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Digital Agriculture to Reduce Nitrogen Losses across the U.S. Corn Belt

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Yield mapping

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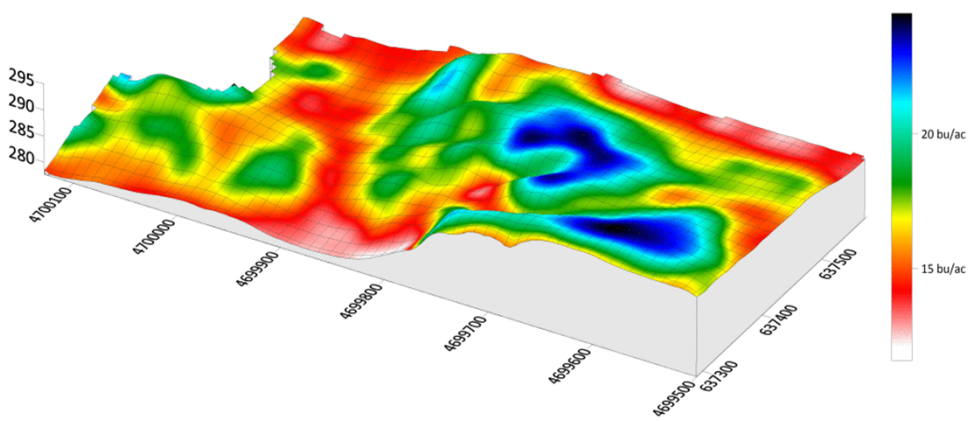
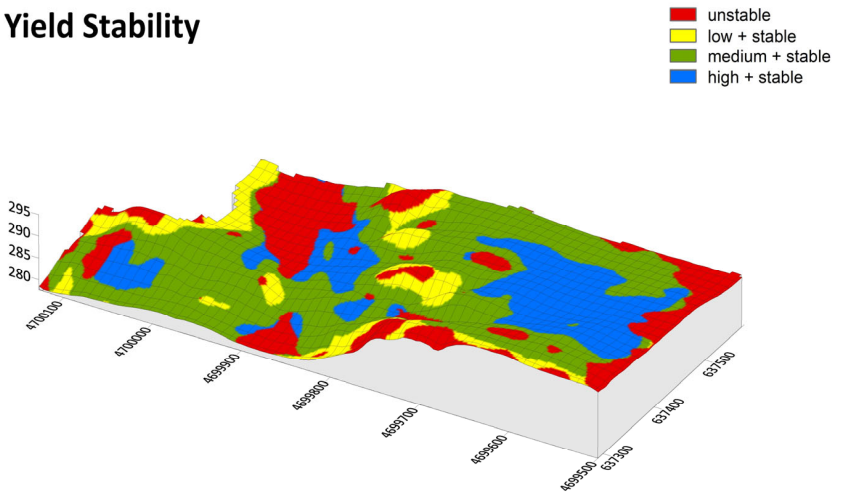
Soybeans 2009

150 bushel/acre ~ 10 ton/ha



Yield Stability



68% of US corn was harvested with combined equipped with yield monitor
45% of the corn area was yield mapped (Lowenberg-DeBoer and Erickson, 2019, *Agron J.*)

Big data set

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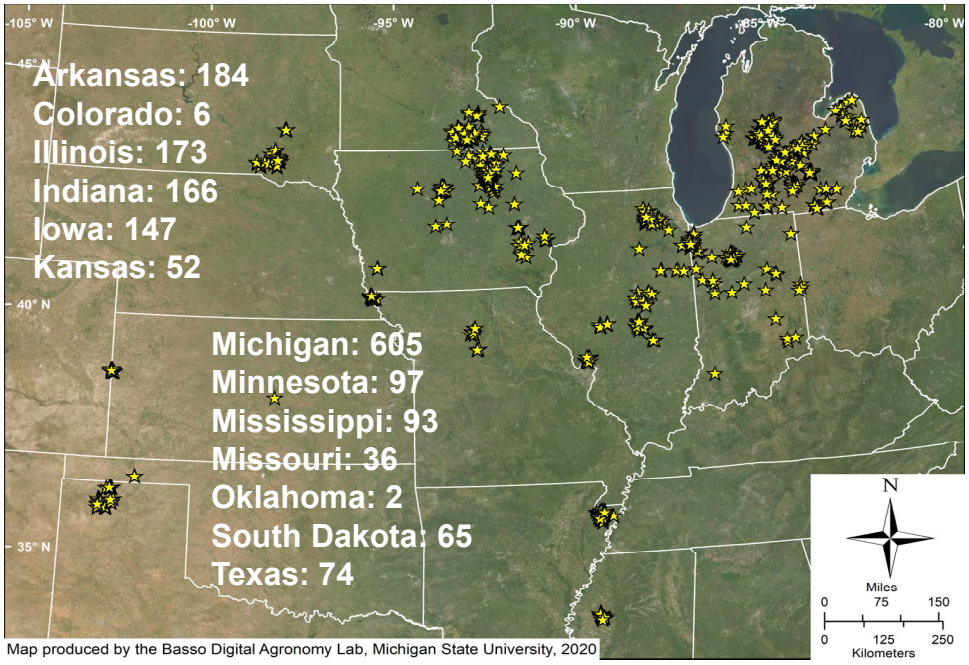
Yield data

- 13 states, 1,701 fields, 7400 yield maps
- Over 150000 acres; 629 with 6 or more years of data
- 171 with 10 or more years of data
- 4 main crops: maize, soybean, wheat, cotton
- Other crops: barley, canola, silage, peas, potatoes, rice



Map produced by the Basso Digital Agronomy Lab, Michigan State University, 2020

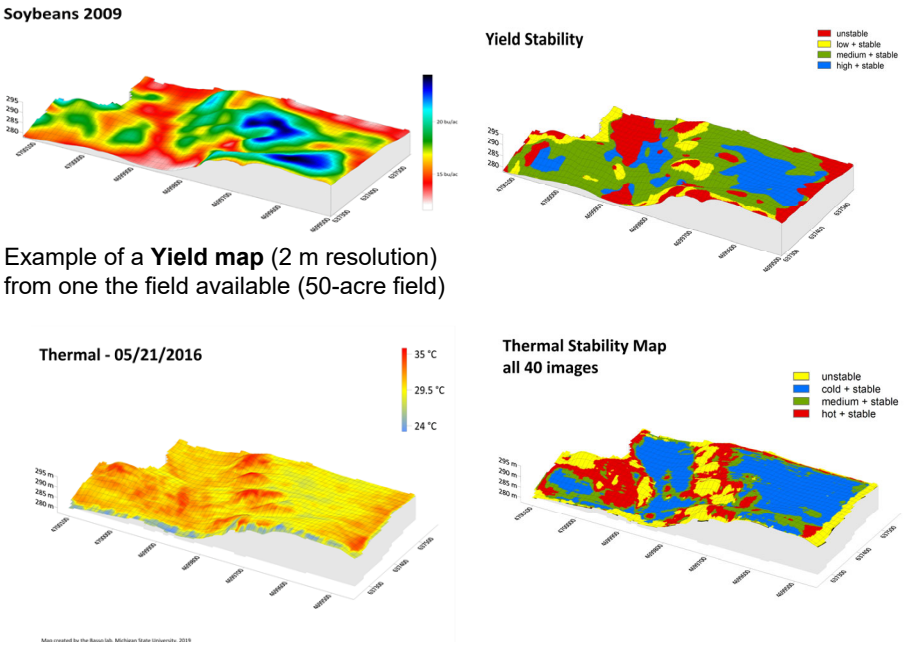
Airborne images

- 4 states, 322 fields; up to 8 years per field
- >55,000 images of visual, thermal and VIs
- Image res 0.5 m (RGB, VIs), 2 m (thermal)

Satellite Images

- Images at 30, 10 and 3 m

Management data (as applied maps)



Example of a **Yield map** (2 m resolution) from one the field available (50-acre field)

Subfield yield spatial and temporal variability

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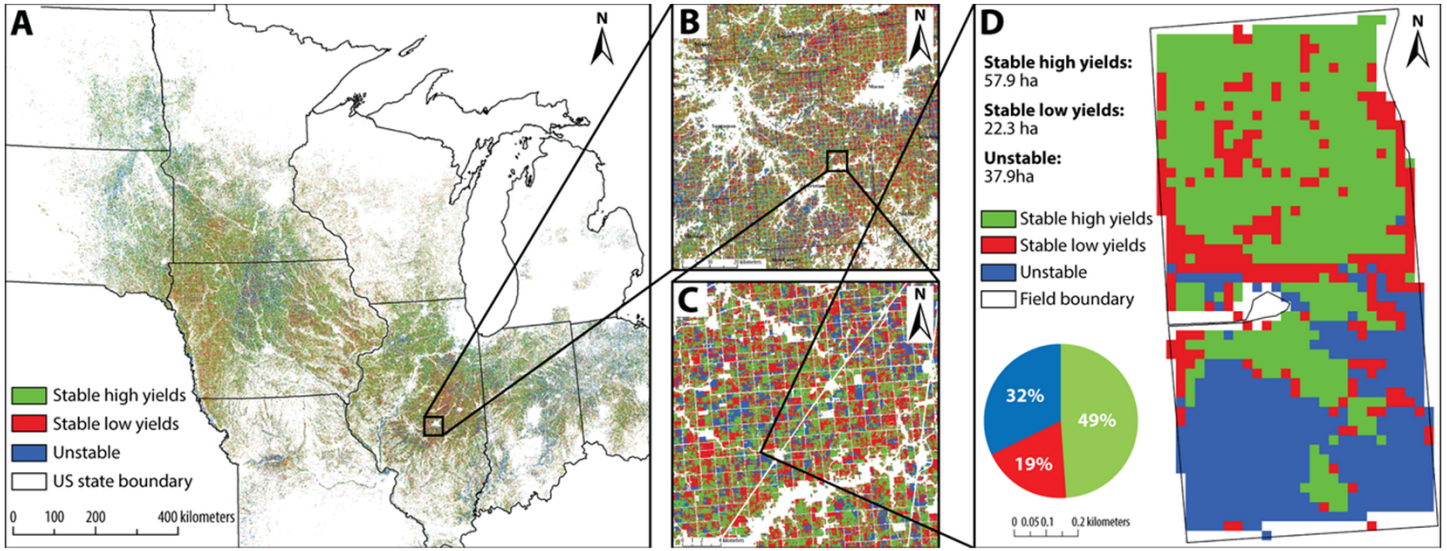

Crop and yield stability maps for (A) 10 Midwest states; (B) 10,000 km2 subregion; (C) 196 km2 subregion; and (D) 118 ha

Methods:

- 10 years NASA Landsat images
- Common Land Units (field boundaries)
- Crop data layers (corn and soybeans)
- NASS Arms (Fertilizer rates)

Subfield productivity across 70 M acres (~ 8 Million fields)

- 48% stable high productivity (HS); N Use Eff.~75%
- 25% stable low productivity (LS); NUE ~45%
- 27% unstable (U; 64% High yield, 26% Low yield); NUE ~ 58%

Impacts

- 0.6 -1.4 Tg N yr^{-1} of N fertilizers is lost to the Gulf of Mexico
- ~ 600 Million US$ yr^{-1} wasted from plant unused fertilizers
- 1.1 Billion Giga Joule of energy lost
- 720 Billion Metric tons yr^{-1} CO_2 lost to the atmosphere

Basso et al., 2019, *Scientific Reports*

N surplus, Water Deficits and Water Excess

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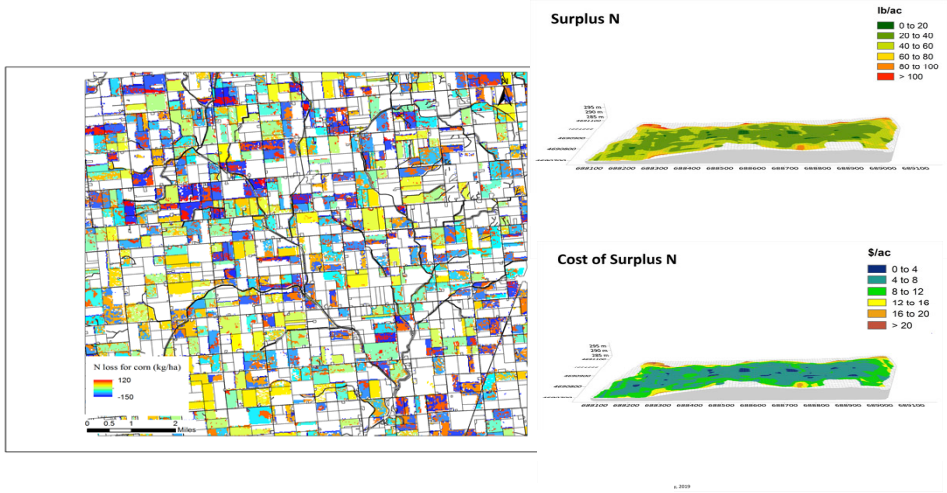
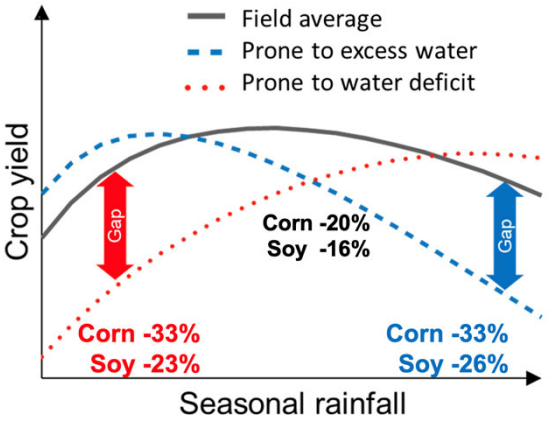
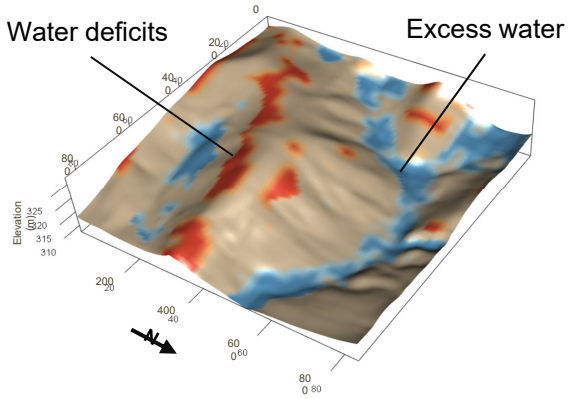


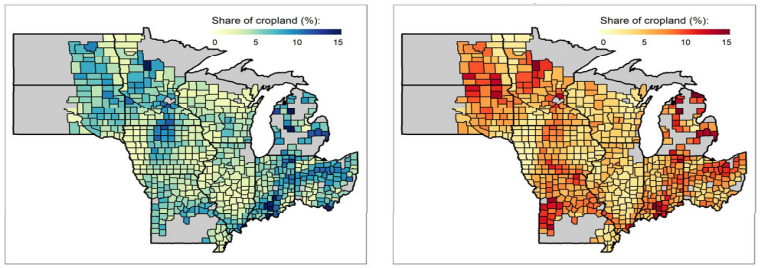




Martinez-Feria and Basso. 2020, *Scientific Reports*

Unstable zones in lowland positions (vulnerable to excess water)

Unstable zones in upland positions (vulnerable to water deficit)



Nearly 2.7 million ha (~10%) might be affected

Low stable and edge of field

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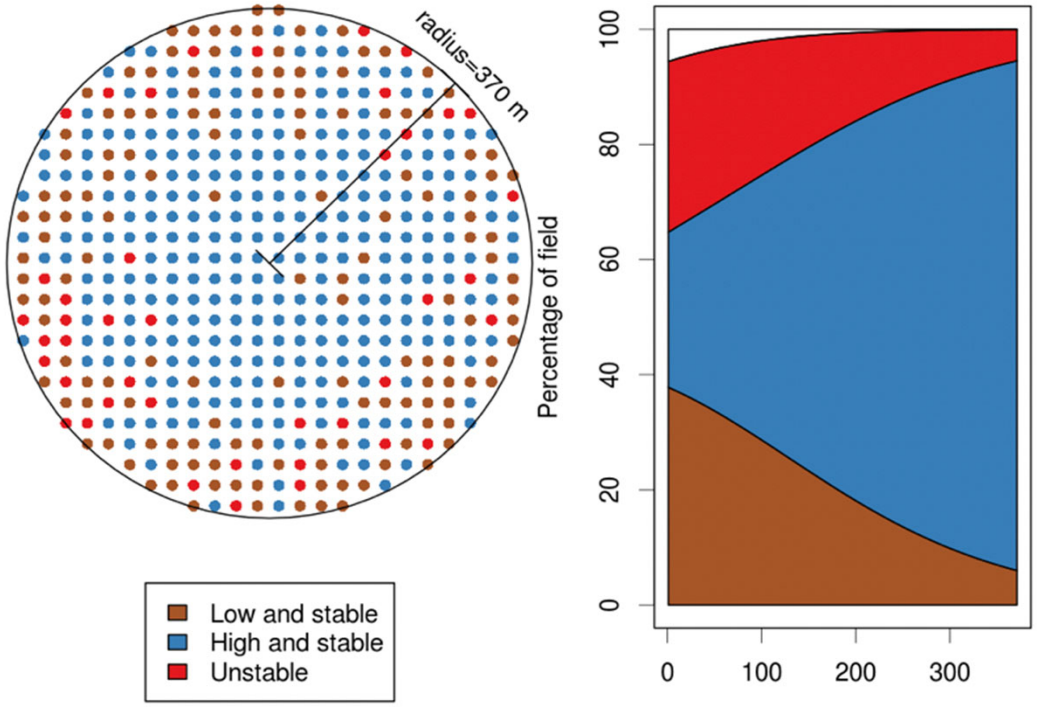

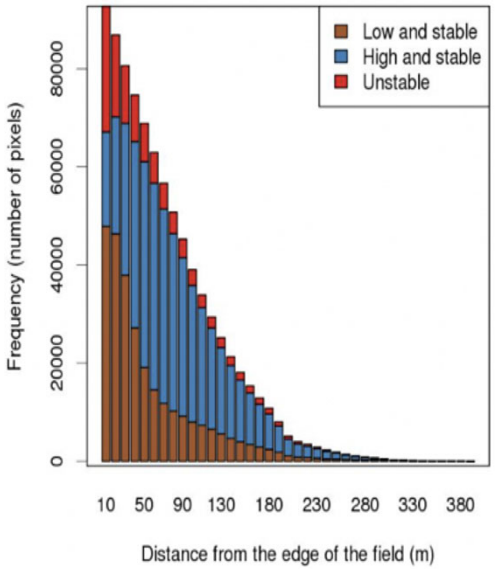

Basso et al., in preparation

Scaling low stable areas across 80M acres

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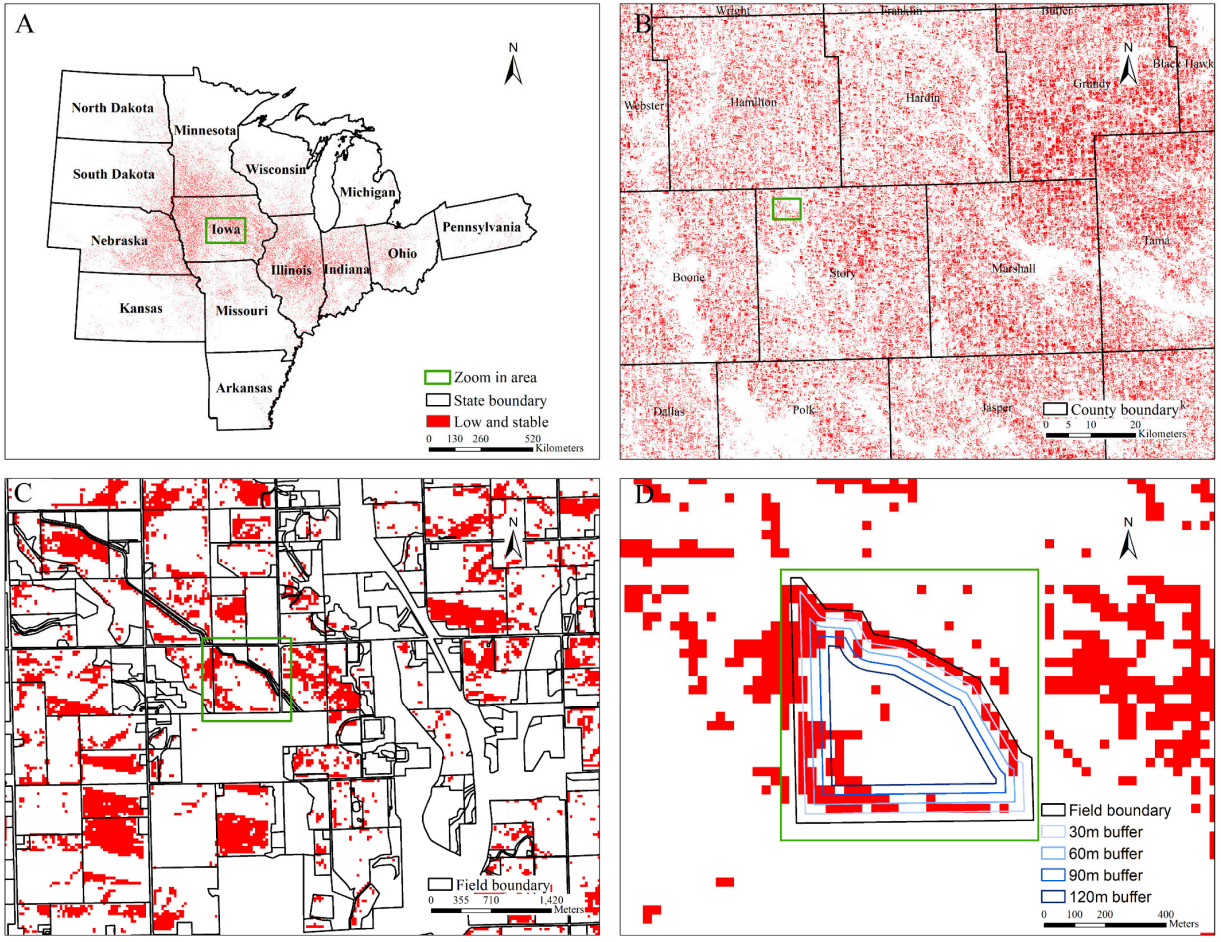

N savings from Digital Agriculture (climate benefits)

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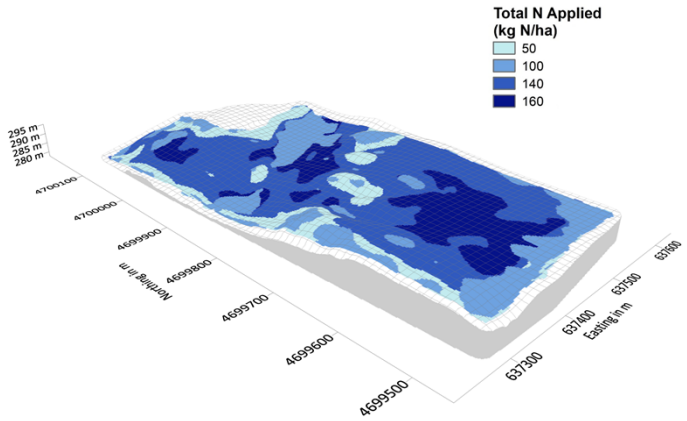
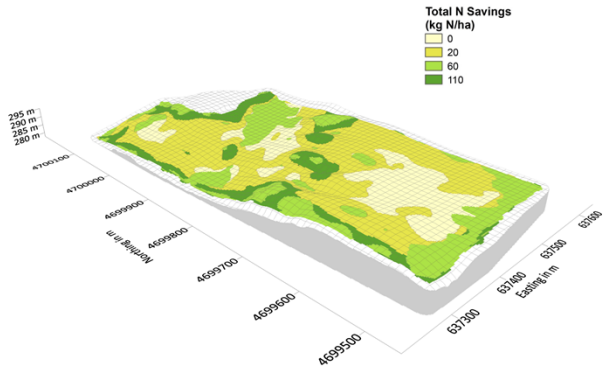
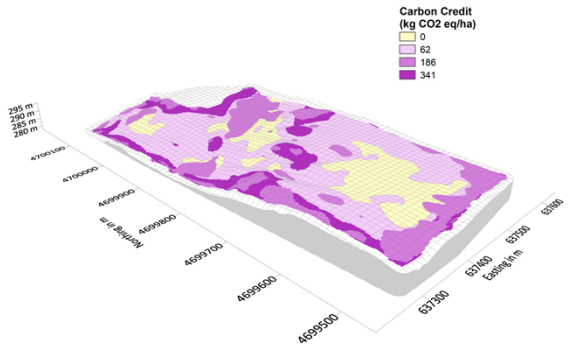
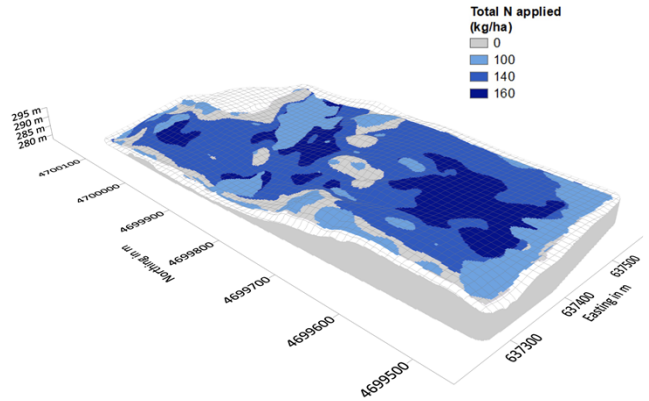
N savings from Variable Rate N

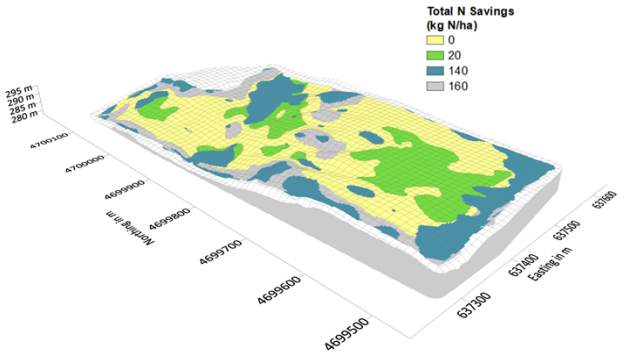


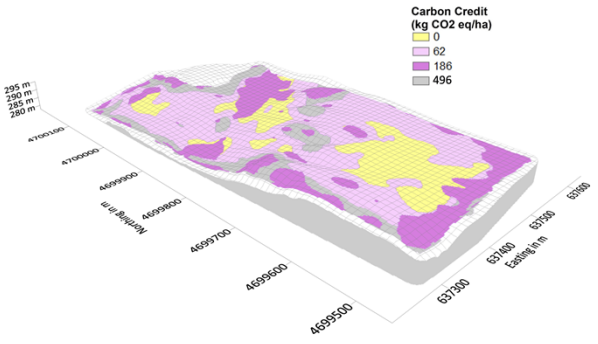




N savings from Precision Conservation







Subfield N saving in Low-Stable areas with Precision Conservation

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State	N rate	LS (ha)	Average N loss	Total N loss	LS_{5p} (ha)		N saving (10^3 Ton N y^{-1})	
	(kg N ha^{-1} y^{-1})		(kg N ha^{-1} y^{-1})	(10^3 Ton N y^{-1})	Middle	Edge	Middle	Edge
Arkansas	197	24,609	calculating		13,140	4,109	2.6	0.8
Illinois	183	2,043,111	45	91.9	1,370,217	495,443	250.7	90.7
Indiana	175	796,340	50	39.8	540,234	146,195	94.5	25.6
Iowa	158	2,330,849	12	28	1,540,689	604,128	243.4	95.5
Kansas	157	253,078	calculating		175,531	42,948	27.6	6.7
Michigan	151	506,268	30	15.2	307,235	99,716	46.4	15.1
Minnesota	160	993,808	14	13.9	677,655	205,318	108.4	32.9
Missouri	197	409,367	89	36.4	268,066	85,310	52.8	16.8
Nebraska	167	1,396,031	calculating		972,514	319,970	162.4	53.4
North Dakota	143	94,624	37	3.5	59,207	9,875	8.5	1.4
Ohio	174	456,333	47	21.4	289,378	95,978	50.4	16.7
Pennsylvania	113	67,856	calculating		38,894	9,916	4.4	1.1
South Dakota	138	414,243	25	10.4	252,443	77,427	34.8	10.7
Wisconsin	117	268,363	0	0	144,413	79,790	16.9	9.3
Sum		**10,054,880**		**260.5**	**6,649,616**	**2,276,123**	**1,103.8**	**376.7**

(10^3 Ton = 0.001 Tg)

Basso et al., 2021 in prep

Profit stability

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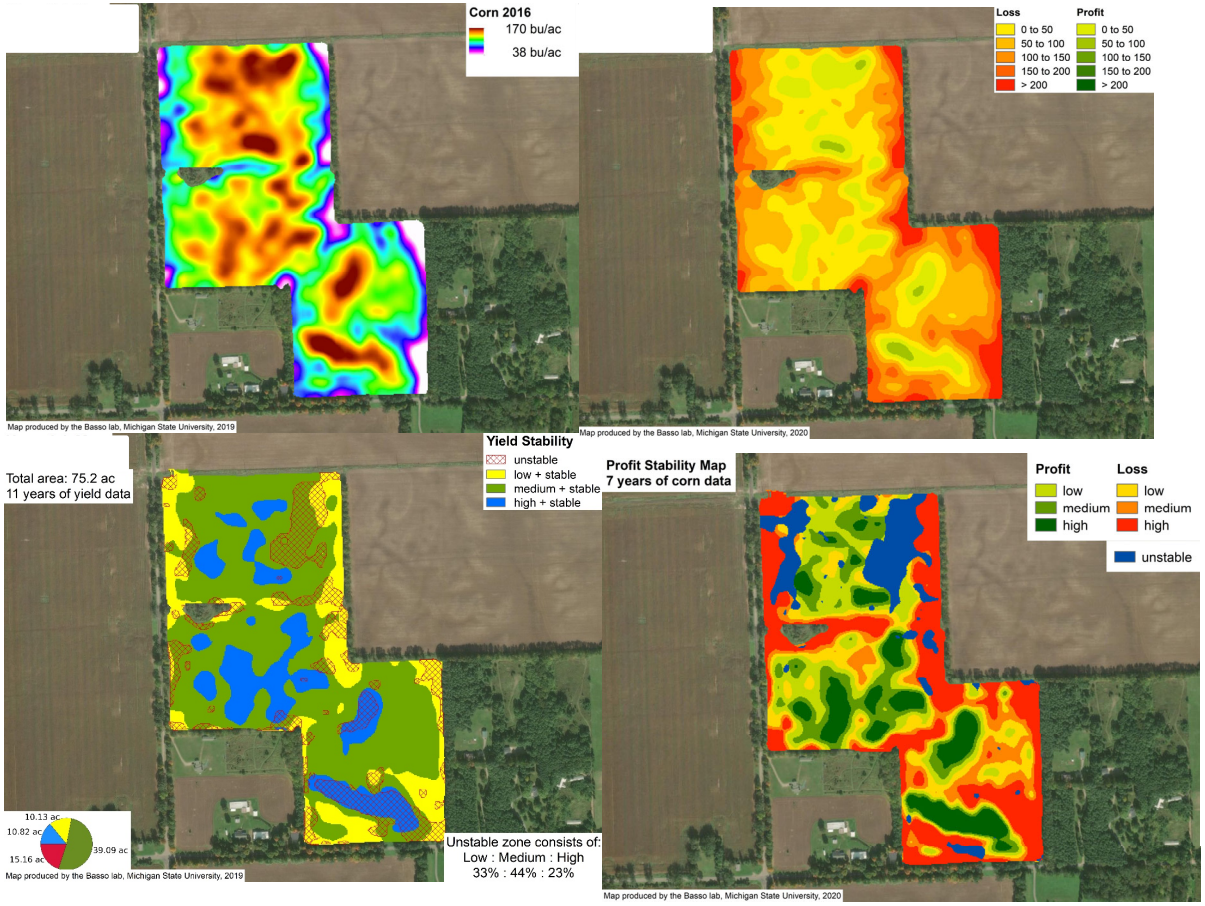
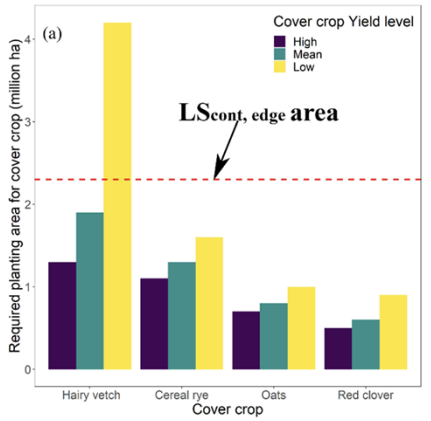
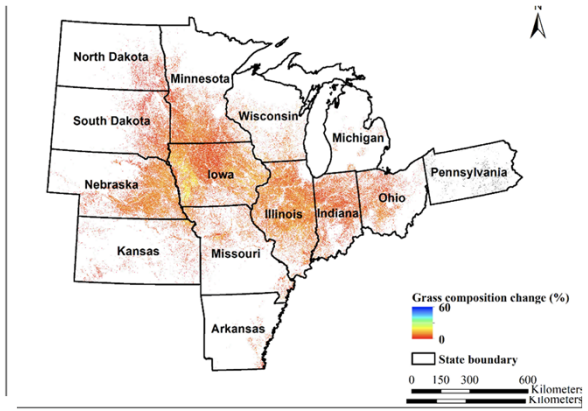


Low $50; Med. $100; High $200





Grassland % change

Modeling spatial variability for greater resource use efficiency

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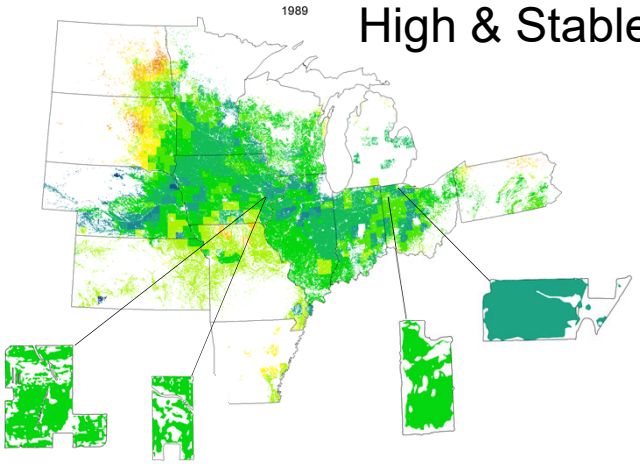
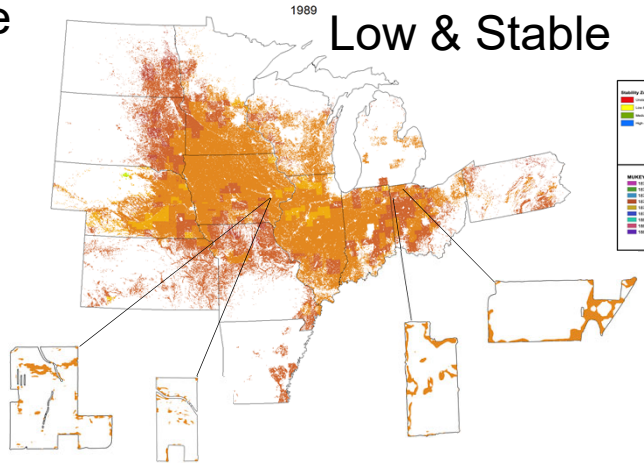
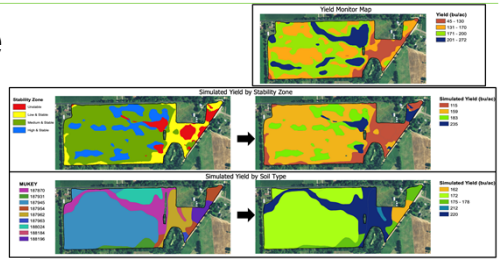
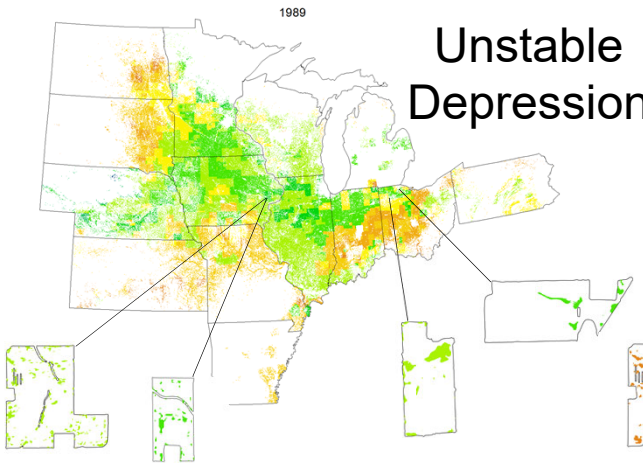


High & Stable

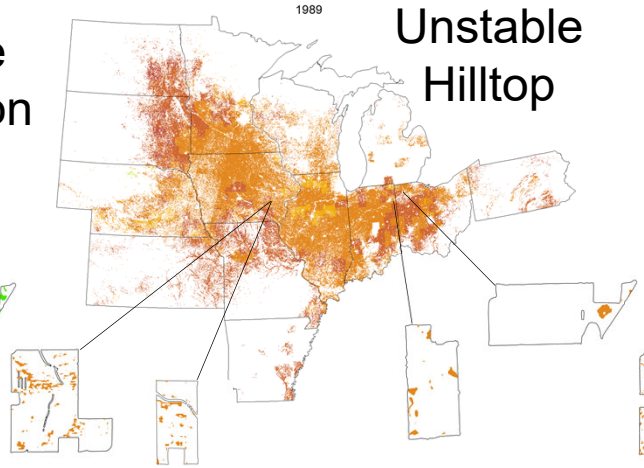


Low & Stable

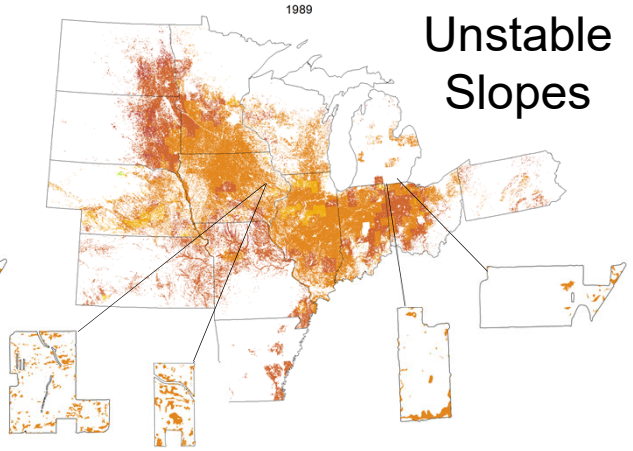




Unstable Depression



Unstable Hilltop



Unstable Slopes

Modeling Precision Conservation for greater sustainability

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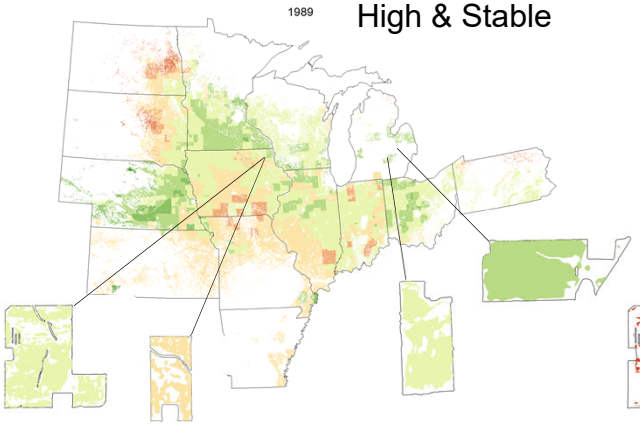
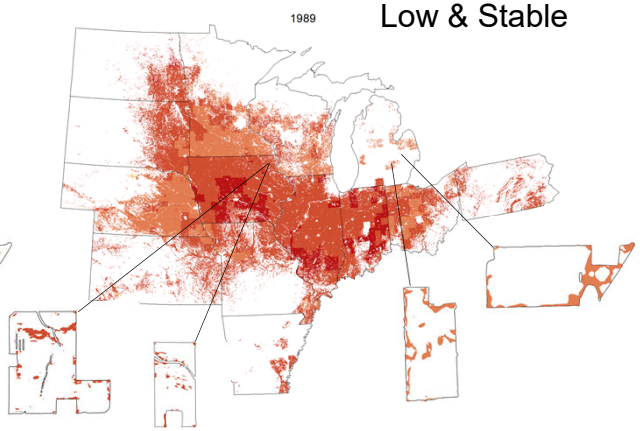
High & Stable



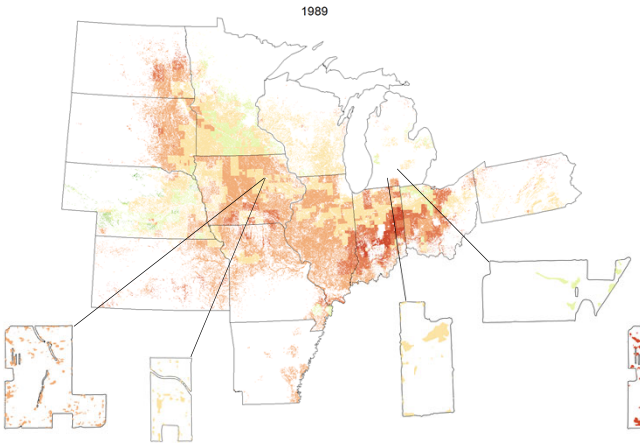
Low & Stable



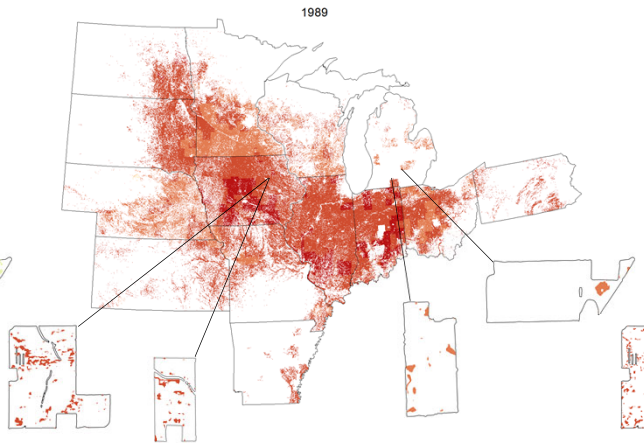
Corn Profit

- < -$400
- -$400 to -$300
- -$300 to -$200
- -$200 to -$100
- -$100 to $0
- $0 to $100
- $100 to $200
- $200 to $300
- $300 to $400
- $400 +

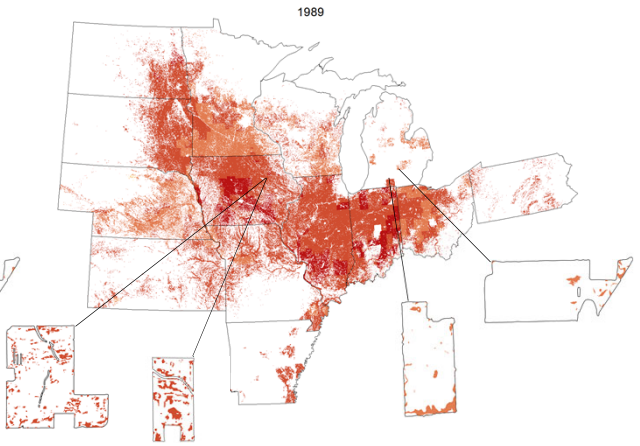
Unstable Depression



Unstable Hilltop



Unstable Slopes



Conclusion

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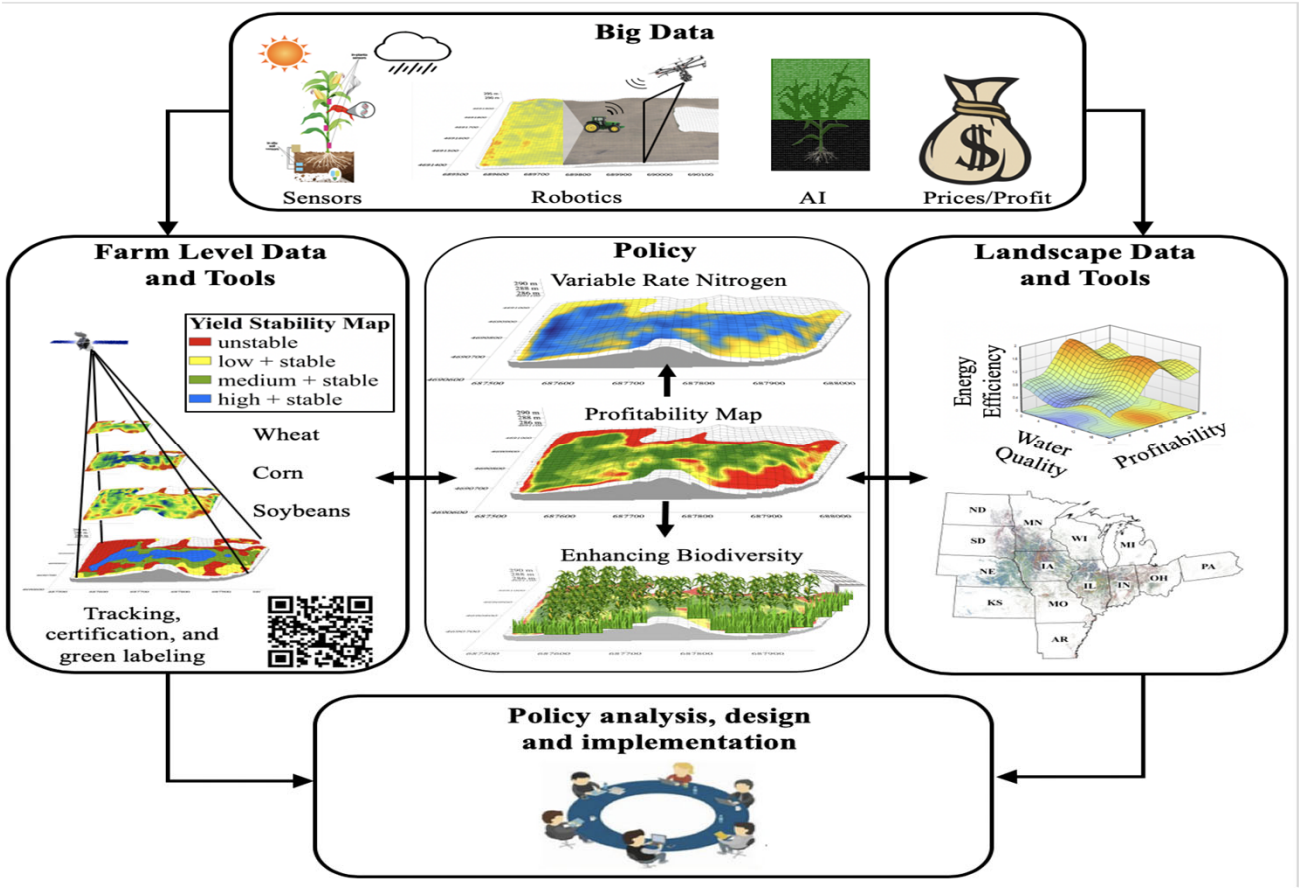

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