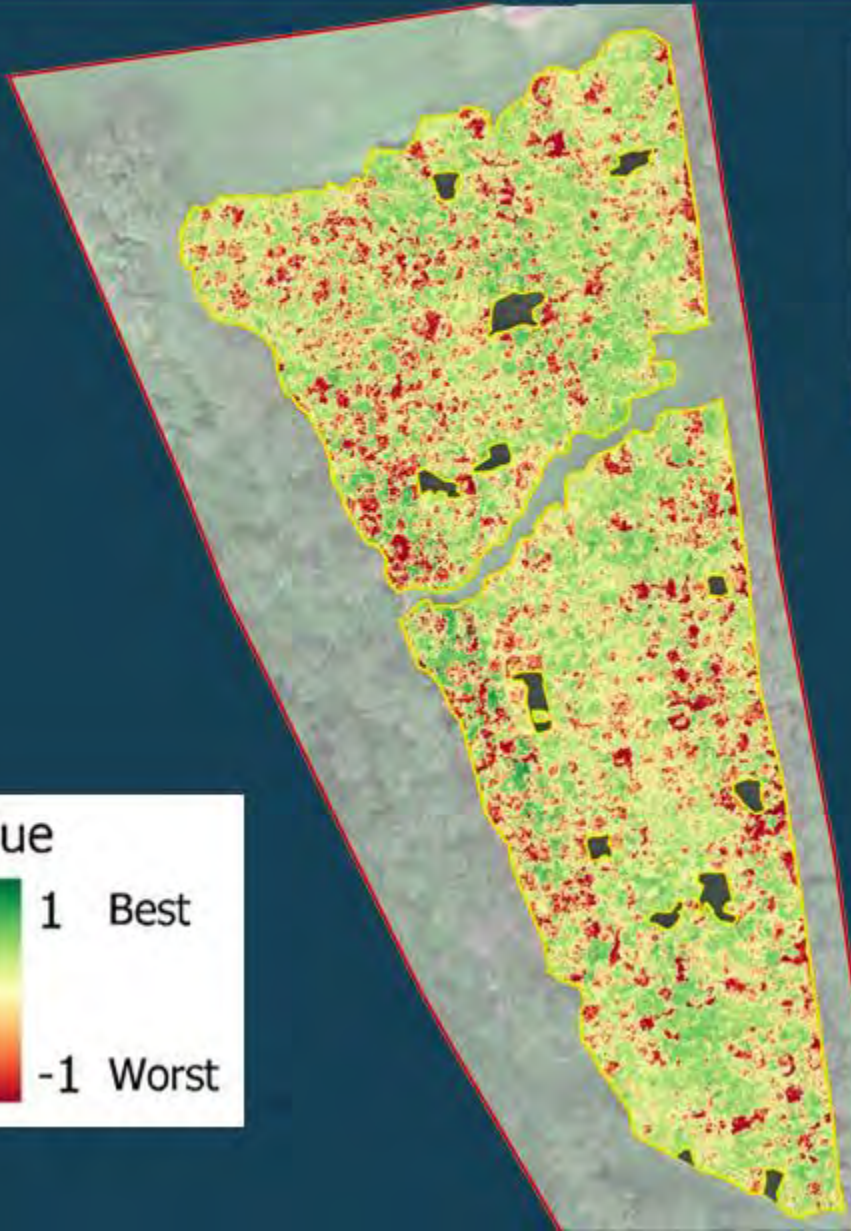
-1

+1



Analysis 1: Basic NDVI Values

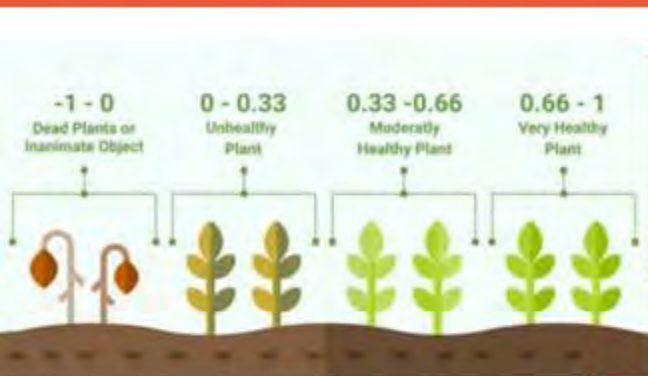
EOS NDVI Values Breaks



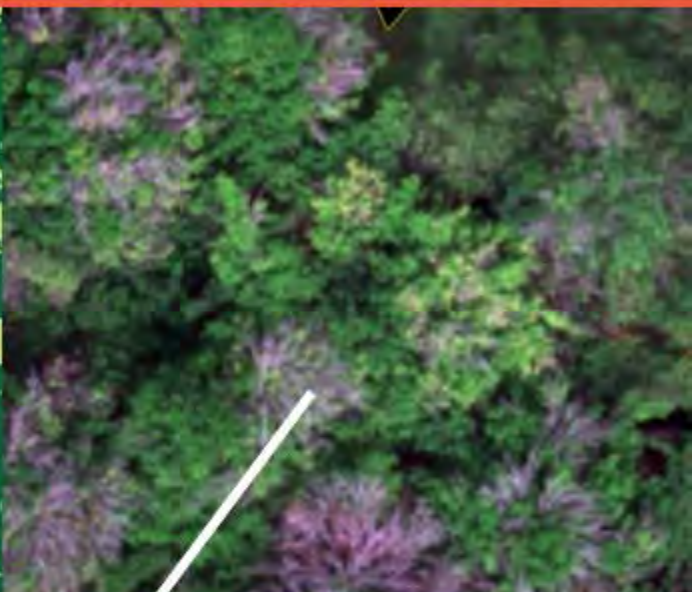
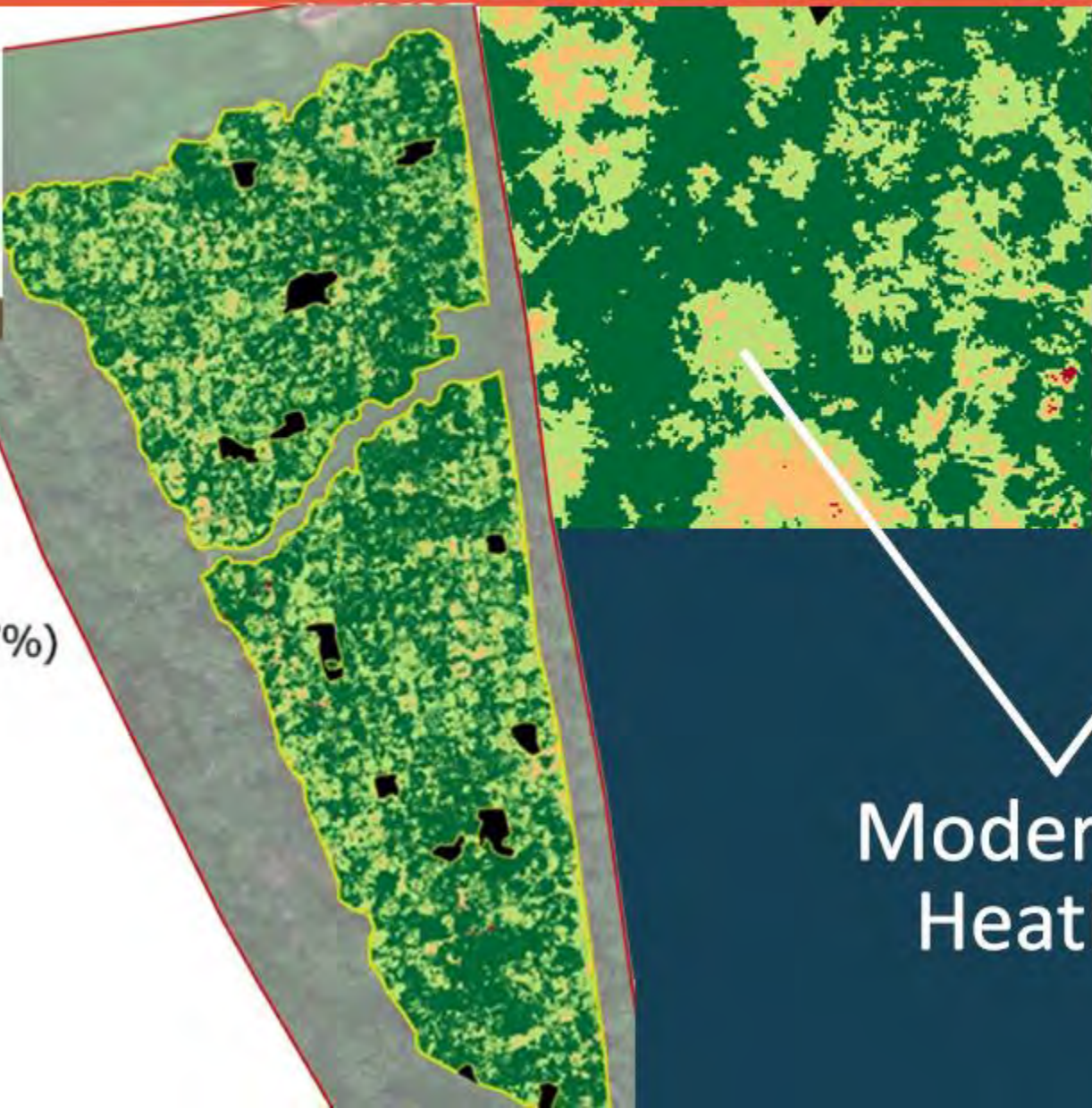
NDVI EOS 4 Classes

- Dead (0%)
- Unhealthy (3%)
- Moderately Healthy (37%)
- Very Healthy (60%)

EOS NDVI Values Breaks vs Ground Truthing

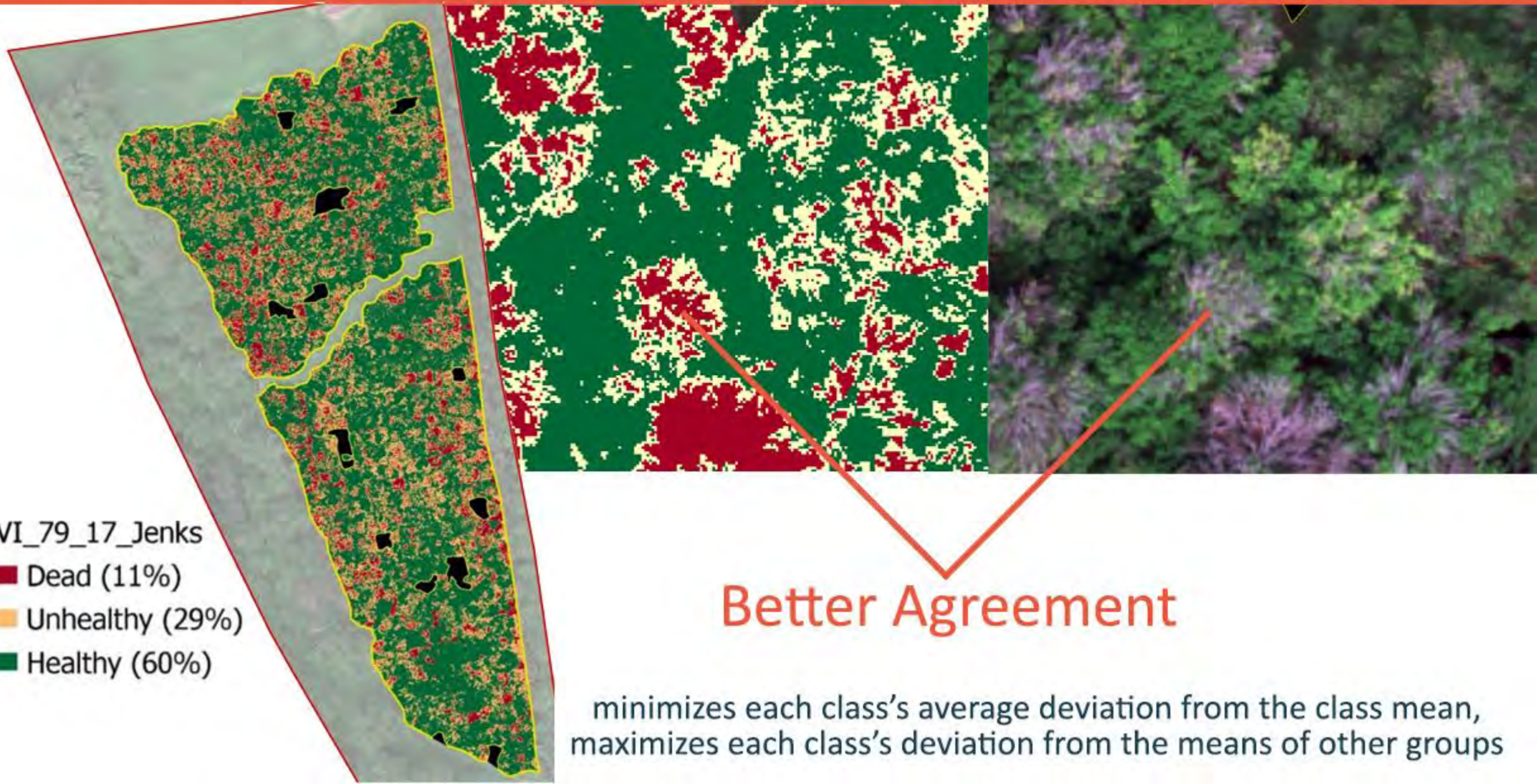


- NDVI EOS 4 Classes
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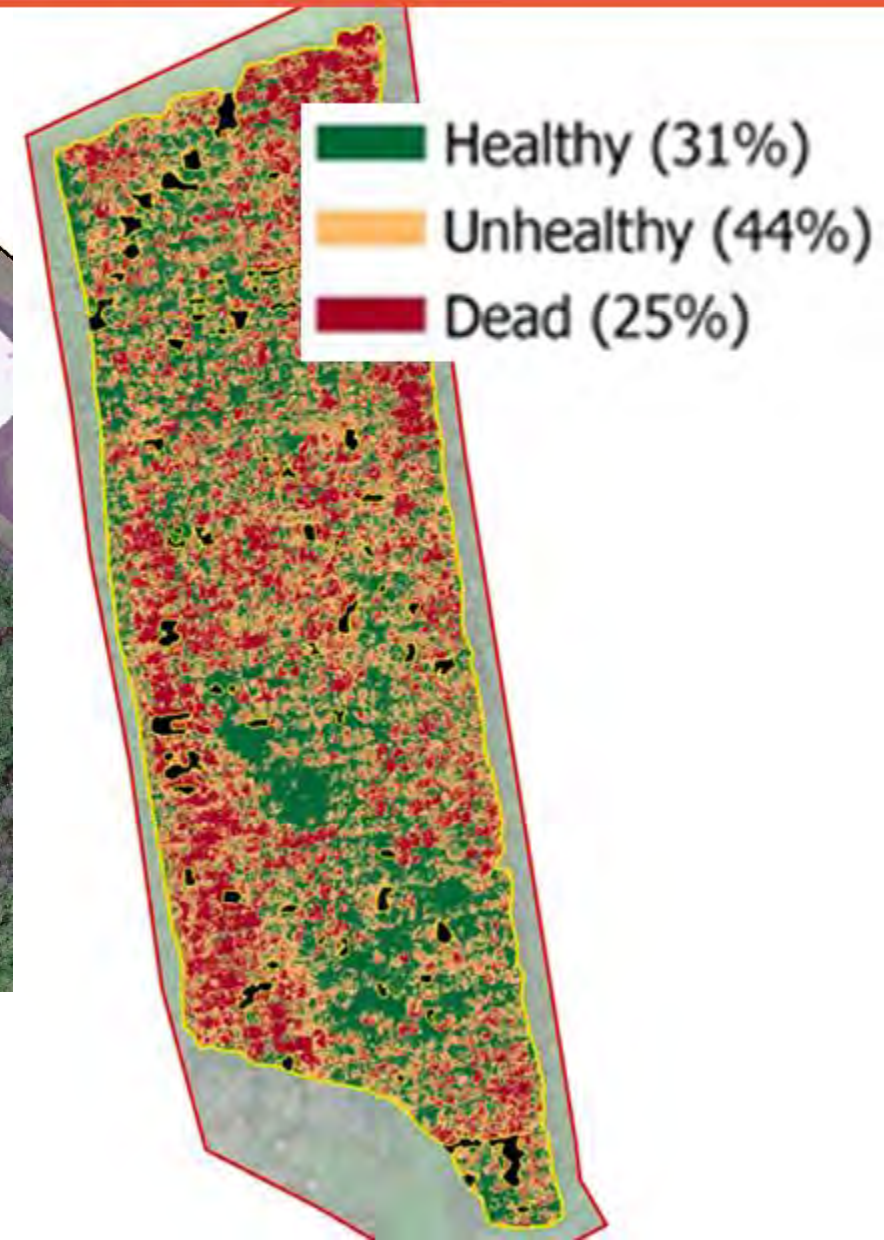


Moderately Healthy?

Analysis 1: Jenks Natural Breaks Classification vs Ground Truthing



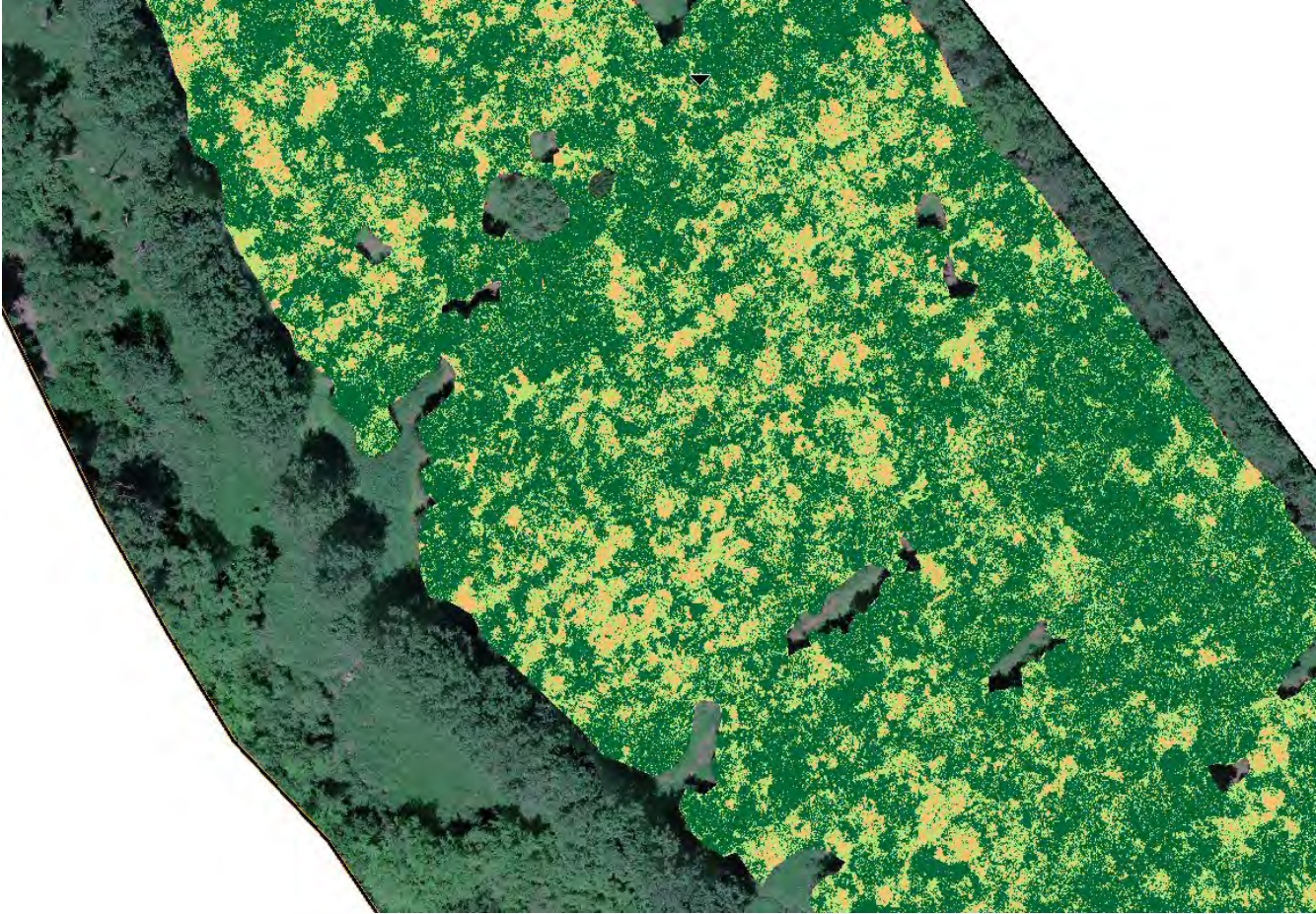
Analysis 2: NDRE + Jenks Natural Breaks



Analysis 2: Refining NDRE Classifications



Comparing NDVI & NDRE Analysis Results



	NDVI	NDRE
Healthy	84%	37%
Unhealthy	16%	41%
Dead	0%	22%

Comparing 4 Common Indices: % Dead Unhealthy Healthy



NDVI



GNDVI
Supervised



NDRE
Supervised



Chlorophyll Index
RedEdge



Determining a Health Score Per Tree

Best Fit Polygon Per Tree



Mean value from Veg Index extracted per tree & given health "score"

Health Category

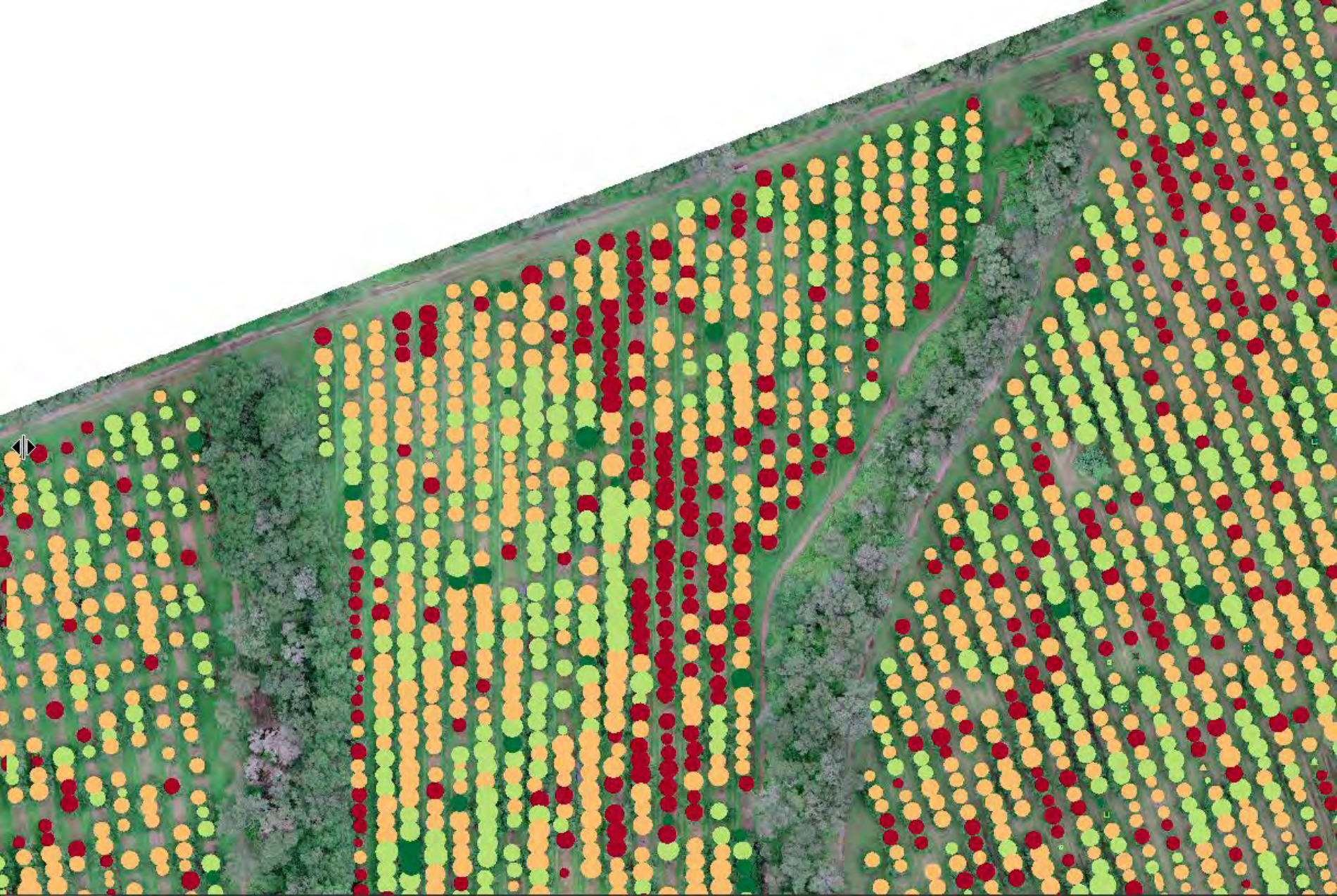
- Dead/Dying
- Declining Health
- Moderate Health
- Good Health

Monitoring Tree Health

2000 vs 2022

Health Category

- Dead/Dying
- Declining Health
- Moderate Health
- Good Health



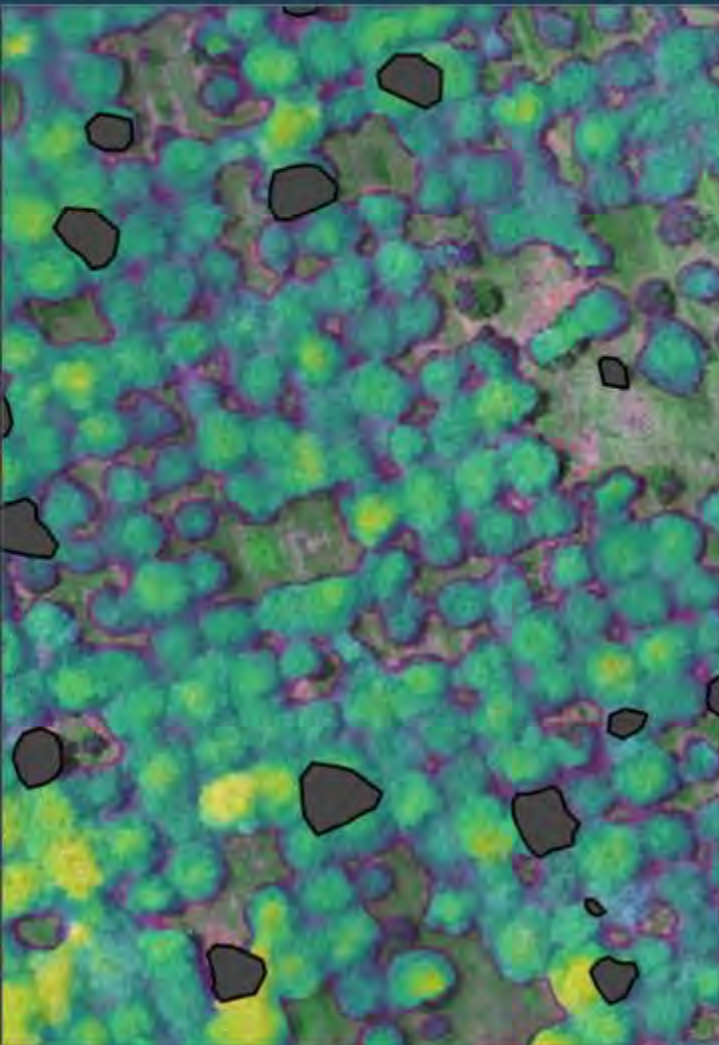
Evaluating Tree Health

Change from 2000 to 2022

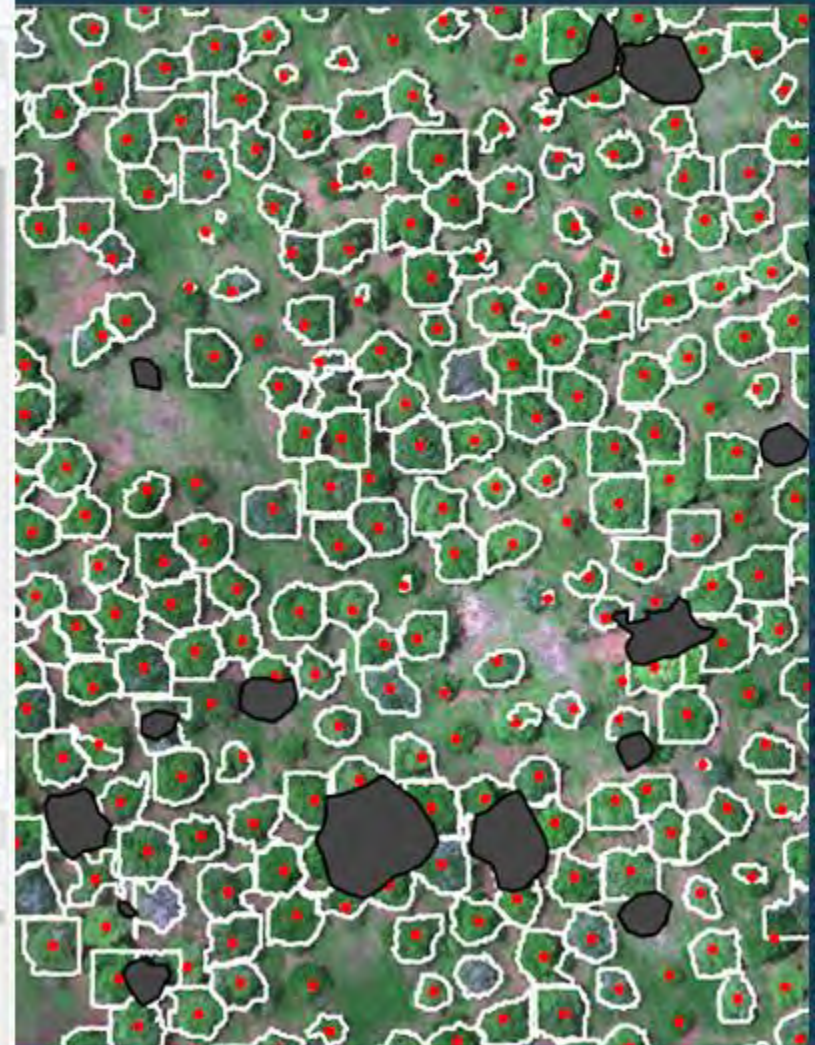


Improving No Change Declining

Future Plans: Streamline Workflow Using R



```
20210923_B106_North.R | 20210924_B106_North.R
Source on Save | Run | Source
5 library(rgdal)
6 library(raster)
7 library(spacial)
8 library(sp)
9
10 #load only x,y,z values and filter out z below zero
11 las_B106_North <- readLAS("M:\\Contracts\\MacNut\\Data\\Drone_Imagery\\
12 las_check(las_B106_North)
13 summary(las_B106_North)
14
15 plot(las_B106_North)
16 plot(las_B106_North, bg = "white", axis = TRUE, legend = TRUE)
17
18 #Classify Ground points using CSF method (Zhang et al 2016)
19 B106_North_Ground_CSF <- classify_ground(las_B106_North, algorithm = c
20 plot(B106_North_Ground_CSF, color = "classification", size = 3, bg = "\
21 las_check(B106_North_Ground_CSF)
22 summary(B106_North_Ground_CSF)
23
24 sort(unique(B106_North_Ground_CSF@data$classification))
25
26 #Point cloud normalization
27 B106_North_nlas <- normalize_height(B106_North_Ground_CSF, knnidw())
28 hist(filter_ground(B106_North_nlas)$Z, breaks = seq(-0.45, 0.45, 0.01)
29
30
3:1 (Top Level) | R Script
Console | Terminal | Background Jobs
Install 'ForestTools' Succeeded 1:16 PM 0:34
Installing 'ForestTools' ...
[1/8] Installing APfun...
Installing package into 'C:/Users/sweet/AppData/Local/R/win-library/4.2'
(as 'lib' is unspecified)
also installing the dependencies 'maptools', 'withr'
```



Take Aways

Multispectral analysis is a proactive monitoring & evaluation methodology.

Choose the vegetation index for the field and verify with ground truthing.

Next Steps: Automate tree detection & design trails on test plots to compare with yield data.

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