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Precision Agriculture : Methods and Applications

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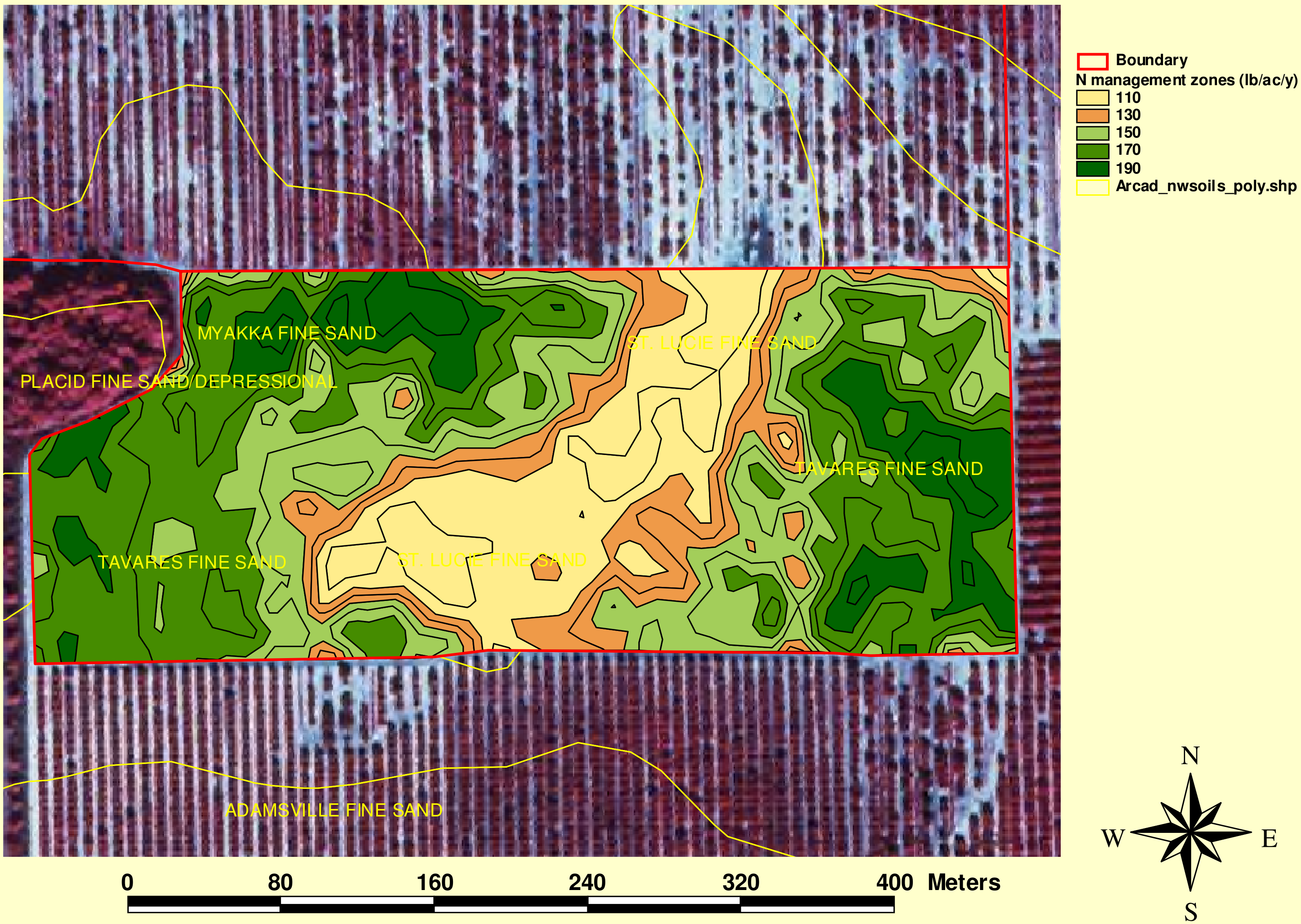
Associate Professor

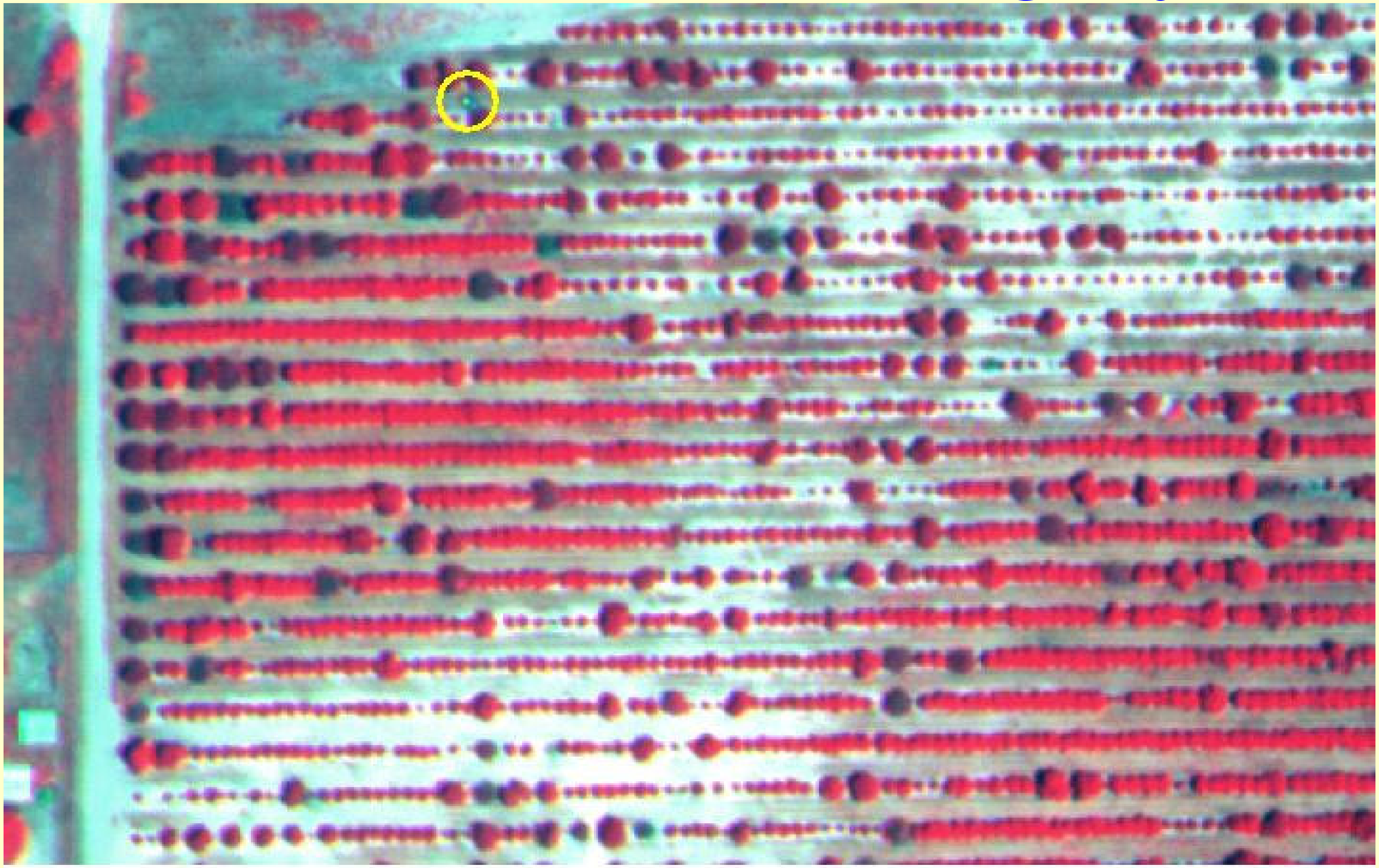
University of Florida
Agricultural and Biological Engineering

What is Precision Agriculture?

In-field variability



Color Infrared Imagery



RDACS, 0.5-meter multispectral image, false-color scheme (close-up). Note Geolocation target (circled in yellow). (Real-time Digital Airborne Camera System)

In-field variability

Spatial variability at different locations in a field

- Soil fertility
- Moisture content
- Soil texture
- Topography
- Plant vigor
- Weed/pest populations
- Soil organic matter content …

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What is precision agriculture?

Managing each crop production input (fertilizer, limestone, herbicide, seed, insecticide, etc.) on a site-specific basis to reduce waste, increase profits, and maintain the quality of the environment.
(Morgan and Ess, 2003)

Tools for precision agriculture

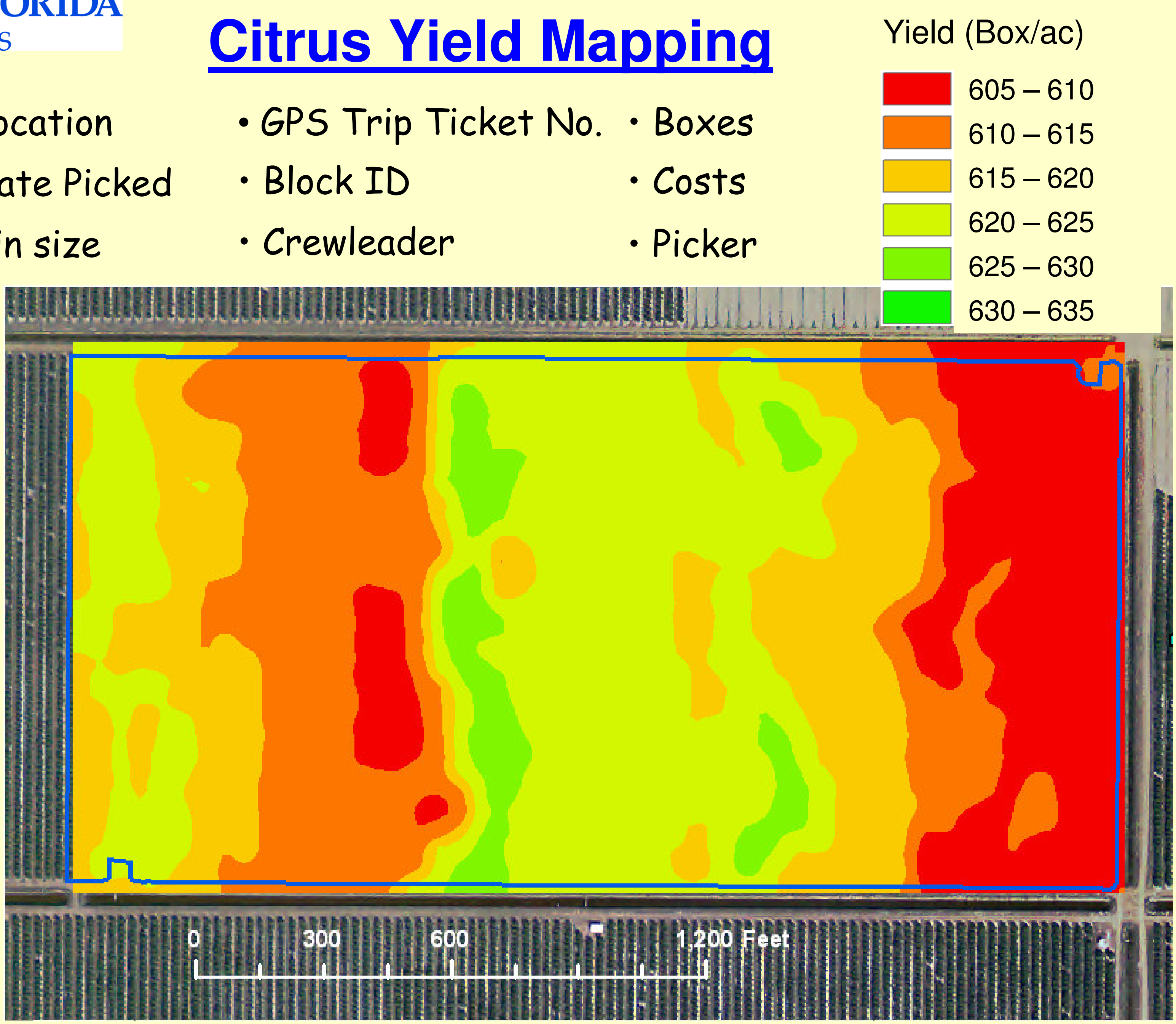
- GPS, GIS
- Yield monitoring and mapping ←
- Soil testing
- Variable rate fertilizer application ←
- Crop scouting/Ground truthing
- Remote sensing ←

Yield Mapping

Citrus yield mapping

Citrus Yield Mapping

- Location
- Date Picked
- Bin size
- GPS Trip Ticket No.
- Block ID
- Crewleader
- Boxes
- Costs
- Picker

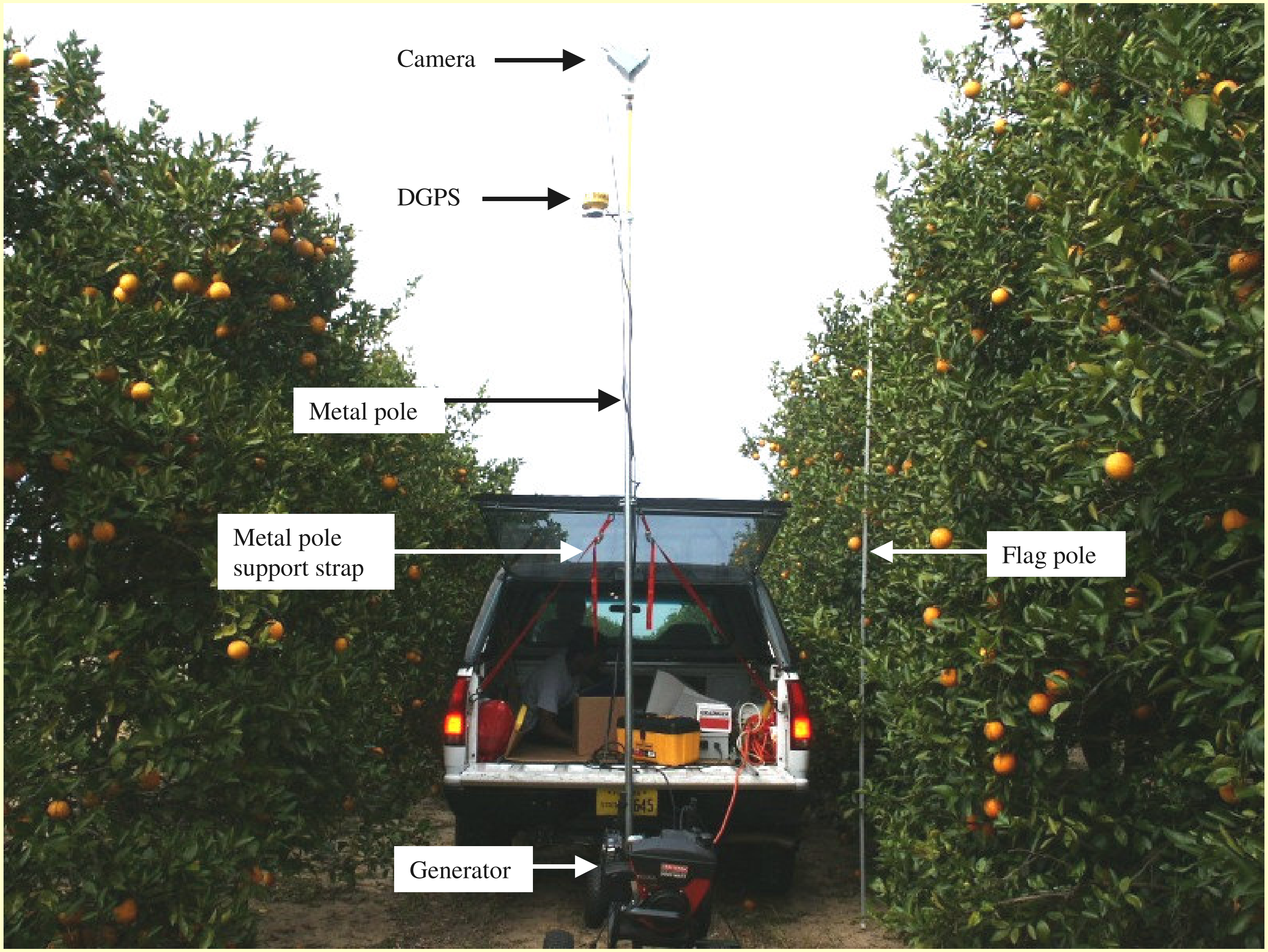


Citrus Yield Mapping using Machine Vision

Objectives are to:

- Complete a machine vision based yield mapping system using a camera, image processing hardware/software, a GPS receiver, and a microprocessor,
- Calibrate and test the yield mapping system in a commercial citrus grove, and
- Evaluate the performance by hand harvesting single tree yield.

Image acquisition system



Camera and DGPS

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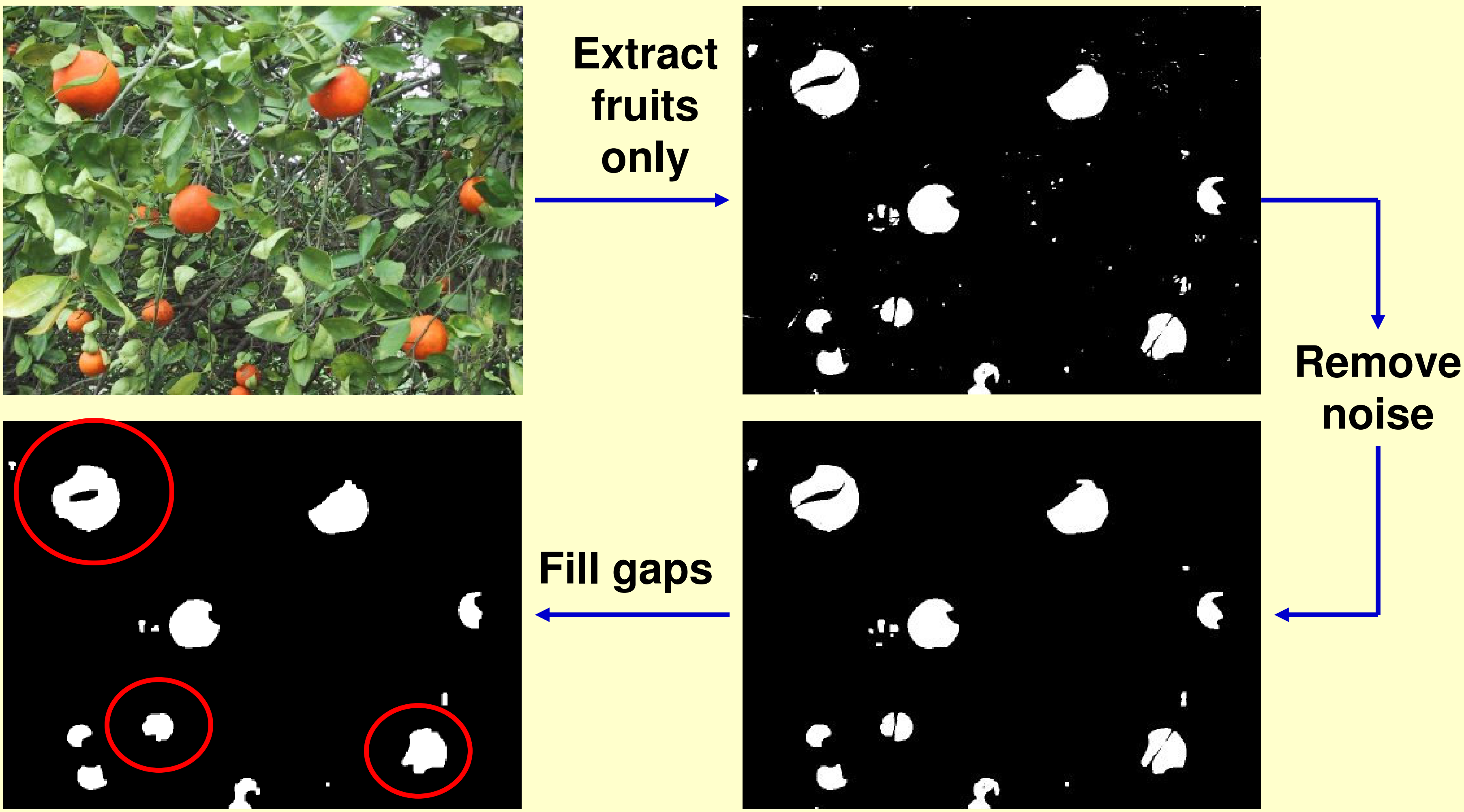
Sample images

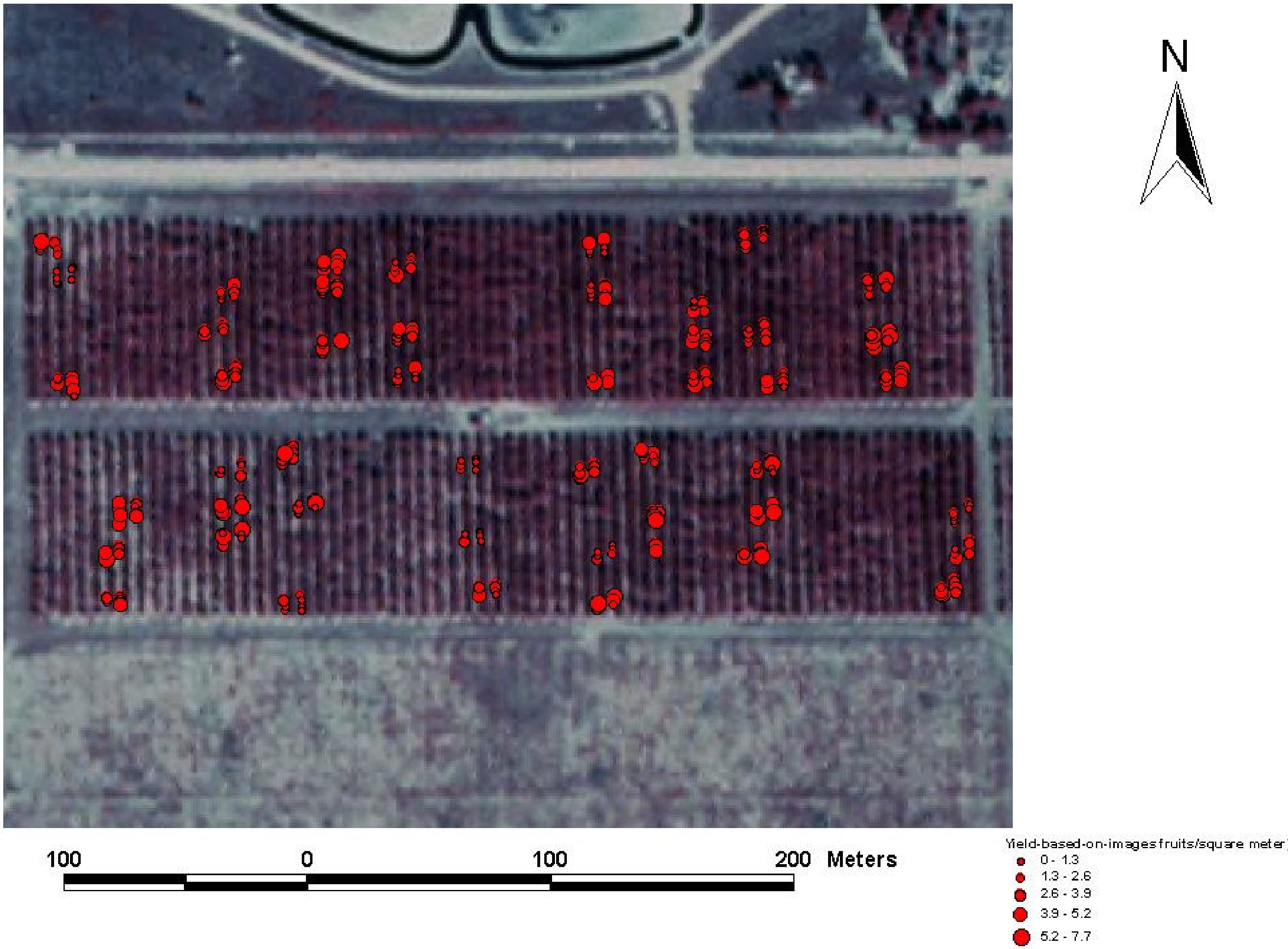





Pre-processing of images



Yield mapping based on citrus fruits in an image



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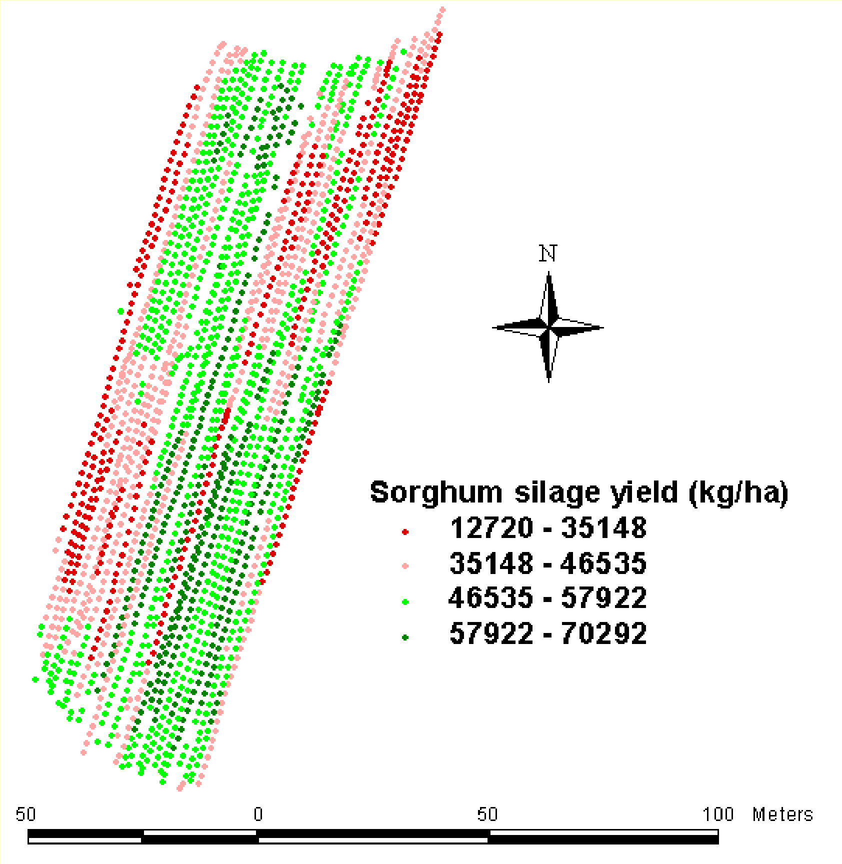
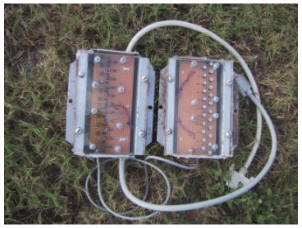
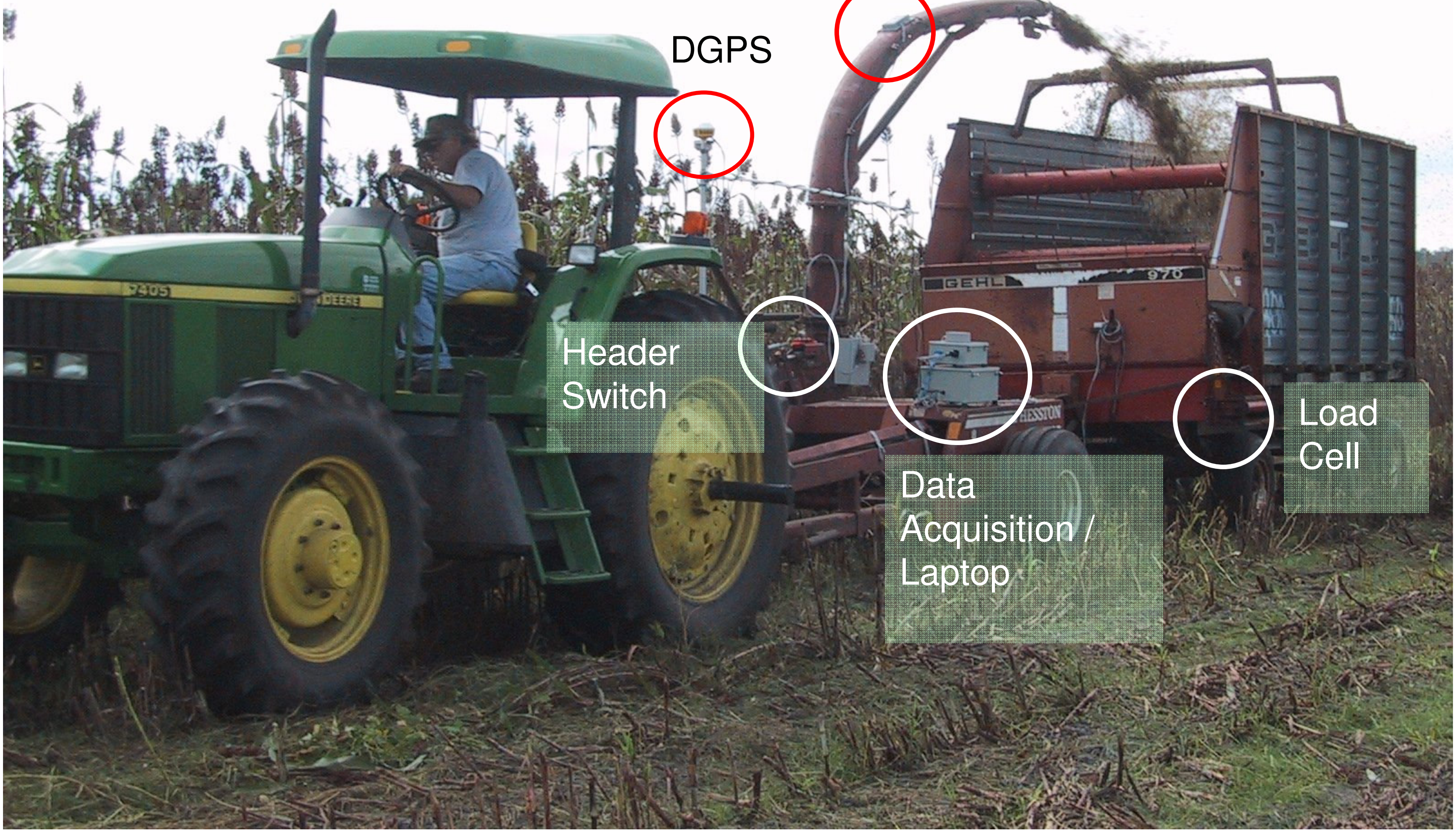
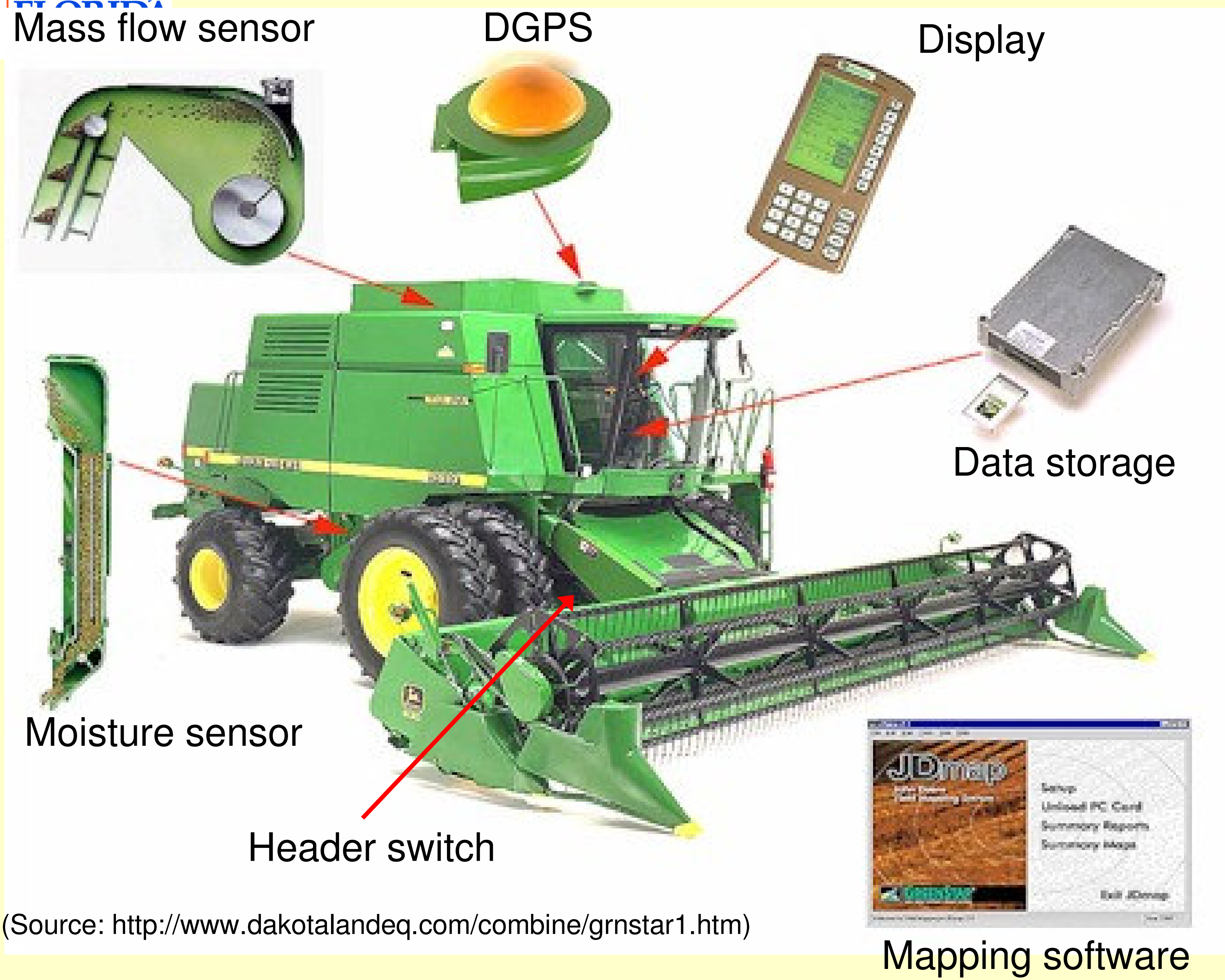
Silage yield mapping



System set up







(Source: http://www.dakotalandeq.com/combine/grnstar1.htm)

Non-grain yield mapping system

Crop	Measurement methods
Citrus	Load cells
Potatoes	Load cells
Tomatoes	Load cells
Sugarbeets	Load cells
Peanuts	Load cells, optical sensors
Cotton	Load cells, optical sensors
Sugar cane	Load cells
Coffee	Load cells
Grapes	Load cells
Strawberries	Load cells
Horseradish	Load cells
Forage (baled)	Load cells
Forage (chopped)	Load cells, radiometric sensors, shaft torque sensing,

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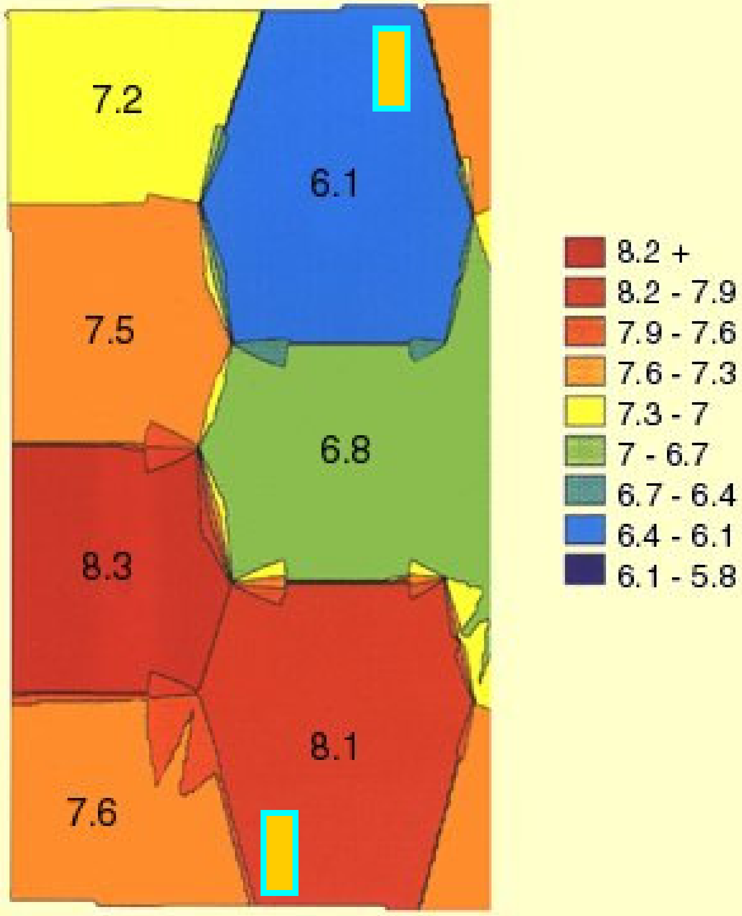
Variable Rate Technology (VRT)

What is VRA / VRT?



Fertilizers

Chemicals

Seeds

(Source: http://www.directag.com/directag/printer_article/1%2C1458%2C757%2C00.html)

Two basic methods

Map-based	Sensor-based
Sensors: positioning, pressure/flow, ground speed Controller Actuator	Sensors: soil/plant, pressure/flow, ground speed Controller Actuator

Spinner spreaders

VRT Examples

Tree See system

(Source: http://www.treesee.com)

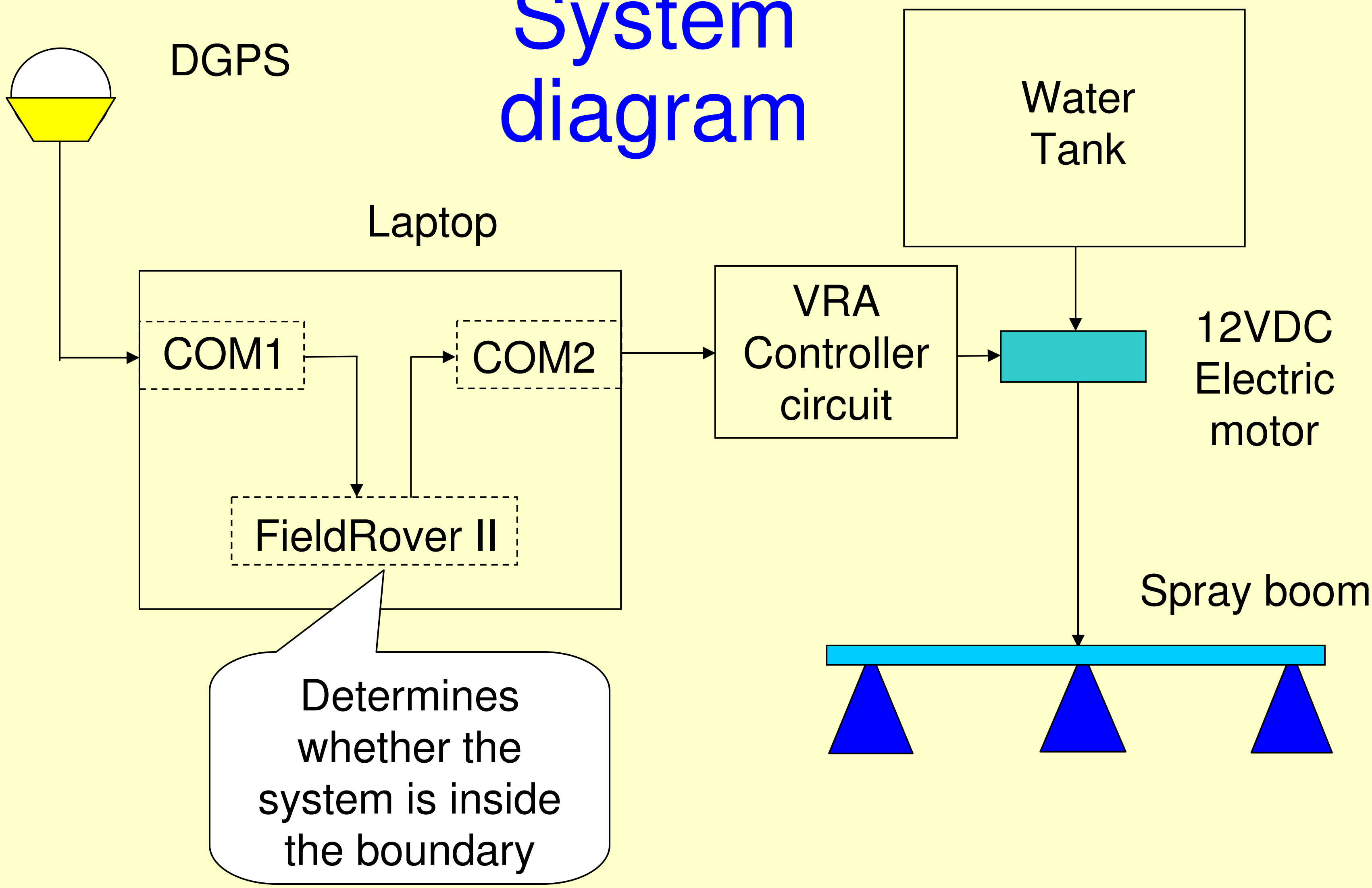
Granule application for citrus

(Source: Dr. Arnold Schumann)

Simple VRT system

(Source: http://muextension.missouri.edu/xplor/waterq/wq0450.htm)

System diagram



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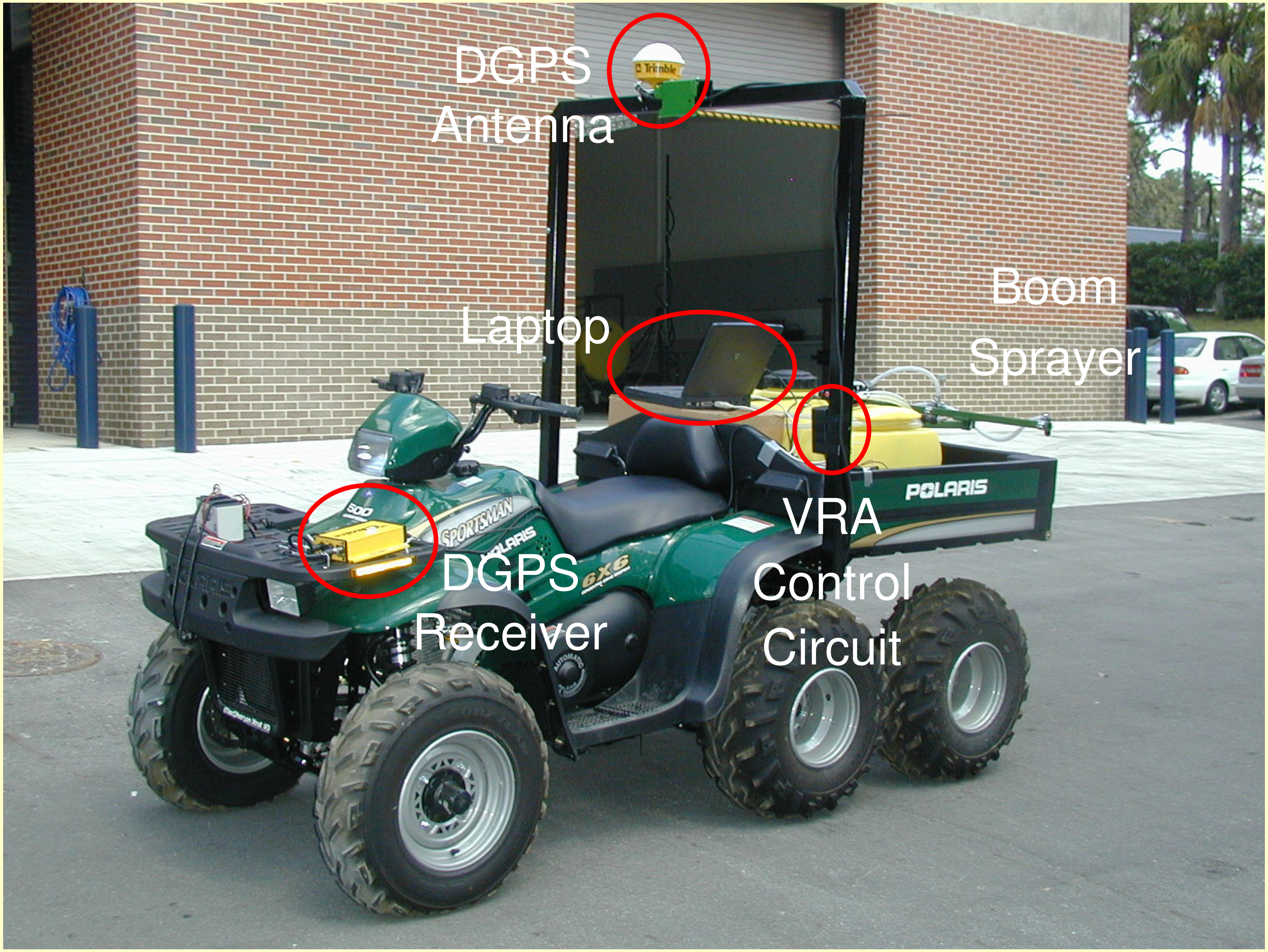
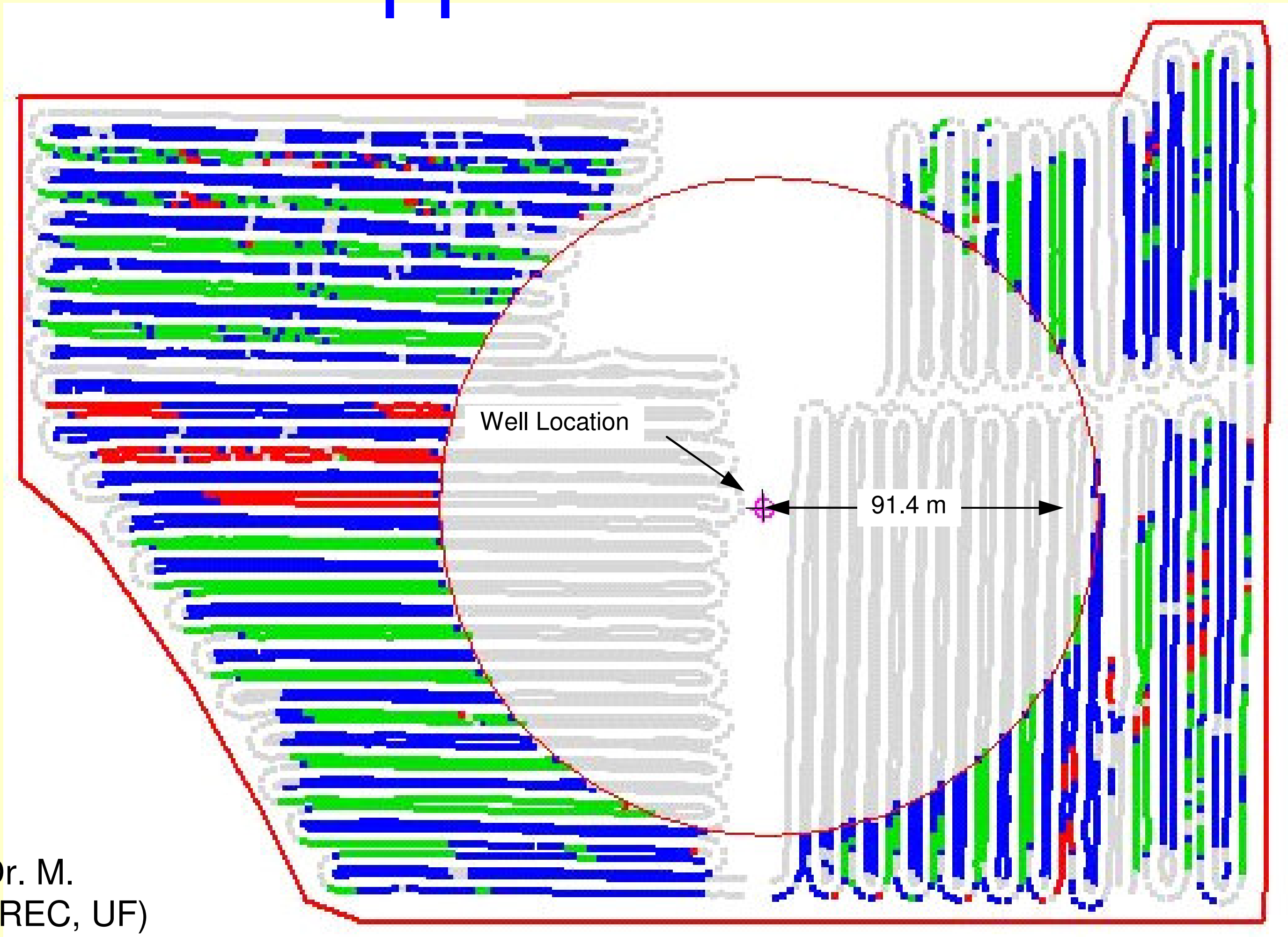


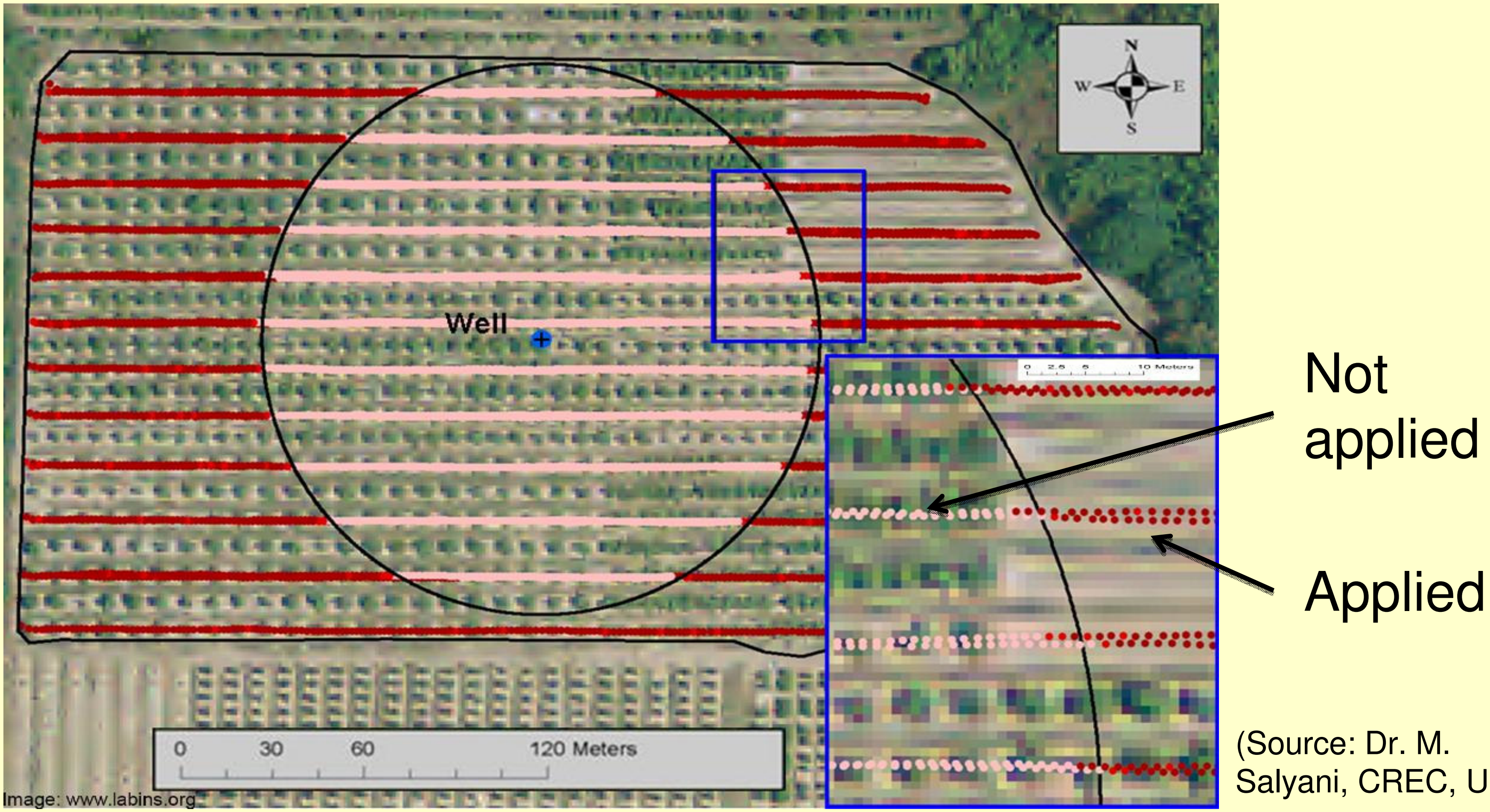
As-applied map of simulated aldicarb application in a citrus grove



(Source: Dr. M. Salyani, CREC, UF)

0 kg/ha   18.5 kg/ha   28 kg/ha   37 kg/ha

Application map recorded by a control system



(Source: Dr. M. Salyani, CREC, UF)

Future applications of VRT

- Planting: soil moisture
- Tillage: SOM sensor
- Manure application: manure nutrient sensor
- Pest management: weed detector
- Crop diagnosis: machine vision system
- Precision irrigation: in-field soil moisture sensor

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Research Projects in Florida using GNSS

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Early Research in Precision Agriculture

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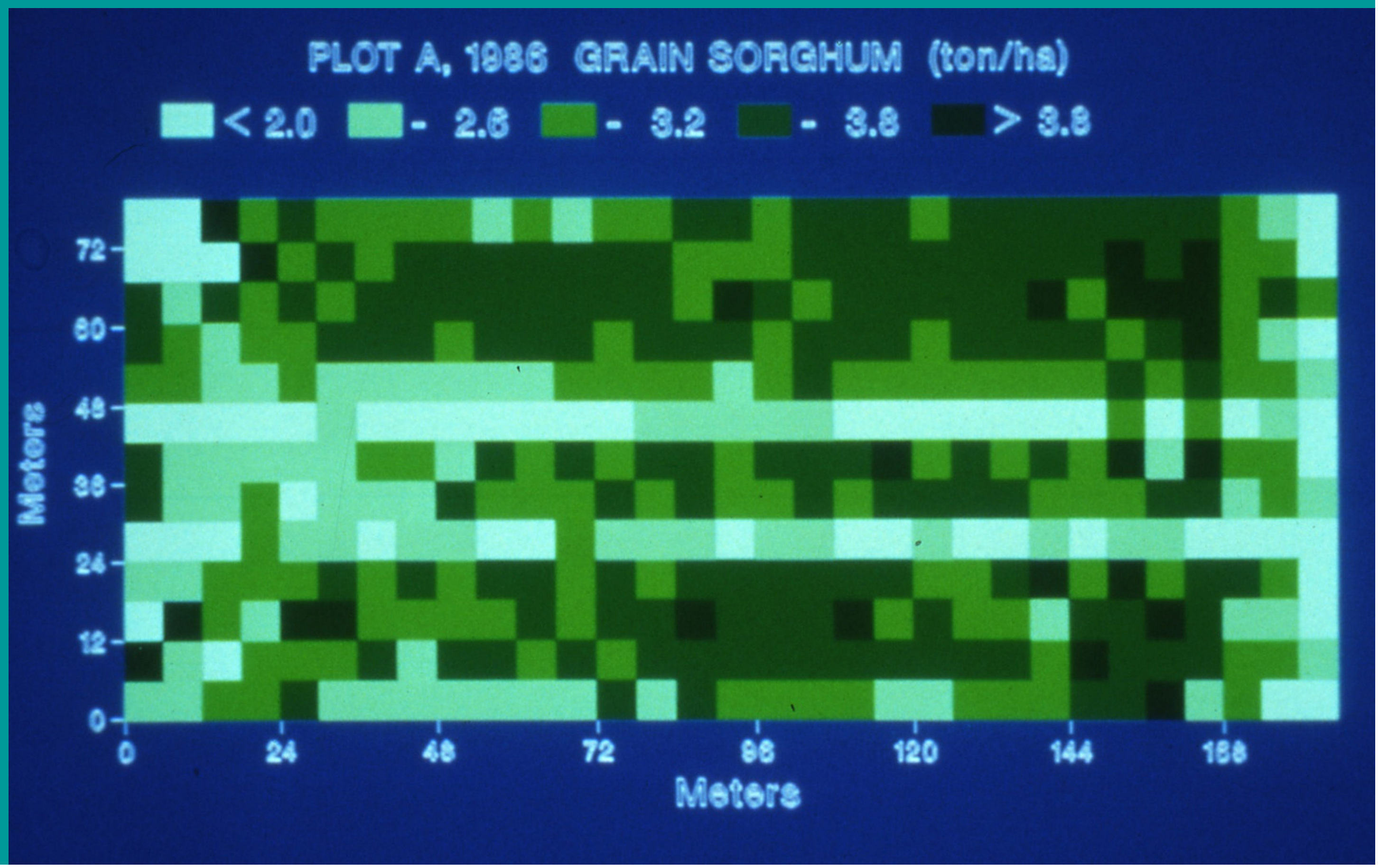
Store Information with Spatial Attributes

Example: Bae, Searcy, Schueller '83-'86

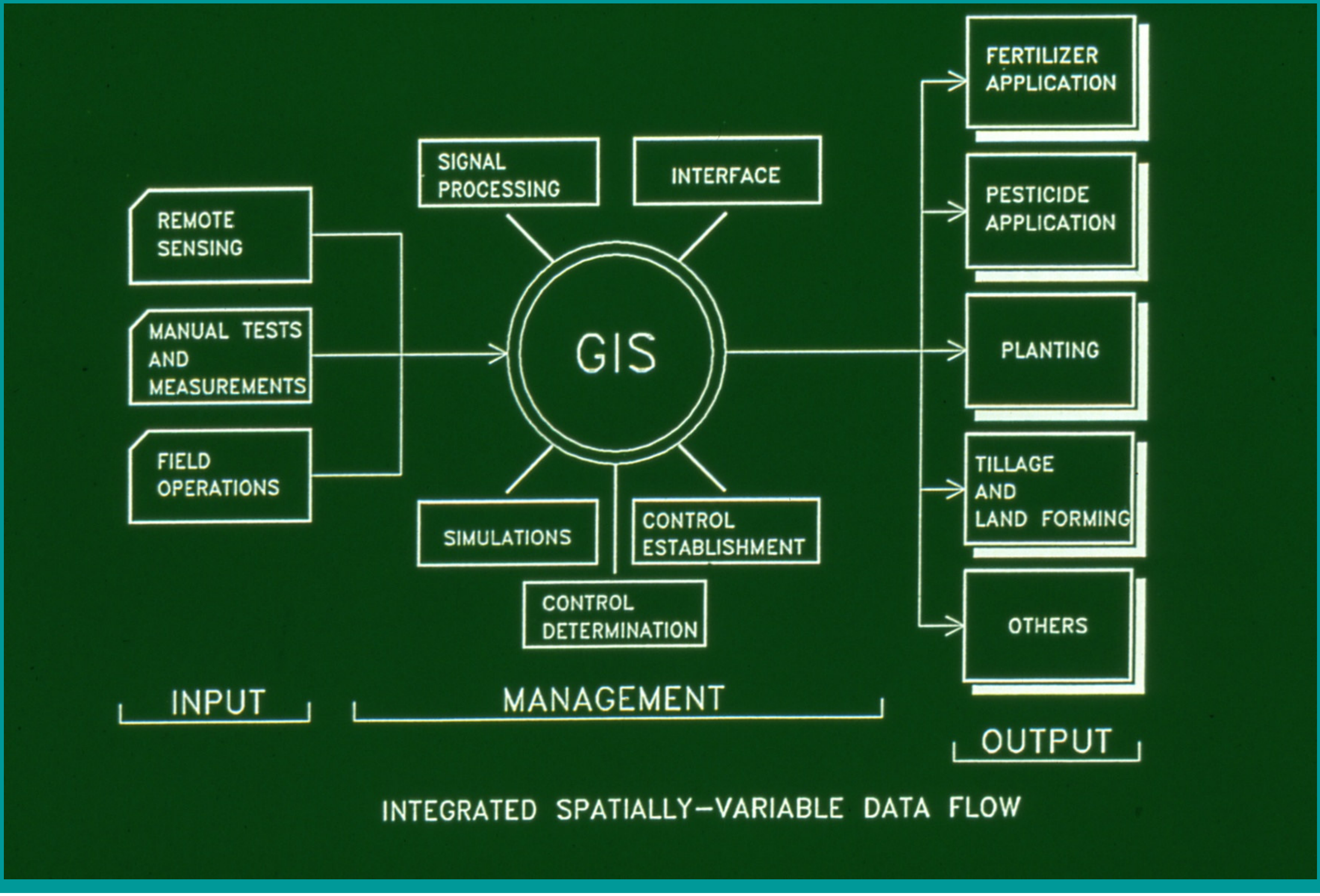
First Published Yield Map?

(Source: Dr. J. K. Schueller, MAE, UF)



Sense (Input) – Manage – Control (Output)

Schueller 1980's Schematic



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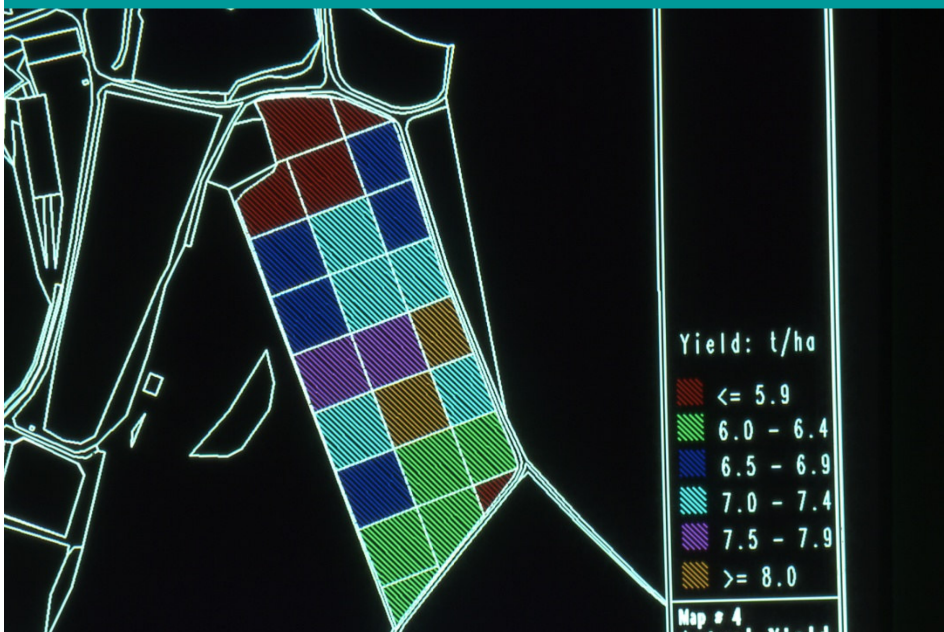
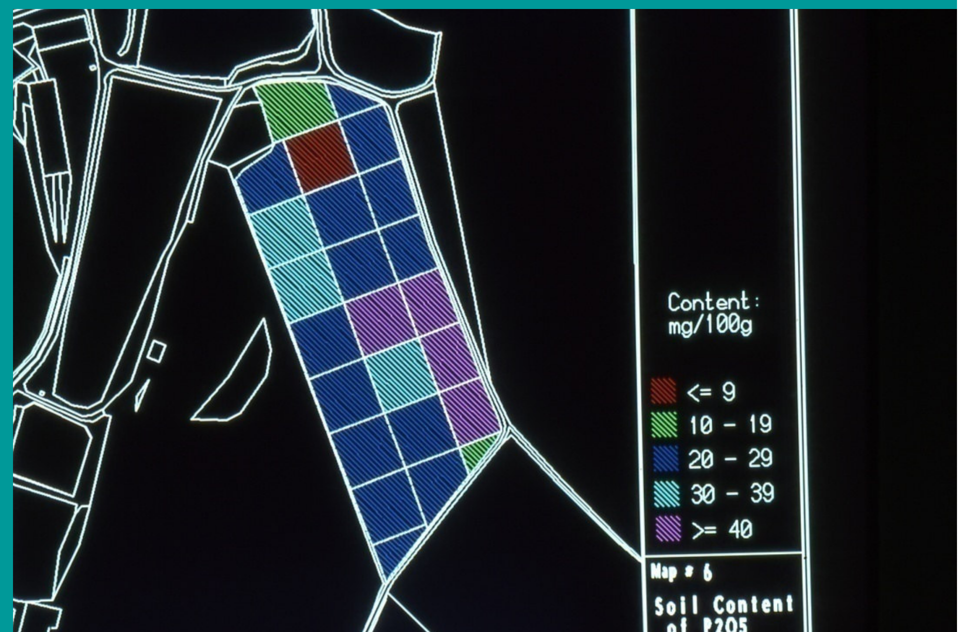
Inputs

Yield Map from Combine



(Source: Dr. J. K. Schueller, MAE, UF)

P Fertility from Soil Samples



Note High Fertility (Purple) Region in Right Corner!

Manage

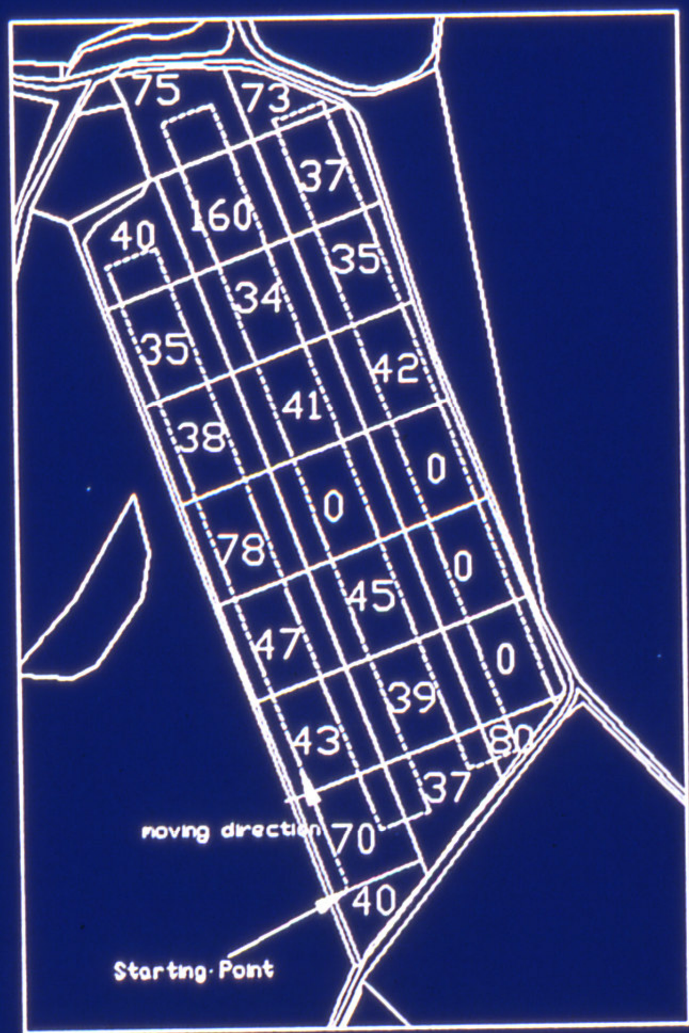
- Must Develop Appropriate Algorithm
- In This Case: Replace Phosphorous Removed By Yield (R), Modified By P Fertility

P Fertility	Desired P_2O_5
Low	R + 90
Middle	R + 40
High	R
Very High	½ R
Extremely High	0

(Source: Dr. J. K. Schueller, MAE, UF)

Output

(Source: Dr. J. K. Schueller, MAE, UF)



Field B Fertilizer Desired Rates (kg/ha) and Applicator Moving Path.

Sensing Systems for Precision Agriculture in Florida

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Remote Sensing – Aerial Photography of Citrus

Weak soils

(Source: Dr. Arnold Schumann, CREC, UF)

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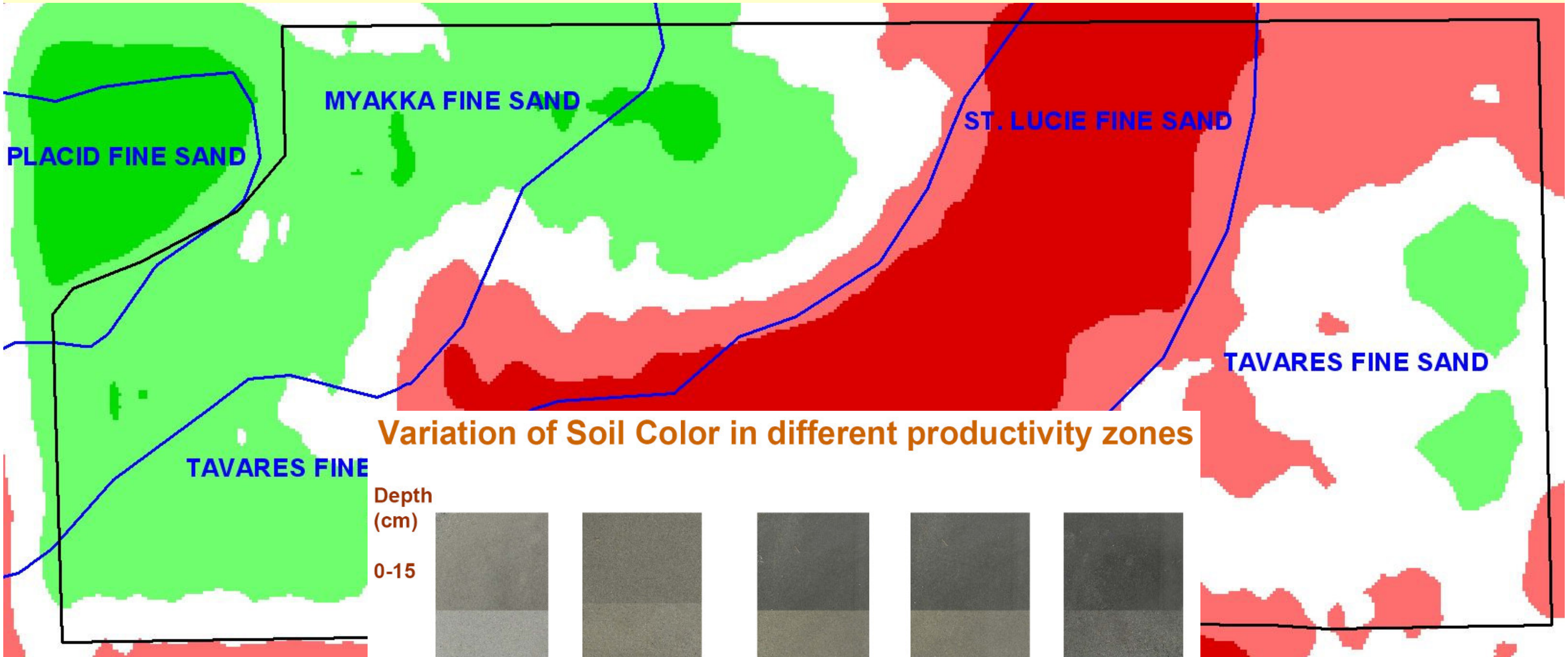
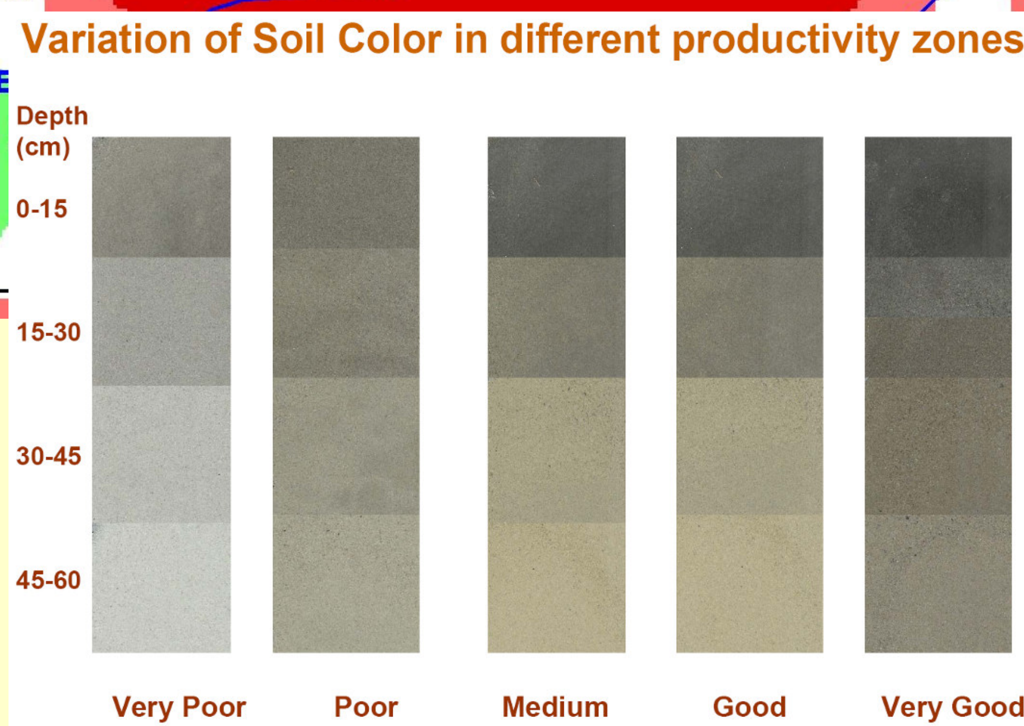
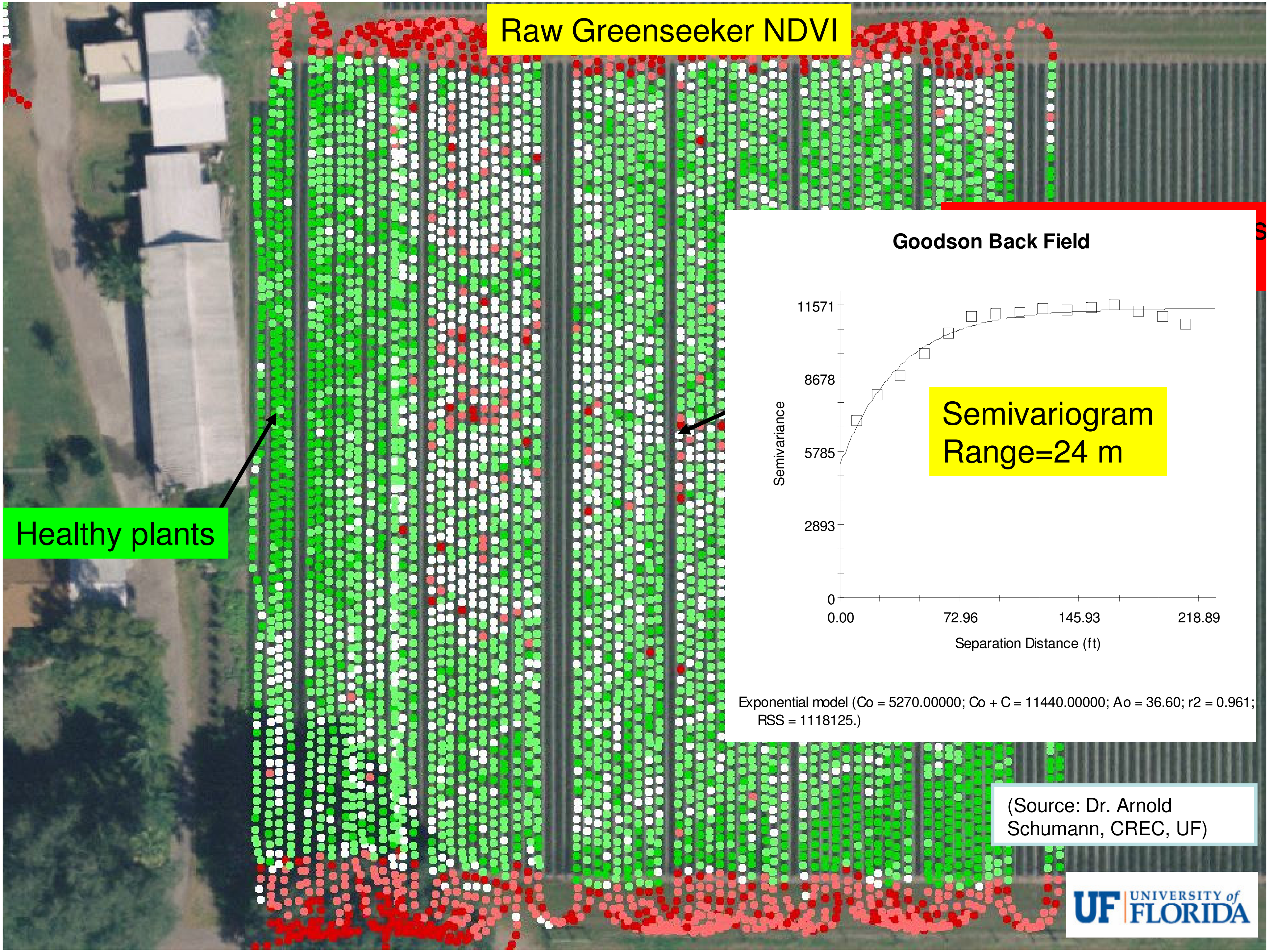
Remote Sensing – NDVI of Citrus





(Source: Dr. Arnold Schumann, CREC, UF)


Raw Greenseeker NDVI
Healthy plants
Goodson Back Field
11571
8678
5785
2893
0
Semivariance
0.00
72.96
145.93
218.89
Separation Distance (ft)
Semivariogram
Range=24 m
Exponential model (Co = 5270.00000; Co + C = 11440.00000; Ao = 36.60; r2 = 0.961; RSS = 1118125.)
(Source: Dr. Arnold Schumann, CREC, UF)
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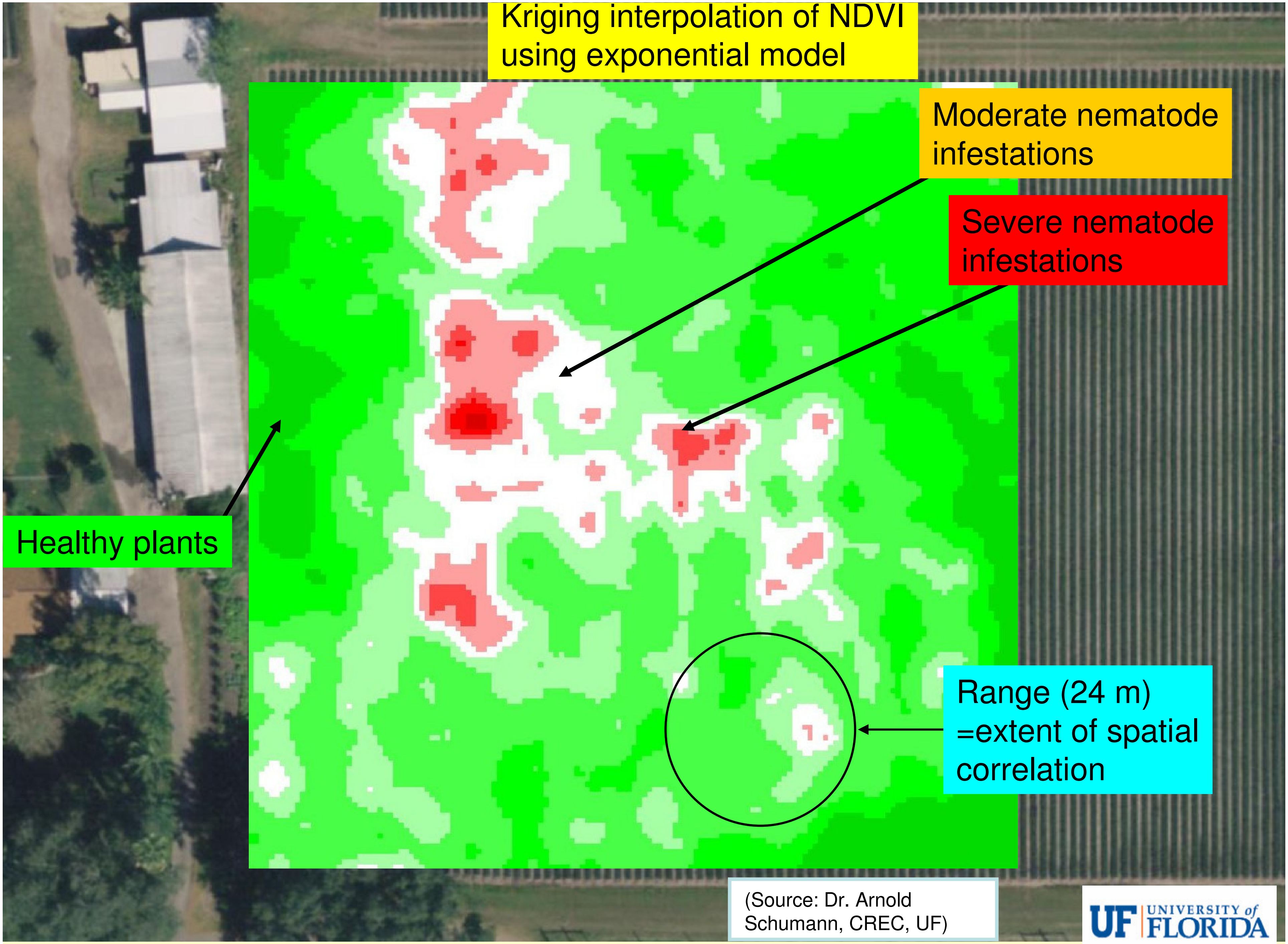

(Source: Dr. Arnold Schumann, CREC, UF)

EM38 Soil Electrical Conductivity Meter

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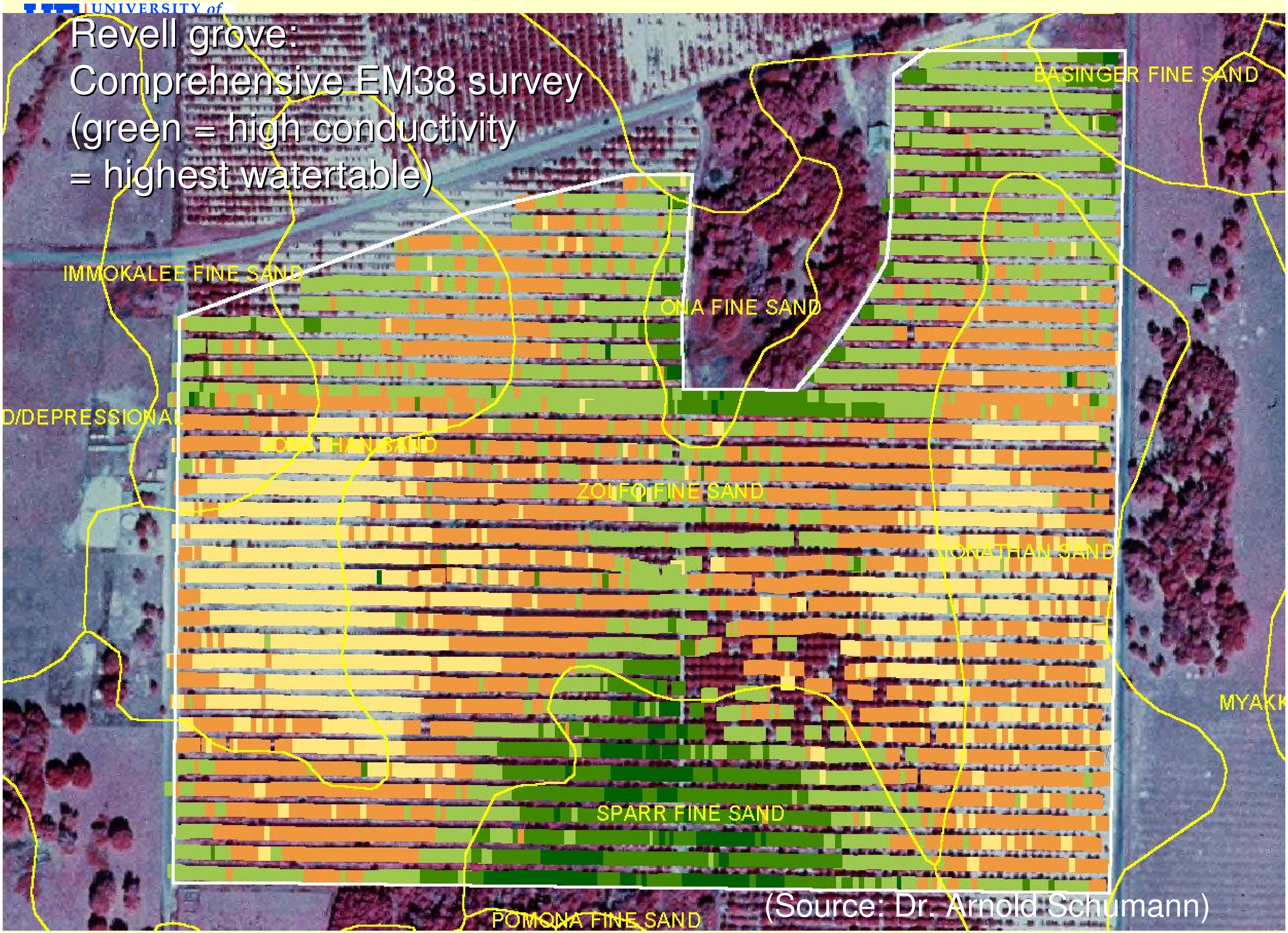
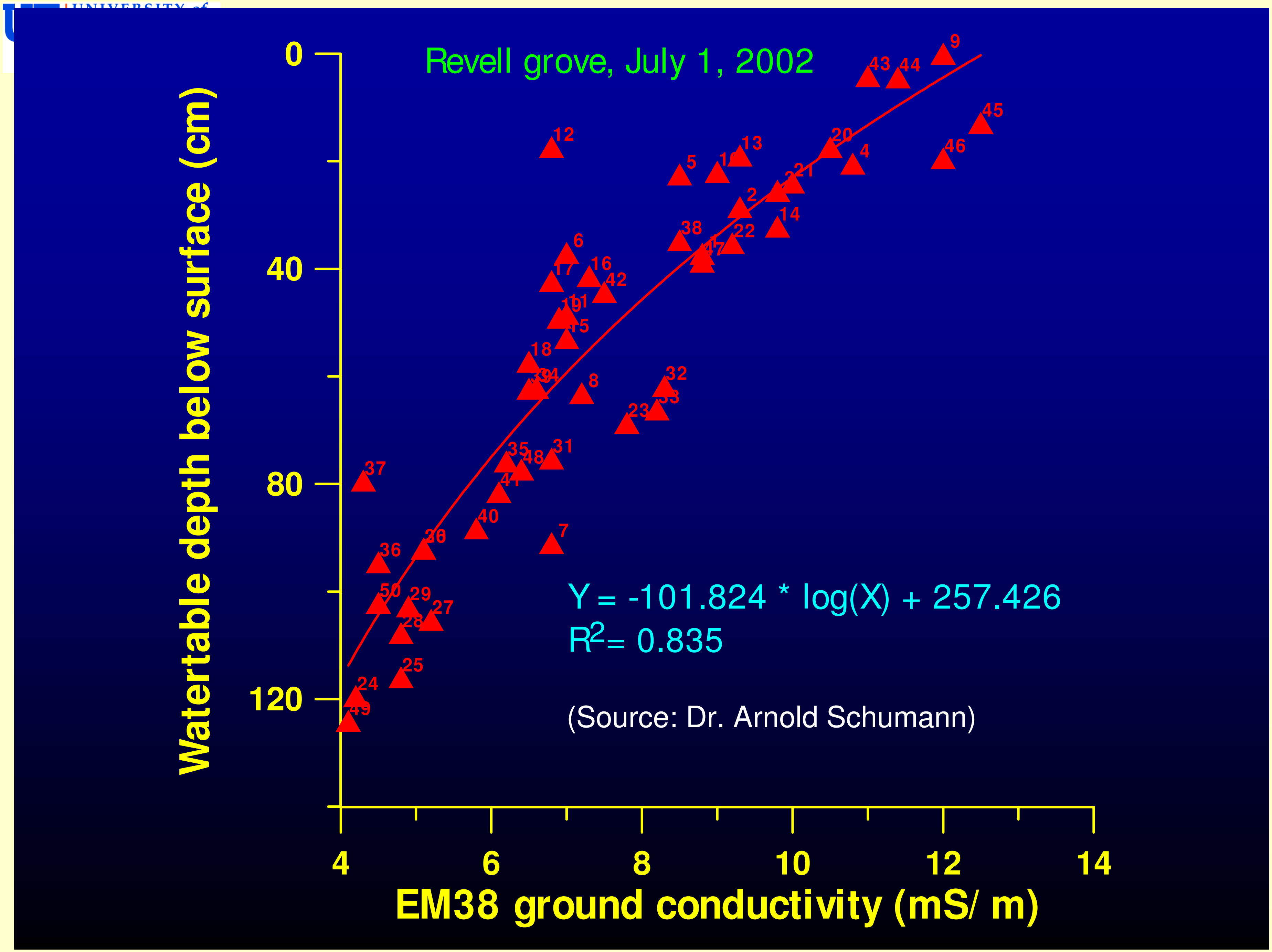
Revell grove:
Comprehensive EM38 survey
(green = high conductivity
= highest watertable)



(Source: Dr. Arnold Schumann)



Revell grove, July 1, 2002
Watertable depth below surface (cm)
0
40
80
120
4
6
8
10
12
14
EM38 ground conductivity (mS/ m)
Y = -101.824 * log(X) + 257.426
R2= 0.835
(Source: Dr. Arnold Schumann)

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Counting Citrus Tree and Estimating Canopy Area for Census Purposes Evaluation of Feature Analyst and GeoCitrus Technique

(Source: Dr. Reza Ehsani, CREC, UF)

Why Count Trees?

We want to count citrus trees to see if domestic crop forecast can be automated: Andrew Meadows, Spokesperson, FDOC(USA Today, December 82004)

,

- Crop management: tree development (size) and health
- Property appraisal

Large Grove- Close Look at Results

Accuracy

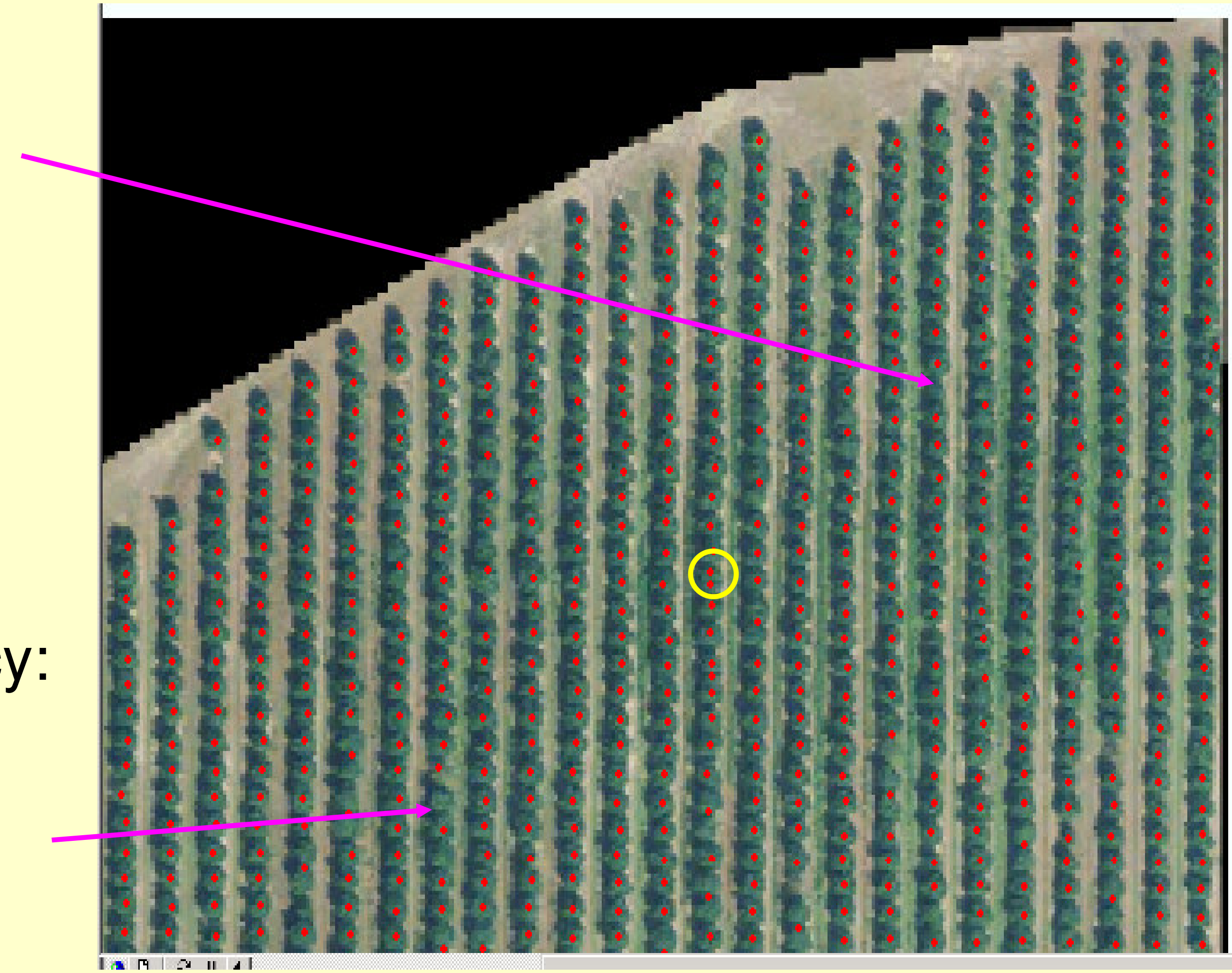
Total Tree #: 2817

Software count: 2640

Double: 5

Missing: 177

Net Count Accuracy: 2640/2817*100= 93.7%



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Wide Spaced Grove- Results

Accuracy

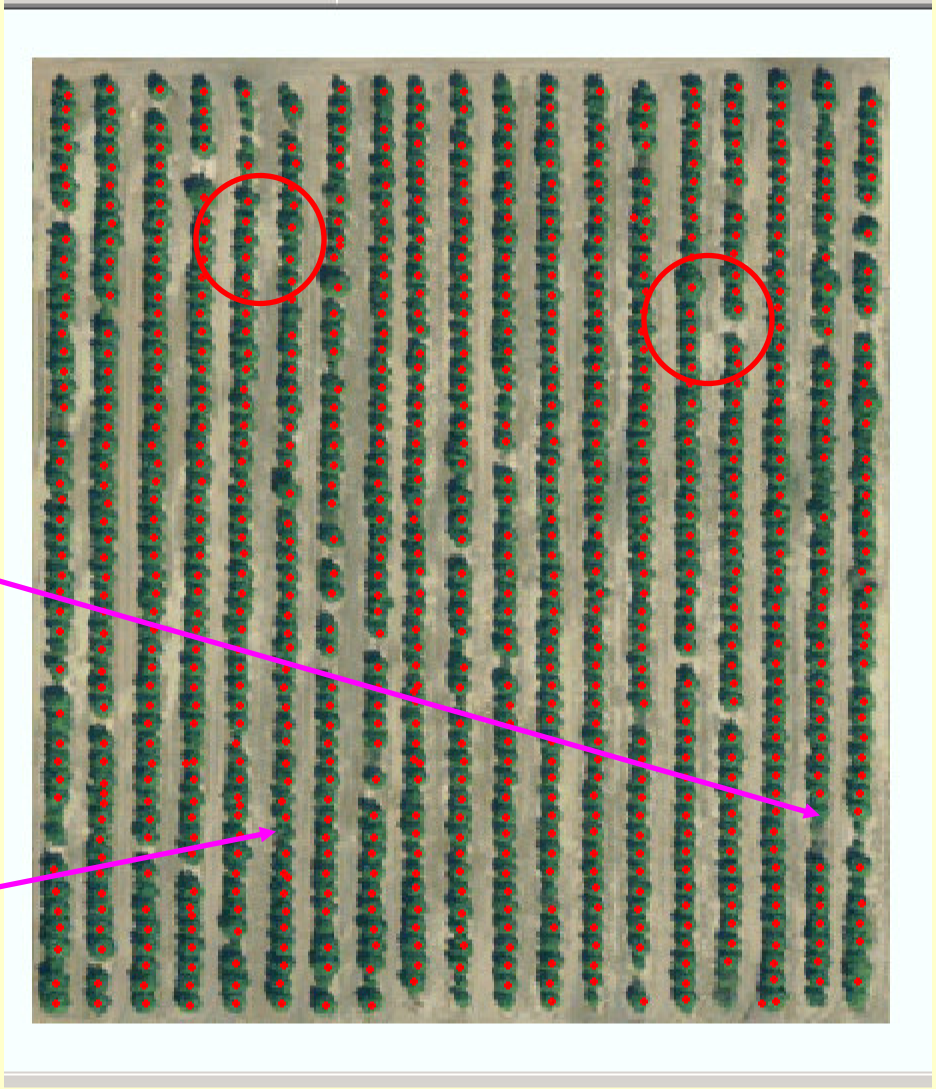
Total Tree #: 898

Software count: 859

Double: 5

Missing: 39

Net Count Accuracy:
898/859*100= 95.7%



Uniform Size Grove- Results

Accuracy

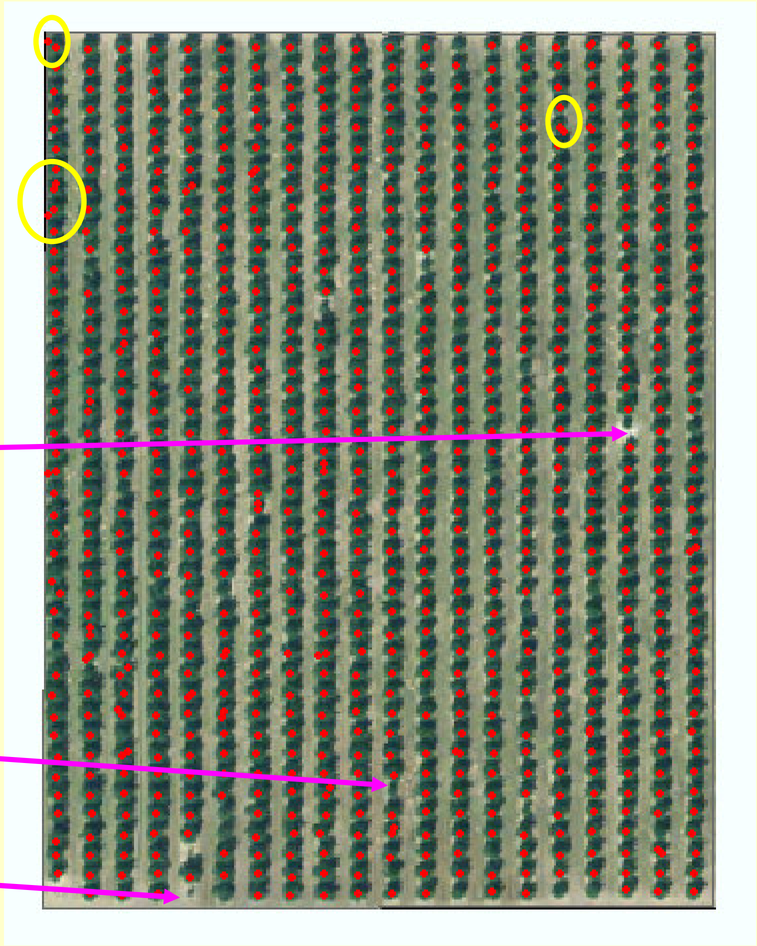
Total Tree #: 857

Software count: 826

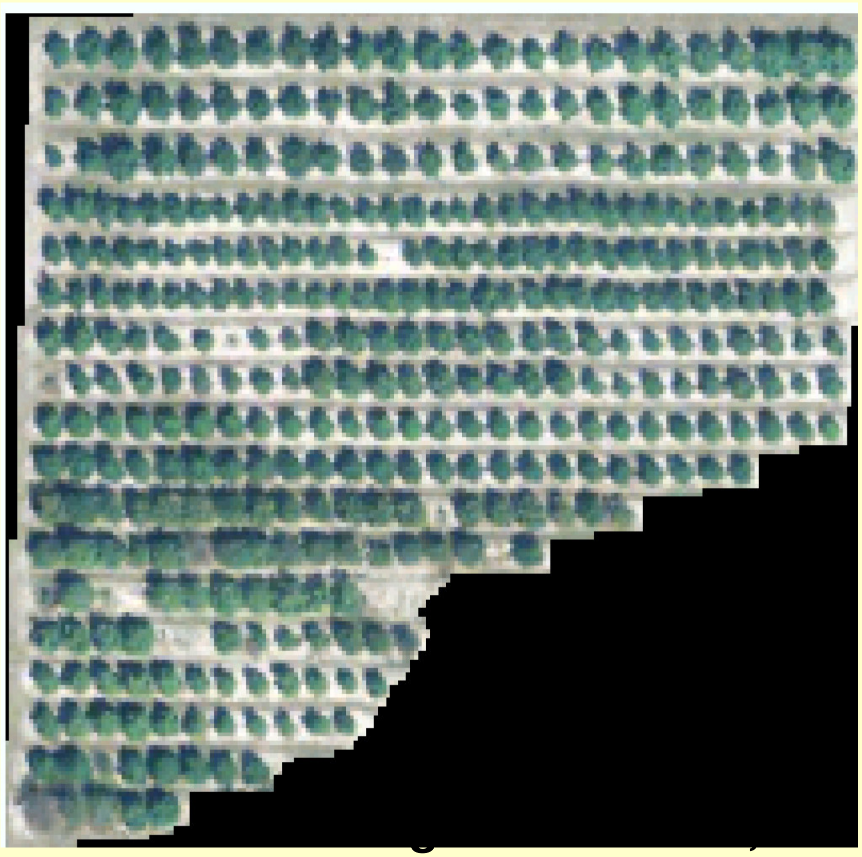
Double: 25

Missing: 31

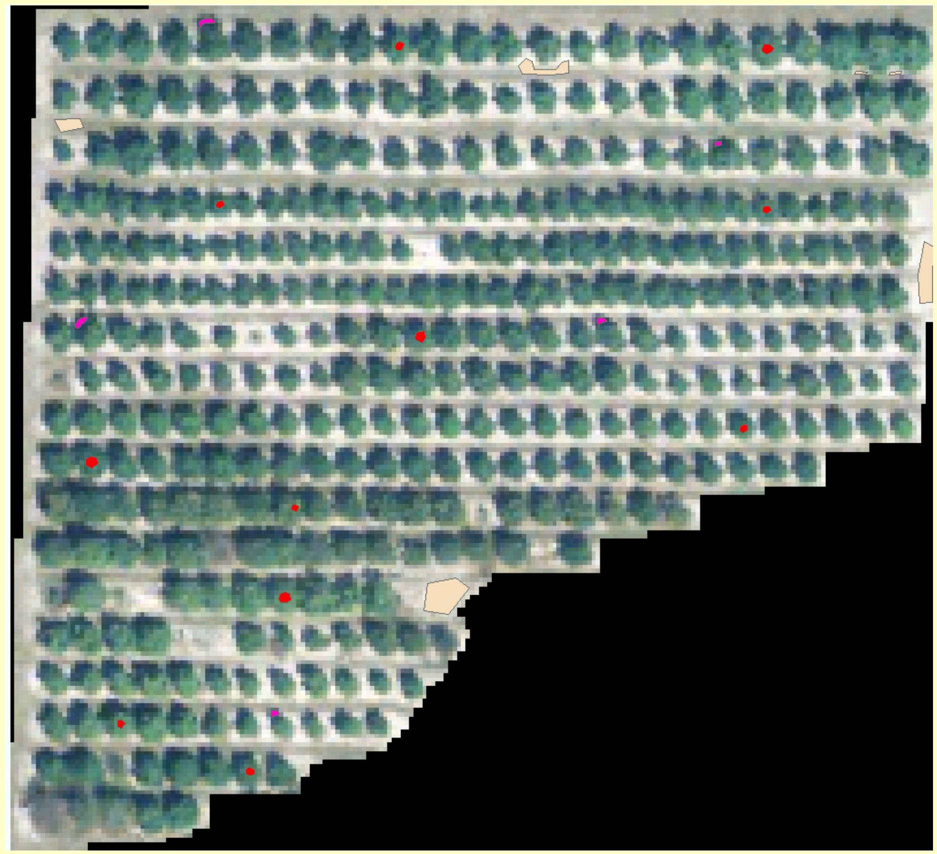
Net Count Accuracy: 826/857*100= 96.4%



Canopy Area Estimation

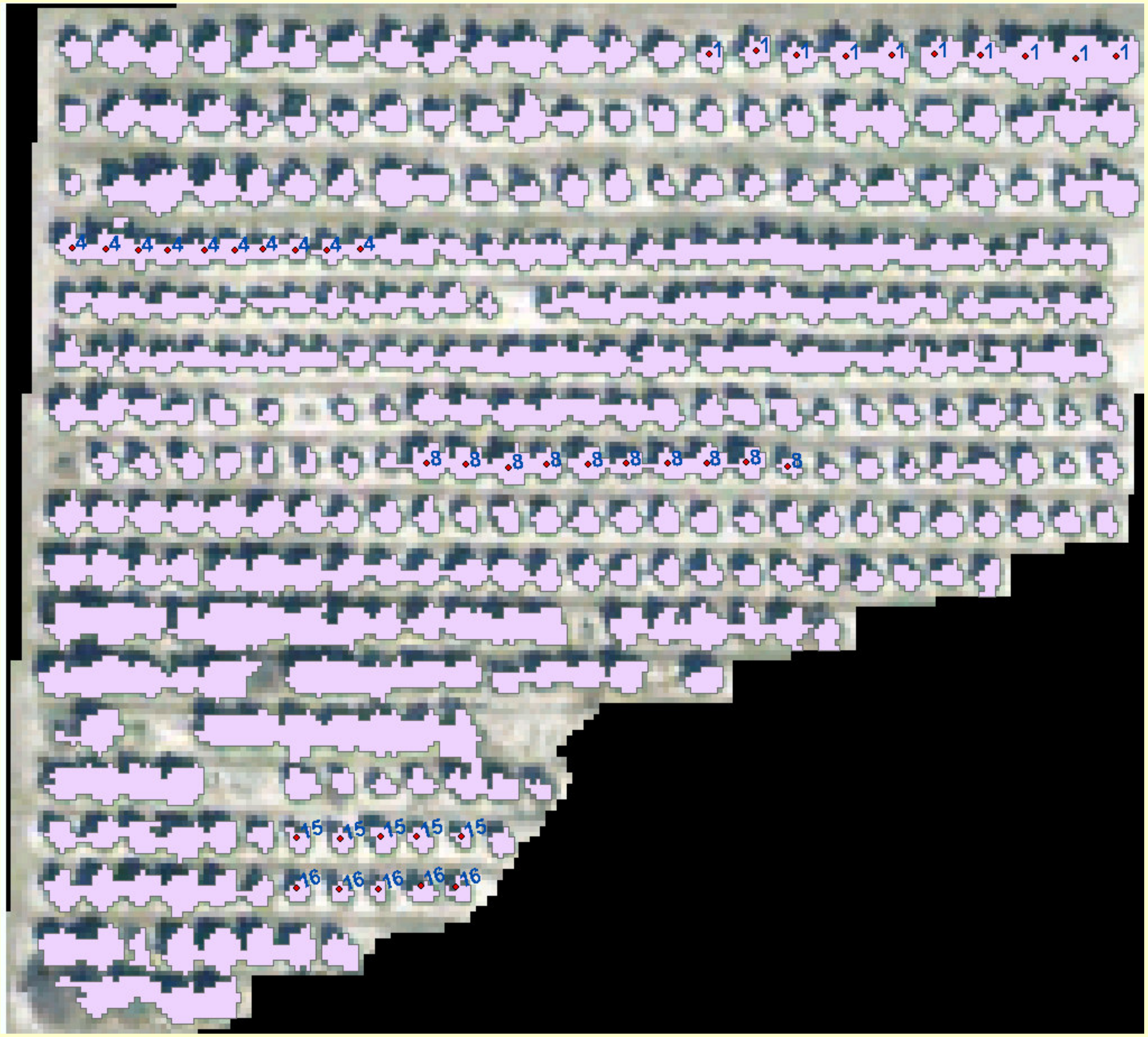


Area: approx. 2.75 acres
Total Tree #: 357



Training Learner

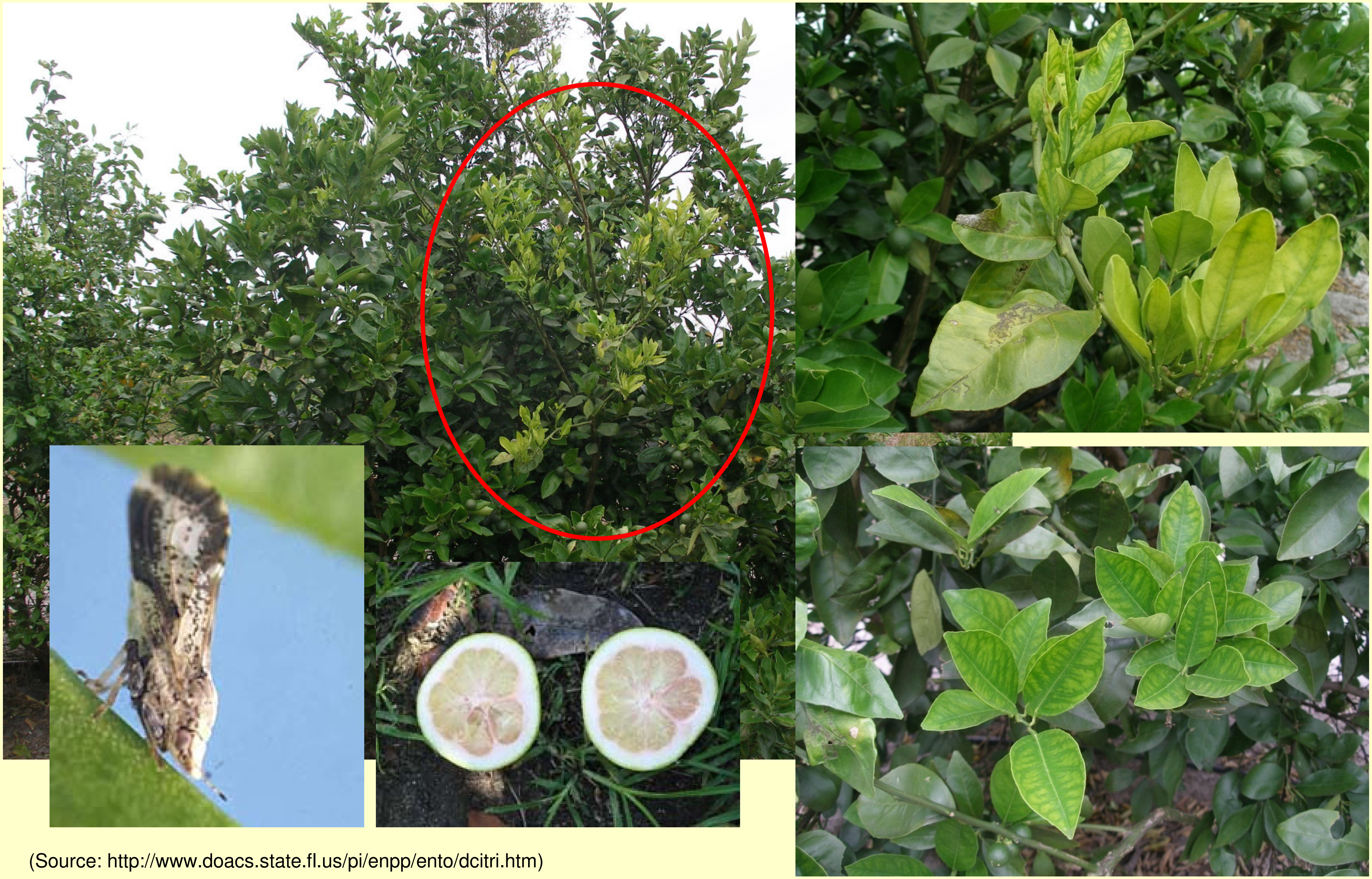
Canopy Area Estimation - Results



% Accuracy : 70- 92%

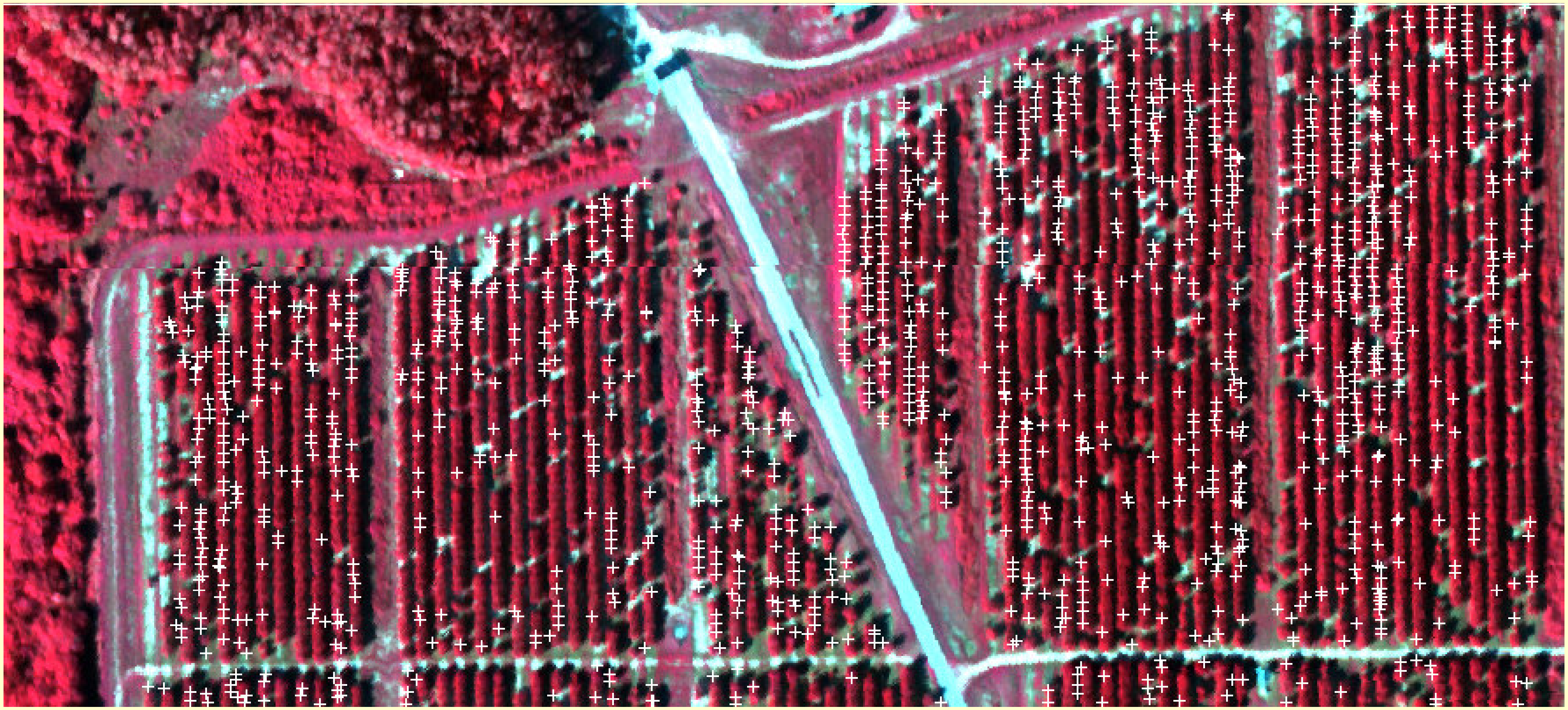
Citrus Greening (Huanglongbing or HLB) Detection

Citrus greening (HLB)



(Source: http://www.doacs.state.fl.us/pi/enpp/ento/dcitri.htm)

HLB detection using hyperspectral imaging: ground truthing



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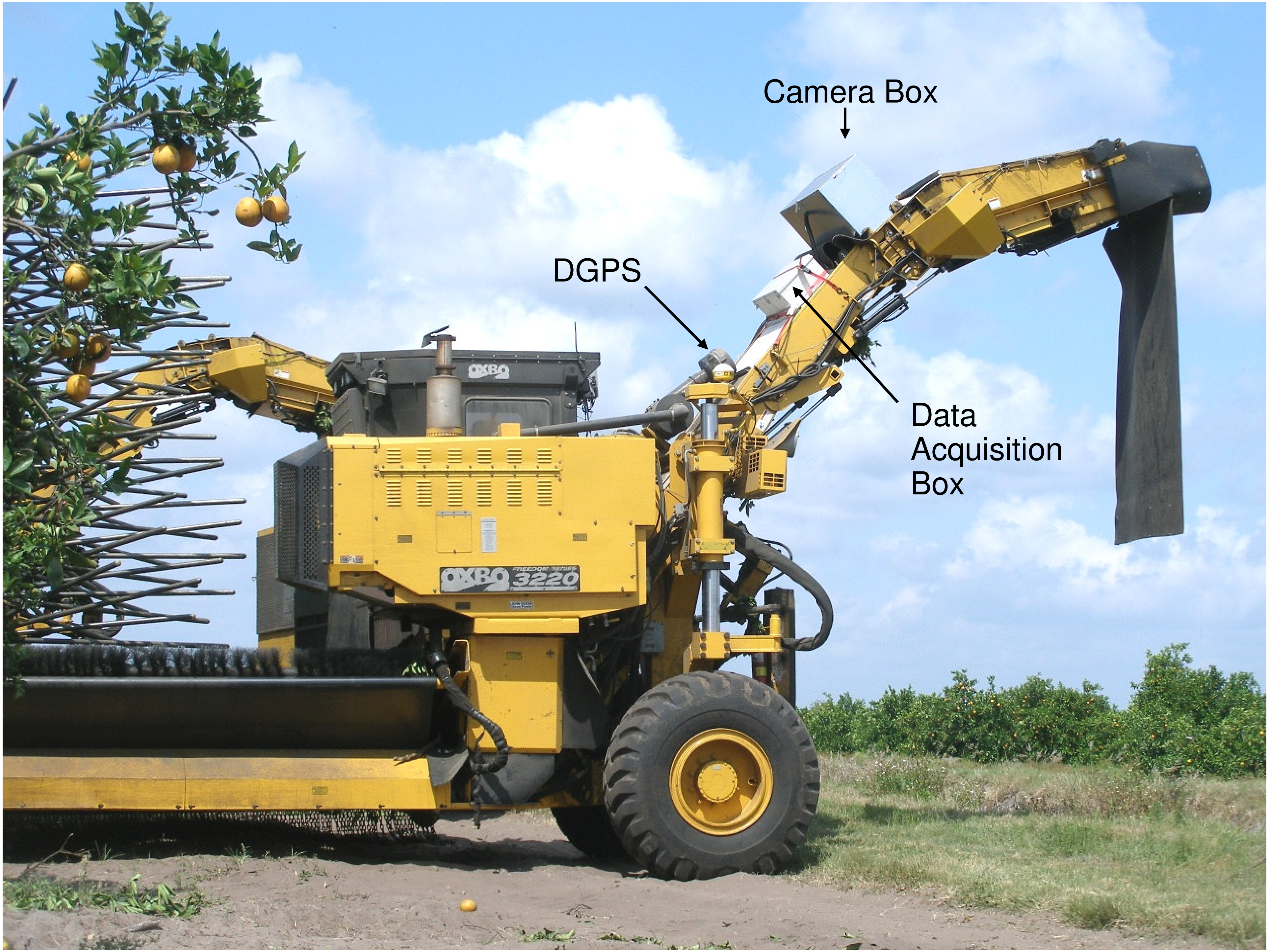
Citrus trash detection system for a canopy shake and catch harvester using machine vision


Camera Box
DGPS
Data
Acquisition
Box
OXBO
OXBO FREEDOM SERIES 3220

Trash detection system

- Objectives: To investigate the amount of trash during harvesting and its effect on harvesting and processing operations

Image acquisition and processing

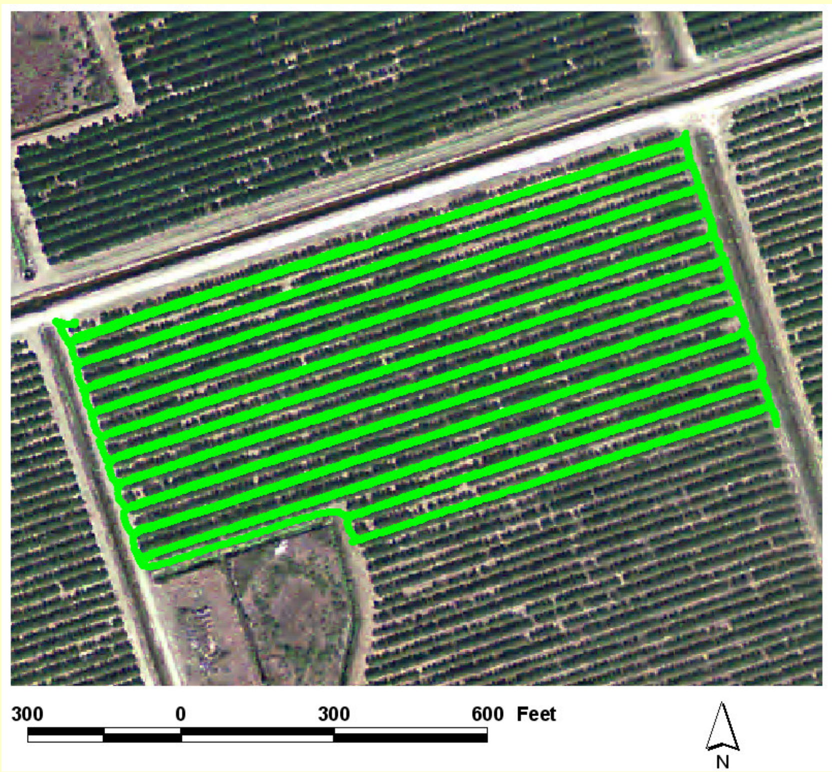
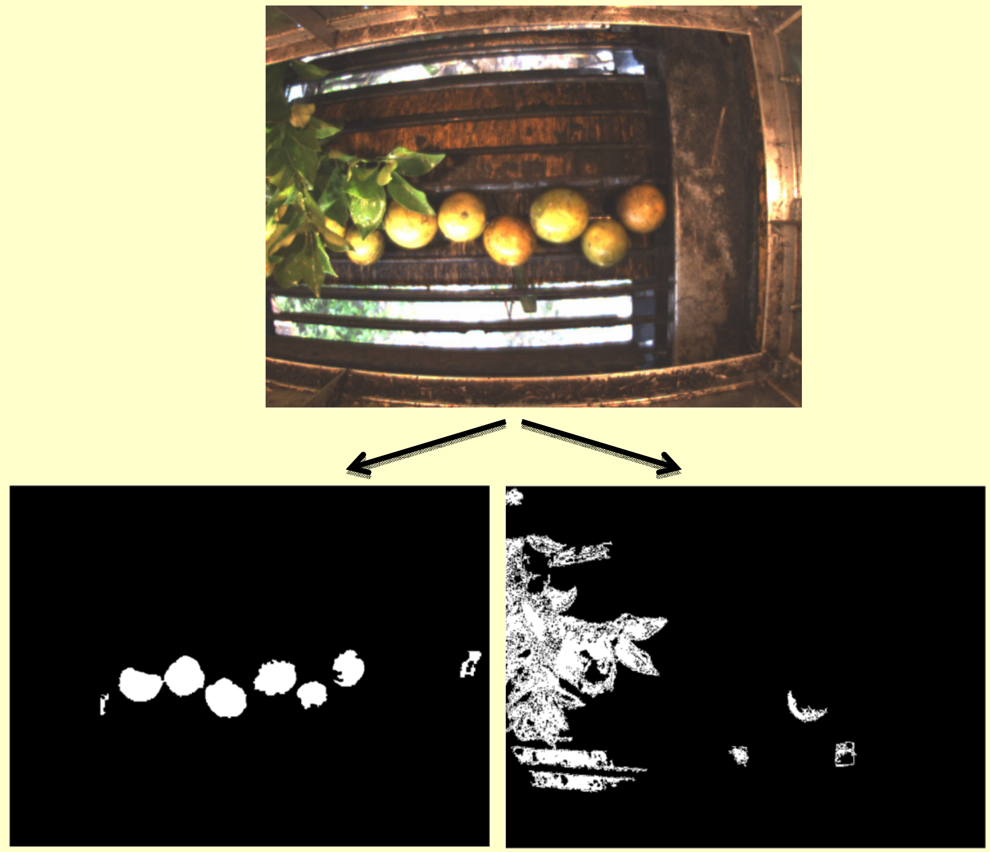


Image acquisition location
in a citrus grove



Binarization of fruit and leaves

Phosphorus (P) detection

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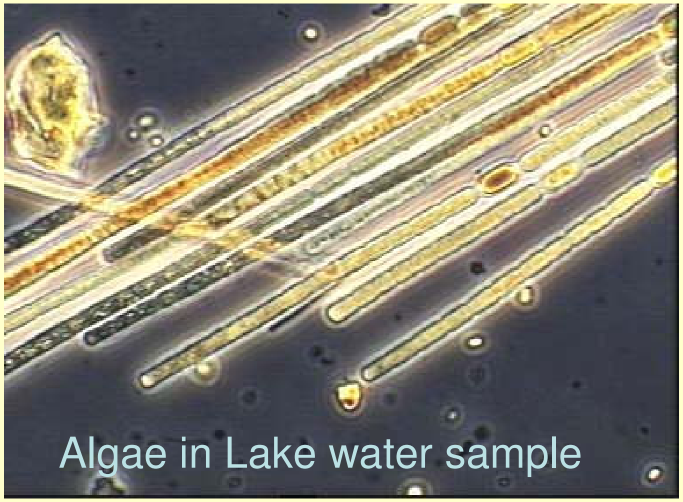
Lake Okeechobee
(“Big water”)

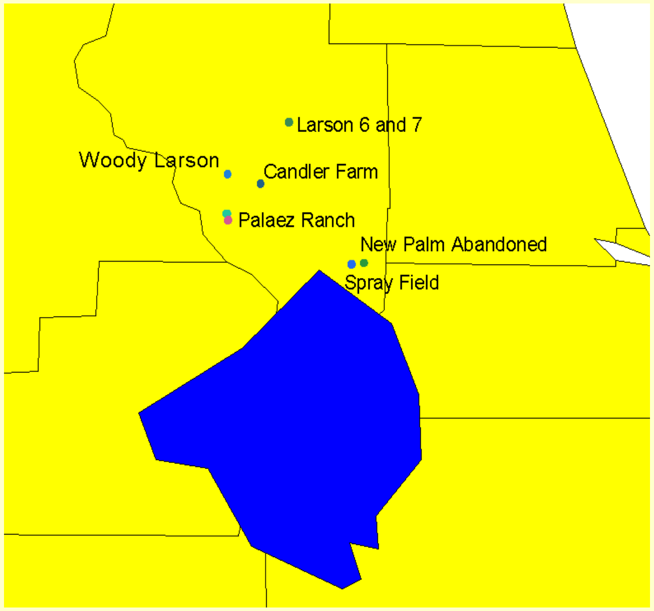
- The “liquid heart” of South Florida.
- 2nd largest freshwater lake in the U.S. (Surface area of 730 square miles)
- Drainage basins covers more than 4,600 square miles (11,913 km^2).
- Shallow: Avg. depth 9 feet
- Source of drinking and irrigation water

Lake Okeechobee

- Natural habitant for fish, birds, and other wildlife.
- Supplies essential water for people, farms and the environment.
- Provides flood protection.
- Attracts boating and recreation enthusiasts.



Okeechobee soil and vegetation sampling

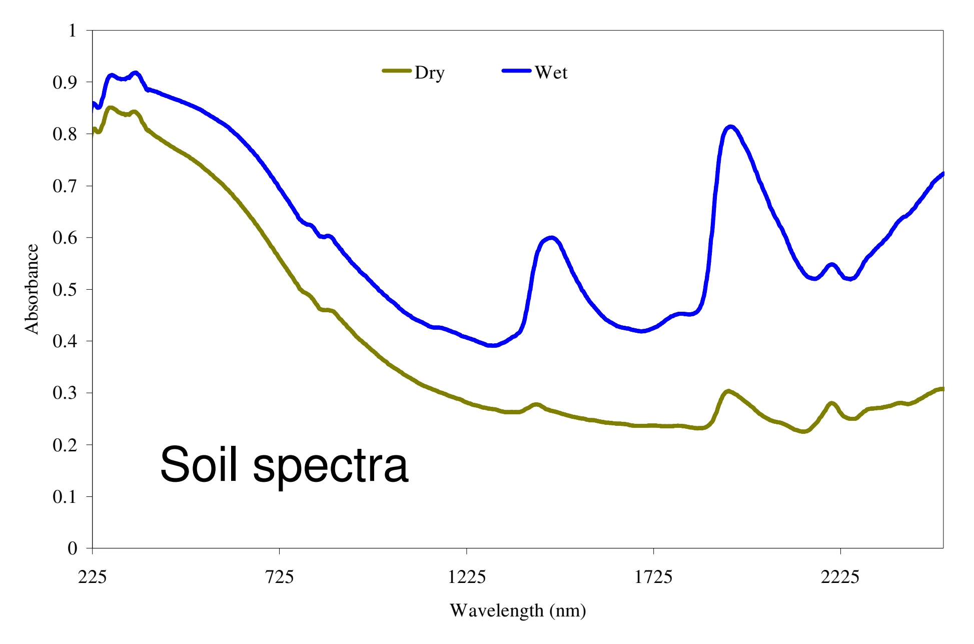


Soil samples and grass samples were obtained from 10 sampling sites

Spectral measurement

- Reflectance measured with an integrating sphere
- 400-2500 nm with 1 nm increment
- Reference (PTFE) used to correct baseline

(Cary 500 UV-VIS-NIR, Varian, Inc.)

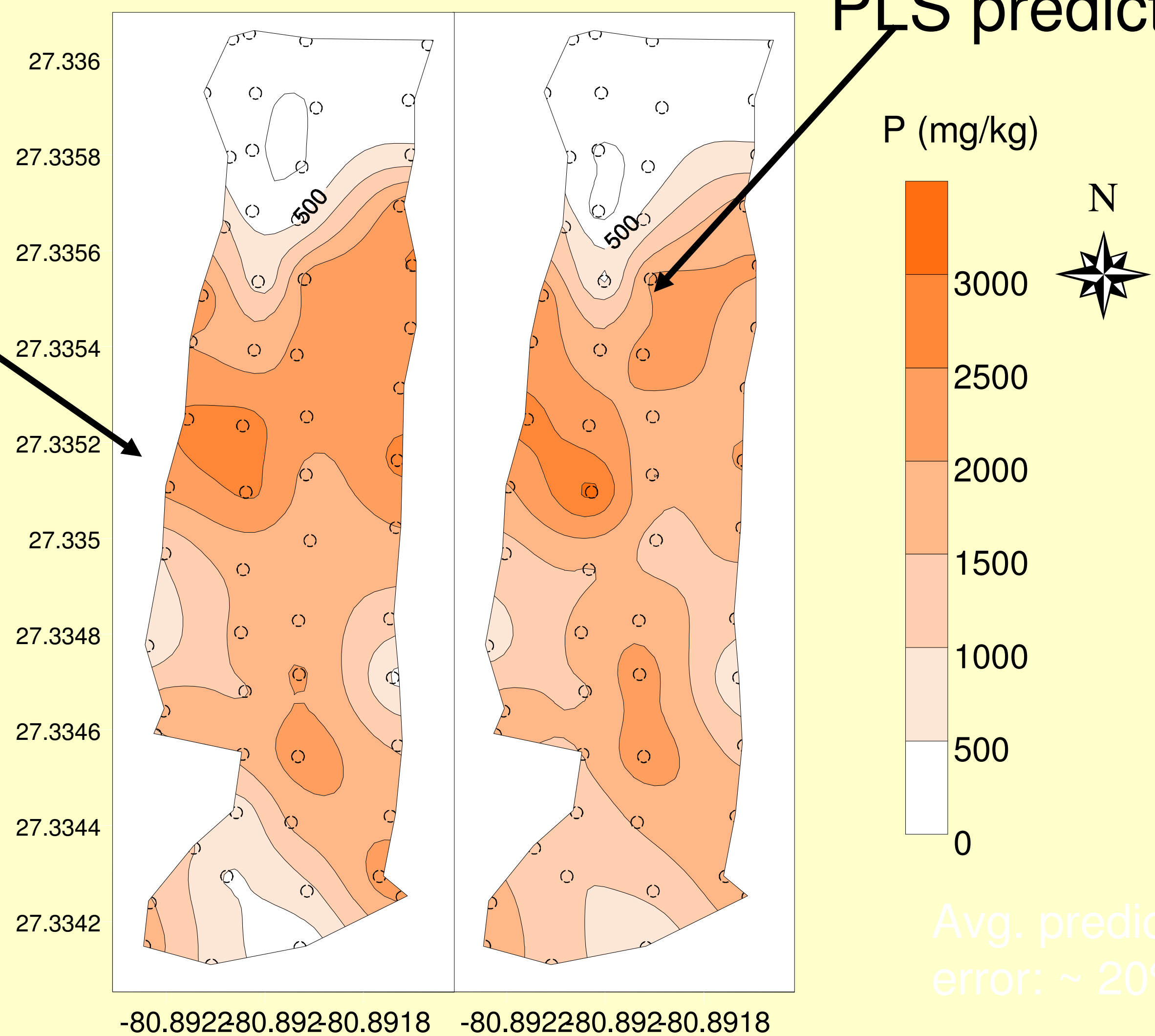


Soil P prediction map

Actual vs. Predicted: Mehlich-1 P

Actual

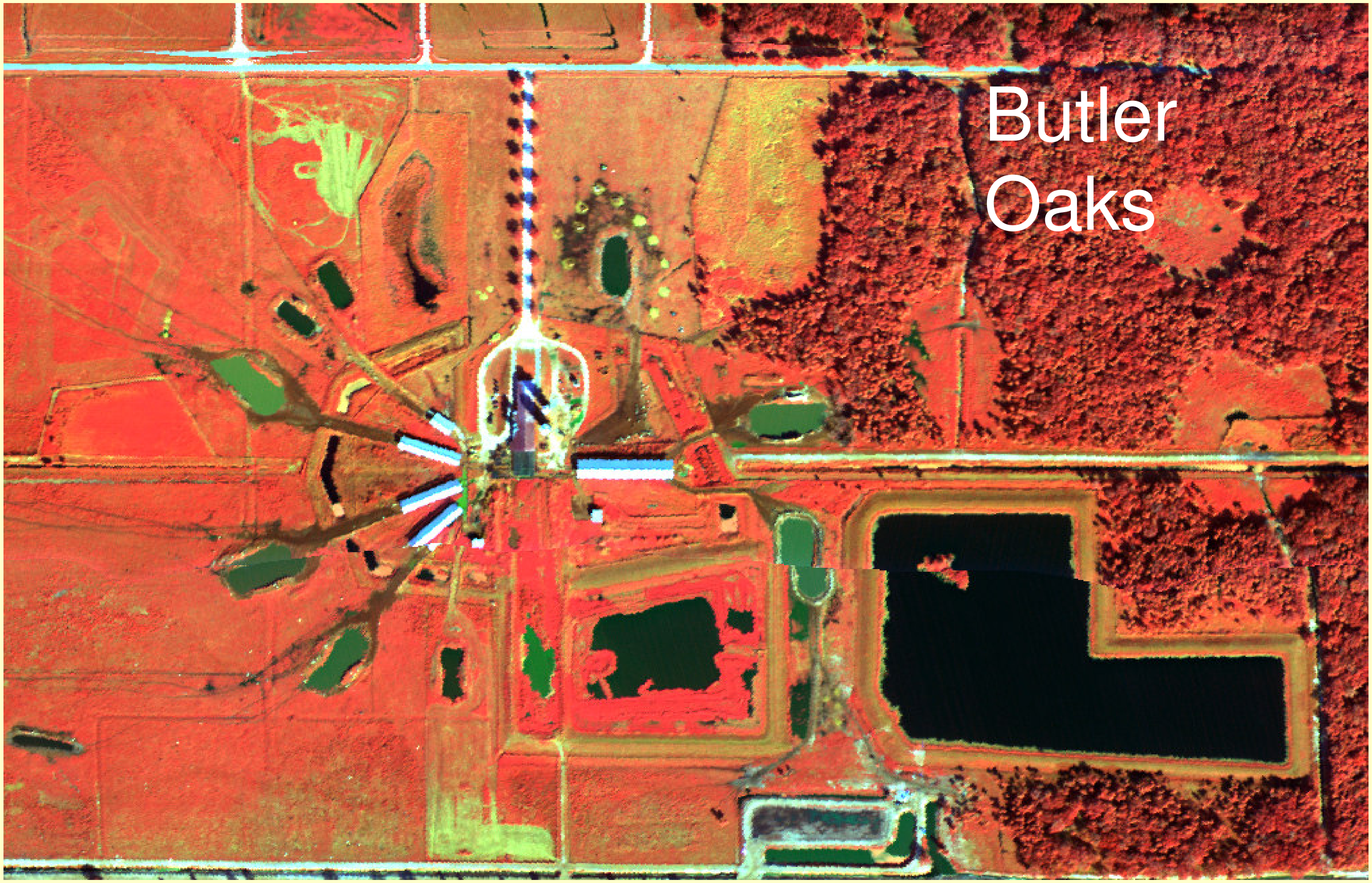
PLS predicted



Candler Farm
24 June 2003
Soil sample
Mehlich 1-P

Avg. prediction error: ~ 20%

Hyperspectral and multispectral image studies



Two class SAM classification

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GNSS in Teaching

Acknowledgment

- Dr. John Schueller, MAE, UF
- Dr. Masoud Salyani, CREC, UF
- Dr. Arnold Schumann, CREC, UF

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Thank you!

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