Development of a New Procedure to Design In-Season Variable Rate Nitrogen Fertilizer Prescription Maps for Michigan Wheat Farmers

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Objectives

- To evaluate the **economic** and **environmental** benefits of implementing a spatially variable N fertilizer application in consideration of spatial variability in wheat fields

Late-season N application by Wilbur Ellis using Basso Rx

Rationale

- Applying N in a spatially variable manner gives the grower the ability to customize their inputs to match the plant's nutrient demand, which varies over space and years

- Decreasing excess fertilizer improves resources (N) efficiency and profitability

Basso Rx map visualized on applicator monitor

History of Basso Lab for MI Wheat Checkoff

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- **2015 & 2016**: Improving Nitrogen Management in Wheat Using Remote Sensing

↓

- **2017 & 2018**: Strategic and Tactical Nitrogen Management Using Drone Images and Crop Modeling to Increase Protein Content and Grain Quality in Wheat

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- **2019 & 2020**: Development of a New Procedure to Design In-Season Variable Rate Nitrogen Fertilizer Prescription Maps for Michigan Wheat Farmers

History of Basso Lab for MI Wheat Checkoff

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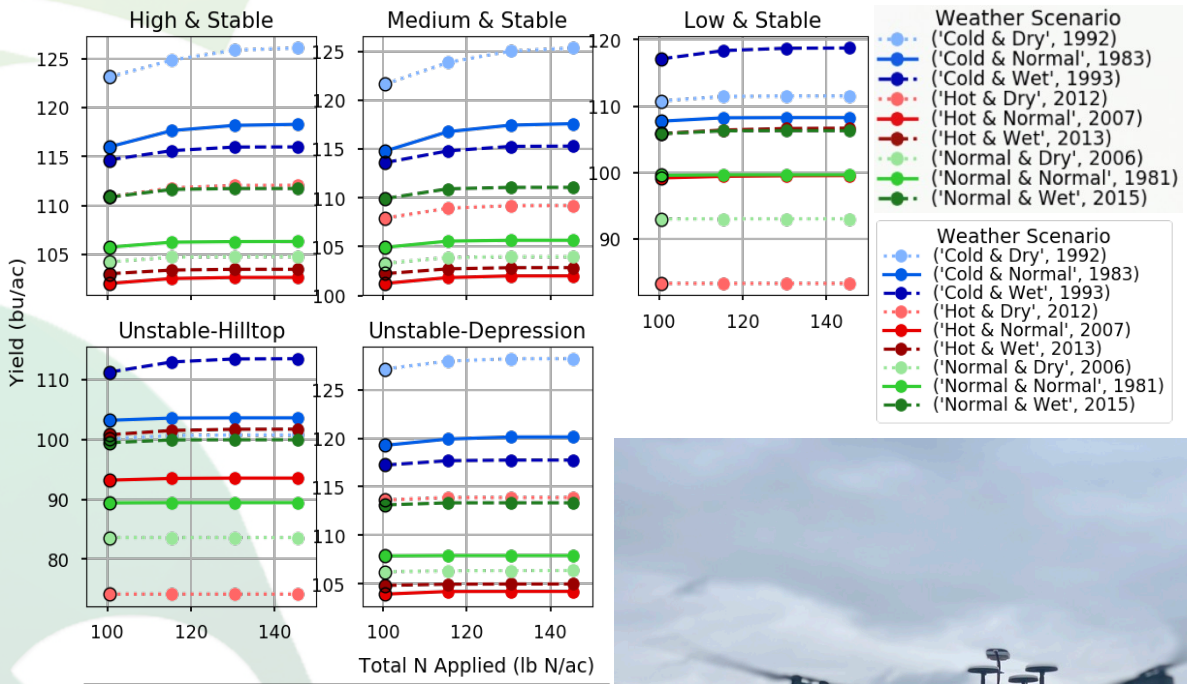
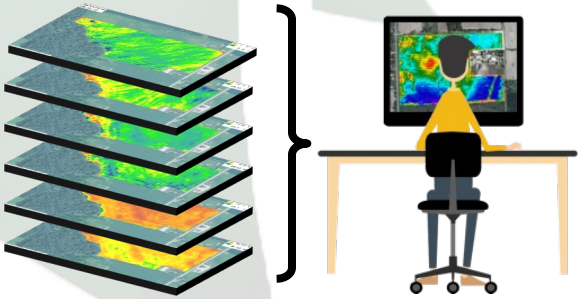
- Crop simulation modeling, yield history, and remote sensing integrated to provide accurate yield forecasts with multiple N scenarios

- **<u>Working towards turn-key solution</u>**



Crop model simulations for different weather scenarios



Basso lab drone collecting remotely sensed imagery

History of Basso Lab for MI Wheat Checkoff

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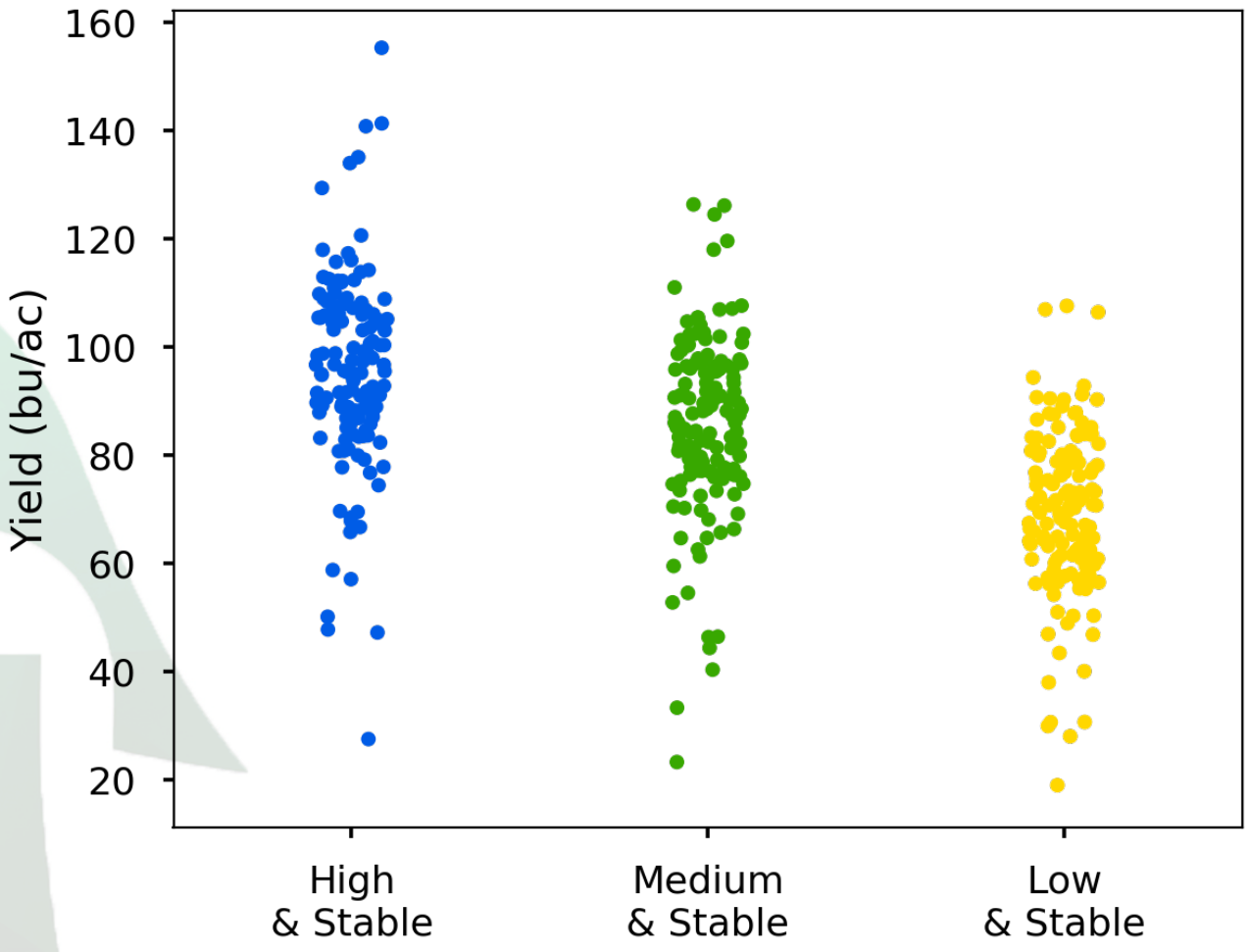
- Trends of wheat yields related to yield stability zone in 145 field-years
- Includes multiple wheat varieties and N management strategies



Yield data at each yield stability zone for 145 site-years

2019-2020 Project Design and Implement Rx Maps in Wheat

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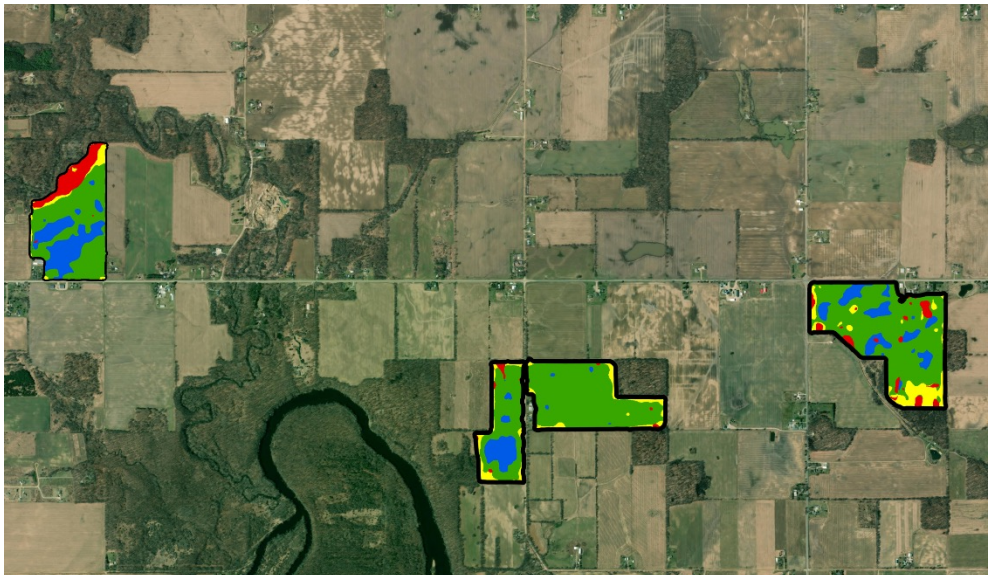
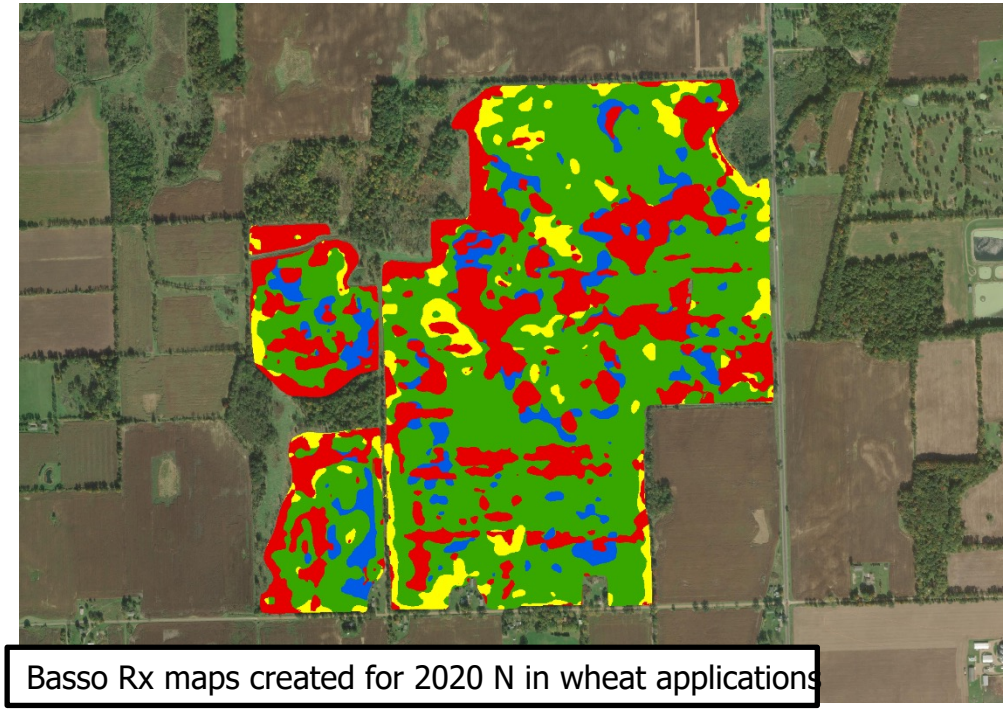
- Scale-up Rx methodology
- 730 acres of Rx made in wheat for 2020
- Provided maps for N application for March-April-May applications





Basso Rx maps created for 2020 N in wheat applications

Methodology

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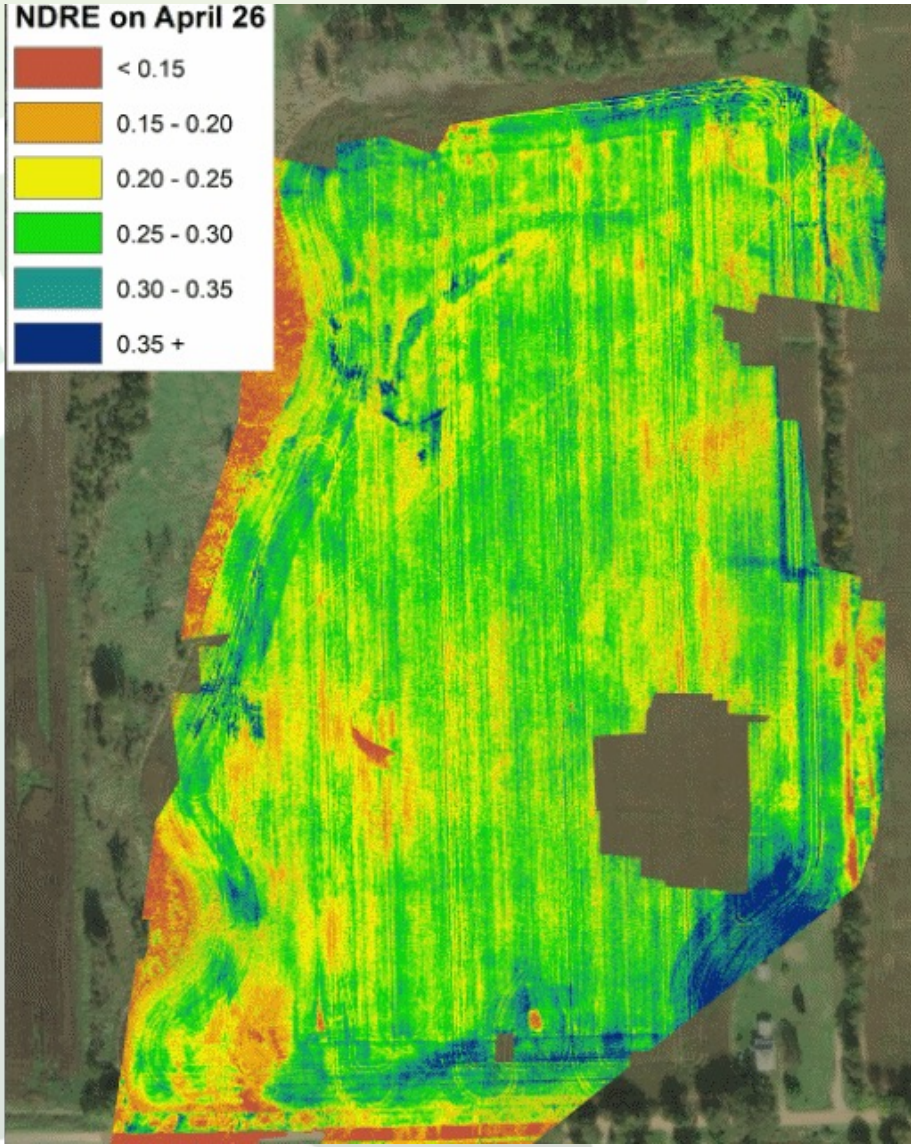

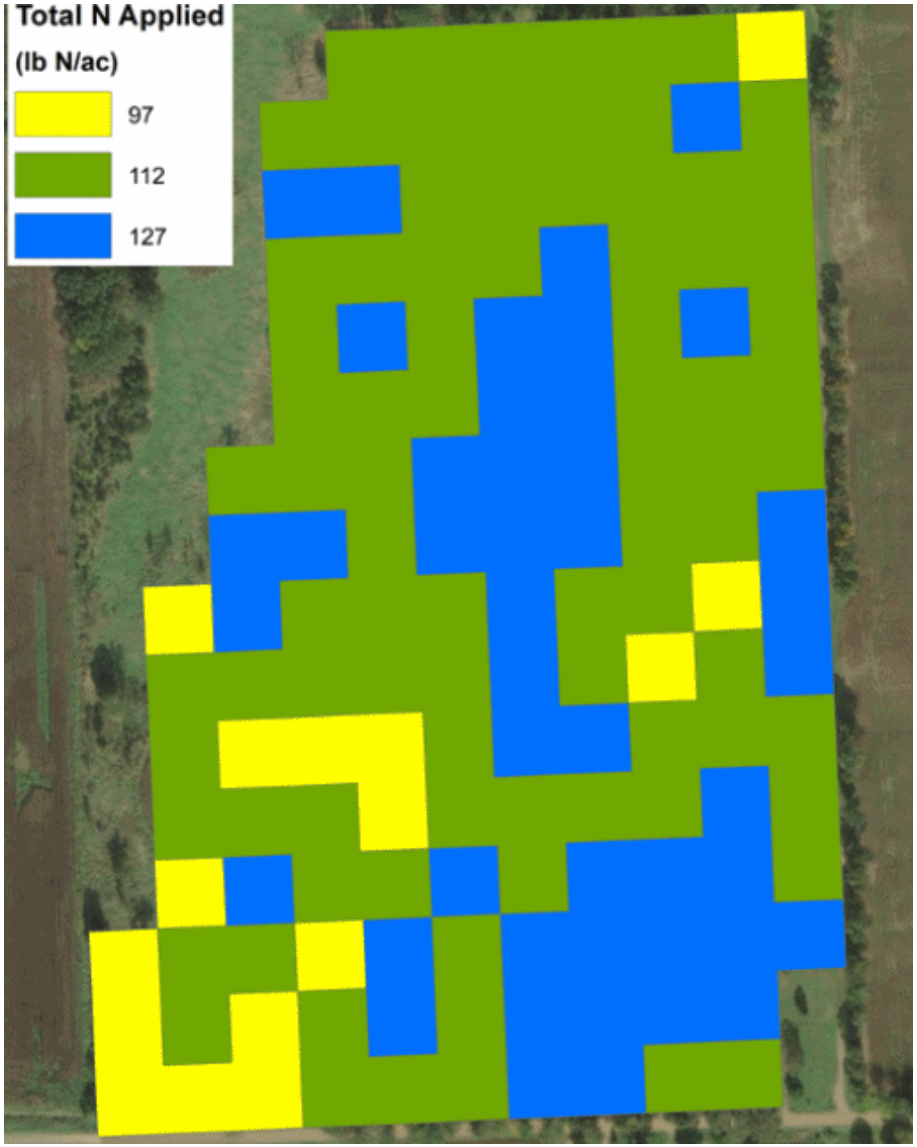

UAV NDRE (left) and generalized grid Rx map (right) with rates adjusted to match model simulations

2019-2020 Project Design and Implement Rx Maps in Wheat

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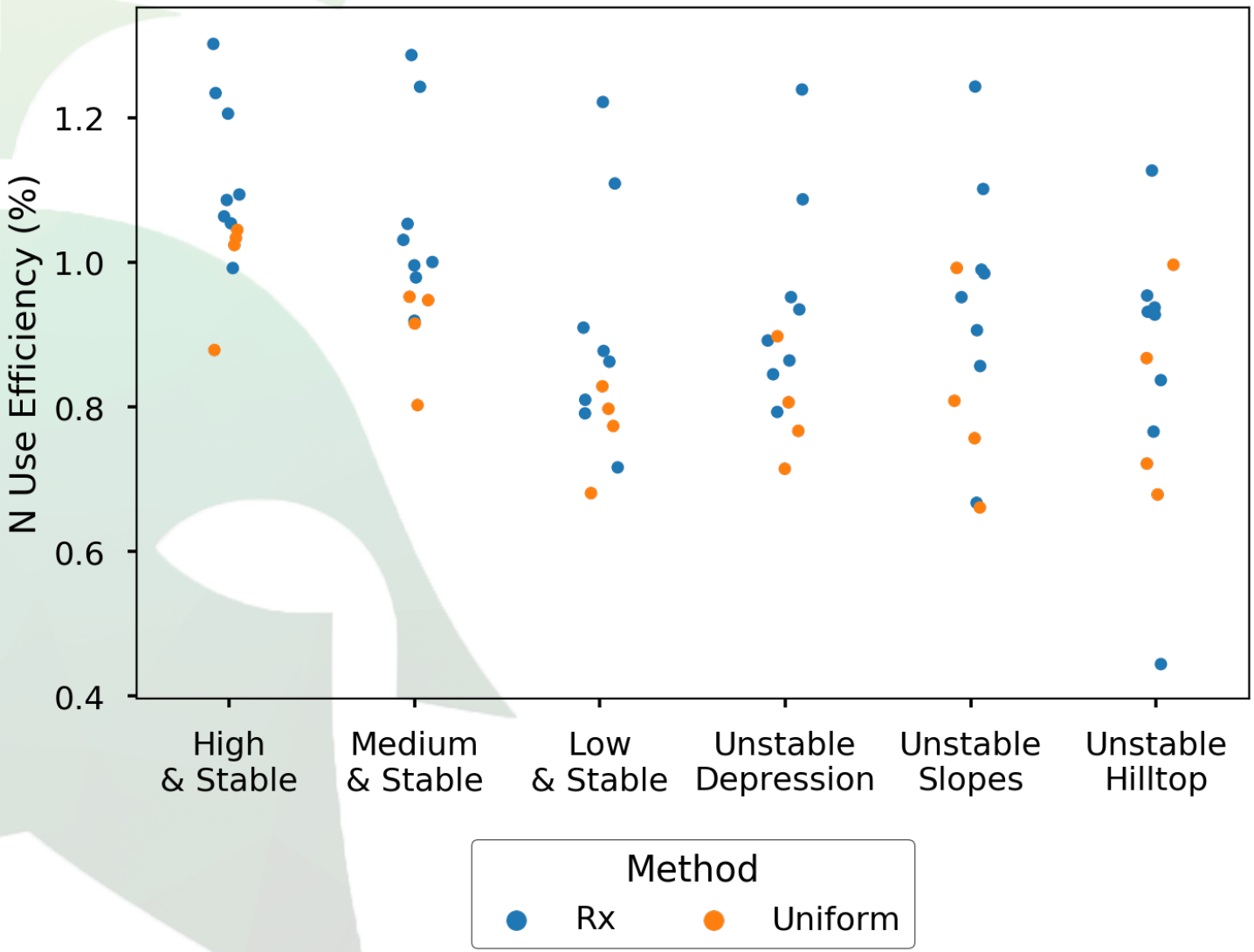

2019-2020 Project Design and Implement Rx Maps in Wheat

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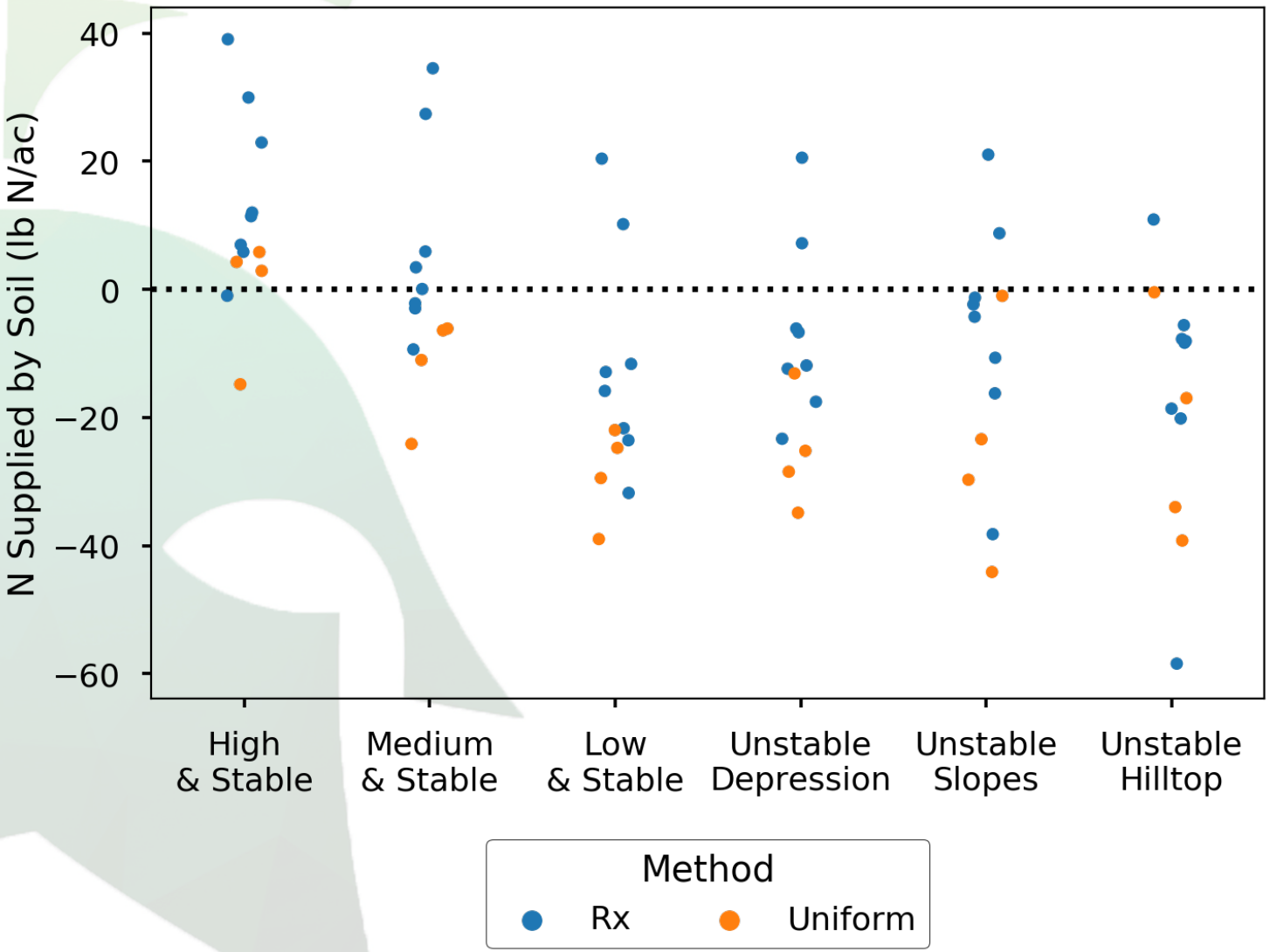

2019-2020 Project Design and Implement Rx Maps in Wheat

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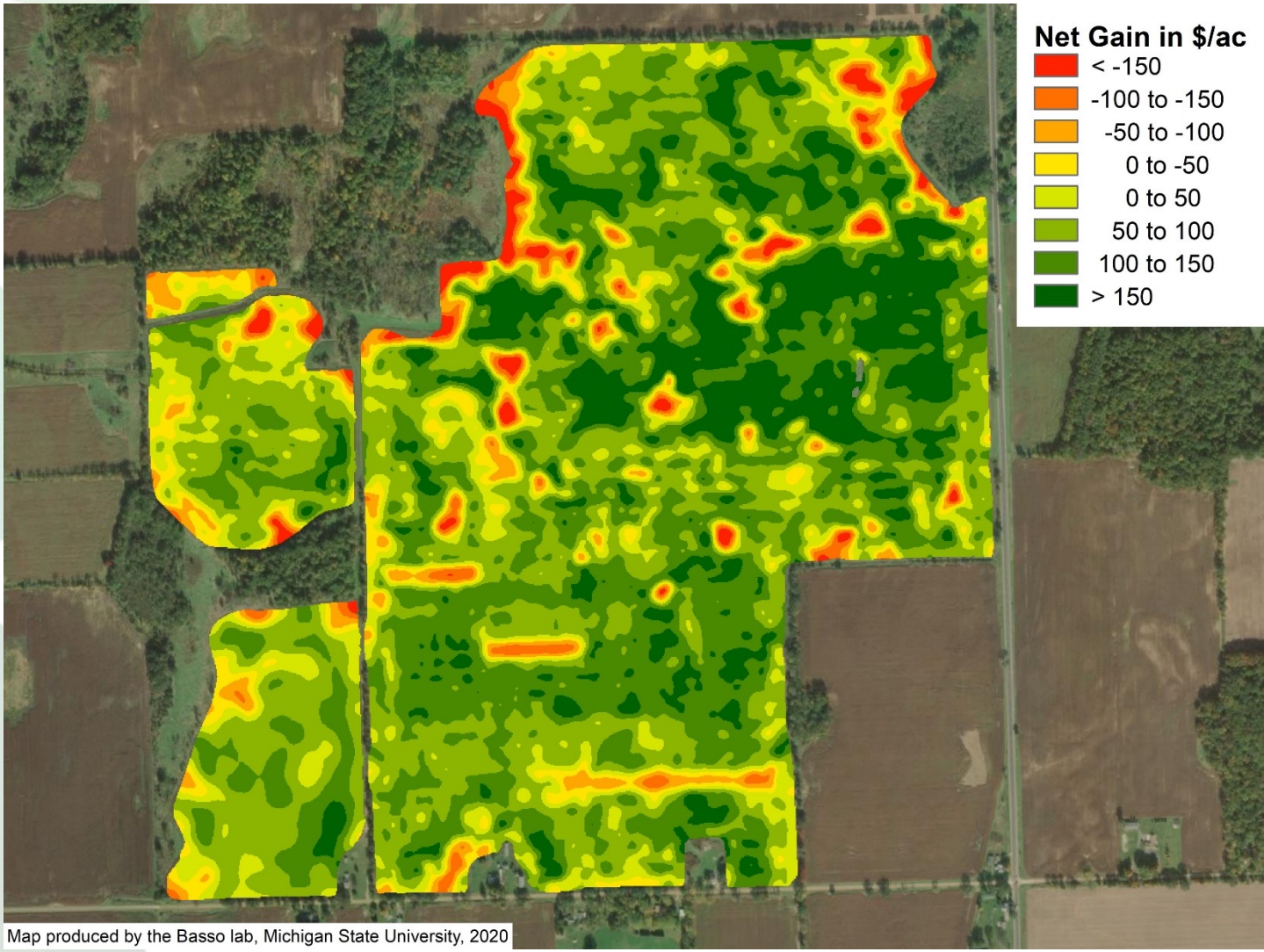
- $0.45/lb of N
- $5/bu of wheat
- $300/acre for production

- **Profit maps** are adapted to adjust input/output costs depending on year



3 out of 8 fields where Rx maps were implemented

Conclusions

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- This 2-year project developed a protocol/procedure for creating variable rate Rx maps in wheat.
- Implemented 2 fields in 2018-2019 and 8 fields in 2019-2020.
- The Basso Rx method showed a benefit to increase NUE (from 75% to 120%) which also leads to a reduction of nitrate losses. **(Environmental benefits)**
- The Rx optimizes the return on investment by showing positive return in stable areas. **(Economic benefits)**

High-Intensity Management of Nitrogen in Wheat: How Soil Water Forecast Modeling Improves Fertilizer Efficiency

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Rationale

- Managing N would be a lot easier if fields were consistent and uniform

- **High-Intensity Management** Trials incorporate additional N with PGRs, fungicides to encourage greater production and quality

Mid-season N application with strip-trial in Springport field

Additional Nitrogen	Plant Growth Regulator Example	Fungicide Example
+ 10-30 lb N/ac	Palisade, Manipulator	Priaxor, Caramba

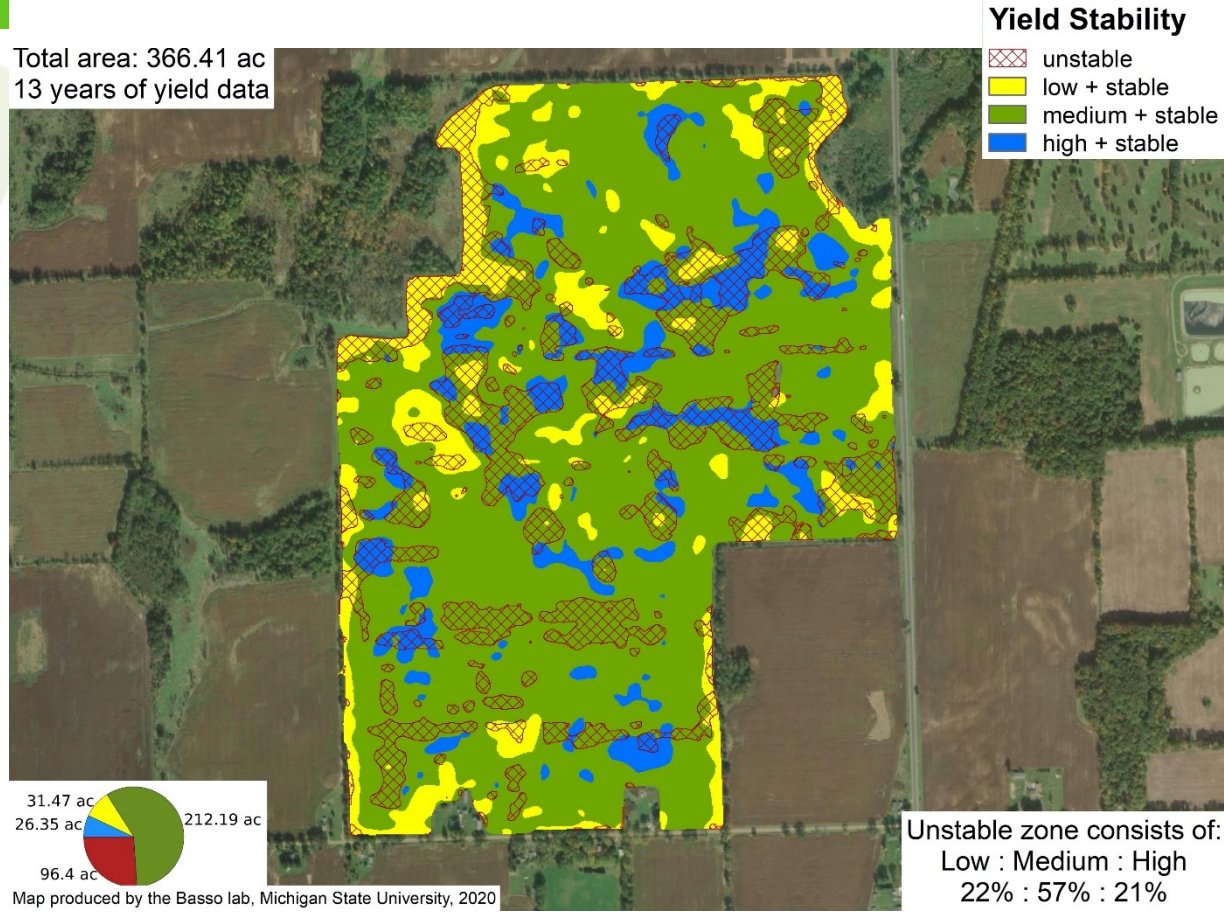
Rationale

- Reality is these fields have immense spatial variability
- This variability affects every management decision
- These patterns of variability are known and quantified!

Springport field visualized via RGB camera on drone at 400 ft.

Rationale

- Reality is these fields have immense spatial variability
- This variability affects every management decision
- These patterns of variability are known and quantified!



Springport field visualized with yield stability map from 13 years of data

Yield Stability Zone	2013 Yields (bu/ac)	2020 Yields (bu/ac)
High & Stable	106.0	86.8
Medium & Stable	95.4	80.7
Low & Stable	76.8	65.5
Unstable- Depression	92.1	69.0
Unstable- Slopes	89.1	74.0
Unstable- Hilltops	89.9	67.1

Rationale & Methodology

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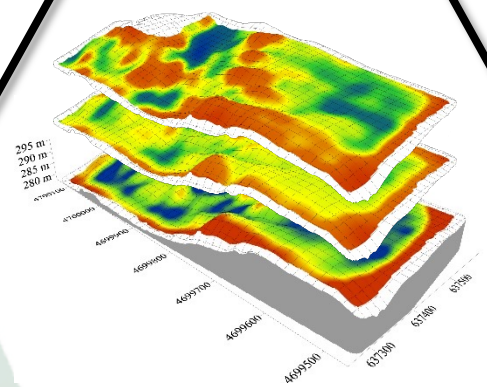
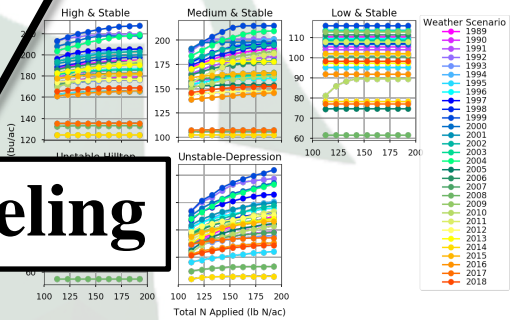
Yield History





Crop Modeling

Remote Sensing

Objectives

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- **The overall goal** of this two-year proposal is to effectively prescribe wheat N strategies for forecasted weather scenarios related to conventional or HIM for Michigan wheat farmers.

- In **year 1**, we aim to collect and **analyze best N practices** by Michigan Wheat Program Districts and relate trends with soil water availability.

- In **year 2**, we aim to **distribute these recommendations** through a web-based decision support tool that is available to every Michigan wheat grower.

Effects of Topography

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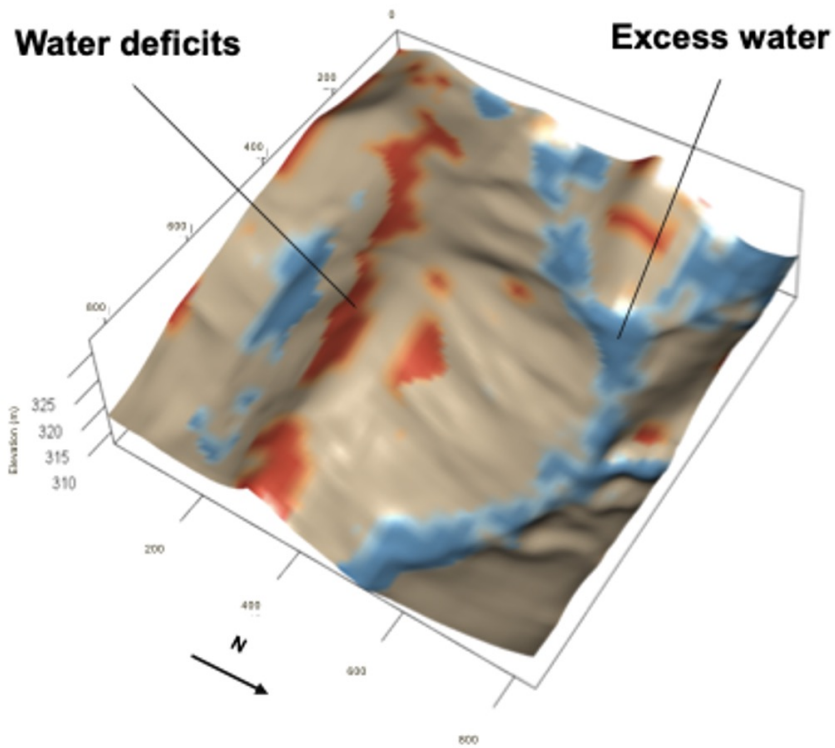
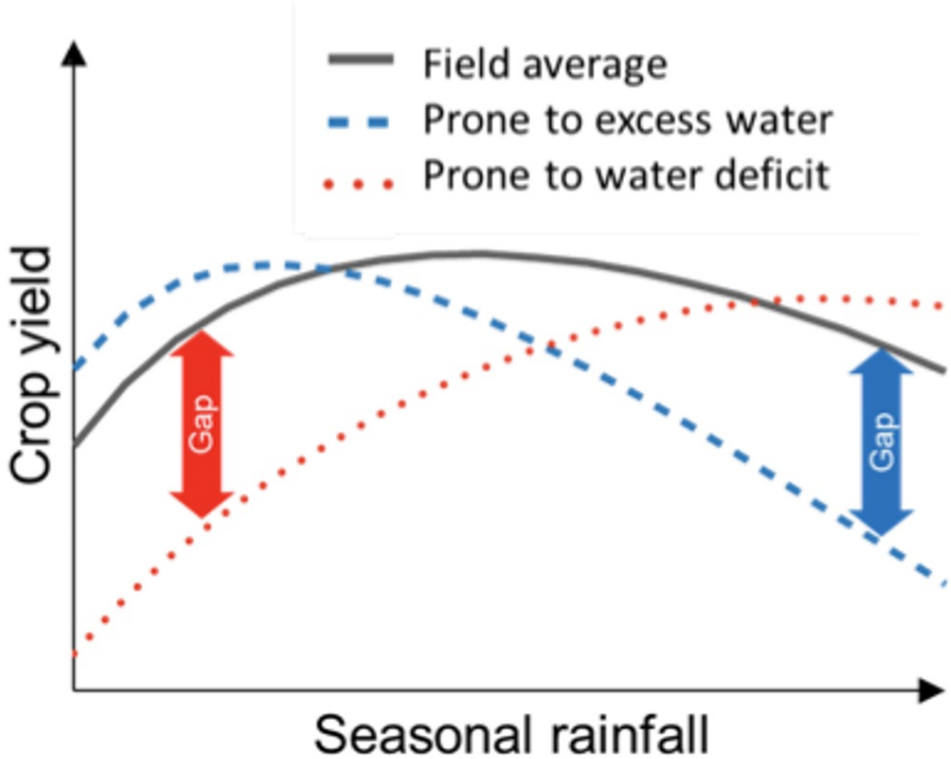
How much land is affected?

How large are the gaps?

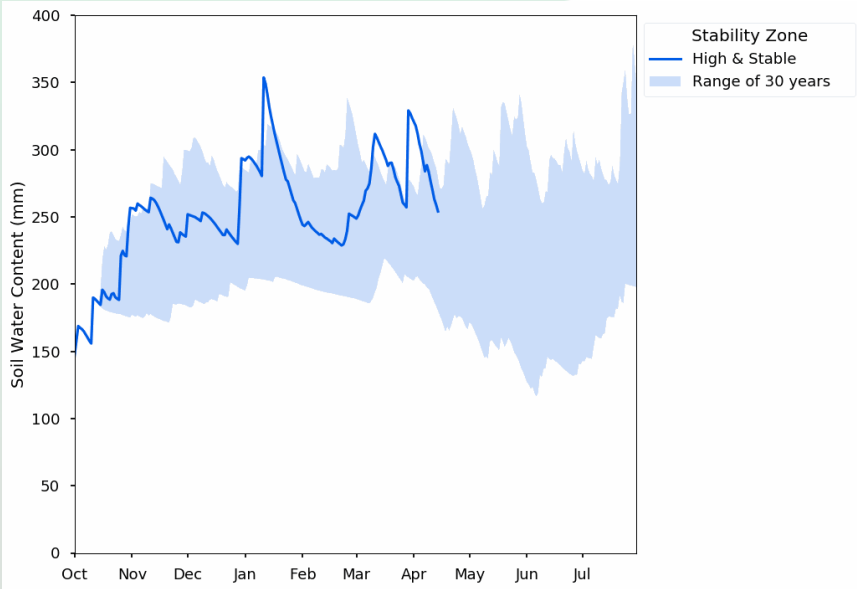




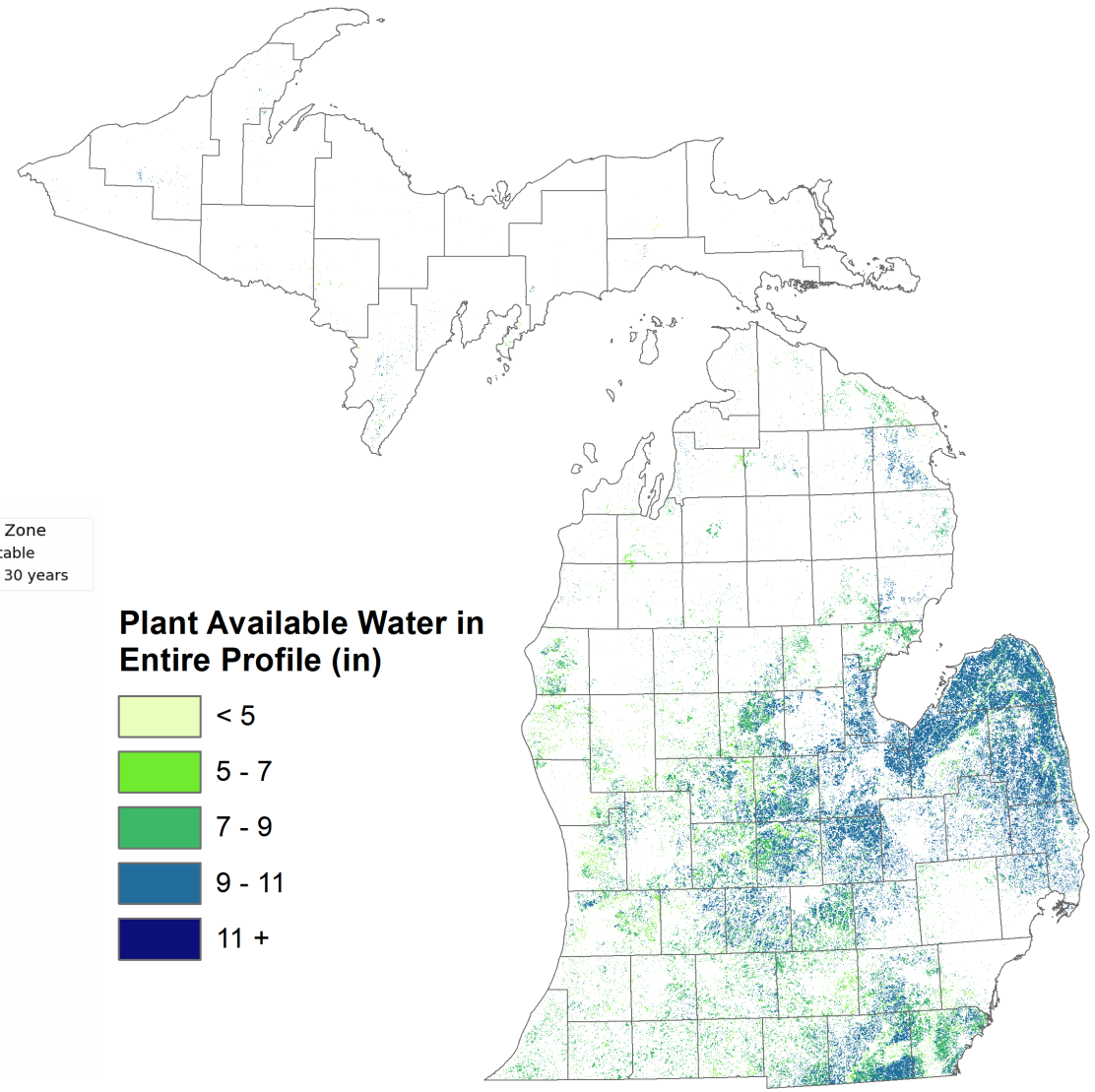
Martinez-Fertia, R.A. & Basso, B., 2020. Unstable crop yields reveal opportunities for site-specific adaptations to climate variability. *Scientific Reports,* 10 (2885).

Methodology

- Soil water drives N uptake
- Soil water content varies across field and within fields due to soil-landscape-weather interactions



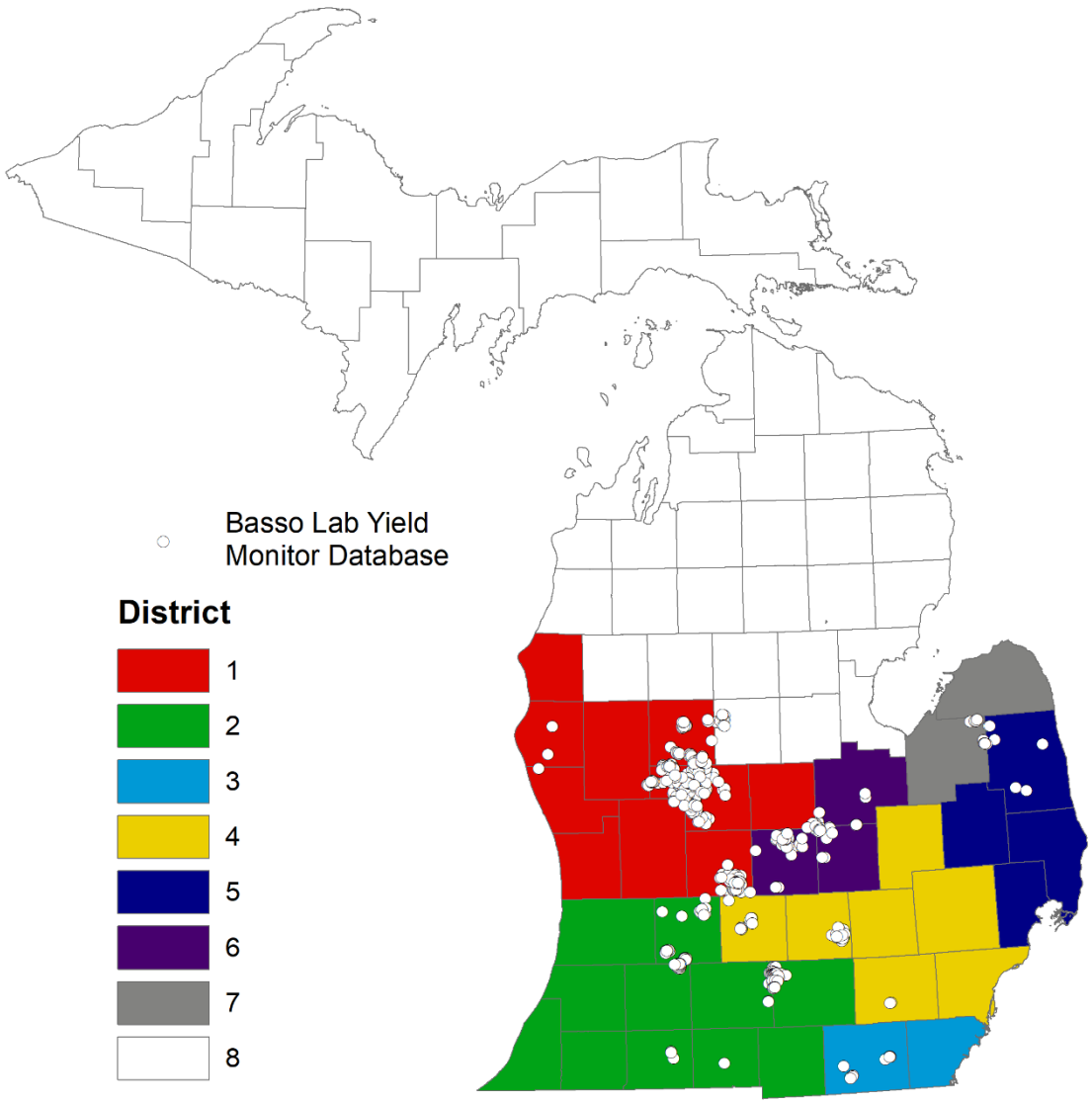
- Ranges of soil water known for each field



Soil water in profile based on soil water capacity for every field in MI where wheat was grown between 2008-2018. (USDA NASS Cropland Data Layer, 2019).

Methodology

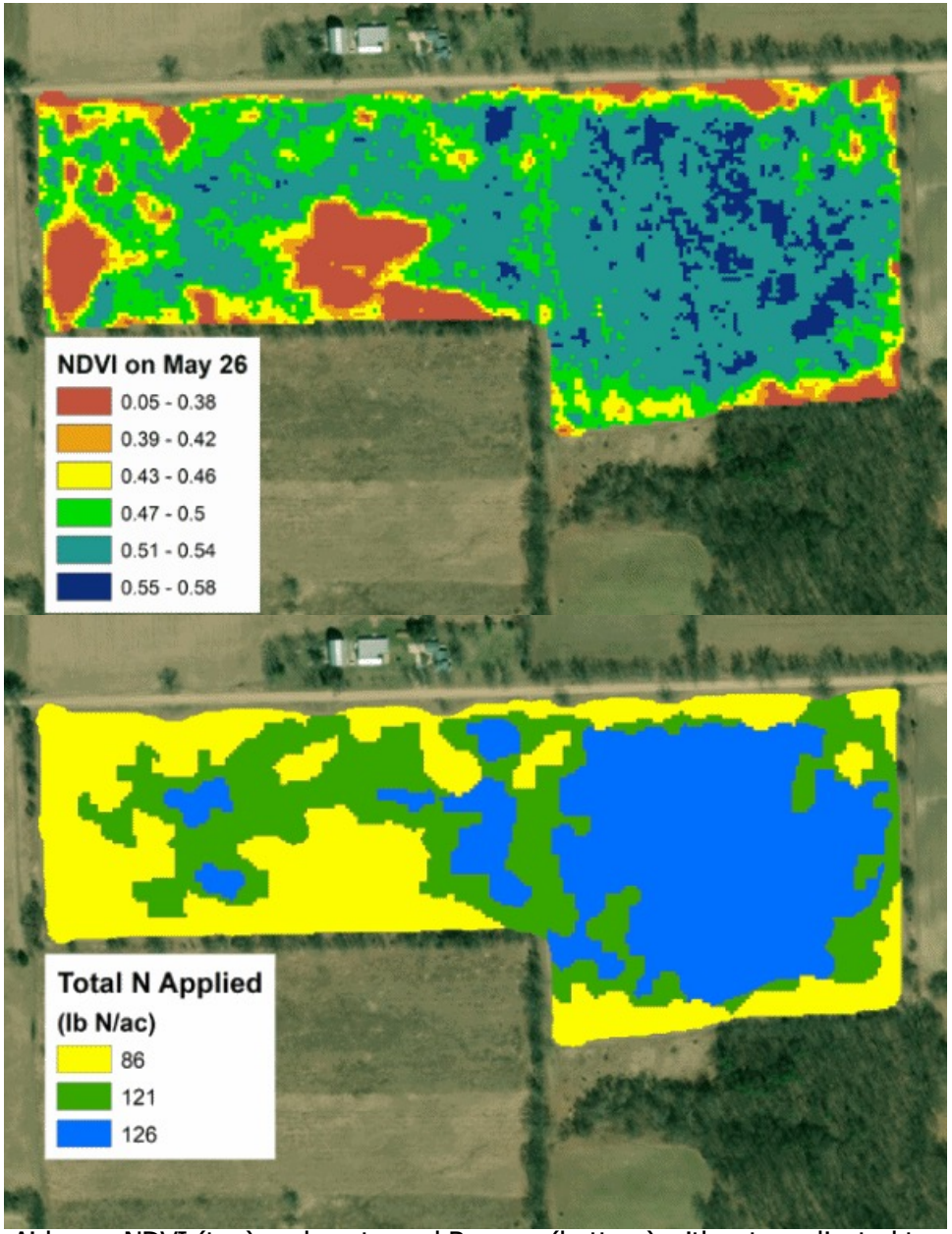
- Field survey to gain knowledge about management strategies in wheat
- Data powers better model calibration and simulation
- Carry out model runs based on regional information for enhanced understanding of soil water variability



Michigan Wheat Program Districts with locations of fields in the Basso Lab yield database.

Methodology

- Design and implement field experiment and trials
- Identify highly productive zones and implement HIM based on field's variability
- Create Rx's based on contour or generalized maps



Airborne NDVI (top) and contoured Rx map (bottom) with rates adjusted to match model simulations

Expected Results

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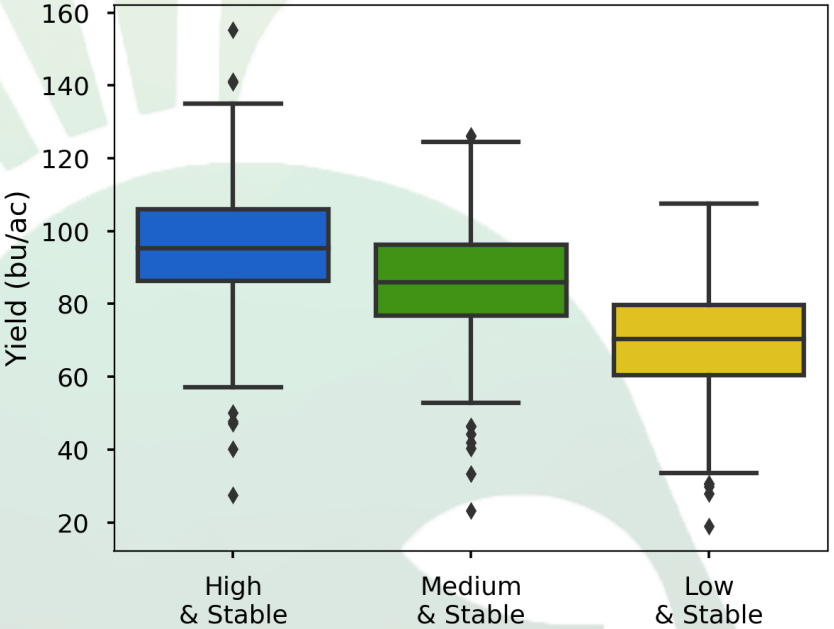
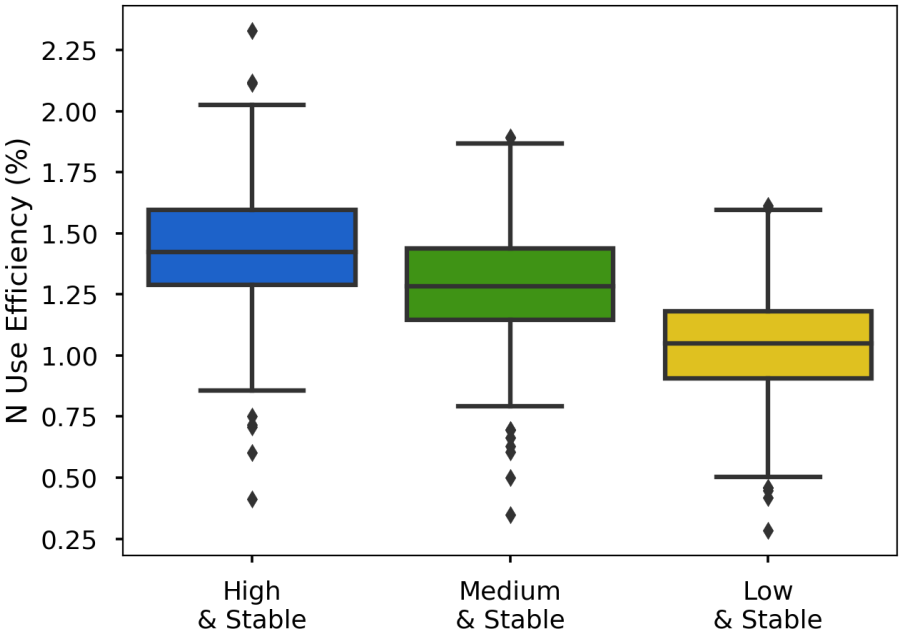
- Trends of wheat yields related to yield stability zone for 145 field-years





Yield Stability	Avg. Yield	Avg. NUE (Assuming 100 lb N/ac)	Adjusted Rx N Rate	Savings from Rx
High & Stable	94.9	1.42	100	n/a
Medium & Stable	84.9	1.27	90	$4/acre
Low & Stable	69.0	1.03	70	$12/acre

Many Thanks to the Michigan Wheat Program for Their Support

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