Combining aerial images and soil sampling to monitor N and P fertility for Dairy farms in New England

Presentation by:
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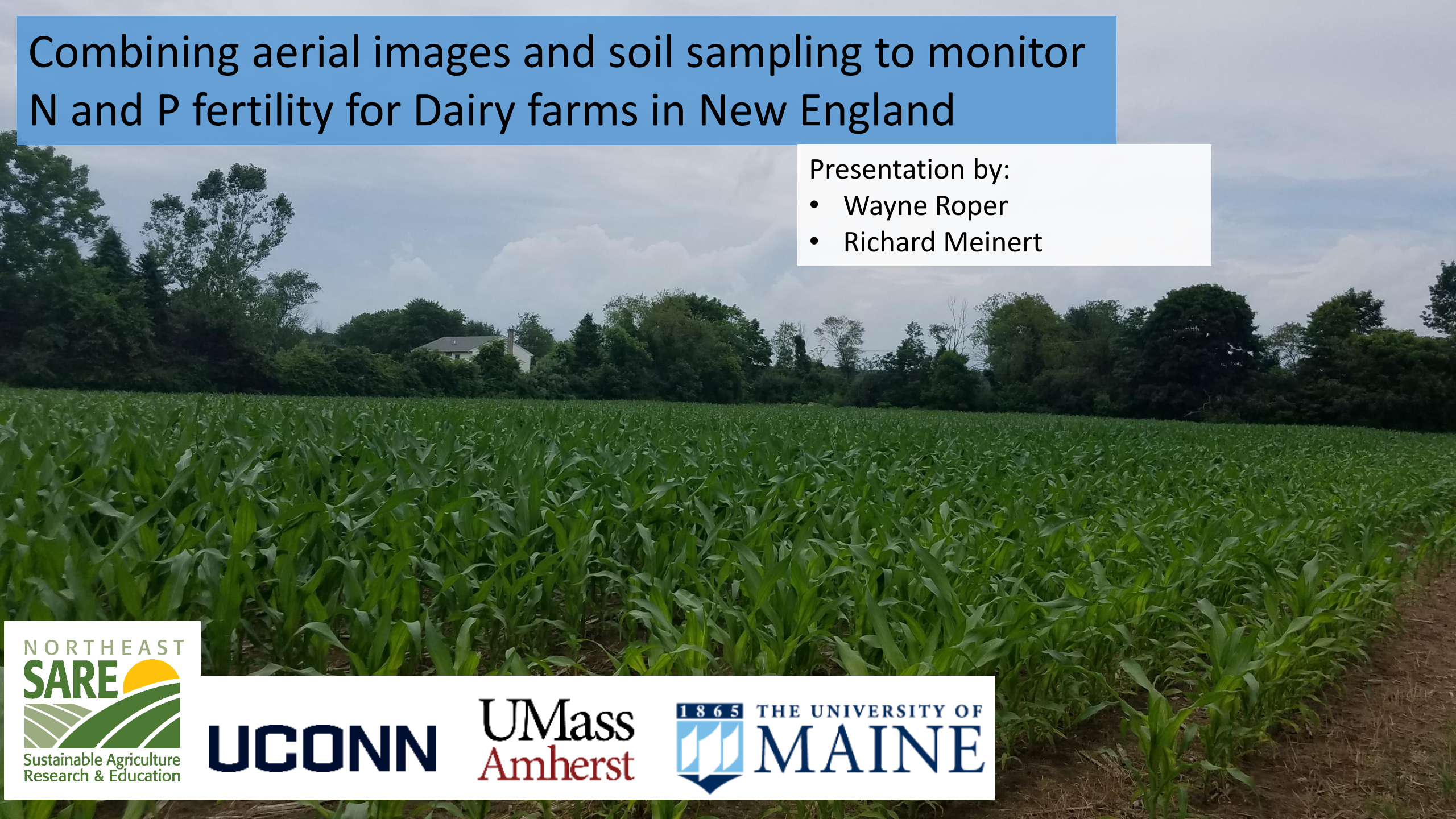

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- Dairy farms regularly apply cow manure to silage corn fields
- Farmers may apply more manure to fields than is necessary, which causes environmental concerns and is an inefficient use of manure nutrients across fields over time

- This project was designed to give dairy farmers more perspective about management of N of P from dairy cow manure
- We hope that farmers will move manure to where it is most needed among their fields

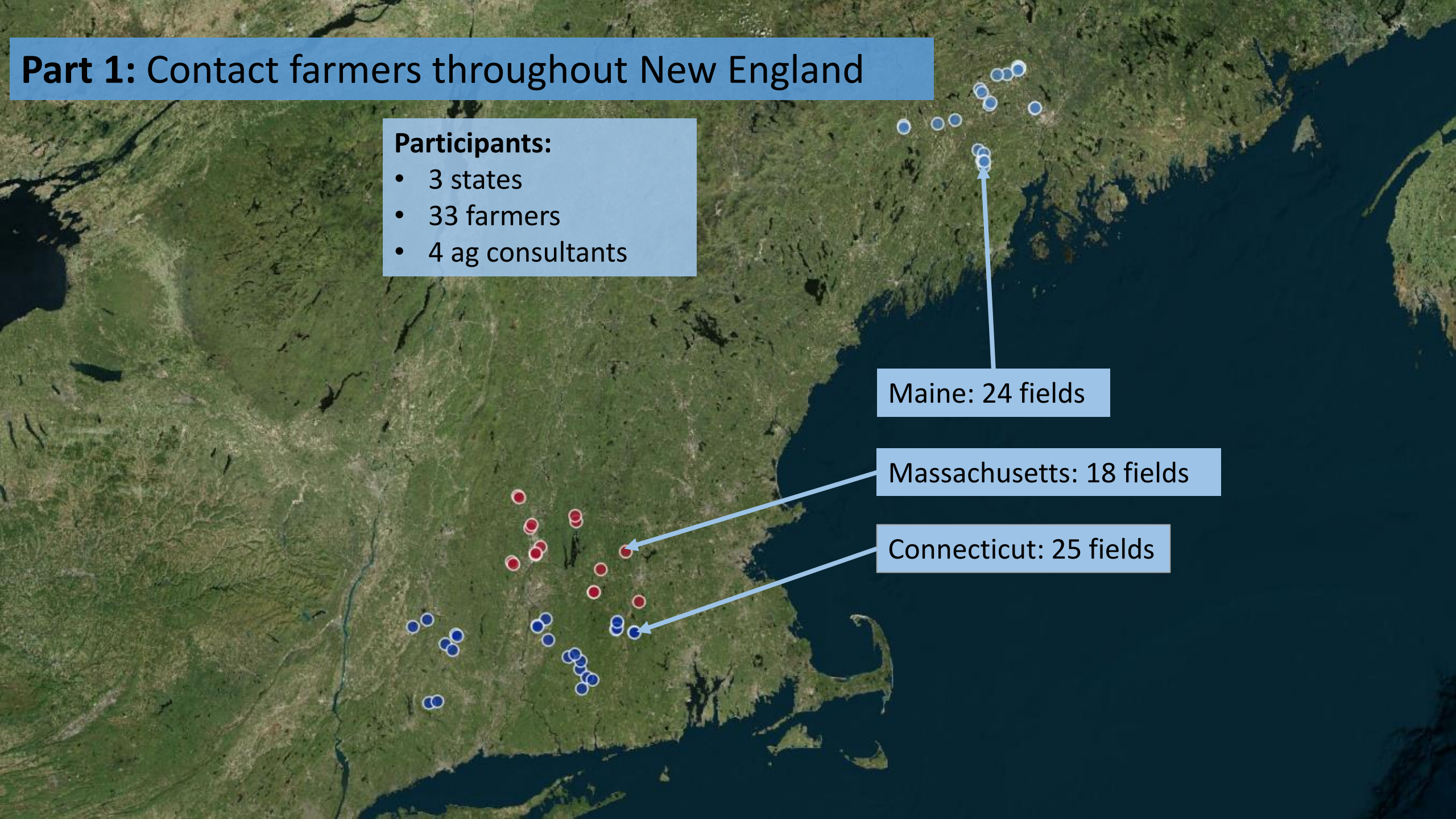
Project objectives

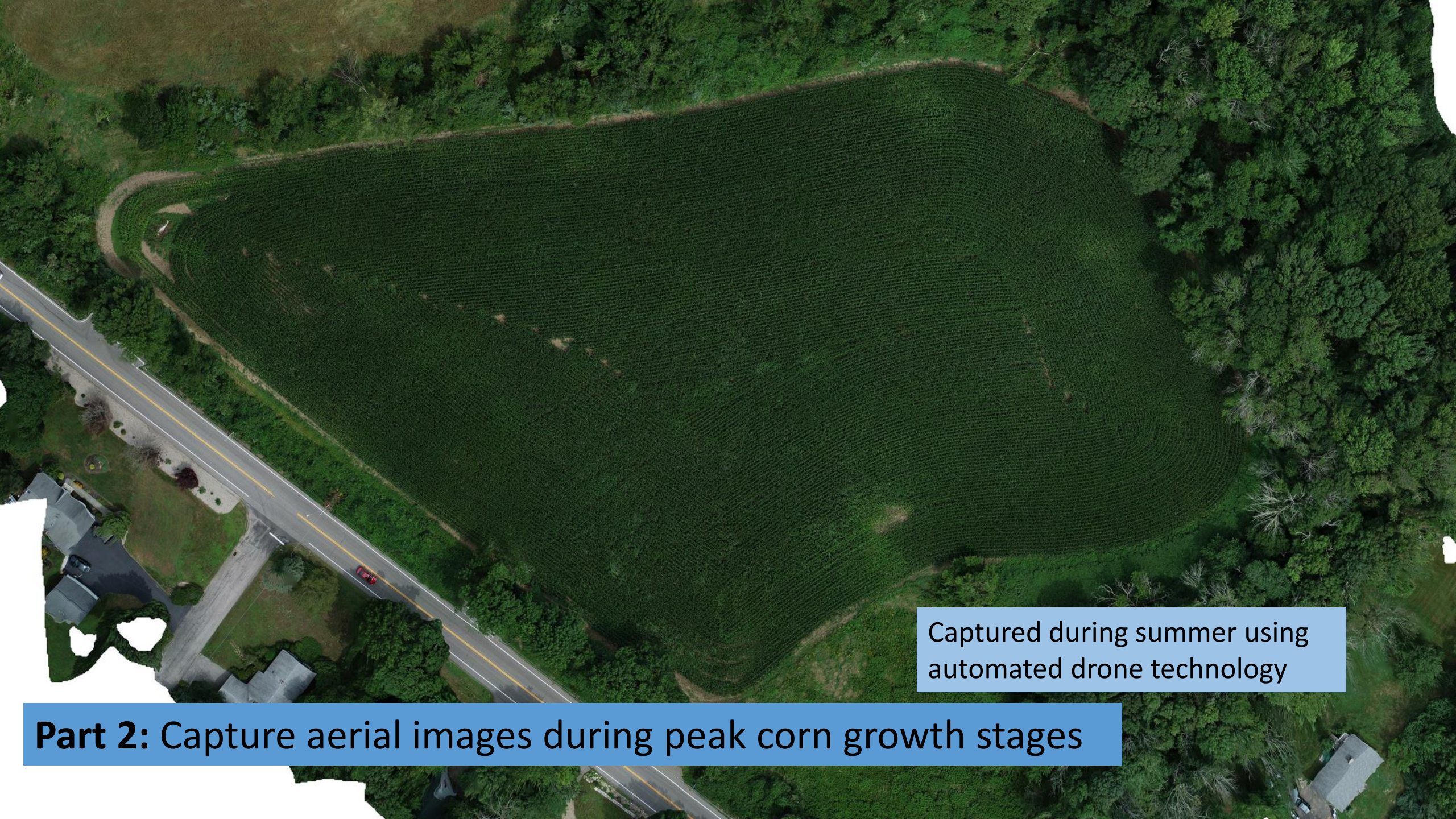
1. Survey 60–70 silage corn fields in CT, MA, and ME
2. Capture aerial imagery of fields during corn maturity
3. Assess soil nutrients and mineralization in all fields
4. Spatial analysis of nutrients in select fields
5. Use the information to recommend management strategies to farmers

Part 1: Contact farmers throughout New England

Participants:

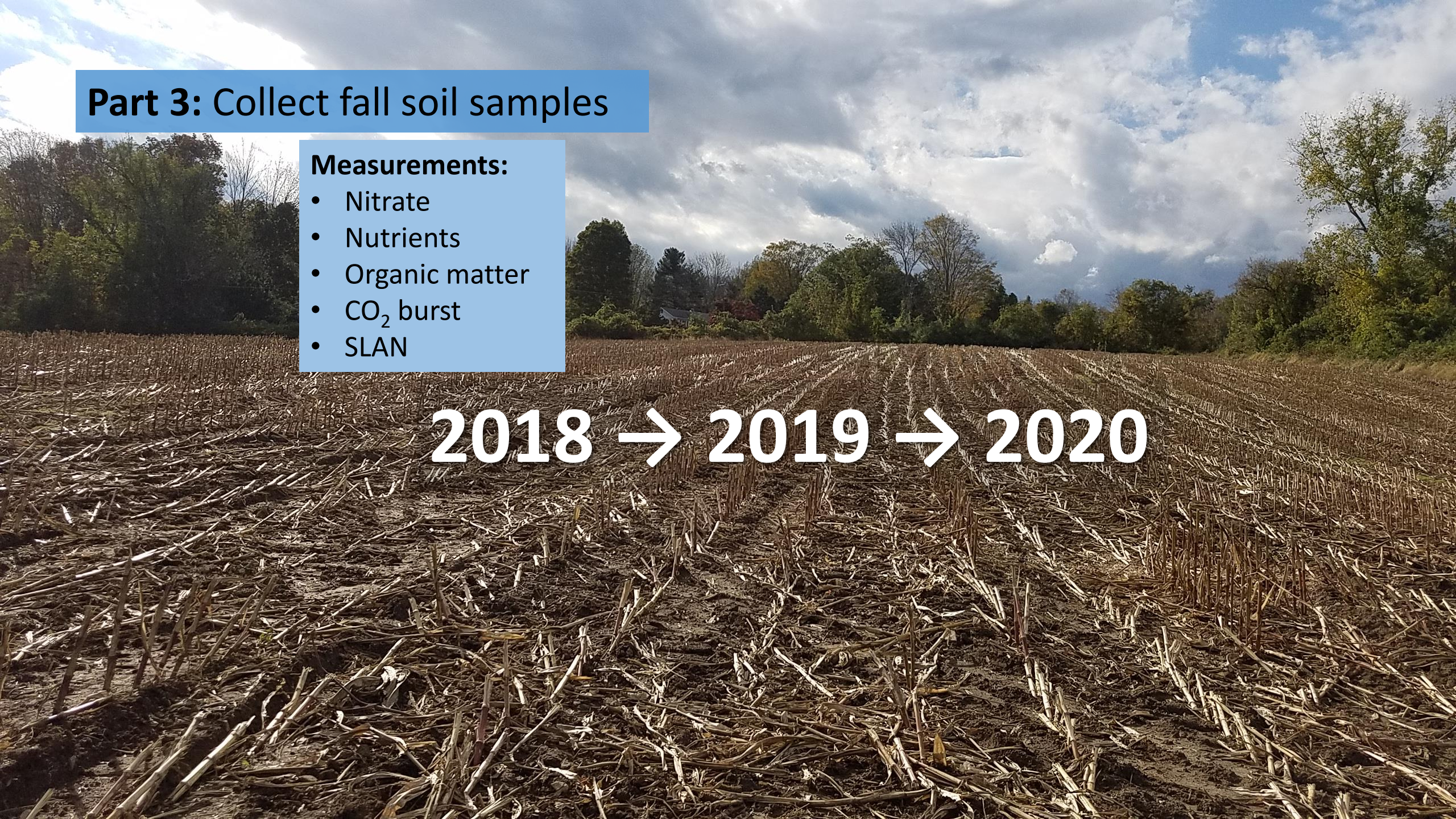
- 3 states
- 33 farmers
- 4 ag consultants





Captured during summer using automated drone technology

Part 2: Capture aerial images during peak corn growth stages



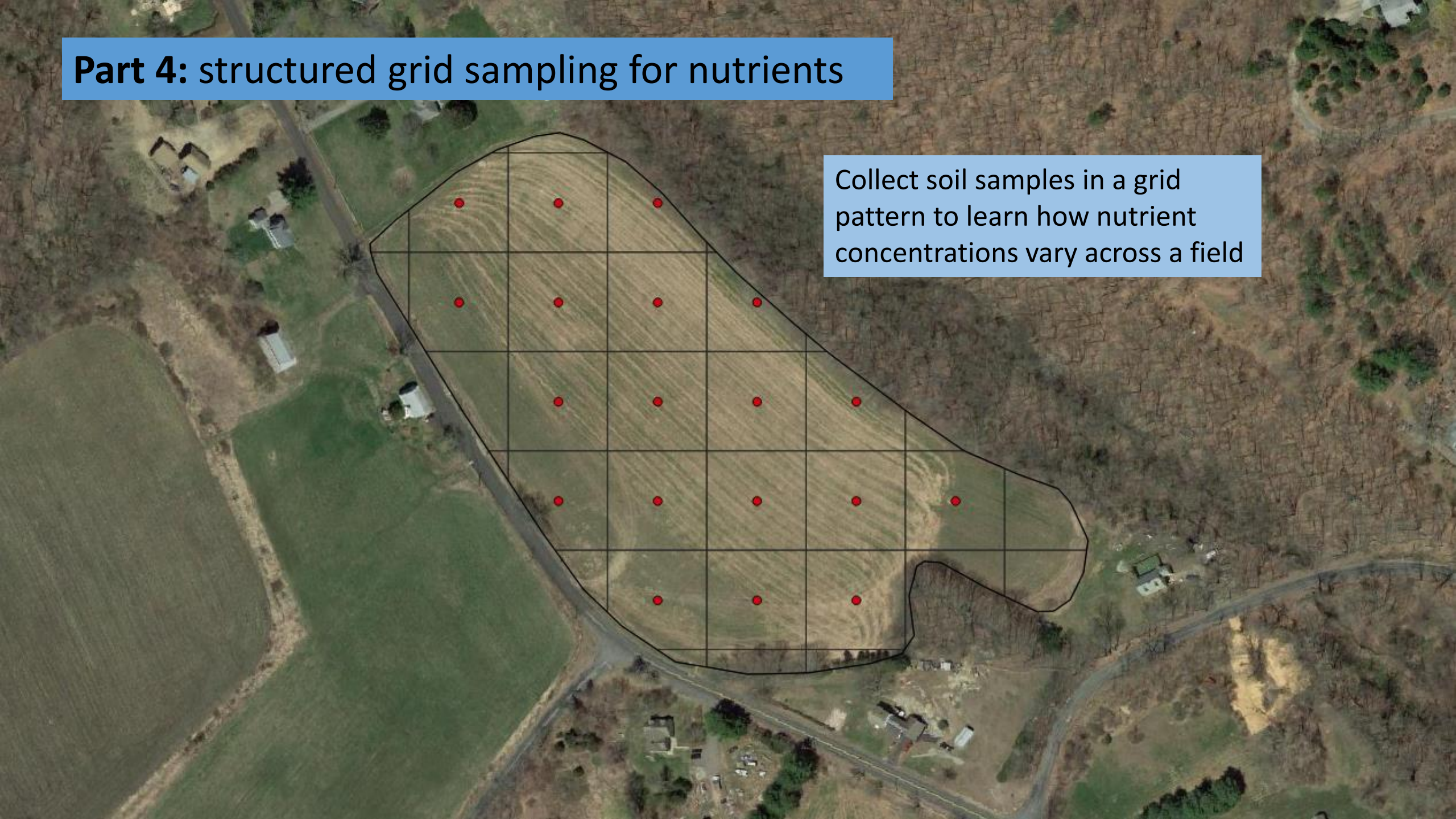
Part 3: Collect fall soil samples

Measurements:

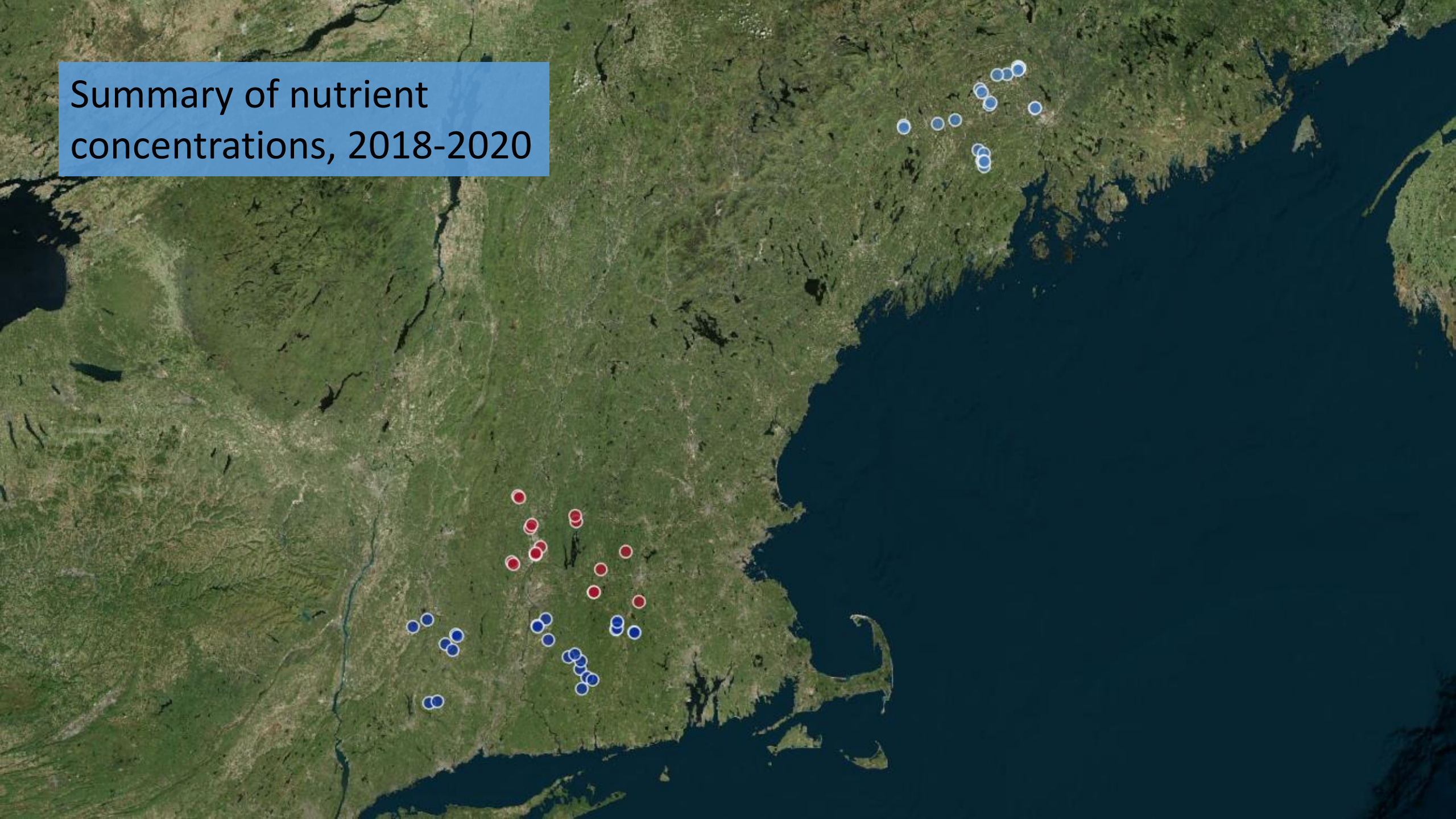
- Nitrate
- Nutrients
- Organic matter
- CO_2 burst
- SLAN

2018 → 2019 → 2020

Part 4: structured grid sampling for nutrients



Collect soil samples in a grid pattern to learn how nutrient concentrations vary across a field

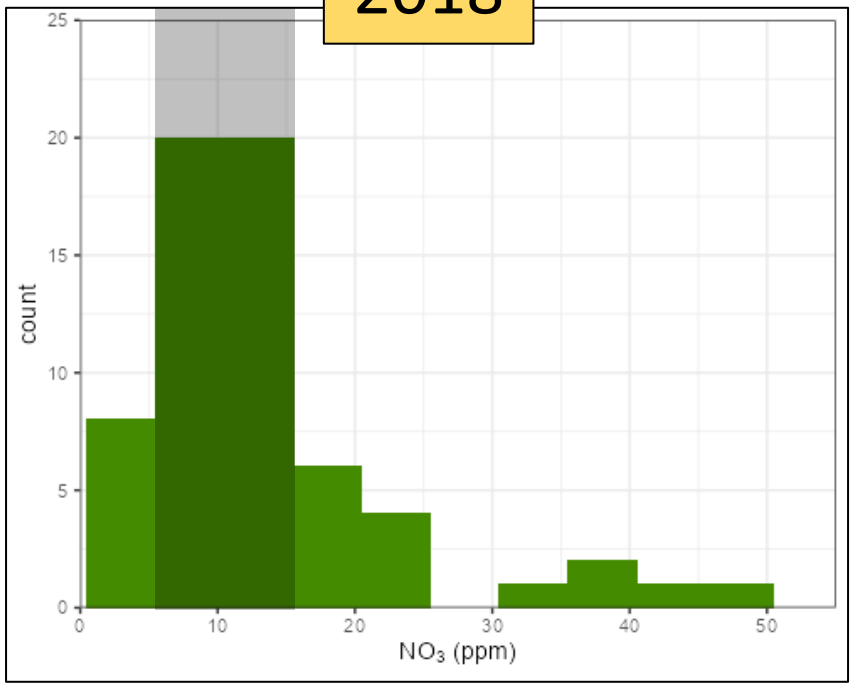

Summary of nutrient concentrations, 2018-2020

Yearly summary

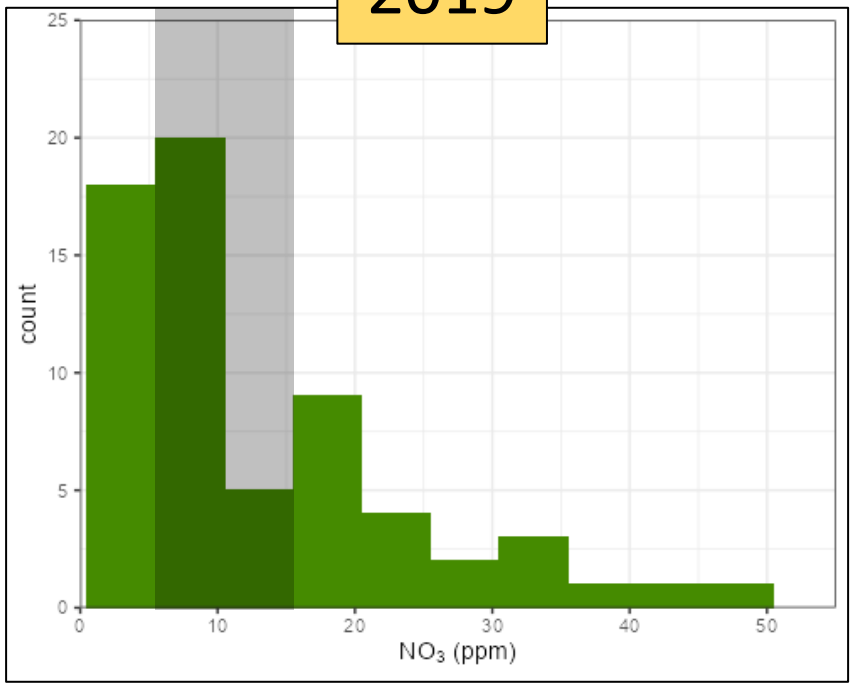
Fall nitrate

		Average
		ppm
CT	2018	10
	2019	21
	2020	25
MA	2018	17
	2019	7
	2020	-
ME	2018	15
	2019	10
	2020	-

2018



2019



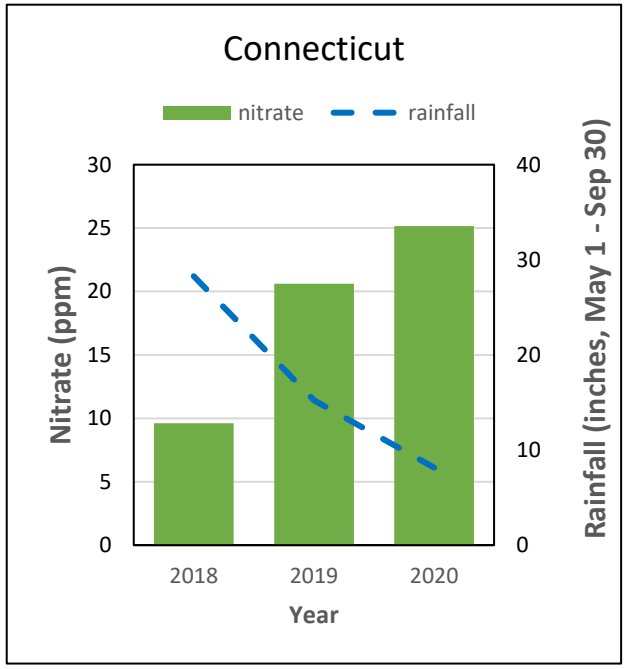
	Deficient	Optimum	Above optimum	Excessive
	——————— NO_3 (ppm) ———————			
In-season	0-20	20-30	30-40	40+
Fall*	0-5	5-15	15-25	25+

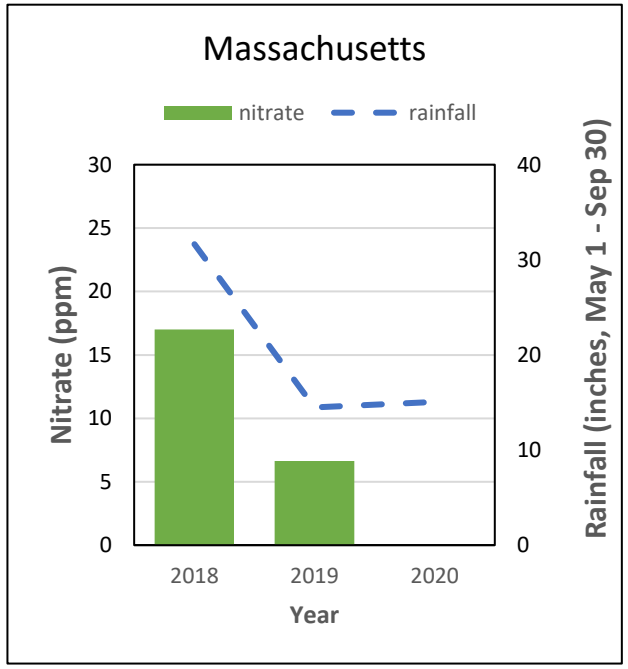
*Fall NO3 values are estimated, in-season values based on expectations for pre-sidedress N test

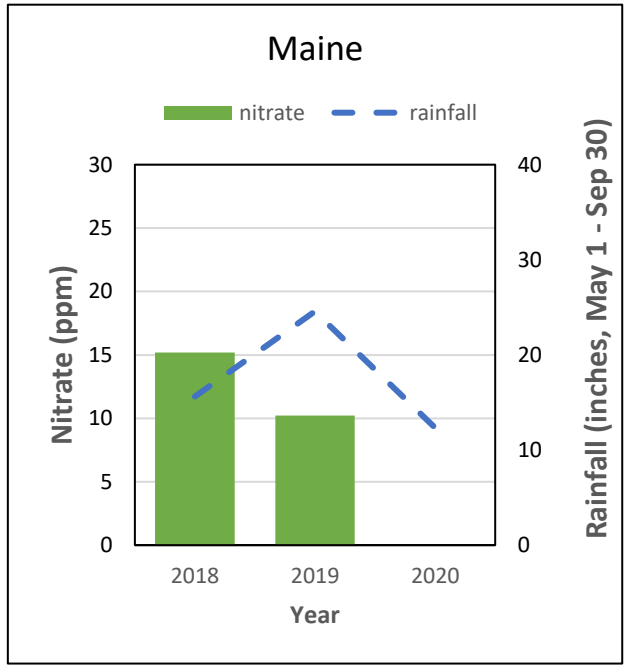
Yearly summary

Fall nitrate with rainfall

	Connecticut		Massachusetts		Maine	
	Seasonal Rainfall	**Difference from normal**	**Seasonal rainfall**	**Difference from normal**	**Seasonal rainfall**	**Difference from normal**
	Inches of rainfall from May 1 – Sep 30					
2018	28	+7	32	+12	16	-4
2019	15	-6	14	-6	25	+5
2020	8	-13	15	-5	12	-8



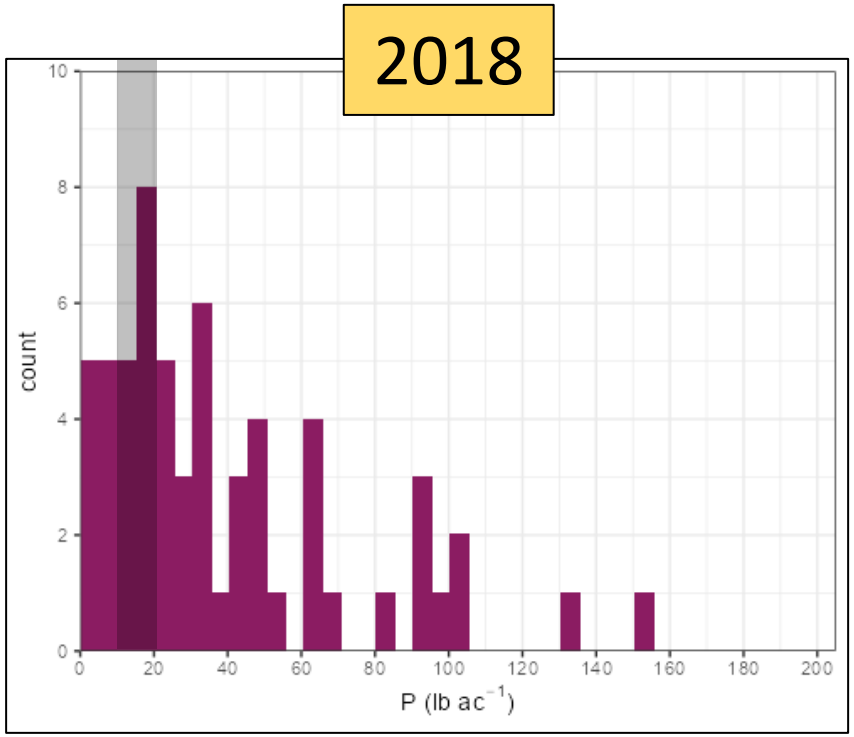


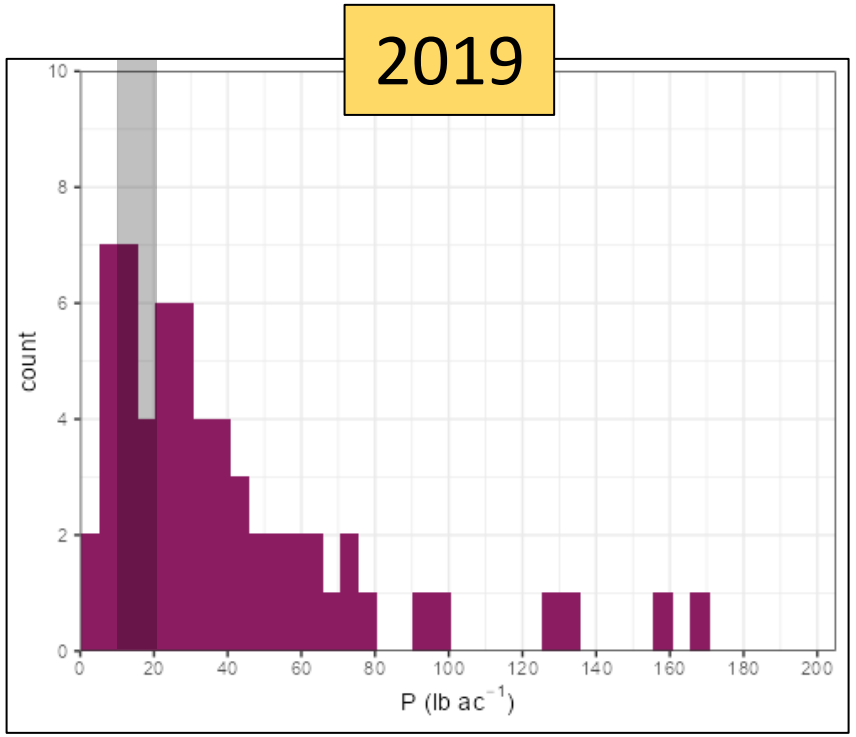


Yearly summary

Phosphorus

		Average
		lb P ac^{-1}
CT	2018	80
	2019	78
	2020	43
MA	2018	35
	2019	31
	2020	-
ME	2018	41
	2019	44
	2020	41



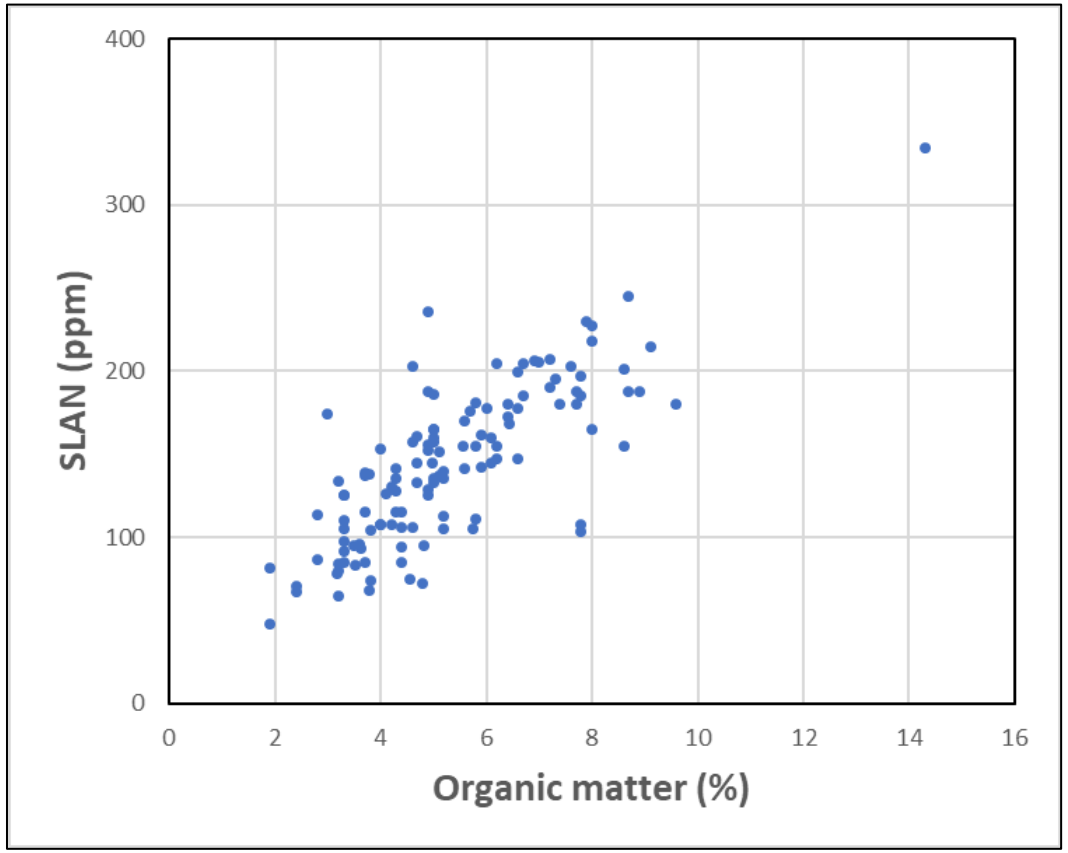


	Deficient	Optimum	Above optimum	Excessive
	lb P ac^{-1}			
Modified Morgan	0-13	14-20	21-35	

Yearly summary

Solvita labile amino N

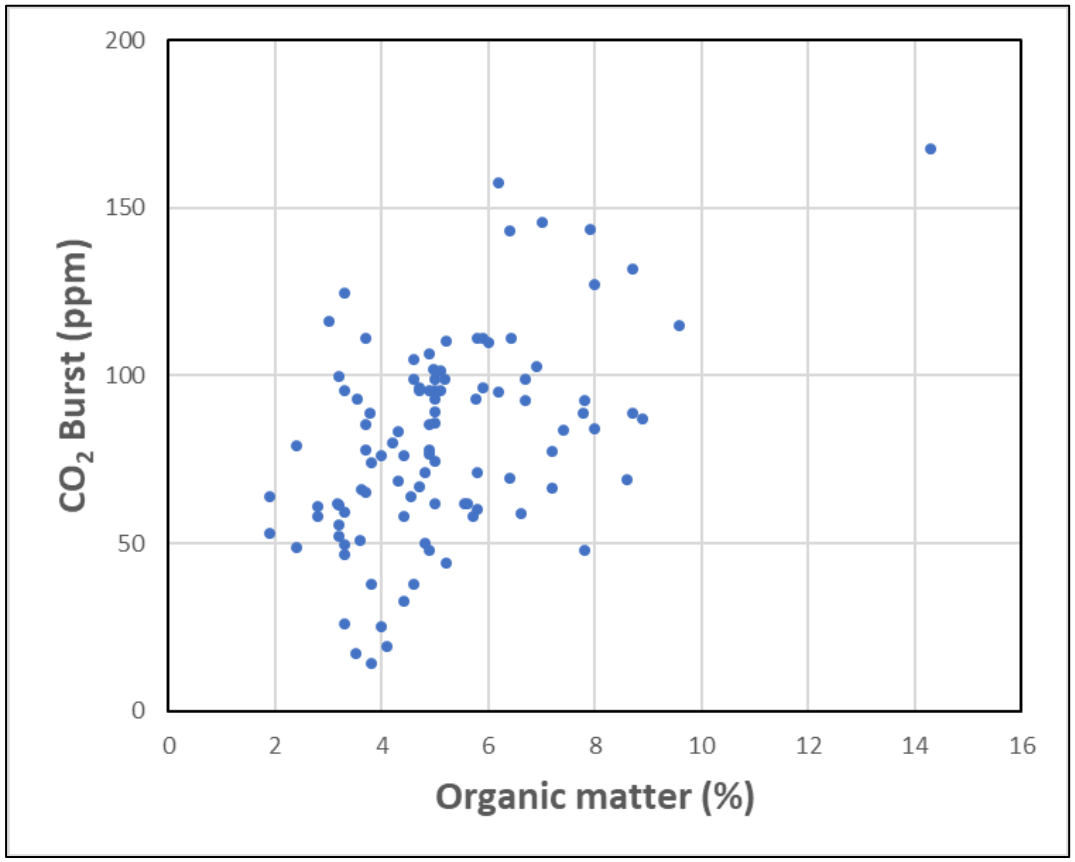
	Year	Min	Average	Max
		——— ppm ———		
CT	2018	48	137	228
	2019	71	150	236
MA	2018	68	122	245
	2019	72	113	188
ME	2018	105	155	215
	2019	86	173	334



Yearly summary

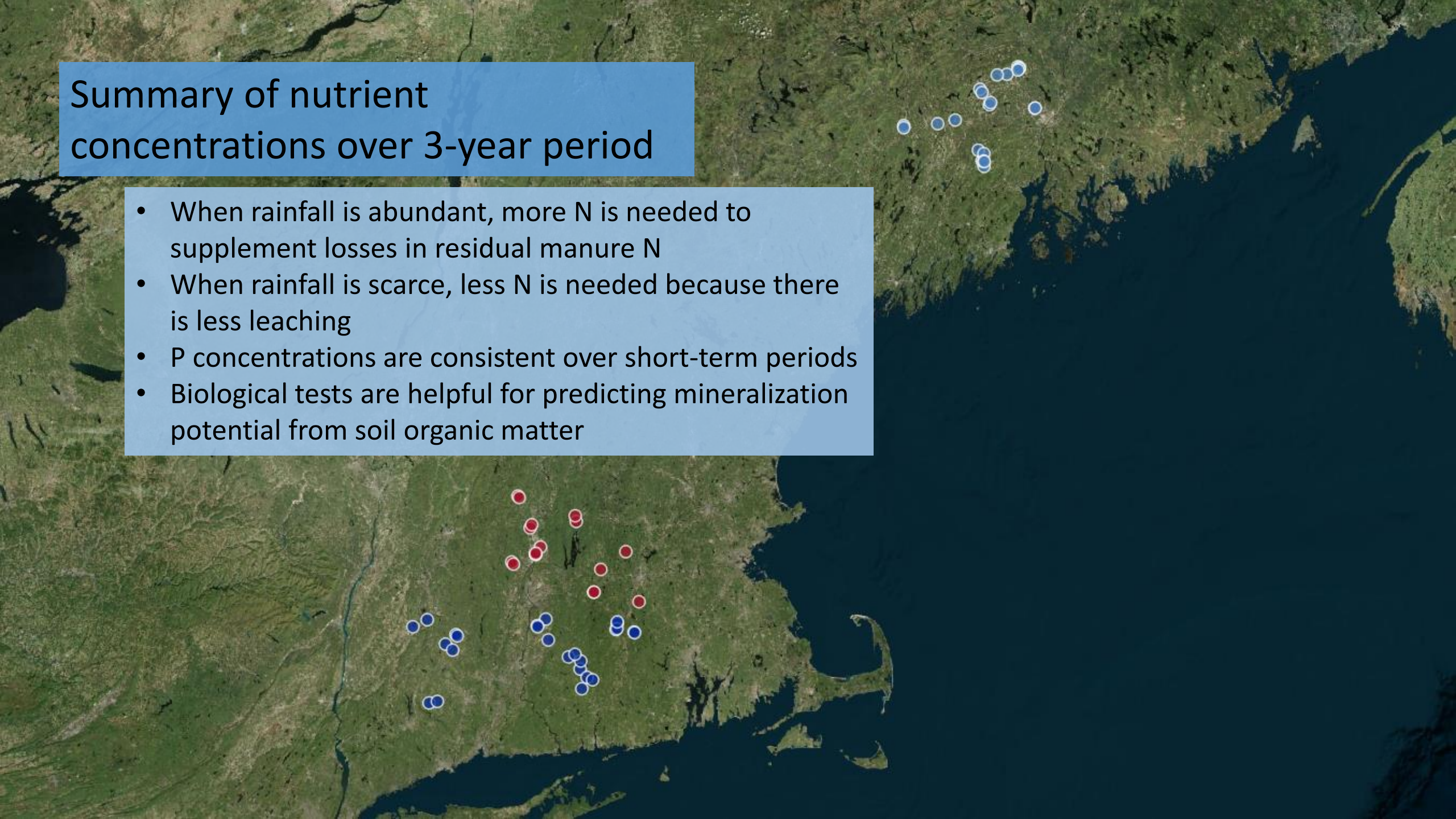
CO_2 burst

	Year	Min	Average	Max
		——— ppm ———		
CT	2018	50	90	143
	2019	26	76	125
MA	2018	62	87	132
	2019	14	52	89
ME	2018	-	-	-
	2019	19	92	168



Summary of nutrient concentrations over 3-year period

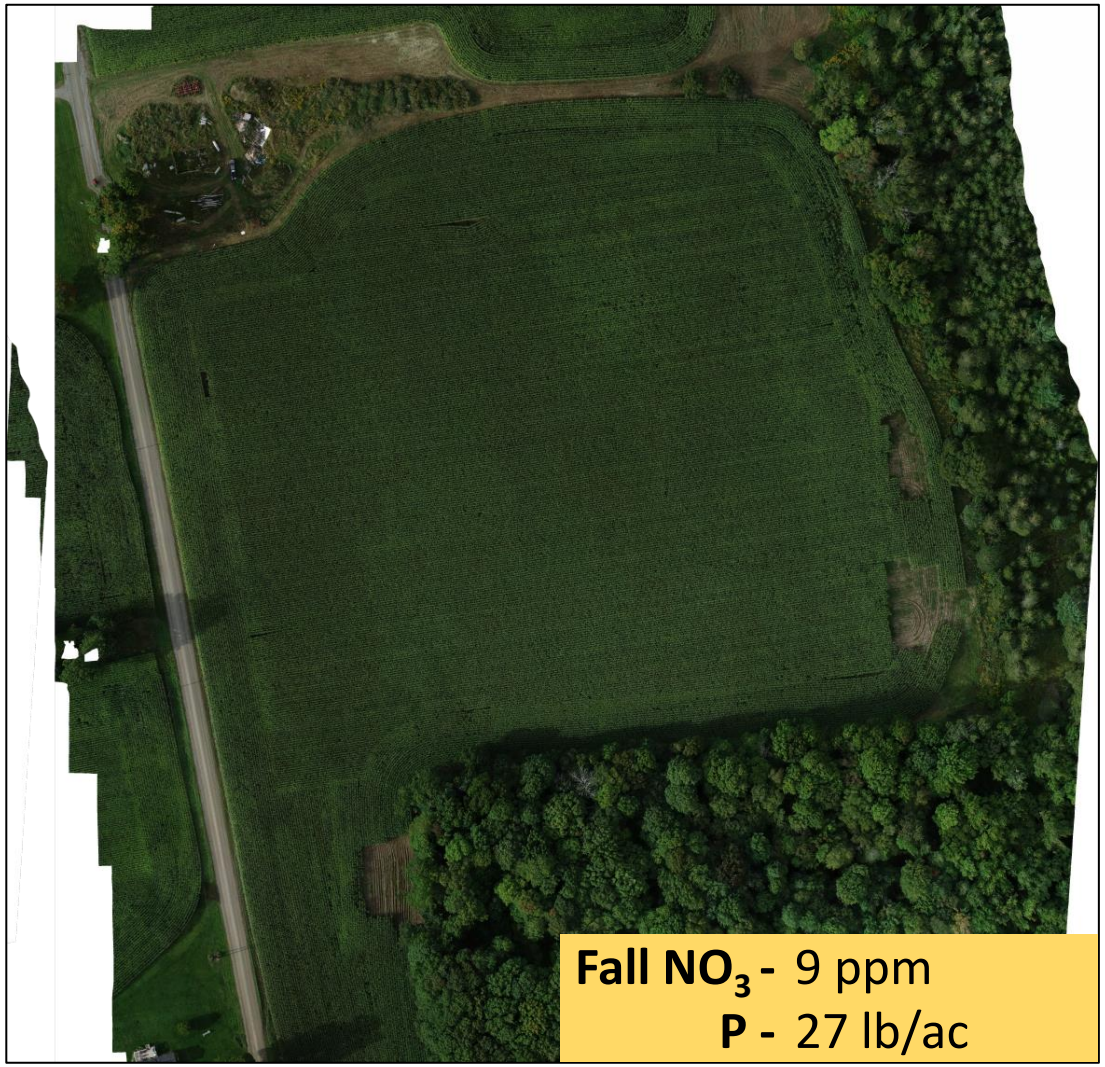
- When rainfall is abundant, more N is needed to supplement losses in residual manure N
- When rainfall is scarce, less N is needed because there is less leaching
- P concentrations are consistent over short-term periods
- Biological tests are helpful for predicting mineralization potential from soil organic matter



Relationships between aerial images and fall nitrate concentrations

Aerial images and fall nitrate

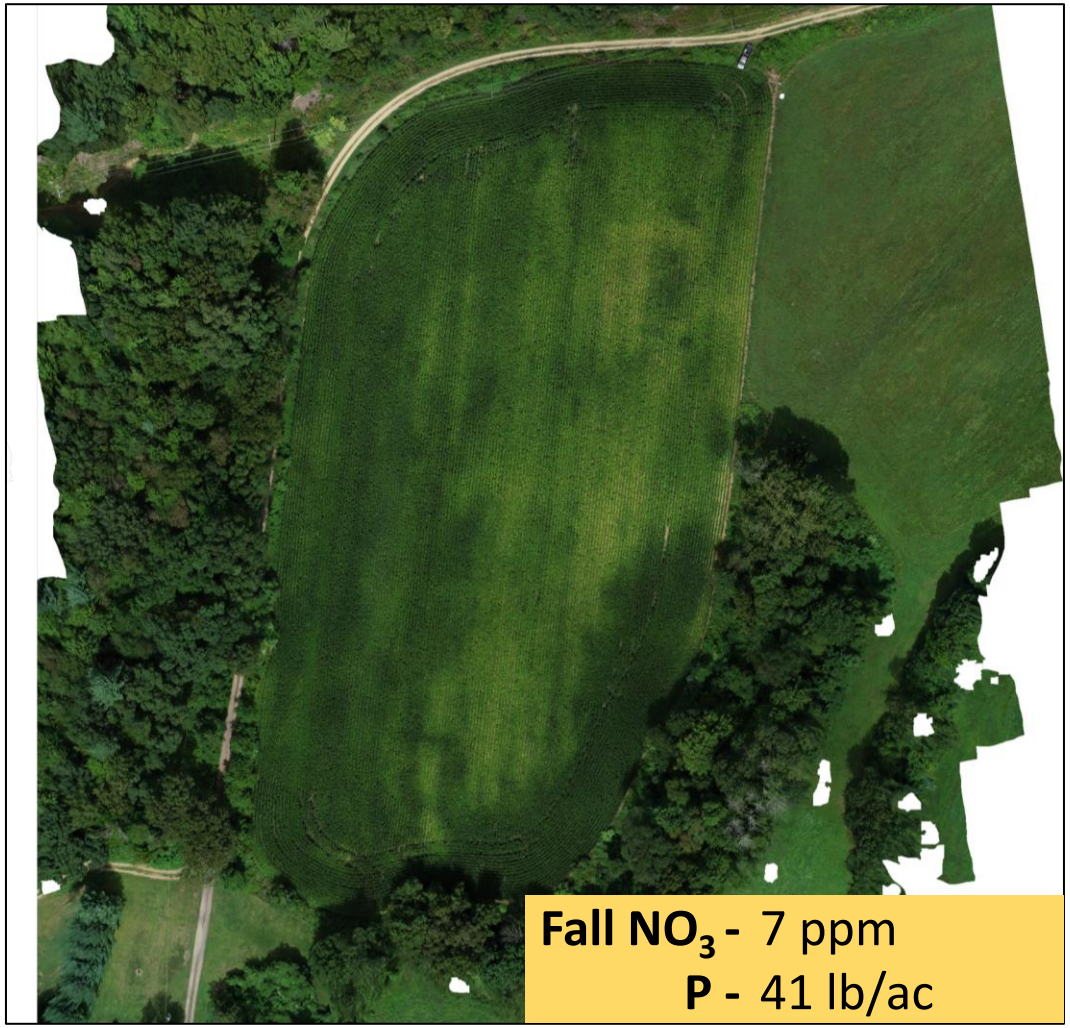
Optimum corn and fall nitrate

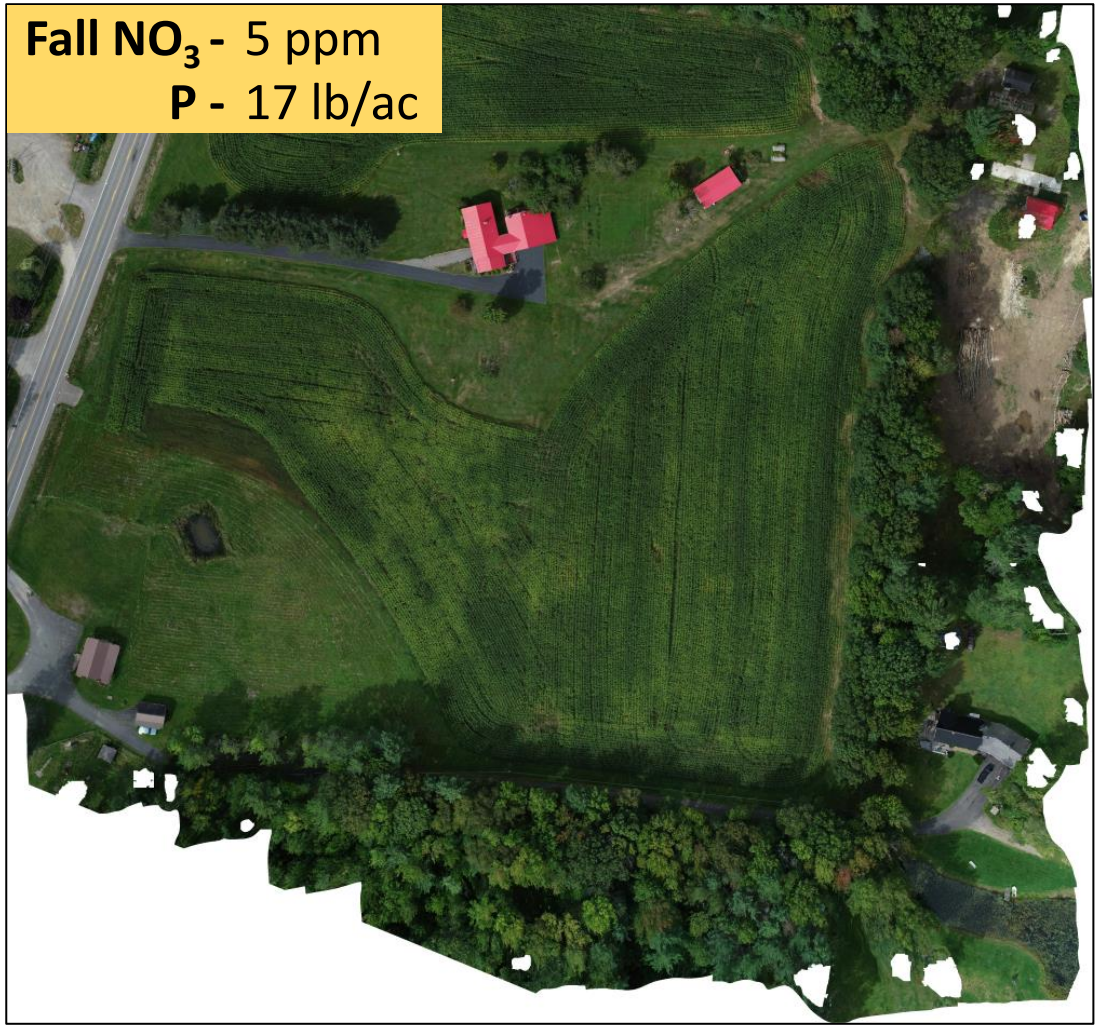


Aerial images and fall nitrate

Yellow corn, low nitrate

Apply **MORE** manure or fertilizer N
(without exceeding P recommendation)

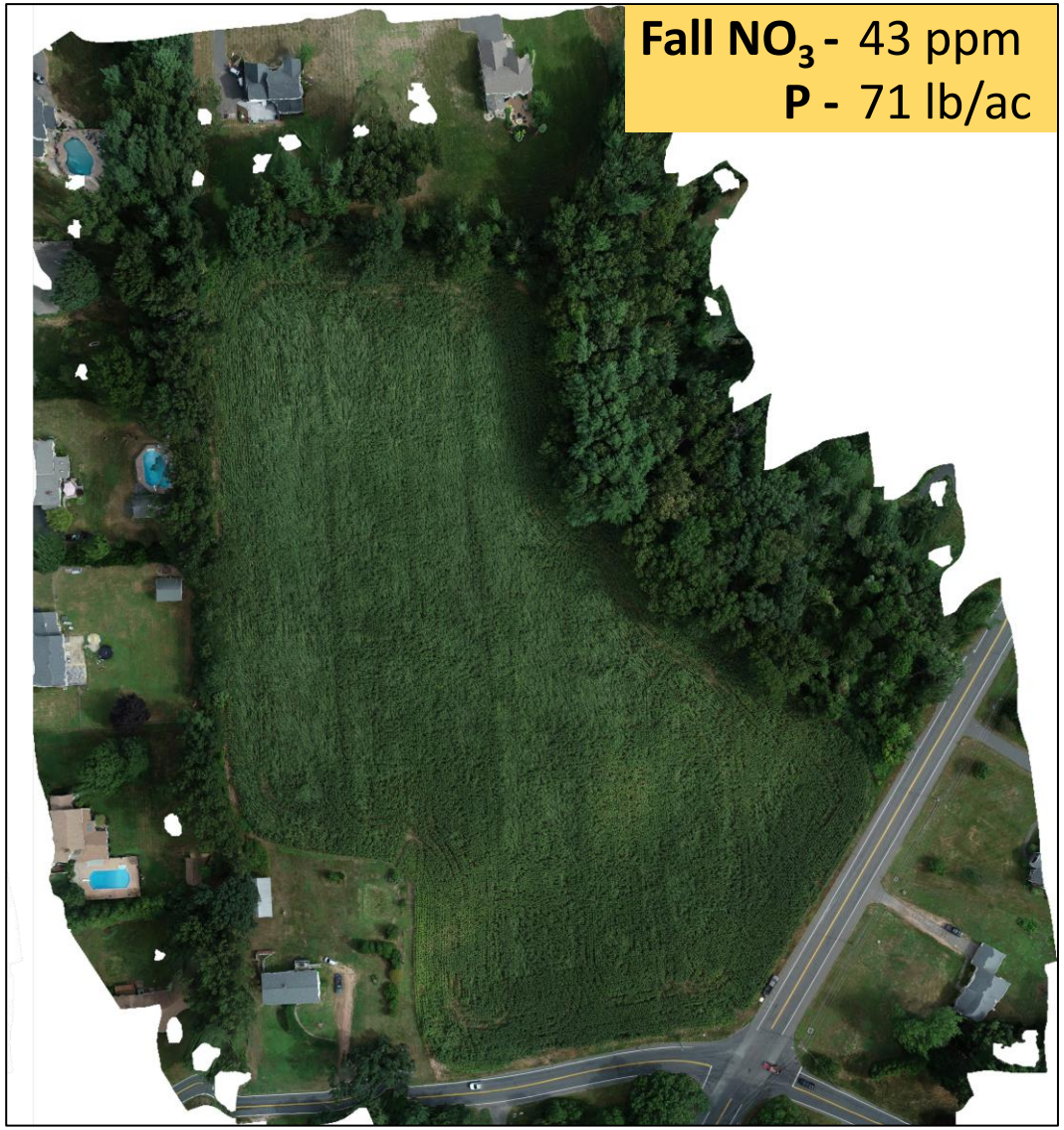




Aerial images and fall nitrate

Yellow corn, high nitrate

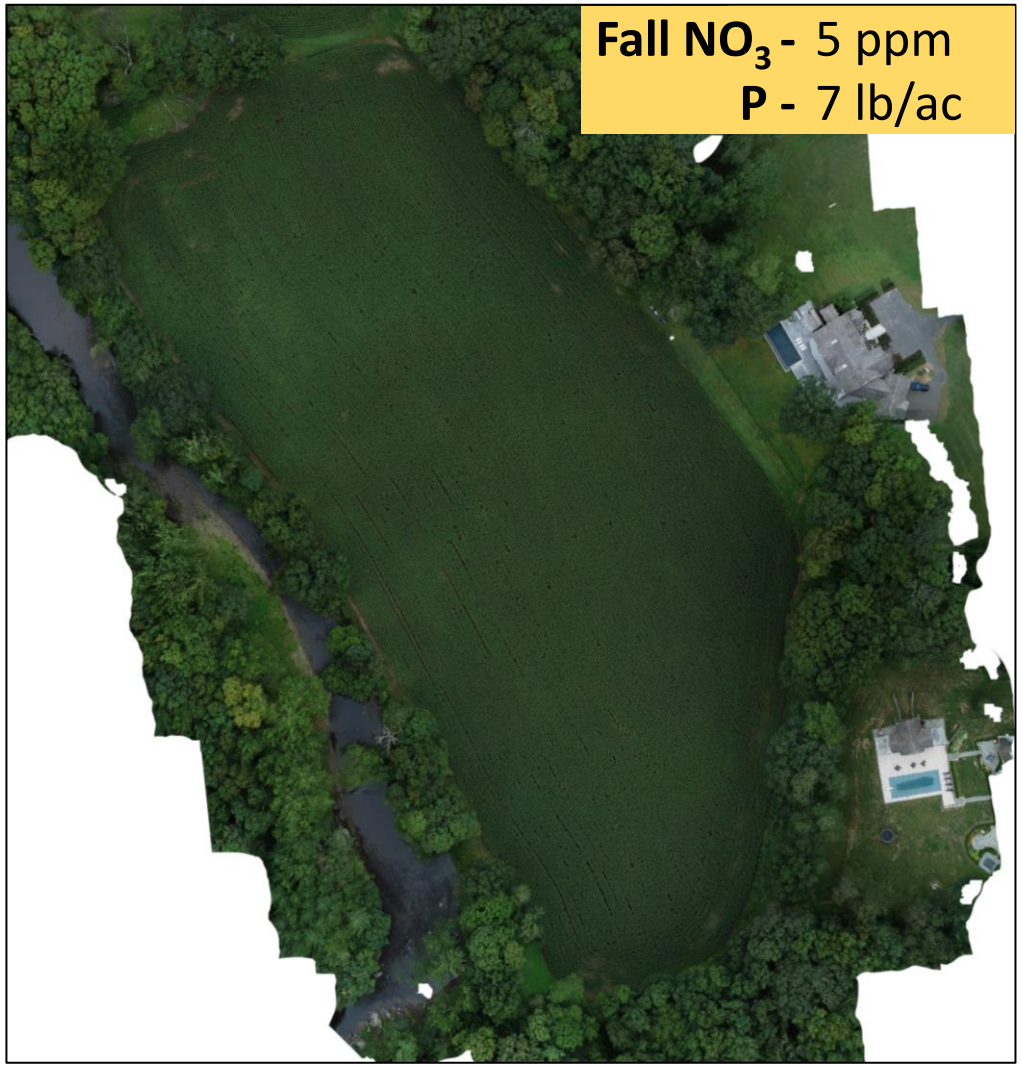
Dry summer/fall after corn matures



Aerial images and fall nitrate

Green corn, low nitrate

Wet summer/fall after corn matures



Aerial images and fall nitrate

Green corn, high nitrate

Apply **LESS** manure or fertilizer N

Aerial images and fall nitrate

Other notable patterns in aerial images

Uneven nutrient application

Different corn varieties

Aerial images and fall nitrate

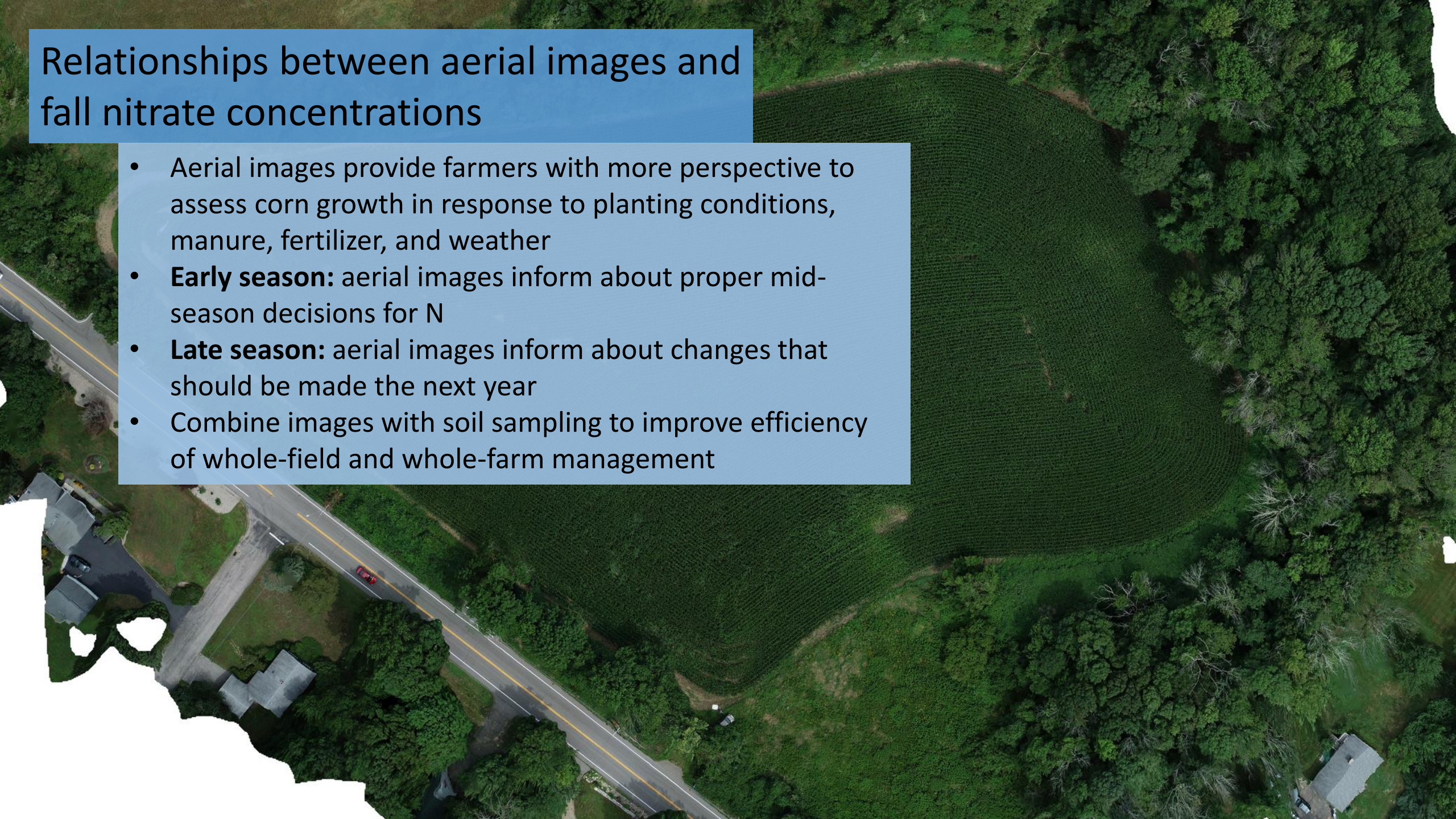
Other notable patterns in aerial images

Cloud cover

Marriage proposals

Relationships between aerial images and fall nitrate concentrations

- Aerial images provide farmers with more perspective to assess corn growth in response to planting conditions, manure, fertilizer, and weather
- **Early season:** aerial images inform about proper mid-season decisions for N
- **Late season:** aerial images inform about changes that should be made the next year
- Combine images with soil sampling to improve efficiency of whole-field and whole-farm management

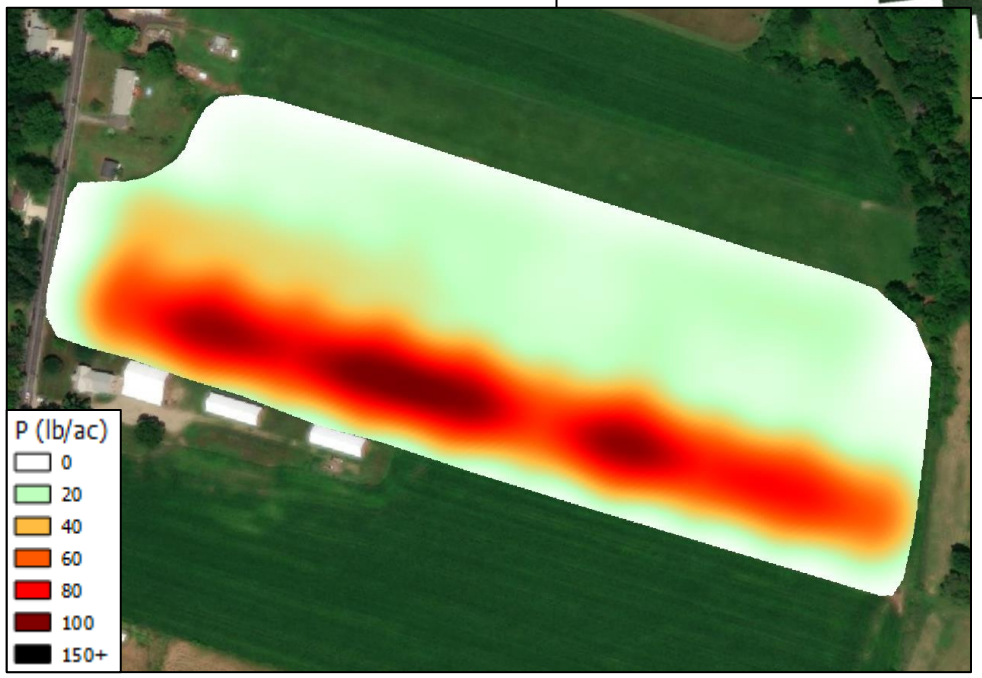


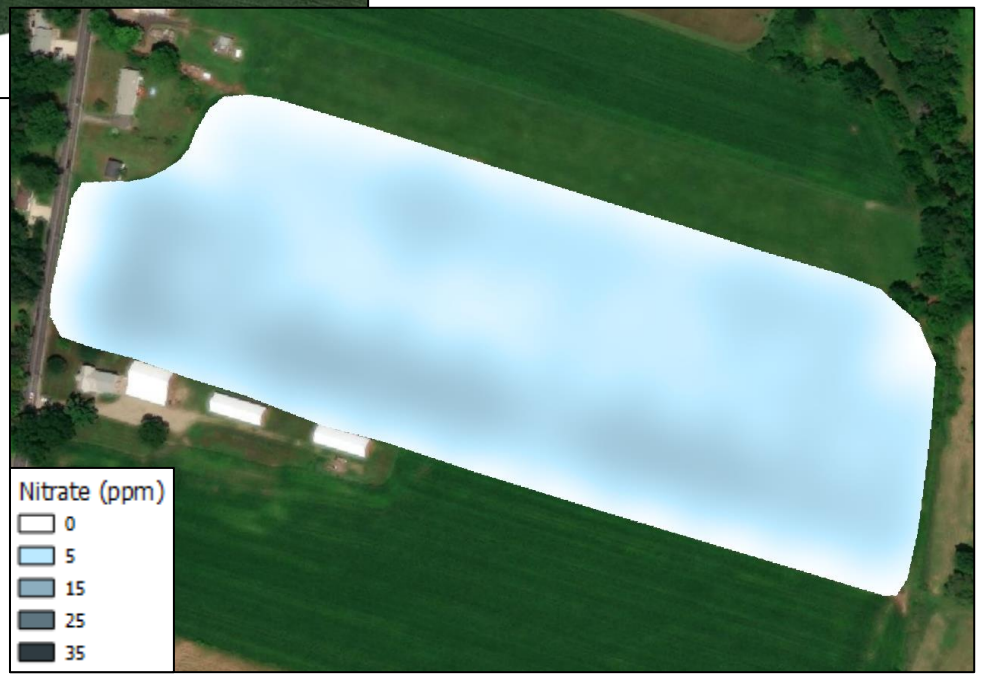
Using grid sampling to assess spatial variability of nutrients

Spatial variability of NO_3 and P compared to aerial images

Spatial variability of NO_3 and P compared to aerial images

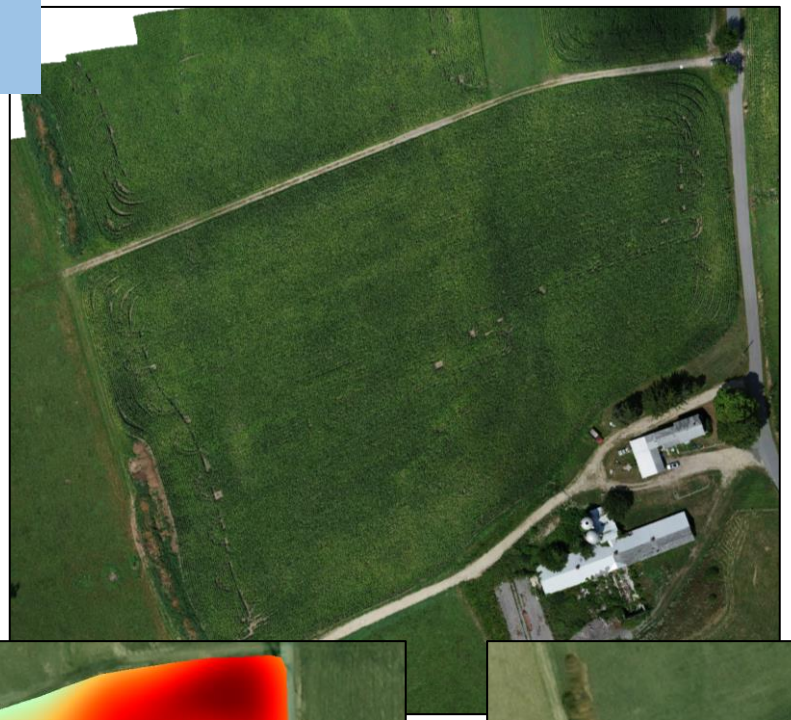
Hotspots matched

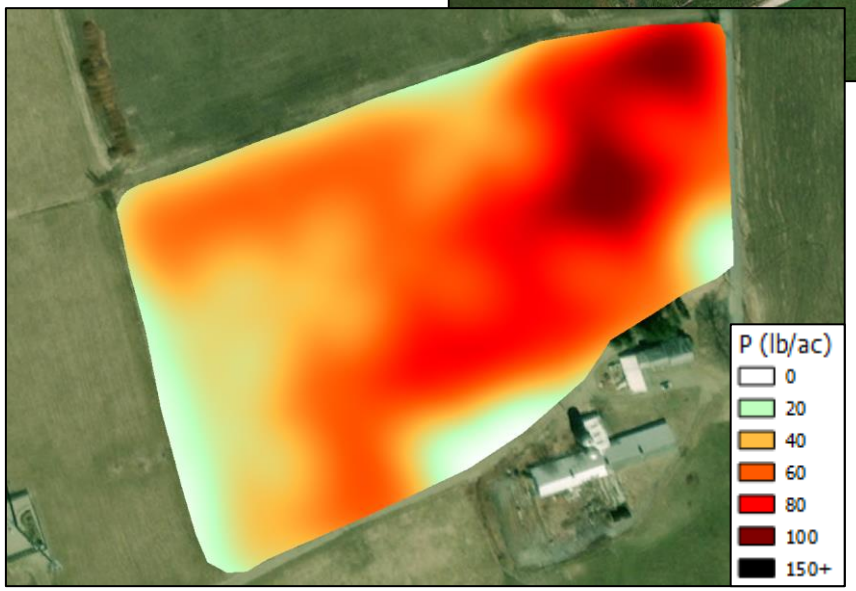


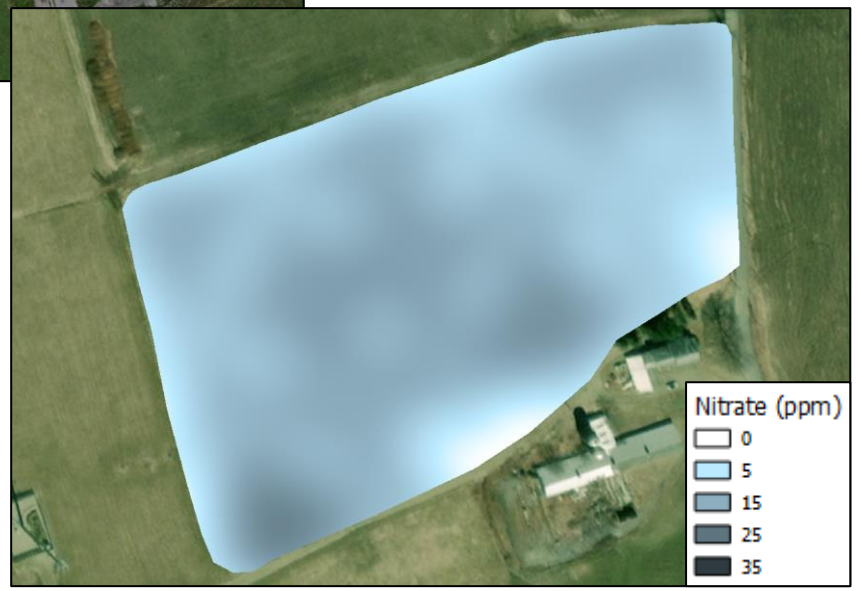


Spatial variability of NO_3 and P compared to aerial images

Hotspots unmatched

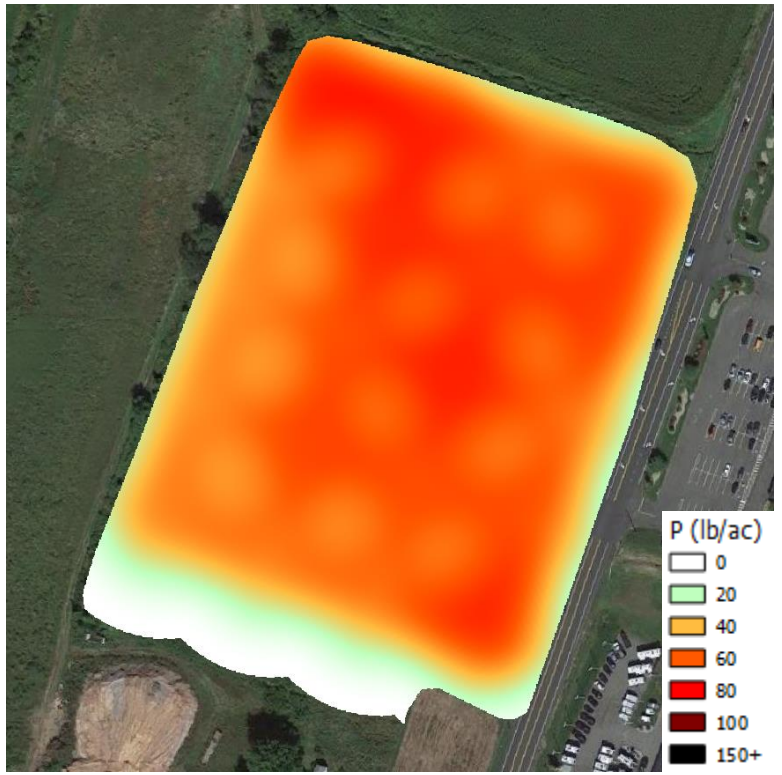


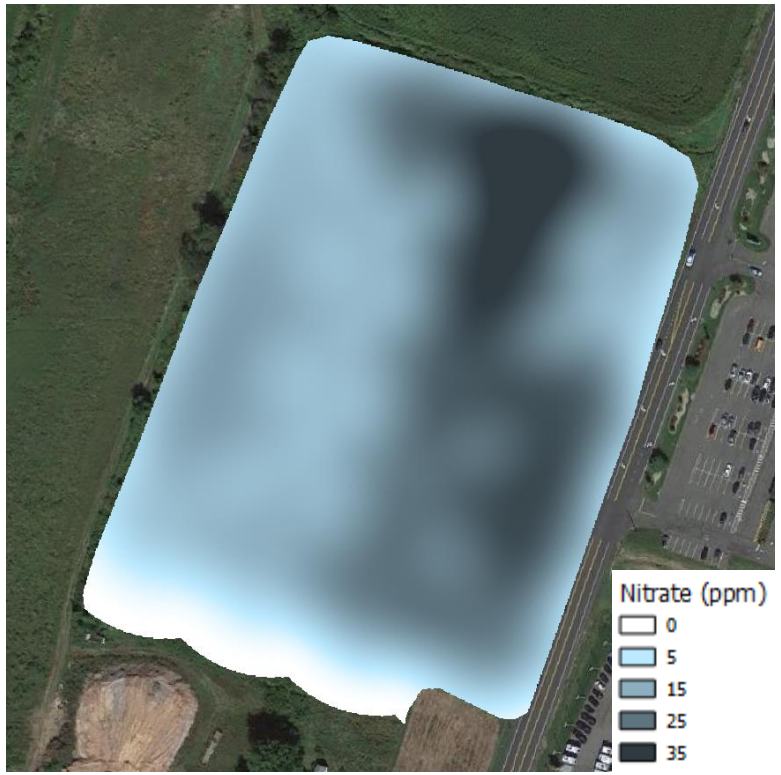




Spatial variability of NO_3 and P compared to aerial images

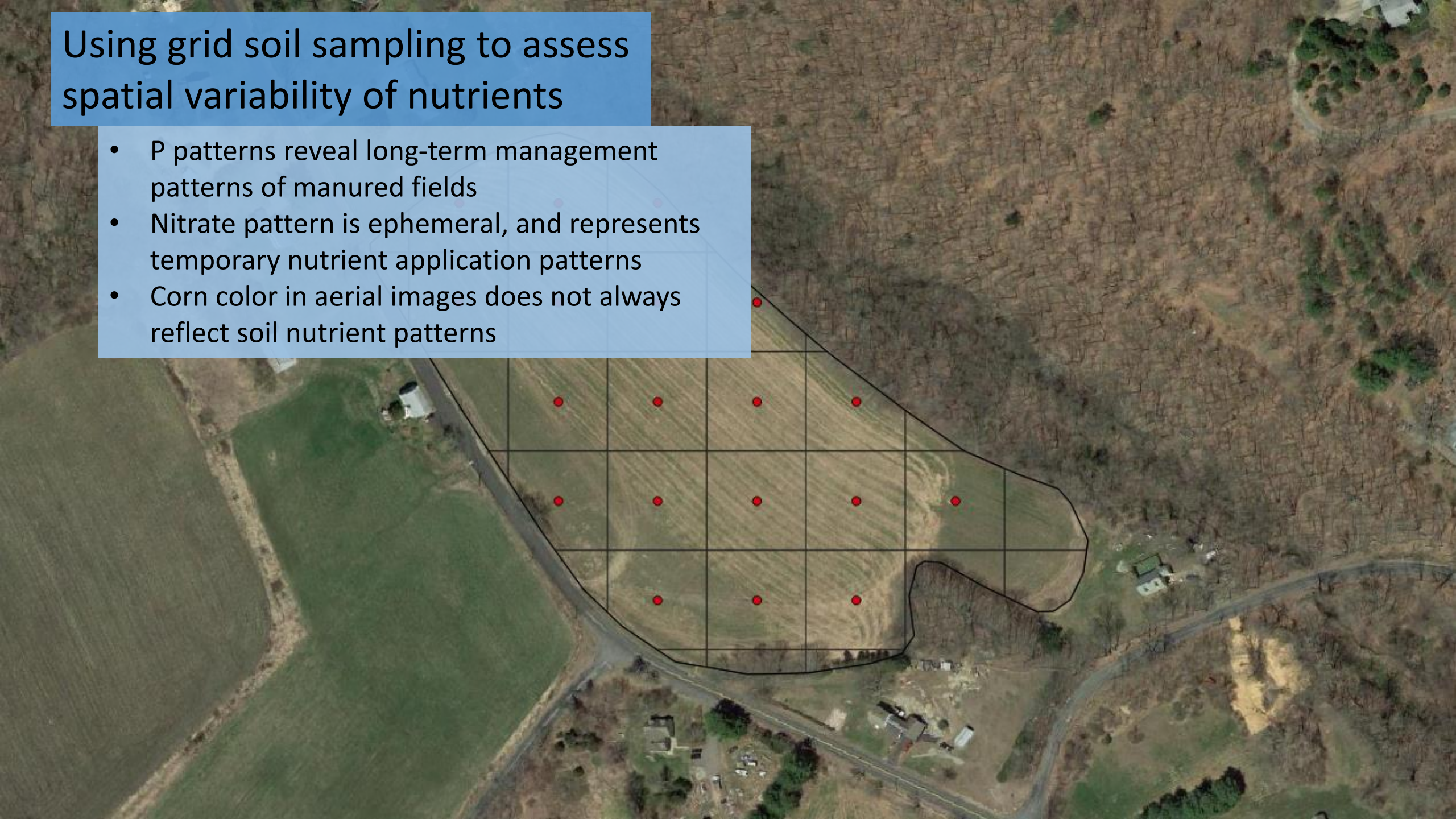
No P hotspots



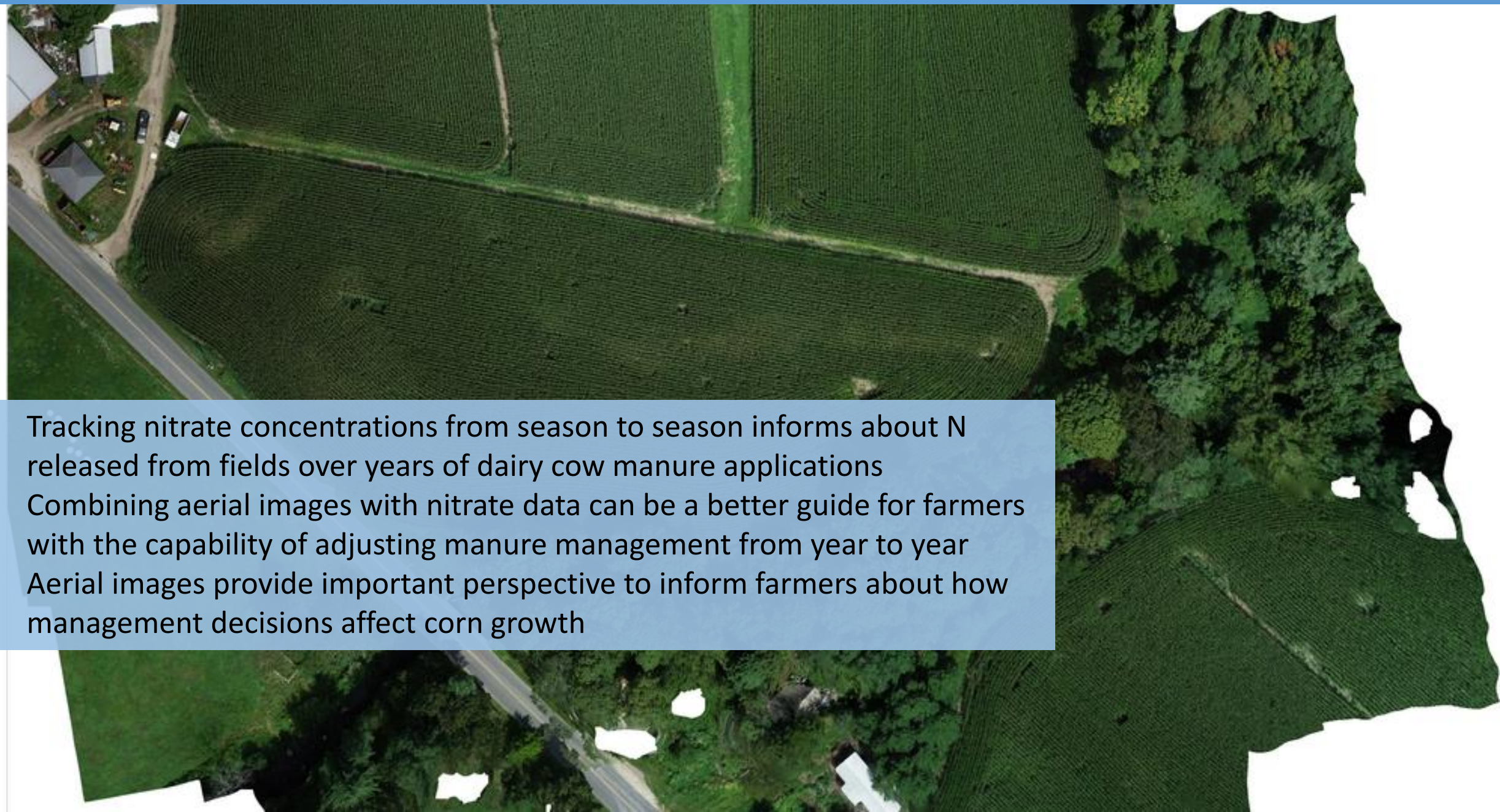


Using grid soil sampling to assess spatial variability of nutrients

- P patterns reveal long-term management patterns of manured fields
- Nitrate pattern is ephemeral, and represents temporary nutrient application patterns
- Corn color in aerial images does not always reflect soil nutrient patterns



Overall conclusions



- Tracking nitrate concentrations from season to season informs about N released from fields over years of dairy cow manure applications
- Combining aerial images with nitrate data can be a better guide for farmers with the capability of adjusting manure management from year to year
- Aerial images provide important perspective to inform farmers about how management decisions affect corn growth

Implications and future work

Implications

- Yearly spring and fall NO_3 soil samples can inform farmers about nutrient uptake by corn and nutrient storage in organic matter from manured fields (in addition to cornstalk NO_3 test)
- A consistent NO_3 surplus could be converted into cover crop to reduce nutrient runoff and reduce reliance on N fertilizer
- Aerial images may become a regular component of short-term nutrient management decisions for dairy farms

Future work

- Combine yield data with soil sample data to show where farmers should focus nutrient applications to improve whole-farm corn production
- Use aerial images to predict corn yield
- Conduct grid sampling in more silage corn fields to detect more management patterns that should be accounted for in nutrient management plans

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