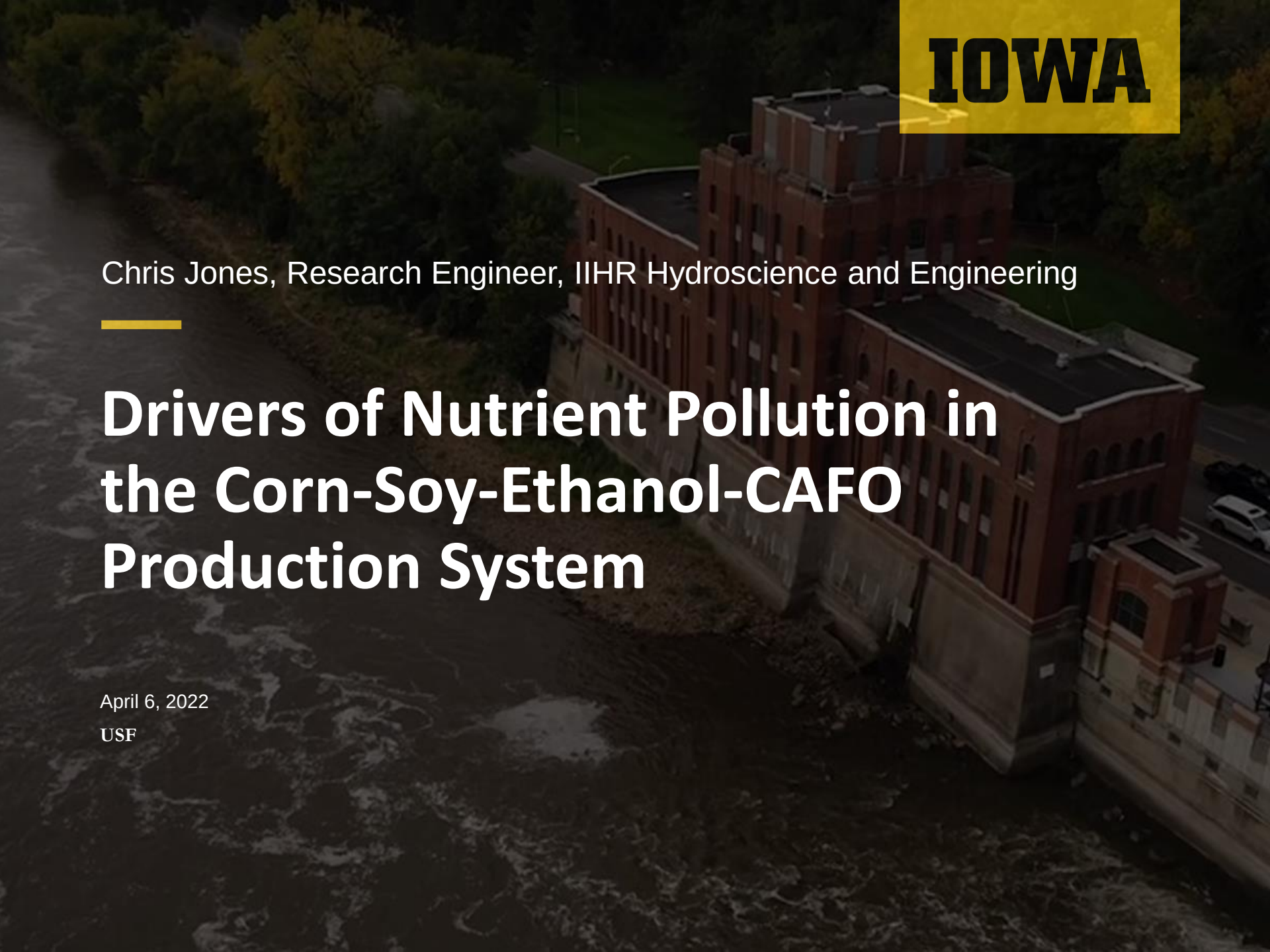


Chris Jones, Research Engineer, IIHR Hydroscience and Engineering

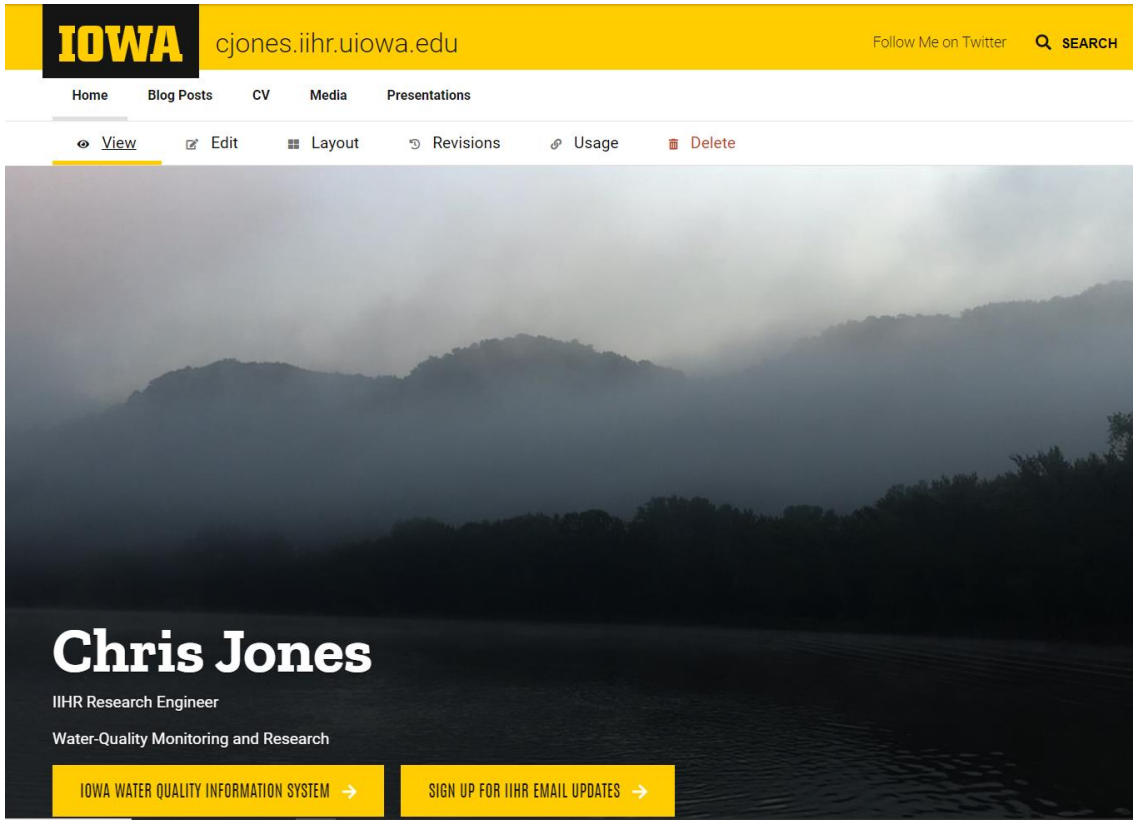
Drivers of Nutrient Pollution in the Corn-Soy-Ethanol-CAFO Production System

April 6, 2022

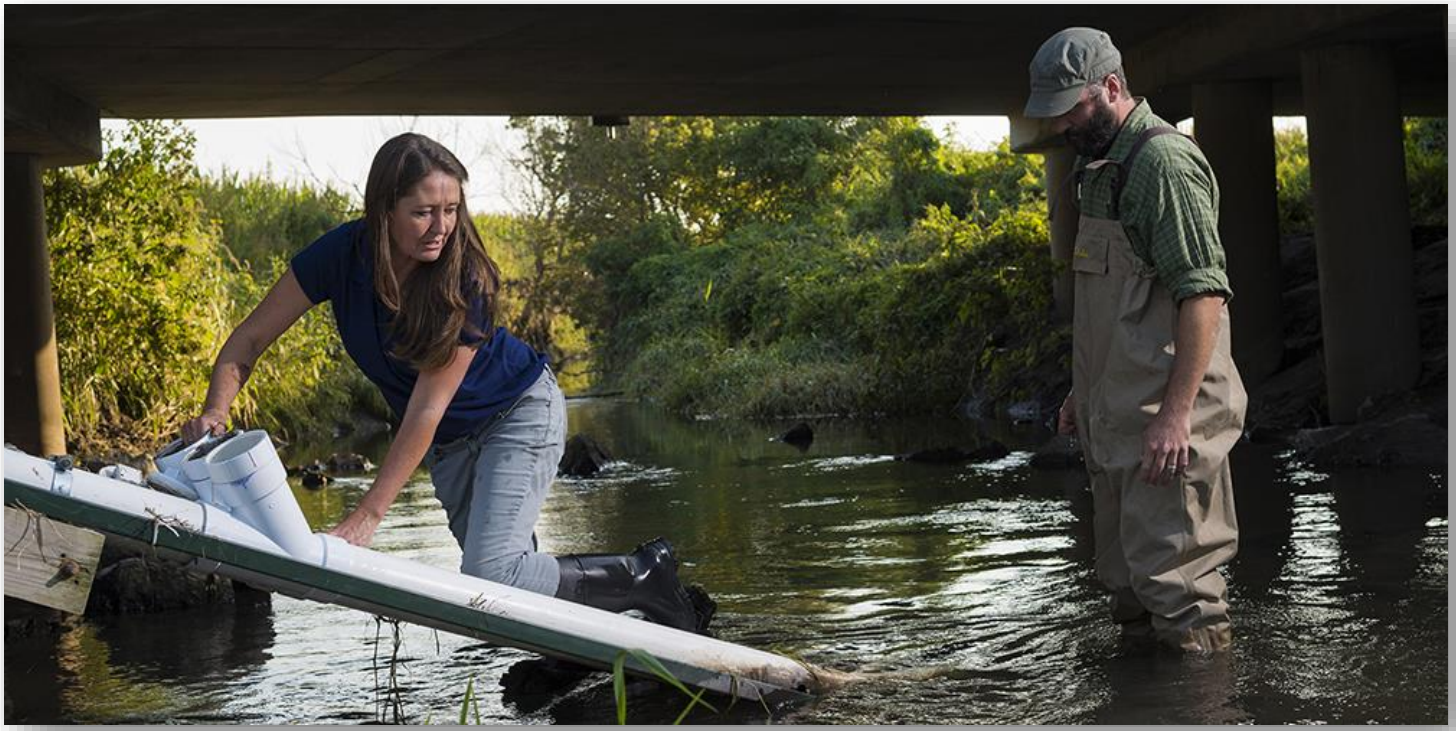
USF

Slides Available at:

https://cjones.iihr.uiowa.edu/



IIHR Water Quality Sensor Network

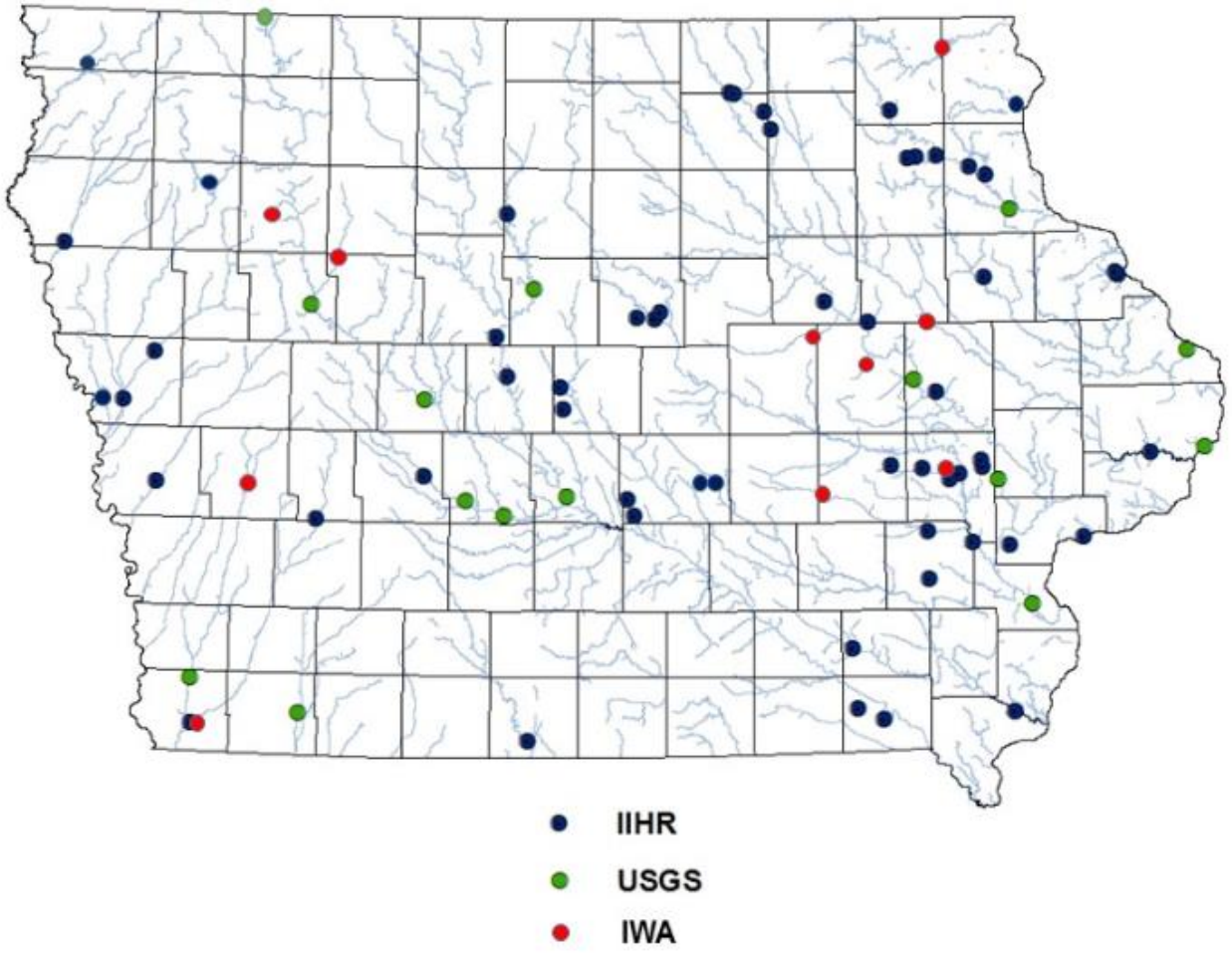


Sites

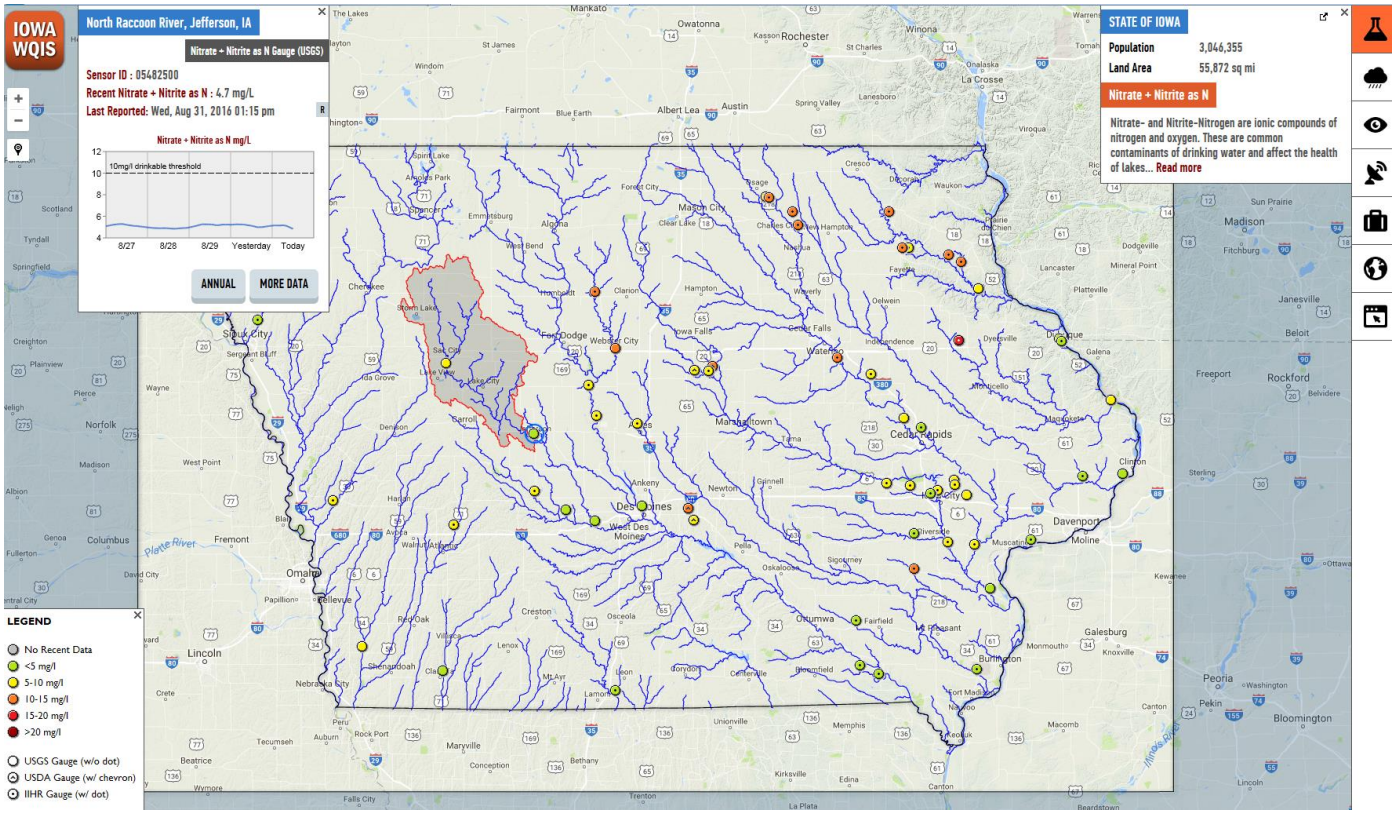
70+ sites
Nitrate-N

20-25 sites

- **Temperature**
- **pH**
- **SC**
- **DO**
- **Turbidity**



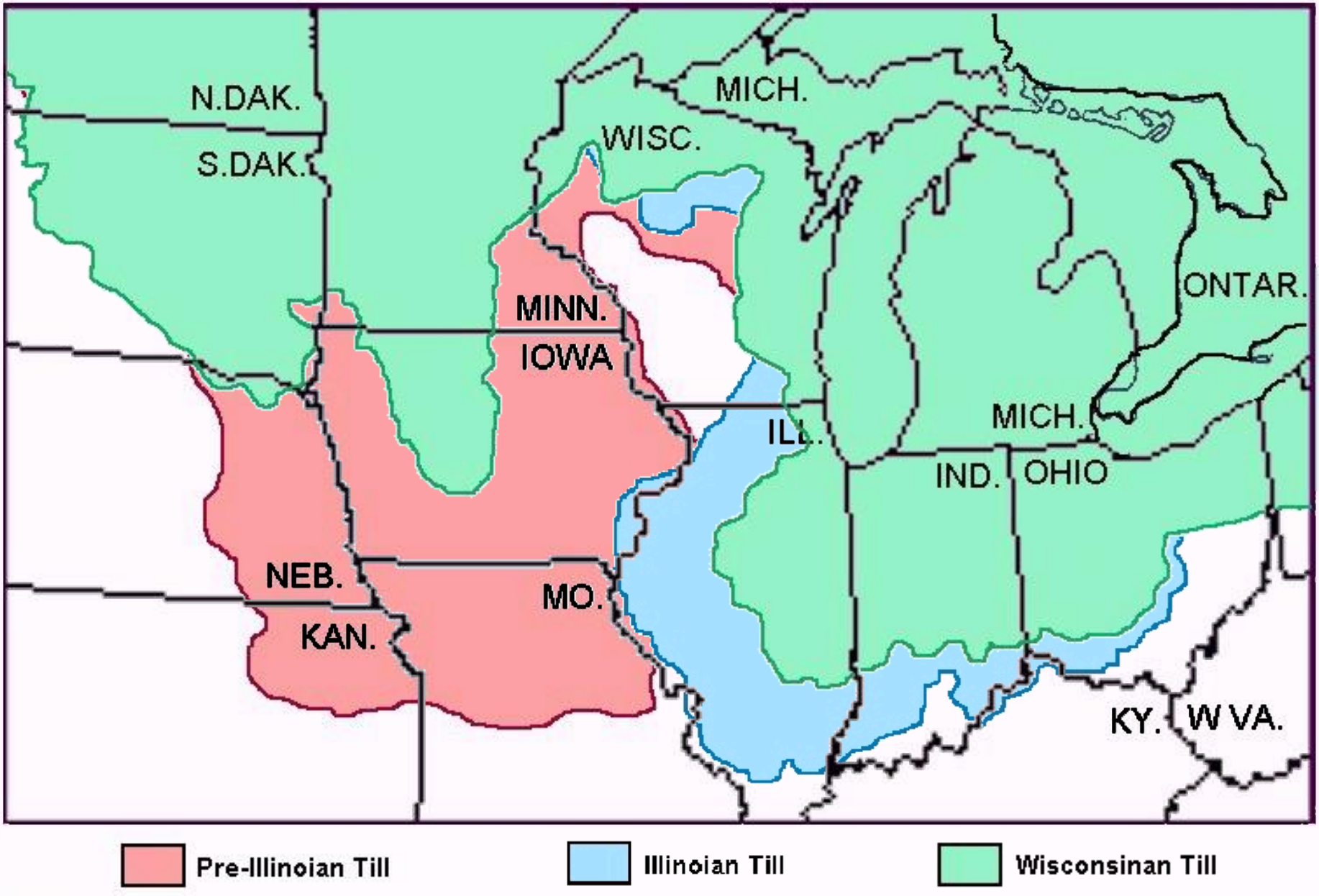
Iowa Water Quality Information System

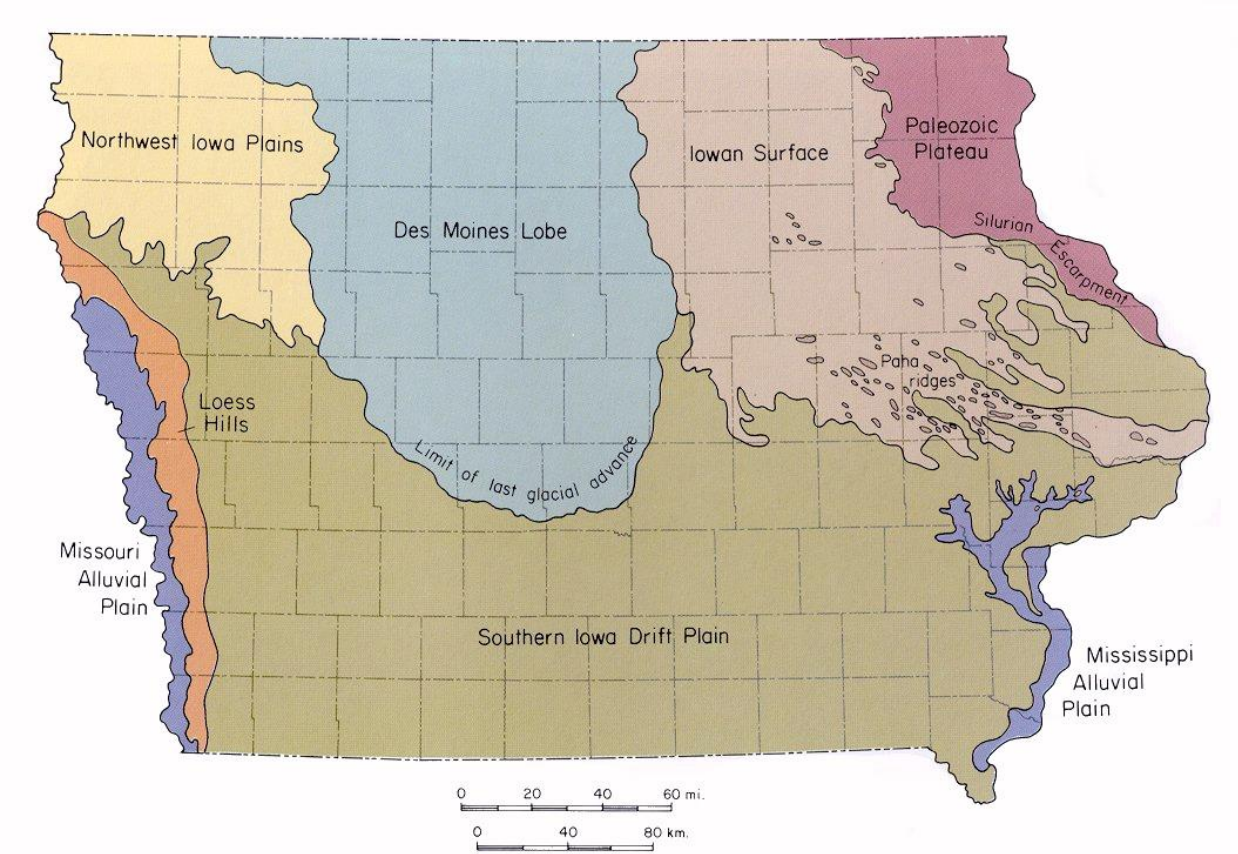


iwqis.iowawis.org/

http://iwqis.iowawis.org/app/?datetime=2017-06-06T13:00

30,000 – 10,500 years





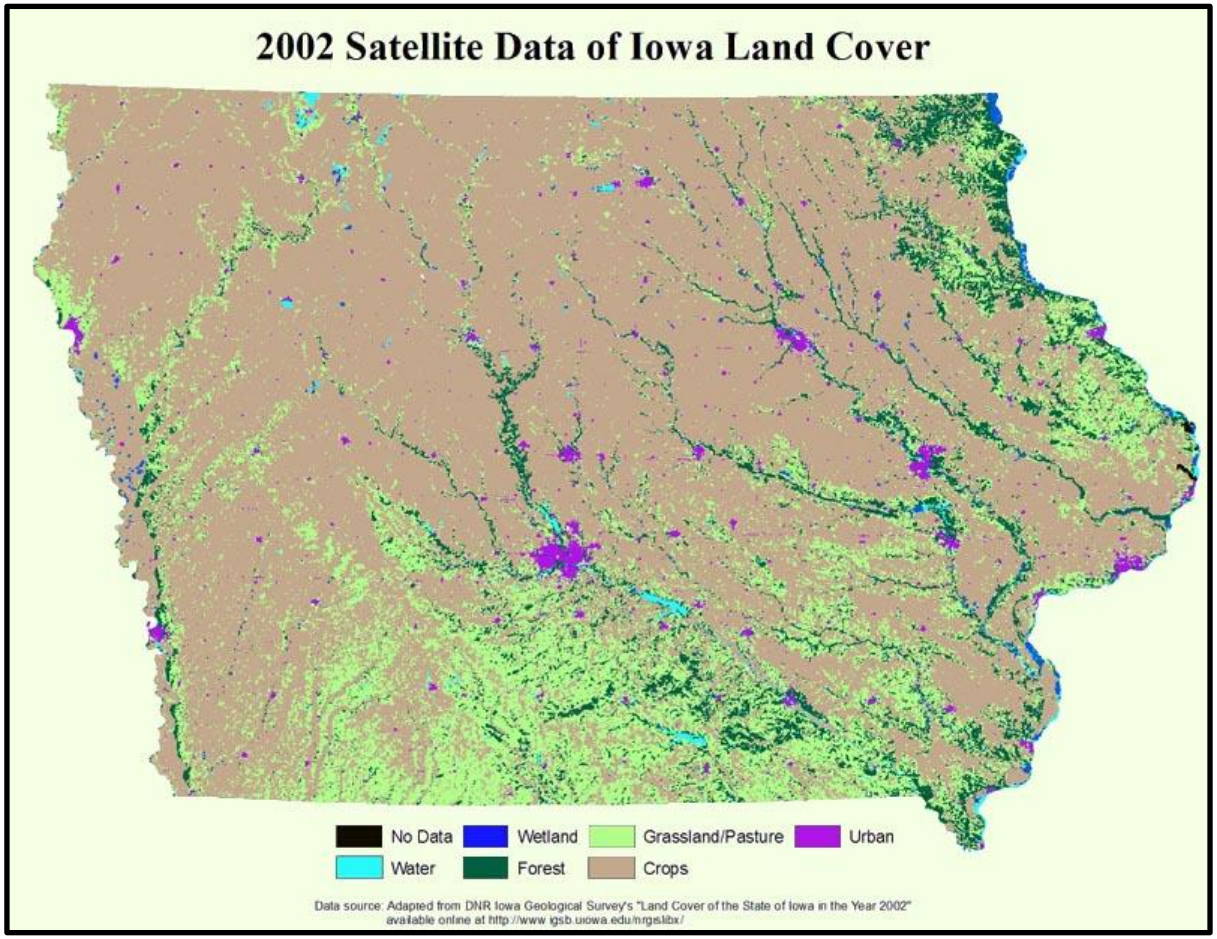
Landform Regions of Iowa


Wetland: 20% of Iowa, 7.6 million acres, < 1% remains

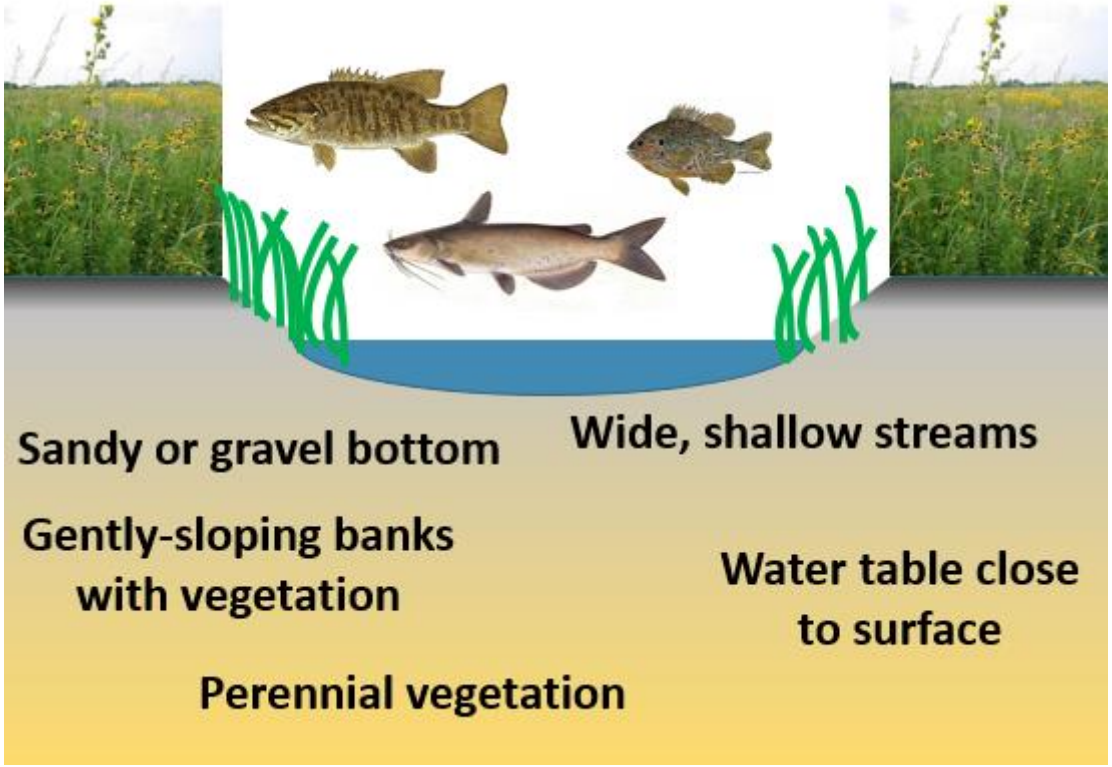

Oak Savannah: ~5%, < 1% remains


Prairie: 70%, 0.1% Remains

Iowa Land Cover



Pre-European Settlement Streams



Breaking the prairie

Photo courtesy of Deere and Company

Hydrological Modification: 1860s-1910s

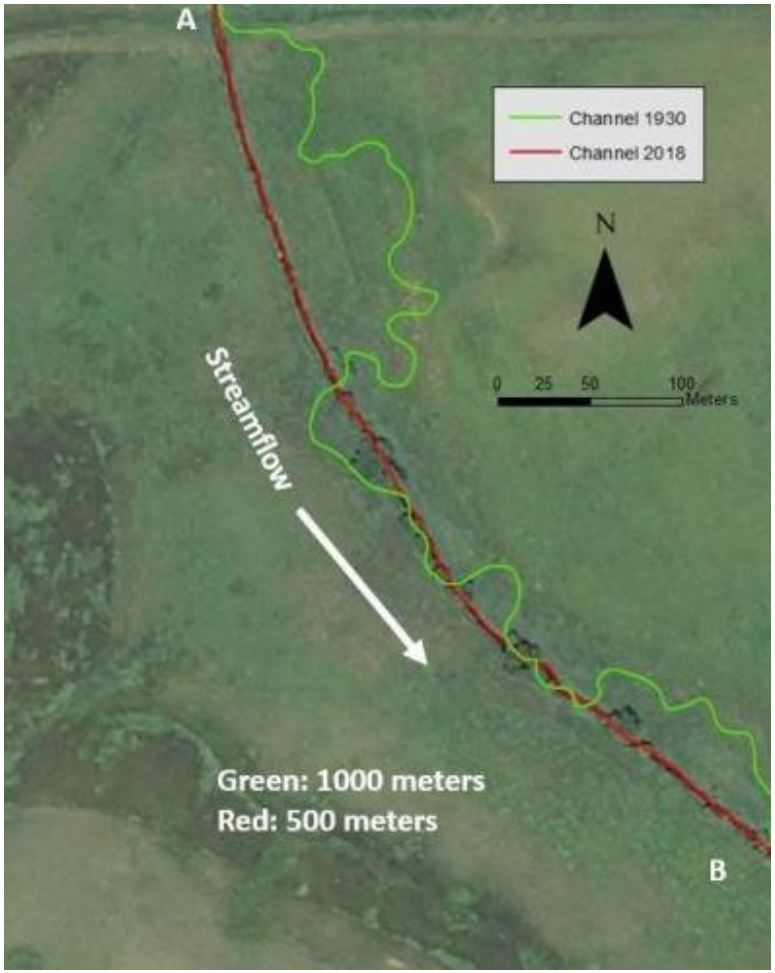
Excavating a large ditch using steam power, circa 1910.

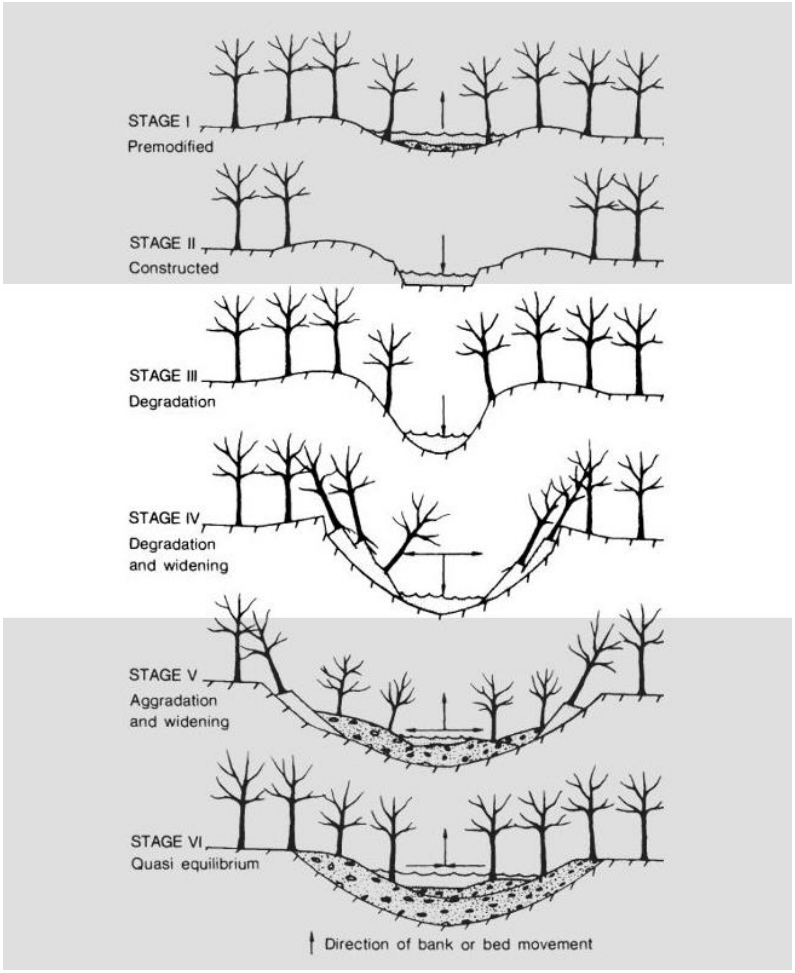
Hand digging tile, Boone Co. IA. ca 1914
Source: 'An Iowa album: a photographic history, 1860-1920' by M. J. Bennet, University of Iowa Press, Iowa City, Iowa

Tiling field now

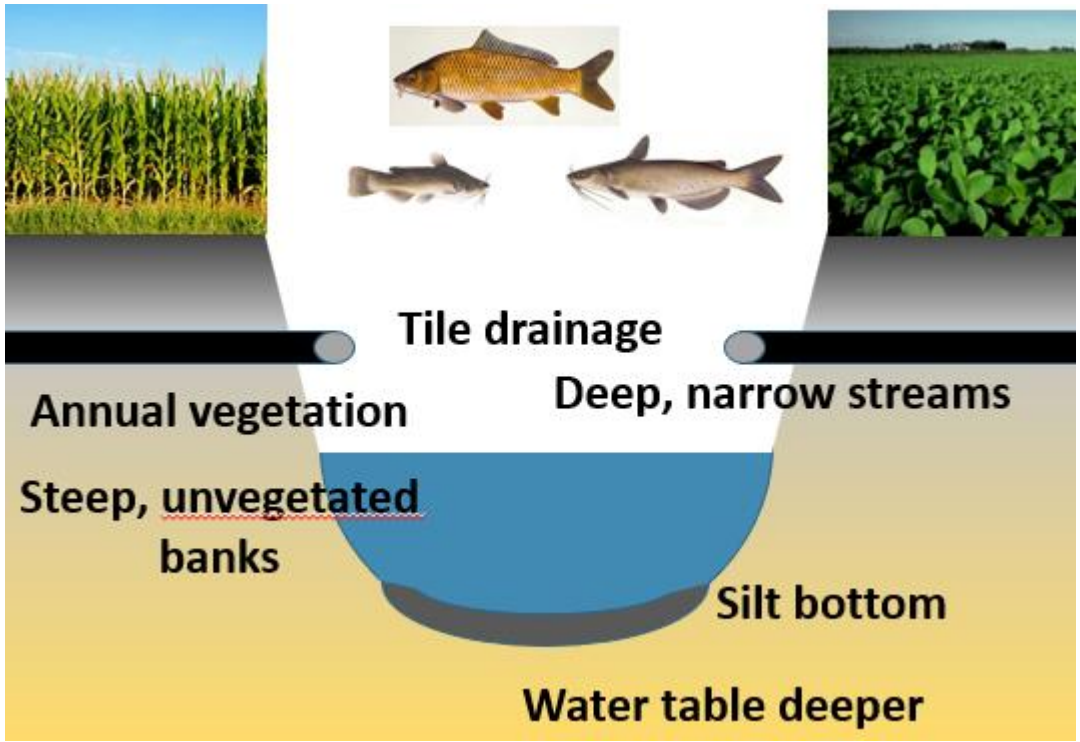
Source of the Iowa River

Stream Straightening, 1930-1975





Modified Streams



Transformation of Iowa Farms

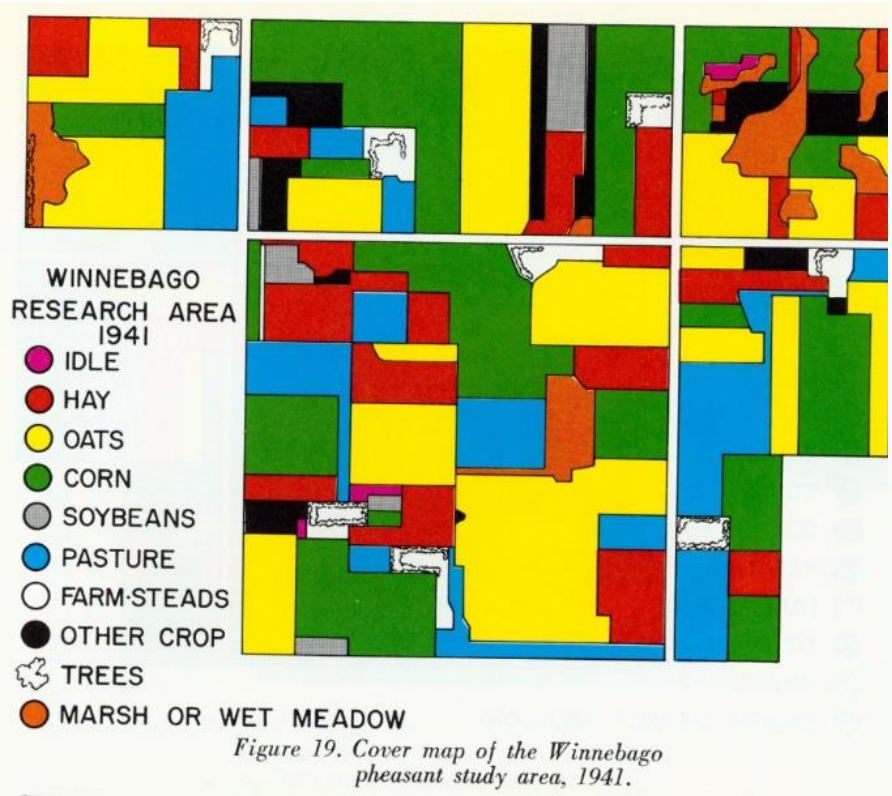


Figure 19. Cover map of the Winnebago pheasant study area, 1941.

1941

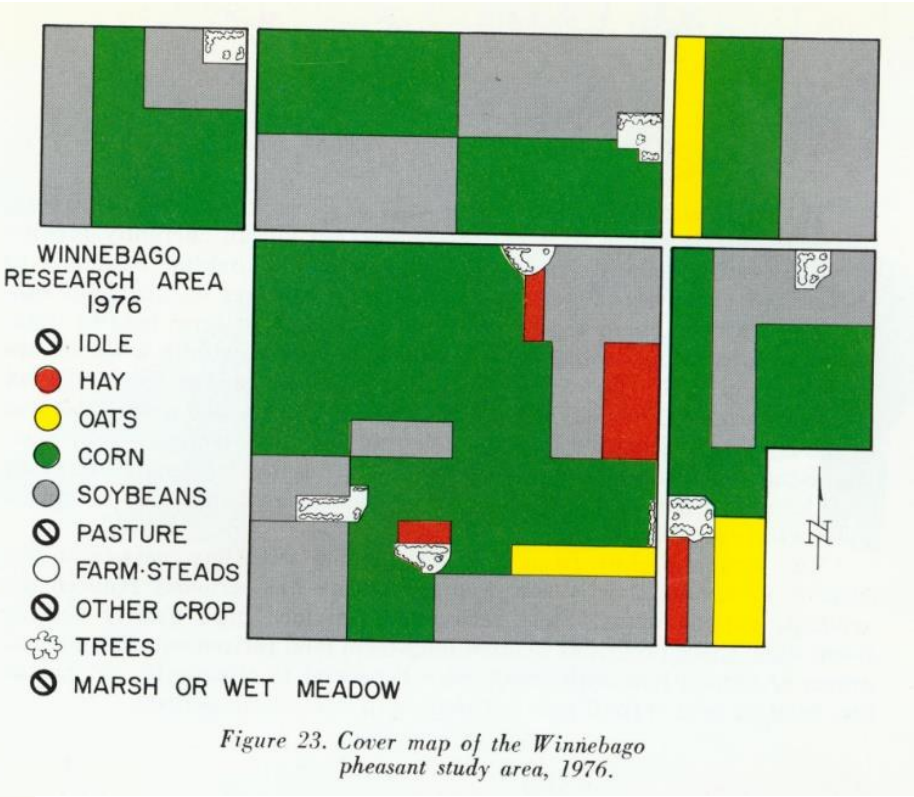
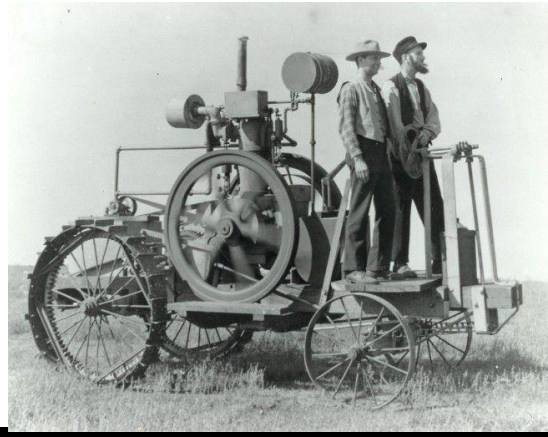


Figure 23. Cover map of the Winnebago pheasant study area, 1976.

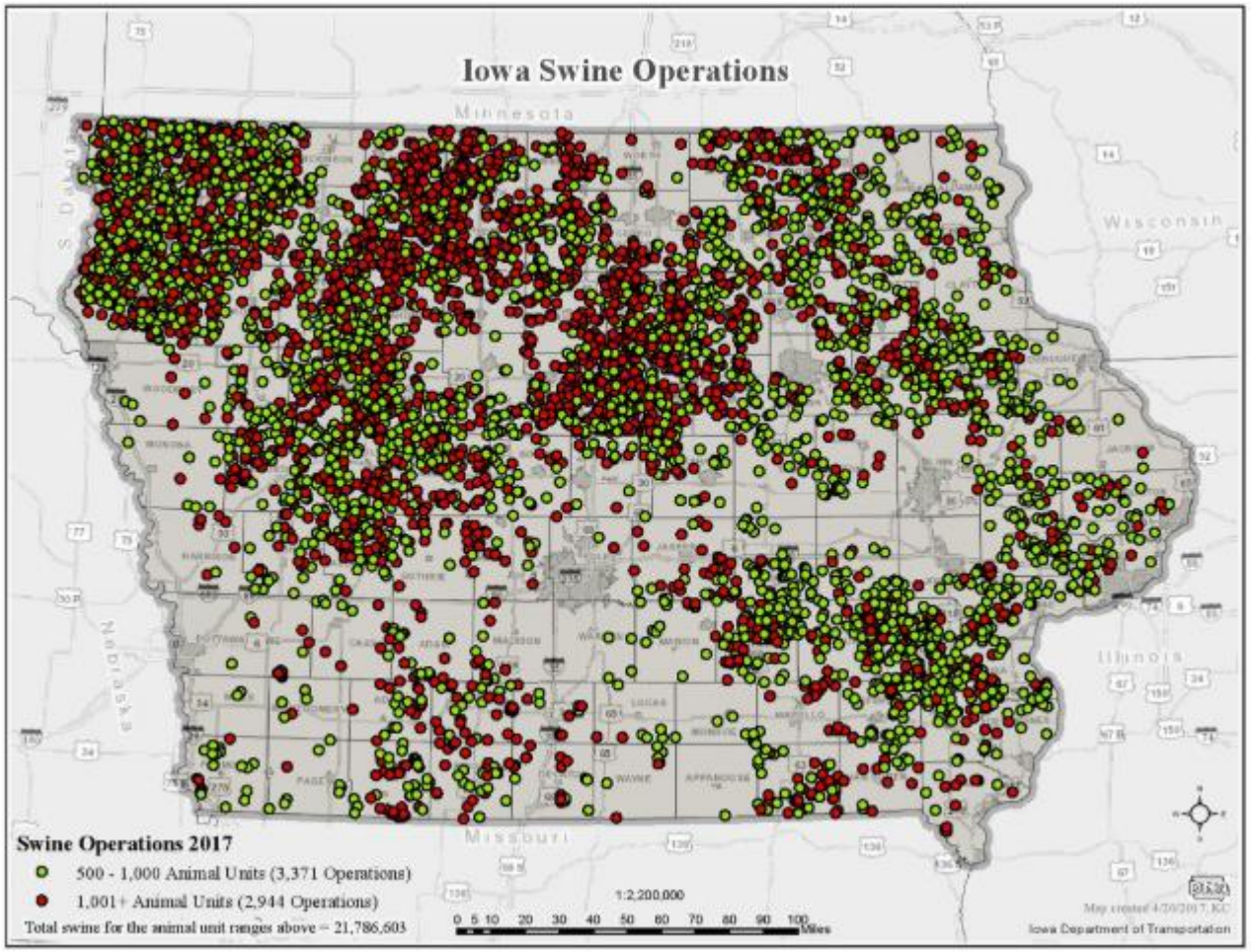
1976

Transformation required Simplification

- Many crops to two crops
- Plant-based energy to fossil fuel energy
  - Animals to tractors and other machinery, 80% had a tractor by 1950
- Organic Fertilizers to Inorganic Fertilizers (Post WWII)
- Many farmers (230,000 in 1951) to Fewer farmers (85,000 today)
- Livestock on almost all farms to livestock on only a few
  - 1980: 65,000 farmers raising 13 million hogs
  - Now: 5,000 farmers raising 25 million hogs
- GMO Crops
  - Roundup Ready Soybeans and Corn (87% of soy RR by 2005)
  - Bt Corn (82% of US Corn Crop)



8000 CAFOs

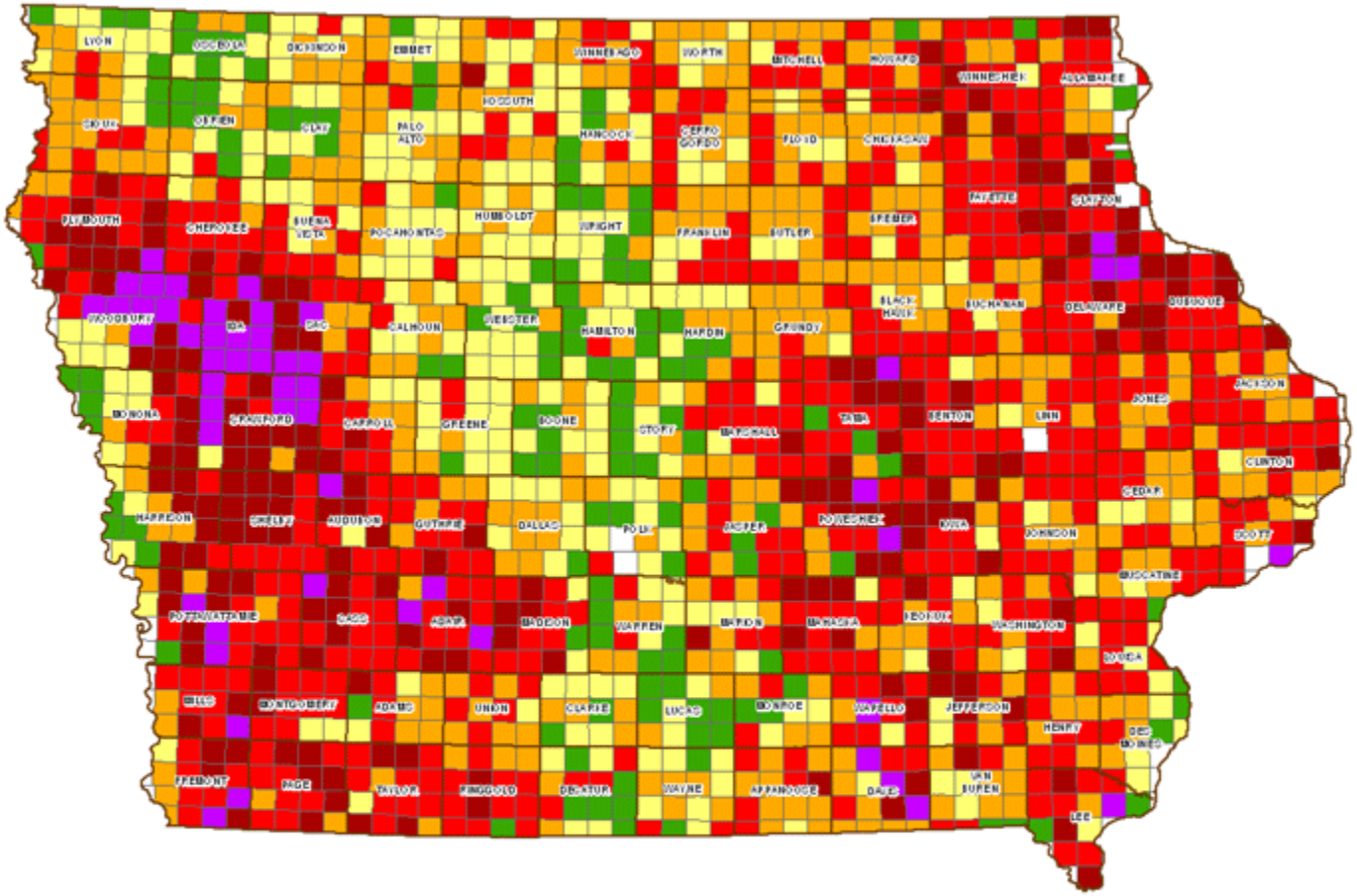

Iowa Swine Operations
Minnesota
Wisconsin
Illinois
Missouri
Nebraska
Swine Operations 2017
500 - 1,000 Animal Units (3,371 Operations)
1,001+ Animal Units (2,944 Operations)
Total swine for the animal unit ranges above = 21,786,603
1:2,200,000
0 5 10 20 30 40 50 60 70 80 90 100 Miles
Iowa Department of Transportation

Problem of Scale

- 70% of land in corn-soy rotation
- 11,000 square miles used for ethanol production
- 25 million hogs
- 4 million beef cattle
- 80 million laying chickens
- 5 million turkeys
- 4 million broiler chickens
- 220,000 dairy cows

Water Quality Consequences

Soil loss is still very high



Source:
EWG

Average Soil Erosion (tons/acre)

No Data | 0 - 5.0 | 5.1 - 10.0 | 10.1 - 20.0 | 20.1 - 50.0 | 50.1 - 100.0 | Greater than 100

Nutrients

Nitrogen: Applied as anhydrous ammonia, urea, UAN, manure, MAP and NAP.

Converted to nitrate in the soil profile, mediated by bacteria

Roughly 40% applied in fall, 60% in spring

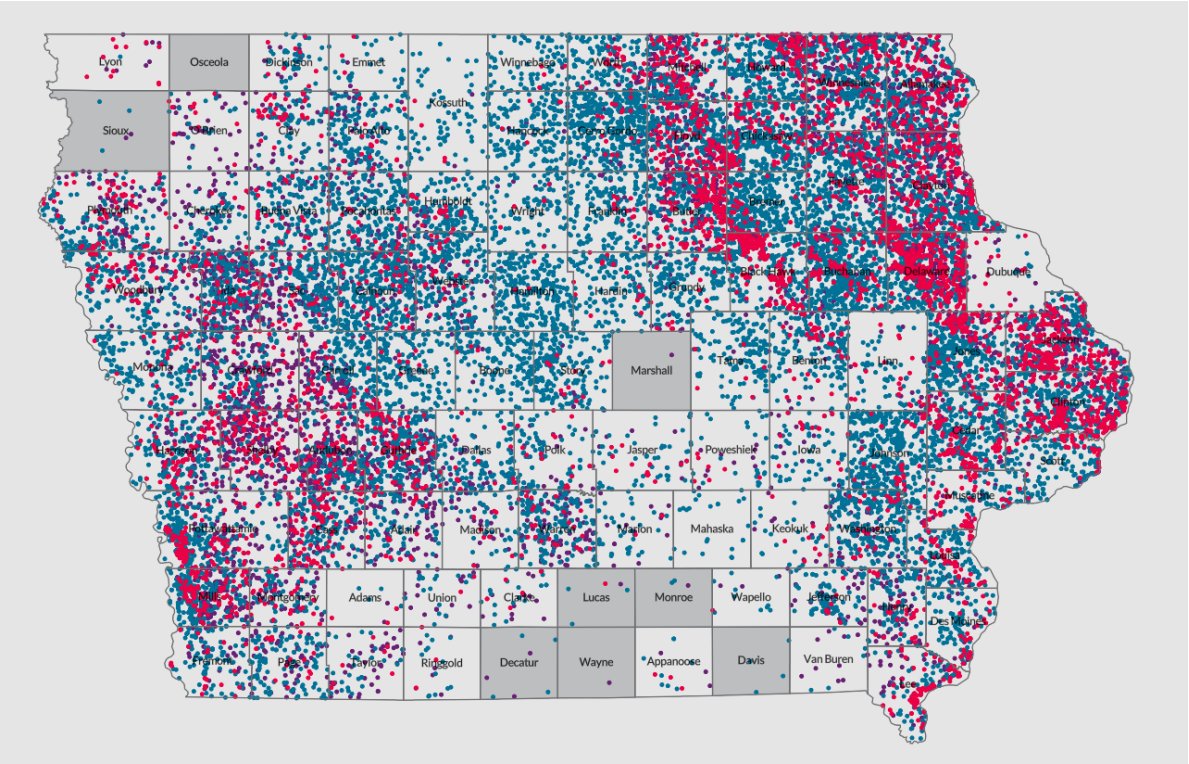
Especially important in marine ecosystems

VERY WATER SOLUBLE

Loss through tile systems and leaching to groundwater

Nitrate: NO_3^-
Regulated drinking water contaminant since 1974
Limit: 10 ppm (as N)

Drinking Water



7000 private wells have tested above the safe drinking water level of 10 mg/L since 2000

1/3 of Iowa's Public Water Supplies are vulnerable to nitrate contamination

60 PWSs are removing nitrate

25% of Iowa drink water that has been treated for nitrate reduction

Surface Water

Lake Erie Algae Blooms

Gulf of Mexico Hypoxia

EPA United States Environmental Protection Agency

Search EPA.gov

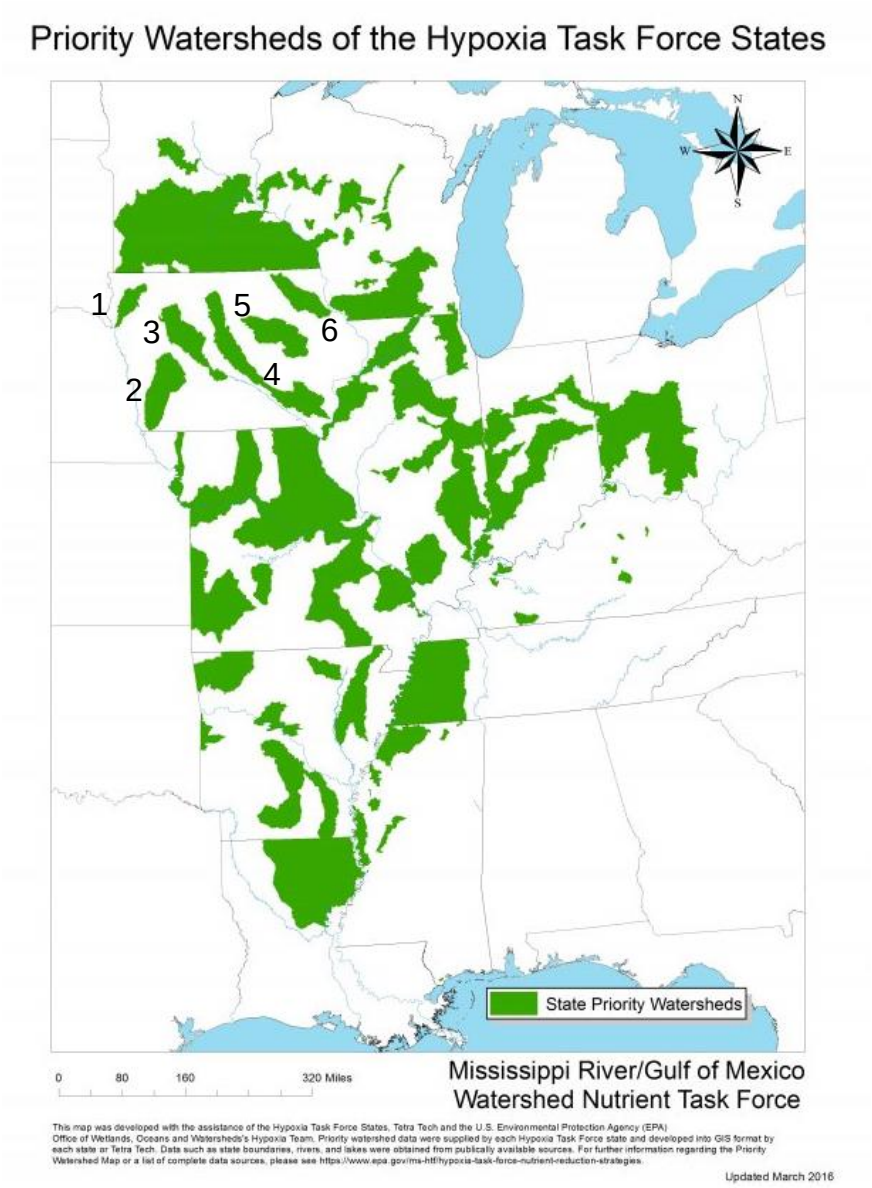
Environmental Topics | Laws & Regulations | Report a Violation | About EPA

CONTACT US

Mississippi River/Gulf of Mexico Hypoxia Task Force

Iowa Priority Watersheds

1) Floyd
2) Nishnabotna
3) North Raccoon
4) Skunk
5) Middle Cedar
6) Turkey



IOWA STATE UNIVERSITY

Iowa Nutrient Reduction Strategy

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- News releases
- Resources
- Contacts
- Submit comments
- Comments and responses
- Iowa Nutrient Research Center

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 Department of Natural Resources, and the Iowa State University College of Agriculture and Life Sciences developed this proposed strategy.

The Iowa Nutrient Reduction Strategy was developed by:

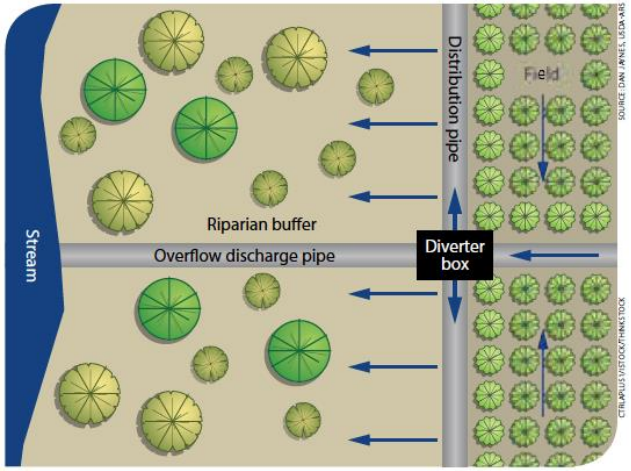
IOWA DEPARTMENT OF AGRICULTURE & LAND STEWARDSHIP

IOWA DEPARTMENT OF NATURAL RESOURCES

IOWA STATE UNIVERSITY

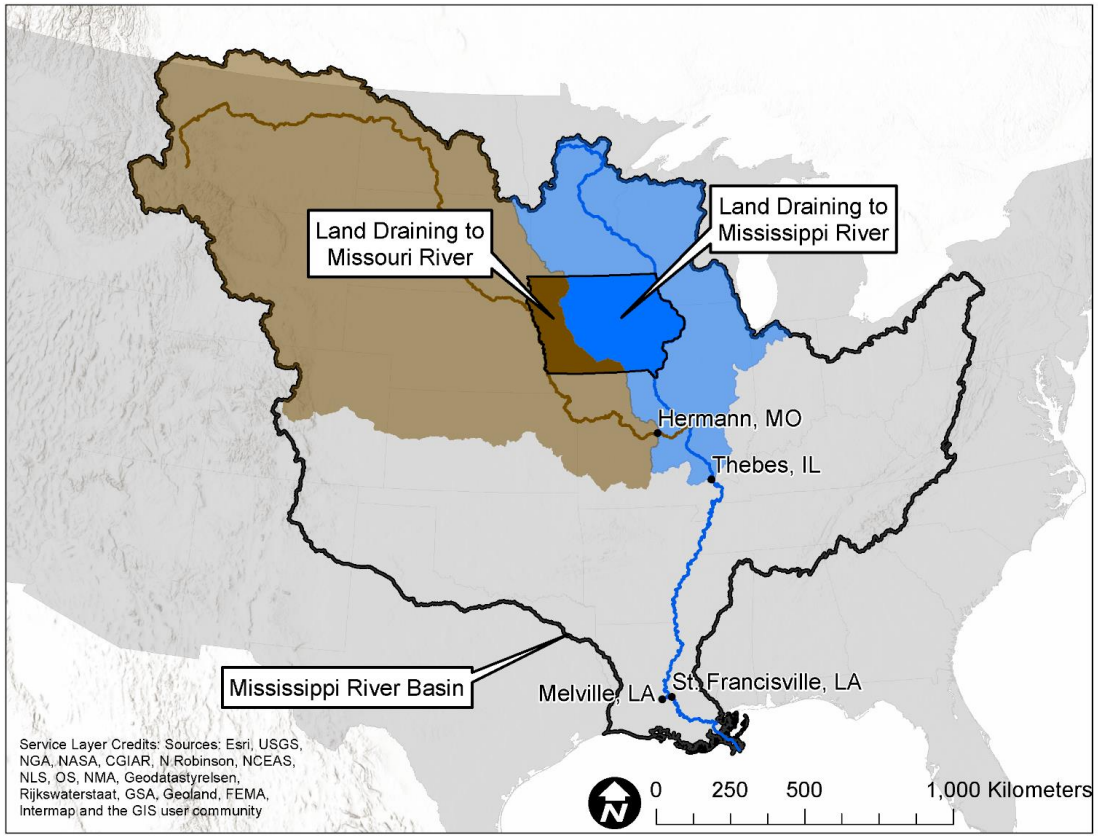
Practices

Cover crops

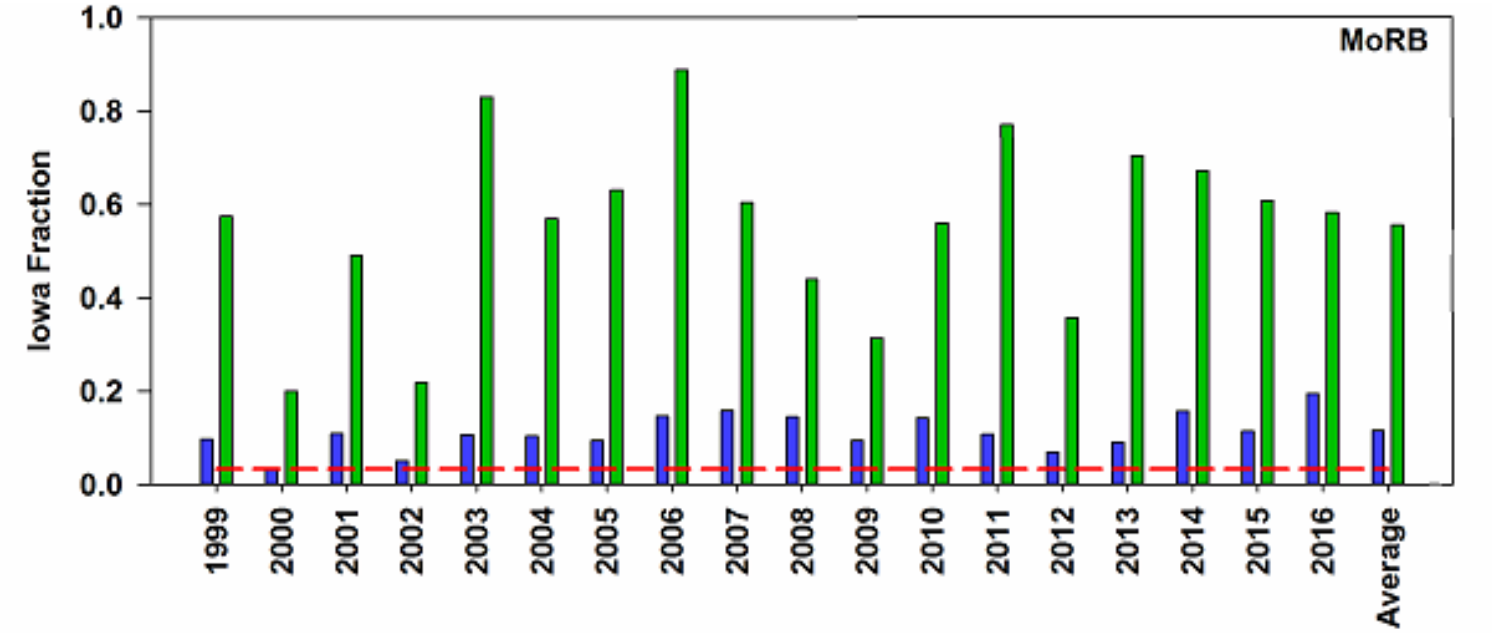


Saturated Buffer

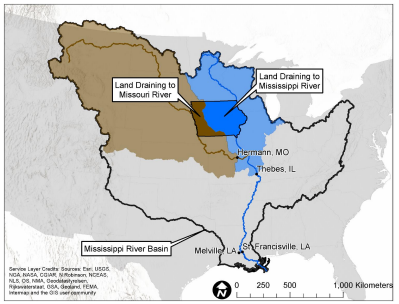
Iowa Contributions



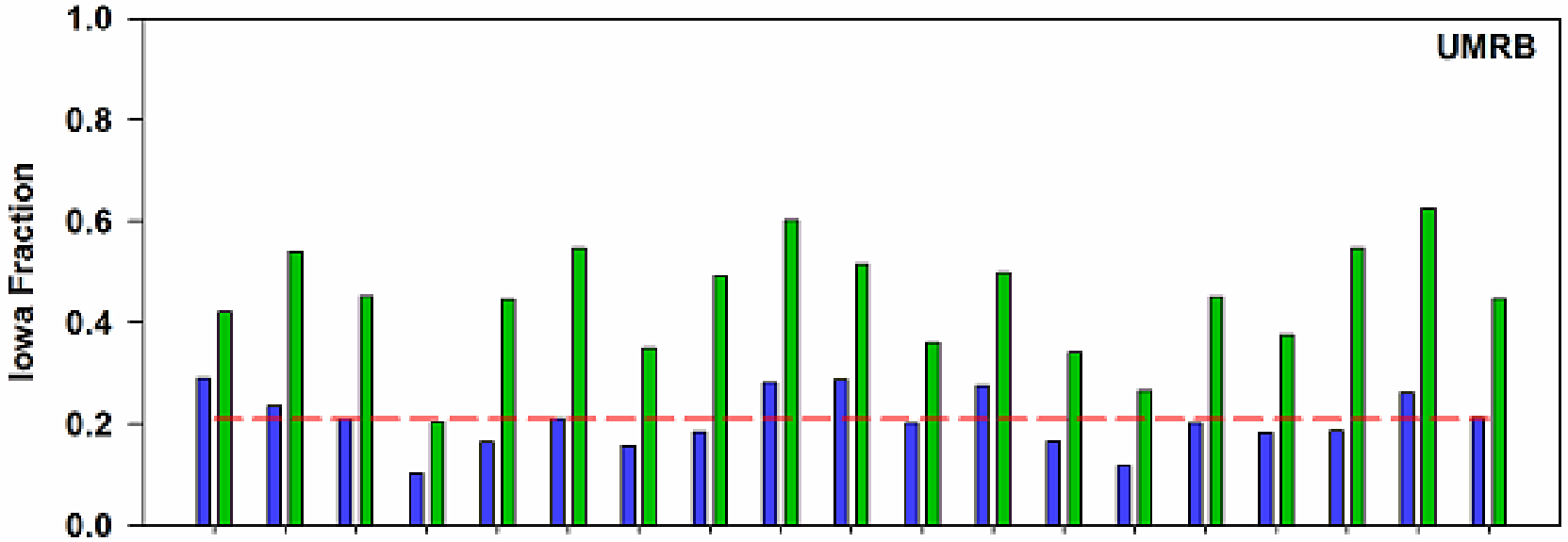
Missouri Basin: Nitrogen



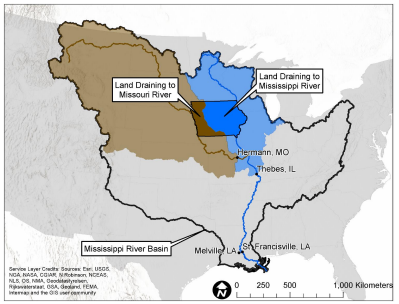
3.3% of the land
12% of the water
55% of the nitrate



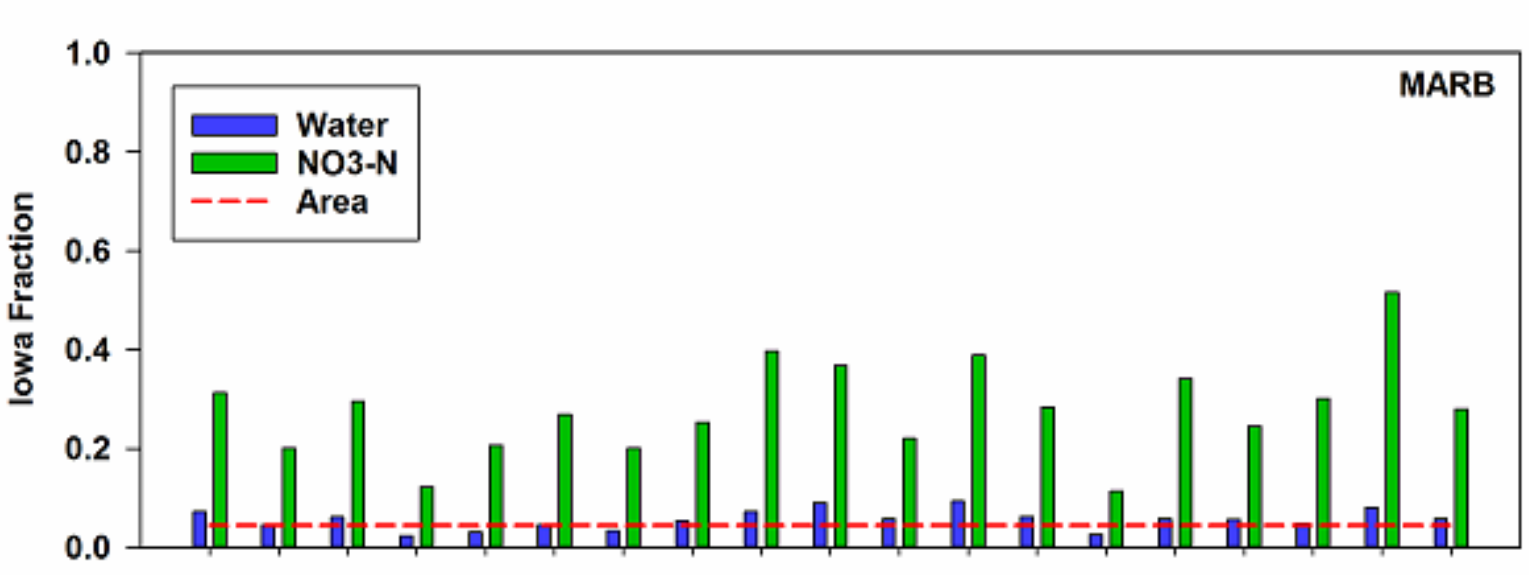
Upper Mississippi: Nitrogen



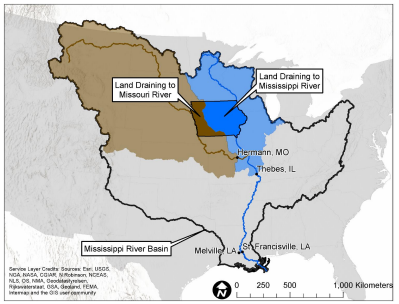
21% of the land
21% of the water
45% of the nitrate



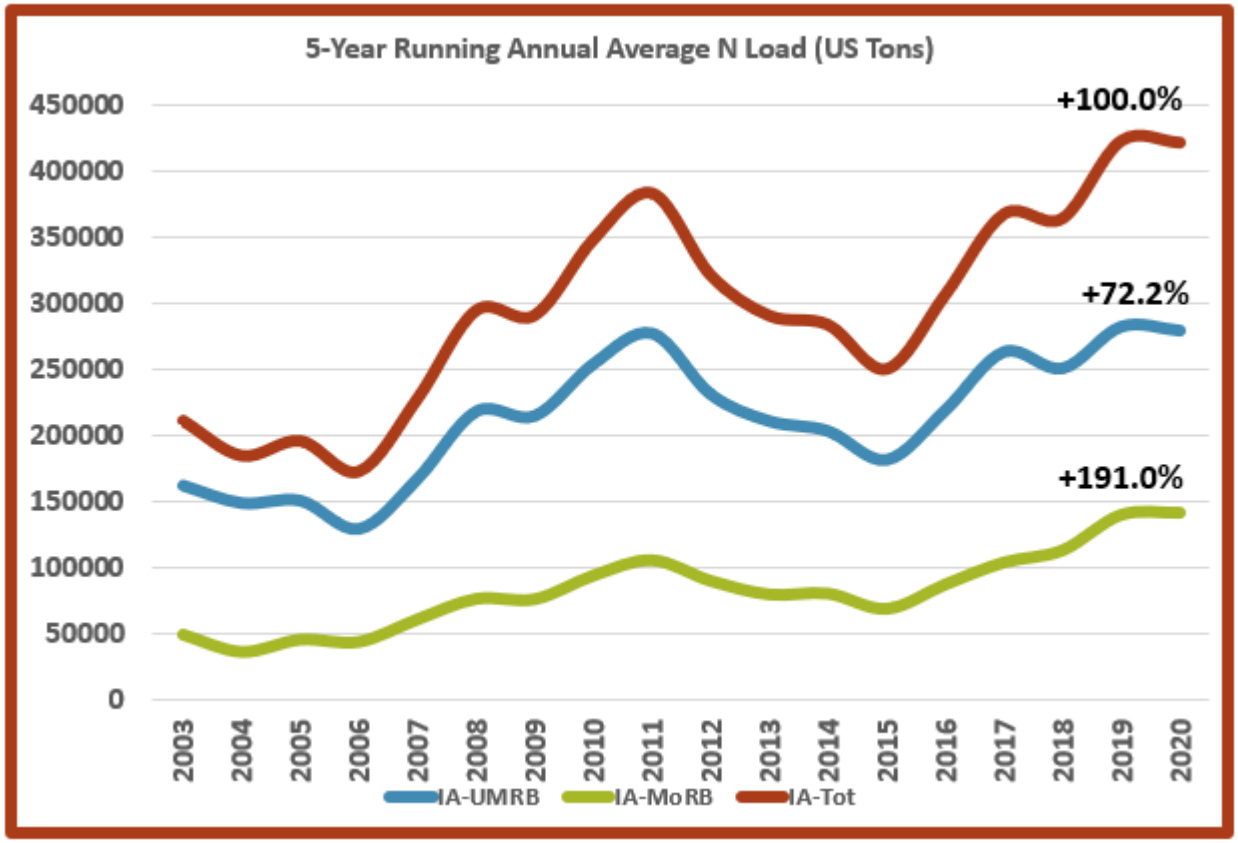
Mississippi-Atchafalaya: Nitrogen

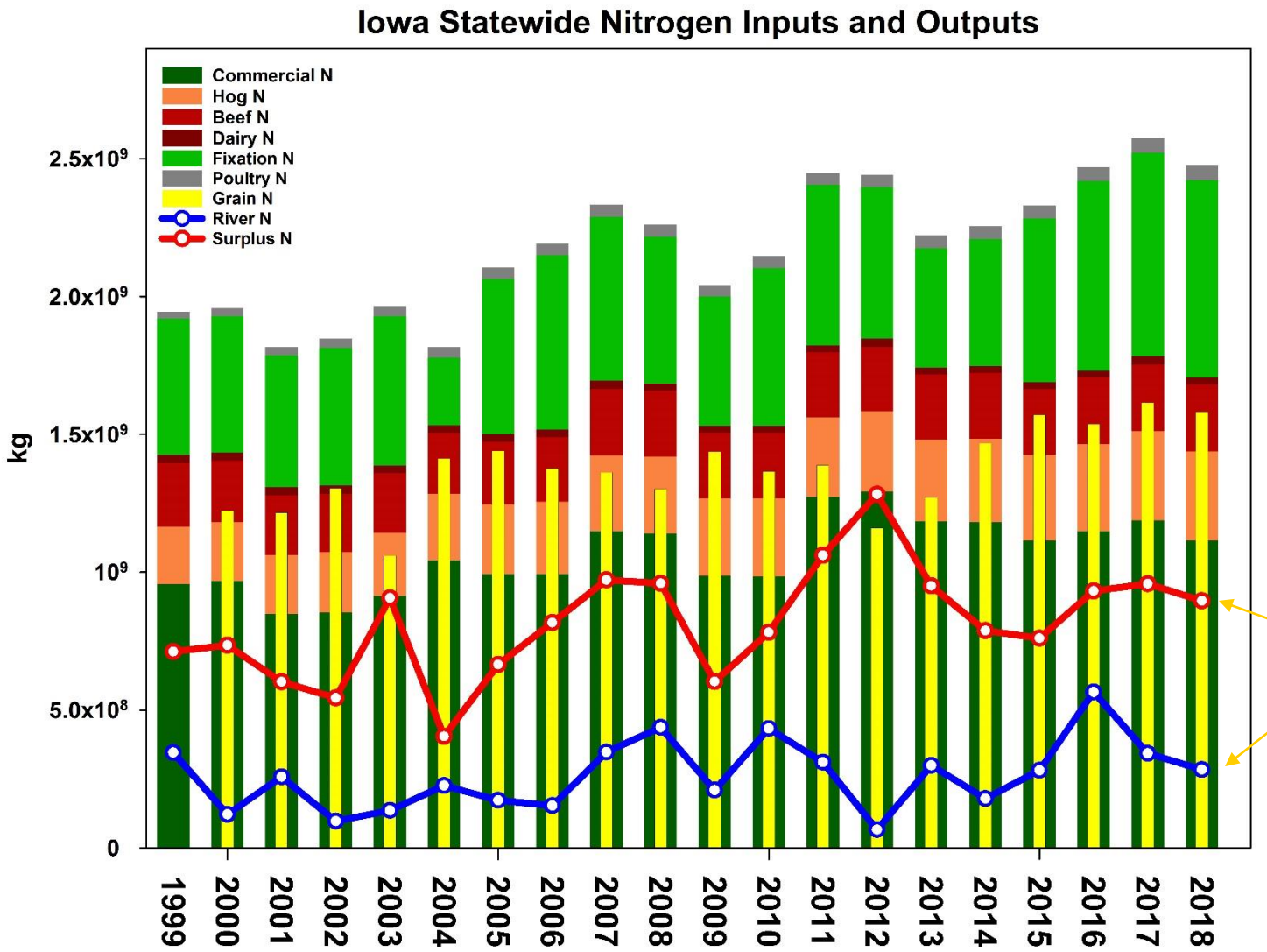


4.5% of the land
5.9% of the water
29% of the nitrate



How Much Nitrogen Leaves Iowa?





About 32% of "surplus" makes it to streams

PLOS ONE

RESEARCH ARTICLE

Iowa stream nitrate and the Gulf of Mexico

Christopher S. Jones[1☯]*, Jacob K. Nielsen[1☯], Keith E. Schilling[2☯], Larry J. Weber[1☯]

1 IIHR-Hydroscience and Engineering, University of Iowa, Iowa City, Iowa, United States of America, **2** Iowa Geological Survey, Iowa City, Iowa, United States of America

☯ These authors contributed equally to this work.
* Christopher-s-jones@uiowa.edu

Phosphorus

Applied as MAP, DAP, Super Triple Phosphate and manure.
Not a regulated drinking water contaminant
Attaches tenaciously to soil particles
Loss through erosion primarily
Especially important in freshwater ecosystems.

Phosphorus

Iowa contributes 15% of Phosphorus Load to Gulf of Mexico (4.5% of Area)

“P concentrations in Iowa streams are likely 2–3 times higher than Illinois streams on average”

“P loads 43% higher in 2017 than in 2004”

Journal of Hydrology 581 (2020) 124397

Contents lists available at ScienceDirect

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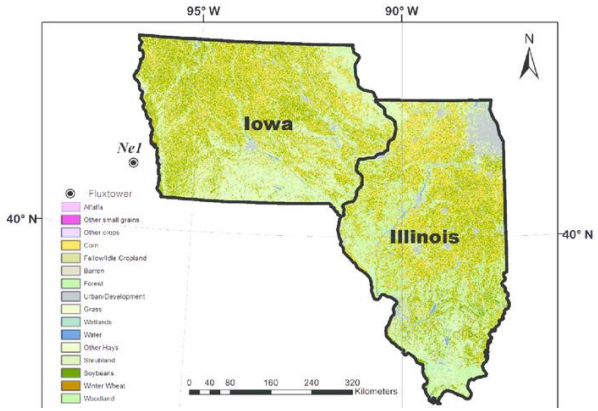
journal homepage: www.elsevier.com/locate/jhydrol

Research papers

Total phosphorus export from Iowa agricultural watersheds: Quantifying the scope and scale of a regional condition

Keith E. Schilling[a,*], Matthew T. Streeter[a], Anthony Seeman[b], Christopher S. Jones[c], Calvin F. Wolter[d]

[a] Iowa Geological Survey, University of Iowa, Iowa City, IA, United States
[b] Iowa Soybean Association, Ankeny, IA, United States
[c] IIHR Hydroscience and Engineering, University of Iowa, Iowa City, IA, United States
[d] Iowa Department of Natural Resources, Des Moines, IA, United States



Economics of N loss

Cost of Nitrogen: today about $1.20/lb

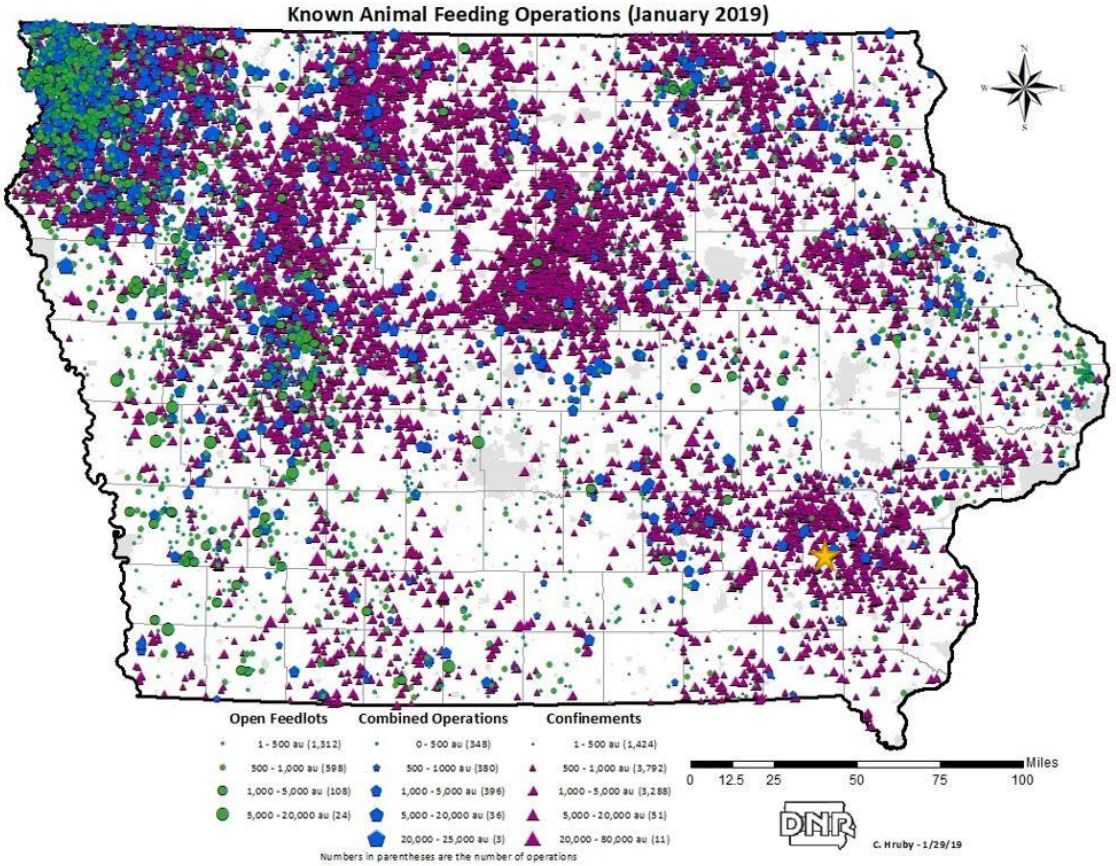
Cost to remove nitrogen using BMPs: $2-$10/pound

Average statewide load: 600 million lbs

45% reduction = 270 million lbs/year

$540M to $2.7B/year

How Do You Overcome Structural Drivers to Bad Water Quality?



More Diverse Farming Systems

Marsden Long Term Rotation Study-ISU

Matt Liebman

Corn/Soybean/Oat/Alfalfa/Alfalfa vs Corn/Soybean

N fertilizer use 91% lower
Herbicide use 97% lower
Weed biomass similar
Soybean sudden death syndrome much lower
Soil health is better
Tile nitrate 57% lower
Soil erosion 50% lower
Fossil Fuel use 60% lower
Net returns similar (revenue lower but input costs also lower)

Regulations?

1. Ban cropping in the 2-year Flood Plain

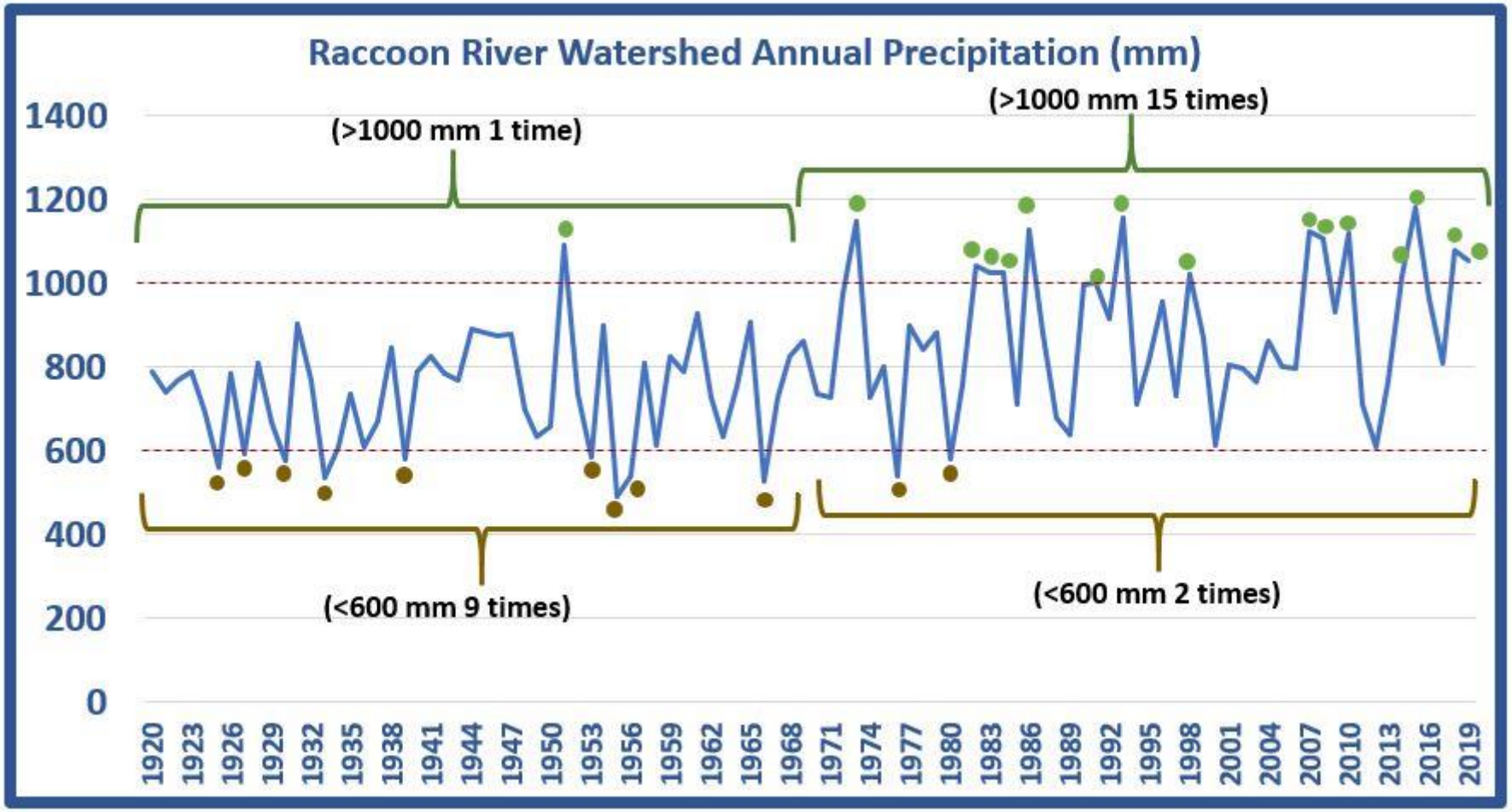
2. Ban fall tillage

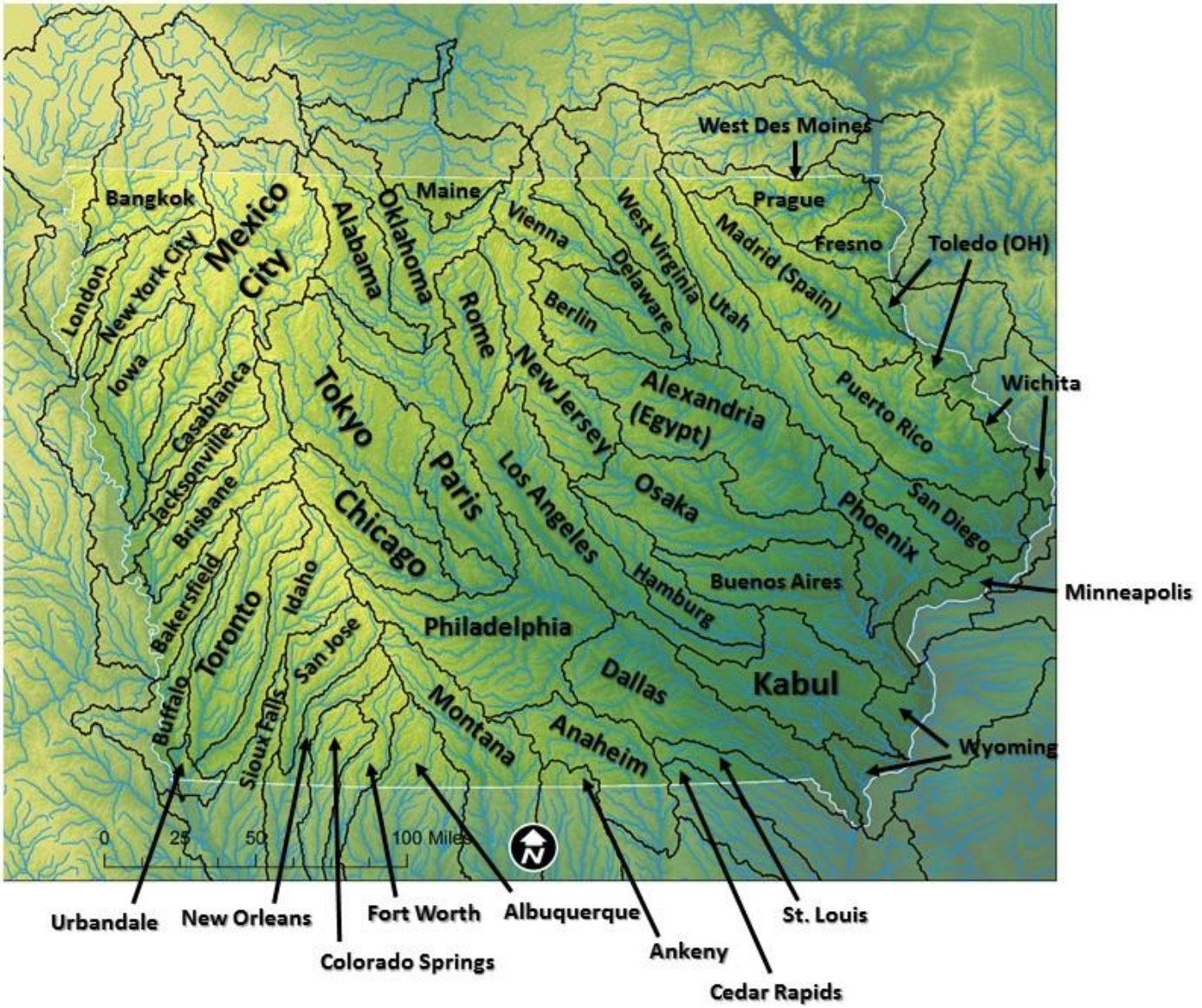
3. Ban manure on snow and frozen ground

4. Make farmers adhere to ISU fertilization guidelines

5. Reformulate CAFO Regulations

Climate Change

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