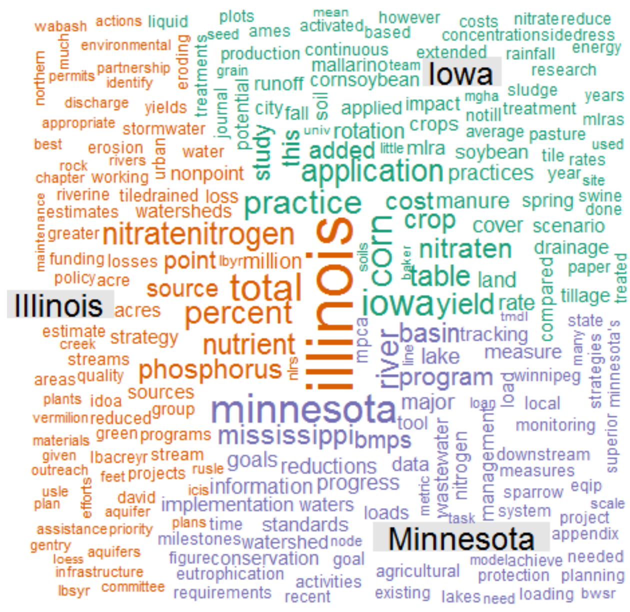
UPPER MISSISSIPPI NUTRIENT (LOSS) REDUCTION STRATEGIES

Illinois, Iowa, and Minnesota

Abstract

This work was funded by the Walton Family Foundation and is intended to highlight similarities between nutrient reduction or nutrient loss reduction strategies for Illinois, Iowa, and Minnesota. In addition, gaps in knowledge as well as focus areas for future research are suggested. As expected, there is substantial overlap in the strategies developed by each state. Ultimately, some general consensus on effectiveness of agricultural best management practices is desired for purposes of funding focus.

Visual Abstract – Words Dominated by each State



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Upper Mississippi Nutrient (loss) Reduction Strategies

1 Purpose

This work is intended to highlight similarities between agricultural nutrient reduction or nutrient loss reduction strategies associated with nutrient reduction goals for the Gulf of Mexico for Iowa, Minnesota, and Illinois. These strategies are in response to EPA's Gulf Hypoxia Action Plan which calls for the 12 states within the Mississippi River basin to produce a plan to reduce nutrients to the Gulf of Mexico by 45%. The three states included here have spent considerable time and effort and enlisted help from scientist and professionals in developing state-specific plans to reduce nutrients leaving their states. While these plans have to account for statewide differences in local climate and agricultural practices, the underlying assumptions and methods used to develop BMP efficiencies should align to ensure their cumulative effectiveness will meet the Gulf Hypoxia Reduction Goal. Further, establishing a consistent Best Management Practice (BMP) currency among states will allow gross tracking in addition to helping multi-state funding programs accurately prioritize resources and uniformly measure progress. State credit trading programs are also dependent on regional markets with consistent trading currencies.

The comparison of these three state strategies representing the Upper Mississippi will help states begin the dialog on how the respective approaches can be better aligned and to identify gaps in knowledge as well as focus areas for future research. Discrepancies between state efforts were highlighted as a point of discussion in an attempt to potentially determine real differences between states and to gain consensus on assumptions, data sources and methodologies that can make state strategies more robust.

Though a number of stakeholder groups are active in the Mississippi River Basin, the Southern Extension and Research Activities committee number 46 (SERA-46), which is a multi-state land-grant university committee supported by the United States Department of Agriculture (USDA) National Institute of Food and Agriculture (NIFA), is a well-respected and active group. This group was specifically created to "operationalize" the agreement between the Hypoxia Task Force and university extension. One of their priority areas is:

> "Identify common attributes and gaps across state nutrient reduction strategies - Review the [Hypoxia Task Force] HTF states' nutrient reduction strategies to identify the state goals, approaches and common attributes. Highlight opportunities for cross state information sharing to enhance other HTF state strategies"

The current effort aligns very well with this priority area and will hopefully provide a platform for future comparison, consensus building, and gap identification.

This document only highlights base agricultural BMPs associated with water quality in the Upper Mississippi River Basin. For specific details on state assumptions, procedures, and limitations, please see the respective state strategy documents as referenced.

2 Terminology/Acronym List

Common terminology used in this document.

Table 2-1. Terms used

Term	Abbreviation	Comments
Equal Annualized Cost	EAC	Annual cost of a project/practice when capital costs are amortized over the life of the practice and annual or semi-annual maintenance is included.
Environmental Quality Incentives Program	EQIP	This is a USDA NRCS program.
Maximum Return to Nitrogen	MRTN	This value is based on market prices for nitrogen and corn.
Phosphorus	P	
Nitrogen	N	
United States Department of Agriculture - Agriculture Research Service	USDA ARS	
United States Department of Agriculture – Natural Resource Conservation Service	USDA NRCS	
National Agricultural Statistics Service	NASS	
Iowa Department of Natural Resources	IDNR	
Iowa Department of Agriculture and Land Stewardship	IDALS	
Iowa State University College of Agriculture and Life Sciences	ISU CALS	
Minnesota Pollution Control Agency	MPCA	
Illinois Environmental Protection Agency	Illinois EPA or IEPA	
Illinois Department of Agriculture	IDOA	
Corn Soybean Rotation	CS	
Continuous Corn System	CC	
Soil Organic Matter	SOM	
Best Management Practice	BMP	
Major Land Resource Area	MLRA	
Conservation Reserve Program	CRP	
Soil Loss Tolerance	T	

3 State Strategies

The state strategies discuss all sources of N and P, including point sources, urban, and agriculture; however, these states, especially the portions in the Mississippi River Basin, are dominated by agriculture (Figure 3-1). Corn and Soybeans are the primary crops in all three states, totaling approximately 63% of the IA land area, 30% of the MN land area, and 57% of the IL land area in 2014 (Han, Yang, Di, & Yue, 2014). As these are the primary crops, most of the agricultural BMPs identified in the strategies, and, subsequently, here, should be considered in terms of these crops. The states modeled various scenarios using these BMPs to show how to best meet their reduction goals. Finally, though the statewide land use for Minnesota and Illinois do not necessarily represent the portion of the state draining to the Mississippi River Basin, decisions about overall strategy to reduce nutrients leaving each state, BMP focus areas, and targeted watersheds are made at the state level and it is important to acknowledge these differences across the region.

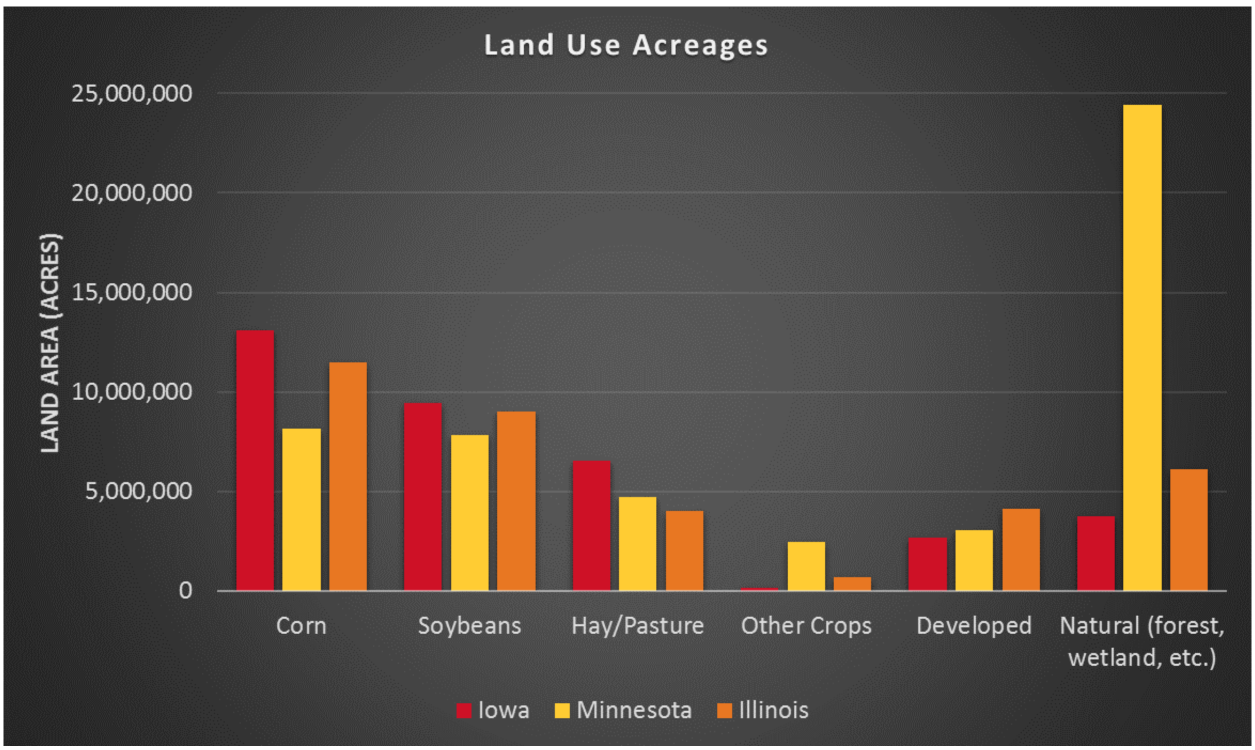

Figure 3-1. Land use information for the three states in the Upper Mississippi River Basin (Han, Yang et al. 2014).

General Agricultural Census information between the three states is similar (Figure 3-2) with the primary difference coming in the form of Estimated Market Value of Land and Buildings ($ per acre) (NASS, 2012). Interestingly, even though the average age of farmers is in the mid to upper 50s, the percentage farmers where farming is their primary occupation is just over 50%. This may imply partial retirement or simply another occupation is needed/wanted. Additionally, technology may allow principals/operators to pursue other opportunities while managing full-time employees.

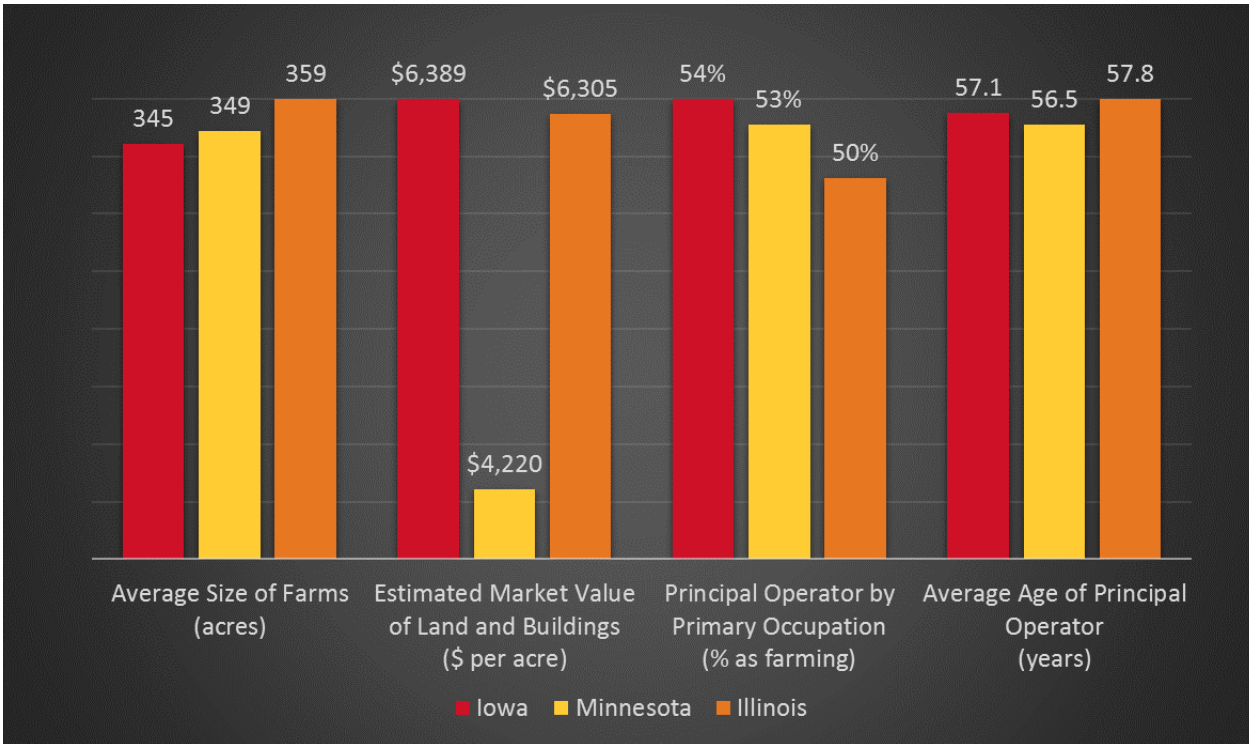

Figure 3-2. General Census of Agriculture information by State (NASS, 2012).

3.1 Iowa

The Nutrient Reduction Strategy for Iowa that was rolled out in 2012, focused on nutrient management, as well as in-field and edge-of-field management strategies (IDALS, IDNR, & ISU, 2013). Overall strategy development included participation from many organizations with political, and outreach components. The core science team for development of scenarios, reductions, and costs included six separate organizations and 23 individuals (Table 9-1).

The science portion of this strategy is split into a nitrogen and phosphorus focus. A word cloud, which is a visual representation of keywords where larger font sizes represent words used more often, has been developed to represent each state strategy. Looking at the Iowa word cloud in Figure 3-3, we see emphasis leans slightly towards nitrogen. As with the other two states, "water" is a central feature of this strategy. Also, commodity crops (corn and soybeans) are a major focus.

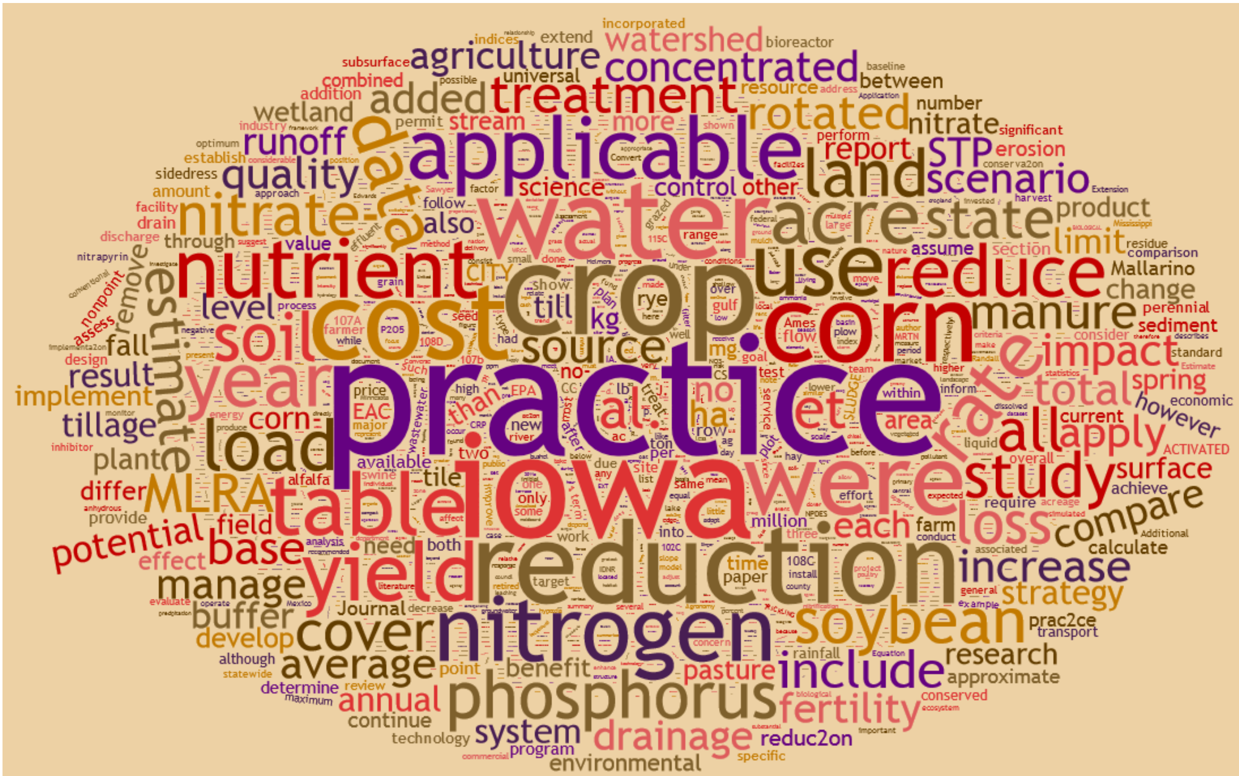

Figure 3-3. Iowa Nutrient Reduction Strategy word cloud. Larger words are used more often than smaller words.

As relative load reductions (45% for N and P) were the adopted goals, consistent load estimation methods across practices and scenarios were an important piece. The Gulf of Mexico TMDL goals are based on water quality data from 1982 to 1996, though IA has focused on achieving relative reductions from current loads on a Major Land Resource Area (MLRA) approach (Figure 3-4). The use of MLRAs allowed assumptions to be made about similar climate, soil, and water resources and cropping practices in these regions. One of the primary reasons for this aggregation technique was limited information on fertilizer and manure application rate on a finer scale (considering cross-county sales). The nitrogen load estimates were determined using a long term average water yield coupled with projected nitrate concentrations associated with nitrogen application. Phosphorus load estimates were made using a modified Iowa P Index calculation for average MLRA conditions.

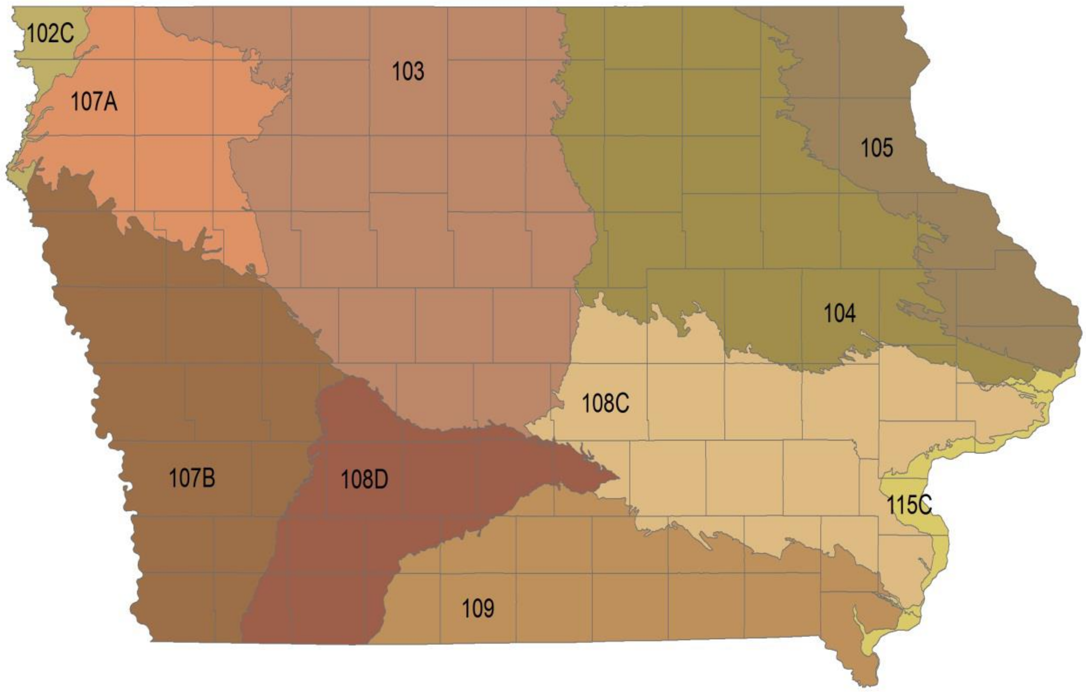

Figure 3-4. Major Land Resource Areas (MLRAs) in Iowa. This was the basis for nutrient reduction calculations and strategy development.

3.2 Minnesota

The Minnesota strategy was published in 2014 (MPCA, 2014) and was a multi-organization effort (Table 9-2). Consisting of over 75 individuals, this team list is the largest of the three states.

Reflecting on the word cloud in Figure 3-5, nitrogen and phosphorus are mentioned a similar number of times throughout the document, which is likely due to the goals of all three drainage areas of the state (Mississippi, Great Lakes, and Red River) rather than simply the Gulf of Mexico, which tends to focus on nitrogen. In contrast to Iowa, primary crops are not highlighted through the document.

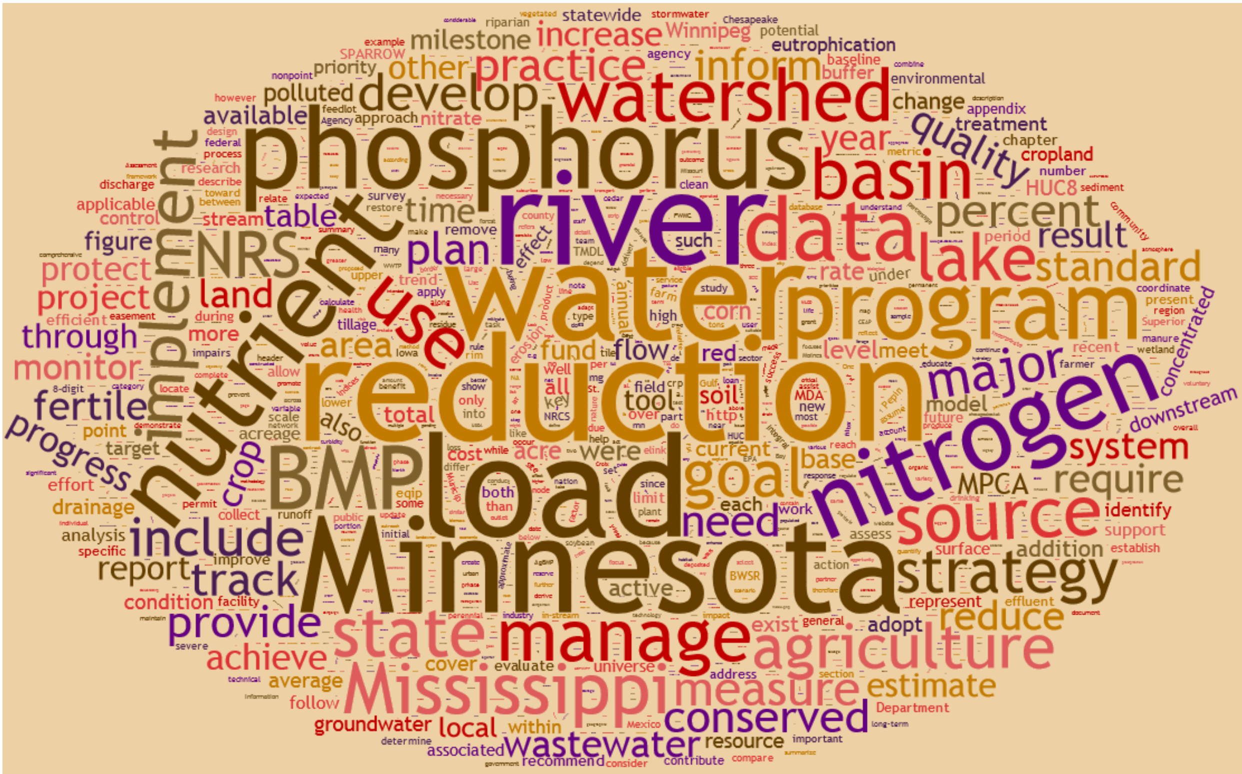

Figure 3-5. Minnesota Nutrient Reduction Strategy word cloud. Larger words are used more often than smaller words.

As opposed to the MLRA approach in the IA strategy, the final MN strategy suggests focus on individual watersheds using an adaptive management approach. This approach encourages targeting of problem areas at the watershed scale. Overall loads were determined using results from the SPARROW model.

For illustration, the Cannon River watershed has a number of local TMDL for lakes and tributaries as well as a set of informative documents. One of the documents is a "Stressor Identification Report," which reviews stressors limiting biotic activity. This document reviews wetland loss, tile drainage, degraded streams, limits to fish passage, and water quality. Using this information, targeting of specific locations with specific water quality practices can occur. Though this approach for evaluating watersheds and targeting does not necessarily influence reduction efficiencies, it is very important for the application of these efficiencies to practice implementation.

Minnesota also has an agricultural BMP tracking program in place – eLINK (http://www.bwsr.state.mn.us/outreach/eLINK/). An analysis from 2013 showed substantial reductions in total phosphorus (TP) across the state with a large focus on the Mississippi River basin (Figure 3-6). This tracking tool takes into account local information when estimating the benefits of BMPs, and is likely a better and more important tool when calculating metrics from implemented BMPs such as phosphorus reduction per dollar spent.

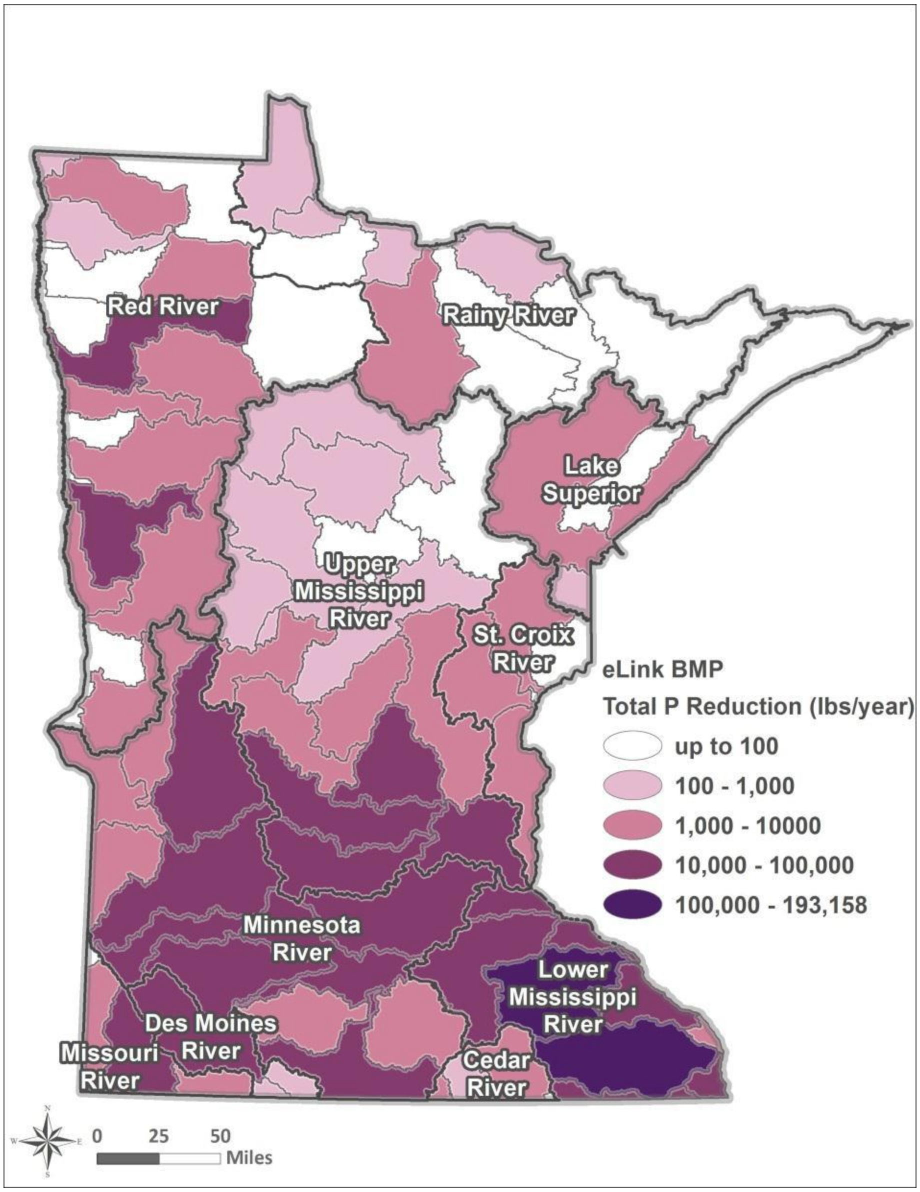

Figure 3-6. Total Phosphorus reductions from an eLINK report in 2013 - as reported by the Minnesota Nutrient Reduction Strategy.

3.3 Illinois

Completed in 2015, the Illinois Nutrient Loss Reduction Strategy involved the Illinois Environmental Protection Agency (Illinois EPA), the Illinois Department of Agriculture (IDOA), federal and state agencies, industry, agriculture, wastewater treatment agencies, and non-governmental organizations (IEPA & IDOA, 2015). Preparation of this strategy consisted of the multi-organization team (Table 9-3) established in 2013.

The key strategies for the Illinois plan are to identify priority watersheds for nutrient loss reduction, coordinate water quality monitoring, and improve collaboration. A visual representation of this strategy is provided as a word cloud in Figure 3-7. Phosphorus tends to be the primary nutrient referenced. In contrast to Iowa, primary crops are not referenced through the document.

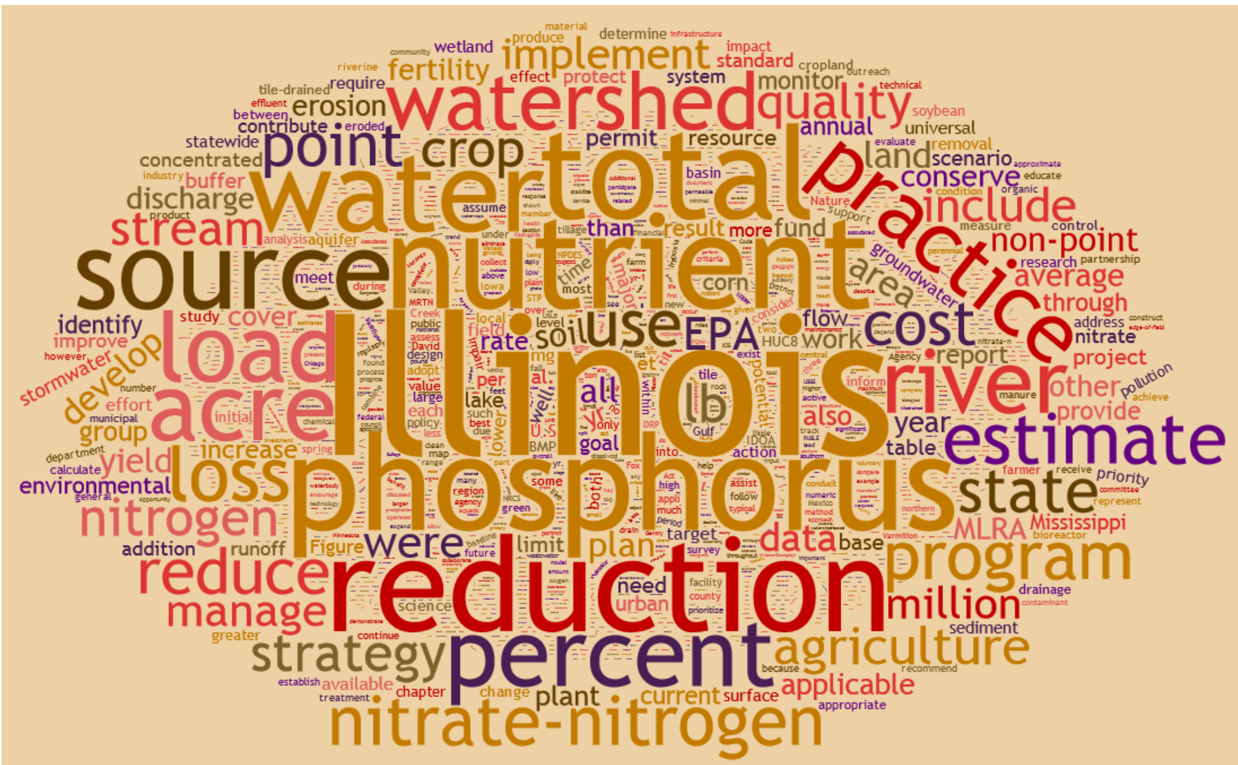

Figure 3-7. Illinois Nutrient Loss Reduction Strategy word cloud. Larger words are used more often than smaller words.

Like IA, IL used MLRAs as the basis for their strategy (Figure 3-8). Additionally, they prioritized on an eight-digit watershed scale similar to MN, which are represented as smaller polygons in Figure 3-8. This approach seems to lend itself well to an overarching strategy with immediate areas to potentially make substantial progress.

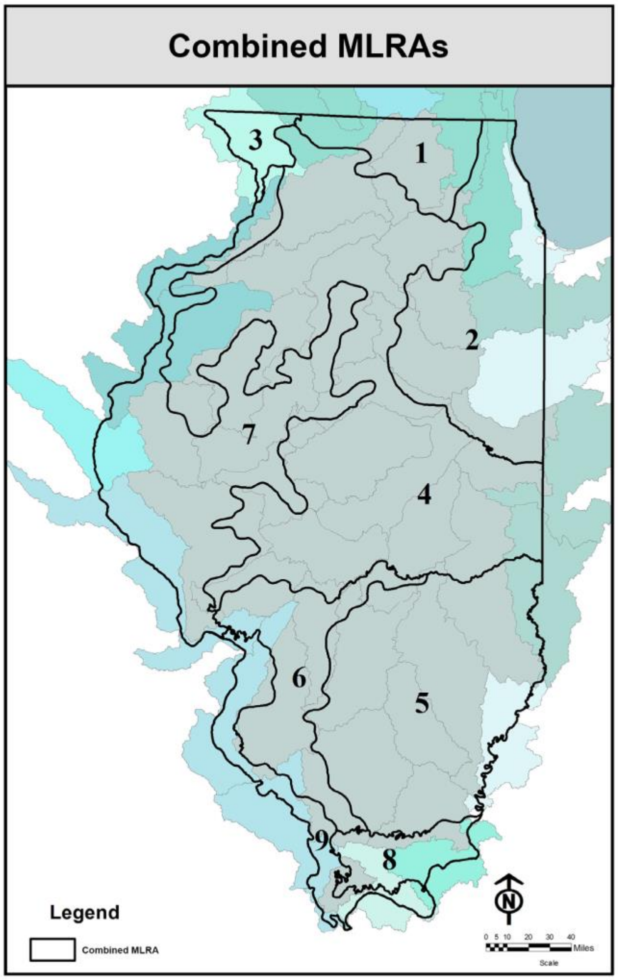

Figure 3-8. Major Land Resource Areas (MLRAs) used in the Illinois Nutrient Loss Reduction Strategy. The numbers indicate the aggregated MLRA areas used in the Illinois strategy. Underlying polygons are 8-digit watersheds.

The Illinois load for 1980-2011 was calculated using stream flow data and nitrogen and phosphorus concentrations provided by the Illinois EPA and USGS. Nitrogen and phosphorus loads were calculated by interpolating from the sources mentioned and by the USGS Weighted Regressions on Time, Discharge, and Season technique. Point source loads were directly estimated, while non-point source loads were estimated by subtracted point source loads from total loads. Practices are categorized by in-field, edge-of-field and land use changes.

4 Comparing Agricultural Best Management Practices

Since Iowa's strategy was published first, Minnesota and Illinois were able to leverage information and also incorporate studies pertinent to their state. Below is a discussion of the similarities and differences in the plans and the reasoning behind the nutrient reductions associated with each practice. The practices are organized based on which nutrient it reduces: both nitrogen and phosphorus, nitrogen only, or phosphorus only. A section is included at the end of each practice where there are questions that would help clarify the gaps and discrepancies among the states. Practices that were only in one strategy are not discussed since values to compare are not available.

Table 4-1. Overall practice comparison between states for nitrogen and phosphorus.

Practice Category	Practice	Nutrient	Iowa	Minnesota	Illinois
Practices that Reduce Nitrogen and Phosphorus					
In-Field	Cover Crops	Nitrogen	28%-31%	10%-51%	30%
In-Field	Cover Crops	Phosphorus	29%	29%	30%-50%
Edge-of-Field	Wetland	Nitrogen	52%	50%	50%
Edge-of-Field	Wetland	Phosphorus	None	None	None
Edge-of-Field	Buffers	Nitrogen	91%	95%	90%
Edge-of-Field	Buffers	Phosphorus	58%	58%	25%-50%
Land Use	Perennial Energy Crops	Nitrogen	72%	95%	90%
Land Use	Perennial Energy Crops	Phosphorus	34%	34%	50%-90%
Land Use	Grazed Pasture/Hayland	Nitrogen	85%	95%	
Land Use	Grazed Pasture/Hayland	Phosphorus	59%	59%	
Land Use	Land Retirement	Nitrogen	85%	83%	
Land Use	Land Retirement	Phosphorus	75%	56%	
Practices that Reduce Nitrogen Only					
In-Field	Nitrification Inhibitor	Nitrogen	9%	14%	10%
In-Field	Nitrogen Management	Nitrogen	4%-7%	26%	7.5%-20%
In-Field	Maximum return to Nitrogen Application Rate	Nitrogen	10%	16%	10%
In-Field	Liquid Swine	Nitrogen	4%		
In-Field	Poultry Manure	Nitrogen	-3%		
Edge-of-Field	Controlled Drainage	Nitrogen	33%	33%-44%	
Edge-of-Field	Bioreactor	Nitrogen	43%	13%	25%
Edge-of-Field	Shallow Drainage	Nitrogen	32%		
Land Use	Living Mulch	Nitrogen	41%		
Land Use	Extended Rotation	Nitrogen	42%		
Practices that Reduce Phosphorus Only					
In-Field	Soil Test Phosphorus	Phosphorus	17%	17%	7%
In-Field	Phosphorus Banding	Phosphorus	24%	24%	
In-Field	Liquid Swine, Dairy, Poultry Manure	Phosphorus	46%		
In-Field	Beef Manure	Phosphorus	46%		
In-Field	Broadcast incorporated within a week	Phosphorus	36%		
Edge-of-Field	Sediment Basin or Pond	Phosphorus	85%		
Edge-of-Field	Terraces	Phosphorus	77%		
Land Use	Conservation Tillage	Phosphorus	33-90%	63%	50%

4.1 Practices that Reduce Nitrogen and Phosphorus

4.1.1 Cover Crops

Nitrogen: In IA, they looked at late summer or early fall seeded winter cereal rye for nitrogen with a seeding rate of 60 lbs/acre. The estimated yield impact for corn following rye is a 6% reduction. There is no yield impact with soybean following rye. The nitrogen reduction efficiency is 31% for rye and 28% for oat (data from one study). Iowa looked at a scenario of planting a rye cover crop on all no-till acres and on all Corn-Soybean and Corn-Corn acres. There is no distinction between fall and spring applied N.

Minnesota looked at cover crops with high seed germination success rate (80% assumed) and cover crops with low success rate (40% assumed). Cover crops grow on fallow and after short season crops, such as peas, sweet corn, sugar beets, corn silage, and wheat are assumed to have high success rate. Cover crops with low potential for success (40%) follow corn grain, soybean, dry bean, potato or sorghum. The nitrogen reduction efficiency for cover crops in MN is 51% after short season primary crops (i.e. sweet corn or peas) and 10% after corn or soybeans. These differences are due to available cover crop growing season and establishment before freeze. Minnesota also noted efficiencies for cover crops after long season crops can be increased through advances in management (i.e. flying seed on early or drilling seed into standing crops in August or September).

In IL, they used 30% reduction for cover crops, an average of the IA reduction of 31% and 28%.

Phosphorus: Minnesota references the IA Strategy for cover crop phosphorus reduction at 29%. The IA assumptions for cover crops include late summer or early fall seeded winter cereal rye. In IL, 1.6 million acres of corn, soybeans, and wheat erode greater than tolerable levels (usually expressed as T, in tons per acre, and represents a normal soil formation rate). If winter cover crops where included in an extended cropping rotation, it is estimated to have 50% P reduction. If a cover crop were planted on a corn and soybean rotation, there would be a 30% P reduction.

Note that targeting cover crops to high risk areas (i.e. land with steep slopes) is being done through individual watershed plans in Minnesota. Also, scientists in both Iowa and Illinois agree planting cover crops after short season crops will increase the benefit, though there may be limited applicability in these states due to the current cropping regime.

Table 4-2. Cover crop comparison.

State	Nitrogen Reduction	Phosphorus Reduction
Iowa	31% (28% for oats)	29%
Minnesota	51% (10% after corn or soybeans)	29%
Illinois	30%	30% (50% extended rotation)

Research Gaps

- Can cover crop management improvements overcome regional limitations on cover crop use?
- Can the water quality benefit of other cover crops (i.e. winter pea, radish, etc.) be quantified?
- Is there a point at which cover crops might increase P loading in areas where dissolved P becomes the dominant transport pathway?
- How much biomass is required to achieve estimated N and P reductions?

4.1.2 Wetlands

Nitrogen: The nitrogen reduction for IA is 52%, which is based on one report looking at multiple wetlands in Iowa (Helmers et al., 2009). In the MN Strategy, the nitrogen reduction efficiency for wetlands is 50%, which was determined from a literature review (W. Lazarus, Kramer, Mulla, & Wall, 2013). The nitrogen reduction for IL is 50%, based on several studies in Illinois. Though Illinois wetlands tend to be smaller, due to the historic drainage structure focusing on draining fields to ditches rather than large mains, this does not exclude larger or targeted wetlands from being developed in the future.

Phosphorus: In the IA Strategy, there is no percent phosphorus reduction noted. This is due to the fact that P retention is highly variable and dependent upon such factors as hydrologic loading and P mass input. Minnesota also does not state a percent phosphorus reduction, because they decided that it is not applicable for permanent phosphorus removal, unless sediments are cleaned out and vegetation harvested. Drainage water retention can indirectly help mitigate phosphorus load through reduction of erosive flows; however, it is not possible to assign general reduction efficiency. Illinois also assumes no net reduction in total phosphorus load from wetlands.

Table 4-3. Wetland comparison.

State	Nitrogen Reduction	Phosphorus Reduction
Iowa	52%	0%
Minnesota	50%	0%
Illinois	50%	0%

Research Gaps:

- Would a "one-time" phosphorus reduction be appropriate?
    - This could be based on expected peak biomass or some initial or steady-state sedimentation. This would be applied to newly created wetlands only.
- Are there simple and inexpensive modifications or management activities to add a P reduction credit?
- Are there any options to include biomass harvest to add a P reduction or increase N removal?

4.1.3 Buffers

Nitrogen: In IA, the use of buffers only pertains to water that interacts with the active root zone below the buffer. This is a small fraction of all water that makes it to a stream due to the heavily tile drained landscape. The nitrogen reduction is 91%, which comes from various literature reviews. The size of the buffer in an IA scenario is 35 feet wide. In MN, the nitrogen reduction for buffers is 95%, which accounts for the land conversion of row crops to a 30 meter perennials buffer in riparian areas (see perennial crop). The reduction in nitrogen only applies to the buffer area. In IL, the nitrogen reduction is 90% for buffers, only for water that interacts with the active root area. This is calculated based on the IA ratio for total phosphorus to nitrate-nitrogen removed and the IL total phosphorus estimate.

Phosphorus: The phosphorus reduction for buffers in MN uses the IA reduction of 58%. In the Minnesota Strategy, it stated that the reduction is calculated as the land conversion of row crops to perennials and the immediate drainage area, which is 3 times the buffer area (30 meters). This is different than nitrogen, as the water does not have to pass directly through the root zone. In IL, they estimated that for non-tile drained land, a 35-ft buffer would reduce total phosphorus load from a cropland without buffers by 50%. Buffers on tile-drained land would have less surface runoff interaction, so a 25% P reduction was assumed. These estimates were based on professional judgement and relevant literature.

Table 4-4. Buffer comparison.

State	Nitrogen Reduction	Phosphorus Reduction
Iowa	91%	58%
Minnesota	95%	58%
Illinois	90%	50% (25% on tiled land)

Minnesota has a buffer rule, which calls for 16.5-ft buffers along ditches and 50-ft buffers along rivers. Though buffers are generally effective for water quality, at 3 to 5 ft, the rule adds benefits for habitat and greenways. For water quality regarding the state strategies, a consistent credit width across states is likely not warranted. The use and targeting of buffers in the non-tile drained landscape, as noted by Illinois, may provide enhanced phosphorus reductions across the region. Scientists from Iowa think there may be enough literature available to start parsing buffer benefits based on landscape features.

Research Gaps:

- Are there available methods for estimating site specific lateral flow that may interact with buffer root zone?
    - These methods need to be freely available and use readily attainable data (i.e. information easily obtained by a producer in the field)
- Could a land use change also be associated with buffers like Minnesota assumed?
    - For example, planting a grass buffer along a stream not currently having one would likely pull that land out of production.

4.1.4 Perennial Energy Crops

Nitrogen: Iowa research showed there was a 72% N reduction from perennial energy crops that replace row crops, again comparing against a corn and soybean rotation. This scenario assumes energy crops are fertilized. These data primarily focused on available tile drainage plots comparing land cover. No preference was given to marginal cropland.

In MN, the nitrogen reduction efficiency for perennial energy crops is 95% (MPCA, 2013). This is assuming that perennial replace row crops on marginal land. This 95% is also used for riparian buffers, when perennials replace row crops near waters and for hayland in marginal cropland, replacing row crops.

In IL, perennial crops on land converted from row crops from pasture has a 90% nitrogen reduction. This is based on results from Iowa, as well as other work from University of Illinois South Farms. Converting corn/soybean tile-drained land to perennials also has an estimated 90% reduction.

Phosphorus: Minnesota cites IA for the perennial energy crops phosphorus reduction of 34%. One of the IA state strategies included planting enough perennial crops to equal pasture/hay acreage from 1987. Row crop acreage is reduced to maintain static overall acreage.

In IL, converting corn, soybeans, and wheat that erode greater than the soil loss tolerance (T) to perennial crops, such as for biofuels, hay or Conservation Reserve Program (CRP), would result in a 90% reduction in soil erosion. One of the statewide scenarios was converting corn/soybean acres that had been hay or pasture in 1987 back to hay/pasture. Additionally, converting corn/soybean rotation acres on tile-drained land to perennial hay or energy crop would result in a 50% P reduction. The reductions are calculated from the Illinois Department of Agriculture (IDOA) tillage transect survey collected in the spring of 2011.

A point of consensus is that additional benefits may be expected in steeply sloping land, which strengthens the Illinois assessment showing a lower expected benefit on tile drained land.

Table 4-5. Perennial energy crops comparison.

State	Nitrogen Reduction	Phosphorus Reduction
Iowa	72%	34%
Minnesota	95%	34%
Illinois	90%	90% (50% on tiled land)

Research Gaps:

- Does fertilization rate have a significant impact on N or P loss from a site?
- How significantly do these crops impact the water balance at a site?
    - For example, does leaching to the groundwater get cut in half?

4.1.5 Grazed Pasture/Hayland

Nitrogen: Iowa lists grazed pastures as a practice, which was assumed to be similar to the "hayland in marginal cropland" practice in the Minnesota document for purposes of this comparison. Iowa assumed this land use would be similar to land retirement and set the nitrogen reduction to 85%. In MN, the nitrogen reduction is 95%, which is the value of replacing row crops with perennial crops. Illinois assumed no nitrate-nitrogen was contributed by ag lands other than row crop, which tended to be a good assumption for the state.

Phosphorus: For grazed pastures and hayland planted in marginal cropland replacing row crops, the reduction in phosphorus in IA is 59%, with MN citing IA.

Illinois did not include this practice.

Table 4-6. Grazed pasture/hayland comparison.

State	Nitrogen Reduction	Phosphorus Reduction
Iowa	85%	59%
Minnesota	95%	59%
Illinois	Not Included	Not Included

Research Gaps:

- Need to better quantify water quality benefits of various perennial land uses.
    - For example, differences between grazing regimes, hay crop type, fertilization, etc.

4.1.6 Land Retirement

Nitrogen: The 85% nitrogen reduction in Iowa for land retirement comes from research and comparing the CRP with spring applied fertilizer row-crop production. MN used the IA values and averaged it with other Upper Midwest research to get 83% for nitrogen.

Phosphorus: The phosphorus reduction for Iowa is 75%. Minnesota used the IA values and averaged it with other Upper Midwest research to get 56% for phosphorus.

Illinois did not include this practice.

Table 4-7. Land retirement comparison.

State	Nitrogen Reduction	Phosphorus Reduction
Iowa	85%	75%
Minnesota	83%	56%
Illinois	Not Included	Not Included

Research Gaps:

- Need to better quantify water quality benefits of various perennial land uses

4.2 Practices that Reduce Nitrogen Only

4.2.1 Nitrification Inhibitor

The Iowa reduction of 9% is based on applying nitrapyrin with all fall-applied anhydrous ammonia, relative to no nitrapyrin in the fall. The reduction calculated is based on average application rate for each MLRA. Illinois cites IA as the source for their stated reduction of 10%.

The MN reduction of 14% is based on an average of literature reviewed (MPCA, 2013). Ultimately this is based on the Iowa reduction of 9% and Fabrizzi and Mulla (2012) of 18%. Minnesota cites the IA cost for nitrification inhibitor.

Table 4-8. Nitrification inhibitor comparison.

State	Nitrogen Reduction
Iowa	9%
Minnesota	14%
Illinois	10%

Research Gaps:

- Quantify the prevalence of inhibitor use across the Upper Mississippi (when, how much, perceived benefit).

4.2.2 Nitrogen Management

In Minnesota, the practice of shifting fall application to spring and sidedressing with rate reduction has a reduction efficiency of 26% (W. Lazarus et al., 2013; MPCA, 2013). This only applies to corn grain and silage acres. Components were not broken out due to limited information in Minnesota, though research is currently underway. One strategy being recommended by the University is a 45 lbs N/ac application at plant, which is followed-up with an early season application based on crop needs (i.e. remote sensing).

In contrast to the combined efficiency developed by Minnesota, IA developed four separate practices for nitrogen application timing reduction (based on literature).

- Moving from fall to spring pre-plant application at the same rate (6% reduction)
- Spring pre-plant/sidedress 40-60 split compared to fall applied at the same rate (5% reduction)
- Sidedress- compared to pre-plant (spring applied) fertilizer at the same rate (7% reduction)
- Sidedress- soil test based compared to pre-plant (spring applied) fertilizer (4% reduction)

Sidedressing is only considered as early sidedress timing (corn height below 24-inch) or application based on soil nitrate sampling.

In IL, there are three practices for nitrogen application timing:

- Moving from fall to spring pre-plant application on tile-drained corn acres (15 to 20% reduction, depending on if the field is in the north or south part of the state, respectively)
- Moving from fall to a split application of 50% fall and 50% spring on tile drained corn acres (7.5 to 10% reduction, depending on if the field is in the north or south part of the state, respectively)
- Moving from fall to a split application of 40% fall, 10% pre-plant, and 50% sidedress (15 to 20% reduction, depending on if the field is in the north or south part of the state, respectively)

The spring-only application reduction is based on the results of Clover (2005) and Gentry et al. (2014). 15% is used for the cooler northern Illinois, and 20% is used for Central Illinois. There were no data to support the 50%/50% split scenario, so this scenario assumes half the benefit of a 100% switch from fall to spring. Data from Clover (2005) showed a 20% reduction in nitrate losses from tile drains when spring and side-dressing applications were compared, which set the upper bounds for the sidedressing practice (15 to 20%).

Table 4-9. Nitrogen management comparison.

State	Timing (fall to spring)	Sidedressing (or spring split application)	Split application (40% fall, 10% spring, 50% sidedressed)	Fall to spring, sidedressing, and reduced rate
	Nitrogen Reduction			
Iowa	6%	~5% (across options)	Not Included	Not Included
Minnesota	Not Included	Not Included	Not Included	26%
Illinois	15 to 20%	Not Included	15 to 20%	Not Included

Research Gaps:

- How do multiple practices stack together? For example, using the Illinois scenario comparing 100% fall applied to 40% N in fall, 10% pre-plant, and 50% sidedress would give a 4% reduction when using the Iowa single practice numbers, proportionally.
    - Can this be easily coupled with reduction from decreases in N application rate?
- How do we account for existing nitrogen in soil organic matter (SOM), which, potentially, makes up a sizeable fraction of the nitrogen balance?
    - For example, assume, for argument, that 50% of available nitrogen comes from SOM and 50% comes from applied nitrogen. Giving 20% N reduction for nitrogen management along with this assumption is, essentially, saying you are controlling 40% of applied N loss. This may not be true in the long term, but for the season where the decision is being made, this would likely hold true.

4.2.3 Maximum Return to Nitrogen (Application Rate)

The maximum return to nitrogen (MRTN) is the nitrogen application rate where the addition of more nitrogen will not provide a large enough yield increase to pay for the extra nitrogen. Iowa uses a nitrogen application rate of 133 lbs N/ac as the MRTN for corn in a corn and soybean rotation, and 190 lbs N/ac for continuous corn. These values came from the Iowa Corn Nitrogen Rate Calculator (Sawyer et al., 2011) and took the average MRTN for low and high profitability. The science team used 0.10 as the nitrogen:corn (N:C) price ratio (i.e. $0.50 per pound of nitrogen and $5.00 per bushel of corn). The statewide average nitrogen reduction is 10%, which is based on initial application rate for each MLRA. Illinois uses the same 10% reduction figure Iowa suggested.

Minnesota used a corn soybean rotation MRTN of 141 lbs N/ac, though when coupled with University of MN recommended nitrogen application rates for high productivity soils, the MRTN scenario results in an average 105 lbs N/ac. Corn following Corn average MRTN-University recommendation is an average of 135 lbs N/ac. The percent nitrogen reduction efficiency is for corn after soybean assumes proper manure crediting. In other words, the recommended rate applies only to fertilizer since it was assumed the difference between the MRTN and their recommended rate is made up for by manure. The nitrogen reduction for this practice in MN is 16% (MPCA, 2013).

Table 4-10. Maximum Return to Nitrogen (MRTN) rates.

Cropping System	Iowa (lb N/acre)	MN (lb N/acre)
Corn Soybean	133	100 to 110
Corn Corn	190	130 to 140
Corn Alfalfa	N/A	30 to 40
Corn with manure	N/A	<130 to <140

Table 4-11. Maximum Return to Nitrogen (MRTN) comparison.

State	Nitrogen Reduction
Iowa	10%
Minnesota	16%
Illinois	10%

Research Gaps:

- Is there risk of mining soil nitrogen if N application rates fall to MRTN? How about below those levels?

4.2.4 Controlled Drainage

In IA, the nitrogen load reduction of controlled drainage is 33%. This value is based a literature survey from studies in and around IA. Iowa defines drainage water management (analogous to controlled drainage) as actively managing tile control structures that raise or lower the water table in a field. As a statewide strategy, IA used an assumption that land would be tile drained if land slope met a certain criteria. New research in Iowa is suggesting controlled drainage may have up to a 50% nitrate reduction efficiency when considering an “average” moisture year.

In MN, controlled drainage, limited to tile-drained land with nearly flat slope (<1%), has a nitrogen reduction efficiency of 33% to 44%. The 33% is from the Iowa documents, and the 44% is from the Nitrogen Reduction Planning Tool worksheet (W. Lazarus et al., 2013).

Although there was information about controlled drainage in IL, strategy authors did not include it as a potential practice due to uncertainties surrounding the study; however, the Science Assessment Team is interested in adding this practice to the strategy. Additionally, there is concern about adoption and proper management.

Table 4-12. Controlled drainage comparison.

State	Nitrogen Reduction
Iowa	33%
Minnesota	33 to 44%
Illinois	Not Included

Research Gaps:

- Can controlled drainage be done in steeper landscapes with varying levels of efficiency?
  - For example, on a location with 2% slope that may only reduce annual water loss by 10% rather than 33%.

4.2.5 Bioreactor

The nitrogen reduction rate for bioreactors in IA is 43%, which comes from an Iowa study that measured flow rates through four bioreactors and coupled those flow data to nitrate concentrations before and after the bioreactors (Christianson, 2011). This study took into account water bypassing the bioreactors.

The MN Strategy references the “Nitrogen in Minnesota Surface Waters” report, where the estimated reduction rate is 44% (MPCA, 2013) but assumes that only 30% of the total flow is actually treated due to bypass during high spring flows. This results in a 13% (44% x 30%) nitrogen reduction from bioreactors; however, research is continuing to be done in the state using different designs, and the addition of supplemental carbon sources to increase efficiency.

The reports on bioreactors tend to test with warmer waters than average in Illinois and bioreactors decrease in efficiency over time, so Illinois used a conservative value of 25% reduction.

There is potential to design bioreactors for a specific nitrate removal efficiency (i.e. 60% reduction) and recent advances in bioreactor modeling using, for example, a method proposed by Richard Cooke (http://web.extension.illinois.edu/bioreactors/design.cfm) may be a starting point.

Table 4-13. Bioreactor comparison.

State	Nitrogen Reduction
Iowa	43%
Minnesota	13%
Illinois	25%

Research Gaps:

- Can design features overcome regional differences in performance?
  - Due to drainage patterns, water temperature, etc.
- Can we quantify treatment of groundwater using denitrifying walls?

4.3 Practices that Reduce Phosphorus Only

4.3.1 Soil Test Phosphorus (STP)

The phosphorus practice referenced in the Minnesota and Iowa documents assume no phosphorus would be applied to soil until soil test phosphorus drops to optimum value. Minnesota cites the Iowa plan for phosphorus reduction efficiency of 17%. Iowa determined this value from average estimates based on reducing the average STP (Bray-1) of the two highest counties in Iowa and the statewide average STP (A. Mallarino, Hill, & Culp, 2011), respectively, to an optimum level of 20 ppm (AP Mallarino, Stewart, Baker, Downing, & Sawyer, 2002).

Illinois has a phosphorus reduction of 7% for P reduction on fields with soil test P above the recommended maintenance level. This is a state-wide average and combines reductions in the high, medium, and low phosphorus supplying regions. This practice primarily influences dissolved reactive phosphorus, which is assumed to be 20% of TP.

Table 4-14. Soil test phosphorus (STP) comparison.

State	Phosphorus Reduction
Iowa	17%
Minnesota	17%
Illinois	7%

Research Gaps:

- Can this concept be coupled with something like an energy crop to increase the rate of soil phosphorus reduction?
  - How would water quality benefits for multiple practices with different treatment methods be estimated?

4.3.2 Phosphorus Banding

The phosphorus banding practice includes adding P with seed or in knifed bands compared to surface application with no soil incorporation. Iowa assumes a 24% P reduction, and Minnesota references the Iowa estimate.

Illinois did not include this practice, as this is not a common application method in the state.

Table 4-15. Phosphorus banding comparison.

State	Phosphorus Reduction
Iowa	24%
Minnesota	24%
Illinois	Not Included

4.3.3 Conservation Tillage

Iowa has a 33% phosphorus reduction for conservation till, comparing chisel plowing to moldboard plowing. IA also has a 90% phosphorus reduction for no till compared to chisel plowing. The reductions were calculated using the Iowa P Index.

Minnesota has a phosphorus reduction efficiency for conservation tillage and residue management of 63%. This is an average of Midwest and Chesapeake Bay studies. Due to potential soil phosphorus stratification, conservation tillage should be done in conjunction with BMPs like applying phosphorus based on soil tests. The term conservation tillage is used generally in the strategy and represents a proven way to reduce erosion. Additionally, MN did some re-apportioning of their P-Index modeling results to credit portions of the conservation tillage practice to the fertilizer use efficiency practice.

Illinois estimates a reduction of 50% for converting 1.8 million acres of conventional till that is eroding greater than the soil loss tolerance (T) to reduced tillage, mulch tillage, or no-till. The reductions are calculated from the Illinois Department of Agriculture (IDOA) tillage transect survey collected in the spring of 2011.

Table 4-16. Conservation tillage comparison.

State	Phosphorus Reduction
Iowa	33 to 90% (depending on starting point)
Minnesota	63%
Illinois	50%

Research Gaps:

- Is it possible to separate the benefits of conservation tillage, residue management, and soil test phosphorus recommended P application?

4.4 Practices Only in One Strategy

For the Iowa Strategy, there were a few more practices that were not included in the other strategies.

Table 4-17. Additional practices included in the Iowa strategy science assessment.

Practice	Nitrogen Reduction	Phosphorus Reduction
Living mulch (continuous corn planted into a perennial crop)	41%	Not Applicable
Extended rotation (at least two years of alfalfa in a 4 or 5 year rotation) compared to a corn and soybean rotation	42%	Not Applicable
Shallow drainage (same drainage intensity) compared to standard drainage	32%	Not Applicable
Changing from spring applied commercial fertilizer to poultry manure	(-)3%	Not Applicable
Changing from spring applied commercial fertilizer to liquid swine manure	4%	Not Applicable
Changing from commercial fertilizer to beef, dairy, poultry or liquid swine manure (assuming runoff shortly after application)	Not Applicable	46%
Change from no incorporation of broadcasted fertilizer to broadcast fertilizer with incorporation within one week	Not Applicable	36%
Terraces	Not Applicable	77%
Sedimentation basins	Not Applicable	85%

5 Cost Estimates

The three state strategies include cost estimates for implementing many of these practices. Cost data was presented in various ways in all three strategies, but the most comparable values are the dollar per acre cost or benefit. States also presented cost data as dollars per pound of nutrient removed.

There are several unanswered questions associated with cost data. Global shifts in markets due to broad scale implementation of certain practices, regional demand, cost savings through efficiency, etc. are all hard questions to answer when considering specific scenarios developed around wide adoption of a BMP, let alone competition between individual BMPs. Additionally, costs are farm, year, region, and operator experience specific. This means, for example, values presented in the strategies, and directing state decisions, are general and likely dynamic in nature. The methods of calculating cost estimates also varied by state, making the values even harder to compare.

Presenting cost data effectively can be a challenge, due to the various factors involved in BMP selection. Some typical factors include:

- Farm land availability (ex. Farmer A can only give up 10% of his/her land)
- Which nutrient is to be reduced and by how much
- Funding available
- Area the BMP can actually be located in (i.e. stream buffers can only be next to streams)

On top of these factors is the efficiency of the practice. Efficiency can be viewed in three ways, technical (percent of load reduction for the BMP), economic (most bang for your buck), and spatial (most affordable per acre). Different stakeholders rank the importance of the efficiencies differently, therefore various cost values are reported. For example, Farmer A might have thousands of acres to work with, so he/she might have several options and opt for a lower cost per acre, versus Farmer B who might have a very small farm with the need to choose a more spatially efficient BMP to meet water quality goals.

The chart below rates the nitrogen BMPs based on the three types of efficiency. Green is high efficiency, yellow is average efficiency, and red is low efficiency. The chart is not meant to be the decision tool; it is to show that there is no one size fits all BMP. These efficiencies do not include phosphorus benefits of BMPs that can reduce both nutrients, due to the increased complexity of adding another factor.

Table 5-1. Comparing Efficiencies of select Nitrogen BMPs

Nitrogen BMP	Technical Efficiency	Spatial Efficiency	Economic Efficiency
CRP			
Crop to Pasture/Hay			
Perennial Energy			
Wetland			
Bioreactor			
Controlled Drainage			
Riparian Buffers			
Cover Crops			
MRTN			
Nitrogen Inhibitors			

5.1.1 Cover Crops

Iowa looked at late summer or early fall seeded winter cereal rye for nitrogen with a seeding rate of 60 lbs/acre, at a cost of $0.125/lb. A base cost of $32.5/acre/year is used for cover crop implementation (before corn yield impact). The state average equal annualized cost ranges from $45/acre for rye on all no-till acres to $49/acre, on all corn/soybean and corn/corn acres, which includes corn yield reduction. In MN, the calculated lifecycle cost is $53/acre/year. This MN strategy cites the NBMP tool, which considers seeds, aerial seeding, and termination. Ultimately, the cost efficiency of cover crops after grain ranges from $8.90 to $31.80/lb N reduction and $13.88/lb N reduced for cover crops after a short season crop. In IL, cover crops on all corn/soybean tile-drained acres is $3.21/lb for nitrogen and $130.4/lb for phosphorus. Cover crops on all corn/soybean non-tiled acres is $11.02/lb for nitrogen. Cover crops on acres eroding more than the tolerable amount, T, currently in reduced tillage, mulch or no-till acres a cost of $24.5/lb of phosphorus removed. The calculated cover crop cost per acre in IL is $29/acre. This includes seeds, seeding, and partial herbicide spraying.

5.1.2 Wetland

The IA Average EAC is $15/treated acre, which translates to a cost of $1.38 per pound of N reduction when considering a state implementation program. In MN the cost is $6-18/treated acre/year, with an estimation of $1.59/pound of nitrogen reduced. The estimated cost for IL is $60.63/treated acre (W. F. Lazarus, Mulla, & Wall, 2014) and $4.05-5.06/lb of N removed if used on till drained land. The primary discrepancy between IL and the other states is the assumptions on contributing drainage area size. As suggested in the IL strategy, IA focuses on regional wetlands treating up to 2,000 acres, while IL focuses on smaller wetlands with drainage areas closer to 10 acres. Development of larger wetlands targeted for denitrification may reduce the costs associated with nitrogen reduction in Illinois.

5.1.3 Buffer

Iowa has a state average equal annualized cost of $231/acre of buffer installed (includes costs associated with phosphorus and nitrogen reduction), nitrogen reduction cost of $1.91/lb removed and phosphorus reduction cost of $14/lb. The lifecycle cost in MN is $30-$300/acre of buffer/year and the nitrogen reduction cost is $14.43/lb N removed for riparian buffers and $1.24/lb N removed for saturated buffers, which are not defined in the report, and $14.43/lb removed for riparian buffers. IL estimated nitrogen reduction cost is $1.63/pound removed for nitrogen and $11.97/lb removed for phosphorus, with a total cost of $294/acre.

5.1.4 Perennial energy crops

For perennial energy crops in IA, information from a report published in the Ag Decision Maker (Duffy, 2008) was used. This approach factors in costs from land use change and land rent for corn and soybean rotation, which is used to represent the cost of switching from row crops to perennials. Assuming a production rate of 4 ton/acre with a value of $50/ton, the revenue is $200/acre. Including harvest, storage, transport, and land rent, the IA statewide average EAC is $390/acre.

Minnesota assumes a lifecycle cost of $30/acre/year, although it cites the IA Strategy, several sources were used in the development of this number (i.e. personal communications with biofuel producers). IL estimates $9.34/lb of nitrogen removed and $102.30/lb of phosphorus removed for perennial/energy crops equal to the pasture/hay acreage from 1987. For perennial/energy crops on 10% of tile-drained land, the cost is $3.18/lb of nitrogen removed and $250.07/lb of phosphorus. For perennial/energy crops on 1.6 million acres of highly erodible ground, the cost is $40.40/lb of phosphorus removed. The estimated IL cost per acre is $86.

5.1.5 Grazed pasture/hayland

Iowa calculated an EAC of $192/acre for pasture conversion and land retirement equal to the acreage from 1987. Minnesota reports the lifecycle cost as $30-$110/acre/year. Additionally, forage and biomass production is one of the three Environmental Quality Incentives Program (EQIP) priority areas in MN. In the Mississippi portion of MN, generally less than 0.5% of eligible land is taking advantage of this program. IL did not include this practice.

5.1.6 Land retirement

Iowa calculated an EAC of $192/acre for pasture conversion and land retirement equal to the acreage from 1987. MN has a cost of $6-110/acre/year for conservation easement and land retirement. Applying Conservation Reserve Program (CRP) on marginal cropland, MN suggests a $6.97/lb N reduced value. IL did not include this practice.

5.1.7 Nitrification inhibitor

The IA state average equal annualized cost is $-3/acre (benefit) and MN also has a cost of $-3/acre/year. IL has the cost of $2.33/lb removed. The estimated IL cost per acre is $7.

5.1.8 Nitrogen management

In IA, sidedressing all spring applied N has a state average equal annualized cost of $0/acre. In MN, the lifecycle cost is $-(7 to 26)/acre/year (benefit) for shifting fall application to spring and sidedressing with rate reduction. In IL, split application of 50% fall and 50% spring on tile drained corn acres has a cost of $6.22/lb N reduced, spring-only application on tile-drained corn acres has a cost of $3.17/lb N reduced and split application of 40% fall, 10% pre-plant, and 50% side dress has a cost of $3.21/lb N reduced. The estimated IL cost per acre is $17-18.

5.1.9 MRTN

The IA state average equal annualized cost is $-2/acre (benefit). The lifecycle cost in MN is $-(15 to 19)/acre/year (benefit) with a suggested $-(4.11)/lb N reduced (savings). IL estimated that the cost is $-(4.25)/lb N reduced (savings) for reducing N rate from current high rates (~10% of acres) to MRTN. The estimated IL cost per acre is $-8 (benefit).

5.1.10 Controlled drainage

Nitrogen: The IA state average EAC is $10/acre for installing controlled drainage on all applicable acres. The MN lifecycle cost is $9/acre/yr with a suggested cost efficiency of $2.40/lb N reduced.

5.1.11 Bioreactor

Nitrogen: The IA Average EAC is $10/acre. The MN cost is $18/acre/year with a suggested cost efficiency of $14.66/lb N reduced. IL calculated bioreactors to cost $2.21/lb N reduced. The estimated IL cost per acre is $17.

5.1.12 Soil test P

The IA state average equal annualized cost is $-11/acre (benefit). It is unclear what the cost associated is for MN. IL has a cost of $-48.75/lb P reduced (benefit). The estimated IL cost per acre is $-7.5 (benefit).

5.1.13 P banding

The IA average EAC of $15/acre. MN references the IA estimate and has a lifecycle cost of $15/acre/year.

5.1.14 Conservation tillage

IA has an average EAC of $-1/acre when comparing chisel plowing to moldboard plowing. When comparing no till to chisel plowing, the average EAC is $12/acre. MN has a cost of $-1/acre/year for conservation tillage and residue management. IL has a cost of $-16.6/lb P reduced for 1.8 million acres of conventional till with erosion rates >T convert to reduced, mulch, or no-till. The estimated IL cost per acre is $-17 (benefit).

6 Summary

All three state strategies took a considerable amount of time and enlisted numerous scientists and professionals to develop robust estimates on the effectiveness of agricultural BMP's. While there is a great deal of similarity in the efficiencies among the states, appreciable differences exist (see figures in Appendix B and C). In order for the Gulf Hypoxia Action Plan to be effective, it is critical that the assumptions and data sources used to develop BMP efficiency estimates are aligned. Establishing a consistent BMP currency among states will also help multi-state funding programs to prioritize resources and measure progress. State credit trading programs are also dependent on regional markets with consistent trading currencies. In order to ensure the use of the most accurate science for regional agricultural BMP efficiencies, it would be advantageous to highlight the most representative numbers for each practice. If there are real and observed regional differences, due to climate, for example, these should also be highlighted. Calling out regional differences can help inform decision making as well as add justification for regional decision making.

All practice efficiencies for each state have been summarized in Table 6-1 with general cost information summarized in Table 6-2. For more details, refer to above sections or the original state strategies. There was general agreement between the three strategies. The obvious exceptions are:

1) Cover crops – MN has about a 20% higher N removal efficiency than IA or IL and IL has about a 20% higher P removal efficiency than IA or MN.
2) Land retirement – IA has about a 20% higher P removal efficiency than MN (IL did not evaluate).
3) Nitrogen management – the states evaluated this differently, which is likely one cause for the discrepancies, though, generally, IL and MN have put higher N reduction on this.
4) Bioreactors – IA has the highest N reduction efficiency for bioreactors at 43% compared to the IL efficiency at 25% and the MN efficiency at 13%. There are likely regional as well as design factors accounting for these differences. Also, as bioreactors are a newer agricultural BMP, the body of literature supporting the efficiencies tends to be limited.

Table 6-1. Overall practice comparison between states for nitrogen and phosphorus.

	Nitrogen Reduction			Phosphorus Reduction		
Practice	Iowa	Minnesota	Illinois	Iowa	Minnesota	Illinois
Wetlands	52%	50%	50%	0%	0%	0%
Buffers	91%	95%	90%	58%	58%	50% (25%[*])
Cover Crops	31% (28%[^])	51% (10%[&])	30%	29%	29%	30% (50%[@])
Perennial Energy Crops	72%	95%	90%	34%	34%	90% (50%[*])
Land Retirement	85%	83%	NI	75%	56%	NI
Grazed Pasture or Hayland	85%	95%	NI	59%	59%	NI
Controlled Drainage	33%	33 to 44%	NI			
Nitrification Inhibitor	9%	14%	10%			
Nitrogen Management			[+]			
→Timing & rate reduction	NI	26%	NI			
→Timing	6%	NI[#]	7.5 to 10%		NA	
→Sidedress	5%	NI[#]	NI			
→Split application	NI	NI	15 to 20%			
Maximum Return to Nitrogen (MRTN)	10%	16%	10%			
Bioreactor	43%	13%	25%			
Conservation Tillage				33% (90%[†])	63%	50%
Soil Test Phosphorus (STP)		NA		17%	17%	7%
Phosphorus Banding				24%	24%	NI

* Reduced efficiency on tile drained land.
^ Oats have a slightly lower efficiency than rye.
& For cover crops planted after corn or soybeans grown for grain
@ Used with extended rotation (corn-soybeans-wheat)
NI = Not included in strategy.
NA = Not applicable.
+ The larger number is applicable to central and southern Illinois.
# Included in the “Stacked” number
† If moving to no-till from chisel tillage.

Table 6-2. General cost information from the state strategies. Parenthesis () represents a negative value (benefit).

Practice	Iowa EAC ($/ac/yr)	Minnesota ($/ac/yr)	Illinois		
			N ($/lb)	P ($/lb)	$/ac/yr
Cover Crops	45 to 49	53	3.21 to 11.02	24.5 to 130.4	29
Wetland	15	6-18	4.05 to 5.06		60.63
Buffer	231	30 to 300	1.63	11.97	294
Perennial Energy Crops	390	30	3.18 to 9.34	40.4 to 102.3	86
Grazed Pasture/Hayland	192	6 to 110			
Land Retirement	192	6 to 110			
Nitrification Inhibitor	(3)	(3)	2.33		7
Nitrogen Management	0	(7 to 26)	3.17 to 6.22		17 to 18
Maximum return to Nitrogen Application Rate	(2)	(15 to 10)	(4.25)		(8)
Controlled Drainage	10	9			
Bioreactor	10	18	2.21		17
Soil Test Phosphorus	(11)			(48.75)	(7.5)
Phosphorus Banding	15	15			
Conservation Tillage	(1) to 12	(1)		(16.6)	(17)

7 Recommended Consensus

The overall goal, is to come to agreement on whether the differences between states could be reconciled to assist with general decision making as well as comparisons of cost efficiency. A strawman table with efficiencies is provided in Table 7-1. This table is simply to suggest some general numbers and to help facilitate some discussion.

Table 7-1. Consensus efficiency table - strawman.

Practice	Nitrogen Reduction	Phosphorus Reduction
Wetlands	50%	0%
Buffers	90%	55%
Cover Crops	30%	30%
Perennial Energy Crops	90%	35%
Land Retirement	85%	65%
Grazed Pasture or Hayland	90%	60%
Controlled Drainage	35%	NA
Nitrification Inhibitor	10%	NA
Maximum Return to Nitrogen (MRTN)	10%	NA
Conservation Tillage	NA	60%
Soil Test Phosphorus (STP)	NA	15%
Phosphorus Banding	NA	25%

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9 Appendix A: State Strategy Teams

Each state had designated experts to highlight important features and points through the development of each unique strategy.

9.1 Iowa

Table 9-1. Iowa Nutrient Reduction Strategy team.

Member	Affiliation
John Lawrence	ISU CALS
Matt Helmers	ISU CALS
Tom Isenhart	ISU CALS
Jim Baker	ISU CALS
Mike Castellano	ISU CALS
Reid Christianson	ISU CALS
Bill Crumpton	ISU CALS
Rick Cruse	ISU CALS
Mike Duffy	ISU CALS
Phil Gassman	ISU CALS
Antonio Mallarino	ISU CALS
John Sawyer	ISU CALS
Dave Webber	ISU CALS
Dean Lemke	IDALS
Shawn Richmond	IDALS
Keith Schilling	IDNR
Calvin Wolter	IDNR
David James	USDA ARS
Dan Jaynes	USDA ARS
John Kovar	USDA ARS
Mark Tomer	USDA ARS
Katie Flahive	USEPA
Eric Hurley	USDA NRCS

9.2 Minnesota

Table 9-2. Minnesota Nutrient Reduction Strategy team.

Committee/Team	Members
Strategy Development Team - MPCA	Wayne P Anderson
	David Wall
	Dennis Wasley
Strategy Development Team - Tetra Tech	Jennifer Olson
	Kellie DuBay
	Jon Butcher
	Heather Fisher
	Kevin Kratt
	Maureen Habarth
Communication Team	CoriAhna Rude-Young
	Forrest Peterson
Agriculture Focus Group	John Nieber
	Bill Lazarus
	Joe Magner
	Bruce Wilson
	Al Kean
	Chris Lenhart
	Bobbi Hernandez
	John Lamb
	Fabian Fernandez
	David Mulla
	Bruce Montgomery
	Gary Sands
	Dave Wall
	Wayne Anderson
	Carissa Spencer
	Larry Baker
	John Baker
	Mike Schmitt
	Forrest Izuno
	Heidi Peterson
	Joshua Stamper
	Nick Gervino
	Larry Gunderson
	Bill Thompson
	Greg Johnson
	Mark Dittrich
	Rob Sip

Wastewater and Point Source Focus Group	Marco Graziani
	Dennis Wasley
	Scott Casey
	Aaron Luckstein
	Larry Rogacki
	Mary Gail Scott
	Judy Sventek
	Steve Weiss
	Nicole Blasing
	Bruce Henningsgaard
	Bill Priebe
	Mike Trojan
Interagency Coordination Team	Rebecca Flood
Steering Committee Members	MPCA – Rebecca Flood, Mark Schmitt, Gaylen Reetz
	BWSR – Steve Woods
	University of Minnesota – Mike Schmitt
	MDA – Greg Buzicky
	DNR – Steve Hirsch, Steve Colvin
	MDH – Tom Hogan
	Public Facilities Authority – Jeff Freeman
	Met Council – Leisa Thompson
	NRCS – Don Baloun
	USGS – Jim Stark
Work Group Members	MPCA – Jeff Stollenwerk, Wendy Turri, Marni Karnowski, Randy Hukreide, Doug Wetzstein, Glenn Skuta, Katrina Kessler
	BWSR – Tim Koehler, Marcey Westrick
	University of Minnesota - Carl Rosen, John Nieber, Gary Sands
	MDA – Dan Stoddard, Rob Sip, Mary Hanks, Bruce Montgomery, Ron Struss
	DNR – Dave Wright
	MDH – Randy Ellingboe
	Met Council – Judy Sventek, Mary Gail Scott, Larry Rogacki
	NRCS – Carissa Spencer, Myron Taylor
	USGS – Dave Lorenz
	FSA – Wanda Garry

9.3 Illinois

Table 9-3. Illinois Nutrient Loss Reduction Strategy Policy Working Group Members.

Member	Affiliation
Kay Anderson	American Bottoms Regional Wastewater Treatment
Tim Bachman	Urbana-Champaign Sanitary District
Howard Brown	Illinois Council on Best Management Practices
Dr. George Czapar	University of Illinois Extension
Dr. Mark David	University of Illinois at Urbana-Champaign, Department of Natural Resources and Environmental Sciences
Kerry Goodrich	U.S. Department of Agriculture, Natural Resources Conservation Service
Albert Ettinger	Attorney
Liz Hobart	Illinois Council on Best Management Practices
Dr. Stacy James	Prairie Rivers Network
Jim Kaitschuk	Illinois Pork Producers Association
Bradley Klein	Environmental Law and Policy Center
Lauren Lurkins	Illinois Farm Bureau
Rick Manner	Urbana-Champaign Sanitary District
Dr. Greg McIsaac	University of Illinois at Urbana-Champaign, Department of Natural Resources and Environmental Sciences
Nick Menninga	Downers Grove Sanitary District
Alec Messina	Illinois Environmental Regulatory Group
Emerson Nafziger	University of Illinois at Urbana-Champaign, Department of Crop Sciences
Rich Nichols	Association of Illinois Soil and Water Conservation Districts
Jean Payne	Illinois Fertilizer and Chemical Association
Dr. Gary Schnitkey	University of Illinois at Urbana-Champaign, Department of Agricultural and Consumer Economics
Dr. Cindy Skrukrud	Sierra Club
David St. Pierre	Metropolitan Water Reclamation District of Greater Chicago
Rod Weinzierl	Illinois Corn Growers Association
Warren Goetsch	Illinois Department of Agriculture
Marcia Willhite	Illinois Environmental Protection Agency

10 Appendix B: Nitrogen Reductions by Practice Location

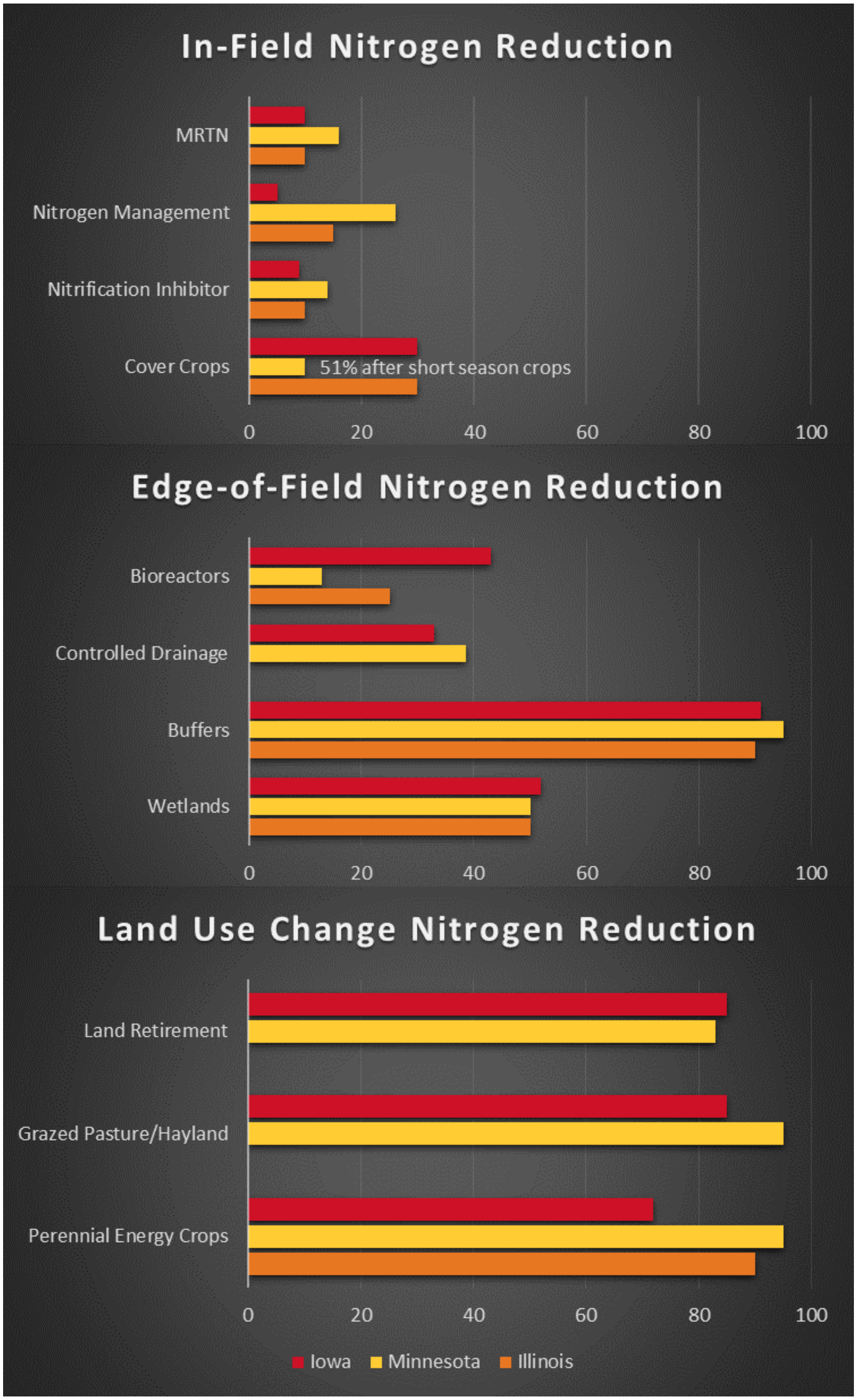

Figure 10-1. Nitrogen reductions (%) for each state based on practice type and location. Note that nitrogen management was defined differently in each state.

11 Appendix C: Phosphorus Reductions by Practice Location

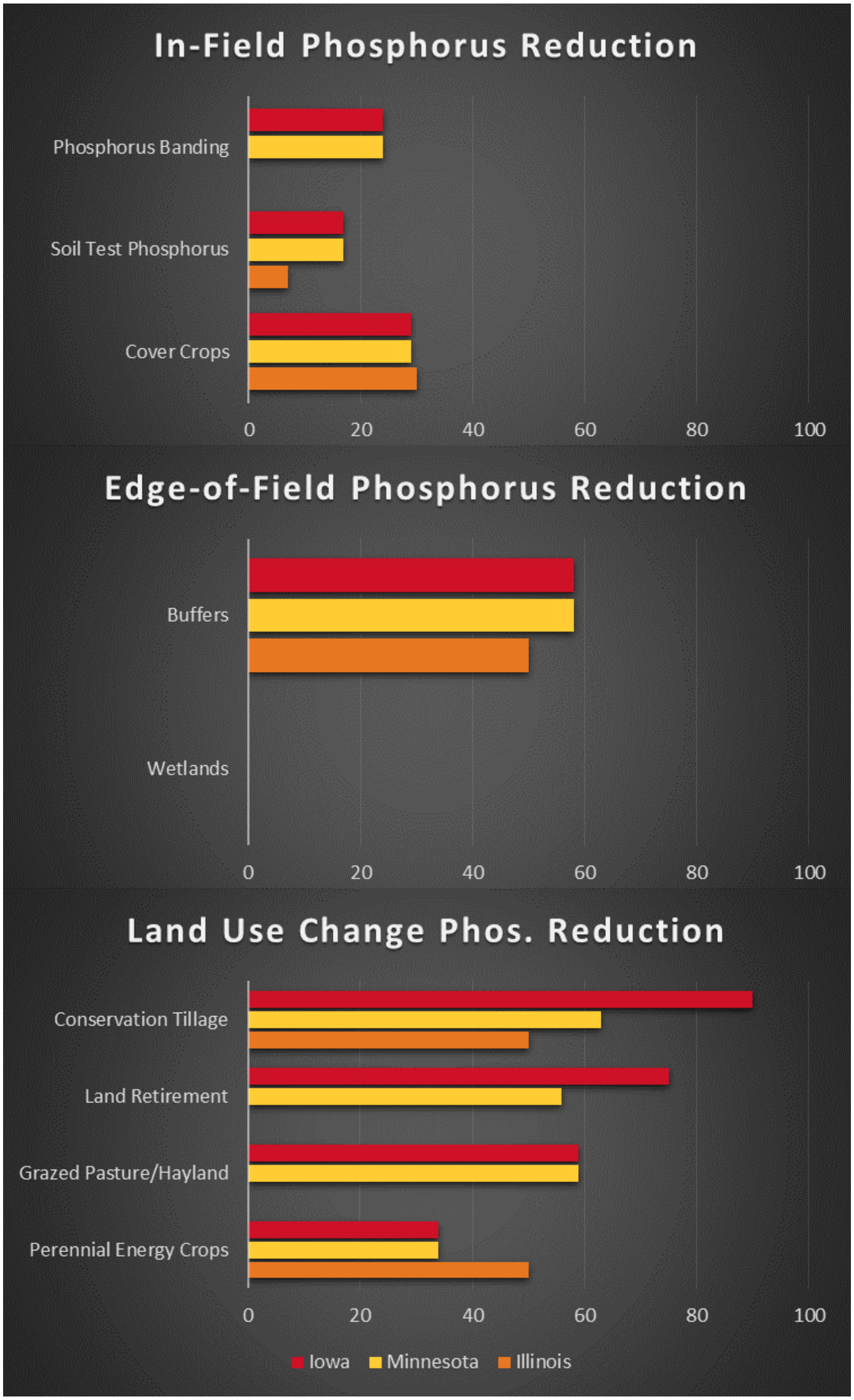

Figure 11-1. Phosphorus reductions (%) for each state based on practice type and location.