# University of Illinois Extension and Illinois Nutrient Strategy

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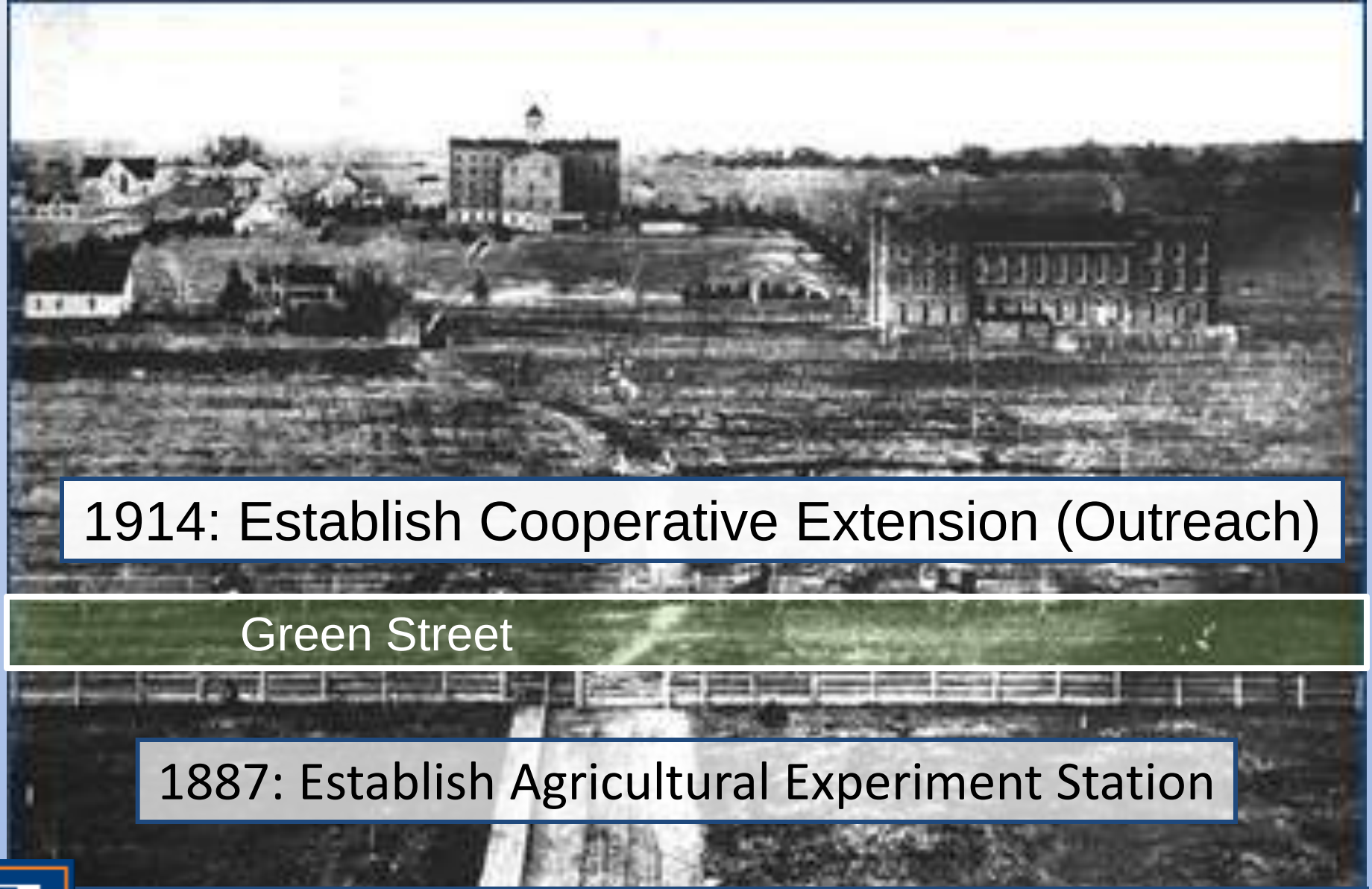
IFCA Convention
January 22, 2014


University of Illinois Archives



1914: Establish Cooperative Extension (Outreach)

Green Street

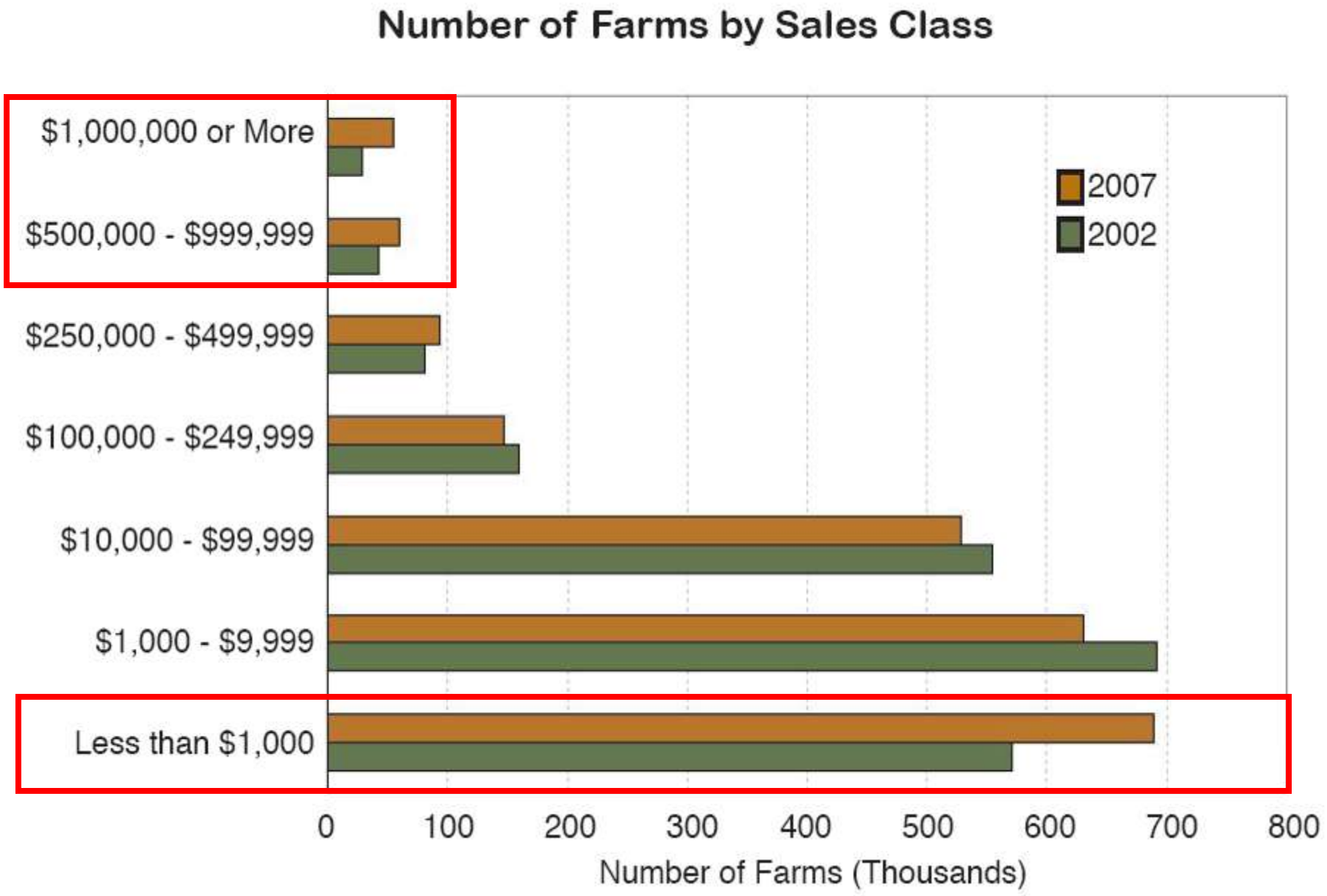
1887: Establish Agricultural Experiment Station

1867: Land Grant College – *Illinois Industrial University*
Teach Agriculture and Mechanical Arts

1867

Sampling soil from the Morrow Plots, 1904


orrow Plots, 1904


Number of Farms by Sales Class
$1,000,000 or More
$500,000 - $999,999
$250,000 - $499,999
$100,000 - $249,999
$10,000 - $99,999
$1,000 - $9,999
Less than $1,000
2007
2002
0
100
200
300
400
500
600
700
800
Number of Farms (Thousands)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**Rescheduled Meetings**
**Soybean Classic**

Posted on January 7, 2014 by

Nature reminded us earlier this
in advance, the weather often
meeting. Our long streak of
weather and road
Classic meeting

**Categories**

- Insects
- Weeds
- Diseases
- Crop Production
- Soils
- News

**Useful Pages**

- Resources
- Past Issues

additional informa
http://www.crops




UNIVERSITY OF ILLINOIS EXTENSION 100 YEARS investing in You

# Commercial Agriculture Educators


## Angie Peltier – Crops
Northwestern Illinois Agricultural Research & Demonstration Center

## Travis Meteer – Livestock
Orr Agricultural Research & Demonstration Center

## Russ Higgins – Crops
Northern Illinois Agronomy Research Center

## Dennis Bowman – Crops
Crop Sciences Research & Education Center

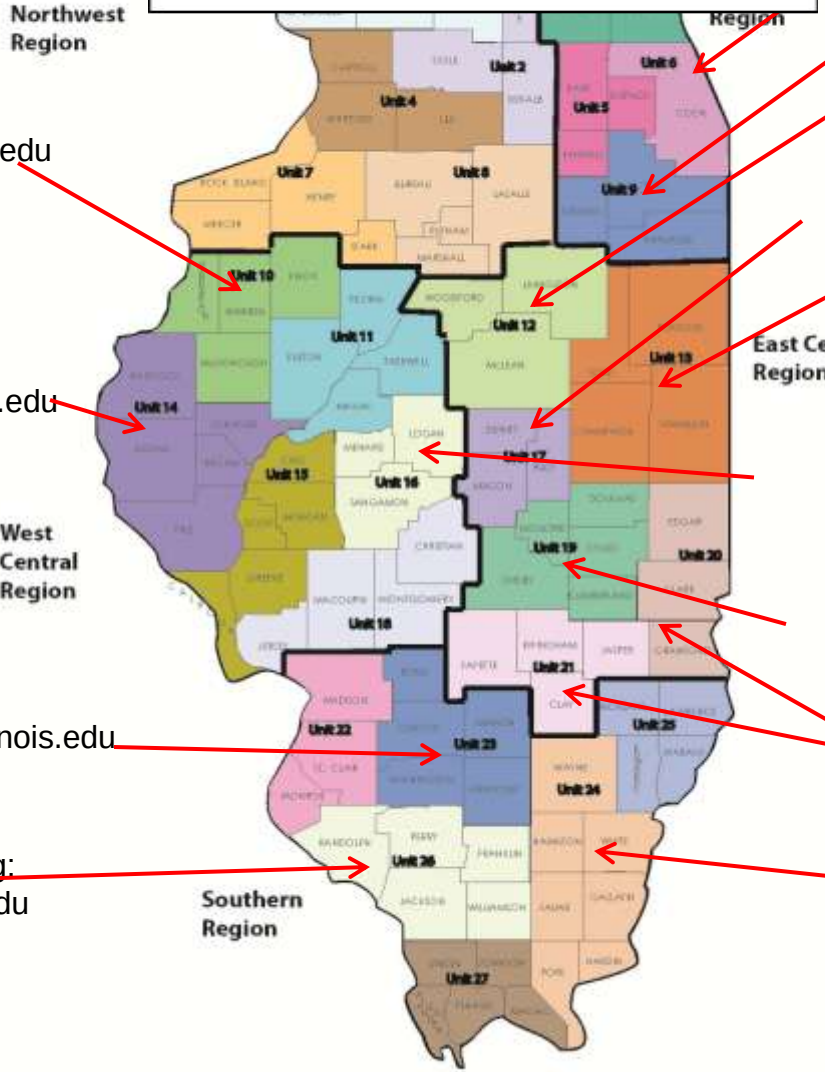
## Robert Bellm – Crops
Brownstown Agronomy Research Center

## Teresa Steckler – Livestock
Dixon Springs Agricultural Center

UNIVERSITY OF ILLINOIS EXTENSION 100 YEARS investing in You

- Environmentally and economically sound crop production practices
  - Insect, weed & disease management
  - Nutrient source, placement, & timing
  - Crop rotations & innovative cropping systems
  - Geospatial Information System and crop sensors

# Local Food Systems/Small Farms Extension Educators 15

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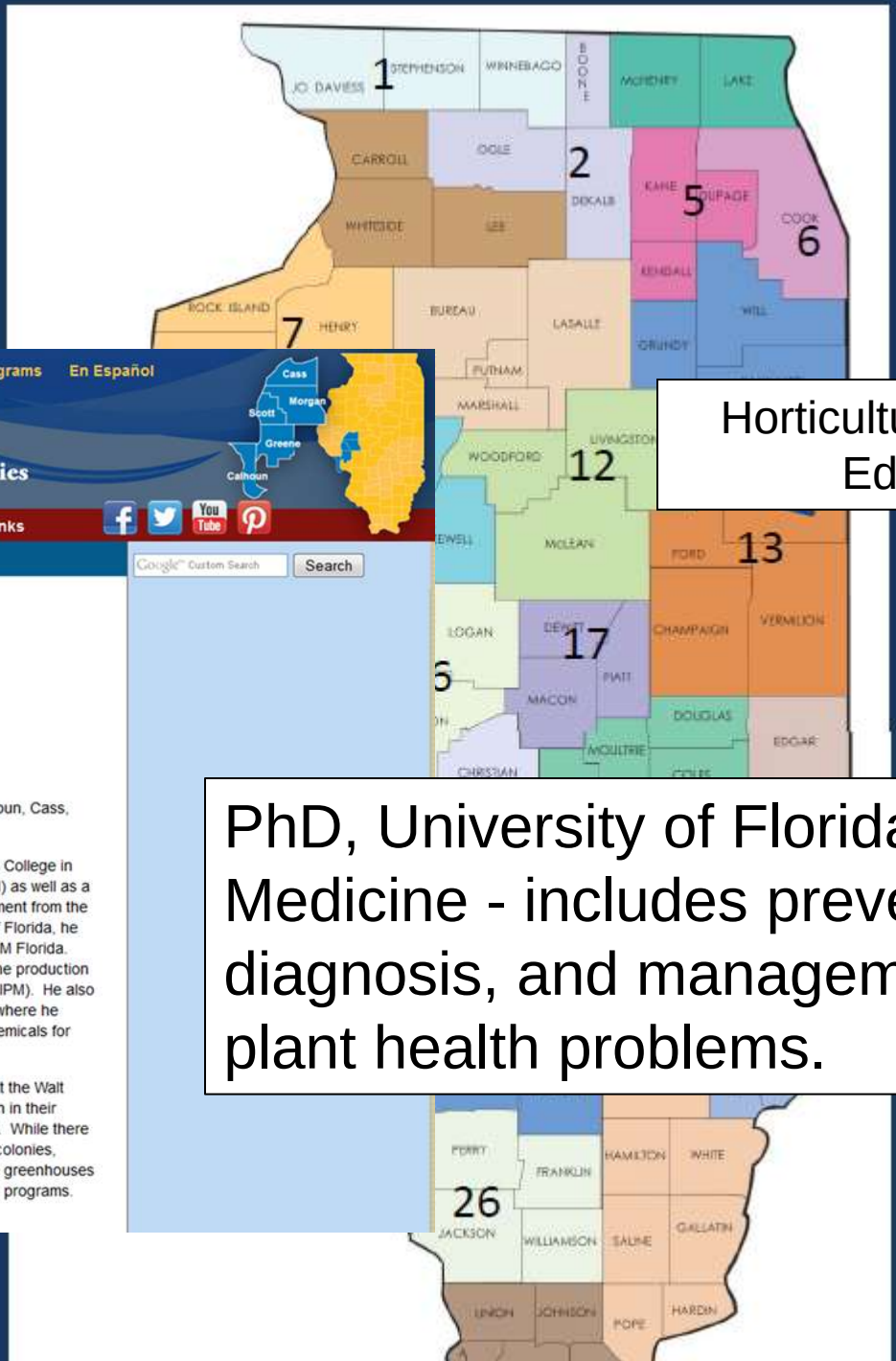
- Develop scale-appropriate business and farm management plans for new and transitional producers

- Increase local food production

- Increase understanding of marketing and distribution

336 Farmer Markets in Illinois
(2012)

# 17 Educators
# 16 Units





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Horticulture Extension Educators

PhD, University of Florida, Plant Medicine - includes prevention, diagnosis, and management of plant health problems.

# Master Gardener Program

- 2012 MG volunteer hours: 197,497 hours to Illinois residents
- 2012 economic value of volunteer service: $4.3 million
- 2012 new MGs trained: 470
- Over 36,000 youth, 53,000 adults received instruction by MG volunteers in 2012

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# Across team boundaries

- Commercial Agriculture
  - Educational programs on new 2, 4-D and Dicamba resistant crops, spray drifts, etc…
  - Home gardeners education on GMO crops

# Across team boundaries

- Current collaboration
  - Small Farms and Local food systems
    - Joint in-service training
    - Putting Small Acres to Work
  - Pesticide Safety Education Programs (PSEP)
    - General standard IPM, Ornamental and turf diseases
  - Energy and Environment
    - Private well testing program

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Environmental & Energy Stewardship Extension Educators 5

## Jay Solomon

- Jo Daviess/Stephenson/Winnebago

## Peggy Doty

- Boone/DeKalb/Ogle

## Duane Friend

- Calhoun/Cass/Greene/Morgan/Scott

## Jason Haupt

- Fulton/Mason/Peoria/Tazewell

## Gary Letterly

- Christian/Jersey/Macoupin/Montgomery

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# Soil & Water Management Workshops

- Statewide land management:
  - landowners, farmers, ranchers and agribusiness professionals
- Over 150 participants over the past two years:
  - Certified Crop Advisor accredited.
  - EES team members have served as organizers and presenters during this time period
- Other program collaborators:
  - U of I – ACES staff, Ohio State University, University of Minnesota and Iowa State University

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# Certified Crop Adviser

## Welcome

Welcome to the Certified Crop Adviser website. Below are the courses that are currently available. If you do not have an account with University of Illinois Extension yet, you can register here and sign up for the courses you would like to take. This registration is separate from your ICCA login. **An individual may only receive credit for taking a module once.**

Once you complete a course, University of Illinois Extension will report any CEUs you receive to the International Certified Crop Adviser Program in Madison.

If you have problems logging into this site, please contact uie-ewd@illinois.edu.

**Soils and Flooding**
Explore how flooding occurs and about its affect on soil and crops.
$7.50 - 0.5 CEU in Soil and Water Management

**Corn Residue and Foliar Disease**
Learn about corn foliar diseases and best practices to avoid them.

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### Login

Username (or email):

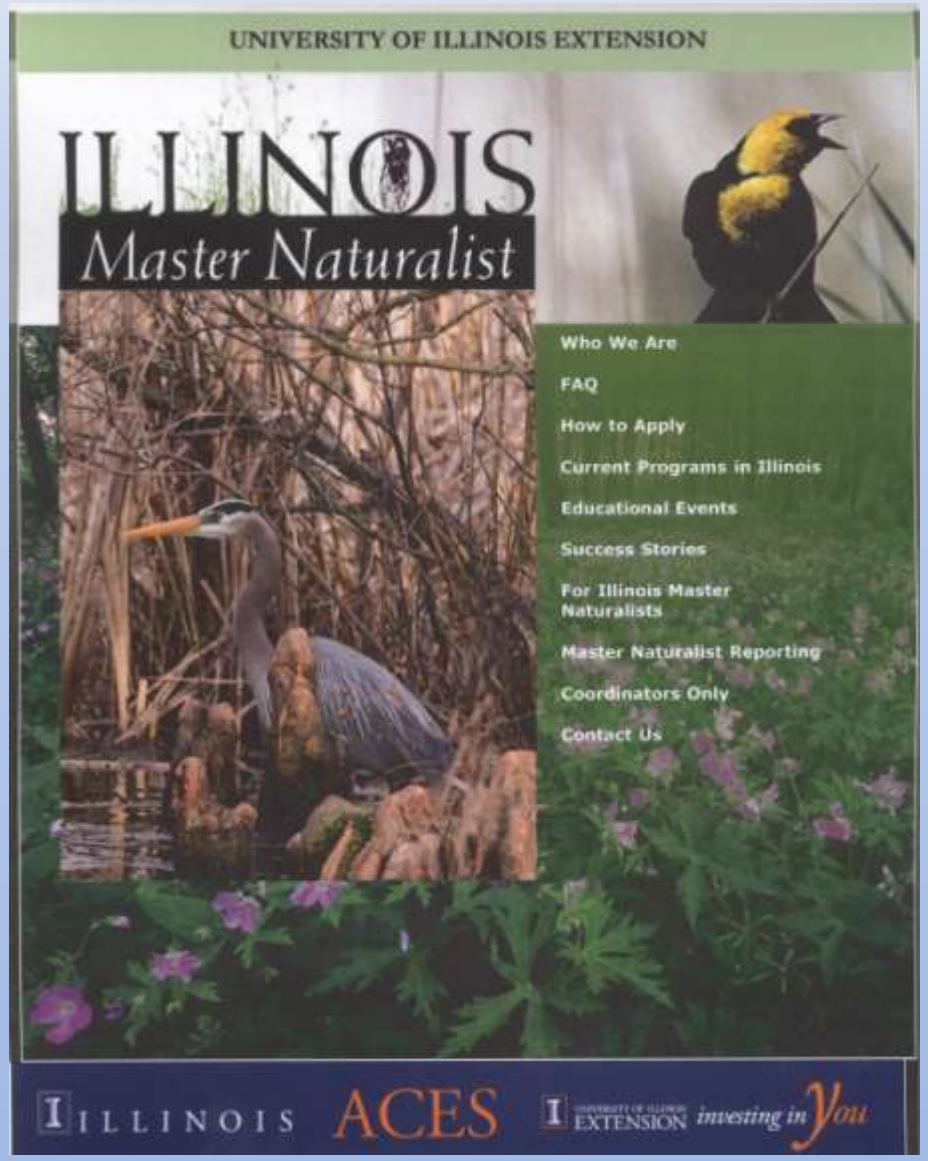
Password:

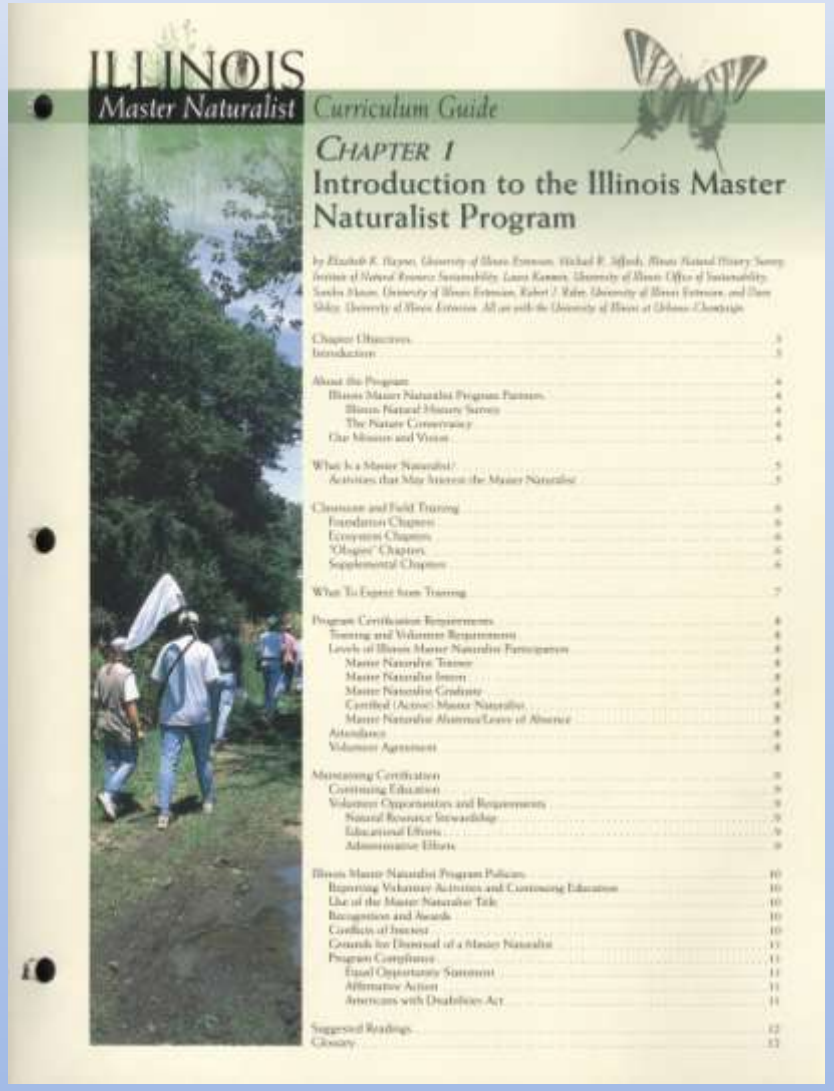
Login

Lost your password?

### Other Online Courses

- Soil Organic Matter Management
- Eight Simple Rules for Crop Scouting
- Soil Quality Tests Part I
- Drought, Soil, and Plants
- Riparian Forest Buffers
- Soil Quality Tests Part II
- Soils and Flooding
- Windbreaks and Crops
- Streambank Stabilization Methods

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# Private Well Testing

- Statewide private well water sampling project in collaboration with the Prairie Research Institute/Illinois State Water Survey.
- Team members and other unit staff worked with private well owners in areas across 6+ units.
- At the local-level stakeholder groups were used to identify private wells.
- State Water Survey Public Service Lab provided analysis of several potential contaminants including arsenic and nitrate.
- Results /Outcomes

ILLINOIS STATE WATER SURVEY
PRAIRIE RESEARCH INSTITUTE

- Illinois Natural History Survey
- Illinois State Archaeological Survey
- Illinois State Geological Survey
- Illinois State Water Survey
- Illinois Sustainable Technology Center

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EXTENSION

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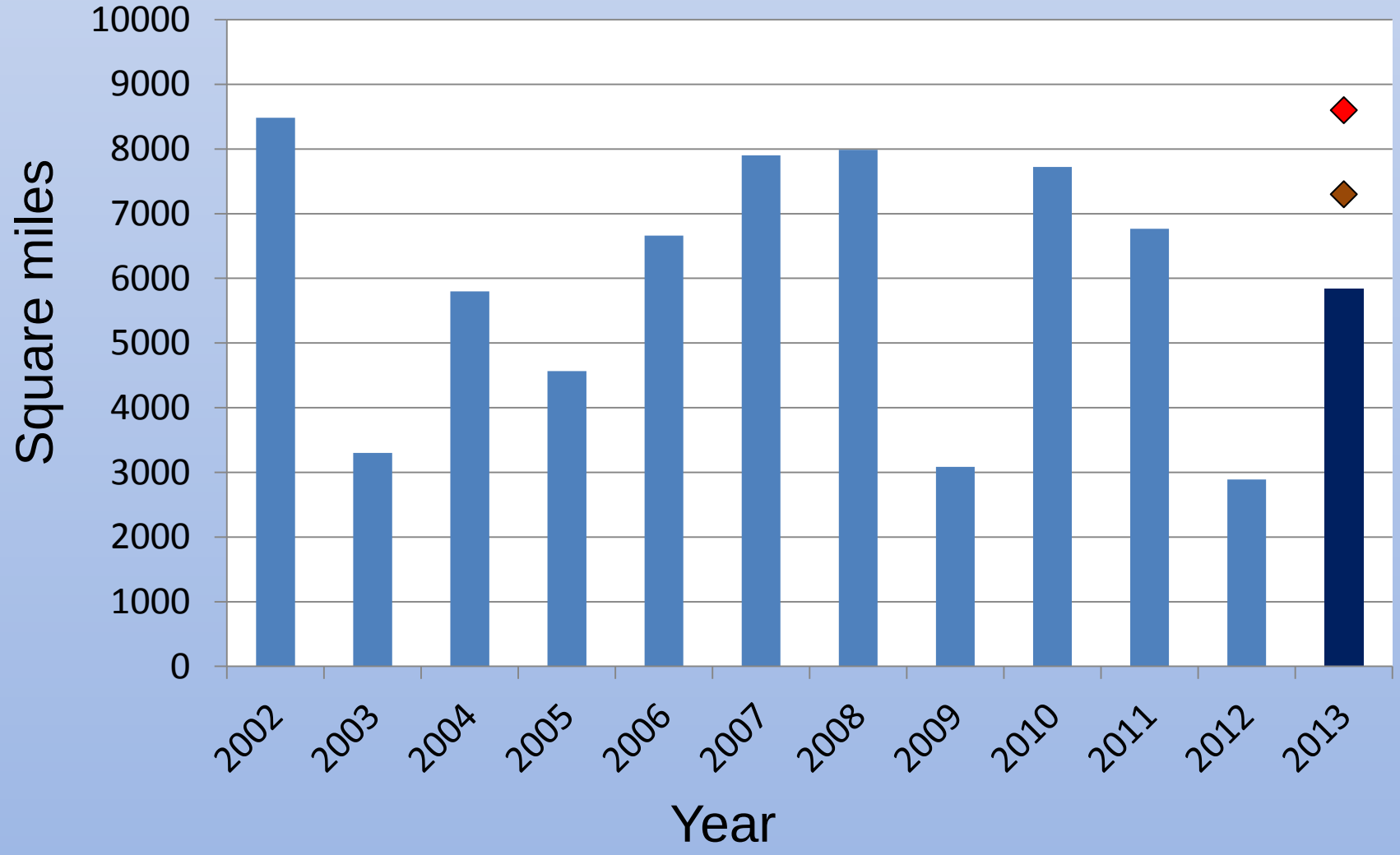
# Area of Mid-Summer Bottom Water Hypoxia (Dissolved Oxygen < 2.0 mg/L)




Source: N.N. Rabalais, Louisiana Universities Marine Consortium and R.E. Turner, Louisiana State University

## Real-Time Data and the "Super Gage"

The USGS operates and maintains national hydrologic monitoring networks consisting of more than 8,000 streamgages that typically provide water stage data and volumetric streamflow data. Often, other parameters are monitored at streamgage sites, such as water temperature, precipitation, and water quality. The physical infrastructure of a streamgage and the data recording and telemetry instrumentation it contains makes the streamgage an ideal platform for measuring and transmitting a variety of parameters—simultaneously, in real time—to examine unique trends in water resources in a critical resource area such as agricultural and urban land-use effects, water-related human health issues, floods and droughts, or hazardous-substance spills. The USGS has developed the "super gage" concept to describe such streamgages.

An example of a super gage is White River at Hazleton, Indiana (USGS streamgage 03374100). This is a large-river site with a drainage area of 11,305 square miles of primarily agricultural land. Parameters collected at this streamgage are the following:

- Physical water parameters: stage, streamflow, water velocity, water temperature, and suspended sediment (using measurements of turbidity as a surrogate).
- Water-quality parameters: dissolved oxygen, specific conductance, pH, and nitrate.

The USGS and partner agencies will use these data to assess environmental impacts of agricultural and other land-use practices through a better understanding of short-term, long-term, and seasonal trends and through more accurate water-quality modeling.


**Figure 5.** Example of a super gage is White River at Hazleton, Indiana (U.S. Geological Survey streamgage 03374100).

USGS science for a changing world

# WaterQualityWatch -- Continuous Real-Time Water Quality of Surface Water in the United States

About USGS WaterQualityWatch

Current RTWQ Maps | Redisplay

State: United States

Measurement: Nitrate

Animate Map

RTWQ Sites

Google Map of all USGS Real-Time Water Data

**RTWQ FAQ**

- What is the USGS?
- What is continuous RTWQ?
- How are sites selected?
- Why continuous and real time?
- How are these data used?
- What are these measurements?
- How are monitors maintained?
- What is a surrogate?

**Example of Sites Displaying Surrogates**

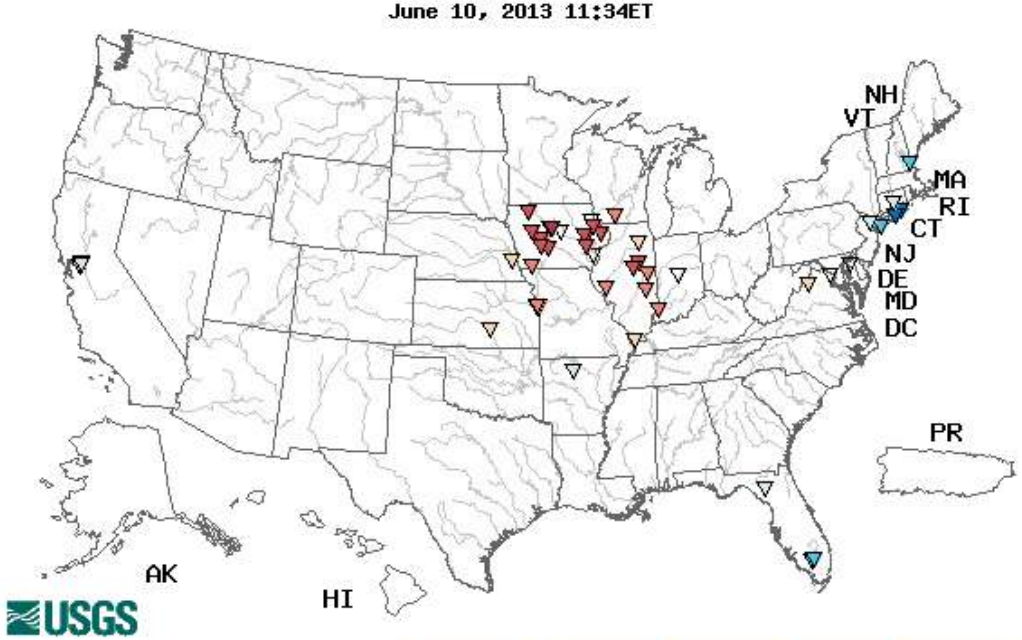
California
Colorado
Georgia
Kansas
Maryland
Montana
North Dakota
Ohio
South Dakota
Wyoming

**Examples of Surrogates Methods and Reports**

National
California
Colorado
Florida
Georgia
Kansas
Montana
Maryland
North Dakota
Ohio
Oregon
Wyoming

## Real-Time Nitrate, in mg/L

June 10, 2013 11:34ET




Explana

| <.1 | .1-.29 | .3-.99 | 1-2.99 |
|---|---|---|---|

Temp | Cond | pH | D.O. | Turb | Nitrate | Disch

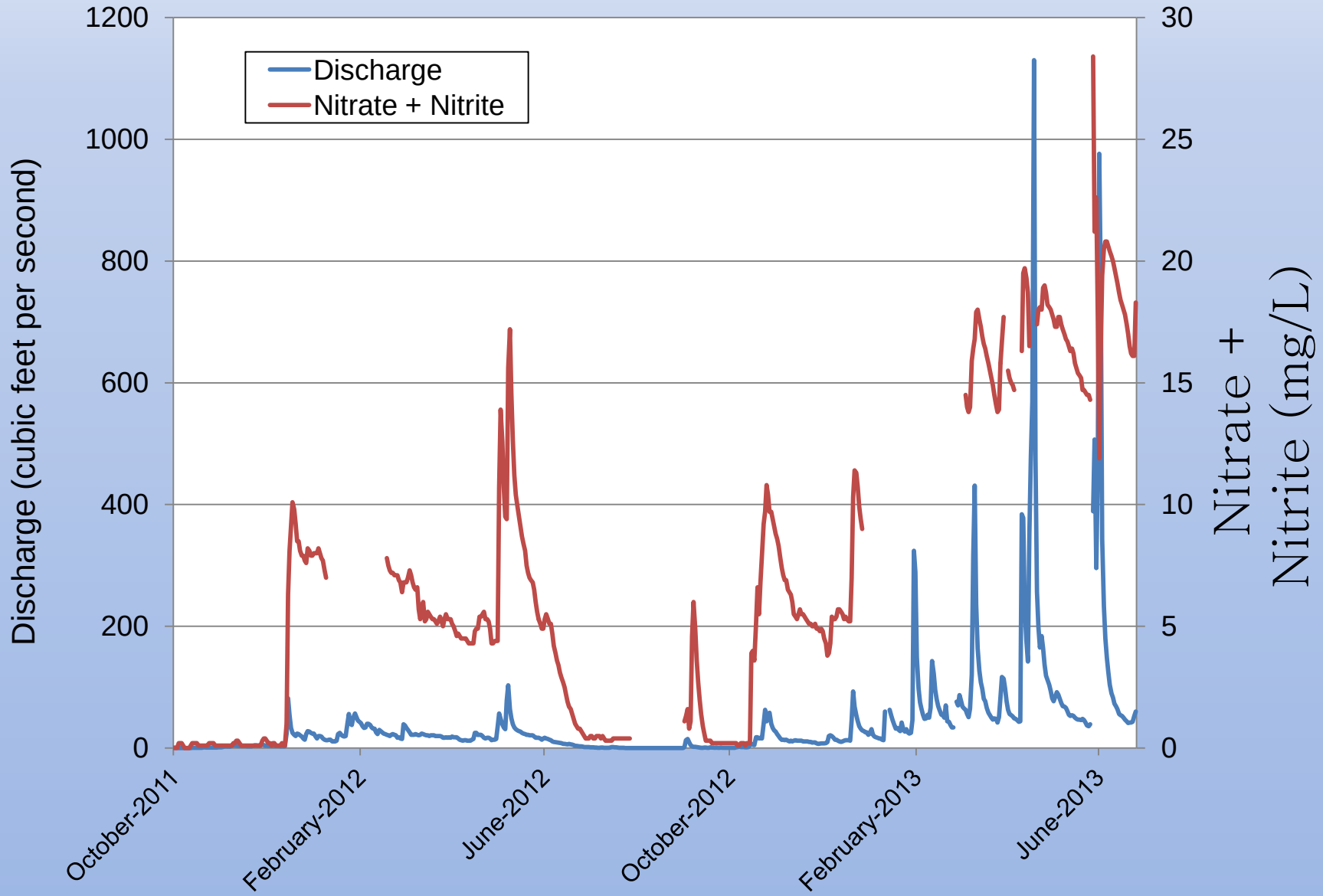
* Site operated on a seasonal basis or currently is not operating.
No values are available for the last 6 hours.

The "Real-time" map tracks short-term changes (over several hours) of water quality. Although the general appearance of the map changes very little from one h
change rapidly in response to major rain events or to reservoir releases. The data used to produce this map are provisional.

**Animate national map by current Month, or last 12 months**

http://waterwatch.usgs.gov/wqwatch/

# USGS 05554300 INDIAN CREEK NEAR FAIRBURY, IL




waterwatch.usgs.gov

# IOWA STATE UNIVERSITY

Iowa Nutrient Reduction Strategy





## Iowa Nutrient Reduction Strategy

The Iowa Nutrient Reduction Strategy is a science and technology-based framework to assess and reduce nutrients to Iowa waters and the Gulf of Mexico. It is designed to direct efforts to reduce nutrients in surface water from both point and nonpoint sources in a scientific, reasonable and cost effective manner.

The Mississippi River/Gulf of Mexico Watershed Nutrient Task Force was established in 1997 to coordinate activities to reduce the size, severity and duration of hypoxia in the Gulf. Hypoxia is a large area of low oxygen that can't sustain marine life. Nutrients that lead to algae growth are the main culprit.

In its 2008 Action Plan, the task force called upon each of the 12 states along the Mississippi River to develop its own nutrient reduction strategy.

Working together, the Iowa Department of Agriculture and Land Stewardship, the Iowa

**The Iowa Nutrient Reduction Strategy was developed by:**

IOWA DEPARTMENT OF AGRICULTURE AND LAND STEWARDSHIP

## Iowa Strategy to Reduce Nutrient Loss: Nitrogen Practices

This table lists practices with the largest potential impact on nitrate-N concentration reduction (except where noted). Corn yield impacts associated with each practice also are shown as some practices may be detrimental to corn production. If using a combination of practices, the reductions are not additive. Reductions are field level results that may be expected where practice is applicable and implemented.

| | Practice | Comments | % Nitrate-N Reduction[+] | % Corn Yield Change[++] |
|---|---|---|---|---|
| | | | Average (SD*) | Average (SD*) |
| Nitrogen Management | Timing | Moving from fall to spring pre-plant application | 6 (25) | 4 (16) |
| | | Spring pre-plant/sidedress 40-60 split Compared to fall-applied | 5 (28) | 10 (7) |
| | | Sidedress – Compared to pre-plant application | 7 (37) | 0 (3) |
| | | Sidedress – Soil test based compared to pre-plant | 4 (20) | 13 (22)** |
| | Source | Liquid swine manure compared to spring-applied fertilizer | 4 (11) | 0 (13) |
| | | Poultry manure compared to spring-applied fertilizer | -3 (20) | -2 (14) |
| | Nitrogen Application Rate | Nitrogen rate at the MRTN (0.10 N:corn price ratio) compared to current estimated application rate. (ISU Corn Nitrogen Rate Calculator – http://extension.agron.iastate.edu/soilfertility/nrate.aspx can be used to estimate MRTN but this would change Nitrate-N concentration reduction) | 10 | -1 |
| | Nitrification Inhibitor | Nitrapyrin in fall – Compared to fall-applied without Nitrapyrin | 9 (19) | 6 (22) |
| | Cover Crops | Rye | 31 (29) | -6 (7) |
| | | Oat | 28 (2) | -5 (1) |
| | Living Mulches | e.g. Kura clover – Nitrate-N reduction from one site | 41 (16) | -9 (32) |
| Land Use | Perennial | Energy Crops – Compared to spring-applied fertilizer | 72 (23) | |
| | | Land Retirement (CRP) – Compared to spring-applied fertilizer | 85 (9) | |
| | Extended Rotations | At least 2 years of alfalfa in a 4 or 5 year rotation | 42 (12) | 7 (7) |
| | Grazed Pastures | No pertinent information from Iowa – assume similar to CRP | 85 | |
| Edge-of-Field | Drainage Water Mgmt. | No impact on concentration | 33 (32) | |
| | Shallow Drainage | No impact on concentration | 32 (15) | |
| | Wetlands | Targeted water quality | 52 | |
| | Bioreactors | | 43 (21) | |
| | Buffers | Only for water that interacts with the active zone below the buffer. This would only be a fraction of all water that makes it to a stream. | 91 (20) | |

[+] A positive number is nitrate concentration or load reduction and a negative number is an increase.

[++] A positive corn yield change is increased yield and a negative number is decreased yield. Practices are not expected to affect soybean yield.

* SD = standard deviation. Large SD relative to the average indicates highly variable results.

** This increase in crop yield should be viewed with caution as the sidedress treatment from one of the main studies had 95 lb-N/acre for the pre-plant treatment but 110 lb-N/acre to 200 lb-N/acre for the sidedress with soil test treatment so the corn yield impact may be due to nitrogen application rate differences.

SP 435 February 2013



Iowa N

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lead to alga

In its 2008
Mississippi

Working together, the Iowa Department of Agriculture and Land Stewardship, the Iowa

# Science Assessment to Support an Illinois Nutrient Reduction Strategy

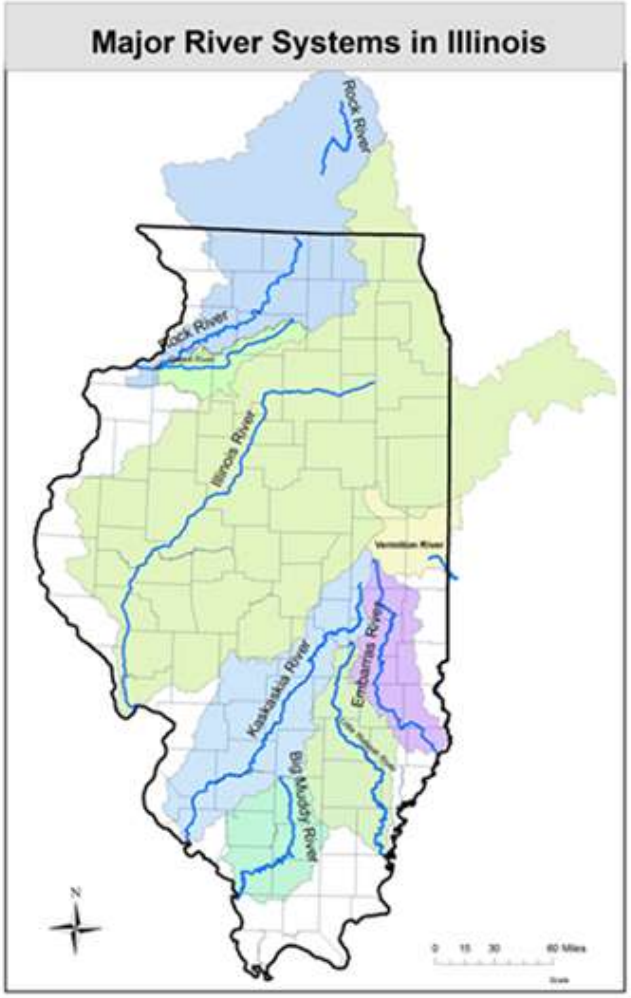
Mark David, George Czapar,
Greg McIsaac, Corey Mitchell, and
Gary Schnitkey

# Science Assessment to Support an Illinois Nutrient Reduction Strategy, Illinois EPA

1. Determine current conditions

# Riverine N and P Loads (1997-2011)

**Million pounds/year**



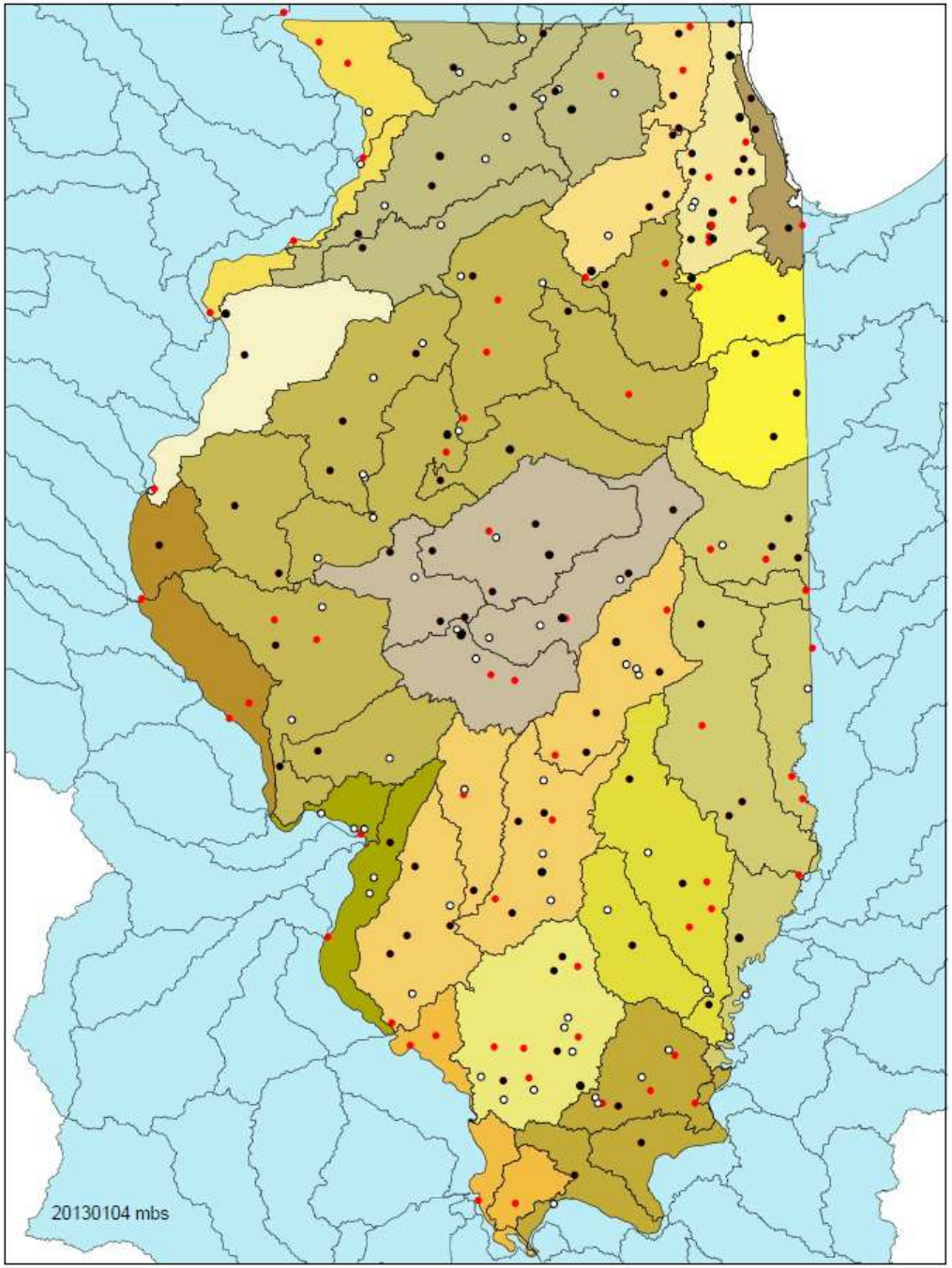

| | Nitrate-N | Total P |
|---|---|---|
| Illinois River | 229.3 | 18.7 |
| Green River | 9.0 | 0.4 |
| Big Muddy | 19.8 | 1.1 |
| Kaskaskia River | 10.4 | 2.9 |
| Little Wabash | 5.5 | 2.4 |
| Rock River | 28.7 | 1.8 |
| Vermilion River | 19.0 | 0.9 |
| Embarras River | 14.6 | 1.3 |
| | | |
| State | 410.1 | 37.9 |

# Science Assessment to Support an Illinois Nutrient Reduction Strategy, Illinois EPA

1. Determine current conditions

2. Identify critical watersheds

**Figure 2. 8-digit HUCs in Illinois and IEPA ambient water quality stations. Black = active with gage, Red = active WQ only, open circle = inactive.**

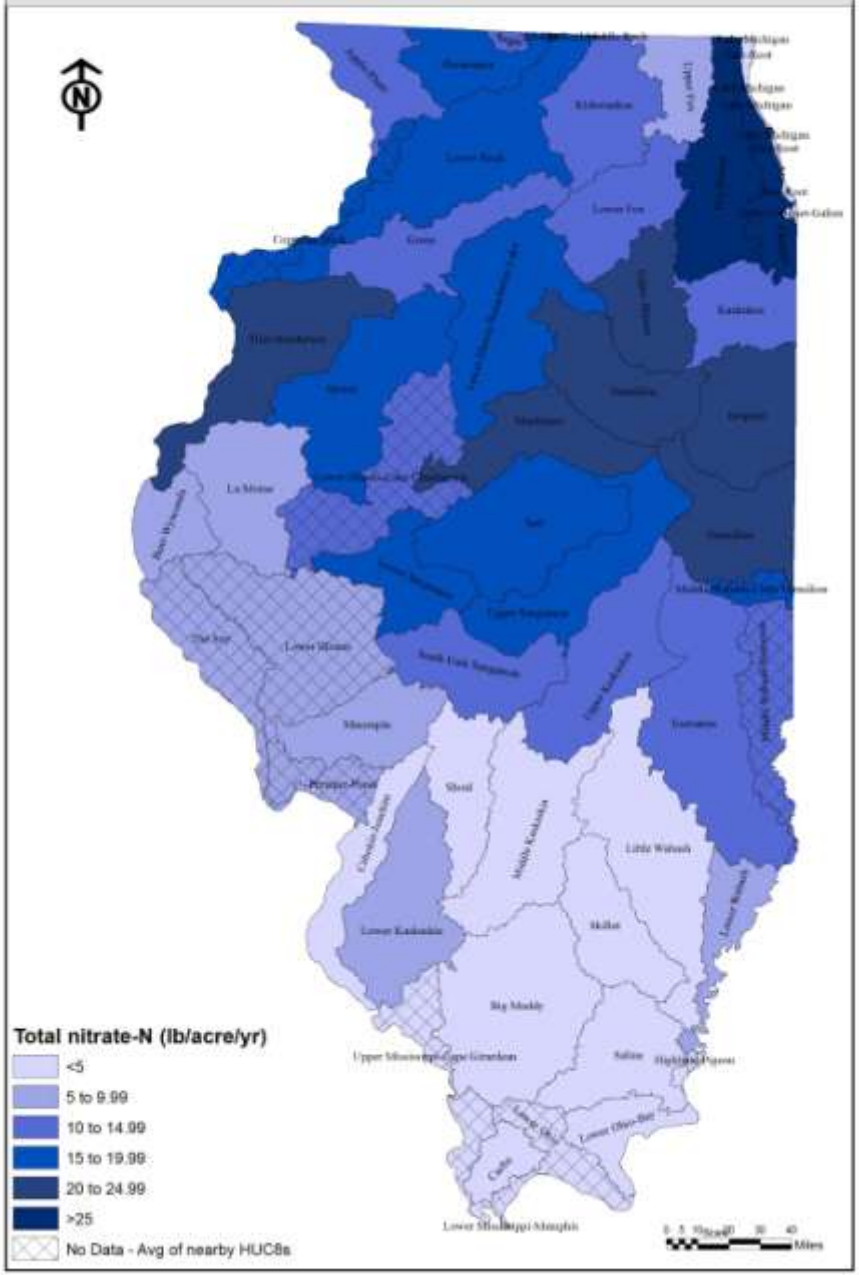



Watershed Terminology:
Region = HUC-2
Subregrion = HUC-4
Basin = HUC-6
**Subbasin = HUC-8**
**Watershed = HUC-10**
**Subwatershed = HUC-12**

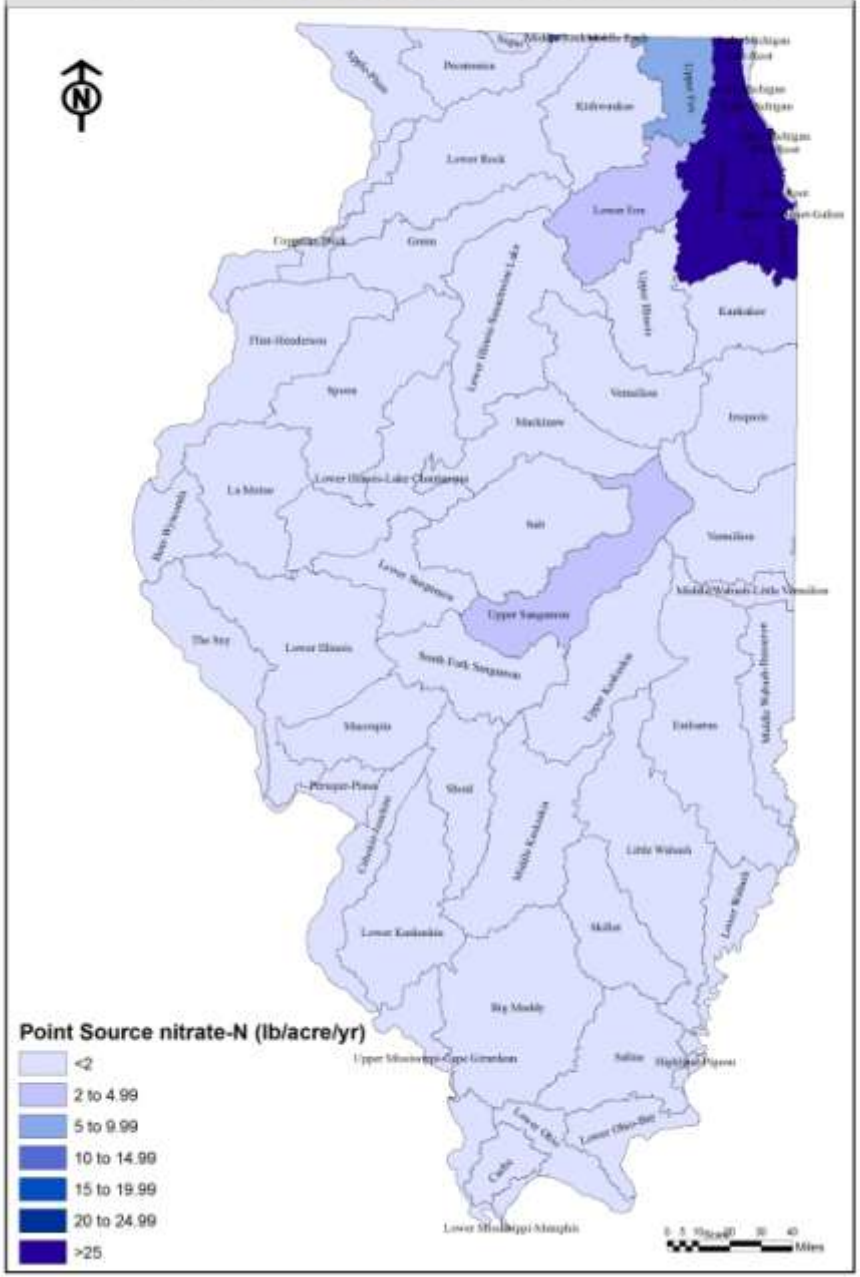
# Critical Watershed Identification

- Identify 8 digits HUCs with the highest nutrient yields and loads to the Gulf of Mexico
- Estimate point and non-point sources of N and P within watersheds

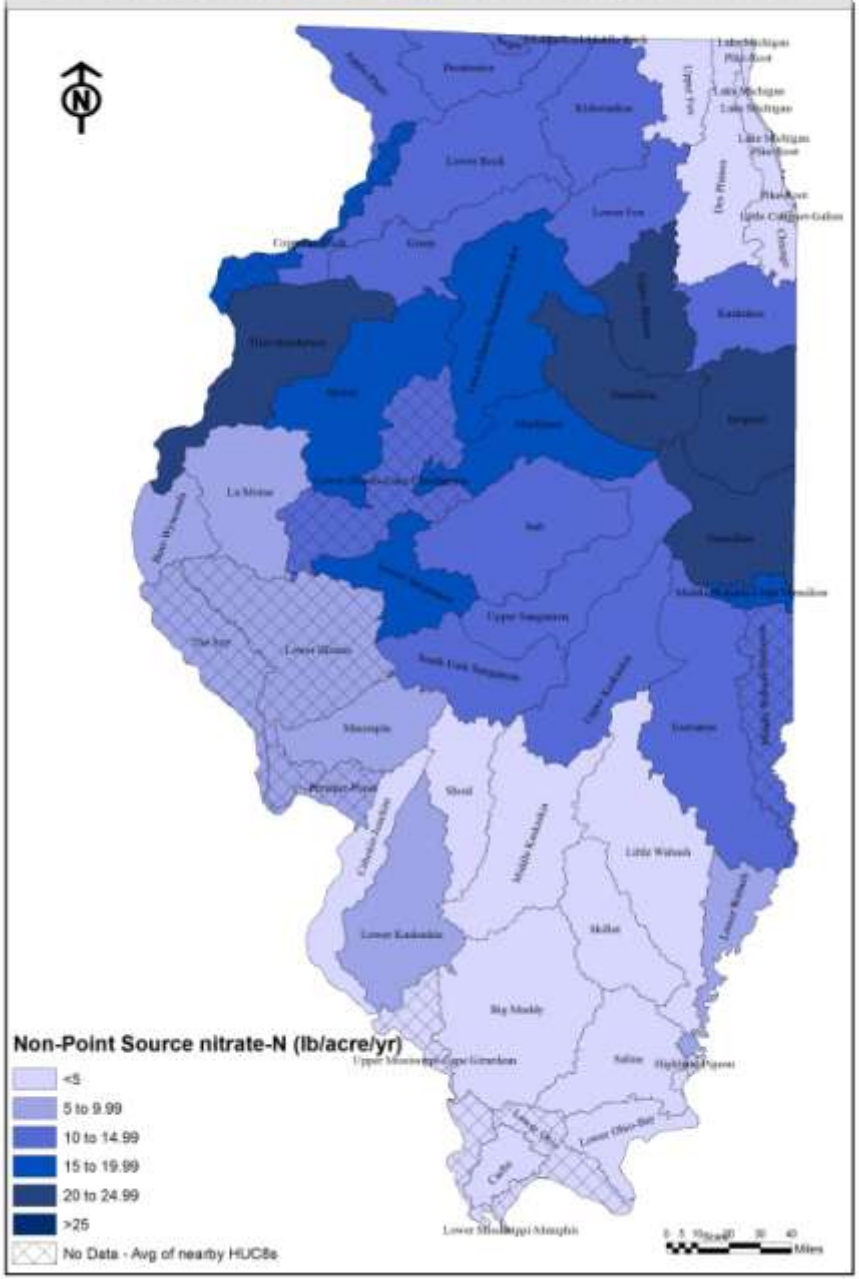
# HUC8 Total nitrate-N Yields



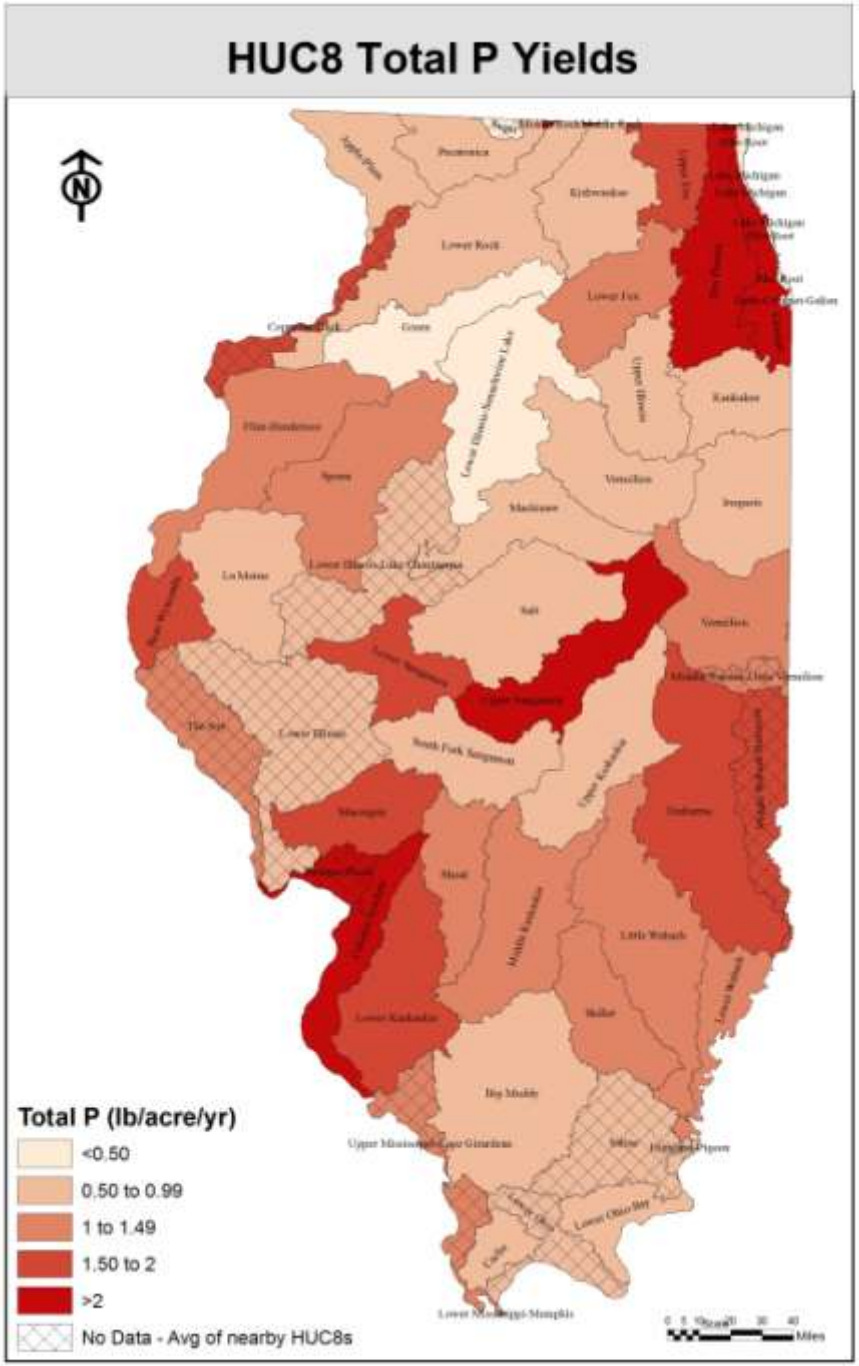
## HUC8 Point Source nitrate-N Yields



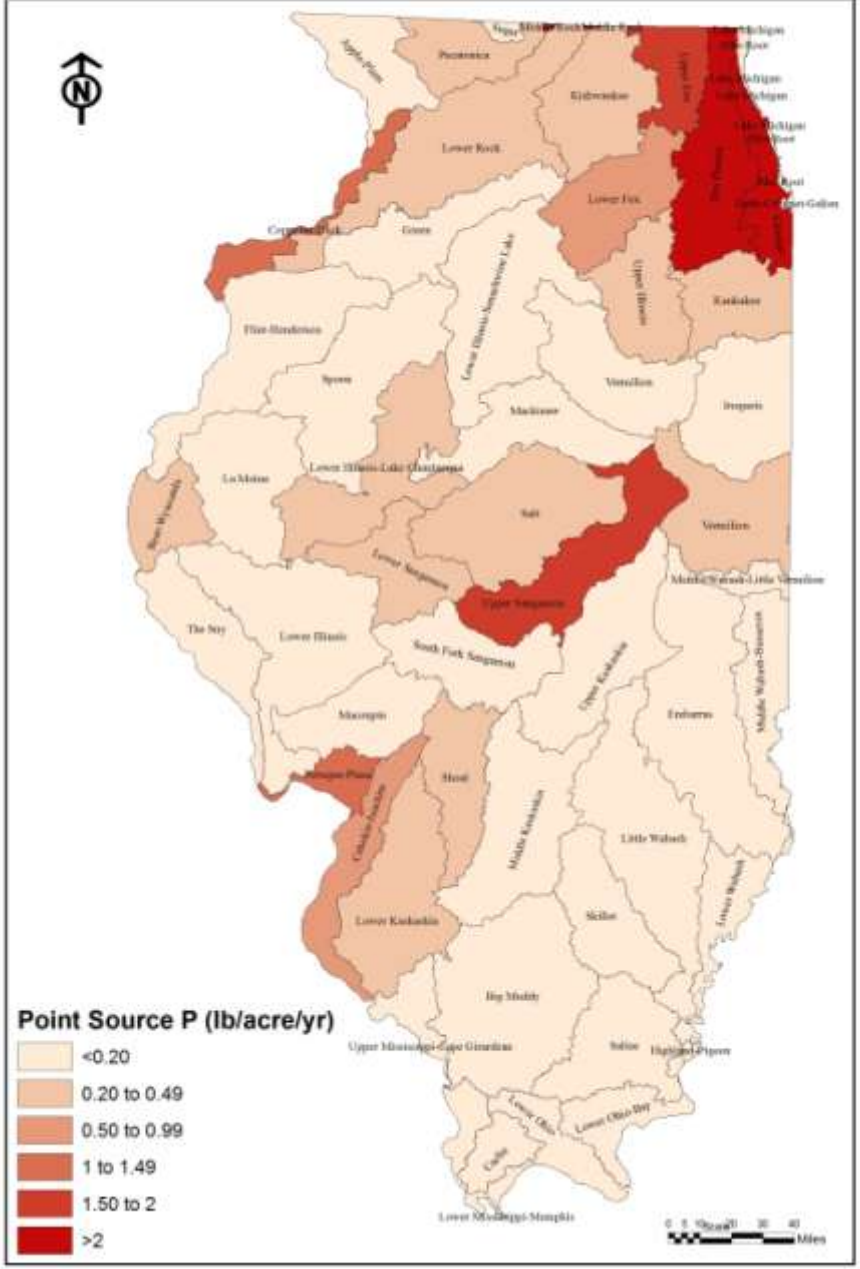

## HUC8 Non-Point Source nitrate-N Yields



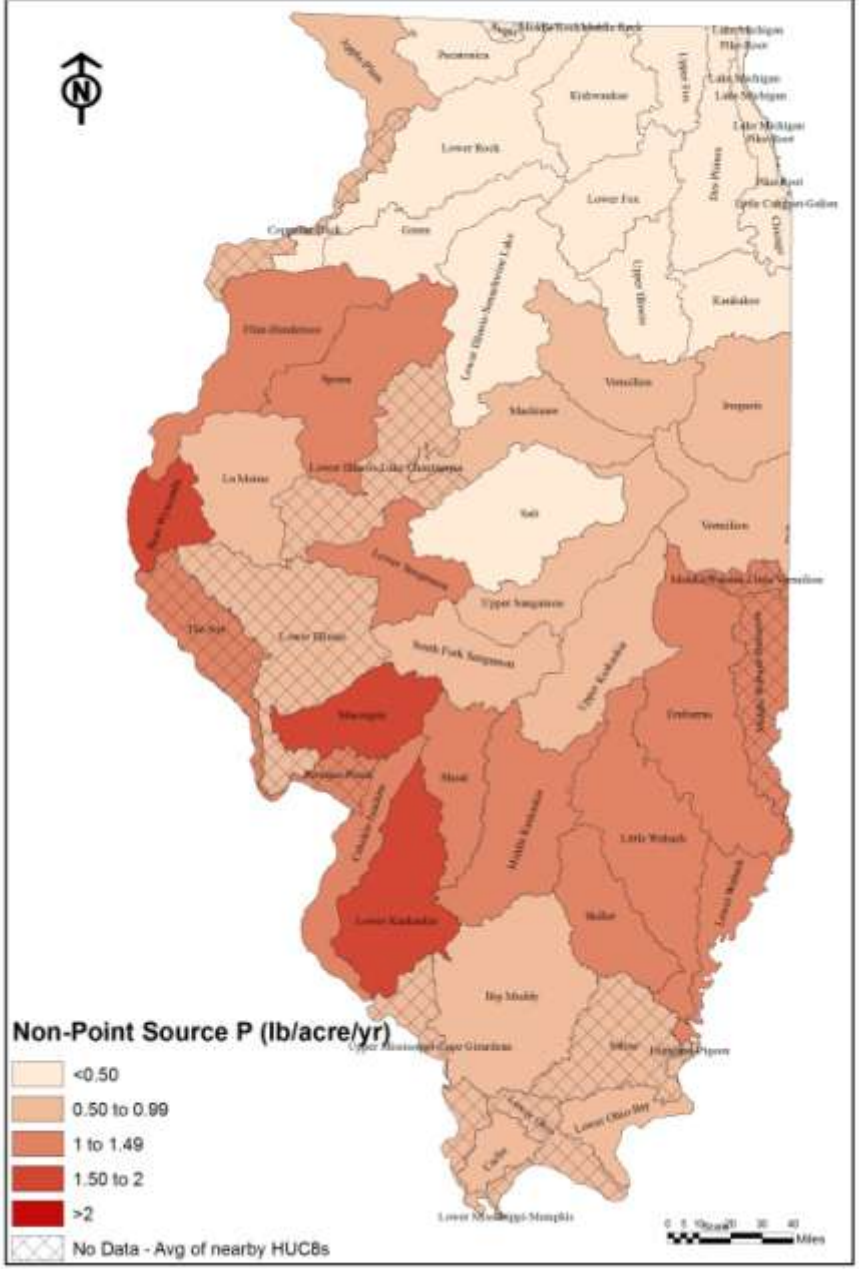
# HUC8 Total P Yields



## HUC8 Point Source P Yields




## HUC8 Non-Point Source P Yields



# Science Assessment to Support an Illinois Nutrient Reduction Strategy, Illinois EPA

1. Determine current conditions
2. Identify critical watersheds
3. Estimate potential reductions and costs

DRAFT

# Example Statewide Results for N

| | Practice/Scenario | Nitrate-N reduction per acre (%) | Nitrate-N reduced (million lb N) | Nitrate-N Reduction % (from baseline) |
|---|---|---|---|---|
| | Baseline | | 410 | |
| In-field | Reducing N rate from background to the MRTN (10% of acres) | 10 | 2.3 | 0.6 |
| | Nitrification inhibitor with all fall applied fertilizer on tile-drained corn acres | 10 | 4.3 | 1.0 |
| | Split (50%) fall and spring (50%) on tile-drained corn acres | 7.5 to 10 | 13 | 3.1 |
| | Fall to spring on tile-drained corn acres | 15 to 20 | 26 | 6.4 |
| | Cover crops on all corn/soybean tile-drained acres | 30 | 84 | 20.5 |
| | Cover crops on all corn/soybean non-tiled acres | 30 | 32 | 7.9 |
| Edge-of-field | Bioreactors on 50% of tile-drained land | 40 | 56 | 13.6 |
| | Wetlands on 25% of tile-drained land | 40 | 28 | 6.8 |
| | Buffers on all applicable crop land (reduction only for water that interacts with active area) | 90 | 36 | 8.7 |
| Land use change | Perennial/energy crops equal to pasture/hay acreage from 1987 | 90 | 10 | 2.6 |
| | Perennial/energy crops on 10% of tile-drained land | 90 | 25 | 6.1 |
| Point source | Point source reduction to 10 mg nitrate-N/L | | 14 | 3.4 |
| | Point source reduction in N due to biological nutrient removal for P | | 8 | 1.8 |

# Costs per acre

| | Practice/Scenario | Cost Per Acre | Notes |
|---|---|---|---|
| In-field | Reducing N rate from background to the MRTN (10% of acres) | -$8 | Reduce N rates (20 pounds) |
| | Nitrification inhibitor with all fall applied fertilizer on tile-drained corn acres | $7 | Cost of inhibitor |
| | Split (50%) fall and spring (50%) on tile-drained corn acres | $17 | Additional field pass, switch to N solutions |
| | Fall to spring on tile-drained corn acres | $18 | Switch to N solutions, higher ammonia price, additional application costs |
| | Cover crops on all corn/soybean tile-drained acres | $29 | Aerial applications of cereal rye |
| | Cover crops on all corn/soybean non-tiled acres | $29 | Aerial applications of cereal rye |
| Edge-of-field | Bioreactors on 50% of tile-drained land | $17 | Upfront costs of $133 per acre |
| | Wetlands on 25% of tile-drained land | $60 | 5% of farmland out of production<br>Major cost is land ($11,000) |
| | Buffers on all applicable crop land (reduction only for water that interacts with active area) | $294 per buffer acre | Land costs plus $50 planting, $10 yearly maintenance |
| Land use change | Perennial/energy crops equal to pasture/hay acreage from 1987 | $86 | Less profit compared to corn-soybean rotation |
| | Perennial/energy crops on 10% of tile-drained land | $86 | Less profit compared to corn-soybean rotation |

# Science Assessment to Support an Illinois Nutrient Reduction Strategy, Illinois EPA

1. Determine current conditions
2. Identify critical watersheds
3. Estimate potential reductions and costs
4. Develop scenarios

# Example Statewide N Scenarios

| Name | Combined Practices and/or Scenarios | Nitrate-N (% reduction) | Total P (% reduction) | Cost of N Reduction ($/lb) | Annualized Costs (million $/year) |
|---|---|---|---|---|---|
| N1 | MRTN rate, all spring N application, cover crops 70% tile-drained & 45% non-tiled, bioreactors 50%, wetlands 25%, all ag streams have buffers | 45 | 20 | 3.71 | 690 |
| N2 | MRTN rate, all spring N application, cover crops 100% tile-drained & 70% non-tiled, bioreactors 50%, perennial crops non-tiled, point source to 10 mg nitrate-N/L | 45 | 33 | 4.30 | 800 |
| N3 | MRTN rate, cover crops 100% tile-drained & 70% non-tiled, wetlands 25%, perennial crops non-tiled, all ag streams have buffers, point source to 10 mg nitrate-N/L | 45 | 24 | 4.51 | 838 |
| N4 | MRTN rate, all spring N application, cover crops 5% tile-drained, bioreactors 50% | 20 | 0.3 | 1.99 | 163 |
| N5 | MRTN rate, cover crops 35% tile-drained, bioreactors 50% | 20 | 2 | 2.00 | 162 |
| N6 | MRTN rate, cover crops 75% tile-drained, 55% non-tiled | 20 | 8 | 4.62 | 382 |

http://www.epa.state.il.us/water/nutrient

# Illinois Statewide Nutrient Reduction Strategy

The impact of excess nitrogen and phosphorus in Illinois rivers, lakes, streams and the Gulf of Mexico is a very high profile water quality issue. Under the right conditions, nutrients can cause excessive algal blooms, low oxygen and nuisance conditions that adversely impact aquatic life, drinking water and recreational uses of the water.

- Nutrient Reduction Strategy Update Presentation - December 2013

Nutrients can come from many sources, including:

- Fertilizers from agriculture, golf courses, and suburban lawns
- Erosion of nutrient-rich soils
- Discharges from industrial and sewage treatment plants and
- Failing onsite septic systems.
- Deposition of atmospheric nitrogen

In other words, most aspects of modern society contribute to this pollution problem. The proportion of loading to a particular waterbody from these sources varies from watershed to watershed, and includes point sources and non-point sources, in both urban and agricultural landscapes.

Illinois EPA hosted meetings in 2010 for stakeholders representing government, environmental groups, municipal and industrial wastewater dischargers, agricultural groups, academia, non-governmental organizations and consulting firms with an interest in the topic of nutrient pollution. This was the beginning of a collaborative, problem-solving process to craft a Statewide Nutrient Reduction Strategy to address excess nutrients in Illinois waters and the Gulf of Mexico.

## March 2013 Strategy Development Kick-off Meeting

On March 11, 2013, Illinois EPA hosted a meeting of stakeholders to announce that development of a statewide Nutrient Reduction Strategy was beginning. Approximately 100 attendees were present, representing the agricultural community, wastewater dischargers, environmental groups, government, technical assistance providers and academia. Attendees were welcomed by Warren Goetsch, Illinois Department of Agriculture, who identified that the 2008 Gulf of Mexico Hypoxia Action Plan includes development of statewide nutrient reduction strategies

- Draft Agenda
- Meeting Notes
- Illinois Science Assessment Update

Nutrient Reduction Strategy Policy Working Group, November 13, 2013: NRCS Illinois State Office, Champaign

- Draft Agenda
- Meeting Notes
- Illinois Science Assessment Update

Nutrient Reduction Strategy Policy Working Group, January 15, 2014: Asmark Agricenter, Bloomington

- Draft Agenda
- Agriculture BMP Scenario Analysis

## Upcoming Nutrient Reduction Strategy Policy Working Group Meetings

- February 19, 2014, 1:30-3:30 p.m., Illini Center-Chicago
- March 19, 2014, 1:30-3:30 p.m., Illinois Department of Agriculture-Springfield
- April 16, 2014, 1:30-3:30 p.m., Location TBD
- May 21, 2014, 1:30-3:30 p.m., Location TBD

## Planned Discussion Topics and Goals for Future Meetings/Subcommittees

- Meeting Topics/Goals

## Mississippi River/Gulf of Mexico Watershed Nutrient Task Force and Action Plan

The Mississippi River/Gulf of Mexico Watershed Nutrient Task Force was established in 1997 to understand the causes and effects of eutrophication in the Gulf o poxia. Activities include coordinati ate nutrients, and supporting

The role of the Task Force, ating the actions of participating orga

The Mississippi River/Gulf o gy to reduce, mitigate and control hypoxia in the Northern Gulf of Mexico and improve water quality in the Mississippi River Basin.

http://www.epa.state.il.us/water/nutrient

C-BMP
Illinois Council on Best Management Practices

Working to assist adoption of best management practices (BMPs) to minimize environmental impact, optimize harvest yields and maximize input utilization.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## Illinois NREC Brochure


## We are:

- a coalition of agribusinesses and agricultural organizations
- a clearinghouse on current research to protect water quality in Illinois
- a source for information and support for local watershed groups and water quality initiatives

## Focus on Stewardship

### Focus on Stewardship Through Farm Profitability and Nutrient Utilization

Lake Springfield Watershed Project
Thursday, February 6, 2014,
8:30 to 11:30 a.m.
Northfield Conference Center,
3280 Northfield Drive,
Springfield, Illinois
CCA CEUs: 1.5 NW, 1.5 SW
No fee for meeting but
pre-registration is requested

Register Online Today

or phone (217) 241-6635 ext. 3

**Topic: Cover crops as a tool for**

## Dan Schaefer, CPAg, CCA

Dan Schaefer, CPAg, CCA
CBMP Director of Nutrient Stewardship

Dan joined CBMP in January 2012 to manage the "Keep it for the Crop (KIC) by 2025" nutrient stewardship program

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Sampling soil from the Morrow Plots, 1904


orrow Plots, 1904


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# "In Order to Aid in Diffusing Useful and Practical Information": Agricultural Extension and Boundary Organizations

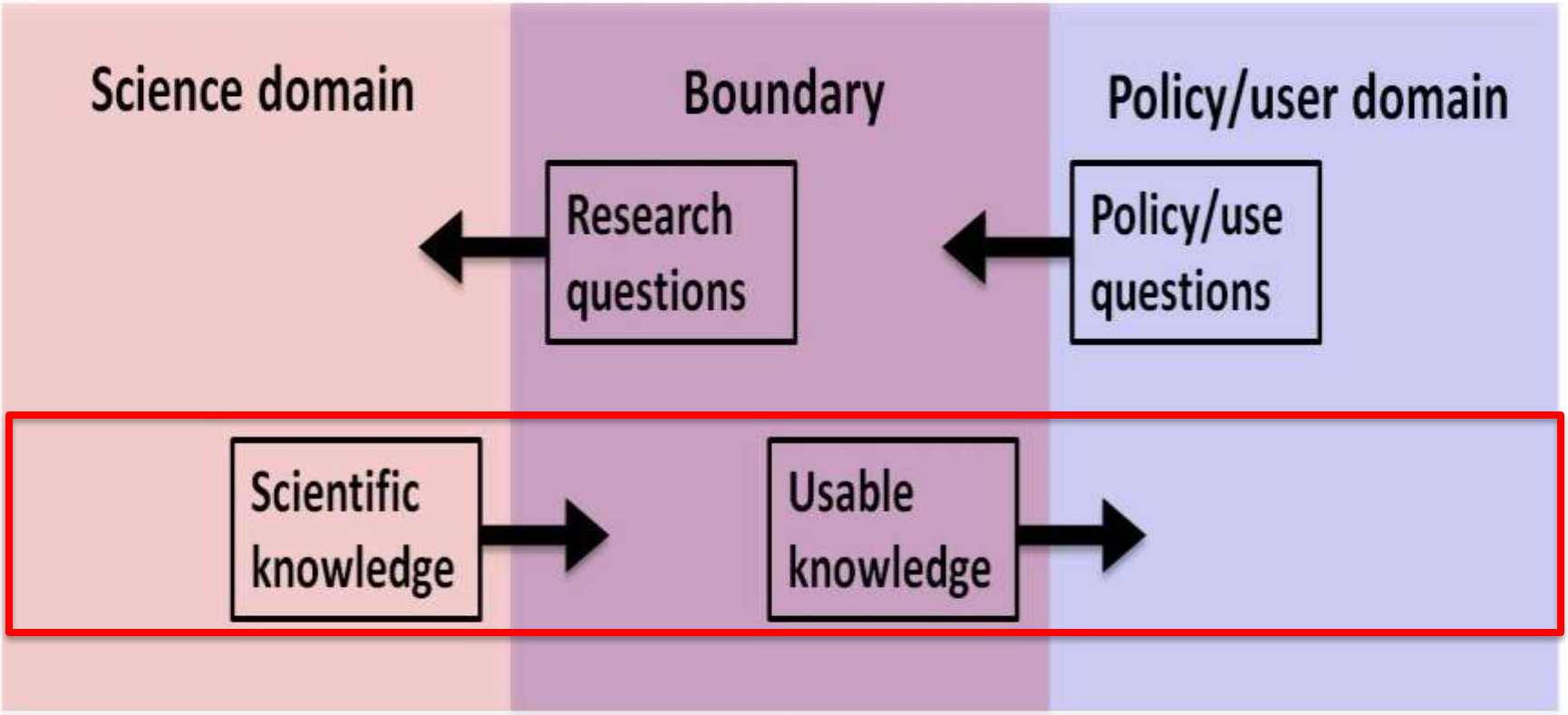
**David W. Cash**
*Harvard University*

*Agricultural decision making is characterized by two challenges common to multiple arenas: linking science to decision making and linking science and decision making across multiple levels. The U.S. agricultural research, education, and extension system was designed to address these challenges. By investigating this system, this study deep-*

"linking science to decision making…"



Cash, 2001




Turnhout, 2007, *Ecological Indicators*

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