Using UAV Technology
Detect Cherry Leaf Spo
Disease & UAS
Applications in Special
Crops and Orchards

meron White

and Vegetable Crop Management Student
Institute of Agricultural Technology &
western Michigan College (NMC)

Collaborators:

Nikki Rothwell -	NWMHR
Brian Matchett -	MSU/NM
Will Schultz -	MSU/NM
Carl Rocheleau -	NMC Av
Rob Dreer -	NMC Av
Bob Goodwin -	MSU, R
George Sundin -	MSU PS
Karen Powers -	NWMHR

2016 Cherry Leaf
pot & UAS Project

ct Goals:

llect weekly data utilizing fixed wing UAS over
LS Spray Efficacy Trial

alyze data for potential to detect CLS

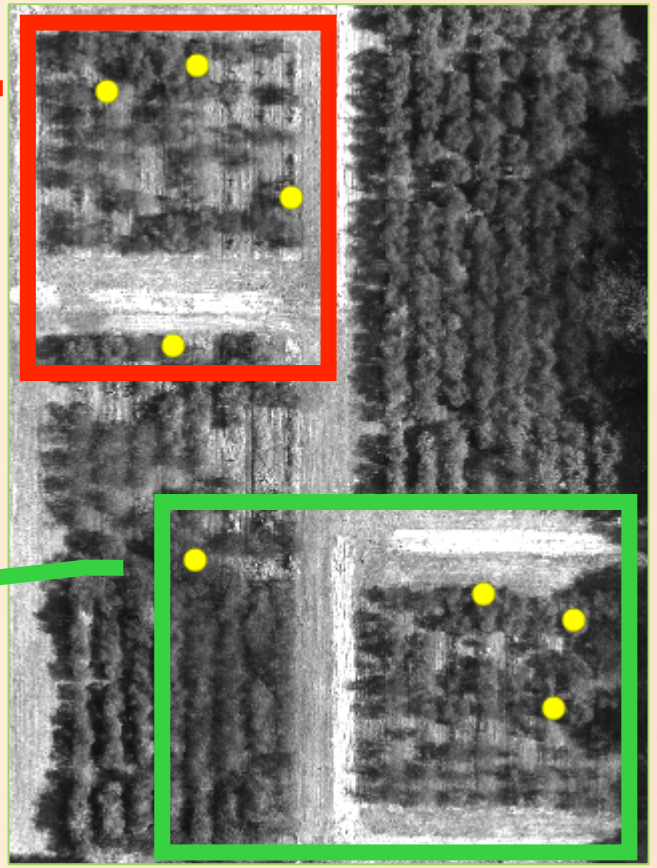
nthesize data and determining future
plicability of UAS technology

LS Spray Efficacy Trial: Data Collection Si

- Northwest Michigan Horticulture Research Station
- Montmorency Cherry Blocks

Untreated Controls
CLS Trial 1

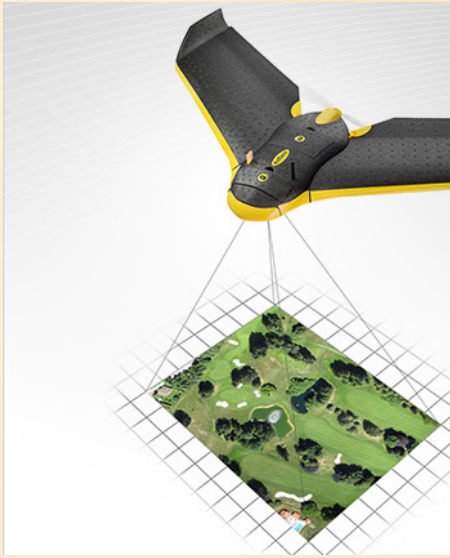
CLS Treated Trees
CLS Trial 2



Flights

- SenseFly eBee Fixed Wing Unmanned Aircraft System
- Weekly flights at NWMHRC
- .6 acres surveyed, 20 min. flights
- Altitude: 107 ft. = 1.7 in./pixel
- Multispectral and RGB cameras equipped

AS & Optical Equipment Utilized



seFly “eBee” Fixed Wing UAS System

nov MultiSpec 4C Multispectral Camera
our Lenses simultaneously collecting multispectral data

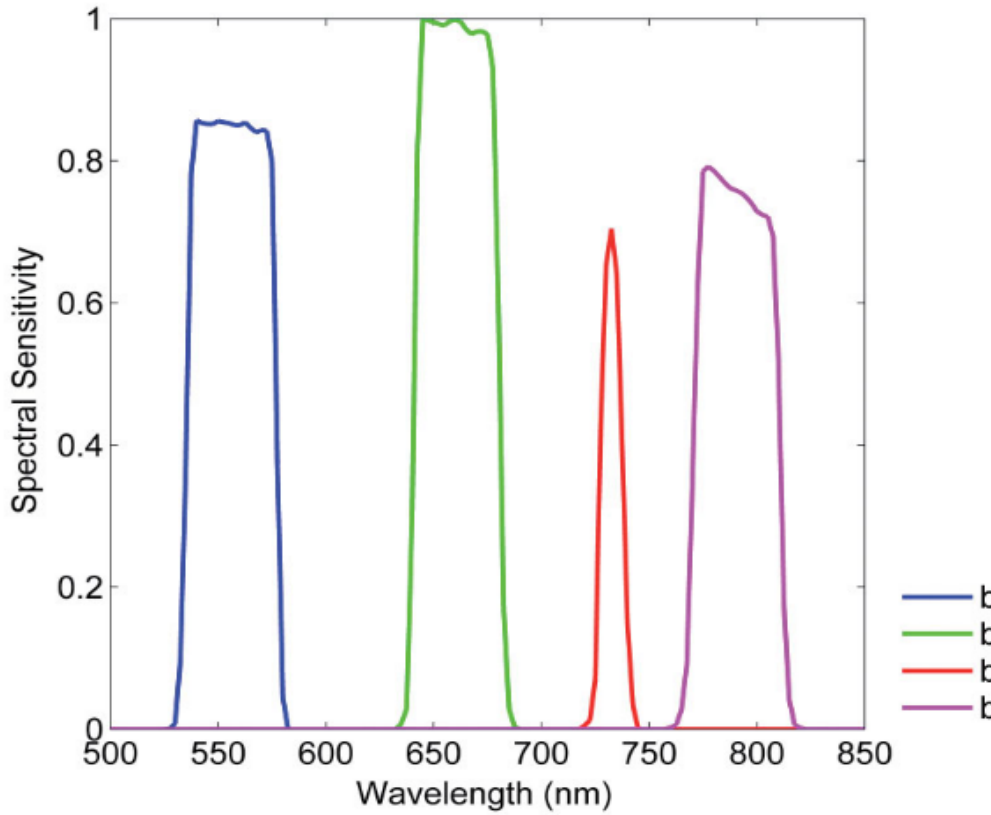
Green (550 nm)

Red (660 nm)

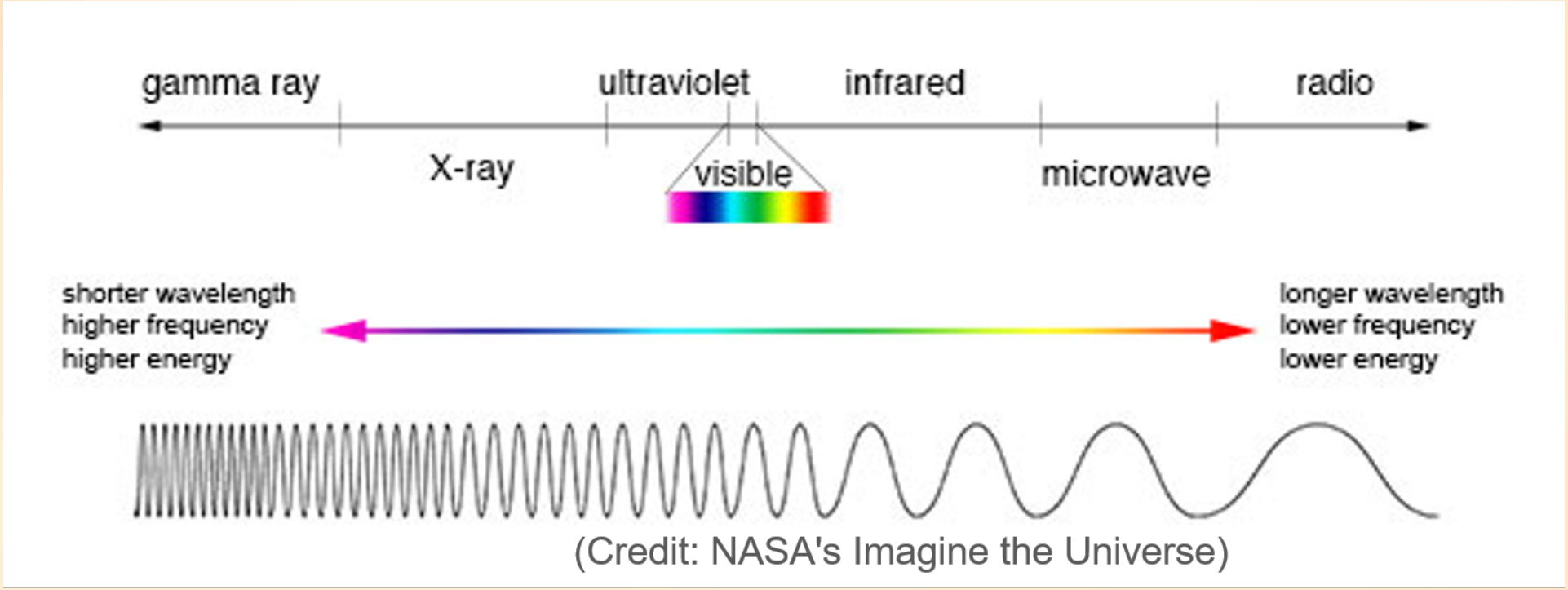
Red-edge (735 nm)

Near infrared (790 nm)

y CyberShot DXC WX220
igital Camera (Red/Green/Blue)

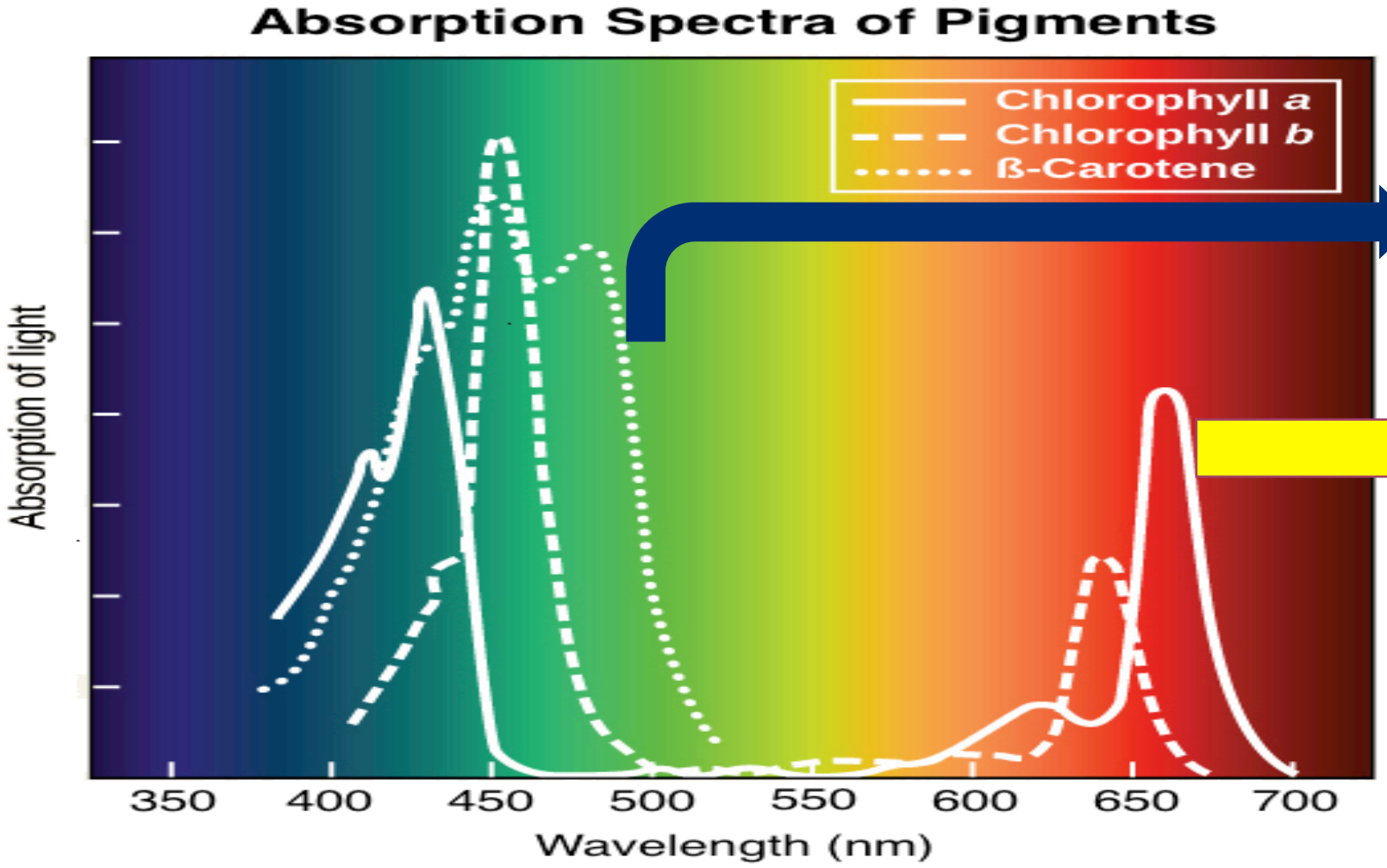


The Electromagnetic Spectrum



- Basis for our data comes from reflectance in the small visible spectrum
- Electromagnetic Radiation is very measurable and hence can provide precise inputs/feedback (think X-Ray machine, dialing in radio stations)

What are we trying to measure?



Are disturbances
canopy photosynt
activity and pigme
absorption due to
Symptoms measu
detectable?

Vegetative Indices Used

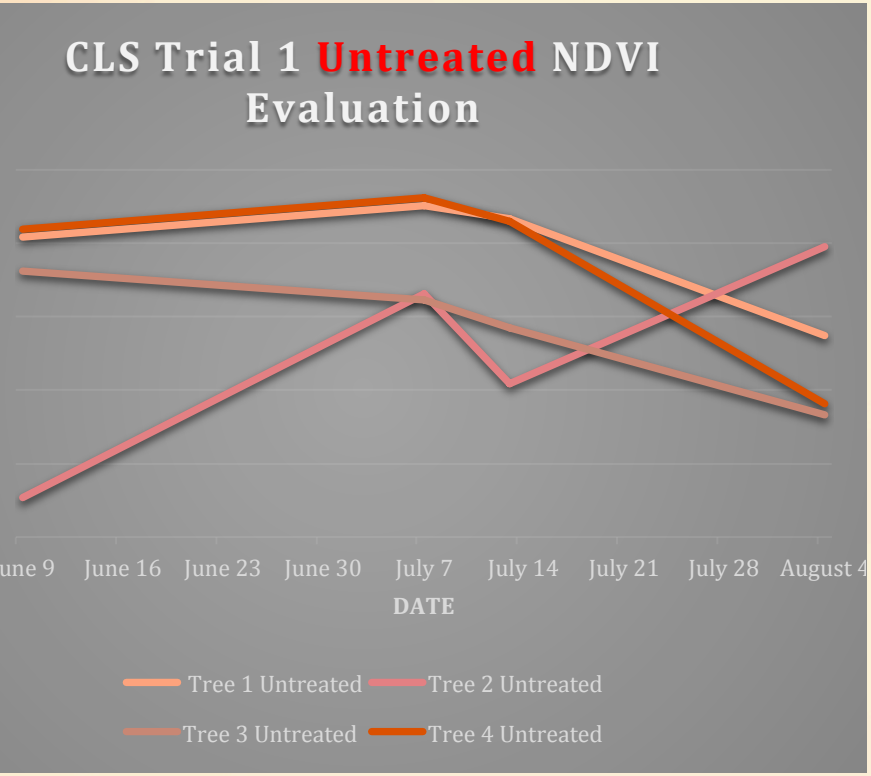
Index Name	Formula	Scale	Focus of Application
lormalized Difference Vegetation Index (NDVI)	NDVI=$\rho NIR-\rho Red/\rho NIR+\rho Red$	-1.0 to +1.0	Spectral range of Chl-a+ Chl b absorption, 660 nm & 790 nm **Past uses:** assess row crop N f vegetative densities, water stres
reen Chlorophyll Index (GCI)	CI $_{Green}$=$\rho NIR/\rho Green$ -1	0 to 16	Spectral range of many plant pigment's absorption (at low leve 550 nm **Past uses;** irrigation & fertility comparisons, LAI
-edge Chlorophyll Index (RECI)	CI $_{Red-edge}$=$\rho NIR/\rho Red-edge\downarrow\uparrow$ -1	0.0 to 0.9	Steep range of increased reflect 690-730 nm, where Chl absorpti ends **Past uses;** soil background imp analysis, row crop canopy densi

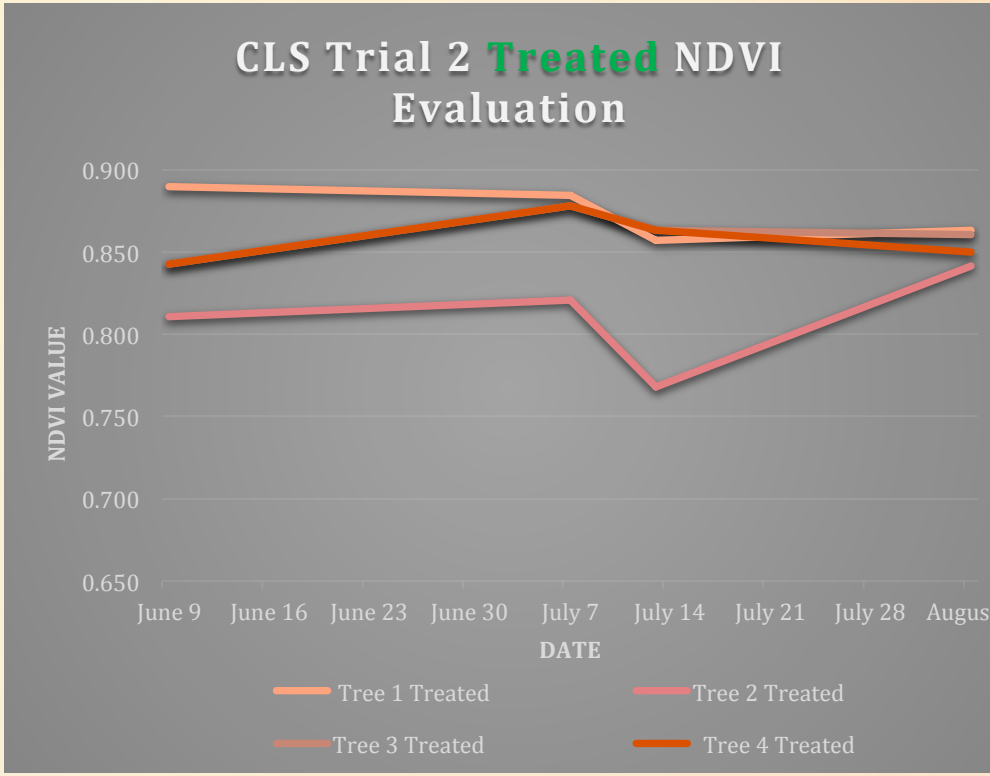
herry Leaf Spot Life Cycle

- *Blumeriella* jaapii - Pathogen
- omycota Fungal Disease
- rwinters in leaf litter
- xual life cycle can create foliar emic
- y detection key to control

UAS help us manage?...

rmalized Difference Vegetative Index (NDVI) Resu
Untreated (UTC) vs. Treated





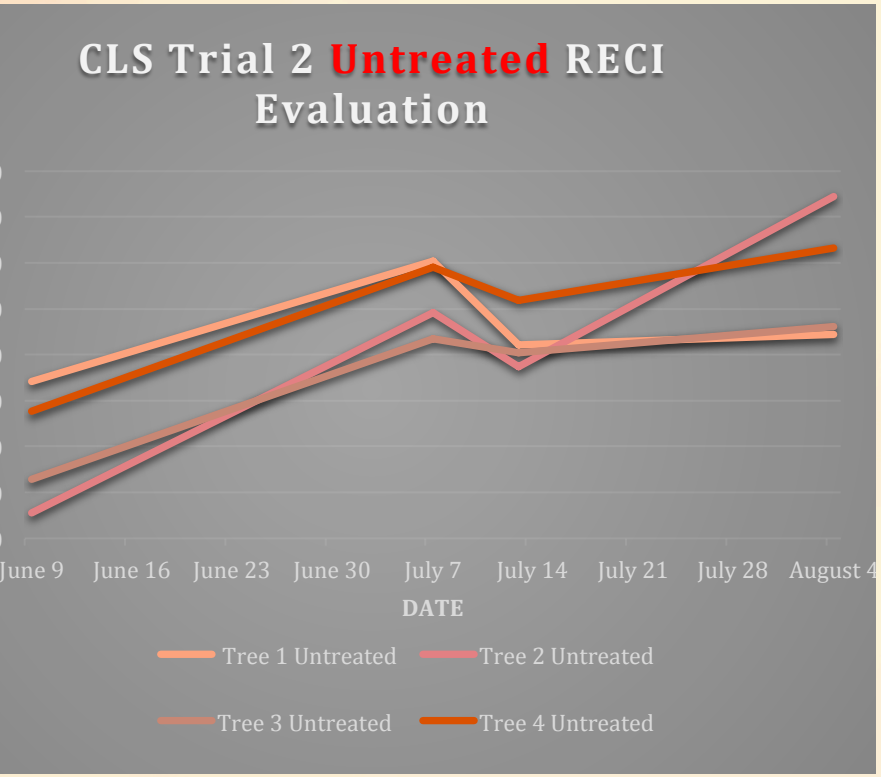
ted Control

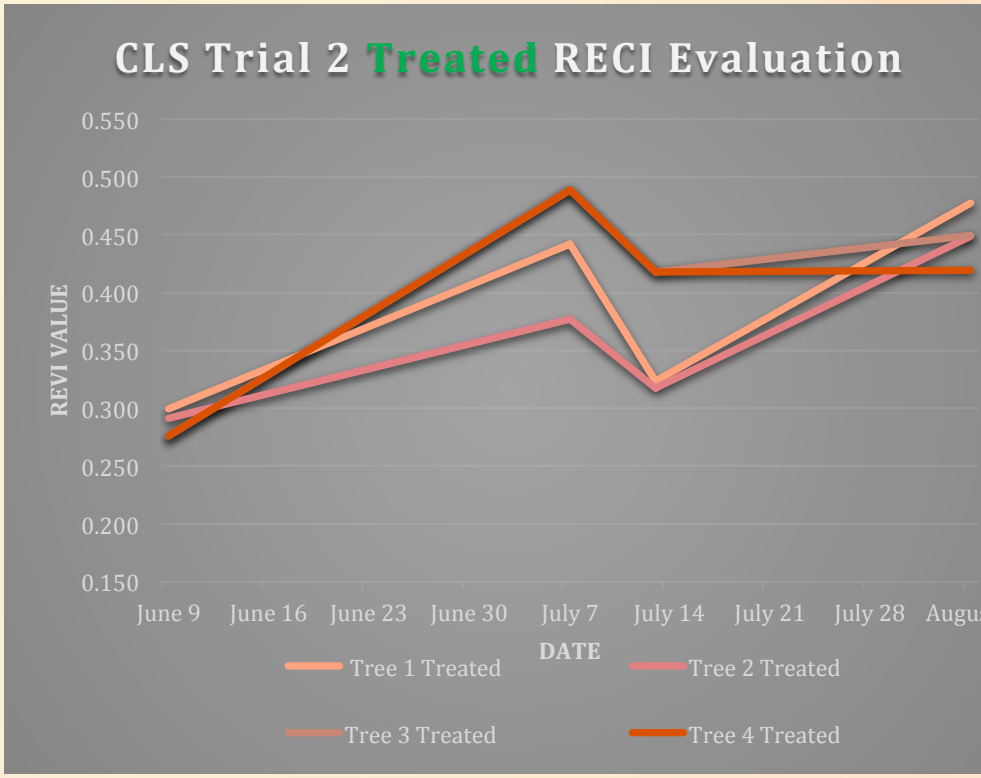
stent loss of tree vigor amongst 3 of 4 UTC
consistent +/- 5% amongst 3 of 4 UTC
s consistently lower than treated, 3 of 4
g below .80, 2 below .75

Treated

- Sustained higher values, 3 of 4 finishing above .840
- More parallel, steadier NDVI trends amongst treated trees

Red-edge Chlorophyll Index (RECI) Results: Untreated (UTC) vs. Treated





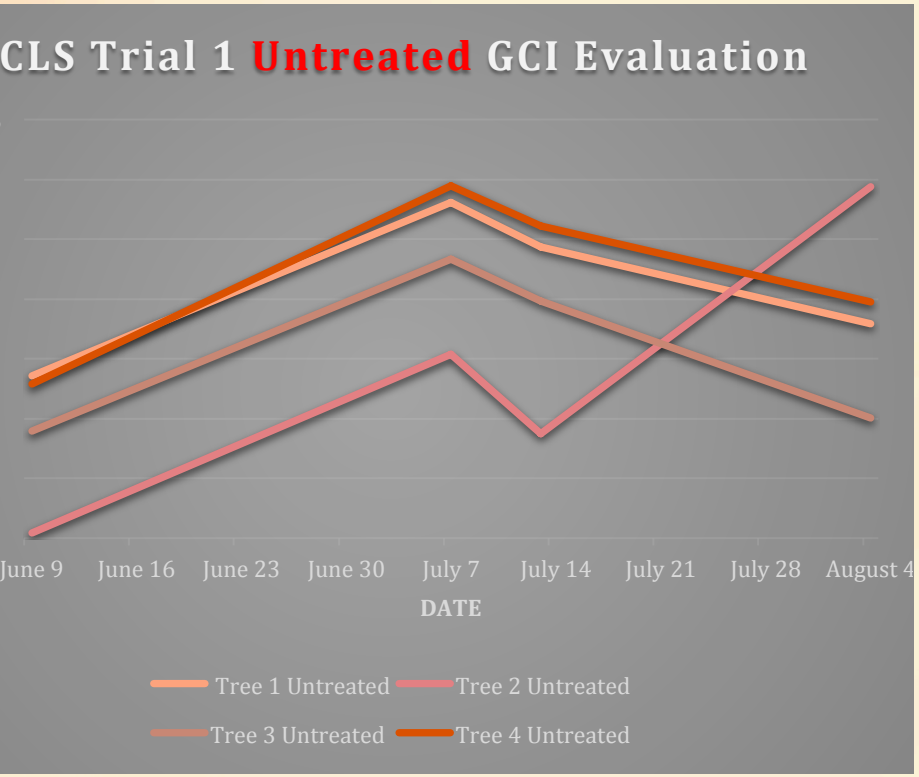
ted

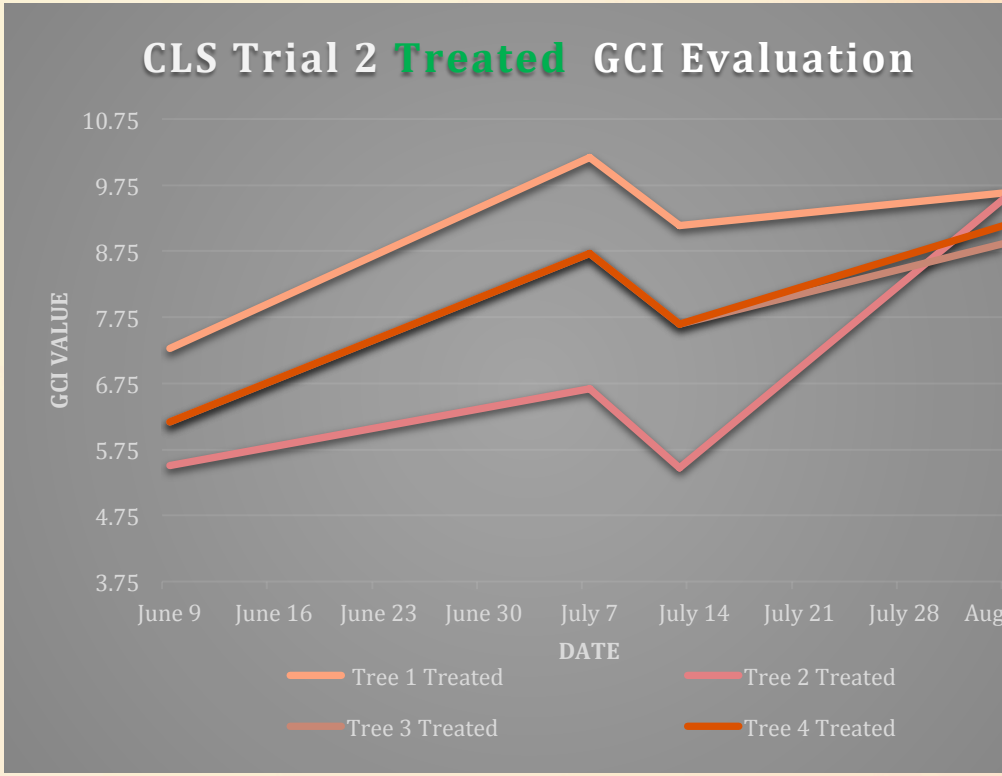
showing no notable correlation in trend
esence of CLS symptoms
s equivalent to treated trees

Treated

- Values parallel those of UTC, no correlation lack of CLS progression
- Consistent trend across index= complimenta tool?

Green Chlorophyll Index (GCI) Results: Untreated UTC vs. Treated





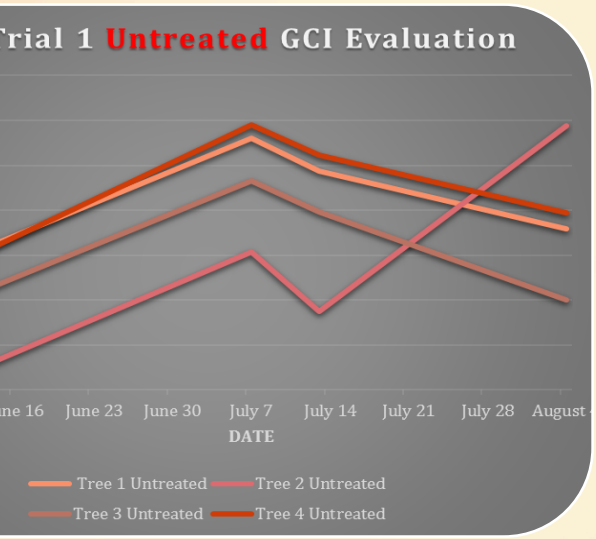
ated Control

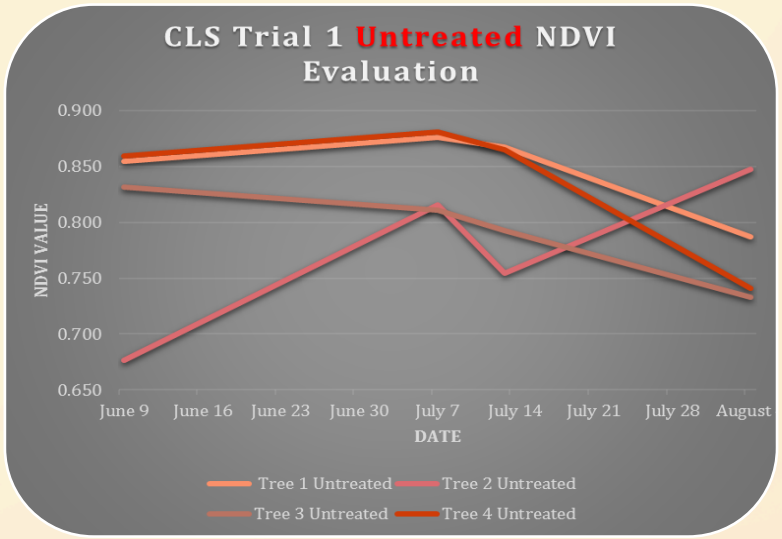
ar trends similar NDVI, may suggest
f β carotene, depleted photosynthetic
y in Green λ500-550 nm range
st margins on scale between trees in
ng (UTC) : vs NDVI & RECI scales

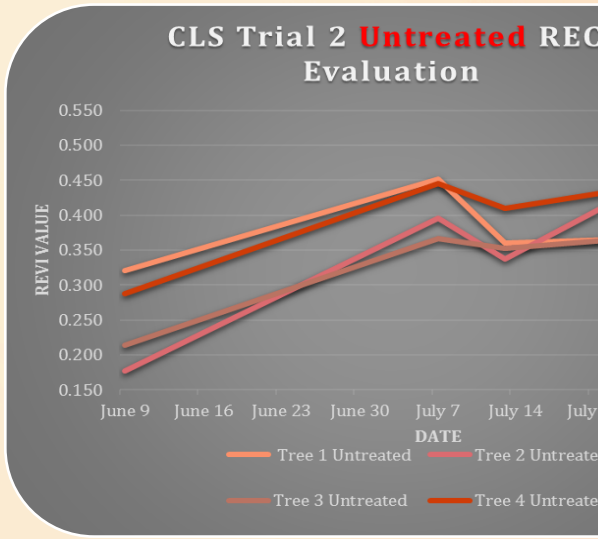
Treated

- Like NDVI, treated trees sustaining highe
GCI values versus UTC, (appr. 19%) endin
- Wide margins on scale, but strong trends
amongst group, and trends with NDVI

Comparison of Indices Used : UTC

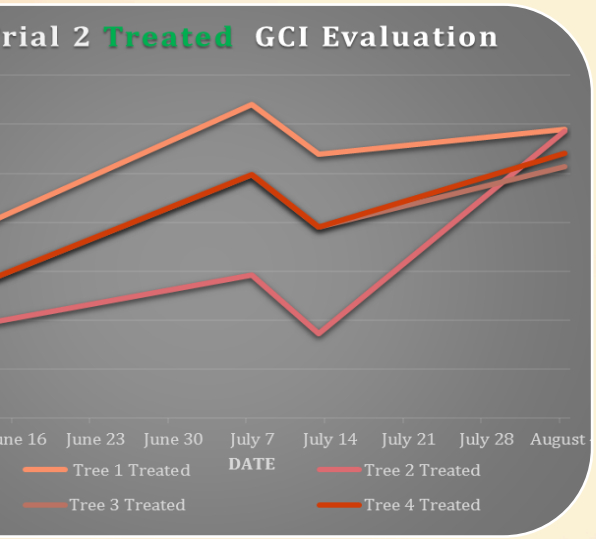


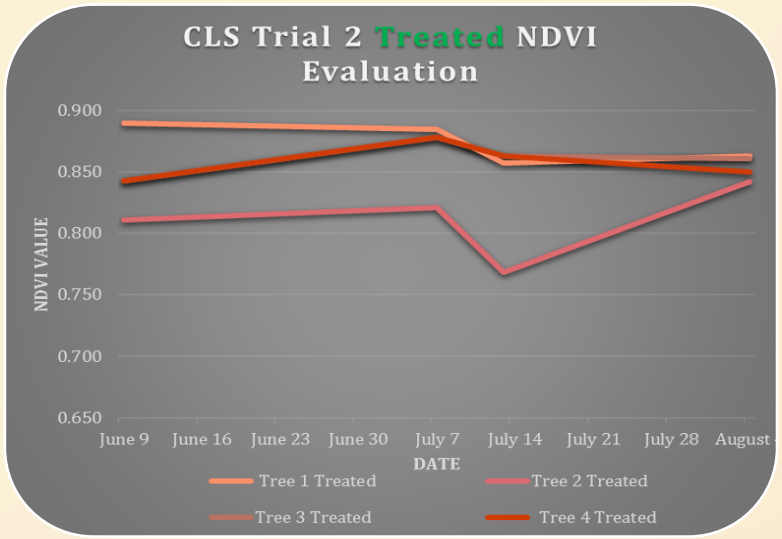


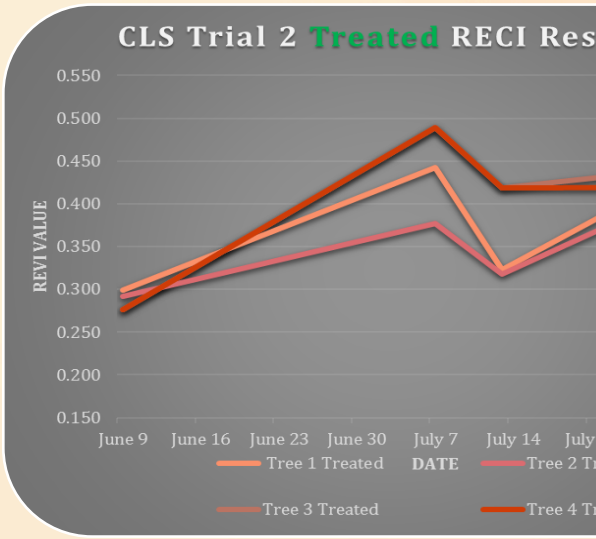


GCI NDVI RECI

omparison of Indices Used : Treat







GCI NDVI RECI

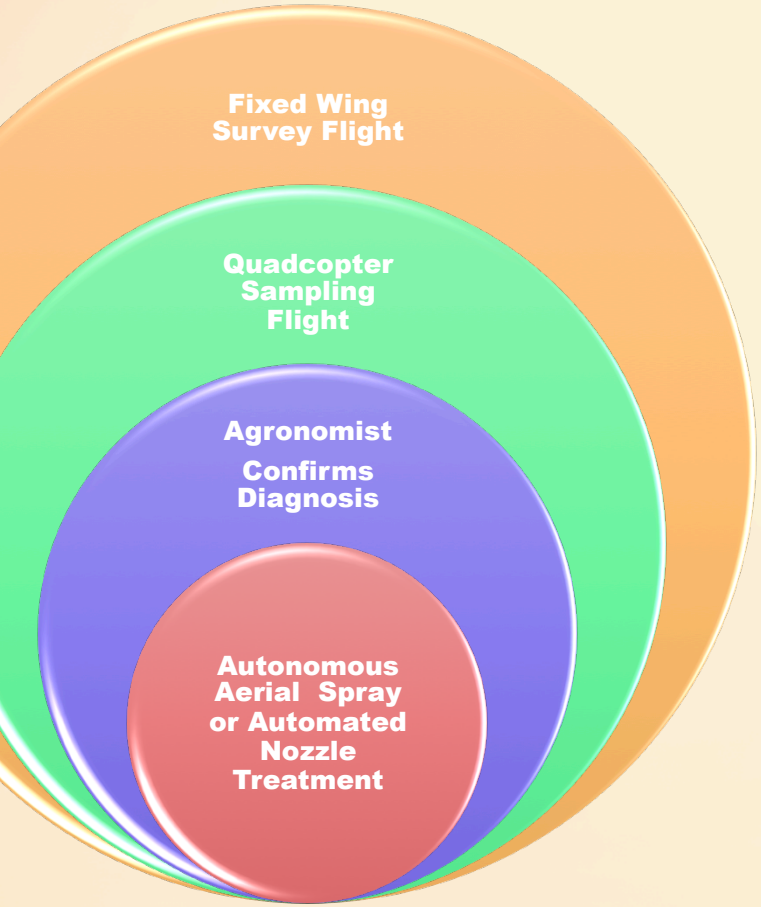
Conclusions

an not scientifically single out CLS as sole cause of UTC lower alues, however, highly likely there was positive association

General photosynthetic activity & tree vigor can be assessed via UAS sing the NDVI and GCI indices

RECI may be an effective complimentary filter to NDVI or GCI, focuses n a narrow wave length near edge of photosynthetic activity, variable esults UTC vs treated

Model for Future UAS Agronomy: outing, Diagnostic & Treatment Techniqu



1) Fixed Wing UAS Surveying Flight
   - Efficiently maps and detects areas of concern utiliz vegetative indices optimized for crop, GDD
2) Low-Altitude Quad-Copter or Hex-Copter Flight
   - GIS Tagged Areas of Concern Inspected and Sam
   - LIDAR, Robotic Sampling Tools, and/or VR (Virtua Reality)
3) Agronomist Confirms Diagnosis
   - Agronomist or Scout confirms UAS diagnosis and samples, writes spray recommendation
4) Autonomous Aerial Spray or Automated Nozzles Spra Treatment
   - UAS Device can make autonomous aerial applicat agro-chemical with GIS, LIDAR, automatic nozzle
   - Or Tractor + sprayer equipped with precision auton nozzle technology is used

Potential for Future UAS Applications and Research in Specialty Crops

ruit

tinue to develop, optimize indices and algorithms for use at canopy her altitude, “fixed wing”) and leaf scale (low altitude, “copter”)

S robotic attachments for optical and destructive leaf tissue npling, soil sampling

l deterrents

ential impact in High-Density, Tall-Spindle, Fruiting Wall systems for , irrigation control and automation techniques

indices to monitor water content and stress in vines, precision gation

notely sample individual berries/clusters Brix/Ta/Ph, improve product trol, yield estimates

erry

etative indices and/or thermal imaging to monitor frost pockets + ught stress, control irrigation valves

cknowledgements

- **Funding Provided by**
  - NMC Foundation Innovation Grant
  - MSU AgBioResearch
  - NMC Aviation Division
  - MSU Institute of Agricultural Technology
- **Resources and Expertise Provided by**
  - Matt Lyons(In memory of)
  - NWMHRC Research Staff & Technicians
  - Bob Goodwin
  - George Sundin and Graduate Students

HIGAN STATE
IVERSITY

Spartans Lead the Wa

ORTHWESTERN MICHIGAN COLLEGE
WK OWLS

(…and Hawk Owls too