Science Assessment to Support an Illinois Nutrient Loss Reduction Strategy

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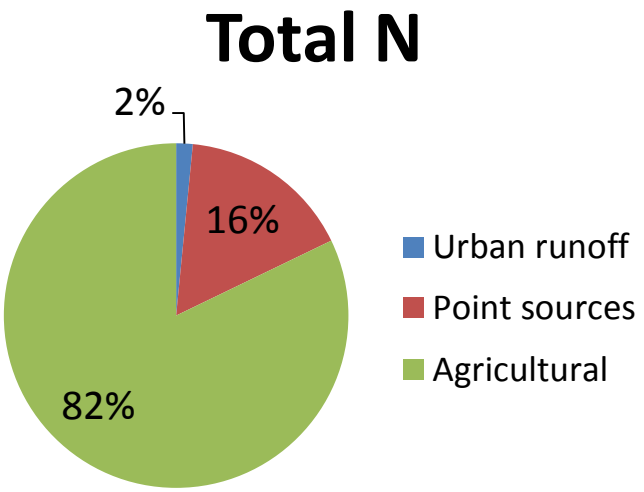
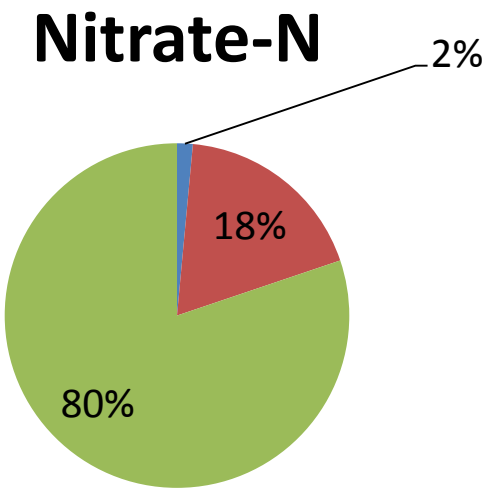
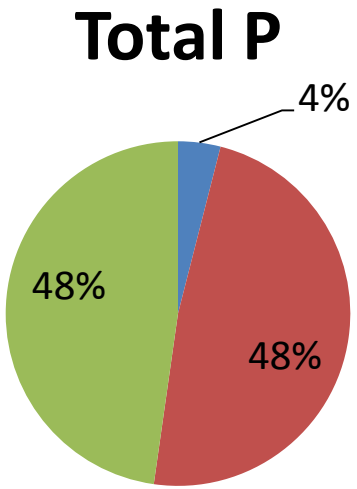
Riverine N and P Fluxes

	Water	Nitrate-N	Total N	DRP	Total P
	10^{12} ft^3 yr^{-1}	million lb N or P yr^{-1}			
David & Gentry (2000)	1.6		538		31.3
1980-1996	1.70	404	527	15.4	34.0
1997-2011	1.72	410	536	18.5	37.5
Urban runoff		6.0	8.3		1.5
Point sources		75.2	87.3		18.1
		Percent of 1997-2011 load			
Point sources		18.4	16.3		48
David & Gentry (2000)			16		47

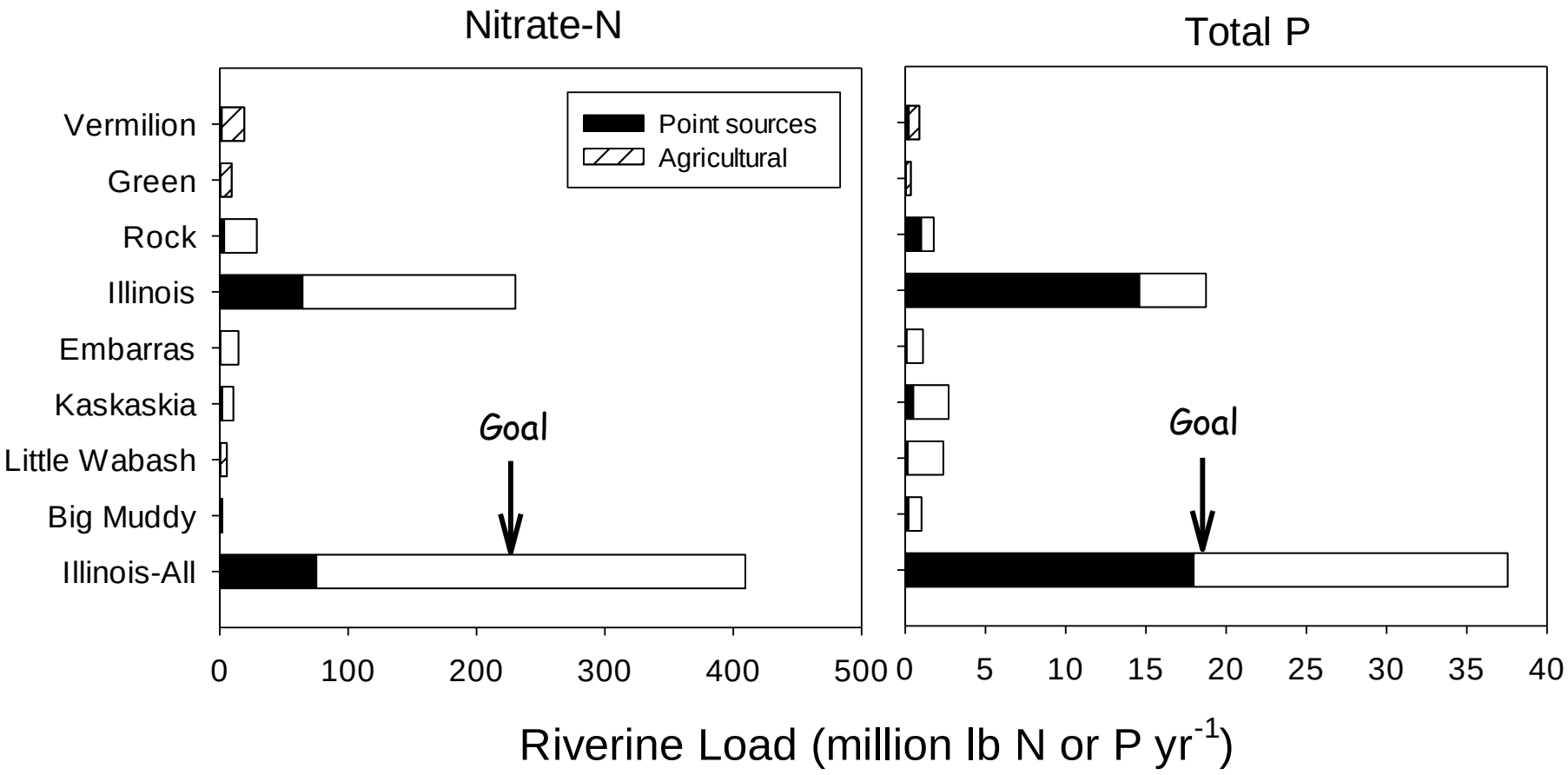
Illinois Nutrient Sources



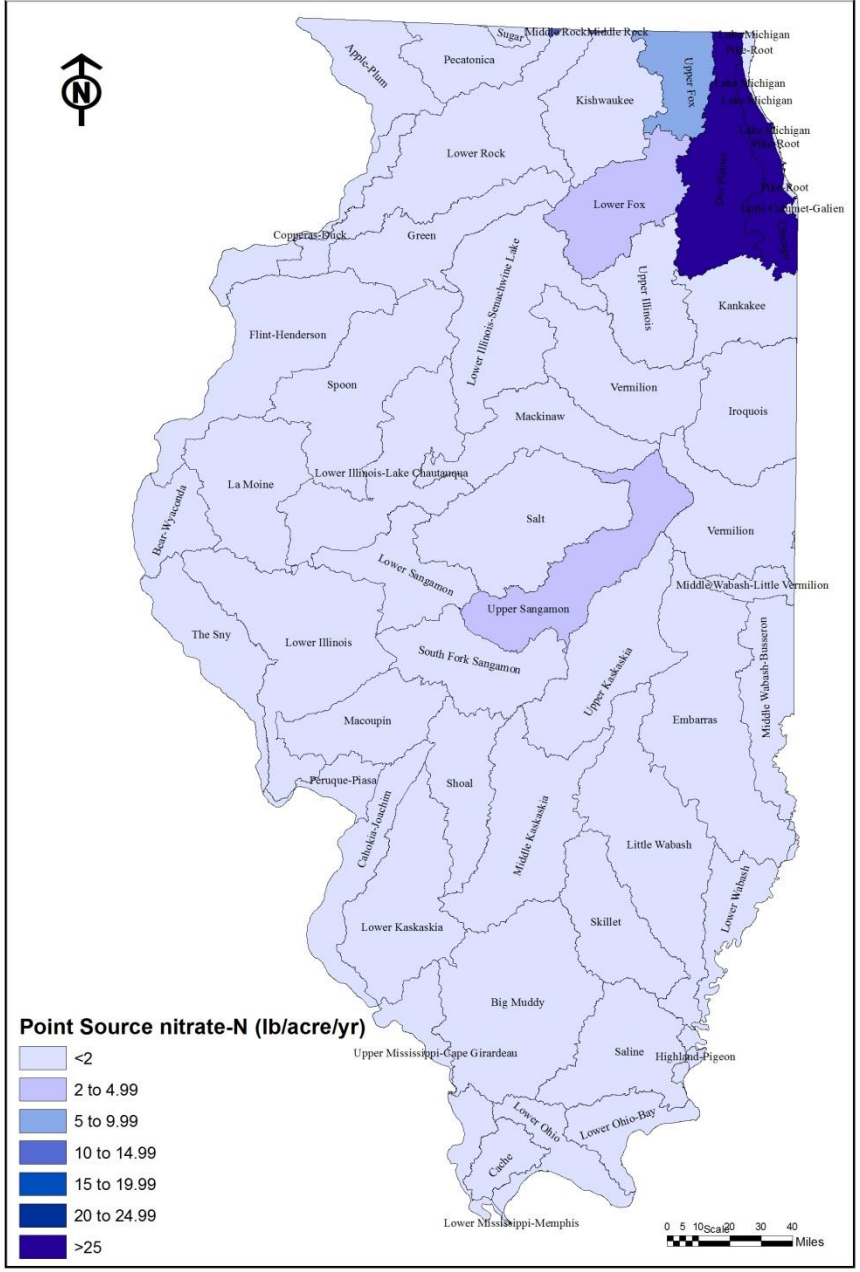




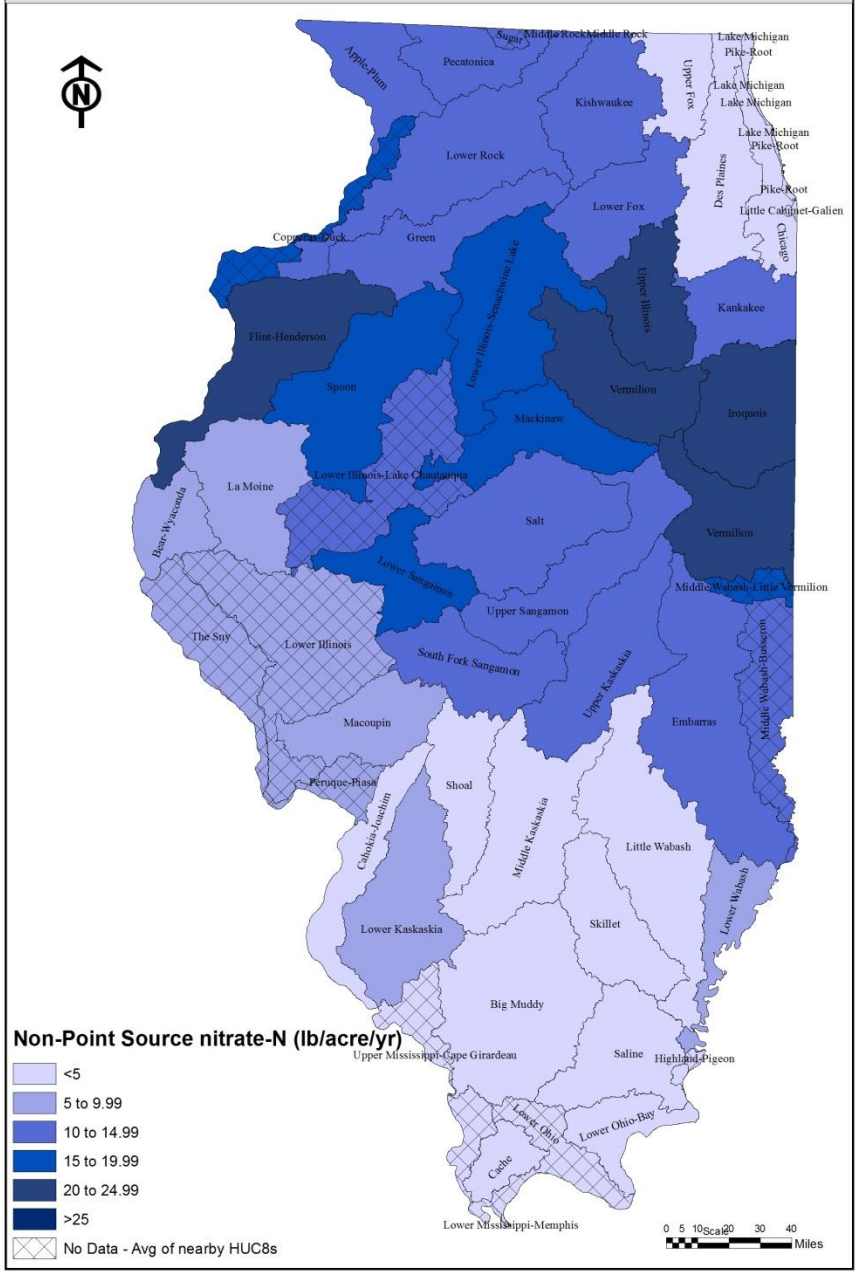
Point and agricultural sources (1997-2011)



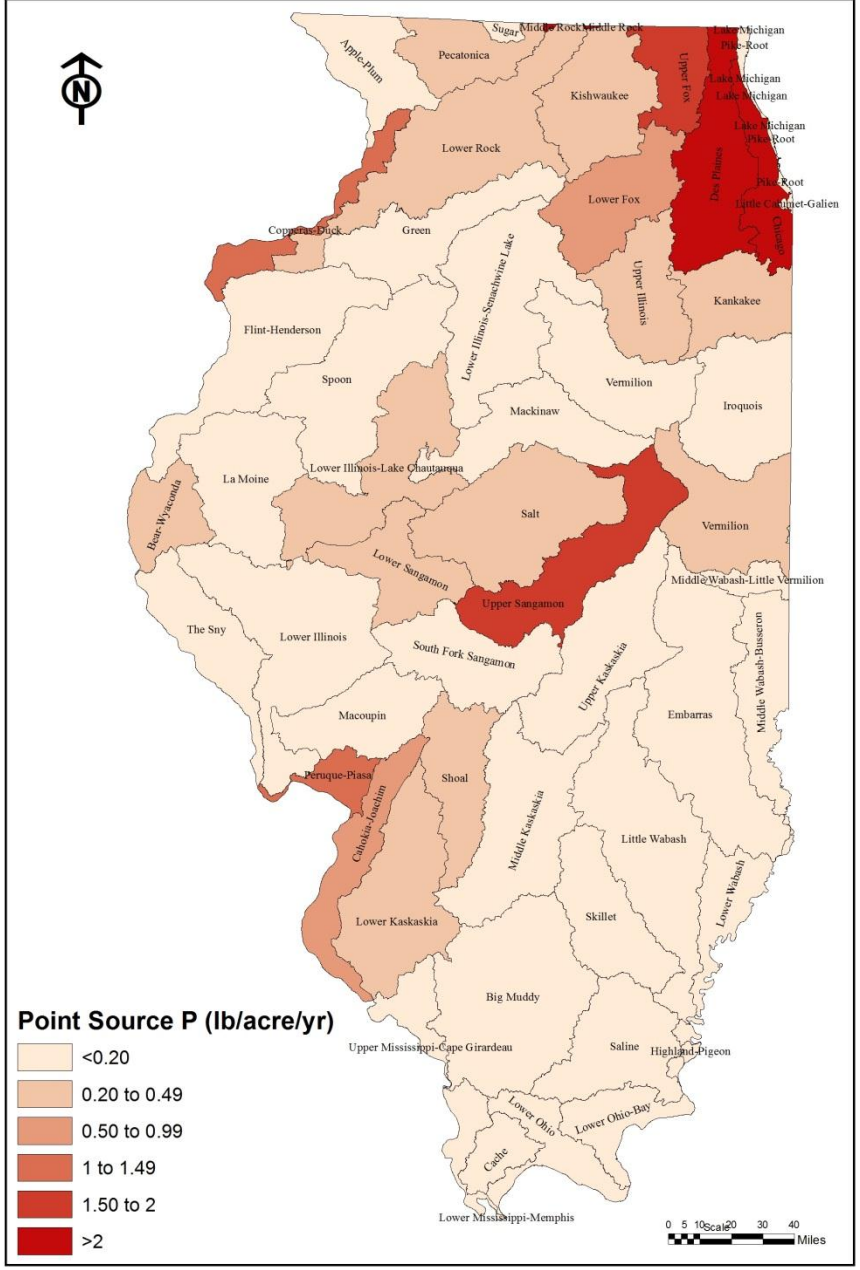
HUC8 Point Source nitrate-N Yields



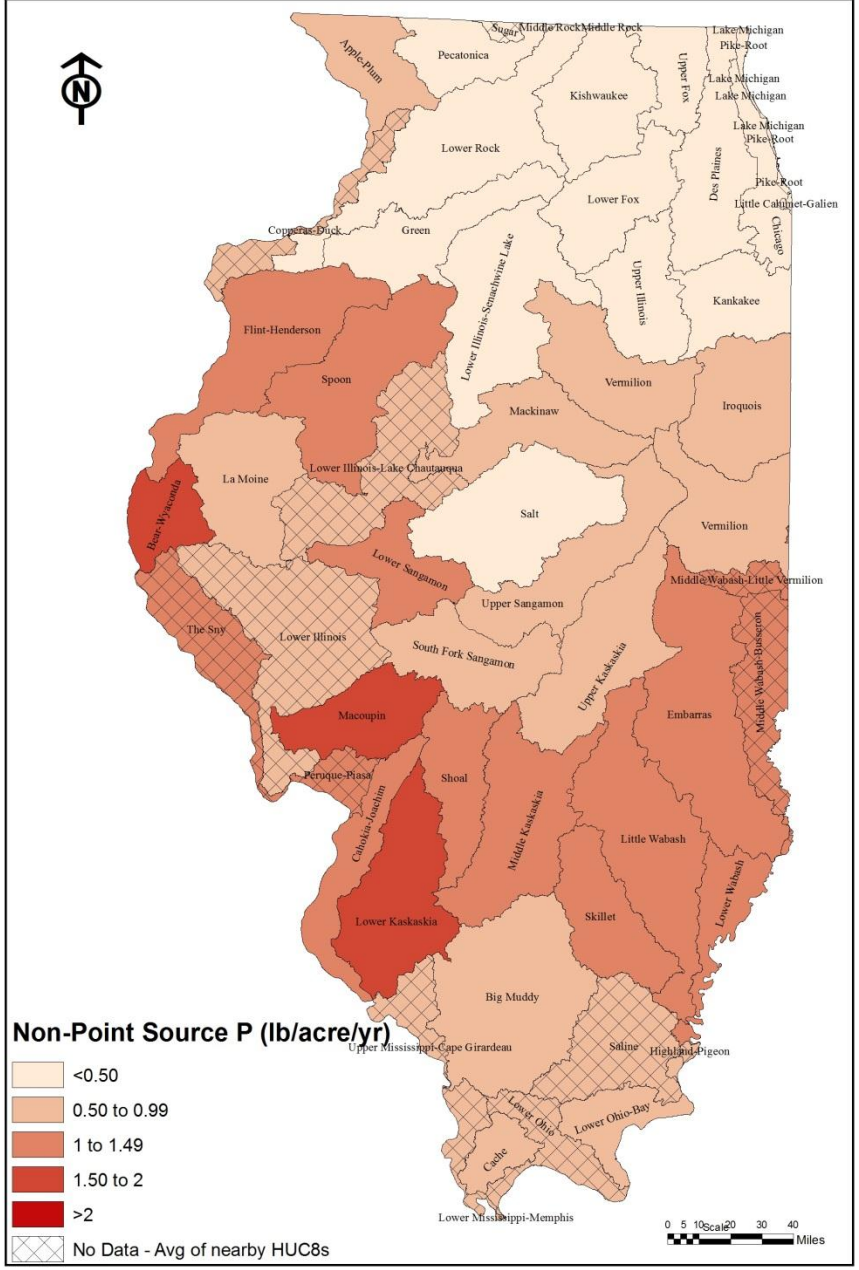
HUC8 Non-Point Source nitrate-N Yields

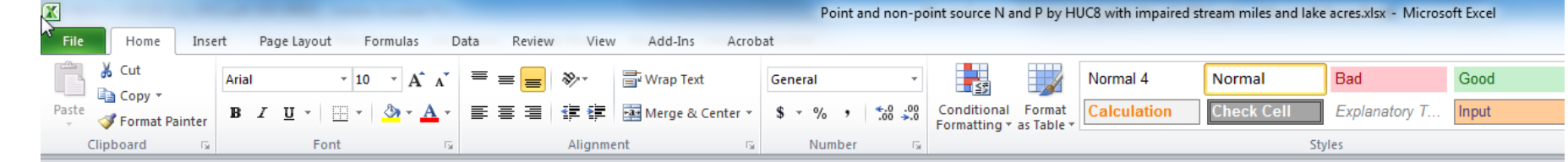


HUC8 Point Source P Yields



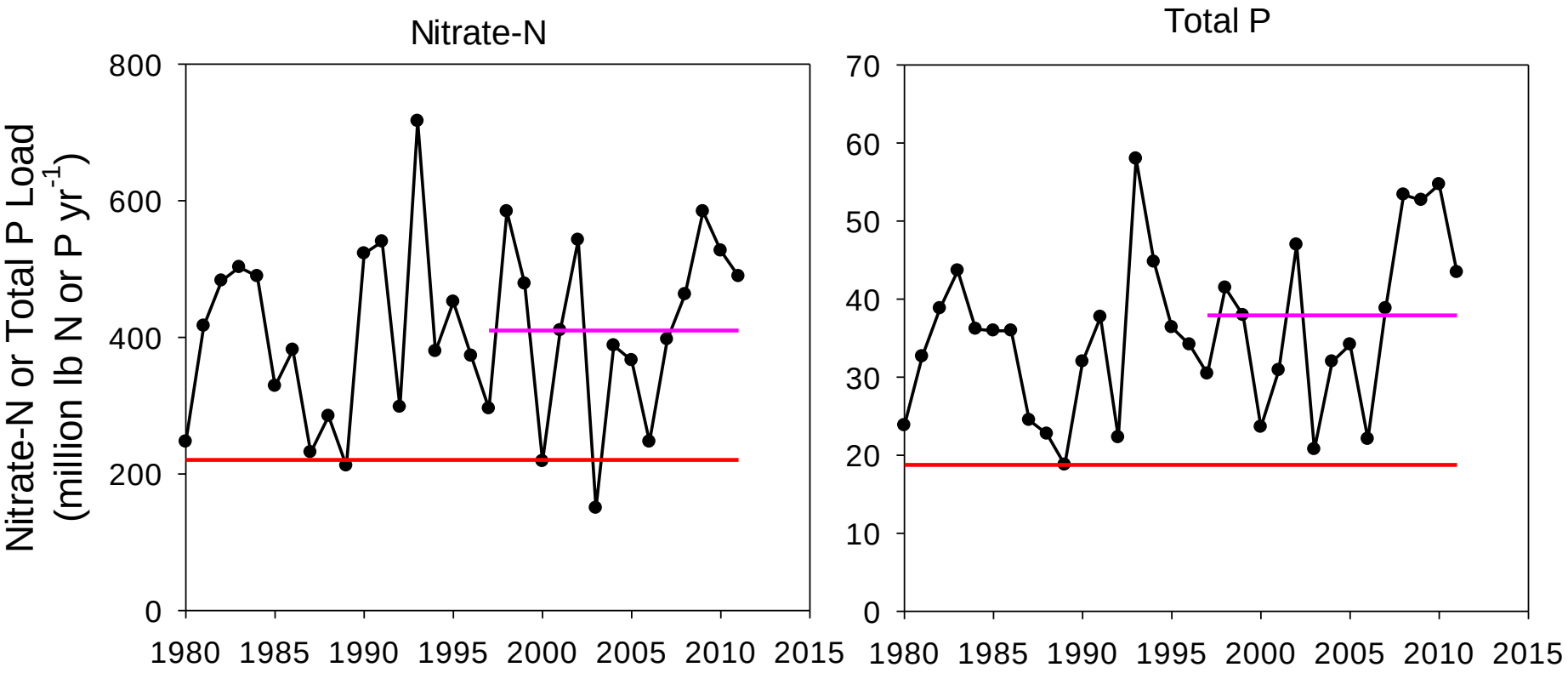
HUC8 Non-Point Source P Yields





	A	B	C	D	E	F	G	H	I	J	K	L	M
1			Total for HUC8	Point source	Non-point source					Total for HUC8	Point source	Non-point source	
2	Name	HUC8	lbs N/acre/yr	lbs N/acre/yr	lbs N/acre/yr			Name	HUC8	lbs N/acre/yr	lbs N/acre/yr	lbs N/acre/yr	
3													
4	Des Plaines	7120004	40.90	40.90	0.00			Flint-Henderson	7080104	24.08	0.48	23.61	
5	Chicago	7120003	41.75	38.35	3.40			Upper Illinois	7120005	23.82	0.33	23.49	
6	Middle Rock	7090002	27.17	12.88	14.29			Vermilion (IL)	7130002	22.57	0.42	22.15	
7	Upper Fox	7120006	9.25	9.25	0.00			Iroquois	7120002	22.12	0.11	22.01	
8	Lower Fox	7120007	14.09	3.87	10.23			Vermilion (Wabash)	5120109	21.94	1.66	20.28	
9	Upper Sangamon	7130006	15.66	2.18	13.48			Mackinaw	7130004	20.07	0.20	19.87	
10	Copperas-Duck	7080101	18.88	1.94	16.94			Lower Illinois-Senachwine Lake	7130001	18.82	0.50	18.32	
11	Vermilion (Wabash)	5120109	21.94	1.66	20.28			Spoon	7130005	17.84	0.28	17.56	
12	Cahokia-Joachim	7140101	2.50	1.60	0.90			Copperas-Duck	7080101	18.88	1.94	16.94	
13	Lower Rock	7090005	15.43	1.45	13.98			Lower Sangamon	7130008	17.93	1.21	16.72	
14	Kishwaukee	7090006	14.18	1.30	12.88			Middle Wabash-Lil Verm	5120108	16.06	0.33	15.73	
15	Lower Sangamon	7130008	17.93	1.21	16.72			Salt	7130009	15.79	1.03	14.76	
16	Lower Kaskaskia	7140204	6.42	1.12	5.30			Sugar	7090004	14.59	0.00	14.59	
17	Salt	7130009	15.79	1.03	14.76			Pecatonica	7090003	15.34	0.76	14.59	
18	Bear-Wyaconda	7110001	6.78	0.89	5.89			Middle Rock	7090002	27.17	12.88	14.29	
19	Lower Illinois-Lake Chautauqua	7130003	14.90	0.88	14.01			Lower Illinois-Lake Chautauqua	7130003	14.90	0.88	14.01	
20	South Fork Sangamon	7130007	14.18	0.81	13.38			Lower Rock	7090005	15.43	1.45	13.98	
21	Pecatonica	7090003	15.34	0.76	14.59			Upper Sangamon	7130006	15.66	2.18	13.48	
22	Big Muddy	7140106	1.43	0.71	0.72			South Fork Sangamon	7130007	14.18	0.81	13.38	
23	Lower Illinois-Senachwine Lake	7130001	18.82	0.50	18.32			Apple-Plum	7060005	13.38	0.14	13.24	
24	Flint-Henderson	7080104	24.08	0.48	23.61			Kishwaukee	7090006	14.18	1.30	12.88	
25	La Moine	7130010	9.63	0.42	9.22			Green	7090007	12.65	0.14	12.51	
26	Vermilion (IL)	7130002	22.57	0.42	22.15			Kankakee	7120001	12.67	0.37	12.30	
27	Shoal	7140203	3.39	0.39	3.00			Upper Kaskaskia	7140201	11.69	0.32	11.37	
28	Kankakee	7120001	12.67	0.37	12.30			Embarras (Lawrenceville)	5120112	11.51	0.34	11.17	
29	Embarras (Lawrenceville)	5120112	11.51	0.34	11.17			Middle Wabash-Busseron	5120111	11.46	0.29	11.17	
30	Upper Illinois	7120005	23.82	0.33	23.49			Lower Fox	7120007	14.09	3.87	10.23	
31	Middle Wabash-Lil Verm	5120108	16.06	0.33	15.73			La Moine	7130010	9.63	0.42	9.22	
32	Lower Illinois	7130011	8.12	0.32	7.79			Lower Illinois	7130011	8.12	0.32	7.79	
33	Upper Kaskaskia	7140201	11.69	0.32	11.37			Macoupin	7130012	7.14	0.25	6.89	
34	Little Wabash	5120114	3.49	0.32	3.17			The Sny	7110004	6.84	0.00	6.84	
35	Lower Ohio	5140206	1.34	0.32	1.02			Lower Wabash	5120113	6.51	0.00	6.51	
36	Middle Wabash-Busseron	5120111	11.46	0.29	11.17			Bear-Wyaconda	7110001	6.78	0.89	5.89	
37	Spoon	7130005	17.84	0.28	17.56			Lower Kaskaskia	7140204	6.42	1.12	5.30	
38	Macoupin	7130012	7.14	0.25	6.89			Peruque-Piasa	7110009	5.29	0.10	5.19	
39	Middle Kaskaskia	7140202	3.57	0.23	3.34			Chicago	7120003	41.75	38.35	3.40	
40	Upper Miss/Cape Girardeau	7140105	2.24	0.22	2.02			Middle Kaskaskia	7140202	3.57	0.23	3.34	
41	Saline	5140204	1.07	0.20	0.87			Little Wabash	5120114	3.49	0.32	3.17	
42	Mackinaw	7130004	20.07	0.20	19.87			Shoal	7140203	3.39	0.39	3.00	
43	Green	7090007	12.65	0.14	12.51			Highland-Pigeon	5140202	2.69	0.00	2.69	
44	Apple-Plum	7060005	13.38	0.14	13.24			Upper Miss/Cape Girardeau	7140105	2.24	0.22	2.02	
45	Iroquois	7120002	22.12	0.11	22.01			Skillet	5120115	1.69	0.01	1.69	
46	Peruque-Piasa	7110009	5.29	0.10	5.19			Cache	7140108	1.34	0.00	1.34	
47	Skillet	5120115	1.69	0.01	1.69			Lower Ohio	5140206	1.34	0.32	1.02	

Nitrate-N and Total P Targets



Red line is target, purple is average 1997 to 2011

Point Source P Estimates

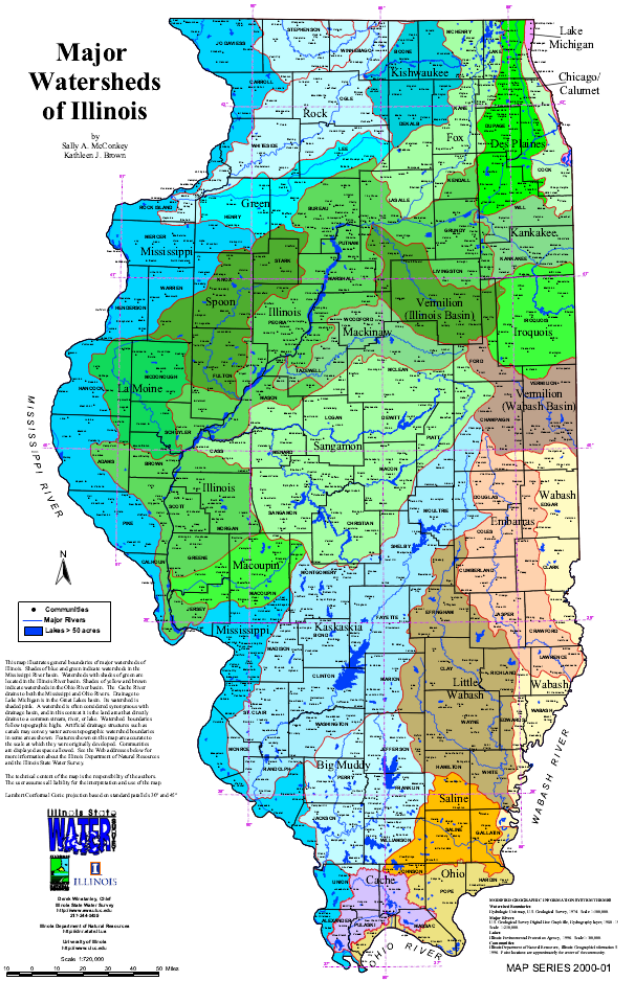
Point Source Limit (mg P/L)	million lb of P reduced	% of target (18.8 million lb P)
All majors to 1 mg/L standard (0.7 mg P/L actual)	10.4	55
Top 20 majors to 0.7	6.1	32
Top 30 majors to 0.7	7.0	37
Top 50 majors to 0.7	7.8	41
All majors to 0.3	13.1	70
Top 20 majors to 0.3	8.0	42
Top 30 majors to 0.3	8.9	47
Top 50 majors to 0.3	9.9	52

Total P from point sources currently ~18.1 million lb P per year

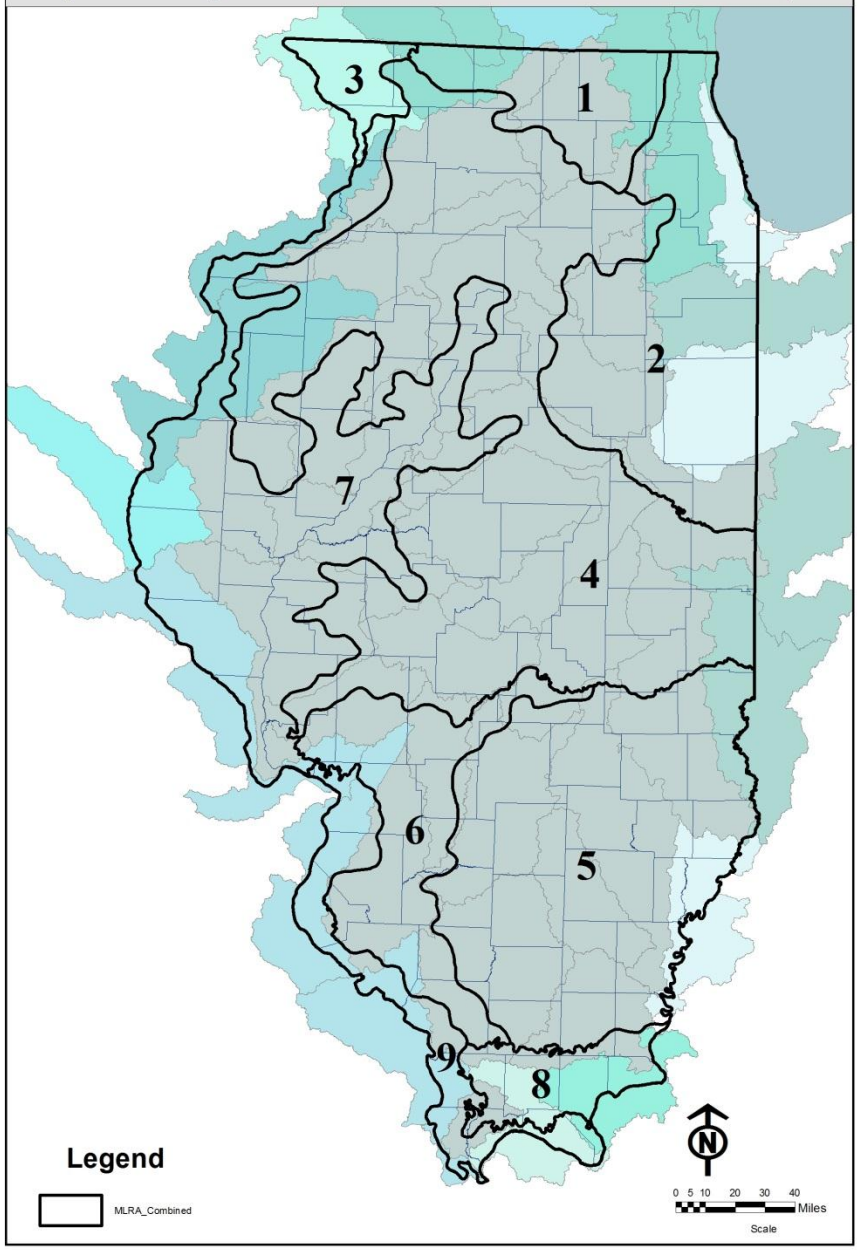
Possible intermediate reduction goal

- 30% total P reduction by 2025
  - top 50 majors reduce total P to 0.7 mg P/L (21%)
  - buffers and cover crops (9%)
- 20% nitrate-N reduction by 2025
  - fertilizer timing, cover crops, buffers, and bioreactors (20%)

to Gulf of Mexico



Combined MLRAs for Illinois
(Overlayed with HUC 8s & Counties)



Nitrate Yield by MLRA

Combined MLRA	Description	Drained cropland (acres)	Nitrate-N yield per row crop acre (lb N/acre/yr)	Nitrate-N yield per tile drained acre (lb N/acre/yr)	Nitrate-N yield from non-tiled land (lb N/acre/yr)
MLRA 1	Northern Illinois drift plain	288,491	20.4	43	6.6
MLRA 2	Northeastern Illinois heavy till plain	2,063,695	25.0	29	10.8
MLRA 3	Northern Mississippi Valley	20,942	31.3		31.3
MLRA 4	Deep loess and drift	5,437,807	19.6	26	9.9
MLRA 5	Claypan	310,087	6.6		6.6
MLRA 6	Thin loess and till	226,971	7.4	30	3.5
MLRA 7	Central Mississippi Valley, Northern Part	1,284,588	24.5	46	11.8
MLRA 8	Sandstone and shale hills and valleys	49,565	3.9		3.9
MLRA 9	Central Mississippi Valley, Western Part	23,769	4.0		4.0

Cost analysis

- Gary Schnitkey
  - agricultural costs per acre
- Mark David
  - point source costs
  - N loss reduction costs
- Greg McIsaac
  - P loss reduction costs

Agricultural Cost Estimates

- No changes in corn and soybean yields across scenarios
- No reduction in nitrogen application rates with timing changes
- Up front costs amortized over 20 years at 6% interest rate

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 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

P Reduction Practices

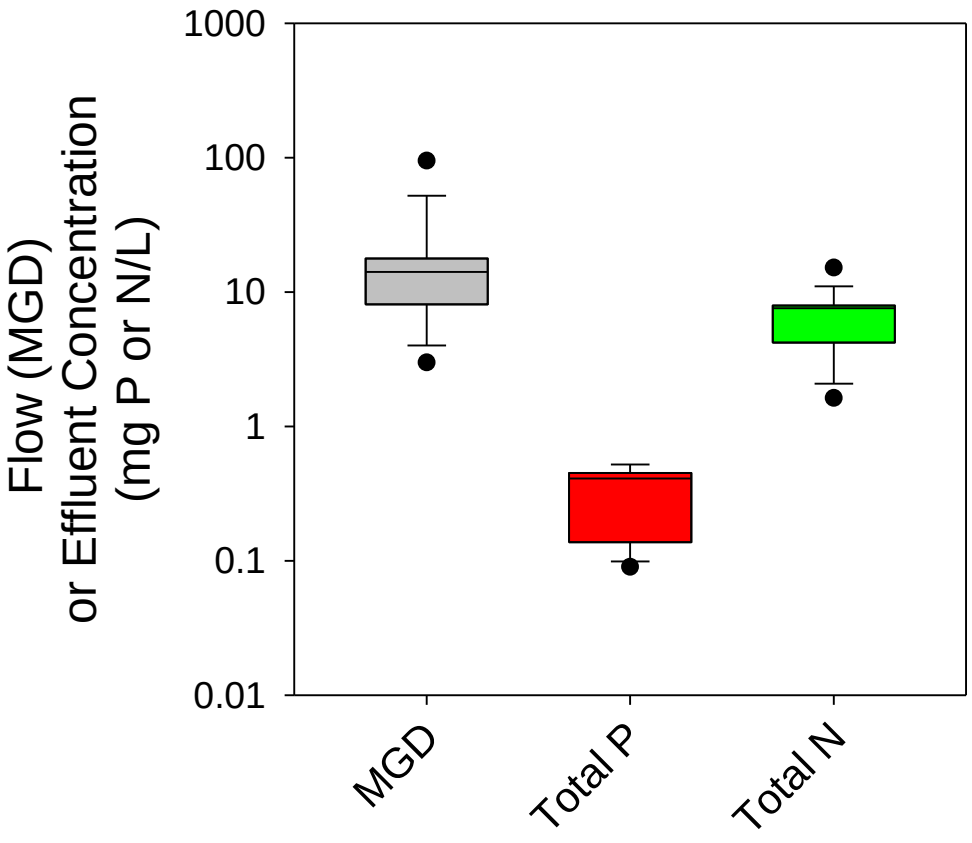
- Reduce tillage: -$16 per acre
  - One less field pass
- Eliminate P application for six years: -$15 per acre
  - Eliminate 6 years of applications, spread over 20 years to draw down P reserves
- Incorporate P: $6 per acre
  - Additional application costs

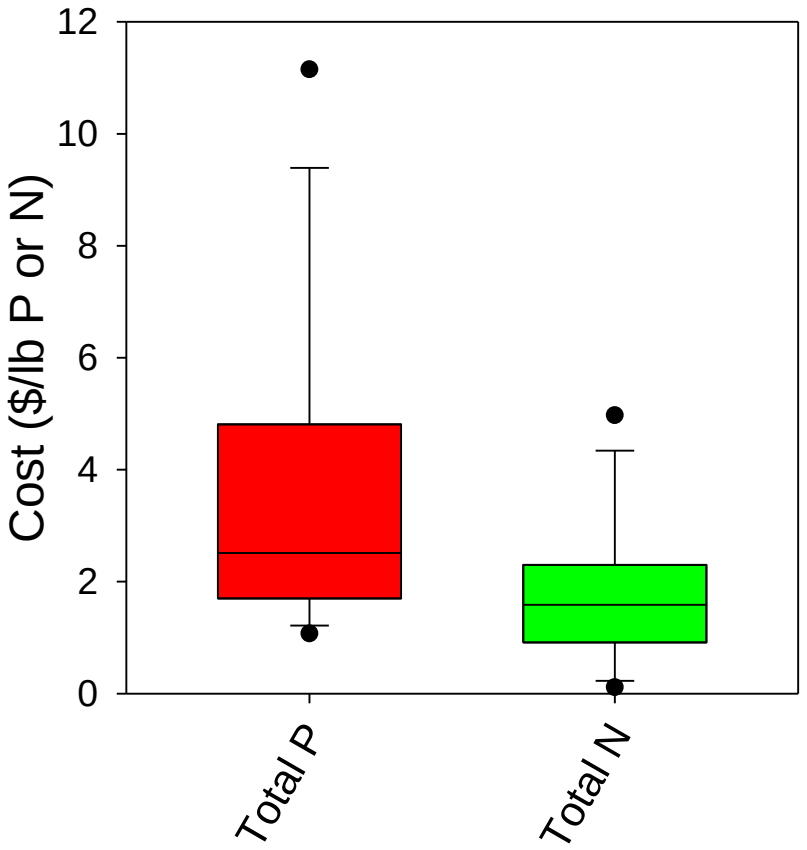
Point Source Costs

- dependent on size of facility
  - costs >>>> for smaller STP's (< 1-2 MGD)
- great variability among STP's
- used data from:
  - North Shore Sanitary District
    - three plant cost analysis
  - USEPA 2008 Municipal Nutrient Removal Technologies report
    - eight plant case study
- more data to come, cost per lb likely to increase

Point Source Cost Summary

(more estimates to be added)





Median $2.92/lb P $1.72 lb/N

Example Statewide Results for N

	Practice/Scenario	Nitrate-N reduction per acre (%)	Nitrate-N reduced (million lb N)	Nitrate-N Reduction % (from baseline)	Cost ($/lb N removed)
	Baseline		410		
In-field	Reducing N rate from background to the MRTN (10% of acres)	10	2.3	0.6	-4.25
	Nitrification inhibitor with all fall applied fertilizer on tile-drained corn acres	10	4.3	1.0	2.33
	Split (50%) fall and spring (50%) on tile-drained corn acres	7.5 to 10	13	3.1	6.22
	Fall to spring on tile-drained corn acres	15 to 20	26	6.4	3.17
	Cover crops on all corn/soybean tile-drained acres	30	84	20.5	3.21
	Cover crops on all corn/soybean non-tiled acres	30	32	7.9	11.33
Edge-of-field	Bioreactors on 50% of tile-drained land	40	56	13.6	1.38
	Wetlands on 25% of tile-drained land	40	35	8.5	4.05
	Buffers on all applicable crop land (reduction only for water that interacts with active area)	90	36	8.7	1.63
Land use change	Perennial/energy crops equal to pasture/hay acreage from 1987	90	10	2.5	9.72
	Perennial/energy crops on 10% of tile-drained land	90	25	6.1	3.18
Point source	Point source reduction to 10 mg nitrate-N/L		14	3.4	1.72
	Point source reduction in N due to biological nutrient removal for P		8	1.8	

Example Statewide Results for P

	Practice/Scenario	Total P reduction per acre (%)	Total P reduced (million lb P)	Total P Reduction % (from baseline)	Cost ($/lb P removed)
	Baseline		37.5		
In-field	Convert 1.8 million acres of conventional till eroding >T to reduced, mulch or no-till	50	1.8	5.0	-16.60
	P rate reduction on fields with soil test P above the recommended maintenance level	7	1.9	5.0	-97.50
	Cover crops on all corn/soybean acres	30	5.7	15.2	109.40
	Cover crops on 1.6 million acres eroding>T currently in reduced, mulch or no-till	50	1.9	5.0	24.50
	Incorporation of all P fertilizers	25	Unknown area	Unknown	
Edge-of-field	Wetlands on 25% of tile-drained land	0	0	0.0	
	Buffers on all applicable crop land	25-50	4.8	12.9	11.97
Land use change	Perennial/energy crops equal to pasture/hay acreage from 1987	90	1.0	2.7	93.59
	Perennial/energy crops on 1.6 million acres>T currently in reduced, mulch or no-till	90	3.5	9.0	40.40
	Perennial/energy crops on 10% of tile-drained land	50	0.3	0.8	250.07
Point source	Point source reduction to 0.5 mg total P/L		11.7	31.2	2.92

University of Illinois Science Team Website

http://biogeochemistry.nres.illinois.edu/Biogeochem_lab/Illinois_Science_Assessment.html

Iowa Costs

Overall Comparison of Nitrate-N Practices

Practice/Scenario	Nitrate-N Reduction % (from baseline)	Cost of N Reduction ($/lb)	Other Benefits (Ecosystem Services)
Reducing nitrogen application rate from background to the MRTN	9	-0.58	
Cover crops (rye) on ALL CS and CC acres	28	5.96	++
Install Wetlands to treat 45% of the ag acres	22	1.38	++
Install Denitrification Bioreactors on all tile drained acres	18	0.92	
Install Buffers on all applicable lands	7	1.91	++
Installing Controlled Drainage on all applicable acres	2	1.29	
Perennial crops (energy crops) on ~6.5 million acres	18	21.46	++

Overall Comparison of Phosphorus Practices

Practice/Scenario	P Reduction % (from baseline)	Cost of P Reduction ($/lb)	Other Benefits (Ecosystem Services)
Cover crops (rye) on ALL CS and CC acres	50	60	++
Convert all tillage to no-till	39	14	++
P rate reduction in MLRA's that have high to very high soil test P	7	-110	
Establish streamside buffers (35ft) on all crop land	18	14	++
Perennial crops (energy crops) equal to pasture/hay acreage from 1987	29	238	++
Pasture and Land Retirement to equal acreage of Pasture/Hay and CRP from 1987	9	120	++