2020 ILLINOIS NUTRIENT LOSS REDUCTION STRATEGY SCENARIOS

December 2020

Abstract

This document drafts agricultural conservation practice scenarios to meet both interim and long-term water quality goals relating to nutrients leaving Illinois to the Mississippi River.

Christianson, Reid David

reiddc@illinois.edu

Contents

Background

The Illinois Nutrient Loss Reduction Strategy (NLRS) was released in July 2015 (IEPA, IDOA, & University of Illinois Extension 2015). The Science Assessment, contained in Chapter 3, present example implementation scenarios that detail combinations of conservation practices, scales of implementation, and the associated level of nutrient load reductions that may be realized when fully implemented. Two of the example implementation scenarios met the 45% reduction goals set for both nitrogen and phosphorus. However, none of them reflected the interim reduction goals of 15% nitrate and 25% total phosphorus. In addition, tracking and reporting on some of the conservation practices as described in the scenarios has proven difficult. The purpose of this document is to provide additional implementation scenario examples that meet the interim nutrient reduction goals as well as provide additional scenario examples that meet the 45% reduction long-term goal, all with conservation practice scales that are more amenable for tracking and reporting.

These additional implementation scenarios were developed by the University of Illinois and funded by the Illinois Environmental Protection Agency through a grant provided by the United States Environmental Protection Agency. The intent is to align implementation scenarios with data available for tracking implementation across the state. Previous scenarios were set up without the knowledge of data availability or how to potentially track progress with available data sources over time (e.g., conservation tillage practices on soil eroding greater than the tolerable level (>T)). Many of these practices are excellent, though direct measurement of these systems would require data not currently available or not consistently collected. There are six scenarios focused on nitrogen, phosphorus, or combined scenarios. The first three meet the interim water quality goals while the last three focus on the 45% long-term reduction goals. An additional three scenarios were developed to highlight the use of potentially new conservation practices that have yet to be assessed as part of the Nutrient Loss Reduction Strategy.

Interim scenarios have undergone a simple cost optimization. Full scenarios required substantial adoption of practices, and cost optimization was not attempted since 100% adoption was largely required for all conservation practices. Further, the scenario development framework has been designed to allow new or updated costs to be incorporated as they are developed, so development of new scenarios to accommodate new information can be easily done in the future.

Point source reductions for phosphorus have been included in all scenarios. Urban stormwater was included as a line-item, though this was not populated, and will likely have little impact on the overall scenario development. Further, each scenario was broken into three distinct land-use categories based on a combination of information available in the NLRS, the Science Assessment produced by David et al. (2014), and available information on practice implementation. The three groups were general agricultural land consisting of corn and soybeans, tile-drained land, and non-tile drained land. The two drainage categories are important to differentiate due to the applicability of certain conservation practices in the tile-drained landscape (e.g., denitrification bioreactors). Further, data sources available to track this information make the distinction. Taking advantage of this information provides more detail and control over scenario development.

The science assessment developed for the NLRS was used to supply the agricultural conservation practice performance values (percent nitrogen or phosphorus reduction) (Table 1) for all scenarios. All nitrogen management practices are assumed to only apply to corn acres. The Policy Working Group has recently adopted a process to update or add conservation practice performance values to the strategy. As part of scenario development, a custom spreadsheet was developed to accommodate practice updates as they become available, so scenarios can be quickly modified using the most current scientific information available. Potential practices to add may include some of the highest funded practices by the US Department of Agriculture's (USDA) Environmental Quality Incentive Program (EQIP). Between 2008 and 2016, this program provided roughly $4.4 million in funding for water and sediment control basins, $3.9 million for grass waterways, $2.9 million for heavy use area protection, $2.8 million for grade stabilization structures, and $2.5 million for terraces across Illinois.

Table 1. Conservation practice performance values. These values were part of the initial NLRS.

Conservation Practice Efficiencies (% Reductions)	Nitrogen Reduction (%)	Phosphorus Reduction (%)	Data Source
Cover Crops (Grass Based) - Tile Drained	30%	30%	State NASS Survey
Cover Crops (Grass Based) - Non-Tile Drained	30%	30%	State NASS Survey
Maximum Return to Nitrogen (MRTN)	10%	0%	State NASS Survey
Soil Test Phosphorus (STP) (rate reduction)	0%	7%	State NASS Survey
Wetlands	50%	0%	Wetland Reserve Easement Program, NRCS EQIP, IL DNR CREP Easements
Bioreactors	25%	0%	USDA NRCS
Nitrogen Management (Fall to spring) - Tile Drained	18%	0%	State NASS Survey
Nitrogen Management (50% in fall & 50% spring pre-plant) - Tile Drained	9%	0%	State NASS Survey
Nitrogen Management (40% in fall; 10% spring pre-plant; 50% sidedress) - Tile Drained	18%	0%	State NASS Survey
Perennial Energy Crops - Generic	90%	70%	Cropland Data Layer
Nitrification Inhibitor - Tile Drained	10%	0%	State NASS Survey
Nitrification Inhibitor - Non-Tile Drained	10%	0%	State NASS Survey
Nitrogen Management (Fall to spring) - Non-Tile Drained	18%	0%	State NASS Survey
Nitrogen Management (50% in fall & 50% spring pre-plant) - Non-Tile Drained	9%	0%	State NASS Survey
Nitrogen Management (40% in fall; 10% spring pre-plant; 50% sidedress) - Non-Tile Drained	18%	0%	State NASS Survey
Conservation Tillage	0%	50%	Tillage Transect Survey
Buffers - Non-Tile Drained	90%	50%	None

The science assessment also developed costs associated with the various conservation practices. These costs included expected life of the practice and typical area treated. Full details can be found in appendix B of the original Nutrient Loss Reduction Strategy (IEPA, IDOA, & University of Illinois Extension, 2015). The approach noted five "issues to consider" when developing costs.

1) Costs represent a change from current practice
2) Initial cost of practice investment (if lasting longer than a year) is amortized over the life of the practice with a discount factor of 6%. A lifespan of 20 years was most common. This is called the equal annualized cost (EAC).
3) A yield change due to implementing a practice was determined using the Illinois Agronomy Handbook as a general guide.
4) If per acre net returns on farmland are $55/ac, additional costs due to conservation practice implementation of even $10/ac would represent a substantial reduction in agricultural returns.
5) Some of the practices would require significant capital investment and may expose farmers to additional risk. Similarly, limiting the time available to do field operations (i.e., all field activities to be done in the spring), may also increase risk.

All of the practices used in the scenarios developed here had additional nuances, as discussed in the original nutrient strategy. The resulting costs are summarized in Table 2. Cost development did not consider the "human capacity" isues with rapid ramp-up of conservation activities. In other words, the cost assume the costs for a given practice without "competition" for design, installation, or other technical skills needed from experts to complete. These costs were briefly reviewed for potential to update. Suggested changes can be found in the Appendix of this document.

Table 2. Conservation practice costs included in the original NLRS (Table B1 page B-8) (IEPA, IDOA, & University of Illinois Extension, 2015).

Practice	Cost ($/ac)	Other economic concerns, as noted in NLRS
Redced tillage	-$17.00	Potential yield reductions
P rate reduction	-$7.50	
Stream buffer	$294.00	Cost is per acre of buffer; negative impacts on farmland
N rates reduced from background to MRTN	-$8.00	
N inhibitor with fall-only fertilizer application	$7.00	
Split N fertilizer application on tile-drained soils (50% fall and 50% spring)	$17.00	
Spring-only N fertilizer application on tile-drained acres	$18.00	Timeliness
Cover crops	$29.00	Planting difficulty; potential impact on yields
Bioreactors	$17.00	Large investment costs; increasing costs with large adoption
Wetlands	$60.63	Large investment costs
Perennial crops	$86.00	Lower forage prices due to large shifts

Scenario Summary

A brief summary of the six basic scenarios is provided here for quick reference. Costs were broken into annual cost and cost savings as well as net annual cost. Cost savings are associated with reduced tillage management, phosphorus rate reductions to lower soil test phosphorus from high to optimum, and using the maximum return to nitrogen (MRTN) application rate. Scenario details are listed in the following sections, including the number of acres and percent adoption of included conservation practices. The area impacted quickly rises above our approximately 22 million acres of rowcrop due to the use of multiple practices on a given acre. For example, reducing nitrogen application rates to the maximum return to nitrogen would likely happen in combination with the addition of cover crops, or applying phosphorus based on the Illinois Agronomy Handbook recommendations for soil test phosphorus levels. These scenarios have also been refined based on stakeholder feedback, which has been summarized in the Appendix of this document.

Table 3. Summary of agricultural conservation practices to meet water quality goals. These estimates assume the point source sector meets goals.

Scenario ID	Scenario	Equal Annualized Cost ($/yr)	Equal Annualized Cost Savings ($/yr)	Net Equal Annualized Cost ($/yr)	Area Impacted (ac)^	Equal Annualized Cost ($/ac/yr)	N Reduction (%) from Agricultural Conservation	P Reduction (%) from Agricultural Conservation	Number of Practices Used
N7	Interim Nitrogen Reduction Goal of 15% from Benchmark	$279,000,000	-$19,000,000	$260,000,000	15,648,124	$16.62	13%	4%	5
P7	Interim Phosphorus Reduction Goal of 25% from Benchmark	$193,000,000	-$95,000,000	$98,000,000	24,833,378	$3.95	7%	13%	4
NP7	Interim Combined Reduction Goal of 15% for N and 25% for P from Benchmark	$280,000,000	-$125,000,000	$155,000,000	35,296,798	$4.39	13%	13%	7
N8	Nitrogen Reduction Goal of 45% from Benchmark	$912,000,000	-$19,000,000	$893,000,000	35,190,344	$25.38	35%	14%	8
P8	Phosphorus Reduction Goal of 45% from Benchmark	$576,000,000	-$107,000,000	$469,000,000	40,923,111	$11.46	22%	23%	4
NP8	Combined Reduction Goal of 45% for N and P from Benchmark	$915,000,000	-$126,000,000	$789,000,000	56,239,371	$14.03	35%	24%	11
EXT1	Example scenario showing the potential to distinguish between tillage types	$33,000,000	-$42,000,000	-$9,000,000	7,784,315	-$1.16	0%	9%	3
EXT2	Example scenario showing the use of saturated buffers	$27,000,000	$0	$27,000,000	2,667,057	$10.12	4%	0%	1
EXT3	Example scenario with land use change from rowcrop to perennials to meet both nitrogen and phosphorus water quality goals	$1,330,000,000	$0	$1,330,000,000	15,467,415	$85.99	51%	23%	1
EXT4	Example scenario showing the use of only nutrient management	$68,000,000	-$118,000,000	-$50,000,000	19,903,022	-$2.51	3%	2%	5
EXT5	Example scenario showing the use of only in-field practices	$692,000,000	-$126,000,000	$566,000,000	49,183,644	$11.51	27%	24%	8

^Practices may be implemented on the same acreage, though no data sources are available for estimating this. There are no estimates developed showing combined impact of practices on the same area.

Methods

The backdrop for all scenarios was historical land use acreages and nitrogen and phosphorus loads. Background information was compiled accordingly and is shown in Table 4 for the benchmark time period of 1997 to 2011. Many of these values were initially included in the original NLRS, though National Agricultural Statistics Service (NASS) survey results, Cropland Data Layer, and Census of Agriculture values were also used. The corn to soybean ratio and the tile-drained to non-tile drained ratio were used to area proportionally distribute information on implementation potential for certain practices, like cover crops, when needed. Distinctions were made between tile drained rowcrop agriculture and non-tile rowcrop agriculture due to data availability. Specifically, the National Agricutlrual Statistics Service survey done for the state askes questions distinguishing between this land management, and some conservation practices (e.g., bioreactors) are only applicable in the tile drained landscape.

Table 4. Background information for the benchmark period. These values were largely reported in the NLRS; however, some extended calculations were added to facilitate proportionally distributing conservation practices. The 1997 to 2011 time period represents the benchmark time period for nutrient load in water, and 2011 is the benchmark period for agricultural managemnet.

Parameter	1997 to 2011
TN Loss (lbs)	536,000,000
Nitrate-N Loss (lbs)	410,000,000
P Loss (lbs)	37,500,000
Point Source TN Loss (lbs)	87,300,000
Point Source Nitrate-N Loss (lbs)	75,200,000
Point Source P Loss (lbs)	18,100,000
Urban TN Loss (lbs)	8,300,000
Urban Nitrate-N Loss (lbs)	6,000,000
Urban P Loss (lbs)	1,500,000
Agricultural TN Loss (lbs)	440,400,000
Agricultural Nitrate-N Loss (lbs)	328,800,000
Agricultural P Loss (lbs)	17,900,000
Corn Area (ac)	12,848,492
Soybean Area (ac)	8,520,101
Small Grains Area (ac)	727,714
Total Rowcrop Ag (ac)	22,096,307
Corn to Soybean Ratio	0.60
Pasture/Hay Area (ac)	4,223,842
Tile-Drained Land (ac)	8,900,026
Tile-Drained to Non-Tile Drained Ratio	0.40
Corn Area Tile-Drained (ac)	5,175,159
Soybean Area Tile-Drained (ac)	3,431,755

As the scenarios developed here are from the view of the 1997 to 2011 benchmark period, the land use areas and ratios along with nitrogen and phosphorus loads from this period were used. Information about conservation practice implementation during the benchmark period was collected from the original NLRS, where available, and from supplemental sources, where needed. For example, the existing cover crop area was not indicated in the NLRS, though through the state NASS survey, we have an estimate of the area using cover crops for 2011.

Maximum potential/practical area available to host specific conservation practices was estimated using a combination of background data and narrative provided in the NLRS as well as the supporting science assessment (David et al., 2014), literature, and the USDA Cropland Data Layer (USDA, 2018). The intent with including maximum potential area was to add a realistic check to scenario development, though through the developed framework, these maximum values can be updated with new information.

Estimating the maximum potential for buffers was based on the equivalency of previous scenarios P1 and P2 (IEPA et al., 2015), which were identical with the exception of buffers being used in scenario P1 and cover crops being used in scenario P2. Making this equivalency for phosphorus (assuming all buffers were on non-tile drained land with a phosphorus loss reduction efficiency for buffers of 50% and 30% for cover crops) resulted in approximately 12.3 million acres being treated by buffers. Buffers were the one practice included that does not have a suitable data source to allow tracking.

Some effort was made to adjust the maximum potential implementable area by reducing to account for competing practices. For example, increasing perennial land requires a land-use change, which was subtracted from applicable corn and soybean acreages. As these adjustments are not necessarily a direct subtraction from a given conservation practice, the initial maximums were divided by the total rowcrop area to develop a ratio. Land-use changes in a given scenario were subtracted from corn or corn and soybean areas, but the practice maximum ratio was maintained. For example, the maximum return to nitrogen (MRTN) practice could be implemented on all corn area, which is roughly 54% of the rowcrop landscape. A change to perennial would be subtracted from ALL rowcrop area with the result multiplied by 54%, which would be the new maximum for the MRTN practice. Nitrogen management practices were treated in the same manner, though all nitrogen management practices were in direct competition with each other, meaning changing from 100% fall applied N to 100% spring applied N is in direct conflict with applying 50% of N in fall and 50% in spring.

The addition of cover crops is a major component in all scenarios due to the relatively high nutrient loss reduction efficiency values for both nitrogen and phosphorus. To date, cover crop adoption across the state has been relatively low, though adoption is accelerating. Historic estimates of cover crop area have included winter wheat, which is technically not defined as a cover crop, as it is a commodity and would factor into the base land use. Since tracking sources for cover crops (the NASS survey), has not split these two apart, no effort was made here to split. As cover crop adoption increases, this discrepancy will become less important, assuming winter wheat acreage stays relatively constant, which it has over the last 5 to 10 years.

Cost optimization included implementing the least expensive practice up to the practical maximum before moving the the next least expensive. End results were rounded and, in one case, adoption percentages were equated (wetlands and bioreactors in scenario N8), as treated area was reduced.

Data Dictionary

Since several parameters were reported in the scenarios, a brief data dictionary was developed to provide additional details surrounding the meaning of each parameter. The column headings for the summary tables and the practice tables are listed here with a short description. Any nuances or assumptions have been ignored, here, for simplicity.

Scenario Summary Tables (e.g., Table 5)

Summary: This column highlights the sector being evaluated. The sectors include point sources, urban stormwater sources, and agricultural sources. Agriculture was further broken into general agriculture, tile-drained agriculture, and non-tile drained agriculture. This separation was made to facilitate the use of available data.

N Reduction (lbs): How many pounds of nitrogen were reduced from the benchmark year of circa 2011.

P Reduction (lbs): How many pounds of phosphorus were reduced from the benchmark year of circa 2011.

State-wide N Reduction (%): Percentage of the total state nitrogen load is being reduced from the benchmark year.

State-wide Agricultural N Reduction (%): Percentage of the total agricultural nitrogen load in the state is being reduced from the benchmark year.

State-wide P Reduction (%): Percentage of the total state phosphorus load is being reduced from the benchmark year.

State-wide Agricultural P Reduction (%): Percentage of the total agricultural phosphorus load in the state is being reduced from the benchmark year.

Area Impacted (ac): number of acres needing new agricultural conservation practices.

Net Equal Annualized Cost (EAC) (per acre): A per-acre cost for each agricultural category (general, tile-drained non-tile drained), as well as overall scenario cost per acre.

Total Net Equal Annualized Cost (nearest $1 million): The total annual cost of the scenario. This includes cost savings as well as costs.

Equal Annualized Cost (EAC) (nearest $1 million): This parameter only adds up the costs and does not include cost savings.

Equal Annualized Cost Savings (EACs) (nearest $1 million): This parameter only adds up the cost savings.

Number of Practices: Number of different conservation practices used in the scenario for a given agricultural category.

Practice Tables (e.g., Table 6)

Practice: The specific agricultural conservation practice being included in the scenario. These have been described more fully in the original NLRS documentation.

Practice N Efficiency (% Reduction): The relative reduction of nitrate-nitrogen due to implementing the practice. These values were developed as part of the science assessment (David et al., 2014) supporting the NLRS.

Practice P Efficiency (% Reduction): The relative reduction of nitrate-nitrogen due to implementing the practice. These values were developed as part of the science assessment (David et al., 2014) supporting the NLRS.

Treated Area Needed (ac): The number of acres where the specific practice is implemented in the scenario. This value is the sum of the "Benchark (~2011) Treated Area (ac)" and the "Increased Treated Area Needed (ac)" columns.

Benchmark (~2011) Treated Area (ac): The number of acres where a practice was implemented during the benchmark period (circa 2011). These data were from the same source as those indicated as a "Tracking Source" or from the original NLRS.

Increased Treated Area Needed (ac): Number of additional acres, beyond 2011 acreage, where the practice would need to be implemented to meet water quality goals in the scenario. This value added to the "Benchmark (~2011) Treated Area (ac)" value equals the "Treated Area Needed (ac)" column. The sum of this column can be larger than the total rowcrop acreage due to potentially multiple conservation practices on a given acre. This is the value that was increased or decreased to meet scenario goals.

Adoption Needed (%): The resulting adoption level for a given practice needed to meet water quality goals of the scenario. This is a calculation where the "Benchmark (~2011) Treated Area (ac)" is added to the "Increased Treated Area Needed (ac)" then divided by the "Treated Area Needed (ac)." The resulting fraction is represented as a percent.

Maximum Implementation (ac): The maximum number of acres that could play host to the specific conservation practice. This value has been determined based on several sources, including the original NLRS. An effort was made to modify these values when practices compete for the same acreage. For example, only one specific nitrogen management practices can be implemented on a given acre, meaning that acre is no longer available for a different management strategy.

State-wide N Reduction (%): The resulting statewide nitrogen impact of the conservation practice given the "Increased Treated Area Needed (ac)" implemented acreage. This is a calculation using a statewide average of the N loss (lbs/ac) from agricultural land times the number of acres of the practice, times the practice efficiency divided by the entire state N load.

State-wide Agricultural N Reduction (%): The resulting statewide nitrogen impact of the conservation pactice given the "Increased Treated Area Needed (ac)" implemented acreage only considering the agricultural sector loads. This is a calculation using a statewide average of the N loss (lbs/ac) from agricultural land times the number of acres of the practice, times the practice efficiency divided by the entire state agricultural N load.

State-wide P Reduction (%): The resulting statewide phosphorus impact of the conservation practice given the “Increased Treated Area Needed (ac)” implemented acreage. This is a calculation using a statewide average of the P loss (lbs/ac) from agricultural land times the number of acres of the practice, times the practice efficiency divided by the entire state P load.

State-wide Agricultural P Reduction (%): The resulting statewide phosphorus impact of the conservation pactice given the “Increased Treated Area Needed (ac)” implemented acreage only considering the agricultural sector loads. This is a calculation using a statewide average of the P loss (lbs/ac) from agricultural land times the number of acres of the practice, times the practice efficiency divided by the entire state agricultural P load.

Tracking Source(s): The data sources available to track implementation of the practice over time. These sources can be used to measure progress towards adoption of the specific conservation practices. See Table 1 for sources.

Scenario Results

Most of the following sections contain two tables and a figure. The first table includes a summary of the scenario with nitrogen and phosphorus reduction in pounds per year and percent. The next contains information about conservation practice implementation to meet the scenario water quality goals. The figure summarizes acreages and provides a visual of the scenario. All nitrogen reduction results presented are for nitrate-nitrogen, as most of the conservation practices assessed focused on nitrate, which makes up over 75% of total nitrogen leaving the state (IEPA et al., 2015).

Interim Goals

N7 - Nitrogen – 15% Reduction; 61.3 million lbs of N

This scenario includes increasing acres being managed at the Maximum Return to Nitrogen (MRTN) application rate to 100% of corn acres, implementation of nitrification inhibitors with fall nitrogen application on all applicable acres, increasing cover crops, and treating tile water with bioreactors.

Table 5. Interim nitrogen loss reduction scenario summary table.

Summary	N Reduction (lbs)^	Statewide N Reduction (%)	Area Impacted (ac)	Net Equal Annualized Cost (EAC) (per acre)	Total Net Equal Annualized Cost (nearest $1 million)	Equal Annualized Cost (EAC) (nearest $1 million)	Equal Annualized Cost Savings (EACs) (nearest $1 million)	Number of Practices
Total	**61,328,845**	**15.0%**	**15,648,124**	**$17**	**$344,000,000**	**$363,000,000**	**-$19,000,000**	
Point Source	8,730,000	2.1%	0		$84,000,000	$84,000,000	$0	
Urban Stormwater	0	0.0%	0	$0	$0	$0	$0	
Agriculture	52,598,845	12.8%	15,648,124	$17	$260,000,000	$279,000,000	-$19,000,000	5
--General Agriculture	3,541,515	0.9%	2,380,000	-$8	-$19,000,000	$0	-$19,000,000	1
--Tile-Drained Agriculture	29,970,479	7.3%	7,503,111	$21	$161,000,000	$161,000,000	$0	2
--Non-Tiled Agriculture	19,086,851	4.7%	5,765,013	$20	$118,000,000	$118,000,000	$0	2

^ Total values leaving the state were estimated from data tables contained in the original Nutrient Loss Reduction Strategy or the supporting Science Assessment

Table 6. Interim nitrogen loss reduction scenario: conservation practices implemented on agricultural land.

Practice	Practice N Efficiency (% Reduction)	Treated Area Needed (ac)	Benchmark (~2011) Treated Area (ac)	Increased Treated Area Needed (ac)	Adoption Needed (%)	Maximum Implementation (ac)**	State-wide N Reduction (%)	State-wide Agricultural N Reduction (%)	Tracking Source(s)
Maximum Return to Nitrogen (MRTN)	10%	11,200,000	8,820,000	2,380,000	100%	11,200,000	0.9%	1.1%	State NASS Survey
Bioreactors	25%	4,736,773	160	4,736,613	100%	4,736,773	4.3%	5.4%	USDA NRCS
Cover Crops (Grass Based) - Tile Drained	30%	2,986,498	220,000	2,766,498	31%	9,707,010	3.0%	3.8%	State NASS Survey
Cover Crops (Grass Based) - Non-Tile Drained	30%	3,910,950	380,000	3,530,950	32%	12,389,297	3.8%	4.8%	State NASS Survey
Nitrification Inhibitor - Non-Tile Drained	10%	3,141,263	907,200	2,234,063	100%	3,141,263	0.8%	1.0%	State NASS Survey
Total				**15,648,124**			**12.8%**	**16.0%**	

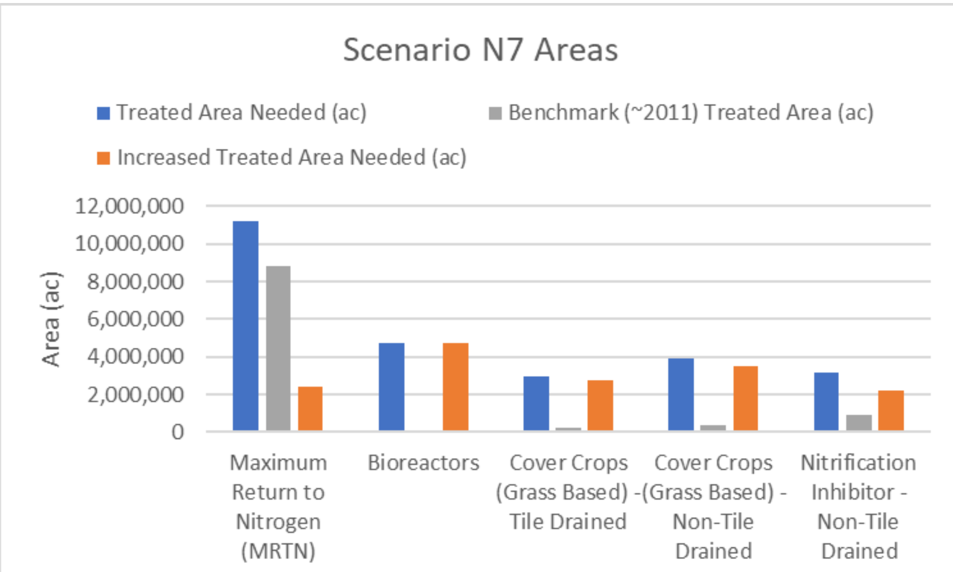

Figure 1. Interim nitrogen loss reduction scenario: treatment area.

P7 - Phosphorus – 25% Reduction; 9.4 million lbs of P

This scenario includes increasing acres being managed with conservation tillage, cover crops, and increased phosphorus management based on soil test information and following the Illinois Agronomy Handbook recommendations for calculating phosphorus application, including limiting application where soil test phosphorus is above optimum. An estimated 59% of fields in ~2008 tested above optimum. Note the "Increased Treated Area Needed (ac)" column sum is larger than the total rowcrop agriculture acreage. This indicates more than one practice per acre.

Table 7. Interim phosphorus loss reduction scenario summary table.

Summary	P Reduction (lbs)^	Statewide P Reduction (%)	Area Impacted (ac)	Net Equal Annualized Cost (EAC) (per acre)	Total Net Equal Annualized Cost (nearest $1 million)	Equal Annualized Cost (EAC) (nearest $1 million)	Equal Annualized Cost Savings (EACs) (nearest $1 million)	Number of Practices
Total	**9,366,063**	**25.0%**	**24,833,378**	**$4**	**$189,000,000**	**$284,000,000**	**-$95,000,000**	
Point Source	4,525,000	12.1%	0		$91,000,000	$91,000,000	$0	
Urban Stormwater	0	0.0%	0	$0	$0	$0	$0	
Agriculture	4,841,063	12.9%	24,833,378	$4	$98,000,000	$193,000,000	-$95,000,000	4
--General Agriculture	3,221,566	8.6%	18,169,523	-$5	-$95,000,000	$0	-$95,000,000	2
--Tile-Drained Agriculture	714,736	1.9%	2,940,973	$29	$85,000,000	$85,000,000	$0	1
--Non-Tiled Agriculture	904,761	2.4%	3,722,882	$29	$108,000,000	$108,000,000	$0	1
^ Total values leaving the state were estimated from data tables contained in the original Nutrient Loss Reduction Strategy or the supporting Science Assessment								

Table 8. Interim phosphorus loss reduction scenario: conservation practices implemented on agricultural land.

Practice	Practice P Efficiency (% Reduction)	Treated Area Needed (ac)	Benchmark (~2011) Treated Area (ac)	Increased Treated Area Needed (ac)	Adoption Needed (%)	Maximum Implementation (ac)**	State-wide P Reduction (%)	State-wide Agricultural P Reduction (%)	Tracking Source(s)
Soil Test Phosphorus (STP) (rate reduction)	7%	20,720,575	8,841,595	11,878,980	94%	22,096,307	1.8%	3.8%	State NASS Survey
Conservation Tillage	50%	20,602,535	14,311,992	6,290,543	93%	22,096,307	6.8%	14.2%	Tillage Transect Survey
Cover Crops (Grass Based) - Tile Drained	30%	3,160,973	220,000	2,940,973	33%	9,707,010	1.9%	4.0%	State NASS Survey
Cover Crops (Grass Based) - Non-Tile Drained	30%	4,102,882	380,000	3,722,882	33%	12,389,297	2.4%	5.1%	State NASS Survey
Total				**24,833,378**			**12.9%**	**27.0%**	

ILLINOIS Crop Sciences COLLEGE OF AGRICULTURAL, CONSUMER & ENVIRONMENTAL SCIENCES

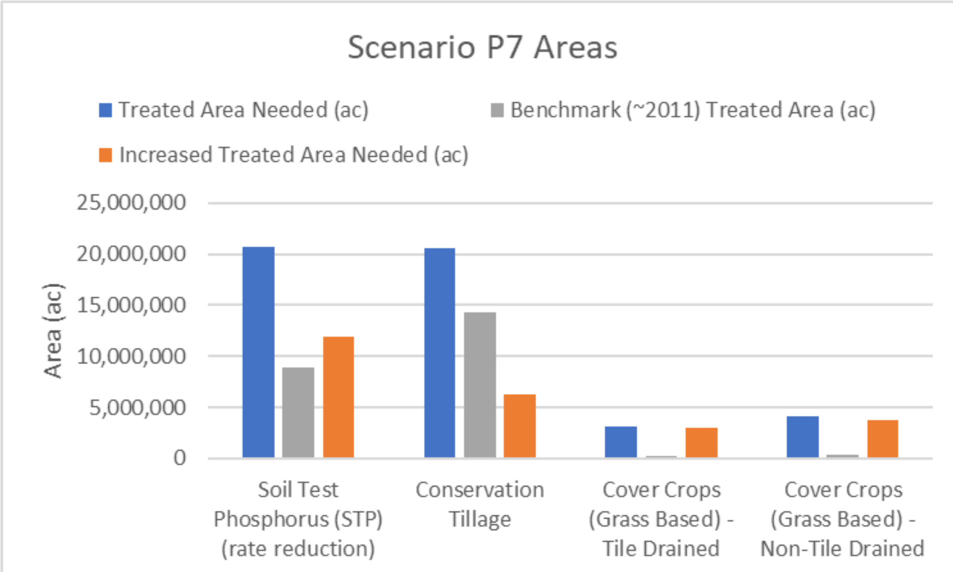

Figure 2. Interim phosphorus loss reduction scenario: treatment area.

NP7 - Combined Reduction Nitrogen (15%; 61.5 million lbs) and Phosphorus (25%; 9.4 million lbs)

This scenario includes increasing acres being managed at the Maximum Return to Nitrogen (MRTN) rate to 100% of corn acres, increasing nitrification inhibitors with all fall applied nitrogen, increasing cover crops, and treating tile water with bioreactors. This scenario also includes increasing acres being managed with conservation tillage and increased phosphorus management based on soil test information, as in scenario P7. As with the previous scenario, the increased treated area above rowcrop area indicates more than one practice per acre.

Table 9. Interim combined reduction scenario summary table.

Summary	N Reduction (lbs)^	P Reduction (lbs)^	Statewide N Reduction (%)	Statewide P Reduction (%)	Area Impacted (ac)	Net Equal Annualized Cost (EAC) (per acre)	Total Net Equal Annualized Cost (nearest $1 million)	Equal Annualized Cost (EAC) (nearest $1 million)	Equal Annualized Cost Savings (EACs) (nearest $1 million)	Number of Practices
Total	**61,525,097**	**9,389,796**	**15.0%**	**25.0%**	**35,296,798**	**$4**	**$246,000,000**	**$371,000,000**	**-$125,000,000**	
Point Source	8,730,000	4,525,000	2.1%	12.1%	0		$91,000,000	$91,000,000	$0	
Urban Stormwater	0	0	0.0%	0.0%	0	$0	$0	$0	$0	
Agriculture	52,795,097	4,864,796	12.9%	13.0%	35,296,798	$4	$155,000,000	$280,000,000	-$125,000,000	7
--General Agriculture	3,541,515	3,323,662	0.9%	8.9%	21,984,712	-$6	-$125,000,000	$0	-$125,000,000	3
--Tile-Drained Agriculture	30,114,087	680,152	7.3%	1.8%	7,535,280	$21	$162,000,000	$162,000,000	$0	2
--Non-Tiled Agriculture	19,139,495	860,982	4.7%	2.3%	5,776,806	$20	$118,000,000	$118,000,000	$0	2
^ Total values leaving the state were estimated from data tables contained in the original Nutrient Loss Reduction Strategy or the supporting Science Assessment										

Table 10. Interim combined reduction scenario: conservation practices implemented on agricultural land.

Practice	Practice N Efficiency (% Reduction)	Practice P Efficiency (% Reduction)	Treated Area Needed (ac)	Benchmark (~2011) Treated Area (ac)	Increased Treated Area Needed (ac)	Adoption Needed (%)	Maximum Implementation (ac)**	State-wide N Reduction (%)	State-wide Agricultural N Reduction (%)	State-wide P Reduction (%)	State-wide Agricultural P Reduction (%)	Tracking Source(s)
Maximum Return to Nitrogen (MRTN)	10%	0%	11,200,000	8,820,000	2,380,000	100%	11,200,000	0.9%	1.1%	0.0%	0.0%	State NASS Survey
Soil Test Phosphorus (STP) (rate reduction)	0%	7%	22,096,307	8,841,595	13,254,712	100%	22,096,307	0.0%	0.0%	2.0%	4.2%	State NASS Survey
Conservation Tillage	0%	50%	20,661,992	14,311,992	6,350,000	94%	22,096,307	0.0%	0.0%	6.9%	14.4%	Tillage Transect Survey
Bioreactors	25%	0%	4,736,772	160	4,736,612	100%	4,736,773	4.3%	5.4%	0.0%	0.0%	USDA NRCS
Cover Crops (Grass Based) - Tile Drained	30%	30%	3,018,668	220,000	2,798,668	31%	9,707,010	3.0%	3.8%	1.8%	3.8%	State NASS Survey
Cover Crops (Grass Based) - Non-Tile Drained	30%	30%	3,922,743	380,000	3,542,743	32%	12,389,297	3.9%	4.8%	2.3%	4.8%	State NASS Survey
Nitrification Inhibitor - Non-Tile Drained	10%	0%	3,141,263	907,200	2,234,063	100%	3,141,263	0.8%	1.0%	0.0%	0.0%	State NASS Survey
Total					**35,296,798**			**12.9%**	**16.1%**	**13.0%**	**27.2%**	

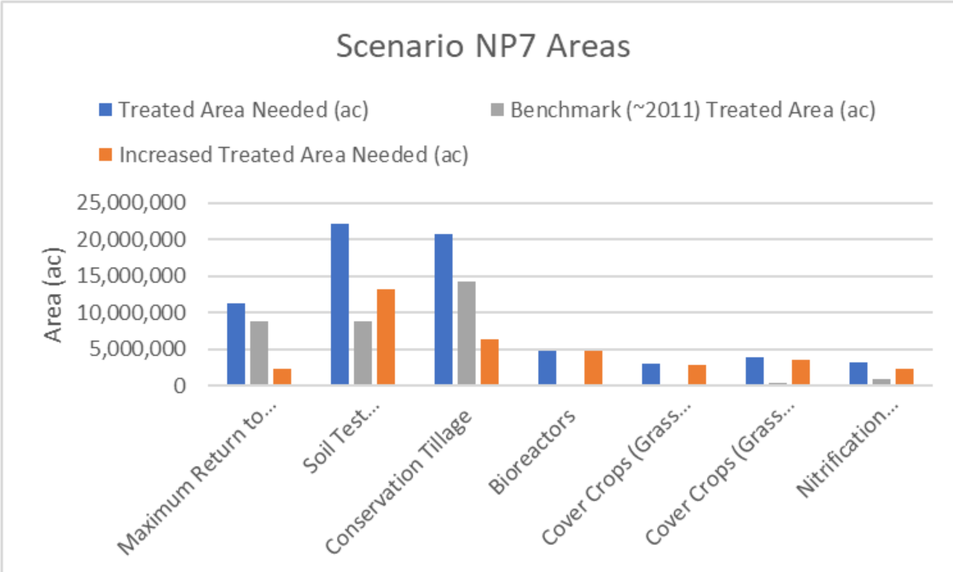

Figure 3. Interim combined nitrogen and phosphorus loss reduction scenario: treatment area.

Full Goals

N8 - Nitrogen – 44.9% Reduction; 184.2 million lbs of N

This scenario, basically, maxed out MRTN, split N application on tile and non-tile drained land, nitrification inhibitors with all fall applied N, cover crops, bioreactors, and wetlands. As with previous scenarios, the increased treated area above rowcrop area indicates more than one practice per acre.

Table 11. Full nitrogen reduction scenario summary table.

Summary	N Reduction (lbs)^	Statewide N Reduction (%)	Area Impacted (ac)	Net Equal Annualized Cost (EAC) (per acre)	Total Net Equal Annualized Cost (nearest $1 million)	Equal Annualized Cost (EAC) (nearest $1 million)	Equal Annualized Cost Savings (EACs) (nearest $1 million)	Number of Practices
Total	**184,180,237**	**44.9%**	**35,190,344**	**$25**	**$1,077,000,000**	**$1,096,000,000**	**-$19,000,000**	
Point Source	39,285,000	9.6%	0		$184,000,000	$184,000,000	$0	
Urban Stormwater	0	0.0%	0	$0	$0	$0	$0	
Agriculture	144,895,237	35.3%	35,190,344	$25	$893,000,000	$912,000,000	-$19,000,000	8
--General Agriculture	3,541,515	0.9%	2,380,000	-$8	-$19,000,000	$0	-$19,000,000	1
--Tile-Drained Agriculture	79,384,845	19.4%	17,390,317	$29	$510,000,000	$510,000,000	$0	4
--Non-Tiled Agriculture	61,968,878	15.1%	15,420,027	$26	$402,000,000	$402,000,000	$0	3

^ Total values leaving the state were estimated from data tables contained in the original Nutrient Loss Reduction Strategy or the supporting Science Assessment

ILLINOIS Crop Sciences COLLEGE OF AGRICULTURAL, CONSUMER & ENVIRONMENTAL SCIENCES

Table 12. Full nitrogen reduction scenario: conservation practices implemented on agricultural land.

Practice	Practice N Efficiency (% Reduction)	Treated Area Needed (ac)	Benchmark (~2011) Treated Area (ac)	Increased Treated Area Needed (ac)	Adoption Needed (%)	Maximum Implementation (ac)**	State-wide N Reduction (%)	State-wide Agricultural N Reduction (%)	Tracking Source(s)
Maximum Return to Nitrogen (MRTN)	10%	11,200,000	8,820,000	2,380,000	100%	11,200,000	0.9%	1.1%	State NASS Survey
Bioreactors	25%	4,736,773	160	4,736,613	100%	4,736,773	4.3%	5.4%	USDA NRCS
Wetlands	50%	2,368,386	59,271	2,309,115	100%	2,368,386	4.2%	5.2%	Wetland Reserve
Cover Crops (Grass Based) - Tile Drained	30%	9,707,010	220,000	9,487,010	100%	9,707,010	10.3%	12.9%	State NASS Survey
Nitrogen Management (40% in fall; 10% spring pre-plant; 50% sidedress) - Tile Drained	18%	2,587,580	1,730,000	857,580	100%	2,587,580	0.5%	0.7%	State NASS Survey
Cover Crops (Grass Based) - Non-Tile Drained	30%	12,389,297	380,000	12,009,297	100%	12,389,297	13.1%	16.3%	State NASS Survey
Nitrification Inhibitor - Non-Tile Drained	10%	1,376,264	907,200	469,064	100%	1,376,264	0.2%	0.2%	State NASS Survey
Nitrogen Management (40% in fall; 10% spring pre-plant; 50% sidedress) - Non-Tile Drained	18%	3,836,666	895,000	2,941,666	100%	3,836,666	1.9%	2.3%	State NASS Survey
Total				**35,190,344**			**35.3%**	**44.1%**	

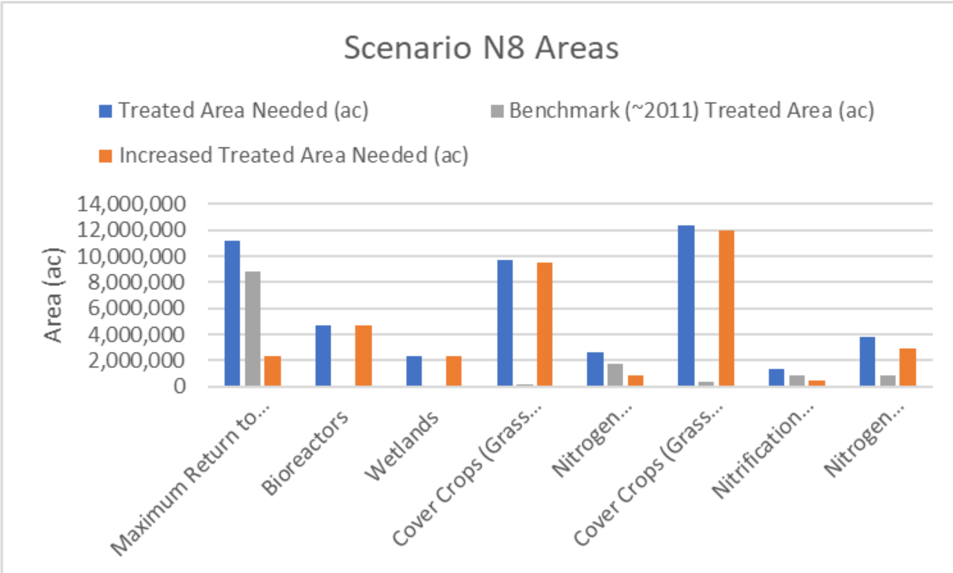

Figure 4. Full nitrogen loss reduction scenario: treatment area.

P8 - Phosphorus – 45% Reduction; 16.9 million lbs of P

This scenario included maxing out conservation tillage, phosphorus management based on soil test phosphorus (as described in scenario P7) and increasing cover crops. As with previous scenarios, the increased treated area above rowcrop area indicates more than one practice per acre.

Table 13. Full phosphorus reduction scenario summary table.

Summary	P Reduction (lbs)^	Statewide P Reduction (%)	Area Impacted (ac)	Net Equal Annualized Cost (EAC) (per acre)	Total Net Equal Annualized Cost (nearest $1 million)	Equal Annualized Cost (EAC) (nearest $1 million)	Equal Annualized Cost Savings (EACs) (nearest $1 million)	Number of Practices
Total	**16,881,994**	**45.0%**	**40,923,111**	**$11**	**$609,000,000**	**$716,000,000**	**-$107,000,000**	
Point Source	8,145,000	21.7%	0		$140,000,000	$140,000,000	$0	
Urban Stormwater	0	0.0%	0	$0	$0	$0	$0	
Agriculture	8,736,994	23.3%	40,923,111	$11	$469,000,000	$576,000,000	-$107,000,000	4
--General Agriculture	3,904,624	10.4%	21,039,027	-$5	-$107,000,000	$0	-$107,000,000	2
--Tile-Drained Agriculture	2,132,680	5.7%	8,775,484	$29	$254,000,000	$254,000,000	$0	1
--Non-Tiled Agriculture	2,699,690	7.2%	11,108,600	$29	$322,000,000	$322,000,000	$0	1

^ Total values leaving the state were estimated from data tables contained in the original Nutrient Loss Reduction Strategy or the supporting Science Assessment

Table 14. Full phosphorus reduction scenario: conservation practices implemented on agricultural land.

Practice	Practice P Efficiency (% Reduction)	Treated Area Needed (ac)	Benchmark (~2011) Treated Area (ac)	Increased Treated Area Needed (ac)	Adoption Needed (%)	Maximum Implementation (ac)**	State-wide P Reduction (%)	State-wide Agricultural P Reduction (%)	Tracking Source(s)
Soil Test Phosphorus (STP) (rate reduction)	7%	22,096,307	8,841,595	13,254,712	100%	22,096,307	2.0%	4.2%	State NASS Survey
Conservation Tillage	50%	22,096,307	14,311,992	7,784,315	100%	22,096,307	8.4%	17.6%	Tillage Transect Survey
Cover Crops (Grass Based) - Tile Drained	30%	8,995,484	220,000	8,775,484	93%	9,707,010	5.7%	11.9%	State NASS Survey
Cover Crops (Grass Based) - Non-Tile Drained	30%	11,488,600	380,000	11,108,600	93%	12,389,297	7.2%	15.1%	State NASS Survey
Total				**40,923,111**			**23.3%**	**48.8%**	

ILLINOIS Crop Sciences
COLLEGE OF AGRICULTURAL, CONSUMER & ENVIRONMENTAL SCIENCES

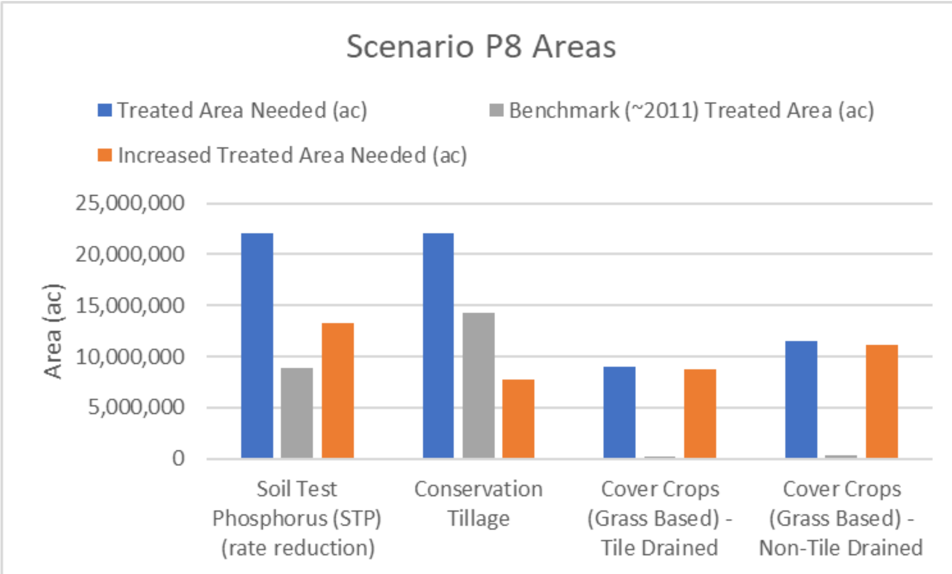

Figure 5. Full phosphorus loss reduction scenario: treatment area.

NP8 - Combined Reduction Nitrogen (45%; 184.3 million lbs) and Phosphorus (46%; 17.3 million lbs)

This scenario, maxes out MRTN, phosphorus management based on soil test phosphorus (as described in scenario P7), conservation tillage, cover crops, split nitrogen application on tile-drained land, nitrification inhibitors on fall applied N on tile-drained land, bioreactors, and wetlands. Also, an increase in land treated with buffers was needed to close the nutrient loss reduction gap. As with previous scenarios, the increased treated area above rowcrop area indicates more than one practice per acre.

Table 15. Full combined reduction scenario summary table.

Summary	N Reduction (lbs)^	P Reduction (lbs)^	Statewide N Reduction (%)	Statewide P Reduction (%)	Area Impacted (ac)	Net Equal Annualized Cost (EAC) (per acre)	Total Net Equal Annualized Cost (nearest $1 million)	Equal Annualized Cost (EAC) (nearest $1 million)	Equal Annualized Cost Savings (EACs) (nearest $1 million)	Number of Practices
Total	**184,314,160**	**17,277,858**	**45.0%**	**46.1%**	**56,239,371**	**$14**	**$1,030,000,000**	**$1,156,000,000**	**-$126,000,000**	
Point Source	39,285,000	8,145,000	9.6%	21.7%	0		$241,000,000	$241,000,000	$0	
Urban Stormwater	0	0	0.0%	0.0%	0	$0	$0	$0	$0	
Agriculture	145,029,160	9,132,858	35.4%	24.4%	56,239,371	$14	$789,000,000	$915,000,000	-$126,000,000	11
--General Agriculture	3,541,515	3,904,624	0.9%	10.4%	23,419,027	-$5	-$126,000,000	$0	-$126,000,000	3
--Tile-Drained Agriculture	79,384,845	2,305,600	19.4%	6.1%	17,390,317	$29	$510,000,000	$510,000,000	$0	4
--Non-Tiled Agriculture	62,102,800	2,922,634	15.1%	7.8%	15,430,027	$26	$405,000,000	$405,000,000	$0	4
^ Total values leaving the state were estimated from data tables contained in the original Nutrient Loss Reduction Strategy or the supporting Science Assessment										

Table 16. Full combined reduction scenario: conservation practices implemented on agricultural land.

Practice	Practice N Efficiency (% Reduction)	Practice P Efficiency (% Reduction)	Treated Area Needed (ac)	Benchmark (~2011) Treated Area (ac)	Increased Treated Area Needed (ac)	Adoption Needed (%)	Maximum Implementation (ac)**	State-wide N Reduction (%)	State-wide Agricultural N Reduction (%)	State-wide P Reduction (%)	State-wide Agricultural P Reduction (%)	Tracking Source(s)
Maximum Return to Nitrogen (MRTN)	10%	0%	11,200,000	8,820,000	2,380,000	100%	11,200,000	0.9%	1.1%	0.0%	0.0%	State NASS Survey
Soil Test Phosphorus (STP) (rate reduction)	0%	7%	22,096,307	8,841,595	13,254,712	100%	22,096,307	0.0%	0.0%	2.0%	4.2%	State NASS Survey
Conservation Tillage	0%	50%	22,096,307	14,311,992	7,784,315	100%	22,096,307	0.0%	0.0%	8.4%	17.6%	Tillage Transect Survey
Bioreactors	25%	0%	4,736,773	160	4,736,613	100%	4,736,773	4.3%	5.4%	0.0%	0.0%	USDA NRCS
Wetlands	50%	0%	2,368,386	59,271	2,309,115	100%	2,368,386	4.2%	5.2%	0.0%	0.0%	Wetland Reserve
Cover Crops (Grass Based) - Tile Drained	30%	30%	9,707,010	220,000	9,487,010	100%	9,707,010	10.3%	12.9%	6.1%	12.9%	State NASS Survey
Nitrogen Management (40% in fall; 10% spring pre-plant; 50% sidedress) - Tile Drained	18%	0%	2,587,580	1,730,000	857,580	100%	2,587,580	0.5%	0.7%	0.0%	0.0%	State NASS Survey
Cover Crops (Grass Based) - Non-Tile Drained	30%	30%	12,389,297	380,000	12,009,297	100%	12,389,297	13.1%	16.3%	7.8%	16.3%	State NASS Survey
Nitrification Inhibitor - Non-Tile Drained	10%	0%	1,376,264	907,200	469,064	100%	1,376,264	0.2%	0.2%	0.0%	0.0%	State NASS Survey
Nitrogen Management (40% in fall; 10% spring pre-plant; 50% sidedress) - Non-Tile Drained	18%	0%	3,836,666	895,000	2,941,666	100%	3,836,666	1.9%	2.3%	0.0%	0.0%	State NASS Survey
Buffers - Non-Tile Drained	90%	50%	4,436,988	4,426,988	10,000	36%	12,297,189	0.0%	0.0%	0.0%	0.0%	None
Total					**56,239,371**			**35.4%**	**44.1%**	**24.4%**	**51.0%**	

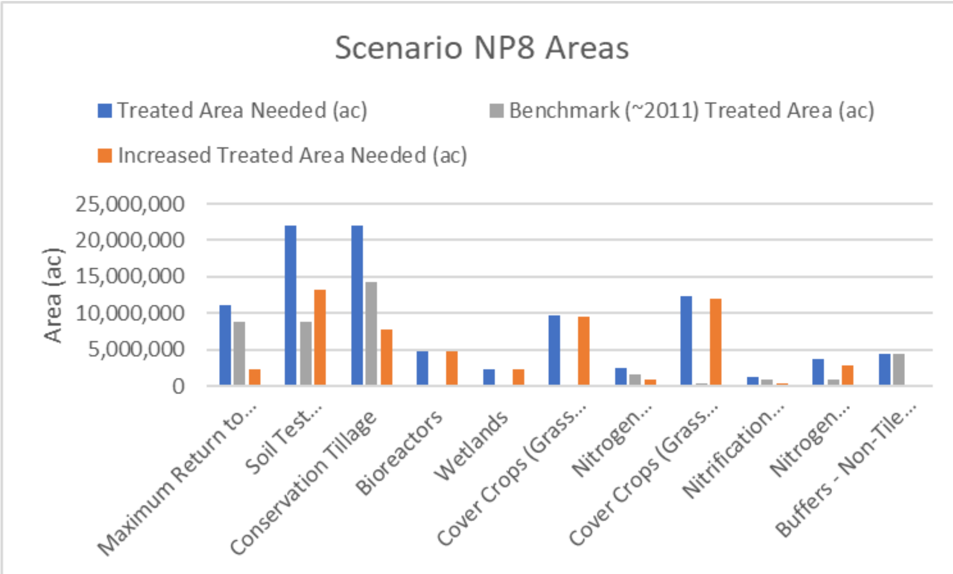

Figure 6. Full combined nitrogen and phosphorus loss reduction scenario: treatment area.

Extended Goals

The following scenarios are intended to provide information on nitrogen and phosphorus loss reduction using practices that may not have been included in the initial Nutrient Loss Reduction Strategy or practices without a data source to use for tracking purposes. As some of these practices have not been officially vetted by the Science Team, they have been included here to provide a “what if” type discussion point. The point source reductions were maintained at 45% for consistency with the full scenarios.

EXT1 - Detailed Tillage Categories (point sources excluded)

The phosphorus loss reduction efficiency of conservation tillage practices were lumped together in the Nutrient Loss Reduction Strategy; however, data are available to track the implementation of no-till, mulch till, and reduced tillage as unique tillage management practices. Taking advantage of this information, along with estimated sediment (and assumed associated phosphorus) reduction provided by the Illinois Department of Agriculture (IDOA) Tillage Transect Survey (Illinois Department of Agriculture, 2019), allows refinement of the tillage assessment across the state. Tillage phosphorus loss reduction efficiency was estimated here by reviewing IDOA erosion reduction estimates using the Revised Universal Soil Loss Equation across the state and taking the first quartile (or reduction value where just 25% of estimates are lower). Resulting phosphorus loss reduction estimates for no-till, mulch till, and reduced till were 70%, 60%, and 30%, respectively. Using the conservation tillage increase from scenario P8 of 7,784,315 acres proportionally distributed across no-till, mulch till, and reduced till based on 2011 tillage levels, state wide phosphorus loss reduction would increase from 8.4% of the state load to 9.1% of the state load, which is the scenario shown here. A point of interest, converting all 7.78 million acres of conservation tillage from scenario P8 to no-till would increase phosphorus loss reduction from 8.4% to 11.8% of the state load. Tillage categories specified by the IDOA (Legacy, 2020) include:

1) Conventional tillage with reside between 0 and 15%
2) Reduced tillage with residue between 16 and 30%
3) Mulch tillage with residue greater than 30%
4) No-till with residue greater than 30%

Table 17. Detailed tillage reduction scenario summary table.

Summary	P Reduction (lbs)^	Statewide P Reduction (%)	Area Impacted (ac)	Net Equal Annualized Cost (EAC) (per acre)	Total Net Equal Annualized Cost (nearest $1 million)	Equal Annualized Cost (EAC) (nearest $1 million)	Equal Annualized Cost Savings (EACs) (nearest $1 million)	Number of Practices
Total	**3,408,207**	**9.1%**	**7,784,315**	**-$1**	**-$9,000,000**	**$33,000,000**	**-$42,000,000**	
Point Source	0	0.0%	0		$0	$0	$0	
Urban Stormwater	0	0.0%	0	$0	$0	$0	$0	
Agriculture	3,408,207	9.1%	7,784,315	-$1	-$9,000,000	$33,000,000	-$42,000,000	3
--General Agriculture	3,408,207	9.1%	7,784,315	-$1	-$9,000,000	$33,000,000	-$42,000,000	3
--Tile-Drained Agriculture	0	0.0%	0	$0	$0	$0	$0	0
--Non-Tiled Agriculture	0	0.0%	0	$0	$0	$0	$0	0

^ Total values leaving the state were estimated from data tables contained in the original Nutrient Loss Reduction Strategy or the supporting Science Assessment

Table 18. Detailed tillage reduction scenario: conservation practices implemented on agricultural land.

Practice	Practice P Efficiency (% Reduction)	Treated Area Needed (ac)	Benchmark (~2011) Treated Area (ac)	Increased Treated Area Needed (ac)	Adoption Needed (%)	Maximum Implementation (ac)**	State-wide P Reduction (%)	State-wide Agricultural P Reduction (%)	Tracking Source(s)
No-Till	70%	7,984,147	5,171,409	2,812,738	47%	17,124,730	4.3%	8.9%	Tillage Transect Survey
Mulch Till	60%	7,066,189	4,576,839	2,489,350	42%	16,801,342	3.2%	6.8%	Tillage Transect Survey
Reduced Till	30%	7,045,971	4,563,744	2,482,227	42%	16,794,220	1.6%	3.4%	Tillage Transect Survey
Total				**7,784,315**			**9.1%**	**19.0%**	

EXT2 - Maximum Adoption of Saturated Buffers (point sources excluded)

Saturated buffers are a relatively new practice and have not been included in the NLRS yet. The potential to be implemented in Illinois has been estimated by Chandrasoma et al (2019) at over 2.5 million acres treated. With current designs of saturated buffers and bioreactors, these two practices could be indirect competition in the tile drained landscape. Nitrogen loss reduction effectiveness of saturated buffers, based on work in Iowa, is around 44% (Jaynes & Isenhart, 2018) and Iowa has adopted this practice into their strategy at a nitrate-nitrogen loss reduction of 50%. Point sources were set to zero to illustrate this one practice only.

Table 19. Full adoption of saturated buffers reduction scenario summary table.

Summary	N Reduction (lbs)^	Statewide N Reduction (%)	Area Impacted (ac)	Net Equal Annualized Cost (EAC) (per acre)	Total Net Equal Annualized Cost (nearest $1 million)	Equal Annualized Cost (EAC) (nearest $1 million)	Equal Annualized Cost Savings (EACs) (nearest $1 million)	Number of Practices
Total	**17,462,125**	**4.3%**	**2,667,057**	**$10**	**$27,000,000**	**$27,000,000**	**$0**	
Point Source	0	0.0%	0		$0	$0	$0	
Urban Stormwater	0	0.0%	0	$0	$0	$0	$0	
Agriculture	17,462,125	4.3%	2,667,057	$10	$27,000,000	$27,000,000	$0	1
--General Agriculture	0	0.0%	0	$0	$0	$0	$0	0
--Tile-Drained Agriculture	17,462,125	4.3%	2,667,057	$10	$27,000,000	$27,000,000	$0	1
--Non-Tiled Agriculture	0	0.0%	0	$0	$0	$0	$0	0
^ Total values leaving the state were estimated from data tables contained in the original Nutrient Loss Reduction Strategy or the supporting Science Assessment								

Table 20. Full adoption of saturated buffers reduction scenario: conservation practices implemented on agricultural land.

Practice	Practice N Efficiency (% Reduction)	Treated Area Needed (ac)	Benchmark (~2011) Treated Area (ac)	Increased Treated Area Needed (ac)	Adoption Needed (%)	Maximum Implementation (ac)**	State-wide N Reduction (%)	State-wide Agricultural N Reduction (%)	Tracking Source(s)
Saturated Buffers	44%	2,667,057	0	2,667,057	100%	2,667,057	4.3%	5.3%	USDA NRCS
Total				**2,667,057**			**4.3%**	**5.3%**	

ILLINOIS Crop Sciences COLLEGE OF AGRICULTURAL, CONSUMER & ENVIRONMENTAL SCIENCES

EXT3 - Conversion to Perennial

Though not a realistic scenario, shifting approximately 70% of rowcrop agriculture to a perennial system (along with point source reductions of 45% for both N and P) would reduce state wide N and P losses to 60% and 45%, respectively, when implemented with full point source reductions. Costs associated with this practice are not valid, as initial NLRS assumptions were based on a market for forage material, which a 70% shift would not facilitate.

Table 21. Conversion of approximately 70% of rowcrop to perennial reduction scenario summary table.

Summary	N Reduction (lbs)^	P Reduction (lbs)^	Statewide N Reduction (%)	Statewide P Reduction (%)	Area Impacted (ac)	Net Equal Annualized Cost (EAC) (per acre)	Total Net Equal Annualized Cost (nearest $1 million)	Equal Annualized Cost (EAC) (nearest $1 million)	Equal Annualized Cost Savings (EACs) (nearest $1 million)	Number of Practices
Total	**246,429,000**	**16,916,000**	**60.1%**	**45.1%**	**15,467,415**	**$86**	**$1,571,000,000**	**$1,571,000,000**	**$0**	
Point Source	39,285,000	8,145,000	9.6%	21.7%	0		$241,000,000	$241,000,000	$0	
Urban Stormwater	0	0	0.0%	0.0%	0	$0	$0	$0	$0	
Agriculture	207,144,000	8,771,000	50.5%	23.4%	15,467,415	$86	$1,330,000,000	$1,330,000,000	$0	1
--General Agriculture	207,144,000	8,771,000	50.5%	23.4%	15,467,415	$86	$1,330,000,000	$1,330,000,000	$0	1
--Tile-Drained Agriculture	0	0	0.0%	0.0%	0	$0	$0	$0	$0	0
--Non-Tiled Agriculture	0	0	0.0%	0.0%	0	$0	$0	$0	$0	0
^ Total values leaving the state were estimated from data tables contained in the original Nutrient Loss Reduction Strategy or the supporting Science Assessment										

Table 22. Conversion of approximately 70% of rowcrop to perennial reduction scenario: conservation practices implemented on agricultural land.

Practice	Practice N Efficiency (% Reduction)	Practice P Efficiency (% Reduction)	Treated Area Needed (ac)	Benchmark (~2011) Treated Area (ac)	Increased Treated Area Needed (ac)	Adoption Needed (%)	Maximum Implementation (ac)**	State-wide N Reduction (%)	State-wide Agricultural N Reduction (%)	State-wide P Reduction (%)	State-wide Agricultural P Reduction (%)	Tracking Source(s)
Perennial Energy Crops - Generic	90%	70%	19,691,257	4,223,842	15,467,415	370%	5,323,842	50.5%	63.0%	23.4%	49.0%	Cropland Data Layer
Total					**15,467,415**			**50.5%**	**63.0%**	**23.4%**	**49.0%**	

EXT4 – Nutrient Management Only (point sources excluded)

If only nutrient management practices were fully adopted, there could be a statewide N loss reduction of 3.4% and a P loss reduction of 2.0%.

Table 23. Full adoption of nutrient management practices scenario summary table.

Summary	N Reduction (lbs)^	P Reduction (lbs)^	Statewide N Reduction (%)	Statewide P Reduction (%)	Area Impacted (ac)	Net Equal Annualized Cost (EAC) (per acre)	Total Net Equal Annualized Cost (nearest $1 million)	Equal Annualized Cost (EAC) (nearest $1 million)	Equal Annualized Cost Savings (EACs) (nearest $1 million)	Number of Practices
Total	**14,132,942**	**751,626**	**3.4%**	**2.0%**	**19,903,022**	**-$3**	**-$50,000,000**	**$68,000,000**	**-$118,000,000**	
Point Source	0	0	0.0%	0.0%	0		$0	$0	$0	
Urban Stormwater	0	0	0.0%	0.0%	0	$0	$0	$0	$0	
Agriculture	14,132,942	751,626	3.4%	2.0%	19,903,022	-$3	-$50,000,000	$68,000,000	-$118,000,000	5
--General Agriculture	3,541,515	751,626	0.9%	2.0%	15,634,712	-$8	-$118,000,000	$0	-$118,000,000	2
--Tile-Drained Agriculture	2,233,185	0	0.5%	0.0%	857,580	$17	$15,000,000	$15,000,000	$0	1
--Non-Tiled Agriculture	8,358,242	0	2.0%	0.0%	3,410,730	$16	$53,000,000	$53,000,000	$0	2
^ Total values leaving the state were estimated from data tables contained in the original Nutrient Loss Reduction Strategy or the supporting Science Assessment										

Table 24. Full adoption of nutrient management practices reduction scenario: conservation practices implemented on agricultural land.

Practice	Practice N Efficiency (% Reduction)	Practice P Efficiency (% Reduction)	Treated Area Needed (ac)	Benchmark (~2011) Treated Area (ac)	Increased Treated Area Needed (ac)	Adoption Needed (%)	Maximum Implementation (ac)**	State-wide N Reduction (%)	State-wide Agricultural N Reduction (%)	State-wide P Reduction (%)	State-wide Agricultural P Reduction (%)	Tracking Source(s)
Maximum Return to Nitrogen (MRTN)	10%	0%	11,200,000	8,820,000	2,380,000	100%	11,200,000	0.9%	1.1%	0.0%	0.0%	State NASS Survey
Soil Test Phosphorus (STP) (rate reduction)	0%	7%	22,096,307	8,841,595	13,254,712	100%	22,096,307	0.0%	0.0%	2.0%	4.2%	State NASS Survey
Nitrogen Management (40% in fall; 10% spring pre-plant; 50% sidedress) - Tile Drained	18%	0%	2,587,580	1,730,000	857,580	100%	2,587,580	0.5%	0.7%	0.0%	0.0%	State NASS Survey
Nitrification Inhibitor - Non-Tile Drained	10%	0%	1,376,264	907,200	469,064	100%	1,376,264	0.2%	0.2%	0.0%	0.0%	State NASS Survey
Nitrogen Management (40% in fall; 10% spring pre-plant; 50% sidedress) - Non-Tile Drained	18%	0%	3,836,666	895,000	2,941,666	100%	3,836,666	1.9%	2.3%	0.0%	0.0%	State NASS Survey
Total					**19,903,022**			**3.4%**	**4.3%**	**2.0%**	**4.2%**	

EXT5 – In-field Practices Only (point sources excluded)

If only in-field management practices were fully adopted, there could be a statewide N loss reduction of 26.9% and a P loss reduction of 24.3%.

Table 25. Full adoption of in-field management practices scenario summary table.

Summary	N Reduction (lbs)^	P Reduction (lbs)^	Statewide N Reduction (%)	Statewide P Reduction (%)	Area Impacted (ac)	Net Equal Annualized Cost (EAC) (per acre)	Total Net Equal Annualized Cost (nearest $1 million)	Equal Annualized Cost (EAC) (nearest $1 million)	Equal Annualized Cost Savings (EACs) (nearest $1 million)	Number of Practices
Total	**110,094,485**	**9,128,808**	**26.9%**	**24.3%**	**49,183,644**	**$12**	**$566,000,000**	**$692,000,000**	**-$126,000,000**	
Point Source	0	0	0.0%	0.0%	0		$0	$0	$0	
Urban Stormwater	0	0	0.0%	0.0%	0	$0	$0	$0	$0	
Agriculture	110,094,485	9,128,808	26.9%	24.3%	49,183,644	$12	$566,000,000	$692,000,000	-$126,000,000	8
--General Agriculture	3,541,515	3,904,624	0.9%	10.4%	23,419,027	-$5	-$126,000,000	$0	-$126,000,000	3
--Tile-Drained Agriculture	44,584,091	2,305,600	10.9%	6.1%	10,344,589	$28	$290,000,000	$290,000,000	$0	2
--Non-Tiled Agriculture	61,968,879	2,918,584	15.1%	7.8%	15,420,027	$26	$402,000,000	$402,000,000	$0	3

^ Total values leaving the state were estimated from data tables contained in the original Nutrient Loss Reduction Strategy or the supporting Science Assessment

Table 26. Full adoption of in-field management practices reduction scenario: conservation practices implemented on agricultural land.

Practice	Practice N Efficiency (% Reduction)	Practice P Efficiency (% Reduction)	Treated Area Needed (ac)	Benchmark (~2011) Treated Area (ac)	Increased Treated Area Needed (ac)	Adoption Needed (%)	Maximum Implementation (ac)**	State-wide N Reduction (%)	State-wide Agricultural N Reduction (%)	State-wide P Reduction (%)	State-wide Agricultural P Reduction (%)	Tracking Source(s)
Maximum Return to Nitrogen (MRTN)	10%	0%	11,200,000	8,820,000	2,380,000	100%	11,200,000	0.9%	1.1%	0.0%	0.0%	State NASS Survey
Soil Test Phosphorus (STP) (rate reduction)	0%	7%	22,096,307	8,841,595	13,254,712	100%	22,096,307	0.0%	0.0%	2.0%	4.2%	State NASS Survey
Conservation Tillage	0%	50%	22,096,307	14,311,992	7,784,315	100%	22,096,307	0.0%	0.0%	8.4%	17.6%	Tillage Transect Survey
Cover Crops (Grass Based) - Tile Drained	30%	30%	9,707,010	220,000	9,487,010	100%	9,707,010	10.3%	12.9%	6.1%	12.9%	State NASS Survey
Nitrogen Management (40% in fall; 10% spring pre-plant; 50% sidedress) - Tile Drained	18%	0%	2,587,580	1,730,000	857,580	100%	2,587,580	0.5%	0.7%	0.0%	0.0%	State NASS Survey
Cover Crops (Grass Based) - Non-Tile Drained	30%	30%	12,389,297	380,000	12,009,297	100%	12,389,297	13.1%	16.3%	7.8%	16.3%	State NASS Survey
Nitrification Inhibitor - Non-Tile Drained	10%	0%	1,376,264	907,200	469,064	100%	1,376,264	0.2%	0.2%	0.0%	0.0%	State NASS Survey
Nitrogen Management (40% in fall; 10% spring pre-plant; 50% sidedress) - Non-Tile Drained	18%	0%	3,836,666	895,000	2,941,666	100%	3,836,666	1.9%	2.3%	0.0%	0.0%	State NASS Survey
Total					**49,183,644**			**26.9%**	**33.5%**	**24.3%**	**51.0%**	

ILLINOIS Crop Sciences
COLLEGE OF AGRICULTURAL, CONSUMER & ENVIRONMENTAL SCIENCES

Conclusion

This type of planning is important to orient all stakeholders and provide some general guidance on the direction conservation efforts could/should be going for purposes of water quality. These scenarios are for information only – they are not prescriptive. All agricultural conservation activities are voluntary, so the numbers here represent hypothetical avenues to meet water quality goals. It is apparent with all scenarios that substantial effort is required to meet our nitrogen and phosphorus reduction goals. The primary benefit of having these scenarios published is to allow for conservation practice tracking to be correlated with associated metrics of accomplishment so that an accurate story can be told. Finally, since buffers are a part of scenarios P8 and NP8, developing a mechanism to track implementation over time would be a helpful addition to tracking efforts.

References

Chandrasoma, J. M., Christianson, R. D., & Christianson, L. E. (2019). Saturated buffers: What is their potential impact across the US Midwest? *Agricultural & Environmental Letters, 4*(1), 1-4.

David, M., McIsaac, G., Schnitkey, G., Czapar, G., & Mitchell, C. (2014). *Science Assessment to Support an Illinois Nutrient Loss Reduction Strategy.* Retrieved from

IDALS, IDNR, & ISU. (2016). *Iowa Nutrient Reduction Strategy A Science and Technology-based Framework to Assess and Reduce Nutrients to Iowa Waters and the Gulf of Mexico*. Retrieved from Ames, IA: http://www.nutrientstrategy.iastate.edu/sites/default/files/documents/INRSfull-161001.pdf

IEPA, IDOA, & University of Illinois Extension (2015). *Illinois Nutrient Loss Reduction Strategy*. Retrieved from Springfield, IL: https://www2.illinois.gov/epa/Documents/iepa/water-quality/watershed-management/nlrs/nlrs-final-revised-093115.pdf

Illinois Department of Agriculture. (2019). Illinois Soil Conservation Transect Survey Reports. Retrieved from https://www2.illinois.gov/sites/agr/Resources/LandWater/Pages/Illinois-Soil-Conservation-Transect-Survey-Reports.aspx

Jaynes, D. B., & Isenhart, T. M. (2018). Performance of Saturated Riparian Buffers in Iowa, USA. *Journal of Environmental Quality*. doi:10.2134/jeq2018.03.0115

Legacy, E. (2020). [Soil Transect Survey--tillage types].

Liu, X., Zhang, X., & Zhang, M. (2008). Major factors influencing the efficacy of vegetated buffers on sediment trapping: A review and analysis. *Journal of Environmental Quality, 37*(5), 1667-1674.

Messer et al. (Under Review). Effectiveness of Wetlands on Water Pollutant Reduction from Agricultural Areas. In.

MPCA. (2014). *The Minnesota nutrient reduction strategy*. Retrieved from St. Paul, MN: https://www.pca.state.mn.us/sites/default/files/wq-s1-80.pdf

Myers, R., Weber, A., & Tellatin, S. (2019). Cover Crop Economics: Opportunities to Improve Your Bottom Line in Row Crops. In S. A. R. Education (Ed.): Sustainable Agriculture Research & Education.

Plastina. (2017). Economic Evaluation of Cover Crops in Midwest Row Crop Farming. Retrieved from https://projects.sare.org/project-reports/lnc15-375/

USDA. (2018). CropScape - NASS CDL Program. Retrieved from http://nassgeodata.gmu.edu/CropScape/

Appendix: Stakeholder Comments and Responses

Public Comments on scenario development for inclusion in the Illinois Nutrient Loss Reduction Strategy

The following comments are related to a presentation by Dr. Reid Christianson at the October 20, 2020 Agriculture Water Quality Partnership Forum (AWQPF) and the associated draft report provided to stakeholders. Responses are **bolded** below.

Comments have been very generally summarized here:

Comment Synopsis

- Revisit practical maximums for cover crops
- Add discussion about other states scenario development to the biennial report (for comparison).
    - This should include discussion on watershed specific implementation plans.
- Make methods more transparent through discussion in the scenario report and by providing the spreadsheet.
- Add discussion in the scenario report about interactions of multiple conservation practices on the same acre (i.e., are they synergistic?). Note that there is a large gap in literature on this front.
- Add one extended scenario with only nutrient management and one with only in-field practices.
- Add information on tillage categories.

Group 1

The May 16, 2011 USEPA Memorandum entitled "Working in Partnership with States to Address Phosphorus and Nitrogen Pollution through Use of a Framework for State Nutrient Reductions", Nancy K. Stoner, Acting Assistant Administrator. The framework included eight elements for a state framework, which included setting goals for watersheds based on monitoring information, reducing loadings through non-regulatory reduction measures, and tracking additional BMP implementation. Perhaps the vision of setting statewide scenarios is inappropriate, and efforts should remain at the watershed level.

- **There is no doubt that each farm is different and the suite of conservation activities suitable for each farm will differ substantially. Further, the development of watershed specific implementation plans could serve as a much more refined and prescriptive approach to meeting water quality goals. One of the major hurdles is the development or adoption of an appropriate method to create NLRS specific watershed plans. For example, Minnesota has 12-didgit specific watershed plans built into their new modeling framework, which was a substantial undertaking. An approach like this in Illinois would take a dedicated effort.**

If we choose to continue to develop scenarios to cover the entire state, please see some of our suggestions for improving the end result, as well as the process for developing the same:

- It is important to continue to describe these scenarios as informational, and not prescriptive. This should be expanded in the "reporting challenges" section of the future reports. As such, the multiple uncertainties in any scenario should be clearly explained.
    - **Any developed scenarios act as a metric for general tracking and comparing what we are doing on the ground to a hypothetical set of conservation practices to meet water quality goals. Uncertainties surrounding scenarios includes costs and changes in costs over time, and if market conditions change due to conservation practice implementation, agriculture in general and if production systems stay the same or change over time, and nuances in conservation practice performance.**
- We do believe there may be a lot of value in comparing our work on scenario development with other states' work.
    - **This is a very good idea. As we heard at the Nutrient Loss Reduction Strategy Partnership Workshop, other states have also developed scenarios, though Illinois is adaptively managing by developing additional scenarios to align with available data sources to track conservation practice implementation.**
- Efforts should be made to disseminate clear methods descriptions that are replicable. Providing such information ahead of asking for comments on the scenarios would allow for more valuable insight on the part of the commenters, including IFB. Specifically, we would be interested in reviewing how the methods have improved among the updates to the scenarios and the caveats with the cost assumptions. This should also state justification for why the specific scenario development includes the levels of implementation of each of the practices (i.e., optimized, chosen based on practicality, etc.).
    - **Thank you for this insight. The plan is to provide the scenario development spreadsheet on the IEPA website, which would facilitate replicability.**
    - **The levels of implementation were controlled by the maximum practical acreage and a rudimentary cost optimization. Costs from the original NLRS were used, though these costs are under preliminary review now.**
- Attempts should be made to generate more realistic practice maximum acres. In the alternative, explanatory text should be included stating limitations. For example, the report should identify which practices are mutually exclusive; an explanation of the assumed cumulative (as opposed to synergistic or antagonistic) relationship of practices; and the overlap of acreage estimates should be explained. Specifically, many infield practices will most likely not be cumulative or synergistic with woodchip bioreactors or saturated buffers. With that hypothesis, priorities in the scenarios need to be decided. This could be made by optimizing acreage or cost. In other words, instead of plugging in "scenarios," one could allow the data to tell us the best exploratory way forward.
    - **Thank you for suggesting more realistic practical maximums be developed. Another group thought the maximum listed for cover crops was now obsolete due to advanced management cover crops. With this in mind, the maximum for cover crops has been changed to corn and soybean acreage.**
    - **Thank you for highlighting potential conflict between conservation practices. The interaction of practices is also a huge gap in literature, with impact (cumulative or multiplicative or other) largely unknown.**
    - **These scenarios were developed to reduce costs, while allowing available data to guide the types of practices included.**

Group 2

We were asked to evaluate the practice feasibility, number of suggested acres and need for additional scenarios. We are happy to provide this input and we feel that we are well-positioned to understand the challenges and opportunities presented by the revised scenarios. Our primary concern is the lack of transparency in terms of the sources of data used and calculations made to generate new scenario assumptions and recommendations. Were agronomists and economists consulted in the generation of assumptions and calculations in the revised scenarios?

- **Thank you for these comments. The scenario development spreadsheet will be made available online once changes based on comments have been integrated. These scenarios were developed using previously generated nutrient loss reduction efficiencies and costs for conservation practices. All available details surrounding the development of these efficiencies and costs were included in the original NLRS documentation. With this in mind, no, neither agronomists nor economists were explicitly consulted during the development of these draft scenarios. Assumptions beyond efficiency and cost were based on literature, available data, or professional judgment, which has been noted in the spreadsheet.**
    - **We have developed a process to update performance of practices, but we have not had submissions yet (see: https://www2.illinois.gov/epa/topics/water-quality/watershed-management/excess-nutrients/Documents/NLRS%20Practice%20Approval%20Process_Final%20201812.pdf).**

Another concern is the general inaccessibility and infeasibility of bioreactor construction and maintenance relative to their effectiveness for addressing nitrate loading to water leaving tile drainage systems. The number of acres that are expected to be treated by bioreactors in Scenarios N7, NP7, N8 and NP8 is unrealistic both logistically and economically, even if NRCS or other state agency reappropriated conservation dollars from proven and effective in-field practices to support construction of bioreactors. Based on current adoption and available practices, we do not think it is feasible for Illinois to increase the acres covered by bioreactors from 160 in 2011 to more than 4.7 million acres by 2025. If one bioreactor can treat 50 acres, more than 94,000 bioreactors are needed across the state.

- **Thank you for highlighting the difficult of implementing this level of bioreactors. I realize this is an example, as the same infeasibility could be applied to many of the conservation practices listed. This illustrates the scale of implementation needed to meet water quality goals. The goals cannot be met without heavily relying on edge-of-field practices, conversion to perennial/energy crops, or a combination.**
    - **We added two extended scenarios that focus on nutrient management alone (EXT4) and in-field practices alone (EXT5). These two scenarios highlight the need to include edge-of-field practices or conversion to perennial/energy crops to meet water quality goals.**

Despite the argument that scenarios only represent a “starting point” or “maximum potential” for these practices, we argue that it is obvious that some practices are more feasible and more beneficial to farmers and the environment than others. We encourage the committee to prioritize those practices that are more beneficial over less beneficial practices. Less beneficial practices include the following:

- practices that address a single resource concern (only nitrate or phosphorus loss)
- practices that lack convincing long-term datasets demonstrating effectiveness for water quality improvement in Illinois
- practices that do not have a full, rigorous, and long-term economic analysis
- edge-of-field practices – because they do not address nutrient use efficiency or other critically important natural resource concerns (e.g. soil carbon sequestration, erosion, and climate change)

We encourage the Steering Committee to explore other scenarios that look at additional practices including double crop soybean and wheat rotations, more cover crops, drainage water management and other in-field practices.

- **These are great comments, and the sentiment has been well received. There are only a few practices we can track that provide both nitrogen and phosphorus reductions, which are cover crops, land use change to perennials, and the implementation of buffers. The land use change and buffer practices are very expensive on a per-acre basis, and we have limited sources of information available to track buffer implementation. Unfortunately, implementation of in-field practices, alone, will not get us to the water quality goals on the books. To this end, two scenarios have been included to evaluate implementation on nutrient management alone (EXT4), and nutrient management with tillage and cover crops (in-field practices) (EXT5).**
- **As research is done on conservation practices and enhanced nutrient management/precision application, these practices should be submitted to the NLRS team for evaluation and inclusion as a recognized water quality practice in Illinois (https://www2.illinois.gov/epa/topics/water-quality/watershed-management/excess-nutrients/Documents/NLRS%20Practice%20Approval%20Process_Final%20201812.pdf).**

Group 3

We offer the following comments to strengthen scenario development:

- Science should lead the NLRS strategy, and any part of its development. The process for adding new practices, and updating information on current practices, should be more inclusive, not limited to only reviewing new practices every 2 years. While holding peer-reviewed data as a gold standard, we recognize there is a wealth of knowledge on ag/nutrient loss research that may operate outside of peer-reviewed journals, like USDA/CIG-funded research. Practices, such as saturated buffers, that are relevant to N and P reduction and are already included in farm bill conservation programs should be automatically included in the NLRS strategy or prioritized for immediate inclusion. Failure to include them compromises the effectiveness of the NLRS to reach water quality goals and undercounts efforts by farmers.
    - **Though the description about submitting new practices may have indicated these could only be submitted every 2 years, the intent of having a cut-off date was**

simply so discussion surrounding the addition could be presented in the biennial reporting of the NLRS. With this in mind, submissions could occur at any time but official "release" would only happen every 2 years. We will clarify this in the submission instructions as part of the 2021 biennial report release.
    - **Yes, there are substantial amounts of great information in grey literature. This information can be included in submissions, and the science team will evaluate the strength of the work.**
    - **The two limitations surrounding inclusion of ALL NRCS practices in the strategy or scenario development is that we have to have a data source to track implementation, AND we have to have estimates for nutrient reduction on record. Without both of these items, inclusion would result in zero impact (on paper), due to incomplete information. The structure of reporting does undercount efforts by farmers (likely by a large measure), which is why continuing to strengthen data sources is essential.**
- None of the scenarios address in-stream phosphorus loss, a major source of non-point P. Practices to address this (e.g., stonetoe protection, riffles, peakstone) should be assessed. More broadly, this may point to the need for more practices in general to be included as possible solutions especially in-stream and edge of field practices to treat tile drainage water and address in-stream erosion. Given the scale of the issue, all solutions will be needed.
    - **We agree with the sentiment of this comment! Not including in-stream processes, contributions, and mitigation practices is a gap in the NLRS. Unfortunately, this is a gap in other state nutrient strategies as well. The inclusion of these practices would provide additional, and potentially powerful, tools to account for nutrient reduction efforts. Substantial future research is needed to fill this gap.**
- For transparency, the Nutrient Reductions table (pg.2) should include citations for estimated removal efficiencies, including any changes in estimated efficiencies since publication of the 2015 NLRS Science Assessment. In particular, the nitrate removal efficiency for buffers on tile- drained land (90%) is greatly overestimated for these scenarios. Tile drains bypass conventional buffers and deliver nitrates directly to streams without treatment.
    - **Thank you for noting this. In the original documentation, the science team noted the short-circuiting of buffers in the tile-drained landscape, and also noted the difficulty in estimating water actually interacting with the buffer root zone (which would still have 90% of the nitrate reduced). With this in mind, buffers on tile-drained land were not included in the scenarios presented on October 20th, 2020. Further, due to this comment, "buffers on tile-drained land" were removed from the table in question.**
- Practical Maximum Acres for scenario development.
    - Practical cover crop acres should be all row crop acres. During the AWQPF meeting October 20, 2020, Kladivko's 2014 paper is cited for the reason cover crops are only practical on ~50% of acres (saying only grass-based covers before beans is practical). Since 2014, the understanding of the practice has greatly increased, including expertise of advisors/farmers in IL. Given the relatively low cost and many co-

benefits farmers can see from the use of cover crops, we should not limit their use in the scenarios.

    - **Thank you for this comment! This practical maximum was changed to all corn and soybean acreages.**

  - EXT3-Conversion to Perennial: Please consider realistic land use change scenarios. Specifically, perennial vegetation and/or land retirement on HEL and floodplains could avoid loss or capture a lot of nutrients, and possibly at reasonable cost since the profitability of those soils is often marginal. While not a wholesale 70% land use change, a realistic acreage could be developed and then inserted into other scenarios.
    - **This would be a nice addition to other scenarios. The spreadsheet used to develop these scenarios will be provided online, which would allow a user to enter their own acres for various conservation practices and run their own scenario.**

- Tracking practices: Satellite imagery technology for tracking structural conservation practices is increasing rapidly, to capture structural practices beyond those funded by federal/state cost-share programs. For example, in the last five years, TNC and IL Corn Growers have worked collaboratively with CropGrower, LLC to track buffers (& cover crops) in IL.
  - **Continued improvement of data available to track conservation practices is essential. One of the primary needs for these datasets is longevity so these data could be used for seeing where we were, where we are, and where we are in 20 or 30 years. With this in mind, any tool providing this type of persistence would be welcomed.**
- Capacity of IL, economic prioritization. The scenarios use “Equal Annualized Cost.” We understand the value of comparing costs of various conservation practices on an equal basis, but it would be valuable for the reader to understand the baseline assumptions that are used to develop “Equal Annualized Cost”. Practice Lifespan, estimated annual operations and maintenance, interest rates, etc. can all have a significant impact on these costs. Please provide a footnote and the assumptions that are used to develop each of the individual practice cost figures. If the scenarios are to be used for agencies & public funding discussions, all costs should include the human capacity as well, not just the cost of materials. This will give an honest assessment of which practices are more feasible given IL’s capacity constraints.
  - **This is a great comment, and the human capacity piece was not explicitly included during the development of the original NLRS. A table with costs and source has been included in the scenario development report. Adding this type of analysis was outside the specific scope of this work.**
- Climate Change. As noted in the 2019 NLRS biennial assessment, for the 2013-2017 period, water leaving the state increased by 13% over the 1980-1996 baseline. Climate models show the Midwest region will likely experience increased precipitation in the winter and spring, with the total amount coming in shorter, more intense rain events. We suggest the NLRS committee be more intentional in its consideration of potential climate changes for the development of all nutrient loss reduction scenarios, including incorporating research on practice performance associated with short, high-flow events, and evaluating how

practices may work synergistically to mitigate nutrient losses under future climate scenarios.

  - **We recognize that the future of our climate is uncertain, but the science is not available to assess how this may impact our conservation efforts at the moment. We are unsure how this impacts our scenarios. It would likely increase acreage needed for conservation. Ultimately, this type of future research is needed but is outside the scope of this scenario development project.**

Group 4

- The following recommendations are geared toward increased transparency to provide clarity to the document and can be incorporated in the short-term:

A. Expand on methodology to fully disclose calculations and assumptions used, specifically regarding

a. Baseline loading estimates (i.e. are lbs./ac representative of a statewide average, regional or HUC 8 scale, tile vs non-tile drained area, other?)

- **These were statewide estimates based on the original NLRS. The estimates were extended to allow partitioning to corn, soybean, and tile and non-tile drained land, though the lbs/ac estimates did not change. This will be clear with notes included in the scenario development spreadsheet, which will be posted online.**

b. Determination of maximum implementation acres (i.e. Cover crops are reported as applicable on 12,649,944 acres, how was this calculated?)

- **This was an extrapolation from work done in Indiana. That said, this condition was removed due to your comment along with comments from others.**

c. Inclusion of any additional reviews and/or data consulted since prior scenario development

- **New data primarily came in the form of data sources being used to track implementation of conservation for the NLRS biennial report. These include the state NASS survey, NRCS data for the Environmental Quality Incentive Program and the Conservation stewardship program, and the Illinois Department of Agriculture's Tillage Transect Survey. These were not available or not heavily used during development of the NLRS.**

B. Revise instances in N7 and NP7 where the description of the scenario does not match the corresponding table, specifically regarding wetland implementation.

a. Thank you for catching this! This has been fixed.

C. Further clarify/define nuances between tillage categories. The detailed tillage categories discussion is appreciated but given the difficulty in deciphering between tillage types and associated environmental impacts, we suggest including a definition for conservation tillage in the Data Dictionary. The IDOA and SWCD Tillage Transect categories utilize the NRCS definition of conservation tillage systems (mulch till, ridge till, no till) as maintaining 30% or more residue before planting. Similarly, reduced tillage is defined as 15-30% residue, and conventional tillage is any practice that leaves less than 15% residue.

   a. **Thank you for the suggestion. The Illinois Department of Agriculture (IDOA) Tillage Transect Survey does not explicitly state the tillage type and residue level equivalencies in their reports, though we have reached out to IDOA and have received this response:**
      - **Tillage Choices:**
         - **Conventional (Residue code = 1)**
         - **Reduced tillage (Residue code = 2)**
         - **Mulch-till (Residue code = 3, 4, or 5)**
         - **No-till (Residue code = 3, 4, or 5)**
      - **Residue Choices:**
         - **1 - 0-15%**
         - **2 - 16-30%**
         - **3 - 31-50%**
         - **4 - 51-75%**
         - **5 - 76-100%**

Appendix: Suggested Cost Estimate Updates

As information surrounding agricultural conservation practices increases, supporting information can be updated. In this short report, costs for the Maximum Return to Nitrogen (MRTN), tillage management, cover crop implementation, wetlands, and stream buffers were considered. Estimation methods are described below.

Maximum Return to Nitrogen

The maximum return to nitrogen (MRTN) is a function of nitrogen price, corn grain price, and yield reposne due to nitrogen application rates. The intent with using the MRTN is to reduce application rates from background. The original strategy estimated nitrogen application rates across the various Major Land Resource Areas (MLRAs). These data have need to be updated, as there is not a current estimate of nitrogen application rates across the state. Since these data are in need of updating, an application rate of 200 lb N/ac was used as the starting rate to estimate cost reductions associated with implementing the MRTN. The costs developed for the original strategy estimated an eight dollar cost savings by lowering the nitrogen application rate. Re-assessing cost was done using the Corn Nitrogen Rate Calculator (http://cnrc.agron.iastate.edu/). Three regions of the state were defined (North, Central, and South). Resulting cost savings in net return to N at the MRTN was compared to the net return at 200 lb N/ac (Table A- 1).

Table A- 1. Cost estimates for reducing nitrogen application rates from 200 lb N/acre to MRTN in three regions of Illinois.

Item	North Region	Central Region	South Region
MRTN Rate (lb N/acre):	169	180	195
Net Return to N at MRTN Rate ($/acre):	$267.44	$348.90	$320.67
Net return at 200 lb N/acre	$263.68	$346.64	$320.43
Cost Savings by using MRTN (assuming a N application rate of 200 lb N/ac)	-$3.76	-$2.26	-$0.24
Average	-$2.09		

Tillage Management

Tillage cost estimates were broken into three separate groups, and compared to full inversion (moldboard plow) management. The Iowa State University Ag Decision Maker (https://www.extension.iastate.edu/agdm/crops/pdf/a1-20.pdf) was used to develop most of these costs. For costs not included in the report, the "No_a1-20croprotation.xlsx" spreadsheet was modified to include full tillage and no-till (https://www.extension.iastate.edu/agdm/crops/xls/a1-20croprotation.xlsx). These costs assume the work is custom hired. The cost savings (Table A- 2) listed for Conservation Tillage is an average of no-till, mulch till, and reduced till, as that is how tillage is represented in the Illinois strategy now.

Table A- 2. Tillage management costs from the Iowa State University Ag Decision Maker suite of tools.

Tillage Practice	Cost Savings ($/acre)
Conservation Tillage	-$24.00
No-Till	-$29.45
Mulch Till	-$27.34
Reduced Till	-$15.15

Cover Crops

The costs for cover crops can be evaluated different ways. Estimates here are from literature, and include only estimates for one year of implementation. This effort does not account for any long-term positive impacts cover crops may have on soil health and resulting increases in yield. The sources used in Table A- 3include (IDALS, IDNR, & ISU, 2016; IEPA et al., 2015; MPCA, 2014; Myers, Weber, & Tellatin, 2019; Plastina, 2017). The resulting $36/acre is slightly higher than originally estimated at $29/acre.

Table A- 3. Cost estimates for cover crop implementation.

Cover Crop Costs		
Source	**Before**	**Costs (1 year; $/acre)**
Meyers et al., 2019	Corn	$31.17
Meyers et al., 2019	Soybean	$23.48
Illinois NLRS	CS Rotation	$29.03
Minnesota NRS	CS Rotation	$53.04
Iowa NRS	CS Rotation	$44.94
Iowa NRS	CS Rotation	$48.99
Plastina, 2017 (https://projects.sare.org/project-reports/lnc15-375/)	CS Rotation	$42.92
Plastina, 2017 (https://projects.sare.org/project-reports/lnc15-375/)	Soybean	$2.95
Plastina, 2017 (https://projects.sare.org/project-reports/lnc15-375/)	Corn	$46.09
		$35.85

Wetlands

A pending review article by Messer et al. (Under Review) estimated a 15 year cost of $162/ha treated/year. This value was transformed by extending the life to 20 years and converting into $/acre. The resulting cost was $53/acre treated/year, which is slightly lower than originally used in the Illinois strategy of $60.63/acre treated/year.

Stream Buffers

The original costs for stream buffers was based on the cost per acre of the buffer itself. This was opposed to other practices, where the cost per acre treated was developed. Using a paper by Liu et al.

(2008), a drainage area to buffer area ratio of 20:1 was applied to stream buffer estimates in Illinois. If this assumption is applied to the original cost of $294/buffer acre/year, the result would be $14.70/treated acre/year.

Summary

These cost estimates are summarized in Table A- 4.

Table A- 4. Cost estimates based on selected review.

Practice	Suggested Cost ($/ac treated)
Maximum Return to Nitrogen (MRTN)	-$2.09
Cover Crops (Grass Based)	$35.85
Wetlands	$53.00
No-Till	-$29.45
Mulch Till	-$27.34
Conservation Tillage	-$24.00
Reduced Till	-$15.15
Buffers	$14.70