Quantifying Corn Nitrogen Deficiency with Active Canopy Sensors

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What is an Active Canopy Sensor?

- A form of “remote” sensing
- An instrument designed to determine plant nitrogen stress deficiency
- Basic operating principle
  - Pulse emits set light wavelengths
  - Measures reflected light from the plant canopy at same set wavelengths
- Sensor readings interpreted for on-the-go N application rate determination

Active Sensors

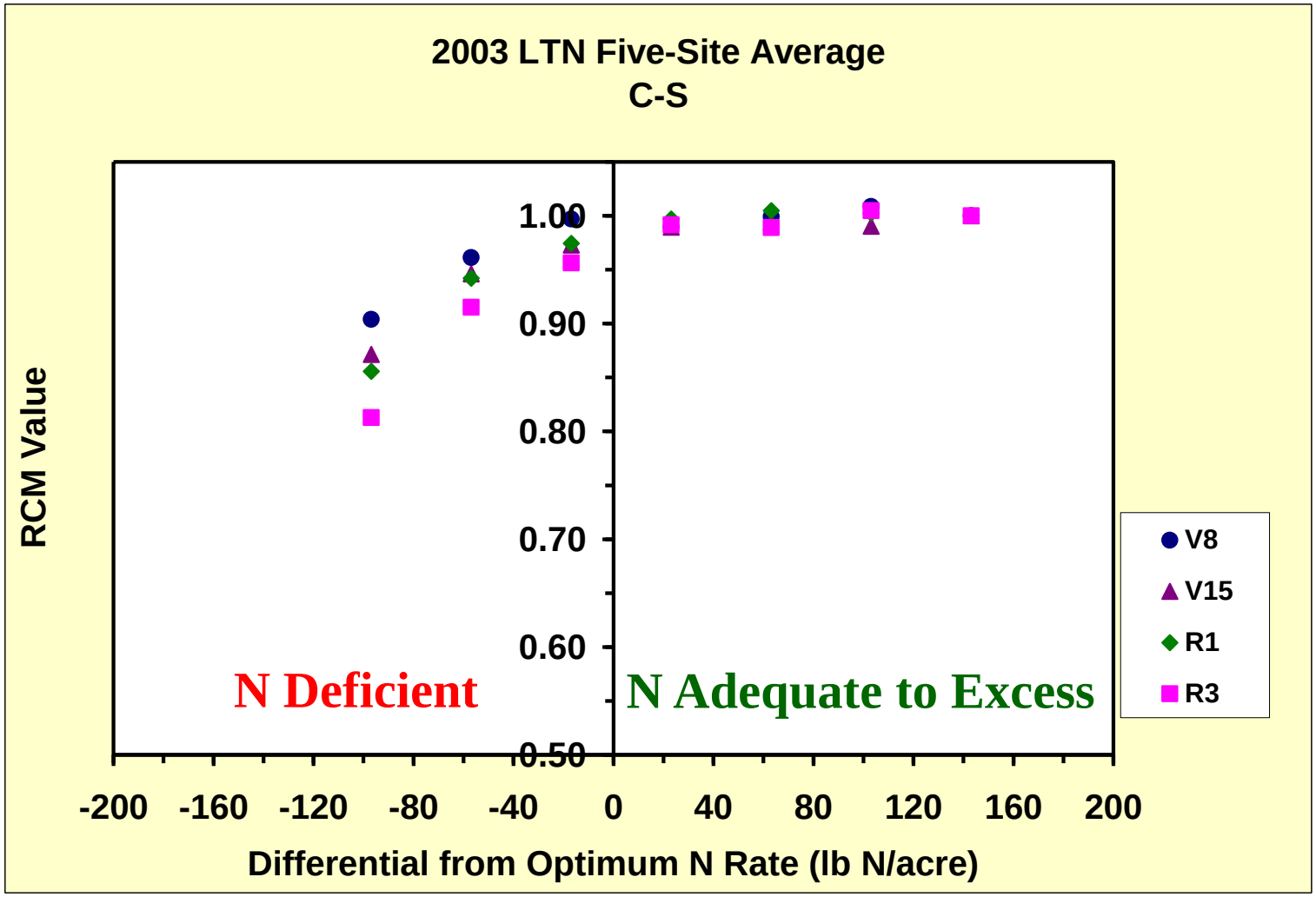
GreenSeeker
Crop Circle

Minolta
SPAD-502 Meter

Sensing Corn to Determine N Sufficiency

- Corn plant must go N deficient to “see” N stress
- Does not indicate excess available N

Sensing Timing (Minolta SPAD Meter)

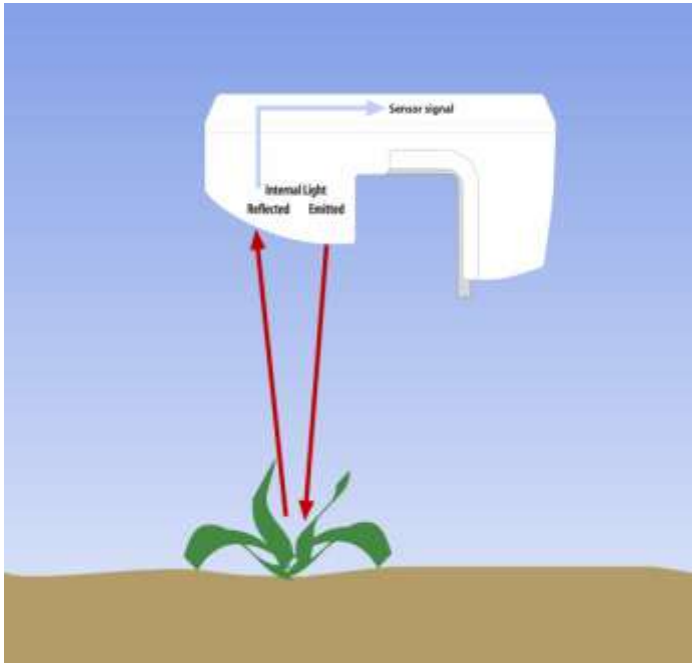


Commercially Available Active Sensors

- Minolta SPAD-502 meter
  - Konica Minolta/Spectrum Technologies
- GreenSeeker
  - NTech/Trimble
- Crop Circle/OptRx
  - Holland Scientific/AgLeader
- CropSpec
  - TOPCON

Active Canopy Sensor Mode of Operation

- Modulated light output at set wavelengths
- Measured set light wavelengths reflected back to sensor



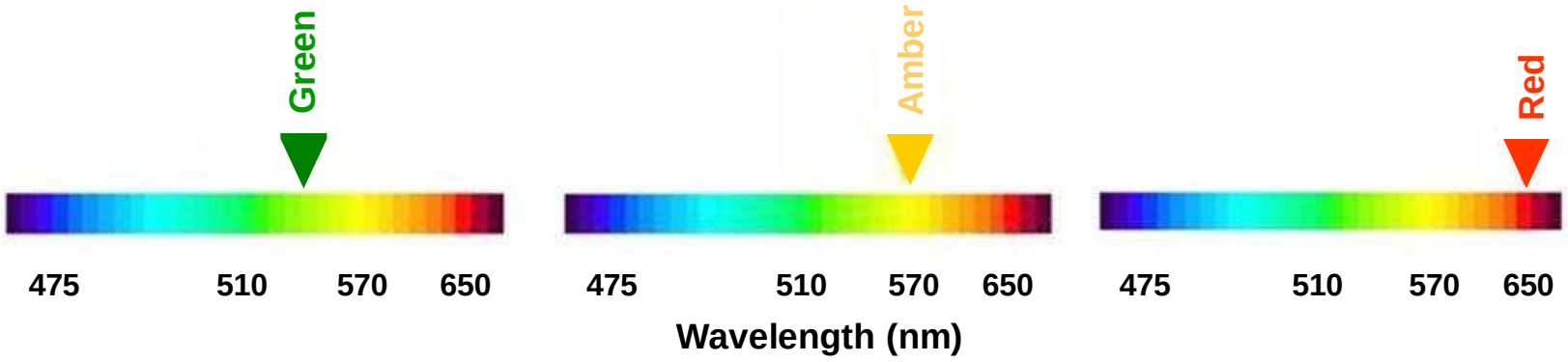
What Happens to Emitted Light

- Light will be reflected, absorbed and/or transmitted
- Interested in the light reflectance (canopy reflectance)

What Happens to Emitted Light

- At specific wavelengths sensors provide
  - Proportion of emitted light that is reflected
  - Example with two wavelengths
    - NIR: light reflected ÷ light emitted
    - VIS: light reflected ÷ light emitted

Active Sensor Wavelengths



Sensor	Visible, nm	NIR, nm	Other, nm
Minolta SPAD Meter	650 (red)	940	
GreenSeeker 506	560 (green)	774	
GreenSeeker 505	656 (red)	774	
Crop Circle ACS-210	590 (amber)	880	
Crop Circle ACS-430	670 (red)	780	730 (red edge)
Crop Circle ACS-470	various	various	various
CropSpec		800-810	730-740 (red edge)

Sensor Evaluation Research

- Nitrogen rate trials with SC and CC
  - 62 site-years at seven ISU research farms
- Sensing at V10 - V12 corn growth stages
- Sensor at 24 - 36 inches above canopy
- Sensor positioned between corn rows
- Active sensors
  - Holland Scientific Crop Circle ACS-210 (“amber”)
  - NTech GreenSeeker 506 (“green”)
  - NTech GreenSeeker 505 (“red”)
  - Minolta SPAD-502 meter

Canopy Indices

- Many indices evaluated
  - SPAD is a direct reading from the meter
  - Most common active canopy sensor indices
    - Normalized Difference Vegetative Index (NDVI)
      - (NIR – VIS) ÷ (NIR + VIS)
    - Chlorophyll index (CHL)
      - (NIR ÷ VIS) – 1

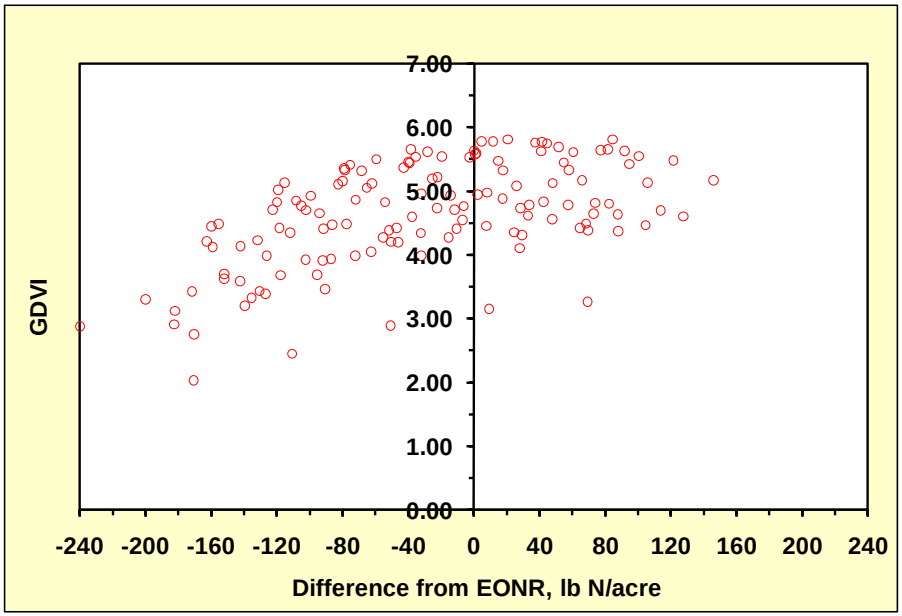
Relative Index Values

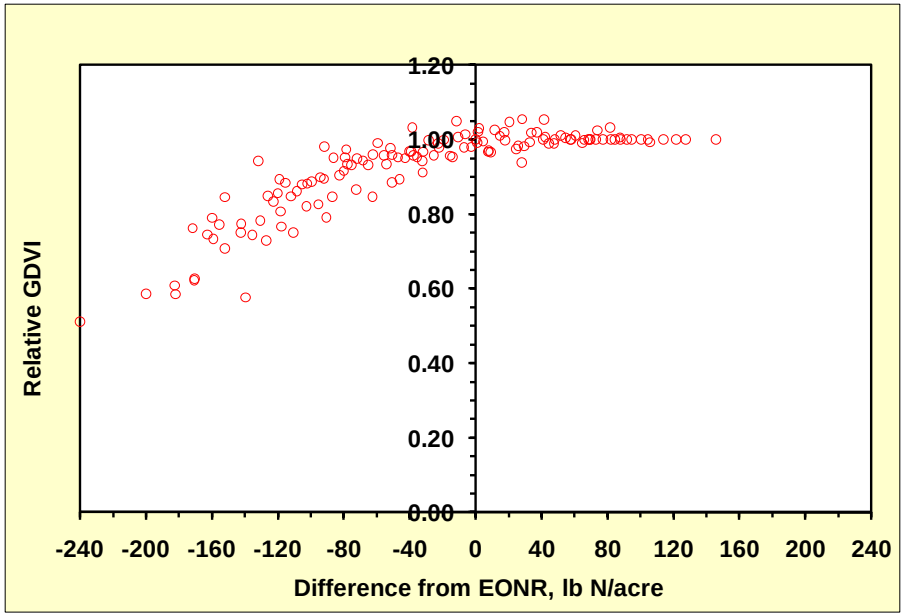
- Sensor index for each N rate normalized to highest N rate in study
  - Normalized to non-N stressed corn
  - N deficient (target) ÷ non-N stressed (reference)

Why Use Relative Index Values?

- Various canopy characteristics influence sensor readings and index values
  - Leaf chlorophyll
  - Whole plant biomass
  - Canopy temperature
  - Canopy moisture
  - Hybrid
  - Plant density (population)
  - Other nutrient deficiencies

Why Use Relative Index Values?

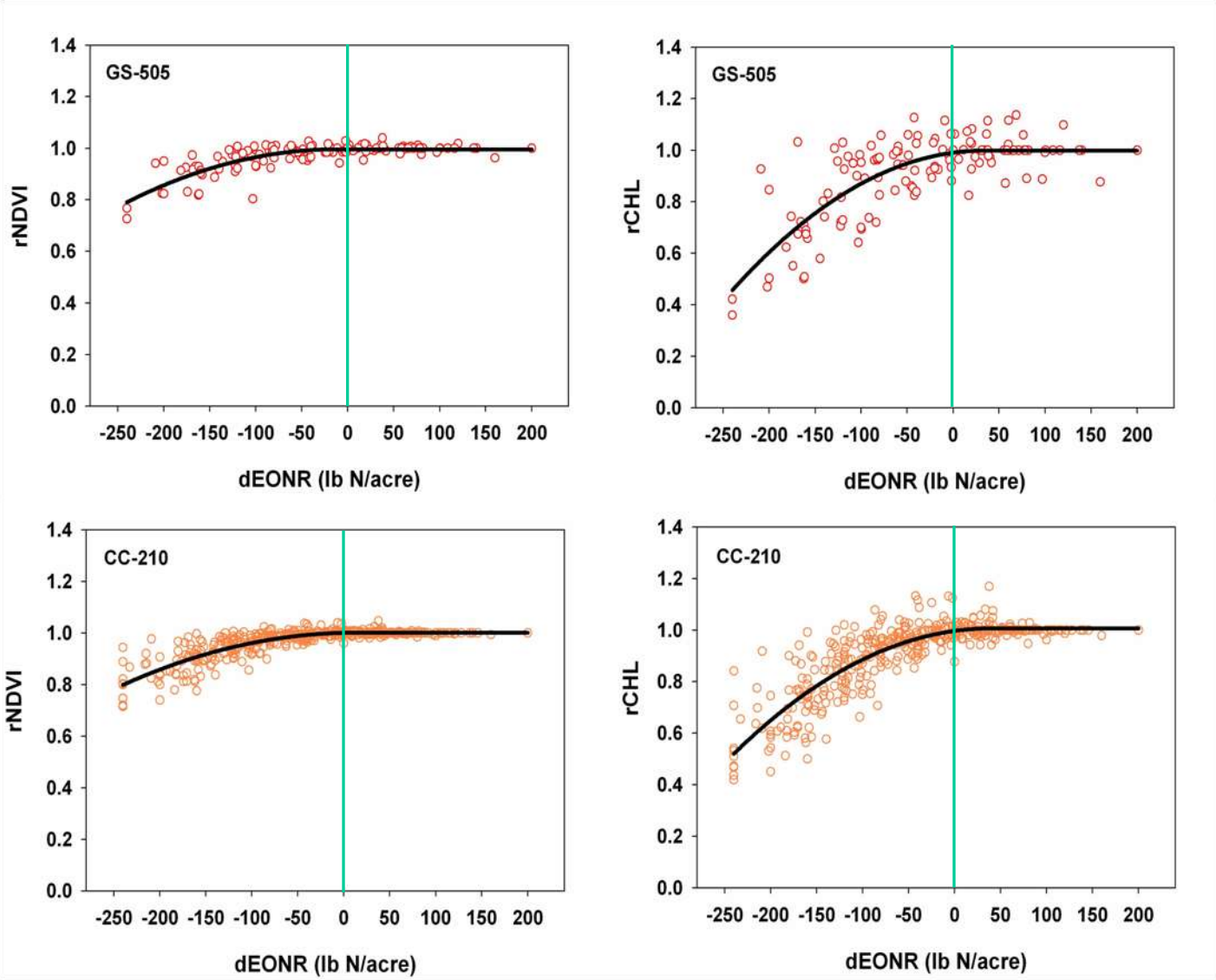




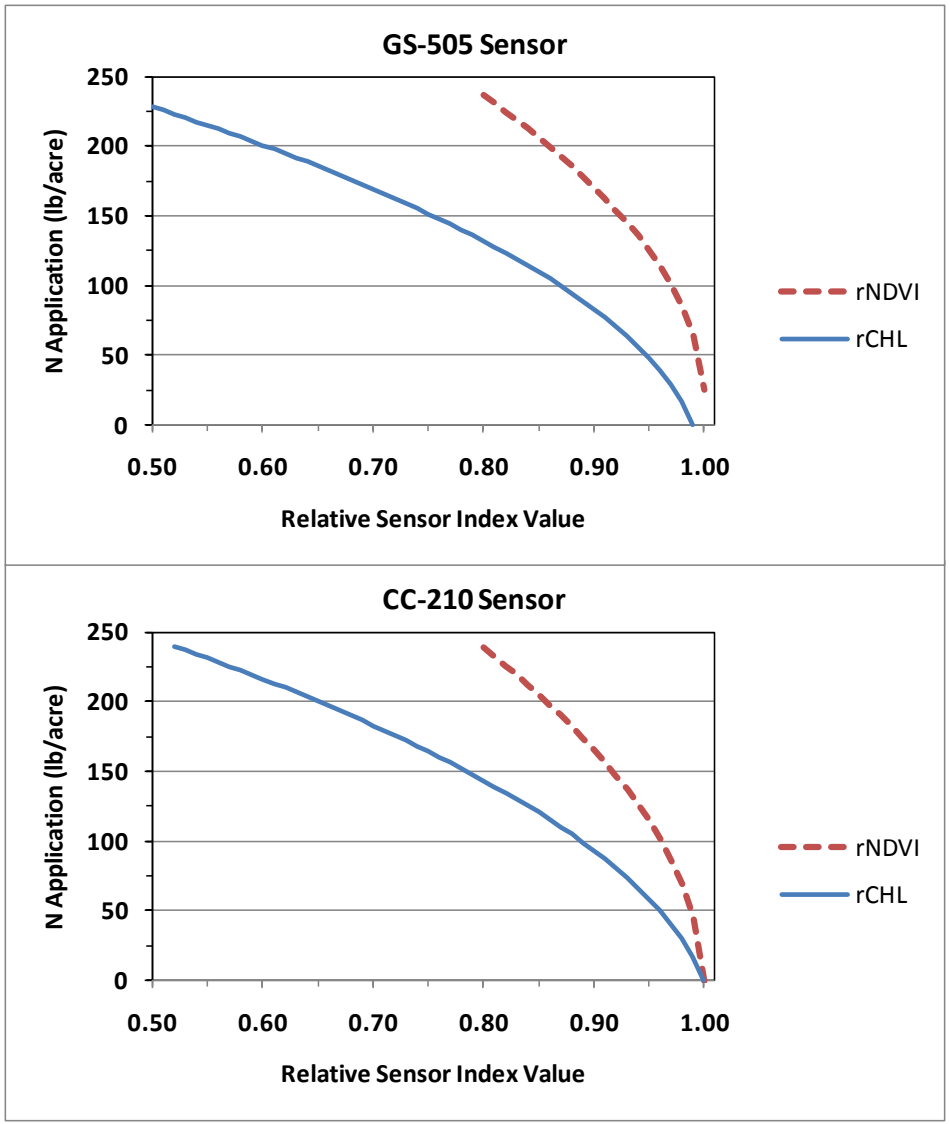
Index Calibration Research

- Calibration of relative index values is a key to making N rate recommendations with active canopy sensors
- Differential from EONR (dEONR) compared to relative index value

Calibration – GreenSeeker and Crop Circle



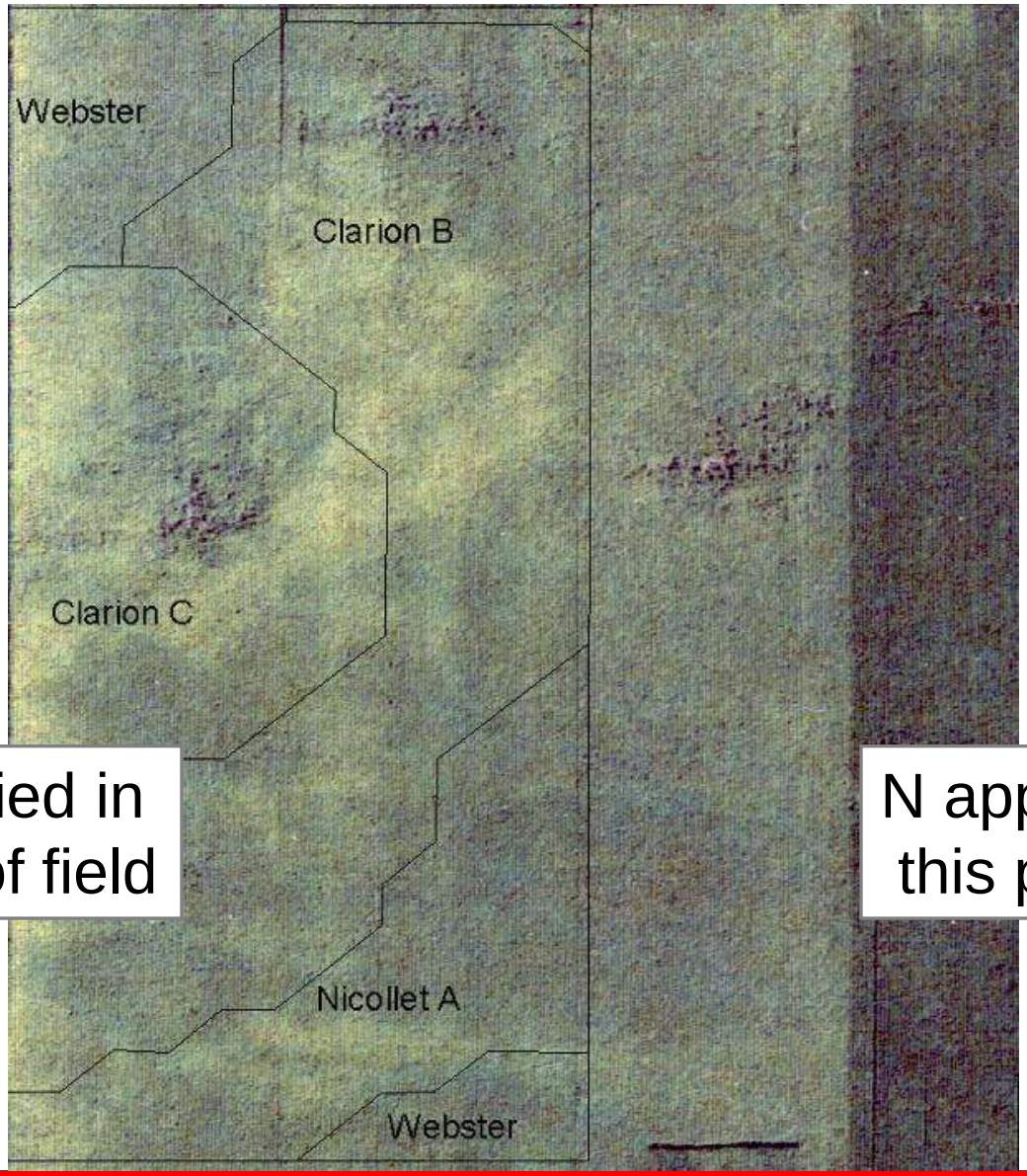
Sensor Based N Application Rate Estimation



Challenges with Sensing Corn for N Application Adjustment

- Corn plant must go N deficient to “see” N stress
- Avoid yield loss
  - N deficient plant
  - Late applied N available to plant
- Preplant/at-planting N rate
- Predict in-season N rate
- Time, availability, and cost for sensing data

Seeing Field Variability in N Deficiency



No N applied in this part of field

N applied in this part of field

Thoughts on Corn Canopy N Sensing

- Optical canopy sensors can differentiate N stress in corn at mid-vegetative growth stages
- Slight N deficiency is hard to “see”
- Need calibrated sensors and indices
- Need sensor indices
  - That are highly related to optimum N
  - That have a wide range across deficit N
  - That have high differentiation with slight to moderate deficit N

Thoughts on Corn Canopy N Sensing

- Decisions when to limit or not apply N
  - Limit application when chance of response is low or avoid application when corn will not respond
  - Avoid application when there are no plants
  - Avoid application when biomass (growth) stress is not due to N stress
- Refinement of protocol for non-N limiting reference
  - Is a must for N-stress sensing

Reference Corn?

Thoughts on Corn Canopy N Sensing

- Need good user manual
  - Sensor operation
    - Ex. height above corn, timing/crop stages
  - Integration with VRT
    - Number of sensors, controller, smart software
  - Non-N limiting reference
    - Real or virtual
  - Dealing with situations driving incorrect prescribed N application
    - Poor/missing plants, water damaged plants, etc.

Thoughts on Corn Canopy N Sensing

- Which approach?
  - Planned sensing and in-season N application
    - Attempt to fine-tune N rate and enhance NUE
  - Reactive to climatic conditions
    - Dealing with a wet year