Nitrogen: Obstacles, Progress, BMPs

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Obstacles

- Denial that ag is the major source
- ‘N Runoff’ perception
  - Structures are not effective
  - N rate & timing ARE effective
- The ‘best rate’ varies widely
- Diagnosing the best rate is hard
- Logistics drive early applications

Progress

- Yield is increasing faster than N rates
- Increasing awareness of N loss
- Equipment for in-season N application is becoming:
  - Faster
  - Wider
  - More widely available
- Crop sensors to diagnose N need are becoming a realistic option

BMPs

- In-season N application
- Crop sensors to guide variable-rate in-season N application
- Coated urea
- Agrotain volatilization inhibitor
- Interception/removal BMPs are more expensive than source reduction

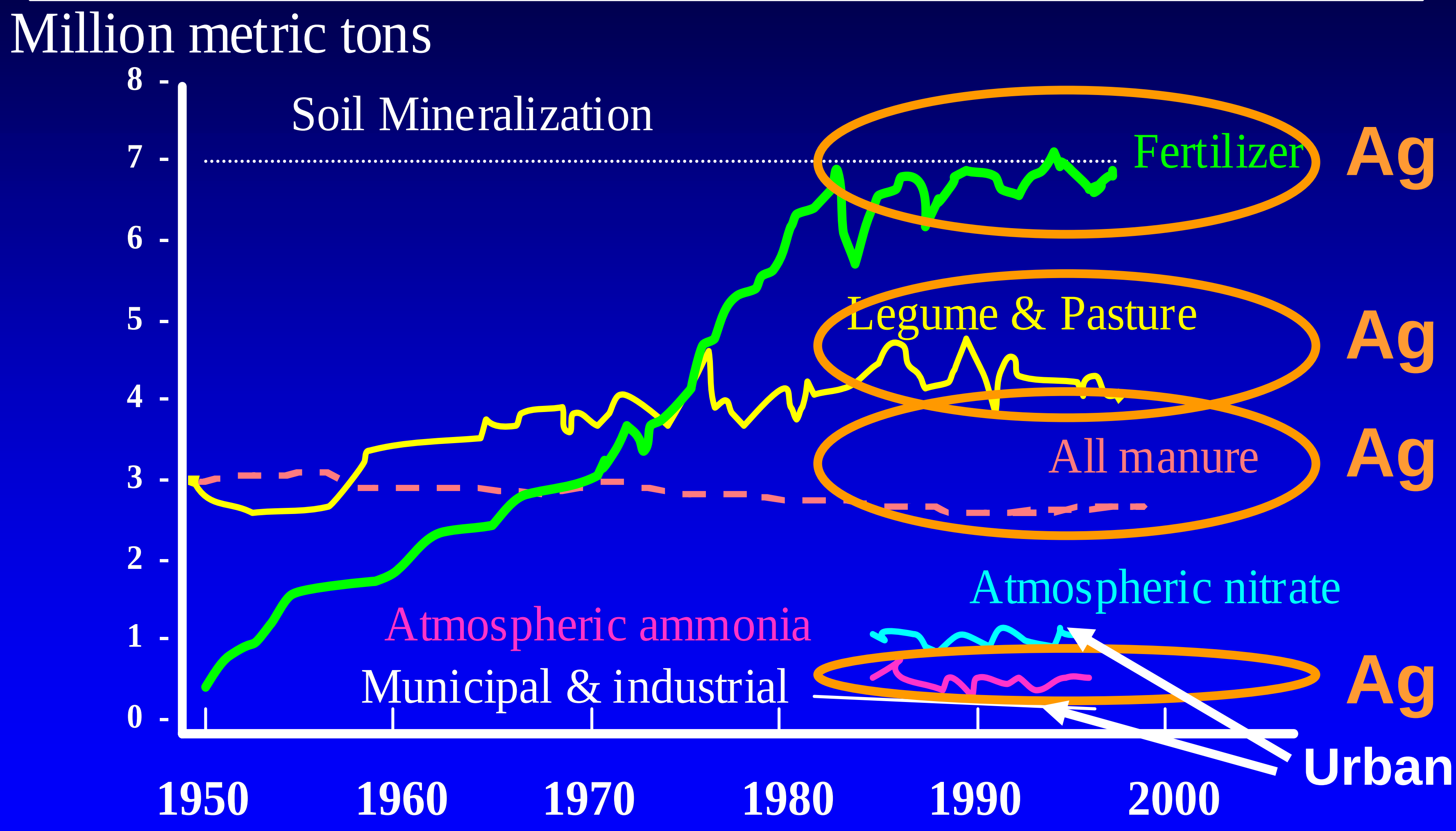
Obstacles

Denial that ag is the major source

"What about the sewage treatment plants?"

Annual N Inputs to Mississippi Basin

Approximated from Goolsby. USGS. 1999. CENR Report #3



Circumstantial evidence: N fertilizer is a major source

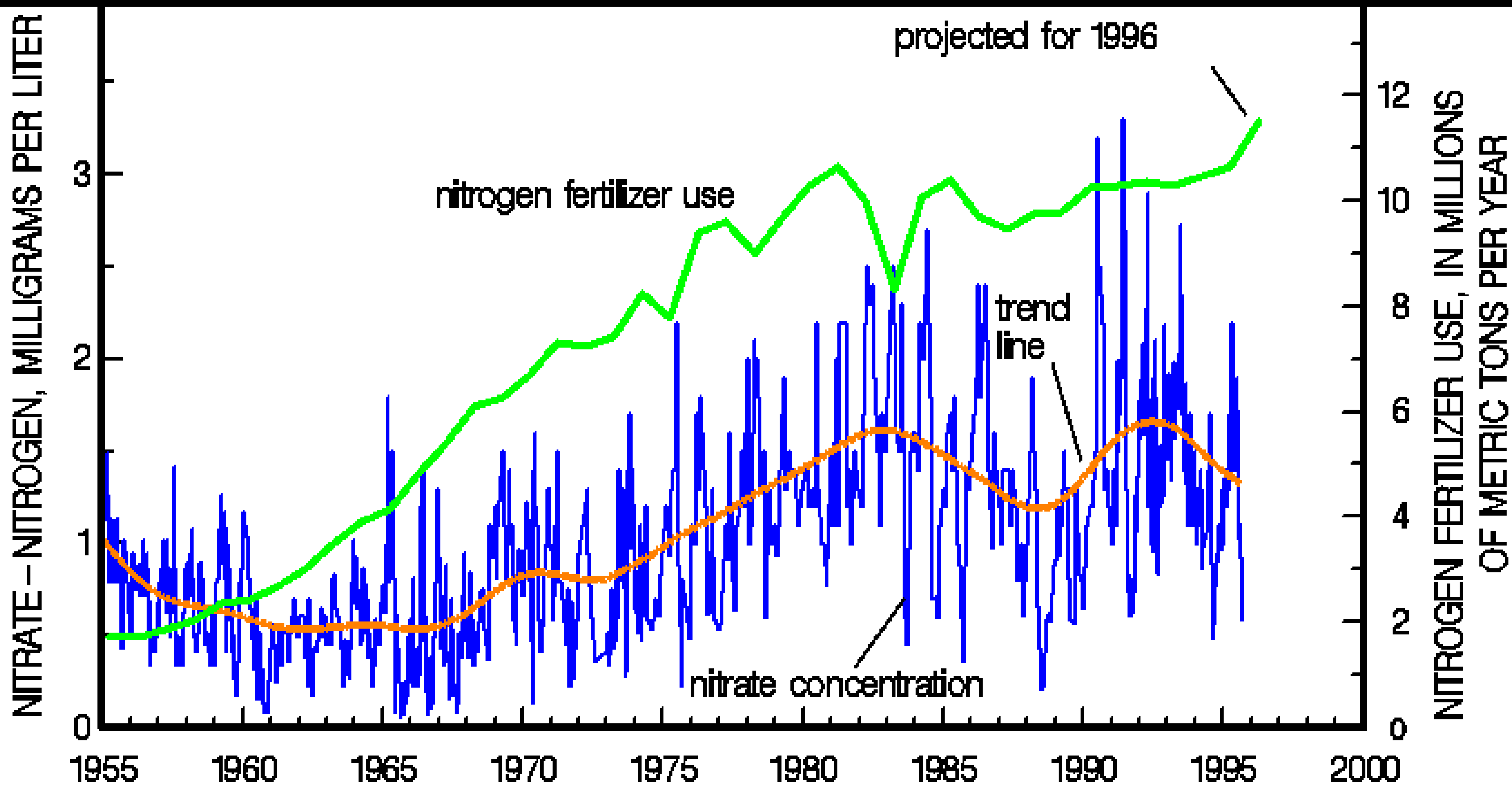


Figure 1. Estimated nitrogen fertilizer use in the Unites States, and nitrate concentrations in the Mississippi River at St. Francisville, LA., 1955–95.

How can the water quality effects of N be addressed?

- Need to focus on agricultural sources of N
  - Primarily fertilizer N
  - Also N from soil organic matter, manure, legumes
- Taking advantage of easy progress in municipal & industrial N also makes sense

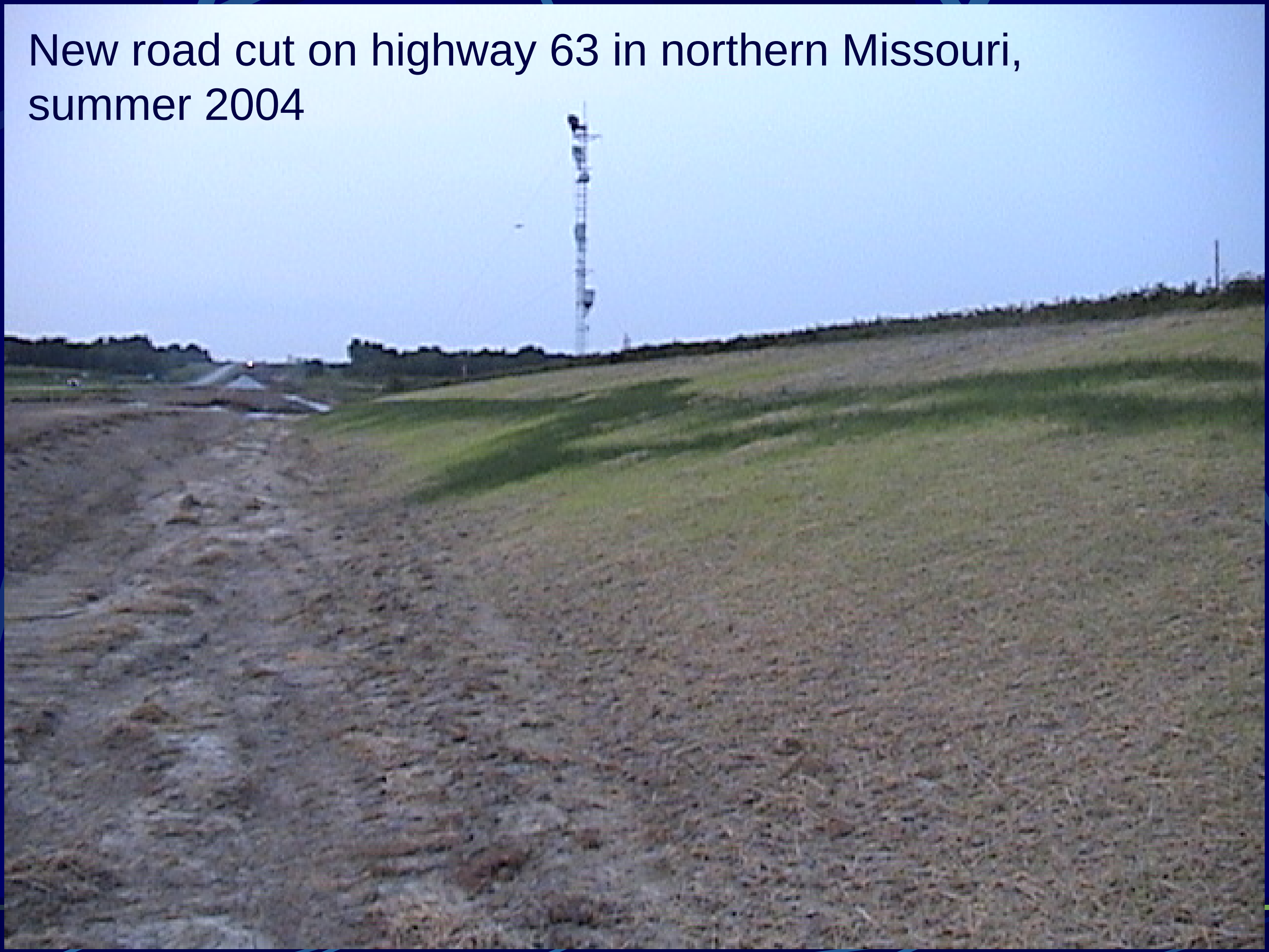
‘Nitrogen runoff’

- In every news story on Gulf hypoxia
- Implies overland transport (like P, sediment)
- Points to WRONG SOLUTIONS
- Drives me crazy
- Need education on N transport

N transport to water resources

- Runoff: a minor pathway in most cases
- Nitrate leaching is the major pathway
  - UNDERGROUND!!
  - movement with percolating water
  - to groundwater (permanent or transient)
  - substantial groundwater emerges to surface as springs & seeps
  - artificial drains in agricultural fields directly move leached nitrate to surface waters

Nitrate in base flow



Landscape slope

Loess cap

Old glacial till (dense)

N transport to water resources

- Missouri MSEA: 15 times more N leached than in runoff
- Iowa MSEA: 16 times more N entering stream via subsurface flow than in runoff
- Georgia: 115 times more N in subsurface flow than in runoff (Jackson et al., 1973)

Major point #1:

Best Management Practices (BMPs) aimed at reducing runoff will NOT reduce N movement to ground and surface waters

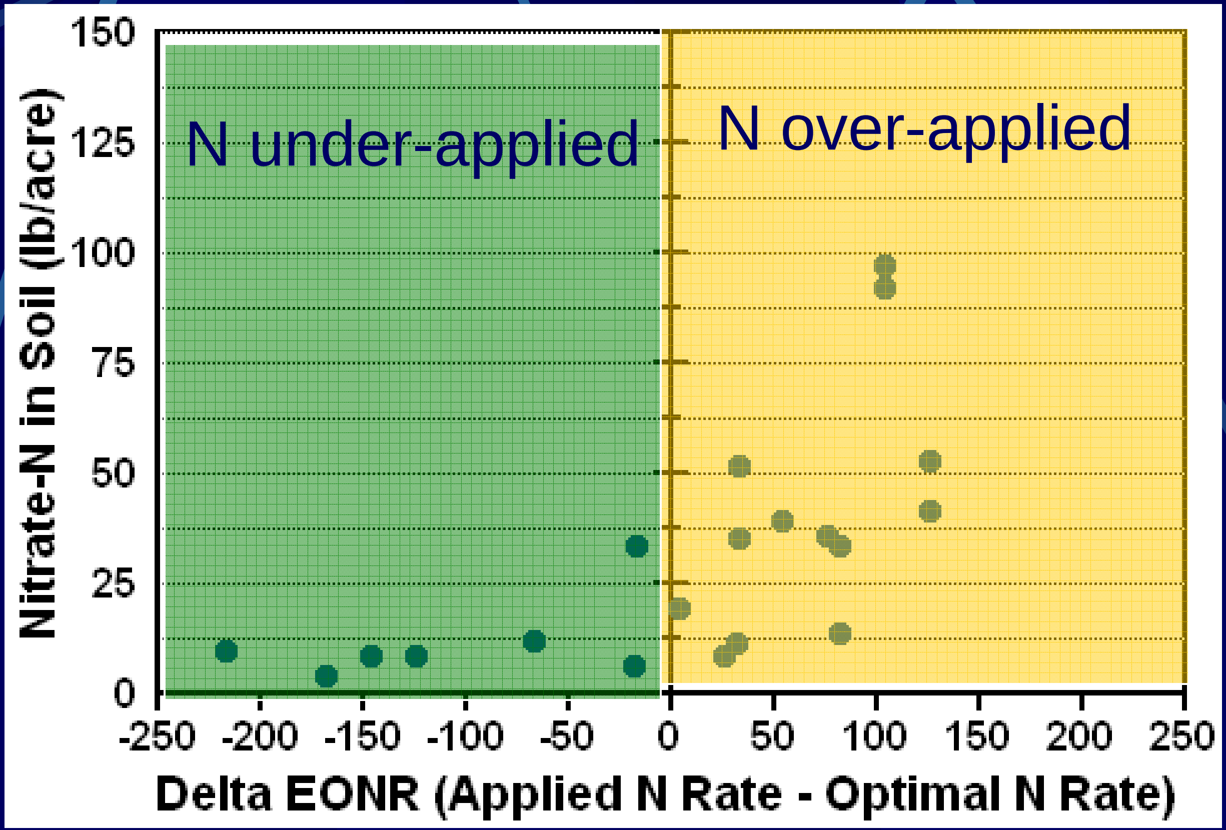
N transport to water resources

- Grasslands/forages leach very little N
  - Not much water percolation
    - Dense growth, long growing season
  - Little free nitrate, great potential to take up nitrate

Major point #2:

Very little N is lost from forages to water resources

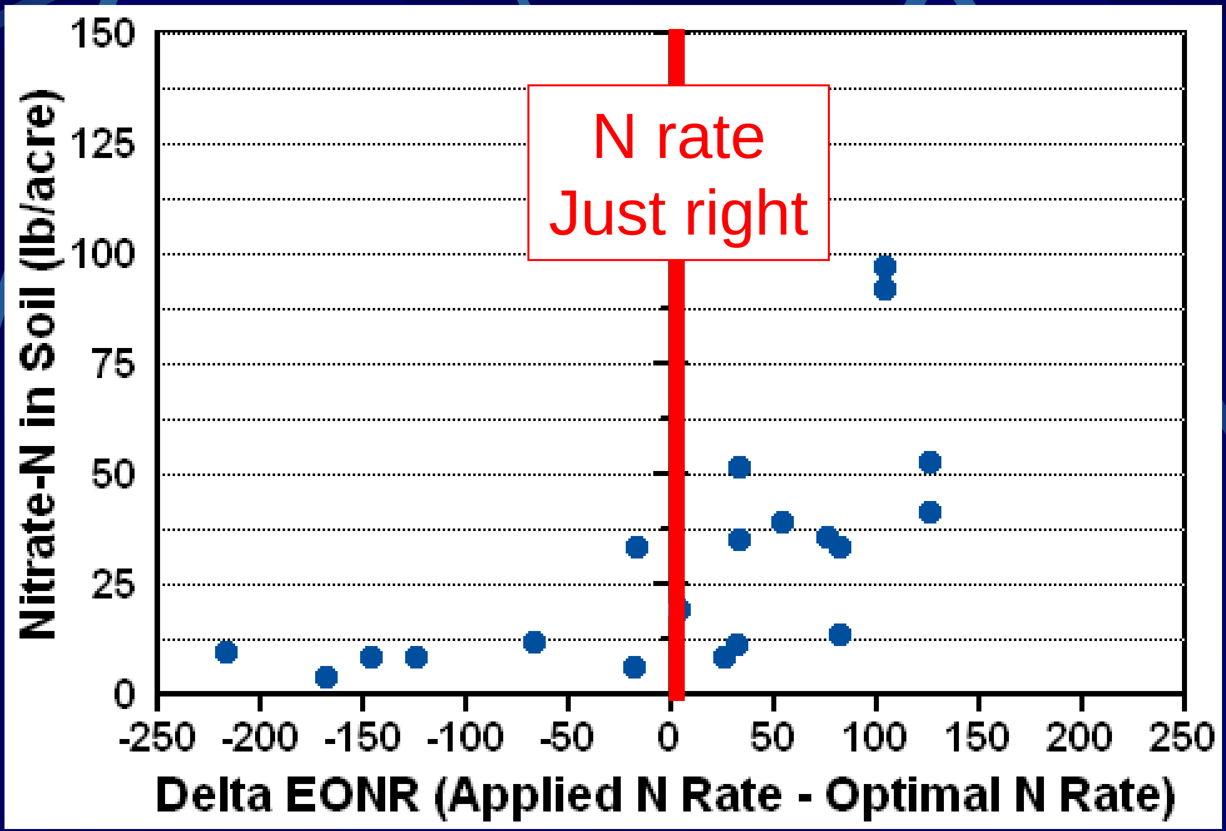
N rate above crop need = high soil N at harvest



Soil nitrate in the top 4 feet after harvest is high only when optimum N fertilizer rate for corn is exceeded. Centralia, MO, 2000

N rate = crop need

keeps soil N low, gives full yield



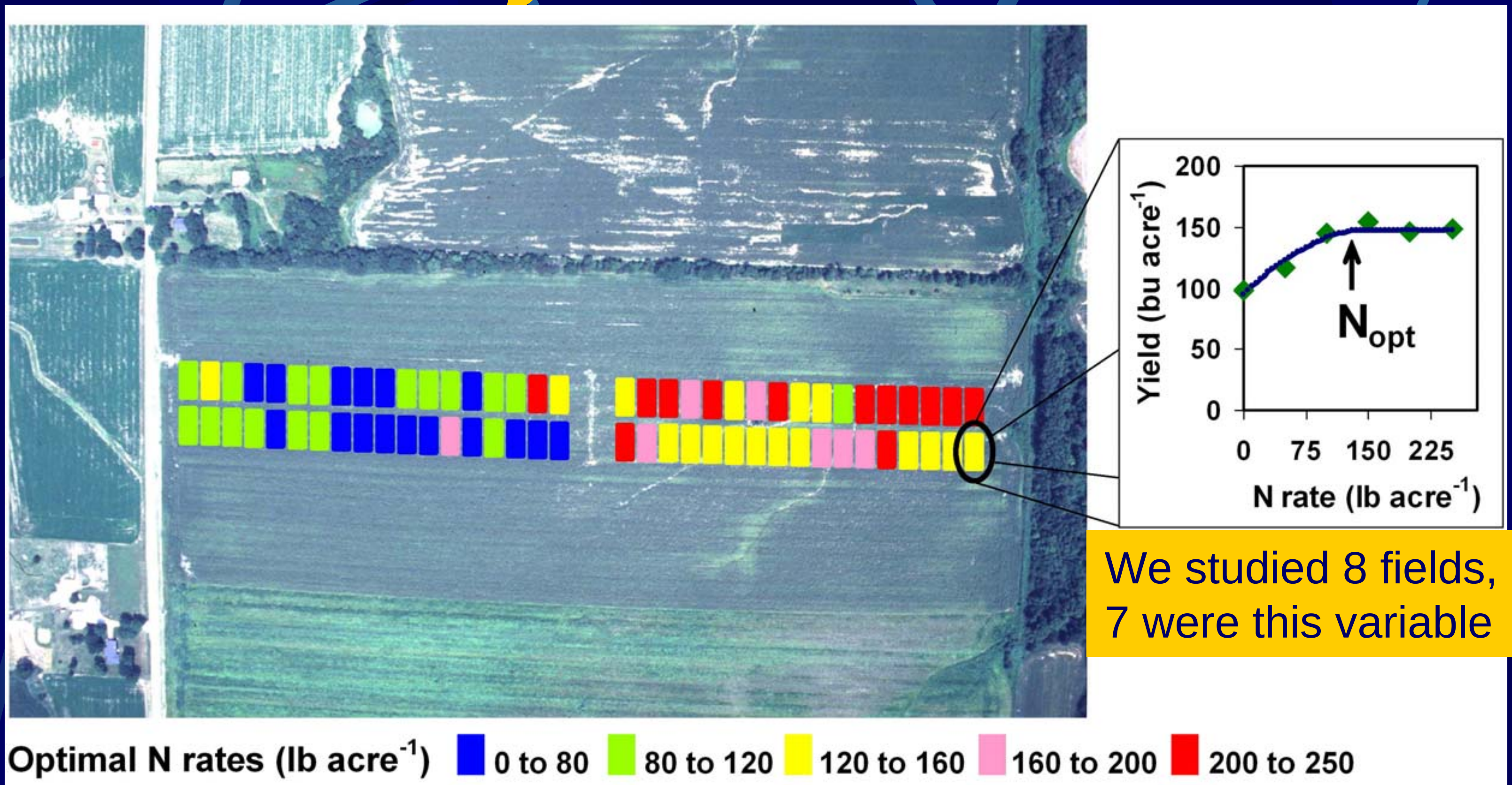
Soil nitrate in the top 4 feet after harvest is high only when optimum N fertilizer rate for corn is exceeded. Centralia, MO, 2000

Matching N rate to crop need:

HOW?

The ‘best N rate’ varies widely

Optimal N rate varies widely within a field



We studied 8 fields,
7 were this variable

What happens if you apply 150 lb N/acre to this whole field?

Yes: Minnesota, Kansas, Missouri, Pennsylvania

No: Wisconsin

A uniform N rate is usually BOTH under- and over-application

You're wrong in both directions at the same time

To apply 'the best rate', variable-rate application is necessary

But how do you know where to apply more? And where to apply less?

N transport to water

- Nitrate leaching occurs mainly during the "recharge period" when precipitation exceeds evapotranspiration
- In Missouri, maybe October to May
  - Nitrate in soil is vulnerable to

Over-application

- Mainly unused N left after harvest
- Also fall-applied N (and early spring)

Answer: Diagnosis

But correct diagnosis is difficult

Diagnosing the best N rate—how?

- ~~Soil nitrate test~~
- ~~Yield goal~~
- ~~Soil texture~~
- Crop color

Diagnosing the best N rate: crop color

- N-deficient plants are much lighter in color than plants that have enough N
- Crop sensors! (Will discuss in BMP section)

Logistics drive early N applications

- An example from spring 2010: Anhydrous ammonia shortage
  - Little applied in fall 2009
  - Supply logistics can’t keep up this spring
  - Producers are frustrated
  - They will be motivated to apply N in fall

Logistics drive early N applications

- Trend: farm more acres
- Logistics: more difficult
- Corn: tall, fast-growing
  - sidedress application creates risk of growing taller than tractor before finished
- High-clearance applicators are expensive

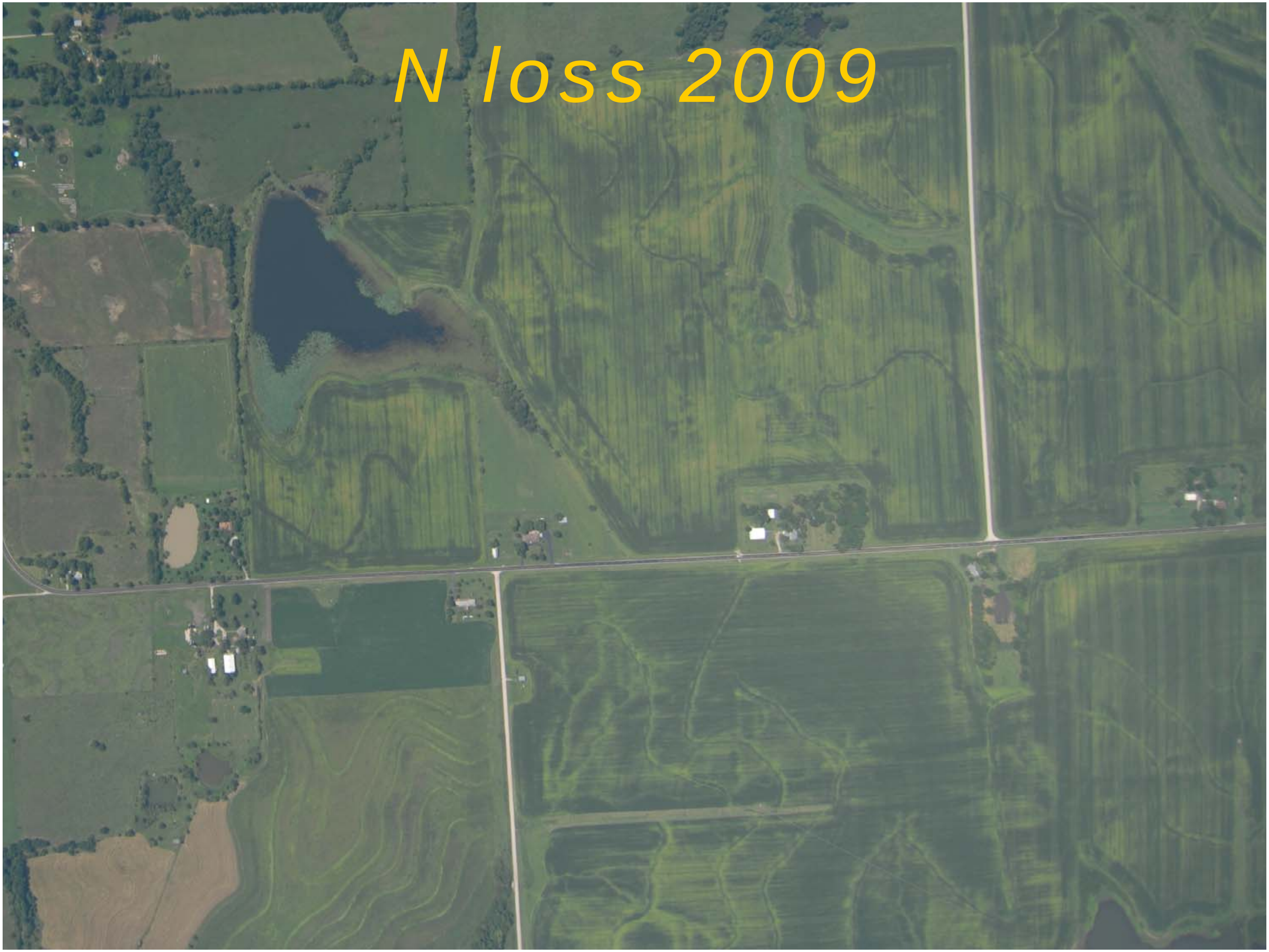
Progress

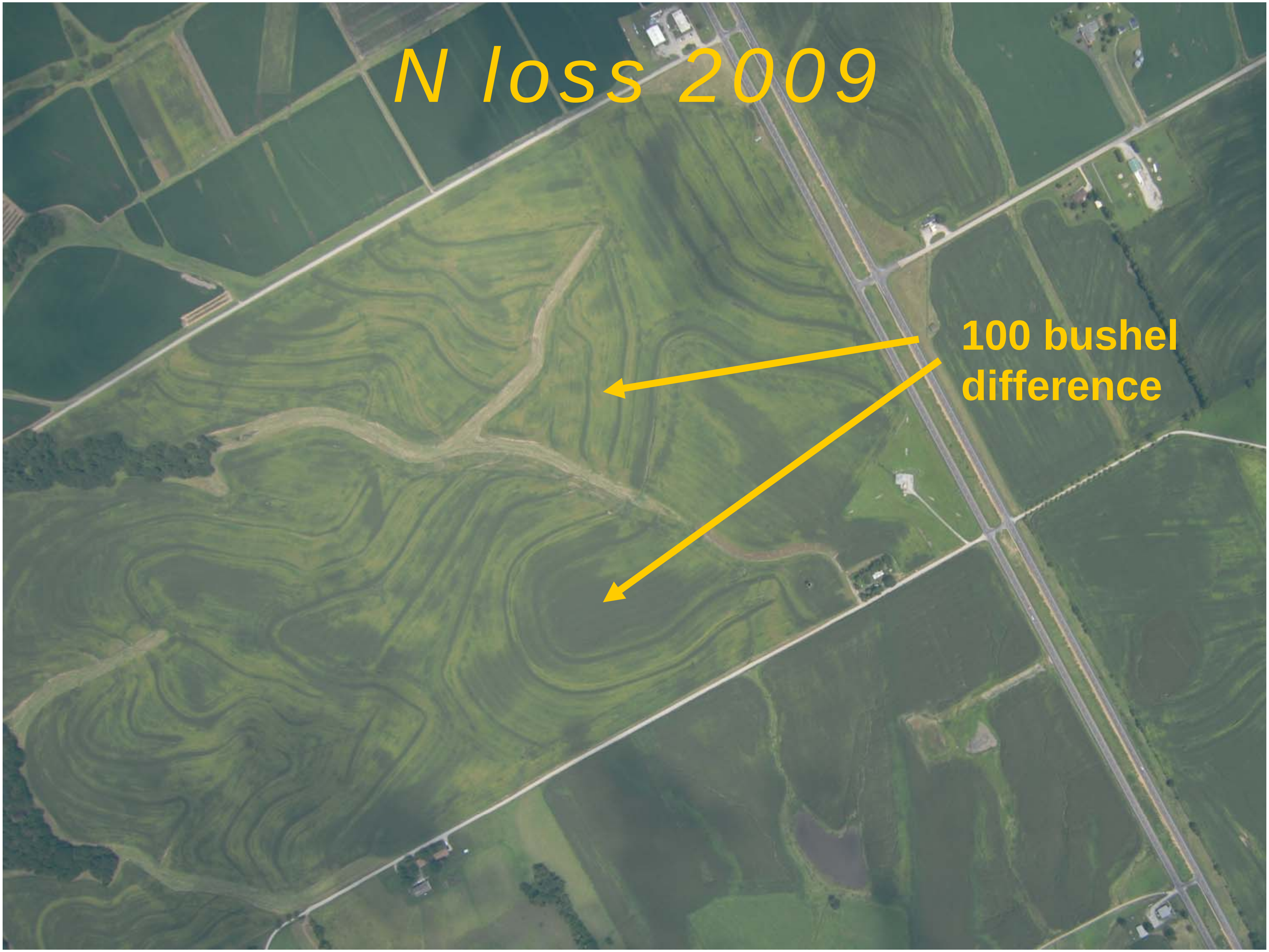
Yield is increasing faster than N rates

- Corn: yield up about 45% since 1980
- N use up about 10% since 1980 (in MO)
- A higher proportion of applied N is getting into the crop
- A smaller proportion is lost to water

Increasing awareness of N loss

- Six farm press articles on N loss so far in 2010
- Why? Big $
- I estimate 1 billion bushels lost in 2008-2009 in the midwest
- Motivation to apply N in-season


N loss 2009


N loss 2009
100 bushel
difference

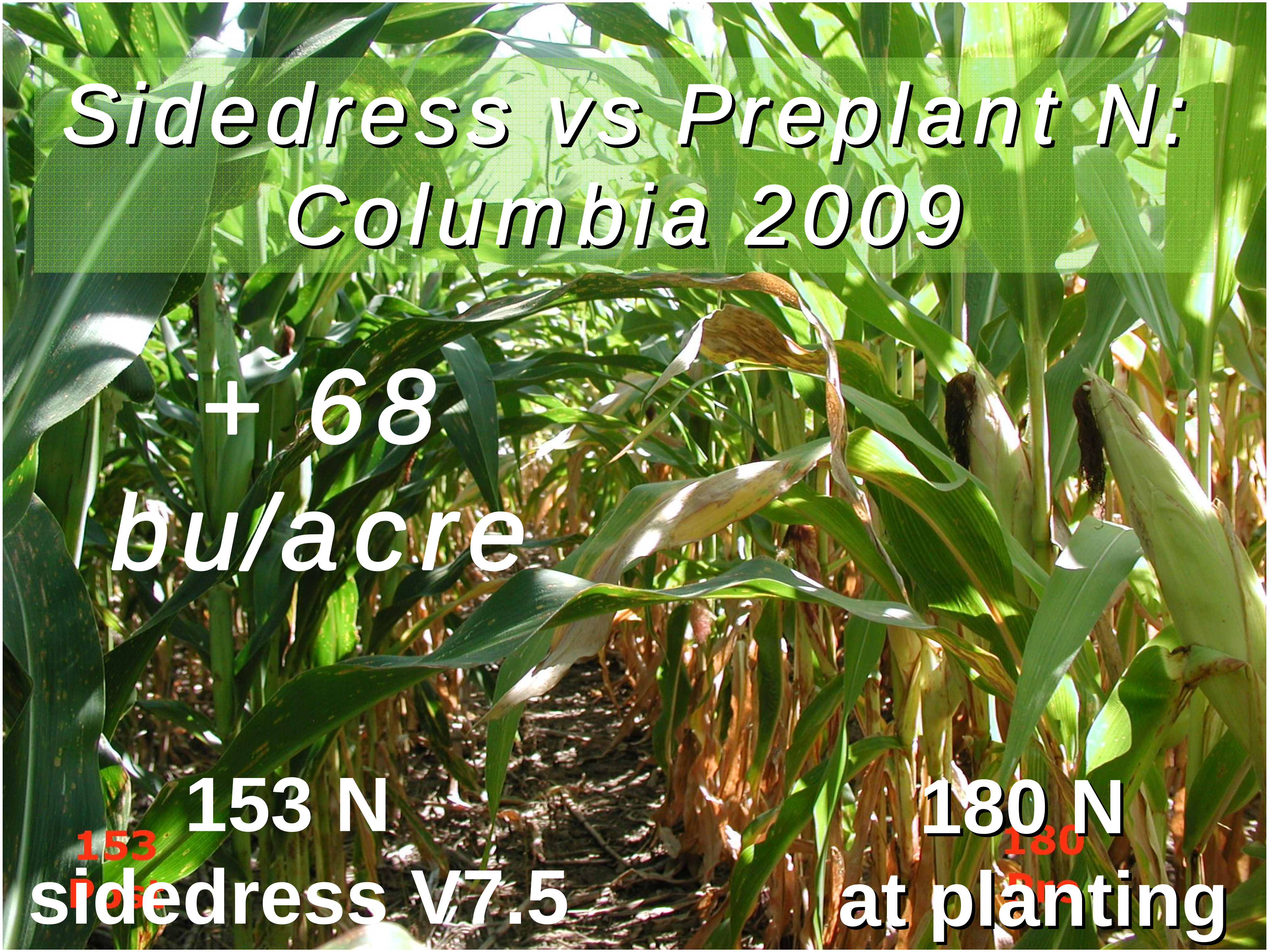
Better equipment for in-season N applications

- Faster
  - Example: new John Deere anhydrous bar
- Wider swaths: spinners, booms, bars
  - More acres per day
- More machines available
  - Retailer-owned
  - Producer-owned
  - Airplanes

BMPs

In-season N application

- Universal in MO wheat, cotton
- Some in MO rice
- Rare in MO corn, milo except in bootheel
- Why bootheel? More rain = more risk of N loss = more yield payoff

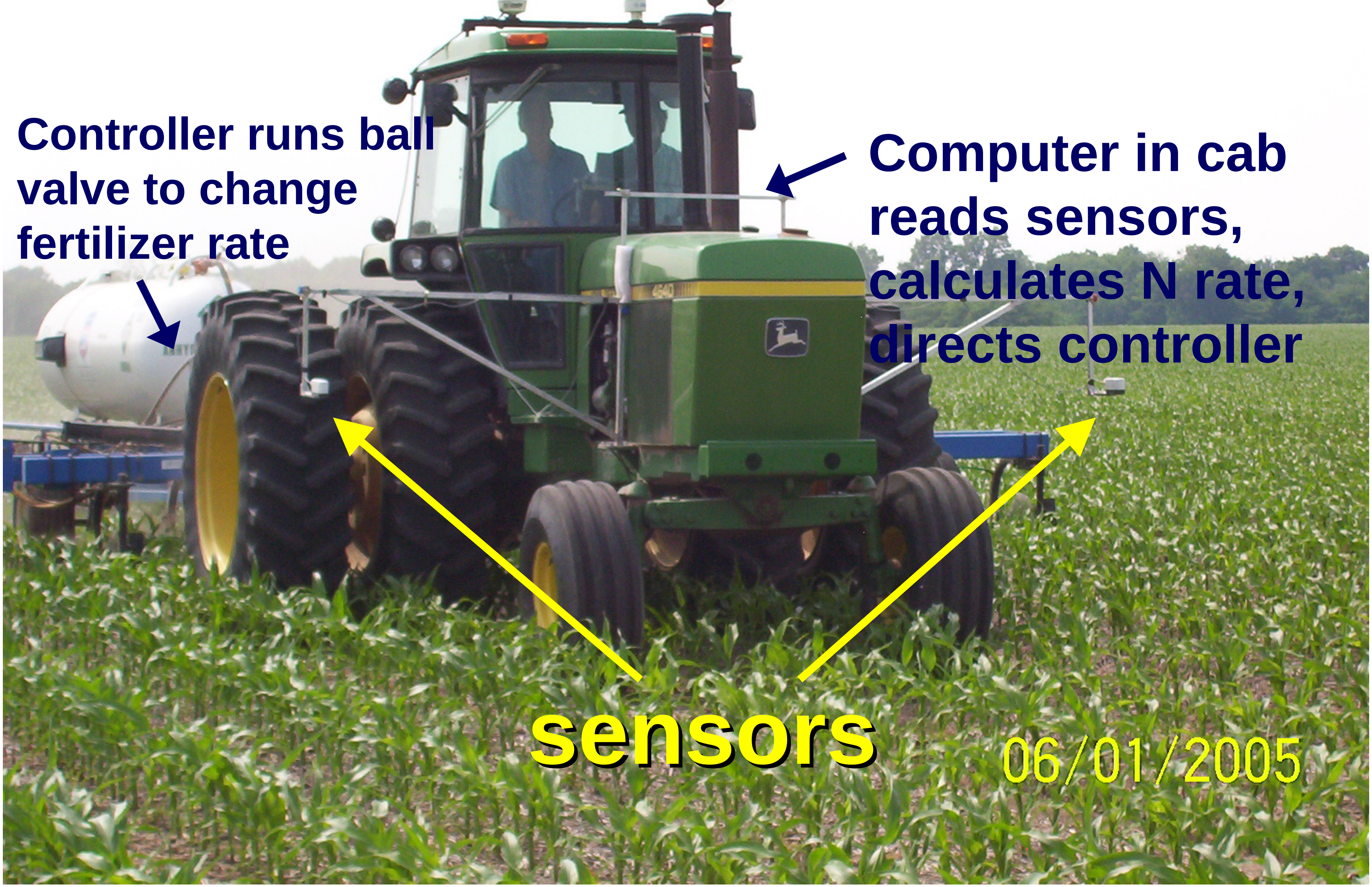

Sidedress vs Preplant N:
Columbia 2009
+ 68
bu/acre
153 N
sidedress V7.5
180 N
at planting
153
180

In-season N: yield advantage

- 2009 Columbia: 68 bushels
- 2008 Columbia: 44 bushels
- 2005 various locations: preplant gave higher yields (10-15 bushels?) (drought year)
- Many years: no effect

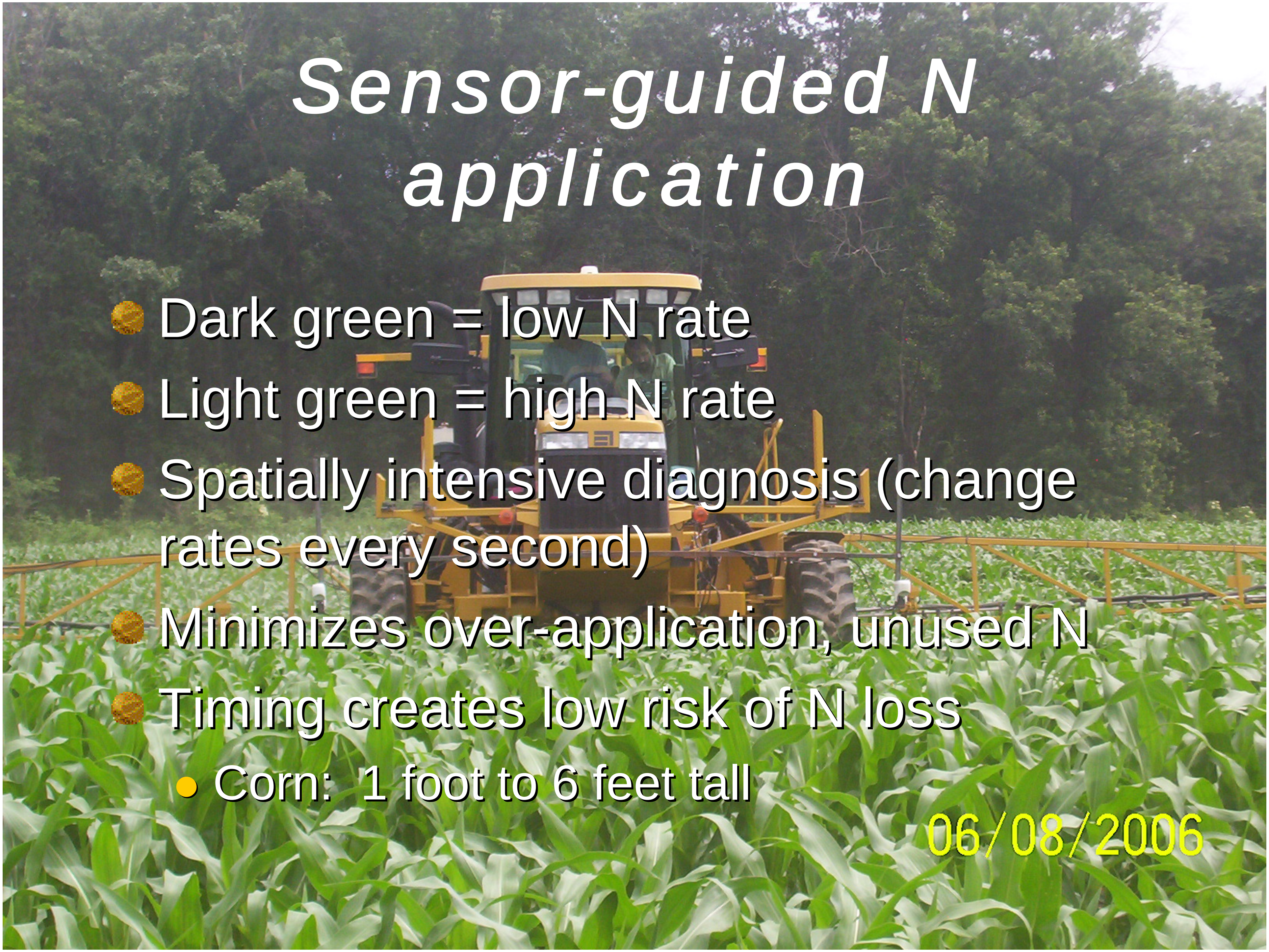
In-season N allows N rate diagnosis based on crop color (most accurate)

How does it work?



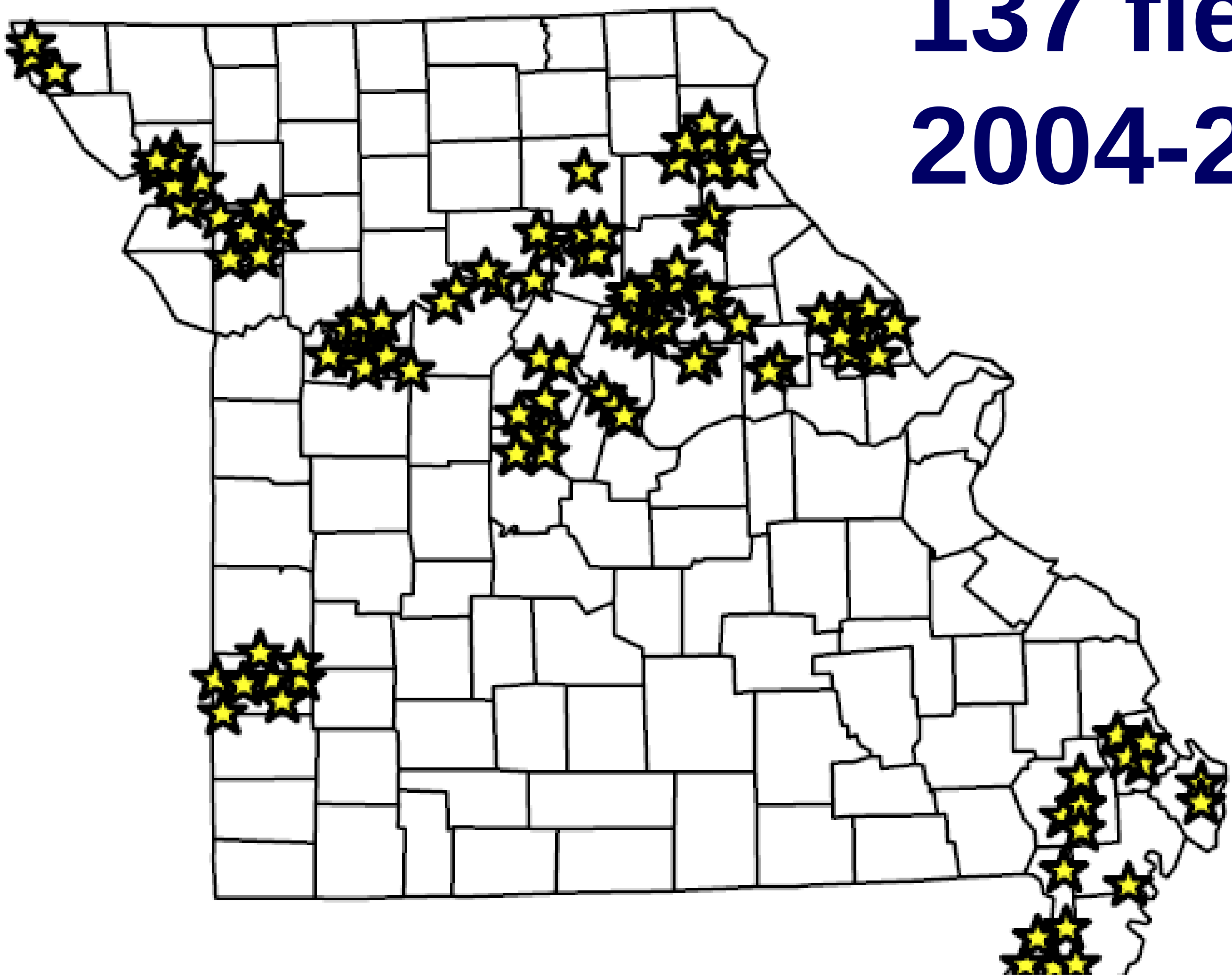
Sensor-guided N application

- Dark green = low N rate
- Light green = high N rate
- Spatially intensive diagnosis (change rates every second)
- Minimizes over-application, unused N
- Timing creates low risk of N loss
  - Corn: 1 foot to 6 feet tall



Demonstration program: started in 2004 to help farmers try this technology

137 fields, 2004-2009



Sensor outcomes:

Producer rate side-by-side with sensor rate

- 2004-2007: 41 corn fields
  - Broke even on yield
  - Saved 24 lb N/acre (avoid post-harvest loss)
  - +$12/ac
- 2008: 12 corn fields, very wet April-June
  - 9 bu/acre yield increase (152 to 161)
  - Used 16 lb extra N/acre
  - **But avoided large losses of preplant N!**
  - +$29/acre

Summary: Sensors target N loss from crops to water

- Targets the sources
  - N-fertilized crops (corn, wheat, cotton, milo)
  - N applied 'too early'
    - Lost before crop uptake period
  - N applied beyond crop needs
    - Vulnerable to loss after harvest (left in soil)
    - Crop need is spatially variable, allows diagnosis
- Targets the loss pathway
  - Underground, difficult to intercept
    - Need to keep N from entering this pathway

ESN: Coated urea

- 20 bushel advantage over urea in 2009
- Reduced N loss due to wet weather
- But still 25 bushels short of yield with in-season N

Agrotain

- Reduces ammonia volatilization from urea
- Urea left on the soil surface: average loss is 25% of N
- Sprayed onto urea before application
- Yield response:
  - Corn 7 bushels (15 MO tests)
  - Wheat 4 bushels (9 MO tests)


Questions?
06/08/2006