Science Assessment to Support an Illinois Nutrient Reduction Strategy

Mark David, George Czapar,
Greg McIsaac, Corey Mitchell
March 11, 2013

Technical Tasks

- develop a science based technical assessment of:
  - current conditions in Illinois of nutrient sources and export by rivers in the state from point and non-point sources
  - methods that could be used to reduce these losses and estimates of their effectiveness throughout Illinois
  - estimates of the costs of statewide and watershed level application of these methods to reduce nutrient losses to meet TMDL and Gulf of Mexico goals

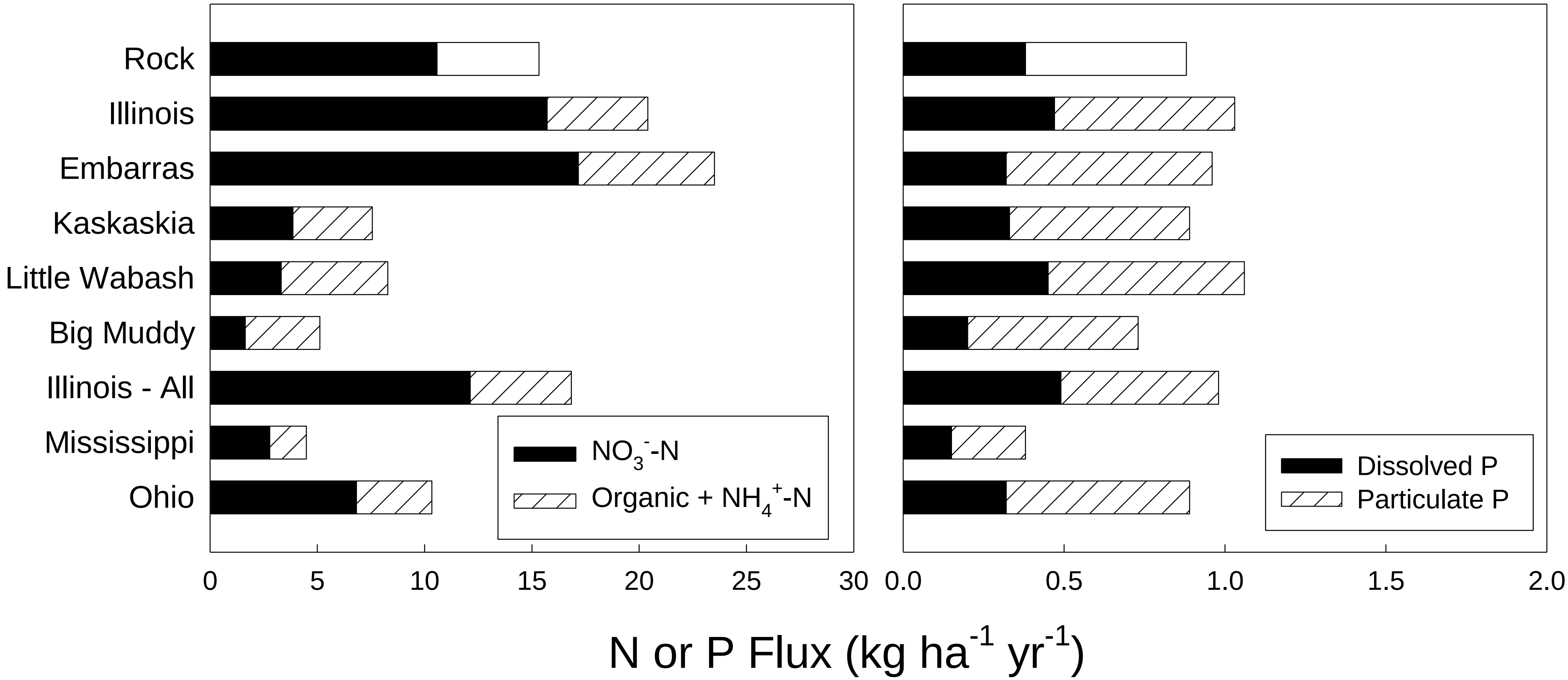
Steps we will take

1. determine current conditions
2. identify critical watersheds
3. estimate potential reductions and costs
4. develop scenarios

1. Current Conditions

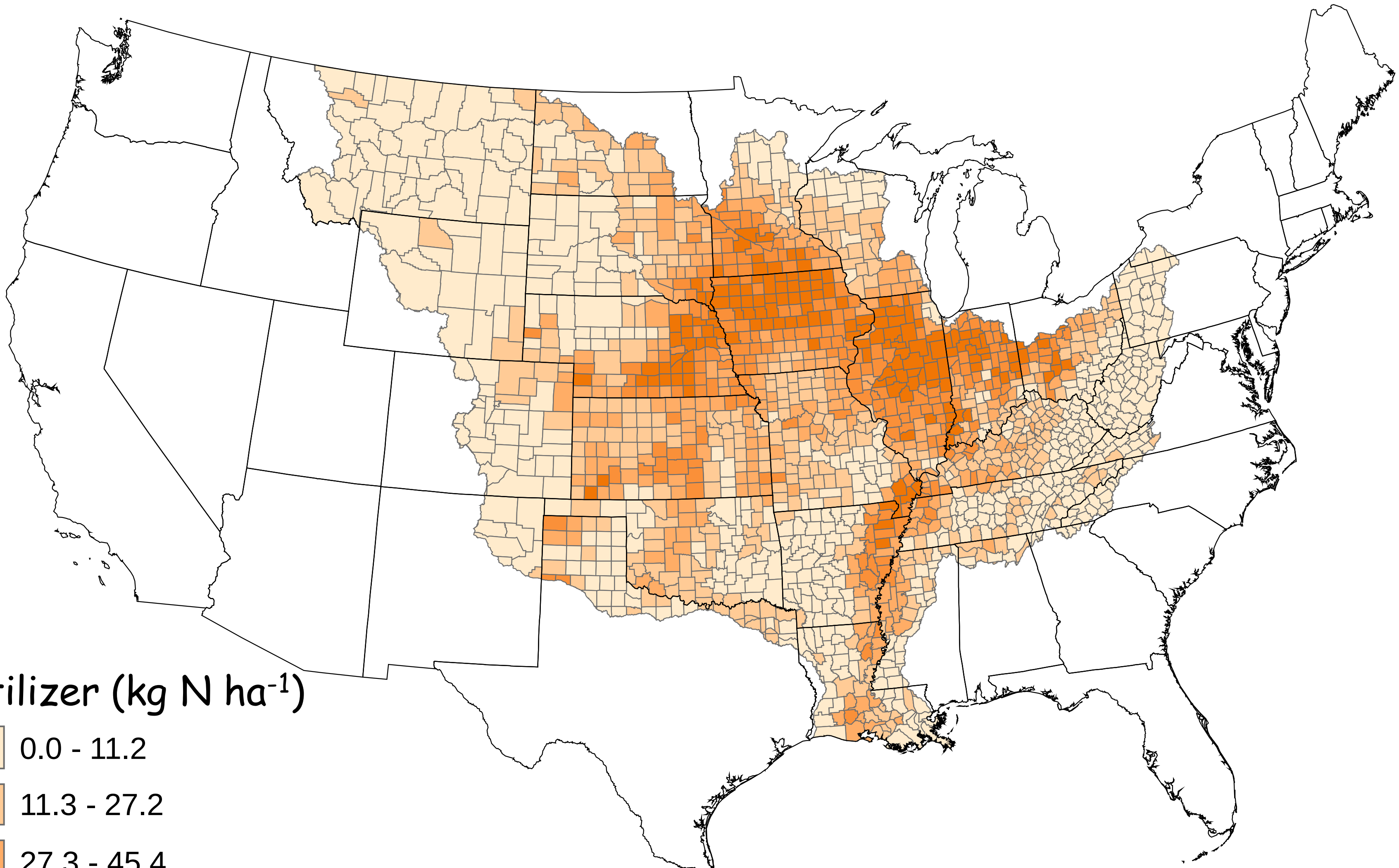
- nutrient (nitrate and total P) loads from major river basins of Illinois
  - estimates of point and non-point sources
  - compare 1980-1996 with 1997-2010
  - determine direction of loads
- determine current agricultural management practices across the state
  - nutrient inputs and management (fertilizers and manure)
  - current cropping practices
  - P losses from water quality data
  - nutrient balances

N and P Fluxes for State, 1980 to 1997



From David and Gentry (2000)

Annual N Fertilizer Applications

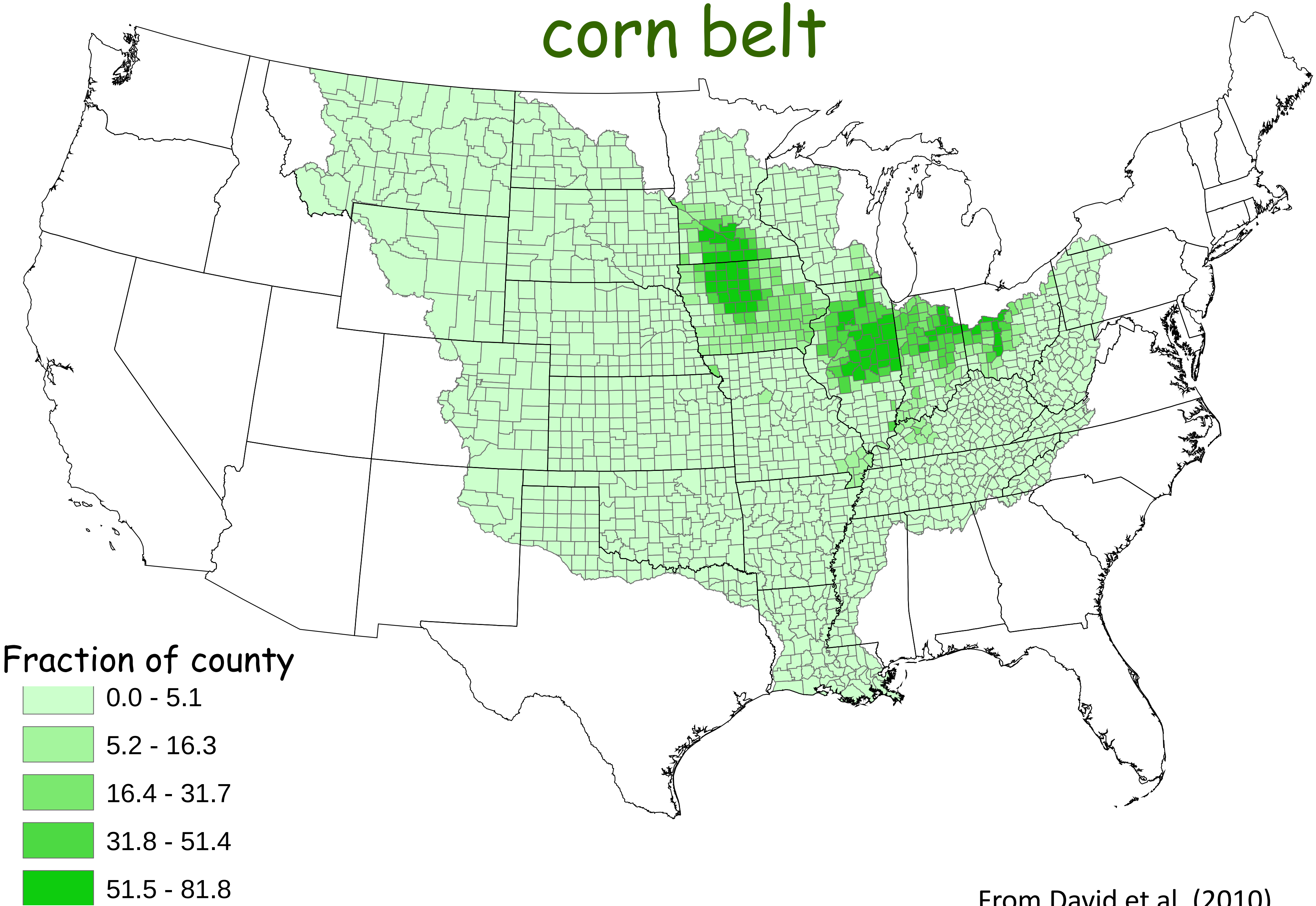


Fertilizer (kg N ha^{-1})

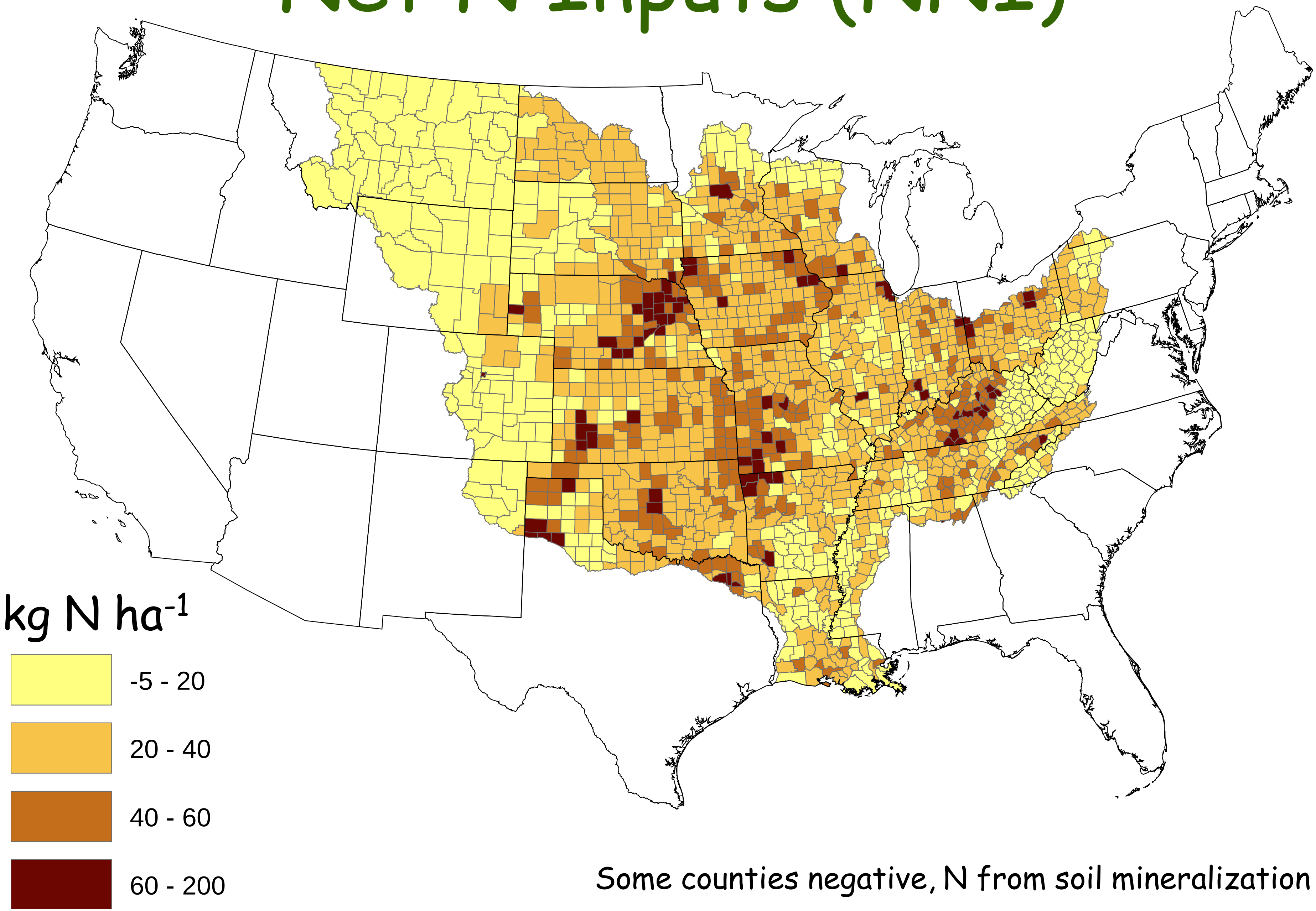
- 0.0 - 11.2
- 11.3 - 27.2
- 27.3 - 45.4
- 45.5 - 65.9
- 66.0 - 107.1

From David et al. (2010)

Tile drainage is concentrated in the corn belt

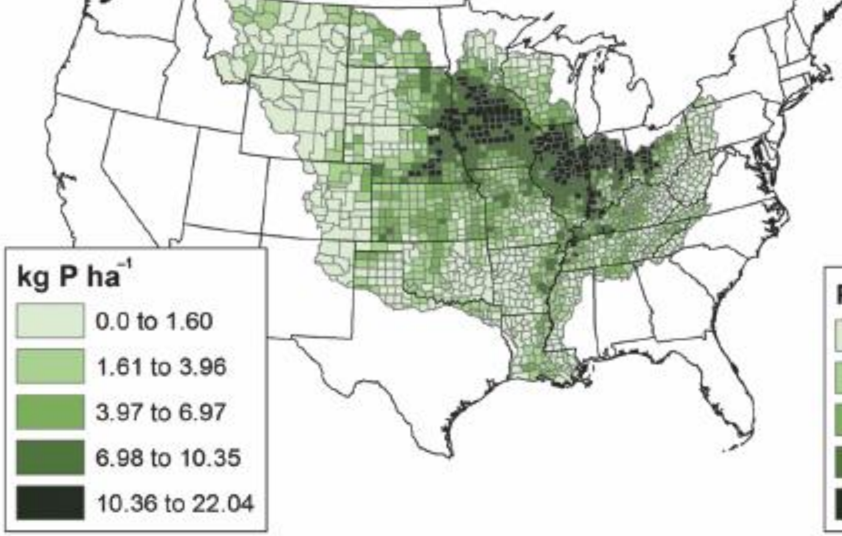


Net N Inputs (NNI)

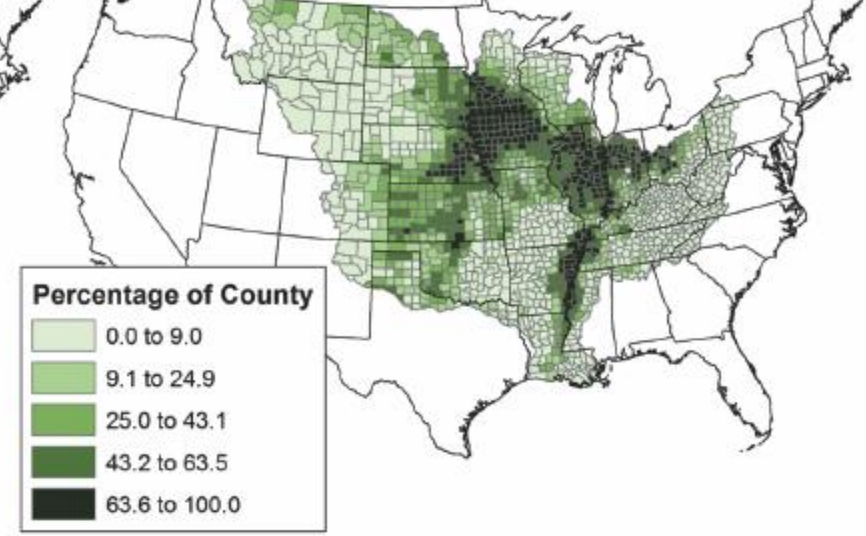


Some counties negative, N from soil mineralization

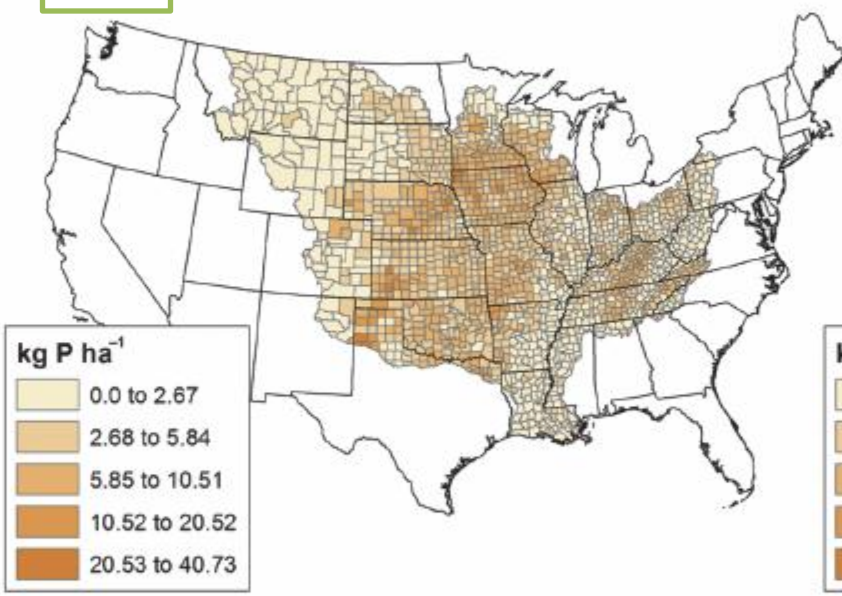
Fertilizer P



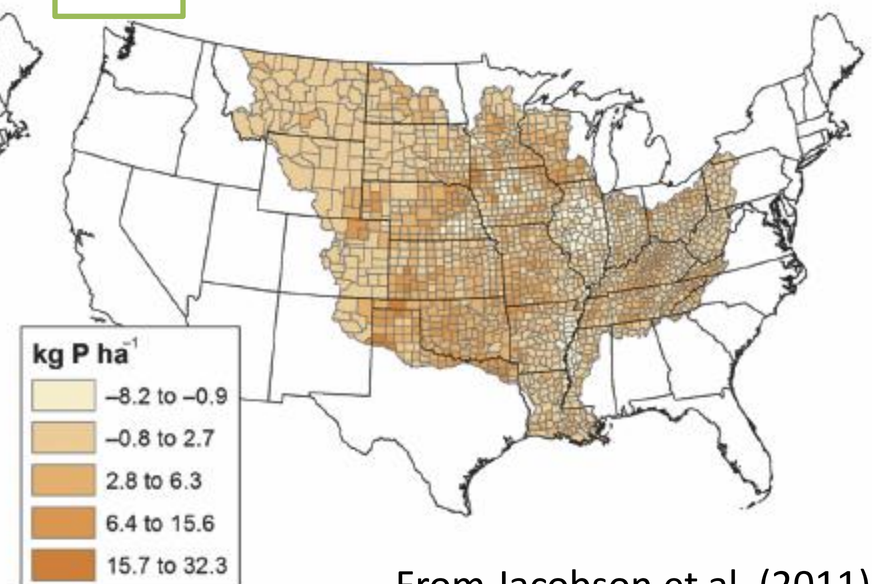
Row Crop %



Manure P

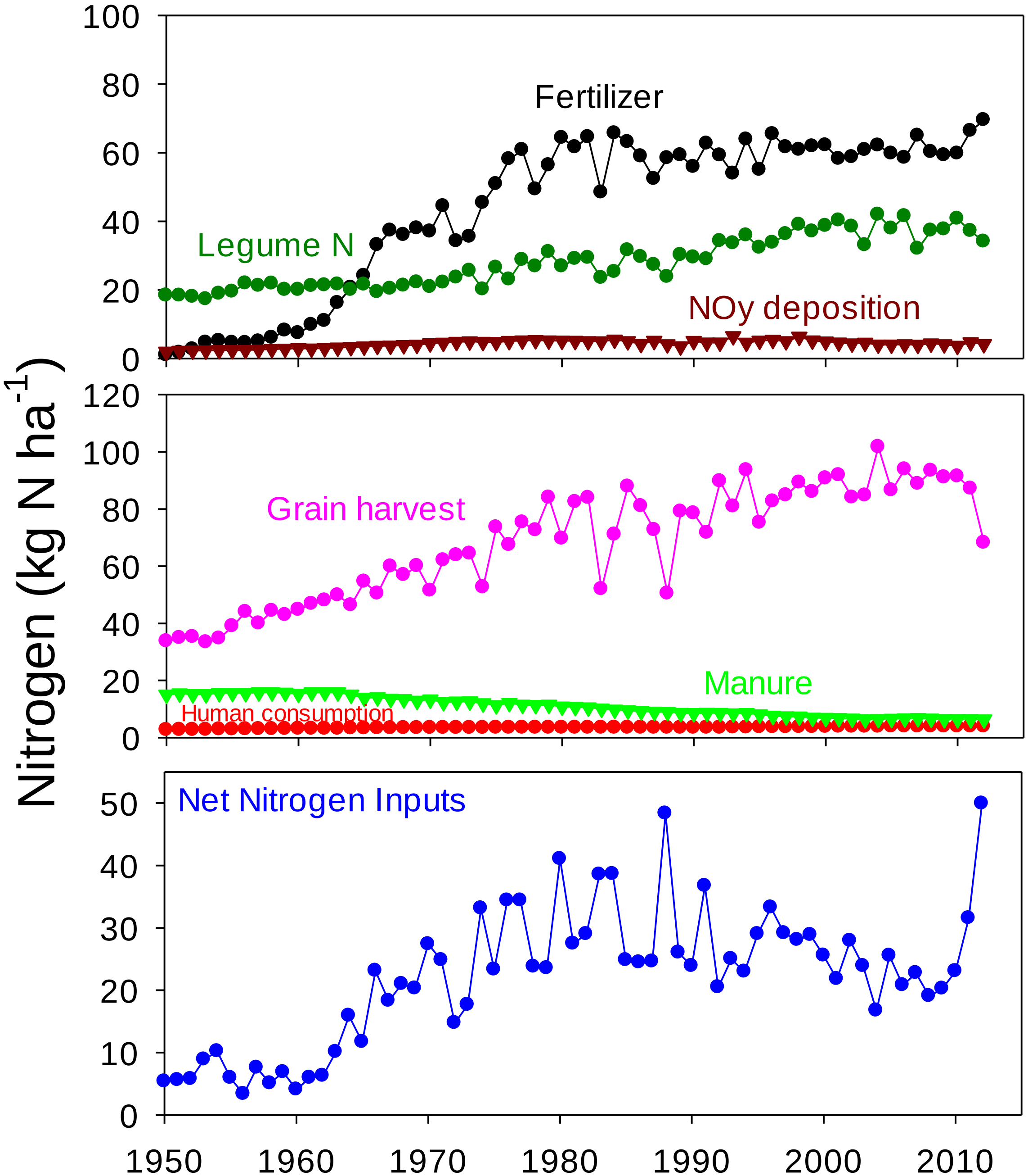


Net P Inputs

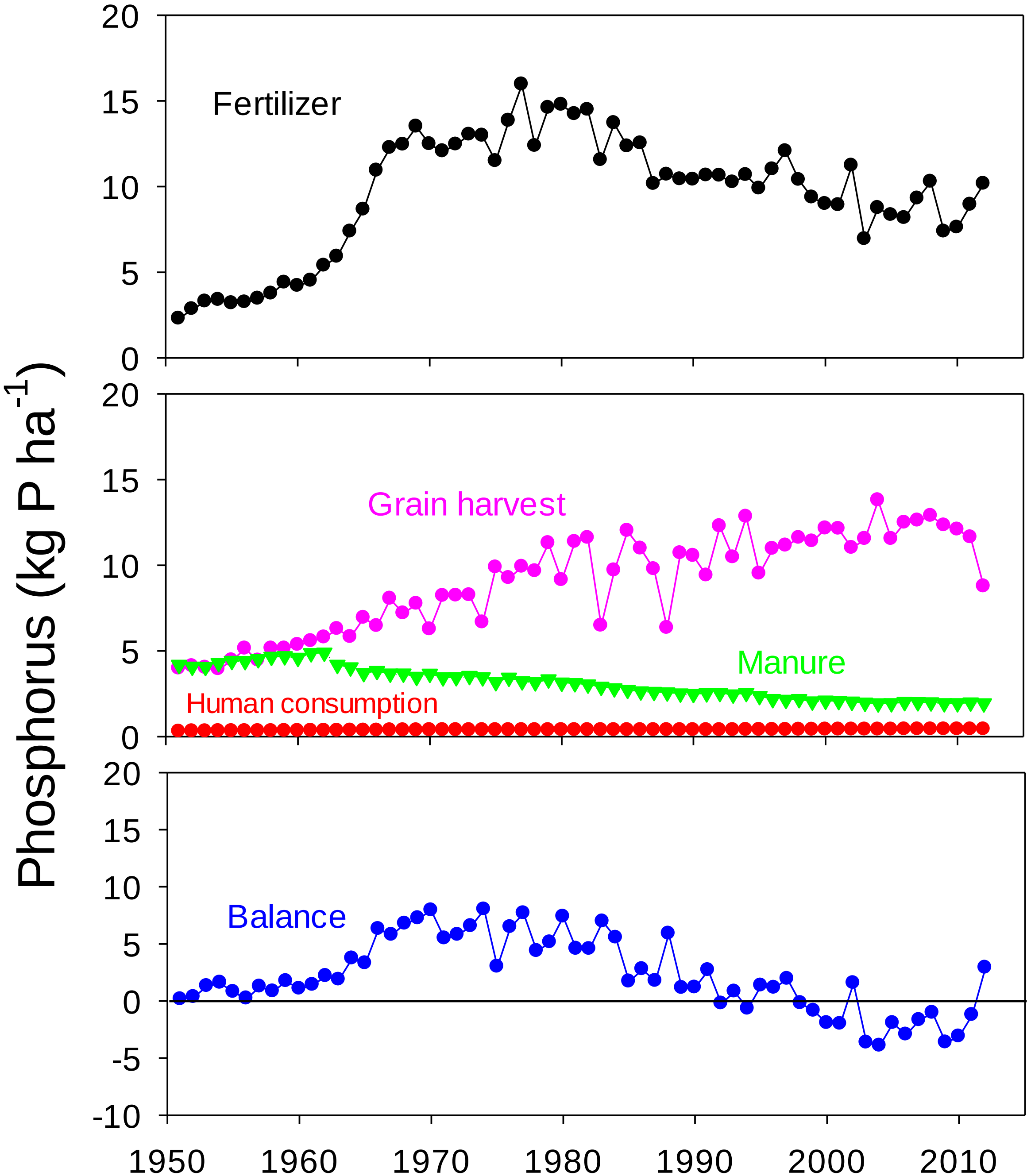


From Jacobson et al. (2011)

Illinois N budget through 2012



Illinois P budget through 2012



Sewage Effluent –12.9 million people

16% of total N load statewide

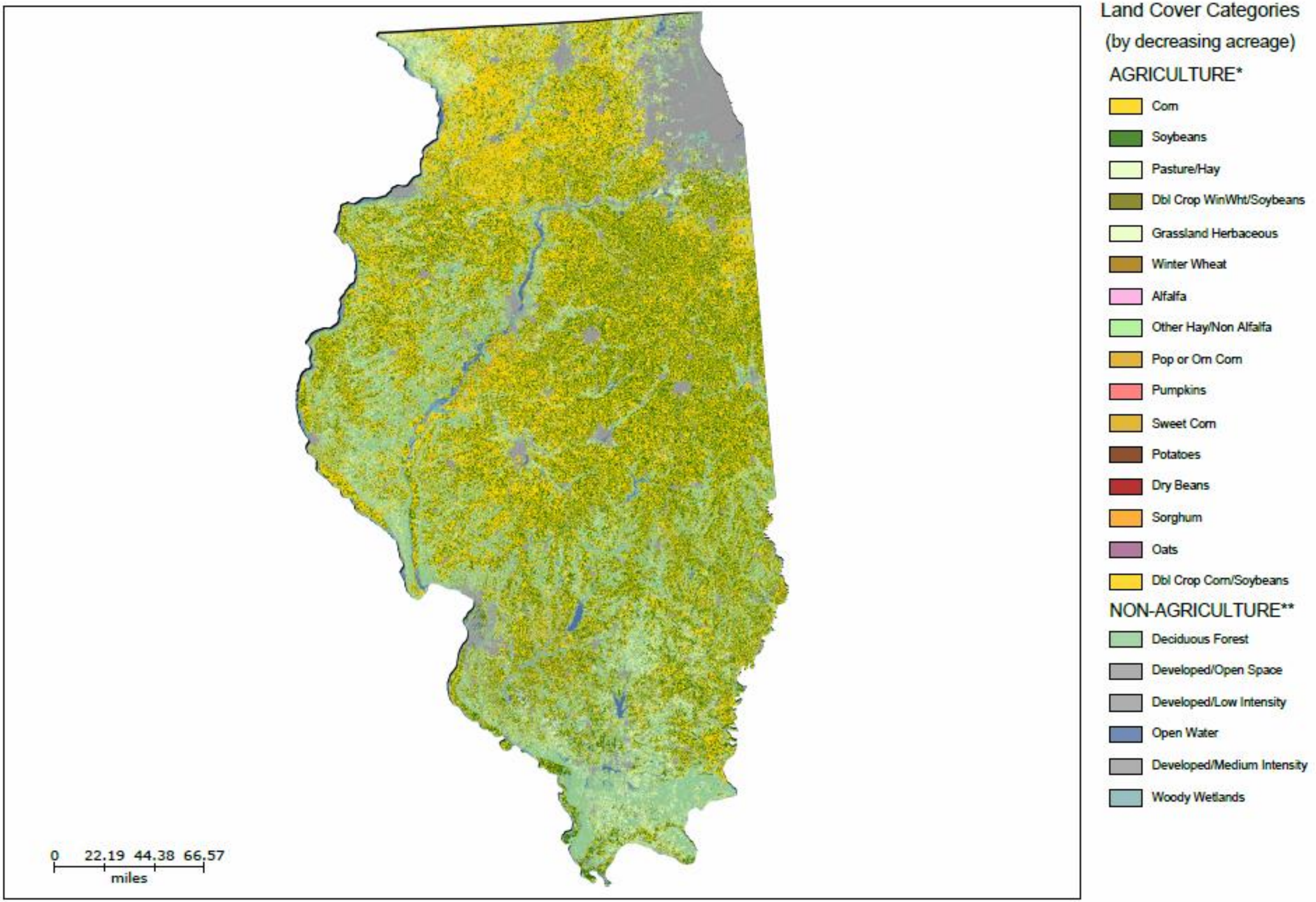
21% for Illinois River, 14% for others

47% of total P load statewide

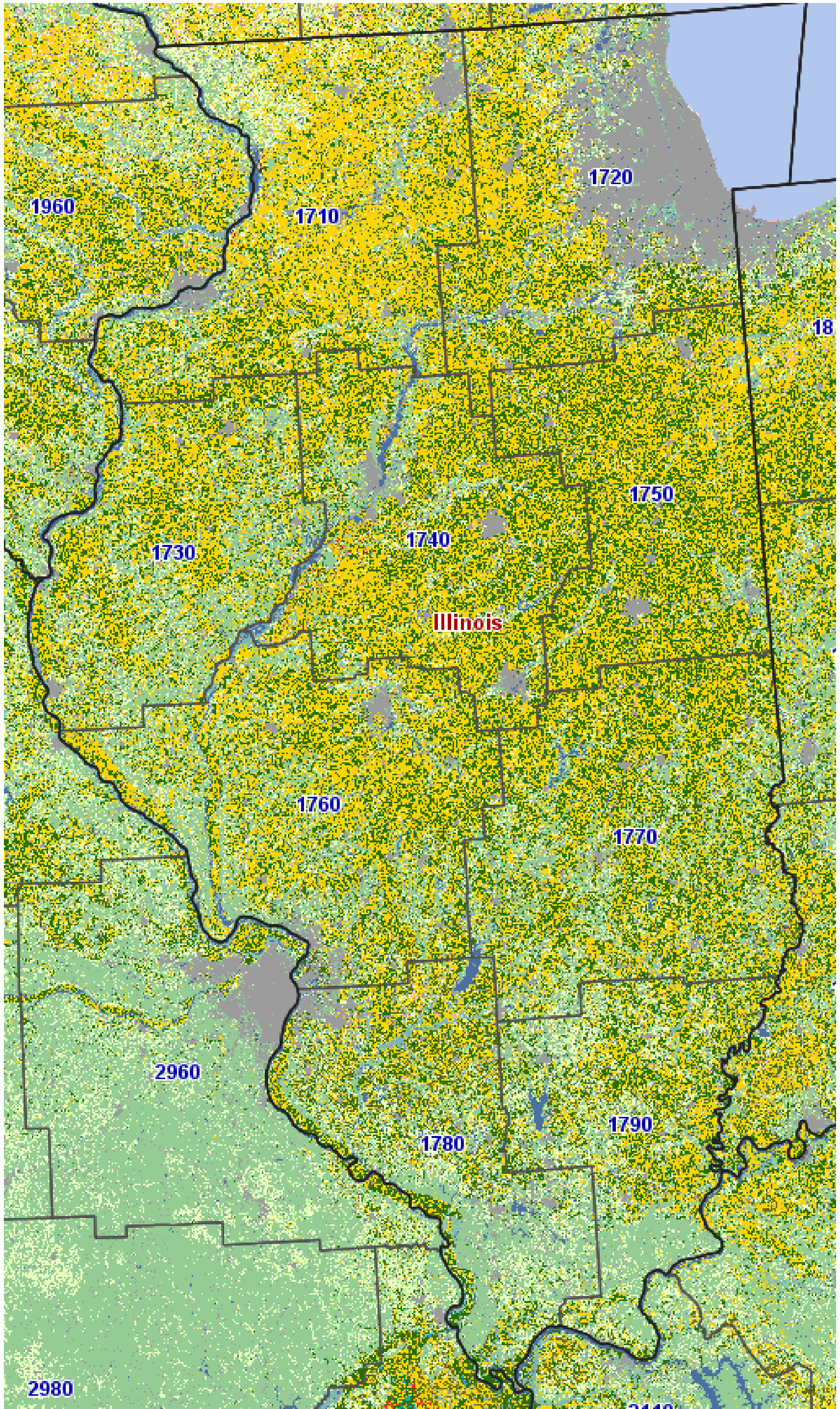
70% for Illinois River, 33% for others

From David and Gentry (2000)

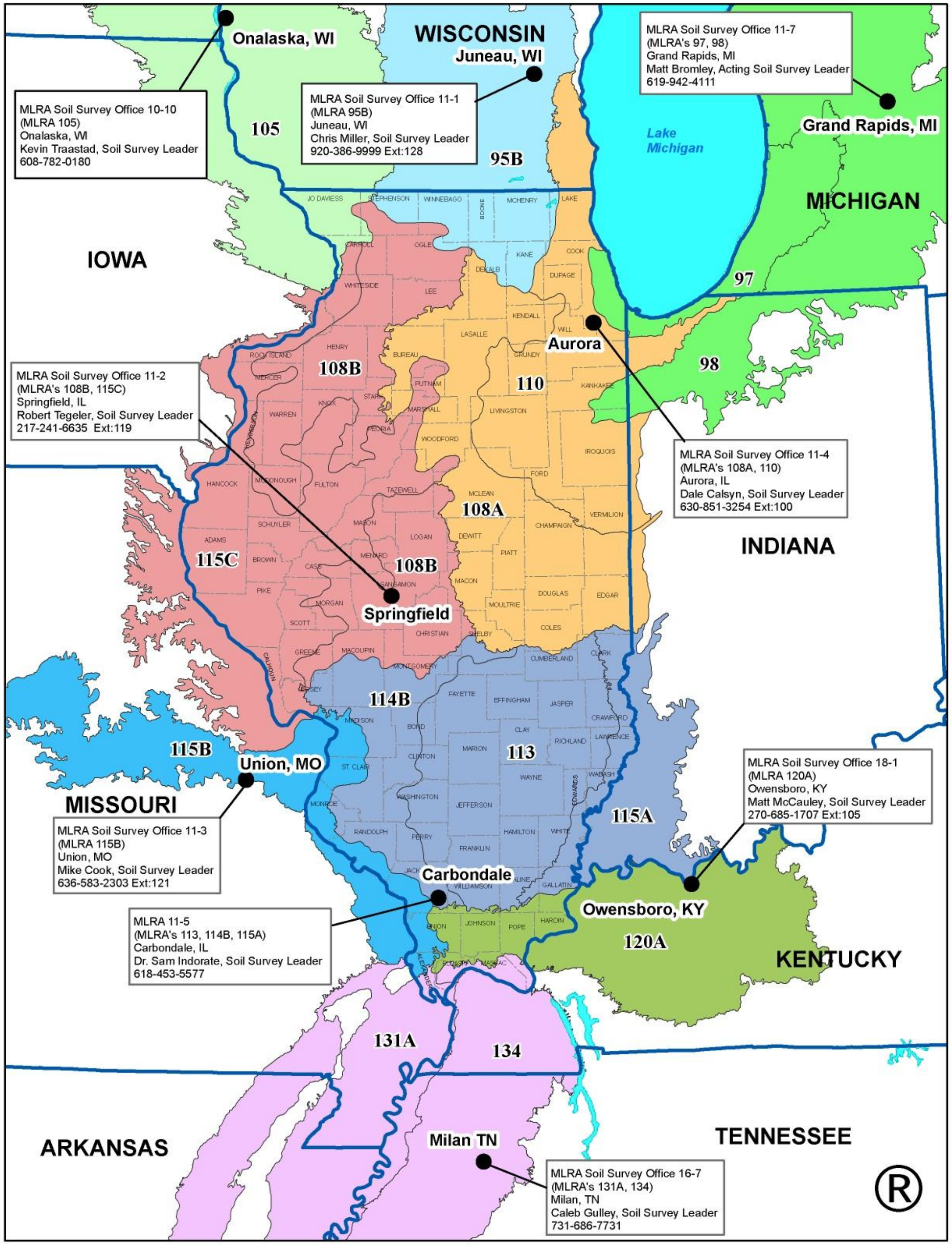
2012 Illinois



Crop Reporting Districts



Illinois MLRAs



Combined MLRA's

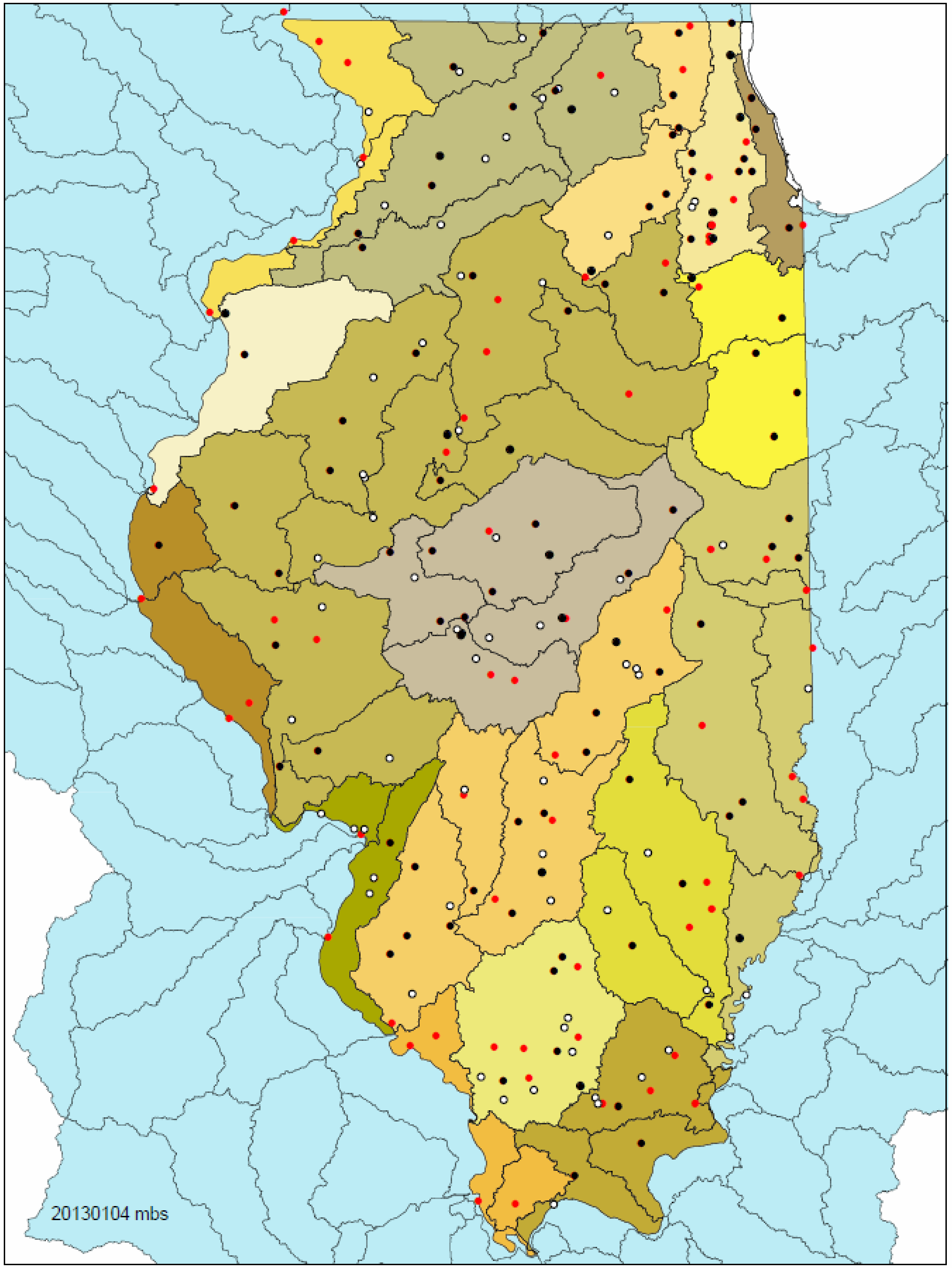
Major Land Resource Areas (MLRAs) in Illinois, showing combinations to be used for analysis (15 combined into 9). Bold MLRAs are the numbers that will be used throughout our analysis.

		Landscape		Climate		
MLRA	**Description**	**Elevation m (ft)**	**Local Relief m (ft)**	**Precipitation mm (inches)**	**Annual Temperature °C (°F)**	**Freeze Free Days**
95B	Southern Wisconsin and Northern Illinois Drift Plain	200 to 300 (660 to 980)	8 (25)	760 to 965 (30 to 38)	6 to 9 (43 to 48)	170
97	Southwestern Michigan Fruit and Truck Crop Belt	200 to 305 (600 to 1000)	2 to 5 (5 to 15)	890 to 1,015 (35 to 40)	8 to 11 (47 to 52)	200
98	Southern Michigan and Northern Indiana Drift Plain	175 to 335 (570 to 1,100)	15 (5)	735 to 1,015 (29 to 40)	7 to 10 (44 to 50)	175
110	Northern Illinois and Indiana Heavy Till Plain	200 (650)	3 to 8 (10 to 25)	785 to 1,015 (31 to 40)	7 to 11 (42 to 52)	185
105	Northern Mississippi Valley Loess Hills	200 to 400 (660 to 1,310)	3 to 6 (10 to 20)	760 to 965 (30 to 38)	6 to 10 (42 to 50)	175
108A	Illinois and Iowa Deep Loess and Drift, Eastern Part	200 to 300 (660 to 985)	1 to 3 (3 to 10)	890 to 1,090 (35 to 43)	8 to 12 (47 to 54)	195
108B	Illinois and Iowa Deep Loess and Drift, East-Central Part	200 to 300 (660 to 985)	1 to 3 (3 to 10)	840 to 990 (33 to 39)	8 to 12 (47 to 54)	185
113	Central Claypan Areas	200 (660)	1.5 to 3 (5 to 10)	915 to 1,170 (36 to 46)	11 to 14 (51 to 57)	205
115A	Central Mississippi Valley Wooded Slopes, Eastern Part	100 to 310 (320 to 1,020)	3 to 15 (10 to 50)	1,015 to 1,195 (40 to 47)	11 to 14 (53 to 57)	210
114B	Southern Illinois and Indiana Thin Loess and Till Plain, Western Part	105 to 365 (350 to 1,190)	3 to 15 (10 to 50)	940 to 1,170 (37 to 46)	11 to 14 (52 to 56	210
115C	Central Mississippi Valley Wooded Slopes, Northern Part	130 to 270 (420 to 885)	3 to 6 (10 to 20)	865 to 1,015 (34 to 40)	9 to 13 (48 to 55)	200
120A	Kentucky and Indiana Sandstone and Shale Hills and Valleys, Southern Part	105 to 290 (345 to 950)	Varies widely	1,145 to 1,370 (45 to 54)	13 to 14 (55 to 58)	210
115B	Central Mississippi Valley Wooded Slopes, Western Part	100 to 310 (320 to 1,020)	3 to 15 (10 to 50)	965 to 1,220 (38 to 48)	12 to 14 (53 to 57)	205
131A	Southern Mississippi River Alluvium	0 to 100 (0 to 330	Max 5 (15)	1,170 to 1,525 (46 to 60)	14 to 21 (56 to 69)	210 (North)
134	Southern Mississippi Valley Loess	25 to 185 (80 to 600)	3 to 6 (10 to 20)	1,195 to 1,525 (47 to 60)	14 to 20 (57 to 68)	215 (North)

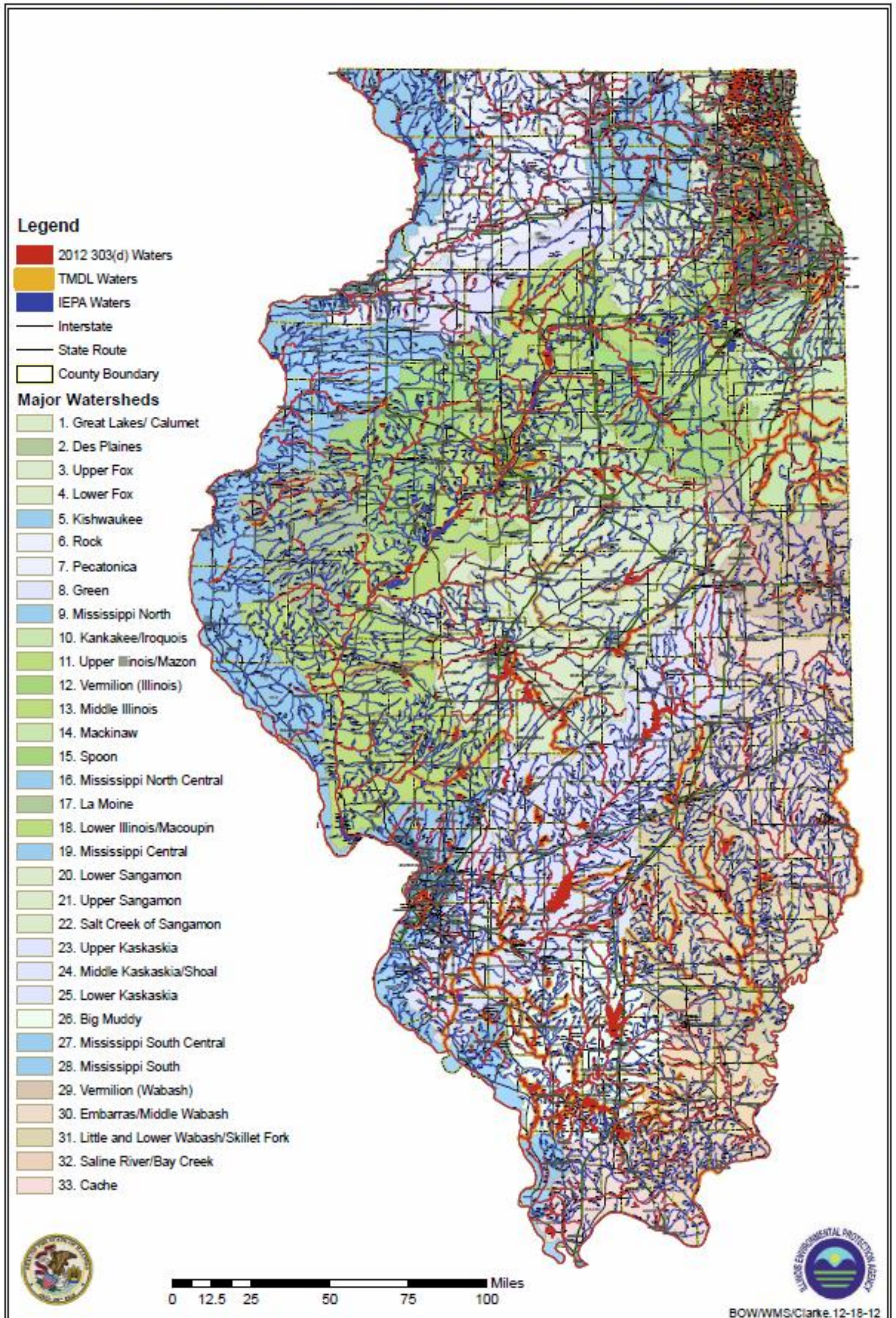
2. Critical Watershed Identification

- identify 8 digits HUCs with the highest nutrient yields and loads to the Gulf of Mexico
- identify watersheds with nutrient impaired water bodies (303d list)
- determine overlap
- estimate point and non-point sources of N and P within watersheds

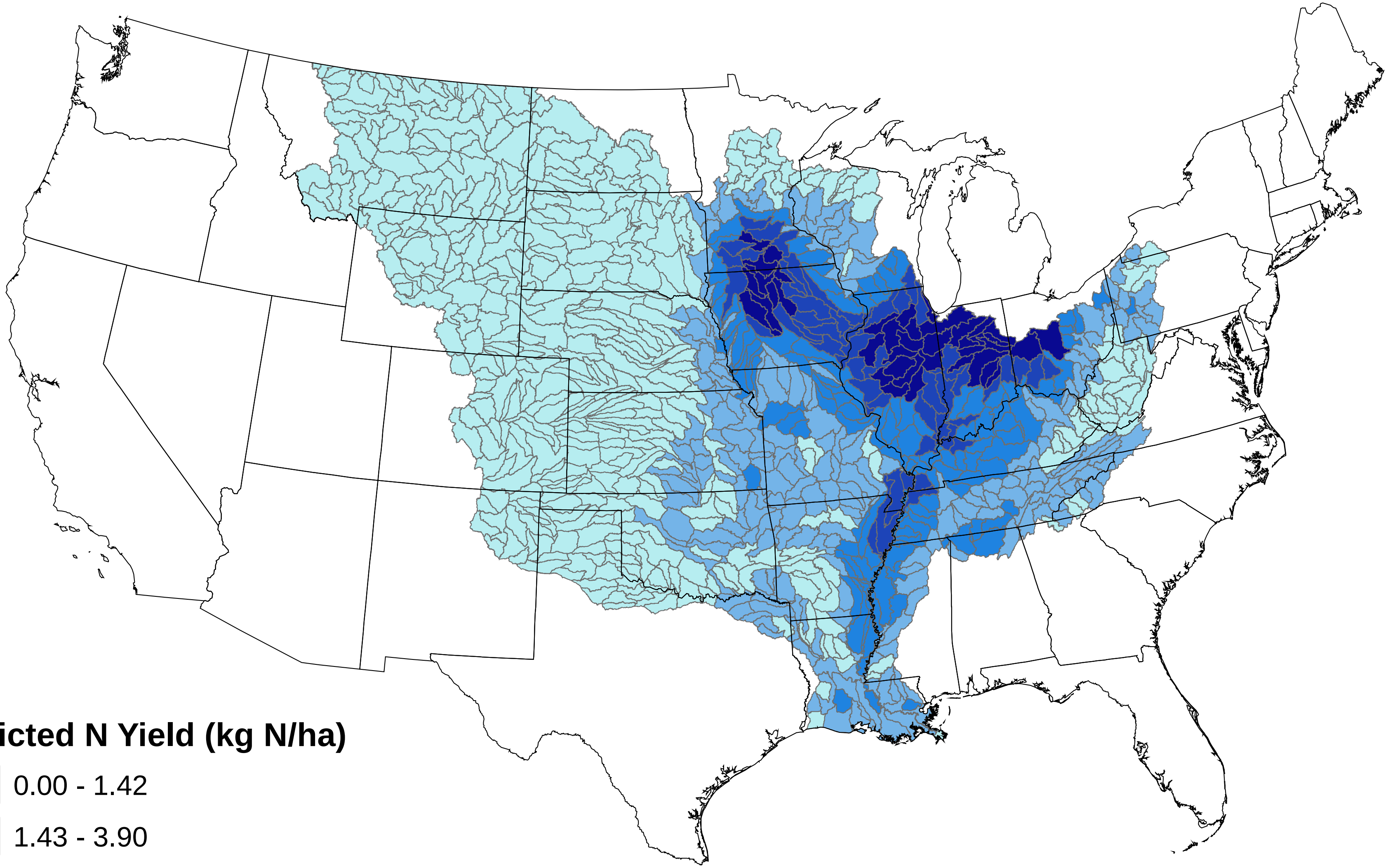
Figure 2. 8-digit HUCs in Illinois and IEPA ambient water quality stations. Black = active with gage, Red = active WQ only, open circle = inactive.



2012 Illinois EPA Waters



January to June Nitrate-N Yield

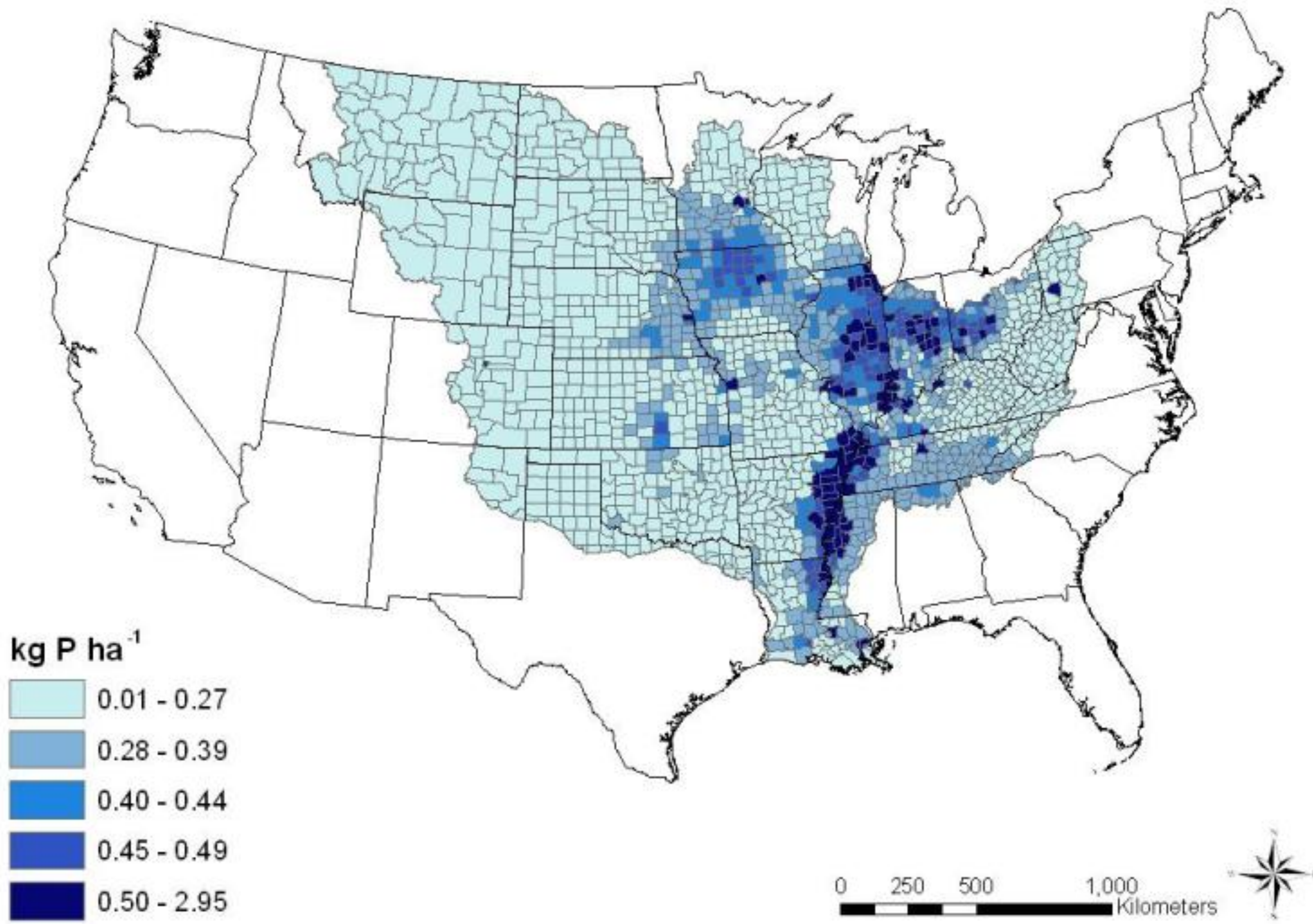


Predicted N Yield (kg N/ha)

- 0.00 - 1.42
- 1.43 - 3.90
- 3.91 - 8.00
- 8.01 - 13.98
- 13.99 - 21.75

Adapted from David et al. (2010)

Modeled January to June Total P



From Jacobson et al. (2011)

3. Estimate Potential Reductions and Costs

- estimate field-level effectiveness of various agricultural management practices
  - utilize SAB, Iowa, and Lake Bloomington Project estimates
  - involve scientific panel from throughout the state
- determine possible point source reductions
- estimate costs
  - agricultural economist will lead
  - initial investments
  - annualized costs over 25 years

Nitrogen reduction practices

- in-field
  - rate, source, time of application
  - nitrification inhibitor
  - cover crops
- edge-of-field
  - drainage water management
  - wetlands, bioreactors, buffers
- land use
  - extended rotations
  - land retirement: pasture, energy crops, perennials

Phosphorus Reduction Practices

- in-field
  - rate and source of application
  - incorporation and tillage
  - cover crops
- edge-of-field
  - buffers
- land use
  - extended rotations
  - land retirement: pasture, energy crops, perennials

4. Develop Scenarios

- combine possible point source reductions and field level agricultural reductions
  - percent reduction by practice
  - costs of implementation
  - target 45% reductions in N and P
- scale-up to critical watersheds and statewide
- provide a range of scenarios to meet reduction targets
  - area needed by practice
  - initial investment and annualized costs

Questions, comments?