Proceedings of the 3rd Annual Nitrogen: Minnesota's' Grand Challenge & Compelling Opportunity Conference

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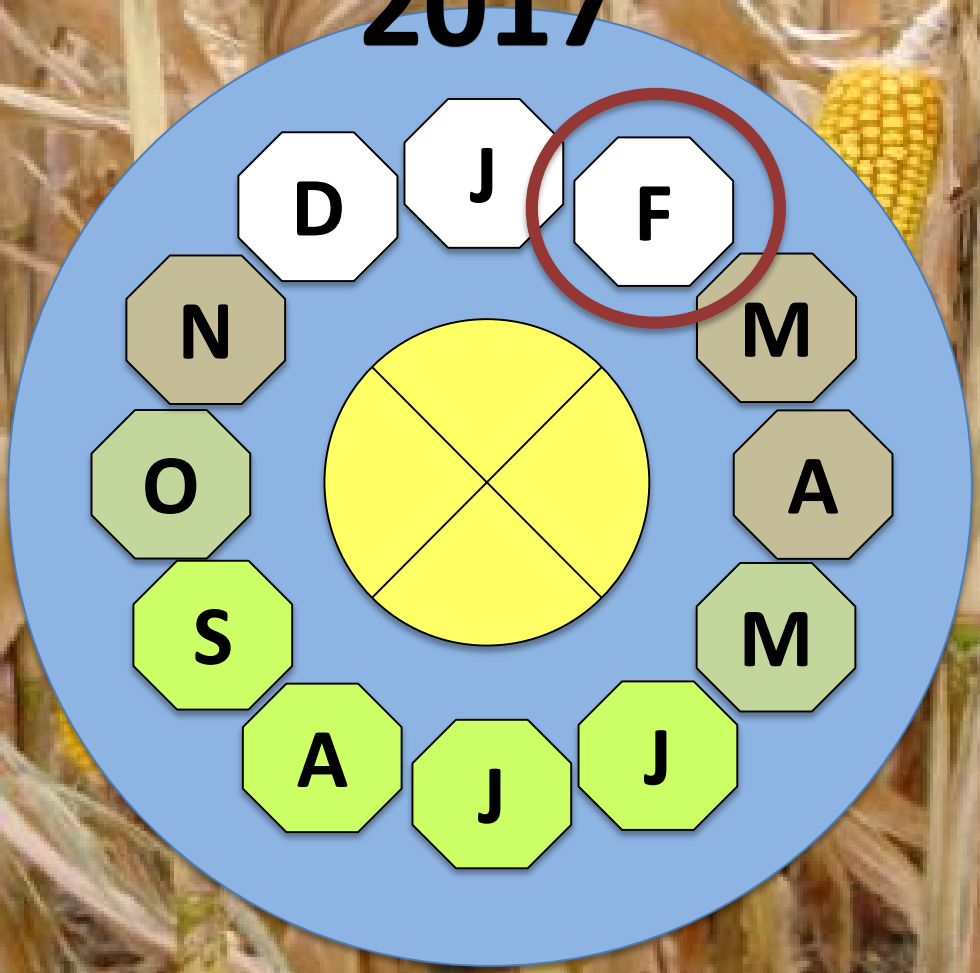
Corn Yield and N Management Tools

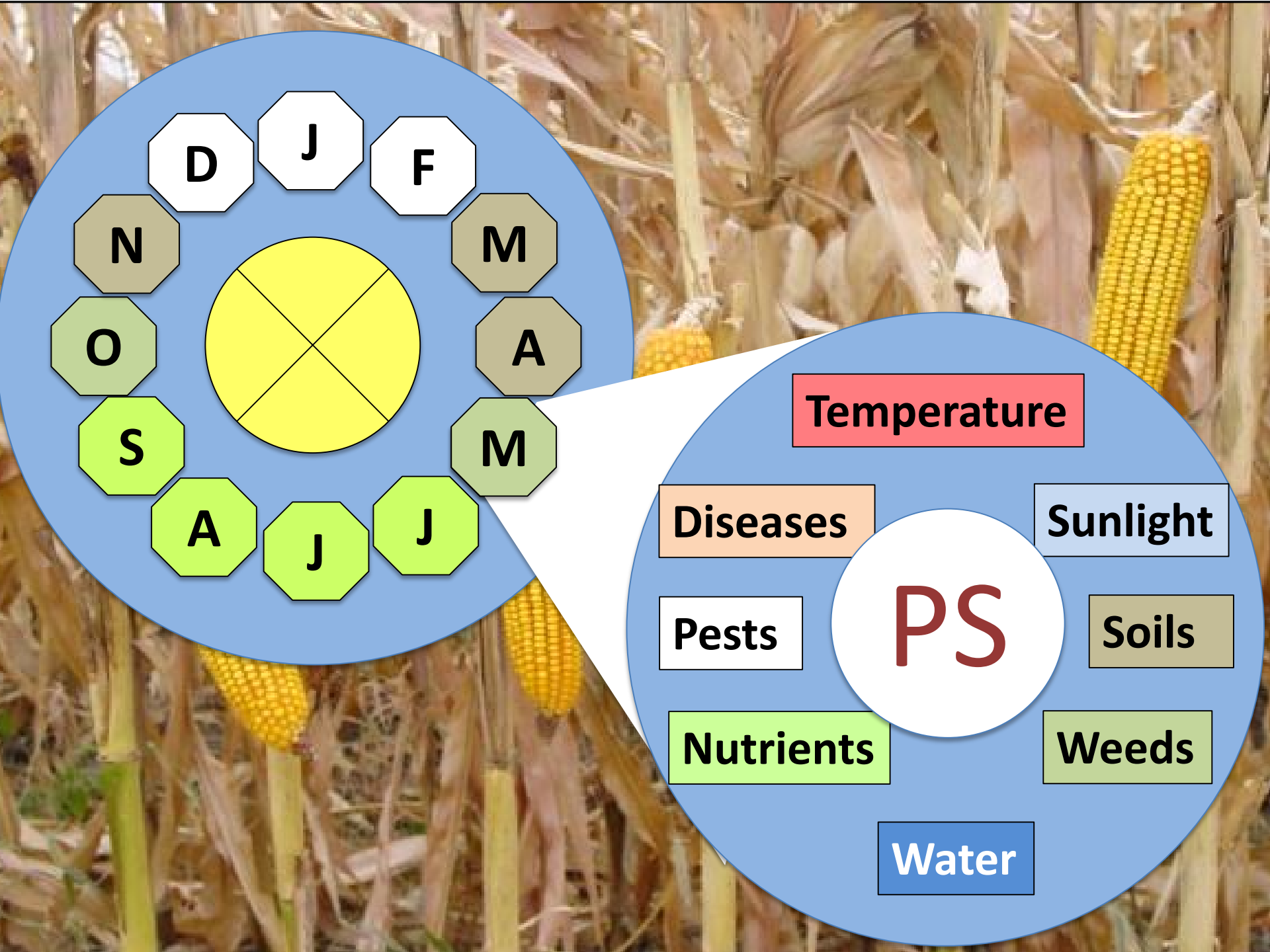
A .....
B .....
C .....
D .....
E .....
.

Promises

Pitfalls



Jim Schepers
Retired USDA-ARS


D
J
F
N
M
O
A
S
M
A
J
J
Temperature
Diseases
Sunlight
PS
Pests
Soils
Nutrients
Weeds
Water

Tasks and Activities . . . . . Services ?

Corn Production

Soil sampling and fertilizer rates

Seed selection

Plant emergence survey

Weed scouting

Insect and disease scouting

Irrigation scheduling

Irrigation water quality testing

Tissue testing

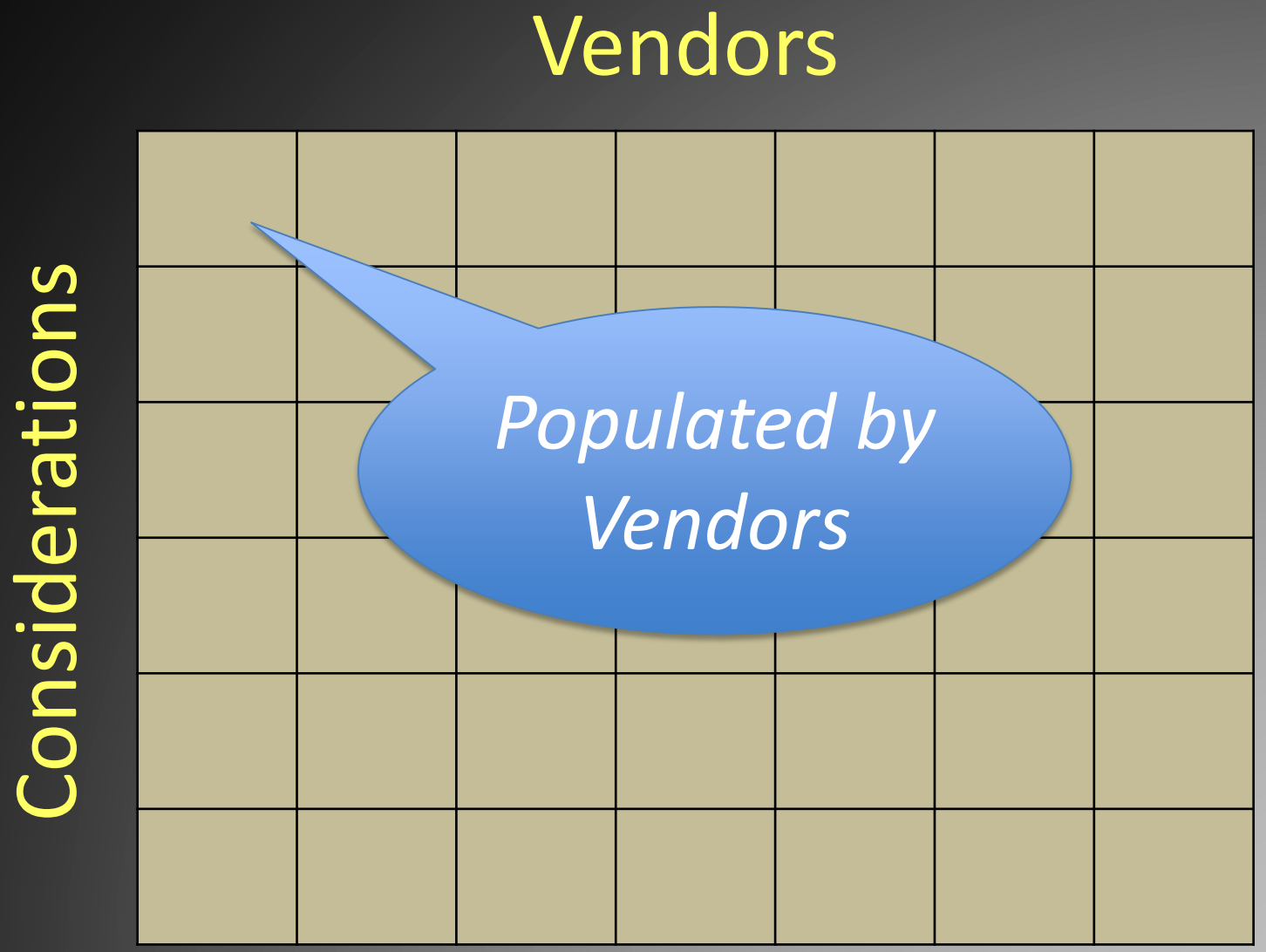
Remote sensing (*plant health, irrigation problems*)

Yield map analysis

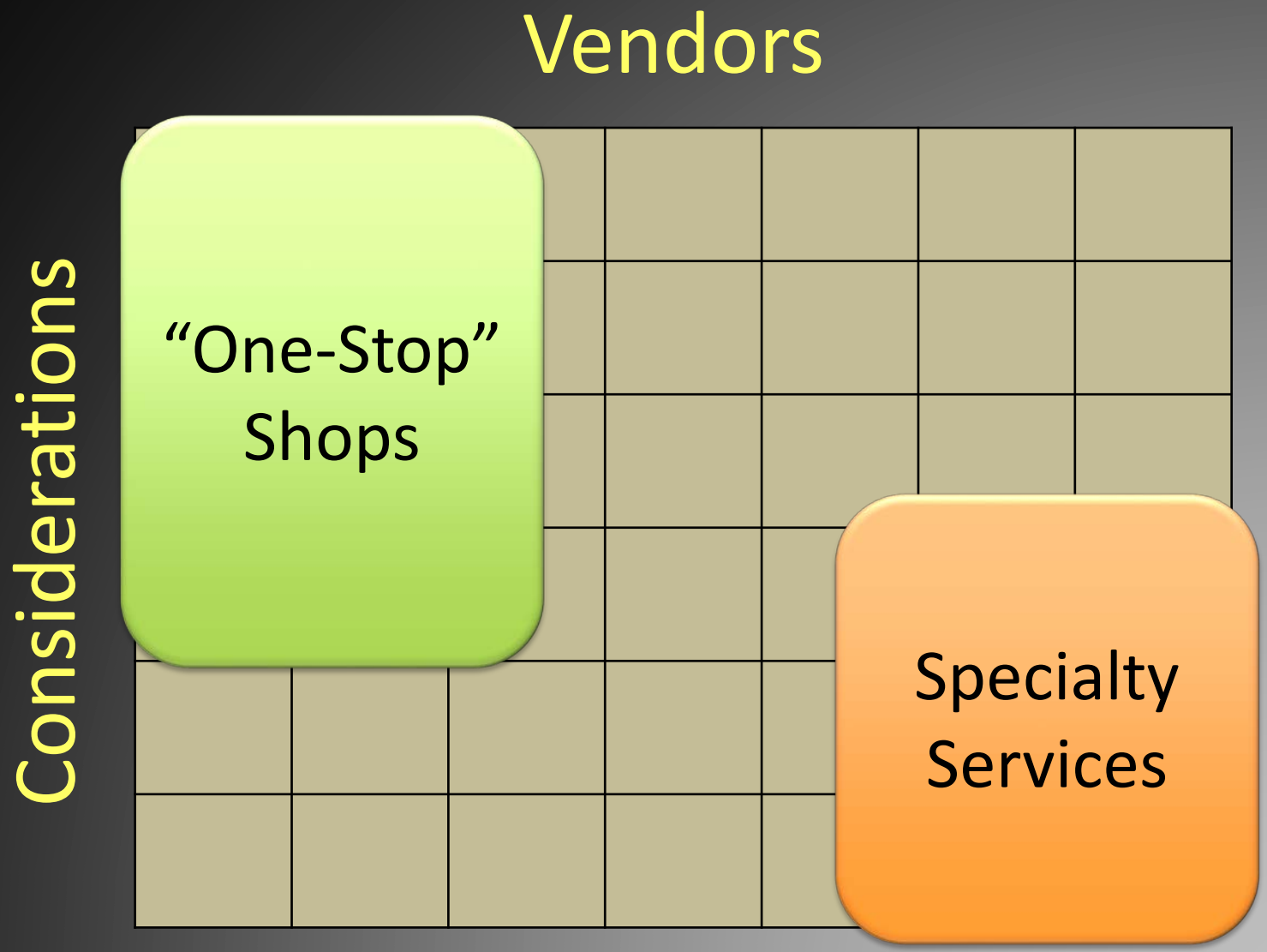
Reporting requirements

- nitrate-N concentration in groundwater
- fertilizer N recommendation
- total N applied
- inches of water applied
- yield

Nitrogen Management



Nitrogen Management



Commercial Management Products

DuPont Pioneer "***Encirca***"	*genetics*
Monsanto Climate Corp "***FieldView***"	*genetics*
"***Adapt-N***"	*software*
WinField "***R7 Tool***"	*resch/advisory*
Western Ag	*consulting*
Farmer's Edge	*consulting*
ServiTech	*consulting*
Beck's Hybrid "***FARM Server***"	*genetics*
Yield 360 Center	*tools/devices*
SATSHOTS	*imagery*

Considerations

- **Goal**
  - **Climate**
  - **Soil**
    - **Water Processes**
    - **Models** (crop, water, nutrients & climate)
      - **Hybrid Selection**
        - **Yield Maps**
        - **Tissue Testing**
        - **Remote Sensing**
          - **Previous Crop**
          - **Residual N**
          - **Field Level vs. Spatial Nutrients**
          - **Cultural Practice Tools**
            - **In-Season Advice**
            - **Marketing** (sales & purchases)
            - **Multiple Product Sales**
            - **Web Site**

Goals

Conveniently-deliver decision support services that help growers ***increase profitability***, ***production stability***, and ***sustainability***

Solution to help ***maximizing inputs*** while ***optimizing yield***

Profit maximization, ***risk mitigation***, and ***scalable environmental benefits***

Maximize yield profitability

Optimize profitability using multiple nutrient response (N, P, K, S) curves, crop prices, and fertilizer costs

Sustainable production of ***high yielding*** and ***high quality*** crops

Goals

Optimize producer profitability by routine field inspections, by recommending and helping incorporate appropriate technologies for fertility, varieties, irrigation, tillage, weed/insect management, federal/insurance programs, etc;

Offer a simple, secure, web based program to monitor variables and collect and analyze data to ***increase productivity***

Measure and supply the right amount of N when the crop is ready to use it

Deliver "***Crop-Health Imagery"*** analysis and notifications that **facilitate real-time management** and actionable variable rate application maps of fields

Climate

Class-A Weather Station

Provides long-term records

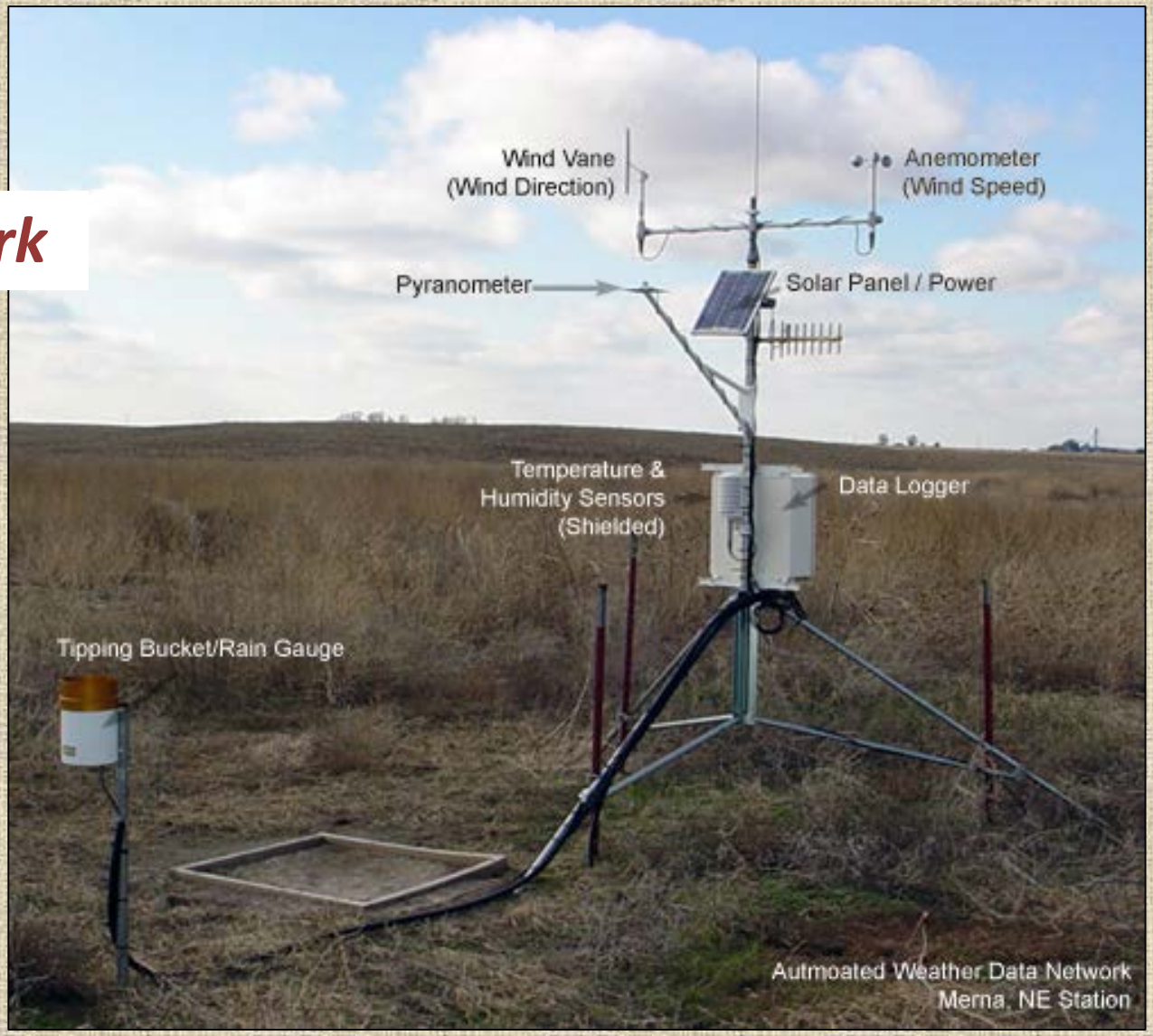
Farm Weather Data

DTN network

Typical Network Weather Station

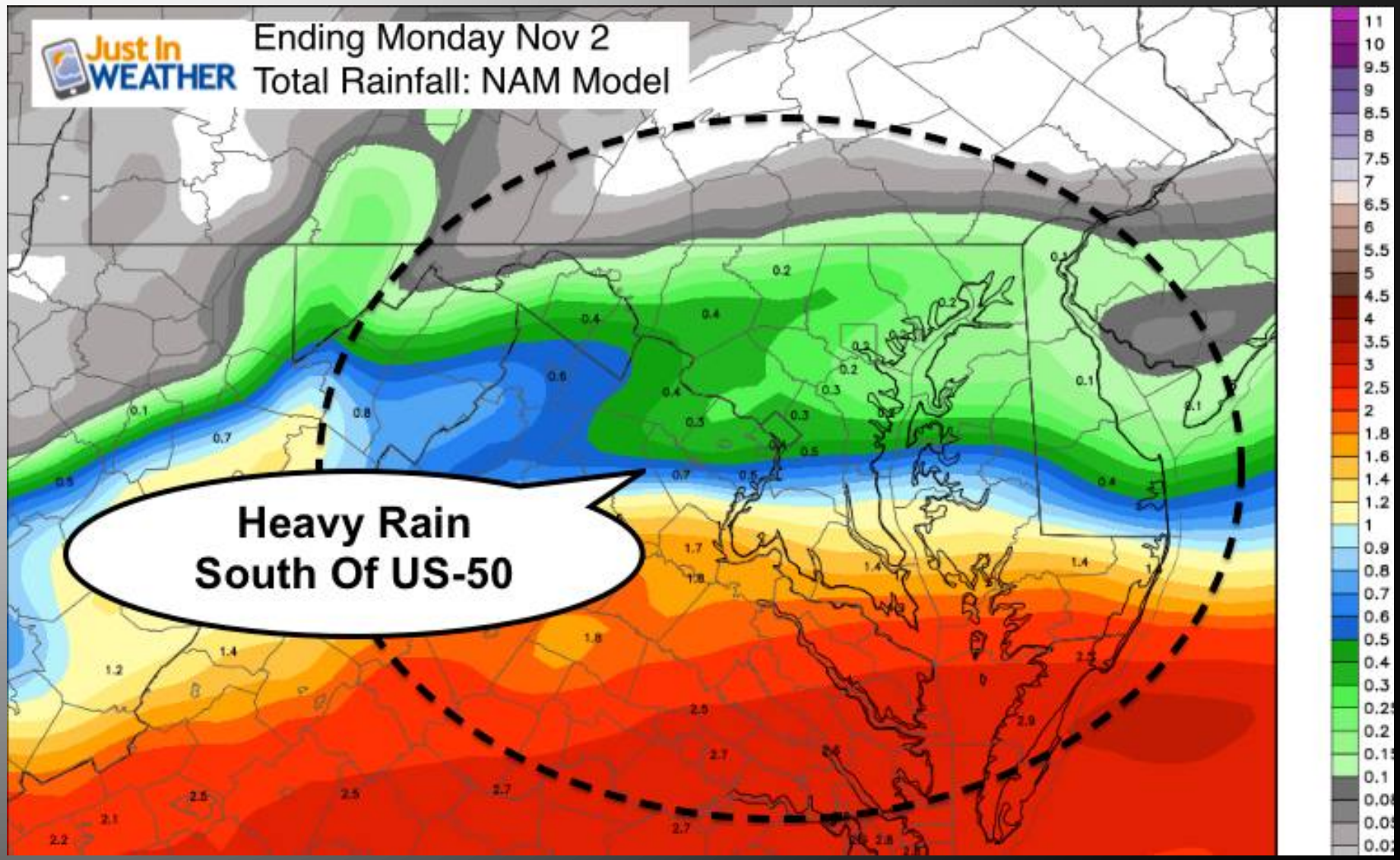
10 - State Network

"Mesonet" Stations



High Plains Regional Climate Center, Lincoln, NE (www.hprcc.unl.edu)

Simulated Precipitation Map - Example



Map based on radar data that was calibrated using rainfall records

Encirca Weather Network

Layer Settings

Base Map

Official Stations

Local Ag Wx Stations

Soils

SSURGO data base (*means* Soil Survey Geographical)

Generated and maintained by USDA - NRCS

See: websoilsurvey.sc.egov.usda.gov

Search

Area of Interest

Import AOI

Quick Navigation

Address
State and County
Soil Survey Area
Latitude and Longitude
PLSS (Section, Township, Range)

SSURGO → Automatically linked to some service providers

Water Processes

"Infiltration"

Some commercial services use models to estimate water infiltration, percolation and N losses.

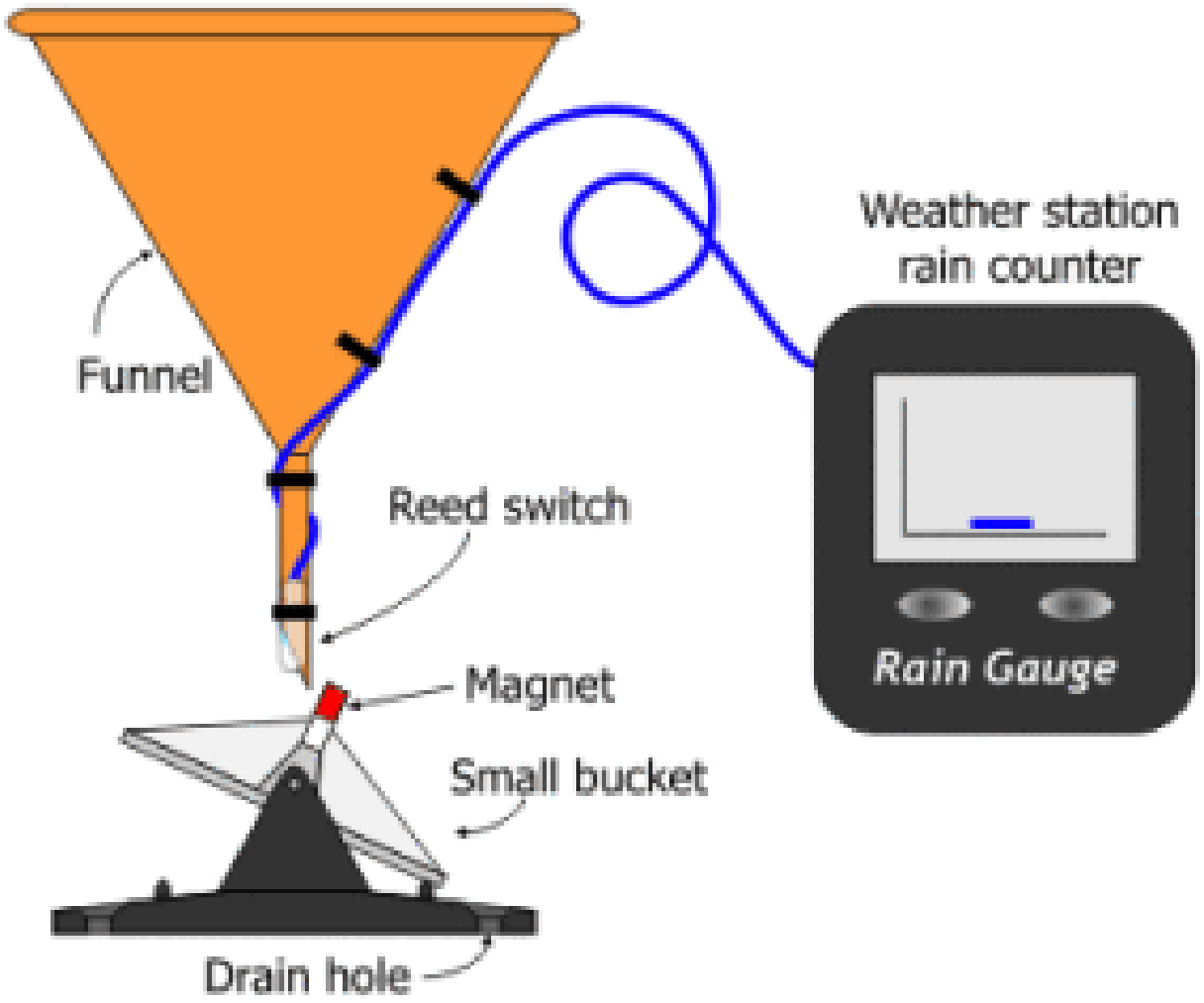
needs SSURGO soil ***PLUS*** *climate data*

most use the tipping-bucket rain gauge approach, **IF ANY**

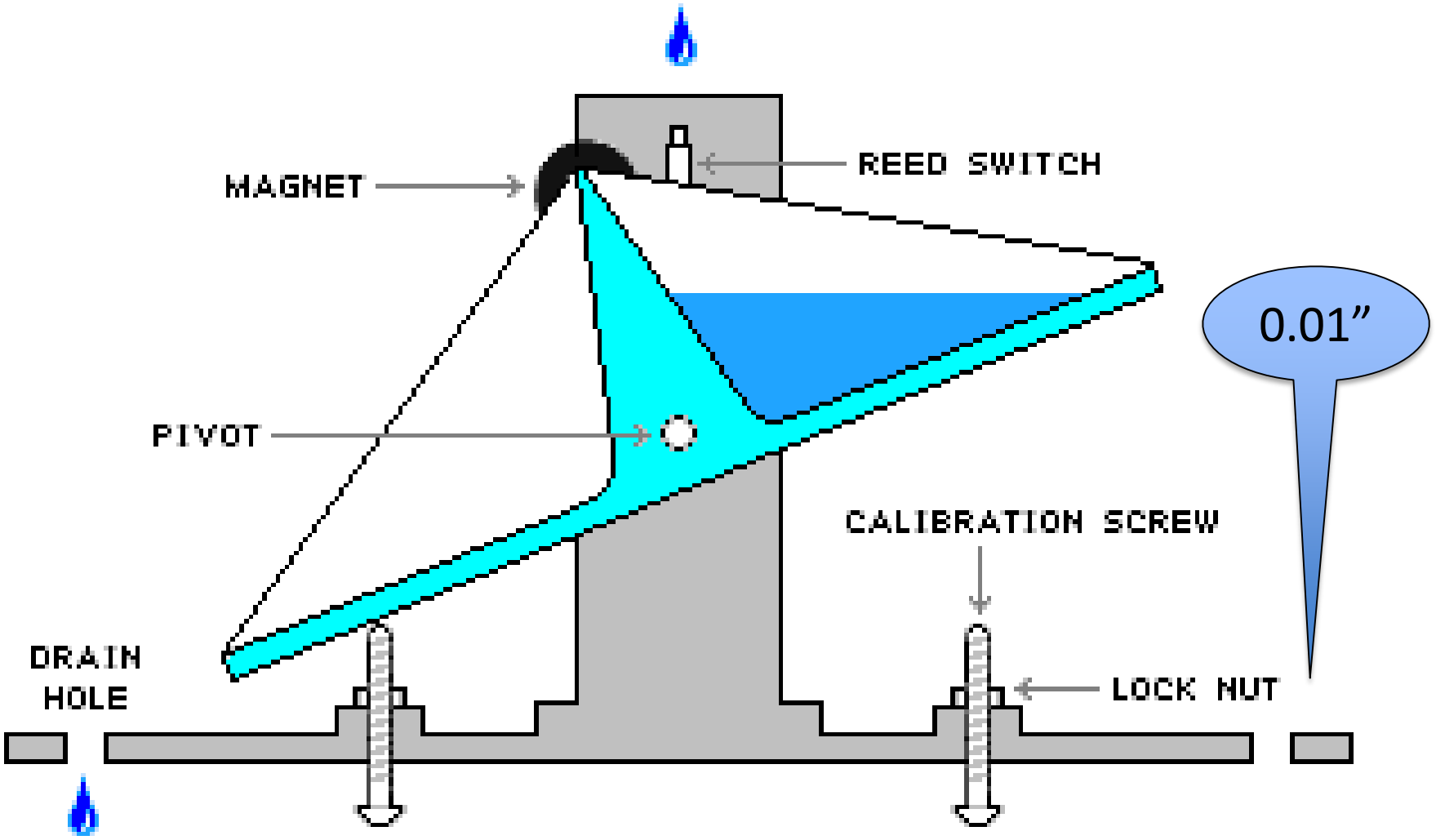
"Hydrology"

Some commercial services use models to route water across the landscape and to the edge of the field.

Tipping Bucket Rain Gauge

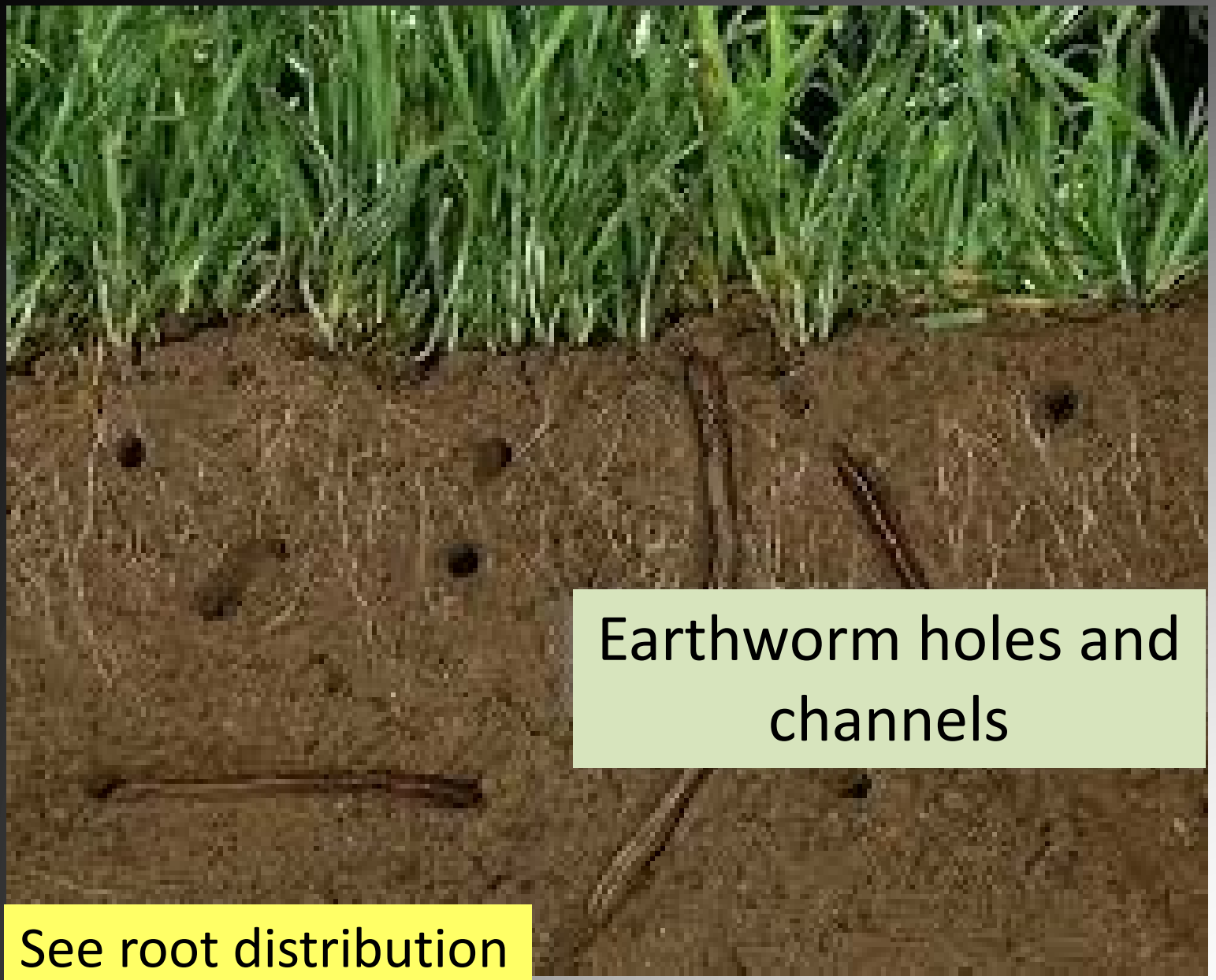


Tipping Bucket Rain Gauge



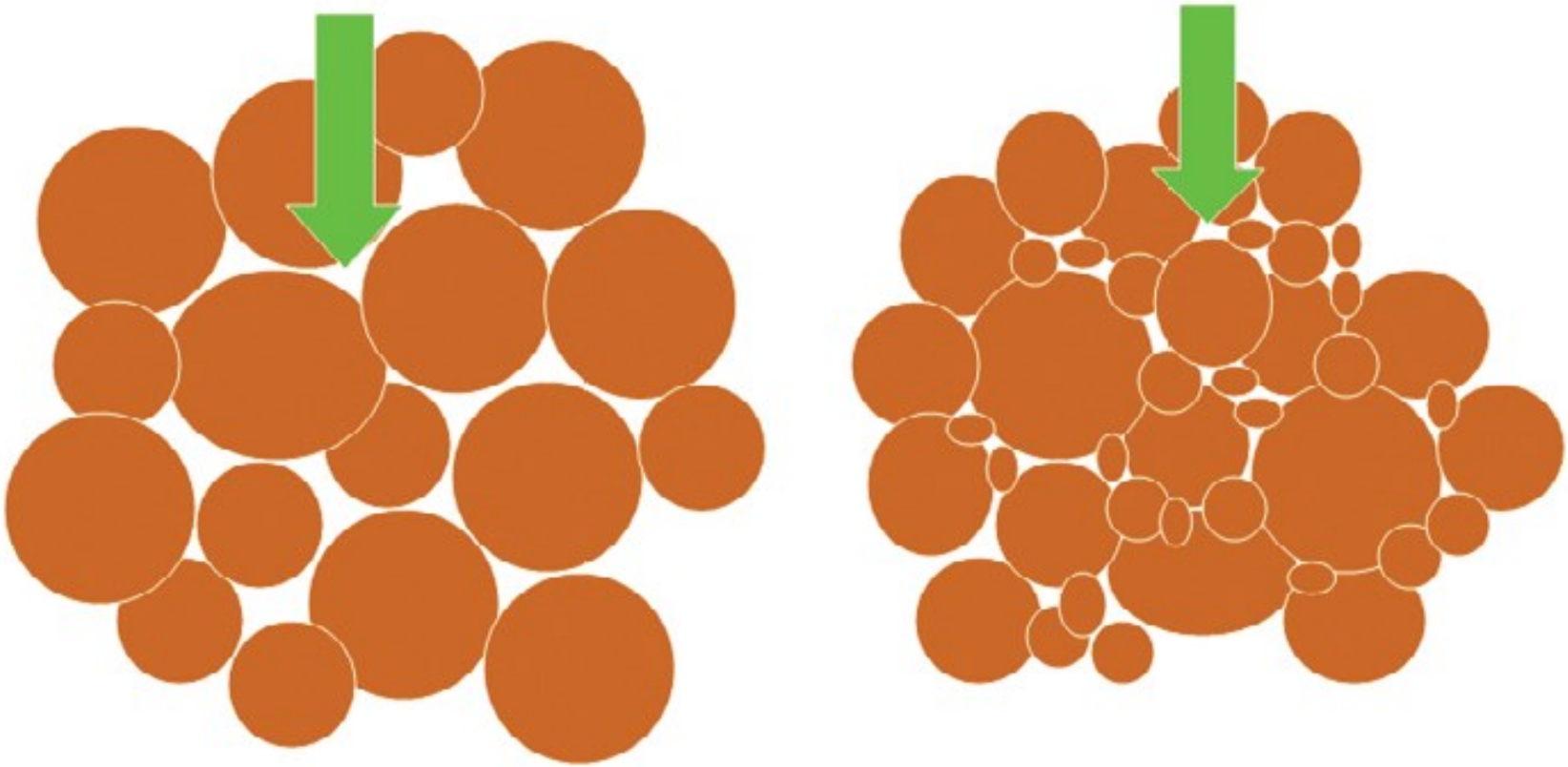
Sample of Soil Profile Variability

Samples of Soil Development



H_2O

See root distribution


LARGE
MACROPORES
SMALL
MICROPORES

Tracer Dye

See vertical flow until water reached impeding layer

See vertical flow through dense layer via cracks and root channels

Tracer Dye

Chisel, Strip-Till, Injected Fertilizer

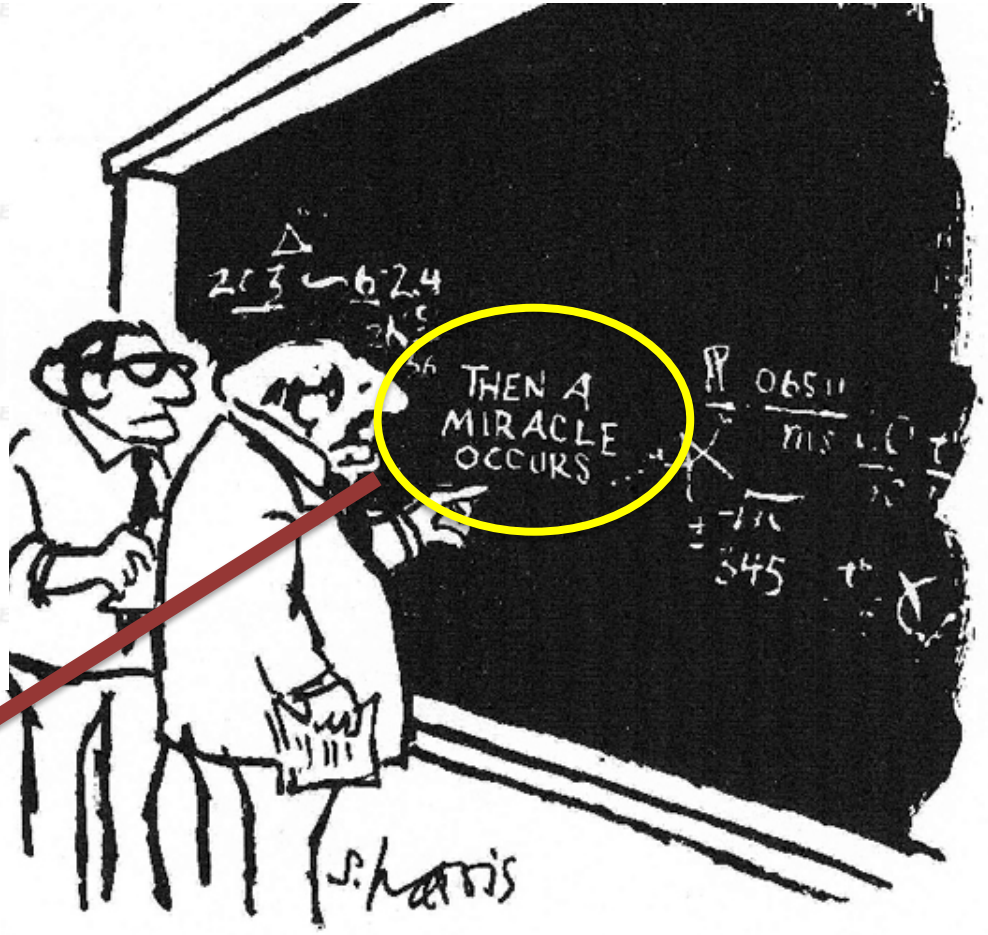
Models

N recommendations ***(yield goal , OM, some residual N)***

Mineralization ***(OM & climate)***

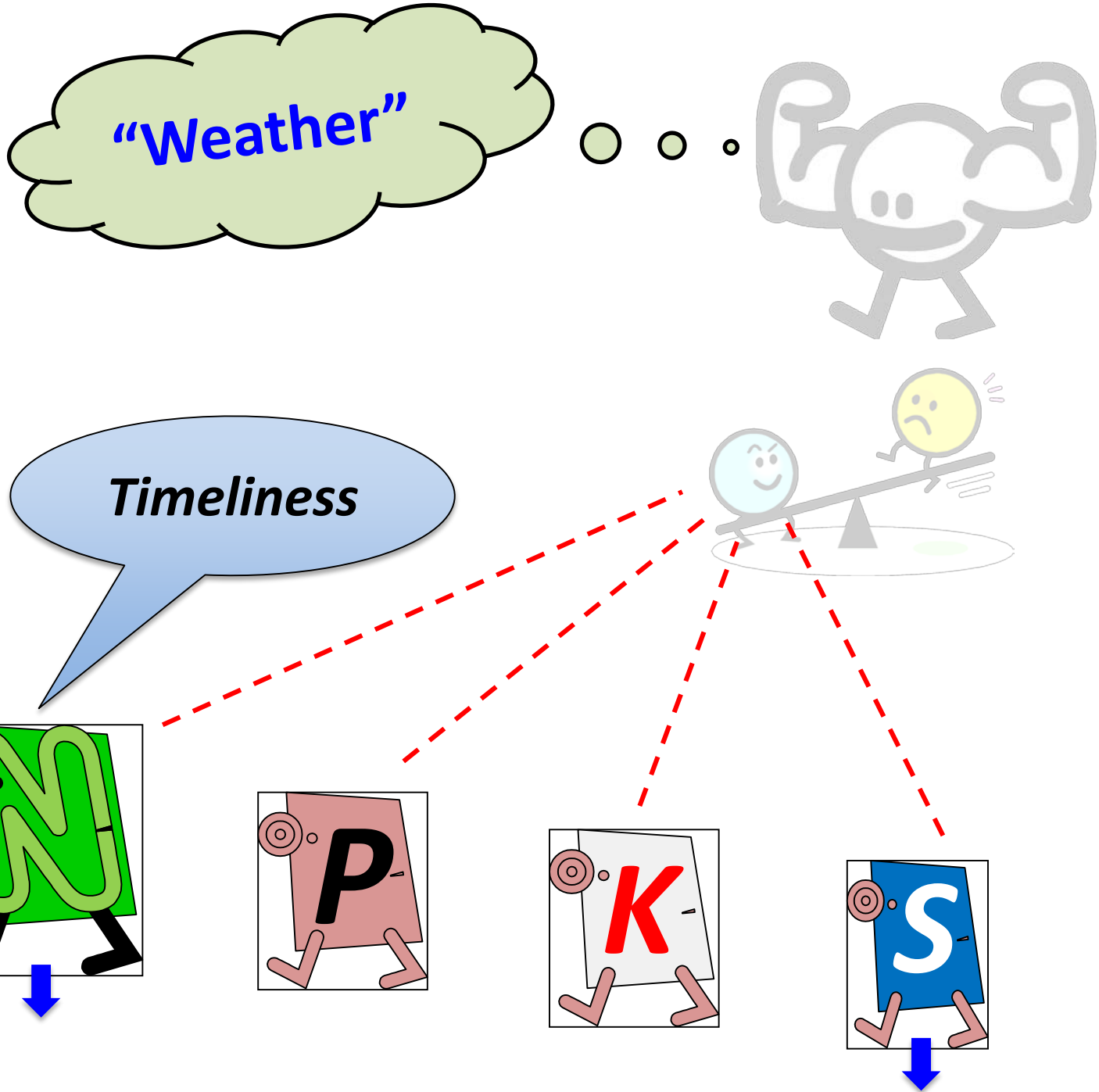
N losses ***(nitrate leaching or denitrification)***

Crop growth



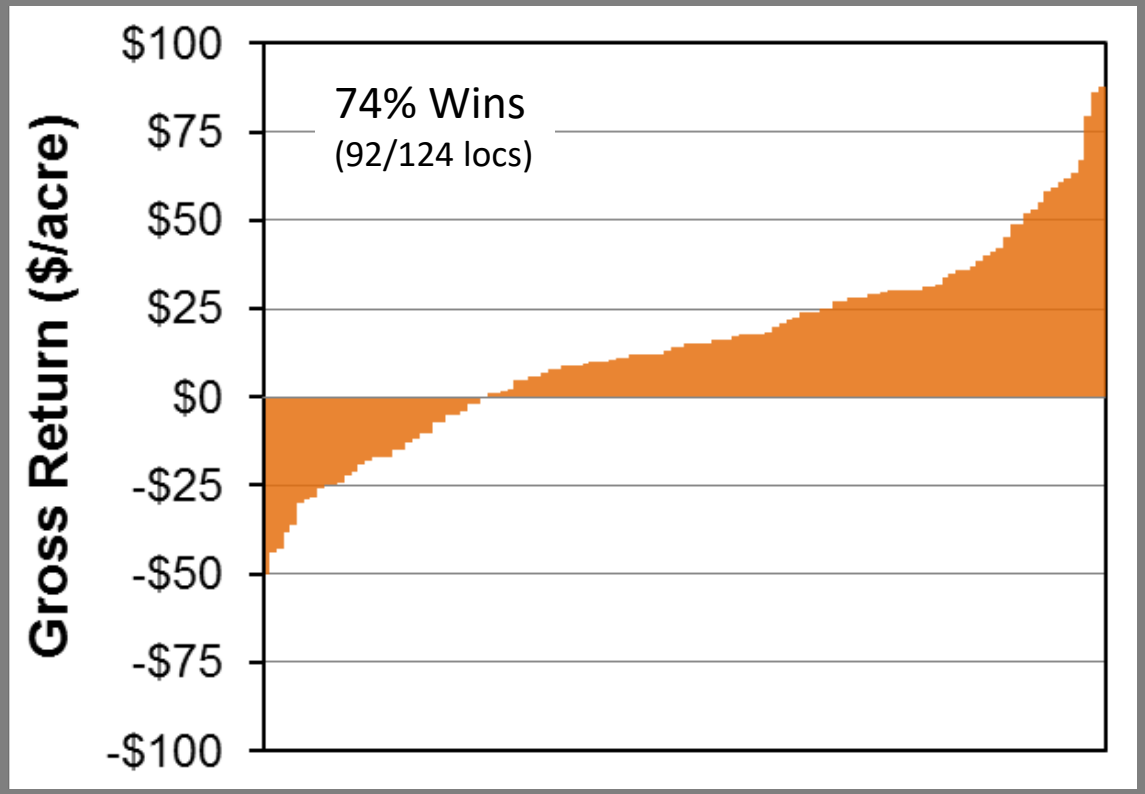
"I think you should be more explicit here in step two."

"Then a MIRACLE occurs"


"Weather"
Timeliness
N
P
K
S

2015 Results: Win Ratio

Encirca[SM] *improved return on N fertilizer investment in 74 % of trials*

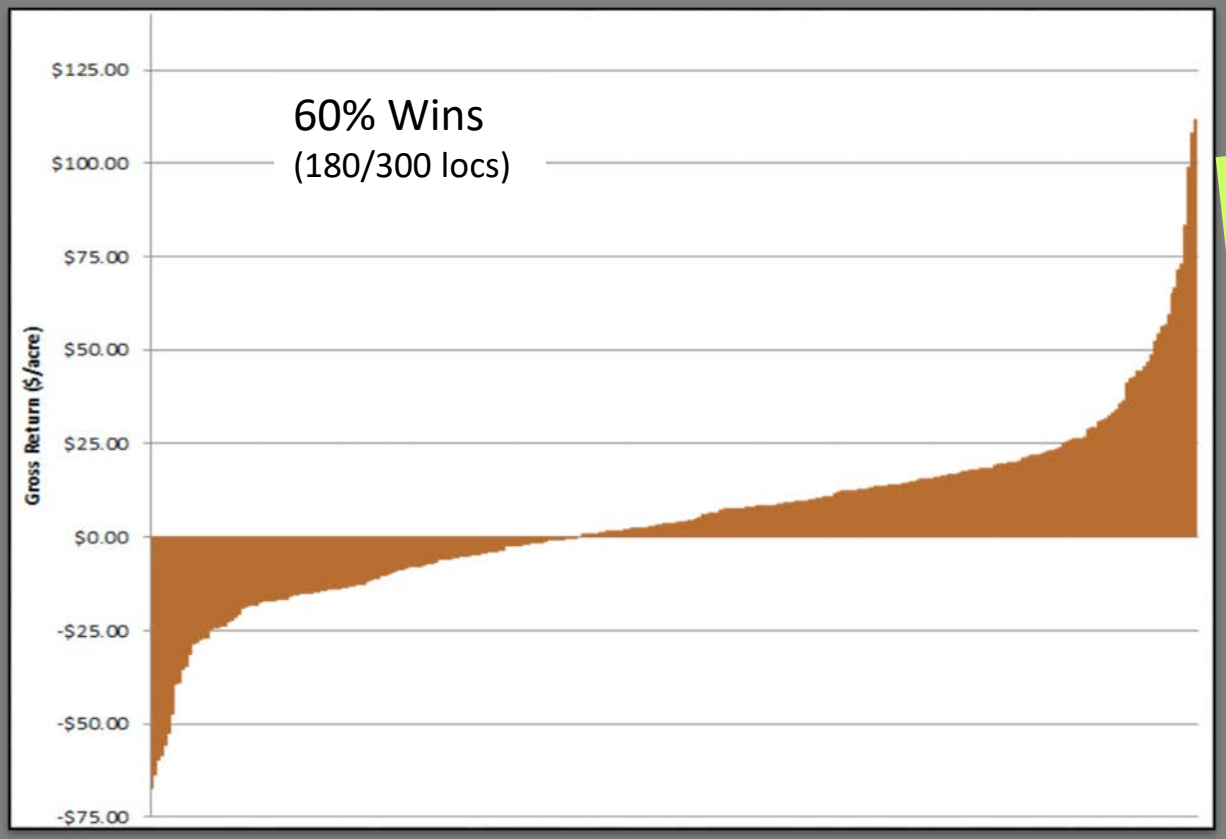


Wet Year

Return on N =
[(Encirca yield x price) – (Encirca N rate x price)] –
[(Grower yield x price) – (Grower N rate x price)]

2016 Results: Win Ratio

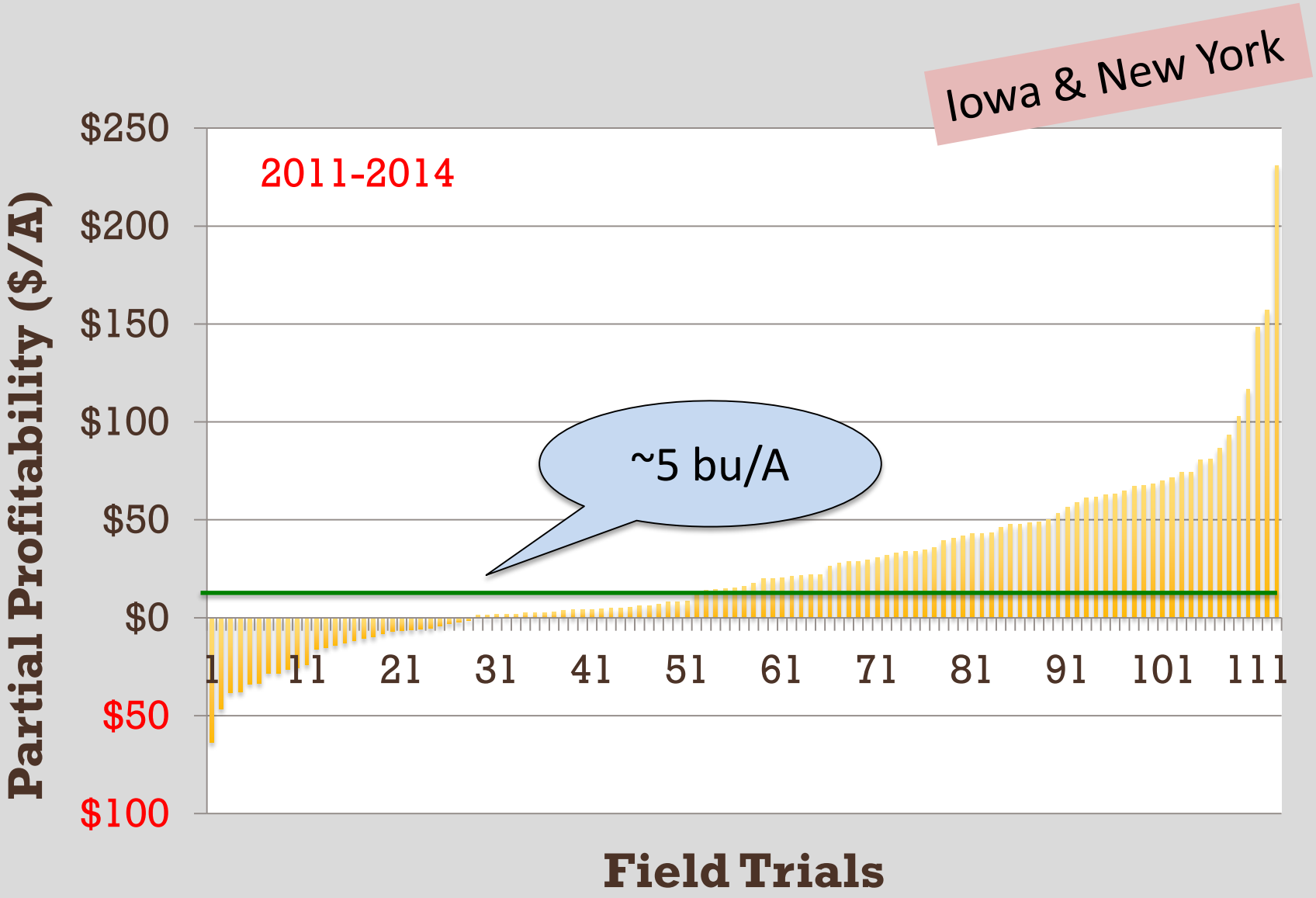
Encirca[SM] improved return on N fertilizer investment in 60 % of trials



"Normal" Year

Return on N =
[(Encirca yield x price) – (Encirca N rate x price)] –
[(Grower yield x price) – (Grower N rate x price)]

Adapt – N . . . Partial Profitability



Previous Crop

Programs that consider the previous crop in terms of legume credits also credit for manure and other non-fertilizer sources of nutrients.

Residual N

Preplant soil sampling (mostly field level, but some spatial)

- Conventional extraction with wet chemistry analysis
- ***Ion exchange*** extraction with wet chemistry analysis

In-season soil sampling for side-dress N recommendation

- Conventional extraction with wet chemistry analysis
- Rapid "in-field" procedure for extraction of nitrate in moist soil with ***nitrate electrode*** analysis

Plant Root Simulator

Anion PRS Probe

adsorbs:
NO_3^-, $H_2PO_4^-$, SO_4^{2-}, micros, etc.

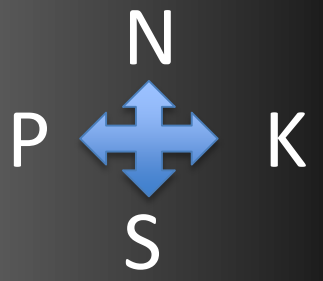
Anion Resin Quaternary R-NH_4^+

Cation PRS Probe

adsorbs:
NH_4^+, K^+, Ca^{2+}, Mg^{2+}, etc.

Cation Resin sulfonic acid R-SO_3^-

Producer Interactive Software



PRS Cropcaster® 2.9.2016.7 (PAC:800) C:\Software\PRS Cropcaster800\prs\midwestdemo.prs

File Settings Download Optimize About Billing

PRS CROPCASTER®

Total Water Use

Soil Moisture 4.7
Precipitation 17 22
Irrigation 0

Heat Units (base 42F) 3076

Corn
Max Yield: 300
Yield: 271

Water Storage Sandy

Soil Density 44% Clay

VAM

Soil pH 1.3

Soil EC 1:1 6.48

0.8

N

P

K

S

DAVIS CORE 4 AL 09-09-09 W9

N	165.8	480.0	146.6
P_2O_5	56.0	136.8	48.5
K_2O	62.1	366.0	218.2
S	12.6	42.0	29.4
Ca	1348.1	51.8	
Mg	210.0	38.1	
Cu	1.11	0.45	
Zn	3.63	3.00	
Mn	20.68	0.30	
Fe	51.15	1.20	
B	1.26	0.54	

WESTERN AG

Field Map

Summary

Economics

Gross Income

$/bushel	$/acre
$2.70	$730.67

Other Expenses

$290.00

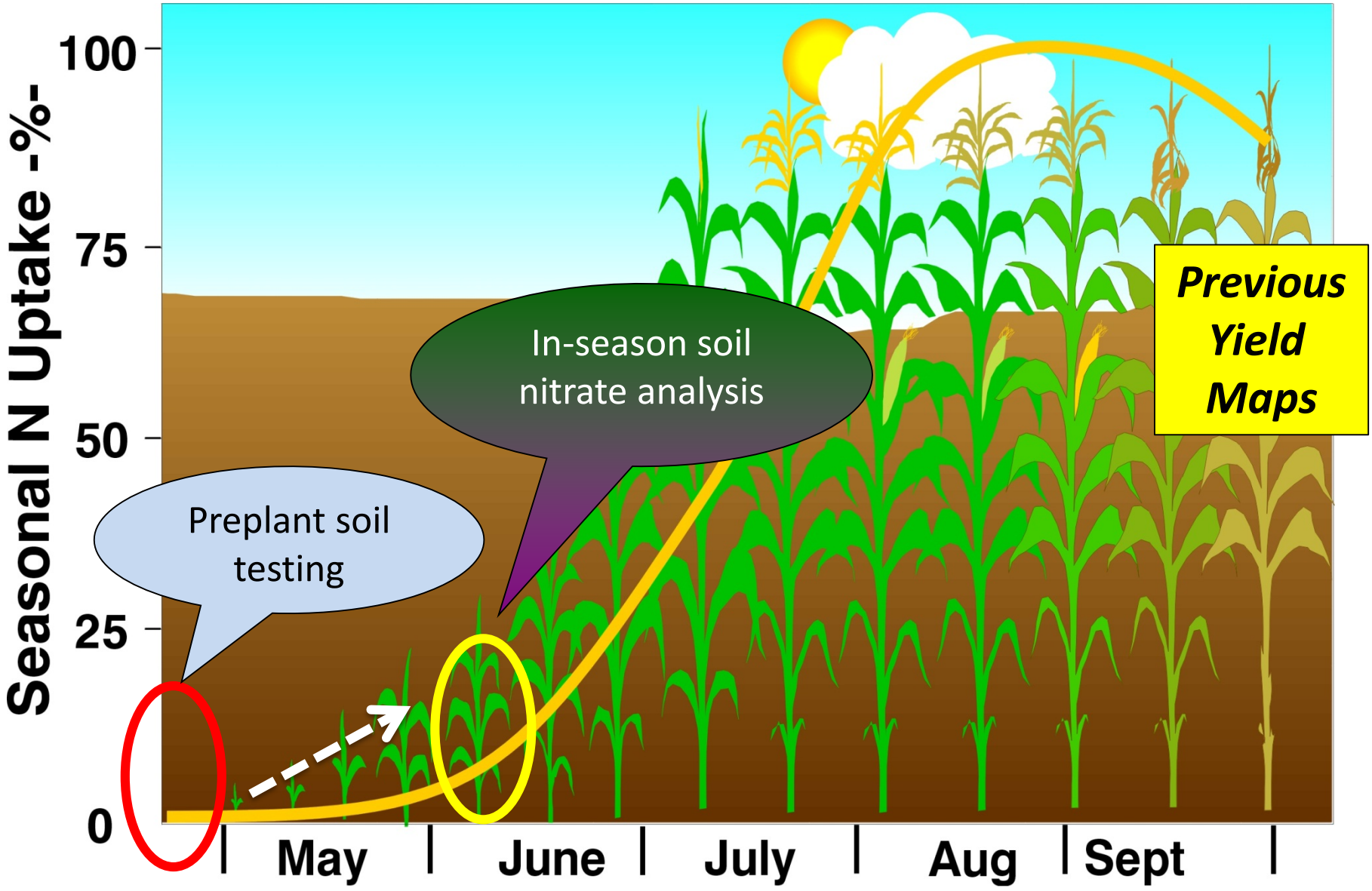
Fertilizer Cost

	$/lb	$/acre
N	$0.50	$73.30
P	$0.53	$25.71
K	$0.43	$93.83
S	$0.32	$9.41
Total:		**$202.25**

Quick Summary

Net $/acre:	$238.42
Break Even $/b	$1.82

Where Does ***Soil Testing*** *Fit ?*



Yield 360 Center - Rapid-Nitrate Test

Moist soil sample
Add distilled water
Mix well
Nitrate electrode analysis

“ You can’t work on a solution until a problem has been identified ”

Early Detection and Analysis

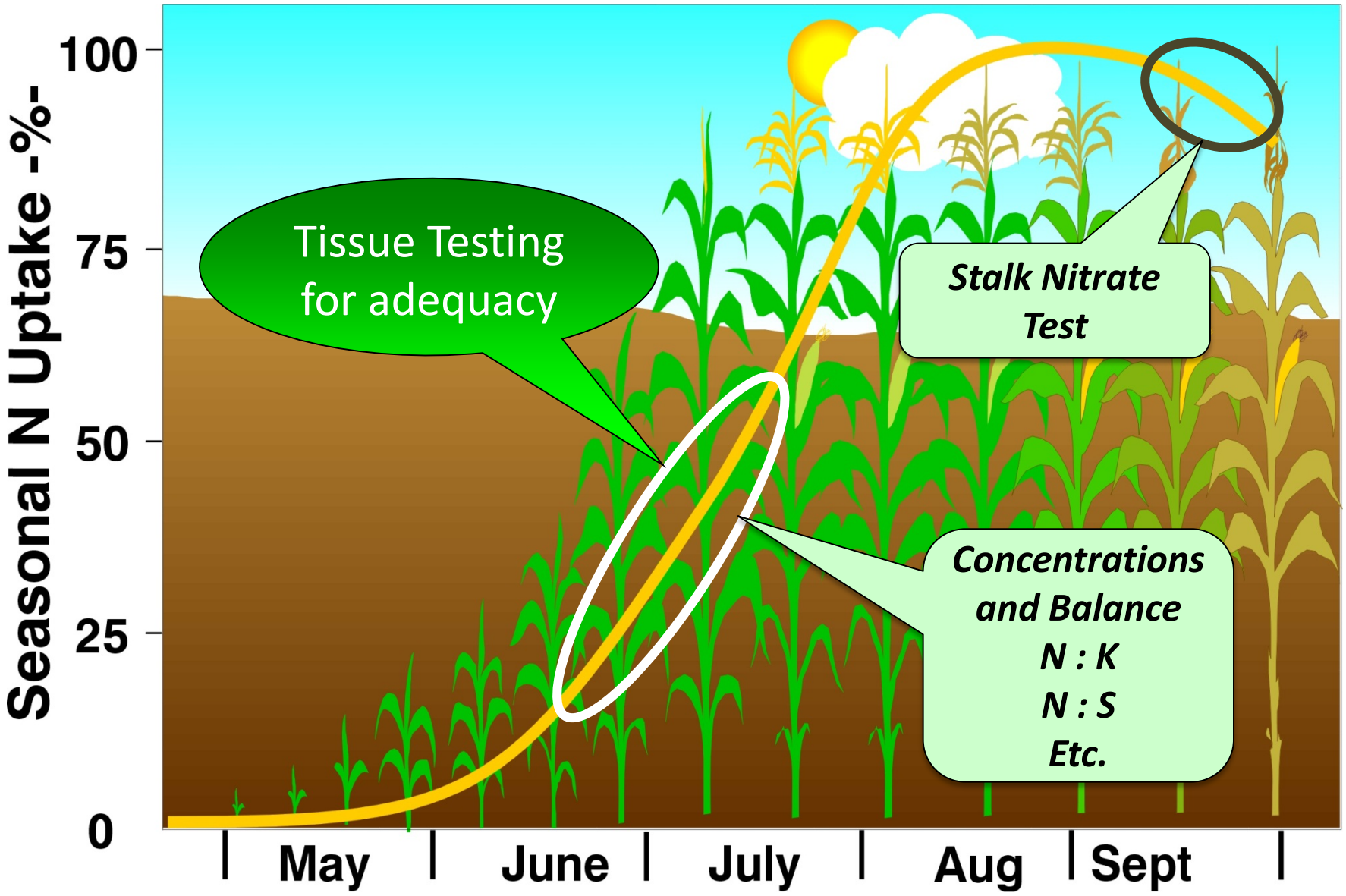
Only a few tools use **tissue testing**

- In-season nutrients
- Stalk nitrate test

Some N management packages offer a **remote sensing option**

Independent **remote sensing services** are available

Where Does Tissue Testing Fit ?



Remote Sensing

Satellite

3 or 4 – band aircraft

Drones ? ? ?

Crop canopy sensors

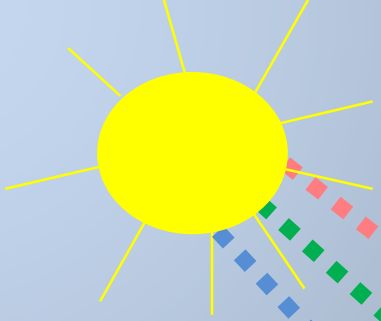
Evolving Technology

Indices

- NDVI
- NDRE
- Thermal
- others

" A picture is worth 1000 words ! "

or **MORE**



Photosynthesis

Chlorophyll

Biomass

Assumes nutrients and water are adequate

Productivity (yield) is proportional to :

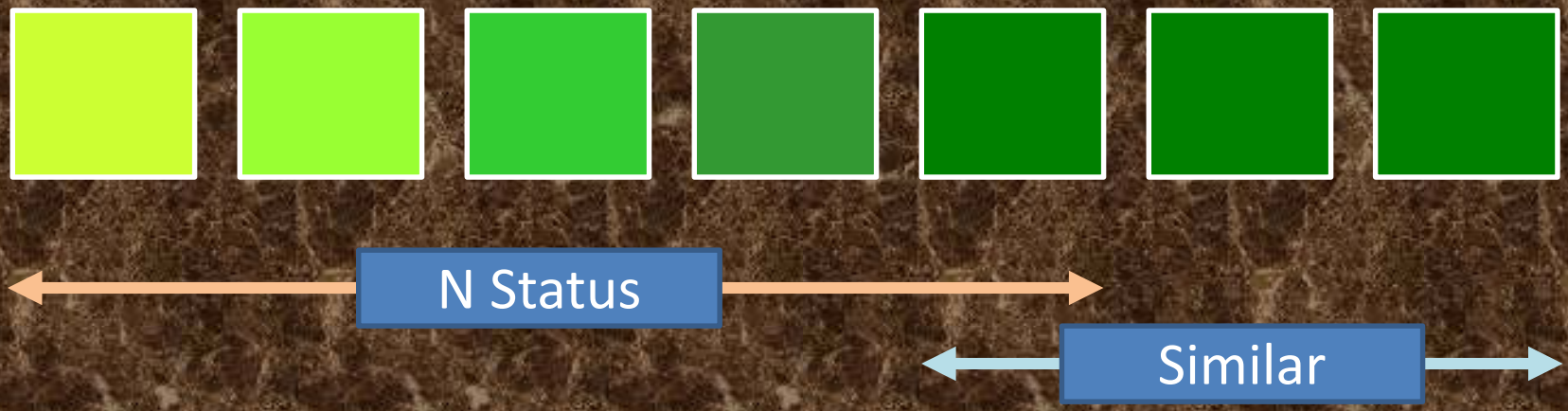
Chlorophyll Content **X** *Incoming Radiation*

Imagery and crop sensor values are indicative of :

"living biomass" and ***"chlorophyll content"***

Treatments / N-rates

"luxury consumption"

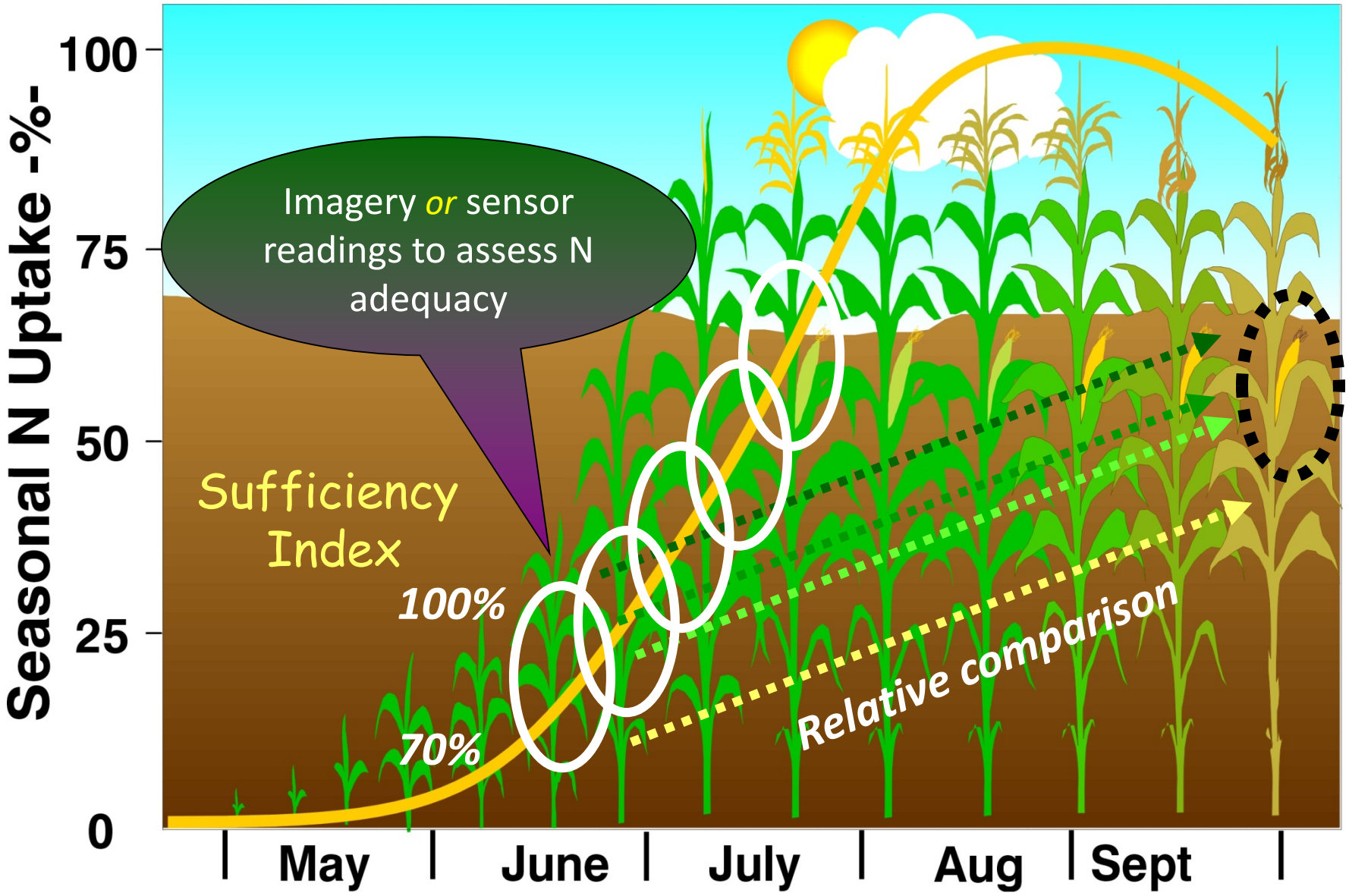


Sensors and images can not quantify excess N

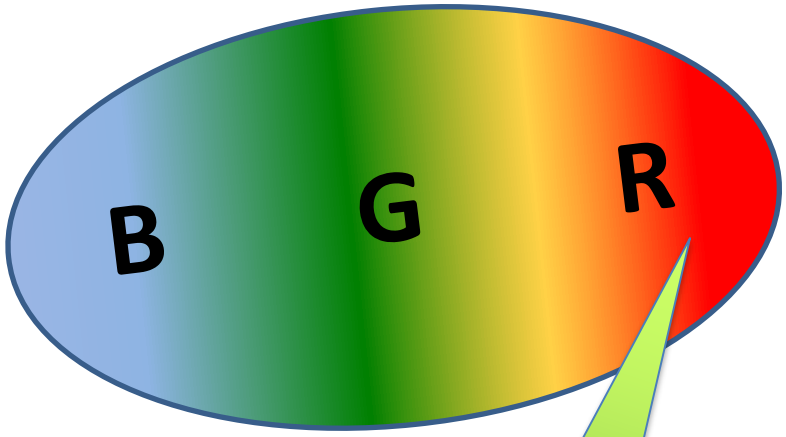
AND

Soil background reduces sensitivity

Where Does **Remote Sensing** *Fit ?*



Remote Sensing



Chlorophyll Status

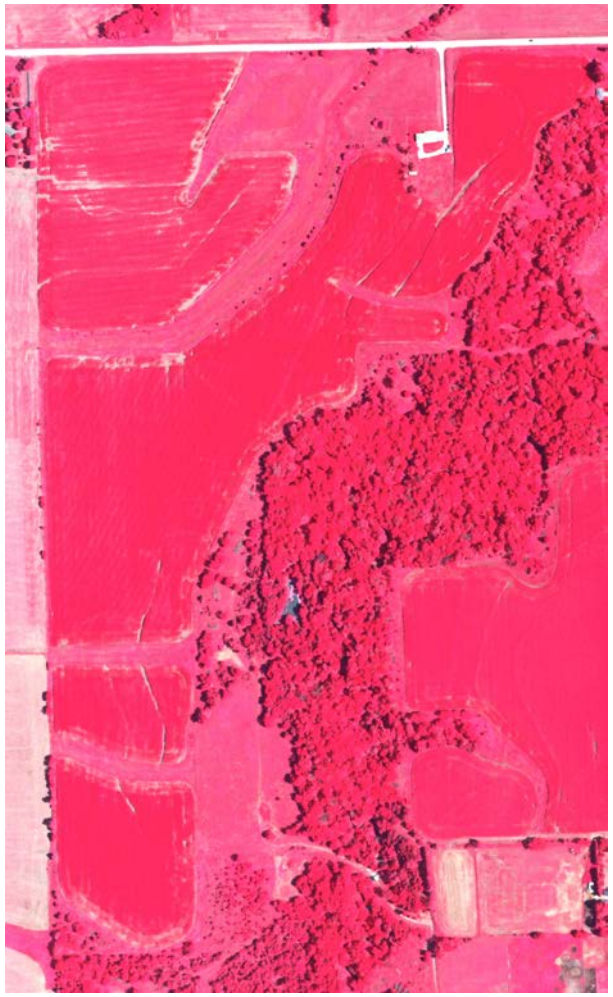
Living Vegetation

John Niemeyer Field *(July 27, 2015)*

Color (R G B)

Color Infrared

John Niemeyer Field *(July 27, 2015)*



Color Infrared

Stretched Color Infrared over Color Image

NDVI

low *high*

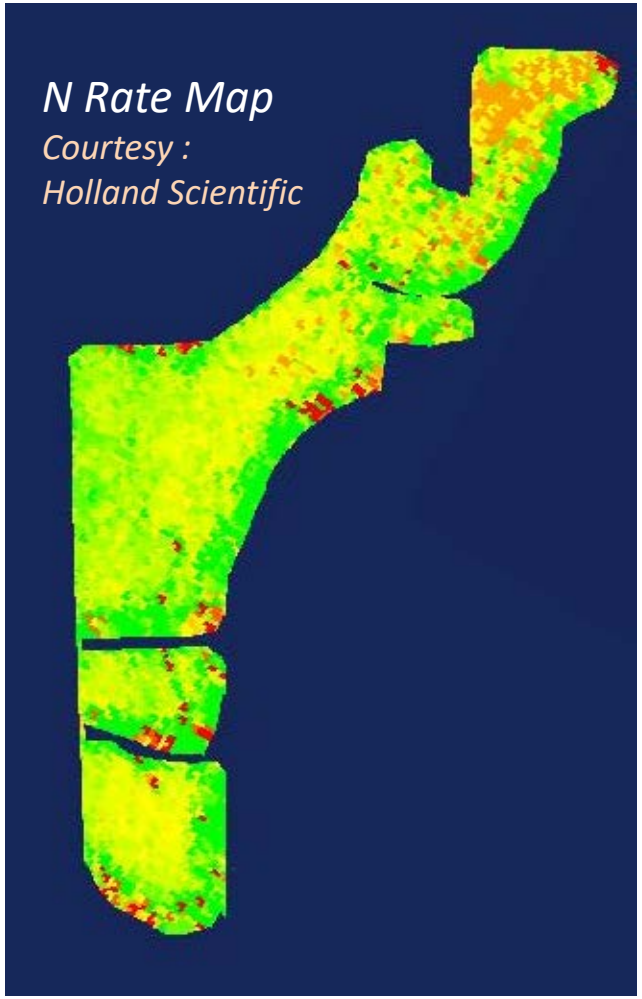
John Niemeyer Field *(July 27, 2015)*

NDVI

low *high*

Management Zones

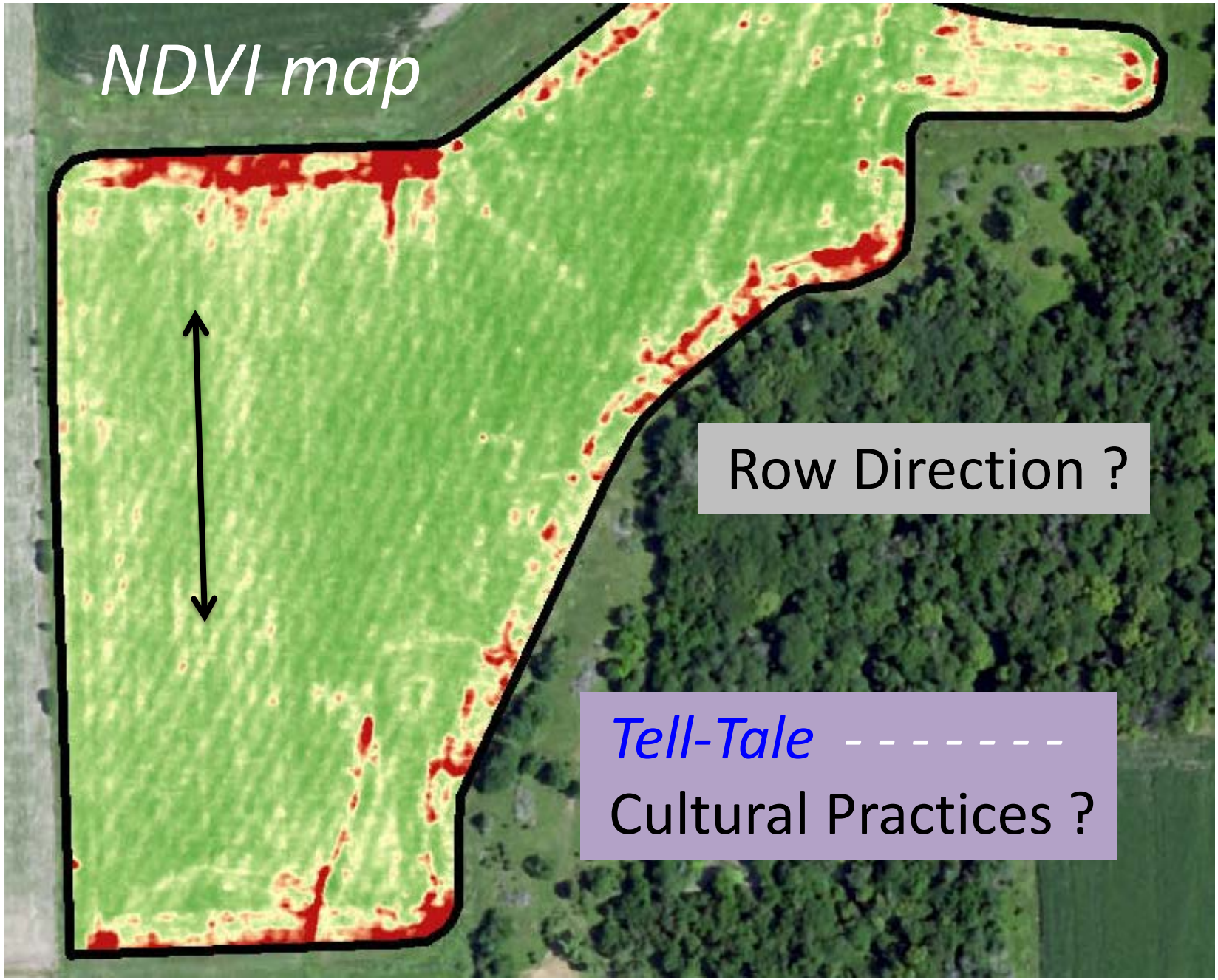
"***Real-Time***" Algorithm



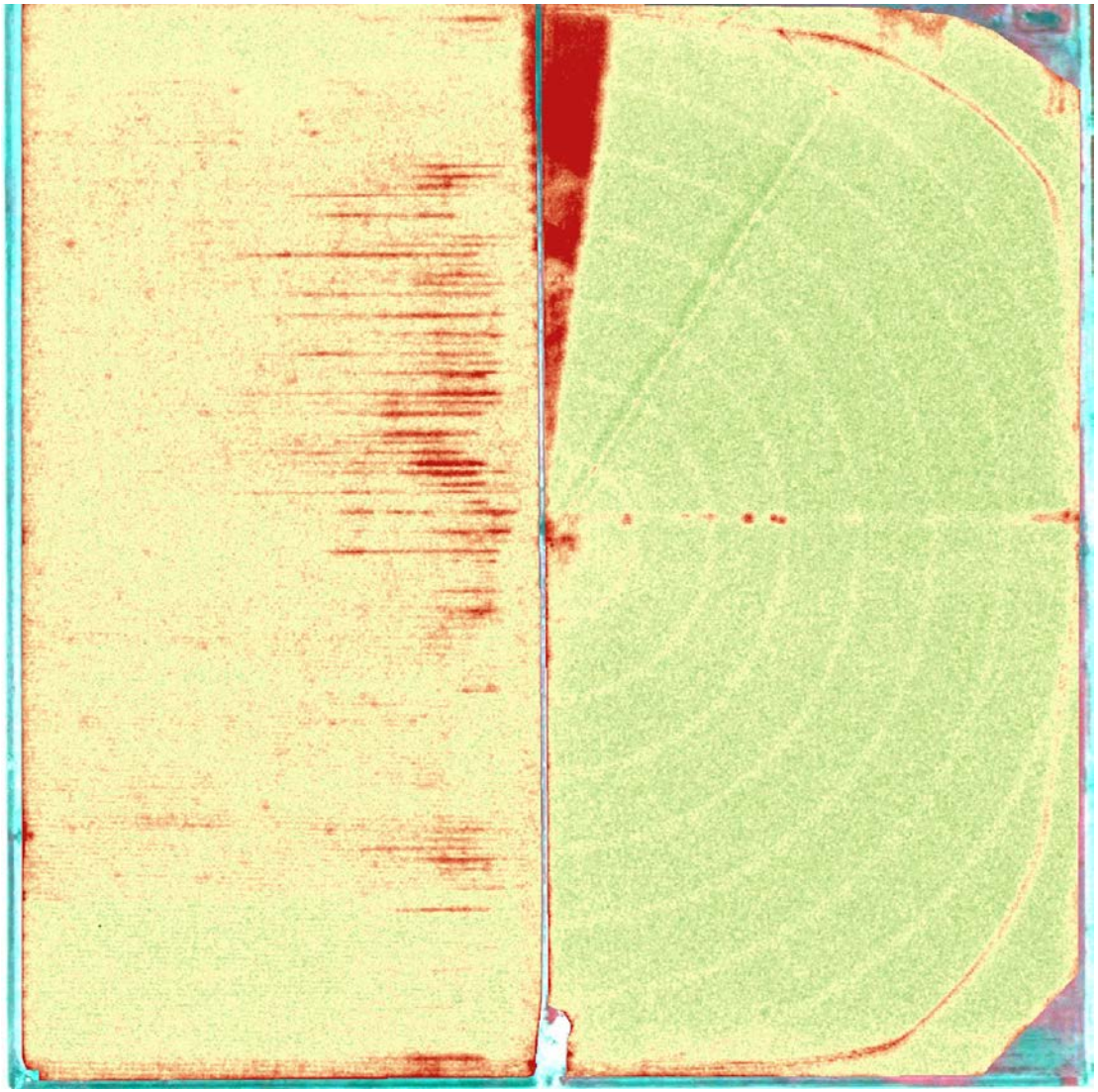
Variable N Rate

very low *medium* *high*

cut-back


NDVI map
Row Direction ?
Tell-Tale - - - - - - -
Cultural Practices ?

Irrigated Corn - 2012



Furrow

Pivot

Color IR Image

NDVI Map

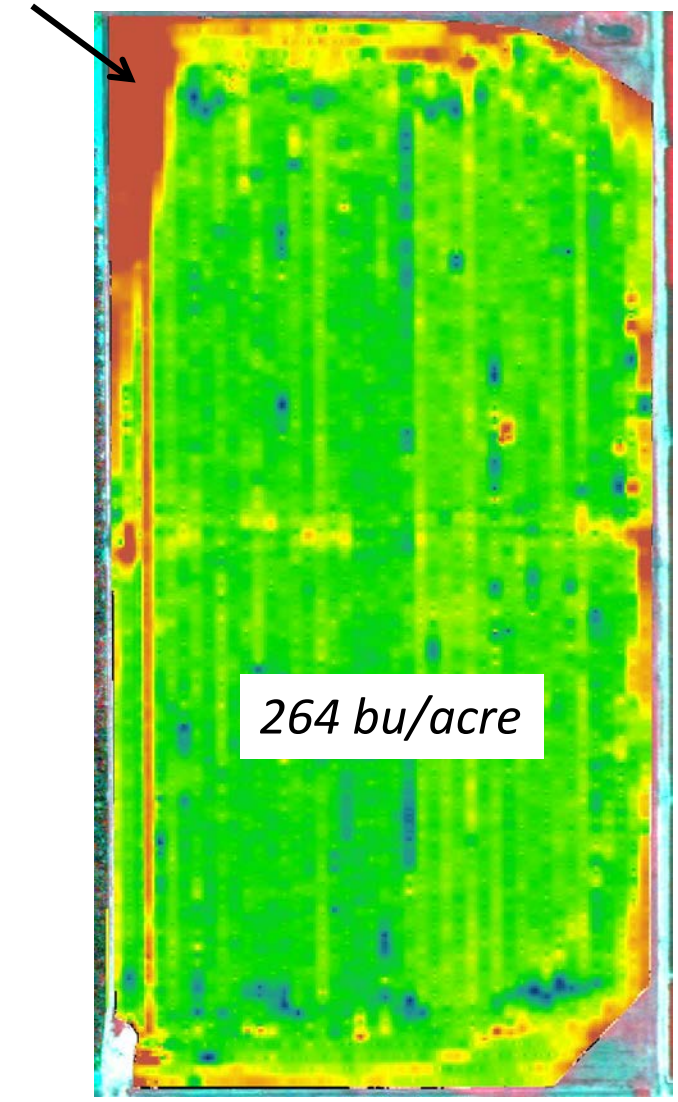
Grain-fill (R2)

Best

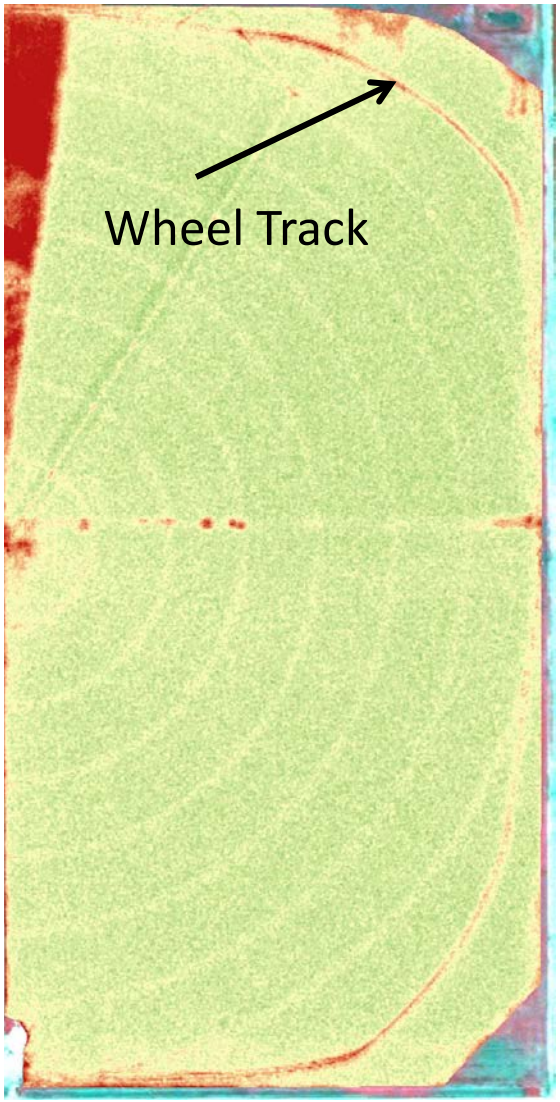
Average

Worst

Irrigated Corn - 2012



Yield Map



NDVI Map

Color IR Image

NDVI Map

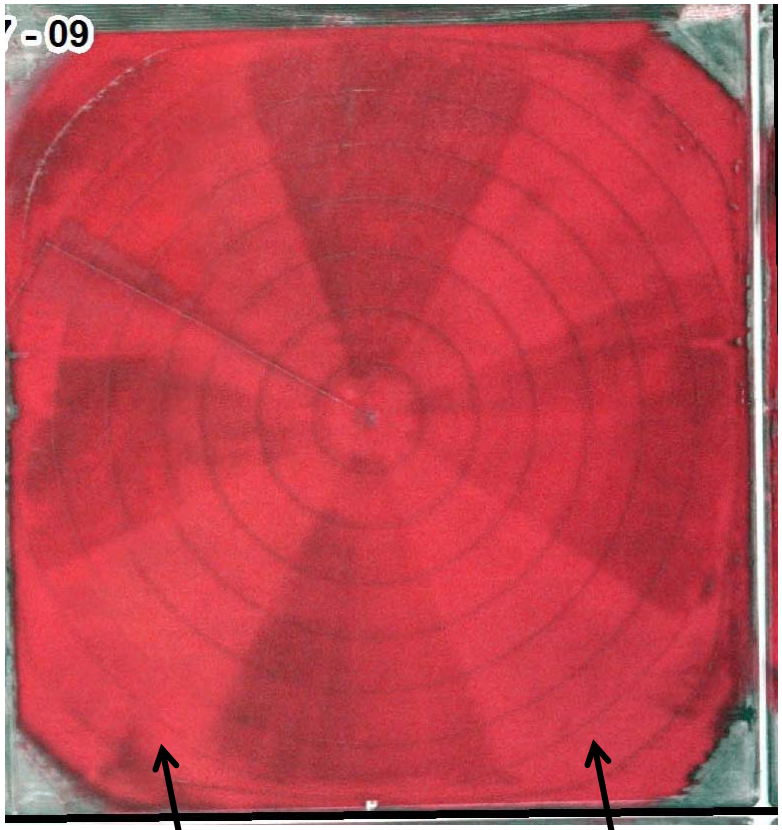
Grain-fill (R2)

Best

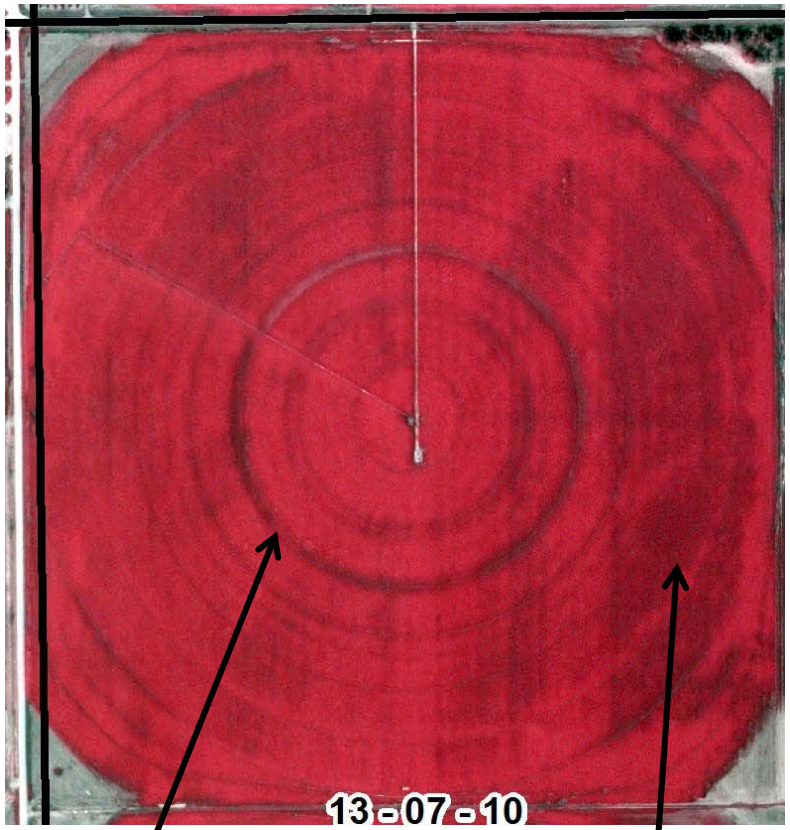
Average

Worst

Color IR Image (Corn 2012)



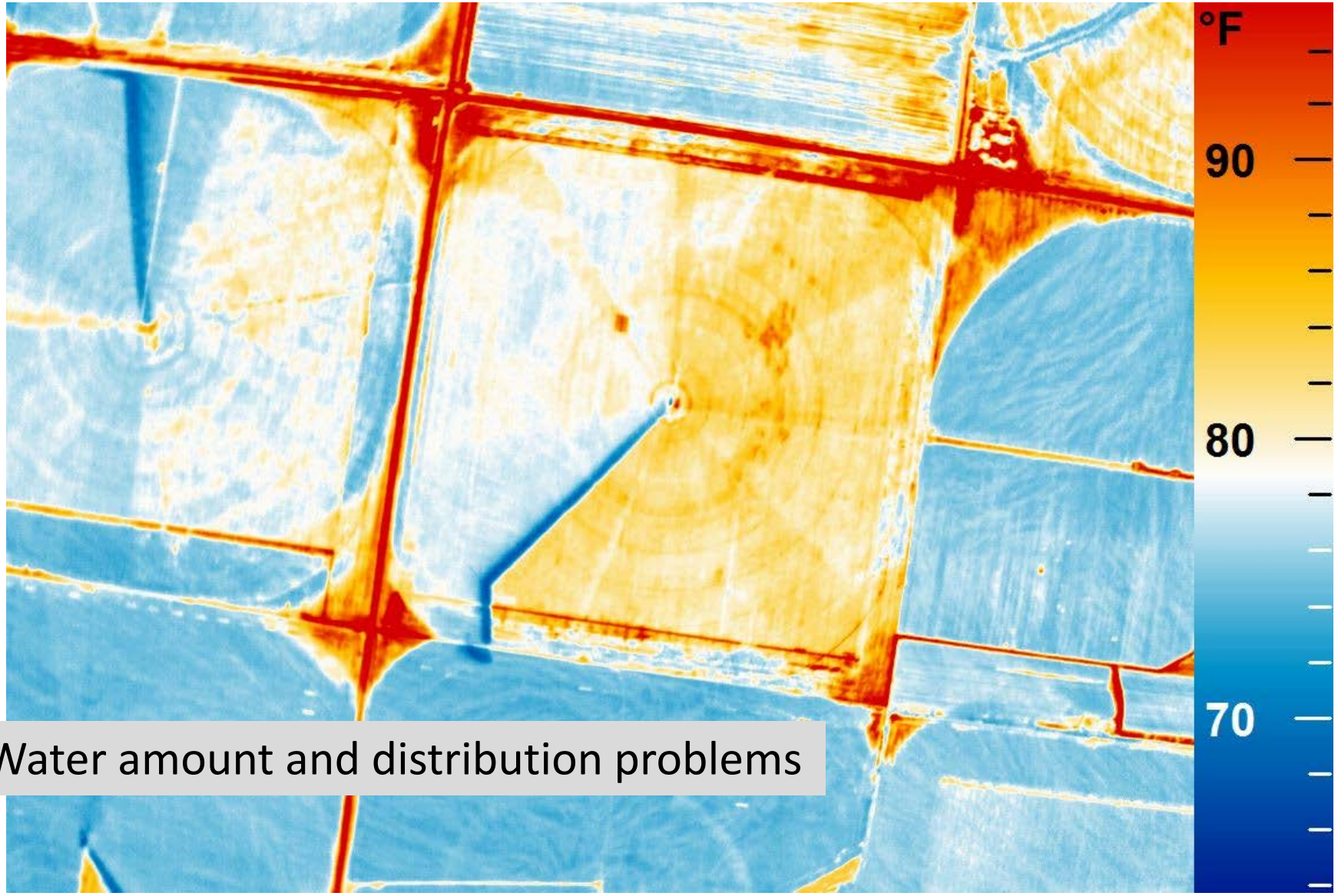
Low water application rate in corners when swing-span is extended



Nozzle problem near pivot track

Cultural practice difference (hybrid, previous crop, ?)

Thermal Infrared *(canopy temperature)*



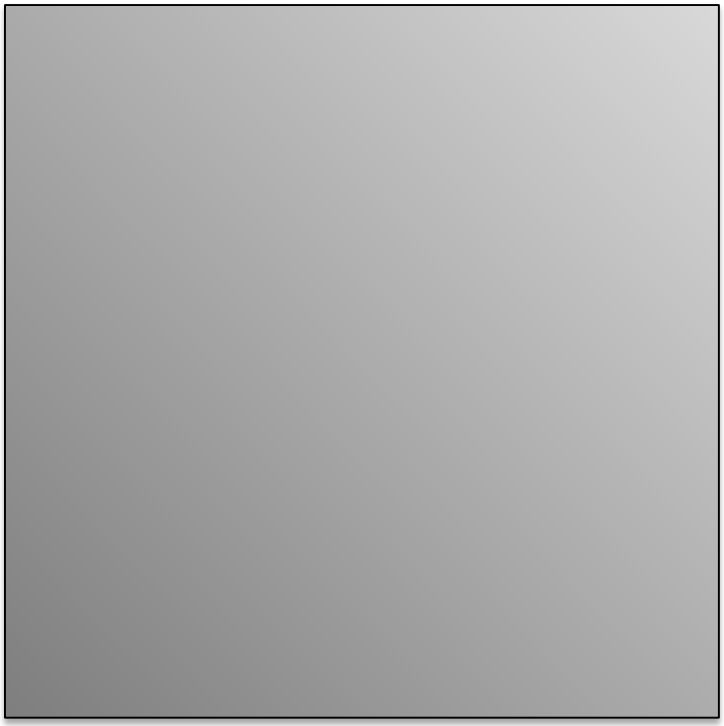
Water amount and distribution problems

Field Strip

12 rows @ 30”

- - 30 ft - -

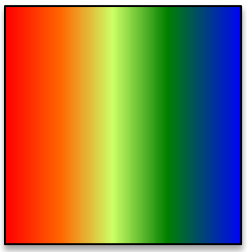
Need 4 to 5 pixels (cells) within the width of the target being managed



15 meter (~50 ft)

LANDSAT 8

“free”



5 meter (~15 ft)

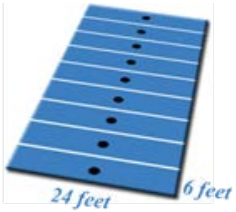
2 meter

1 meter

Spatial Resolution

Problems with Spatial Resolution

- Yield maps



Width of combine head
Distance per second

Cell Size

~250 cells/ac (12 rows @ 4 mph and 1 Hz logging)

- - Wedge-shaped cells - -

- Imagery

Inches to many feet

~1.6 million pixels/ac @ 2 in
43,560 pixels/ac @ 1 ft
10,890 pixels/ac @ 2 ft
4,840 pixels/ac @ 3 ft
1,210 pixels/ac @ 6 ft
194 pixels/ac @ 15 ft

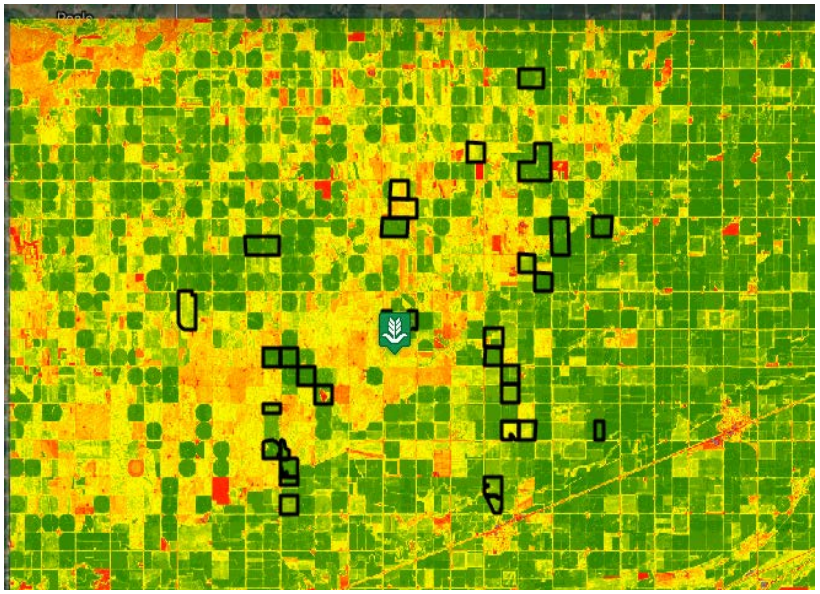
Cell and pixel shapes are different

Re-sampling

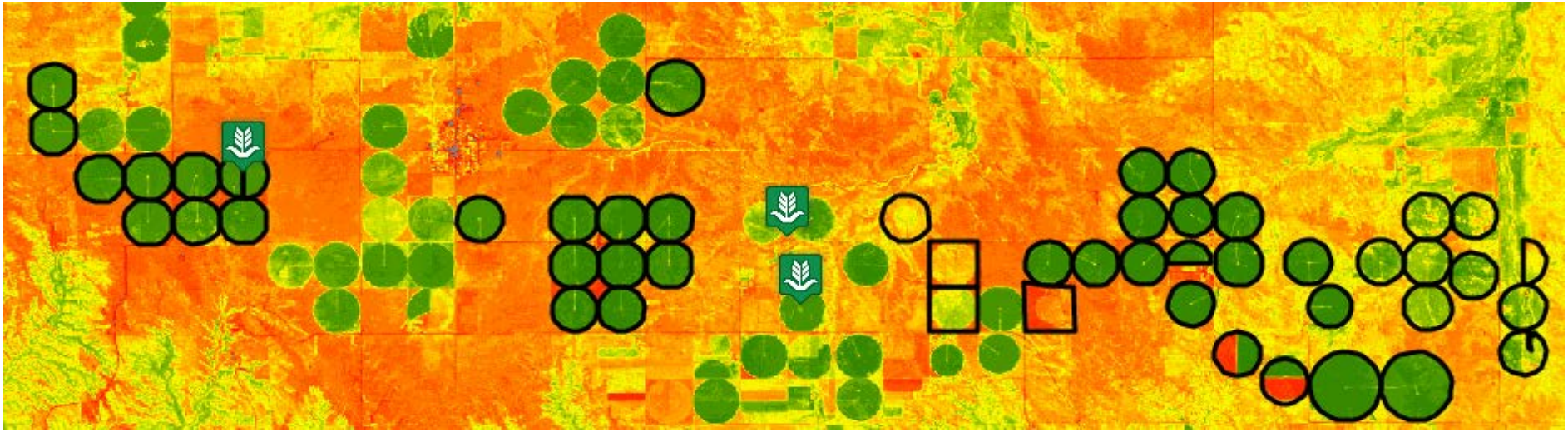
Imagery from Farmshots

2016

South Farm



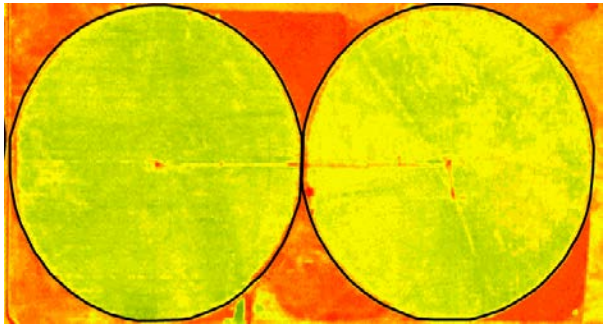
North Farm



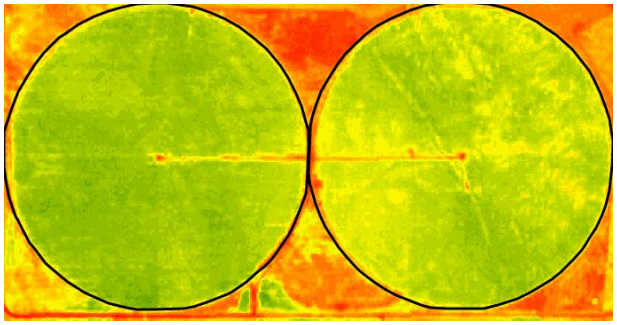
Imagery Time Series

Bare Soil

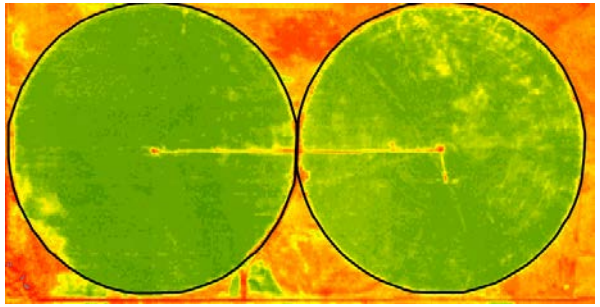
NDVI – June 19



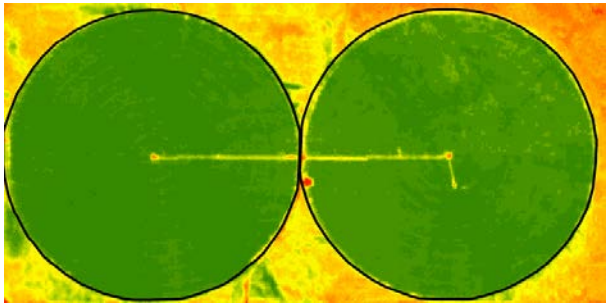
NDVI – June 23



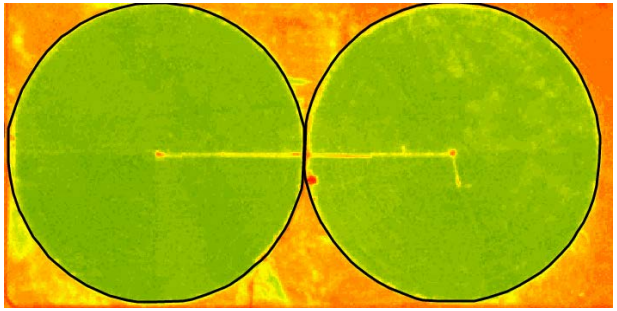
NDVI – June 28



NDVI – July 12



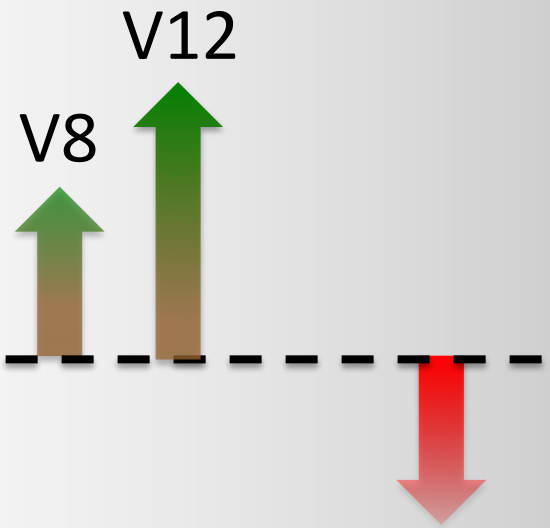
Red Edge – July 12



Source : Farmshots

High *Low*

NDVI



Bare Soil Reference

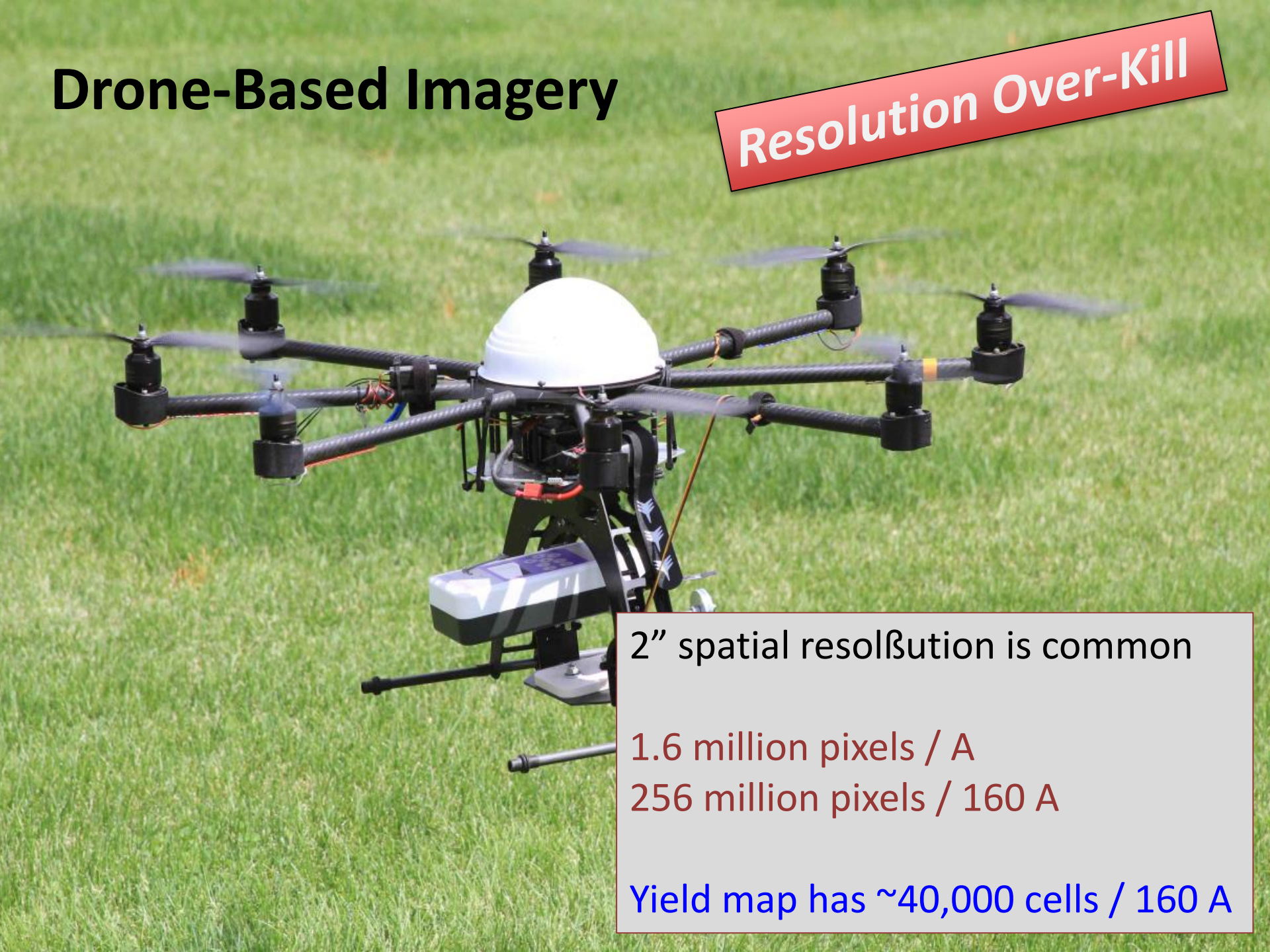
V8 …….. R3

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

			NDVI
Bare soil	28%	18%	.22
V8	44%	6%	.76
V12	55%	6%	.80

Drone-Based Imagery

Resolution Over-Kill



2” spatial resolßution is common

1.6 million pixels / A
256 million pixels / 160 A

Yield map has ~40,000 cells / 160 A

Vignetting

Means : “light fall-off”

Effect : gradual darkening

Some

More

Are you planning to use a drone to view your field ?

Are you paying for someone to image your field ?

Check out the following web site :

agribotix.com/blog/2015/12/12/vignetting-effects-illustrated/

Examples :

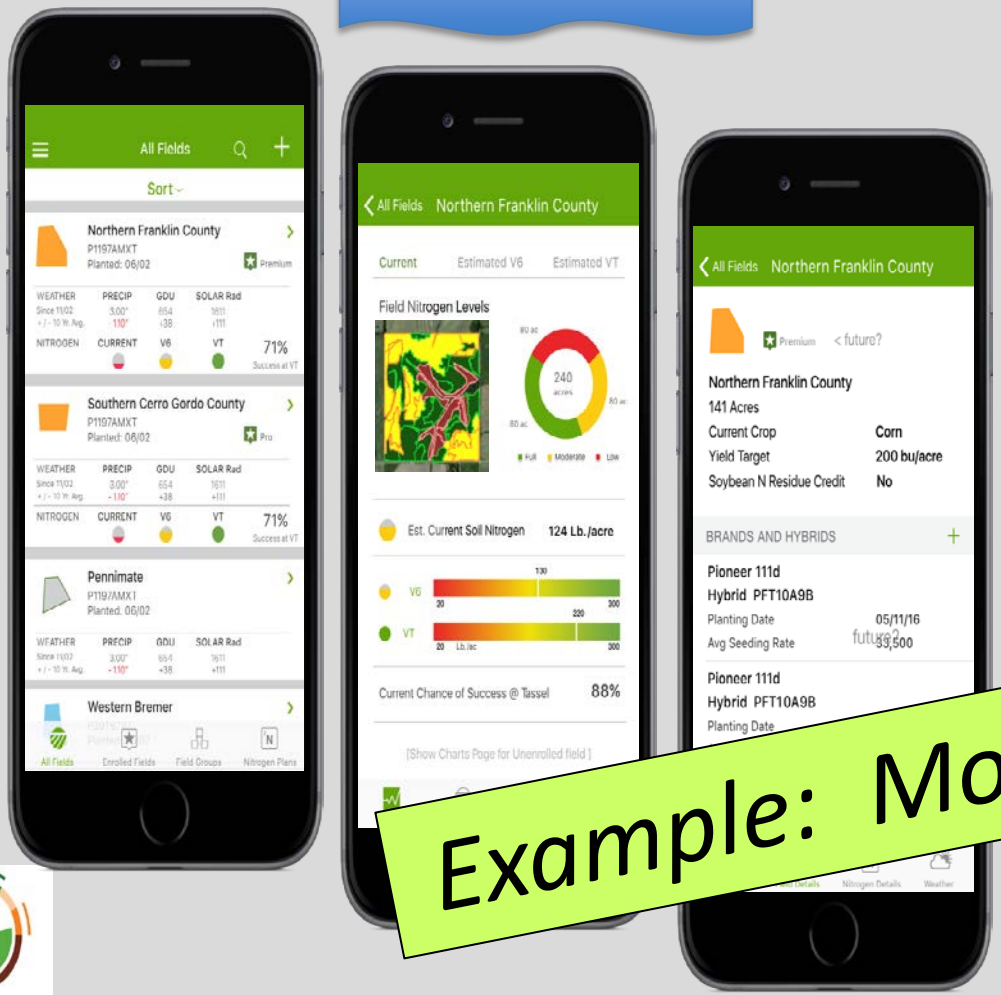
- “time of day” images
- over-sampling
- vignetting
- cloud cover

Information and *Technology Transfer*

Specially Trained Agents	Demonstrations Field Days Conferences Dealers	Web Sites Advertising
Encirca	Winfield	SATSHOT
FieldView	FieldView	Farmshots
Western Ag	Adapt-N	FarmLogs
Farmers Edge	Beck's Seed	Mavrx
ServiTech	Yield 360	TerrAvion
Crop Quest		GeoVantage
Independents		senseFly
		Senera
		FarmLens

Encirca℠ Nitrogen Service

NEW PRO LEVEL!



- Real time nitrogen monitoring at your fingertips
- Create nitrogen plan simulations customized for each field
- Convenient mobile app to access nitrogen, weather and product planting

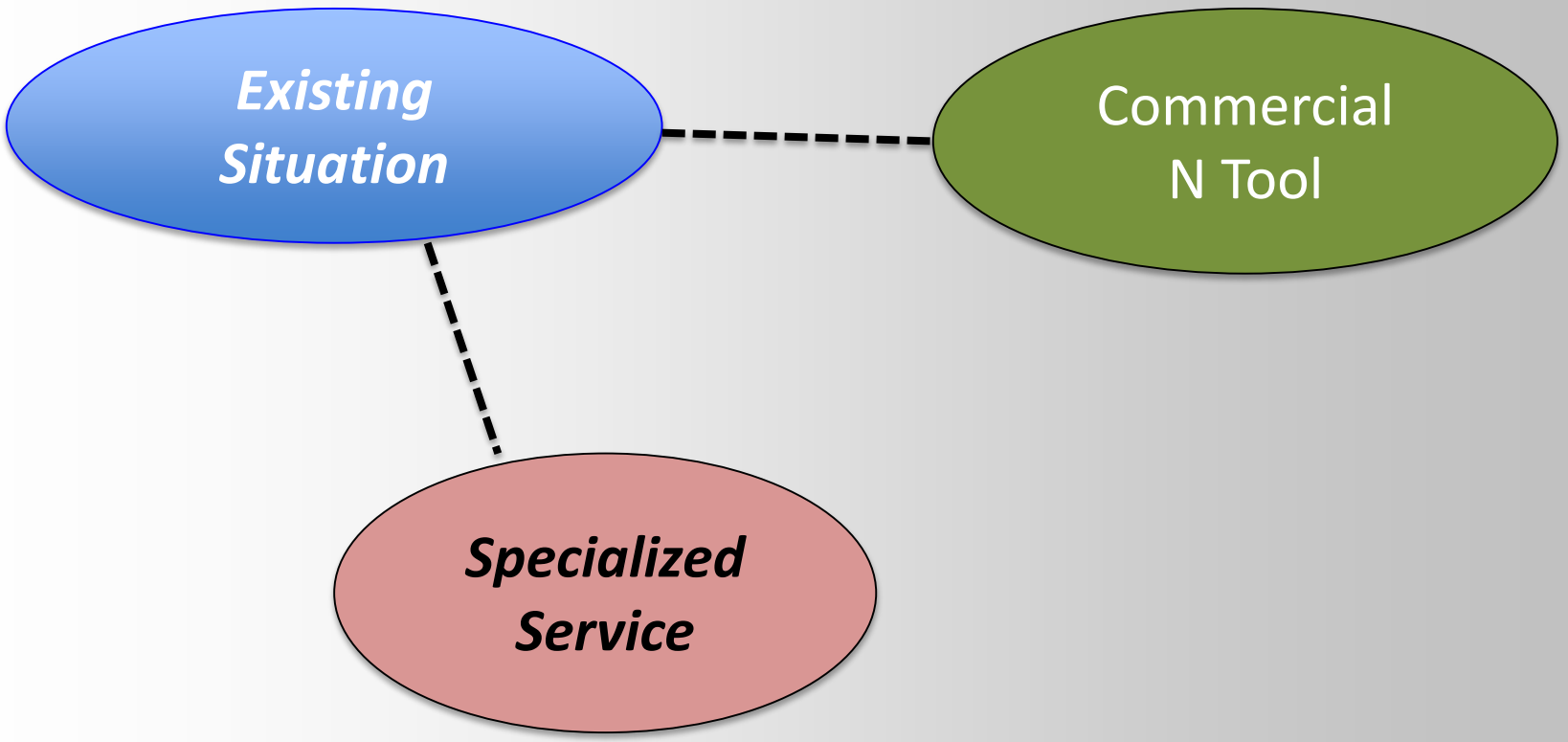
Example: Mobile App

Cab Display (FieldView)

Challenge :

Add enough value to pay for N management tools and services :

Which ones ?



Thank You

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