



New Tool for Adaptive Management of Nitrogen: Mitigation and Adaptation of Climate Change

Harold van Es



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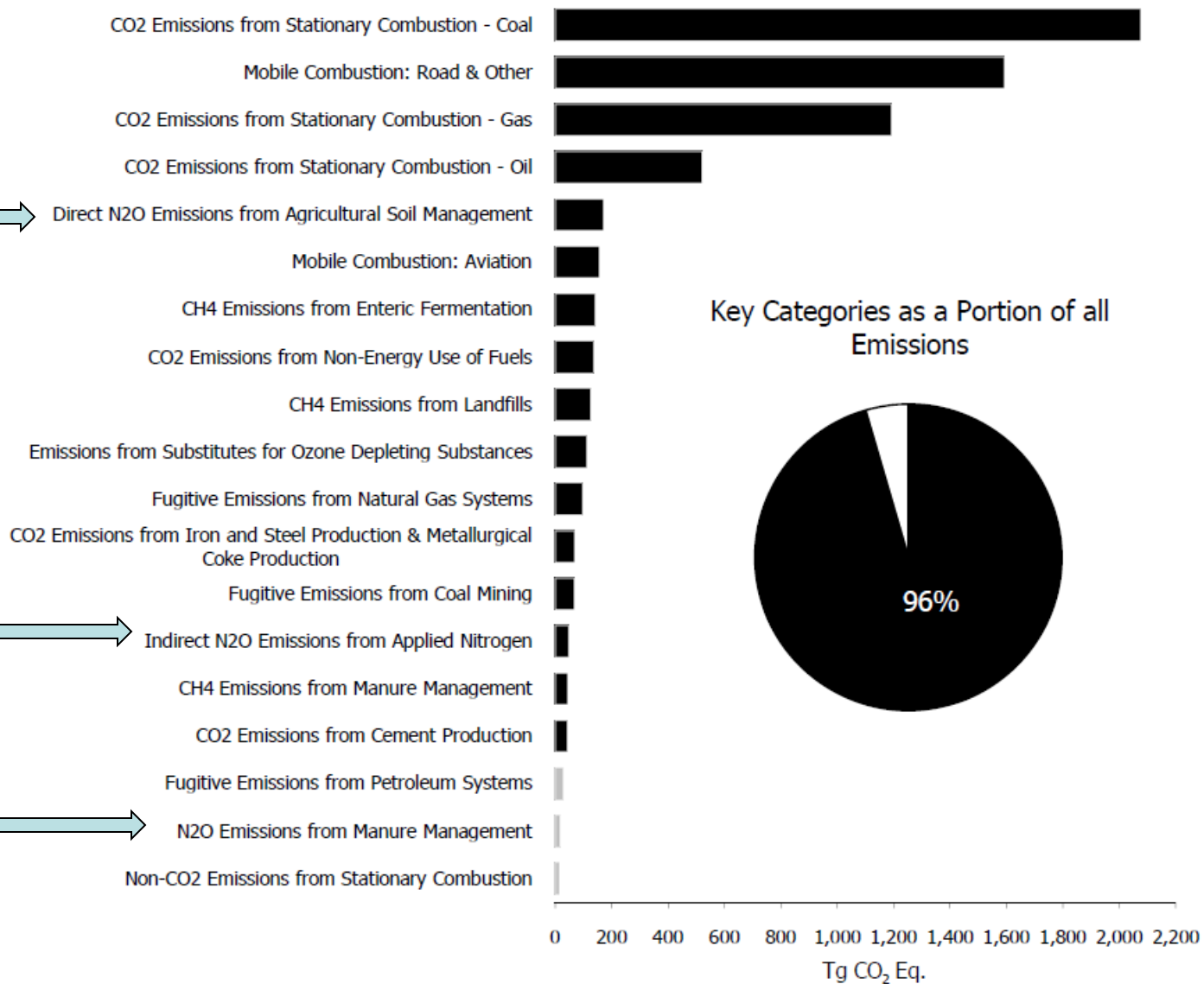
Adaptive Management, Operationally

“Refinement of management practices based on *localized* information on the resource base, system performance, experience and science”



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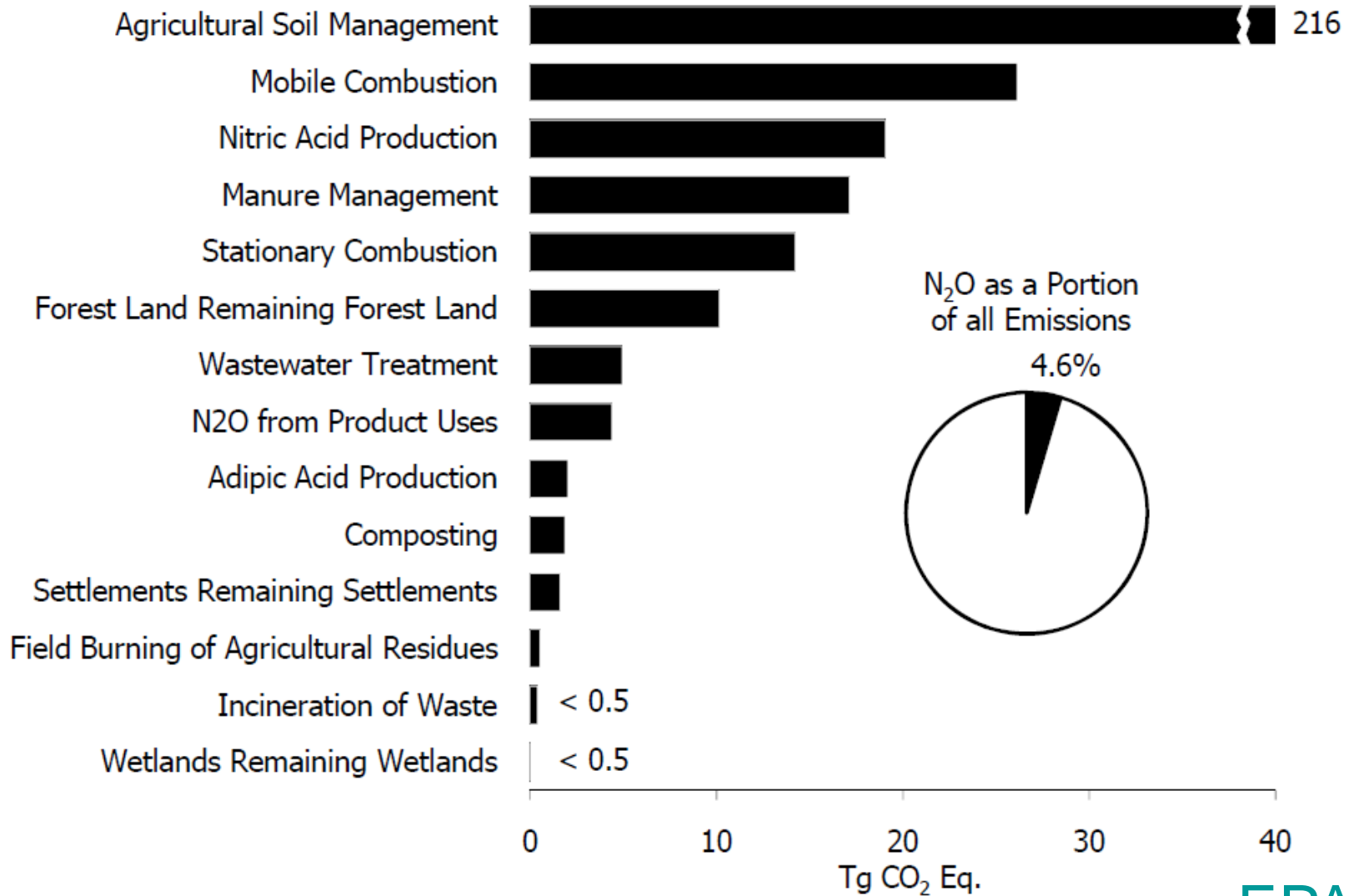




EPA, 2010



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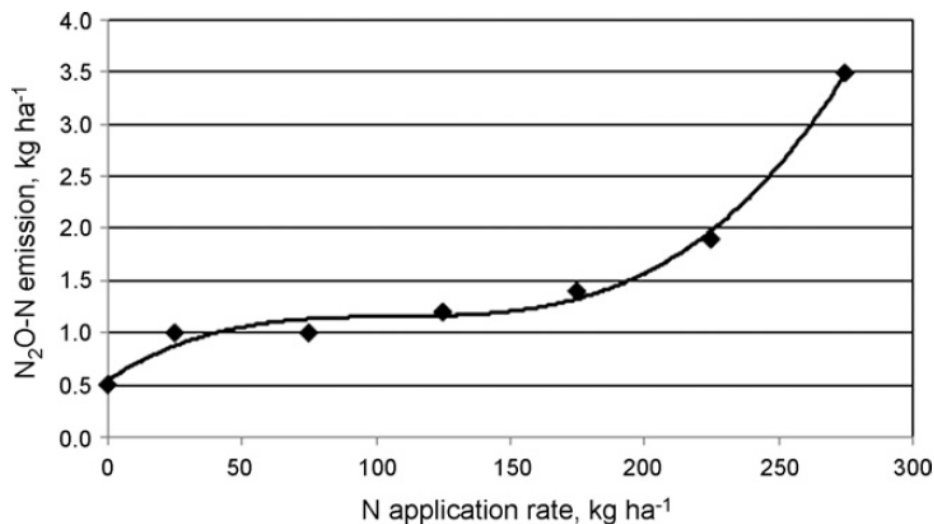


EPA, 2010

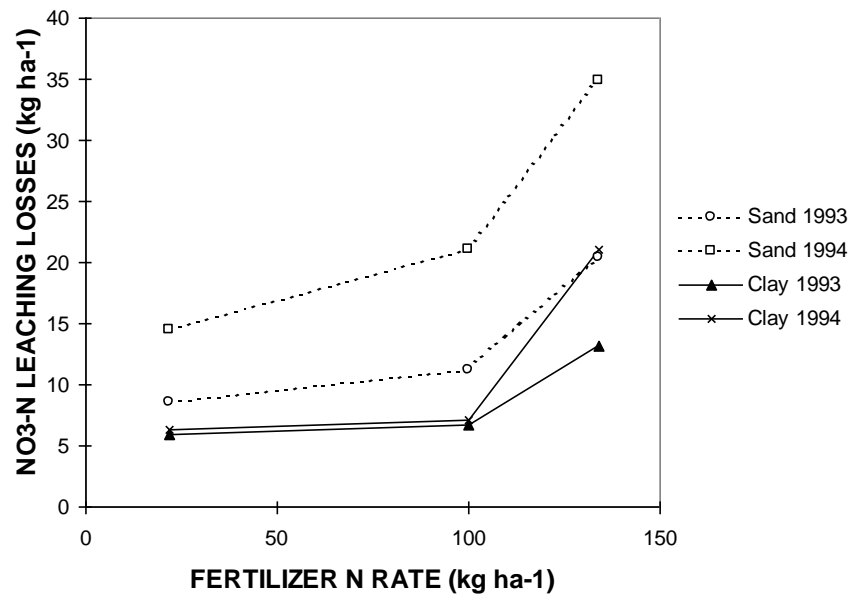


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Precise Estimation of Maize N Fertilizer Needs is Important



From: Snyder et al., 2009, based on data by Bouwman et al., 2002



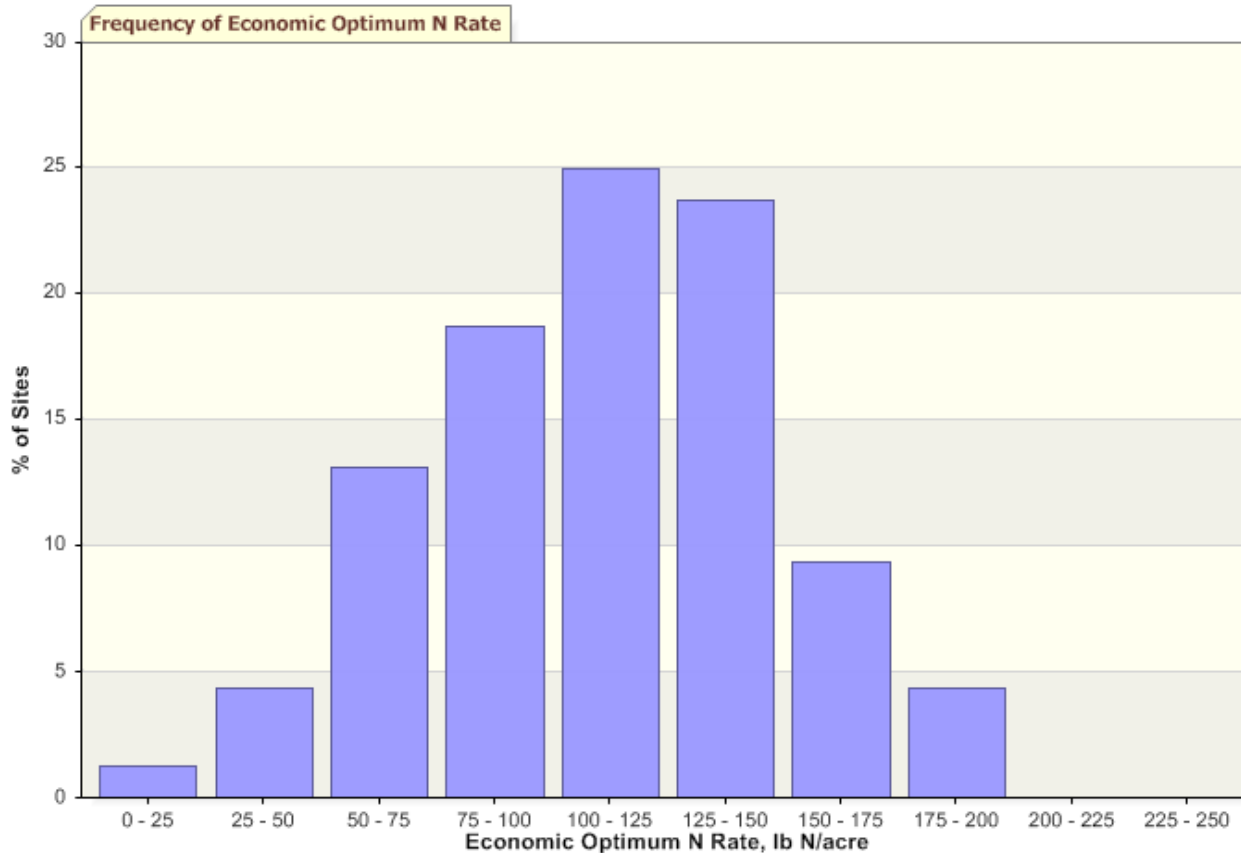
van Es et al., 2002



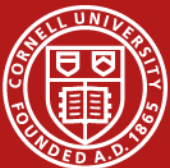
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Distribution of Optimum N Rates

from: <http://extension.agron.iastate.edu/soilfertility/nrate.aspx>

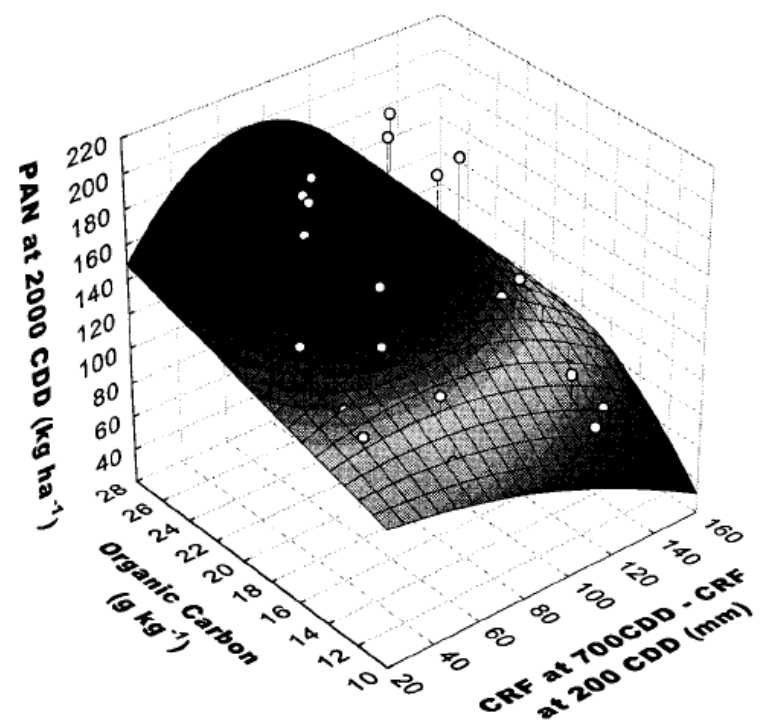


Price ratio = 0.08



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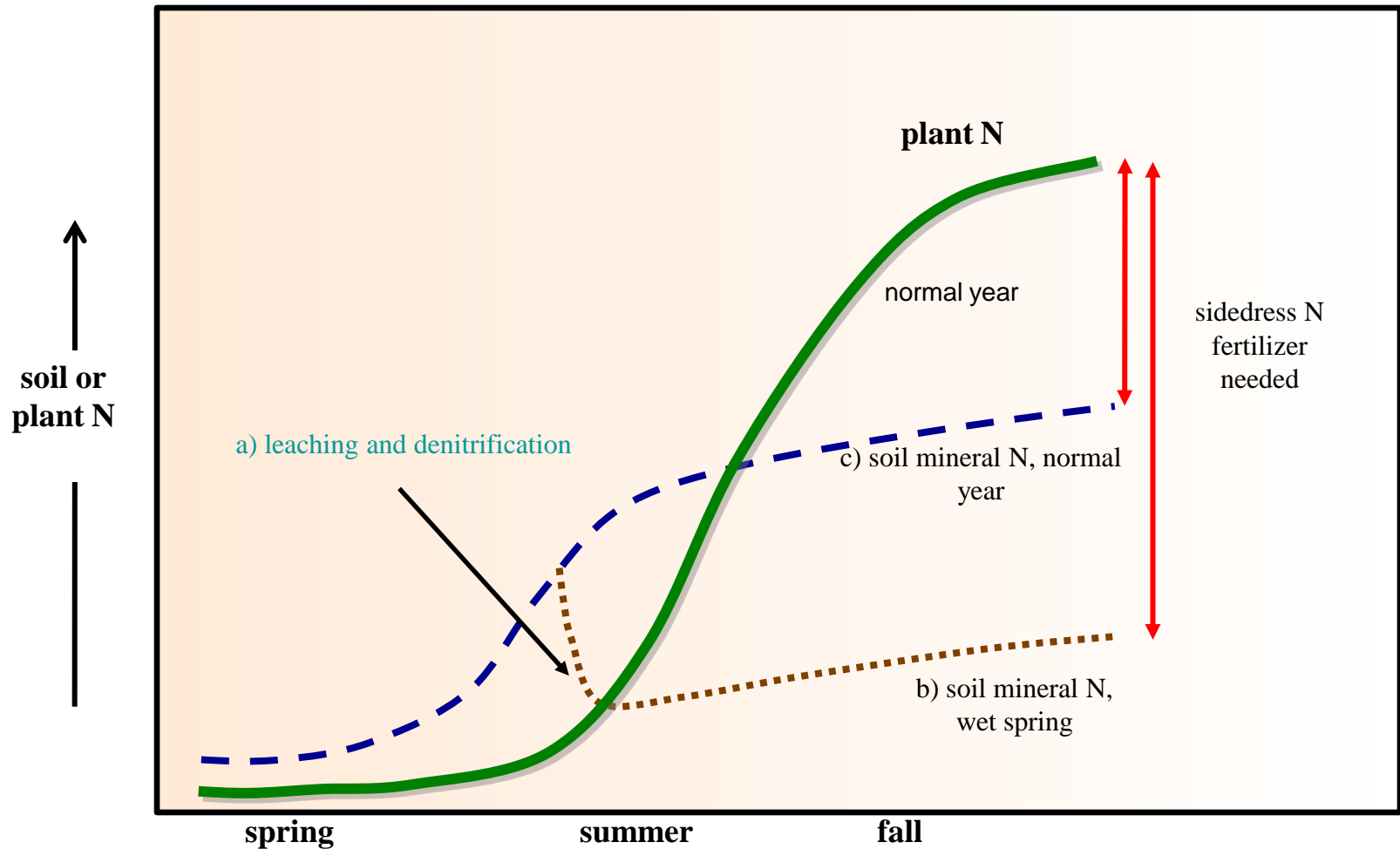
N Contribution from Soil Organic Matter is Variable



- A significant fraction of plant-available N comes from mineralization of SOM (mostly in spring) or manure
- Fertilizer N supplements N from SOM
- The release of SOM-N is affected by soil temperature and moisture
- SOM-derived N may be partially lost by leaching or denitrification

Kay, B.D., A. A. Mahboubi, E. G. Beauchamp, and R. S. Dharmakeerthi. 2006. Integrating Soil and Weather Data to Describe Variability in Plant Available Nitrogen. *Soil Sci. Soc. Am. J.* 70:1210–1221.

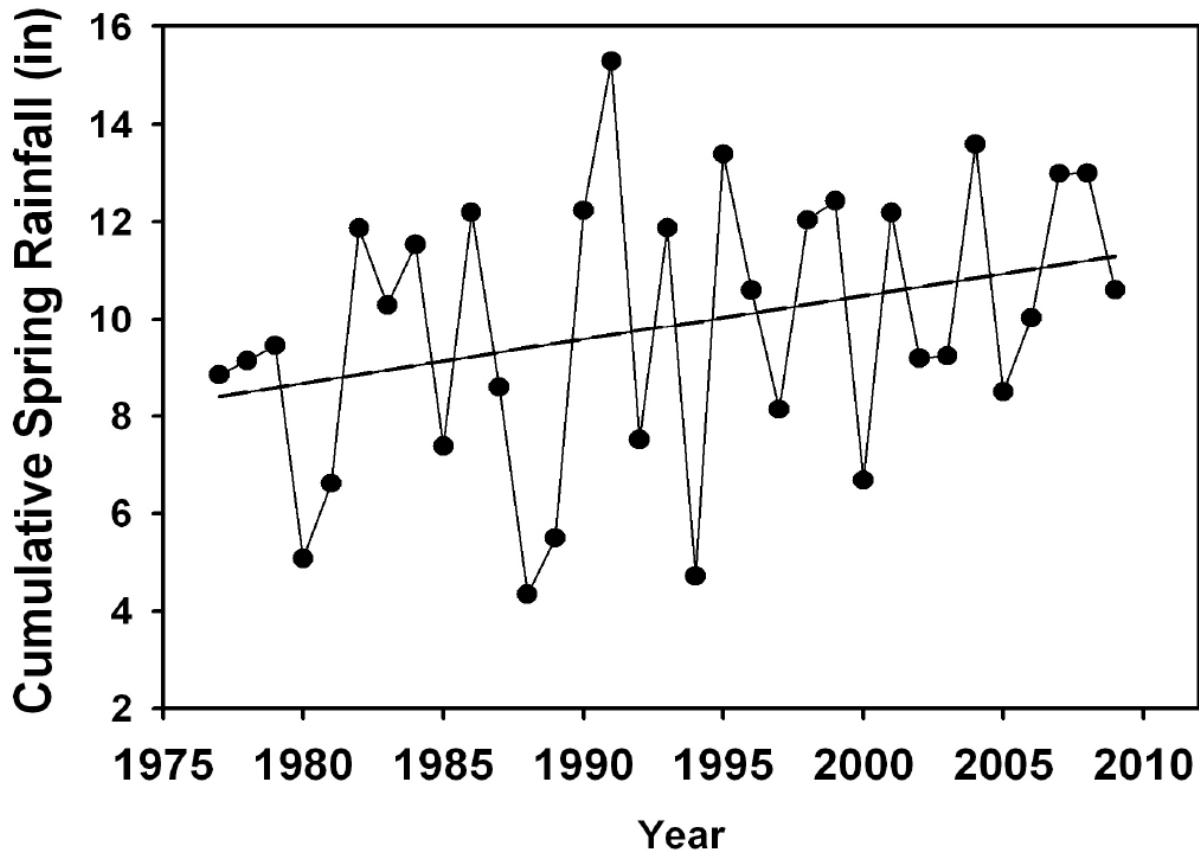
Need for supplemental N fertilizer depends on early season weather



Need for Adaptation

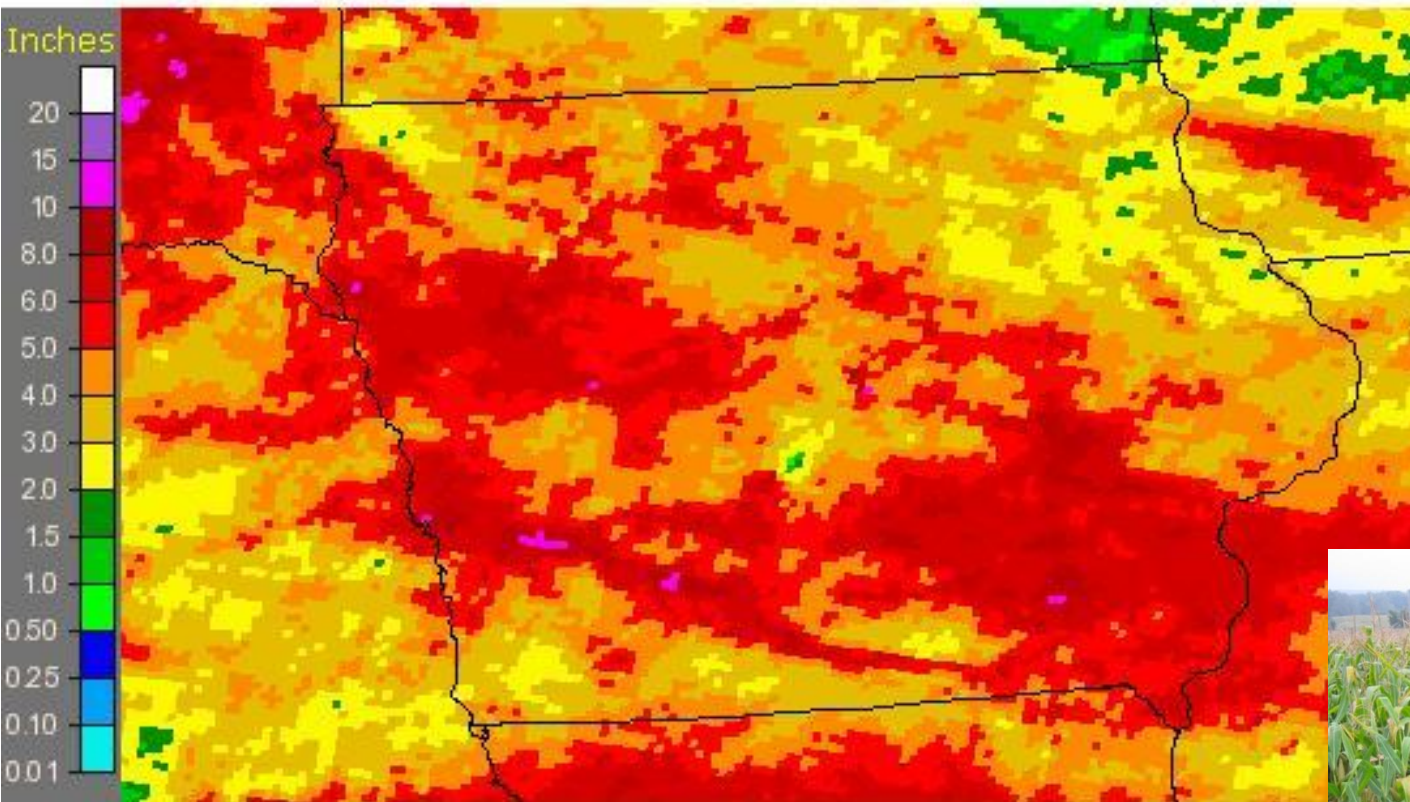
(from P. Kyveriga, Iowa Soybean Assn.)

Average Spring Rainfall across Iowa



Late Spring Precipitation Variability- Iowa 2009

Iowa: Current 30-Day Observed Precipitation
Valid at 7/9/2009 1200 UTC- Created 7/9/09 23:14 UTC



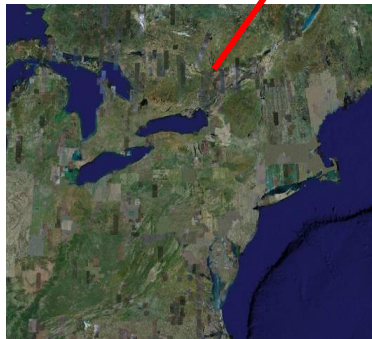
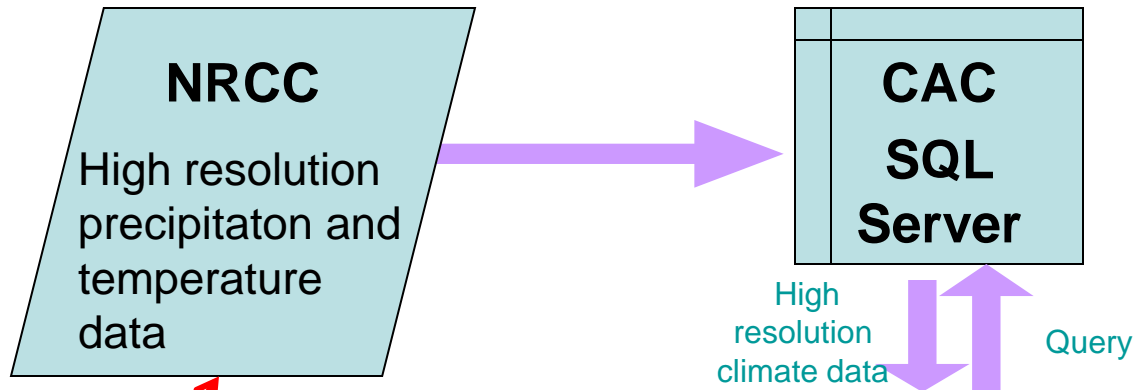
Source: NOAA

Estimating crop N fertilizer needs is actually quite difficult.....

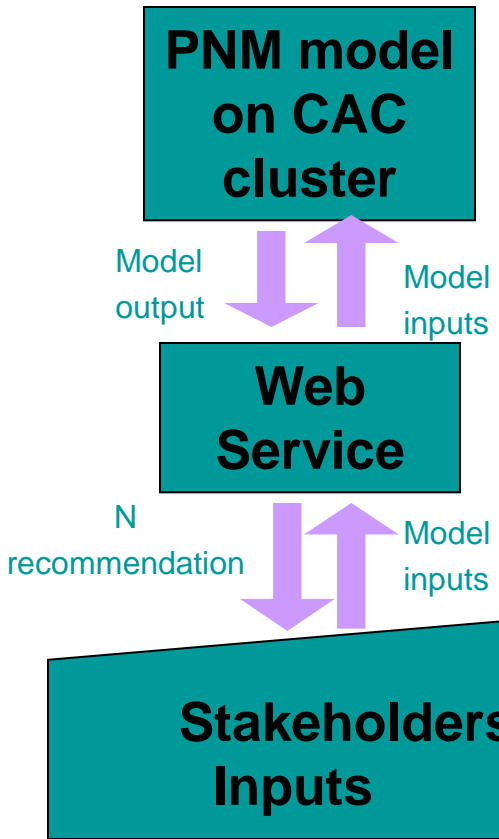
- Soil type differences
- Soil organic matter contents
- Organic amendments (manure, compost, etc.)
- Crop rotations
- Early season weather (warm vs cool; wet vs dry)
- Late season weather (warm vs cool; wet vs dry; **not easily managed**)

Corn N fertilizer needs cannot be predicted accurately at the beginning of the growing season

Adapt – N : A Web Based N Decision Tool



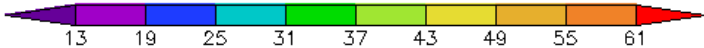
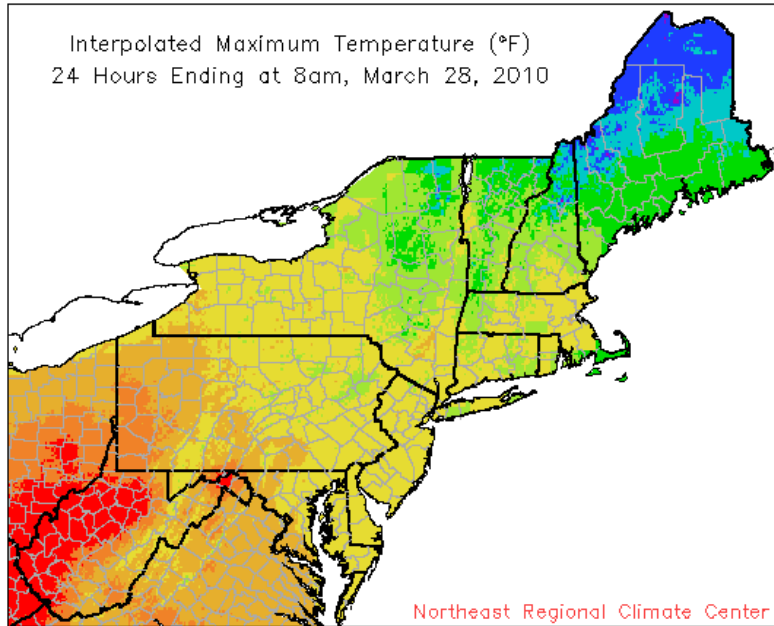
Currently available for NE /
Expanding to the Mid-West
(including Iowa).



Adapt-N Input:

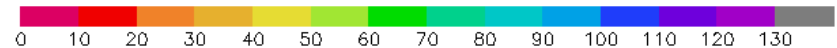
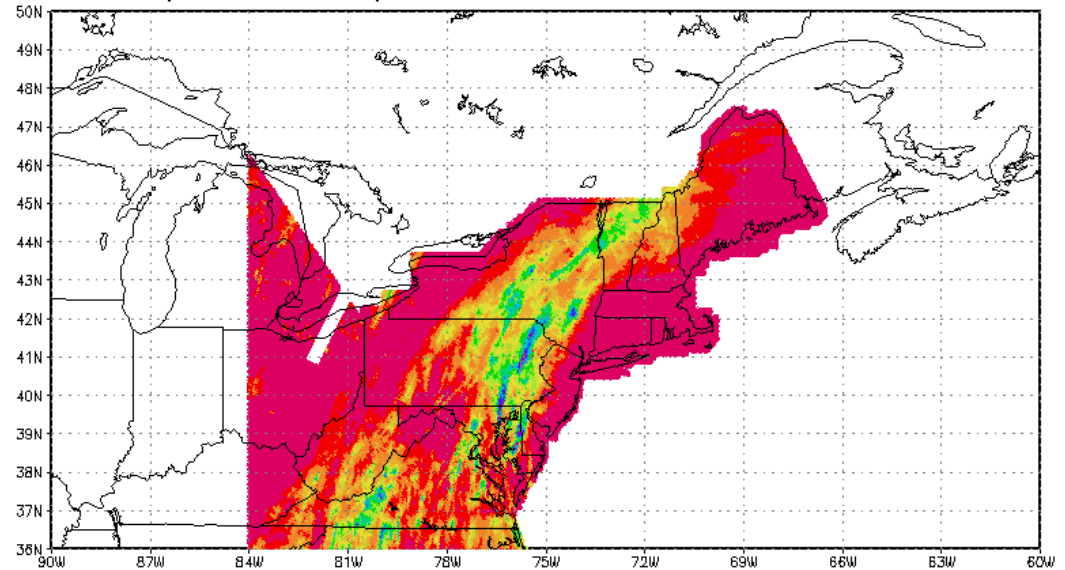
High Resolution Precipitation Data Error-Corrected Radar Estimates

Interpolated Maximum Temperature (°F)
24 Hours Ending at 8am, March 28, 2010



4X4 km

Interpolated Precipitation in Millimeters: June 27, 2006



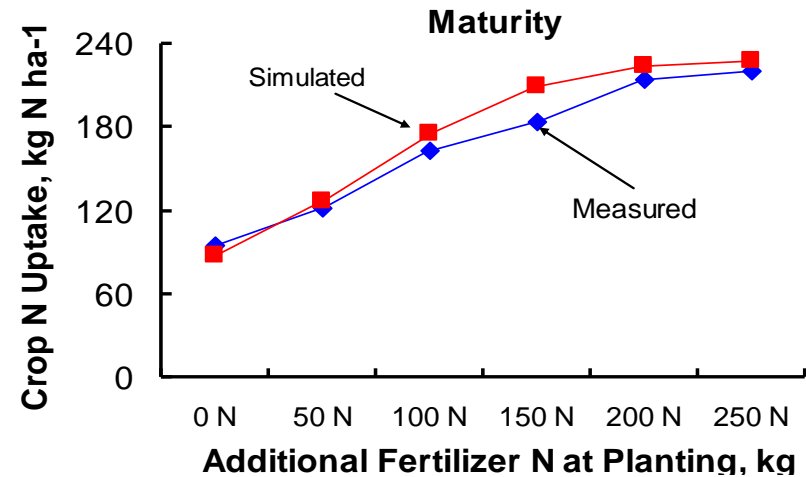
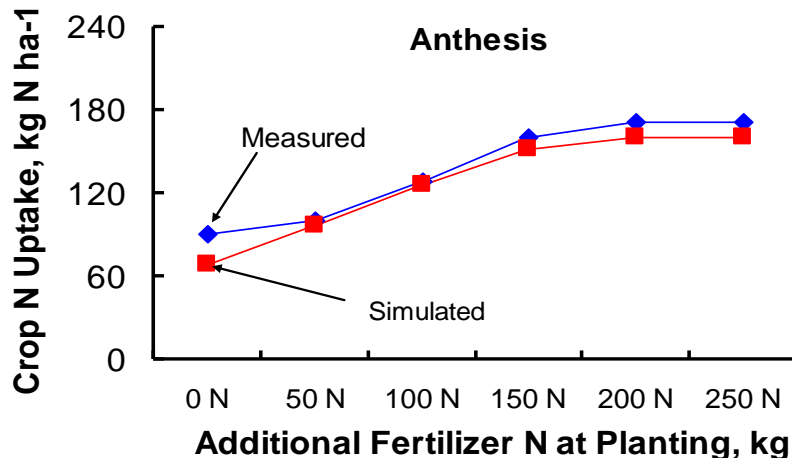
Precision Nitrogen Management (PNM) model: the core of the Adapt-N tool

Linkage between two models:

- Soil processes model (Hutson and Wagenet)
- Crop growth/N uptake model (Sinclair and Muchow)

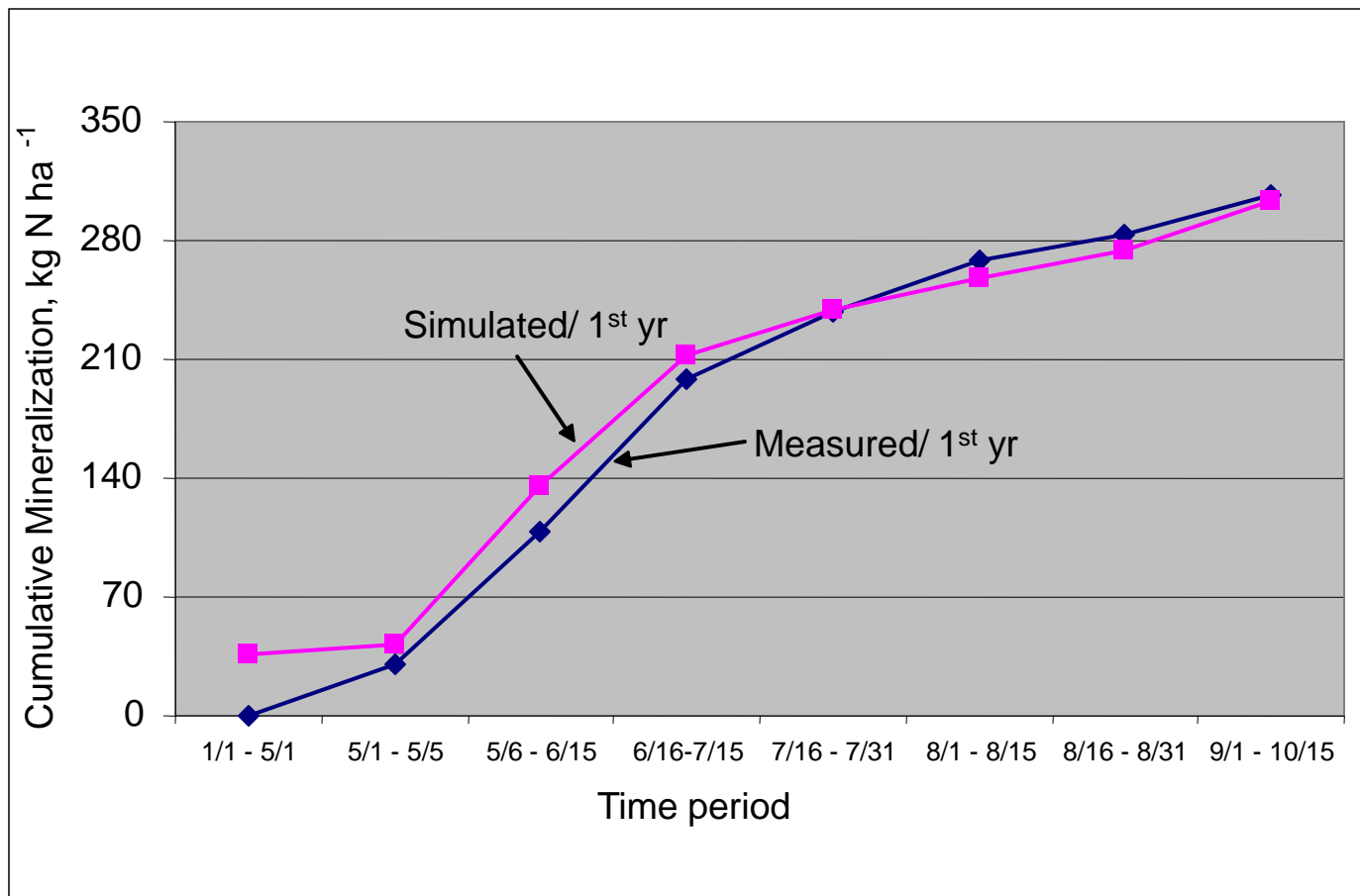
PNM Model Performance:

Simulation of crop N uptake



PNM Model Performance:

Measured vs simulated cumulative N mineralization:
First year after alfalfa plow down



Adapt-N: Information needed

Soil/Tillage

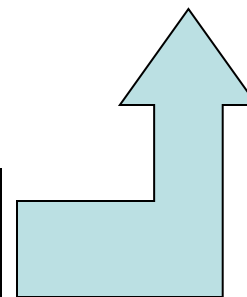
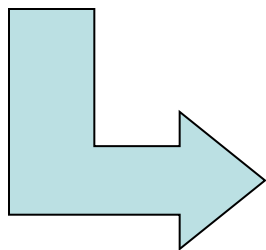
- User ID / Field ID
- Latitude / Longitude
- Soil textural group
- Approximate field slope
- Drainage
- Soil test information
- Tillage information

Fertilizer/Crop

- Starter fertilizer:
type/rate/application date
- Additional fertilizer
- Cultivar maturity class
- Planting date
- Expected harvest population

Organic Inputs

- Manure applications:
Two previous years / current year
- Previous sod crop
- 1st year corn after soybean?



N Recommendation Methodology

Mass Balance Approach

Approximated as:

$$N_{\text{rec}} = N_{\text{upt}} - N_{\text{rz_pre-sidedress}} - N_{\text{rz_post-sidedress}}$$

where

N_{rec} = N sidedress recommendation

N_{upt} = Seasonal crop N uptake based on a yield estimate

$N_{\text{rz_presidedress}}$ = Rootzone N presidedress, estimated by model based on recent weather

$N_{\text{rz_postsidedress}}$ = Estimated N mineralized post-sidedress to harvest, based on historical climate data

Adapt-N A tool for calculating corn sidedress nitrogen rates

[Login](#) [Mineral Nitrogen/Cultivar](#) [Soil/Tillage](#) [Manure/Sod/Soybean](#) [Add Application](#) [Results](#)

Add a Field [Cancel Request](#)

Please enter a field name, latitude and longitude. You may obtain latitude and longitude for a given address, (e.g. City and State) by following these easy steps:

- Go to the following website: <http://terraserver-usa.com/> When you click on this link, the window will open in a new tab
- Type in the desired address in the appropriate area at the top of the left column and press "go".
- Click on either "aerial photo" or "topo map" under "available image".
- The latitude and longitude is now displayed in the left hand column.
- Save this information, return to Adapt-N and enter the latitude and longitude in the "Add a Field page"

Field Name Longitude Latitude

Assign a unique field name **Enter longitude and latitude to the hundredths place (0.00).**

When you've entered all your information, please click the submit button [Submit When Complete](#)

Adapt-N *A tool for calculating corn sidedress nitrogen rates*

Login **Mineral Nitrogen/Cultivar** **Soil/Tillage** **Manure/Sod/Soybean** **Add Application** **Results**

Region

Nitrogen Fertilizer Applications for this Growing Season

Please select the choice that describes your ' fertilization application

(lbs N/acre)

Crop Information

Planting Date

When you've entered all your information, please click the submit button

Growing Season Change Field Menu

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Adapt-N Ovid: Welco... /EURUSD: 0.8... AHPs Precipit... s uchida kelp ... Horticulture C... Cornell Soil H... Facebook ny_cig_2010... PMC Result

Do you want Firefox to remember the password for "hmv1" on cornell.edu? Remember Never for This Site Not Now

Adapt-N *A tool for calculating corn sidedress nitrogen rates*

Login **Mineral Nitrogen/Cultivar** **Soil/Tillage** **Manure/Sod/Soybean** **Add Application** **Results**

Soil Information

Please select a soil texture class (New York) or soil series (Iowa) that best describes the soil in the field.

medium: (silt loams)

Please select the estimated rooting depth. **22-26 inches**

Please select the approximate slope (%) of the field. **less than 3%**

Was there a soil test? **There was a soil test in 2009**

If you know the sample depth, please enter it in inches.
Otherwise, please enter 6 inches. (inches) **6**

soil organic matter: (%) **3.5**

Tillage System Information

Please select the tillage system for this field. **tillage (plow till, chisel till, disk till)**

Approximate Date **04/21/2010** Approximate Depth of Primary Tillage (inches) **8**

When you've entered all your information, please click the submit button **Submit When Complete**

Done

Adapt-N *A tool for calculating corn sidedress nitrogen rates*

Manure N Applications

Date	Added	Organic N	Ammonia N	Depth	Solids	Delete Button
04/17/2008	6000	9	10	injected/incorporated within 5 days	n/a	<input type="button" value="Delete"/>
10/23/2009	8000	9	10	injected/incorporated within 5 days	n/a	<input type="button" value="Delete"/>

You may enter up to three applications for 2008, up to three applications for 2009 and one application for 2010

Select Manure Application

N from Sod Rotation

Previous sod crop in the past three years?

Previous Soybean Crop

First year corn after soybean?

When you've entered all your information, please click the submit button

Growing Season

 Change Field Menu

Adapt-N *A tool for calculating corn sidedress nitrogen rates*

[Login](#)
[Mineral Nitrogen/Cultivar](#)
[Soil/Tillage](#)
[Manure/Sod/Soybean](#)
[Add Application](#)
[Results](#)

Date: 06/11/2010	Latitude: 42.45	Longitude: 76.45
Soil/Field Information		
Soil Texture: medium: (silt loams)	Field Slope: less than 3%	
Soil Management: tillage (plow till, chisel till, disk till)	Preplant Soil Test: test in 2009	
Crop Information		
Maturity Class: Grains: mid-maturing (85-105 days)	Planting Date: 04/29/2010	Planting Density 25,000 plants/acre
GDD to maturity: 2300		
Expected Yield: 180 bu/acre		
Nitrogen Inputs:		
Organic Sources		
Sod: sod not applied		
Manure	Manure Input	Manure Management
10/23/2009	8000.0 gals/acre manure added	injected/incorporated within 5 days
	9.0 lbs Organic N/1000 gals	
	10.3 lbs Ammonium N/1000 gals manure	
04/17/2008	6000.0 gals/acre manure added	injected/incorporated within 5 days
	9.0 lbs Organic N/1000 gals	
	10.3 lbs Ammonium N/1000 gals manure	
Mineral Fertilizer	Date	Depth of Incorporation
starter: monoammonium phosphate, 20 lbs N/acre	04/29/2010	3 inches
additional: not used	not used	not used

Sidedress Nitrogen Recommendation: 70 lbs N/Acre

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Adapt-N Ovid: Welco... /EURUSD: 0.8... AHPS Precipit... s uchida kelp ... Horticulture C... Cornell Soil H... Facebook ny_cig_2010.... PMC Result

Do you want Firefox to remember the password for "hmv1" on cornell.edu?

10/23/2009	9.0 lbs Organic N/1000 gals 10.3 lbs Ammonium N/1000 gals manure	injected/incorporated within 5 days
04/17/2008	6000.0 gals/acre manure added 9.0 lbs Organic N/1000 gals 10.3 lbs Ammonium N/1000 gals manure	injected/incorporated within 5 days
Mineral Fertilizer	Date	Depth of Incorporation
starter: monoammonium phosphate, 20 lbs N/acre	04/29/2010	3 inches
additional: not used	not used	not used

Sidedress Nitrogen Recommendation: 70 lbs N/Acre

This recommendation is based on an "Expected Yield" entry that is assumed to be the economically optimal yield for your field. As such, it is relatively insensitive to profit within a range of +/- 15 lbs per acre around the recommended rate at current fertilizer and grain prices.

Additional Information

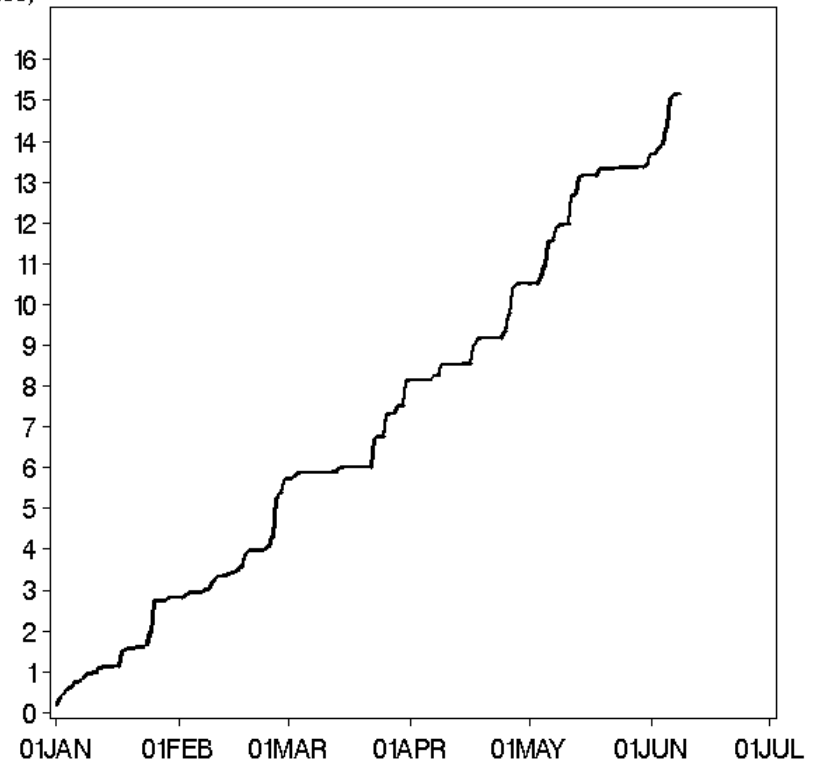
- [Results in a printable format](#)
- [Growing Season Daily Average Temperature](#)
- [Post Planting Growing Degree Days](#)
- [Growing Season Rainfall](#)
- [Cumulative Rainfall for Growing Season](#)
- [Cumulative Nitrogen Losses from the Root Zone](#)
- [Cumulative Nitrogen Uptake by the Crop](#)
- [Cumulative Nitrogen \(N\) Mineralization \(all organic N sources\)](#)
- [Crop available N in the top 12 inches of the Root Zone](#)
- [Post Planting Leaf Number](#)

When you've entered all your information, please click the submit button

Growing Season Change Field Menu

Growing Season Cumulative Rainfall

Cumulative Rainfall (inches)

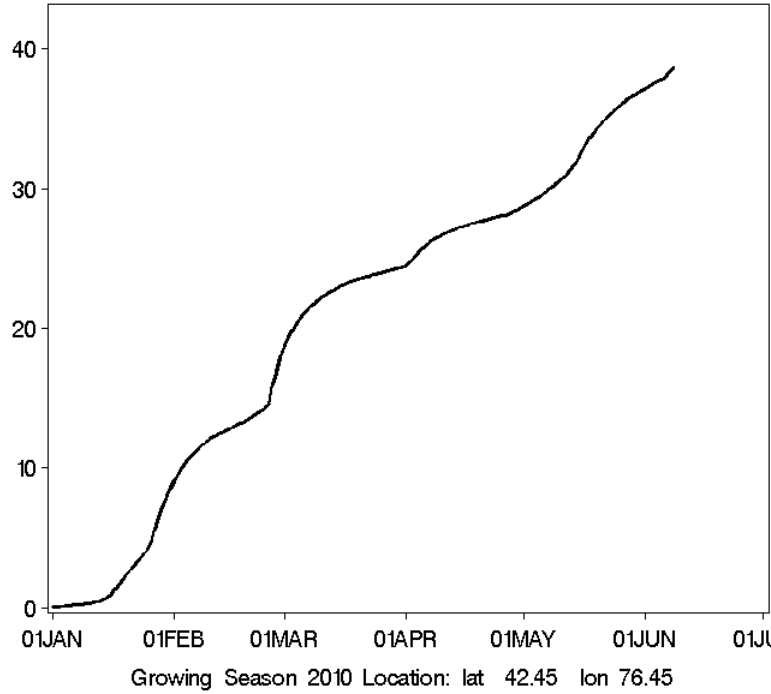


Growing Season 2010 Location: lat 42.45 lon 76.45



Cumulative Nitrogen Losses From the Root Zone

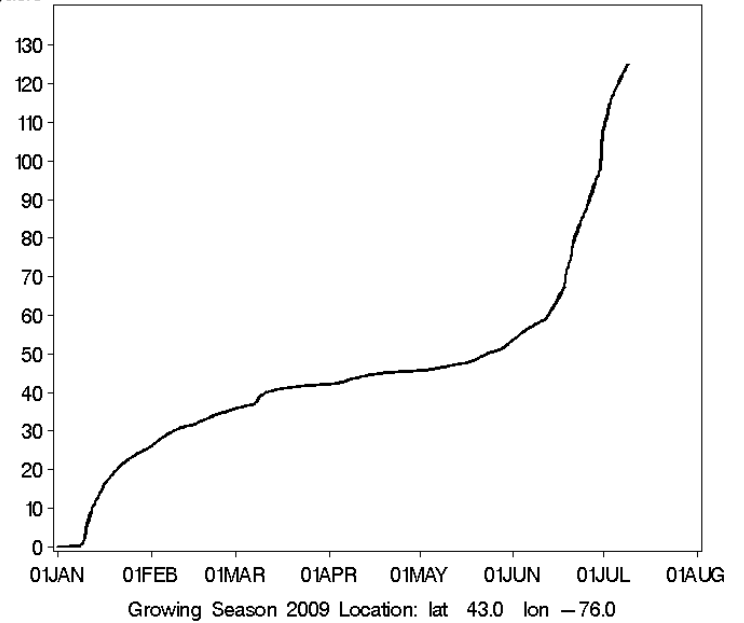
N Losses, lbs/acre



2010

2009

N Losses, lbs/acre



Adapt-N Applications

- Adapt-N can be used for a wide range of N management practices for corn:
 - Split applications: Sidedress N rate recommendation
 - Applications at planting: When are additional in-season N applications necessary?
 - Manured fields – Is additional N necessary, and how much?
 - Hindcasting after growing season

Combining Spatial and Temporal Processes in Adaptive Management

(in collaboration with the National Laboratory for Agriculture and Environment, Dr. David Laird)

- Temporal (for making annual adjustments):
 - Weather, management practices, soil dynamic changes (esp. SOM)
- Spatial (for using variable-rate applicators)
 - Field variability in SOM, soil type

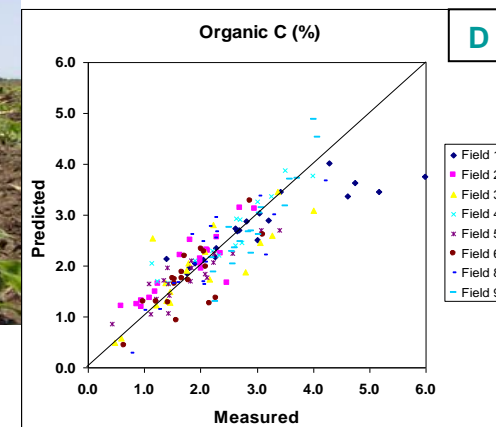
Soil Survey and Soil Organic C Data



Soil Survey Information

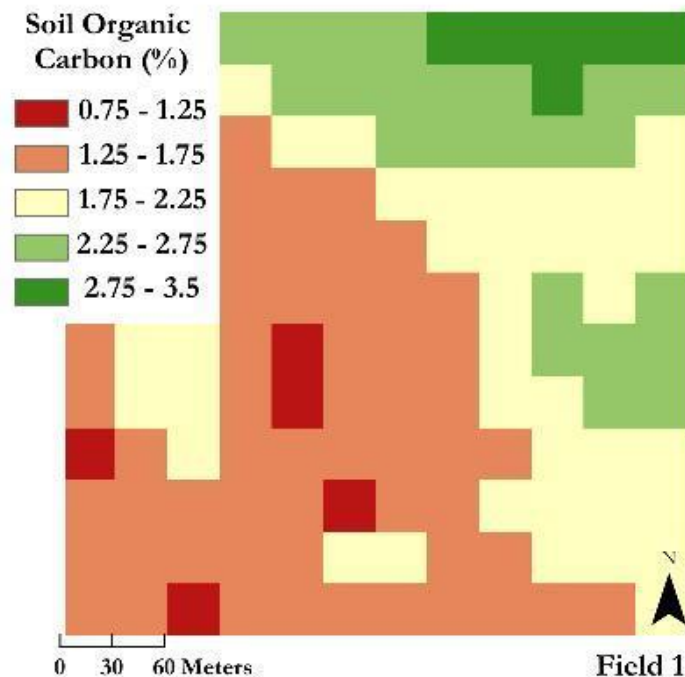


In-field NIR Spectroscopy



Organic Carbon Content (%)

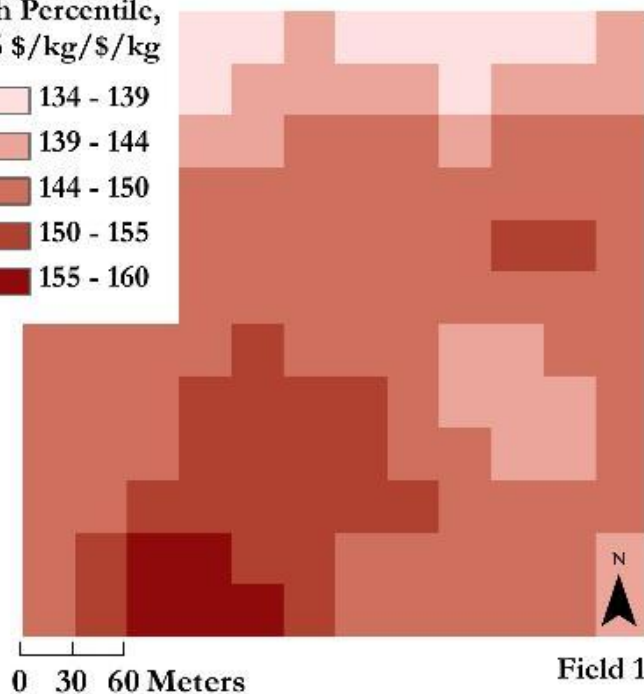
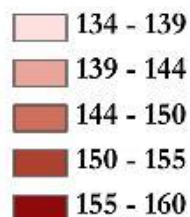
- 1342 OC estimates were distilled to 136 blocks (30x30 m management units) using kriging with ArcGIS Geostatistical Analyst



N Sidedress Recommendation (kg/ha) 10th Percentile (wet spring)

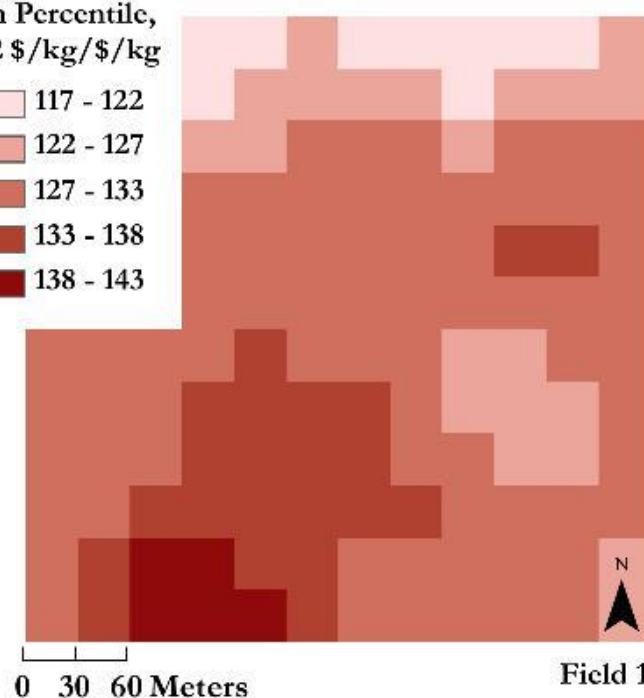
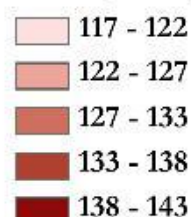
0.1 Fertilizer to Grain Price Ratio

N Recommendation (kg/ha),
10th Percentile,
5.6 \$/kg/\$/kg



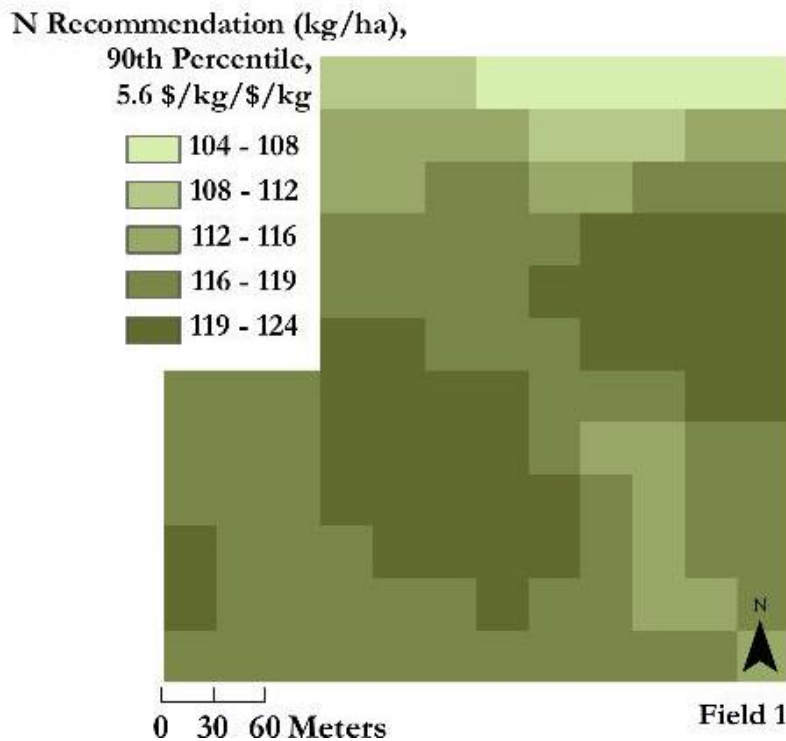
0.2 Fertilizer to Grain Price Ratio

N Recommendation (kg/ha),
10th Percentile,
11.2 \$/kg/\$/kg

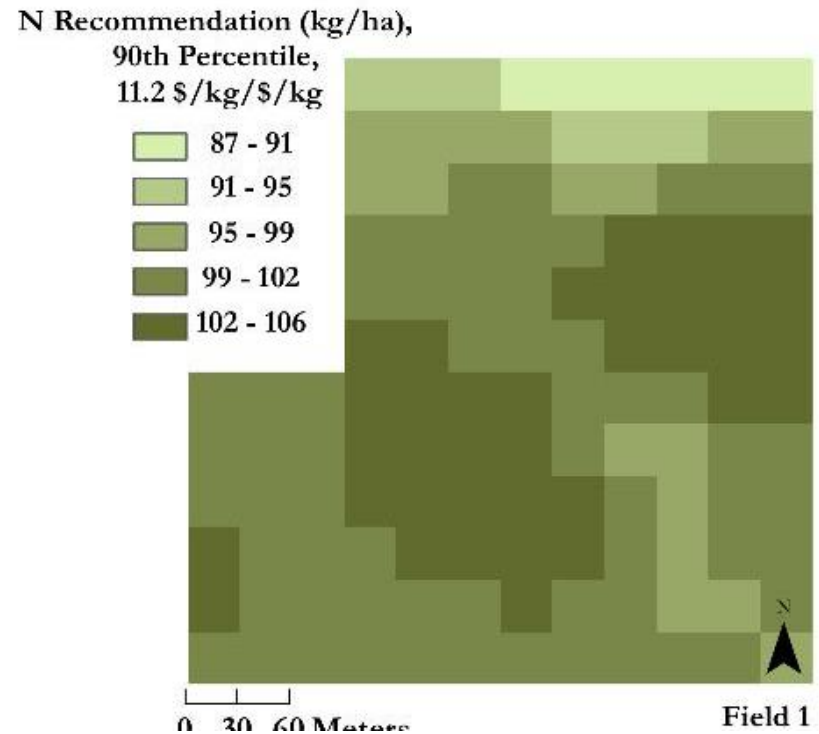


N Sidedress Recommendation (kg/ha) 90th Percentile (dry spring)

0.1 Fertilizer to Grain Price Ratio



0.2 Fertilizer to Grain Price Ratio



Conclusions

- Natural soil variability and management-induced soil change reduce the applicability of generalized management recommendations
- Adaptive management is based on local data and scientific/practical knowledge
- Adaptive N management allows for adaptation to, and mitigation of, climate change



Main Collaborators

Adaptive N management

CU-Crop and Soil Sciences: Jeff Melkonian, Chris Graham, and Jean Sogbedji

CU-Earth and Atmospheric Sciences: Art DeGaetano, Laura Joseph,

CU-Center for Advanced Computing: Linda Woodard

USDA-ARS: David Laird

Thank you!



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