# *In-Season Adaptive Nitrogen Management Tools for Corn*

## *- managing the weather component -*

***Harold van Es, Bianca Moebius-Clune, Jeff Melkonian***
***Art DeGaetano, Laura Joseph***

Cornell University
College of Agriculture and Life Sciences
Department of Crop and Soil Sciences

# Outline for Today

**Why is in-season adaptive N management needed?**

- Nitrogen in agriculture and the environment
- N dynamics and sources of variability:
  - Soil quality, manure, cover crops, crop rotations
  - Influences on N dynamics by weather & climate change

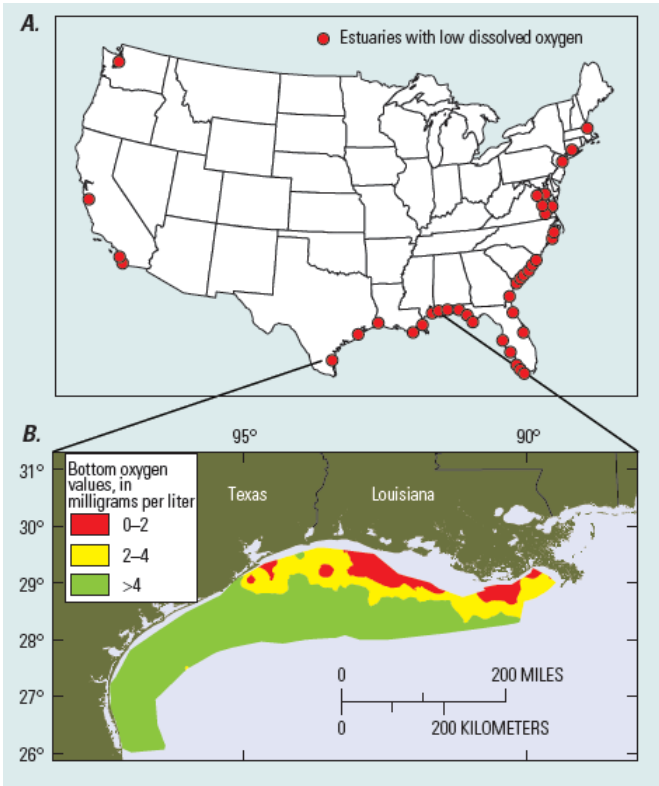
**Tools**

- PSNT - LSNT
- Chlorophyll Measurements, Canopy Reflectance Spectroscopy
- Adapt-N—Precise N management for Corn Production
- Demo of Adapt-N online tool
  - In-season N management
  - Excess N after growing season
  - Hind-sight evaluation/scenario testing

# Nitrogen in Agriculture and the Environment

# Corn Nitrogen Concerns:
## Economic and Environmental

- ~ $5 billion/yr of N fertilizer applied to corn
- N use efficiency very low (30-40%)
- Largest energy input in cropping system
- High groundwater nitrate levels
- Hypoxia/anoxia in estuaries
- Greenhouse gases
- Sensitivity to climate change




From: Dubrovsky et al., 2010

# MRB water quality concerns not improving:

Net Change in Flow-Normalized Nitrate Concentration and Flux between 1980 and 2008

From: Sprague et al., 2011

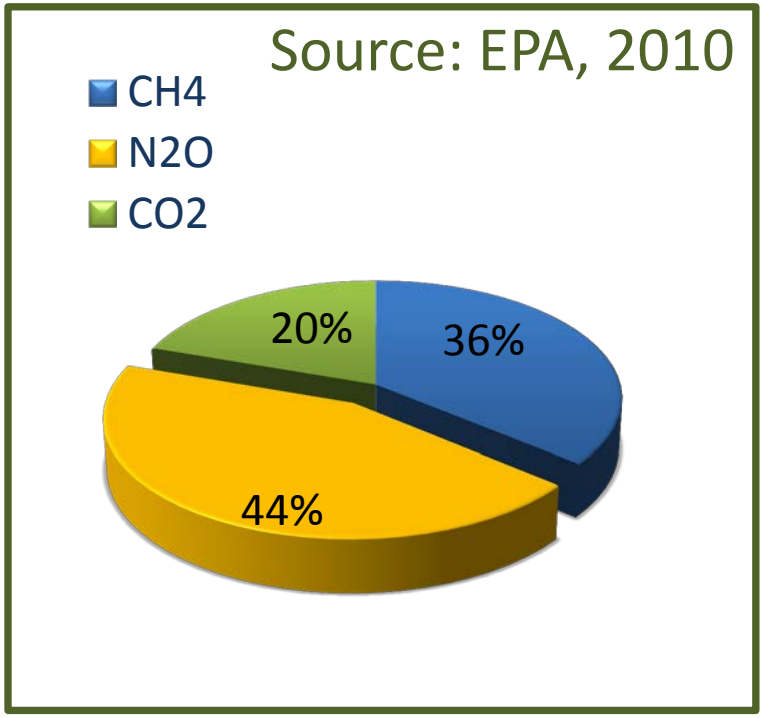
*"The results show that little consistent progress has been made in reducing riverine nitrate since 1980, and that flow-normalized concentration and flux are increasing in some areas."*

| | flow-normalized concentration of nitrate as N | | |
|---|---|---|---|
| | | change, 1980–2008 | |
| site | annual mean flow-normalized concentration in 1980, mg/L | mg/L | % |
| MSSP-CL | 1.13 | 0.86 | 76 |
| IOWA-WAP | 5.02 | 0.17 | 3 |
| ILLI-VC | 3.81 | −0.04 | −1 |
| MSSP-GR | 2.56 | 0.49 | 19 |
| MIZZ-HE | 0.96 | 0.72 | 75 |
| MSSP-TH | 1.93 | 0.38 | 20 |
| OHIO-GRCH | 0.99 | 0.03 | 3 |
| MSSP-OUT | 1.25 | 0.13 | 10 |

# How Does Agriculture Affect Climate Change? (1)

- Agriculture produces 8% of US GHG emissions, but only 1.2% of GDP.
- Largest fraction associated with N management (global warming potential of $N_2O$ is ~300 times that of $CO_2$)
- N fertilizer manufacture consumes a lot of energy (about 8,000 kcals per lb of urea)
- $N_2O$ emissions from corn fertilizer can be high, especially as a result of a major rainfall events

## Agricultural Greenhouse Gas Emissions (2008)

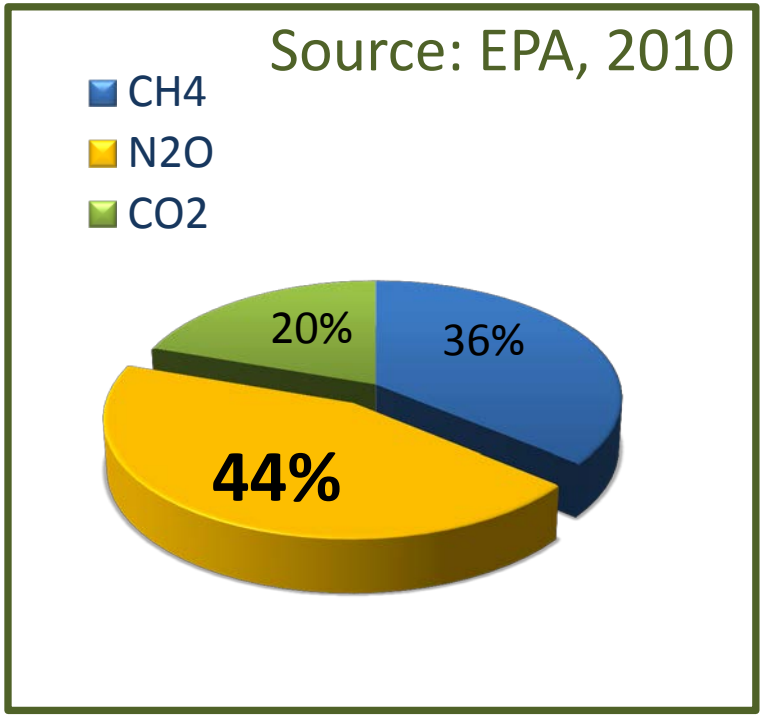


# How Does Agriculture Affect Climate Change? (2)

**N application to agricultural lands in 2008 accounted for:**

- 92% of Agricultural $N_2O$ losses
- 1.5 times greater global warming potential than Enteric Fermentation
- Greater global warming potential than all of US Aviation

## Agricultural Greenhouse Gas Emissions (2008)



# How Does Agriculture Affect Climate Change? (3)

**To put corn $N_2O$ emissions in perspective:**

GHG impact of 1 acre of corn N fertilizer use per year is guesstimated to be equivalent to the GHG impact of 4000 miles of driving a car.

For 100 acres, this would be equivalent to 400,000 miles

**That's ~16 times around the earth!**

**Opportunity to mitigate!**

# How Does Climate Change Affect N Management?

## More precipitation extremes

**Excess wetness:** N shortages from water logging and subsequent denitrification and leaching → reduced yields

**Drought:** water shortage and unattained yield potential → reduced yields & excess residual N

## Higher temperatures

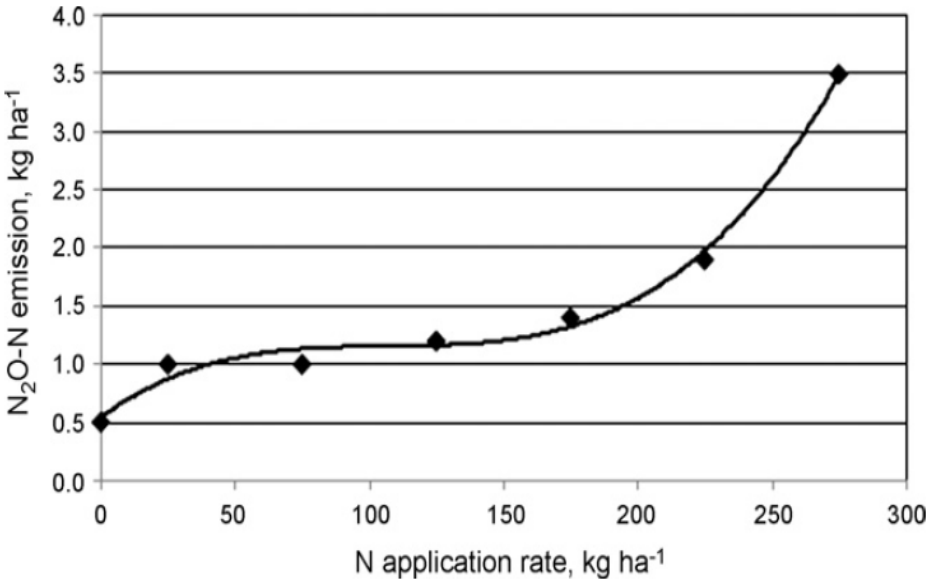
**Longer growing season:** greater GDD → higher N needs?

**Greater potential for heat stress:** → lower N needs?

# We need to adapt!

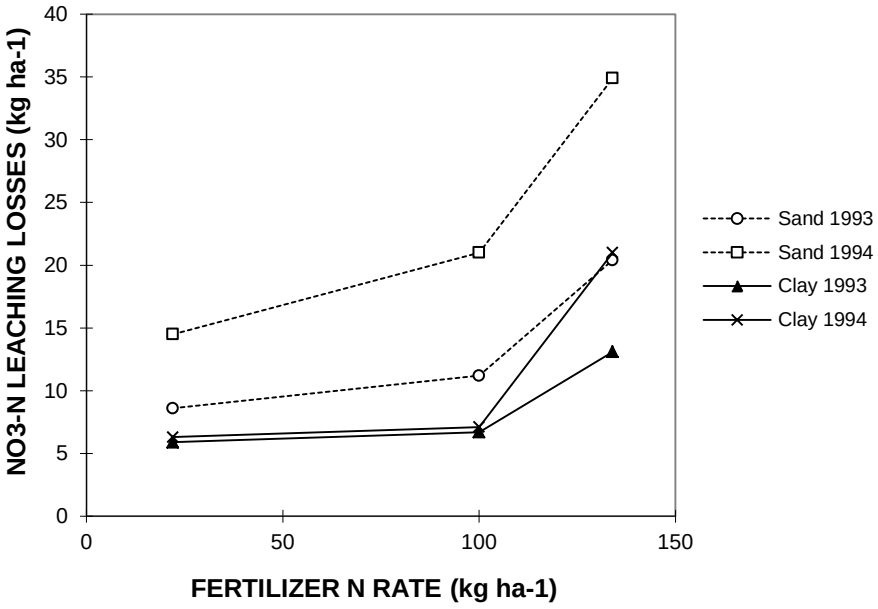
# Win – Win Opportunities:
# Precise N Fertilization would prevent majority of losses

## NITROUS OXIDE




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

## NITRATE LEACHING

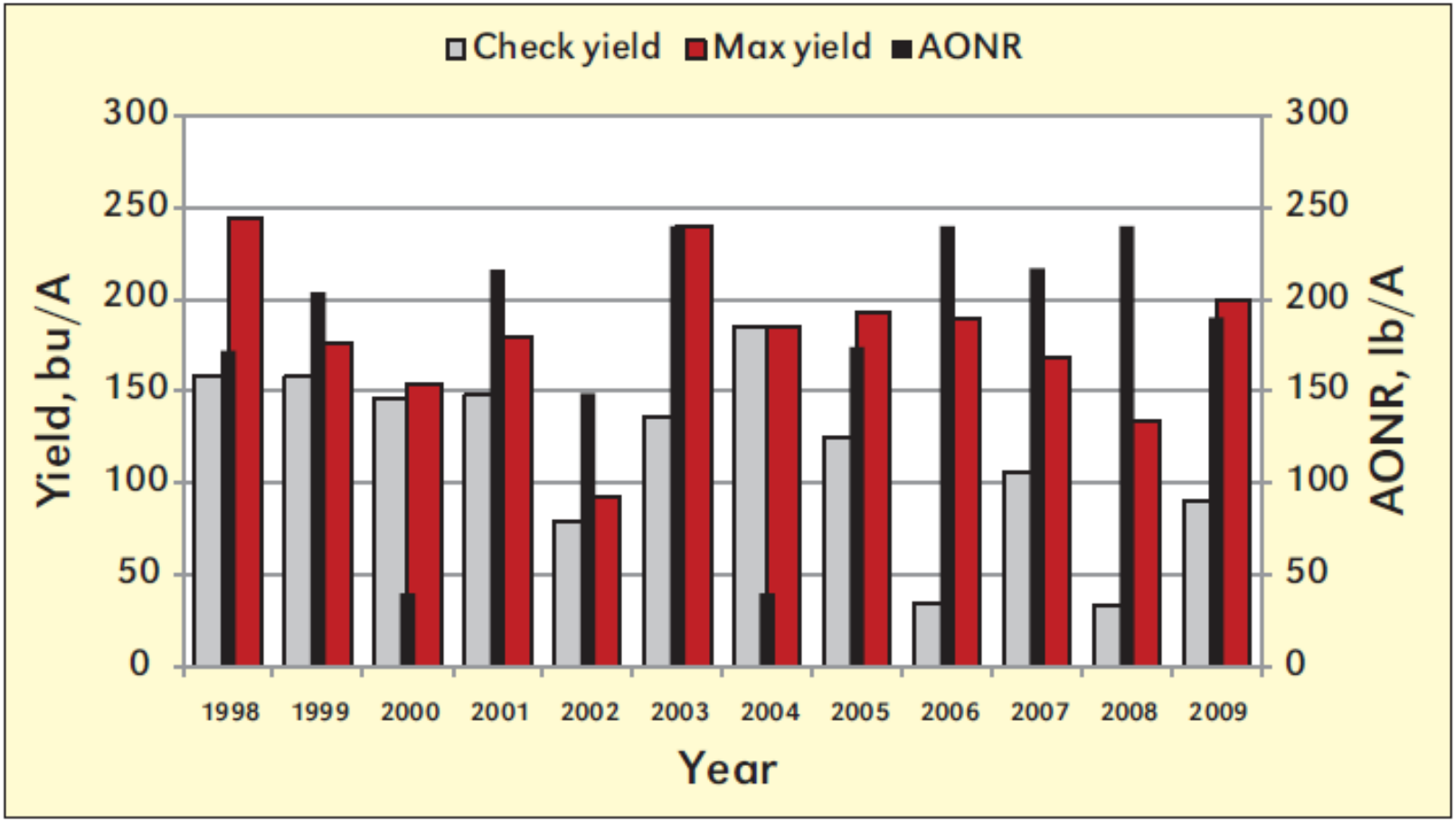



van Es et al., 2002

****Losses increase once crop demand is satisfied****

# How Can We Precisely Estimate Seasonal Corn N Fertilizer Needs?

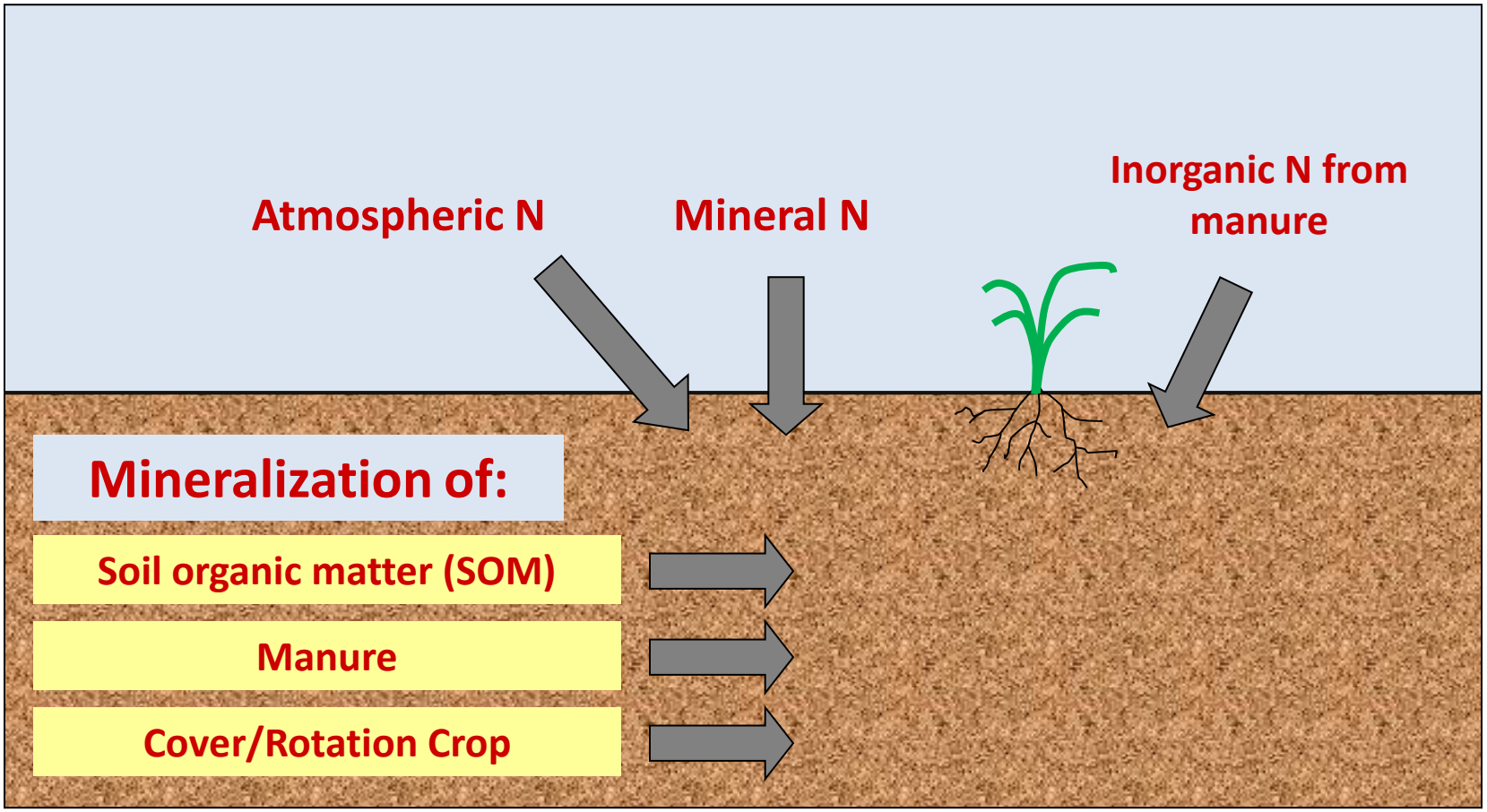
## Maximum and Check Yields, and Agronomic Optimum N Rate (corn after soybean, Ohio)




From: Mullen, LaBarge and Diedrick, 2010, Better Crops, Vol. 94 (3).

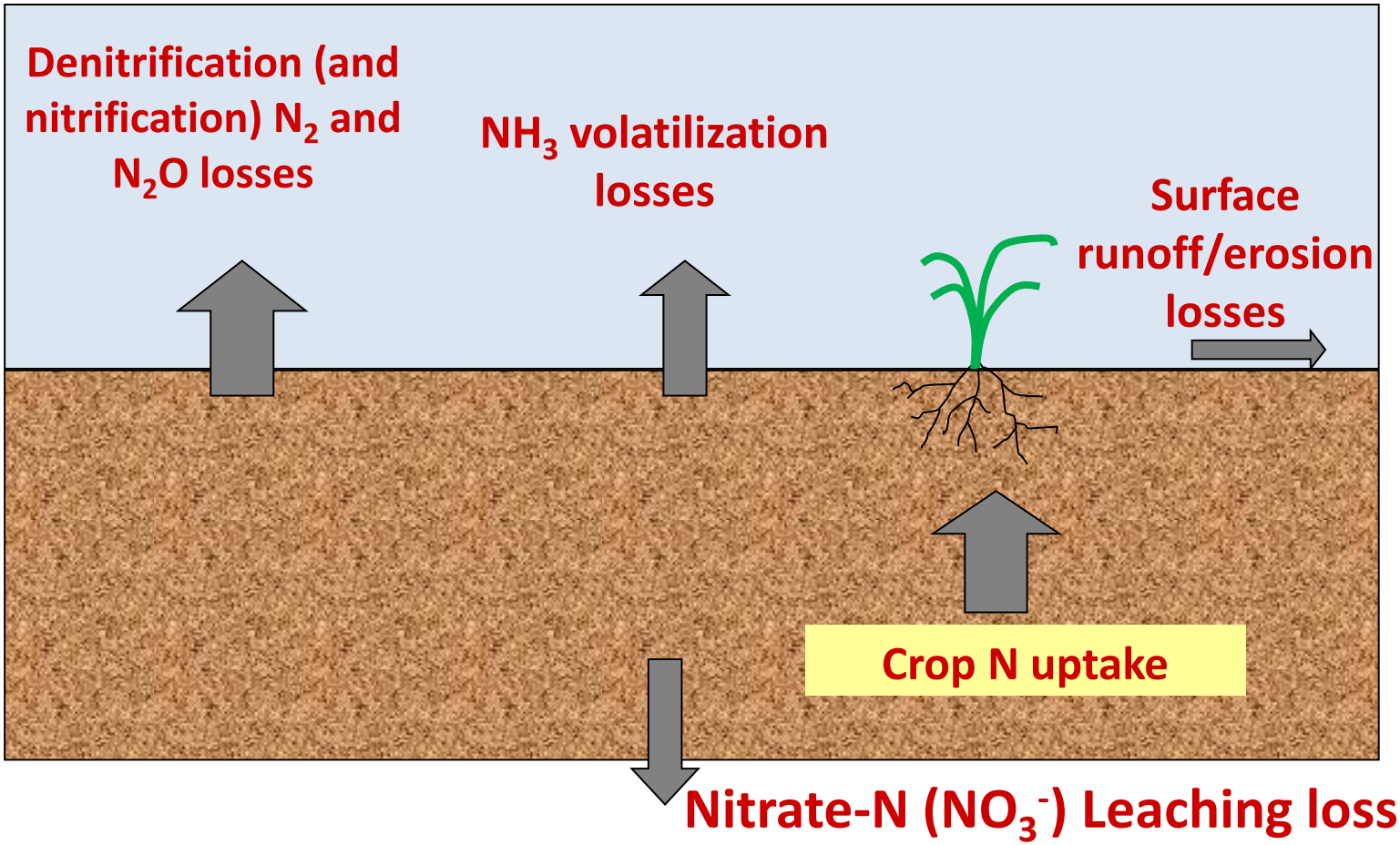
# Nitrogen Dynamics and Sources of Variability

# Sources of Soil N




→ influenced by management, soil quality **and weather**

# Pathways for N losses




→ influenced by management, soil quality **and weather**

# Soil Quality → Soil Change

## Divergence: e.g. Grain vs. Livestock on similar soil

http://soilhealth.cals.cornell.edu/

**CORNELL SOIL HEALTH TEST REPORT (COMPREHENSIVE)**

Cash Grain Farm 2009
Central NY, Lima silt loam
Corn for grain for 10+ years
7-9" plow depth

| | Indicators | Value | Rating | Constraint |
|---|---|---|---|---|
| PHYSICAL | Aggregate Stability (%) | 53 | 83 | |
| | Available Water Capacity (m/m) | 0.10 | 12 | water retention |
| | Surface Hardness (psi) | 70 | 89 | |
| | Subsurface Hardness (psi) | 420 | 9 | Subsurface Pan/Deep Compaction |
| BIOLOGICAL | Organic Matter (%) | 2.6 | 25 | energy storage, C sequestration, water retention |
| | Active Carbon (ppm) [Permanganate Oxidizable] | 460 | 21 | Soil Biological Activity |
| | Potentially Mineralizable Nitrogen (µgN/ gdwsoil/week) | 6.2 | 1 | N Supply Capacity |
| | Root Health Rating (1-9) | 3.5 | 75 | |
| CHEMICAL | *pH | 7.9 | 0 | Toxicity, Nutrient Availability (for crop specific guide, see CNAL report) |
| | *Extractable Phosphorus (ppm) [Value <3.5 or >21.5 are downscored] | 6.0 | 100 | |
| | *Extractable Potassium (ppm) | 50 | 72 | |
| | *Minor Elements | | 56 | |
| OVERALL QUALITY SCORE (OUT OF 100): | | | 45.2 | Low |

*Measured Soil Textural Class:==> silt loam*
*SAND (%): 40.1* *SILT (%): 51.9* *CLAY (%): 8.0*

**CORNELL SOIL HEALTH TEST REPORT (COMPREHENSIVE)**

Dairy Farm 2009
Volusia silt loam
Grass hay until 2007, Corn silage 2008/ 09
7-9" plow depth
20 Tons/ A/ year manure

| | Indicators | Value | Rating | Constraint |
|---|---|---|---|---|
| PHYSICAL | Aggregate Stability (%) | 78 | 99 | |
| | Available Water Capacity (m/m) | 0.26 | 97 | |
| | Surface Hardness (psi) | 239 | 22 | rooting, water transmission |
| | Subsurface Hardness (psi) | 350 | 27 | Subsurface Pan/Deep Compaction |
| BIOLOGICAL | Organic Matter (%) | 6.1 | 98 | |
| | Active Carbon (ppm) [Permanganate Oxidizable] | 815 | 86 | |
| | Potentially Mineralizable Nitrogen (µgN/ gdwsoil/week) | 22.9 | 100 | |
| | Root Health Rating (1-9) | 5.2 | 50 | |
| CHEMICAL | *pH | 6.7 | 100 | |
| | *Extractable Phosphorus (ppm) [Value <3.5 or >21.5 are downscored] | 19.5 | 100 | |
| | *Extractable Potassium (ppm) | 228 | 100 | |
| | *Minor Elements | | 100 | |
| OVERALL QUALITY SCORE (OUT OF 100): | | | 81.5 | High |

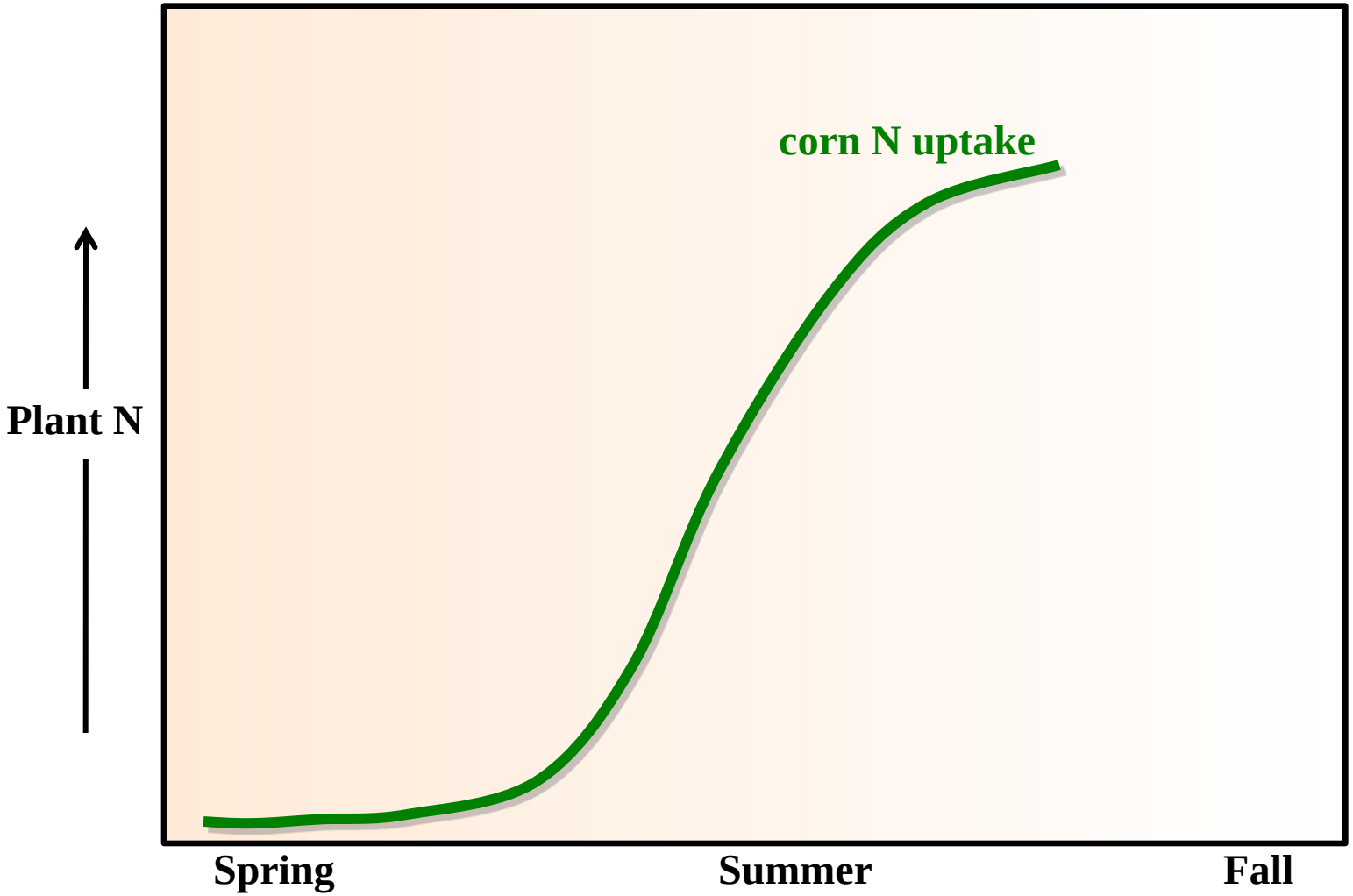
*Measured Soil Textural Class:==> silt loam*
*SAND (%): 24.3* *SILT (%): 69.2* *CLAY (%): 6.4*

# How Does Weather Generally Affect Optimum N Rate for Corn?

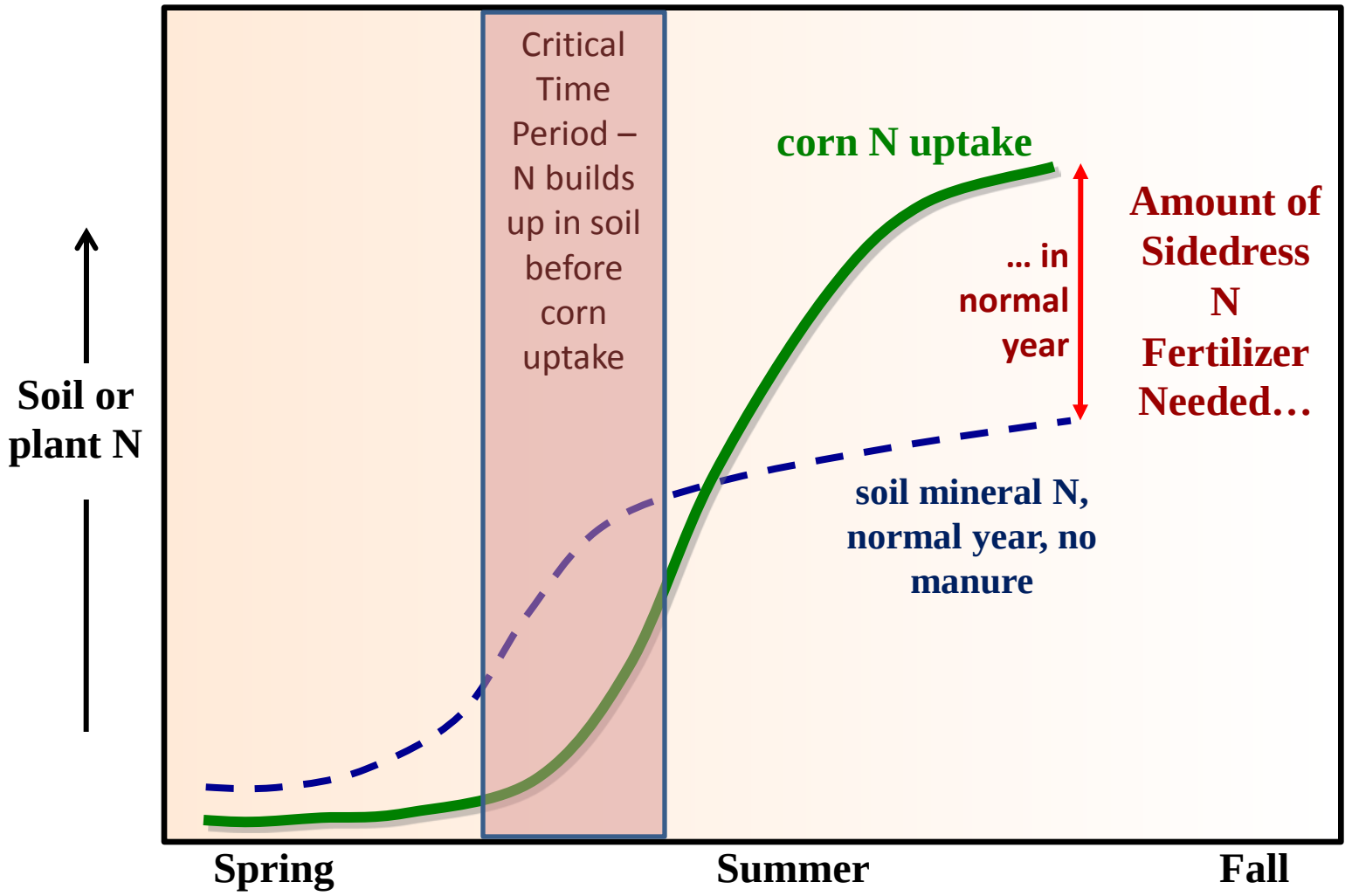
- Early season:
  - Excessive precipitation causes soil N losses through leaching and denitrification (when soil T is high), resulting in higher supplemental N fertilizer needs, and increased pollution
  - manageable
- Mid-Late Season:
  - Leaching and denitrification losses are minimal
  - Droughts cause unattained yield potential, reducing N fertilizer uptake
  - not manageable

Photos from ISU Extension Publ. No. 48

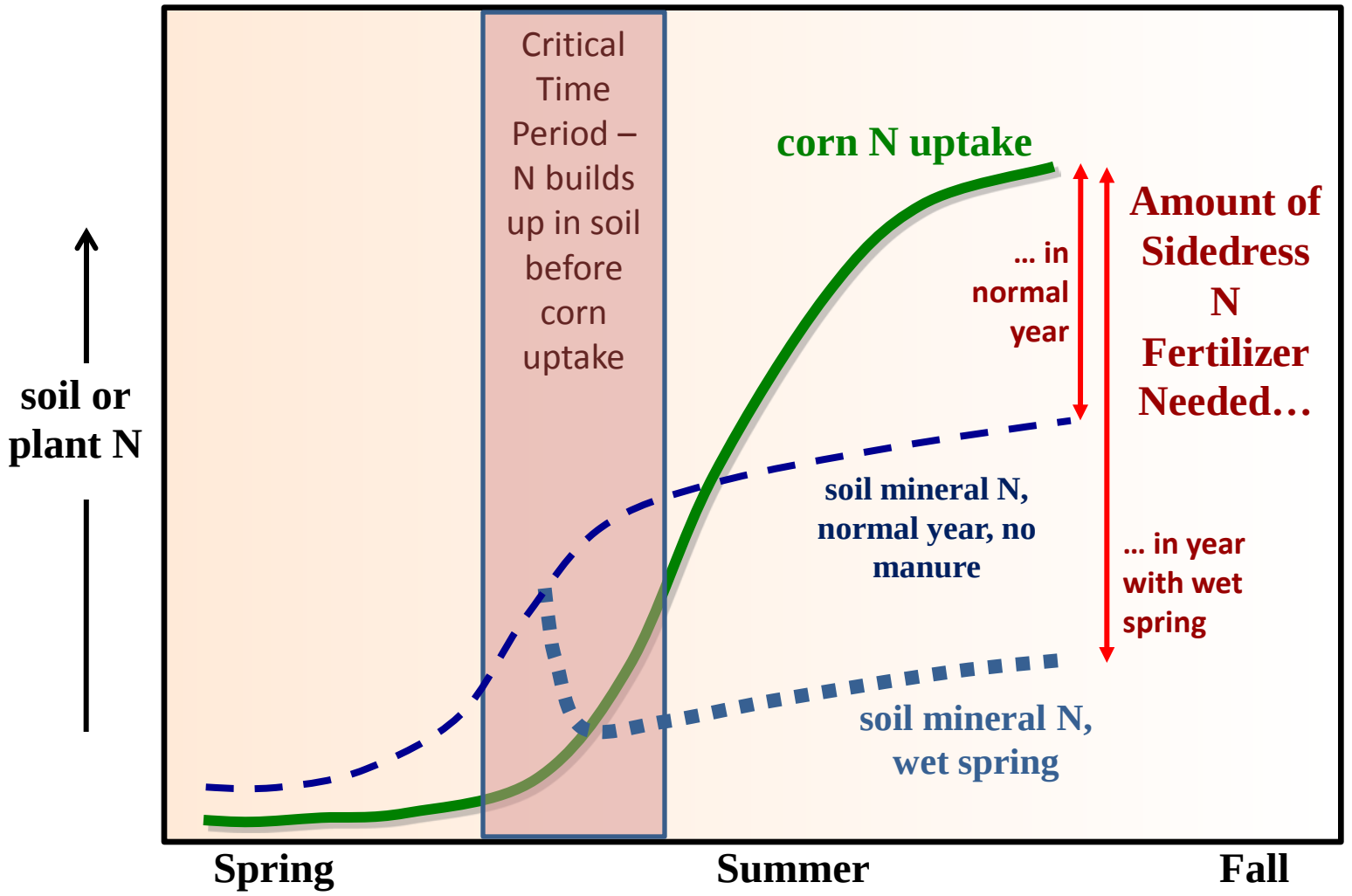
# *Crop N uptake …*



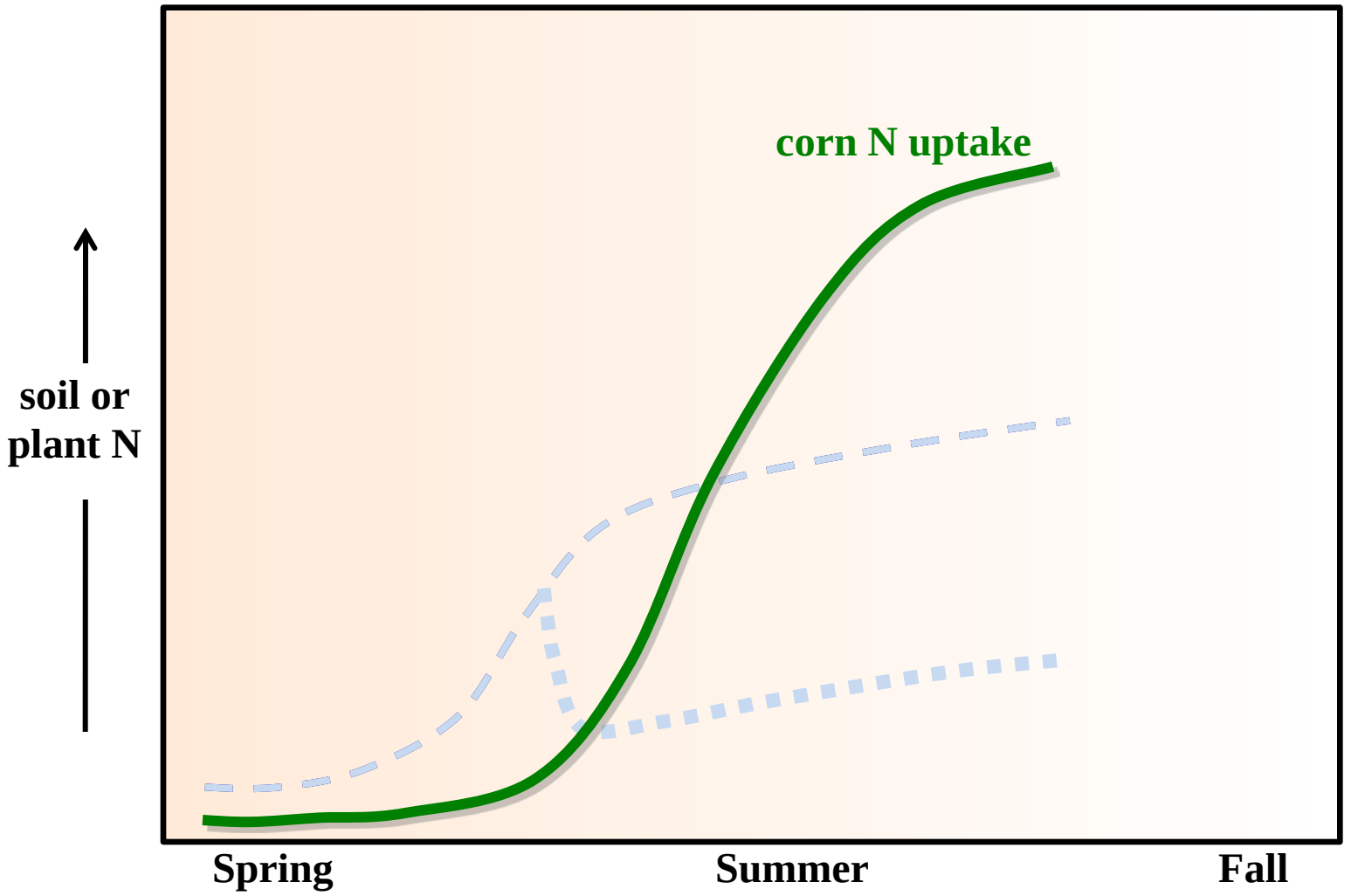
# *SOM mineralization occurs ahead of corn N uptake…*



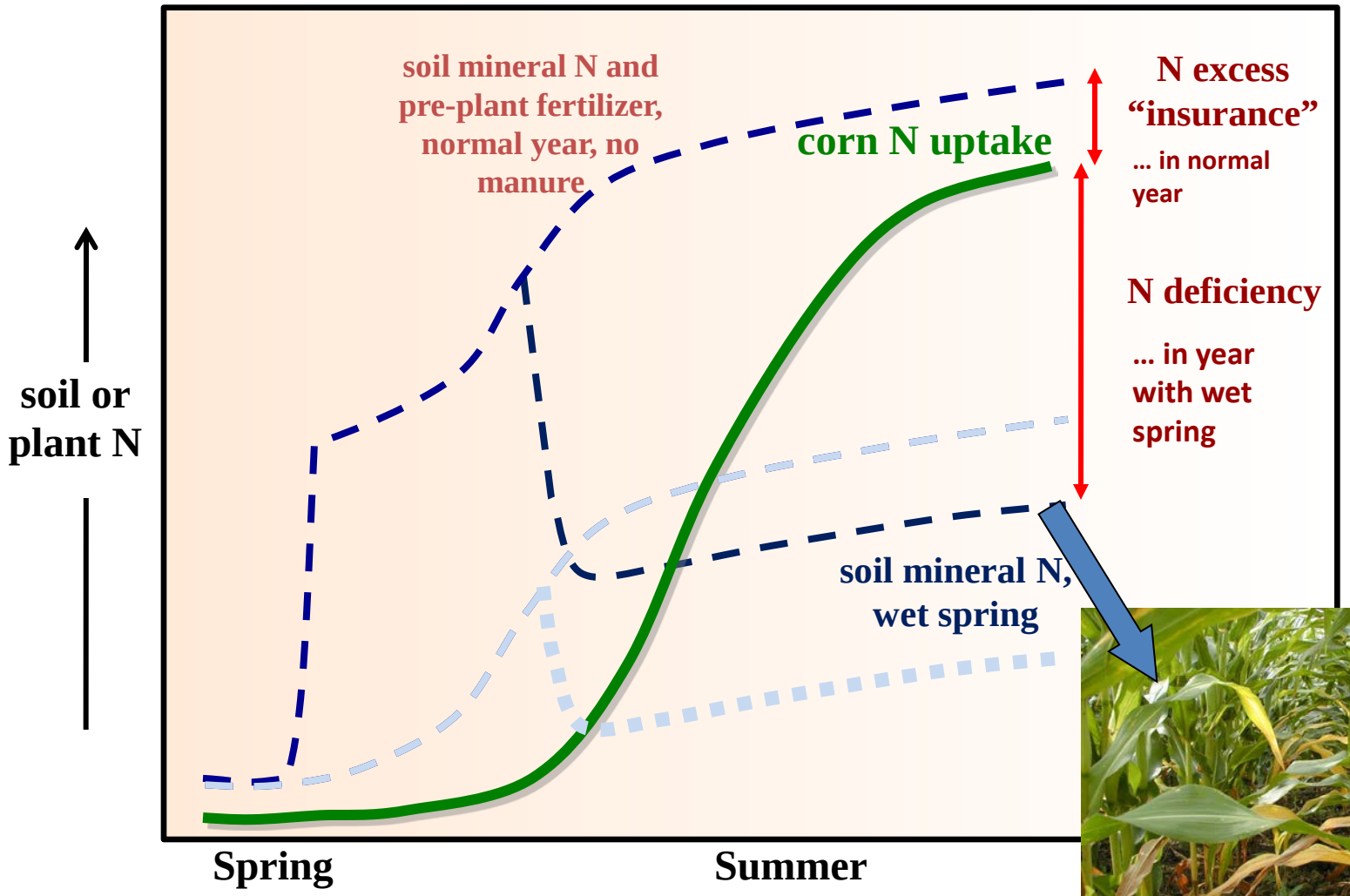
# *Need for supplemental N fertilizer depends on early season weather …*



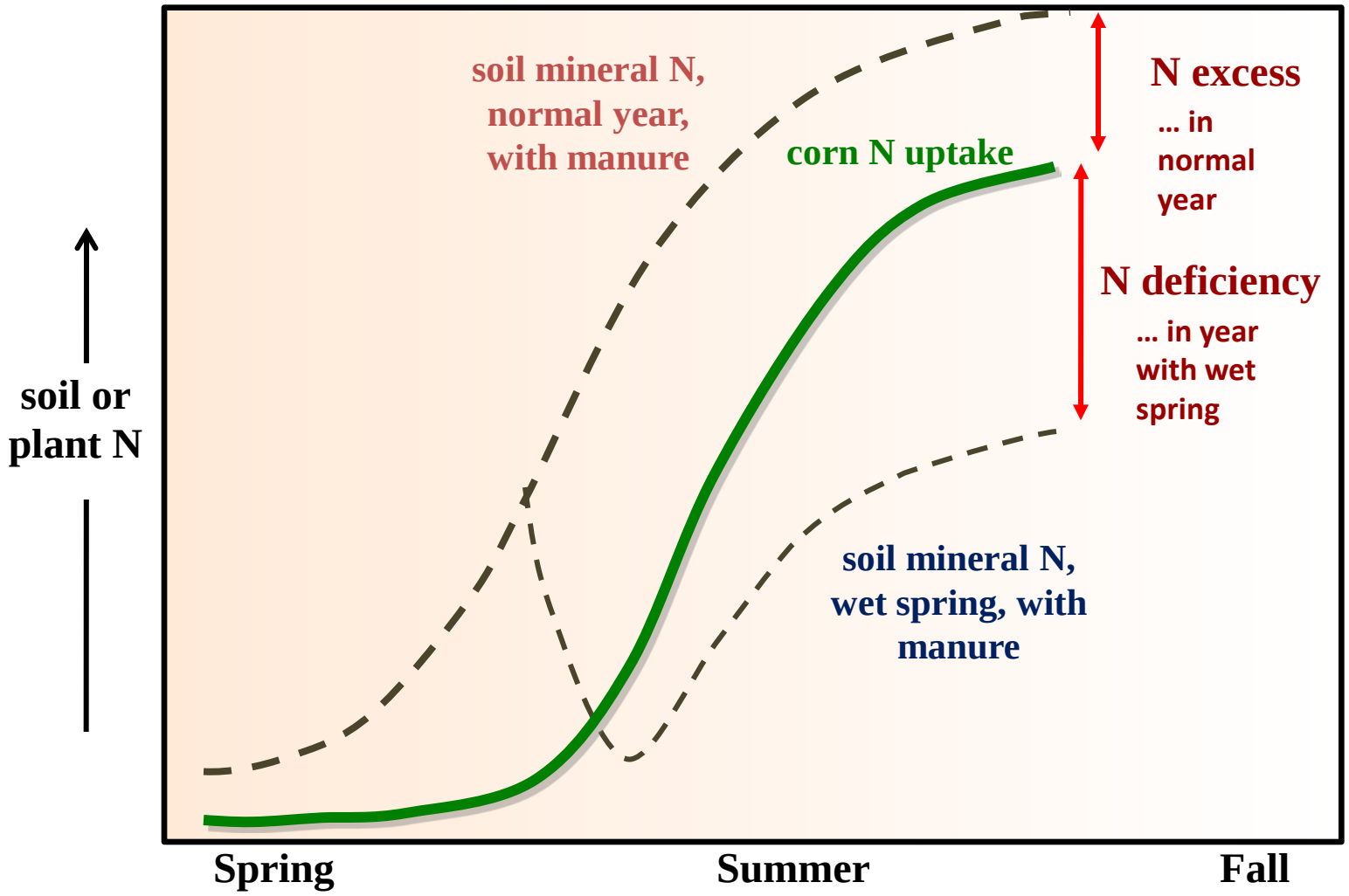
# *Pre-plant application of N risks major losses*



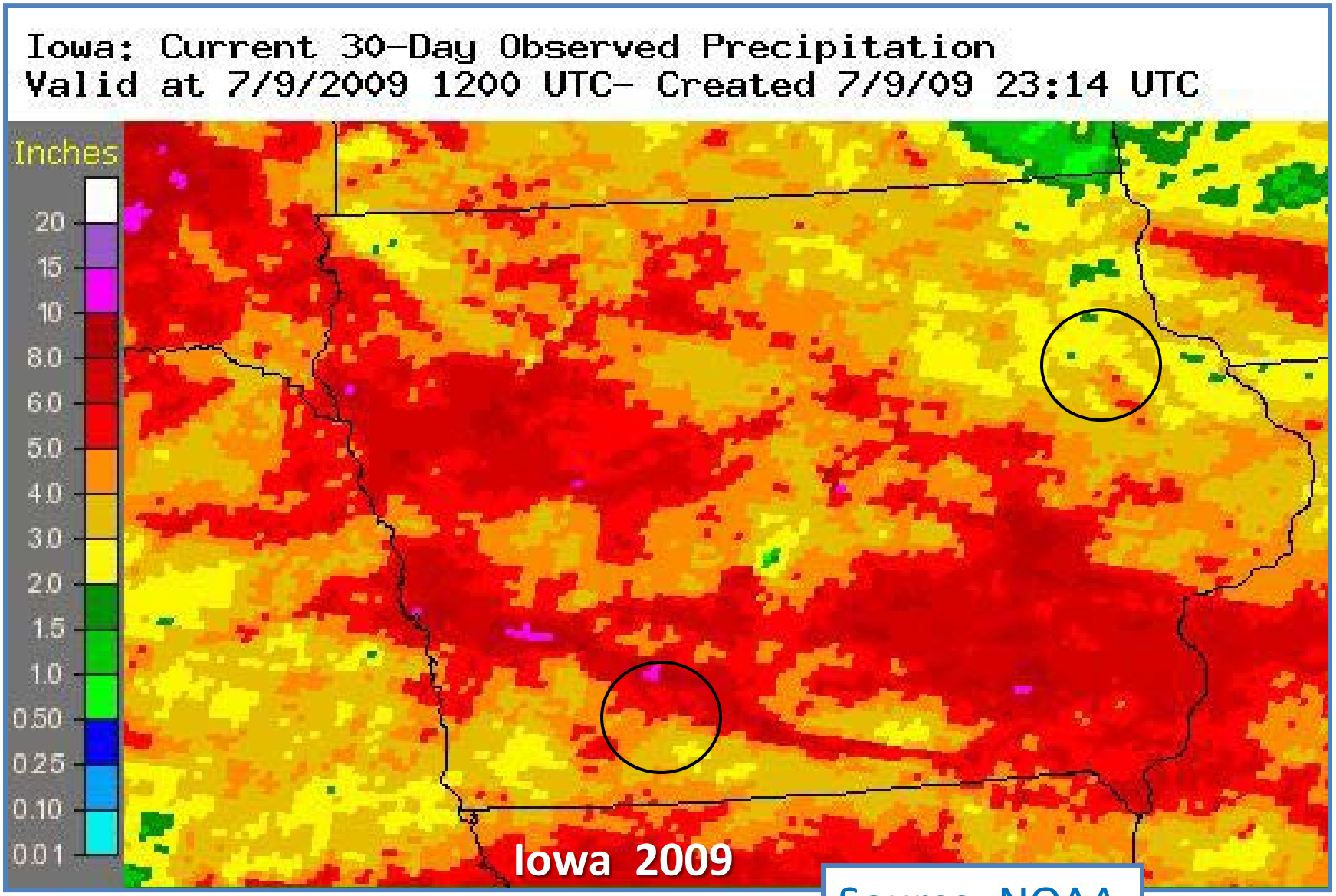
# *Pre-plant application of N risks major losses*




# *High-N Scenario: Soil N mineralizes from SOM and Manure/Cover Crop/Sod Rotation*

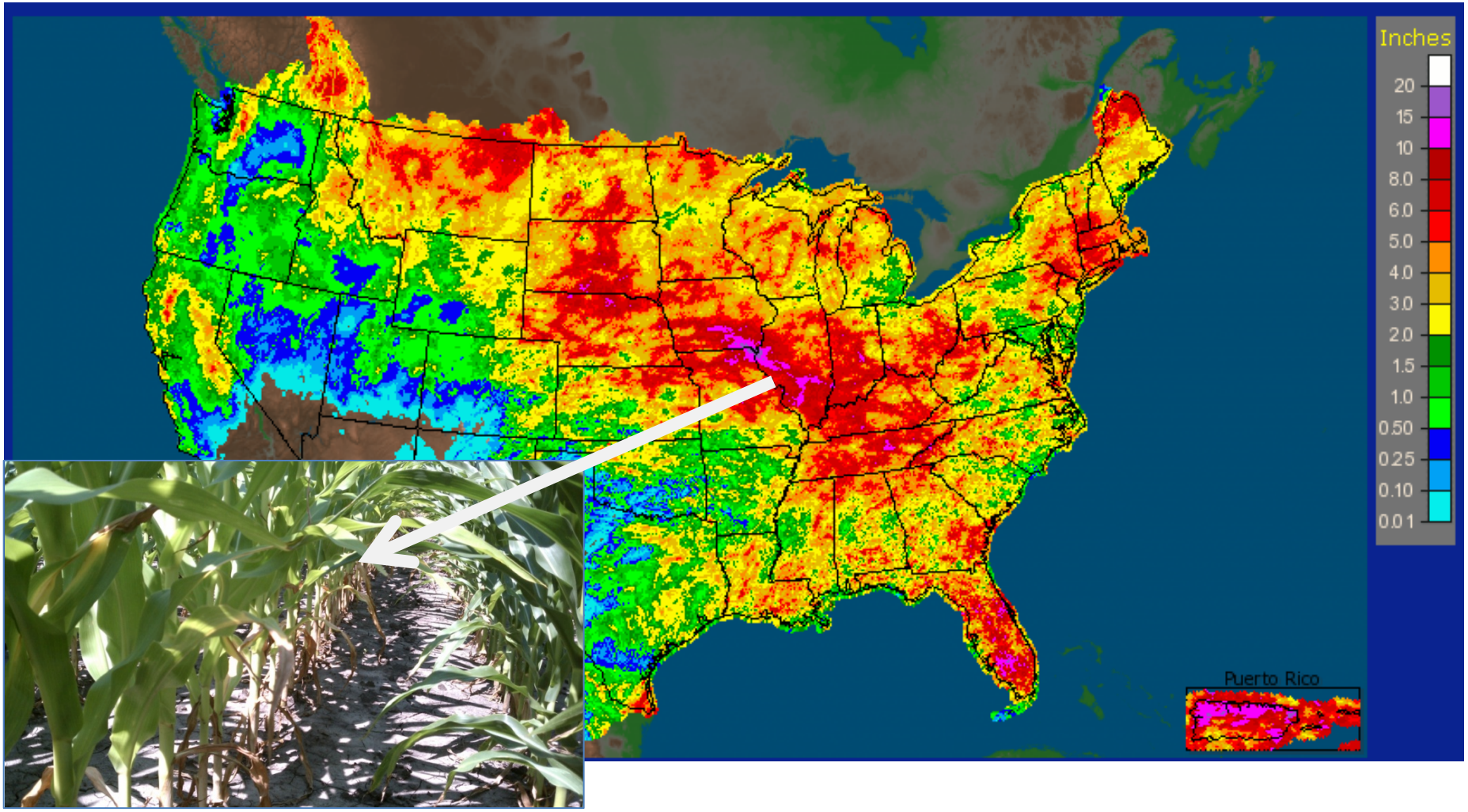


# Late Spring Precipitation Variability




Source: NOAA

# CONUS Precipitation
# June 1-30, 2011



# Climate Change Adaptation and Mitigation

## Using Adaptive N Management

- ***Adaptation:*** incorporating weather effects in N rate calculations
  - Maintains yields in wet years by accounting for losses
  - Allows for decreased fertilizer/manure N inputs in normal and dry years
- ***Mitigation:*** Better timing of N application and better matching of N inputs to crop needs
  - Decreased denitrification losses (lower $N_2O$ emissions)
  - Lower energy use (lower $CO_2$ emissions)

# Multiple sources of variation in N availability - 1

- Soil type differences
- Soil organic matter contents (management-induced soil change)
- Recent organic amendments (manure, compost, etc.)
- Crop rotations and cover crops
- Fertilizer Application
  - Type (ammonia – urea – nitrate forms)
  - Application timing (fall, at planting, sidedress)
  - Enhanced efficiency technology
    - Nitrification Inhibitors
    - Urease Inhibitors
    - Slow or Controlled Release

# Multiple sources of variation in N availability - 2

- Early season weather (warm vs. cool; wet vs. dry)

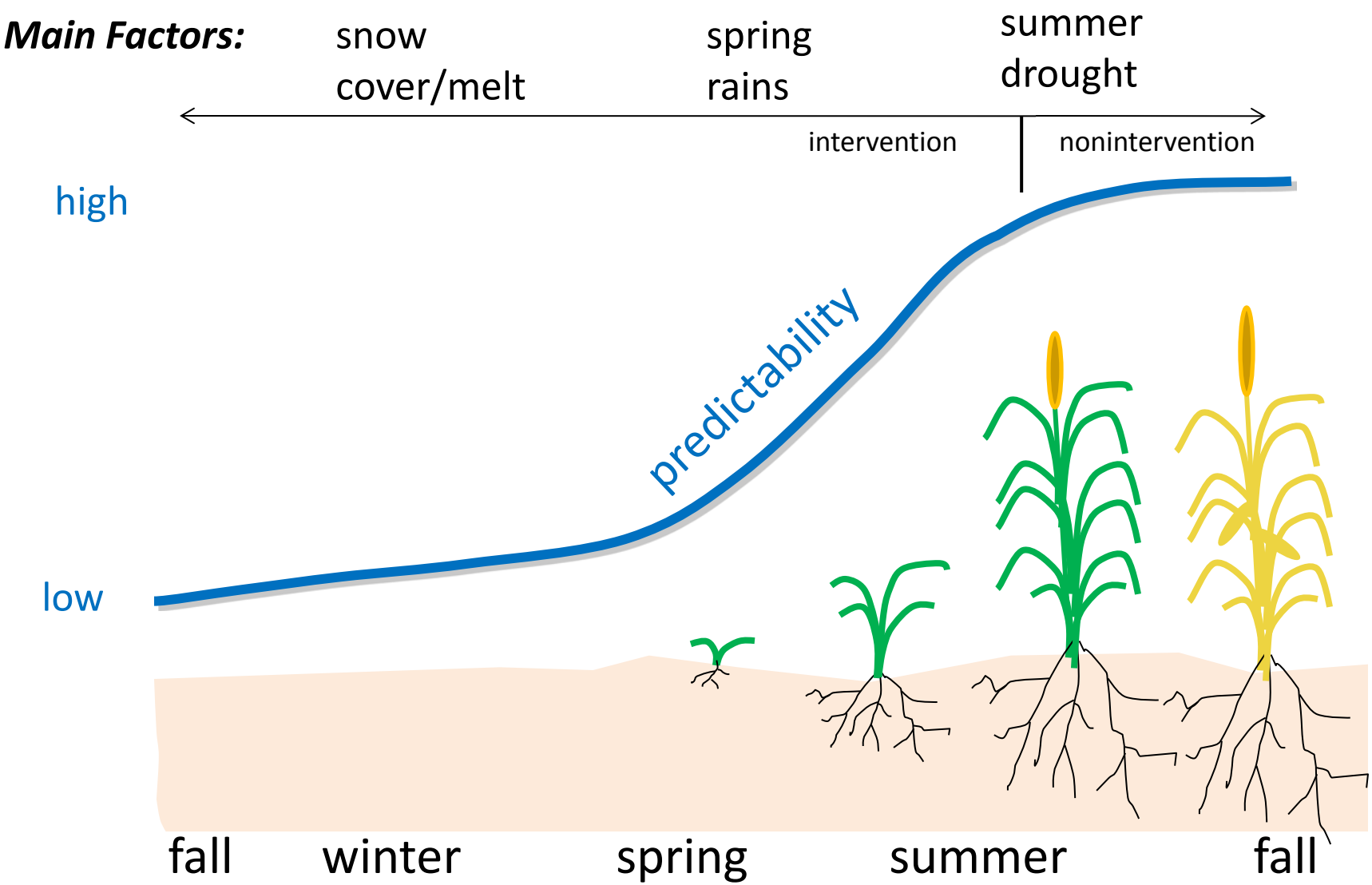
  → *Interactions can be managed in-season*

- Late season weather (warm vs. cool; wet vs. dry)

  → <u>not easily managed</u>

**→ Corn N needs CANNOT be accurately predicted at the beginning of the growing season**

# Predicting N Needs for Corn: Precision for Different Times of Application



# Equipment is Critical:

## High-Clearance Provides Greater Sidedress Flexibility


# Tools for Adaptive N Management

# Tools to guide Adaptive N Management in Corn

Pre-season: Potential N availability

In-season: N availability / needs, incorporating early-season weather effects on mineralization and losses

End-of-Season: Hindsight evaluation

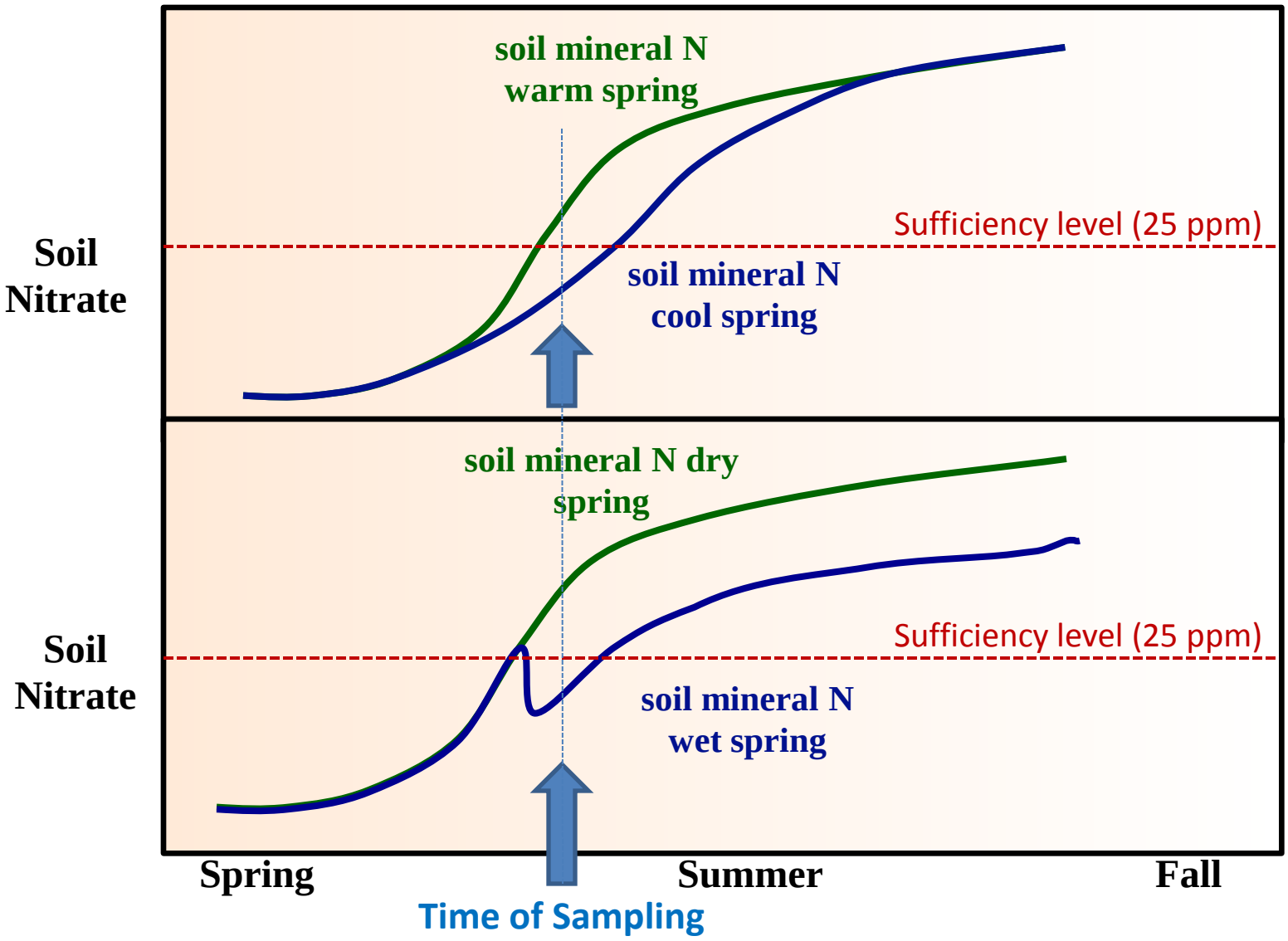
# Evaluating Crop N Needs: In-Season Tests

| Test | Pros | Cons |
|---|---|---|
| In-Season Tests: | | |
| Soil<br>PSNT/LSNT | Incorporates OM mineralization & spring weather effects, reasonably accurate in sufficiency scenarios | Imprecise without weather interpretation in deficiency scenarios, costly due to special sampling. |
| Crop<br>Chlorophyll Meters, Leaf/Canopy Sensing | Incorporates effects of OM mineralization, spatial variability & spring weather | Needs reference strips, not yet well validated for corn, high upfront cost for all but CM, a-priori unknown for on-the-go |
| Computer<br>(crop and soil)<br>Adapt-N Model | Incorporates SOM & weather dynamics after critical period has passed, low cost | Requires paradigm shift: models as a tool for N management, not yet well validated |

All incorporate OM mineralization and spring weather effects during the critical period, and thus provide basis for in-season adaptation.

# PSNT – LSNT:

## Impacts of Weather Scenarios



# Evaluating Crop N Needs: In-Season Tests

| Test | Pros | Cons |
|---|---|---|
| In-Season Tests: | | |
| Soil<br>PSNT/LSNT | Incorporates OM mineralization & spring weather effects, reasonably accurate in sufficiency scenarios | Imprecise without weather interpretation in deficiency scenarios, costly due to special sampling. |
| Crop<br>Chlorophyll Meters, Leaf/Canopy Sensing | Incorporates effects of OM mineralization, spatial variability & spring weather | Needs reference strips, not yet well validated for corn, high upfront cost for all but CM, a-priori unknown for on-the-go |
| Computer<br>(crop and soil)<br>Adapt-N Model | Incorporates SOM & weather dynamics after critical period has passed, low cost | Requires paradigm shift: models as a tool for N management, not yet well validated |

All incorporate OM mineralization and spring weather effects during the critical period, and thus provide basis for in-season adaptation.

# Chlorophyll Meters

Table 1. Relative SPAD chlorophyll meter (RCM) value and in-season N application rate.

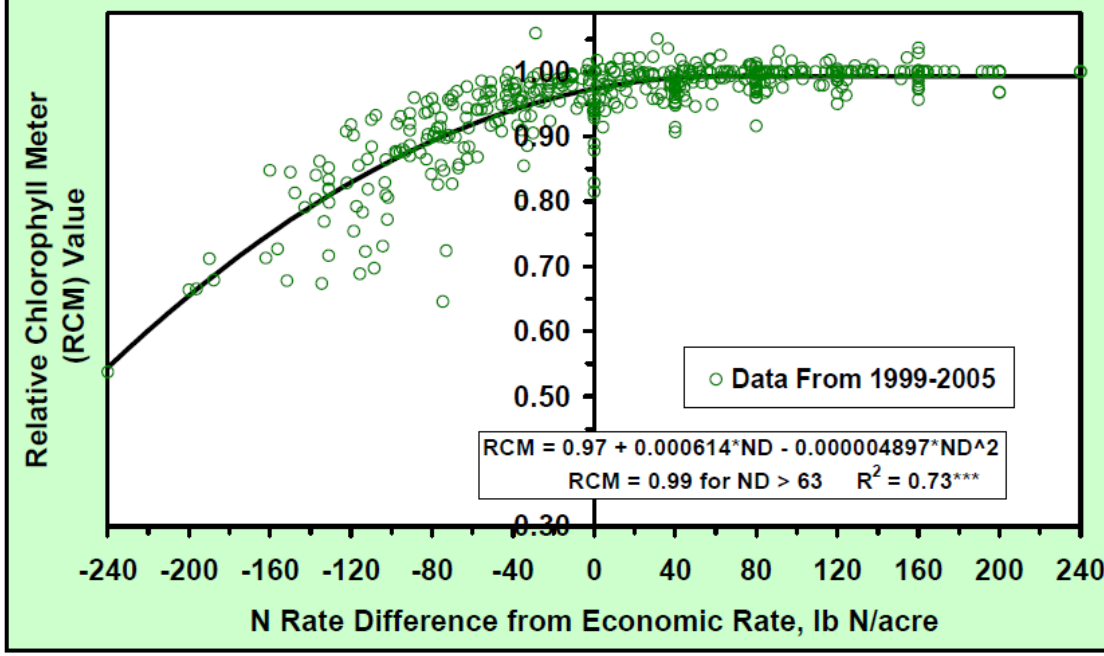
| Relative CM Value† | N Rate to Apply‡ |
|---|---|
| RCM | lb N/acre |
| < 0.88 | 100 |
| 0.88 - 0.92 | 80 |
| 0.92 - 0.95 | 60 |
| 0.95 - 0.97 | 30 |
| > 0.97 | 0 |

† Readings taken from V10 to VT corn growth stages.

‡ Suggested N rate limited to a maximum of 100 lb N/acre.

From: Sawyer et al., 2006
Iowa State University

Figure 1. Relative SPAD chlorophyll meter (RCM) value versus N rate difference from economic optimum rate, R1 corn growth stage.



# Canopy Spectral Sensing

## Passive → Active

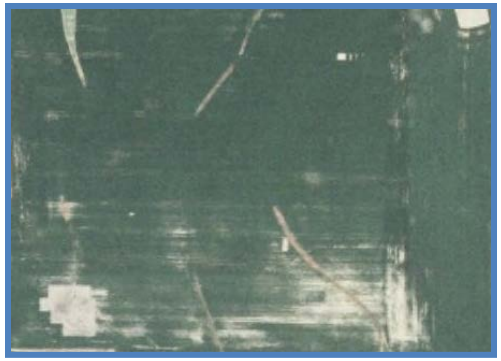

Photo by Holland Scientific.

Photo by AgLeader




Photo by P. Kyveryga, Iowa Soybean Assn.

# Canopy Spectral Reflectance Sensing



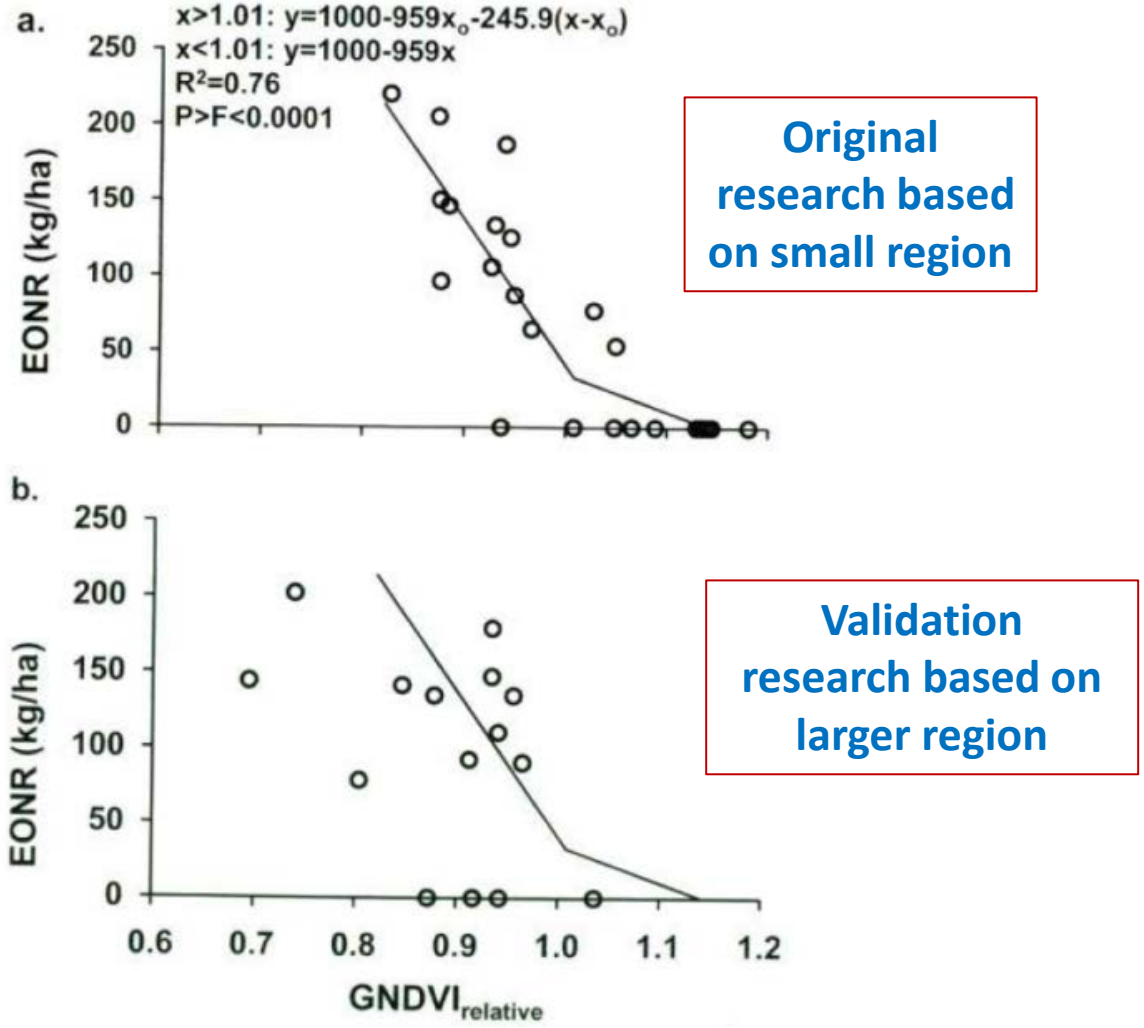
Strengths:

- Incorporates early-season effects of mineralization and weather by assessing N needs after critical time period has passed
- Incorporates spatial variability
  → high opportunity to evaluate localized N needs, especially important in wet years
- Use with high-clearance application equipment; on-the-go, no turnaround time
- Potential for further development of technology

Weaknesses:

- High upfront equipment cost
- Reference strips needed (presumably, not with OptRx)
- For on-the-go application, amount of N needed is *a-priori* unknown (trip across field even if no N is needed)
- Low prediction accuracy at this time
- No universal predictive equations available; independent validations often weak

# Economic Optimum N Rate and Green Normalized Difference Vegetation Index PA Research




**Original research based on small region**

**Validation research based on larger region**

Schmidt, J., R. Sripada, D. Beegle, and A. Dellinger. 2009. Using an active sensor to make in-season recommendations for corn. Precision Agriculture 09: 71-79.

# Evaluating Crop N Needs: In-Season Tests

| Test | Pros | Cons |
|---|---|---|
| In-Season Tests: | | |
| Soil<br>PSNT/LSNT | Incorporates OM mineralization & spring weather effects, reasonably accurate in sufficiency scenarios | Imprecise without weather interpretation in deficiency scenarios, costly due to special sampling. |
| Crop<br>Chlorophyll Meters, Leaf/Canopy Sensing | Incorporates effects of OM mineralization, spatial variability & spring weather | Needs reference strips, not yet well validated for corn, high upfront cost for all but CM, a-priori unknown for on-the-go |
| Computer<br>(crop and soil)<br>Adapt-N Model | Incorporates SOM & weather dynamics after critical period has passed, low cost | Requires paradigm shift: models as a tool for N management, not yet well validated |

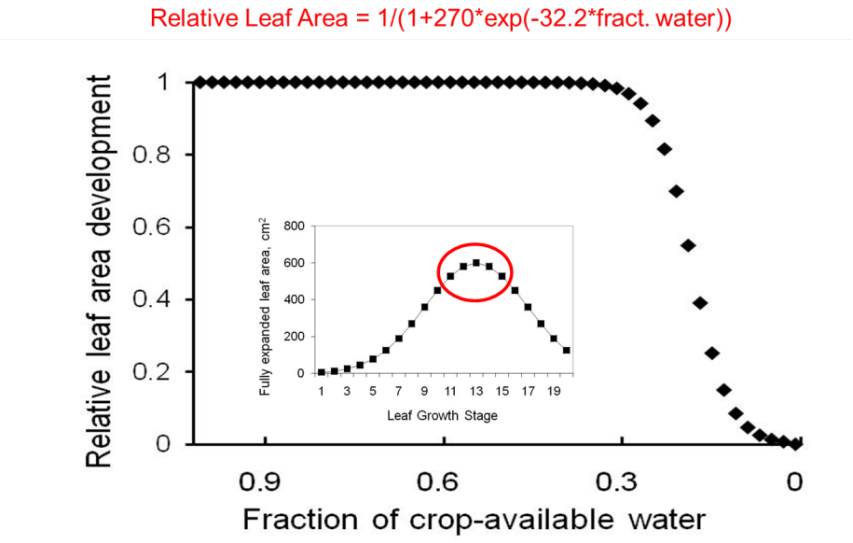
All incorporate OM mineralization and spring weather effects during the critical period, and thus provide basis for in-season adaptation.

# *Adapt-N:*

## *A Tool for Adaptive Nitrogen Management in Corn*

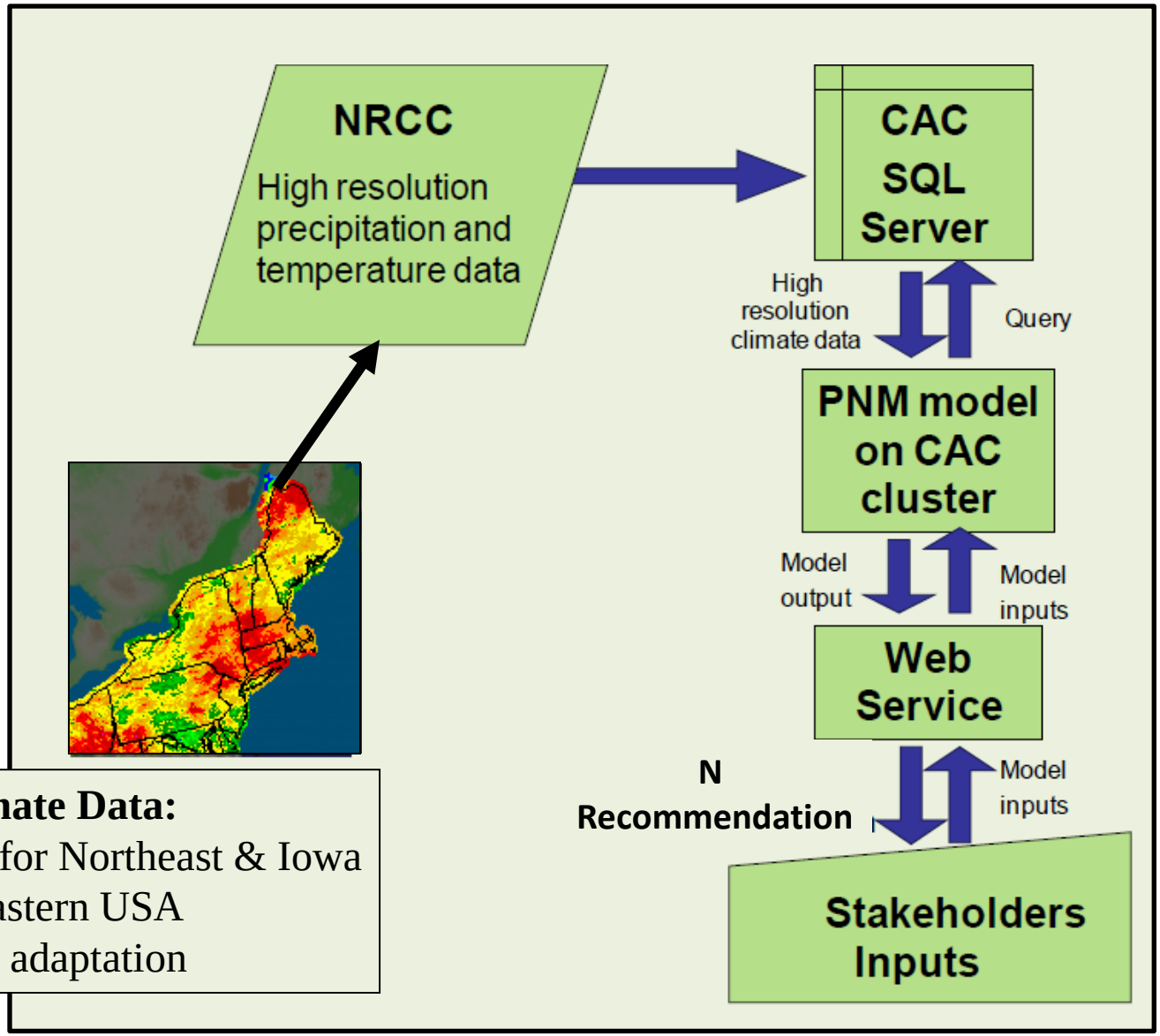
# Nitrogen Management with Computational Tools

- Move from generalized to site-specific recommendations
- Allows for Adaptive, Real-Time Management
  - Weather conditions
  - Local soils and crop management
- Universal process-based approach
  - Incorporates system complexity through relevant processes
- Low cost
- Allows for progressive refinement



# *Infrastructure for Adapt-N: web-based N Decision Tool*

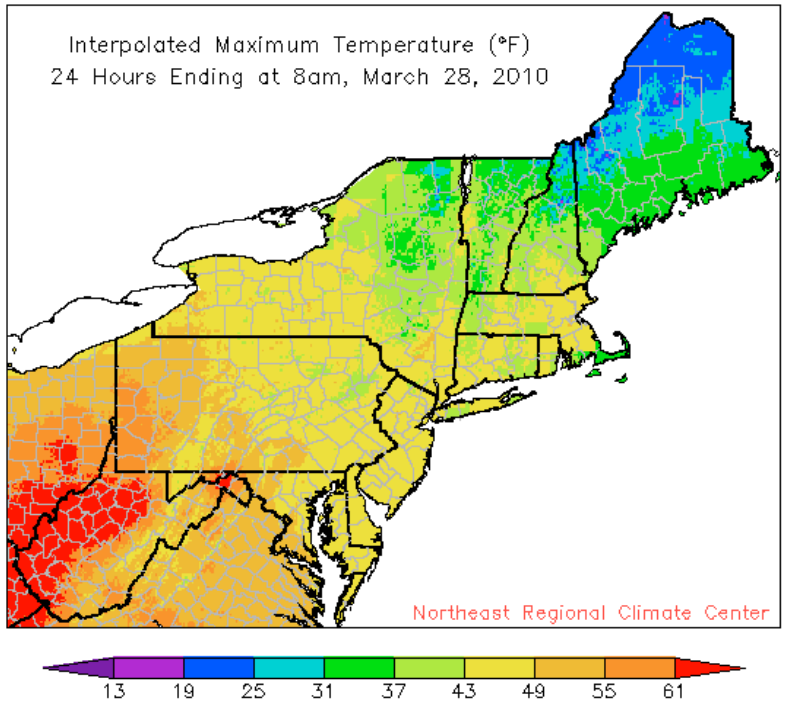
**http://adapt-n.cals.cornell.edu/**




**High Resolution Climate Data:**

- Currently available for Northeast & Iowa
- Expanding to the Eastern USA
- Enables Field-Scale adaptation

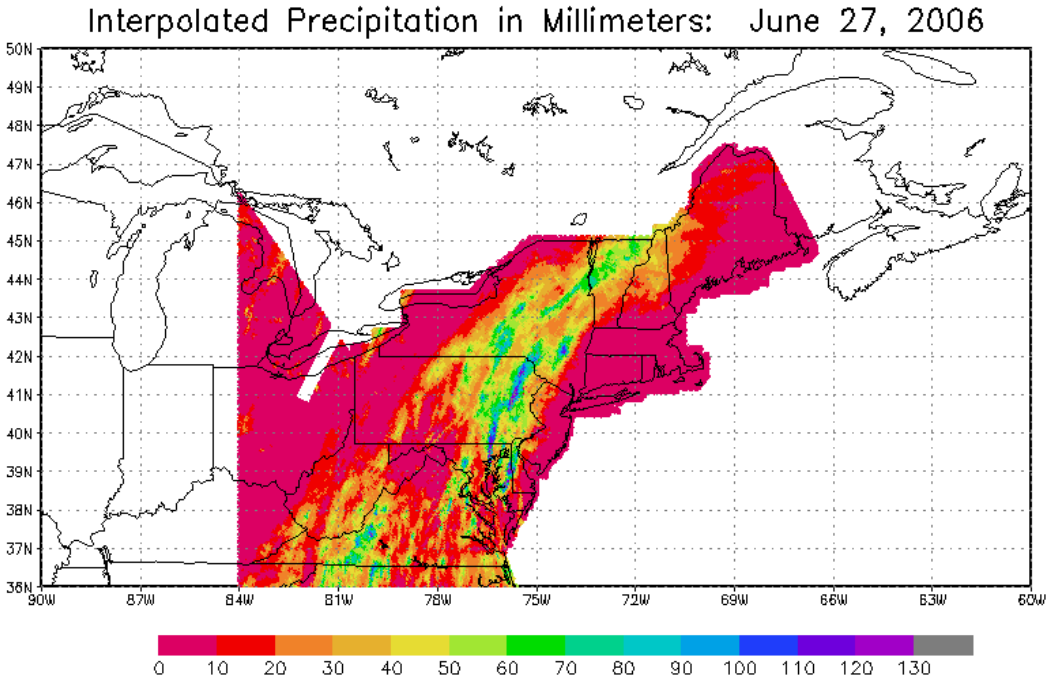
# Adapt-N Input:
# High Resolution Climate Data




Temperature: Elevation-Corrected Interpolations from weather stations

**4X4 km**

Precipitation: Error-Corrected Daily Radar Estimates




DeGaetano, A.T. & Wilks, D.S. (2008) Radar-guided interpolation of climatological precipitation data. International Journal of Climatology 29:185-196.

# PNM model: The core of the *Adapt-N* tool

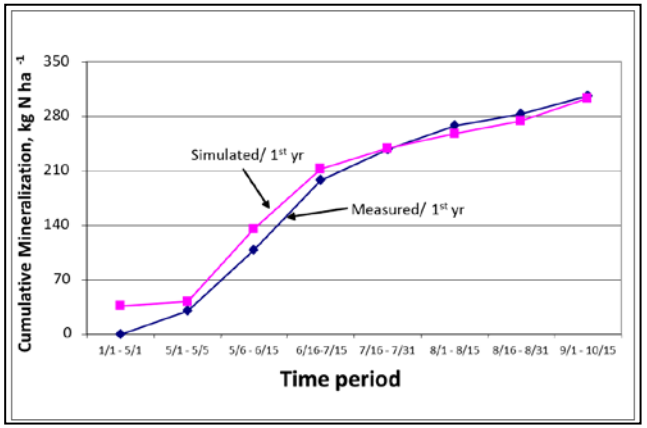
New model based on the linkage of two simulation models:

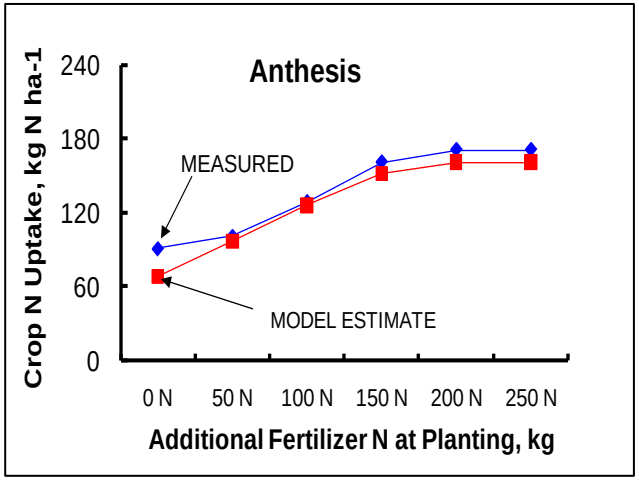
- Soil processes model, LEACHN

  Hutson et al., 2003

- Crop growth/N uptake model

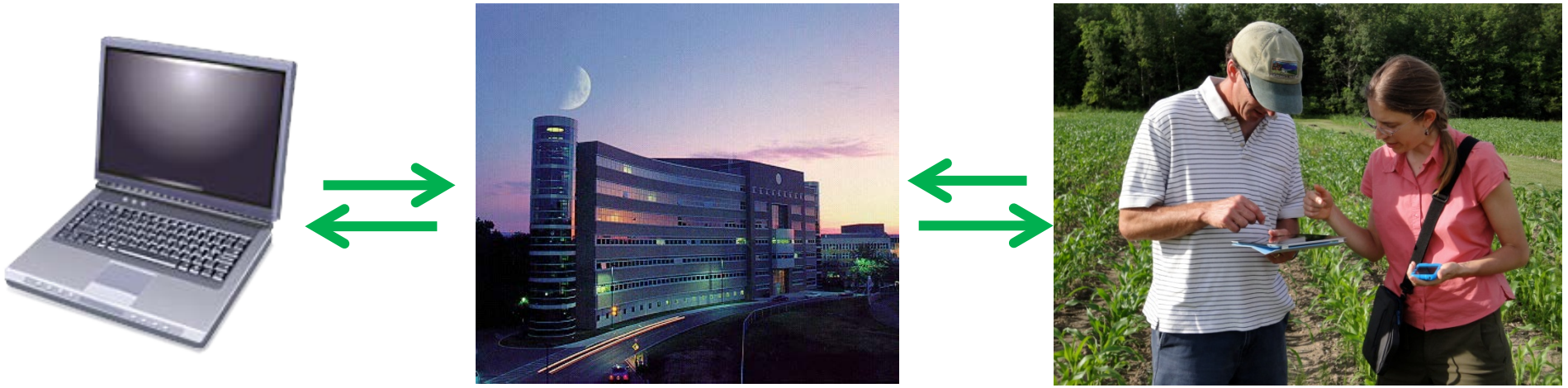
  Sinclair and Muchow, 1995



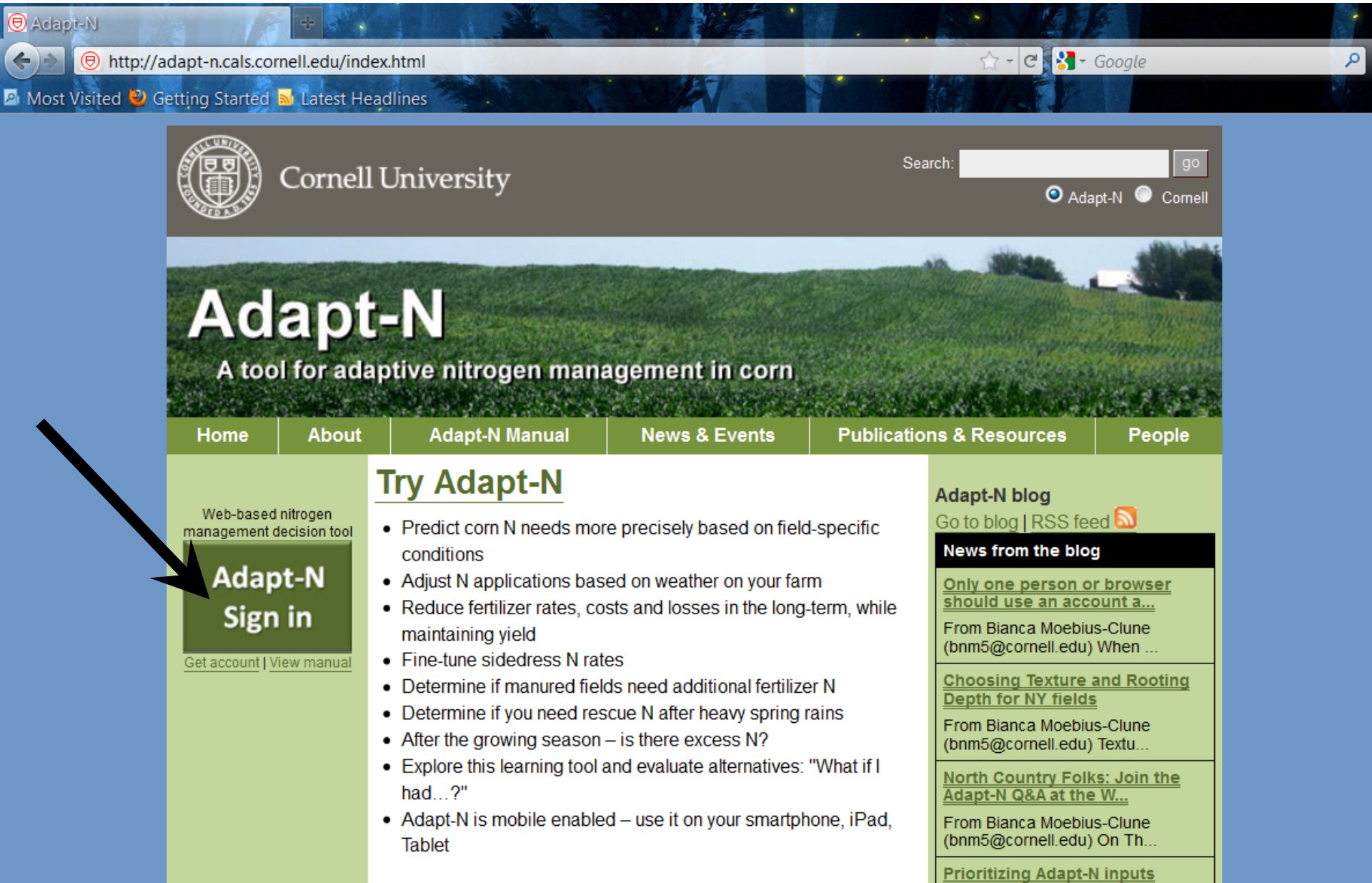



# “Cloud” Computing Model

- Server-based, with universal access through Web
  - Anywhere with internet access
  - Many platforms and operating systems (incl. tablets and phones)
- No software exchange with users, nor installation
- Easy and rapid updates
  - Databases
  - software
- Centralized processing and records



# Simply Log In On Our Website at:
# *adapt-n.cals.cornell.edu*



# Adapt-N Interface: entering Mineral N/Cultivar info

Login | Mineral Nitrogen/Cultivar | Soil/Tillage | Manure/Sod/Soybean | Add Application | Results | Manage Locations

Adapt-N Home

**Region** Northeast

**Nitrogen Fertilizer Applications for this Growing Season**

| Application | Name | lbs N/acre | Placement Depth | Date | Delete Button |
|---|---|---|---|---|---|
| starter (fertilizer banded with seed} | ammonium nitrate | 30 | 3.0 | n/a | Delete |

*You may enter one starter and up to four preplant/sidedress applications.* Select Fertilizer Application

**Crop Information**

Field Corn | Grains: medium/early maturity (85-105 d CRM)

Planting Date 04/30/2011 | 32,500 plants/acre

Grain Cultivars (bu/acre) | 150 - 170

- Select Expected Optimum Yield
- Grain Cultivars (bu/acre)
- Silage Cultivars (tons(65% moisture)/acre)
- Sweet Corn (processing) (tons/acre, unhusked)
- Sweet Corn (fresh market) (ears/acre)

*ur information, please click the submit button* Submit

Cu Locations **Current Location: Test field 1**

Log Off

# Adapt-N Interface: entering Soil/Tillage info

Login | Mineral Nitrogen/Cultivar | Soil/Tillage | Manure/Sod/Soybean | Add Application | Results | Manage Locations

Adapt-N Home

**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.* 26-30 inches

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

*Was there a soil test?* There was a soil test in the last 3 years.

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

soil organic matter: *(%)* 3

---

**Tillage System Information**

*Please select the tillage system for this field.* Conservation tillage

- Select Tillage System
- Conservation tillage
- Spring plowing
- Fall plowing

25%

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

Current Season: 2011 | Current Group: NY Locations | Current Location: Test field 1

# Adapt-N Interface: entering Manure/Sod/Soybean info

**Adapt-N:** ***A tool for adaptive nitrogen management in corn production.***

Login | Mineral Nitrogen/Cultivar | Soil/Tillage | Manure/Sod/Soybean | Add Application | Results | Manage Locations

Adapt-N Home

## Manure N Applications

| Date | Added | Organic N | Ammonia N | Depth | Solids | Delete Button |
|---|---|---|---|---|---|---|
| 04/15/2011 | 10000 | 9 | 12 | injected/incorporated within 1 day | 3 | Delete |

*You may enter up to three applications for 2009, up to three applications for 2010 and up to three applications for 2011*

Select Manure Application

## N from Sod Rotation

*Previous sod crop in the past three years?* sod not applied

- Select Sod Application
- sod not applied
- sod terminated in 2009
- sod terminated in 2010
- sod terminated in 2011

## Previous Soybean Crop

*First year corn after soybean?* no, did not plant soybeans last year

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

When done entering all field info, click 'Submit' to run the simulation.

# Adapt-N Results Page

## Example with need for sidedress N

Login | Mineral Nitrogen/Cultivar | Soil/Tillage | Manure/Sod/Soybean | Add Application | Results | Manage Locations

Adapt-N Home

**Sidedress Nitrogen Recommendation: 100 lbs N/Acre (91 - 118 lbs N/Acre)**

This recommendation is based on an "Expected Yield" entry that is assumed to be the economically optimum yield for this field. The recommended range reflects the uncertainty with post-application fertilizer losses for the remainder of the growing season due to unknown future weather events. This uncertainty decreases with the progression of the growing season.

1. Calculation of Sidedress N Rate

   Sidedress N rate estimated by AdaptN = $CropN_{Harvest}$ - $CropN_{Current}$ - $SoilN_{Current}$ - $SoilN_{postsidedress}$ - $SoybeanN_{Credit}$ + $Loss_{postapplication}$

| | |
|---|---|
| $CropN_{Harvest}$ | 164 *(lbs N/acre)* |
| $CropN_{Current}$ | 1 *(lbs N/acre)* |
| $SoilN_{Current}$ | 45 *(lbs N/acre)* |
| $SoilN_{postsidedress}$ | 31 *(lbs N/acre)* |
| $SoybeanN_{Credit}$ | 0 *(lbs N/acre)* |
| $Loss_{postapplication}$ | 16 *(lbs N/acre)* |

**Root Zone Crop Available Water**

*Note that these estimates are for non-irrigated corn production.*

| | |
|---|---|
| Current root zone crop available water: | ***4 inches*** |
| Crop available water at field capacity | 4 *inches* |

- Full Report and Graphs (pdf file)
- Sidedress N Definitions

# N Recommendation Methodology
# Mass Balance Approach

$$\mathbf{SidedressNrate} = \mathbf{CropN_{Harvest} - CropN_{Current} - SoilN_{Current} - SoilN_{postsidedress} - SoybeanN_{credit} + Loss_{postapplication}}$$

| | |
|---|---|
| $CropN_{Harvest}$ | Total crop N uptake from planting to harvest, based on "Expected Yield" input. |
| $CropN_{Current}$ | Crop N uptake from planting to the current/simulated date, based on growth and N uptake according to weather data. |
| $SoilN_{Current}$ | Crop-available N in the root zone on the current/simulated date, based on soil, organic inputs, previous soy or sod crops, crop uptake and weather effects. |
| $SoybeanN_{Credit}$ | Estimate of contribution of N to the current corn crop from a previous season soybean crop. |
| $SoilN_{postsidedress}$ | Estimated crop-available N (from mineralization/urea hydrolysis – estimated N losses) from the current date to harvest. |
| $Loss_{postapplication}$ | Estimated post-N recommendation losses from the Adapt-N recommended N application. |

# Adapt-N Results Page

## Example with excess N in the system

Login | Mineral Nitrogen/Cultivar | Soil/Tillage | Manure/Sod/Soybean | Add Application | Results | Manage Locations

Adapt-N Home

**Sidedress Nitrogen Recommendation: No sidedress N recommended at this time (0 - 0 lbs N/Acre)**

This recommendation is based on an "Expected Yield" entry that is assumed to be the economically optimum yield for this field. The recommended range reflects the uncertainty with post-application fertilizer losses for the remainder of the growing season due to unknown future weather events. This uncertainty decreases with the progression of the growing season.

1. Calculation of Sidedress N Rate

   Sidedress N rate estimated by AdaptN = $CropN_{Harvest}$ - $CropN_{Current}$ - $SoilN_{Current}$ - $SoilN_{postsidedress}$ - $SoybeanN_{Credit}$ + $Loss_{postapplication}$

| | |
|---|---|
| $CropN_{Harvest}$ | 164 *(lbs N/acre)* |
| $CropN_{Current}$ | 1 *(lbs N/acre)* |
| $SoilN_{Current}$ | 149 *(lbs N/acre)* |
| $SoilN_{postsidedress}$ | 70 *(lbs N/acre)* |
| $SoybeanN_{Credit}$ | 0 *(lbs N/acre)* |
| $Loss_{postapplication}$ | 0 *(lbs N/acre)* |

2. Excess N

   Adapt-N has estimated that the seasonal N supplied (all sources) will exceed total crop N demand ($CropN_{Harvest}$) by at least 10 *lbs N/acre*.

   Estimated Excess N: ***55 lbs N/acres***

**Root Zone Crop Available Water**

*Note that these estimates are for non-irrigated corn production.*

| | |
|---|---|
| Current root zone crop available water: | ***4 inches*** |
| Crop available water at field capacity | 4 *inches* |

- Full Report and Graphs (pdf file)
- Sidedress N Definitions

Downloadable pdf

# Adapt-N Results
## Example Report

*Adapt-N Report*

| Settings | |
|---|---|
| Current Date | 06/01/2011 |
| Simulation End Date | 05/29/2011 |
| Field Name | Test field 1 |
| Group Name | NY Locations |
| Latitude | 42.5 |
| Longitude | -76.24 |
| Soil/Field Input | |
| Soil Type | medium: (silt loams) |
| Rooting Depth | 26-30 inches |
| Field Slope | less than 3% |
| Soil Management | Conservation tillage |
| % Surface Residue Cover | 25% |
| Preplant Soil Test | test in the last 3 years |
| Sample Depth | 6 inches |
| Soil Organic Matter | 3% |
| Crop Information | |
| Planting Date | 04/30/2011 |
| Planting Density | 32,500 plants/acre |
| Maturity Class | Grains: mid-maturing (85-105 days) |
| GDD to maturity | 2300 |
| Expected Yield | 150 - 170 bu/acre |
| Nitrogen Inputs: Sod | sod not applied |
| Nitrogen Inputs: Manure | |
| Mineral Fertilizer: starter | |
| starter | ammonium nitrate, 30 lbs N/acre |
| Date | 04/30/2011 |
| Depth of Incorporation | 2-4 inches |
| | |
| Mineral Fertilizer: additional | additional not applied |

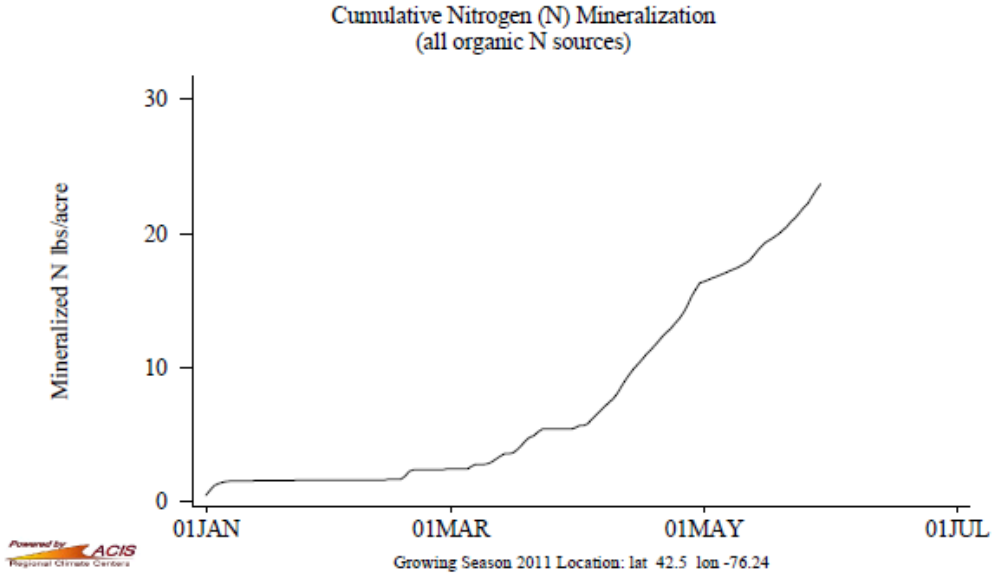
| Sidedress N and Crop Available Water | |
|---|---|
| Sidedress N recommendation | 100 lbs N/Acre |
| | (91-118 lbs N/Acre) |
| CropN (Harvest) | 164 lbs N/acre |
| CropN (Current) | 1 lbs N/acre |
| SoilN (Current) | 45 lbs N/acre |
| SoilN (postsidedress) | 31 lbs N/acre |
| SoybeanN (Credit) | 0 lbs N/acre |
| Loss (postapplication) | 16 lbs N/acre |
| Crop Available Water | |

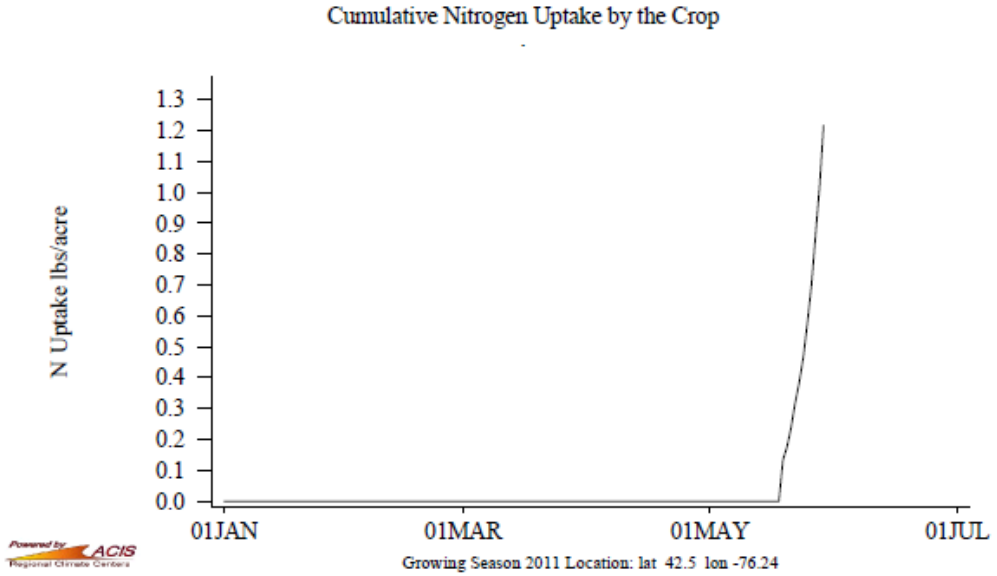
A downloadable pdf file provides:

- All user inputs listed for easy record keeping.
- Recommendations from Results page on interface
- Graphs describing N dynamics and relevant weather, soil water and plant parameters

# Adapt-N Graphs

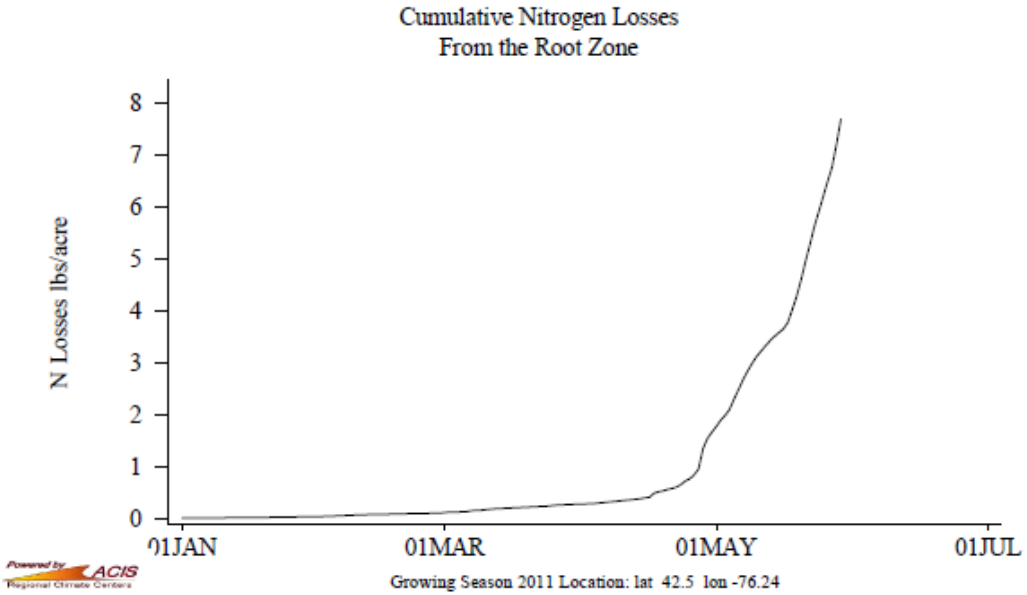
*Adapt-N Report*

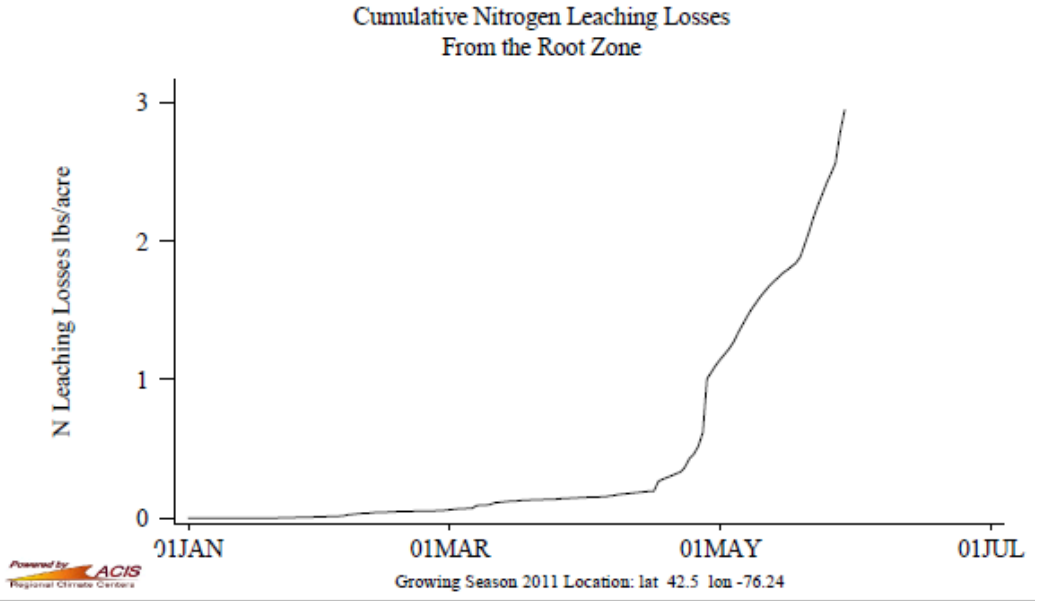


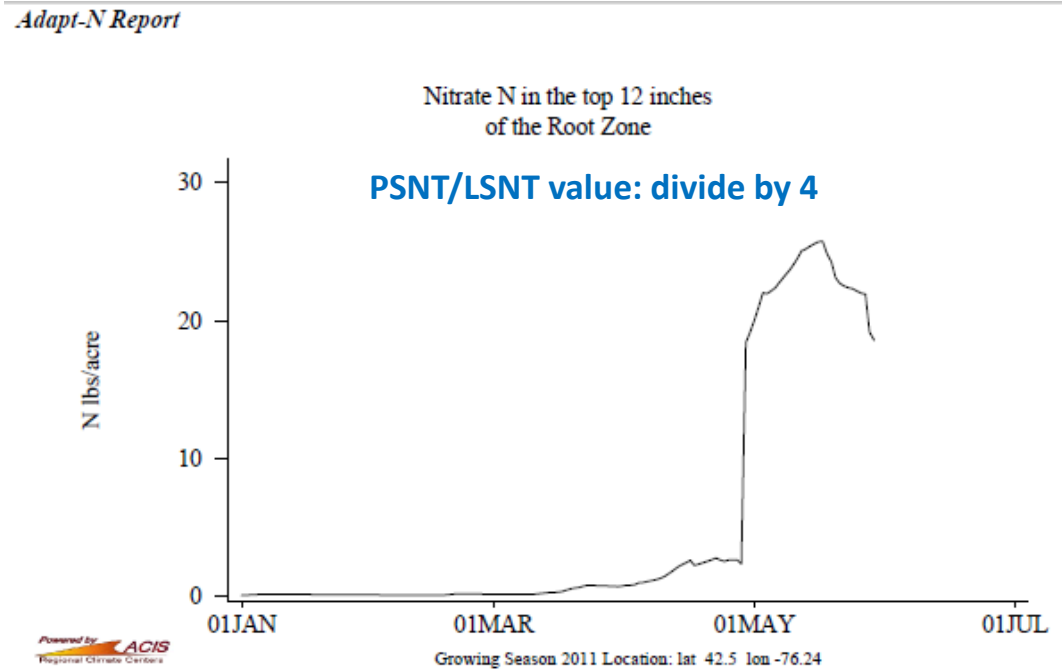
# Adapt-N Graphs

*Adapt-N Report*



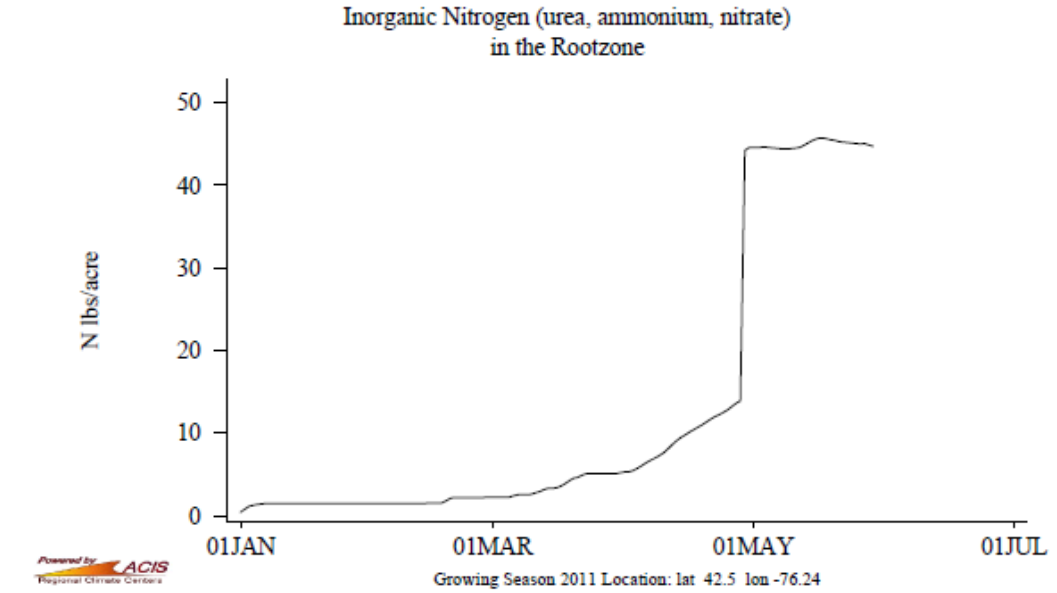



# Adapt-N Graphs




**Other graphs provided:**

- Growing Season Daily Rainfall
- Cumulative Rainfall for Growing Season
- Post-Emergence Growing Degree Days
- Post Planting Day Leaf Number
- Growing Season Daily Average Temperature



# Adapt-N Applications

Adapt-N can be used for a wide range of N management practices for corn (grain, silage, sweet):

- Sidedress N rate recommendation
- Rescue N application rate
- Manured fields – Is additional N necessary, and how much?
- After pre-plant applications or applications at planting: Are additional in-season N applications necessary?
- Hindcasting after growing season (Excess? Deficient? What-if?)
- Potential for use in variable rate application

# Example
# corn after soybean 2011
# near Des Moines, IA

>5 inch rain-event in mid June

Is additional sidedress N needed in late June?

# Adapt-N management inputs…

## Note that all N (150 lb) was applied as preplant in April

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

**Region** Iowa

**Nitrogen Fertilizer Applications for this Growing Season**

| Application | Name | lbs N/acre | Placement Depth | Date | Delete Button |
|---|---|---|---|---|---|
| preplant/sidedress | solution n | 150 | 3.0 | 04/21/2011 | Delete |

*You may enter one starter and up to four preplant/sidedress applications.* Select Fertilizer Application

**Crop Information**

Grains: 103 d crm

Planting Date 05/11/2011 | 32,500 plants/acre

Grain Cultivars (bu/acre) | 190 - 210

# Adapt-N Results Page

## High recommendation suggests high losses…

Login | Mineral Nitrogen/Cultivar | Soil/Tillage | Manure/Sod/Soybean | Add Application | Results | Manage Locations

**Sidedress Nitrogen Recommendation: 65 lbs N/Acre (56 - 72 lbs N/Acre)**

This recommendation is based on an "Expected Yield" entry that is assumed to be the economically optimum yield for this field. The recommended range re
uncertainty with post-application fertilizer losses for the remainder of the growing season due to unknown future weather events.

1. Calculation of Sidedress N Rate

Sidedress N rate estimated by AdaptN = $CropN_{Harvest}$ - $CropN_{Current}$ - $SoilN_{Current}$ - $SoilN_{postsidedress}$ - $SoybeanN_{Credit}$ + $Loss_{postapplication}$

| | |
|---|---|
| $CropN_{Harvest}$ | 205 *(lbs N/acre)* |
| $CropN_{Current}$ | 92 *(lbs N/acre)* |
| $SoilN_{Current}$ | 21 *(lbs N/acre)* |
| $SoilN_{postsidedress}$ | 6 *(lbs N/acre)* |
| $SoybeanN_{Credit}$ | 30 *(lbs N/acre)* |
| $Loss_{postapplication}$ | 9 *(lbs N/acre)* |

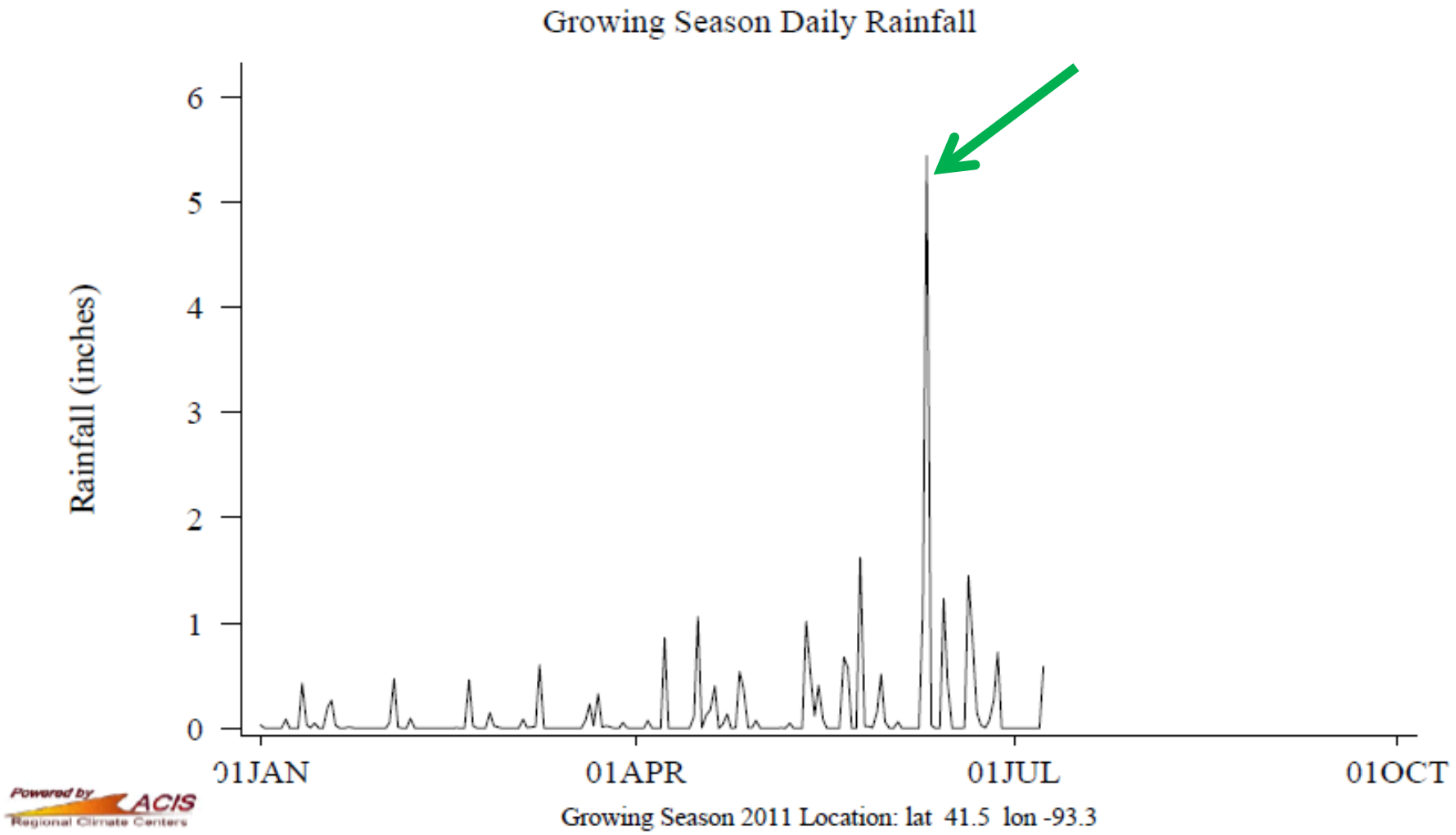
**Root Zone Crop Available Water**

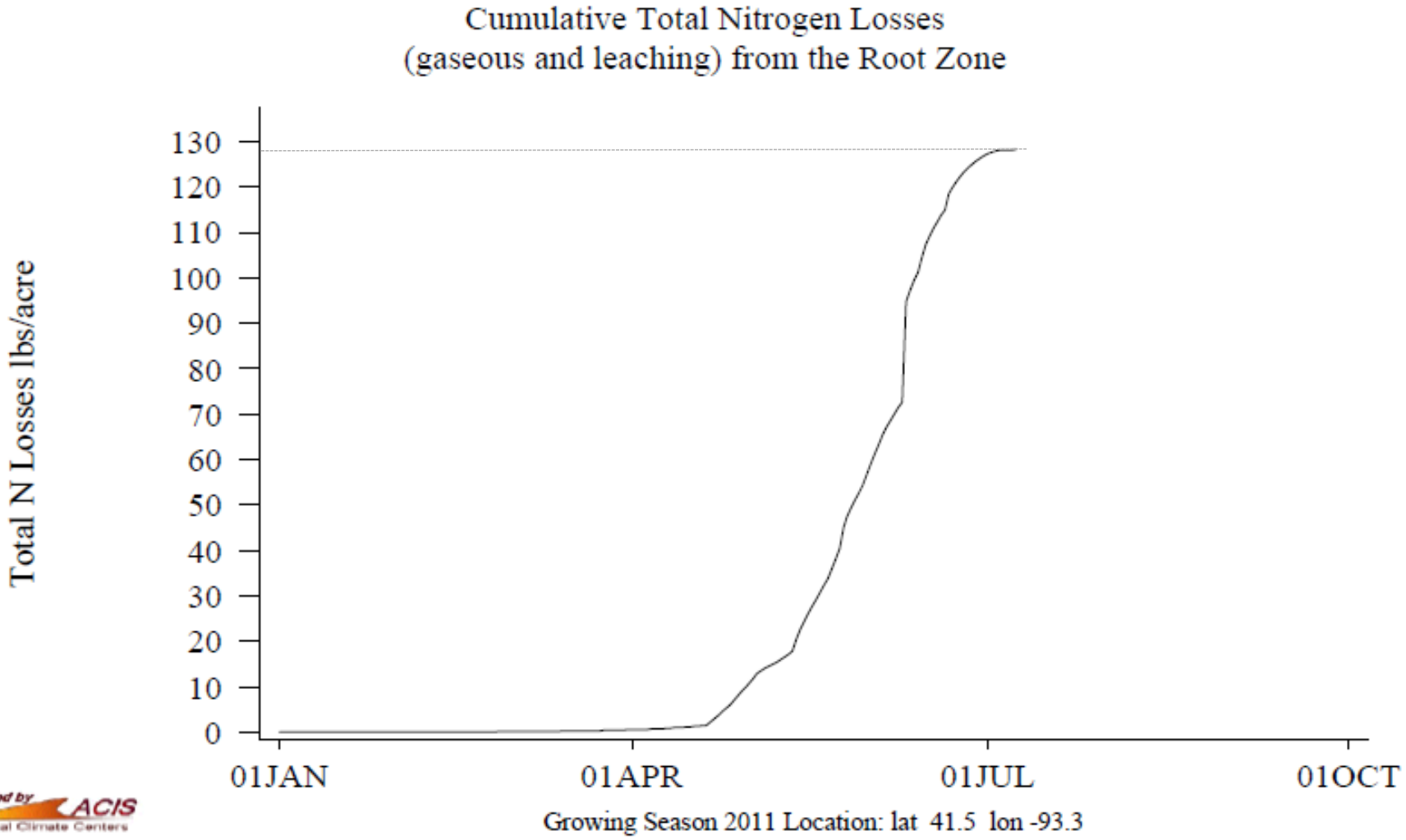
*Note that these estimates are for non-irrigated corn production.*

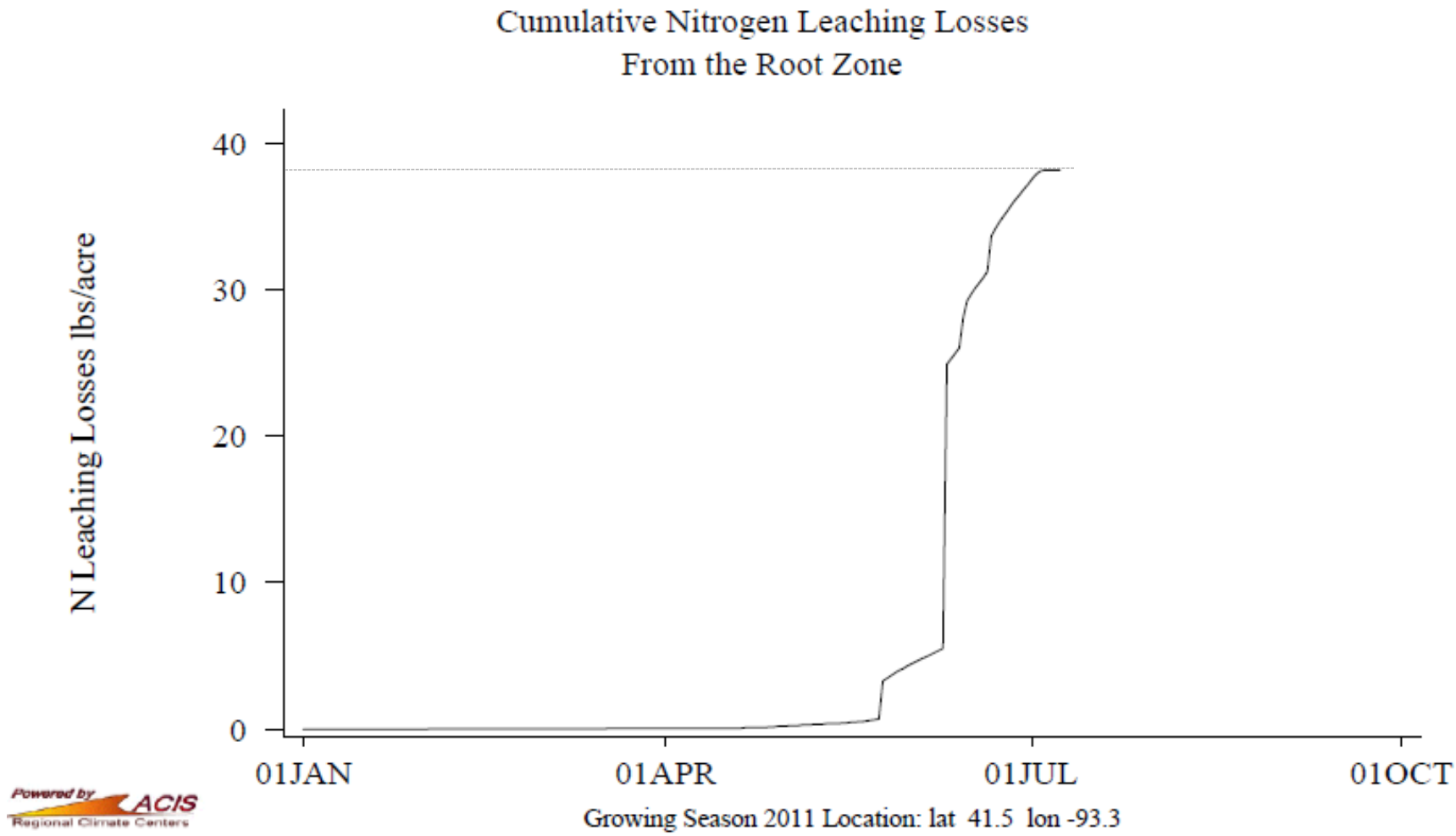
| | |
|---|---|
| Current root zone crop available water: | ***4 inches*** |
| Crop available water at field capacity | 5 *inches* |

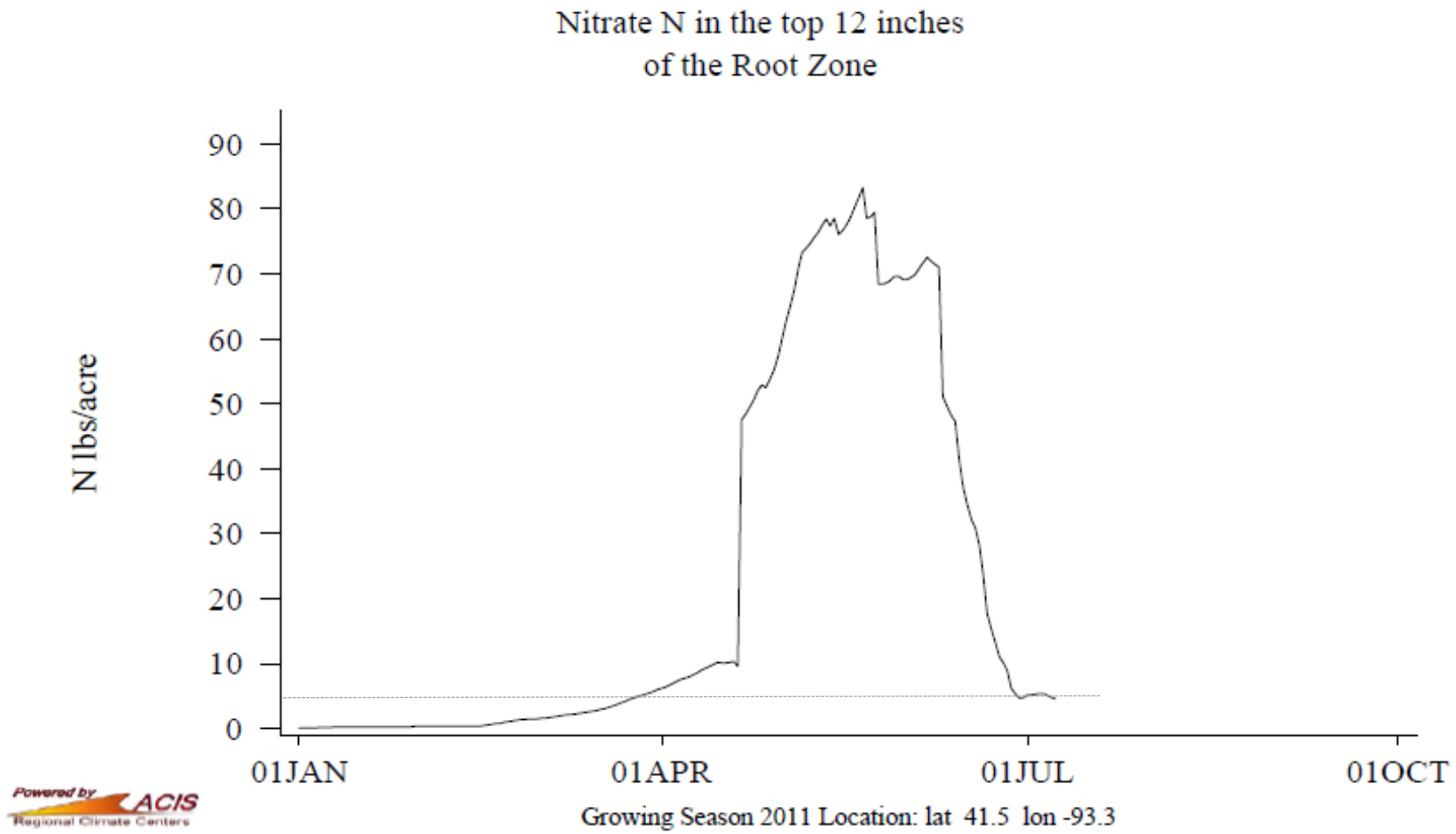
- Full Report and Graphs (pdf file)
- Sidedress N Definitions

Log Off


Growing Season Daily Rainfall
Rainfall (inches)
6
5
4
3
2
1
0
01JAN
01APR
01JUL
01OCT
Powered by ACIS
Regional Climate Centers
Growing Season 2011 Location: lat 41.5 lon -93.3


Cumulative Total Nitrogen Losses
(gaseous and leaching) from the Root Zone
Total N Losses lbs/acre
130
120
110
100
90
80
70
60
50
40
30
20
10
0
01JAN
01APR
01JUL
01OCT
Growing Season 2011 Location: lat 41.5 lon -93.3
Powered by ACIS
Regional Climate Centers


Cumulative Nitrogen Leaching Losses
From the Root Zone
N Leaching Losses lbs/acre
40
30
20
10
0
01JAN
01APR
01JUL
01OCT
Growing Season 2011 Location: lat 41.5 lon -93.3
Powered by ACIS
Regional Climate Centers


Nitrate N in the top 12 inches
of the Root Zone
N lbs/acre
90
80
70
60
50
40
30
20
10
0
01JAN
01APR
01JUL
01OCT
Growing Season 2011 Location: lat 41.5 lon -93.3
Powered by ACIS
Regional Climate Centers

# End of Season Evaluations with Adapt-N

# Example: Northeast Iowa, 2010

Spring Manure Application (5000 gal/ac)

corn after soybean

30 lbs/ac at planting

## Sidedress Nitrogen Recommendation: No sidedress N recommended at this time (0 - 0 lbs N/Acre)

This recommendation is based on an "Expected Yield" entry that is assumed to be the economically optimum yield for this field. The recommended range reflects the uncertainty with post-application fertilizer losses for the remainder of the growing season due to unknown future weather events.

1. Calculation of Sidedress N Rate

   Sidedress N rate estimated by AdaptN = $CropN_{Harvest}$ - $CropN_{Current}$ - $SoilN_{Current}$ - $SoilN_{postsidedress}$ - $SoybeanN_{Credit}$ + $Loss_{postapplication}$

| | |
|---|---|
| $CropN_{Harvest}$ | 184 *(lbs N/acre)* |
| $CropN_{Current}$ | 170 *(lbs N/acre)* |
| $SoilN_{Current}$ | 4 *(lbs N/acre)* |
| $SoilN_{postsidedress}$ | 11 *(lbs N/acre)* |
| $SoybeanN_{Credit}$ | 30 *(lbs N/acre)* |
| $Loss_{postapplication}$ | 0 *(lbs N/acre)* |

2. Excess N

   Adapt-N has estimated that the seasonal N supplied (all sources) will exceed total crop N demand ($CropN_{Harvest}$) by at least 10 *lbs N/acre*.

   Estimated Excess N: ***30 lbs N/acres***

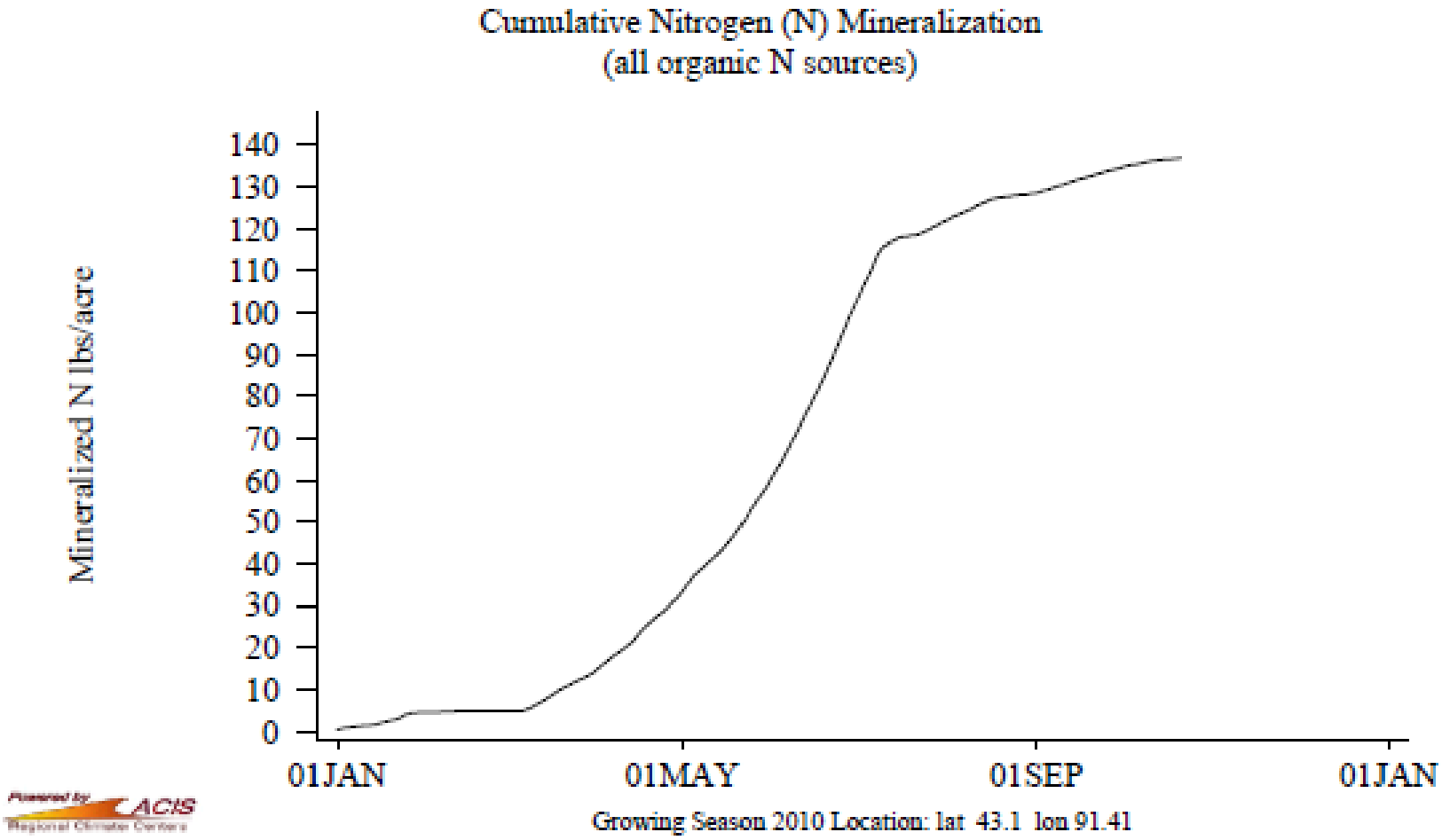
## Root Zone Crop Available Water

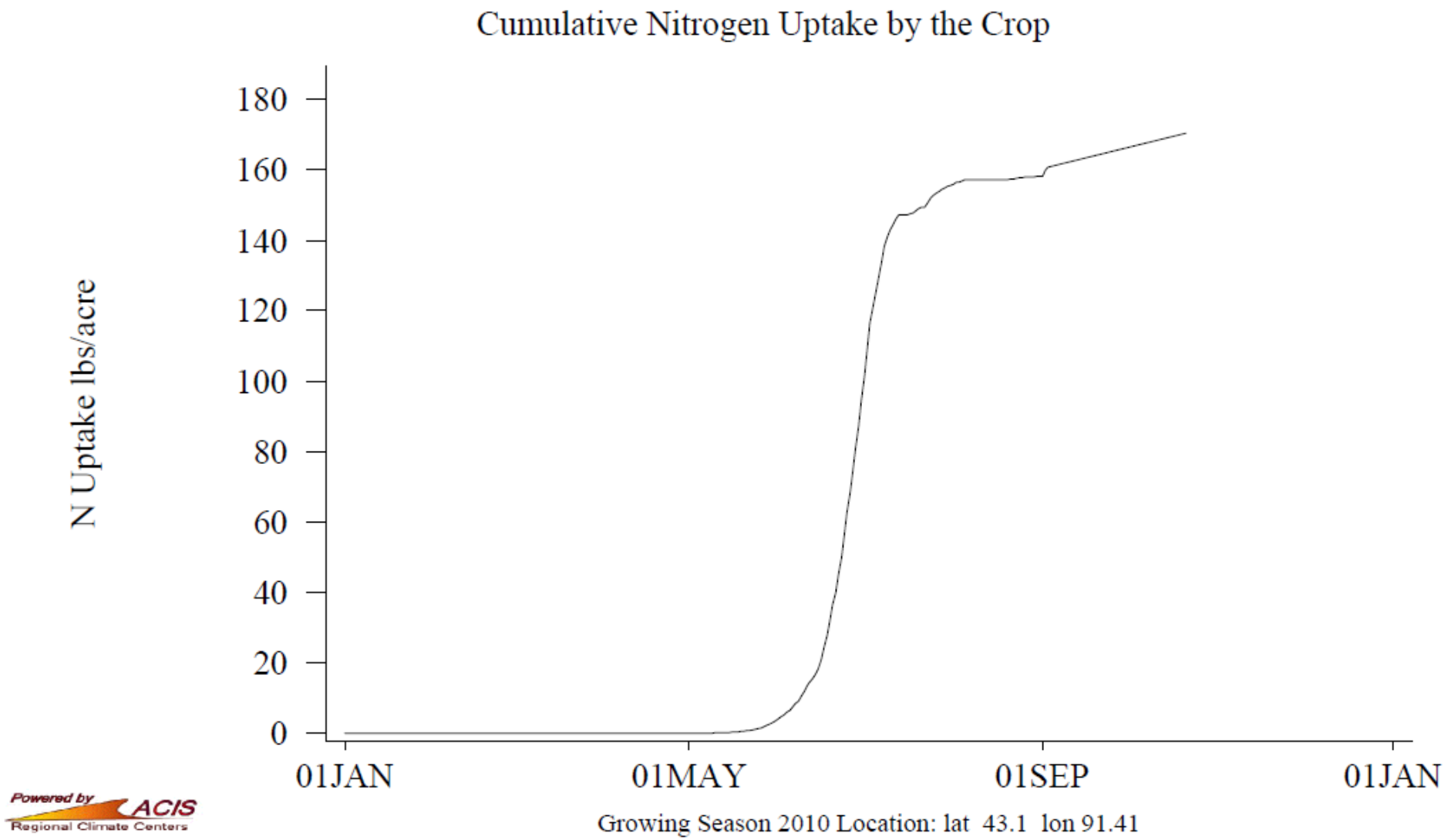
*Note that these estimates are for non-irrigated corn production.*

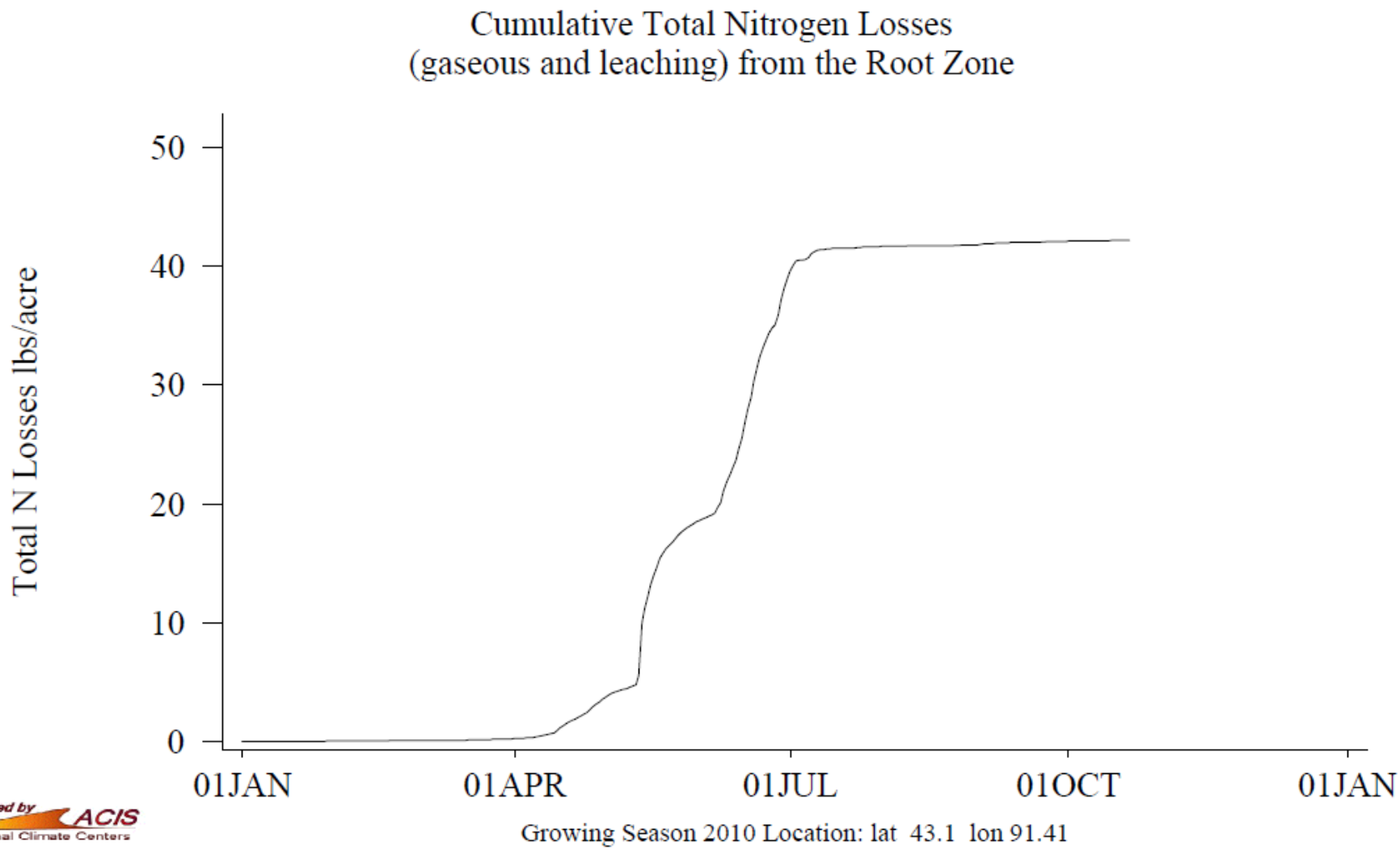
| | |
|---|---|
| Current root zone crop available water: | ***2 inches*** |
| Crop available water at field capacity | 4 *inches* |

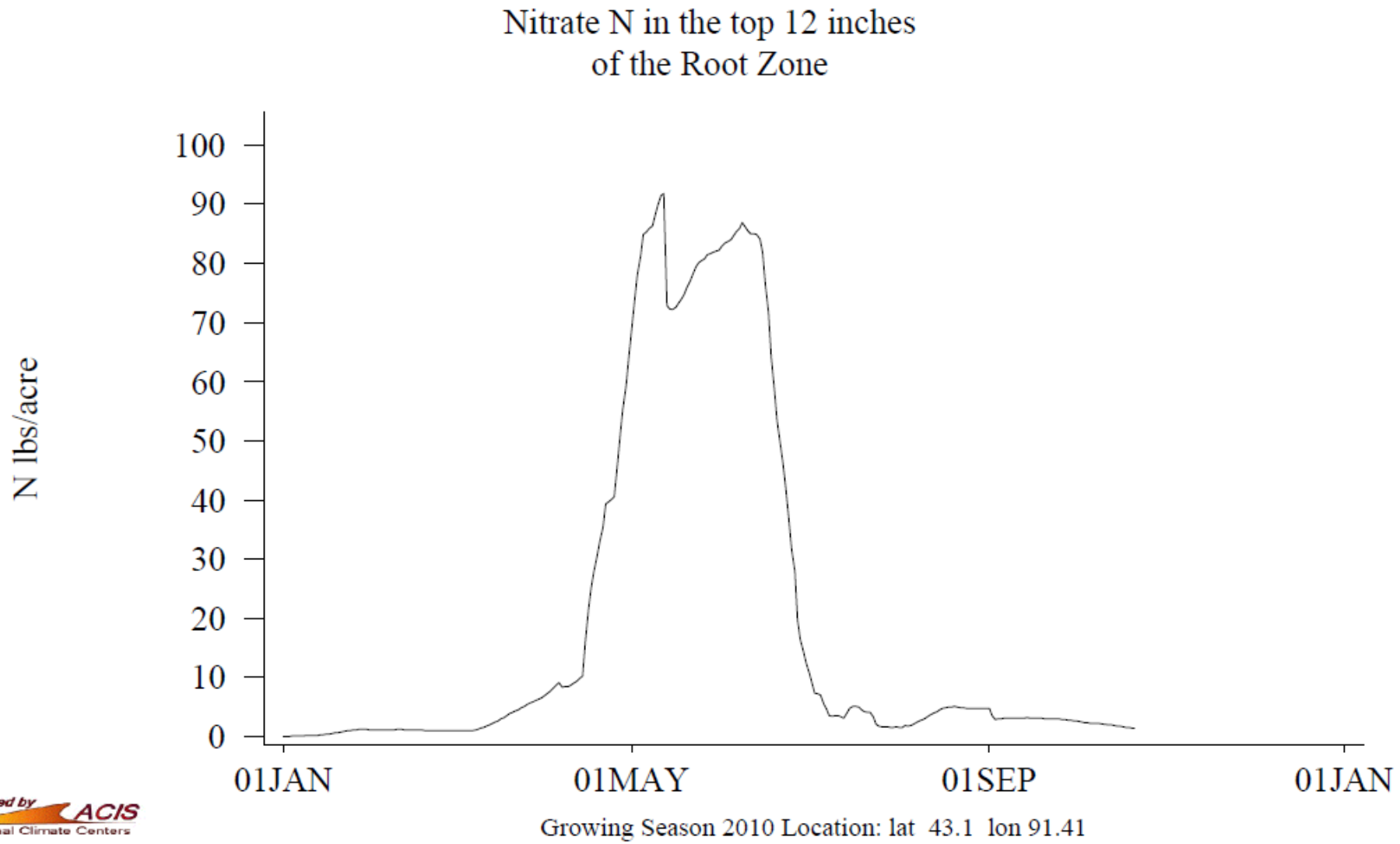
- Full Report and Graphs (pdf file)
- Sidedress N Definitions

Log Off


Cumulative Nitrogen (N) Mineralization
(all organic N sources)
Mineralized N lbs/acre
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
01JAN
01MAY
01SEP
01JAN
Growing Season 2010 Location: lat 43.1 lon 91.41


Cumulative Nitrogen Uptake by the Crop
N Uptake lbs/acre
180
160
140
120
100
80
60
40
20
0
01JAN
01MAY
01SEP
01JAN
Growing Season 2010 Location: lat 43.1 lon 91.41
Powered by ACIS
Regional Climate Centers


Cumulative Total Nitrogen Losses
(gaseous and leaching) from the Root Zone
Total N Losses lbs/acre
50
40
30
20
10
0
01JAN
01APR
01JUL
01OCT
01JAN
Growing Season 2010 Location: lat 43.1 lon 91.41
Powered by ACIS
Regional Climate Centers




Powered by ACIS Regional Climate Centers

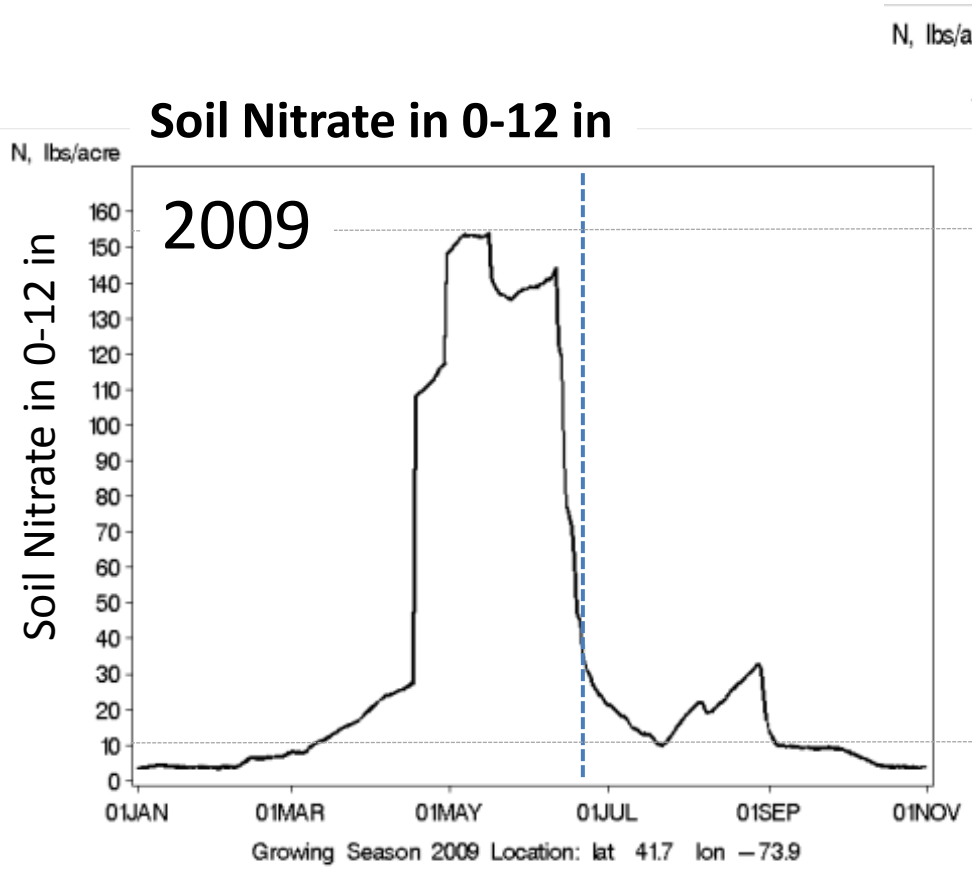
# Example:
# SE New York
# 2009 and 2010

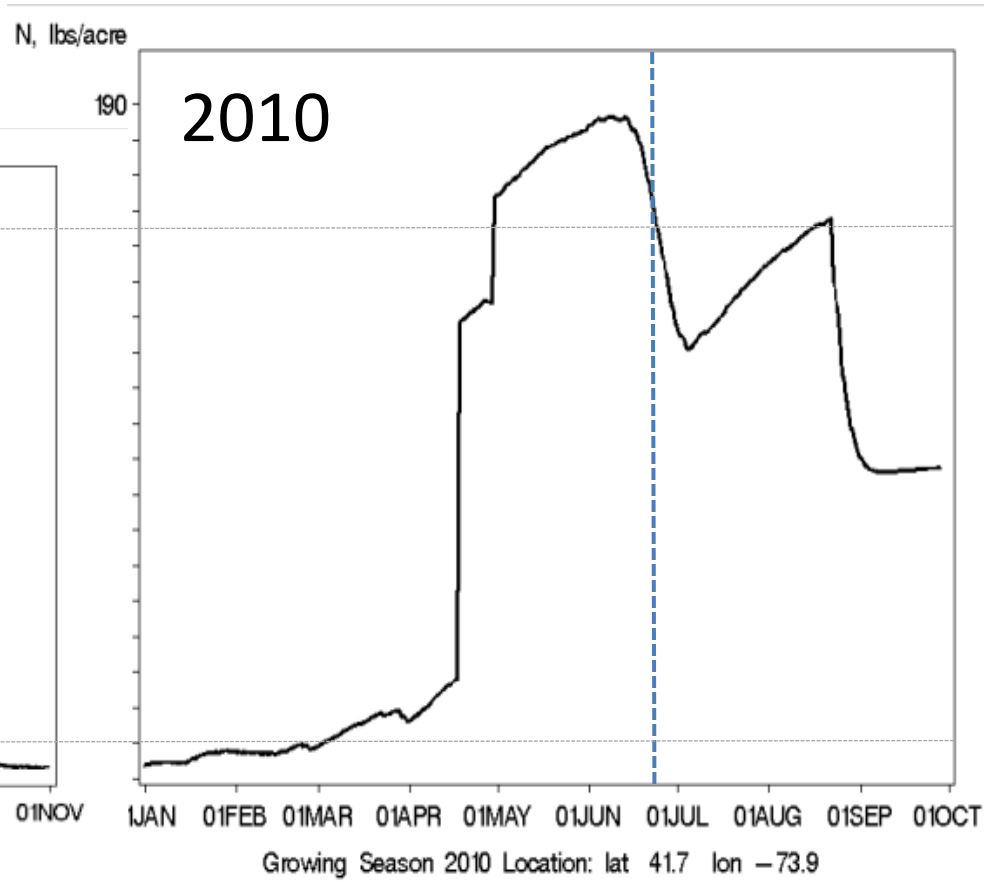
- Rotate from sod two years prior
- 10,000 gal/ac manure on 4/18
- 30 lbs/ac starter N as MAP on 5/1

# Example: SE New York

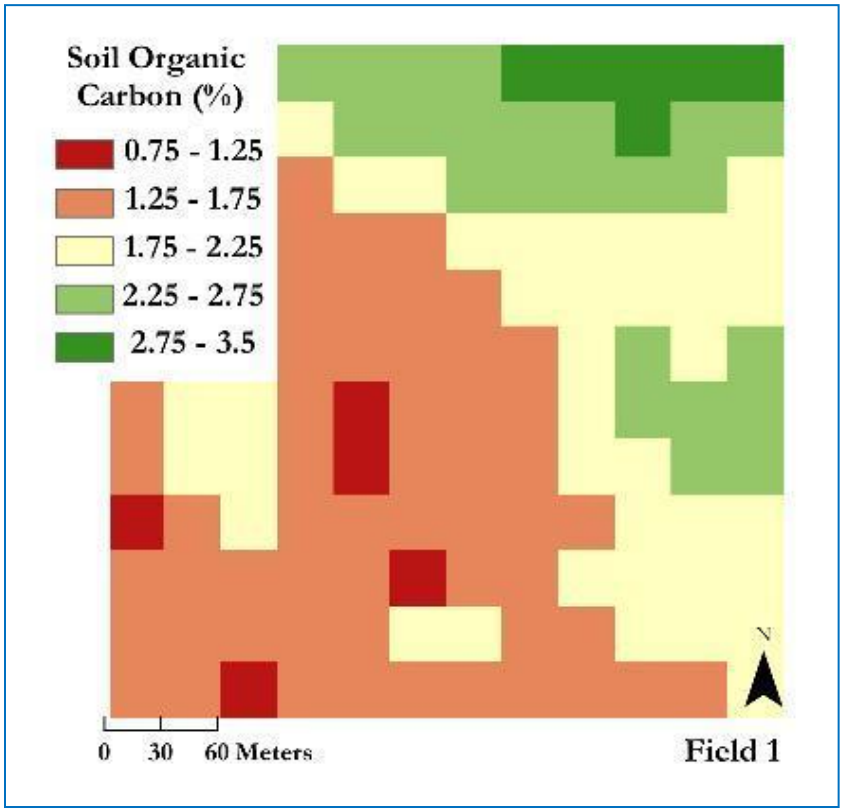
## 2009 (wet late spring) vs. 2010 (average)

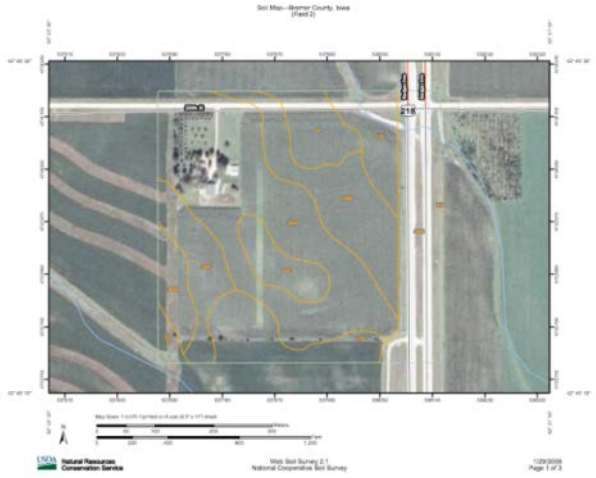
### Same management, different weather



# Using *Adapt-N* for Site-Specific Adaptive Management



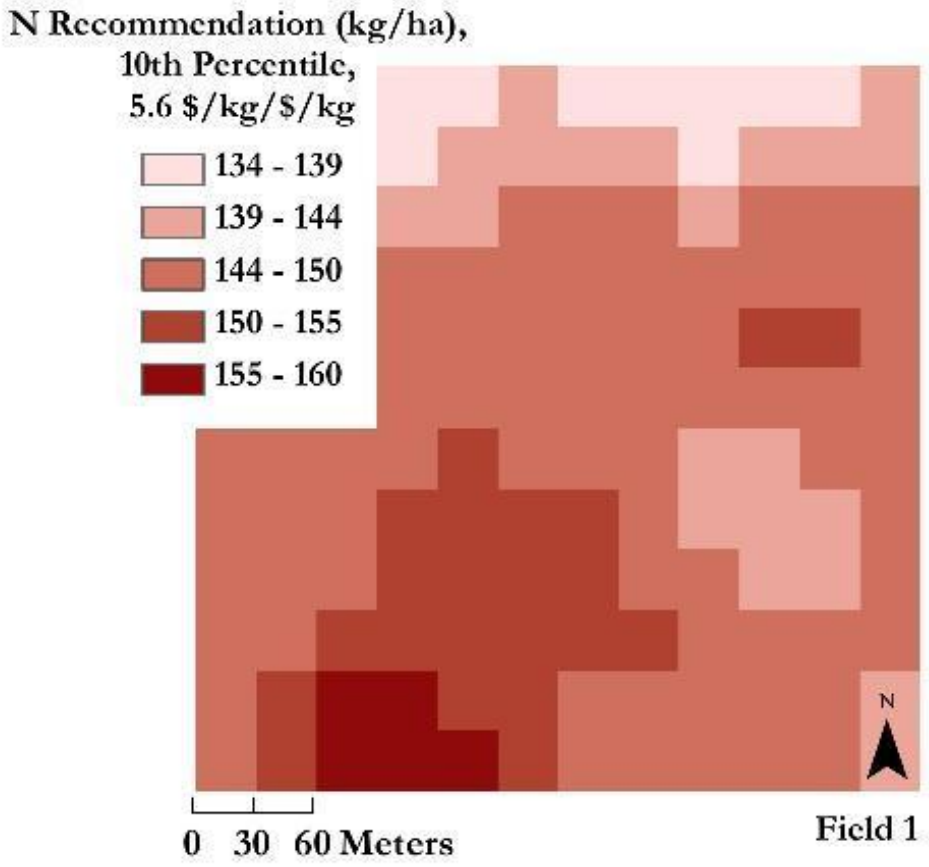
NRCS Soil survey

Organic Carbon Content (%) estimated with VIS-NIR Spectroscopy (Veris Technologies)

# N Sidedress Recommendation (kg/ha)

## 0.1 Fertilizer to Grain Price Ratio

## wet spring




Graham, C.J., H.M. van Es, J. Melkonian, and D.A. Laird. 2010. Improved nitrogen and energy use efficiency using NIR estimated soil organic carbon and N simulation modeling. In: D.A. Clay and J. Shanahan. GIS Applications in Agriculture – Nutrient Management for Improved Energy Efficiency. pp 301-325, Taylor and Francis, LLC.

# Notes on Adapt-N

- Web site http://adapt-N.eas.cornell.edu
- To register, email Jeff Melkonian – jjm11@cornell.edu. Provide preferred UserID and password
- Operational for Northeast US and Iowa
- Conducting 40 field demonstrations/validations (2011-2012)
- Planned expansion to other humid regions in US next year, with initial focus on corn belt states (2012 growing season)

# Conclusions

- Nitrogen use on corn has many economic and environmental concerns
- Optimum N rates for corn cannot be predicted accurately at the start of the growing season, especially in humid regions
- End of season measurements are not directly predictive of future years due to seasonal weather effects
- In-season N fertilizer recommendations become more precise as the season progresses
- Win-Win Opportunities: Adaptive N management reduces input costs, allows for adaptation to and mitigation of climate change, and lowers environmental losses.

# Thanks to Our Funders

The development and testing of the Adapt-N tool was supported through funds from:

- USDA-NIFA Special Grants on Computational Agriculture (U.S. Rep. Maurice Hinchey-NY)
- USDA Natural Resources Conservation Service Conservation Innovation Grant
- Northern New York Agricultural Development Program
- New York Farm Viability Institute

## Further info on our website:

## *adapt-n.cals.cornell.edu*