Chris Jones, Research Engineer, IIHR Hydroscience and Engineering

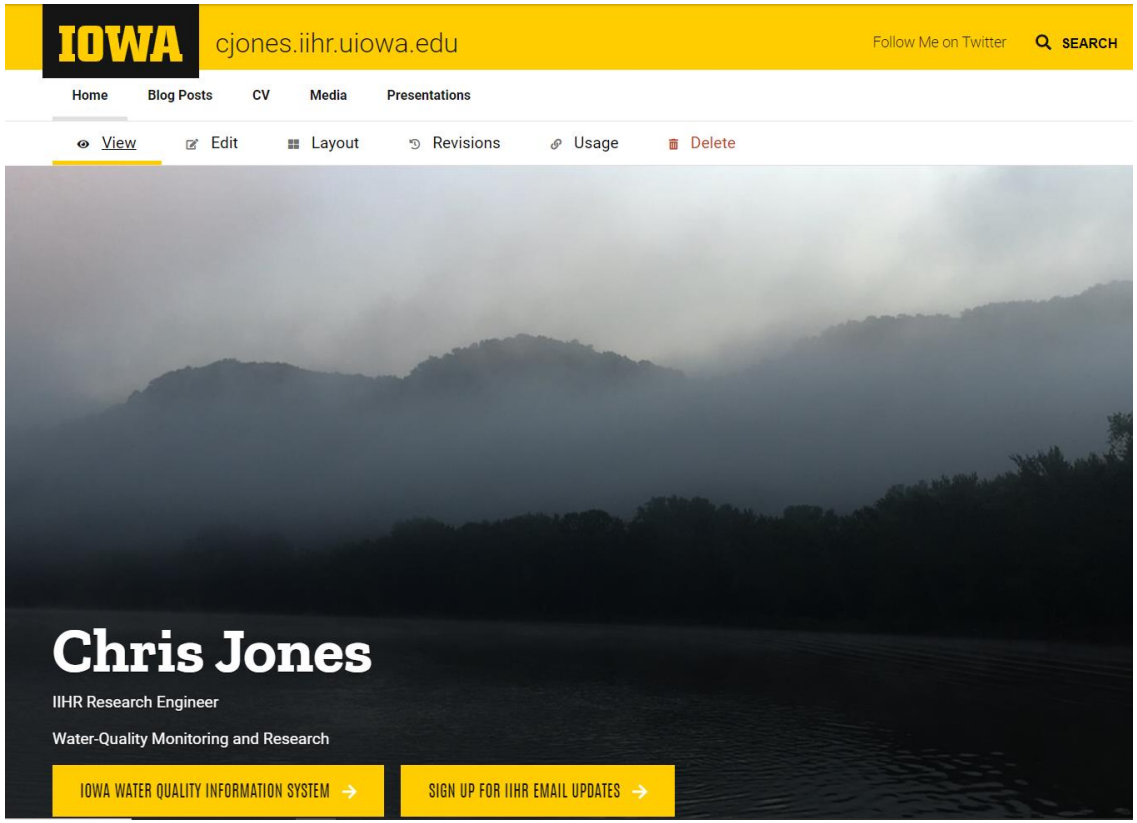
Iowa's Troubled Waters

July 20, 2022

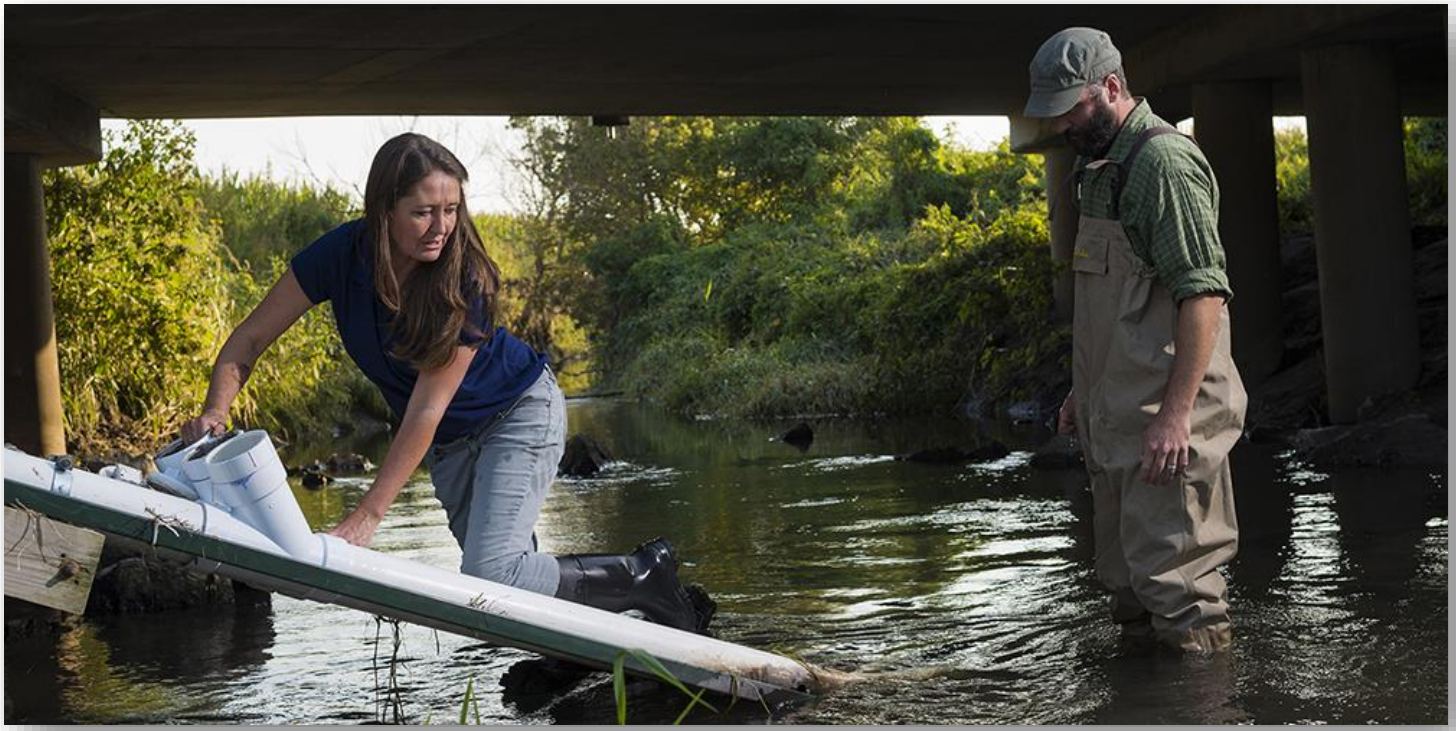
Southeast Iowa Sierra Club

Slides Available at:

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



IIHR Water Quality Sensor Network

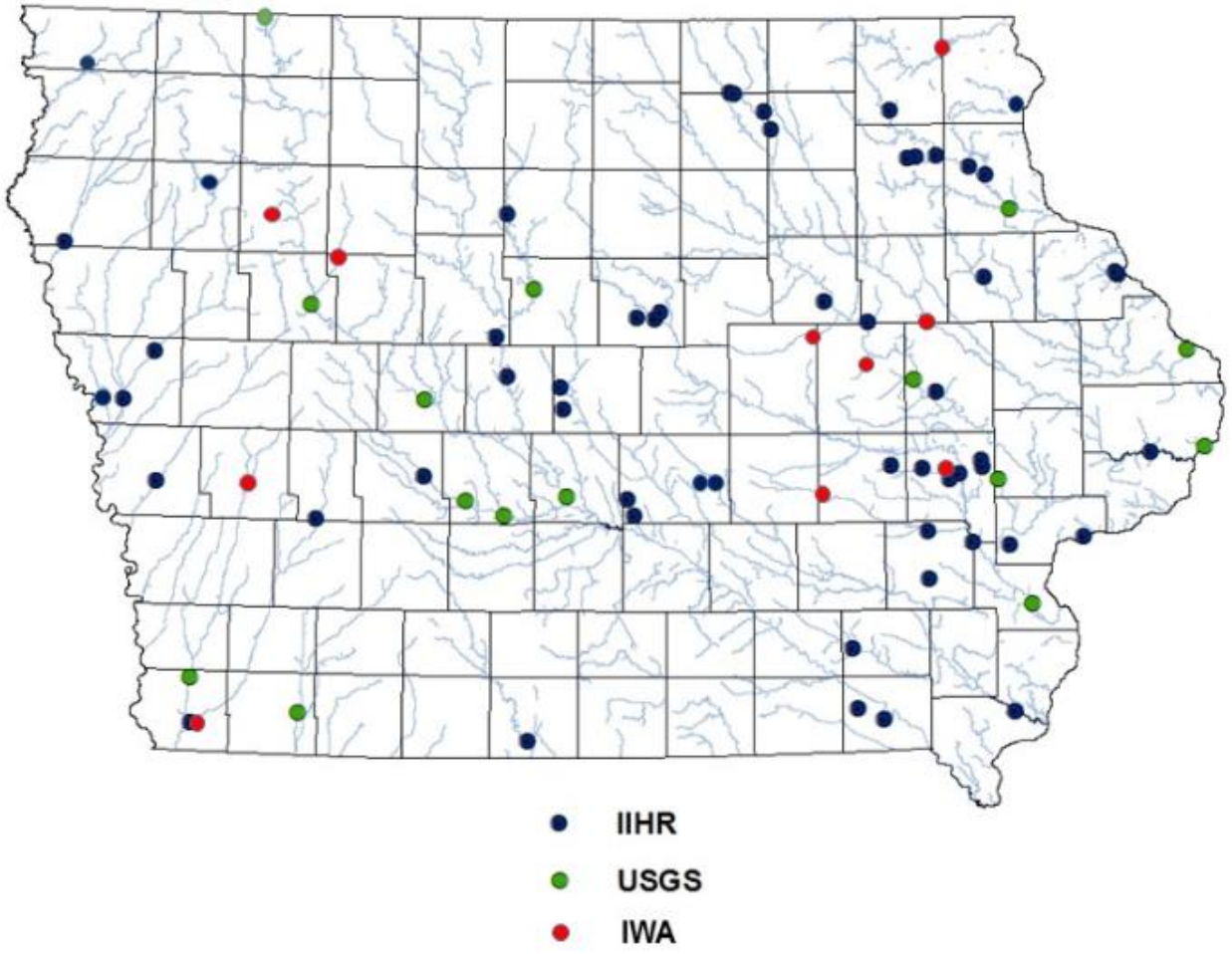


Sites

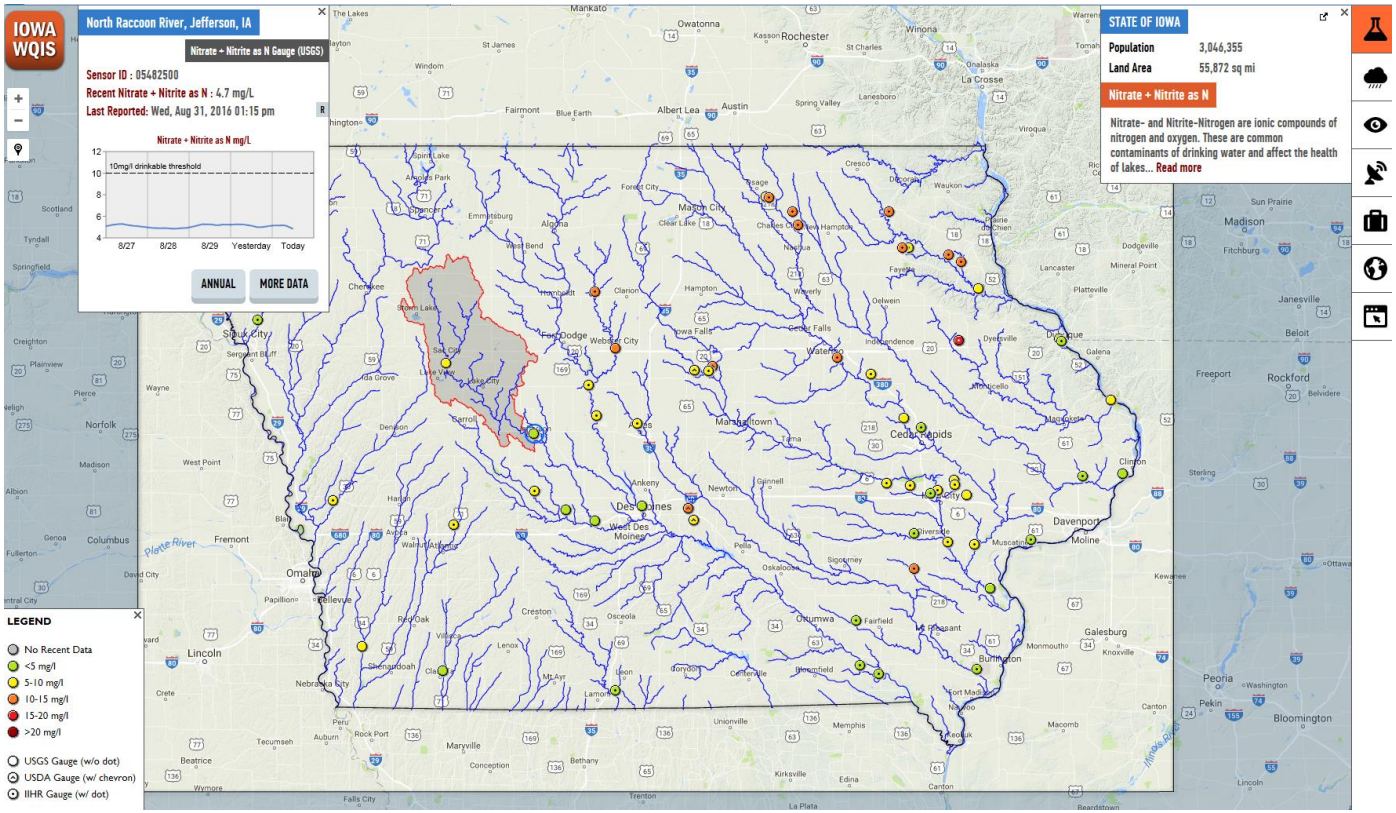
70+ sites
Nitrate-N

20-25 sites

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



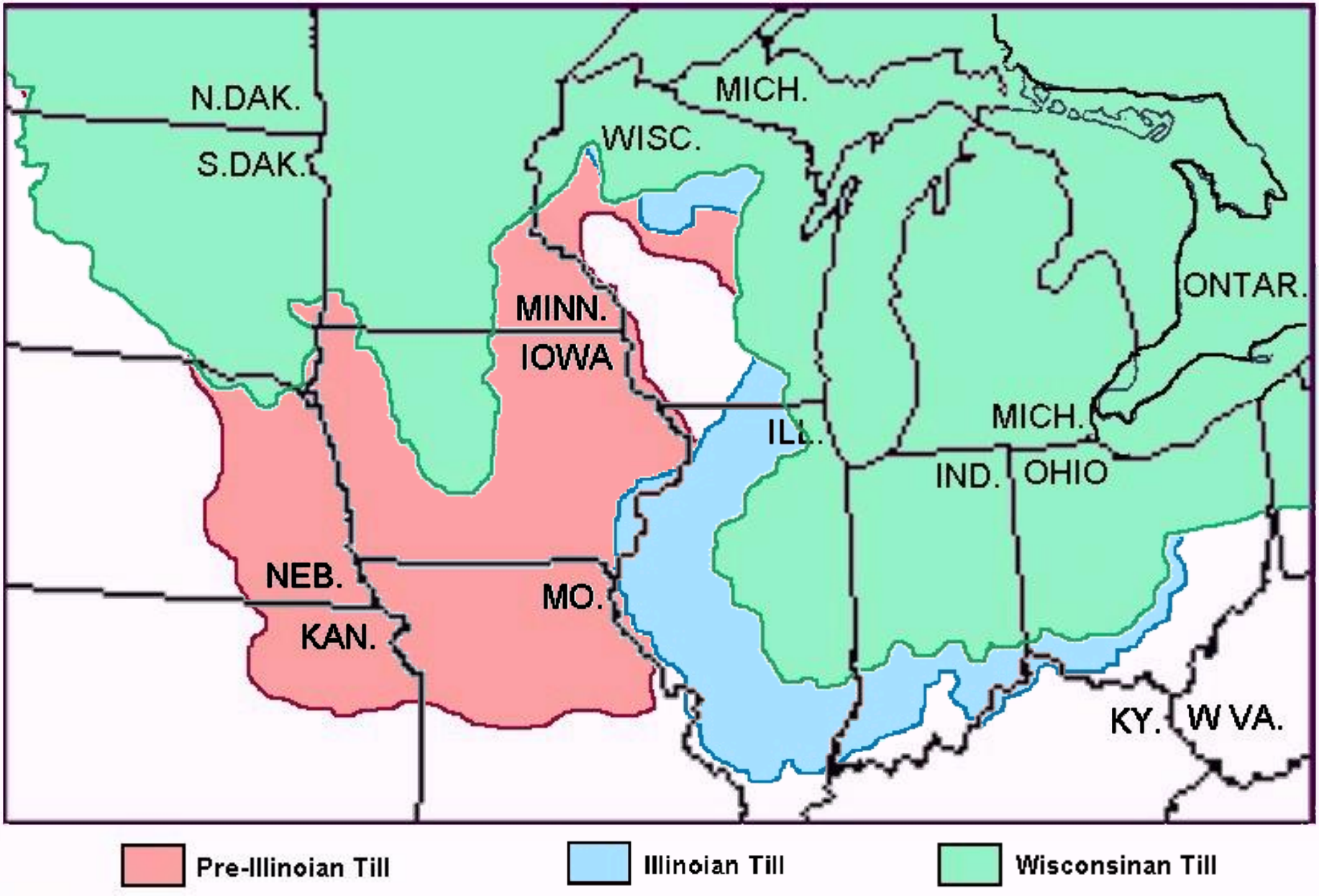
Iowa Water Quality Information System

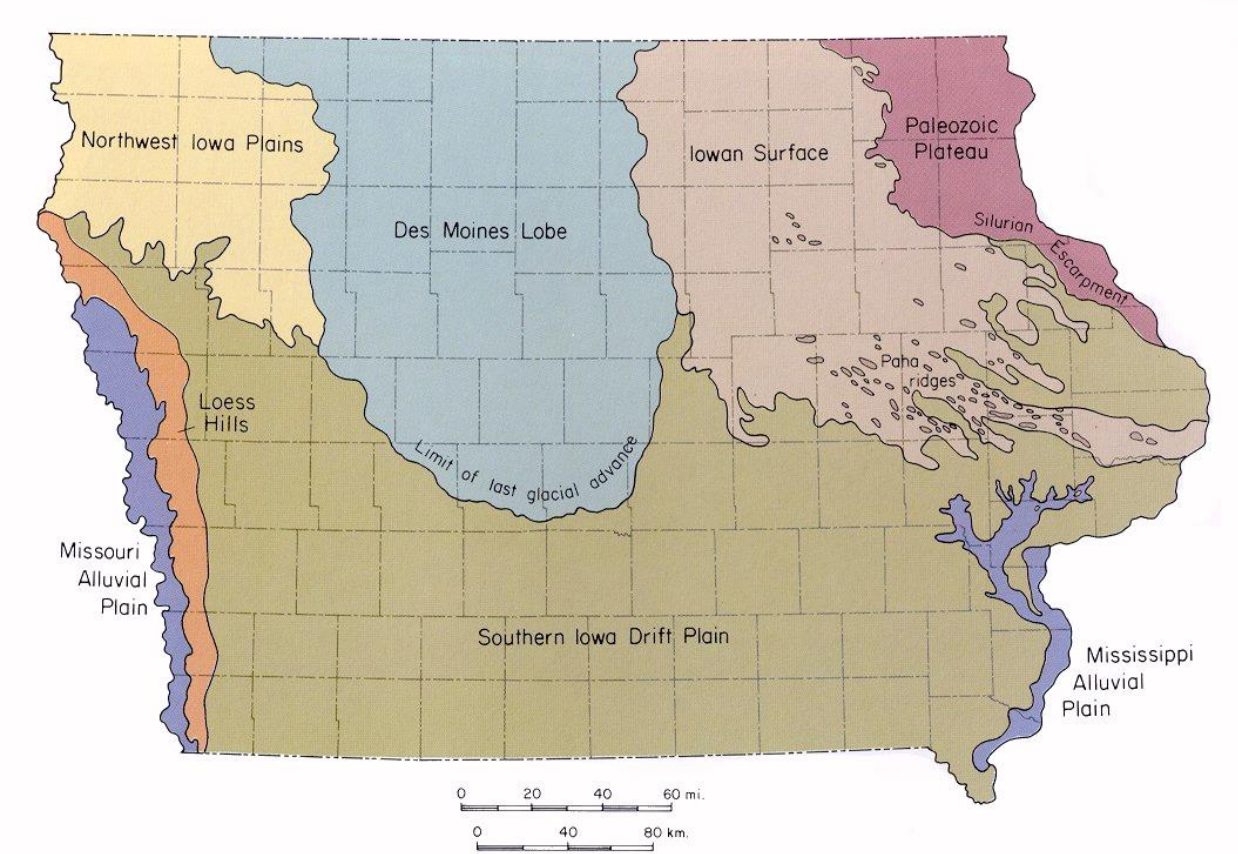


iwqis.iowawis.org/

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

30,000 – 10,500 years





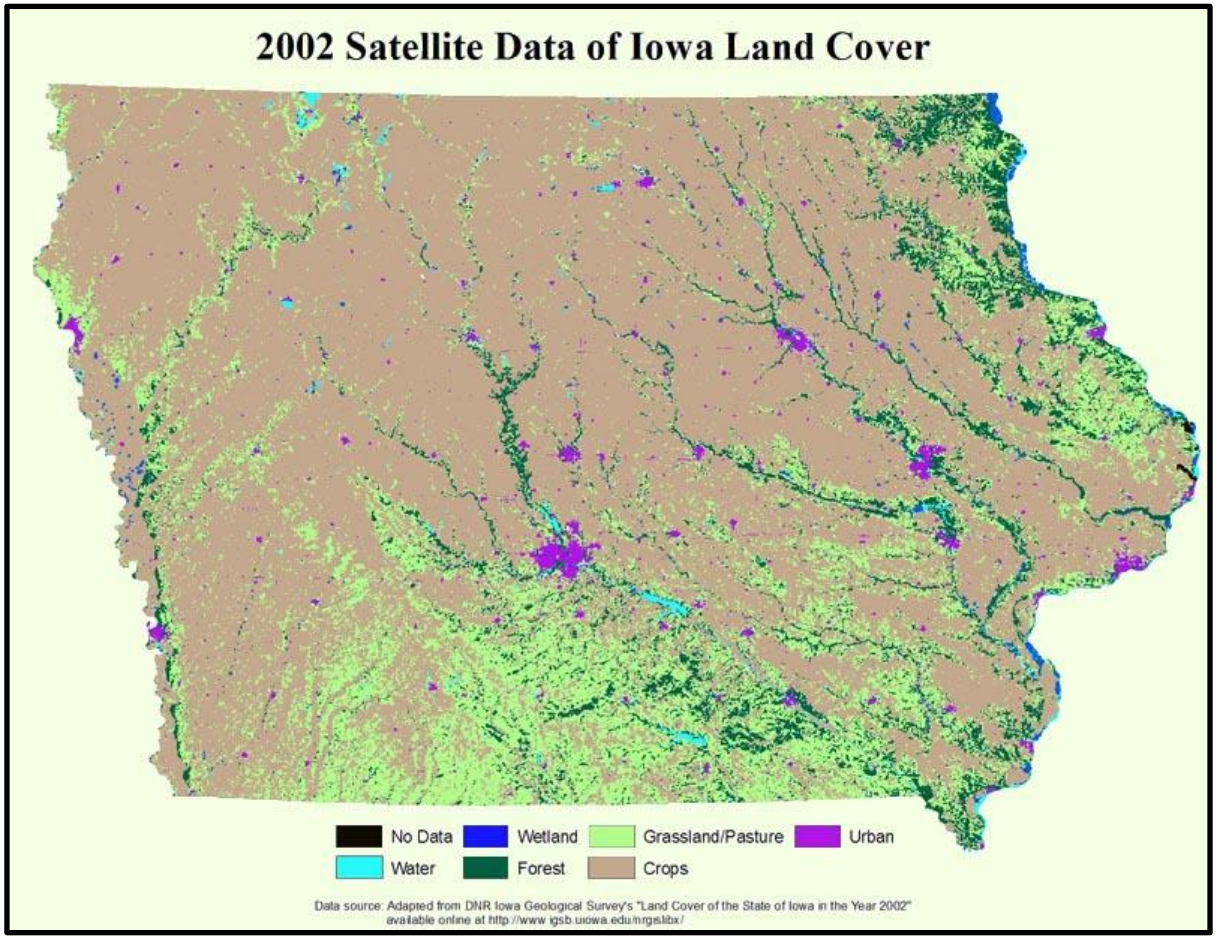
Landform Regions of Iowa


Wetland: 20% of Iowa, 7.6 million acres

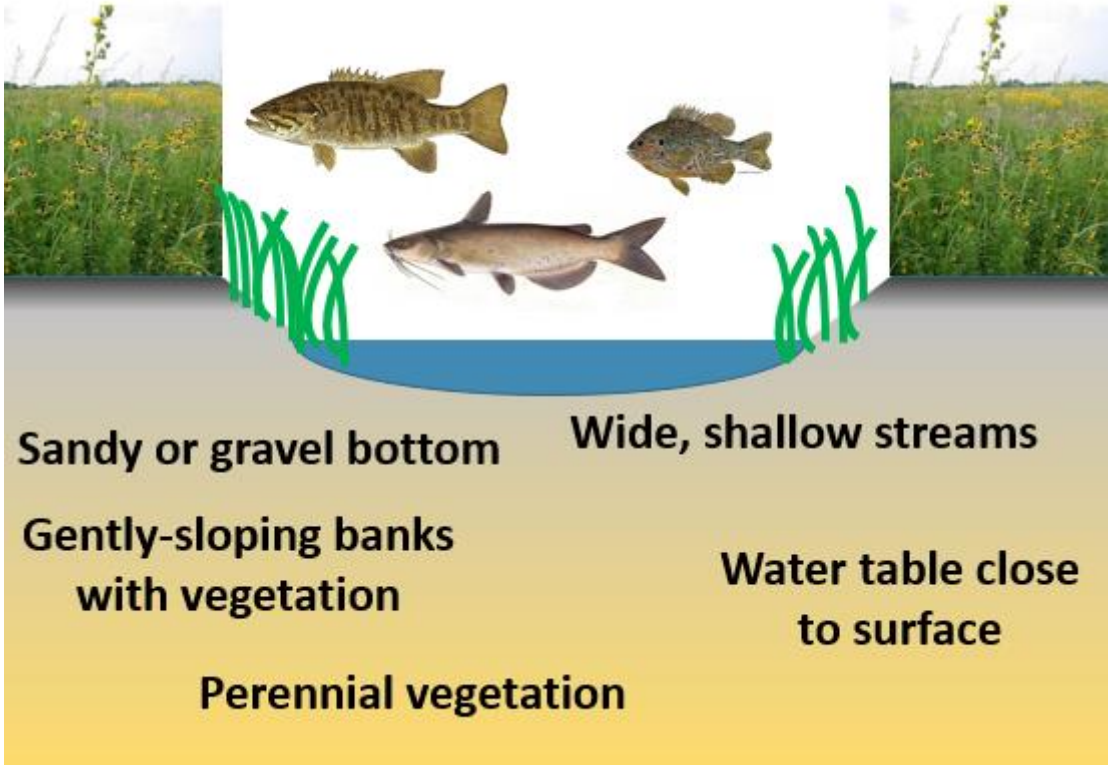

Oak Savannah: ~5%, < 1% remains


Prairie: 70%, 0.1% Remains

Iowa Land Cover



Pre-European Settlement Streams



Hydrological Modification: 1860s-1910s

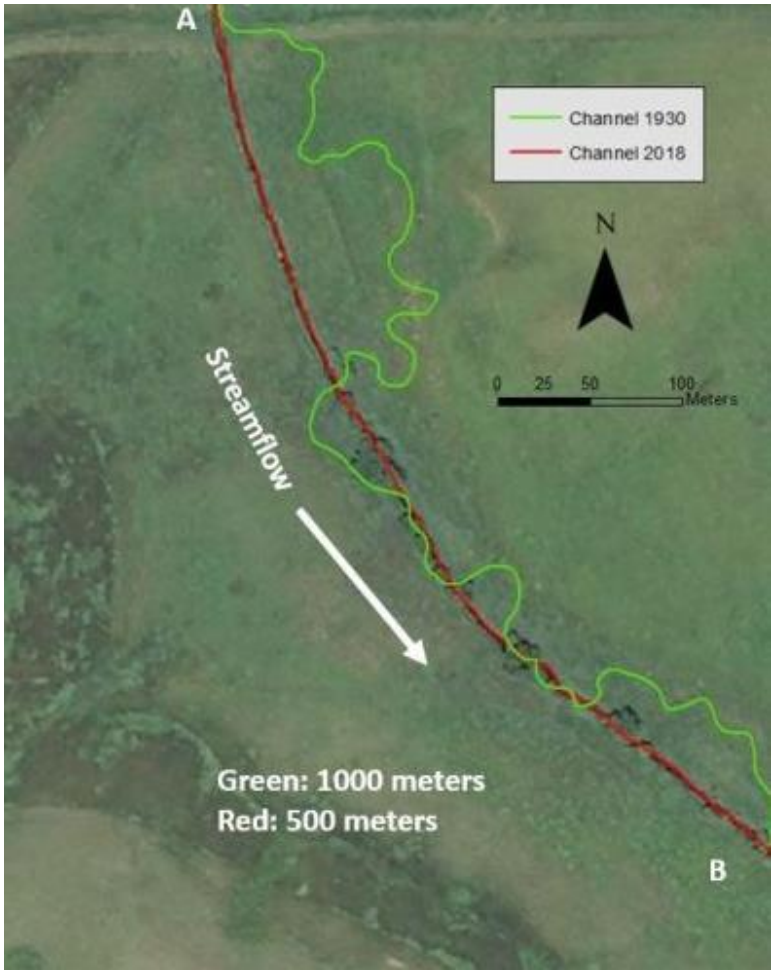
Excavating a large ditch using steam power, circa 1910.

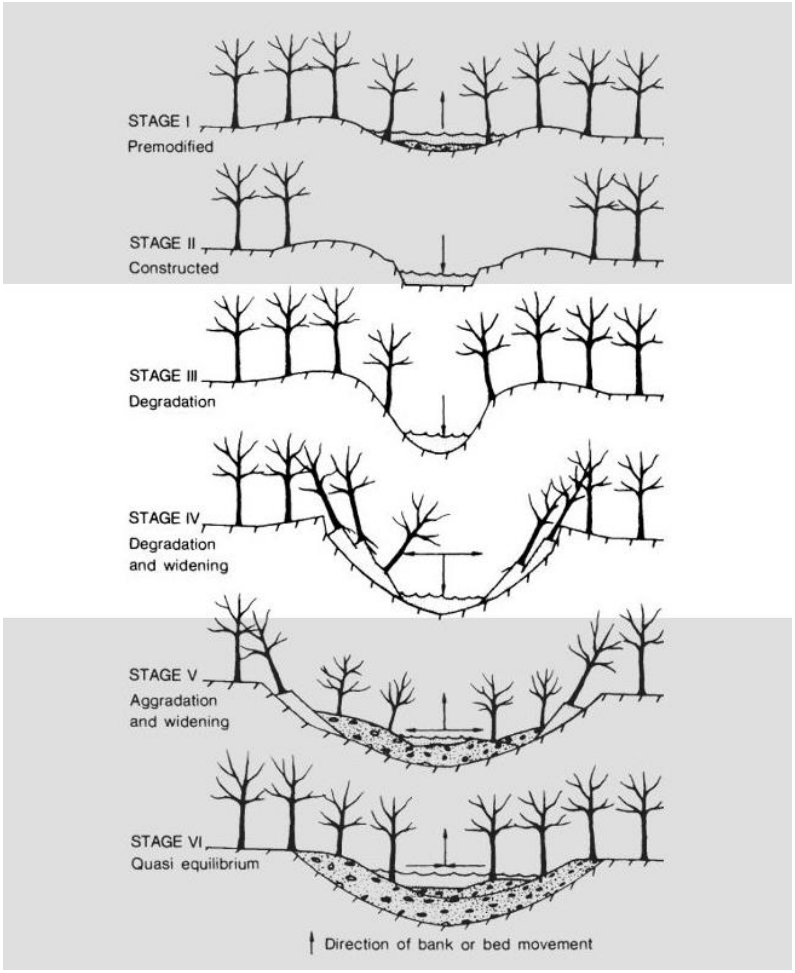
Hand digging tile, Boone Co. IA. ca 1914
Source: 'An Iowa album: a photographic history, 1860-1920' by M. J. Bennet, University of Iowa Press, Iowa City, Iowa

Tiling field now

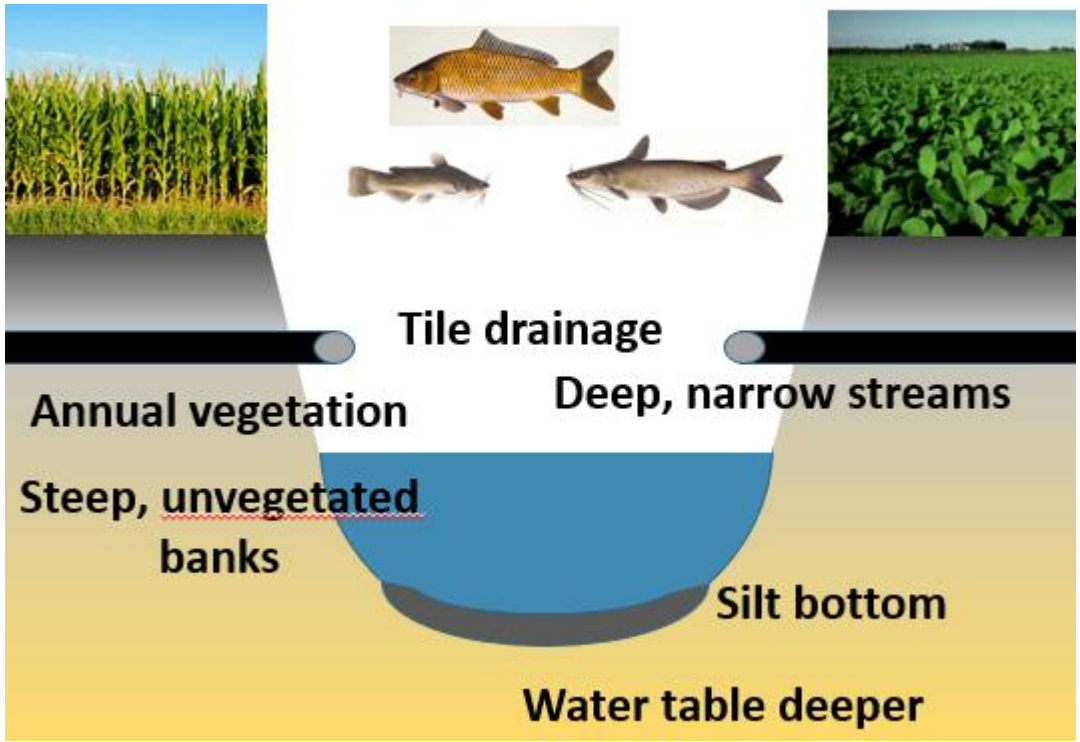
Source of the Iowa River

Stream Straightening, 1930-1975





Modified Streams



Transformation of Iowa Farms

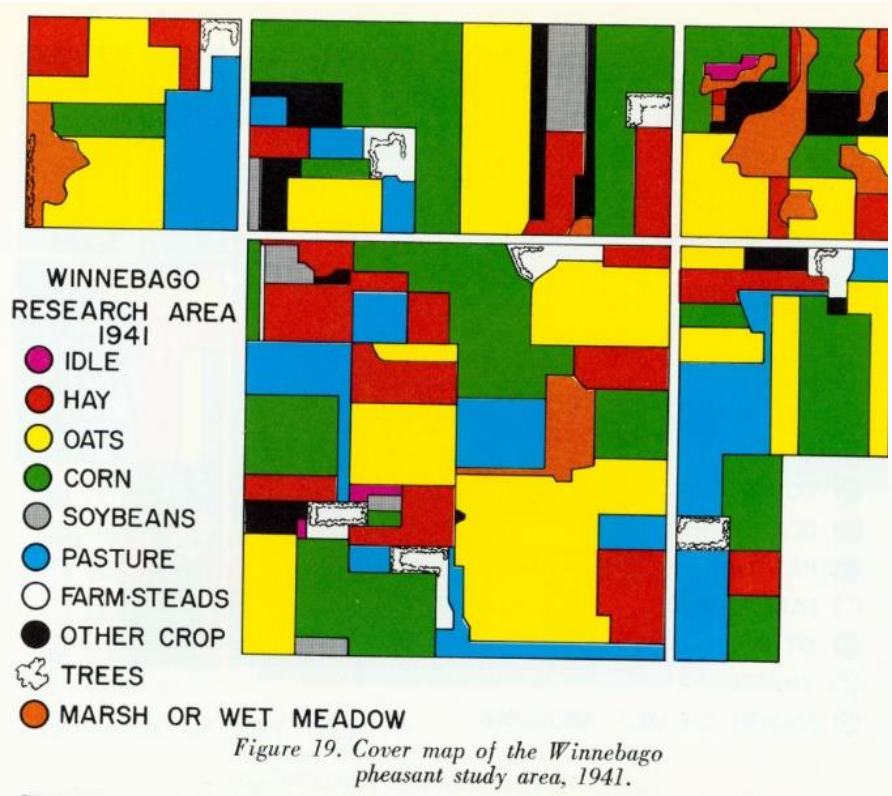


Figure 19. Cover map of the Winnebago pheasant study area, 1941.

1941

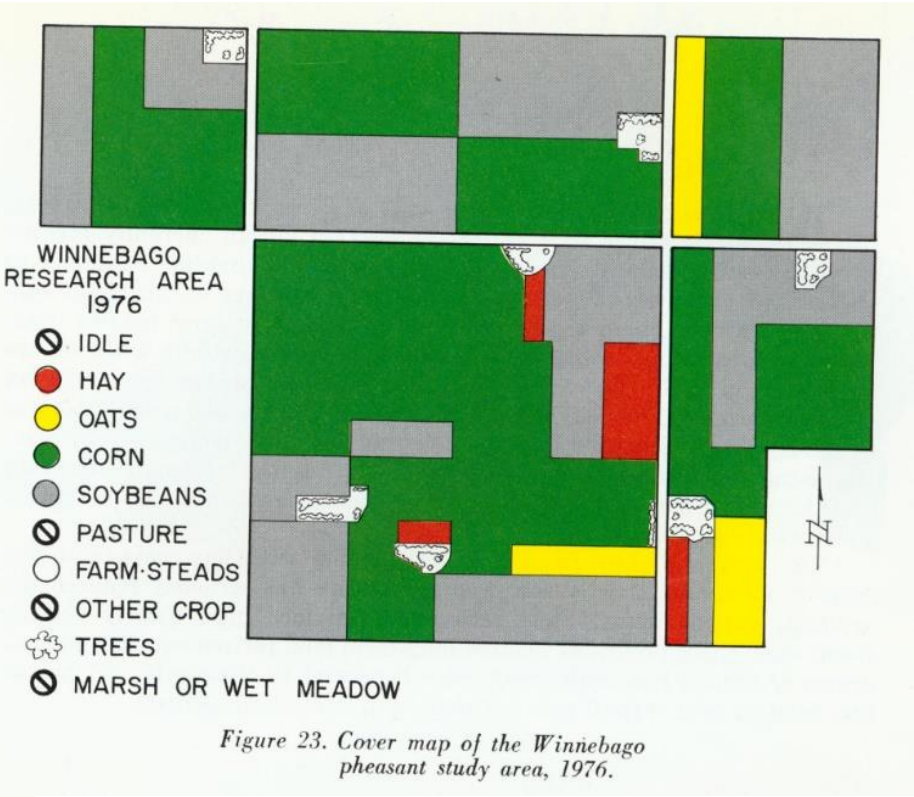
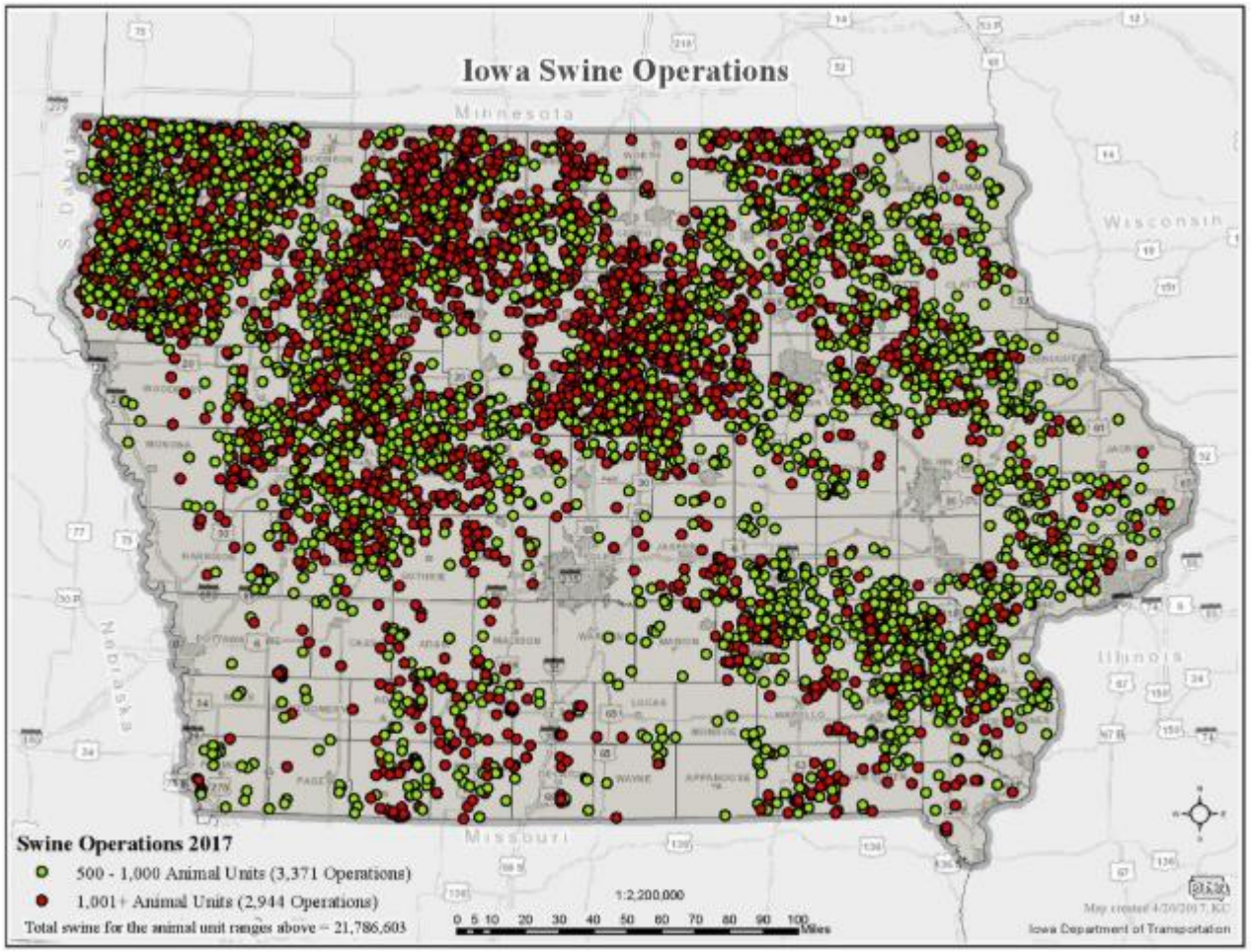


Figure 23. Cover map of the Winnebago pheasant study area, 1976.

1976

8000 CAFOs

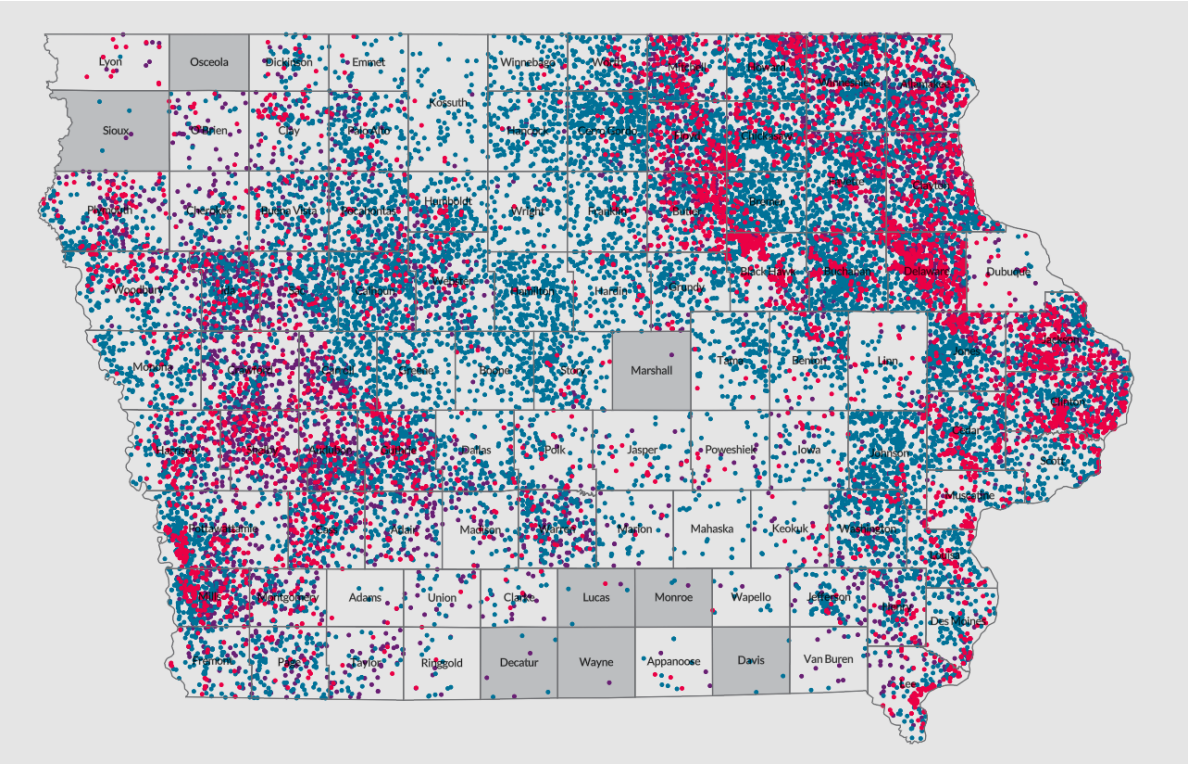

Iowa Swine Operations
Minnesota
Wisconsin
Illinois
Missouri
Nebraska
Swine Operations 2017
500 - 1,000 Animal Units (3,371 Operations)
1,001+ Animal Units (2,944 Operations)
Total swine for the animal unit ranges above = 21,786,603
1:2,200,000
0 5 10 20 30 40 50 60 70 80 90 100 Miles
Iowa Department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

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

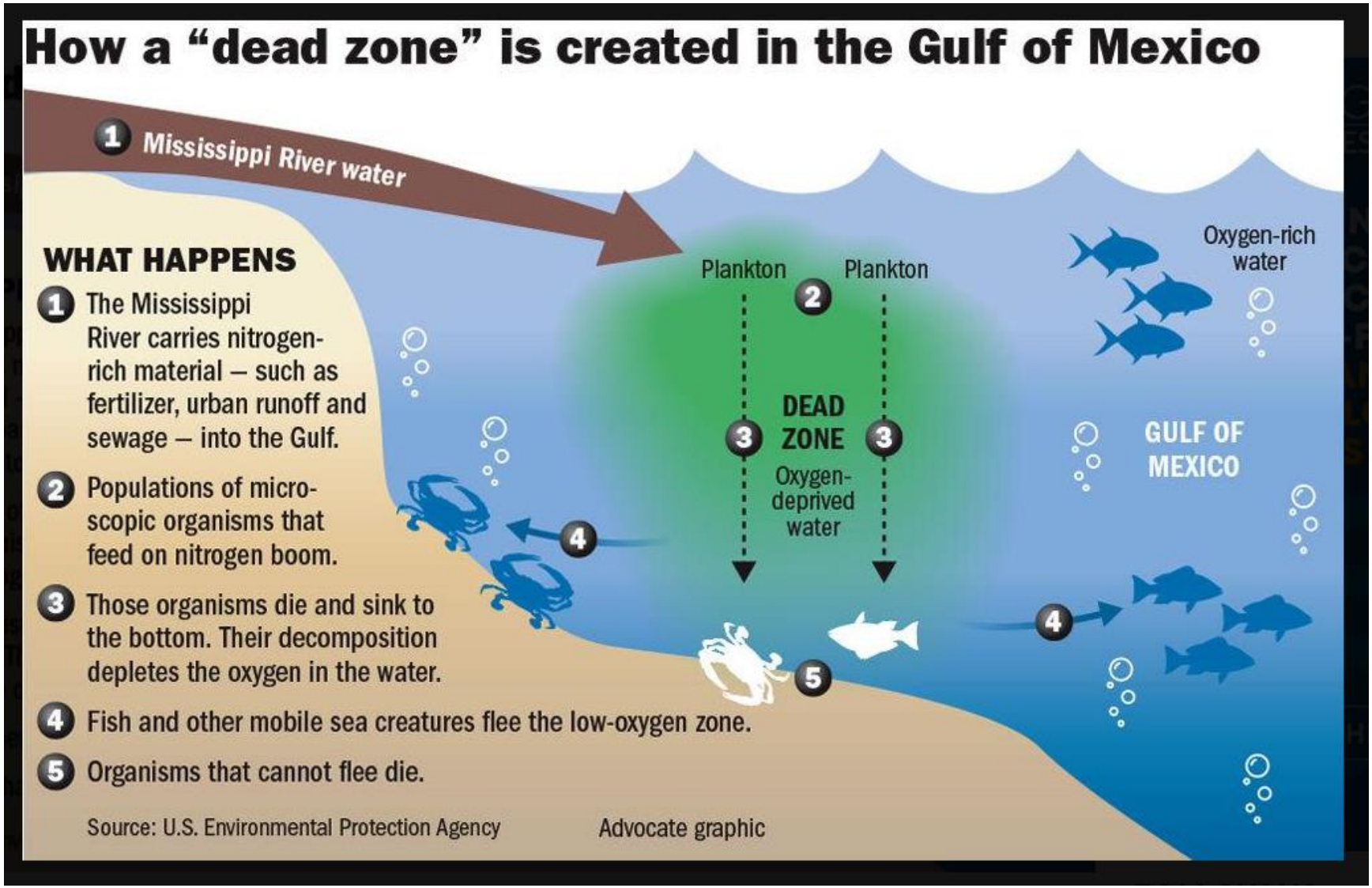
60 PWSs are removing nitrate

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

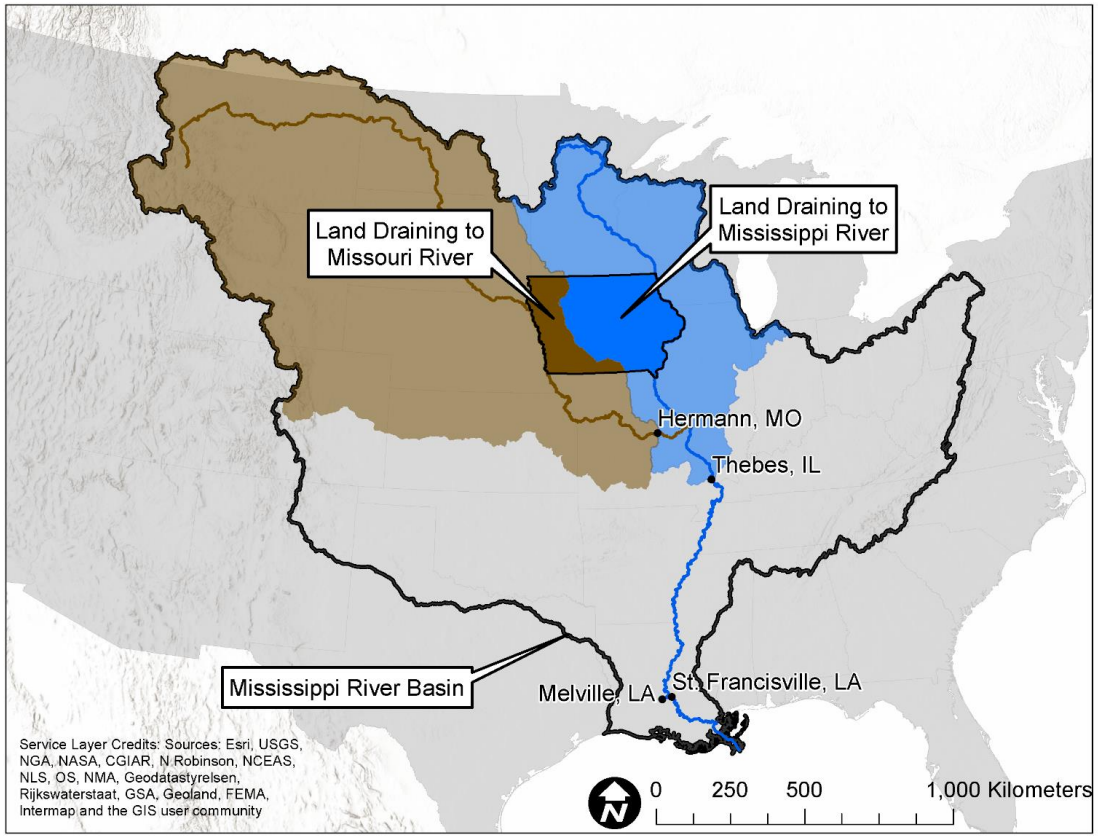
Surface Water

Lake Erie Algae Blooms

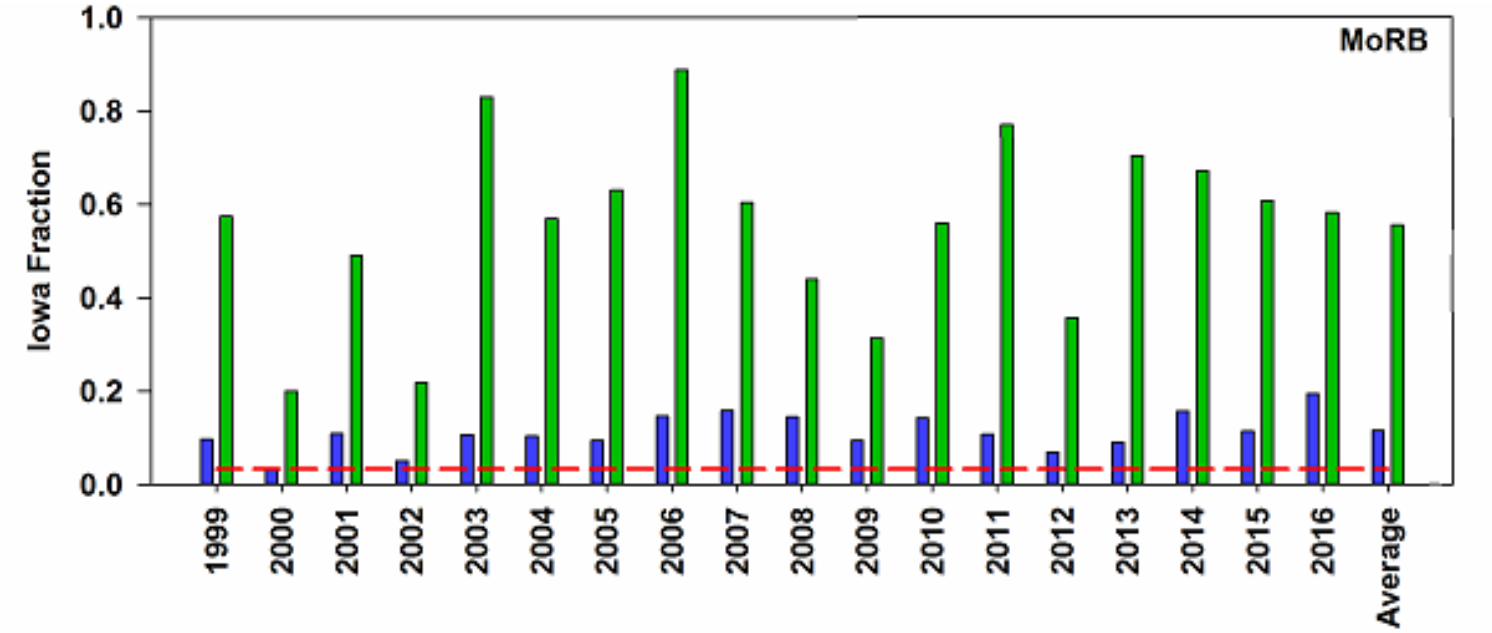
Gulf of Mexico Hypoxia


How a “dead zone” is created in the Gulf of Mexico
1 Mississippi River water
WHAT HAPPENS
1 The Mississippi River carries nitrogen-rich material – such as fertilizer, urban runoff and sewage – into the Gulf.
2 Populations of micro-scopic organisms that feed on nitrogen boom.
3 Those organisms die and sink to the bottom. Their decomposition depletes the oxygen in the water.
4 Fish and other mobile sea creatures flee the low-oxygen zone.
5 Organisms that cannot flee die.
Plankton
Plankton
2
DEAD ZONE
3
3
Oxygen-deprived water
Oxygen-rich water
GULF OF MEXICO
4
4
5
Source: U.S. Environmental Protection Agency
Advocate graphic

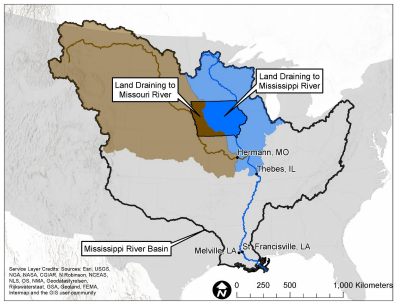
Iowa Contributions



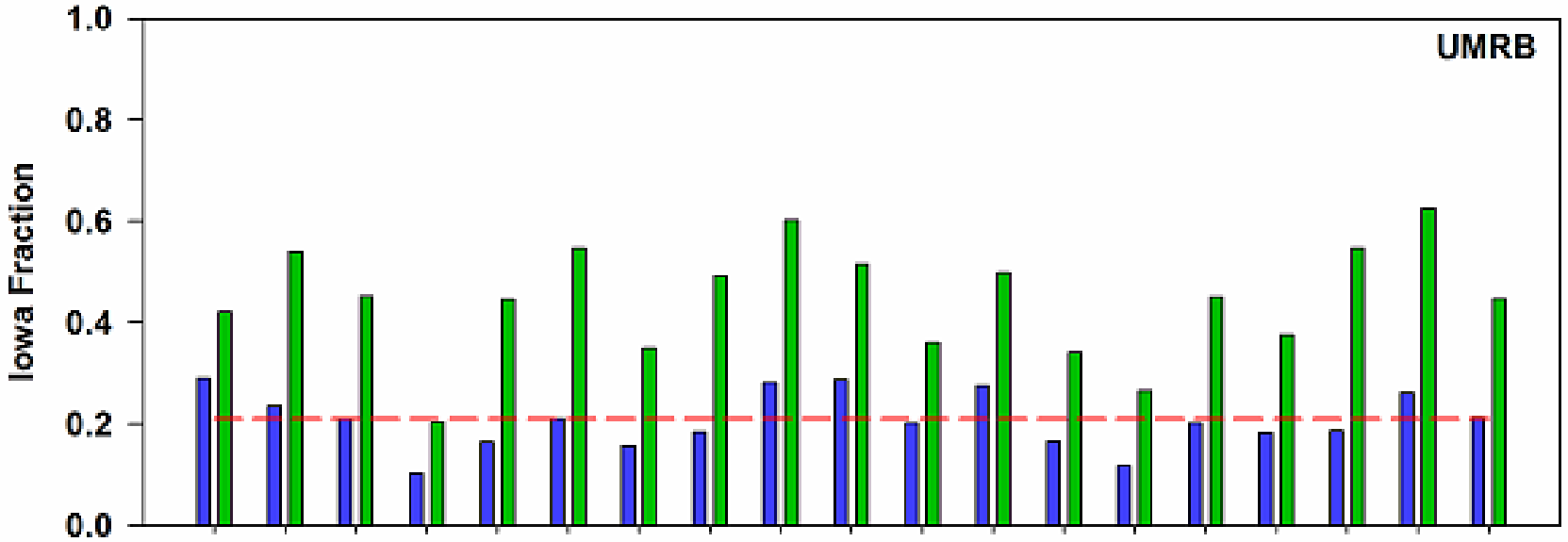
Missouri Basin: Nitrogen



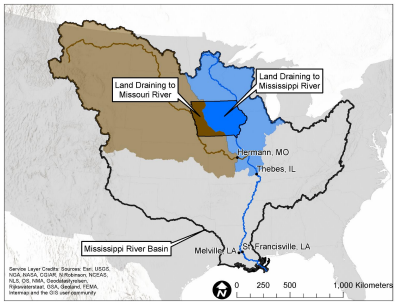
3.3% of the land
12% of the water
55% of the nitrate



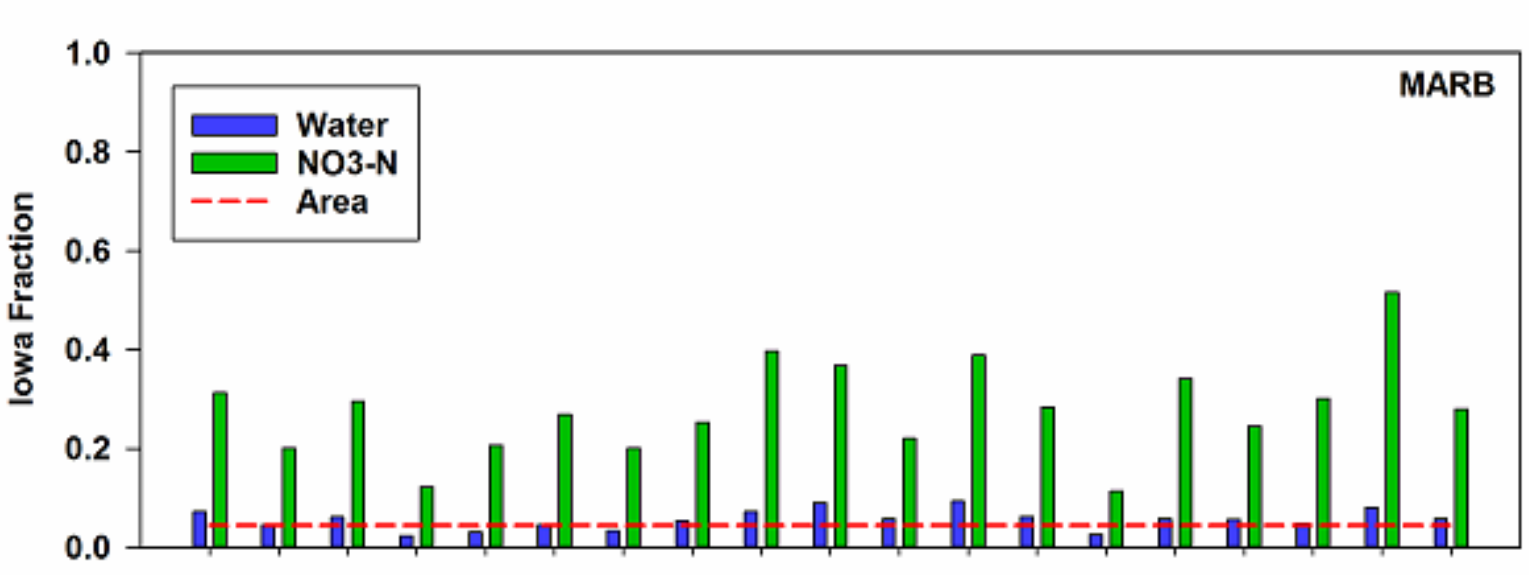
Upper Mississippi: Nitrogen



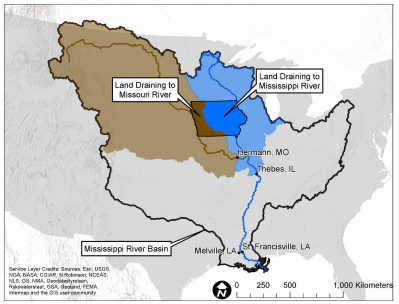
21% of the land
21% of the water
45% of the nitrate



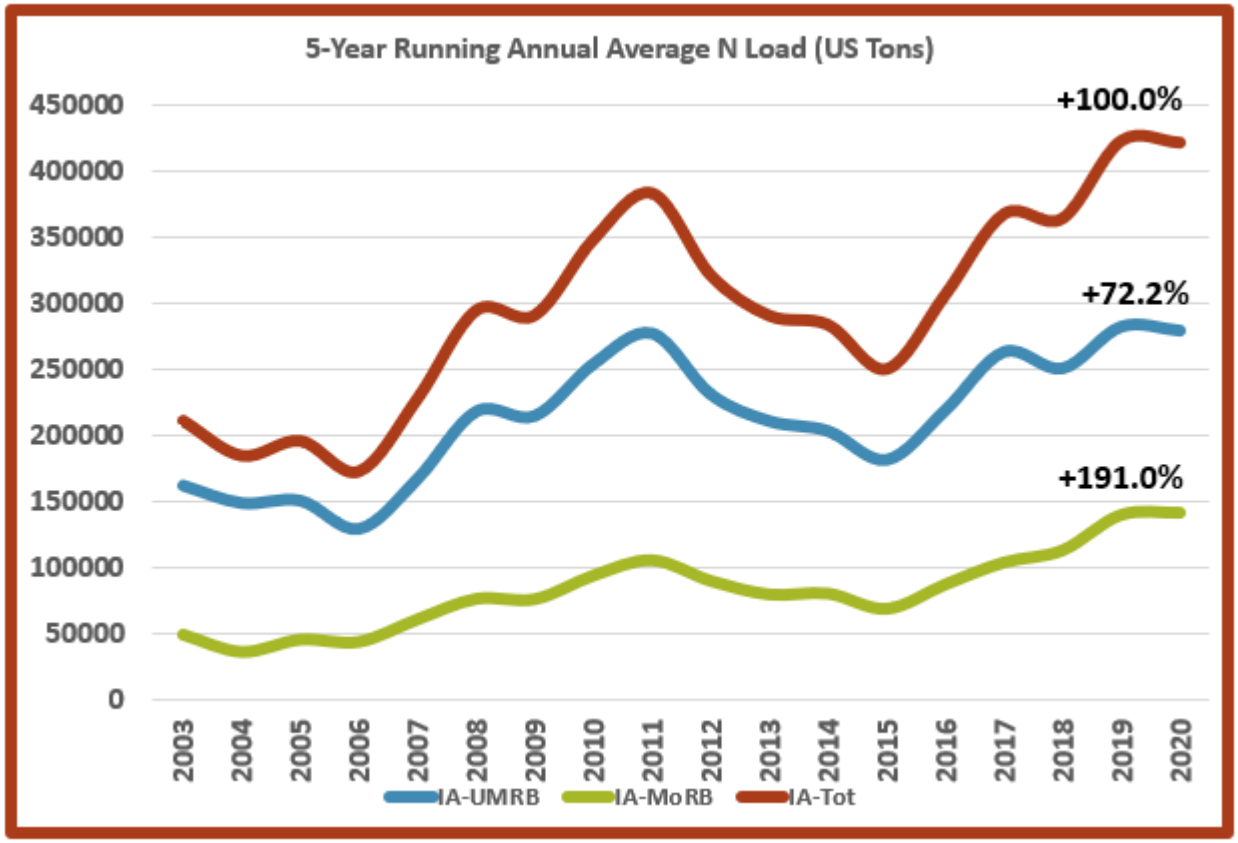
Mississippi-Atchafalaya: Nitrogen

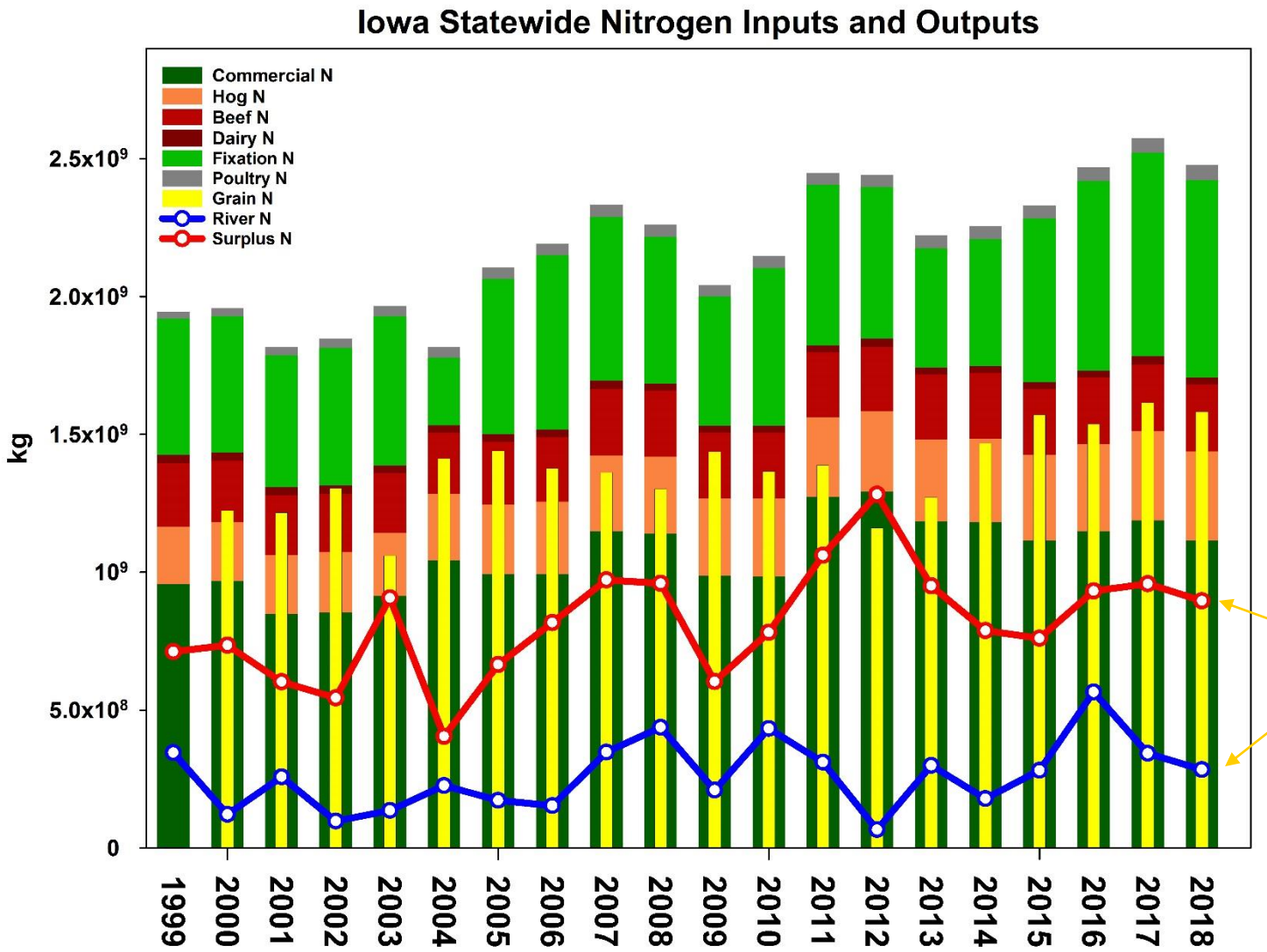


4.5% of the land
5.9% of the water
29% of the nitrate



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

Water Quality Index

- Single value index that objectively translates a body of data into one value
- Concept dates to at least 1848

Two types:

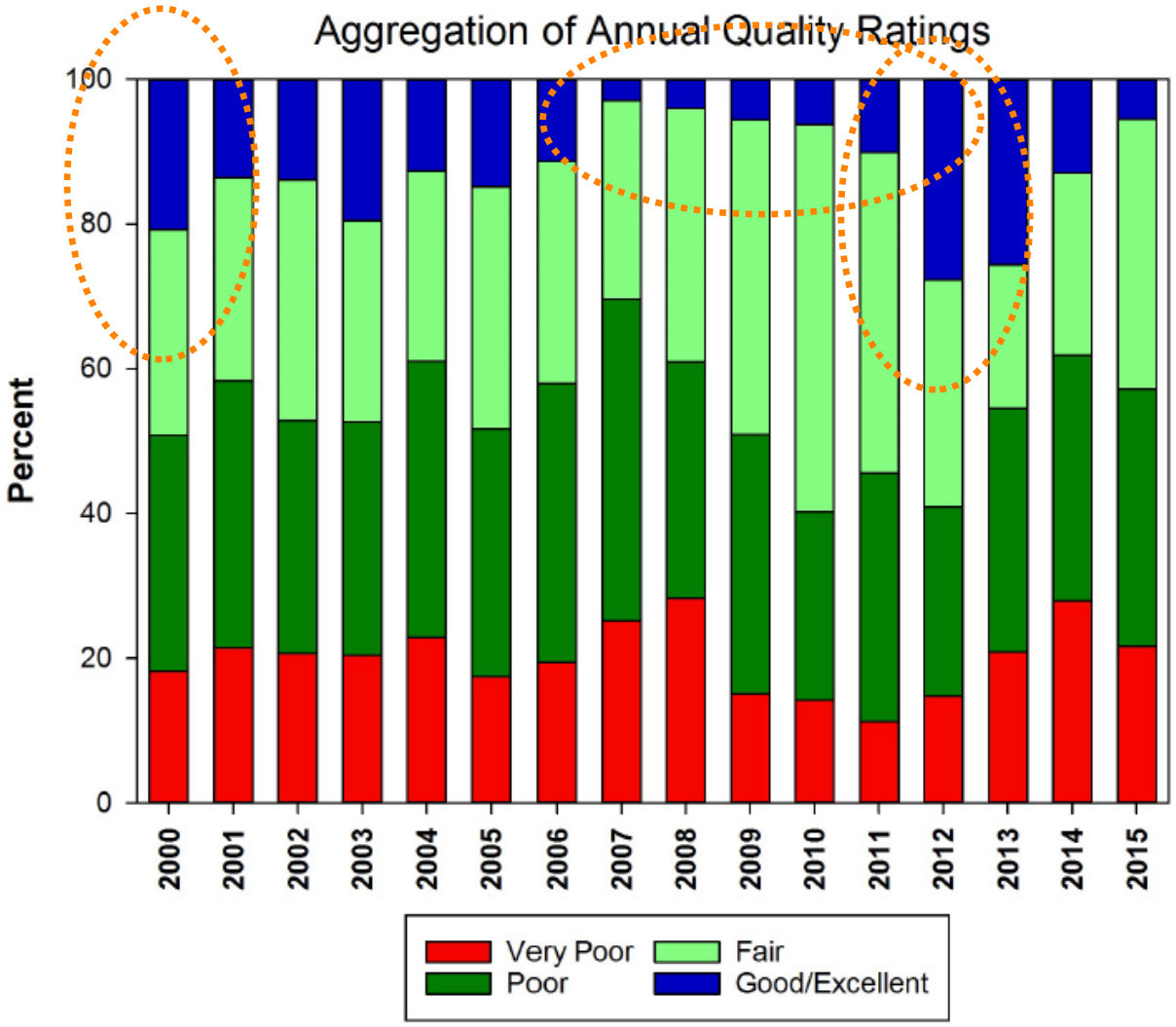
- Water Quality Index (high #'s for good water, low #'s for bad water)
- Water Pollution Index (low #'s for good water, high #'s for bad water)

Iowa

- WQI created by DNR in 2005
- Modification of WQI created by the National Sanitation Foundation

Parameter	IWQI	NSFWQI
Biological Oxygen Demand (BOD)	Yes	Yes
Dissolved Oxygen (DO)	Yes	Yes
E. coli	Yes	No
Fecal coliforms	No	Yes
Nitrate as Nitrogen (NO3-N)	No	Yes
Nitrate + Nitrite as Nitrogen (NOx-N)	Yes	No
Pesticides	Yes	No
Temperature	No	Yes
Total Dissolved Solids (TDS)	Yes	Yes
Total Phosphorous (TP)	Yes	Yes
Total Suspended Solids (TSS)	Yes	No
Turbidity	No	Yes

Figure 1: Aggregate IWQI Ratings for Iowa Streams, 2000-2015



Rating	Index Value
Very Poor	10 to 25
Poor	25 to 50
Fair	50 to 70
Good	70 to 90
Excellent	90 to 100

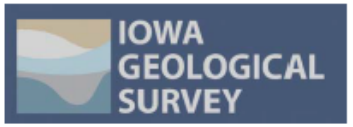
Analysis of Iowa Water Quality Index

and

Proposed Alternative

Christopher S. Jones, Ph.D., Research Engineer
University of Iowa IIHR Hydroscience and Engineering

Richard J. Langel, M.S. Research Specialist
Iowa Geological Survey

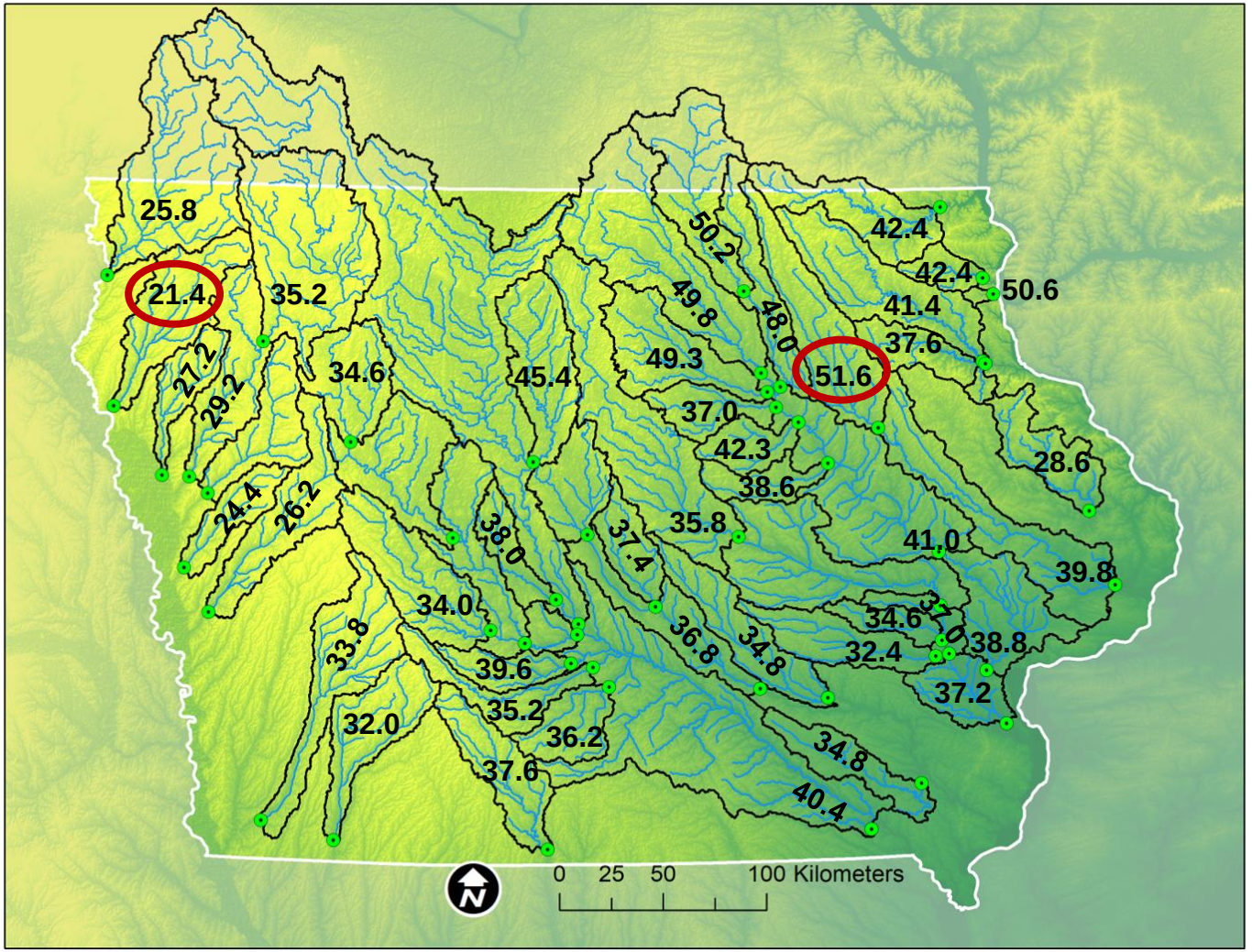


IIHR – Hydroscience and Engineering
College of Engineering
The University of Iowa
Iowa City, Iowa 52242-1585

Prepared for: Iowa Department of Natural Resources

July 15, 2016

2016-2020



>96=Excellent
81-95=Good
66-80=Fair
46-65=Marginal
10-45=Poor
<10=Very Poor

wqi	water quality index
DO	Dissolved oxygen
EC	E. coli
N	Total nitrogen
P	Total phosphorus
Turb	Turbidity
	less than 5% change
	5 to 10% improvement
	10-20% improvement
	>20% improvement
	5-10% deterioration
	10-20% deterioration
	>20% deterioration

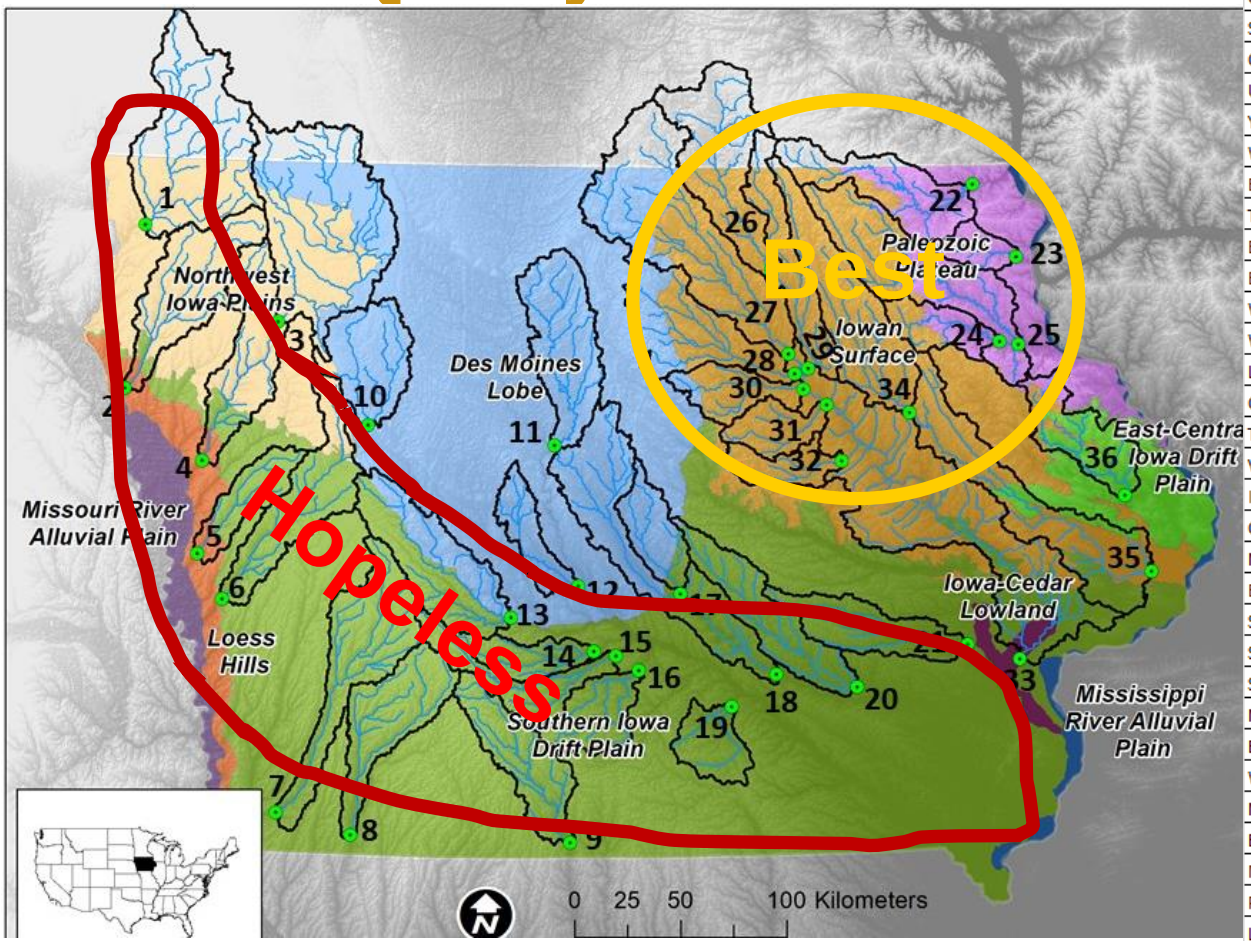
3/44 improving (>5%)

16/44 <5% change

25/44 declining (>5%)

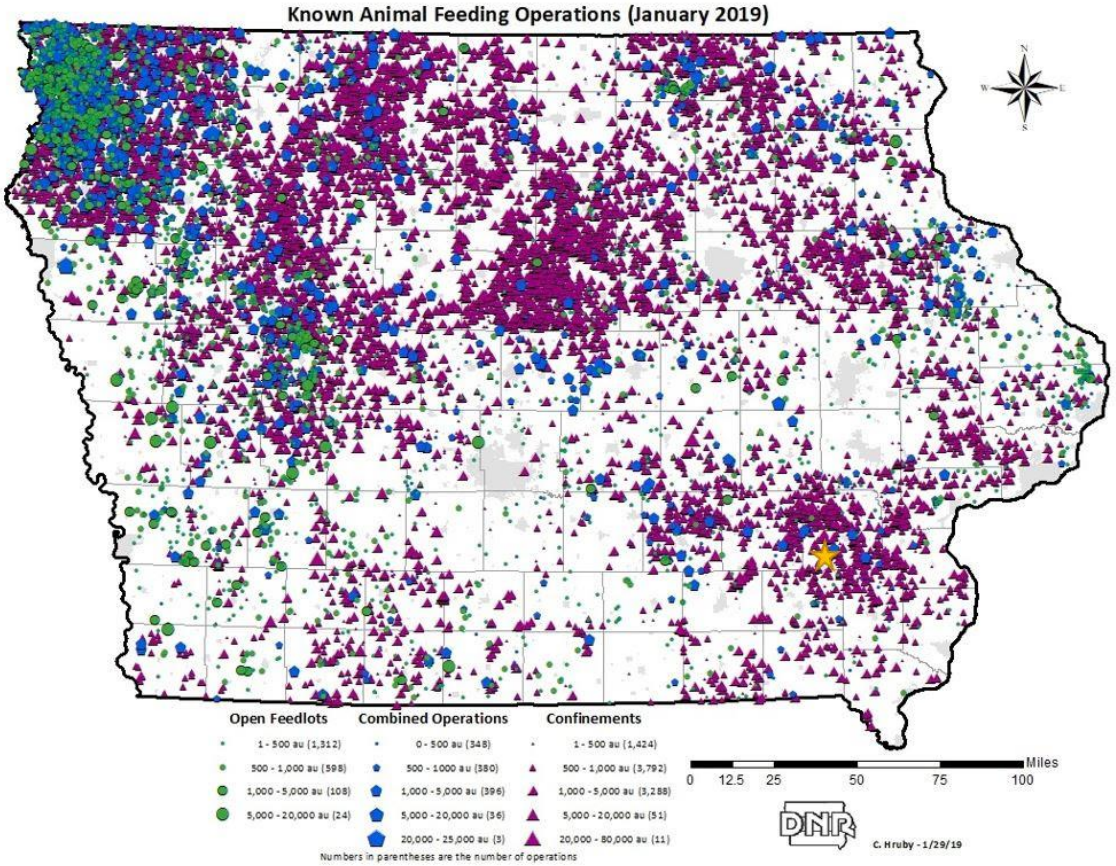
Location	group	WQI 2016-20	Percent Change, 2016-20 versus pre-2016					
			change wqi	change DO	change EC	change N	change P	change turb
Wapsipinicon River at Independence	Iowan Surface	51.6	-5.1	-1.0	31.6	12.0	50.0	18.3
Bloody Run Cr at Marquette	Paleozoic Plateau	50.6	-14.4	-1.7	111.8	18.0	62.5	198.3
Cedar River at Charles City	Iowan Surface	50.2	4.4	-1.8	-38.1	-2.6	-9.5	-0.7
Shellrock River at Shellrock	Iowan Surface	49.8	-4.8	-5.2	30.0	-2.1	11.1	-12.3
W. Fork of the Cedar River at Finchford	Iowan Surface	49.3	2.8	-4.7	55.6	0.1	21.4	0.0
Cedar River at Janesville	Iowan Surface	48.0	-11.1	-9.8	51.5	3.3	11.8	-12.1
Boone River at Stratford	Des Moines Basin Up	45.4	1.3	-4.3	-16.8	-8.0	-16.7	-13.8
Upper Iowa River at Dorchester	Paleozoic Plateau	42.4	-14.7	-8.4	-51.7	20.5	0.0	-9.3
Yellow River at Ion	Paleozoic Plateau	42.4	-17.3	-5.8	-48.7	27.6	21.1	76.5
Blackhawk Creek at Waterloo	Iowan Surface	42.2	-0.2	0.0	-5.8	-2.3	-5.9	20.4
Turkey River at Garber	Paleozoic Plateau	41.4	-5.5	-2.7	-44.3	8.8	-10.3	5.4
Cedar River Downstream of Cedar Rapids	Iowan Surface	41.0	0.7	0.9	17.6	5.9	-13.3	31.0
Des Moines River at Keosauqua	Des Moines Basin Down	40.4	-6.5	-1.8	161.9	7.8	-17.1	53.6
Wapsipinicon River at DeWitt	Iowan Surface	39.8	-5.0	-8.2	6.0	1.1	13.6	0.3
North River at Norwalk	Des Moines Basin Down	39.6	23.0	2.1	-80.6	-19.1	-24.2	-21.1
Cedar River at Conesville	Iowan Surface	38.8	-4.2	-9.4	21.5	-0.7	-5.6	-6.0
Wolf Creek at LaPorte City	Iowan Surface	38.6	-7.4	1.0	58.3	-6.3	12.5	15.4
Beaver Creek at Grimes	Des Moines Basin Up	38.0	4.4	3.8	-11.6	-16.7	43.8	-26.8
Thompson River at Davis City	Missouri River Trib	37.6	-7.8	-4.0	-32.3	0.5	10.7	-5.8
Volga River at Elkport	Paleozoic Plateau	37.6	-7.8	-3.7	-41.3	8.2	-7.4	-2.5
Indian Creek at Colfax	Iowa-Skunk	37.4	-1.8	-1.9	25.7	-20.9	3.6	25.1
Beaver Creek at Cedar Falls	Iowan Surface	37.0	-16.7	-3.6	-39.8	11.6	-7.1	13.3
South Skunk River at Oskaloosa	Iowa-Skunk	36.8	2.5	-2.8	-28.6	-29.1	-11.8	-3.7
South River at Ackworth	Des Moines Basin Down	36.0	-0.8	1.0	-35.9	0.0	3.2	18.8
Iowa River Downstream of Marshalltown	Iowa-Skunk	35.8	0.3	-0.9	-1.3	-3.5	-13.2	67.9
Middle River at Indianola	Des Moines Basin Down	35.2	7.0	-2.8	-68.7	-19.6	-16.7	-6.6
Little Sioux River at Larrabee	Missouri River Trib	35.2	-16.0	-8.0	200.0	9.2	8.0	39.9
Cedar Creek at Oakland Mills	Iowa-Skunk	34.8	-11.2	0.0	12.1	-25.0	-6.9	-13.6
North Skunk River at Sigourney	Iowa-Skunk	34.8	-7.9	0.0	12.1	-7.7	-6.9	-13.6
Iowa River at Lone Tree	Iowa-Skunk	34.8	-8.9	0.9	75.7	0.7	22.2	34.6
North Raccoon at Sac City	Des Moines Basin Up	34.6	-3.6	-2.8	87.6	-26.9	-37.5	12.9
Old Mans Creek at Iowa City	Iowa-Skunk	34.6	-1.4	-3.8	-48.7	-18.8	3.6	45.0
South Raccoon River at Redfield	Des Moines Basin Up	34.0	-8.4	-1.8	19.3	6.8	-14.3	-36.0
South Skunk River at Cambridge	Iowa-Skunk	34.0	7.3	-1.9	-24.1	-23.3	-40.0	80.5
E. Nishnabotna at Shenandoah	Missouri River Trib	33.8	2.4	-2.8	-43.8	-5.4	-19.1	-42.2
English River at Riverside	Iowa-Skunk	32.4	-5.0	1.0	-54.8	-9.4	6.3	38.9
W. Nodaway at Shambaugh	Missouri River Trib	32.0	-5.3	0.9	-15.9	-9.6	10.8	-17.5
Little Sioux River at Smithland	Missouri River Trib	29.2	-15.1	-2.8	-23.5	10.8	9.4	32.5
N. Fork Maquoketa R. at Hurtsville	Iowan Surface	28.6	-6.8	-2.8	7.7	7.7	56.3	85.1
West Fork Ditch at Hornick	Missouri River Trib	27.2	-9.6	-1.9	-22.2	17.6	21.1	8.8
Boyer River at Missouri Valley	Missouri River Trib	26.2	0.8	-6.5	70.9	-2.2	-36.6	-36.5
Rock River at Rock Valley	Missouri River Trib	25.8	-24.8	-3.8	392.8	44.7	38.5	31.4
Soldier River at Pisgah	Missouri River Trib	24.4	-10.0	0.0	-44.5	36.8	-1.9	-20.3
Floyd River at Sioux City	Missouri River Trib	21.4	-26.5	-1.0	235.9	35.2	6.8	88.4
	Iowan Surface	42.9	-4.5	-3.7	16.3	2.3	11.3	12.7
	Paleozoic Plateau	42.9	-11.9	-4.5	-14.8	16.6	13.2	53.7
	Des Moines Basin Up	38.0	-1.6	-1.3	19.6	-11.2	-6.2	-15.9
	Des Moines Basin Down	37.8	5.7	-0.4	-5.9	-7.8	-13.7	11.2
	Missouri River Trib	29.3	-11.2	-3.0	71.7	13.8	4.8	7.9
	Iowa-Skunk	35.0	-2.9	-1.0	-3.5	-15.2	-4.8	29.0

Water Quality Index



Site	Rank	Map #	00-20
Wapsipinicon River at Independence	1	34	53.7
Cedar River at Janesville	2	29	51.7
Shellrock River at Shellrock	3	27	51.7
Cedar River at Charles City	4	26	48.9
Upper Iowa River at Dorchester	5	22	48.1
Yellow River at Ion	6	23	48.1
W. Fork of the Cedar River at Finchford	7	28	47.9
Boone River at Stratford	8	11	45.0
Turkey River at Garber	9	25	43.2
Beaver Creek at Cedar Falls	10	30	42.7
Blackhawk Creek at Waterloo	11	31	42.3
Wapsipinicon River at DeWitt	12	35	41.1
Wolf Creek at LaPorte City	13	32	41.0
Little Sioux River at Larrabee	14	3	40.3
Cedar River at Conesville	15	33	40.1
Thompson River at Davis City	16	9	40.0
Volga River at Elkport	17	24	39.9
Indian Creek at Colfax	18	17	37.9
Cedar Creek at Oakland Mills	19	19	37.4
North Skunk River at Sigourney	20	20	37.1
Beaver Creek at Grimes	21	12	36.8
South Raccoon River at Redfield	22	13	36.4
South River at Ackworth	23	15	36.2
South Skunk River at Oskaloosa	24	18	36.1
North Raccoon at Sac City	25	10	35.0
English River at Riverside	26	21	33.5
W. Nodaway at Shambaugh	27	8	33.3
North River at Norwalk	28	14	33.1
E. Nishnabotna at Shenandoah	29	7	32.8
Middle River at Indianola	30	15	32.4
Rock River at Rock Valley	31	1	32.2
Little Sioux River at Smithland	32	4	31.6
N. Fork Maquoketa R. at Hurtsville	33	36	29.9
Floyd River at Sioux City	34	2	26.8
Soldier River at Pisgah	35	5	26.4
Boyer River at Missouri Valley	36	6	26.0

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

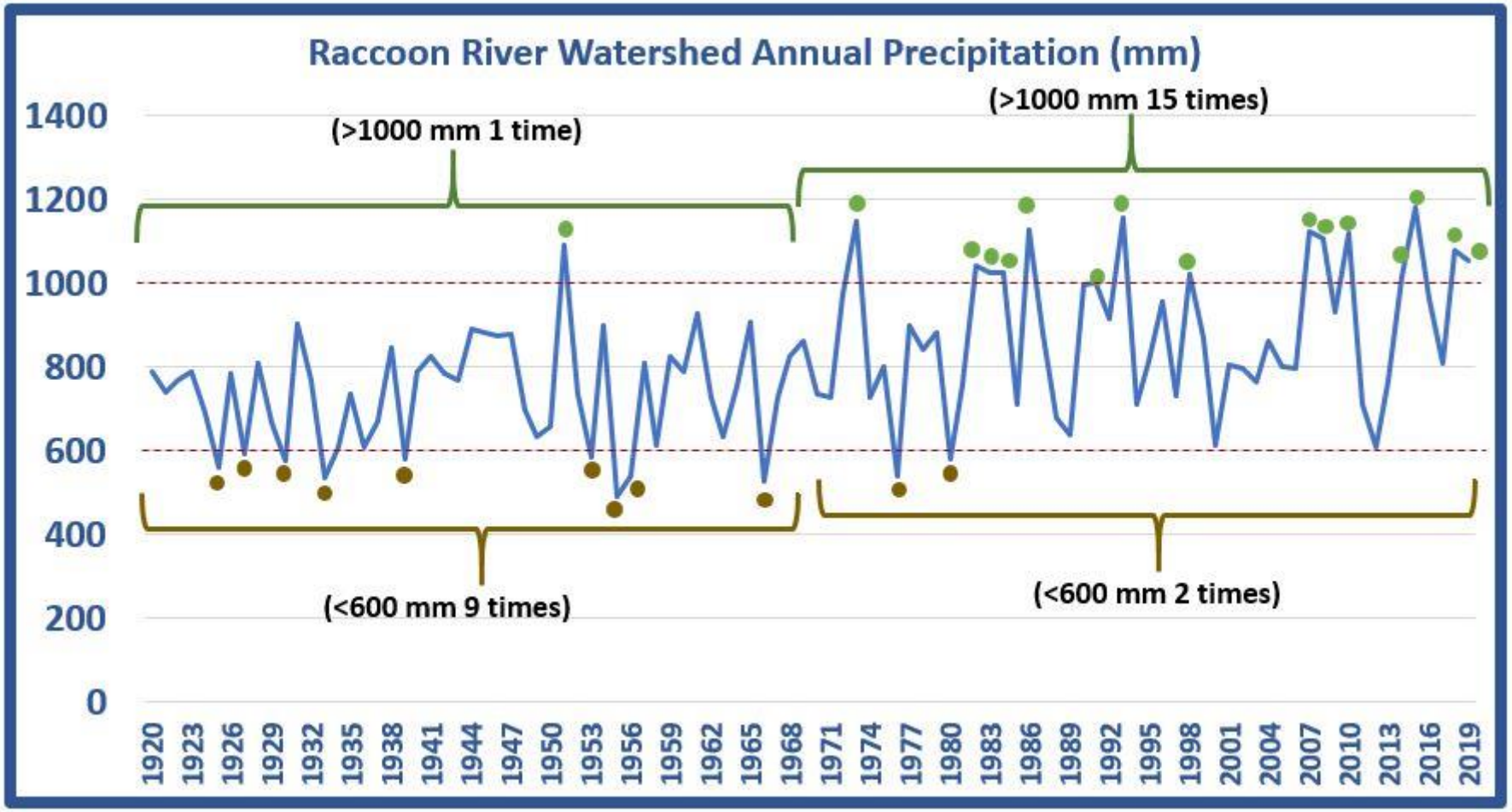
2. Ban fall tillage

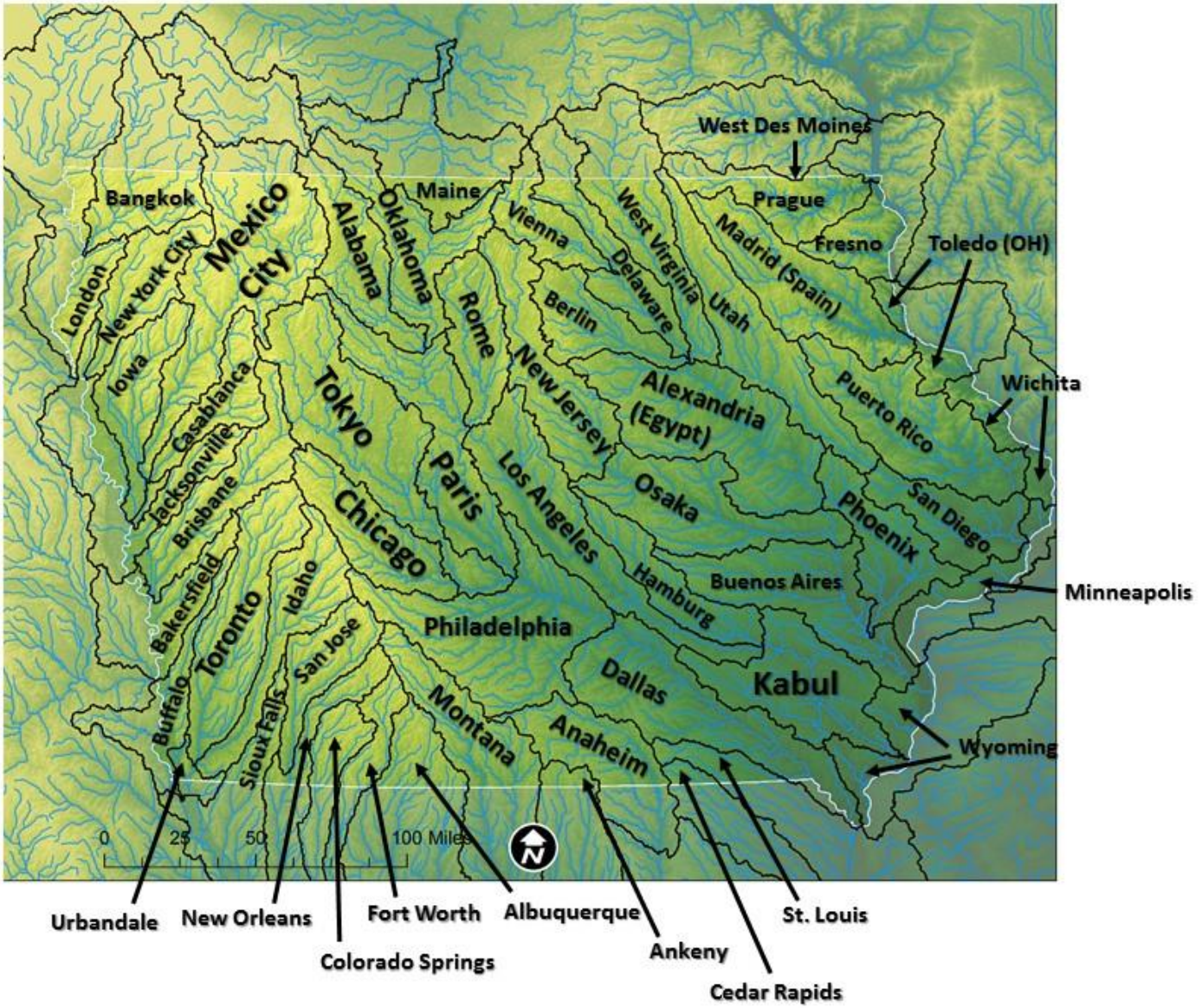
3. Ban manure on snow and frozen ground

4. Make farmers adhere to ISU fertilization guidelines

5. Reformulate CAFO Regulations

Climate Change




West Des Moines
Bangkok
Mexico City
Maine
Prague
Vienna
West Virginia
Madrid (Spain)
Fresno
Toledo (OH)
London
New York City
Alabama
Oklahoma
Delaware
Utah
Berlin
Rome
Iowa
Casablanca
Tokyo
New Jersey
Alexandria (Egypt)
Puerto Rico
Wichita
Jacksonville
Paris
Los Angeles
Osaka
Phoenix
San Diego
Brisbane
Chicago
Hamburg
Buenos Aires
Minneapolis
Bakersfield
Idaho
Toronto
Philadelphia
San Jose
Dallas
Kabul
Buffalo
Sioux Falls
Montana
Anaheim
Wyoming
0
25
50
100 Miles
N
Urbandale
New Orleans
Fort Worth
Albuquerque
St. Louis
Colorado Springs
Ankeny
Cedar Rapids

What do we want our production system to look like?

Commerce

Nutrition?

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

IOWA