Sensor Based Nitrogen Management For More Efficient Nitrogen Management In Corn

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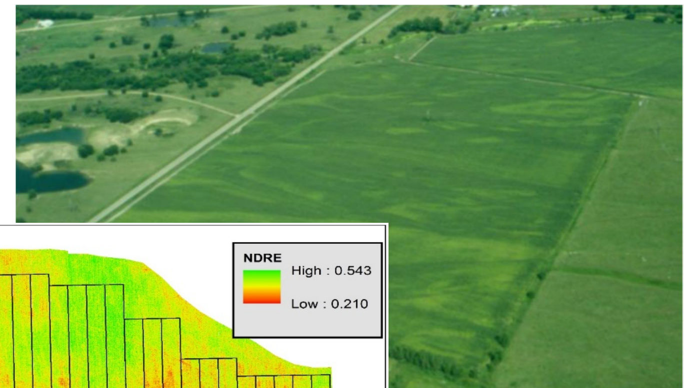
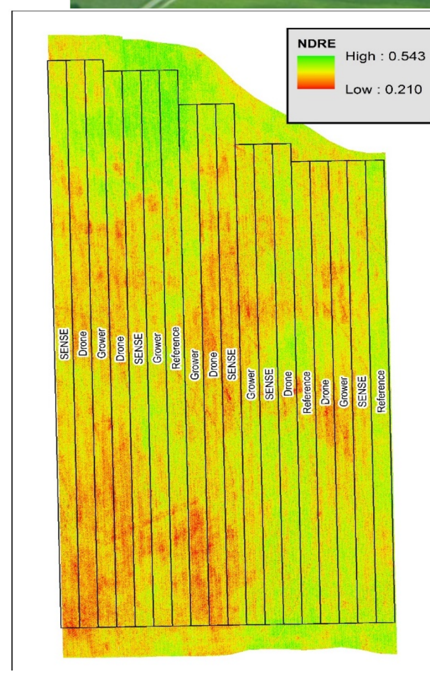
Remote Sensing

- Remote sensing refers to collecting information about an object using a sensing device that is not in contact with the object of interest
- Proximal sensing typically refers to a remote-sensed application at a distance of less than 1 m
- Two important considerations for remote sensing relate to timing and spatial resolution of images captured

Spatial Patterns within a Field:



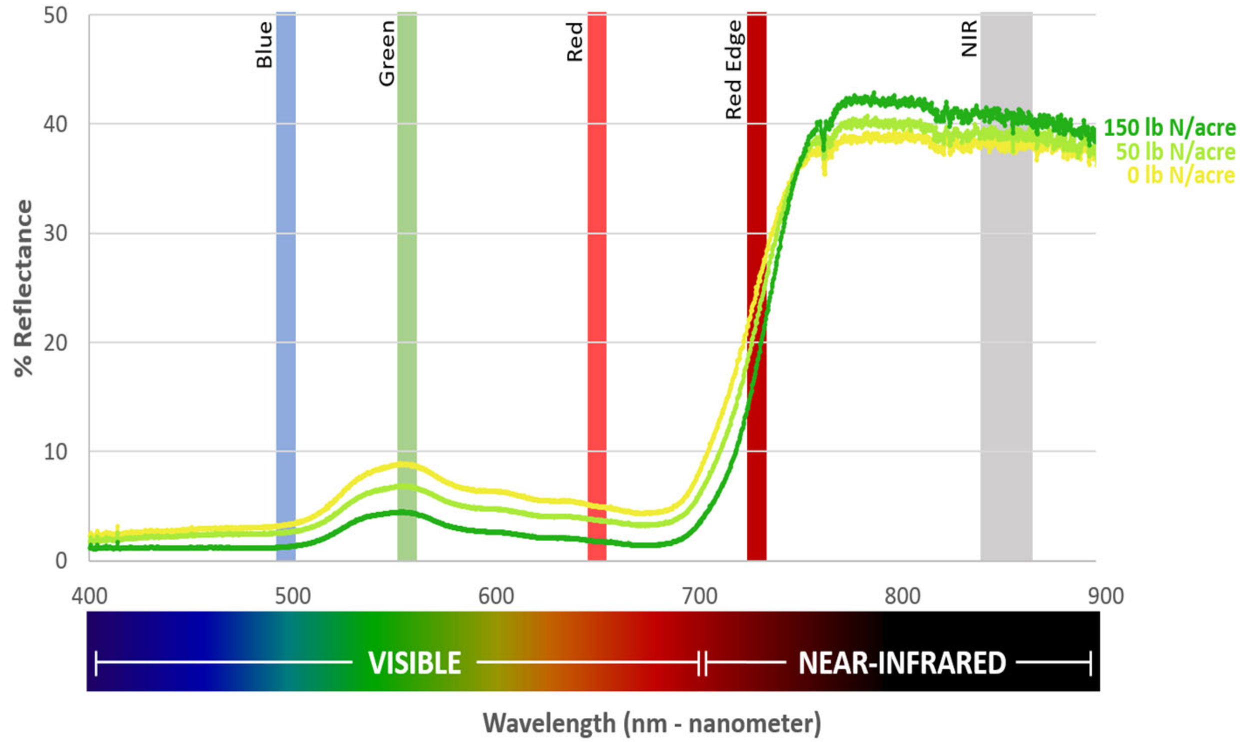


Crop Canopy Sensing

- When selecting sensors, the light source is important
- Passive sensors – rely on sunlight
  - Sunlight/clouds can greatly affect output
  - Time window of sensing can become an issue
- Active sensors – generate their own source of light
  - Light is modulated to reduce effects of sun
  - Proximity to the target may be an issue for active sensors
- Many choices of mobile platforms for remote sensing exist:
  - Satellite
  - Airplane
  - Unmanned Aerial Vehicles (UAVs)
  - Ground-based Vehicles

Electromagnetic Spectral Signature

- In this example, chlorophyll content and leaf area of corn plants show us a different spectral signature:

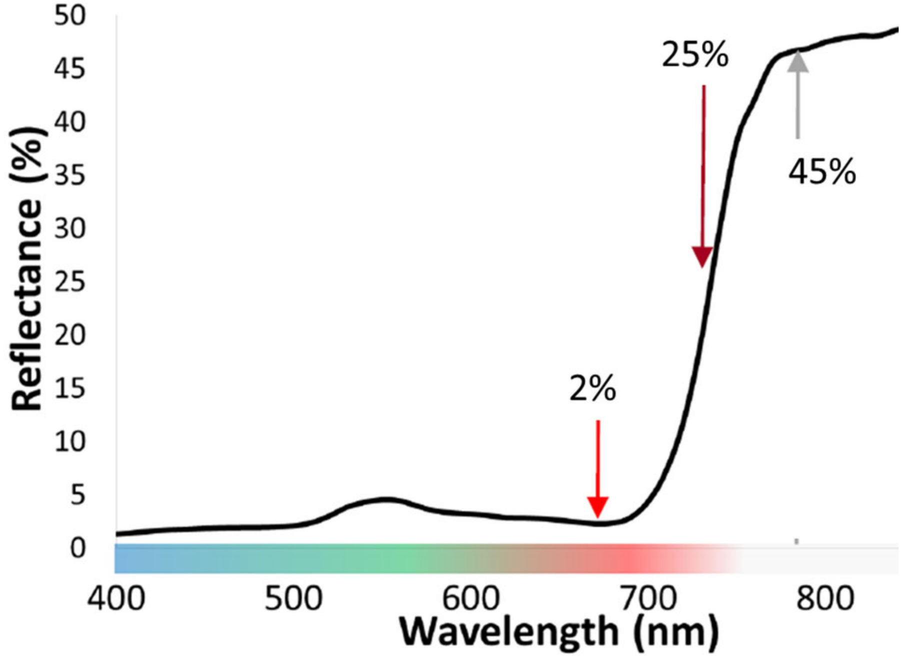


Vegetation Indices:

- Vegetation indices quantify crop reflectance based on reflectance at particular wavelengths

$$NDVI = \frac{NIR_{760} - VIS_{670}}{NIR_{760} + VIS_{670}}$$

$$NDRE = \frac{NIR_{760} - RE_{720}}{NIR_{760} + RE_{720}}$$



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Example of NDRE

- Below shows how corn 'looks' with different N supply according to NDRE:

Calculating the Sufficiency Index

- For real-time application, the system will store the reference VI
- The SI values are calculated on-the-go by dividing the ‘target’ (where you’re applying) values by the one reference value

Active Systems and Algorithm

- Sensor selection will determine VI to be used as well as algorithm
- For corn in NE, two algorithms have been developed:
- Solari

$$N\ (lb/ac) = 317 \cdot \sqrt{0.97 - SI}$$

- Holland-Schepers (OptRx system)

$$N\ (lb/ac) = (N_{OPT} - N_{PreFert} - N_{CRD}) \cdot \sqrt{\frac{(1-SI)}{\Delta SI}}$$

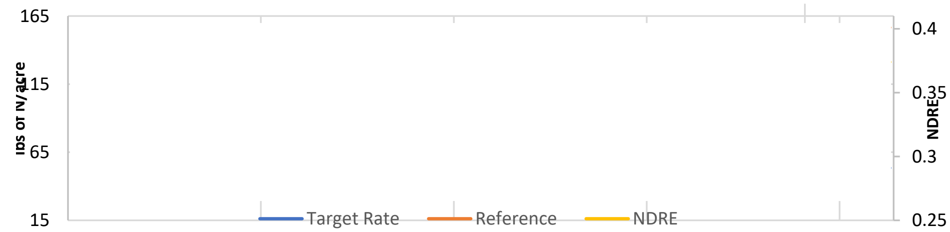
Trimble Greenseeker®

Ag Leader OptRx™

Topcon (Yara) CropSpec™

N Application in Real-Time

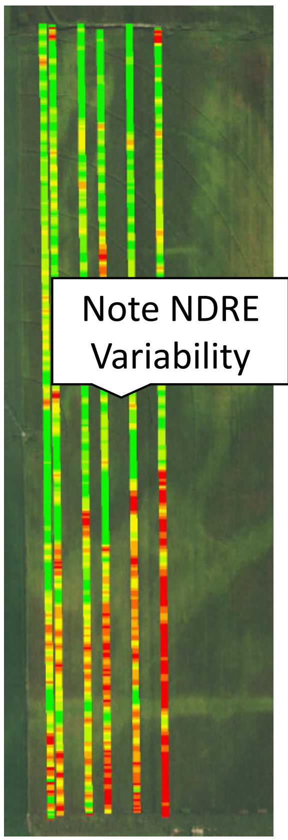
- Base rate of nitrogen is applied (75-100 lb-N/ac at or near planting)
- High nitrogen reference strip is established
- Nitrogen rate is based upon the Holland-Schepers model in relation to NDRE between V8-V12
  - Optimal N Rate
  - N already applied
  - N Credits
  - Min/Max N Rates

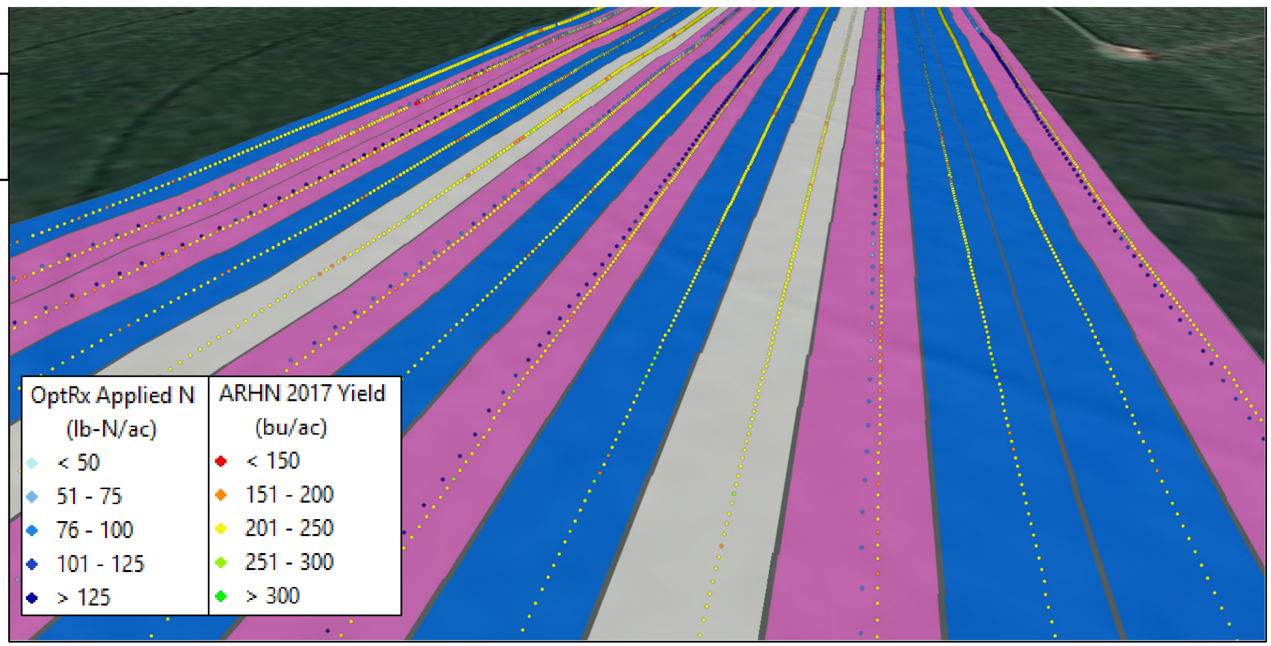


Project SENSE

Sensors for Efficient N Use and Stewardship of the Environment

- N application data were summarized per field-length strip
- Base N and grower applications estimated based on target rates
- As-applied data from Ag Leader monitor used to calculate total N
- Yield monitor data were post-processed using Yield Editor software and buffered approximately 50’ within strips
- Yield data were averaged within field-length strips for grower and SENSE treatments





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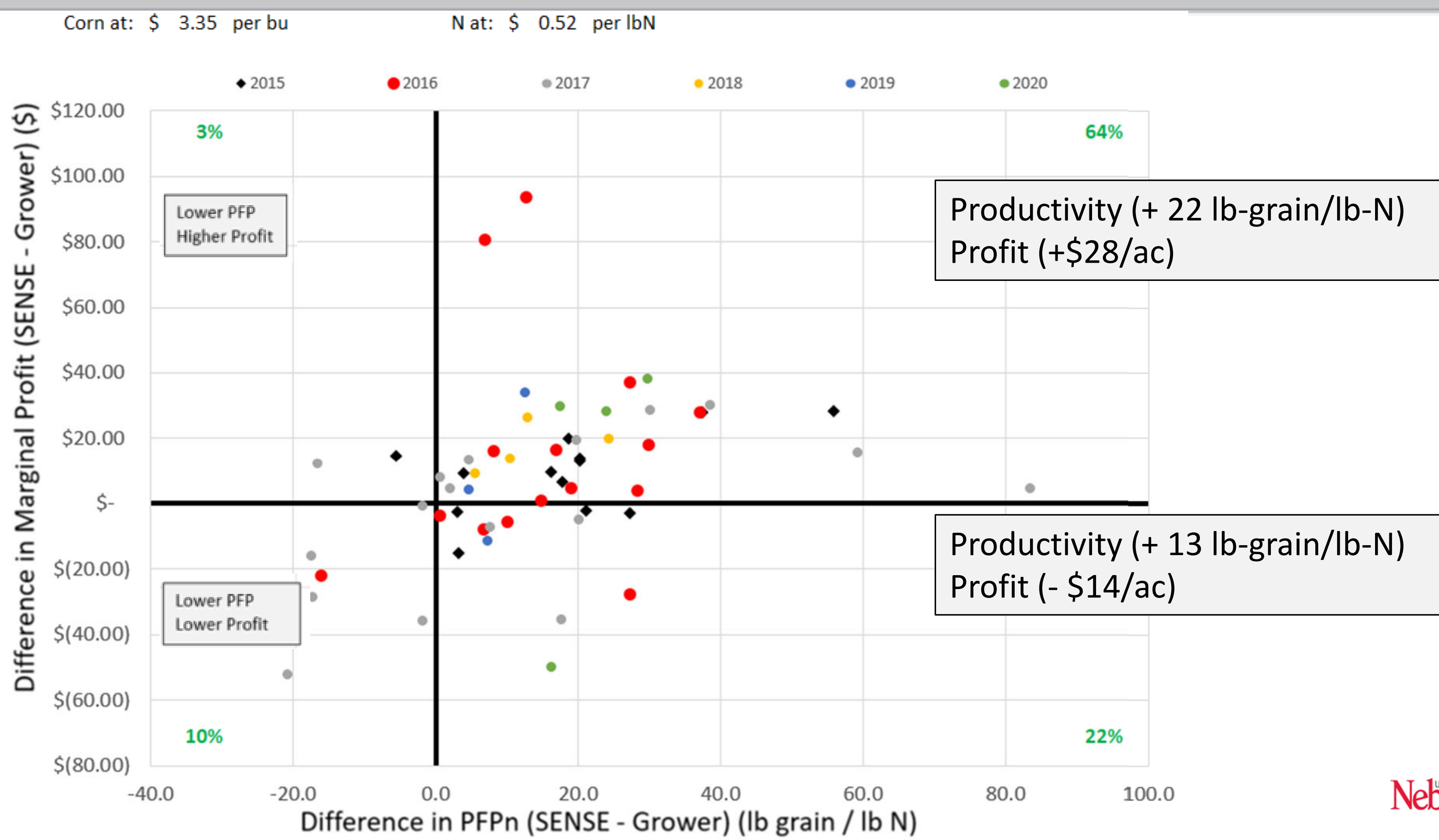

Project SENSE

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- Six-year Differences (Grower – SENSE) All sites averaged by year:

Five Year Average	SENSE	Grower
Total N rate (lb-N/ac)	159.3 B*	190.8 A
Yield (bu/ac)	216.9 B	218.0 A
Nitrogen Use Efficiency (lb-N/bu grain)	0.75 B	0.92 A
Partial Profitability ($/ac) [@3.65/bu and $0.65/lb-N]	$693.17 A	$676.44 B
Partial Profitability ($/ac) [@3.15/bu and $0.41/lb-N]	$622.20 A	$612.82 B

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Adoption

Opportunities

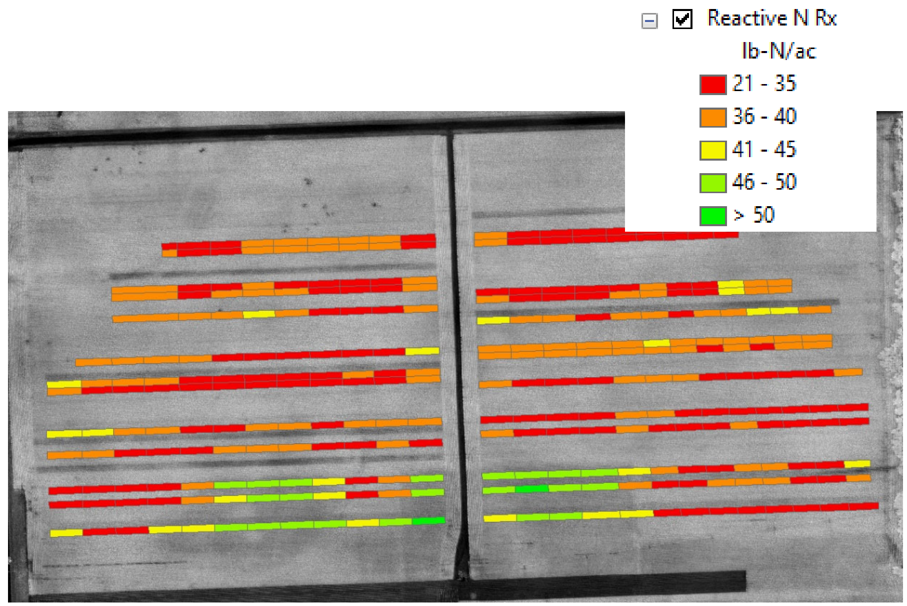
- Adjusting for spatial and temporal variation.
- ‘Plug and Play’ and real-time technology
- Responsive approach has high potential for reducing N needs
- Breakeven acres could be very low if you’re currently operating specific equipment for in-season N management

Challenges

- Terrain, soil texture, and OM variability can affect potential returns
- Reasonable N optimum estimates are critical…still requires input
- Algorithm and sensor measurements
- Consider NUE metrics that you are currently operating at…how much more efficient can you operate economically?

What other options exist?

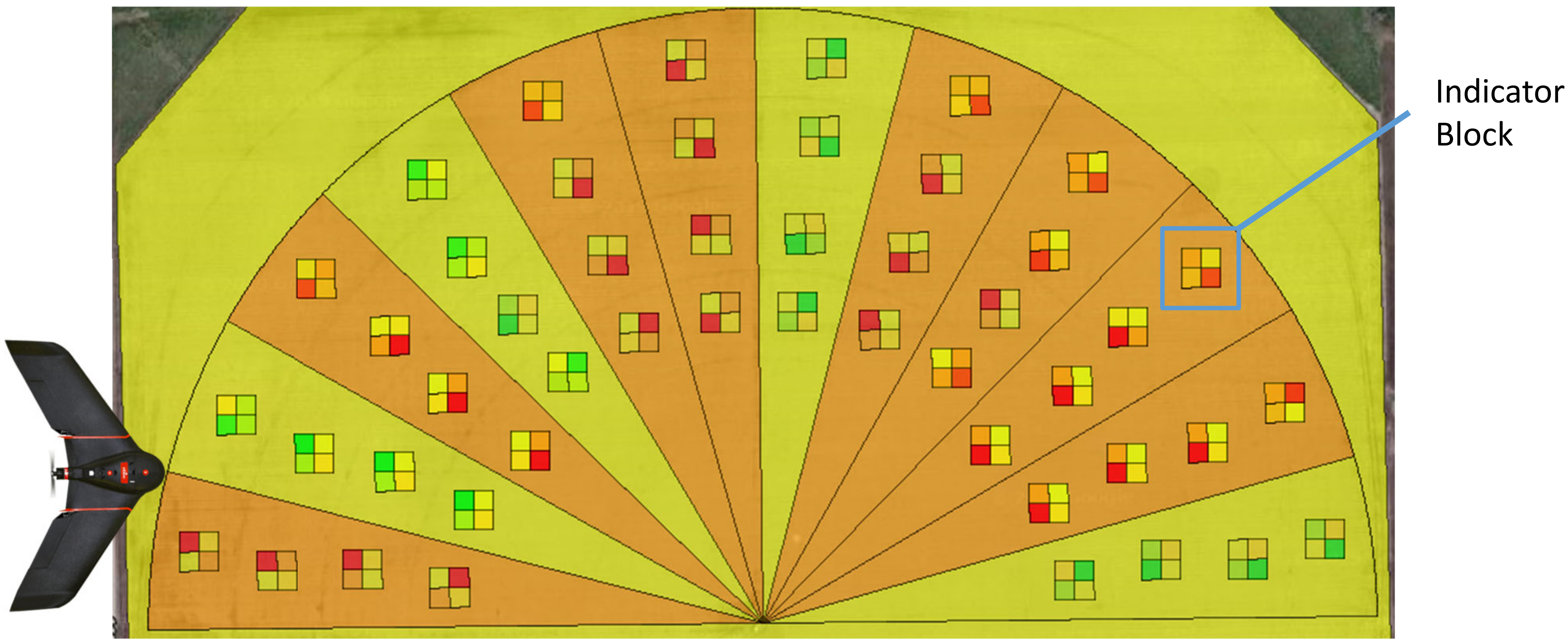
- Further work has demonstrated the benefits of split N and sensor-based N management using passive aerial-based recommendations
- Mobile-platform mounted sensors give us the ability to better manage based on large spatial variability



Treatment	Yield (bu/ac)		Profit ($/ac) [@$3.23/bu]	Total N (lb-N/ac)	N Cost ($/ac)	MNR ($/ac)		NUE (lb-N/bu)
0 N	168.1	A	$ 542.96	0	$ -	543	A	-
Irr_N	217.5	B	$ 702.53	150	$ 44.80	657.7	B	0.69
V5 Split	218.8	B	$ 706.72	150	$ 48.81	657.9	B	0.69
Reactive	224.4	C	$ 724.81	110	$ 34.71	690.1	C	0.49
V12 Split	232.4	D	$ 750.65	150	$ 48.70	701.9	C,D	0.65

What other options exist?

- Sensor-based fertigation:



Basic idea: use indicator blocks to predict N stress and make weekly fertigation decisions through the use of aerial imagery.

N EXTENSION

Project SENSE

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- Supporters of the 2015-2017 project:

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