

# Application of Real-Time Sensor Systems for Precision Cotton Management

## 2006 Crop Management Seminar

Sponsored by Cotton Inc.

Memphis, Tennessee

**John Wilkerson**

Professor of Biosystems Engineering

The University *of* Tennessee



# Spectral Reflectance Sensing for Crop Management

1. Opportunities for Variable Rate Control of:  
Nitrogen  
Growth Regulators  
Defoliants
2. Airborne Imagery for Scouting and VR application maps vs. Equipment Mounted Crop Sensors
3. Emerging Technologies

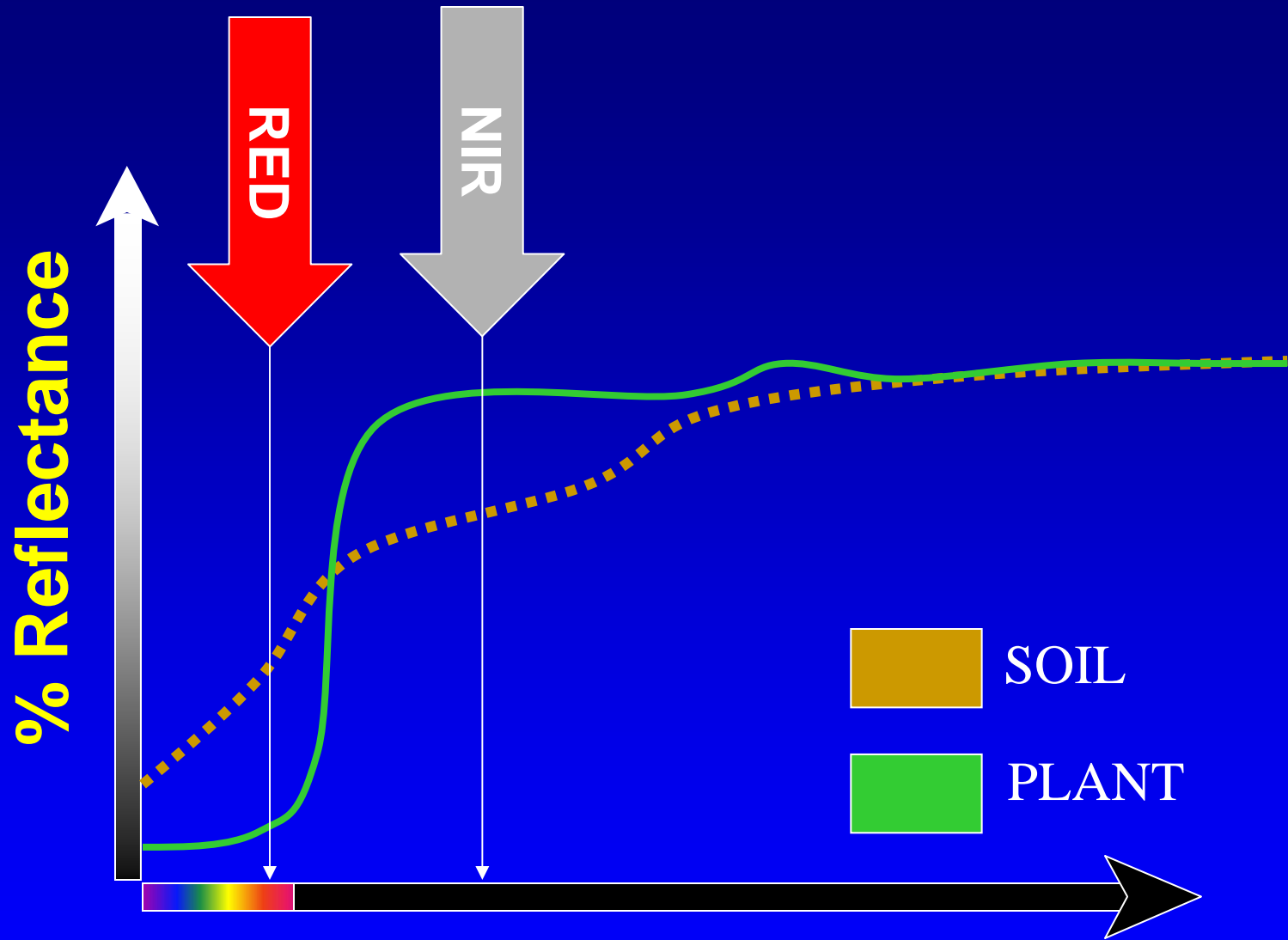
# Why use remotely sensed spectral reflectance?

- Scouting Aid (not a replacement)
- Mid-season decisions on variable rate:
  - Nitrogen
  - Growth Regulators
  - Defoliant

# Approach

## Remote Sensing of Reflected Light

- Satellite Imagery
- Airborne Imagery
- Real-time on-the-go sensing (ground-based)



**Reflected Light from Field (wavelength)**

# NDVI

## Normalized Difference Vegetation Index

$$\text{NDVI} = \frac{\text{NIR} - \text{Red}}{\text{NIR} + \text{Red}}$$

**Low NDVI**

**High NDVI**



**Lowest  
Biomass**

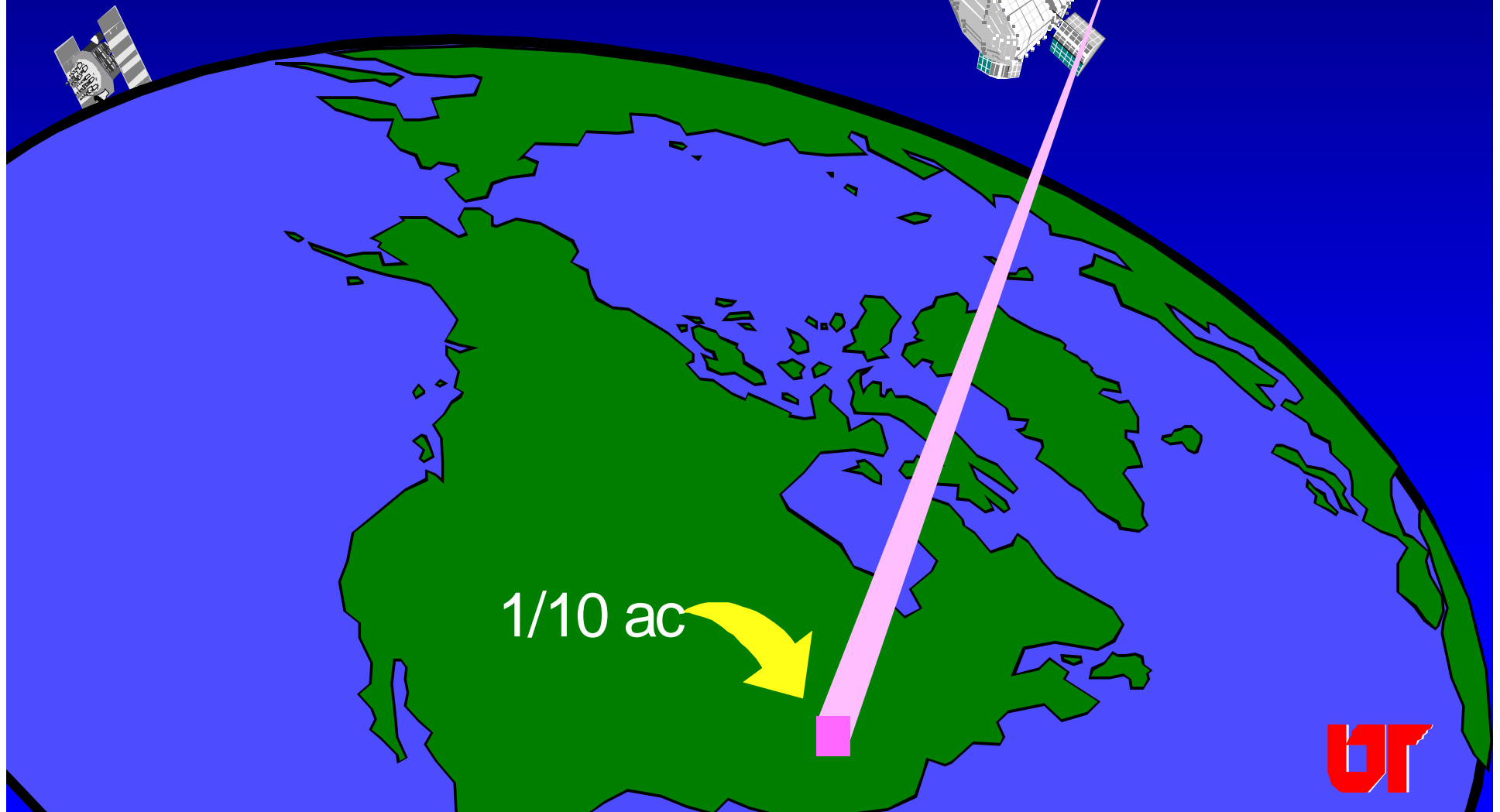
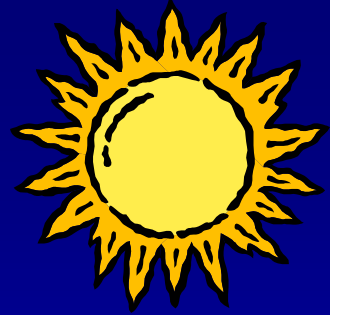
**Highest  
Biomass**

Thinner Canopy  
Stressed Plants

Thicker Healthy  
Canopy  
Not Stressed

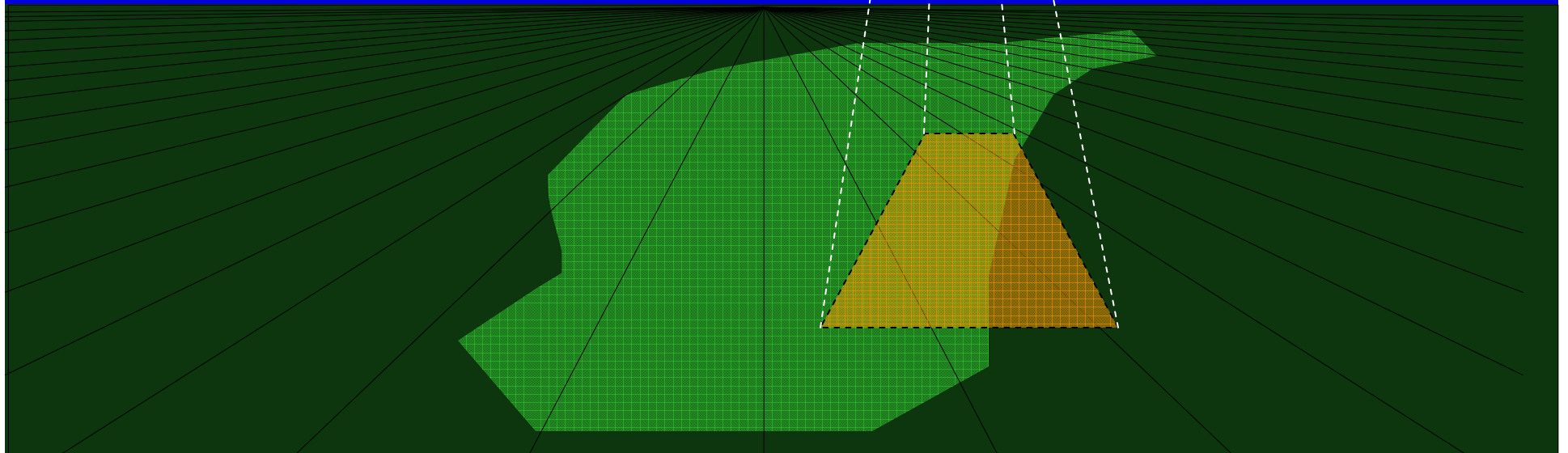
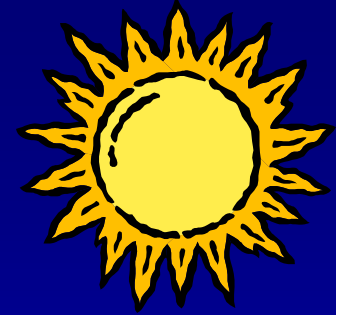


# Multi-Spectral Remote Sensing

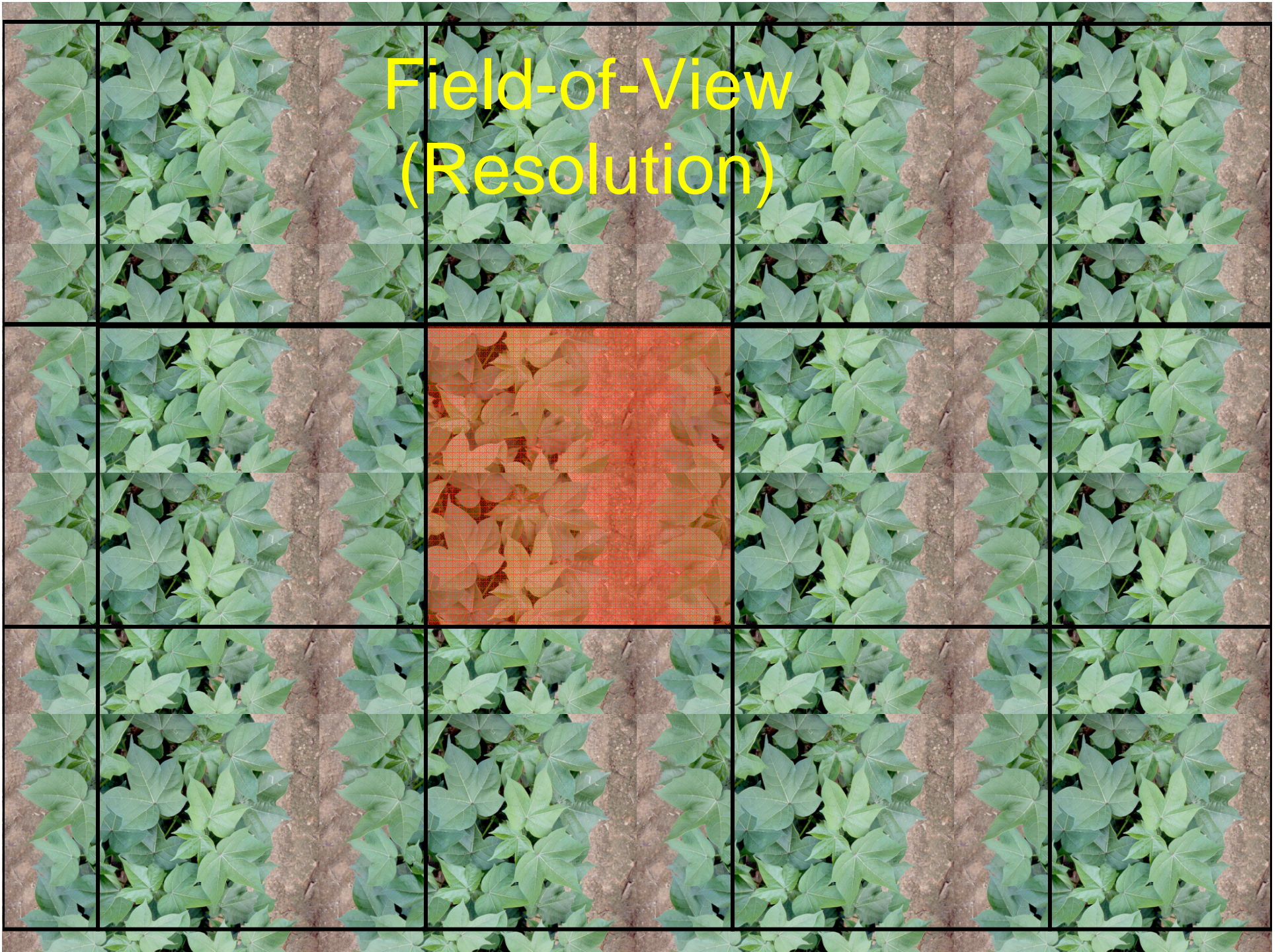




# Airborne Imagery



# Field-of-View (Resolution)



# Image Acquisition → Variable Rate

- An image is requested {date, field(s) }
- Acquisition of imagery from aircraft
- Image is processed to create a scouting map
- Geo-referenced image made available to consultant/producer via the internet



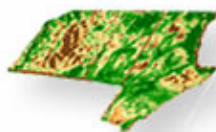
UT Milan

Blake Brown

Client Toolbox

Toolbox Home

- Imagery Status
- Data Acquisition
- Scout Maps
  - Create New Scout Map
  - Download Scout Maps
- Prescriptions
  - Create New Prescription
  - Download Prescriptions
- Settings
  - View Profiles
  - Edit Farm Profile
  - Change My Password
  - Edit My Profile
  - View/Edit Zones
- Log Out



Create New Scout Map



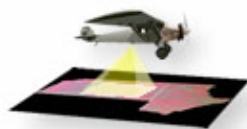
Download a Scout Map



Create New Prescription



Download a Prescription



Data Acquisition



Imagery Status



**JOHN DEERE**  
AGRI SERVICES

Imagery

Order Imagery

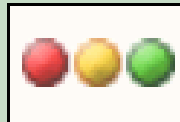
Order Status

Zone Creation

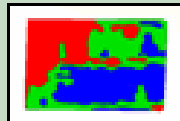
Export Application



Order Imagery



Order Status

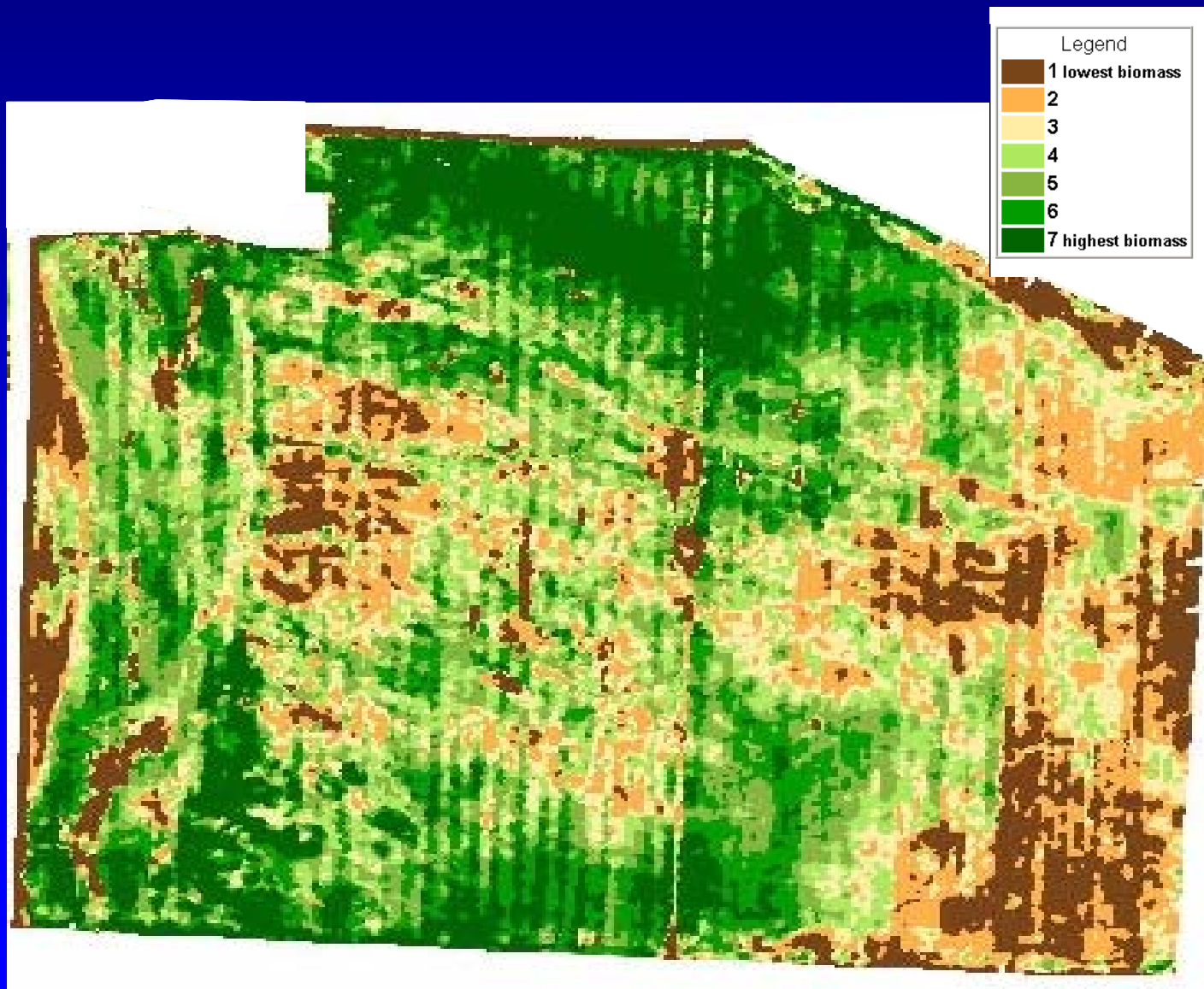


Zone Creation



Export Application

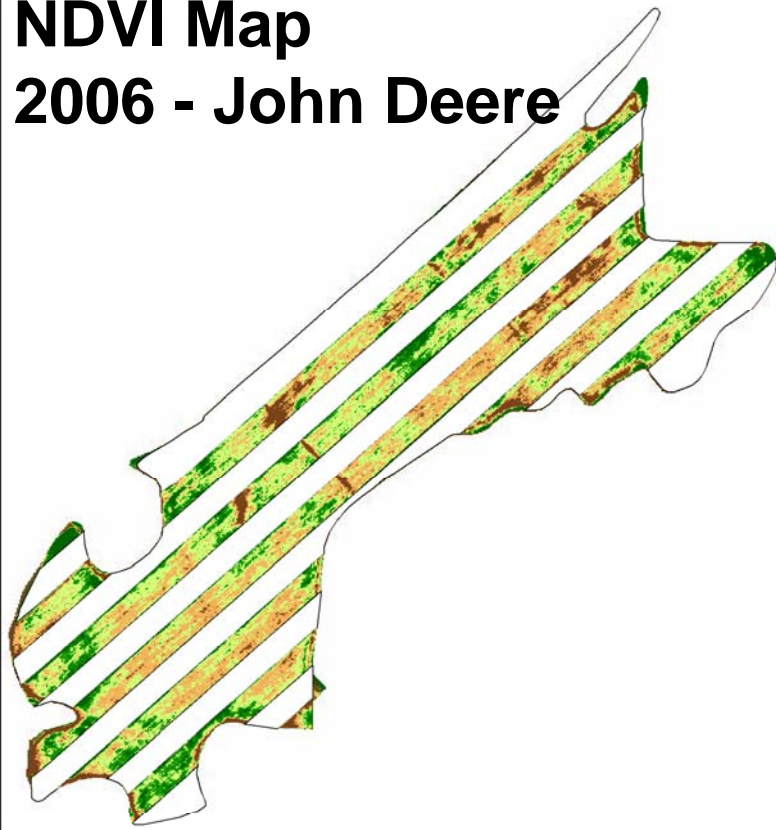
# Geo-referenced Scouting Map



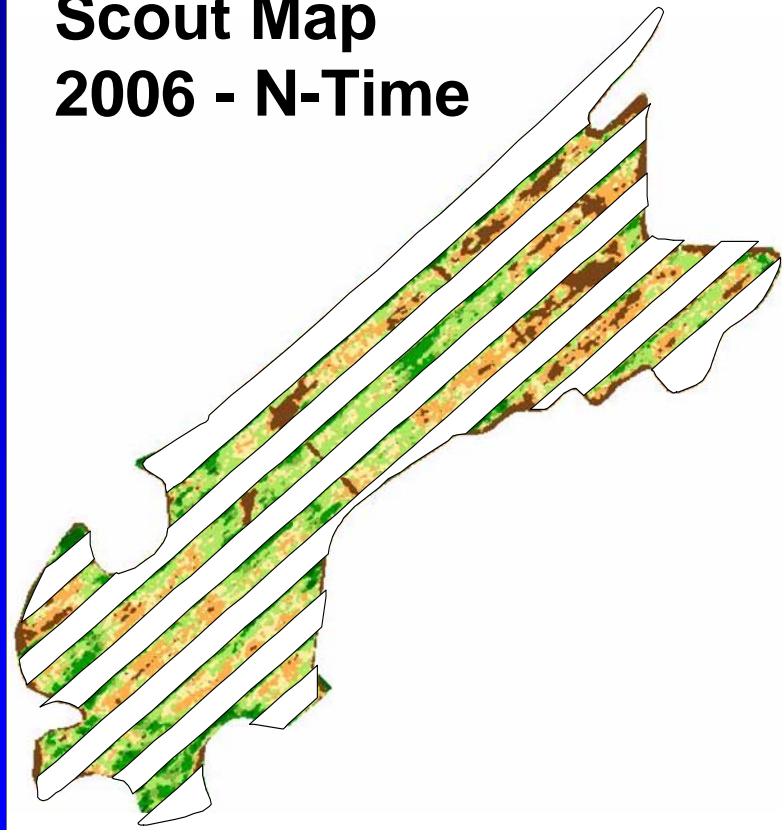
# Scout Maps

## July 5, 2006

**NDVI Map  
2006 - John Deere**

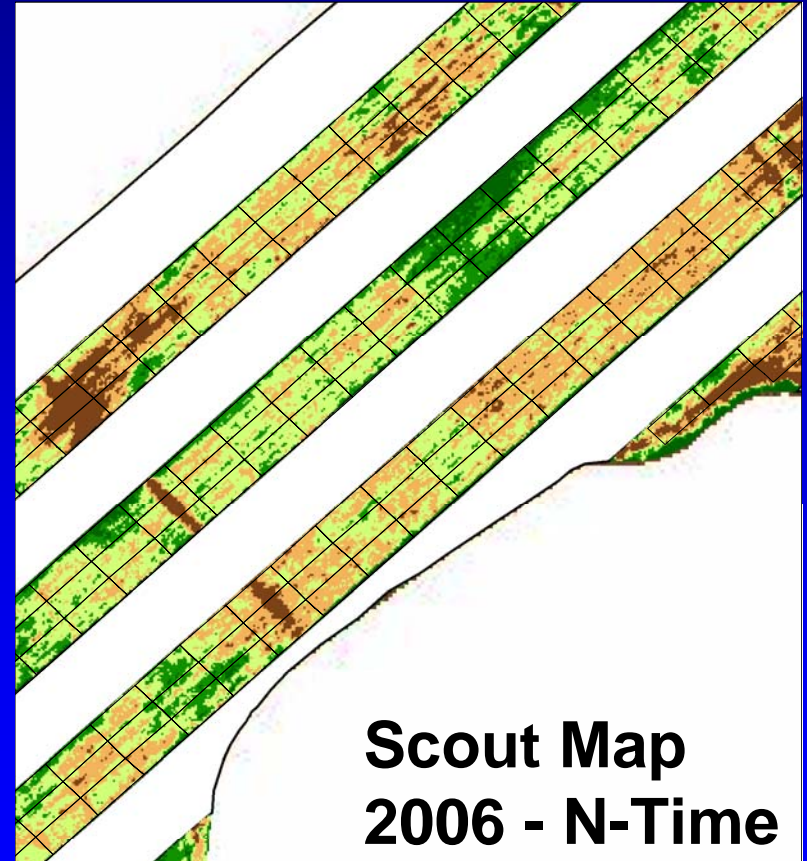
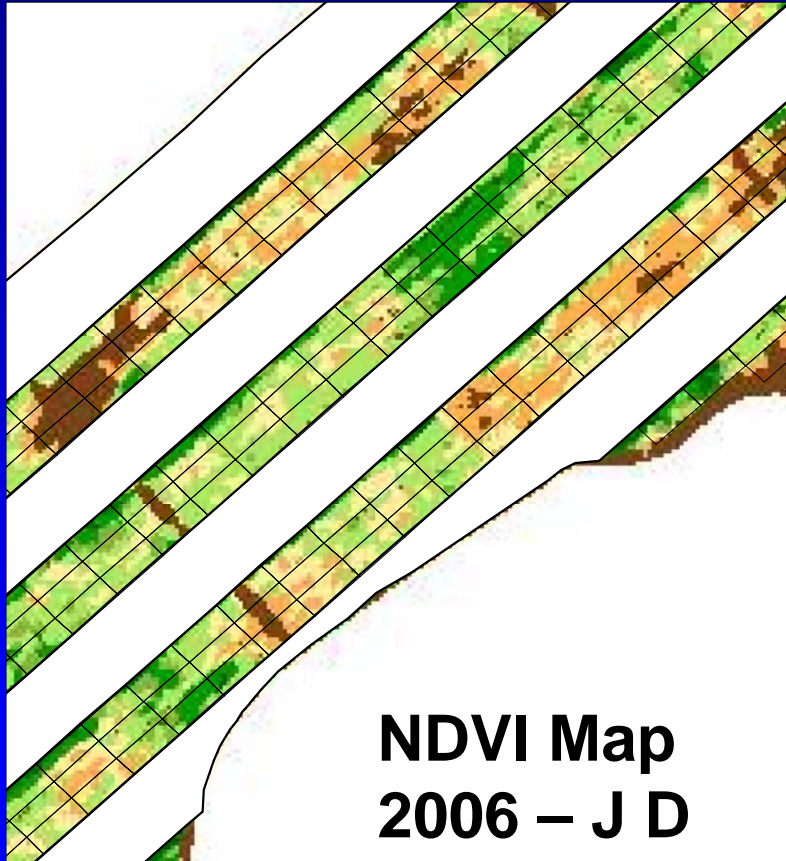


**Scout Map  
2006 - N-Time**



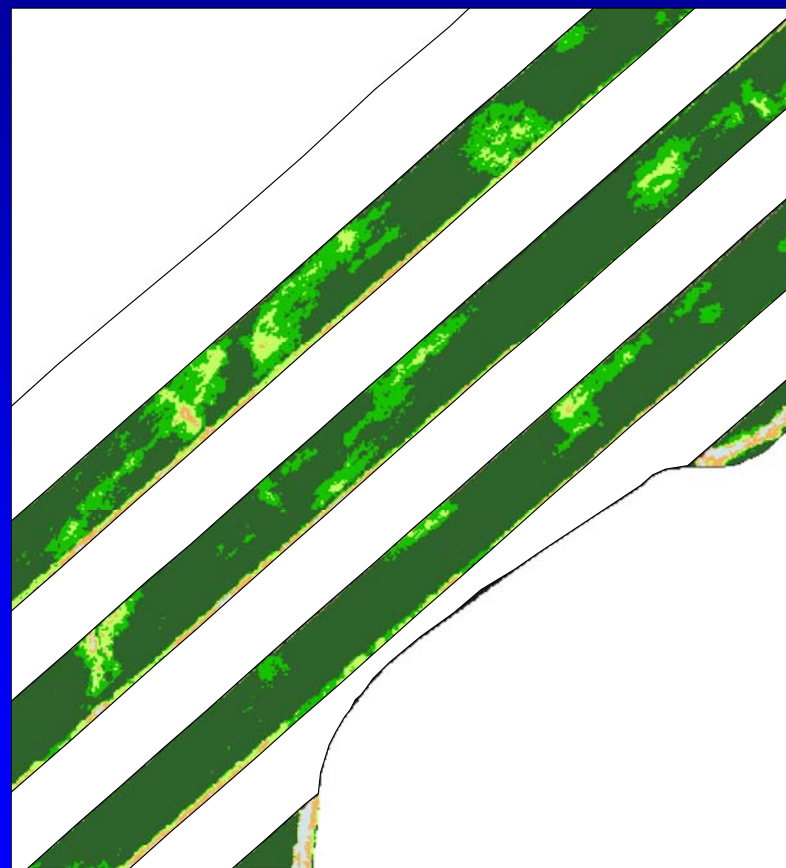
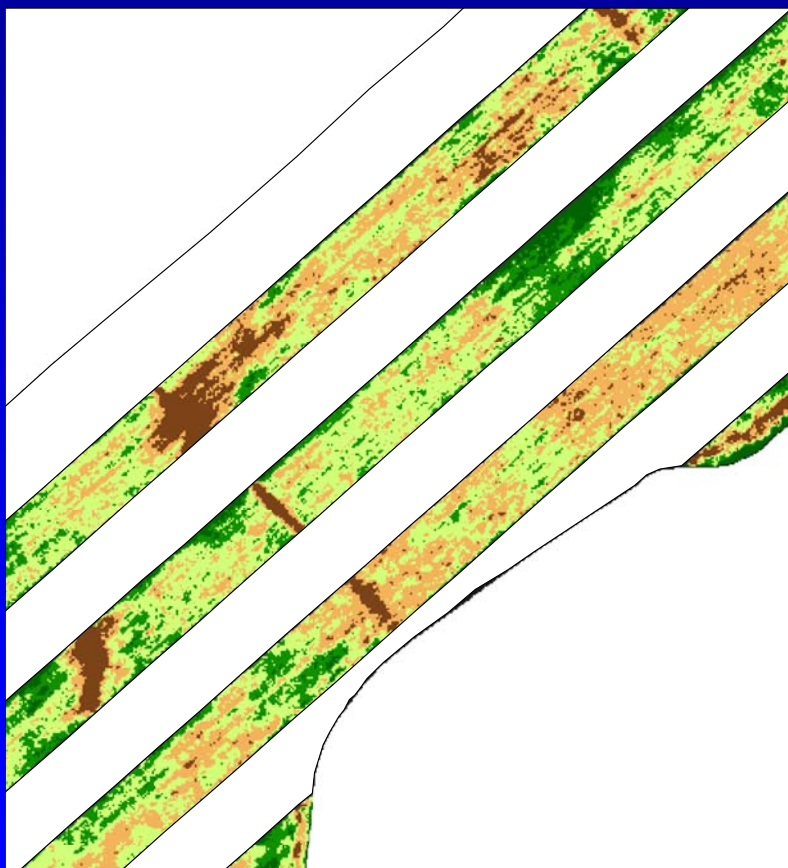
**UT Milan Research & Education Center**

# Scout Maps July 5, 2006





# Early vs. Late Season



# Factors Impacting Scouting Maps

- Spatial Variability in:
  - The Crop (health)
  - Plant/Row Spacing
  - Crop Variety
  - Crop(s) within a Field (scene)

# Image Acquisition → Variable Rate

- Producer scouts field with image (printed map or PDA+GPS)
- Decisions (crop consultants & producers)?
- Application map is created from scout map for producers variable rate controller or aircraft sprayer
- Application map is transferred from PC to Variable Rate Controller & application is made

Mode: **Single Field Analysis**

Grower **Jim Grief**

Farm **Grief Farms**

Field **Kirkwood**

Data Type **NDVI**

Date **2006-08-04**

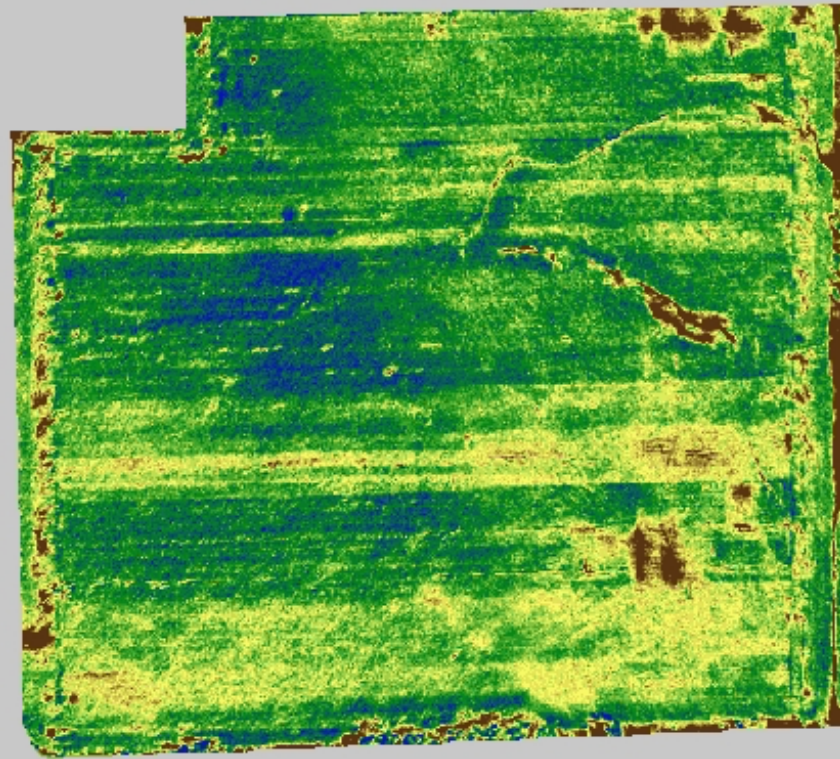
# Zones **4**

Min Zone Size **0.5**

Grid Correction

Custom Break Points

Go



Save

Export

Mode: Single Field Analysis

Grower: Jim Grief

Farm: Grief Farms

Field: Kirkwood

Data Type: NDVI

Date: 2006-08-04

# Zones: 4

Min Zone Size: 0.5

Grid Correction

Custom Break Points

Go

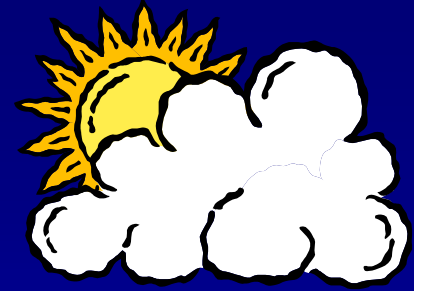


Zone	Acres	Range
1	10.2 Ac.	1.0 - 46.0
2	20.5 Ac.	46.0 - 59.0
3	20.4 Ac.	59.0 - 71.0
4	5.4 Ac.	71.0 - 100.0

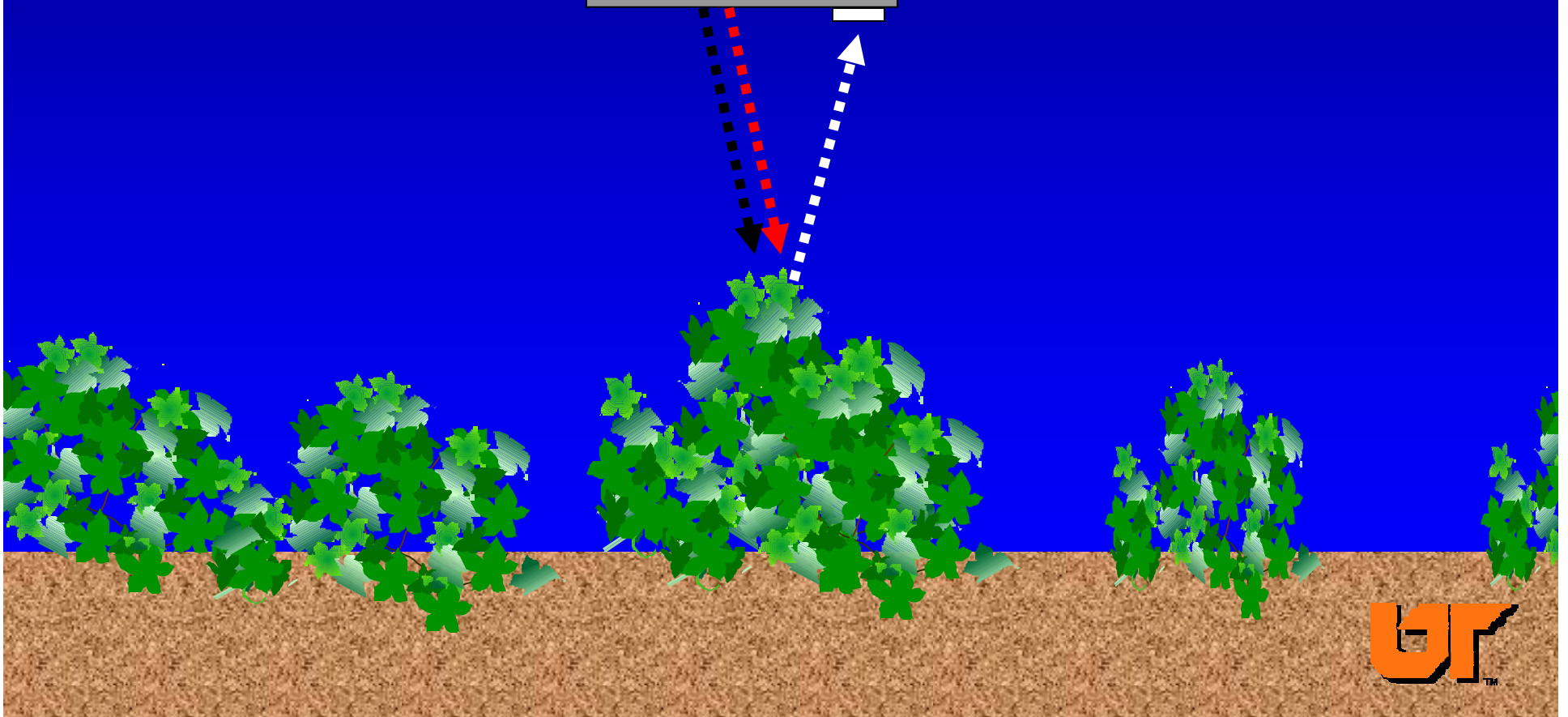
Save

Export

# Real-Time Sensing Machine Mounted



GreenSeeker



# Field-of-View (Resolution)

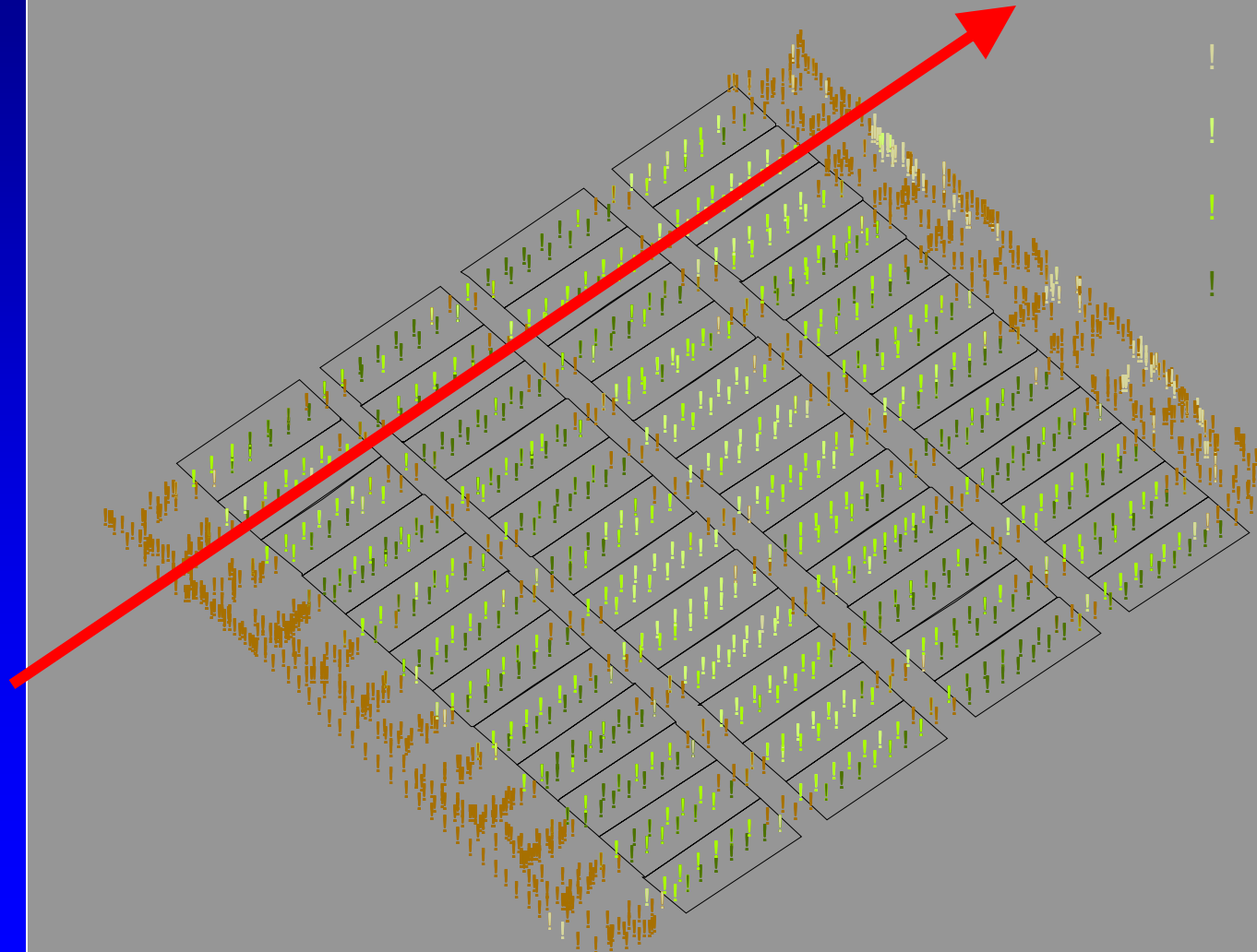


Long-term N-Rate Experiment  
UT Milan Experiment Station

**Legend**

**NDVI**

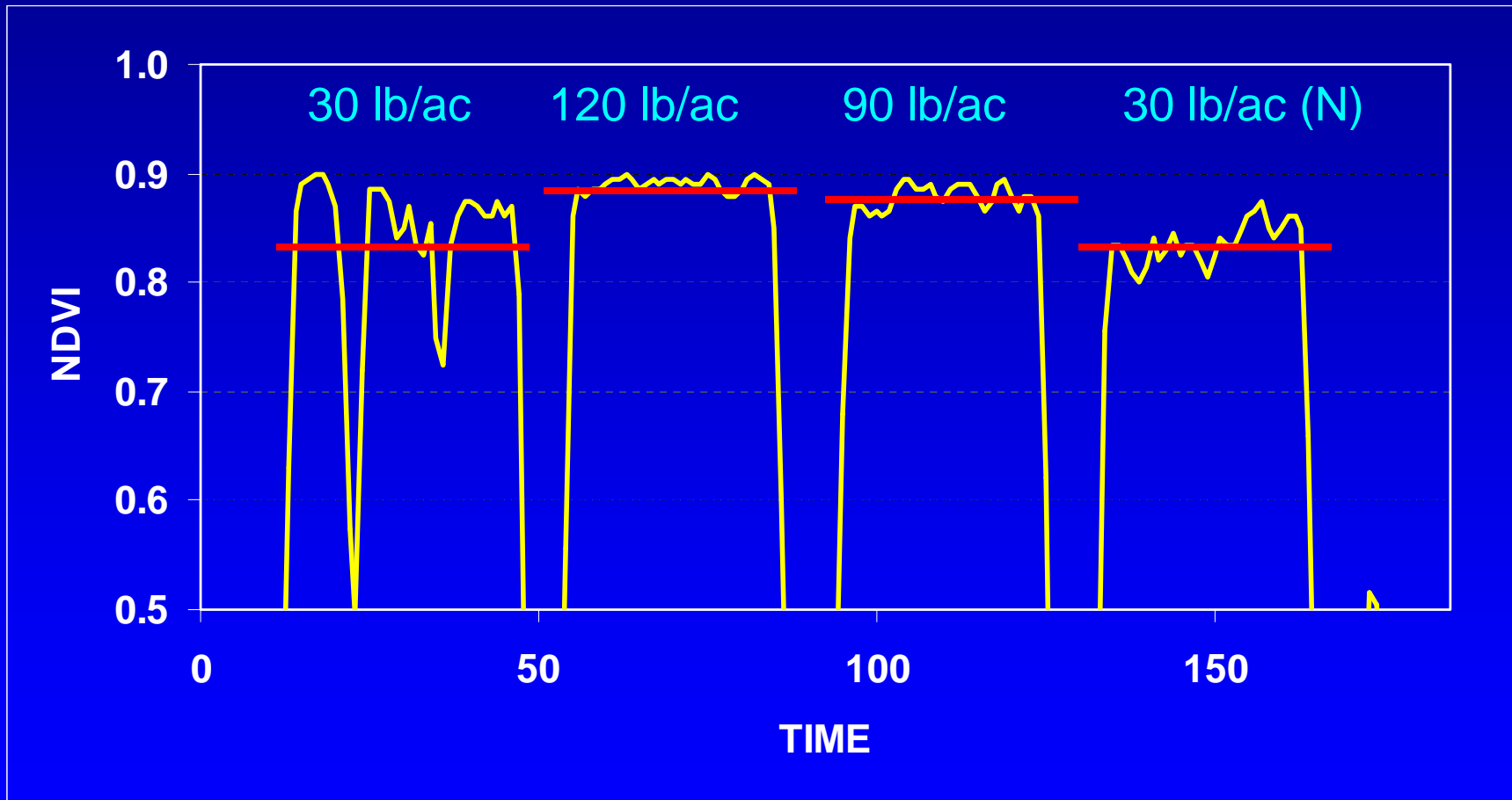
- ! 0.130 - 0.636
- ! 0.637 - 0.773
- ! 0.774 - 0.843
- ! 0.844 - 0.884
- ! 0.885 - 0.919



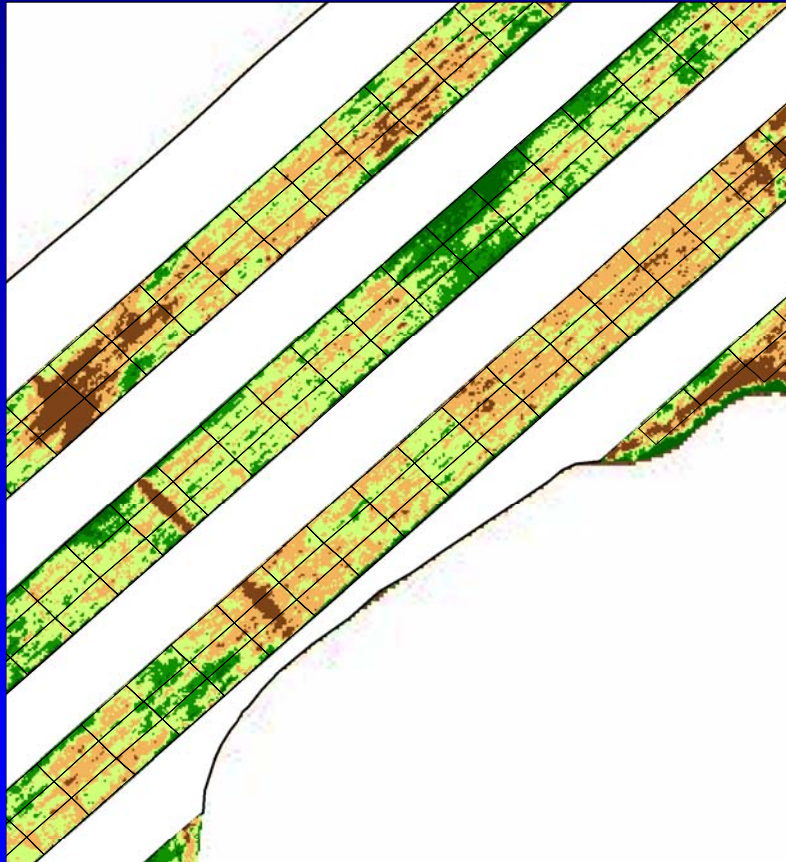


# NDVI

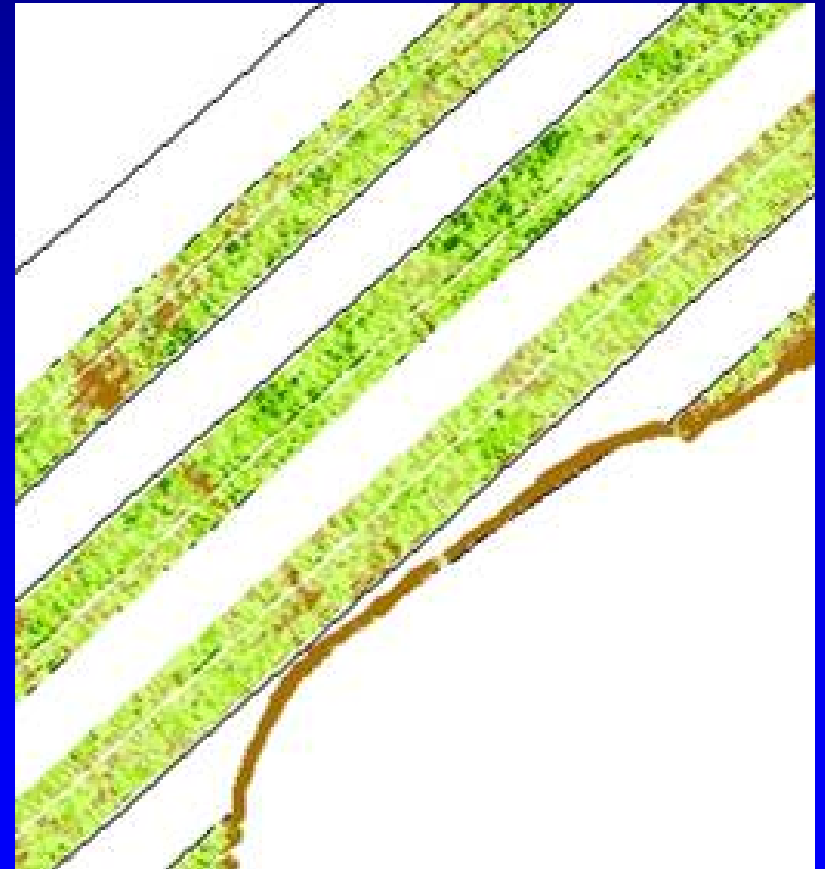
5 reading/sec



**NDVI Map  
from Aircraft (JD)**



**NDVI Map  
from GreenSeeker**



# Airborne Sensing vs. Ground-Based

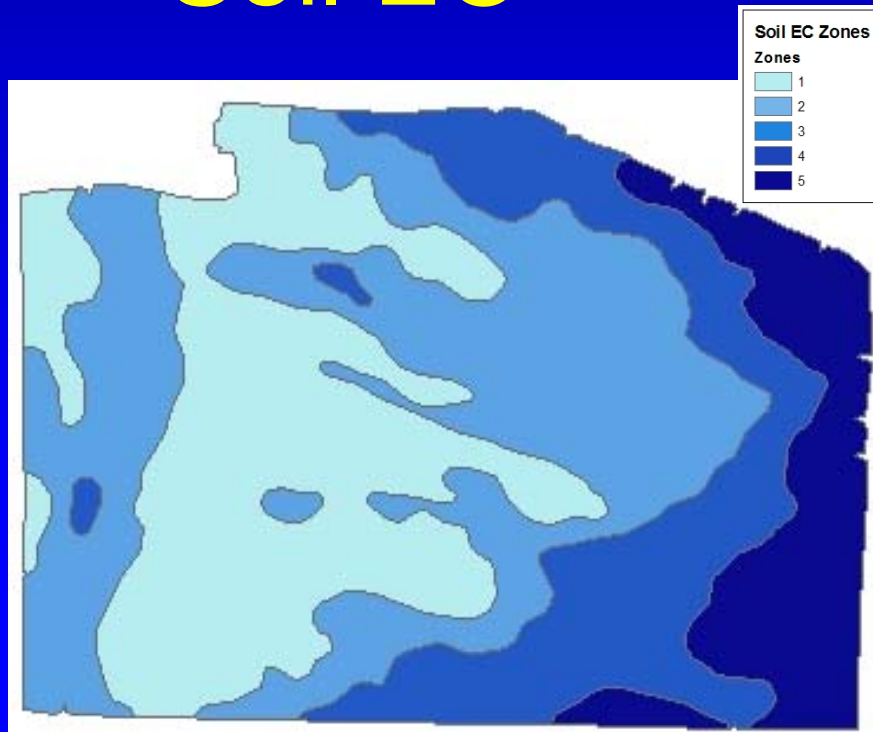
- ✓ Capital Investment
- ✓ Commitment to an Application
- ✓ Weather
- ✓ Producer/Consultant Involvement
- ✓ Spatial Resolution

# Future

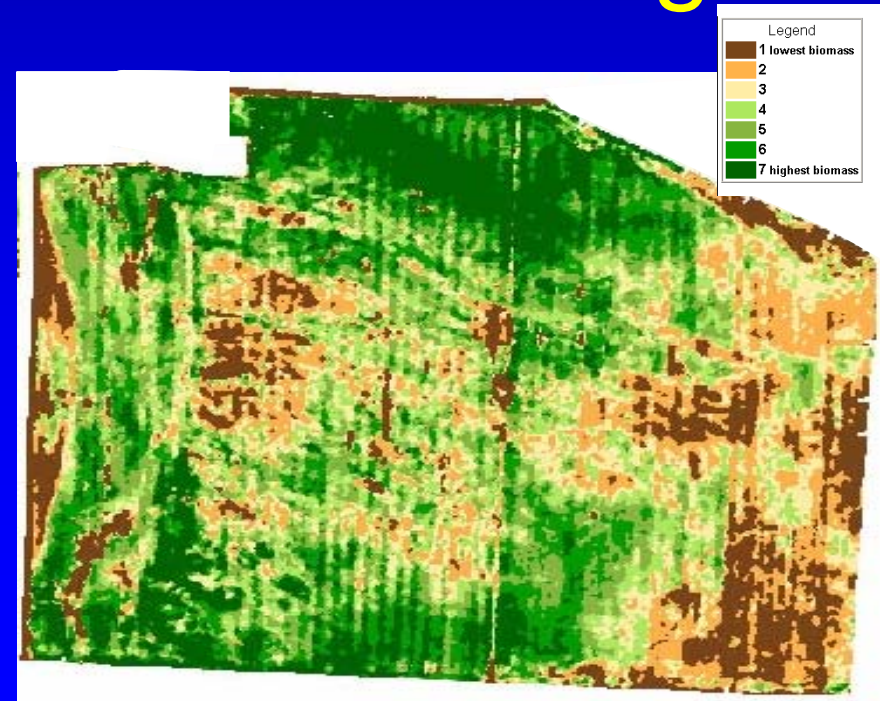
- Difference Maps
  - What has changed from the previous image?
- Integration of real-time sensing with map-based (historic) information
  - Yield maps (yield potential)
  - Soil maps (E.C.)

**Crop reflectance may correlate with:**  
yield, available nitrogen, plant population,  
growth stage, soil properties, moisture  
stress, etc.

## Soil EC

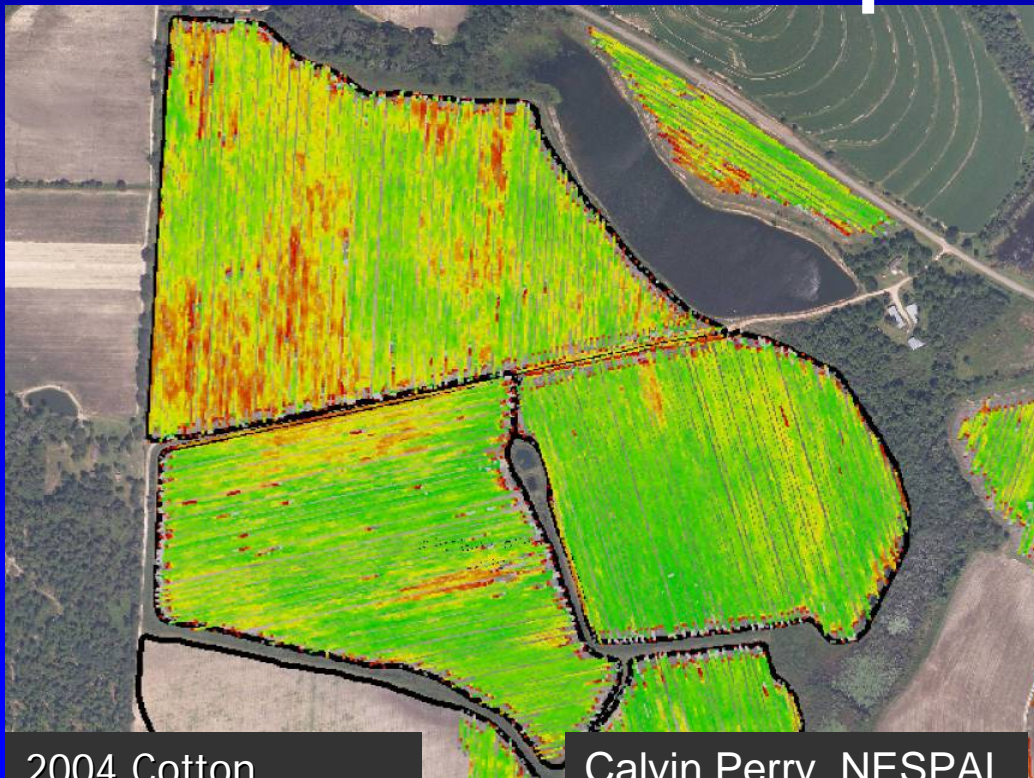


## NDVI Image



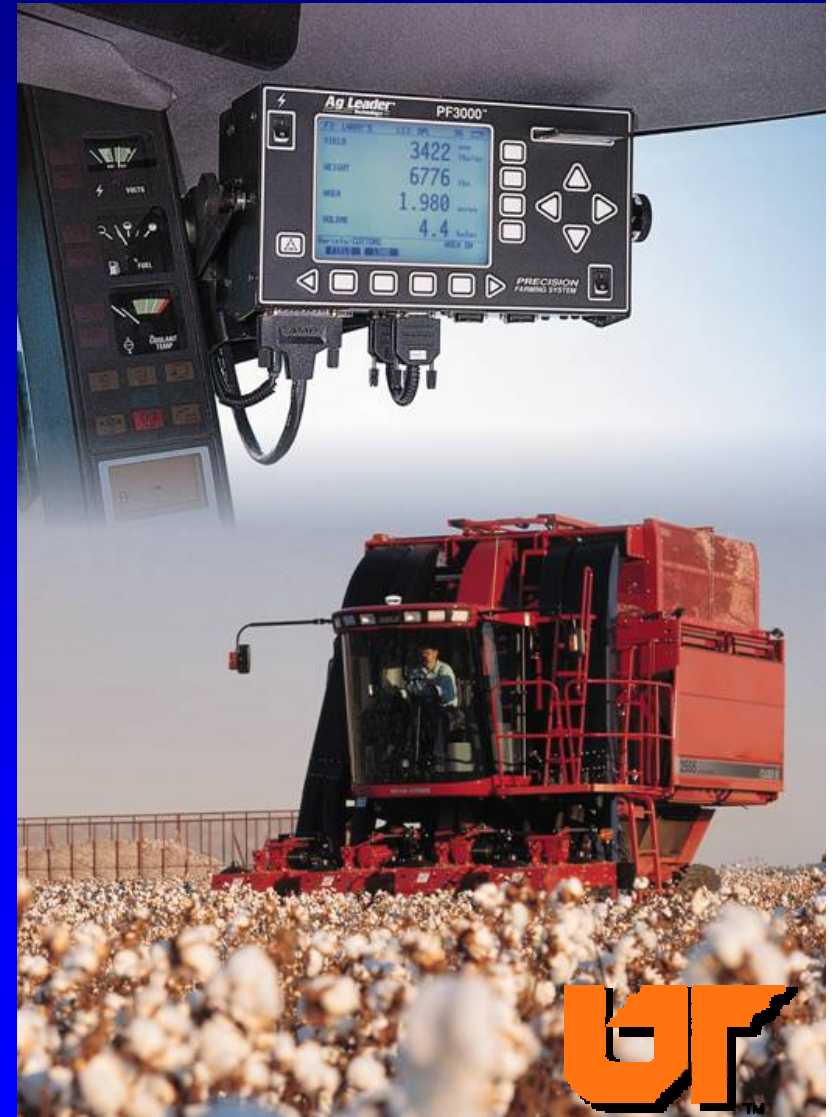
# Did we make the correct decision?

## Cotton Yield Map



2004 Cotton  
Colquitt Co. Georgia

Calvin Perry, NESPAL  
Tifton, GA



**SOLUTIONS**