Agricultural N and P balances: What do they tell us?

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What I will cover

- what goes into N and P balances
- Mississippi River Basin N and P balances
  - average balances 1997-2006
  - relationships to riverine transport
- field scale N balances
- Illinois N and P balances through 2014
- limitations of what balances can provide

Components of Nitrogen Mass Balances

- net nitrogen inputs (NNI or NANI)

  = inputs – outputs

  inputs (deposition, fertilizer, fixation)

  outputs (grain harvest - human and animal consumption)

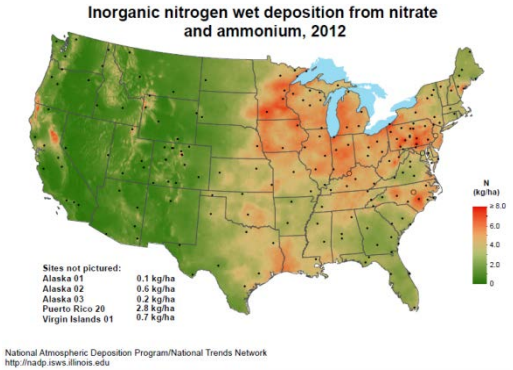
- NNI is N available for leaching, denitrification, adding to N pools
- data from agricultural statistics, fertilizer industry, assumptions about N in various components

Nutrient Mass Balances

inputs

+

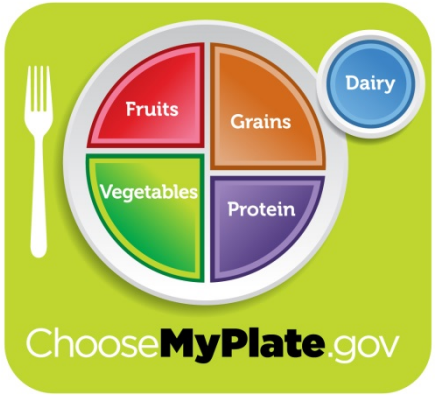
+



- outputs

-

-

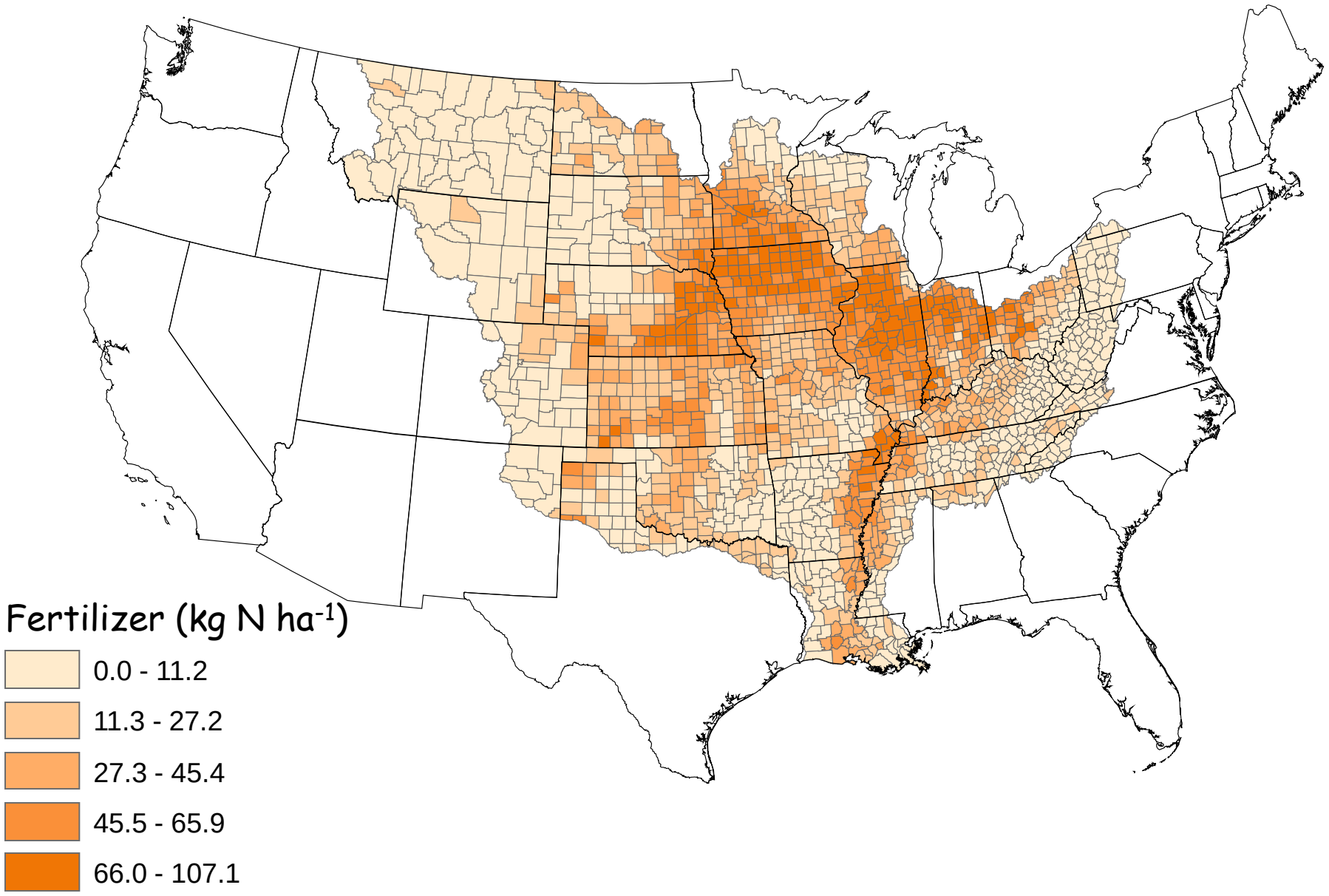


County Level N Analysis

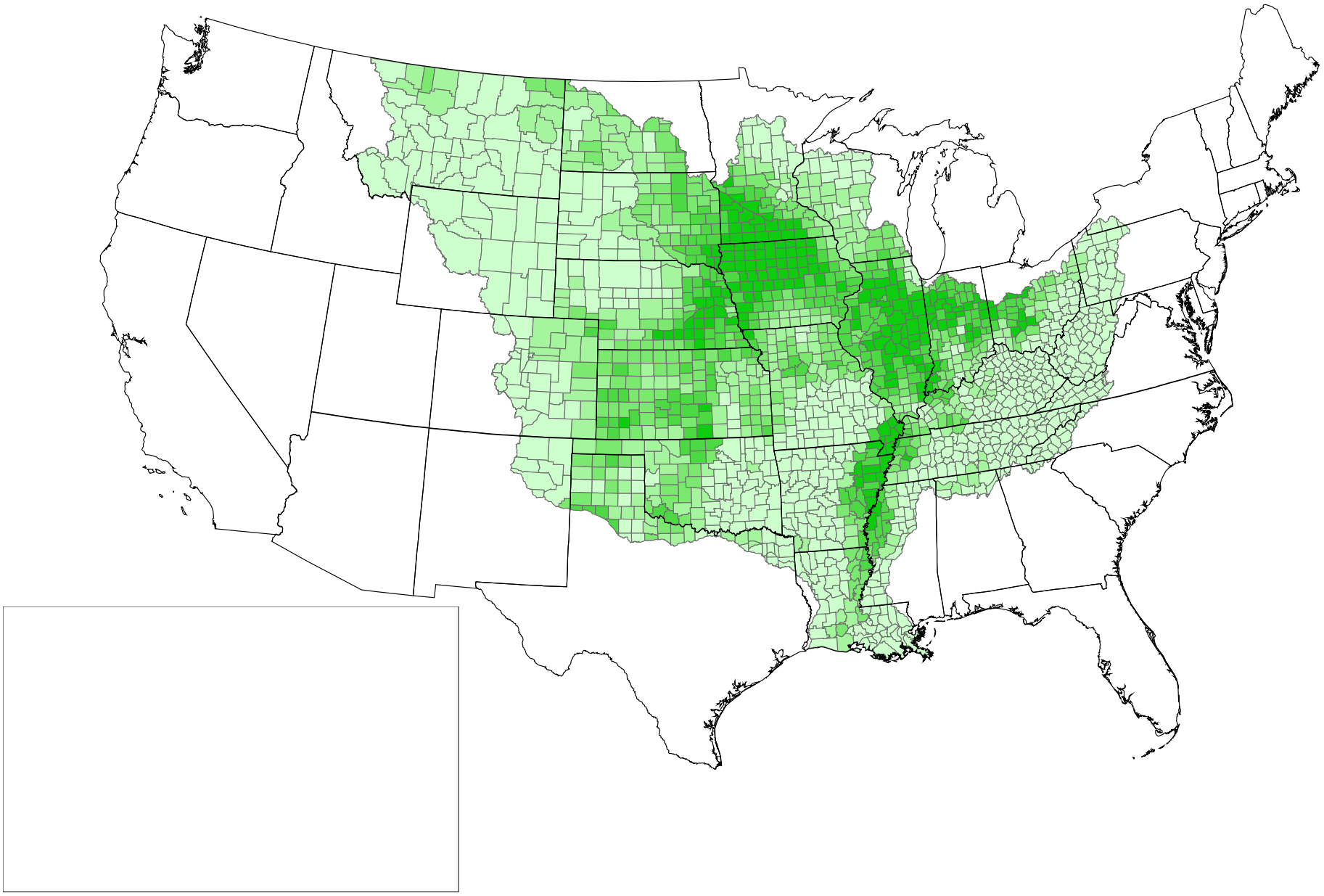
- all counties in MRB
- 1997 to 2006 annual data on fertilizer, crops, animals, people, deposition
- 153 watersheds with winter & spring nitrate concentrations and loads
- predictive model from watersheds applied to all MRB counties

Published in David et al. (2010)

Annual N Fertilizer Applications

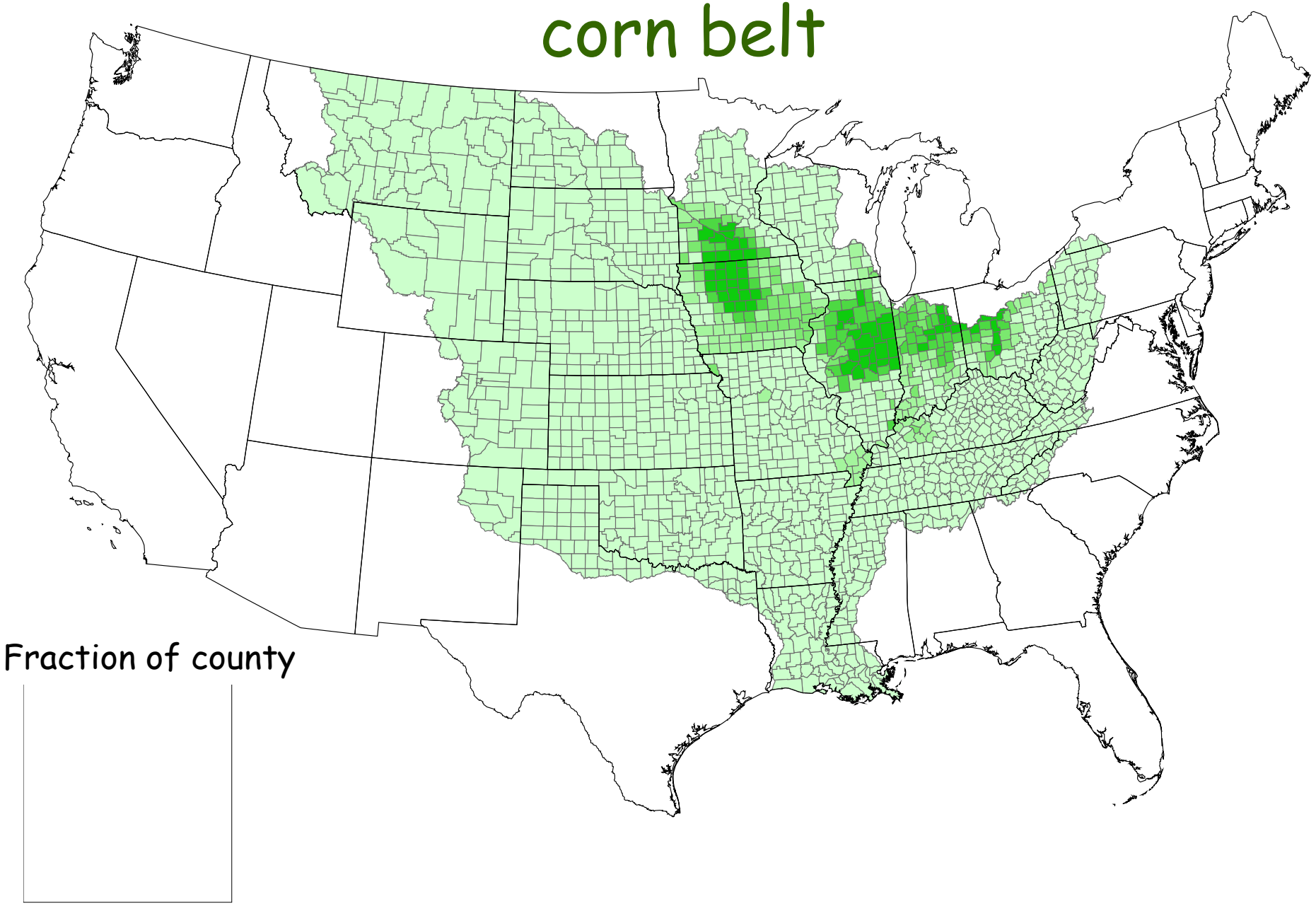


Fraction of County in Row Crops

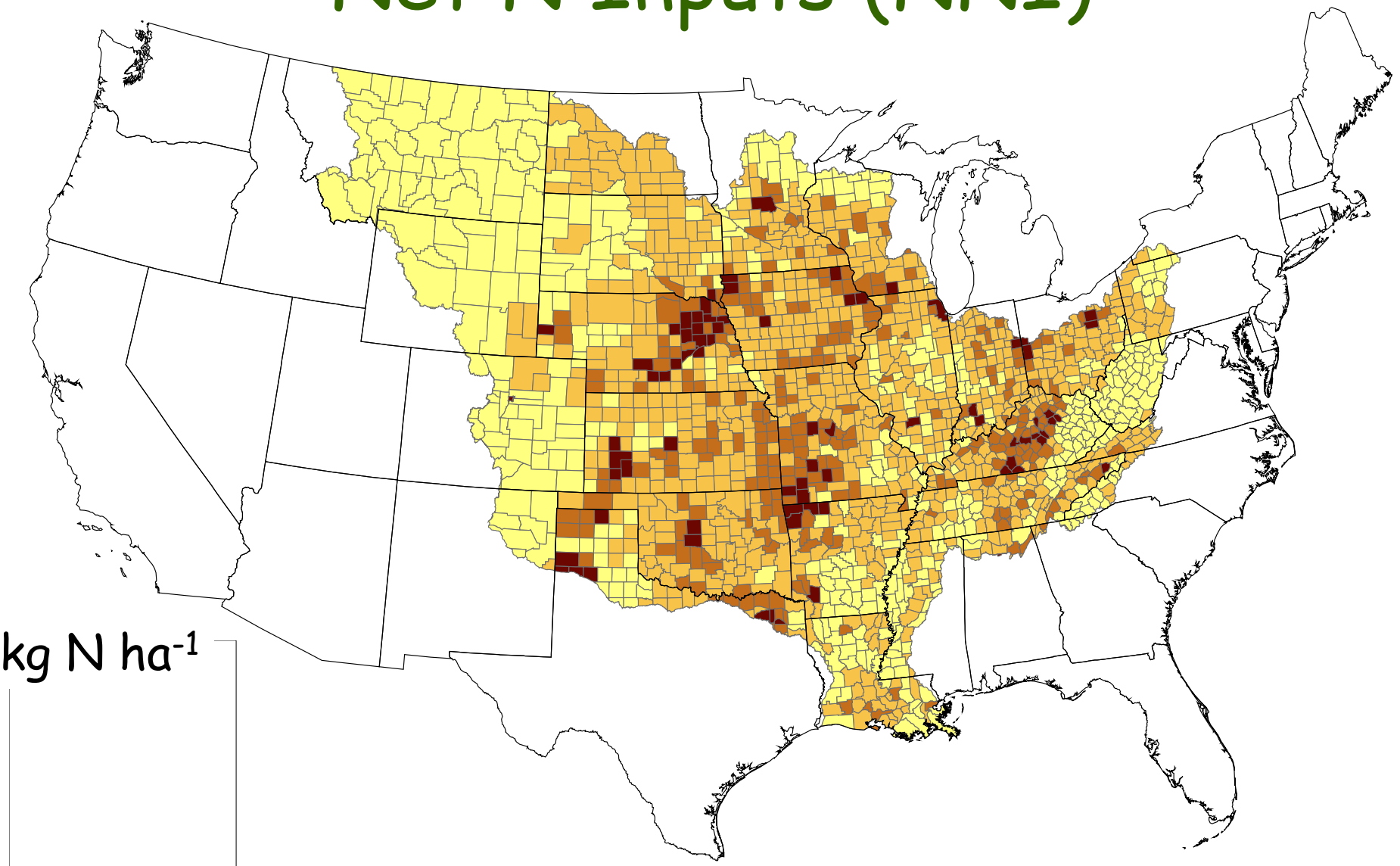


Drainage by tiles and ditches

Tile drainage is concentrated in the corn belt



Net N Inputs (NNI)



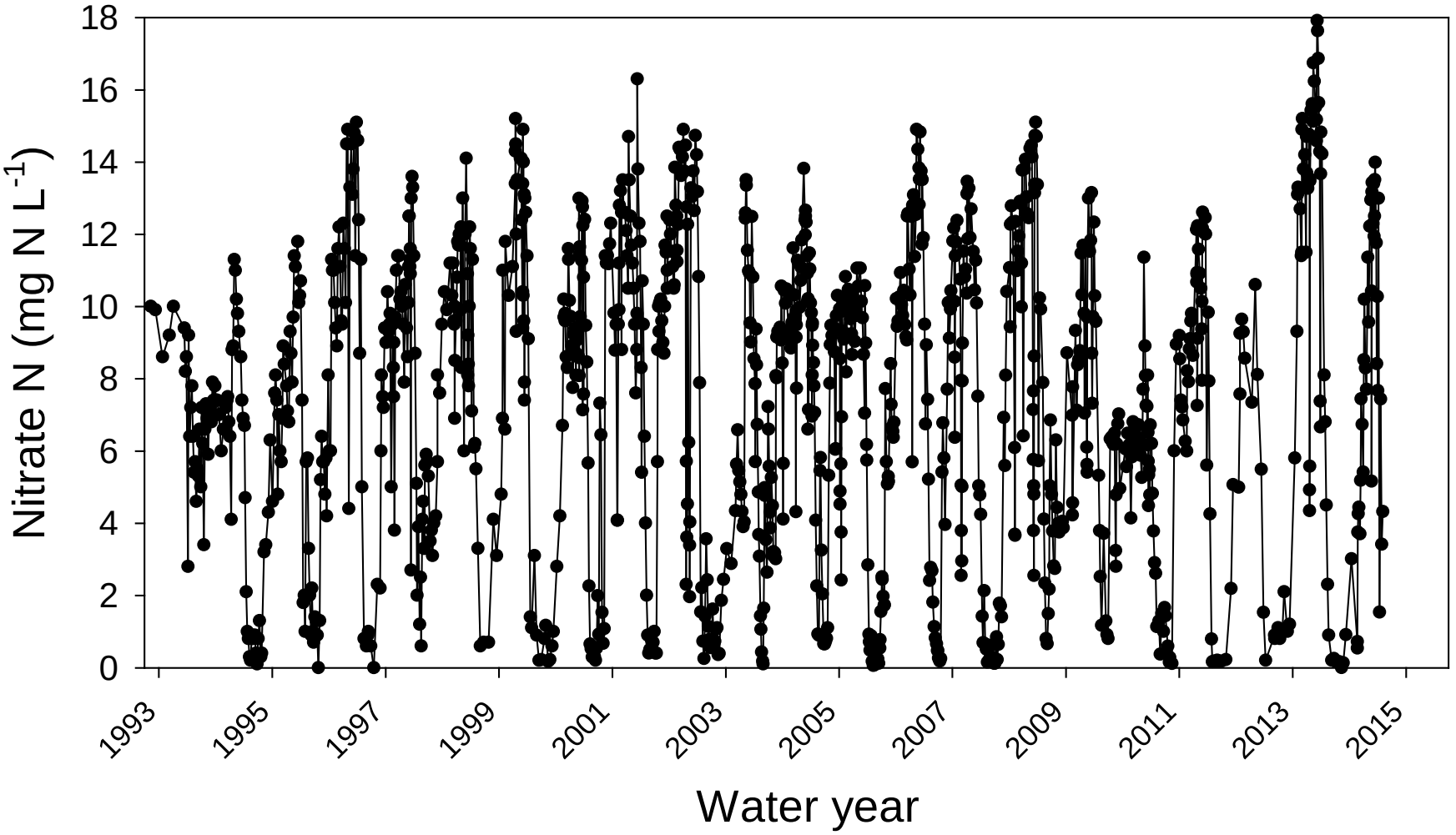
Some counties negative, N from soil mineralization

Linking N balances to N Export

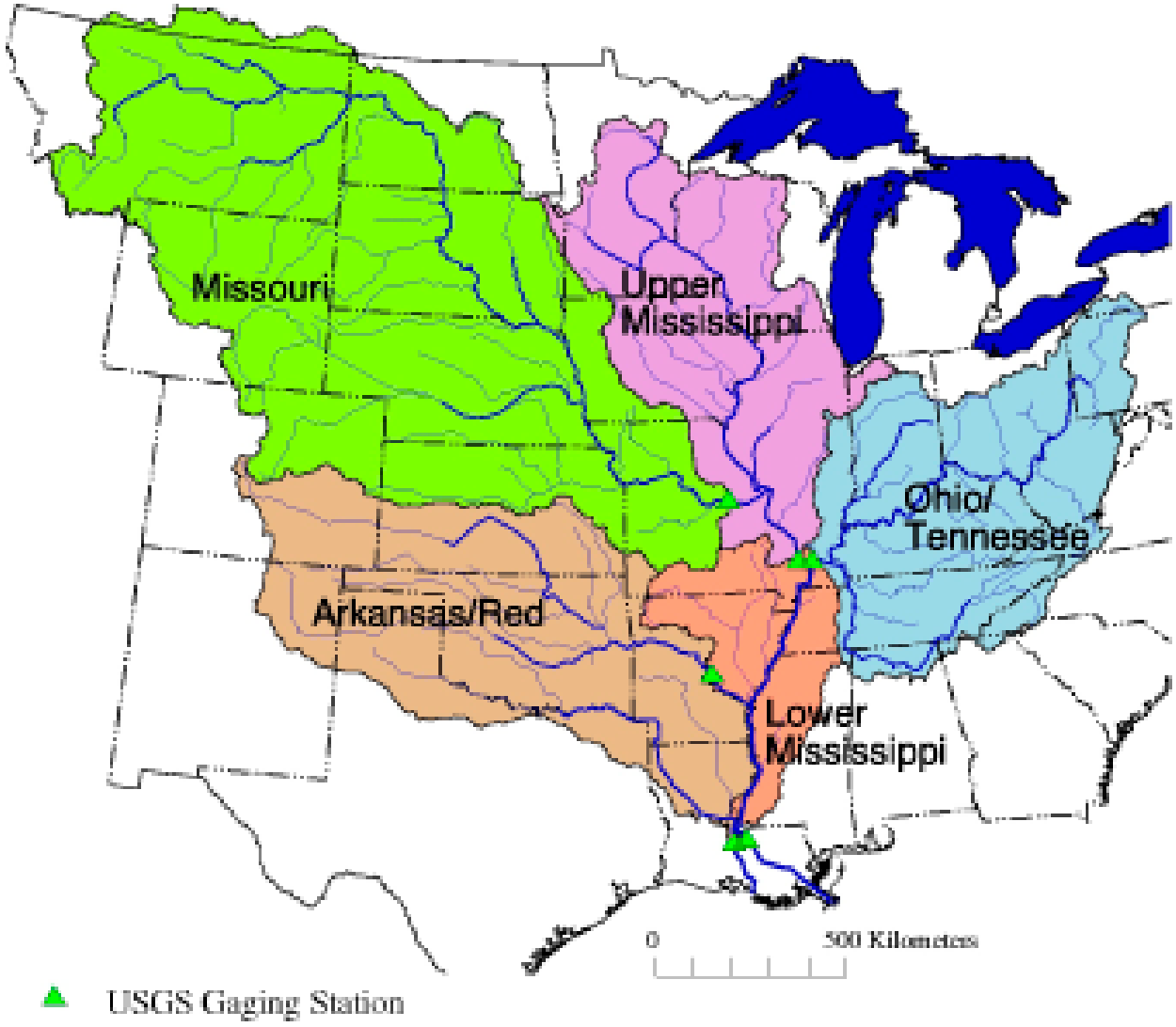
- hydrology overwhelming factor
  - tile drainage, channelization
- can look at watershed N export as a fraction of net N inputs
  - most studies have found this to be about 25%
  - however in MRB we know it is larger in critical areas
  - can be > 100% in Illinois tile drained watersheds

Embarras River - Camargo

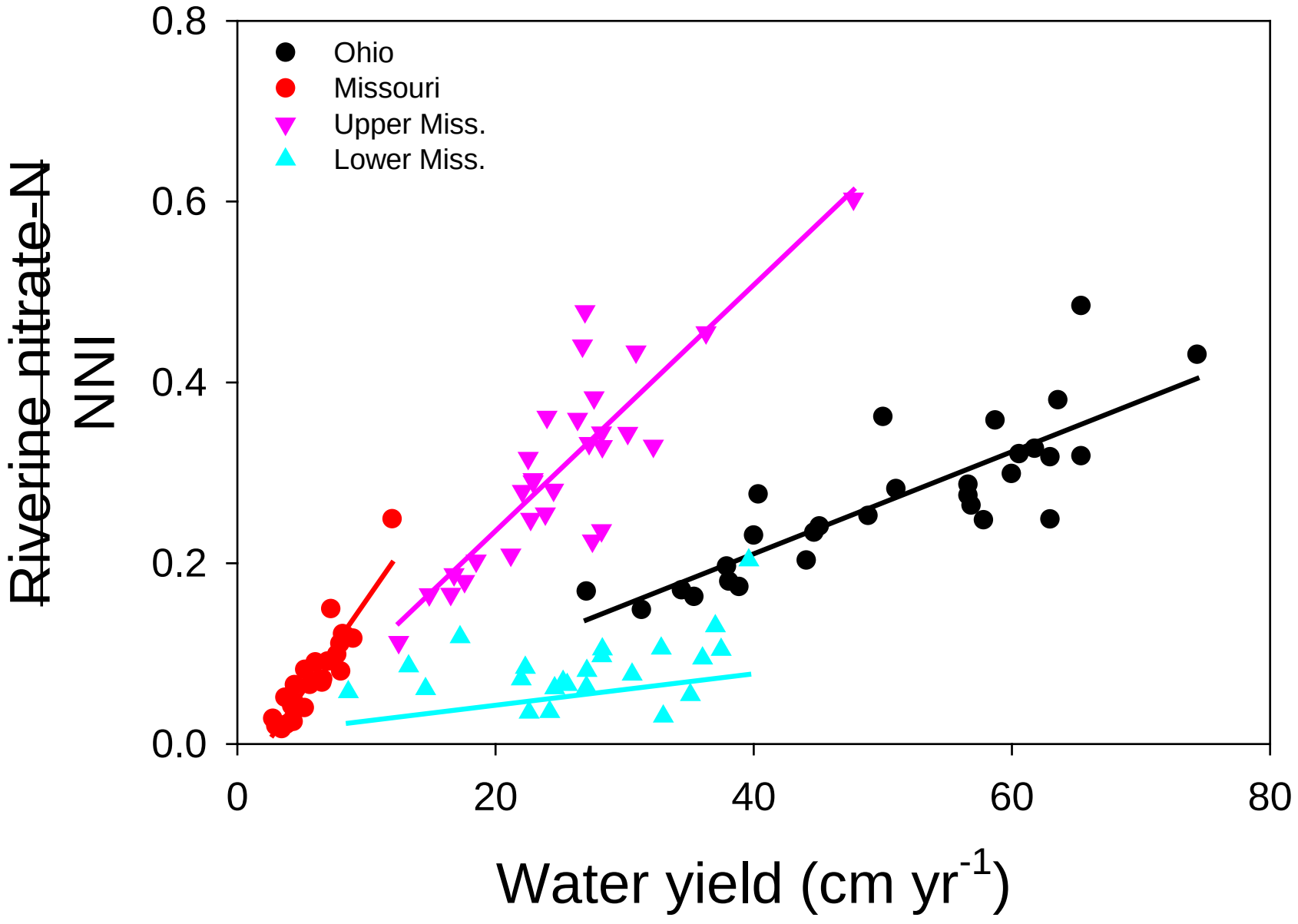
Embarras River



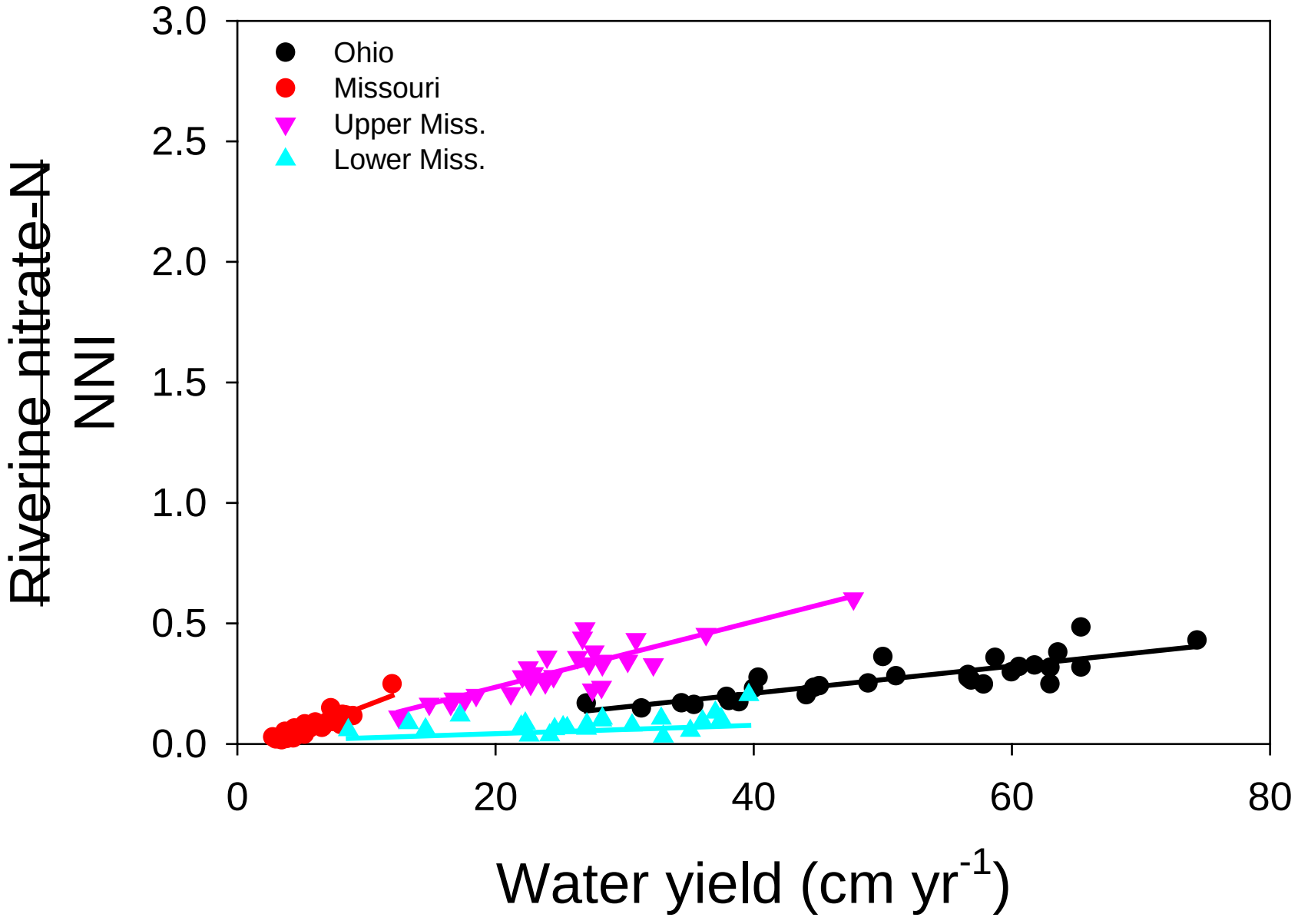
Major Mississippi Subbasins



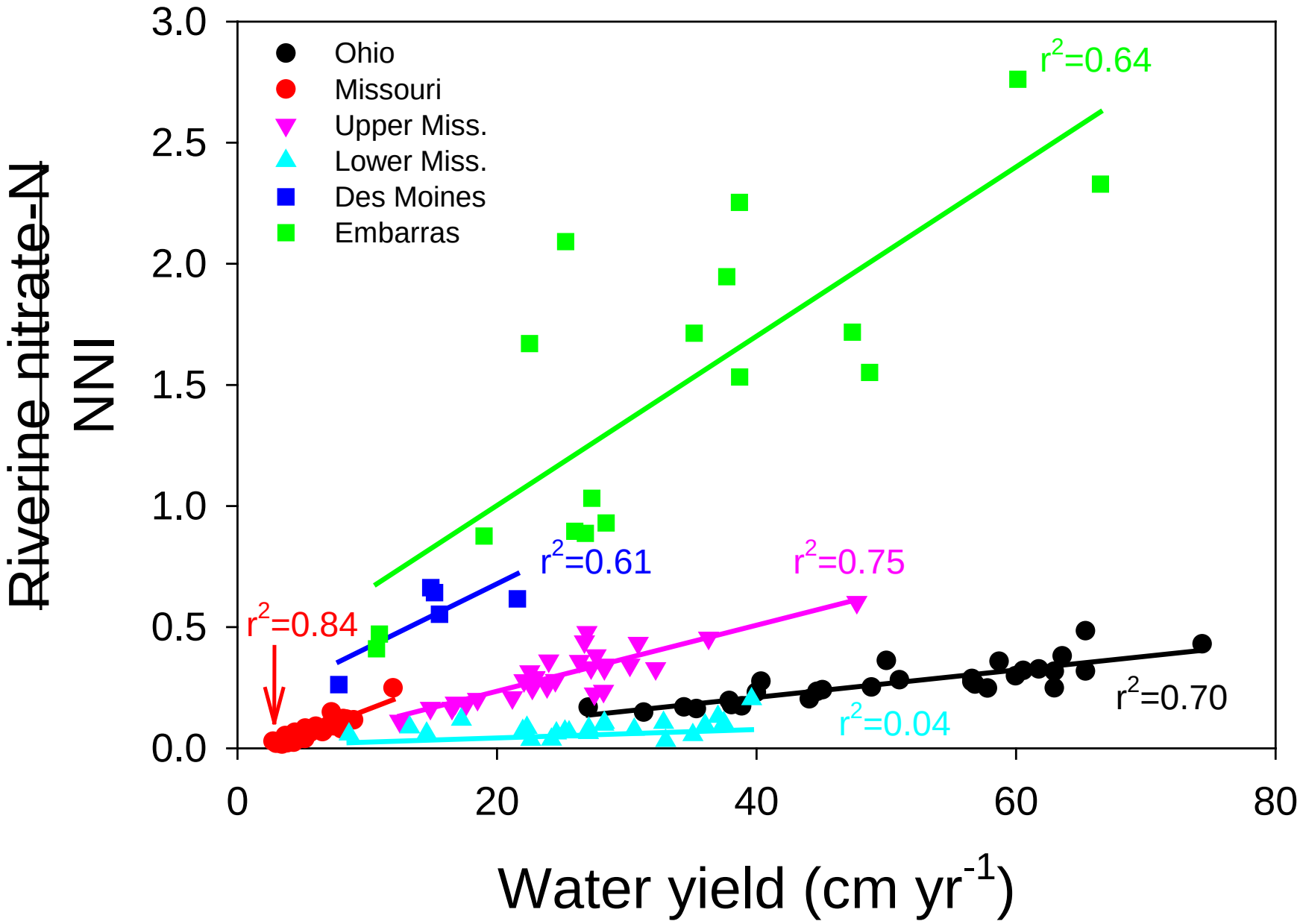
Mississippi River Basin



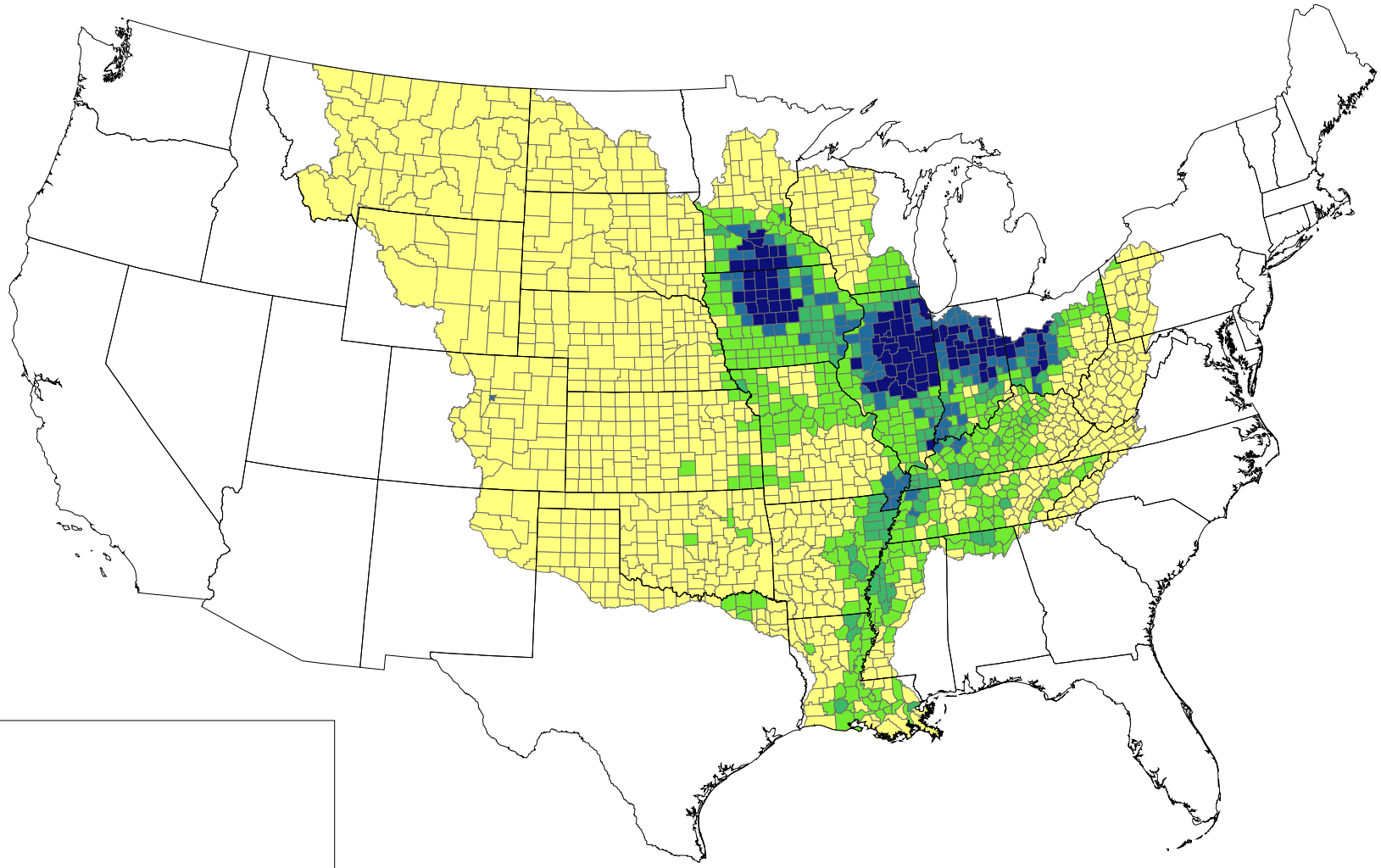
Mississippi River Basin



Mississippi River Basin



Modeled January to June Nitrate Export



Best model includes fertilizer, sewage effluent, and tile drainage

Uncertainty in N Balances

- N fertilizer (amounts, timing)
- crop coefficients
- biological N_2 fixation
- manure
- soil N pool changes (mineralization rates)
- denitrification

Ecological Applications, 23(5), 2013, pp. 1017–1035

The impact of nitrogen source and crop rotation on nitrogen mass balances in the Mississippi River Basin

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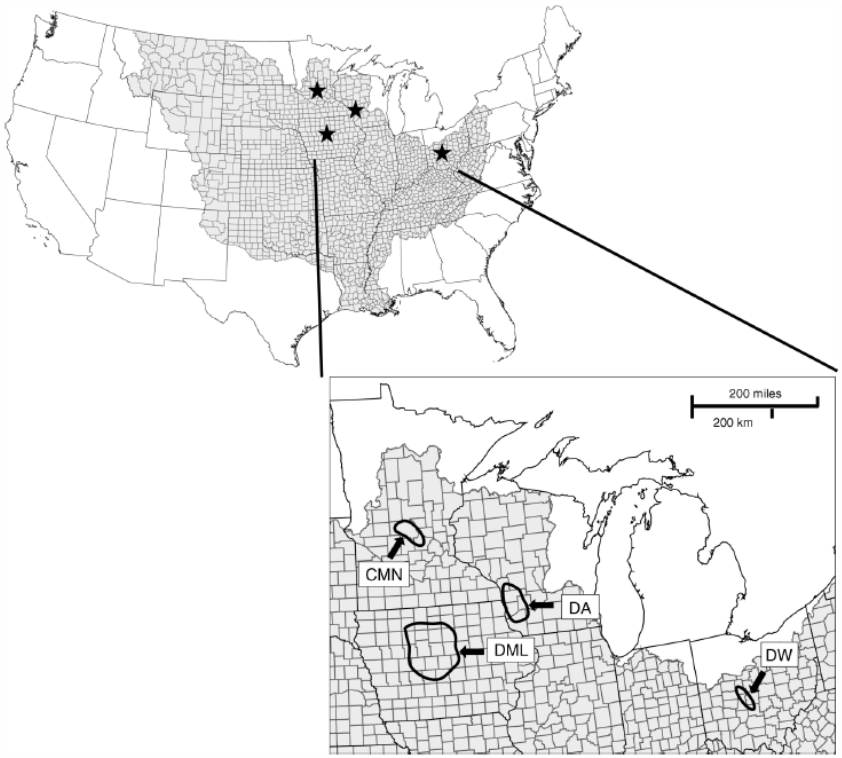
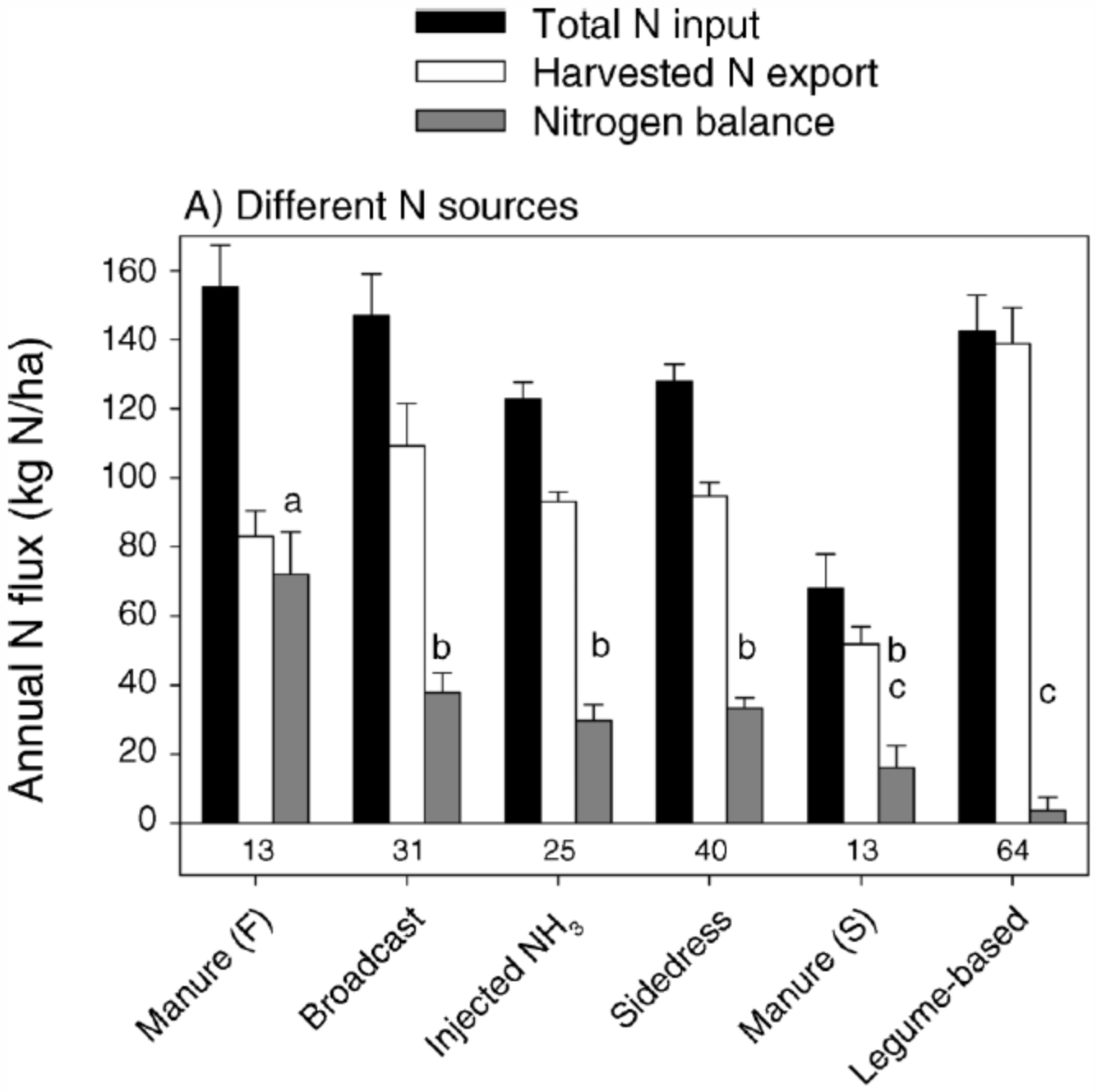
[2]*Department of Horticulture, Cornell University, Ithaca, New York 14853 USA*




Total N input
Harvested N export
Nitrogen balance
A) Different N sources
Annual N flux (kg N/ha)
160
140
120
100
80
60
40
20
0
a
b
b
b
b
c
c
13
31
25
40
13
64
Manure (F)
Broadcast
Injected NH3
Sidedress
Manure (S)
Legume-based

From Hong, Swaney, and Howarth (2013)

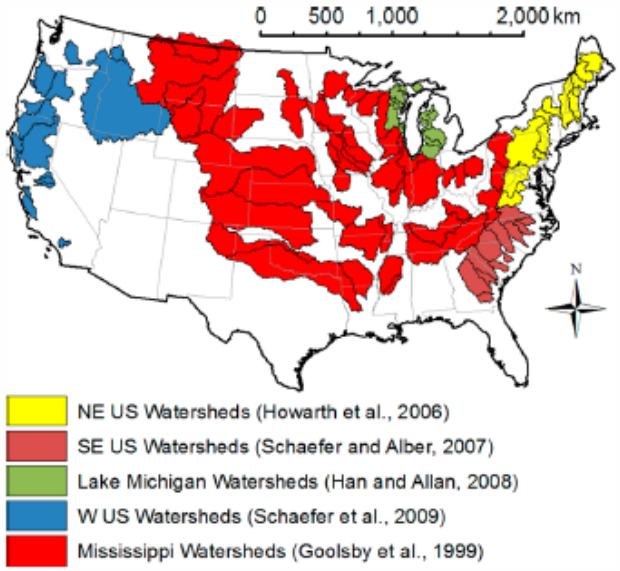
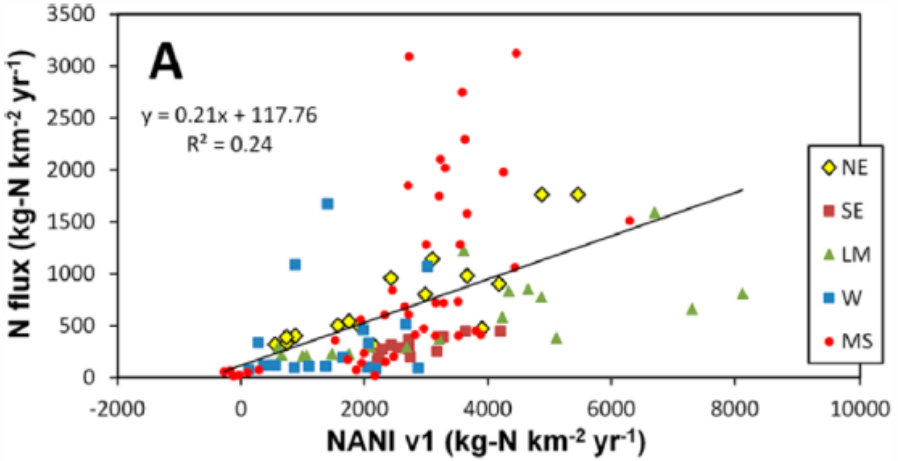
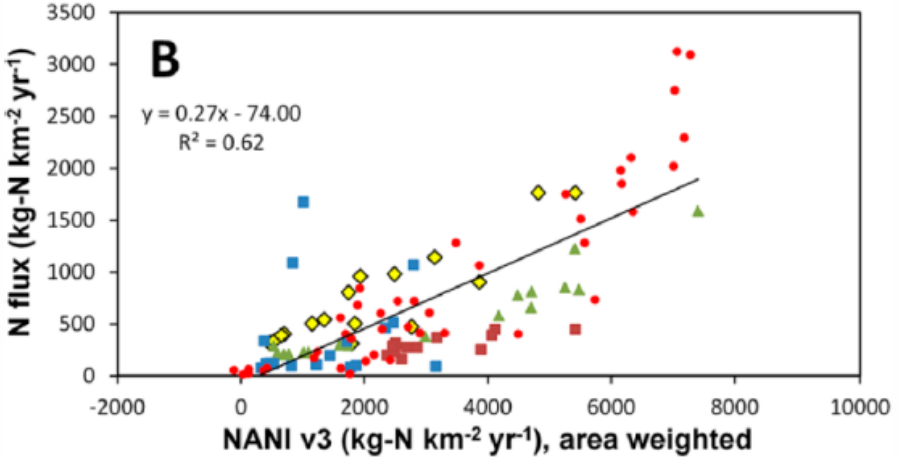
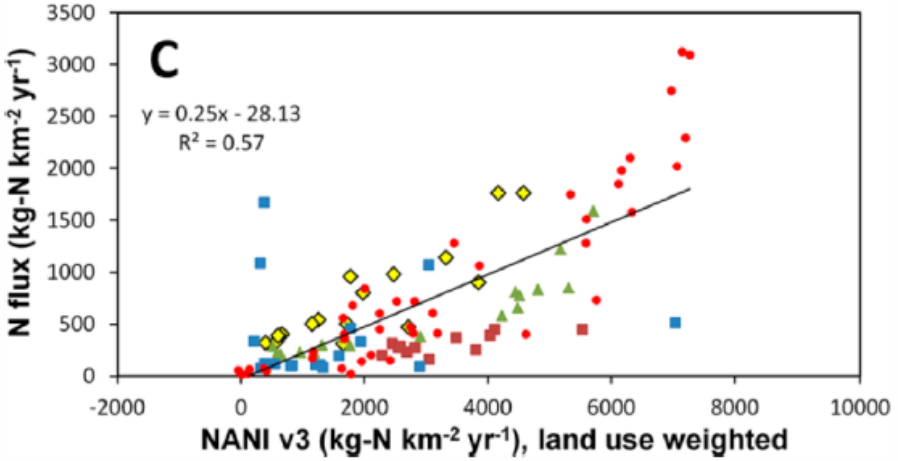


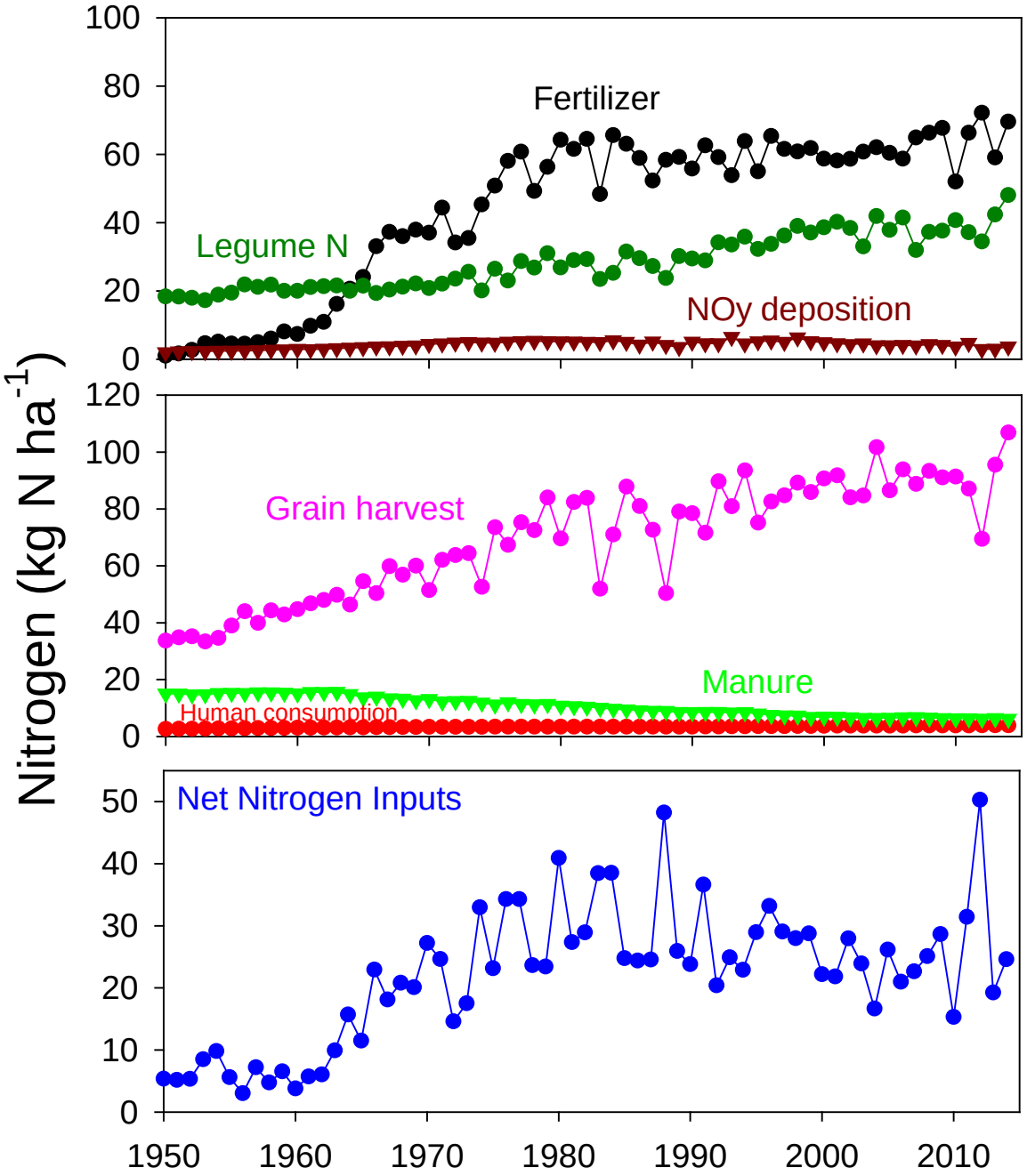
Figure 2. Map of 106 U.S. watersheds used in this study.







Illinois N budget through 2014



Components of Phosphorus Mass Balances

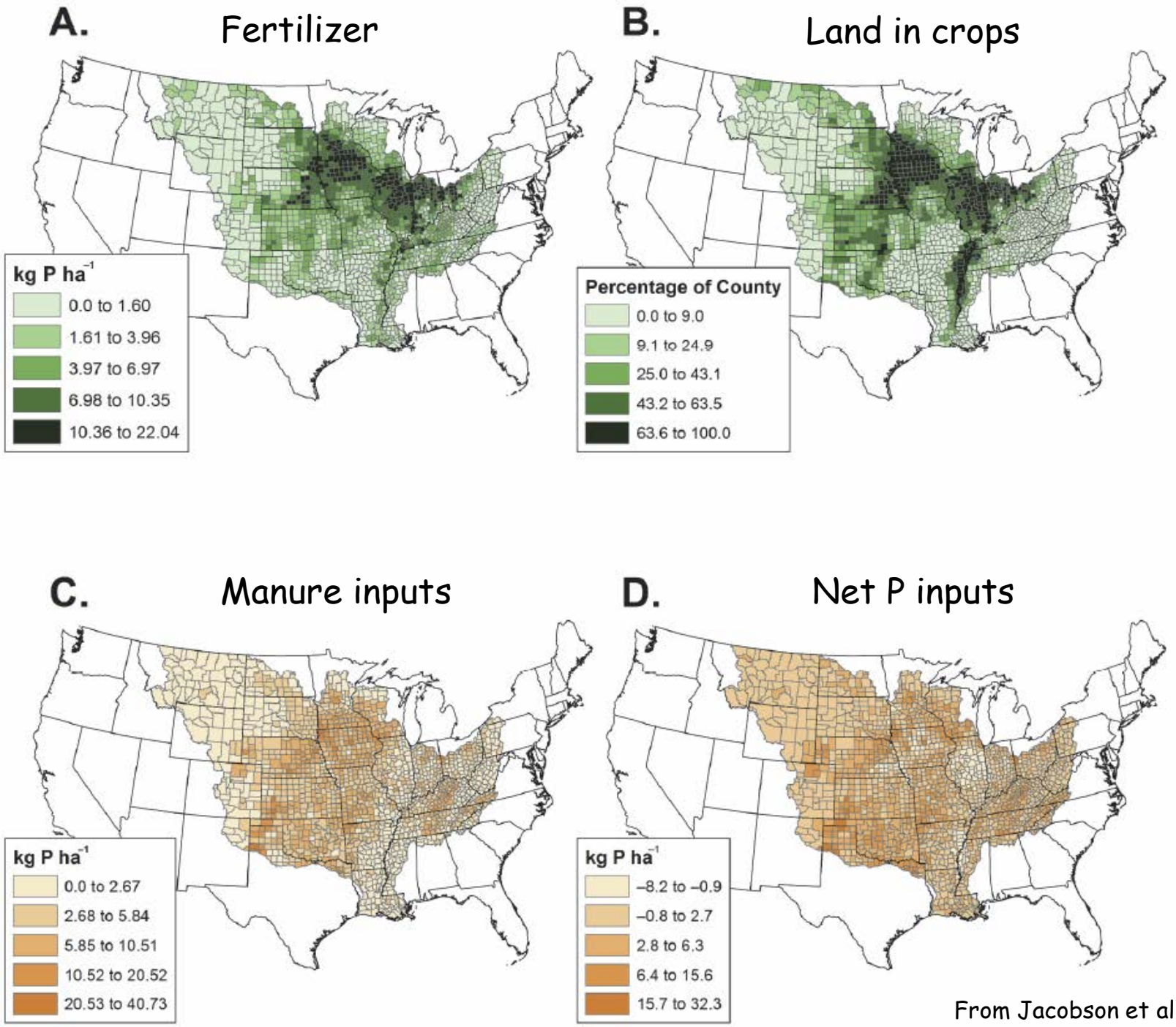
- net P inputs

  = inputs – outputs

  inputs (fertilizer)

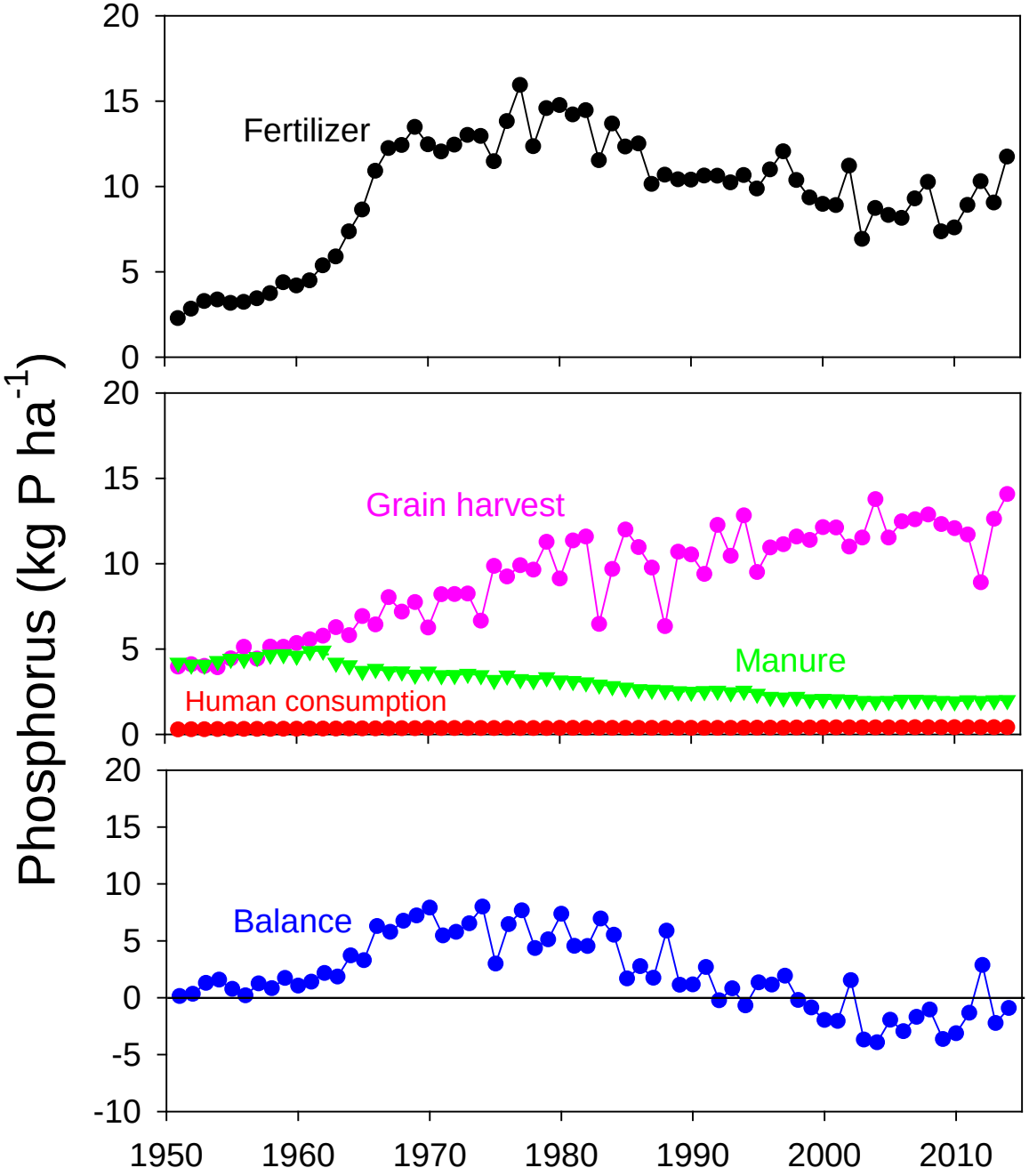
  outputs (grain harvest - human and animal consumption)

- net indicates additions or removals from soil
- little P (relative to N) is lost to streams, but it is biologically important
- surface runoff and tile leaching



From Jacobson et al. (2011)

Illinois P budget through 2014



Final comments

- limitations in data available to construct balances
- balances useful in understanding nutrient flows, pool changes through time
- limitations in how they relate to nutrient losses
  - better for N than for P
  - tile drainage must be considered