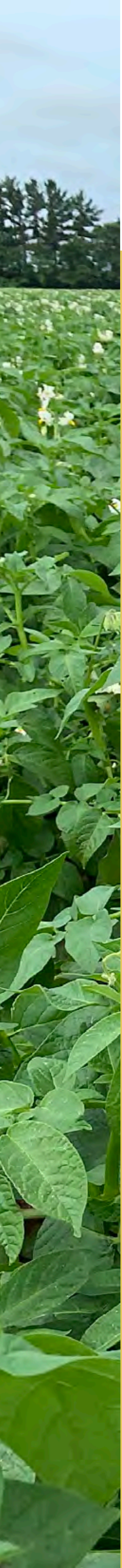

# Preliminary Assessment of the Potential Economic Impacts of Proposed Changes to **NR 151 for Agricultural Operations**


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# Executive Summary

## BACKGROUND

In 2020, the Wisconsin Department of Natural Resources (WDNR) began a process to introduce new targeted performance standards and prohibitions intended to improve groundwater quality. The proposed targeted performance standards and prohibitions would be integrated into state law through chapter NR 151, Wisconsin Administrative Code addressing Runoff Management. As part of their process to consider impacts of the proposed rule changes, WDNR engaged a team at the University of Wisconsin-Madison to conduct a third-party assessment examining the potential economic impacts of the proposed performance standards, including conducting farmer focus groups and a review of existing programs in nearby states. This report is that assessment.

The proposed rule changes target more than 6 million cropped acres and would require annual average nitrogen leaching to be less than 2.2 pounds per acre inch of groundwater recharge for each farm's cropped acres in the targeted areas and annual average nitrogen leaching to be less than 2.2 pounds per acre inch of groundwater recharge over the rotation for each field within these targeted areas. Fall application of commercial nitrogen fertilizer after September 1 would be prohibited in these targeted areas, except for fall seeded crops (including cover crops) or for established perennial crops at a rate of no more than 36 pounds per acre. A subset of the proposed target areas encompassing roughly 1.7 million acres would also be prohibited from fall and winter applications of liquid manure after September 1, except for establishing fall seeded crops (including cover crops), applied to an established crop, or applied at a rate that is no more than 25% of the annual application rate for the nutrient management plan.

Little public data exist on farmer nutrient and manure management in the state. The available data show that a large majority of commercial nitrogen fertilizer is applied to corn in Wisconsin, with applications totaling more than 200 thousand tons annually. The data on the timing of nitrogen fertilizer applications suggest that fall applications are uncommon in the state, with the largest portion of the nitrogen side-dressed after planting, followed closely by pre-plant applications in the spring. Dairy manure accounts for almost all the manure applied to crops in the state, with beef a distant second. Almost all the applied manure is produced on the farm with an average hauling distance that is much less than a mile; fall manure application is more common than spring application. In total, roughly 90 to 110 thousand tons of nitrogen were applied as manure to corn in 2005 and 2010, or less than one third of all nitrogen applied to corn.

## MAIN FINDINGS

The analysis examines the potential economic costs and management issues for the following six concerns that emerged from a series of farmer focus groups:

1) Costs for nutrient management plans,

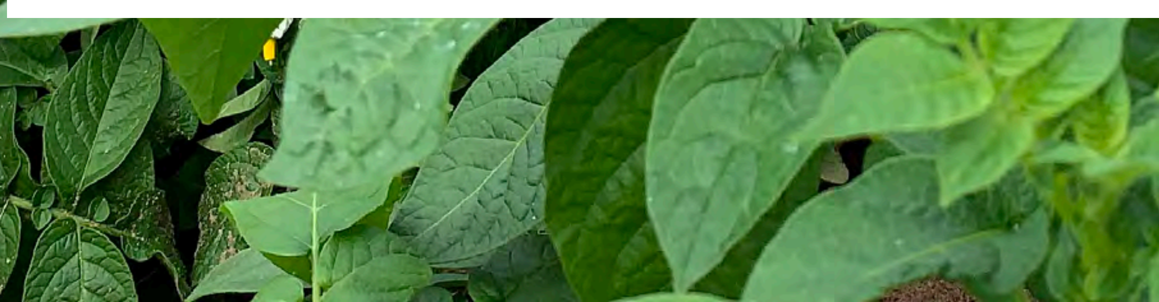
2) Increased manure management costs,

3) Crop yield losses,

4) Losses from expanding crop rotations,

5) Increased farm management costs, and

6) Local economic impacts.



Unfortunately, current data are generally insufficient to develop data-driven estimates of the economic impacts for many of these concerns, and so numerous assumptions were required for analysis and substantial uncertainty exists for the reported estimated economic impacts. **Nevertheless, our main findings for the potential economic impacts of the proposed changes to NR 151 for agricultural operations are:**

- The proposed rule change does not change existing requirements that all Wisconsin agricultural operations have nutrient management plans and does not impose nutrient management plans as a new cost. Growers in the targeted areas who do not have nutrient management plans will need to develop them for their farm, consistent with existing cost share and compliance provisions. The cost to pay for nutrient management plans for the targeted acres (although not a new regulatory cost) could range from $20 to $43 million annually if farms had to hire consultants to develop plans, but is likely near $27 million, or roughly $8 million for growers after cost-share assistance. This range does not account for the value of reduced farmer managerial time from no longer doing their own crop fertility planning, or the effect of these plans on fertilizer costs or crop yields.

- Estimated impacts on manure management costs are unknown without more data, but for a sense of their potential magnitude, if 25% of the state's manure had to be moved an extra quarter mile, costs would increase $7.1 to $8.6 million, or about 10%.

- Crop yield losses from reducing nitrogen would be difficult to measure directly due to the substantial yield variability from other sources and the "flatness" of the yield response curve. However, using a 10% nitrogen reduction and 1% yield loss based on work from Iowa, annual losses would range from $4 million to more than $11 million for corn depending on prices and total about $2.4 million for potatoes.

- Losses from expanding crop rotation are difficult to estimate without more clarity on the process used to estimate nitrogen leaching losses. However, a simplified process indicates that the likely effect would be a shift to more corn silage and alfalfa and reduced acres of corn grain in the state, and a decline in processing vegetables such as sweet corn and snap beans in the Central Sands.

- Increased farm management costs seem likely, but preliminary analysis suggests that overall, these will be substantially less than the other impacts, likely less than $1 million annually.

- Impacts on farm income would have ripple effects throughout the state's economy that would increase the monetary impacts on the local economy, with additional losses of $0.70 for each $1 of loss in net farm income.

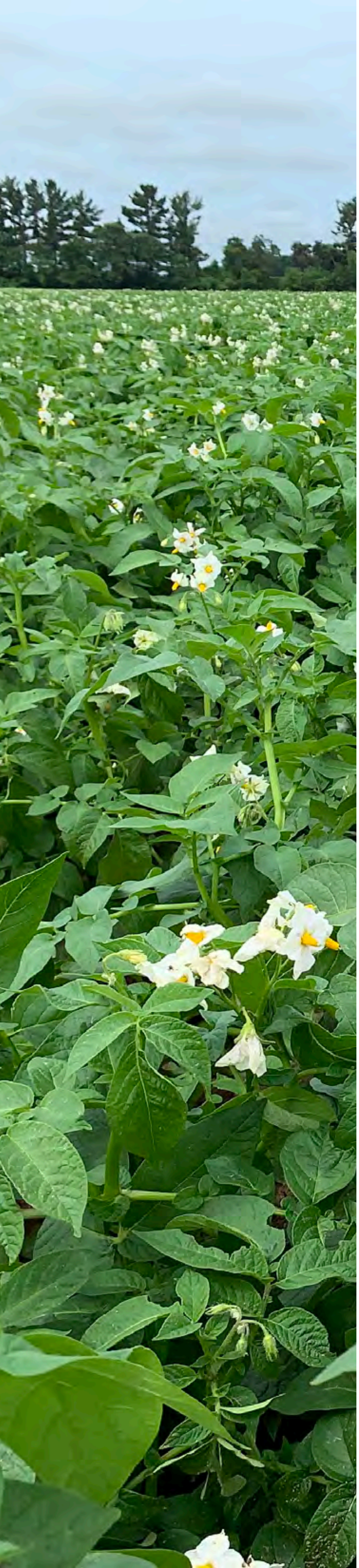
**Based on this process, we have two primary recommendations.**

- First, we recommend renewing partnerships among key stakeholders to generate current data on nitrogen and manure management in Wisconsin. Lack of such data hampers data-driven analysis to understand the economic costs and benefits of improving groundwater quality in Wisconsin.

- Second, we recommend renewing existing partnerships and developing new working partnerships among knowledgeable experts and farmers to conduct applied research specifically to develop a practical process for calculating nitrogen losses from cropping systems and to identify management practices that help reduce these losses.

Once the costs and benefits of improving groundwater quality are better estimated and practical ways to achieve groundwater quality goals are identified, outreach and educational programming can be updated.

The desire to make water quality improvements is prevalent among many key stakeholders and the necessary partnerships already exist. For example, the farmer focus groups conducted for this project show that farmers are generally willing to adopt practical management practices that they believe will help improve groundwater quality. The people and systems are in place, but need a renewed commitment to the vision that we can improve Wisconsin's groundwater quality with practical changes.



# Contents

## INTRODUCTION

# Purpose and Outline

This white paper provides a preliminary assessment of potential economic impacts of proposed changes to NR-151 regarding measures to mediate nitrate contamination of groundwater. The proposed changes were introduced by Wisconsin Department of Natural Resources (WDNR) in spring of 2021 as a set of targeted performance standards and prohibitions intended to improve groundwater quality by reducing nitrate concentrations in groundwater (WDNR 2021a). If approved, the proposal would be incorporated into Chapter NR 151, Wisconsin Administrative Code addressing Runoff Management (https://docs.legis.wisconsin.gov/code/admin_code/nr/100/151).

As part of their process to consider impacts of the proposed rule changes, WDNR engaged a team at the University of Wisconsin-Madison to conduct a third-party assessment examining the potential economic impacts of the proposed performance standards and prohibitions. This report is this assessment, which focuses primarily on the potential economic impact to agriculture and draws from a review of literature and published reports, focus groups with farmers conducted in winter 2021, and data on Wisconsin cropping and agricultural management practices. As a point of clarification, this assessment is separate from the required economic assessment conducted by the Wisconsin DNR (WDNR 2021b, available on the WNDR (https://dnr.wisconsin.gov/topic/nonpoint/nr151nitrate.html), and it is not a comprehensive cost-benefit analysis of the proposed rule.

First a summary of the proposed rule changes is presented with a focus on the implied impact on farming practices, and then a summary of the available data on farmer use and management of nitrogen fertilizer and manure in the state. Next, drawing upon salient themes that emerged from a series of farmer focus groups, the analysis examines potential economic costs and management issues influenced by proposed rule changes. The report concludes with a summary of key issues and reflections on data limitations. Additional materials that provide background and context for the analysis are included as appendices.

# Summary of Proposed Changes to NR 151

In 2020, Wisconsin Department of Natural Resources (WDNR) began a process to introduce new targeted performance standards and prohibitions intended to improve groundwater quality. The proposed targeted performance standards and prohibitions would be integrated into state law through chapter NR 151, Wisconsin Administrative Code addressing Runoff Management. As stated on the WDNR website:

> *Consistent with state statutes, NR 151 directs the DNR to promulgate rule performance standards to meet water quality standards and address specific issues either geographically or by activity. The NR 151 rule modification is to develop a targeted performance standard to abate nitrate pollution in areas of the state with highly permeable soils which are susceptible to groundwater contamination (sensitive areas) for the purpose of achieving compliance with the nitrate groundwater standards. The rule revisions will define sensitive areas in the state and the performance standards needed to protect groundwater quality in these areas.* [source: https://dnr.wisconsin.gov/topic/nonpoint/nr151nitrate.html]

Figure 1 is a screen shot from the DNR web page cited above (WDNR 2021c) showing the proposed target areas for the proposed rule. Consistent with current NR 151 requirements in effect since 2005 (WAC, Chpt NR151.07), the proposed rule anticipates that those farming these sensitive areas will have a nutrient management plan. The nutrient management plan would include all acreage they farm in these targeted areas and would need to specify an annual average nitrogen leaching less than 2.2 pounds per acre inch of groundwater recharge. In addition, each field within these targeted areas would need to achieve an annual average nitrogen leaching less than 2.2 pounds per acre inch of groundwater recharge over the rotation. Additionally, fall application of commercial nitrogen fertilizer after September 1 is prohibited in these targeted areas, except if it is needed for fall seeded crops (including cover crops), or applied to an established perennial crop at a rate of no more than 36 pounds per acre.

Figure 2 is a screen shot from the DNR web page (WI DNR 2021c) showing a subset of the proposed target areas shown in Figure 1. The subset of targeted areas in Figure 2 would also be prohibited from fall and winter applications of liquid manure after September 1, except for establishment of fall seeded crops (including cover crops), applied to an established crop, or applied at a rate that is no more than 25% of the annual application rate for the nutrient management plan.

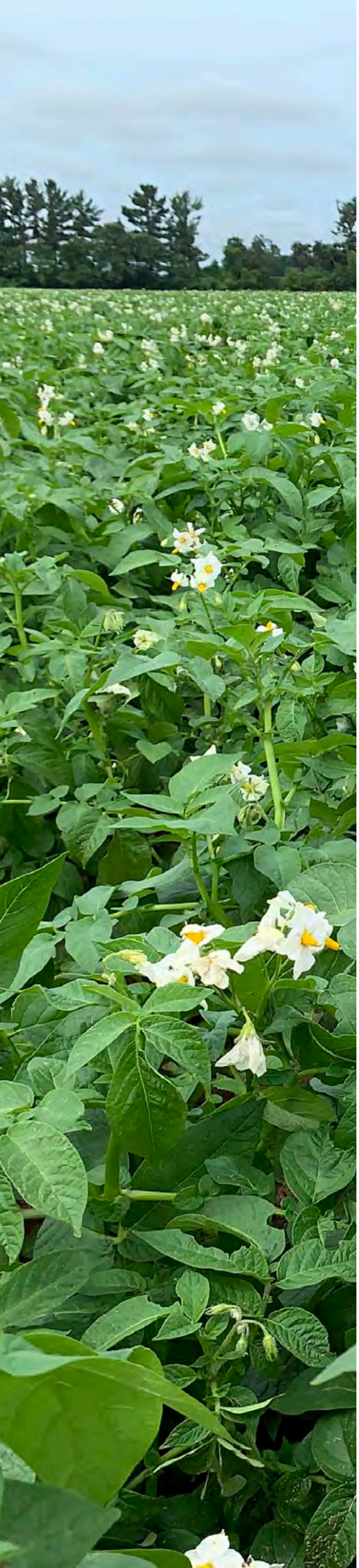


**Figure 1.** Cropland in the proposed targeted area subject to performance standard of less than 2.2 pounds of nitrogen leaching per acre-inch of groundwater recharge per year averaged over the rotation and prohibited from making applications of commercial nitrogen fertilizer after September 1 except for specified exceptions

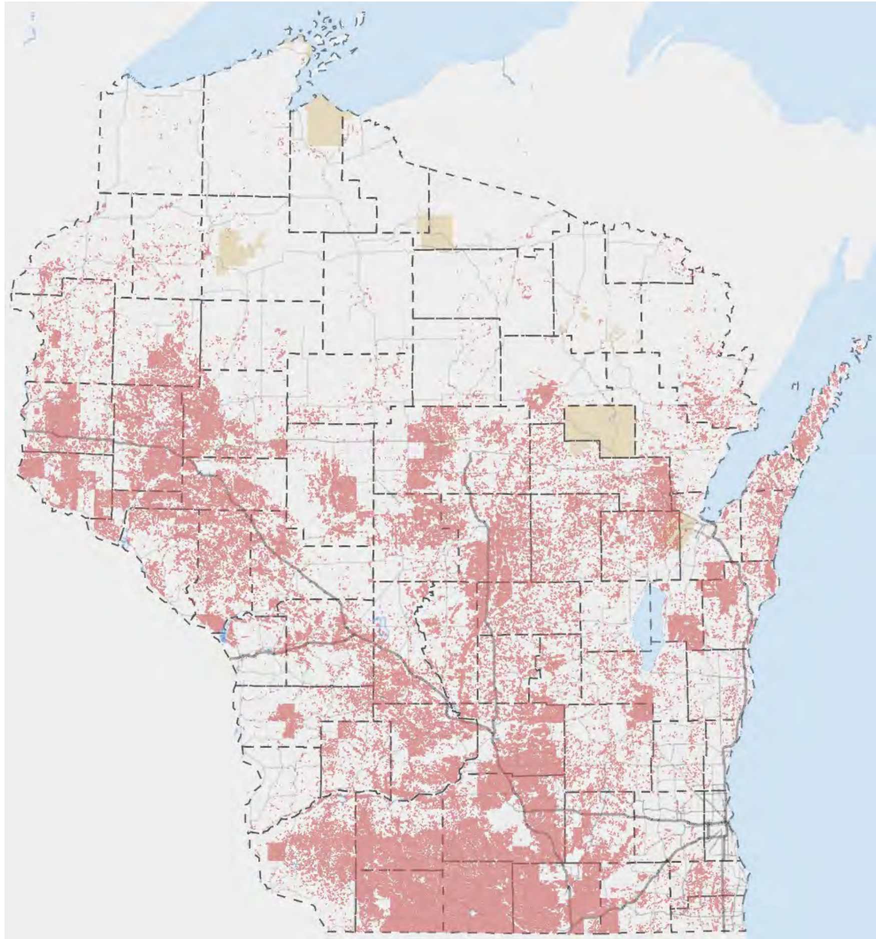


Table 1 reports total acres by crop or land use in 2019 in the proposed target areas illustrated in Figure 1 and the percentage of the state total this acreage represents for each crop. These acreages were provided by WDNR based on GIS data defining the targeted areas and crop information from the USDA NASS Cropland Data Layer (USDA NASS 2021e). Table 1 shows that almost 6.2 million acres are in the proposed targeted areas. The target areas include essentially all Wisconsin potato acres and 50% to 60% of corn, alfalfa, soybean, non-alfalfa hay, and vegetable acres. A little more than one-third of all pasture in the state is in the proposed targeted areas, and a little less than a third of the small grains grown in the state. Acres in the proposed areas illustrated in Figure 2 prohibiting fall-winter liquid manure applications were not available, but DNR staff estimated approximately 1.7 million acres of agricultural land in the proposed areas, or about a quarter of the acres in the larger proposed target areas illustrated in Figure 1.

In brief, the proposed changes to NR 151 are:

1) Farms would have a nutrient management plan so that

   a. Annual average nitrogen leaching would be less than 2.2 pounds per acre inch of groundwater recharge averaged across all land farmed in the targeted areas in Figure 1,

   b. Each field in the targeted areas in Figure 1 would have annual average nitrogen leaching less than 2.2 pounds per acre inch of groundwater recharge over the rotation.

2) Application of commercial nitrogen fertilizer after September 1 would be prohibited on all land in the targeted areas in Figure 1, except to fall seeded crops (including cover crops), or to an established perennial crop at a rate of no more than 36 pounds per acre.

3) The subset of targeted areas in Figure 2 would also be prohibited from fall and winter applications of liquid manure after September 1, except for establishment of fall seeded crops (including cover crops), applied to an established crop, or applied at a rate that is no more than 25% of the annual application rate for the nutrient management plan.

**Figure 2.** Subset of the cropland in the proposed targeted area also prohibited from making applications of liquid manure after September 1 except for specified exceptions

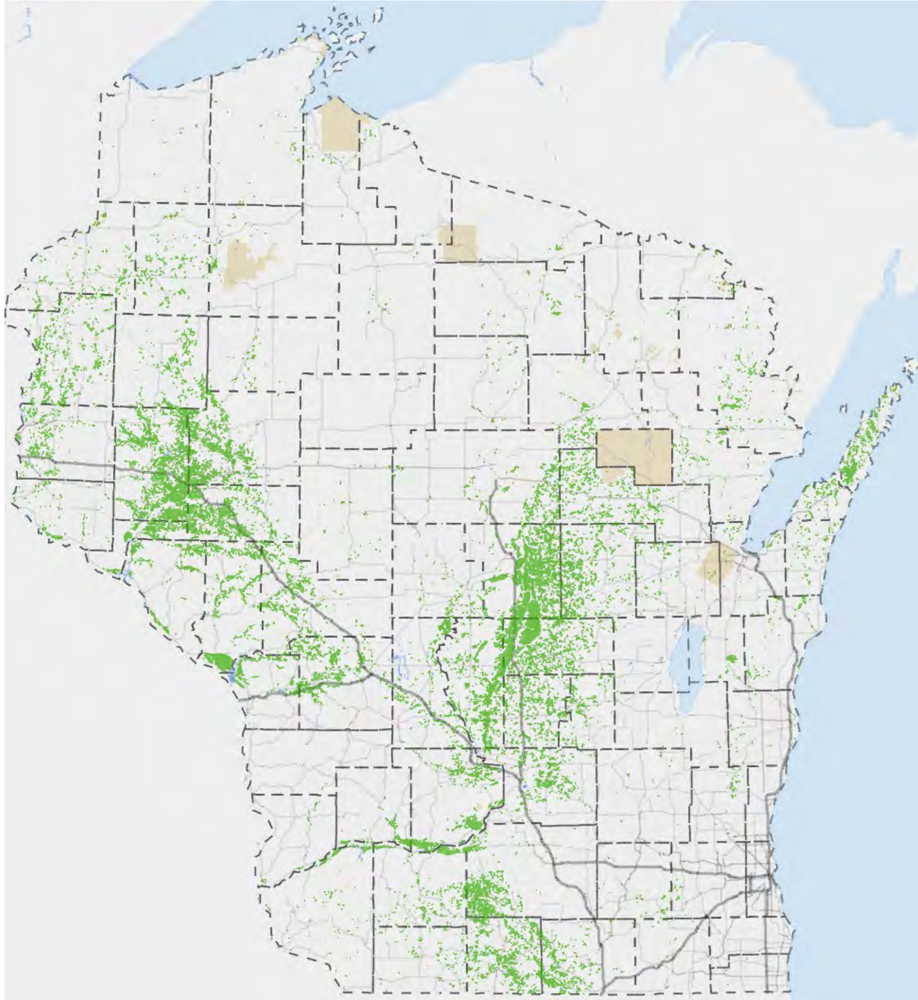
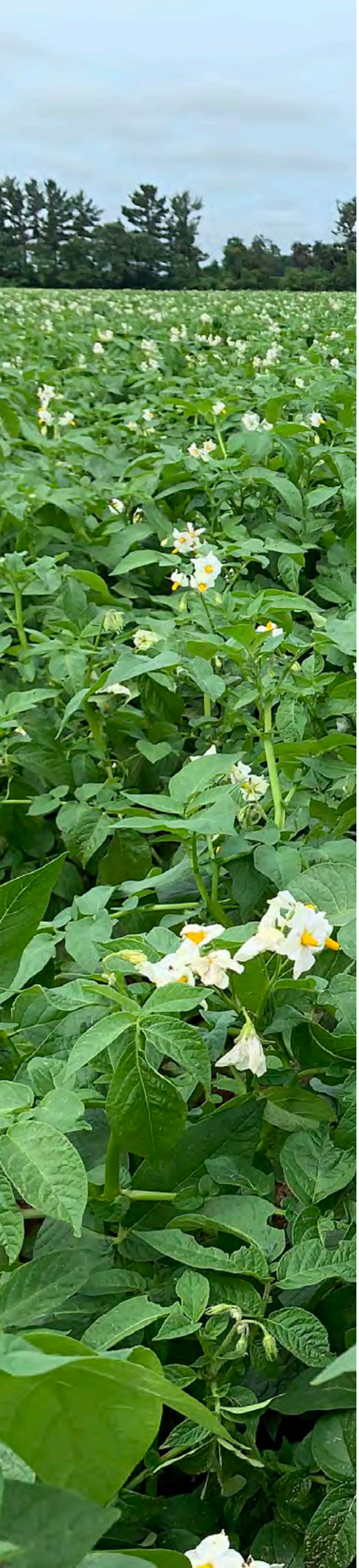


**Table 1.** Acres in proposed targeted areas by crop or land use & percentage of the state total

| Crop | Acres in Proposed Targeted Areas | Total Acres Planted in Wisconsin in 2019[a] | % Total Acres in Wisconsin |
|---|---|---|---|
| Corn | 2,230,283 | 3,800,000 | 58.7% |
| Pasture | 1,161,289 | 3,028,000 | 38.5% |
| Alfalfa | 972,207 | 1,680,000 | 57.9% |
| Soybeans | 948,856 | 1,880,000 | 50.5% |
| Fallow/Idle | 369,335 | 607,000 | 60.5% |
| Grass/Non-Alfalfa Hay | 208,152 | 420,000 | 49.6% |
| Small Grains | 144,172 | 484000 | 29.8% |
| Vegetables | 78,369 | 155,300 | 50.5% |
| Potatoes | 66,714 | 70,000 | 95.3% |
| Other | 6,442 | | |
| **Total** | **6,185,819** | | |

[a] Planted acres data for 2019 from USDA NASS (2021a) except Pasture and Fallow/Idle acres from 2012 Census of Agriculture (USDA ERS 2017)



## Report Focus, Caveats, and Limitations

By design, the use of performance standards in public policy provides flexibility and customized approaches for affected entities to achieve compliance with a standard. In this case, if the proposed performance standards become part of NR 151, then Wisconsin Department of Agriculture, Trade, and Consumer Protection (DATCP) would further propose and finalize practices that farmers can use to satisfy the standard. Thus, the specific practices and flexibilities that may be used to satisfy the performance standards are developed by DATCP after the standards are changed, not before. This sequencing and uncertainty built into the process complicates analysis of potential economic impact. Assumptions are made about how farmers would likely satisfy the proposed rule, and then estimated impacts are derived from these assumptions. However, the actual practices that would be needed to satisfy the proposed rule if it were enacted are a significant unknown at this time and cost estimates reflect a range of potential values based on assumptions.

The analysis is further complicated by the lack of current publicly accessible data about the use and extent of various agricultural management practices in Wisconsin. Although individual producers, trade associations, agronomists, and researchers have anecdotal information and insights on practices and the extent of their use in Wisconsin agriculture, rigorous regional or statewide data are lacking. The specific costs associated with specific technical practices potentially available to satisfy performance standards and a lack of statewide or regional data on current use of practices for the major crops and soils in the state are significant research and data collection needs for establishing more accurate estimates.

Finally, among the other uncertainties, implementation schedules and timelines will also influence economic impact. DNR's Draft Economic Impact Assessment (WDNR 2021b) assumes a 10-year implementation and compliance horizon, based on anticipated funds available for cost sharing for cover crops and manure storage. A longer implementation timeframe is also possible. For example, nutrient management plans have been required for all of Wisconsin's agricultural since at least 2008 (NR 151.07), but due to a variety of factors (e.g., limited cost share funding required for enforcement) as of 2019 nutrient management plans have been filed for less than 40% of Wisconsin's agricultural land (Wisconsin DATCP 2019). A similar compliance timeline would reduce the estimates for annual cost and overall economic impact to Wisconsin agricultural businesses.

## BACKGROUND AND CONTEXT

## Nitrogen Management in Wisconsin

Primarily based on available USDA data, this section summarizes nitrogen and manure use and management in Wisconsin. The purpose is to provide some context regarding farmer use of nitrogen and manure in Wisconsin to better understand how the proposed rule would impact farm management of nitrogen fertilizer and manure.

### Commercial Nitrogen Use in Wisconsin

USDA publishes state-level nitrogen use data for major crops, collected as part of the USDA's Agricultural Resources Management Survey (ARMS). The data are available for different years for major crops on the USDA's Quick Stats online tool (https://quickstats.nass.usda.gov/) or an online report generator (USDA ERS 2021). Tables 2-4 summarize select variables from these surveys and calculations based on them.

Table 2 reports the available data for corn and soybean for all years available from 2005 to the present – five survey years for corn and six for soybean. For nitrogen use, data include the percentage of planted acres receiving commercial (non-manure) nitrogen fertilizer and the average application rate as the total pounds of nitrogen applied per treated acre per year. The total planted acres for each year are included, and then total tons of nitrogen applied calculated based on planted acres, the percent of acres treated, and the average application rate. Table 3 reports comparable data, but for oats and wheat, the two most important small grains in Wisconsin based on planted acres. Note that for wheat, the percent of acres treated and the average application rates are for Michigan as a proxy for Wisconsin, because no USDA data were available for wheat in Wisconsin. The type of wheat grown (soft red winter wheat), production systems and climate are similar.

Table 2 shows that essentially all corn acres in Wisconsin receive commercial nitrogen fertilizer, with an annual application rate of slightly more than 100 pounds of nitrogen per acre. This average rate includes all applications: pre-plant, starter, and any in-season applications.

**Table 2.** USDA data on nitrogen use on corn and soybean in Wisconsin

| | Corn | | | | Soybean | | | |
|---|---|---|---|---|---|---|---|---|
| Year | Planted Acres | % Acres Treated | Rate (lbs/ac) | Nitrogen (tons) | Planted Acres | % Acres Treated | Rate (lbs/ac) | Nitrogen (tons) |
| 2020 | 4,000,000 | | | | 2,000,000 | 55 | 19 | 10,450 |
| 2019 | 3,800,000 | | | | 1,750,000 | | | |
| 2018 | 3,900,000 | 97 | 113 | 213,740 | 2,220,000 | 37 | 20 | 8,214 |
| 2017 | 3,900,000 | | | | 2,150,000 | 59 | 19 | 12,051 |
| 2016 | 4,050,000 | 96 | 110 | 213,840 | 1,960,000 | | | |
| 2015 | 4,000,000 | | | | 1,880,000 | 39 | 18 | 6,599 |
| 2014 | 4,000,000 | 98 | 104 | 203,840 | 1,800,000 | | | |
| 2013 | 4,100,000 | | | | 1,580,000 | | | |
| 2012 | 4,350,000 | | | | 1,710,000 | 45 | 17 | 6,541 |
| 2011 | 4,150,000 | | | | 1,620,000 | | | |
| 2010 | 3,900,000 | 93 | 92 | 166,842 | 1,640,000 | | | |
| 2009 | 3,850,000 | | | | 1,630,000 | | | |
| 2008 | 3,800,000 | | | | 1,610,000 | | | |
| 2007 | 4,050,000 | | | | 1,400,000 | | | |
| 2006 | 3,650,000 | | | | 1,650,000 | 31 | 15 | 3,836 |
| 2005 | 3,800,000 | 93 | 107 | 189,069 | 1,610,000 | | | |

Source: USDA NASS Quick Stats (https://quickstats.nass.usda.gov/)

Table 2 also shows that over the last several years, 30% to 60% of soybean acres in the state have typically received nitrogen fertilizer, with an average rate ranging for 15 to 20 pounds per acre. These applications are likely starter fertilizer. Corn planted acres have been stable at around an average of 4 million acres each year, ranging from 3.65 million in 2006 to 4.35 million in 2012. Soybean acres have increased in the state, reaching 2 million or more acres three times in the last four years. Using these data to calculate total nitrogen fertilizer use shows that use on corn dominated commercial fertilizer applications in the state. Total use on corn exceeded 200,000 tons in the last three survey years, while soybeans barely reached a total use of 12,000 tons at its highest.

Little USDA data was available for nitrogen use on oats in Wisconsin. In Table 3, the two survey years with available data show that about a quarter to half of oat planted acres received nitrogen fertilizer, with an average application rate of 20 to 30 pounds. Based on planted acres, these data imply that 1,000 to 2,000 tons of commercial nitrogen fertilizer are used for oats in Wisconsin annually. Table 3 also shows that essentially all winter wheat in Michigan receives nitrogen fertilizer, with application rates similar to corn, especially in recent years. A brief discussion with Dr. Shawn Conley, UW-Madison professor in Agronomy and Extension state specialist for soybeans and small grains, indicated that Wisconsin farmers likely follow similar practices in terms of nitrogen management for wheat. Based on Wisconsin wheat planted acres, these rates imply that 10,000 to 13,000 tons of commercial nitrogen fertilizer are used annually in Wisconsin on wheat. This total is about the same as for soybeans, but on far fewer planted acres.

The USDA NASS Quick Stats online tool reports fertilizer use data for potato in Wisconsin for 2014 and 2016 (https://quickstats.nass.usda.gov/) comparable to Tables 2 and 3. These data show that 100% of potato planted acres received nitrogen fertilizer, with an average application rate of 237 pounds per acre in 2014 and 239 in 2016. Based on planted acres, these imply 7,500 tons of nitrogen applied in total in 2014 and 7,750 in 2016, which is slightly less than for soybeans and wheat, but substantially more than for oats. No information is given about the timing of applications, but the average number of applications was 6 in 2014 and 7 in 2016, indicating that multiple small applications were made through out the growing season.

Table 4 reports data on the timing of nitrogen fertilizer applications and a few other practices for corn. There are more detailed reports available from USDA for 2010 and 2005 based on

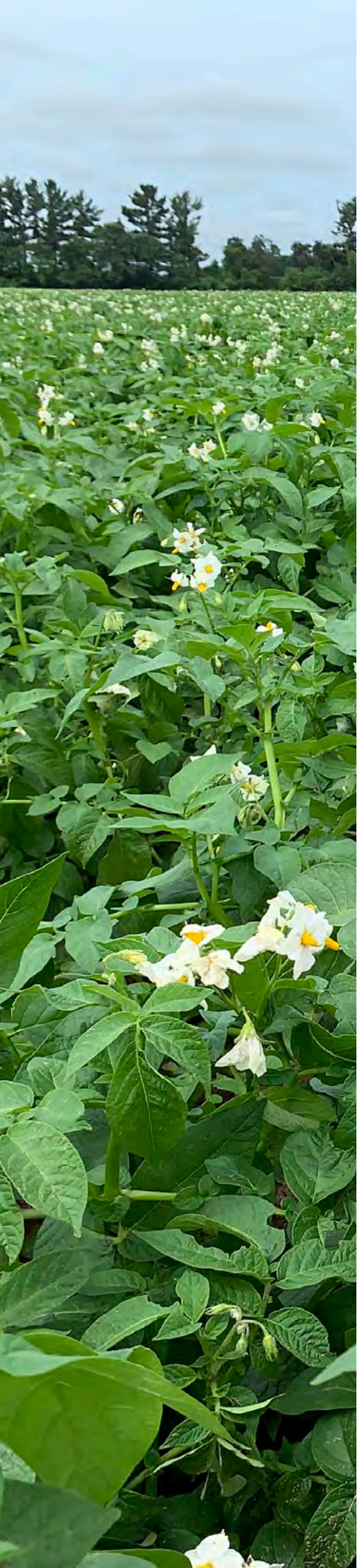


**Table 3.** USDA data on nitrogen use on wheat and oats in Wisconsin

| | Oats | | | | Wheat | | | |
|---|---|---|---|---|---|---|---|---|
| **Year** | **Planted Acres** | **% Acres Treated*** | **Rate** (lbs/ac)* | **Nitrogen** (tons) | **Planted Acres** | **% Acres Treated*** | **Rate** (lbs/ac)* | **Nitrogen** (tons) |
| 2020 | 300,000 | | | | 160,000 | | | |
| 2019 | 265,000 | | | | 195,000 | 96 | 111 | 10,390 |
| 2018 | 200,000 | | | | 240,000 | | | |
| 2017 | 180,000 | | | | 210,000 | 92 | 107 | 10,336 |
| 2016 | 210,000 | | | | 270,000 | | | |
| 2015 | 280,000 | 51 | 28 | 1,999 | 230,000 | | | |
| 2014 | 255,000 | | | | 295,000 | | | |
| 2013 | 255,000 | | | | 315,000 | | | |
| 2012 | 220,000 | | | | 265,000 | | | |
| 2011 | 210,000 | | | | 345,000 | | | |
| 2010 | 310,000 | | | | 240,000 | | | |
| 2009 | 310,000 | | | | 335,000 | 96 | 82 | 13,186 |
| 2008 | 270,000 | | | | 373,000 | | | |
| 2007 | 270,000 | | | | 299,000 | | | |
| 2006 | 370,000 | | | | 261,000 | 98 | 89 | 11,382 |
| 2005 | 400,000 | 23 | 23 | 1,058 | 208,000 | | | |

* The percent of planted acres treated and the application rate per acre treated are for Michigan.
Source: USDA NASS Quick Stats (https://quickstats.nass.usda.gov/)

ARMS data (USDA-ERS 2021). To give some context, the top rows show the % of planted acres receiving nitrogen fertilizer and the implied total acres receiving nitrogen (based on planted acres in Tables 2 and 3). Focusing on the application timing data for corn, only a third of acres receive pre-plant fertilizer, while three-fourths receive starter fertilizer, and half receive fertilizer after planting. However, the average application rates are much higher for the pre-plant and after-plant applications and less than 25 pounds per acres for starter. Note that there is substantial variation in individual farmer application rates around these average rates by timing. Though the 2005 and 2010 surveys show similar average application rates by timing, the standard errors around these average rates ranged 10% to almost 20% in 2010. Finally, note that the percent of acres receiving nitrogen in Table 4 is the same as in Table 2 for corn, but not the average application rates over all acres. The reason for these differences is unclear.

Combining the acres treated with the average application rates gives the total nitrogen applied, both overall and for each timing. Wisconsin farmers applied 182,000 tons of nitrogen fertilizer to corn in 2010 and 193,000 tons in 2005, with a decrease of more than 8 pounds per acre in the average application rate driving the decrease total tons applied from 2005 to 2010. The total application data by timing shows that most nitrogen was applied to corn after planting in 2010 – 73,000 tons, or 40% of the total applied, while 65,000 tons were applied in the spring before planting, or more than 35% of the total applied. Starter fertilizer accounted for 36,000 tons or 20% of the total applied in 2010, while almost 9,000 tons were applied in the previous fall, not quite 5% of the total. These are the most recent data available, yet or more than a decade old. Assuming practices are still roughly the same suggests than Wisconsin farmers commonly side-dress nitrogen in corn and very few use fall applications of commercial nitrogen fertilizer.

The final rows in Table 4 show that more than 20% of corn planted acres reported using soil nitrogen testing in 2005, but this fell to less than 7% in 2010. Given the expanded use of use of precision agriculture nutrient management plans since 2010, it seems likely that more farmers in the state use soil nitrogen test relative to 2010. Finally, 12% of corn planted acres reported use of nitrogen inhibitors in 2005, but not enough did so in 2010 for the USDA to report results. The generally low use of fall nitrogen applications is likely part of the reason for the low use of nitrogen inhibitors. If social or regulatory changes drive Wisconsin farmers to

**Table 4.** Summary of select nitrogen fertilizer management practices for corn in Wisconsin

| Data Item | Corn in 2010 | Corn in 2005 |
|---|---|---|
| **Nitrogen Fertilizer Use** | | |
| Acres Receiving Nitrogen (% Planted Acres) | 93.1 | 93.3 |
| Acres Receiving Nitrogen (Thousands) | 3,632 | 3,546 |
| **Application Timing (% Planted Acres)** | | |
| In Fall Before Planting | | |
| Spring Before Planting | 34.4 | |
| At Planting | 74.9 | |
| After Planting | 50.9 | |
| **Average Application Rate (Pounds per Treated Acre)** | 100.3 | 108.6 |
| In Fall Before Planting | | 54.4 |
| Spring Before Planting | 96.6 | 98.2 |
| At Planting | 24.7 | 17.9 |
| After Planting | 73.2 | 75.8 |
| **Total Nitrogen Applied (Thousand Tons)** | 182 | 193 |
| In Fall Before Planting | 8.7 | |
| Spring Before Planting | 64.8 | |
| At Planting | 36.0 | |
| After Planting | 72.7 | |
| **Nitrogen Management Practices (% Planted Acres)** | | |
| Soil N Tested | 6.8 | 21.5 |
| Nitrogen Inhibitor Used | | 12.3 |

Source: USDA ERS (2021).

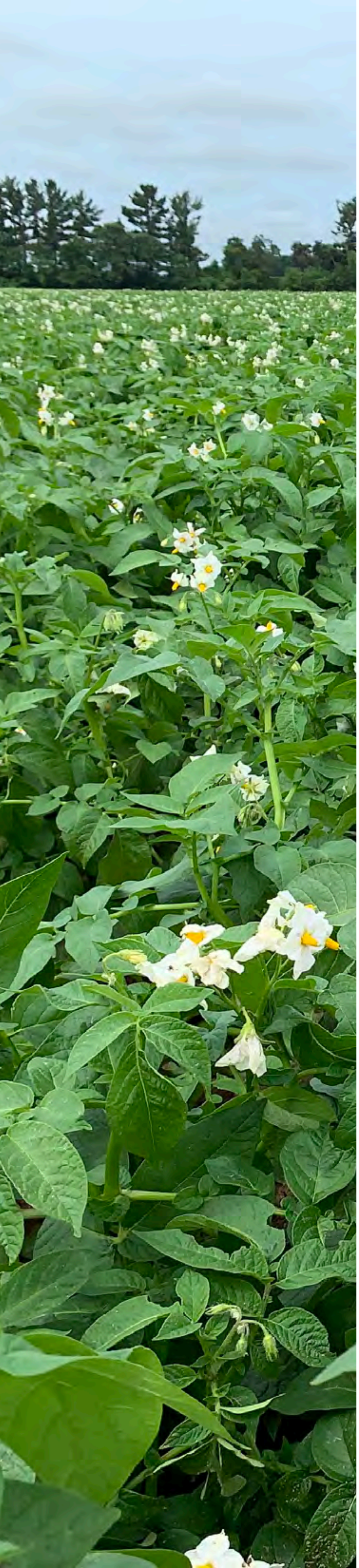
reduce their overall nitrogen application rates, some farmers in the state they may find value in nitrogen inhibitors, but they should know the soil types and environmental conditions that make them valuable (Laboski 2006).

Overall, the data shows that farmer use of commercial nitrogen fertilizer is dominated by use on corn in Wisconsin. This is not surprising, since corn is the crop with the most acres in the state and among the highest average application rates compared to other row crops in the state. The data on the timing of nitrogen fertilizer applications suggest that fall applications are uncommon in the state, with the largest portion of the nitrogen side-dressed after planting, followed closely by pre-plant applications in the spring.

## Manure Management in Wisconsin

The only state-level information summarizing manure use on crops in Wisconsin found was from USDA ARMS data (USDA-ERS 2021). Table 5 summarizes the most recent data available: 2010 and 2005 for corn, 2006 for soybeans and 2005 for oats. No ARMS data were available for more recent years for these crops, nor for manure use on other row crops or on alfalfa or pasture. These data show that applications of dairy manure to corn dominate manure use in the state, with fall application more typical and liquid manure the most common form already in 2010.

Table 5 shows that corn is by far the crop that receives the most manure in Wisconsin. Compared to soybean and oats, farmers plant substantially more corn acres, apply manure to a larger percentage of corn planted acres, and use higher manure application rates on corn. The reported total manure applied (calculated by multiplying planted acres by the percentage of acres treated and the application rate) shows how much applications to corn dominate manure use in Wisconsin. Almost 39 million tons of manure were applied to corn acres in 2010 and almost 32 million in 2005, while soybeans and oats received 1 to 2 million tons in 2006 and 2005, respectively. Planted acres in Wisconsin have shifted slightly since these



data were collected. Corn has remained at around 4 million planted acres each year, while soybeans have increased to average around 2 million acres each year and oats have declined to average less than 240,000 planted acres over the last ten years. Given that corn acres have remained steady, it does not seem likely that these acreage shifts have significantly affected the dominance of corn for manure use in the state.

Milk and cattle (including calves) are the two leading agricultural commodities sold by Wisconsin farmers, with cash receipts in 2020 totaling $5.7 billion and $1.7 billion, respectively (USDA NASS 2021a). Thus, as expected, Table 5 shows that dairy manure accounted for almost all the manure applied, with beef a distant second. Furthermore, almost all the applied manure was produced on the farm, and so the average distance the manure was hauled was much less than a mile. Liquid manure was also the most common form of manure applied. For corn in 2010, 63% of the acres treated received liquid manure, either as a slurry or from a lagoon, up from 45% of acres in 2005, while more than two-thirds of soybean and oat acres treated received dry manure in 2006 and 2005, respectively. The dairy industry in Wisconsin has consolidated significantly in recent years as the number of herds declined rapidly while the number of cows has remained relatively steady. As a result, the average cows per herd increased from 120 to 182 in the seven years from January 2014 to January 2021 (USDA NASS 2021b, 2021c). Dairy consolidation has likely increased use of liquid manure and the average distance manure travels, with less manure from on-farm sources, but how much is unclear. Nevertheless, on-farm production of liquid dairy manure applied to nearby corn acres still dominates manure use in the state.

Table 5 also shows that fall manure application is more common than spring application. More time is typically available in the fall to make manure applications after harvesting corn silage, soybeans, or even grain corn, compared to the spring when farms are rushing to plant crops. Wet weather in the spring has also become more common in the state, further limiting windows for field operations and delaying both manure application and crop planting. For example, the projected average day of corn and soybean planting is now almost one week later in the state than it was twenty years ago.

**Table 5.** Summary of select manure management practices in Wisconsin by crop

| Crop and Survey Year | Corn | | Soybean | Oats |
|---|---|---|---|---|
| **Date Item** | **2010** | **2005** | **2005** | **2006** |
| **Manure Practices** | | | | |
| Acres Receiving Manure (% Planted Acres) | 50.0 | 48.3 | 9.5 | 21.4 |
| Acres Receiving Manure (Thousands) | 1,949 | 1,834 | 157 | 86 |
| Application Rate (Tons per Treated Acre) | 19.9 | 17.2 | 14.1 | 15.6 |
| Rate Influenced by Restrictions (% Treated Acres) | 37.0 | 23.5 | 39.6 | -- |
| Applied in the Fall before Planting (% of Manure) | 55.6 | 47.3 | 64.7 | 69.4 |
| Applied in the Spring before Planting (% of Manure) | 43.9 | 52.7 | 35.3 | 30.6 |
| **Total Manure Applied (Million Tons)** | 38.7 | 31.6 | 2.2 | 1.3 |
| Fall Applied Manure (Million Tons) | 21.6 | 14.9 | 1.4 | 0.9 |
| Spring Applied Manure (Million Tons) | 17.0 | 16.7 | 0.8 | 0.4 |
| Total Nitrogen Applied as Manure (1,000 Tons)[a] | 111 | 90.3 | 6.30 | 3.80 |
| **Manure Characteristics** | | | | |
| Liquid Manure: Slurry or Lagoon (% Treated Acres) | 63.0 | 45.0 | 18.1 | 23.6 |
| Dry or Semi-Dry Manure (% Treated Acres) | 37.0 | 53.1 | 67.9 | 69.4 |
| Dairy Manure (% Treated Acres) | 87.0 | 76.5 | 75.4 | 84.1 |
| Beef Manure (% Treated Acres) | 7.7 | 13.1 | -- | 14.2 |
| Produced on Farm (% Treated Acres) | 96.2 | 89.2 | 97.1 | 85.8 |
| Distance Manure Traveled (Miles) | 0.49 | 0.63 | 0.22 | 0.29 |

a Estimated assuming 24 pounds of N per 1,000 gallons of manure and 8.4 pounds per gallon of manure.
Source: USDA ERS (2021).

Finally, more than a third of corn acres receiving manure in 2010 reported that the application rate was influenced by restrictions, up from about a quarter of the corn acres in 2005. This is likely due to farmer use of nutrient management plans, which are required for a variety of reasons including being a permitted CAFO (Wisconsin DATCP 2021). As the number of permitted CAFOs in the state has continued to increase and they account for a growing proportion of the livestock in the state, the number of crop acres receiving manure while following a nutrient management plan has increased, implying that more acres would report manure application rates influenced by restrictions than in 2010. On the positive side, it seems that NM plans have the desired effect – improvement in the nitrogen use efficiency. Skidmore et al. (2021) find that requiring NM plans for dairy farms in Wisconsin reduced the observed average ammonia concentration in surface water within the farm's watershed. Sneeringer et al. (2018) report a similar finding when hog farms adopt NM plans as well – adopting farms reduce applications of excess nitrogen.

## Farmer Concerns Identified Through Focus Groups

As part of the analysis, and as a basis to document and understand the concerns about the economic impact among farmers, the University of Wisconsin-Madison team organized a series of focus groups with farm operators. The results, summarized below (and described more fully in Appendix 1), shed light on potential implementation challenges and operational costs from the perspective of the land mangers required to meet the new standards. These results highlight feasibility concerns and help guide assumptions for the subsequent quantitative analysis of the economic impact.

In February of 2021, focus groups were administered with Wisconsin farmers who were prompted to discuss their understanding of the standards, the potential economic impact the proposed performance standards may have on their individual operations, and the feasibility of implementing such changes on their individual farms. Participants were invited to identify any other issues or concerns related to the performance standards or the process undertaken by WDNR to develop the proposed standards. Focus group participants were recruited, meetings were facilitated, and data was managed in compliance with University of Wisconsin-Madison Institutional Review Board (IRB) approved criteria and protocols. A total of four focus groups were conducted, with 8 to 10 participants each and a total of 35 participants. Each focus group included participants from a diversity of agricultural farming systems.

All four focus group discussions were recorded and transcribed, and participants' comments were compiled and analyzed across groups to identify general themes and unique high-impact concerns. General themes documented concerns that span multiple growing regions and cropping systems. Based on their understanding of the proposed performance standards and prohibitions at the time, many participants expressed specific comments about how the proposed rule would impact their own farming system, but also discussed their ideas on how the rule would impact the larger agricultural community. Six main themes around economic impacts are summarized here:

**Theme 1 – Increased manure storage needs and shorter manure application windows:** Participants expressed concerns over the timeframe of limiting manure applications after September 1st each year. They discussed the need for longer-term storage and the significant investments growers may need to put into their farms to comply. Concerns over pushing applications to a short timeframe in the spring was discussed, as that may create other environmental concerns and cause problems for roads and for commercial haulers.

**Theme 2 – Decreased crop yields and quality and lower profits:** Participants discussed concerns that limiting fertilizer rates and applications would negatively impact yields which would adversely impact profits. Many are working to be as efficient as possible with their existing applications, so the consensus was that there were not many efficiencies left to limit nitrogen rates. To overcome yield loses, growers would need to expand acres or receive supplemental cost-share dollars.

**Theme 3 – Longer crop rotations and more acres planted:** Participants were certain that limiting applications to the 2.2lbs recharge threshold would cause growers to extend rotational years and add additional acres to allow for fallow years within the rotations. These expanded rotational lengths, cropping systems and potential additional acres for farming may not be economically viable with current markets, volume contracts and supply chain demands. There was also a discussion that this may only work for larger farming systems.

**Theme 4 – Difficulties documenting and complying with irrigation-related requirements:** Participants who irrigated fields felt that the rule requirement to document nitrogen in irrigation water to be difficult to deliver, highly variable during the growing season, and is not applicable due to the research used to develop recommended rates. Having irrigated fields on fallow ground is not economically feasible, and limits on applications would be detrimental to crop health and profits during drought years.

**Theme 5 – Overall challenges with documentation, oversight, and administrative burden of compliance:** Participants questioned how the record keeping, documentation needs and compliance would be implemented under this rule, and they expressed concerns that it would be difficult with the current tools used in Wisconsin agricultural systems. Many are using Nutrient Management Plans (NMP), and questions arose regarding how NMPs would be used to comply with the proposed rule and what other options could be available to minimize additional documentation burdens.

**Theme 6 – Potential negative economic impacts on rural communities:** Participants discussed their concerns regarding the potential impact the proposed standards would likely have on the economic well-being of rural communities across the state. Agriculture is viewed as the lifeblood and largest contributor to the economy of numerous rural communities. Concerns on local roads, transportation options, related agricultural industries and supply chains, and land values were also discussed as an impact to rural areas which are largely dependent on agriculture for their tax basis.

Two additional themes (summarized in Appendix 1) emphasized farmer concerns around a perceived lack of engagement with agricultural stakeholders throughout the process of developing and releasing the proposed rule changes. The first of these, described generally as a lack of transparency and explanations behind changes, reflected limited information available to participants about the underlying research and justification for the proposed standards. The second, concerns about uniform standards instead of situation-specific collaborative solutions, reflected preference for more flexible approaches to agricultural management issues that engaged farmers more directly.

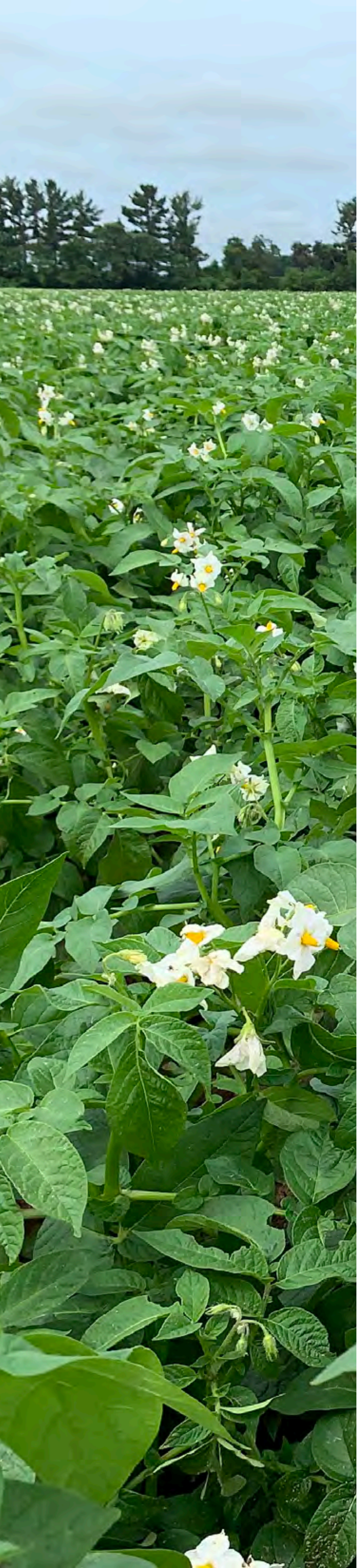
The focus group process allowed for discussion of detailed nuances and insights regarding how growers approach their cropping systems and their nutrient management options. The growers shared details about crop management and described practices already implemented as well as discussing new ideas and options that could be implemented that would reduce negative nutrient impacts on water quality. The summary in Appendix 1 includes additional details and selections of verbatim comments from participants.

## Additional Concerns and Costs Identified Through DNR Public Engagement

While this report focuses primarily on understanding potential costs to agriculture associated with the proposed rule changes, additional concerns associated with continued nitrate contamination of groundwater were identified through WDNR's Draft Economic Impact Assessment and related public comments (https://dnr.wisconsin.gov/topic/nonpoint/nr151nitrate.html). Two themes of current costs to private businesses and residents related to (1) installation and maintenance of private water treatment systems to mitigate or remove excessive nitrate from drinking water and (2) broader human health costs imposed on society due to high nitrate levels in drinking water.

Further analysis of these potential costs is beyond the scope and resources available for this study, however others have examined these issues and published their findings. In a survey of private well owners by Lewandowski et al. (2008), it was discovered that 6% of the wells surveyed tested over the EPA health standard maximum and almost one-third (31%) of those well owners were unaware of the contamination. The survey also found that average remediation costs for well owners with contaminated wells were $190 per year to buy bottled water, $800 to buy a nitrate removal system plus $100 per year for maintenance, and $7,200 to install a new well (Lewandowski et al. 2008). Costs for nitrate removal systems have increased since their study in 2008 and may range closer to $1,000-$1,500 plus annual maintenance; well installation costs vary across Wisconsin with WDNR estimating an average cost of $12,000 to replace a private well (WDNR Draft EIA). The estimate of private wells in the state with nitrate levels that exceed the public health standard has since increased to 10% (Mathewson et al. 2020). Combining estimated exposure to high nitrate in drinking water through community and private wells, Mathewson et al. (2020) provide estimates for annual incidence of multiple adverse health impacts and potential direct medical costs of $23 to $80 million annually. This cost estimate does not include other direct costs or any nonmonetary costs from these adverse health outcomes.





## PRELIMINARY ECONOMIC ANALYSIS: FOCUS ON POTENTIAL COSTS FOR AGRICULTURE

Recognizing the limitations and caveats outlined in the introduction to this report, the preliminary economic analysis described here draws upon issues raised in focus groups to assess potential costs for agriculture associated with proposed rule changes. The analysis emphasizes six areas of potential impacts on farmers and agricultural operations:

1. Costs for nutrient management plans,
2. Increased manure management and storage costs,
3. Crop yield losses,
4. Losses from expanding crop rotations,
5. Increased farm management costs, and
6. Broader losses in local economies due to farm losses.

This section examines these concerns, focusing on determining the potential magnitude of the economic effects. It is worth stating again that in general, a lack of reliable baseline data regarding existing agricultural practices prevents accurate estimation of the costs and benefits of the proposed rule. These summaries should be viewed as descriptions of potential costs whose actual annual and aggregate values would depend on the technical options available for complying with any final targeted performance standards and prohibitions. Also, these are annual total cost and benefit estimates once all affected farms made changes and are recurring costs, not one-time costs. However, many of these changes to farm operations would occur over time as the proposed rule is rolled out and state cost share dollars became available.

## 1. Costs for Nutrient Management Plans

Nutrient management plans have been required for all agricultural operations in Wisconsin since 2008 (with most required as of 2005), contingent upon cost share funding available to the farmer that would provide 70% of the cost to develop a plan. The proposed rule change does not change this existing requirement and does not impose nutrient management plans as a new cost. That said, if the proposed rule becomes established, to be compliant with the standards, growers in the targeted areas who do not have nutrient management (NM) plans will need to develop them for their farm. As of 2019, 3.4 million acres or 37% of cropped acres in the state had filed certified NM plans with the state (Wisconsin DATCP 2019). At the county level, adoption rates for NM plans ranged from no acres in several counties to as high as 95% of cropped land in Door County (Figure 3). About three-fourths of these plans are written by consulting agronomists for larger farms. Farms that write plans for themselves tend to be smaller, as these self-written plans account for 18% of the acres with plans, but 26% of the plans filed (Wisconsin DATCP 2019). NM plans are filed with the state for various reasons including to demonstrate compliance with regulatory requirements and to qualify for tax credit incentives or other subsidies. Of the 3.4 million acres with NM plans on file, 44.0% were due to participation in the farmland preservation tax credit or receiving DATCP cost share, while 31.8% were due to being a permitted CAFO, 20.1% due to manure storage or a livestock citing ordinance, while the remaining 4.3% were enrolled voluntarily or a few due to federal cost share (See Figure 2 in Wisconsin DATCP 2019). These data show the key role that financial incentives and legal requirements play in farmers adopting and filing NM plans. Agronomists suggest anecdotally that a much higher percentage of farmers develop and follow NM plans than the percentage that have filed a plan with DATCP.

If farmers in the targeted areas have not yet developed a plan, based on an anonymous conversation with a company that writes many NM plans in Wisconsin, the cost to hire a consulting agronomist to develop a NM plan for a farm typically ranges from $3 to $7 per acre each year. The higher end of the range is for those operations needing more complex plans that include livestock, more fields, and a wider variety of crops and soil types, while the lower end is for relatively simpler plans for cash grain operations with larger and more homogeneous fields and no manure use. An additional cost for NM planning is the need for soil sampling every 4 years, which has an annualized cost of $2 per acre. Thus, the cost of NM planning is $5 to $9 per acre per year, with a mid-point of $7 per acre, but dairy farms with forage production would likely pay $7 to $9 per acre while cash grain farms with larger fields likely would pay $5 to $7 per acre. This assessment uses $7 per acre as a reasonable estimate, either of the direct farm cost for hiring someone or the cost of farmer time and effort to develop and write one themselves, and to conduct soil testing. As noted, NR 151.07 stipulates that farmers be provided 70% cost share as part of compliance with the requirement to have a nutrient man-

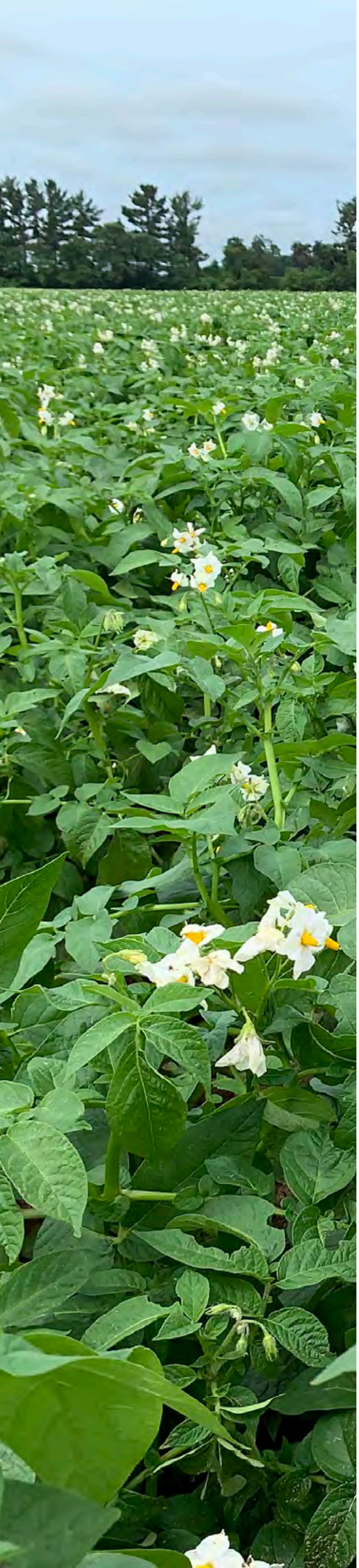
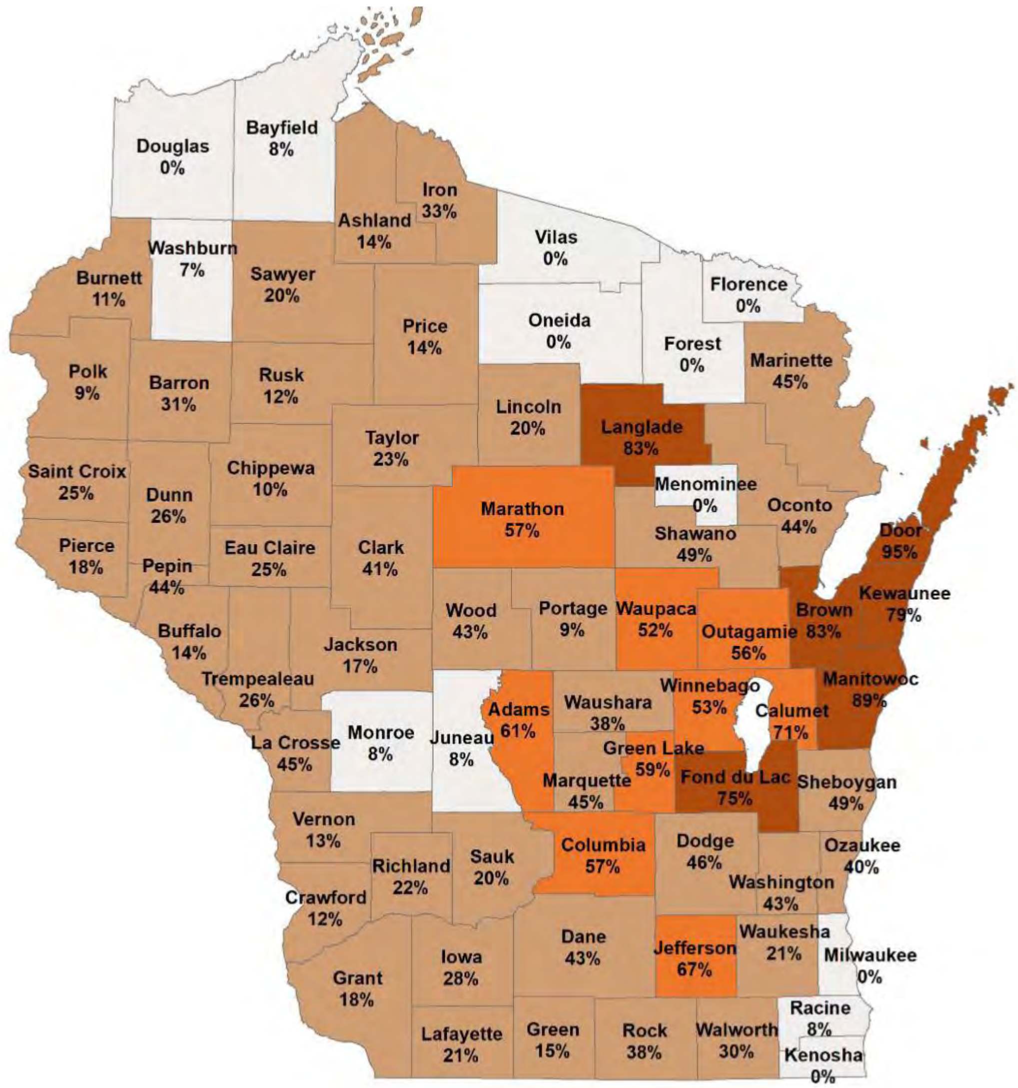


**Figure 3.** Percent of county cropland with 2019 nutrient management plans (Wisconsin DATCP 2019)




agement plan. This cost share lasts for a period of four years for a farm and the annual budget limits the amount of cost share that can be awarded each year.

Of the 6.2 million acres in the proposed targeted areas (Table 1), all or none could overlap with the 3.4 million acres already with certified NM plans (Wisconsin DATCP 2019). If none of the 3.4 million acres of crop land with a NM plan already were in the 6.2 million acres of targeted areas, the total estimated cost would be 6,185,819 acres x $7 per acre = $43.3 million annually. If all of the 3.4 million acres of crop land with a NM plan already were in the 6.2 million acres of targeted areas, the cost would be 6,185,819 – 3,406,000 = 2,779,819 acres x $7 per acre = $19.5 million annually. Both of those values would be subject to the existing 70% cost share requirement, so the estimated range of the costs to farms to create new certified NM plans would be 30% of those values, or $5.8 million to $13.0 million each year for four years. The remaining cost would be paid by the state. In 2019, 36.9% of Wisconsin cropland had certified NM plans (Wisconsin DATCP 2019). If 36.9% of acres in the proposed targeted areas already had NM plans, the acres needing NM plans would be 6,185,819 x (100% – 36.9%) = 3,903,252 acres x $7 per acre = $27.3 million each year in total cost. With 70% covered by cost share, the cost to farmers would be $8.2 million each year. Based on comparing Figures 1 and 3, there is almost certainly some overlap between the two groups of farms, but it is unclear how accurate the state average of 36.9% of acres already having NM plans in the proposed target areas is.

These calculations give some indication of the potential magnitude of the total cost of creating new NM plans could be for farms in the targeted areas – total annual cost somewhere between $19.5 and $43.3 million and likely around $27 million, with annual costs to farmers (30%) between $5.8 and $13.0 million and likely around $8.2 million. Again, note that this cost would not be a new regulatory cost created by the proposed rule, but it is an existing cost based on previous legislation. Also, note that farms will already have crop fertility

plans that they use to decide how much fertilizer and manure to use for each field, which in essence are NM plans. These fertility plans have varying degrees of formality, and the above discussion focuses on certified NM plans that receive state cost share, which would replace these more informal fertility plans. Farm cost savings from replacing current fertility plans with certified NM plans is not accounted for in this analysis, nor the impact of these NM plans on crop yields and fertilizer costs. Assuming a farm management wage rate of $33.50 per hour (US BLS 2021), if an average farmer spends more than $7 / $33.50 x 60 minutes per hour = 12½ minutes of managerial time per acre on crop fertility planning each year (or almost 21 hours per 100 acres), then paying someone $7 per acre annually to develop and update a farm NM plan would be a lower cost option.

No solid data are available on how many new acres would need to file certified NM plans, what the average annual cost would be for them, how much time farms currently spend on crop fertility planning and the average impact of these NM plans on farmer returns. The farmer managerial cost of annually updating their NM plan or hiring an expert to develop such a plan would be offset to some degree by reduced spending for nitrogen and other fertilizers and by yield changes. However, the average net impact on farm returns across the diversity of operations affected by this proposed rule is an important data need to estimate the economic impact, as is the number of new acres that would need to file NM plans in the proposed targeted areas and the cost of such plans (whether incentivized or not). As noted, this cost is already required under the current NR 151 and the proposed rule would likely accelerate compliance and cost share provision in the targeted areas for farms to replace their current crop fertility plans with certified NM plans.

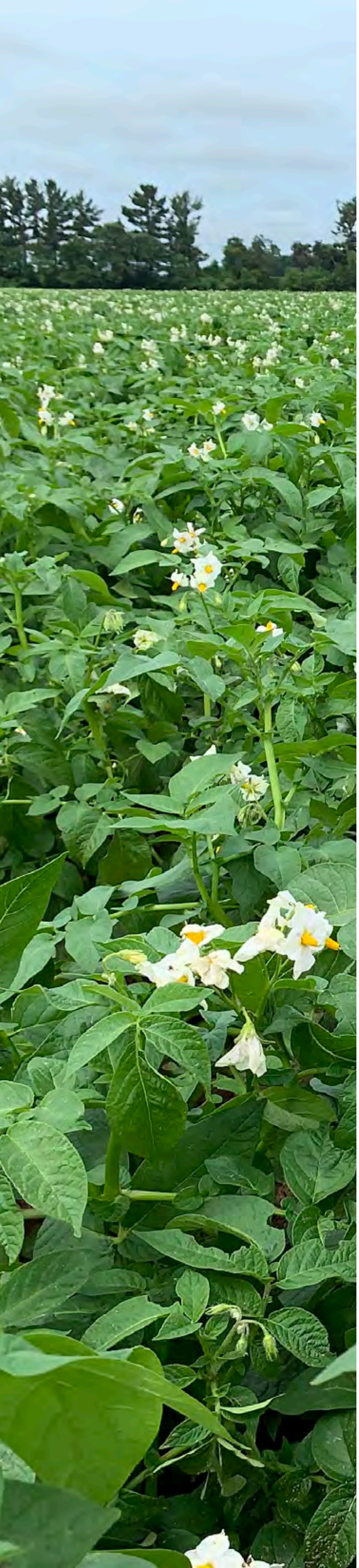
## 2. Increased Manure Management Costs

Manure management and storage are significant issues for Wisconsin's dairy and beef producers. A primary concern among focus group participants with livestock was on the prohibition of fall manure applications after September 1, and the problems it would create. The practical applicability of the stated exemptions in the proposed rule was not clear, and focus group members did not seem to note the available exemptions. Among participants, there seemed to be confusion on whether fall applications could be made on cover crops or if it had to be a cash crop such as winter wheat. There was limited discussion regarding implications of being allowed to make a single manure application at a rate up to 25% of the annual application for the NM plan.

### Manure Transportation and Storage

The proposed rule will increase manure transportation costs due to requiring NM planning and prohibiting fall manure applications in some areas. Manure is heavy and bulky, and transporting and applying it is expensive, and so farms tend to move it as short of distance as possible. Hence, not surprisingly, USDA NASS reported that most manure applied in the state is from on-farm sources and the state average distance for transporting manure was less than a mile (Table 5). An implication is that farmers would tend to over-apply manure on fields near their manure storage to reduce transportation costs. As a result, anecdotally, livestock farms producing liquid manure tend to find that their NM plans imply reductions in their manure application rates, typically due to phosphorus limitations. For example, based on a farmer survey from 2010, USDA NASS reported that 37% of farms reduced manure application rates due to restrictions (Table 5). This percentage has almost certainly increased since then. As a result, farms following NM plans tend to have to transport their manure farther to reduce per acre application rates to limit phosphorus applications, and then supplement with commercial fertilizer to meet crop nitrogen needs, especially for corn and grass forages. In addition, current NM plans will likely not comply with the proposed rule for some farms, which may further restrict manure use for farms currently using NM plans. As a result, some farms currently with NM plans may also need to transport their manure longer distances to meet the proposed rule, depending on their soils and crops. Finally, the prohibition against manure applications after September 1 in some targeted areas (Figure 2) also implies that some farmers would have to transport manure farther.

The overall impact of the proposed rule is to increase the average distance that manure is transported in the state, a point noted by the farmer focus groups. However, there are several significant unknowns, including how much manure would need to be transported and how much farther, and what will this additional transportation cost. Thus, a key data need is for information on how much manure would need to be transported farther and how much farther. Two methods are presented to provide some indication of the potential magnitude of the economic impact of this additional manure transportation, but the results are for illustration purposes only, as the impact of the proposed rule on manure transportation is unknown.



The Wisconsin Custom Rate Guide for 2020 (USDA NASS 2021d) includes costs for custom manure services. Reported average costs for hauling and spreading or dragline pumping and spreading manure ranged $9.30 to $9.41 per 1,000 gallons, with a simple average of $9.36. Research has found that custom rates are less than a farm's actual cost for doing the same activity and should be considered a lower bound on the actual costs (Breaton et al. 2003, Tyndall and Roesch-McNally 2014). Nevertheless, using this cost as an estimate of a farm's costs for transporting and spreading manure, the estimated total cost for farmers in the state to transport and apply manure is calculated. Using 8.4 pounds of manure per gallon gives a liquid equivalent for all manure applied in Wisconsin for the totals in Table 5. Multiplying these values by the $9.36 per 1,000 gallons, gives an estimated total cost of $86.3 million for corn in 2010 and $70.3 million for corn in 2005 (and less than $2 million for soybeans and oats). These values are the estimated total cost for transporting and spreading manure in Wisconsin using 2020 costs and the manure amounts spread in 2010 and 2005 on corn.

Another way to examine the impact is to use cost estimates from commercial manure haulers. Based on an anonymous conversation with an Extension specialist, the mileage surcharge custom haulers use for hauling manure further is $0.015 per gallon per mile. This cost does not include the cost to load or to spread the manure, but the surcharge to extend the hauling distance. Again, using 8.4 pounds per gallon to convert the total tons of manure applied in Table 5 to its liquid equivalent, and combining this value with the average miles hauled in Table 5 and this surcharge per mile gives a total cost of $68.4 million in 2010 and $70.9 million in 2005. These would be the estimated costs for hauling all manure in the state, not loading or spreading it, and assuming the custom cost is a reasonable estimate of the farm cost. Again, these values are the estimated total cost for manure hauling in the state using 2020 costs and the manure amounts spread in 2010 and 2005 on corn. Both costs are similar in magnitude for the two different years and calculated aggregate costs do not differ much between the two methods.

A simple example illustrates the potential magnitude of the cost impact that the proposed rule could have on manure transportation costs in the state. Again 8.4 pounds per gallon is used to convert the total tons of manure applied in Table 5 to its liquid equivalent, and then the commercial surcharge of $0.015 per gallon per mile is used to calculate the cost of moving different amounts of manure farther based on the data for corn in 2010 and 2005 in Table 5. If the rule required 25% of the state's manure applied to corn had to be moved an average of 0.25 miles farther, the cost impact would be $8.6 million for the 2010 corn data and $7.1 million for the 2005 corn data. These increases would represent about a 10% increase in the total annual manure transportation and application costs calculated using the custom rate of $9.36 per 1,000 gallons. These calculations show the impact needed to generate an estimated 10% increase in manure hauling costs – transporting 25% of the manure in the state an additional quarter mile. However, note that that these calculations are purely for illustration. No solid data are available on how much manure would have to be moved and how much farther as a result of the proposed rule. Thus, a key data need is for information on how much manure would need to be transported farther and how much farther, and up-to-date information on the cost of custom manure operations.

Note that these calculations do not include several other costs. Transporting manure farther would accelerate equipment depreciation and increase capital replacement costs and investment in expanded capital equipment such as longer manure pumping pipelines. Also, a point emphasized by the farmer focus groups, roads in the areas would see more concentrated traffic in the spring from heavy equipment and loads, increasing costs for road maintenance and repairs. Moving manure farther would also increase managerial costs for some farmers to move implements of husbandry through more jurisdictions. Also, many farms transport their own manure and these costs based on custom rates are typically lower than actual farm costs (Breaton et al. 2003, Tyndall and Roesch-McNally 2014).

Even more unclear than the impacts on manure transportation costs are impacts on manure storage costs. The farmer focus groups were concerned about the apparent loss of fall manure applications and the implied increases in manure storage needs. However, it seems likely that farmers would not greatly reduce fall manure applications, as there are many practical reasons to continue using them and the proposed rule has exceptions that many farms would likely try to use. Farms generally have more time available in the fall for manure applications and weather conditions are often more favorable over a longer period of time. Also, from the perspective of most farms, increasing storage and relying more on spring applications would be too risky and they would search for ways to continue fall applications, likely using the allowed exceptions in the proposed rule. Thus, farmers would more likely transport the manure farther for fall applications rather than increase manure storage and the risk of trying to apply more manure in the relatively tighter spring application window. Other options would be to include cover crops that would allow fall manure application or to grow alfalfa or other forage crops that would allow summer applications of manure between har-

vests. No public data on summer manure application in the state are available, as USDA NASS did not collect such data in its surveys. However, note that this projected minimal impact on manure storage due to the proposed rule change is based on conjecture. This conjecture should be re-evaluated once farmers and others better understand the specific options that can be used to meet the proposed rule and whether it will be more cost effective to transport manure farther or to increase manure storage. Once more specifics are known about management practices to meet the proposed standard, then the potential impacts on manure storage costs can be better evaluated.

## Cover Crops and Manure Transport

The proposed rule allows fall manure application for establishing cover crops and many farms would likely adopt cover crops to take advantage of this exception. The economics of cover crops have been examined by many. From a practical perspective, the direct benefits of cover crops to farms in terms of increased yields and other changes do not see to be sufficient to overcome the costs. As a result, most analyses find that cover crops decrease farm net returns and are not economical to adopt without an incentive payment (Plastina et al. 2018; Schnitkey et al. 2016, 2018, 2021), though exceptions exist (Hughes and Langemeier 2020). As a result, most farms using cover crops receive incentive payments (at least initially) and tend to plant the lowest cost cover crops (Swanson et al. 2018). Incentive payments vary, with the lower end of the range around $8 to $15 per acre and the upper end exceeding $50 per acre (Tables 1 and 2 in Wallander et al. 2021). The costs vary depending on the cover crop species planted, the seeding method and seeding rate, and termination method, with estimates generally ranging between $15 to $30/ac for lower cost cover cropping practices, though many options have higher costs (Schnitkey et al. 2016, 2018, 2021; Swanson et al. 2018; Plastina et al. 2018). The key point to note is that cover crops generally imply a net loss for most farms and so require incentives to become economical.

For the proposed rule, farms will need to weigh the cost of planting a cover crop against the cost of transporting manure farther for fall application. Suppose a farm currently applies manure to a field in the fall and is deciding whether to plant a cover crop (at a loss) and apply manure in the field or instead to transport the manure farther for fall application. The maximum distance a farmer can afford to transport manure and still be better off than losing money by planting a cover crop can be calculated based on the application rate and the manure surcharge of $0.015 per gallon per mile. If a farmer has to transport manure farther than this distance, then it would be more economical to plant a cover crop and apply the manure. For example, a manure application rate of 20 tons/ac has a liquid equivalent of 4,762 gallons per acre (using 8.4 pounds per gallon as a conversion factor) and multiplying by the mileage surcharge gives 4,762 x 0.015 = $71.43 per acre in cost to transport the manure a mile. If a farm can plant a cover crop for a net loss of $15 per acre, then the maximum distance the farm can transport the manure is $15/$71.42 = 0.21 miles before it is more economical to plant a cover crop at a net loss to make a fall application. Table 6 reports this maximum distance for a range of cover crop costs and fall manure application rates.

**Table 6.** Maximum distance manure can be transported for fall application before it is more economical to plant a cover crop at a loss[a]

| Cover Crop Net Loss ($/ac) | Fall Manure Application Rate | | | | |
|---|---|---|---|---|---|
| | 5 tons/ac | 10 tons/ac | 15 tons/ac | 20 tons/ac | 25 tons/ac |
| **$5** | 0.28 | 0.14 | 0.09 | 0.07 | 0.06 |
| **$10** | 0.56 | 0.28 | 0.19 | 0.14 | 0.11 |
| **$15** | 0.84 | 0.42 | 0.28 | 0.21 | 0.17 |
| **$20** | 1.12 | 0.56 | 0.37 | 0.28 | 0.22 |
| **$25** | 1.40 | 0.70 | 0.47 | 0.35 | 0.28 |
| **$30** | 1.68 | 0.84 | 0.56 | 0.42 | 0.34 |
| **$35** | 1.96 | 0.98 | 0.65 | 0.49 | 0.39 |
| **$40** | 2.24 | 1.12 | 0.75 | 0.56 | 0.45 |
| **$45** | 2.52 | 1.26 | 0.84 | 0.63 | 0.50 |
| **$50** | 2.80 | 1.40 | 0.93 | 0.70 | 0.56 |

[a] Calculated using $0.015 per gallon per mile transportation cost and 8.4 pounds per gallon of manure.

The results in Table 6 shows the expected trends. When cover crops imply larger net losses, farmers have a larger maximum manure transportation distance before it is more economical to plant a cover crop. Similarly, with higher application rates, more manure has to be transported, and so the maximum transportation distance becomes smaller. The distances in Table 6 are relatively short for typical application rates and cover crop losses. Table 5 shows average manure application rates of 17 and 20 tons per acre, and Schnitkey et al. (2021) estimate about $25 per acre as the average income loss for a cover crop, giving a maximum distance of 0.35 miles. Based on Table 5, the average distance manure traveled in Wisconsin for application to corn was 0.49 and 0.63 miles in 2010 and 2005. These results suggest that many farms would find it more economical to plant cover crops at a loss of around $20-$30 per acre in order to make fall manure applications, rather than to transport their manure farther. Only with a lower application rate does the maximum distance become larger. For example, the maximum distance quickly exceeds one mile with an application 5 tons per acre, which is roughly 25% of the average rate and likely satisfying the 25% maximum rate allowed under the proposed rule for fall application. Farms with access to sufficient land may find it more economical to move their manure around and use the 25% fall application rate rather than planting cover crops in order to make fall manure applications. Also, note that these estimates do not include cost share incentive payments for farmers to plant cover crops. Such payments would reduce the net cost to plant cover crops.

Note that these calculations assume no increase in the total manure or nitrogen application rate for the primary crop when planting cover crops. For example, a farm growing continuous corn silage using 160 pounds of nitrogen per acre cannot add a cover crop and then increase the annual application rate to 180 pounds of nitrogen per acre. This issue is a topic needing additional research, especially if the proposed rule is enacted. Ruark et al. (2019) have shown that a cover crop producing a large amount of biomass reduces available nitrogen for the primary crop and so they recommend reducing or eliminating nitrogen manure credits in these cases. Furthermore, it is unclear how the nitrogen budgeting for the proposed rule would change if the farmer uses the cover crop for forage. If the cover crop biomass is removed from the field, potentially the farmer could increase the total amount of (manure) nitrogen applied to the field.

# 3. Crop Yield Losses

The primary benefit of nitrogen for crops is increased yields and so not surprisingly, farmers in the focus groups expressed concern about potential yield losses if they had to reduce nitrogen use, especially for corn, to meet the proposed rule. Corn receives the focus because so much of the nitrogen used in crop production in Wisconsin is used for corn (Tables 2 - 5). For the estimated impact of the proposed rule change, a partial budget approach is used assuming a 10% reduction in the nitrogen application rate and a 1% yield loss based on the fact sheet for corn developed by Iowa State University Extension to support the Iowa Nutrient Reduction Strategy (ISU Extension 2017). With these assumed changes for corn, the estimated net loss to Wisconsin farmers ranges $4.1 to $11.5 million annually depending on the corn price used and using a nitrogen price of $0.40 per pound. Applying the same impact to potatoes (10% nitrogen rate reduction and a 1% yield loss) gives an estimated net loss of $2.4 million. However, before explaining these estimated potential yield losses, some context for farmer management of nitrogen in corn is provided.

## Some Context for Nitrogen Management in Corn

The response of corn yield to nitrogen fertilizer and the implied optimal use of nitrogen have been intensely studied. At low levels of nitrogen availability, adding more nitrogen increases corn yield, but as nitrogen levels increase, the yield increase for each additional unit of nitrogen decreases. As a result, at higher application rates, corn yield becomes relatively non-responsive to nitrogen – the yield curve becomes "flat" so that large changes in the nitrogen rate imply small changes in expected corn yield.

From an economic perspective, farmers balance the cost of additional nitrogen against the value of the expected yield increase it generates. This trade-off shifts the recommended nitrogen rate as the price of fertilizer and the price of corn changes – when nitrogen prices are low and/or corn prices are high, using more fertilizer is optimal and vice versa. Nitrogen prices vary regularly depending on the year and location, as well as the form used, while corn prices vary daily. As a result, Extension researchers in several states have developed a decision aid that uses research data from each state and performs the calculations to develop recommended nitrogen application rates for corn based on prices (http://cnrc.agron.iastate.edu/).

In addition to the effect of nitrogen on corn yield, many other factors also impact yield (e.g., the amount and timing of rainfall and temperatures, soil quality, availability of other nutrients, weed density, and insect and disease pressure). Because these factors also vary between years and locations, actual corn yields vary a lot around the predicted yield response curve. Because of this variability, when farmers are using optimal or near optimal nitrogen application rates along the flat part of the curve, the small yield changes from varying the nitrogen rate are overwhelmed by yield variability from these many other factors. As a result, identifying the effects of nitrogen on corn yield becomes difficult from a statistical perspective (Mitchell 2004).

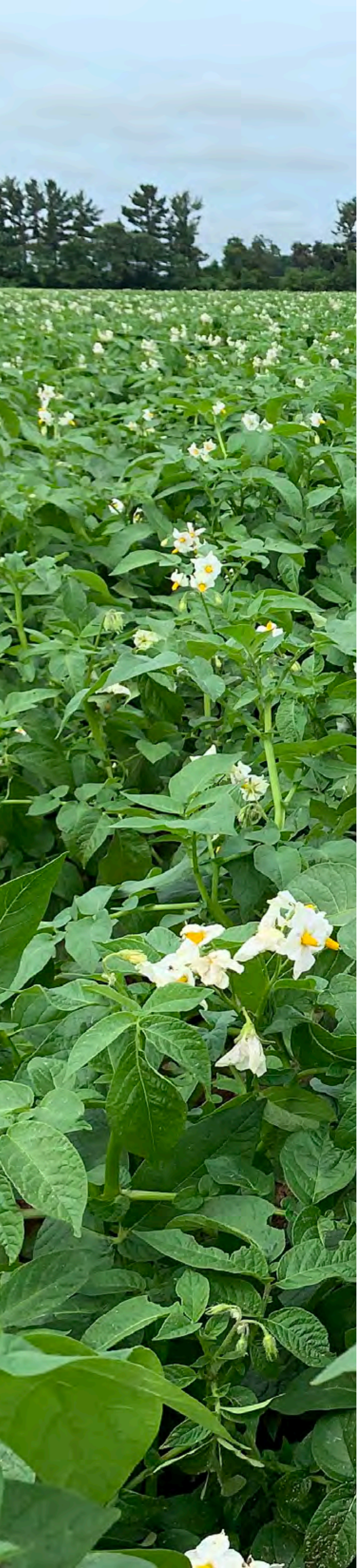
Due to the flatness of the yield response curve to nitrogen, recognizing the substantial variability in yield, and incorporating the effects of varying nitrogen and crop prices, the Extension recommended nitrogen application rate is a range that varies with the previous crop, soil quality and the ratio of the nitrogen price to the corn price. Figure 4 summarizes current recommendations for Wisconsin (Laboski and Peters 2012), based on the same logic and process as used for several Midwestern states. For example, for corn following soybeans in loamy high yield potential soil when the price ratio for nitrogen to corn is around 0.10, the recommended rate is 120 pounds of nitrogen per acre (Figure 4). The acceptable range around this rate is 105 to 130 pounds per acre – a range of 25 pounds. This range is derived by identifying the rate that gives a projected return to the nitrogen within $1 per acre of the expected return when using the optimal rate. Because the yield response curve is so flat, the range is 25 pounds per acre. Across the different combinations of soil, previous crop and price ratio, the acceptable range varies from as wide as 40 pounds to as narrow as 15 pounds (Figure 4), showing the effect of the flat yield response curve.

**Figure 4.** Recommended nitrogen application rates for corn in Wisconsin based on soil and previous crop for different nitrogen to corn price ratios (Source: Table 6.1 on page 43 in Laboski and Peters (2012))

| | Nitrogen:Corn price ratio | | | |
|---|---|---|---|---|
| | **0.05** | **0.10** | **0.15** | **0.20** |
| **Soil** and previous crop | ---------- total lb N/a to apply[a] ---------- | | | |
| **Loamy: high yield potential soil** | | | | |
| Corn, forage legumes, legume vegetables, green manures[d] | **190[b]**<br>170 -------- 210[c] | **165**<br>155 -------- 180 | **150**<br>140 -------- 160 | **135**<br>125 -------- 150 |
| Soybean, small grains[e] | **140**<br>125 -------- 160 | **120**<br>105 -------- 130 | **105**<br>95 -------- 115 | **90**<br>80 -------- 105 |
| **Loamy: medium yield potential soil** | | | | |
| Corn, forage legumes, legume vegetables, green manures[d] | **145**<br>130 -------- 160 | **125**<br>115 -------- 140 | **115**<br>105 -------- 125 | **105**<br>95 -------- 110 |
| Soybean, small grains[e] | **130**<br>110 -------- 150 | **100**<br>85 -------- 120 | **85**<br>70 -------- 95 | **70**<br>60 -------- 80 |
| **Sands/ loamy sands** | | | | |
| Irrigated—all crops[d] | **215**<br>200 -------- 230 | **200**<br>185 -------- 210 | **185**<br>175 -------- 195 | **175**<br>165 -------- 185 |
| Non-irrigated—all crops[d] | **140**<br>130 -------- 150 | **130**<br>120 -------- 140 | **120**<br>110 -------- 130 | **110**<br>100 -------- 120 |

[a] Includes N in starter.
[b] Rate is the N rate that provides the maximum return to nitrogen (MRTN).
[c] Range is the range of profitable N rates that provide an economic return to N within $1/a of the MRTN rate.
[d] Subtract N credits for forage legumes, legume vegetables, animal manures, and green manures. This includes first-, second-, and third-year credits where applicable. Do not subtract N credits for leguminous vegetables on sand and loamy sand soils.
[e] Subtract N credits for animal manures and second-year forage legumes.

The soil and previous crop affect the recommended rate. Rates are highest for more productive soils (irrigated sands/sandy loams) and lowest for the least productive systems (loamy medium yield potential soils). Also, rates are lower for corn following soybeans or small grains. The width of the recommended range does not vary much with the previous crop, and it tends to be narrower for sandy soils. Prices have the largest effect. The nitrogen-to-corn price ratio is the cost of buying nitrogen measured in bushels of corn per pound of nitrogen. When nitrogen is relatively low cost (price ratio of 0.05), the recommended rate is higher than when nitrogen is relatively high cost (price ratio of 0.20). Prices also affect the



recommended range. When nitrogen is relatively low cost, the recommended range is wider than when nitrogen is relatively high cost.

Overall, this information provides context for nitrogen management in crops. Nitrogen is a key input, but the corn yield response becomes relatively flat once nitrogen rates are at optimal or near optimal levels. Because corn yields vary tremendously from a variety of factors other than nitrogen, identifying the small effect of nitrogen on yield becomes difficult when nitrogen is used at optimal or near optimal rates. Across the Midwest, nitrogen recommendations from Extension balance fertilizer costs against expected yield gains, and as a result, vary with the prices of fertilizer and corn. Furthermore, due to the multiple sources of yield variability and the flatness of the yield response curve to nitrogen, Extension recommendations use a range in application rates, not a single recommended rate.

## Specific Example to Illustrate

For the 2021 cropping season, the price of nitrogen was almost $0.40 per pound when farmers were buying fertilizer (Dr. Carrie Laboski, personal communication) and in mid-March the expected harvest time price of corn was around $4.58 per bushel based on the crop insurance initial corn price (USDA-RMA 2021). These prices give a ratio of 0.40/4.58 = 0.087, which is between 0.05 and 0.10 in Figure 5. For high yield potential soil in Wisconsin for corn following soybean and using these prices, the online decision tool gives a recommended rate of 124 pounds per acre with a range from 109 to 138 pounds per acre (http://cnrc.agron.iastate.edu/).

Based on these prices, the first plot in Figure 6 shows the yield response curve generated by the online tool, with the nitrogen rate on the horizontal axis and yield on the vertical axis, expressing yield as a percentage of maximum yield. This curve is the underlying curve used to derive the recommended rate of 124 pounds per acre. It also shows the flatness of the curve at higher application rates, which makes yield relatively non-responsive to changes in nitrogen when using optimal or near optimal rates. The curve becomes relative flat starting at about 100 pounds, where yield already at 97.0% of the maximum, but it does not reach 100% until 200 pounds. Going from 0 to 100 pounds raises expected yield 27 percentage points, from 70% of its maximum at 0 pounds to 97% at 100 pounds. However, adding another 100 pounds to go from 100 to 200 pounds only raises expected yield 3 percentage points, from 97% to 100% of its maximum.

The second plot in Figure 6, also generated by the online tool, shows the derivation of the recommended rate. Again, the nitrogen rate is on the horizontal axis, while the vertical axis is per acre returns or cost. The blue line is revenue (expected corn yield multiplied by the corn price) and the green line is the cost of nitrogen (nitrogen rate multiplied by the nitrogen price). The orange line is the net return to nitrogen: corn revenue minus the cost for fertilizer, or graphically, the gap between the blue and green lines. The orange line peaks at 124 pounds per acre of nitrogen, but is very flat around this maximum. Over the range from 109 to 138 pounds per acre, the expected return is within $1/ac of the maximum, which is how the recommended range is derived.

**Figure 5.** Corn yield response to nitrogen as a percent of maximum yield and returns to nitrogen for high yield potential soils in Wisconsin for corn following soybean with a nitrogen price of $0.40/lb and a corn price of $4.58/bu

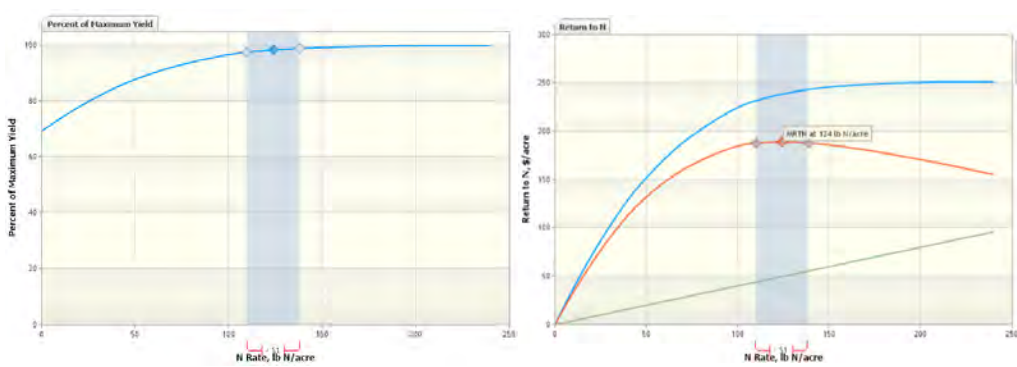
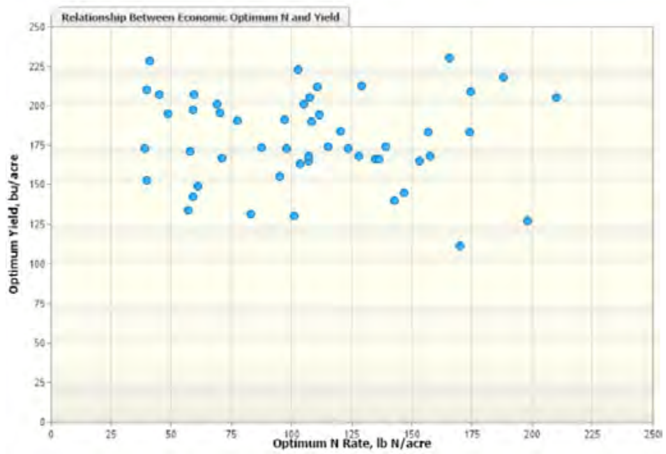


**Figure 6.** Variability in the corn yield and the the optimal nitrogen application rate at the plot level




## Potential Impact on Corn Yields and Farmer Returns

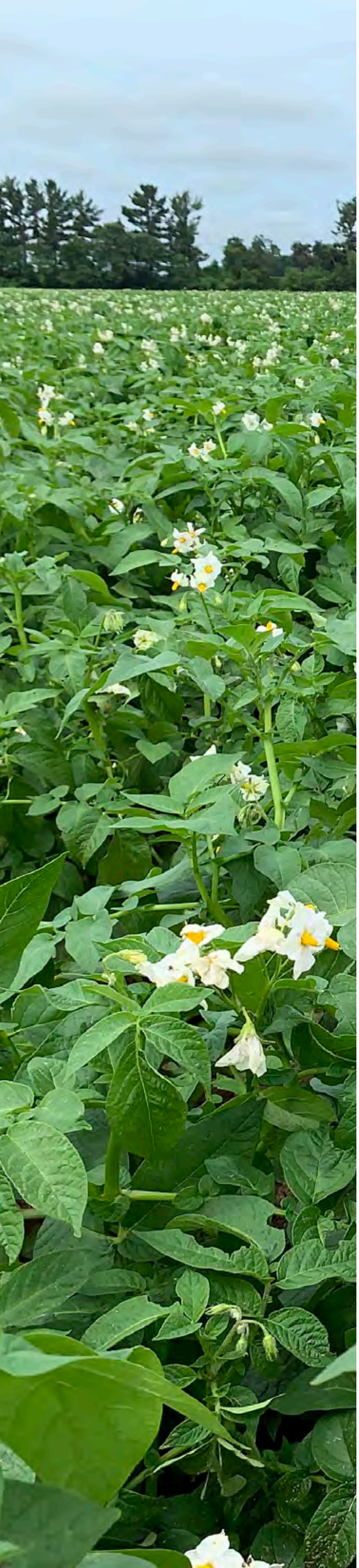
This tool could be used to estimate average corn yield losses if farmers were to reduce their nitrogen application rates to satisfy the proposed rule. These yield losses can then be combined with the nitrogen fertilizer cost savings to conduct a partial budget analysis to estimate the aggregate impact on average farmer returns to corn production.

Suppose a farmer has a field with an expected yield of 180 bushels per acre of corn on a high yield potential soil following soybeans. Using the tool and following the illustration for 2021 in this section, suppose the farmer would typically use 120 pounds per acre, in the range the tool recommends. However, suppose the farmer had to reduce the rate to 105 pounds per acre (a 12.5% reduction) to satisfy the proposed rule. Based on Figure 6, the tool predicts yield is 98.3% of the maximum at 120 pound per acre, and 97.2% of the maximum at 105 pounds per acre, so that reducing nitrogen this much reduces yield by 1.1%. Using the USDA-RMA crop insurance price of $4.58/bu, this loss is 1.1% X 180 bu/ac = 2.0 bu/ac X $4.58/bu = $9.16/ac.

Note however that the farmer (or even a researcher) would not be able to consistently observe this yield loss because yield variably from many other sources would overwhelm a loss of this magnitude. Figure 7 from the online tool shows the raw data points for the recommended application rate for each site contributing data and the associated observed yield. Visually, the average yield looks to be around 180 to 190 bu/ac, but more importantly, the variation is tremendous – ranging from a low yield of around 110 bu/ac to highs for two sites exceeding 225 bu/ac. A yield shift of 2 bu/ac due to reducing the nitrogen rate would not be statistically identifiable with this much yield variability (Mitchell 2004). The point is that the tool could be used to predict the average yield loss from reducing the nitrogen application rate when averaging across multiple years and many farms, but the experience of any specific farmer in a specific year would vary tremendously around this average.

To support the Iowa Nutrient Reduction Strategy, Iowa State University Extension developed a fact sheet summarizing best management practices farmers could adopt, which included information on the impact of each practice on nutrient losses and corn yield (ISU Extension 2017). For those using the maximum return to nitrogen (MRTN) as provided by the online corn nitrogen calculator (http://cnrc.agron.iastate.edu/), the nitrogen losses declined 10% and yield by 1%. This impact is quite similar to the previous illustration developed here. Hence, a yield loss of 1% and a nitrogen rate reduction for 10% are used to project the potential magnitude of the economic losses if the proposed rule were implemented. However, note that no solid data are available on how many corn acres would need to reduce nitrogen rates and by how much and the impact that this would have on average yields. The calculations here indicate the magnitude of potential losses and identify the types of data needed.

For 2018-2020, Wisconsin farmers on average planted 3.9 million acres of corn each year (USDA-NASS 2021a). Based on Table 1, 58.7% of these acres are in the targeted area, or almost 2.29 million acres. For 2018-2020, the Wisconsin state average corn grain yield was 170.7 bu/ac (USDA-NASS 2021a). A 1% loss on these acres using this yield is 170.7 x 1% x 2.29 million acres = 3.91 million bushels. For 2018-2020, the average of the marketing year average farm price for corn was $3.70 for Wisconsin (USDA NASS 2021a), which is well below the current futures prices for corn for the 2021 crop. The initial crop insurance price guarantee for corn set in mid-March for 2021 was $4.58/bu (USDA RMA 2021), while the July USDA WASDE farm price projected for the US is currently $5.60/bu (USDA OCE 2021). Using these three prices

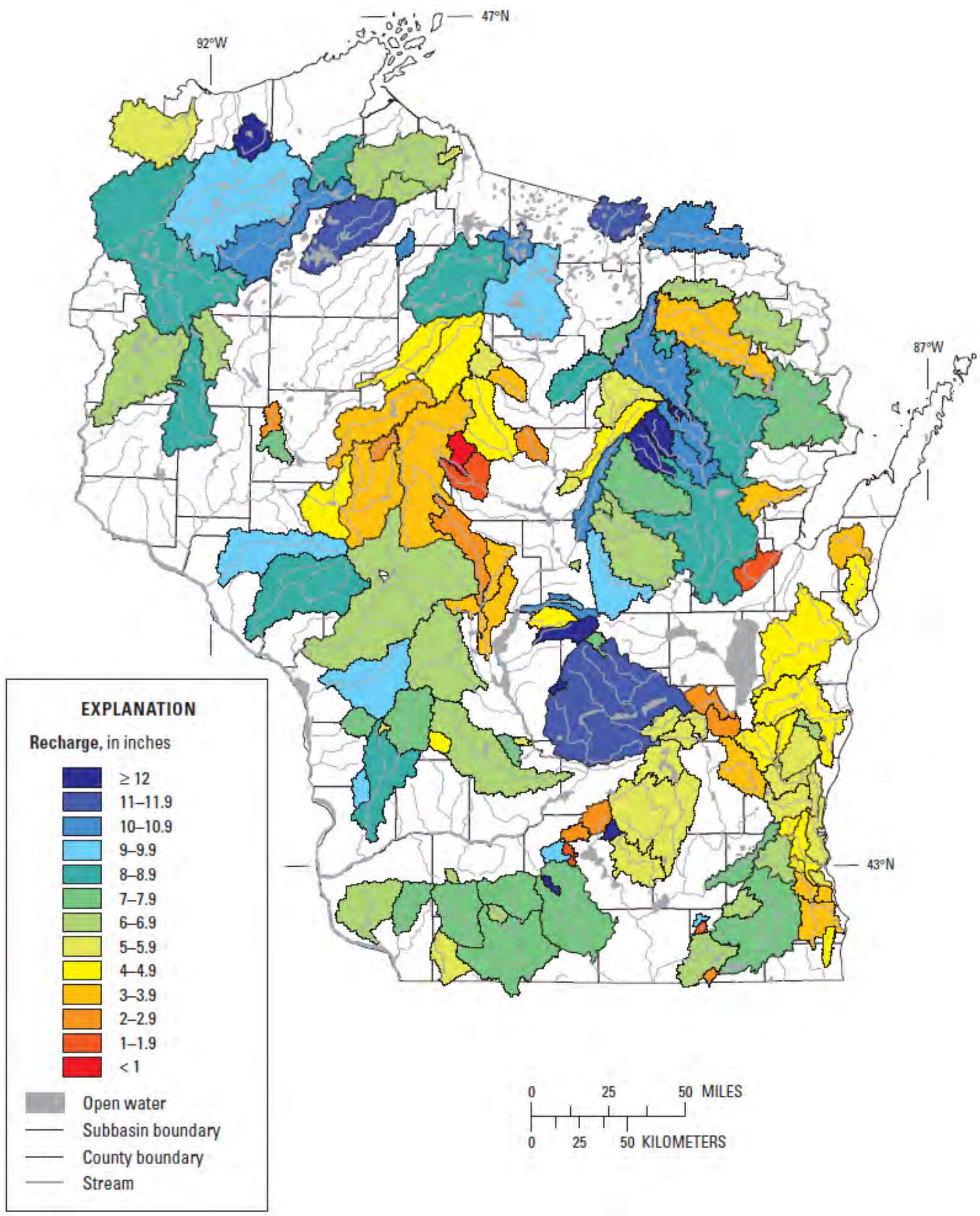


($3.70, $4.58, $5.60), the lost farm revenue from of this 1% yield loss is $14.46, $17.90, and $21.88 million, respectively. Reducing the nitrogen rate would also reduce fertilizer costs. Using the state average nitrogen application rate of 113 lbs/ac in 2018 (Table 2), a 10% rate reduction implies 11.3 lbs/ac. Using a nitrogen price of $0.40/lb gives cost savings of 11.3 x $0.40 = $4.52 per acre, or, after multiplying by 2.29 million acres, a total cost savings of $10.35 million. Combining this cost savings with the revenue losses gives an estimated net loss to farmers of $4.11 million, $7.55 million and $11.53 million with a $3.70, $4.58 and $5.60/bu corn price, respectively.

Several factors imply variation in these estimated losses. Besides the corn price, state average yields vary annually and follow an upward trend. Using a higher yield (or an average loss greater than 1%) would increase the net impact. Nitrogen fertilizer prices also vary. After rising to as high as $0.63 per pound in 2012, the annual average price ranged from $0.30 to $0.38 per pound over the last five years, but have risen in 2021 (Plastina 2021). With lower nitrogen prices, nitrogen cost savings decrease and so the net losses to farmers increase, with the opposite occurring with higher nitrogen prices.

A final issue to note for the proposed rule is that current nitrogen recommendations change in response to the price of corn and nitrogen fertilizer (Figure 5), whereas the proposed rule does not. Thus, fields currently under NM plans using UW recommendations may not satisfy

**Figure 7.** Spatial distribution of average annual recharge, 1970–99, at streamflow-gaging stations in Wisconsin (Gerbert et al. 2009, p. 4)



the proposed rule in years with high corn prices and/or low nitrogen prices when higher nitrogen rates are recommended. This possibility implies that yield losses to satisfy the proposed rule will be larger in such years, which are also years with higher corn prices. This potential for conflict between the Extension recommendation based on the MRTN approach and the proposed rule is a technical issue yet to be resolved and will require additional research to clarify.

### Potential Impacts on Other Crops

This discussion focused on corn, but applied nitrogen is an essential input for other crops in the state, such as winter wheat, potatoes, and processing vegetables. For wheat, data has been collected and analyzed to develop recommendations based on the MRTN approach used for corn (Laboski and Peters 2012, pp. 40-42). Comparable data also exists for potato and vegetables crops in Wisconsin and could also be analyzed using an MRTN approach (e.g., Ruark and Mitchell 2012). This analysis would give the yield response curve to nitrogen to estimate average yield losses for nitrogen reductions, but additional research would be needed to develop reasonable estimates of the nitrogen rate reduction needed to satisfy the proposed rule. Note that using the estimate of a 10% rate reduction and a 1% yield loss for corn from Iowa (ISU Extension 2017) gives some sense of the potential magnitude of losses, but these calculations are not definitive. Additional research is needed to develop better estimates of the rate reduction and yield losses that occur for Wisconsin farmers when using the MRTN approach for corn and other crops.

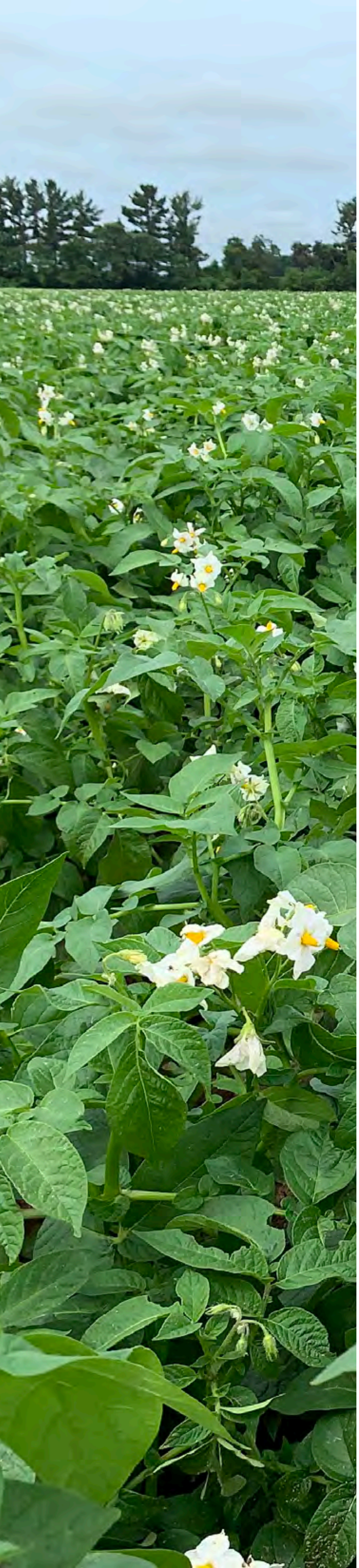
The process used for corn to estimate economic losses from a rate reduction is repeated for potatoes using the same 10% rate reduction and a 1% yield loss. For 2017 to 2019, the state average yield is 415 cwt/ac, the average farm price of $11.00/cwt, and 70,000 acres were planted in Wisconsin (USDA-NASS 2021a). Using on these values, and the 95.3% of potato acres are in the targeted areas (Table 1), a 1% yield loss would generate a total revenue loss of 415 cwt/ac x 1% x $11.00/cwt x 70,000 ac x 95.3% = $3.05 million. Using an average nitrogen application rate of 240 lbs/ac (rounding USDA NASS data upward) and a nitrogen price of $0.40/lb, the cost savings from a 10% rate reduction is 240 lbs/ac x 10% x $0.40 x 70,000 x 95.3% = $640,000. Combining the revenue loss and this cost saving, the net loss for Wisconsin potato farmers would be $2.41 million.

Again, potato yields, acres and prices vary annually, as does the price of nitrogen, all of which would change this estimated value. A significant unknown is the nitrogen rate reduction needed to satisfy the proposed rule and the impact that it would have on total yield. The 10% rate reduction and 1% yield loss assumptions are the estimated values for corn from Iowa. More significantly, this estimate does not account for the impact of the nitrogen rate on potato tuber quality, such as the tuber size profile. For example, too little nitrogen reduces harvested yield because many varieties produce smaller tubers (not fewer tubers of the same average size). Smaller tubers have lower value and so, decreasing nitrogen not only decreases the average yield, but also the average price received. Nitrogen can also affect other quality traits such as specific gravity and sugar content that also affect the average price received. These calculations show the potential magnitude of losses for potato assuming a 1% yield loss and a 10% nitrogen rate reduction, based on corn data. However, additional research is needed to generate more reliable estimates of the rate reductions needed and the associated yield and quality losses using data from potato.

## 4. Losses from Expanding Crop Rotations

Farmers in the focus groups expressed concerns that the proposed rule would not only require that they reduce their nitrogen application rates, but also lengthen their crop rotations away from crops such as corn, corn silage and potatoes that are higher value and higher nitrogen use. The impact of the proposed rule change (or similar rule changes) on crop rotations is a key area requiring additional research. In an attempt to develop some information about potential changes, this section builds simplified nitrogen budgets for common Wisconsin crops, and then explores how hypothetical farms could change crop rotations and/or nitrogen application rates to bring average nitrogen losses from a field into compliance with the proposed rule. Examples are developed for a cash grain operation, a dairy farm producing forage, and an irrigated potato-vegetable farm on sandy soil.

The section is lengthy, but the initial results suggest that the farmers concerns were valid. In addition to nitrogen rate reduction, continuous production of corn grain and/or silage would likely need to add crops such as soybeans, wheat (when possible) and alfalfa into the rotation to satisfy the proposed rule, suggesting substantial income losses. Potato and vegetable production would also face substantial pressure to plant grain and forage crops rather than



commercial vegetables to maintain potato rotations, again implying substantial income losses. However, these results are based on several assumptions that require clarification and data. Hence, the key finding in this section is that farmer concerns are likely valid to some degree, but additional data and research are needed, as well as clarification of how nitrogen losses will be calculated, before the magnitude of the economic impact can be estimated.

Before beginning, based on feedback from reviewers, a few key points require clarification.

1. The potential nitrogen loss and crop rotation examples developed here do **not** represent any state averages. They are examples to illustrate the types of tradeoffs individual farms would likely face.
2. The nitrogen budgeting process used to develop these examples is almost certainly **not** how the proposed rule will actually implement nitrogen budgeting. The process here is simplified for illustration and as a result generates unrealistic results in some cases – high yields from low nitrogen application rates and low yields from high rates. The actual process remains to be developed and would almost certainly be more detailed and comprehensive than used here.

## Example Crop Nitrogen Budgets for Grains

The nitrogen cycle and soil nitrogen dynamics are highly complex and quite variable across years, within the same season, and even spatially within a field. The analysis here abstracts from this variability to create a single-season crop nitrogen budget that only tracks nitrogen inputs and nitrogen removal through the harvested crop. The budgeting process developed here is a simplification of the budgets developed by Masarik (2021a). Carryover of nitrogen across years is ignored, as is nitrogen mineralization from soil organic pools (including crop residues), as well as atmospheric deposition, denitrification, volatilization, losses via runoff or soil erosion and similar factors. Similarly, the timing of application(s) and mineralization relative to crop uptake and precipitation is also ignored. The only nitrogen inputs are nitrogen fertilizer applied to the crop or supplied via credits from manure and/or the previous crop. The only nitrogen loss is removal in the harvested crop material. The difference between these nitrogen inputs supplied and nitrogen removed is then potentially leachable nitrogen as yield and applied nitrogen vary.

An example illustrates the calculations. Assume a continuous corn field receives 180 pounds of nitrogen per acre as commercial fertilizer and annually harvests 180 bushels per acre on average. The market standard bushel of corn weighs 56 pounds and corn grain is 0.73 lbs of nitrogen per bushel, or 0.73 / 56 = 1.3% nitrogen (Table 5-4 in Meisinger and Randall 1991, Masarik 2021a). Thus, 180 bu/ac x 56 lbs/bu x 1.3% = 131 lbs/ac of nitrogen, so that of the 180 lbs/ac of nitrogen applied, 180 – 131 = 49 lbs/ac is potentially leachable. If the field is in a region averaging 8 inches of ground water recharge annually, the potential loss is 49 / 8 = 6.1 pounds of nitrogen per acre inch of recharge per year. Note that this simple calculation ignores many of the details, but indicates the amount of nitrogen potentially susceptible to leaching as yield and applied nitrogen vary. Also note that the process can generate unrealistic results. With high yields and low nitrogen application rates, the estimated pounds of nitrogen lost per acre inch of recharge per year is a large (in magnitude) negative number, while with low yields and high application rates, the estimated pounds of nitrogen lost per acre inch of recharge per year is a large positive number.

Tables 7 to 9 report the results of these calculations for grain corn, corn silage, and wheat for a variety of assumptions. The first column is the assumed yield and the second column is the calculated nitrogen removed in this yield based on the assumed nitrogen content of 1.3% for corn grain, 0.36% for corn silage and 1.83% for soft red winter wheat (Table 5-4 in Meisinger and Randall 1991). The next columns show the potentially leachable nitrogen for different nitrogen application rates listed in the column headings. In Tables 7 and 8, nitrogen rates for corn grain and silage are the mid-point and the lower and upper end for the recommended ranges for a price ratio of 0.10 for a high yield potential loam soil (Laboski and Peters 2012 and Figure 5). For corn following soybeans, the values in the column heading include adding 20 lbs/ac of nitrogen to the applied rate as a soybean credit based on a UW Extension publication (UW Extension 2012). No manure credits are assumed. In Table 9, nitrogen rates for wheat are the mid-point and lower and upper end for the recommended ranges for a price ratio of 0.075 for a loamy soil and for a sandy soil, both after corn without a preplant nitrate test (Laboski and Peters 2012). No manure or legume credits are assumed. Finally, 8 inches of groundwater recharge is assumed for these tables as a "typical" amount based on Gerbert et al. (2009).

Note that these calculations and the associated results reported in these tables do not assume a connection between applied nitrogen and yield. The calculations are done assuming the applied nitrogen can generate that listed yield, even if it is not realistic. For example, Table 7 reports calculation results for 240 bu/ac yield when 125 lbs/ac of nitrogen

is available – likely not a realistic scenario. Indeed, the large negative numbers in Table 7 for some yield-nitrogen rate combinations suggest that the applied nitrogen cannot generate the listed yields, there is simply not enough nitrogen available without additional nitrogen from other sources not accounted for in the calculations, such as mineralization or nitrogen carryover. Also, note that the use of cover crops would not change these calculations since cover crops do not add nitrogen here (non-legume cover crops are assumed). Cover crops can scavenge nitrogen in the fall and hold it for release in the spring/summer via mineralization for crop uptake, which can reduce nitrogen losses. However, these calculations do not include these types of nitrogen dynamics or credits for legume cover crops.

Tables 7 to 9 show that with constant nitrogen application rates, as yield increases (i.e., moving down the rows), more and more of the nitrogen is removed by the crop and so the amount left to potentially leach decreases, eventually satisfying the proposed rule. Also, as the nitrogen rate increases (i.e., moving right across the columns), more and more nitrogen is available to potentially leach and so it takes higher yields to satisfy the proposed rule. To help make this point clear, solid lines in Tables 7 to 9 trace out compliance with the proposed rule of 2.2 pounds of nitrogen per acre inch per year. Entries below or left of the line satisfy the proposed rule, while those above or to the right of the line do not. These tables show that with a high enough yield, the nitrogen remaining can even become negative, implying that for the crop to yield that much, nitrogen from sources outside of the calculations must be used, such as mineralization from soil organic matter, carryover from previous years or atmospheric deposition.

**Table 7.** Implied potential nitrogen loss over a range of assumed yields and nitrogen application rates based on a constant nitrogen removal rate in harvested corn grain and annual groundwater recharge

| | | Potential Nitrogen Loss[b] (lbs/ac-in/yr) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Corn following Soybean Nitrogen Application Rate[c] | | | Corn following Corn Nitrogen Application Rate | | |
| Yield (bu/ac) | Nitrogen Removed (lbs/ac)[a] | Low 125 lbs/ac | Medium 140 lbs/ac | High 150 lbs/ac | Low 155 lbs/ac | Medium 165 lbs/ac | High 180 lbs/ac |
| 140 | 101.9 | 2.9 | 4.8 | 6.0 | 6.6 | 7.9 | 9.8 |
| 145 | 105.6 | 2.4 | 4.3 | 5.6 | 6.2 | 7.4 | 9.3 |
| 150 | 109.2 | 2.0 | 3.9 | 5.1 | 5.7 | 7.0 | 8.9 |
| 155 | 112.8 | 1.5 | 3.4 | 4.6 | 5.3 | 6.5 | 8.4 |
| 160 | 116.5 | 1.1 | 2.9 | 4.2 | 4.8 | 6.1 | 7.9 |
| 165 | 120.1 | 0.6 | 2.5 | 3.7 | 4.4 | 5.6 | 7.5 |
| 170 | 123.8 | 0.2 | 2.0 | 3.3 | 3.9 | 5.2 | 7.0 |
| 175 | 127.4 | -0.3 | 1.6 | 2.8 | 3.5 | 4.7 | 6.6 |
| 180 | 131.0 | -0.8 | 1.1 | 2.4 | 3.0 | 4.2 | 6.1 |
| 185 | 134.7 | -1.2 | 0.7 | 1.9 | 2.5 | 3.8 | 5.7 |
| 190 | 138.3 | -1.7 | 0.2 | 1.5 | 2.1 | 3.3 | 5.2 |
| 195 | 142.0 | -2.1 | -0.2 | 1.0 | 1.6 | 2.9 | 4.8 |
| 200 | 145.6 | -2.6 | -0.7 | 0.6 | 1.2 | 2.4 | 4.3 |
| 205 | 149.2 | -3.0 | -1.2 | 0.1 | 0.7 | 2.0 | 3.8 |
| 210 | 152.9 | -3.5 | -1.6 | -0.4 | 0.3 | 1.5 | 3.4 |
| 215 | 156.5 | -3.9 | -2.1 | -0.8 | -0.2 | 1.1 | 2.9 |
| 220 | 160.2 | -4.4 | -2.5 | -1.3 | -0.6 | 0.6 | 2.5 |
| 225 | 163.8 | -4.9 | -3.0 | -1.7 | -1.1 | 0.2 | 2.0 |
| 230 | 167.4 | -5.3 | -3.4 | -2.2 | -1.6 | -0.3 | 1.6 |
| 235 | 171.1 | -5.8 | -3.9 | -2.6 | -2.0 | -0.8 | 1.1 |
| 240 | 174.7 | -6.2 | -4.3 | -3.1 | -2.5 | -1.2 | 0.7 |

[a] Based on 1.3% nitrogen content per pound of grain.
[b] Based on 8 inches of recharge annually.
[c] Nitrogen from applied fertilizer, manure credits and legume credits.

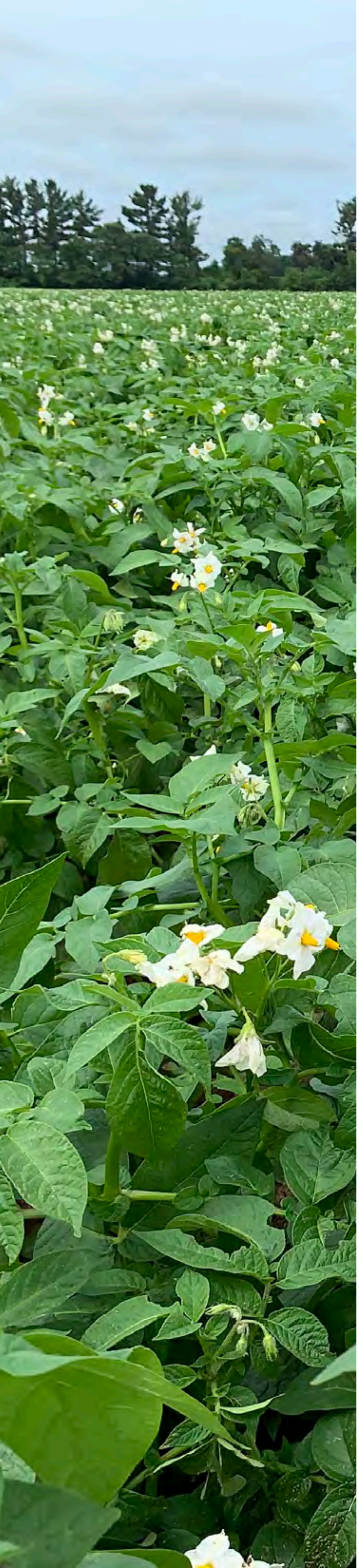


**Table 8.** Implied potential nitrogen loss over a range of assumed yields and nitrogen application rates based on a constant nitrogen removal rate in harvested corn silage and annual groundwater recharge

| | | Potential Nitrogen Loss[b] (lbs/ac-in/yr) | | | | | |
|---|---|---|---|---|---|---|---|
| | | **Corn Silage following Soybean** Nitrogen Application Rate[c] | | | **Corn Silage following Corn Silage** Nitrogen Application Rate | | |
| **Yield** (ton/ac) | **Nitrogen Removed** (lbs/ac)[a] | **Low** 125 lbs/ac | **Medium** 140 lbs/ac | **High** 150 lbs/ac | **Low** 155 lbs/ac | **Medium** 165 lbs/ac | **High** 180 lbs/ac |
| 16.0 | 115.2 | 1.2 | 3.1 | 4.4 | 5.0 | 6.2 | 8.1 |
| 16.5 | 118.8 | 0.8 | 2.7 | 3.9 | 4.5 | 5.8 | 7.7 |
| 17.0 | 122.4 | 0.3 | 2.2 | 3.5 | 4.1 | 5.3 | 7.2 |
| 17.5 | 126.0 | -0.1 | 1.8 | 3.0 | 3.6 | 4.9 | 6.8 |
| 18.0 | 129.6 | -0.6 | 1.3 | 2.6 | 3.2 | 4.4 | 6.3 |
| 18.5 | 133.2 | -1.0 | 0.8 | 2.1 | 2.7 | 4.0 | 5.9 |
| 19.0 | 136.8 | -1.5 | 0.4 | 1.7 | 2.3 | 3.5 | 5.4 |
| 19.5 | 140.4 | -1.9 | -0.1 | 1.2 | 1.8 | 3.1 | 5.0 |
| 20.0 | 144.0 | -2.4 | -0.5 | 0.8 | 1.4 | 2.6 | 4.5 |
| 20.5 | 147.6 | -2.8 | -0.9 | 0.3 | 0.9 | 2.2 | 4.1 |
| 21.0 | 151.2 | -3.3 | -1.4 | -0.2 | 0.5 | 1.7 | 3.6 |
| 21.5 | 154.8 | -3.7 | -1.9 | -0.6 | 0.0 | 1.3 | 3.2 |
| 22.0 | 158.4 | -4.2 | -2.3 | -1.1 | -0.4 | 0.8 | 2.7 |
| 22.5 | 162.0 | -4.6 | -2.8 | -1.5 | -0.9 | 0.4 | 2.3 |
| 23.0 | 165.6 | -5.1 | -3.2 | -2.0 | -1.3 | -0.1 | 1.8 |
| 23.5 | 169.2 | -5.5 | -3.7 | -2.4 | -1.8 | -0.5 | 1.4 |
| 24.0 | 172.8 | -6.0 | -4.1 | -2.9 | -2.2 | -1.0 | 0.9 |
| 24.5 | 176.4 | -6.4 | -4.6 | -3.3 | -2.7 | -1.4 | 0.4 |
| 25.0 | 180.0 | -6.9 | -5.0 | -3.8 | -3.1 | -1.9 | 0.0 |
| 25.5 | 183.6 | -7.3 | -5.5 | -4.2 | -3.6 | -2.3 | -0.4 |
| 26.0 | 187.2 | -7.8 | -5.9 | -4.7 | -4.0 | -2.8 | -0.9 |

[a] Based on 0.36% nitrogen content per pound of silage.
[b] Based on 8 inches of recharge annually.
[c] Nitrogen from applied fertilizer, manure credits and legume credits.

State average corn yields were 174 bu/ac in 2020 (USDA NASS 2021a), while yield trials in southern Wisconsin typically average corn yields of more than 240 bu/ac (Kohn et al. 2021). In 2020, the state average silage yield was 21.0 tons/ac, but county averages were 25.5 tons/ac for Columbia and Dane counties (USDA NASS 2020). The state average wheat yield was 69 bu/ac in 2020, with yield trials in 2020 showing almost all varieties yielding more than 90 bu/ac, and yields averaging more than 100 bu/ac in Chilton in the northeastern part of the state (Conley et al. 2021). These yields and tables suggest that farms can remove much of their applied nitrogen as corn grain, corn silage or wheat systems, depending on yield and how much nitrogen is applied.

With an average yield of 175 bu/ac, the values in Table 7 suggest that compliance with the proposed rule is possible at all three nitrogen application rates used for corn following soybeans even with the 20 lb/ac soybean credit, assuming yields can reach the necessary levels with the assumed application rates. For the higher application rates used for corn following corn, yields need to reach 190, 205 and 225 bu/ac to satisfy the proposed rule, achievable yields based on the corn yield trial results. Corn silage results in Table 8 show a similar outcome. At a yield of 21 ton/ac, nitrogen removal is sufficient to bring compliance for all but the highest application rate, and compliance occurs for all rates once yield reaches 23 ton/ac. The wheat results in Table 9 show that once yields reach 85 bu/ac, compliance occurs for all rates even in the sandy soils. However, the amount of groundwater recharge and the nitrogen content of the harvested biomass are two key assumptions for these results.

**Table 9.** Implied potential nitrogen loss over a range of assumed yields and nitrogen application rates based on a constant nitrogen removal rate in harvested wheat grain and annual groundwater recharge

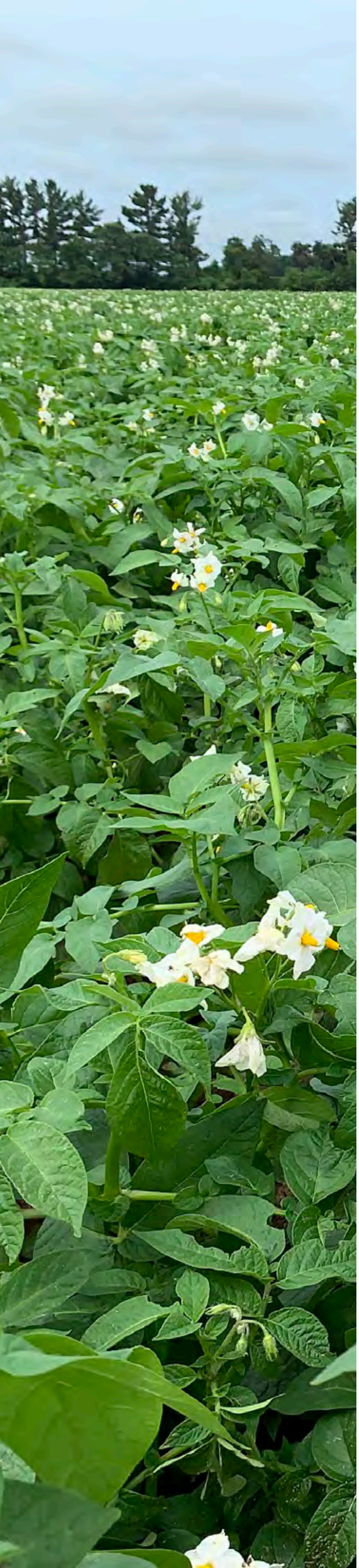
| | | **Potential Nitrogen Loss**[b] (lbs/ac-in/yr) | | | | | |
|---|---|---|---|---|---|---|---|
| | | **Loamy Soil** Nitrogen Application Rate | | | **Sandy Soil** Nitrogen Application Rate | | |
| **Yield** (bu/ac) | **Nitrogen Removed** (lbs/ac)[a] | **Low** 55 lbs/ac | **Medium** 70 lbs/ac | **High** 80 lbs/ac | **Low** 90 lbs/ac | **Medium** 100 lbs/ac | **High** 110 lbs/ac |
| 40 | 45.6 | 1.4 | 3.3 | 4.5 | 6.4 | 7.0 | 8.3 |
| 45 | 51.3 | 0.7 | 2.6 | 3.8 | 5.7 | 6.3 | 7.6 |
| 50 | 57.0 | 0.0 | 1.9 | 3.1 | 5.0 | 5.6 | 6.9 |
| 55 | 62.7 | -0.7 | 1.2 | 2.5 | 4.3 | 5.0 | 6.2 |
| 60 | 68.4 | -1.4 | 0.5 | 1.8 | 3.6 | 4.3 | 5.5 |
| 65 | 74.1 | -2.0 | -0.2 | 1.1 | 3.0 | 3.6 | 4.8 |
| 70 | 79.8 | -2.7 | -0.9 | 0.4 | 2.3 | 2.9 | 4.1 |
| 75 | 85.5 | -3.4 | -1.5 | -0.3 | 1.6 | 2.2 | 3.5 |
| 80 | 91.2 | -4.1 | -2.2 | -1.0 | 0.9 | 1.5 | 2.8 |
| 85 | 96.9 | -4.8 | -2.9 | -1.7 | 0.2 | 0.8 | 2.1 |
| 90 | 102.6 | -5.5 | -3.6 | -2.4 | -0.5 | 0.1 | 1.4 |
| 95 | 108.3 | -6.2 | -4.3 | -3.0 | -1.2 | -0.5 | 0.7 |
| 100 | 114.0 | -6.9 | -5.0 | -3.7 | -1.9 | -1.2 | 0.0 |
| 105 | 119.7 | -7.5 | -5.7 | -4.4 | -2.5 | -1.9 | -0.7 |
| 110 | 125.4 | -8.2 | -6.3 | -5.1 | -3.2 | -2.6 | -1.3 |
| 115 | 131.1 | -8.9 | -7.0 | -5.8 | -3.9 | -3.3 | -2.0 |
| 120 | 136.8 | -9.6 | -7.7 | -6.5 | -4.6 | -4.0 | -2.7 |
| 125 | 142.5 | -10.3 | -8.4 | -7.2 | -5.3 | -4.7 | -3.4 |
| 130 | 148.2 | -11.0 | -9.1 | -7.8 | -6.0 | -5.3 | -4.1 |
| 135 | 153.9 | -11.7 | -9.8 | -8.5 | -6.7 | -6.0 | -4.8 |
| 140 | 159.6 | -12.3 | -10.5 | -9.2 | -7.3 | -6.7 | -5.5 |

[a] Based on 1.9% nitrogen content per pound of grain.
[b] Based on 8 inches of recharge annually.

## Variation in Groundwater Recharge and Crop Nitrogen Content

The yield and nitrogen rate combinations in Tables 7 to 9 that satisfy the proposed rule are sensitive to groundwater recharge. Decreasing recharge from 8 inches to 6 inches increases all the reported values of nitrogen susceptible to leaching in Tables 7 to 9 by 33%, while increasing recharge from 8 to 10 inches decreases all values by 20%. As a result, for example, a yield of 190 bu/ac is needed for the medium rate for corn following corn in Table 7 to satisfy the proposed rule. With 6 inches of recharge, the yield needed increases to 195 bu/ac and decreases to 185 bu/ac with 10 inches of recharge.

Average annual groundwater recharge in the state varies greatly by watershed and within watersheds. Figure 8 shows annual averages by watershed from Gerbert et al. (2009), showing some areas averaging more than 12 inches and others less than 1 inch. Substantial spatial variability occurs within these watersheds as well (see Figure 4 in Gerbert et al. 2009). Smail et al. (2021) use a water budget approach based on evapotranspiration, precipitation, and irrigation to estimate that annual average recharge for agricultural lands in the state ranges from 8.5 to 8.8 inches for dairy and pasture/hay rotations to 10.6 to 10.9 inches for grain and potato-vegetable rotations (see Table 1 in Smail et al. 2021). The implication is that tables for each farm field equivalent to Tables 7 to 9 would vary greatly across farms due to variation in average annual groundwater recharge.



Not surprisingly, the calculated nitrogen susceptible to leaching in Tables 7 to 9 is also sensitive to the amount of nitrogen removed in the harvested crop biomass. Specifically, the calculations for Tables 7 to 9 assume nitrogen contents of 1.3% for corn grain, 0.36% for corn silage and 1.9% for wheat, based on Meisinger and Randall (1991). However, substantial variation occurs in the nitrogen content of crops due to variation in temperature, precipitation, and crop nitrogen management. Meisinger and Randall (1991) report ranges for each crop based on the available literature at that time. More recently, Midwestern corn agronomists documented an average of 1.15% nitrogen content for corn grain in field trials conducted from 1999-2016, but with a range from 0.76% to 1.66% (Tenorio et al. 2019). The nitrogen content for corn silage will vary similarly due to variation in the nitrogen content of both the grain and the stover. Similarly, Jackson (2001) documents the variation in the nitrogen content of winter wheat across yields and nitrogen application rates.

Changing the nitrogen content of the harvested biomass for a crop will change the values in Tables 7 to 9, but the effect is not proportional across entries due to the structure of the formula. For example, decreasing the assumed nitrogen content for corn grain to 1.2% increases the entries in Table 7, but the percentage change increases when moving down the table and decrease when moving to the right. Furthermore, some of the same factors affect both the crop nitrogen content and yield (e.g., temperature, precipitation, nitrogen availability) and so both measures tend to be correlated (Tenorio et al. 2019, Jackson 2001). As a result, the nitrogen content of crops would not be constant for the entries in Tables 7 to 9, but would change when moving down the rows to change yield or moving across columns to change the applied nitrogen. The implication is that tables for each farm field equivalent to Tables 7 to 9 would also vary greatly across farms due to variation in the nitrogen content of the harvested crop.

## Example Grain and Forage Rotations

Tables 10 and 11 use the results in Tables 7 to 9 to explore how a hypothetical farm could satisfy the proposed rule by lengthening their crop rotation and/or reducing nitrogen application rates. Again, note that these hypothetical rotations are not meant as an average or typical farm, but are examples to illustrate the types of tradeoffs a farm would face in order to satisfy the proposed rule. The focus is on rotational changes to satisfy the proposed rule, ignoring other concerns, including farmer returns. These alternative rotations developed here likely imply a reduction in farm income, otherwise farms would already be using these alternatives. The economics of crop rotation changes are discussed more fully in the section titled "Economic Impacts of Extending/Expanding Crop Rotations".

The hypothetical field is planted in a continuous corn grain rotation using the highest rate of nitrogen (180 lbs/ac) with an average yield of 180 bu/ac. Based on Table 7 and its assumptions, nitrogen potentially susceptible to leaching is 6.1 pounds per acre-inch per year in losses. This rotation is the first rotation in Table 10, averaging 6.1 pounds per acre-inch per year, and does not satisfy the proposed rule.

The first option examined in Table 10 is adding soybean to the rotation every third year (a corn-corn-soybean rotation). The first year of corn would be following soybean, and so, with the highest nitrogen application rate, would have a loss of 2.4 pounds of nitrogen per acre-inch per year based on Table 7. The second year of corn would follow corn and so still have a loss of 6.1 pounds per acre-inch per year. Soybean would not have any nitrogen applied and so would have no nitrogen susceptible to leaching (a zero loss). The average loss over the three-year rotation would be 2.8 pounds per acre-inch per year, still not satisfying the proposed rule.

The next option examined in Table 10 is a corn-soybean rotation. Corn following soybeans using the highest nitrogen application rate for corn would again give a loss of 2.4 pounds of nitrogen per acre-inch per year based on the Table 7. Again, soybean would have no nitrogen susceptible to leaching and so has a zero loss. The average loss over the two-year rotation would be 1.2 pounds per acre-inch per year, which would satisfy the proposed rule.

The last option examined in Table 10 is a corn-soybean-wheat rotation, again using the highest nitrogen application rate for the corn. For corn following wheat, Table 10 uses a loss of 6.1 pounds per acre-inch per year based on the Table 7 for a 180 bu/ac yield. For wheat following soybeans, Table 10 uses a zero, since the entries for wheat on a loamy soil are negative for a yield of 75 or more bushels per acre, even with the highest application rates. The average loss over this three-year rotation would be 2.0 pounds per acre-inch per year, which would also satisfy the proposed rule.

These options in Table 10 show that this hypothetical field using a continuous corn rotation with a high nitrogen rate would likely have to extend their crop rotation to satisfy the

**Table 10.** Hypothetical example of farmer extending a grain crop rotation to satisfy the proposed rule

| | Continuous Corn | | Corn-Soybean | | Corn-Soybean | | Corn-Soybean-Wheat | |
|---|---|---|---|---|---|---|---|---|
| **Year** | **Crop** | **N Loss[a]** | **Crop** | **N Loss[a]** | **Crop** | **N Loss[a]** | **Crop** | **N Loss[a]** |
| 1 | Corn | 6.1 | Corn | 2.4 | Corn | 2.4 | Corn | 6.1 |
| 2 | Corn | 6.1 | Corn | 6.1 | Soybean | 0 | Soybean | 0 |
| 3 | Corn | 6.1 | Soybean | 0 | Corn | 2.4 | Wheat | 0 |
| 4 | Corn | 6.1 | Corn | 2.4 | Soybean | 0 | Corn | 6.1 |
| 5 | Corn | 6.1 | Corn | 6.1 | Corn | 2.4 | Soybean | 0 |
| 6 | Corn | 6.1 | Soybean | 0 | Soybean | 0 | Wheat | 0 |
| **Average** | | **6.1** | | **2.83** | | **1.20** | | **2.03** |

[a] Nitrogen loss in pounds per acre inch of recharge per year based on 8 inches of recharge annually.

**Table 11.** Hypothetical example of dairy farmer extending a forage crop rotation or adjusting the corn nitrogen application rate to meet the proposed rule

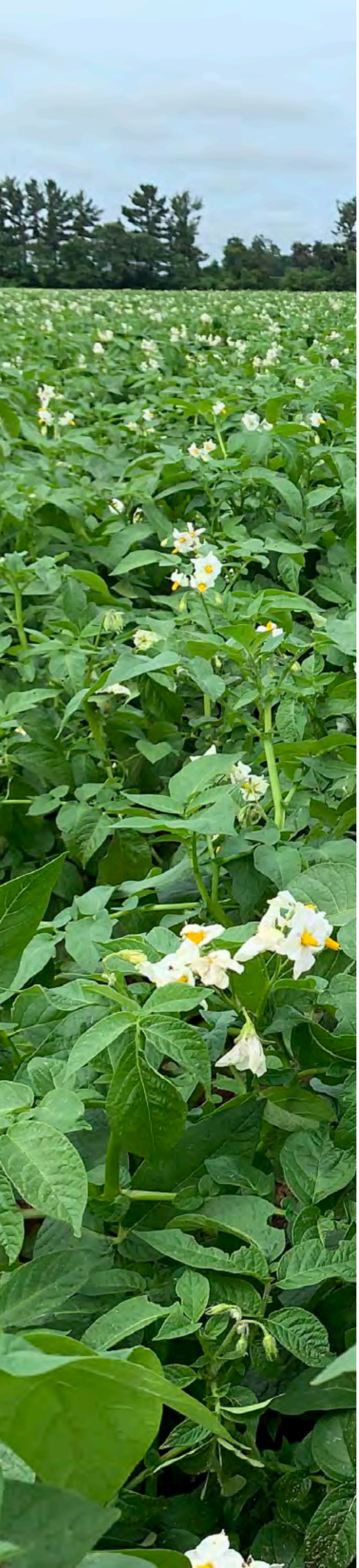
| | Continuous Silage High Corn N Rate | | Continuous Silage Medium Corn N Rate | | Corn Silage-Alfalfa High Corn N Rate | | Corn Silage-Soybean High Corn N Rate | |
|---|---|---|---|---|---|---|---|---|
| **Year** | **Crop** | **N Loss[a]** | **Crop** | **N Loss[a]** | **Crop** | **N Loss[a]** | **Crop** | **N Loss[a]** |
| 1 | Silage | 3.6 | Silage | 1.7 | Silage | 3.6 | Silage | 0 |
| 2 | Silage | 3.6 | Silage | 1.7 | Silage | 3.6 | Silage | 3.6 |
| 3 | Silage | 3.6 | Silage | 1.7 | Silage | 3.6 | Silage | 3.6 |
| 4 | Silage | 3.6 | Silage | 1.7 | Alfalfa | 0 | Silage | 3.6 |
| 5 | Silage | 3.6 | Silage | 1.7 | Alfalfa | 0 | Soybean | 0 |
| 6 | Silage | 3.6 | Silage | 1.7 | Alfalfa | 0 | | |
| **Average** | | **3.6** | | **1.7** | | **1.80** | | **2.16** |

[a] Nitrogen loss in pounds per acre inch of recharge per year based on 8 inches of recharge annually.

proposed rule, adding crops with low or no nitrogen losses such as soybean or wheat. These are not the only options to satisfy the proposed rule for this hypothetical farm. Also, the options in Table 10 are highly dependent on the assumed yields, nitrogen rates, groundwater recharge and crop nitrogen content. Furthermore, implementing the proposed rule will require some clarifications of how leaching losses vary for crops depending on the previous crop. For example, even if the same amount of nitrogen is available to corn (via commercial fertilizer or legume and/or manure crediting), it is unclear whether the leaching potential for corn following corn differs from corn following soybean, alfalfa, or wheat.

Table 11 follows a similar concept for a hypothetical field, but for forage rotations. The hypothetical field is planted in a continuous corn silage rotation using the highest rate of nitrogen (180 lbs/ac) with an average yield of 21 tons/ac. Based on Table 8 and its assumptions, this is the first rotation in Table 11, with 3.6 pounds of nitrogen per acre-inch per year potentially susceptible to leaching, which does not satisfy the proposed rule. The first option keeps the same rotation (continuous corn silage), but reduces nitrogen use to the medium level of 165 lbs/ac. Based on Table 8, losses decrease to 1.7 pounds per acre-inch per year, which satisfies the proposed rule.

The other two options in Table 11 extend the rotation by adding alfalfa or soybean. A six-year rotation with three years of corn silage followed by three years of alfalfa uses 3.6 pounds of nitrogen per acre-inch per year for the silage years and 0 of the alfalfa years. Corn silage following alfalfa still has 3.6 pounds in nitrogen losses, but the first year of silage makes no commercial fertilizer applications, as all nitrogen is from legume crediting and/or manure. Alfalfa has 0 nitrogen losses since no nitrogen is applied. The average loss over the six-year rotation is 1.8 pounds per acre-inch per year, which satisfies the proposed rule. The last option adds soybeans every fifth year to the silage rotation. The first year of silage following soybeans has zero nitrogen losses because the entries in Table 8 for silage after soybeans with a yield of 21



tons/ac are all negative, even with the highest nitrogen rate. The average loss over the five-year rotation is 2.16 pounds per acre-inch per year, which satisfies the proposed rule.

The options in Table 11 show that this hypothetical field focused on continuous corn silage production using a high nitrogen rate could adjust nitrogen application rates or extend the rotation to satisfy the proposed rule by adding crops with low or no nitrogen losses such as alfalfa or soybean. Again, these are not the only options to satisfy the proposed rule for this hypothetical farm. Also, the same caveats apply – the options in Table 11 are highly dependent on the assumed yields, nitrogen rates, groundwater recharge and crop nitrogen content and how previous crops affect leaching losses needs clarification.

## Example Nitrogen Budgets for Potato and Vegetable Crops

Table 12 to 14 are hypothetical single-season nitrogen budgets for potatoes, sweet corn and green beans, the most common vegetable crops grown in the state. These tables use the same process and assumptions as used for the corn, silage and wheat crops in Tables 7 to 9. The first column is crop yield and the second column is the nitrogen removed in the harvested crop biomass. Nitrogen content for each crop is from Meisinger and Randall (1991): 0.4% for potato tubers, 0.43% for sweet corn (ears in husks), and 0.39% for green beans. Again, these percentages are averages, varying substantially with yield, weather, and nitrogen management. Also, these calculations can generate unrealistic outcomes – high yields with low nitrogen application rates and low yields with high application rates respectively giving large (in magnitude) negative losses or large positive losses.

These crops are commonly grown in the Central Sands of Wisconsin with recommended nitrogen rates not based on the previous crop but soil organic matter (Laboski and Peters 2021). The middle nitrogen application rate for potatoes is 240 lbs/ac to match the USDA NASS state average of 237 lbs/ac in 2014 and 239 lbs/ac in 2016 available in the USDA NASS Quick Stats online tool. The high and low rates then added and subtracted 40 lbs/ac around this average to capture a range, even though the 280 lbs/ac rate is above the highest recommended rate for potatoes in the state (Laboski and Peters 2012). For sweet corn and green beans, the middle rate is the recommended rate for sandy (low organic matter) soils: 150 lbs/ac for sweet corn and 60 lbs/ac for green beans, with the high and low rates then adding and subtracting 30 lbs/ac for sweet corn and 15 lbs/ac for green beans to provide a range around this average. No manure or legume crediting is assumed, but these rates include nitrogen in the groundwater applied for irrigation.

Because previous crops do not impact nitrogen application rates, Table 12 to 14 vary groundwater recharge rather than the previous crop. As Figure 8 shows, parts of the Central Sands are not included in Gerbert et al. (2009) estimates of recharge. Smail et al. (2021) estimate state average recharge amounts for crop rotation in the places where they were actually grown and account for irrigation, reporting 10.94 inches (278 mm) of recharge for potato-to-vegetable rotations. Hence, Tables 12 to 14 each use 10 inches and 12 inches of recharge to calculate the amount of nitrogen potentially susceptible to leaching, approximately one inch higher and lower than this average. Again, the tables include lines denoting the break for yield and nitrogen rate combinations satisfying the proposed rule. However, because the nitrogen rate does not vary monotonically when moving across all six columns, there are two lines in Tables 12 to 14, one for 10 inches of recharge and one for 12 inches.

The results in Tables 12 to 14 for a hypothetical field follow the same patterns identified for the grain rotations. As yields increase, potential nitrogen losses decrease, and as nitrogen rates increase, potential losses increase. The tables also show that as recharge increases, potential nitrogen losses decrease, a pattern only discussed for the grain rotations. The values in Tables 12 to 14 also imply that the potential for leaching losses of nitrogen is relatively high for these crops, especially potatoes and sweet corn.

State average potato yields for Wisconsin for 2016 to 2019 averaged 420 cwt/ac (USDA NASS 2021a), but this average includes several short-season lower yielding varieties. Full season russets commonly yield substantially more. For example, the highest yield category for nitrogen recommendations is the 551-650 cwt/ac (Laboski and Peters 2012). Table 12 shows that with 10 inches of recharge, potato yields above 450 cwt/ac would satisfy the standard when using 200 lbs/ac of nitrogen. Required yields increase to 550 cwt/ac and then 650 cwt/ac for 240 lbs/ac and 280 lbs/ac of nitrogen, respectively. With 12 inches of recharge, required yields to satisfy the proposed rule only decrease 10 cwt/ac. These results suggest that it may be possible to satisfy the proposed rule, but growers would need to have consistently high yields using these nitrogen rates, which may or may not be possible. A key point that Table 12 does not include is potato quality. Like most specialty crops, quality is an important part of the value of a potato crop, not just total cwt/ac harvested. Production and marketing

contracts specify a schedule of bonuses and discounts based on quality traits such as specific gravity, sugar content and tuber size, traits that are affected by nitrogen management.

State average sweet corn yields for Wisconsin for 2016 to 2019 averaged 8.6 tons/ac (USDA NASS 2021a). Table 13 shows that, depending on the assumed recharge, yields of 11.0 or 11.5 tons/ac are needed to satisfy the proposed rule, and then only with the lowest nitrogen rate examined (120 lbs/ac). Yields of this size are achievable in the Central Sands, but typically

**Table 12.** Implied potential nitrogen loss over a range of assumed yields and nitrogen application rates based on a constant nitrogen removal rate in harvested potato tubers and annual groundwater recharge

| | | Potential Nitrogen Loss (lbs/ac-in/yr) | | | | | |
|---|---|---|---|---|---|---|---|
| | | With 10 inches of Recharge Nitrogen Application Rate[b] | | | With 12 inches of Recharge Nitrogen Application Rate[b] | | |
| Potato Yield (cwt/ac) | Nitrogen Removed (lbs/ac)[a] | Low 200 lbs/ac | Medium 240 lbs/ac | High 280 lbs/ac | Low 200 lbs/ac | Medium 240 lbs/ac | High 280 lbs/ac |
| 350 | 140.0 | 6.0 | 10.0 | 14.0 | 5.0 | 8.3 | 11.7 |
| 360 | 144.0 | 5.6 | 9.6 | 13.6 | 4.7 | 8.0 | 11.3 |
| 370 | 148.0 | 5.2 | 9.2 | 13.2 | 4.3 | 7.7 | 11.0 |
| 380 | 152.0 | 4.8 | 8.8 | 12.8 | 4.0 | 7.3 | 10.7 |
| 390 | 156.0 | 4.4 | 8.4 | 12.4 | 3.7 | 7.0 | 10.3 |
| 400 | 160.0 | 4.0 | 8.0 | 12.0 | 3.3 | 6.7 | 10.0 |
| 410 | 164.0 | 3.6 | 7.6 | 11.6 | 3.0 | 6.3 | 9.7 |
| 420 | 168.0 | 3.2 | 7.2 | 11.2 | 2.7 | 6.0 | 9.3 |
| 430 | 172.0 | 2.8 | 6.8 | 10.8 | 2.3 | 5.7 | 9.0 |
| 440 | 176.0 | 2.4 | 6.4 | 10.4 | 2.0 | 5.3 | 8.7 |
| 450 | 180.0 | 2.0 | 6.0 | 10.0 | 1.7 | 5.0 | 8.3 |
| 460 | 184.0 | 1.6 | 5.6 | 9.6 | 1.3 | 4.7 | 8.0 |
| 470 | 188.0 | 1.2 | 5.2 | 9.2 | 1.0 | 4.3 | 7.7 |
| 480 | 192.0 | 0.8 | 4.8 | 8.8 | 0.7 | 4.0 | 7.3 |
| 490 | 196.0 | 0.4 | 4.4 | 8.4 | 0.3 | 3.7 | 7.0 |
| 500 | 200.0 | 0.0 | 4.0 | 8.0 | 0.0 | 3.3 | 6.7 |
| 510 | 204.0 | -0.4 | 3.6 | 7.6 | -0.3 | 3.0 | 6.3 |
| 520 | 208.0 | -0.8 | 3.2 | 7.2 | -0.7 | 2.7 | 6.0 |
| 530 | 212.0 | -1.2 | 2.8 | 6.8 | -1.0 | 2.3 | 5.7 |
| 540 | 216.0 | -1.6 | 2.4 | 6.4 | -1.3 | 2.0 | 5.3 |
| 550 | 220.0 | -2.0 | 2.0 | 6.0 | -1.7 | 1.7 | 5.0 |
| 560 | 224.0 | -2.4 | 1.6 | 5.6 | -2.0 | 1.3 | 4.7 |
| 570 | 228.0 | -2.8 | 1.2 | 5.2 | -2.3 | 1.0 | 4.3 |
| 580 | 232.0 | -3.2 | 0.8 | 4.8 | -2.7 | 0.7 | 4.0 |
| 590 | 236.0 | -3.6 | 0.4 | 4.4 | -3.0 | 0.3 | 3.7 |
| 600 | 240.0 | -4.0 | 0.0 | 4.0 | -3.3 | 0.0 | 3.3 |
| 610 | 244.0 | -4.4 | -0.4 | 3.6 | -3.7 | -0.3 | 3.0 |
| 620 | 248.0 | -4.8 | -0.8 | 3.2 | -4.0 | -0.7 | 2.7 |
| 630 | 252.0 | -5.2 | -1.2 | 2.8 | -4.3 | -1.0 | 2.3 |
| 640 | 256.0 | -5.6 | -1.6 | 2.4 | -4.7 | -1.3 | 2.0 |
| 650 | 260.0 | -6.0 | -2.0 | 2.0 | -5.0 | -1.7 | 1.7 |

[a] Based on 0.4% of nitrogen per pound of potato tubers.
[b] Nitrogen from applied fertilizer, manure credits, legume credits, and irrigation water.

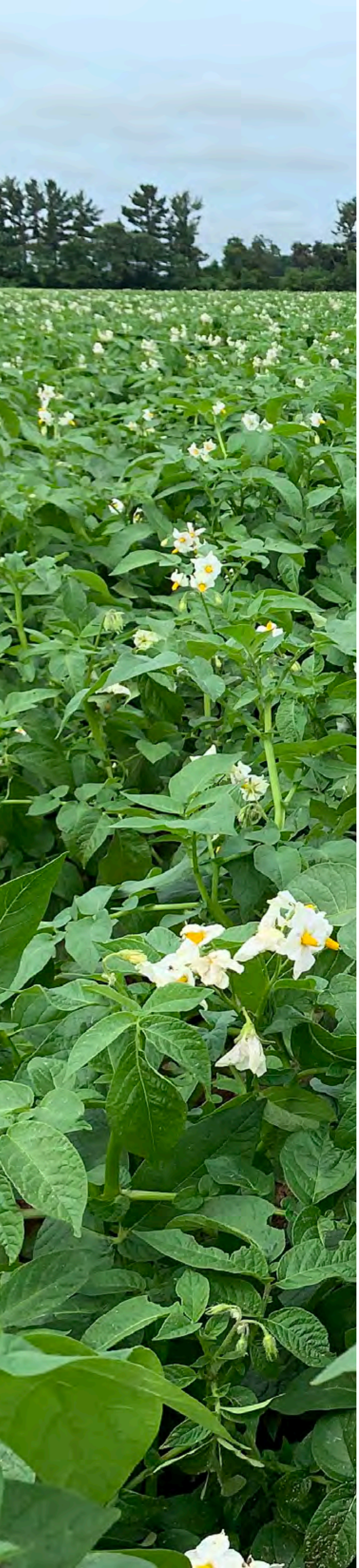


**Table13.** Implied potential nitrogen loss over a range of assumed yields and nitrogen application rates based on a constant nitrogen removal rate in harvested sweet corn (ears and husks) and annual groundwater recharge

| | | **Potential Nitrogen Loss** (lbs/ac-in/yr) | | | | | |
|---|---|---|---|---|---|---|---|
| | | **With 10 inches of Recharge** Nitrogen Application Rate[b] | | | **With 12 inches of Recharge** Nitrogen Application Rate[b] | | |
| **Yield** (tons/ac) | **Nitrogen Removed** (lbs/ac)[a] | **Low** 120 lbs/ac | **Medium** 150 lbs/ac | **High** 180 lbs/ac | **Low** 120 lbs/ac | **Medium** 150 lbs/ac | **High** 180 lbs/ac |
| 5.0 | 43.0 | 7.7 | 10.7 | 13.7 | 6.4 | 8.9 | 11.4 |
| 5.5 | 47.3 | 7.3 | 10.3 | 13.3 | 6.1 | 8.6 | 11.1 |
| 6.0 | 51.6 | 6.8 | 9.8 | 12.8 | 5.7 | 8.2 | 10.7 |
| 6.5 | 55.9 | 6.4 | 9.4 | 12.4 | 5.3 | 7.8 | 10.3 |
| 7.0 | 60.2 | 6.0 | 9.0 | 12.0 | 5.0 | 7.5 | 10.0 |
| 7.5 | 64.5 | 5.6 | 8.6 | 11.6 | 4.6 | 7.1 | 9.6 |
| 8.0 | 68.8 | 5.1 | 8.1 | 11.1 | 4.3 | 6.8 | 9.3 |
| 8.5 | 73.1 | 4.7 | 7.7 | 10.7 | 3.9 | 6.4 | 8.9 |
| 9.0 | 77.4 | 4.3 | 7.3 | 10.3 | 3.6 | 6.1 | 8.6 |
| 9.5 | 81.7 | 3.8 | 6.8 | 9.8 | 3.2 | 5.7 | 8.2 |
| 10.0 | 86.0 | 3.4 | 6.4 | 9.4 | 2.8 | 5.3 | 7.8 |
| 10.5 | 90.3 | 3.0 | 6.0 | 9.0 | 2.5 | 5.0 | 7.5 |
| 11.0 | 94.6 | 2.5 | 5.5 | 8.5 | 2.1 | 4.6 | 7.1 |
| 11.5 | 98.9 | 2.1 | 5.1 | 8.1 | 1.8 | 4.3 | 6.8 |
| 12.0 | 103.2 | 1.7 | 4.7 | 7.7 | 1.4 | 3.9 | 6.4 |
| 12.5 | 107.5 | 1.3 | 4.3 | 7.3 | 1.0 | 3.5 | 6.0 |
| 13.0 | 111.8 | 0.8 | 3.8 | 6.8 | 0.7 | 3.2 | 5.7 |

[a] Based on 0.43% of nitrogen per pound of sweet corn (ears with husks).
[b] Nitrogen from applied fertilizer, manure credits, legume credits, and irrigation water.

require more than 120 lbs/ac of nitrogen (Ruark and Mitchell 2012). Overall, these results suggest that it will be difficult in the Central Sands for rotations including sweet corn to satisfy the proposed rule. Again, note that the results in Table 13 do not include sweet corn quality traits that affect crop value in production contracts and are affected by nitrogen management. Finally, note that the assumed nitrogen content of 0.43% for harvested sweet corn ears with husks from Meisinger and Randall (1991) is at least 30 years old and may be out of date with the more recent widespread planting of supersweet and sugary-enhancer hybrids.

Overall, the results in Table 14 suggest that snap beans will tend to have relatively lower nitrogen losses. The state average snap bean yields for Wisconsin averaged 5.2 tons/ac for 2016 to 2019 (USDA NASS 2021a). Table 14 shows that with 10 or 12 inches of recharge, a yield of 5.0 tons/ac will satisfy the proposed rule when using the recommended nitrogen rate of 60 lbs/ac or less. If the state average is 5.2 tons/ac, higher yields are certainly achievable in the state, but it is unclear what nitrogen rates are typically used to achieve these yields. Again, note that the results in Table 14 do not include the impacts of the nitrogen rate on snap bean quality, particularly size, which impacts the contract price paid, and so the nitrogen content assumed for harvested snap beans may need to be updated.

## Example Potato and Vegetable Rotations

A common rotation in the Central Sands is a three-year rotation of potato-sweet corn-snap beans. Some farms may plant green peas or double crop snap beans and/or green peas or add a fourth year to the rotation. In general, potatoes are the crop that makes the most income for farms, with processing vegetable crops used as a "placeholder" in the rotation to derive some return from the land and equipment while waiting until potatoes can again be planted in the field. As grain prices have increased, some farmers have explored adding field corn and/or soybean into their rotations, as well as forage crops such as silage or alfalfa for the few dairies in the region. Table 15 and 16 use the results in Tables 12 to 14 to explore how

**Table 14.** Implied potential nitrogen loss over a range of assumed yields and nitrogen application rates based on a constant nitrogen removal rate in harvested snap beans and annual groundwater recharge

| | | **Potential Nitrogen Loss** (lbs/ac-in/yr) | | | | | |
|---|---|---|---|---|---|---|---|
| | | **With 10 inches of Recharge** Nitrogen Application Rate[b] | | | **With 12 inches of Recharge** Nitrogen Application Rate[b] | | |
| **Yield** (tons/ac) | **Nitrogen Removed** (lbs/ac)[a] | **Low** 40 lbs/ac | **Medium** 60 lbs/ac | **High** 80 lbs/ac | **Low** 40 lbs/ac | **Medium** 60 lbs/ac | **High** 80 lbs/ac |
| 1.0 | 7.8 | 3.2 | 5.2 | 7.2 | 2.7 | 4.4 | 6.0 |
| 1.5 | 11.7 | 2.8 | 4.8 | 6.8 | 2.4 | 4.0 | 5.7 |
| 2.0 | 15.6 | 2.4 | 4.4 | 6.4 | 2.0 | 3.7 | 5.4 |
| 2.5 | 19.5 | 2.1 | 4.1 | 6.1 | 1.7 | 3.4 | 5.0 |
| 3.0 | 23.4 | 1.7 | 3.7 | 5.7 | 1.4 | 3.1 | 4.7 |
| 3.5 | 27.3 | 1.3 | 3.3 | 5.3 | 1.1 | 2.7 | 4.4 |
| 4.0 | 31.2 | 0.9 | 2.9 | 4.9 | 0.7 | 2.4 | 4.1 |
| 4.5 | 35.1 | 0.5 | 2.5 | 4.5 | 0.4 | 2.1 | 3.7 |
| 5.0 | 39.0 | 0.1 | 2.1 | 4.1 | 0.1 | 1.8 | 3.4 |
| 5.5 | 42.9 | -0.3 | 1.7 | 3.7 | -0.2 | 1.4 | 3.1 |
| 6.0 | 46.8 | -0.7 | 1.3 | 3.3 | -0.6 | 1.1 | 2.8 |
| 6.5 | 50.7 | -1.1 | 0.9 | 2.9 | -0.9 | 0.8 | 2.4 |
| 7.0 | 54.6 | -1.5 | 0.5 | 2.5 | -1.2 | 0.5 | 2.1 |
| 7.5 | 58.5 | -1.9 | 0.2 | 2.2 | -1.5 | 0.1 | 1.8 |
| 8.0 | 62.4 | -2.2 | -0.2 | 1.8 | -1.9 | -0.2 | 1.5 |
| 8.5 | 66.3 | -2.6 | -0.6 | 1.4 | -2.2 | -0.5 | 1.1 |
| 9.0 | 70.2 | -3.0 | -1.0 | 1.0 | -2.5 | -0.9 | 0.8 |

[a] Based on 0.39% of nitrogen per pound of snap beans.
[b] Nitrogen from applied fertilizer, manure credits, legume credits, and irrigation water.

a hypothetical farm could satisfy the proposed rule by lengthening their potato-vegetable crop rotation, adding agronomic or forage crops, and/or reducing their nitrogen application rates. Again, note that these hypothetical rotations are not meant as an average or typical farm, but are examples to illustrate the types of tradeoffs farms would face in order to satisfy the proposed rule. The rotational changes are focused on satisfying the proposed rule, ignoring other concerns, including farmer returns. These alternative rotations developed here likely imply a reduction in farm income, otherwise farms would already be using these alternatives. The economics of crop rotation changes are discussed more fully in the section titled "Economic Impacts of Extending/Expanding Crop Rotations".

The hypothetical field is planted in a potato-sweet corn-snap bean rotation using the highest rates of nitrogen: 280 lbs/ac for potato, 180 lbs/ac for sweet corn, and 80 lbs/ac for snap beans. Average yields for the field are 550 cwt/ac for potato, 10.0 tons/ac for sweet corn and 5.0 tons/ac for snap beans. Based on Tables 12 to 14 and 12 inches of recharge, respective nitrogen losses for each crop are 5.0, 7.8 and 3.4 pound per acre inch per year. This is the first rotation in Table 15, averaging 5.4 pounds per acre-inch per year, and does not satisfy the proposed rule.

The options explored focus on keeping potato at the highest nitrogen rates in the rotation, since it is recognized as the most valuable crop for farmers. The first option examined in Table 15 moves all three crops to medium nitrogen rates with no change in yield, which reduces nitrogen losses for each crop, but the average for the rotation is still 2.93 pound per acre-inch per year and so does not satisfy the proposed rule. The next option keeps potato and snap beans at the medium nitrogen rate, but moves sweet corn to the low rate since it the crop with the highest nitrogen loss rates, again with no yield changes. This change gives a rotation average of 2.1 pound per acre-inch per year, which satisfies the proposed rule. The last option

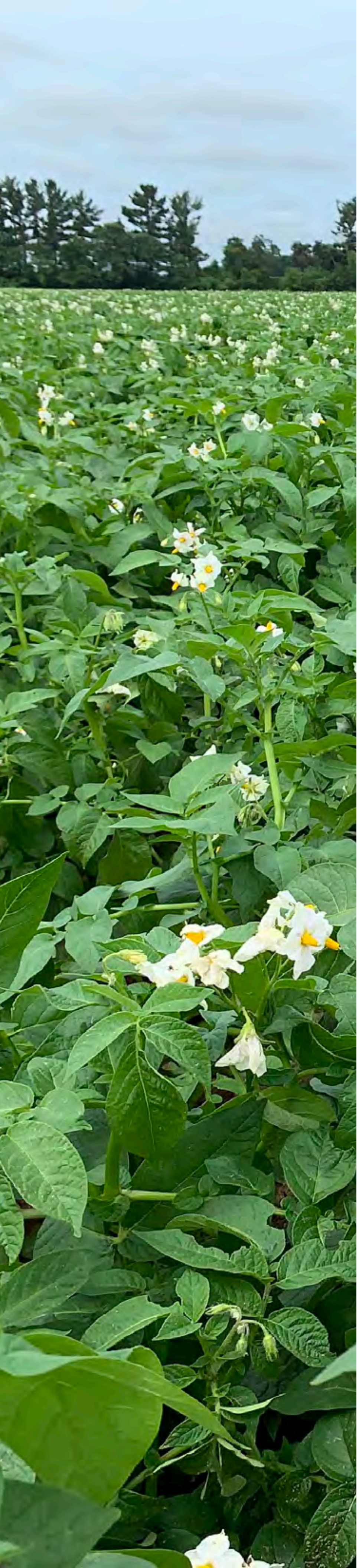


**Table 15.** Hypothetical example of farmer extending a potato-vegetable crop rotation or adjusting nitrogen application rate to meet the proposed rule

| | Three Year Rotations | | | | | | Four-Year Rotation | |
|---|---|---|---|---|---|---|---|---|
| | High N Rates | | Medium N Rates | | Medium/Low N Rates | | High/Low N Rates | |
| Year | Crop | N Loss | Crop | N Loss | Crop | N Loss | Crop | N Loss |
| 1 | Potato | 5.0 | Potato | 1.7 | Potato | 1.7 | Potato | 5.0 |
| 2 | Sweet Corn | 7.8 | Sweet Corn | 5.3 | Sweet Corn | 2.8 | Sweet Corn | 2.8 |
| 3 | Snap Beans | 3.4 | Snap Beans | 1.8 | Snap Beans | 1.8 | Snap Beans | 0.1 |
| 4 | | | | | | | Snap Beans | 0.1 |
| | **Average** | **5.40** | | **2.93** | | **2.10** | | **2.00** |

[a] Nitrogen loss in pounds per acre inch of recharge per year based on 12 inches of recharge annually.

**Table 16.** Hypothetical example of farmer switching to a potato-grain/forage crop rotation, extending the rotation, or adjusting nitrogen application rate to meet the proposed rule

| | Three Year Rotations | | | | | | Four-Year Rotation | |
|---|---|---|---|---|---|---|---|---|
| | High N Rates | | High/Medium N Rates | | Medium N Rates | | Medium/Low N Rates | |
| Year | Crop | N Loss[a] | Crop | N Loss[a] | Crop | N Loss[a] | Crop | N Loss[a] |
| 1 | Potato | 5.0 | Potato | 5.0 | Potato | 5.0 | Potato | 5.0 |
| 2 | Corn | 2.5 | Corn | 0.6 | Silage | 1.4 | Alfalfa | 0 |
| 3 | Soybean | 0 | Soybean | 0 | Soybean | 0.0 | Alfalfa | 0 |
| 4 | | | | | | | Alfalfa | 0 |
| | **Average** | **2.50** | | **1.87** | | **2.13** | | **1.25** |

[a] Nitrogen loss in pounds per acre inch of recharge per year based on 12 inches of recharge annually.

in Table 15 moves potato back to the highest nitrogen rate and adds a fourth crop to the rotation. Sweet corn is kept at the low nitrogen rate and two years of snap beans are planted, also at the low rate. These changes give a rotation average of 2.0 pounds per acre-inch per year, which also satisfies the proposed rule.

Table 16 looks at grain and forage crop options that also focus on keeping potato in the rotation at the highest nitrogen rate. The first rotation adds corn and soybean, with corn having a nitrogen loss of 2.5 pounds per acre-inch per year, the entry from Table 7 for a yield of 220 bu/ac and the highest nitrogen rate, and soybean with no loss. Wheat could also be substituted for soybean and with the high yields typical in the Central Sands, would have little to no nitrogen loss based on the calculations used here. The rotation average is 2.5 pounds per acre-inch per year, which does not satisfy the proposed rule. The second option reduces the corn nitrogen to the medium rate, giving a loss of 0.6 pounds per acre-inch per year for the corn based on Table 7 for a yield of 220 bu/ac, which brings the rotation average loss to 1.87 pounds per acre-inch per year, which satisfies the proposed rule. The third option plants corn silage instead of corn for grain. With a yield of 23.5 tons/ac at the highest nitrogen rate, the nitrogen susceptible to loss is 1.4 pounds per acre-inch per year based on Table 8. This change gives a rotation average loss of 2.13 pounds per acre-inch per year, which also satisfies the proposed rule. The final option extends the rotation by following potato with three years of alfalfa, which has no nitrogen loss, and so brings the rotation average nitrogen loss to 1.25 pounds per acre-inch per year.

Because potatoes generate the most income and nitrogen impacts not only yield but also tuber size and quality, it seems likely that farms would be reluctant to reduce nitrogen rates for potato. Returns and quality consideration are not as significant for sweet corn, snap beans

and other processing vegetables, and so farms would likely reduce nitrogen rates on those crops if they chose to continue growing potato-vegetable rotations, almost certainly reducing yields and quality. However, the high nitrogen losses from sweet corn suggest that farms would still need to extend the typical potato rotation to four or more years to satisfy the proposed rule if they continued to produce processing vegetable crops. Other viable alternatives would be to remove processing vegetables from rotations and instead grow grain and forage crops such as corn for grain, soybean, wheat, corn silage, and/or alfalfa. Indeed, Tables 15 and 16 suggest that a switch to grain and forage crops would be the easiest way for farms to satisfy the proposed rule.

Wisconsin's processing vegetable industry is the second largest in the US, focusing primarily on canning sweet corn, snap beans, green peas, carrots, beets, and crops such a pickling cucumbers. Growing and processing specialty crops such as potatoes, processing vegetables, and cranberries generates more than $5.8 billion in economic activity in the state annually and provides 24,500 jobs (Mitchell et al. 2017). However, vegetable production and processing has been declining in recent years due to shifting consumer preferences, and so the companies producing processing vegetables face thin margins, contributing to more consolidation and plant closings. A substantive concern also raised in the farmer focus groups is that the proposed rule would negatively impact the economic viability of vegetable production and processing in the state, a concern supported by these analyses.

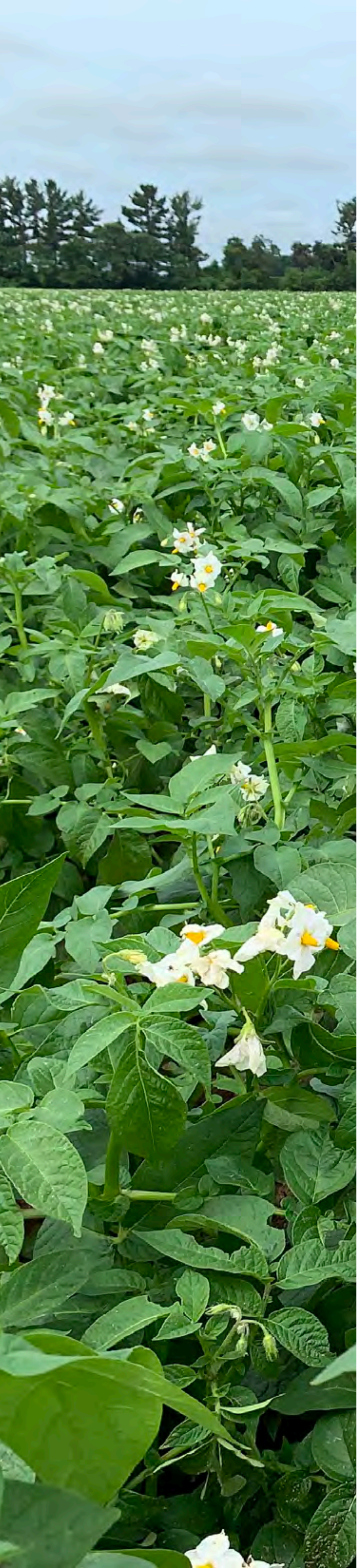
There is no open market for processing vegetables, rather all acres are contracted. Processing vegetable companies have volume budgets needed to run their plants at capacity and contract acres with growers to produce these budgets. Farmers could not simply add another year to their rotation to satisfy the proposed rule unless the processing companies demand those acres. If yields (and quality) were to decline, processors would need to contract more acres to meet their budgets, increasing their costs, and it is unclear if increased processor acreage demand would match grower needs for longer rotations. Another alternative would be for processors to contract with growers outside of the Central Sands in areas not subject to the proposed rule. This change would also increase processor costs to transport raw vegetables from these fields to existing plants. These increased costs for vegetable processors would increase consolidation pressures due to even thinner margins, further contributing to the decline of the industry in the state.

Again, the same caveats apply to the options in Tables 15 and 16 as for previous tables. These are not the only options to satisfy the proposed rule for this hypothetical farm and the options are highly dependent on the assumed yields, nitrogen rates, groundwater recharge and crop nitrogen content and how previous crops affect leaching losses likely needs clarification.

## Conclusions Regarding Losses from Expanding Crop Rotations

These budgets and crop rotations show the types of tradeoffs that farmers would face if the proposed rule were enacted. Not only will they have to explore reducing nitrogen application rates, but also adding crops to their rotations, and reducing corn, potatoes, and likely processing vegetables in their rotations. The numerous caveats and qualifications applied to the results reported in these tables indicates the level of complexity that accurately capturing these tradeoffs will entail for farmers and those developing decision aids for them. For example, parameters on the nitrogen content of harvested crop biomass likely need updating, guidance on groundwater recharge data to use for calculations in affected regions needs to be clarified, and a practical process for estimating the amount and timing of mineralization of crop residues, manure and soil organic matter likely needs to be developed. On top of these factors, crop prices vary regularly, as do fertilizer costs. Finally, developing a practical way to acknowledge the tremendous variably in nitrogen needs and losses and the economics of yield, prices and costs is needed, as farmers use nitrogen fertilizer not only to manage yield, but also to manage risk. Overall, these results indicate that a substantial amount of data collection and applied research is needed, focused specifically on developing a practical process for implementing the proposed rule. Some needs can likely be filled by those with experience and knowledge of the existing published research, but other information is simply unknown and would require data collection and/or field experiments for Wisconsin production systems.

Corn and potatoes are the two most valuable crops farmers plant for grain-forage and potato-vegetable rotations. If the proposed rule requires extending rotations to plant these crops less often, these changes will imply economic losses for farmers, but the extent of these losses cannot be estimated until the extent of the changes is clearer. Given the number and extent of the unknowns, conducting an economic analysis of the impacts of the rotational changes required to satisfy the proposed rule before the details of these changes are clear seems preliminary and beyond the scope of this analysis.



## Economic Impacts of Extending/Expanding Crop Rotations

Many factors influence crop rotation choices, but profitability is a key driver. Corn is generally the most profitable crop for grain and dairy operations, and so moving to rotations with less corn would involve economic losses. Soybeans can also be a profitable crop, but a significant source of their value in rotation with corn is that they reduce the per bushel cost of growing corn (Plastina 2021). They also allow a farm to spread out the workload. Planting and harvest are periods of intense time demand for most farms. Soybean planting usually occurs after corn planting and soybean harvest occurs before corn harvest. However, some dairy or beef farms need more corn silage than they can produce on half of their crop acres, and so find continuous corn rotations more valuable than a corn-soybean rotation. Silage is bulky and expensive to transport, and so localized production (on the farm or near the farm) is needed to make corn silage economical for a dairy or beef operation.

Large areas of the state are not conducive to winter wheat production and so farms in these areas cannot easily add wheat to their corn-soybean rotation. Farms in these areas would struggle to find a third crop to add to their corn-soybean rotation. Small grains like oats generate even lower profits than wheat, while planting soybeans after soybeans is generally not a viable practice in the state due to soybean disease problems that emerge. As a result, farms in these areas would struggle to find a third crop to add to their corn-soybean rotation. Some would likely explore forage crops such as alfalfa, but alfalfa is typically grown for three-consecutive years to justify the cost of establishment. Switching from a corn-soybean rotation to a corn-alfalfa rotation with one or two years of corn and then three years alfalfa is a significant change for farms. Not only is there less corn in the rotation, but they may have to buy new equipment for forage production and find markets for alfalfa hay. Also, their summer workload would change, as they would need to make hay four or more times during the summer. As many farms rely on off-farm income (especially small farms), the schedule for making hay may not be consistent with their off-farm work demands. They can use vacation days to have time to do spring planting and fall harvest but may not also be able to take time off for making hay multiple times in a season.

Estimating costs for switching from continuous corn to a corn-soybean or a corn-alfalfa rotation based on enterprise crop budgets for each crop do not capture the system factors discussed above that impact crop rotation choices. For example, the Iowa crop budgets (Plastina 2021) show costs per bushel and expected yields for several years for corn following corn, corn following soybeans, and soybeans following corn. Based on these budgets and crop insurance price guarantees in the spring, the estimated expected return for continuous corn versus a corn-soybean rotation was calculated. The average advantage for a corn-soybean rotation was more than $67 per acre over the last five years. Nevertheless, many farms in Iowa plant continuous corn – crop budgets do not capture all the system factors that drive crop rotation choices.

Among commercial vegetable farms, potato is the crop that is most profitable to grow, and so rotation changes to plant potatoes less frequently would involve economic losses. Most potato production in the state is irrigated and farmers have installed irrigation systems that require significant annual returns to make the investment economical. Adding one or more additional years to a rotation before returning to potatoes would significantly impact the expected cashflow from irrigation investments. Incorporating grain crops would likely be easiest, but corn for grain can create difficulties satisfying the proposed rule. Forage crops can more easily satisfy the proposed rule, but corn silage requires a near-by buyer to be economical and dairies are scarce in the Central Sands. Switching from a potato-sweet corn-snap bean to potato followed by three-years of alfalfa would extend the rotation by one year, reducing farmer profitability. Also, irrigated alfalfa uses more water than other crops in an area facing groundwater quantity issues, and most farms would likely need to buy forage equipment. It is not clear that forage crops like silage or alfalfa would be economically viable in the Central Sands. Separate crop budgets of the costs and returns from production of each crop do not capture these sorts of system factors that impact crop rotation choices and farmer returns.

At this time, it is unclear how much farms would need to change their crop rotations to satisfy the proposed rule. The results in Tables 7 to 16 show that a wide range of changes may be needed, or few at all. Data linking nutrient application rates and associated yields are lacking for Wisconsin farms to know where farms fall in terms of tables like Tables 7 and 8 for corn and silage and then how these would be put together to make tables like Table 10. Without such data, it is difficult to generate reasonable estimates of how many acres would change rotations.

## 5. Increased Farm Management Costs

Many of the concerns mentioned in the farmer focus groups fall broadly in the area of increased farm management costs as a result of implementing the proposed rule. Many of these are already part of the costs examined above. For example, additional costs for nutrient management planning would already be captured in the cost for expanding use of NM plans or in the existing costs for NM plans. However, a few stand out as likely not having been included elsewhere, especially those related to uncertainty around actions and documentation necessary to demonstrate compliance with the proposed rule changes. For example, these include the cost of tracking nitrogen in irrigation water and adjusting nutrient management accordingly, the costs for planning crop rotations and implementing system changes, and the costs of managing implements of husbandry paperwork to transport manure farther. Some of these costs would be higher initially during a transition period, but then decline once a new system was developed, while others would be continuing.

The average cost of an hour of time for a farm manager varies by experience and state and type of production (crops versus livestock). The US Bureau of Labor Statistics lists the national average salary for farmer managers as almost $37 per hour for 2020, with the Wisconsin average closer to $33.50 per hour (US BLS 2021). Based on this hourly rate, some calculations give a sense of the potential magnitude of that these additional managerial costs could reach.

On July 1, 2021, Wisconsin had 6,755 dairy herds (USDA NASS 2021b). In the analysis assuming 25% of the state's annual manure production had to be transported an additional quarter mile, suppose that this change fell on half of these farms, or 3,377 farms, which would imply that they would have to transport half of their manure and extra quarter mile on average. If 10% of these farms had to file additional paperwork to move manure across more implements-of-husbandry boundaries and/or negotiate more manure disposal contracts, this would affect 337 farms. If it took them an additional 5 hours per year, the added cost to farmers' managerial time would be 337 farms x 5 hours x $33.50 per hour = $56,448.

From 2011 to 2014, Wisconsin averaged 332,182 acres of crops under irrigation (Mitchell et al. 2017). Comparing Figure 1 here with Figure 1 from Mitchell et al. (2017), most of these irrigated acres are coarse textured soils in the proposed targeted areas. If these are center pivot systems with groundwater wells and assuming 145 acres in a 160-acre center pivot (i.e., dropping the "corners") would give 332,182 / 145 = 2,290 pivots. If on average a high-capacity well serves 2 pivots, it takes on average 5 hours per year to sample and test well water and then to make management adjustments for each pivot, the added cost to farmers' managerial time would be 2,290 pivots x ½ x 5 hours x $33.50 per hour = $191,788 annually.

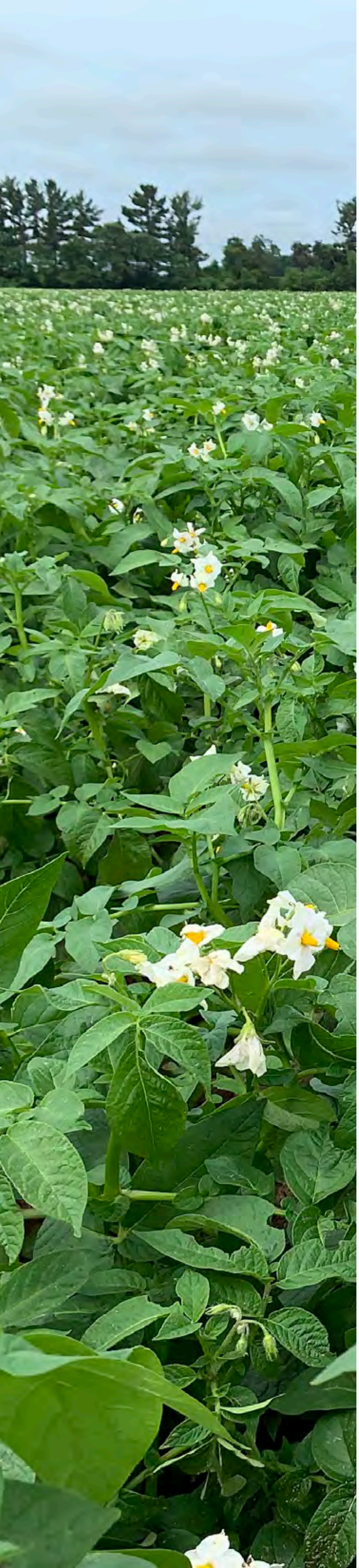
Based on Table 1, 145,083 acres of potatoes and commercial vegetables were in the proposed targeted areas in 2019. Suppose the average field was 80 acres and half of these fields needed 5 additional hours per year to develop new crop rotations and/or re-negotiate contracts with vegetable processors. The added cost to farmers' managerial time would be 145,083 / 80 acres x ½ = 906 fields x 5 hours per field x $33.50 per hour = $151,755 annually.

Finally, based on Table 1, 2.23 million acres of corn were in the proposed targeted areas in 2019. Suppose the average field was 40 acres and 5% of these fields needed 5 additional hours per year to develop new crop rotations. The added cost to farmers' managerial time would be 2,230,000 / 40 acres x 5% = 2,787 fields x 5 hours per field x $33.50 per hour = $466,823 annually.

None of these calculations are meant to be estimates of the actual cost, but rather to give a sense of the process and the potential magnitude that these costs could entail. All estimates are sensitive to the assumptions and would change with different values for the number of additional hours needed, the number of farms or acres affected, and the value of farmer managerial time. These estimates show that the aggregate costs for additional managerial effort can add up and be significant, but in general are likely to be less than the other major impacts identified in the farmer focus groups. Once more is known about how farm practices would need to change to satisfy the proposed rule and how many farms were impacted, better estimates of the increased managerial costs can be developed.

## 6. Local Economic Impacts

Agriculture is a key sector for Wisconsin economy, generating $105 billion in economic activity and 438,000 jobs (Deller 2019). Most of this economic activity is not directly generated on farms, but by input suppliers and especially post-farmgate processing of raw agricultural products into food. Of the $105 billion of economic activity from agriculture, food processing accounts for almost $83 billion, or 13% of the state's total economic activity, and 282,000 jobs (almost 8% of jobs in the state) (Deller 2019). For example, Wisconsin is the leading producer



of cheese and has the second largest vegetable processing industry among US states (Deller 2019, Mitchell et al. 2017). Given the economic importance of agriculture in the state and in many communities (both rural and urban), not surprisingly, farmers in the focus groups expressed concern about potential broader economic losses in the state beyond the farmgate if the proposed rule were enacted.

In a direct sense, farming creates economic activity and jobs within its own industry. However, both crop production and processing also benefit nearly every other Wisconsin industry. For example, farmers purchase equipment and fertilizers from local suppliers, hire contractors to build barns and sheds, pay farm workers, and invest earnings in local banks. In turn, farm workers and workers at these companies use their earnings to pay for housing, groceries and other personal expenditures. In this way, one dollar received by a Wisconsin farmer for producing and selling crops or livestock creates more than one dollar in value as the dollar is spent and re-spent in the statewide economy. The total $105 billion economic impact of agricultural production and processing in Wisconsin captures this ripple effect in statewide spending.

Economists call this ripple effect for an industry its economic multiplier effect and they have developed data and methods to estimate these economic multipliers for many industries (pp. 9-12, Deller 2019). The most commonly used system is IMPLAN (IMpact analysis of PLANning) developed by the IMPLAN Group (https://www.implan.com/). The key variable is the "economic footprint" of the industry as measured by the total revenue or sales it generates. The total economic activity generated by an industry is then this gross revenue multiplied by its multipliers, which captures the spending and re-spending of this revenue in the statewide economy and the jobs generated. These multipliers differ by industry and region based on the economic activity in each industry and region (pp. 26-35, Deller 2019).

For example, the state average multiplier for on farm production is 1.703 (p. 26, Deller 2019). Thus, if the proposed rule were enacted and caused a net loss of $1 million in farm revenue, the total loss to the Wisconsin economy once this $1 million net loss on farms worked its way through the state economy would be $1.703 million. However, this varies depending on the industry impacted and the region of the state. For example, if the $1 million net loss were in dairy farm revenue, the total loss to the state economy would be $1.822 million because dairy farms have a larger multiplier (p. 26, Deller 2019). Because local economies differ, these multipliers also vary depending on which region of the state they occur. Thus, economic methods for estimating the broader losses to the state economy from losses that directly impact net farm revenue exist and suggest that the average multiplier is around 1.7, but higher for some industries like dairy. Also, note that the relevant loss is the net loss to farm income, revenue decline after accounting for cost changes, not just output changes. Once a total impact of the proposed rule on net farm revenue is estimated, this multiplier can be used to estimate the broader economic impact of this loss.

## Summary of the Potential Economic Impact

This section of the assessment focused on developing monetary values for the major concerns that farmer focus groups raised in response to the proposed rule change for NR 151. Table 17 summarizes the results for each concern. In general, the estimates would be improved by additional information. Estimates for many concerns are not even able to be reported due to a lack of data, even for this preliminary assessment. In general, more data on current farmer nitrogen and manure management practices are needed, as well as applied research to develop a practical process for estimating nitrogen leaching losses and how they change with management changes.

The annual cost of nutrient management planning is large, but would be reduced both by cost share payments and if the time farmers no longer spent on crop fertility planning is credited. Also, data on how nutrient management plans impact farmer returns is unavailable, but could also further reduce the cost or even generate a net benefit from nutrient management planning. The cost of crop yield losses is large as well, but is based on the 1% yield loss and 10% nitrogen reduction from the Iowa Nutrient Reduction Strategy impact for corn (ISU Extension 2017). Cost impacts on manure management are generally unknown at this preliminary phase without more information, but if the proposed rule required 25% of the state's manure to have to be transported 0.25 miles farther on average, the annual cost of manure management would increase about 10%. However, many farms would likely find planting cover crops with cost share assistance a more economical option, which would reduce this cost.

The impact of the proposed rule on crop rotations was a farmer concern that seems to be relevant but difficult to estimate without more information on how farms could satisfy the proposed rule. The process for calculating nitrogen leaching losses is unknown at this time, but the simplified process developed for this assessment suggests that many farms would have to shift away from corn for grain to more corn silage and alfalfa, which would likely reduce farm income. Also, potato farms in the Cenal Sands would likely find shift away from processed vegetables and plant more grains and forage crops in rotation with potatoes. Also, key assumptions in the calculations need expert evaluation and input, including groundwater recharge, nitrogen removal in harvested crop biomass, and overall nitrogen dynamics.

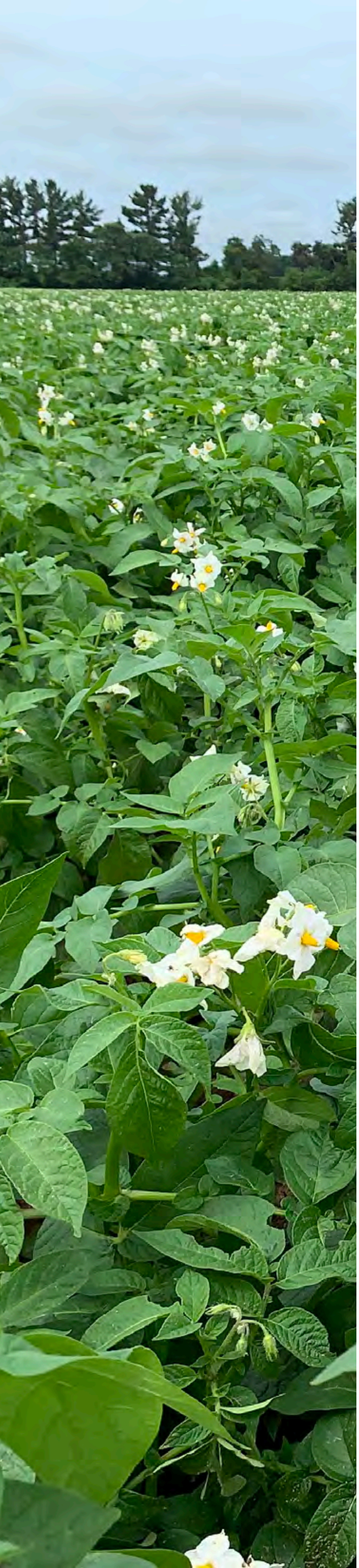
Increased costs due to increased farm managerial time are probable, but likely less than $1 million annually, and so will be secondary compared to the economic impacts of the other concerns. Also, economic impacts on the broader rural economy will occur, but depend on the total amount of farm income lost or gained. A simple rule based on IMPLAN suggests that once the total impact on farm income is determined, adding 70% captures the economic multiplier effects of the farm income changes.

**Table 17.** Summary of economic impacts for each farmer concern

| Farmer Concern | Economic Impact | Key Assumptions |
|---|---|---|
| **Cost of Nutrient Management Planning** | Annual cost for target area:<br>$19.6 to $43.4 million, likely around $27 million<br>Farm cost of $5.9 to $13.0 million with 70% cost share | Does not include:<br>Cost savings from no longer doing own fertility planning<br>Savings in fertilizer spending<br>Effect of yield changes |
| **Manure Management Costs** | Unknown cost impact, but moving 25% of the state's manure an extra 0.25 miles would increases costs $7.1 to $8.6 million, or about 10% | Does not include:<br>Storage cost changes<br>Cost share for cover cropping or manure transport |
| **Crop Yield Losses** | Depending on crop prices and price of nitrogen fertilizer:<br>$4.1 to $11.5 million in annual losses for corn acres<br>$2.4 million in annual losses for potato acres | Assumes 1% yield loss and a 10% nitrogen rate reduction based on Iowa Nutrient Reduction Strategy<br>Ignores potato quality losses |
| **Losses from Expanding Crop Rotations** | Unknown losses, but likely more corn silage and alfalfa acres and reduced acres of corn grain in state and processing vegetables in the Central Sands | Many assumptions, including a simplified nitrogen budgeting process, "typical" groundwater recharge rates and standard (outdated?) crop removal rates |
| **Farm Management Costs** | Unknown, but a secondary cost that likely totals less than $1 million per year | Assumes farm management wage rate of $33.50 per hour and guesses for additional farmer managerial time needed |
| **Local Economic Impacts** | 70% more losses than the net farm income losses to capture local economic impacts | Based on IMPLAN's estimated economic multipliers for Wisconsin agriculture |

## CONCLUSION

This assessment used initial concerns and themes identified through farmer focus groups to develop an assessment of the economic impacts of the proposed rule changes to NR-151 on agriculture. In the process, it become apparent that key data and research are needed and that the economic impact estimates reported in this study provide a range of potential costs. In brief, more information is needed on current nitrogen management practices for major Wisconsin crops and manure management practices and research on how these practices would have to change to satisfy the proposed rule. The most recent data on management practices are more than a decade old. Also, substantial uncertainty exists as to how farmers would calculate nitrogen losses to determine if they are satisfying the proposed rule and the effects of management practices on these calculated losses. Estimating the economic impact is difficult without information on current management practices and how they would change as a result of the proposed rule.



A regular survey of farmers, fertilizer retailers and applicators, manure applicators, and crop consultants would provide the necessary data on nitrogen and manure management in Wisconsin. Such surveys could be modeled on the survey used to develop the Custom Rate Guide (USDA NASS 2021), based on a partnership between USDA NASS, DATCP and the University of Wisconsin. In addition, applied research and assistance from knowledgeable experts is needed to better understand how to practically calculate nitrogen losses from cropping systems and how these would change with shifts in management. These data and research needs were identified in each section. For example, key parameters such as groundwater recharge, nitrogen content of harvested biomass, nitrogen content of manure, mineralization of soil organic matter and crop residues, and crop yields vary substantially from year to year and location to location. These are technical issues that need technical experts to develop practical ways to implement the proposed rule. Nitrogen leaching is a "wicked problem" that is difficult to address despite decades of effort, with experts often focused on documenting the problem and less so on developing solutions (Masarik 2021b). Once practical ways to achieve groundwater quality goals are identified, updated outreach and educational programming can be developed, and economics can focus on developing efficient ways to incentivize farmers to adopt these practices as needed. Many of the technical experts are available in the University of Wisconsin system, the Wisconsin DNR and Wisconsin DATCP, and many are already making contributions to the issue.

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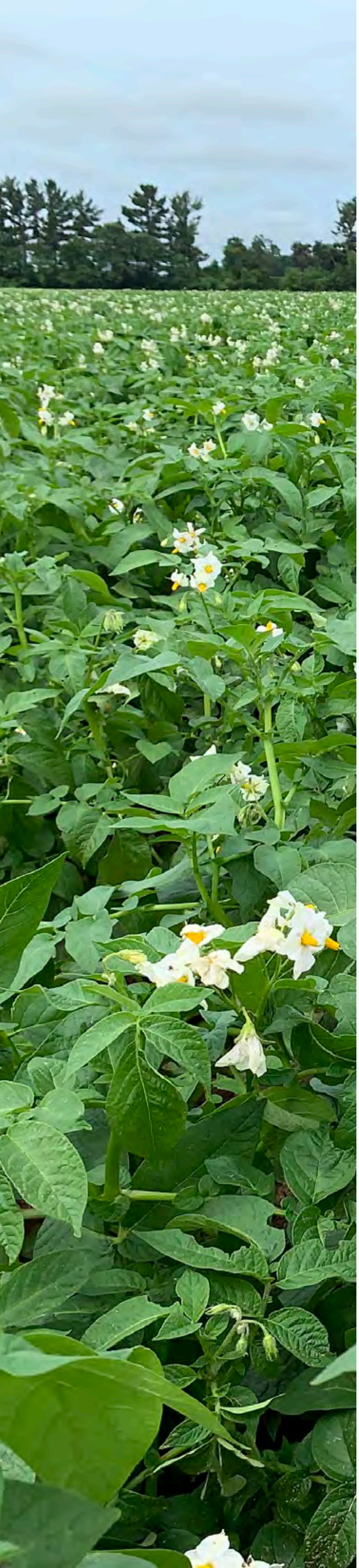


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# Appendix 1: Focus Group Report

## SUMMARY

This report is a summary compilation of comments from four focus groups of agricultural stakeholders conducted in February 2021 regarding performance standards proposed as a rule update for NR 151.

In 2020, the Wisconsin Department of Natural Resources (WDNR) developed proposed targeted performance standards and prohibitions intended to improve groundwater quality by reducing nitrate concentrations in groundwater. If approved, the proposal would be incorporated into Chapter NR 151, Wisconsin Administrative Code (https://docs.legis.wisconsin.gov/code/admin_code/nr/100/151). As part of their process to consider impacts of the proposed rule changes, WDNR engaged a team at the University of Wisconsin-Madison to conduct a third-party assessment examining the potential economic impacts of the proposed performance standards.

As part of the analysis, and in order to document and understand the concerns about economic impact among farmers, the UW-Madison team organized a series of focus groups with farm operators. The results, summarized below, shed light on potential implementation challenges and operational costs from the perspective of the land mangers required to meet the new standards. These results highlight feasibility concerns and help guide assumptions for the accompanying quantitative analysis of economic impact.

In February of 2021, focus groups were administered with Wisconsin farmers who were prompted to discuss their understanding of the standards, the potential economic impact the proposed performance standards may have on their individual operations, and the feasibility of implementing such changes on their individual farms. Participants were invited to identify any other issues or concerns related the performance standards or the process undertaken by WDNR to develop the proposed standards. Focus group participants were recruited, meetings were facilitated, and data was managed in compliance with University of Wisconsin-Madison Institutional Review Board (IRB) approved criteria and protocols. A total of four focus groups were conducted, with between 8 and 10 participants each, for a total of 35 participants. Each focus group included participants from a diversity of agricultural farming systems.

All four focus group discussions were recorded and transcribed, and participants' comments were compiled and analyzed across groups to identify general themes and unique high-impact concerns. General themes documented concerns that span multiple growing regions and cropping systems. Many participants expressed specific comments about how the proposed rule would impact their own farming system, but also discussed their ideas on how the rule would impact the larger agriculture community. Eight themes of concern are summarized below:

**Theme 1 – Increased manure storage needs and shorter manure application windows:** Participants expressed concerns over the timeframe of limiting manure applications after September 1st each year. They discussed the need for longer-term storage and the significant investments growers may need to put into their farms to comply. Concerns over pushing applications to a short timeframe in the spring was discussed, as that may create other environmental concerns and cause problems for roads and for commercial haulers.

**Theme 2 – Decreased crop yields and quality and lower profits:** Participants discussed concerns that limiting fertilizer rates and applications would negatively impact yields which would adversely impact profits. Many are working to be as efficient as possible with their existing applications, so the consensus was that there were not many efficiencies left to limit nitrogen rates. To overcome yield loses, growers would need to expand acres or receive supplemental cost-share dollars.

**Theme 3 – Longer crop rotations and more acres planted:** Participants were certain that limiting applications to the 2.2lbs recharge threshold would cause growers to extend rotational years and add additional acres to allow for fallow years within the rotations. These expanded rotational lengths, cropping systems and potential additional acres for farming

may not be economically viable with current markets, volume contracts and supply chain demands. There was also a discussion that this may only work for larger farming systems.

**Theme 4 – Difficulties documenting and complying with irrigation-related requirements:** Participants who irrigated fields felt that the rule requirement to document nitrogen in irrigation water to be difficult to deliver, highly variable during the growing season, and is not applicable due to the research used to develop recommended rates. Having irrigated fields on fallow ground is not economically feasible, and limits on applications would be detrimental to crop health and profits during drought years.

**Theme 5 – Overall challenges with documentation, oversight, and administrative burden of compliance:** Participants questioned how the record keeping, documentation needs and compliance would be implemented under this rule, and they expressed concerns that it would be difficult with the current tools used in Wisconsin agricultural systems. Many are using Nutrient Management Plans (NMP), and questions arose regarding how NMPs would be used to comply with the proposed rule and what other options could be available to minimize additional documentation burdens.

**Theme 6 – Potential negative economic impacts on rural communities:** Participants discussed their concerns regarding the potential impact the proposed standards would likely have on the economic well-being of rural communities across the state. Agriculture is viewed as the lifeblood and largest contributor to the economy of numerous rural communities. Concerns on local roads, transportation options, related agricultural industries and supply chains, and land values were also discussed as an impact to rural areas which are largely dependent on agriculture for their tax basis.

**Theme 7 – Lack of transparency and explanation behind performance standard provisions and identification of targeted areas:** Participants expressed concerns over how the proposed standards was developed and inadequate justification for certain aspects (e.g., 2.2lbs recharge, Sept 1 manure limit, depth to bedrock, well data, etc.). In general, there was a feeling that these proposed standards did not include enough methodologically sound and research-based information.

**Theme 8 – Challenges of uniform regulations instead of situation-specific collaborative problem solving:** Participants recognized and acknowledged that groundwater quality, specifically nitrate concerns, are a problem and new options and approaches should be developed to work toward equitable solutions. Participants are wary of one-size-fits-all regulations and instead favor collaborative approaches to create locally based options and solutions to work on this complex issue.

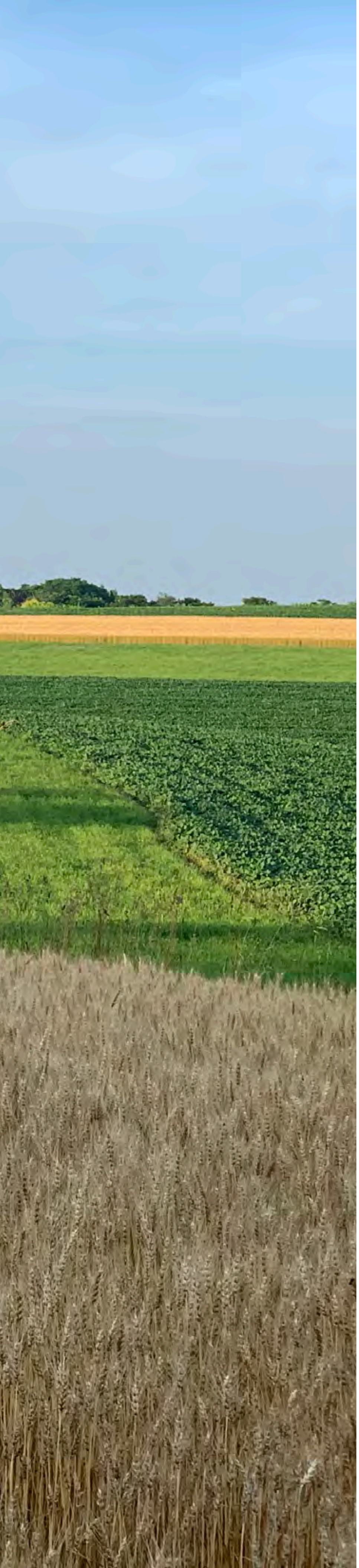
The focus group process allowed for discussion of detailed nuances and insights regarding how growers approach their cropping systems and their nutrient management options. The growers shared details about crop management and described practices already implemented as well as discussing new ideas and options that could be implemented that would reduce negative nutrient impacts on water quality. The report includes additional details and selections of verbatim comments from participants.

## Section 1: Background

In 2020, Wisconsin Department of Natural Resources (WDNR) began a process to introduce new targeted performance standards and prohibitions intended to improve groundwater quality. The proposed targeted performance standards and prohibitions would be integrated into state law through chapter NR 151, Wisconsin Administrative Code addressing Runoff Management. As stated on the WDNR website:

> *Consistent with state statutes, NR 151 directs the DNR to promulgate rule performance standards to meet water quality standards and address specific issues either geographically or by activity. The NR 151 rule modification is to develop a targeted performance standard to abate nitrate pollution in areas of the state with highly permeable soils which are susceptible to groundwater contamination (sensitive areas) for the purpose of achieving compliance with the nitrate groundwater standards. The rule revisions will define sensitive areas in the state and the performance standards needed to protect groundwater quality in these areas.* [source: https://dnr.wisconsin.gov/topic/nonpoint/nr151nitrate.html]

As part of this process, WDNR engaged a research team at the University of Wisconsin-Madison to conduct a third-party assessment examining the potential economic impacts of the proposed performance standards. The UW team (see acknowledgements) was tasked with conducting an expanded assessment of the economic impact of the proposed regulatory change. One component of this assessment was to administer and complete a written anal-



ysis from focus groups with farm operators. Focus groups allow researchers to interact with participants in structured but informal group settings to explore a set of issues and perspectives in detail. The purpose of conducting focus groups with Wisconsin farmers was to help gauge farmer's understanding of the standards, assess the potential economic impact the proposed performance standards may have on their individual operations, assess the feasibility and readiness to implement such changes on their individual farms, and to attempt to uncover any issues or concerns yet to be addressed by the WDNR.

Development of focus group recruitment approaches and materials began during September 2020. In October 2020, UW-Madison's Institutional Review Board (IRB) approved required recruitment, anonymity and confidentiality procedures, and details on questions and data management protocols allowing staff to conduct between 2-4 focus groups with a minimum of 24 participants. In order to contact and recruit focus group participants a one-page informational flyer was created. This informational flyer outlined the scope of the WDNR project, the expectations of participants willing to participate in a focus group, and information on the focus groups such as the plan for virtual administration using the software program Zoom and an expected length between 1-1.5 hours. This information was also uploaded to a landing page on the Renk Agribusiness Institute website to allow for electronic access. An electronic online form was also created to collect participant's basic contact information, basic farm-type information, and general knowledge of nutrient management practices from participants. The farm-type information was later used to stratify participants across focus groups by farm-type (i.e., dairy, corn/soy, vegetables, etc.) to ensure an equal distribution of operators between each focus group. Participants were determined eligible to participate in a focus group if they currently operated a farm in Wisconsin.

This first phase of recruitment took place during December 2020 in order to gauge participant interest prior to the holidays. The one-page informational flyer and online landing page link were sent out to various grower and producer group associations, farm group associations, agricultural agents within UW Division of Extension, and others in order to maximize exposure to group members and other contacts that had direct relationships with farm operators. Fifty-one (51) operators completed this form by early January 2021. At this point the online form was removed and replaced with a message that stated the desired number of producers had been met. During the second phase of recruitment, these fifty-one producers were contacted again in mid-January 2021 in order to determine their continued interest and individual availability to participate in one of the four scheduled focus groups. The schedule of these four focus groups were as follows:

- Focus Group #1 – Wednesday, February 10th at 8:30am
- Focus Group #2 – Wednesday, February 10th at 1:00pm
- Focus Group #3 – Friday, February 12th at 8:30am
- Focus Group #4 – Friday, February 12th at 1:00pm

Producers were requested to report their availability to participate during each of these selected days and times. This information was collected through an online poll and producers were given 10 days to report their availability. At the end of the 10 days, thirty-eight (38) producers had completed the online poll. All producers reported being available to participate in at least one focus group, while several producers reported being available to participate in any of the four focus groups. These thirty-eight producers were then systematically placed into one of the four focus groups based on 1) their availability and 2) their farm-type information collected during the first phase of recruitment. After assigning each participant to a single focus group, a total of nine (9) participants were selected to participate in Focus Group #1 and #4 while a total of ten (10) participants were selected to participate in Focus Group #2 and #3. Each focus group contained between 6-7 dairy farm operators, 1-2 corn/soy grain farm operators, and 1-2 vegetable farm operators.

One week prior to the scheduled focus groups, participants were sent slides containing preliminary draft language on the proposed standards, as it was provided to the UW-Madison team by the WDNR [see WDNR website listed above], and were asked to review it prior to their scheduled focus group. Two to three days prior to their scheduled focus group, participants were sent a link to the WDNR NR 151 webpage with instructions on how to access the Map Viewer Tool. Participants were asked to review this tool as well as the proposed performance standard's Targeted Areas prior to their scheduled focus group.

A total of thirty-five (35) producers participated across the four focus groups over a two-day time period as follows:

- Focus Group #1 – Wednesday, February 10th at 8:30am (8 participants)
- Focus Group #2 – Wednesday, February 10th at 1:00pm (10 participants)

- Focus Group #3 – Friday, February 12th at 8:30am (9 participants)
- Focus Group #4 – Friday, February 12th at 1:00pm (8 participants)

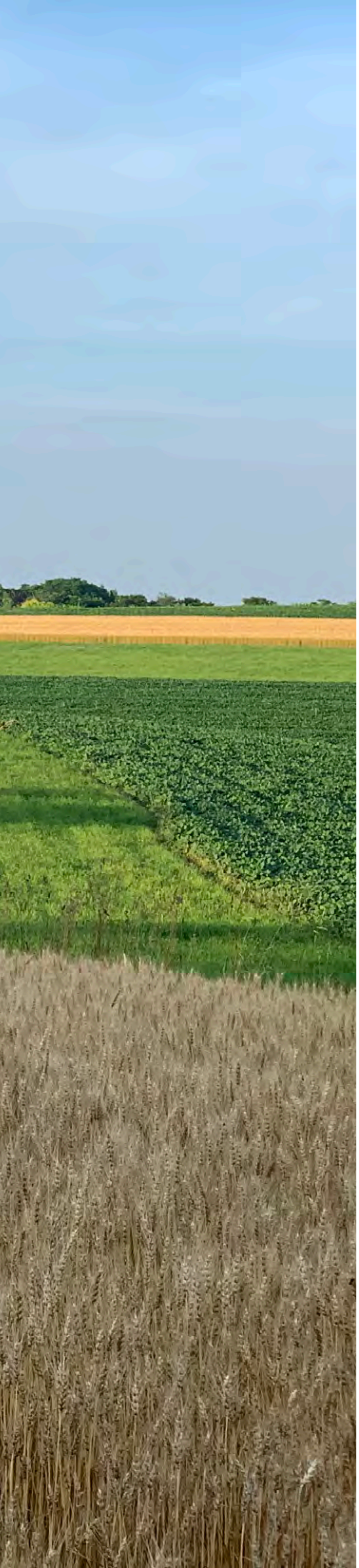
At the selected start time on the day of the scheduled focus group, one of the two focus group moderators from the UW-Madison team started by presenting three sections of background information on the proposed performance standards, logistical information regarding the intent and administration of the focus group, and a confidentiality statement that had been submitted for IRB approval. After each section was read the moderator asked if there were any questions from participants before moving on to the next section. After this information had been communicated, participants were reminded again that the focus group would be recorded for transcription purposes and that their participation was voluntary. Participants were told that if they no longer wished to participate, they were free to leave (no participants left during this time during any of the four focus groups). The moderator then reminded participants that by staying on the virtual call, they would be providing their consent to participate in the focus group. After consent had been received from all participants and all questions had been answered, the moderator started recording prior to the focus group discussion.

Each of the two focus group moderators guided the group discussion by asking participants to provide information to general questions (e.g., "Can you share your thoughts with us about the proposed performance standards and how they may relate to your individual operation?", "What is your first impression of the targeted areas for the proposed performance standards?", etc.), allowing participants to build off of each other's responses on a particular topic, progressively directing the discussion across the pre-determined questions and topics, requesting a clarification on a participant's response if beneficial for project purpose, requesting an expansion on a participant's response if beneficial for project purpose, and ensuring that individual participants were given an opportunity to respond. The general questions are included in Addendum 1. In general, participants in all four focus groups were very willing to share and offer feedback with little interjection necessary by the two focus group moderators.

Focus group discussions were administered and recorded using the software program Zoom. Participants were encouraged to utilize a video connection, if possible, yet were provided with call-in information in case they did not possess the video connection or faced connection issues. The majority of focus group participants across all four focus groups used a video connection to attend while a few did not and were only available through an audio connection. A handful of participants across all four focus groups called in to their scheduled discussion from a phone and were also only available through an audio connection, but even the phone in option proved effective and all participants were able to provide feedback in each focus group. Overall, there were little to no technological issues across all four focus groups. Sessions lasted between 60 and 90 minutes. To ensure participants were allotted enough time to engage and participate, focus group moderators kept the sessions open until all comments were made, and encouraged farmers to enter additional comments through an online form if they wanted to provide additional information after the focus group. Only two short comments were collected using this method.

A recording including both audio and video of each focus group was made, stored in a UW Box file only accessible to focus group moderators, and used only for transcription purposes. After raw transcriptions were created through an online platform, transcription output was reviewed and edited for grammatical errors, removal of names and other personally identifiable information, etc. Edited transcriptions were also reformatted to account for visual separation to distinguish when one participant stopped speaking and a new one began. Every participant in each of the four focus groups was assigned a unique code (i.e., "RA" (Respondent A), "RB", (Respondent B), etc.) to ensure confidentiality while allowing the ability to assess multiple comments from the same participant throughout the entire focus group discussion. After the edited transcriptions were finalized, the original audio/video recordings were deleted.

Themes were identified through analytical review and coding of edited meeting transcriptions. Using the general focus group questions as a starting point, two members of the project team (the two focus group moderators) reviewed each comment independently and assigned theme codes. The two separate codes were compared and reduced to a single set of coding themes, and one researcher re-reviewed all comments using the final coding outline. Final theme names were assigned for clarify in presenting results.



## Section 2: Results

Comments shared by participants across the four focus groups resulted in a set of eight themes of concern and challenges associated with the proposed performance standards. Each of the eight themes presented below begins with a summary description and overview of the theme. Each summary is followed by a selected set of verbatim responses pulled directly from focus group transcriptions that serve as explicit examples of issues associated with the theme. Selected participant responses are not meant to be comprehensive or quantitative representations of the full scope or the number of participant comments on any individual theme, but instead were selected in order to communicate and highlight the diversity of individual responses and their relation to the theme. All individual identifiers were removed during analysis and replaced with unique codes based (RA-RJ) and their corresponding Focus Group (e.g., RB = participant B and FG#1 = Focus Group #1). The verbatim comments are included with only minor grammatical and punctuation corrections.

## Theme 1 – Increased manure storage needs and shorter manure application windows

**Summary:** Overall, participants across all groups voiced concerns regarding the costs related to manure storage and management necessary to be in compliance with the proposed standards. This included costs to make existing manure storage pits larger or to add new pits as well as the purchases of additional application equipment and additional storage. Participants often referred to needing "a year's worth of storage" which may have demonstrated a misunderstanding of the specific exemptions allowed as part of the manure application prohibition.

Participants stressed that the lack of ability to spread manure in the fall would create a very tight window in the spring for application. There was confusion on the exemption for fall planted crops which could receive manure after September 1st, and many questioned if that exemption was only for harvested crops or if it included cover crops. Participants reinforced that the spring is already a very busy time for producers and that spring applications are more likely to lead soil compaction (due to wet soils), runoff (due to extreme weather events), and possible cropping system delays that extend into the growing season. Growers noted that depending on the weather, that window may only be two weeks long, and that timing is difficult. Participants also acknowledged the logistical stress that these application restrictions would have on the custom applicators in trying to meet demand for spring applications during this very short window. Participants believed custom operators would prioritize larger operations due to their size and resulting business, while smaller operations would be passed over and left until late in the planting season.

Participants also predicted a need to acquire additional acres to apply their operation's manure due to a tight market for acreage in close proximity to many dairy farms. These additional acres would likely need to come from outside of the targeted areas. The resulting need to transport manure a greater distance would be more costly for the producer, would likely impose negative impacts on roads which are already in poor condition, and would create the potential for environmental issues during transport. An additional outcome raised by participants was the likely increased prevalence of applying manure to alfalfa should these standards be upheld.

### Selected Participant Comments

**RA FG#1** - for my organization I figured year one it would cost us with adding extra pits and stuff uh probably about 10 million dollars then going forward every year would be a million and a half to two million dollars extra cost per year

**RB FG#1** - I believe for our operation um I don't think it would be feasible to hire a custom manure applicator anymore if you're going to put double the burden onto them in the spring they're no longer going to be able to fulfill that burden in a timely fashion so I believe for our operation we would have to purchase a hundred percent of our manure equipment and all that out um I'm assuming that year one I would be talking somewhere in the neighborhood of four-ish million dollars to set up with the manure equipment

**RB FG#1** - if we have to push most of the manure application across the state to the spring we're gonna have almost all of the manure applied in a two-week window so if we get a year 25-year or hundred year rainfall event the potential for contamination for nonpoint source pollution coming off the field has greatly increased because of the amount of acres that's going to be applied in the same time frame same window you talk cover crops you talk reducing tillage all of that well if we're really going for ground water that's actually 100 opposite of what we want because cover crops and no-till creates larger macro pores in the soil structure

which increases water infiltration rate tillage actually increases evaporation rates so if we're looking at groundwater all of the standards we've put in place have been potentially inhibiting so how do you balance the two

**RD FG#2** - I've already spent twenty thousand dollars trying to build a manure pit and they can't find a suitable site on our farm to dig a hole so I you know it's kind of it's not a matter of how it's going to affect us it's a matter of are we going to be in business after this to be in in the first place and it might not be if that if these rules are too large

**RF FG#2** - when it comes to manure storage the vast majority of dairy farms in the state do not have uh over a year storage so anytime you put any kind of restriction on the majority of the dairy farms are going to be negatively impacted in a major way because they don't have they don't have the physical capability to store the manure

**RF FG#2** - so now we have to cover even more acres to do this so we're doubling the amount of manure we have to put on at once and then I'm limited to how much I can put on per acre because I can't have it running away on me either and so now I have to go find even more acreage to do this and already I have to find neighbors that are cash croppers to work with me on um handling manure and now I'd have to find even more acres and can I even do that I don't know I'm in a very competitive area for finding acres for manure you know that seems to be a driving factor is just finding the acres to put the manure on

**RC FG#2** - well just to explain it on a per cow basis um you know we had to go to a year storage you're talking easily a thousand dollars a cow um just to add six months so if somebody doesn't have any storage uh the daily haul guys you're looking at two thousand dollars a cow and just multiply that times however many cows

**RJ FG#2** - if you're putting manure on within a mile of the dairy it's costing us about 150 dollars an acre if you're out five miles we're up to 520 an acre on drag hosing so uh more miles have to be five miles out because we've got everything within three miles of our dairy tied up in the nutrient management plan already so all the extra land that we have to add is out there five miles and now we're out at five hundred dollars an acre to get the stuff there

**RD FG#2** - I see concerns too to get out five miles we'd have a lot of ground that we couldn't directly drag line through because of development urban sprawl so we're going to be running a significant amount of semis trucks and stuff like that on the roads in the spring which I know our townships are not going to be happy with

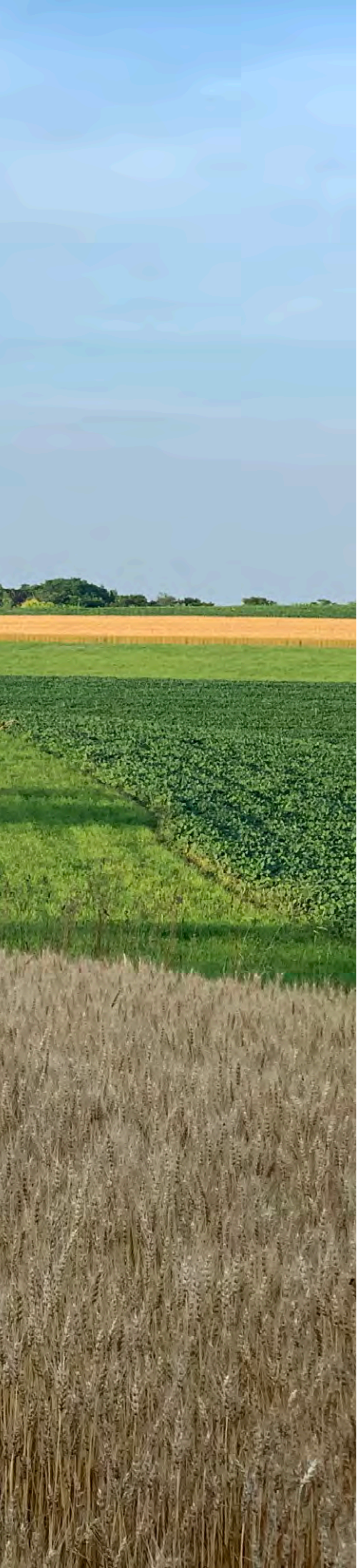
**RA FG#2** - I could add something to what was said before about uh manure on cash crop ground so we like I said before we would be open to doing that you know receiving manure on our farm but uh there again we're just like a lot of other farmers where we would only want that on in the fall there's no way we would take it in the spring it would destroy all the soil building that we've done the last 10 years you know with no-till and cover crops um that just we have too much clay in our ground and rock and that would just be a disaster to put on in the spring

**RI FG#3** - I would need an exemption because in order to put a year's worth of manure storage in I would have to infringe on the 300 foot setbacks I already know this because I'm in the planning process I can barely fit six to seven months of storage in with my current footprint

**RH FG#3** - you can't stop those dairies from daily haul so what are they going to go do then they're going to go take some poor alfalfa field and pound the crap out of it with how many tons of manure hauling it daily just to keep away from their issues they're going to have and then if they say we go with the only spread in the spring what's going to happen if we get a wet years in the spring and all these pits are going to run over then who's going to have the problem because the fines are going to be coming out because oh you let your pit run over but I had a beautiful fall last year but you won't let me spread it but now it's wet in the spring and now I can't spread it

**RC FG#4** - I've talked to a couple other individuals kind of about some of the issues one of those individuals uh does our manure pumping for us and logistically it becomes just a nightmare uh for him I mean they pump they said about 140 million gallons a year and about 100 million of that they pump in the fall um so for him to logistically try and get that all pumped out in spring you'd have to have you know three four drag line hose setups to get that accomplished plus seasonal manpower to do it which just really isn't it's really not possible and it's not going to be efficient to only use utilize that equipment that portion of the year

**RG FG#4** - you know we're so narrow so tight the way it is with weather already with our weather their events the way they are to also take another you know probably two good months a lot of times out of out of the play um for manure application that's it's a scary thing



you know take one problem that you think you're solving but you're actually creating another um in a lot of cases

**RD FG#4** - one of the things that I thought of was when you put all this manure application into the spring in April probably someone mentioned the compaction I'd like to mention the chance for a huge environmental disaster with all that manure going out as much as possible and that's time frame a 3 4 5 6 7 8 9 10 11 12 13 inch rain event like we've had here in my area over the past 10 years would send all that all those nutrients somewhere where we don't want them off target and I think that's a disaster waiting to happen

**RC FG#4** - so my size dairy I'm at 180 cows and I have a custom pumper come in and pump my pit out every fall um if it comes to a point where he has he has and I'm a small guy so he's got big farmers that he's going to probably go toward first because he can push out more gallons in a hurry and he's going to bump some of the small guys down the list so that requires me to either a buy tankers or b by equipment to pump stuff myself which is a huge capital investment um especially for a farm of my size um so that is certainly a concern and some of the other things we've kind of touched on a little bit as far as where some of the numbers or the goals that we're trying to hit are what are other possible things that we can utilize to help get to those numbers whether it's use of cover crops or something like that um what role can that play and possibly trying to you know maybe I can get some of that manure out in the fall

**RC FG#4** - what is defined as liquid manure or just manure in general are we you know is it strictly you know pit manure are we talking like stuff you scraped out of a barn include as liquid are we talking pen pack included under that

**RB FG#4** - my concern if we push spring manure back um as a dairy farm we're going to push our corn silage back also in the fall a lot of dairy farms are doing cover crops right now so um after that fall harvest and if you're if you're gonna push that that window back we're not gonna have as much growth are we if the cover crops are doing what science says they do

**RC FG#4** - I think that though probably the one thing that really gets caught as far as farm size in your smaller farms is going to be if you have to build manure storage um manure storage is honestly it's a money pit and it ain't a good one so if they have to go to that point to build manure storage potentially without cost sharing I think for a lot of farms that that's going to be it especially on the small smaller scale

**RF FG#4** - then the rental issues you know as farms grow there's a lot more rented acres and a lot of landlords to do good conservation you'd need longer term contracts but a lot of landlords just aren't looking for that they're just looking for more dollars so it's harder to do good conservation on acres if you don't have them more than year to year or something like that so it's really hard unless you have a longer term contract to do some of these good conservation practices on those acres

**RD FG#4** - what about competition for a land base if we start having to go greater distances I understand in the eastern side of the state in some areas it gets to be quite a bidding war because they need this land base to spread their nutrients and as soon as we start putting more requirements on this this land base has to get bigger and we have more competition which probably would drive up the rates

## Theme 2 – Decreased crop yields and quality and lower profits

**Summary:** Participants in all groups voiced concerns about decreased crop yield, degraded crop quality, and lower profits due to limits on the quantity and timing of nutrient application they would be allowed under the proposed standards. These concerns were shared across multiple cropping systems. Participants felt like they were already maximizing the nutrient management programs and are applying fertilizer in ideal, efficient manners, so limiting applications would result in yield reductions across many crops. Participants questioned if and how the economic impact from yield loss was taken into consideration with the creation of the standards and wondered if more cost-share dollars would be available to account for these losses. The current impact of cover crops on yields (which many stated is not consistent and varies among systems) came into question, and participants wondered if a similar cost-share structure would be applied to these standards. Similar to other concerns, participants asserted that producers would need more acreage to make up the difference in lower yields resulting from the implementation of these standards, and that will increase competition (and acquisition challenges) for those lands. Participants expressed concern about the economic return and overall market impact of different low nitrogen-use crops necessary to meet the standards.

In addition to production and financial impact of yield drag on their individual operations, participants also raised crop quality and yield concerns related to soil compaction and timing of spring vs. fall manure applications. They noted that later spring planting because of additional work and delays brought about by the standards would delay corn silage harvest, which would interfere with cover crop establishment in the fall. Participants reemphasized that windows of opportunity for fieldwork are already tight for producers and the proposed standards would seem to create even more of a challenge by requiring additional activity and possible cropping system delays.

## Selected Participant Comments

**RE FG#1** - I'll just reiterate what RD said earlier uh in order to be compliant you might need to double triple quadruple your acres to get rid of the manure and I just don't know where I'm going to get those acres

**RA FG#2** - any year that we have had to spread fertilizer in the spring we have had many compaction issues we think it's dry on top and it's wet underneath we're all no-till and it seems like any time that we have to spread fertilizer in the spring because we don't get it done in the fall we've got wheel tracks through the field that you can see all year long um and I'm sure there's a yield reduction there we can't prove it we don't have the best of yield maps

**RA FG#2** - well I was thinking about it here so I guess really the main concern would be the compaction in the spring if we had to spread all the fertilizer in the spring hard to put a number to that like I said before we don't have yield maps to look at or go off of but just some rough figures I guess if we took a five percent yield hit on the corn you know 10 bushel of the acre four dollar corn to be conservative you know 40 bucks an acre uh that that would probably hurt us

**RE FG#2** - I just saw something a test plot that was done back 35 years ago and it was high yields at that time the high yields in that corn plot were 160 bushel well the same farmer growing the same plots this last year same farm their plot average was 260 so 35 years I mean granted there's you know that's a lot a lot due to genetics so we're making great progress with genetics and I don't think the fertilizer standards have kept up to the needs that we need to grow these crops

**RG FG#2** - yep I would say the same is true in the central sands most guys are operating especially on canning crops with newer varieties again you're looking at research trials that were developed 20 30 years ago for most of these crops in a2809 and so most guys just don't think that that recommendation again that was a recommendation it was never written to be a regulation like it's being used now over the last 10 years so

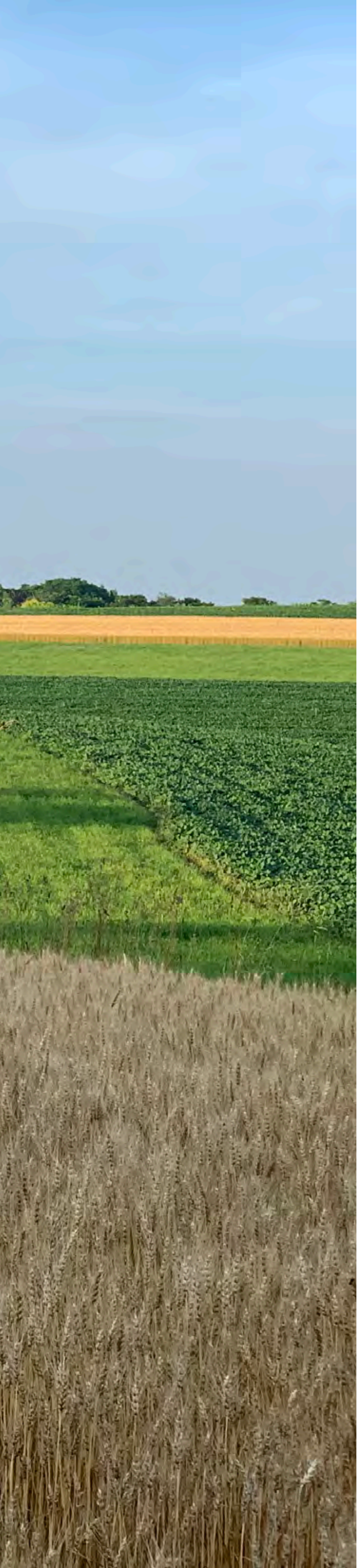
**RB FG#3** - you're likely going to see potato yields cut in half maybe two-thirds we're not paid on total yield we're paid on marketable yield and there's the big kick

**RB FG#3** - in order to meet that volume reducing our nitrogen use we'd have to increase our acreage which is ultimately a new point in negating the goal of this this proposed law you know by increasing acres we're just affecting more area opposed to being more efficient on smaller areas and that's if you can find the land you know we're already doing uh cover crops and putting money into research and have been for well 30 years you know putting basically taxing ourselves to put money towards research to find better varieties and better ways of doing things

**RI FG#3** - my biggest concern comes with the slides we were given it says no one crop can exceed that and the average needs to be less than that well a corn crop again according to UW numbers leaches 36 to 40 pounds of nitrate in a year and I don't understand some of the numbers that were given as far as remediations um were those percentages or those pounds I already use things like cover crops I already use things like nitrogen stabilizers I no till everything we have high organic levels all things that should be helping but if I'm not allowed to plant corn on corn and need to grow more hay um that's going to be extremely problematic I will not be able to grow enough feed on our current ground in order to supply the forage for the dairy

**RI FG#3** - they could do things like subsidize um that second pass on corn to encourage some of these producers that want to put it all on upfront um subsidize an in season application of nitrogen

**RF FG#4** - yeah I think the biggest thing is the move from fall to spring uh applications because fall applications are just it's just a lot better time to get out there from agronomy standpoint you don't have the compaction issues near as bad and from an agronomy standpoint so now all of a sudden you're expanding your land base not being as efficient so you know



not being as good in a carbon footprint standpoint it just really leads a lot of difficulties plus just overall cost of expanded storages you know it's going to be really prohibitive for smaller family farms to grow

**RE FG#4** - you know it's the carbon footprint the extra fuel you know we're gonna have to go further um you know more fuel more hours paid um there again economically uh yield drag you know also our growers we rely on a lot of growers we barely grow any of our own crops um that's one of the benefits that we bring to the community

**RG FG#4** - I know we have 150 feet of clay here over bedrock and you know we still have fields that are showing up here um as being restricted and um I'm what I'm worried about is I'm already seeing yield drag on following UW recommendations on nitrogen and also when we start restricting nitrogen more and more yet and how is that going to affect it

## Theme 3 – Longer crop rotations and more acres planted

**Summary:** Participants—vegetable and non-vegetable farmers as well as those located in and outside of the "Central Sands" region of the state—acknowledged the impact of the standards on increasing crop rotation length and expansion of crops in rotation in order to comply with the standards. Participants believed these changes to crop rotations would impact their individual operations in the ability to produce the higher-value vegetable and potato crops and also the industry as a whole as the supply and demand for these crops would be affected by significant year-to-year fluctuations. Similarly, for the alternative crops that may need to be incorporated into crop rotations for compliance with these standards, existing regional markets for those crops would also be impacted by changes in supply and demand as more growers would change what they produce from year to year. While participants voiced a positive impact from a growing trend towards incorporating grasses, cereals, and legumes into rotations, they also raised concerns regarding the potential need to fallow or take land out of production in order to comply with the standards, especially in very concentrated vegetable and potato growing regions.

### Selected Participant Comments

**RG FG#2** - you know certainly very few of the existing rotations in the central sands could tolerate that if you have anything potatoes field corn you know silage might work soybeans might work almost none of the vegetable crops work um so uh that the impact with that would have to the region to the to the processing industry to the potato industry um are obviously all pretty potentially devastating

**RC FG#2** - one of the avenues you know to get around this somewhat is to plant more grasses and more cereals but that it's not the most efficient you know it's hard to beat the consistency and the efficiency per cost of dry matter of corn silage

**RI FG#2** - I do put manure on my hay fields but my hay fields are getting to be more a mix of ryes and clovers than alfalfa so that works that way I can use the nitrogen so it's kind of changing

**RA FG#3** - I would like to see more producers using multi-species cover crops to absorb some of this but when you narrow that window it makes it even harder

**RA FG#3** - well um obviously in our area there's a lot of individuals on the vegetable areas using uh single species whether it's rye wheat oats things like that and those are really good for different types of plants but um what we're seeing is if we go to uh possibly some clovers and rapes and things like that uh species that we're seeing the nutrients absorb more and held in the soil um and then also then that's something that's released possibly the next spring so it's kind of a host crop

**RB FG#3** - if we have to do this across that rotation a three year or four year rotation it's just not doable so those crops are likely to go out the door where the only thing that even comes close to this is maybe a year of a forage crop and then a legume if everybody that's growing potatoes has to do that that's two more crops and they're going to be markets that are going to be just trashed I mean there's going to be no market for that much corn silage and even beans are gonna it's just gonna overwhelm everything there

**RH FG#4** - I haven't heard that what they're predicting on that but I know currently the you know the rotation is normally one out of three or one out of four years and it's probably going to push it out into a one out of five one out of six year we want healthy soils we want to protect the environment so we want to keep working at this too so we aren't saying not to work at it or not but we just need some um again flexibility and more study done I think to really make sure that we're working together with the DNR and with the university to try to

get the best data the best practices in place to protect the environment and to protect us as farmers you know we need to protect our livelihoods

## Theme 4 – Difficulties documenting and complying with irrigation-related requirements

**Summary:** Participants that irrigate as part of their operation stressed the difficulties proposed standards would create regarding the management of nitrogen in their irrigation water and documenting compliance. Participants highlighted the fluctuations of nutrient levels in irrigation water and described the short term and long term variation both within and across growing seasons. Furthermore, producers who irrigate crops questioned why this is needed since the recommended rates are already based on research which has used the water (assumingly with nitrogen in it). Therefore, this is already accounted for this within their outputs and difficult to measure for an overall minimal impact. With irrigation equipment potentially sitting idle due to the need to limit irrigation or even fallow land, participants commented on the financial burden they would face because of these standards and would need cost-share dollars to assist with this management if the standards were adopted. There were also concerns raised about the need for exemptions for using irrigation water during a drought year, where producers would realize drastically lower yields or potentially lose a crop if they were not allowed to irrigate.

### Selected Participant Comments

**RC FG#1 -** I believe there was a line in the in the proposal too about counting the nitrogen that is going through the irrigation systems we do that anyways we're not going to pour on nitrogen just to put on nitrogen through a pivot so that's something that's tracked anyways you know and does that mean we're going to be filling out a lot more reports on what we're doing and how we're doing it and where are we getting the money to do that I guess that's the other concern I have is documenting is becoming a bigger and bigger part of our lives and we're not getting really any there's no rate of return on that other than letting people know exactly what we're doing and how we're doing it all the time so I had some concerns about that

**RC FG#1** - we depend on that water and that would be absolutely huge to the point where we could potentially lose a crop if we're not allowed to water it

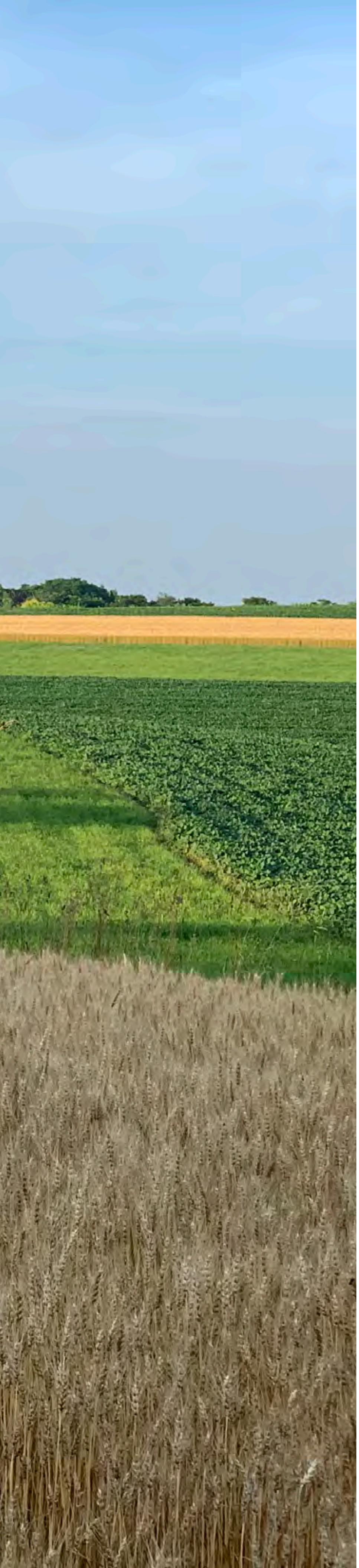
**RB FG#1 -** RB - so I had one other note not related to nutrient management plan um when I was reading through it now I don't have any irrigators but the way I read through this and I just thought it might be part of the impact statement cost was if you had an irrigator and maybe somebody here could specify this that you had 20 parts per million of your ground water and you irrigate half your water from your irrigator you can't put any additional N on that field because you're already out of compliance

**RB FG#2** - the other part is if you let your land go fallow we rent a lot of land what are we going to do with our irrigation system sitting on that land and paying 300 an acre when you can't and you have to pay the taxes well not on that land but on your land so you just can't make it everybody's going to go broke if this is implemented

**RD FG#2** - I think it would be realistic to uh for the central sands and here in XXXX county to have growers uh test their water when they're irrigating for example uh after their well runs for a couple hours and see where their nitrate levels are because um you know different farmers use different practices and if you would start to measure that amount of nitrate um if somebody's doing a better practice having lower levels uh other growers would quickly adopt that um you know all growers learn from each other learn from the university I I know the university has started doing some research on how much nitrate is coming out in irrigation water and I I just think we could learn a lot if we went ahead and did that if the DNR or the state might want to subsidize that just like they subsidized nutrient management plans

**RA FG#4** - then on the irrigation water you know section it's uh you know they want us to keep track of the nitrogen that comes you know that comes from the groundwater but uh the studies that I've seen uh shows that that can vary throughout the year and can even vary from in a 12-hour period of running a pivot so it just seems like a lot of stuff needs to be better explained

**RH FG#4** - the other thing is to have to capture the in our irrigation water we've never had to do that before and so what the rates are what the actual active units are and so forth we need to do more research on that



## Theme 5 – Overall challenges with documentation, oversight, and administrative burden of compliance

**Summary:** All of the focus groups documented concerns regarding the administration, regulation, oversight, and record keeping challenges of the proposed standards. Participants questioned whether the straight lines that delineate township boundaries was the best way to define a targeted area when the topography clearly doesn't follow those lines. They also questioned whether townships would be under this rule forever and if the rule might apply to additional townships or the entire state in the future.

Participants reported frustration with the amount of time and money they already spend on keeping records and projected that these standards would create even more costly and time-consuming record keeping. Participants questioned the mechanism through which compliance with the proposed standards would be measured, whether that be Nutrient Management Plans, SnapPlus, or some other program. Many grower participants already had strong Nutrient Management Plans but they wondered if their plans would be in compliance with the way the rule was written, and if not, how could changes be made with the current planning and SnapPlus program.

There were also concerns raised about oversight and exemptions to the standards should a weather event happen during the spring application window. Participants wondered if they would be allowed to reapply nutrients after a heavy rain event as such. As a final point, participants expressed concerns about the implementation timing of the proposed standards. They noted potential benefits and reduced negative impacts if implementation would follow a gradual or tiered approach of instead of expectations for immediate rule adherence. They also mentioned their preferences for research-based educational alternatives implemented across the board as compared to a proposed targeted rule that seemingly creates winners and losers. Many participants felt that this rule was constructed without enough sound and robust research, and until new methods are proven effective, producer support of implementation would be difficult.

### Selected Participant Comments

**RC FG#2** - if snap plus is going to be the avenue to regulate this um there's a long ways to go a lot of work needs to be done on the logarithms and the recommendations because in my opinion they're way too high and I don't I don't want to run snap plus under the bus it's you know it's the right price program um and it allows you know for some sort of avenue to keep track of everything and to meet compliance but uh I think their numbers need to be upgraded greatly

**RB FG#3** - what happens if you get a two or three inch rain is there any kind of restrictions that you can go back and put some of that back on because that crop is going to be lost completely on our sandy soils we'll get a three inch rain and if we can't go and put a little bit more on we're done the crop's gonna die

**RF FG#3** - these restrictions would you know put us at the mercy of weather events

**RJ FG#3** - you know it's so frustrating when my agronomists spend so much time doing paperwork and doing regulations instead of being out in the field and recommending a type of cover crop that we should be putting on in the fall time and um you know coming up with uh different strategies maybe doing some you know grid sampling soil sampling um stuff like that and we spend so much time in the office doing paperwork DNR paperwork county paperwork

**RB FG#3** - do you even know what the guide is for enforcement on this thing in the first place who's monitoring and what enforcement is

**RF FG#4** - I mean every acre is you know inch of water is what 22 thousand gallons so like even this in our feed area we have about five acre feed area every inch of rain we're collecting over a hundred thousand gallons of water that we have to then either treat as waste water in some way

## Theme 6 – Potential negative economic impacts on rural communities

**Summary:** Participants in all focus groups voiced their concerns regarding not only their individual operations, but also the potential impact the proposed standards would likely have on the economic well-being of rural communities across the state. They noted that agriculture is viewed as the lifeblood and largest contributor to the economy of numerous

rural communities, and they raised concerns regarding the downstream repercussions these standards could cause in these small towns. Specifically, participants believed jobs, local communities, markets, industries, agricultural processors and even entire supply chains would be impacted by the effect these standards would create when enforced on production agriculture operations. Additional focus was placed on the trucking, equipment/implement, and custom work operations within these communities. The amplifier effect of agriculture on rural economies, from both related agricultural industries and local businesses (restaurants, local markets, area suppliers, etc.), were discussed and there was a general feeling that due to the proposed rule, agriculture would be negatively impacted financially which would inherently negatively affect other businesses and rural communities. Much of the local tax base in rural communities is based on agriculture so these may limit tax bases in these areas.

Transportation issues on township and county roads, especially those in poor condition, would only be exacerbated due to the increased activity on these roads in the spring due to the standards. Many roads already have load weight limits and the timing of access can vary significantly from one township or county compared to the next. With a shortened window for application in the spring and an increased need for activity, participants highlighted not only the inefficient logistical concerns they would likely face but also the need for increased state funding to repair the likely road damage incurred by this situation.

Participants also communicated the impact the proposed standards would likely have on land markets. They alluded to the proposed standards causing land values in the targeted area to fall while land in non-targeted areas would become more competitive due to increased demand for these non-targeted acres. Rents would then correspondingly decrease significantly in the targeted areas while the restrictions would impact current and future land values.

## Selected Participant Comments

**RH FG#2** - we've known this problem has been coming for at least 20 years all around the state this is not something new they've got data back years and uh the 10 parts per million just hasn't been enforced by the DNR for quite a while they enforce atrazine and some other insecticide rules but this is their first step at it um it wouldn't it would it would basically devastate the central sands area at the this rate nobody can quite tell us what 2.2 pounds of nitrates per inch of groundwater recharge means and how it's going to be calculated

**RE FG#2** - it's going to be hard to get all that work done in the spring whether you do it yourself and everybody else is required to do it there will be a shortage of fertilizer spreaders you know for tractor pull and for the co-op the people that hire it done as custom work from their co-op um those guys will never get the work done and same thing with the manure spreading if that's all got to be done in the spring turn enough custom haulers around to accommodate the people it would never it's physically impossible to get it done and farmers can't justify doing it themselves from a labor standpoint or the cost of the equipment so those are what I see is some really huge problems

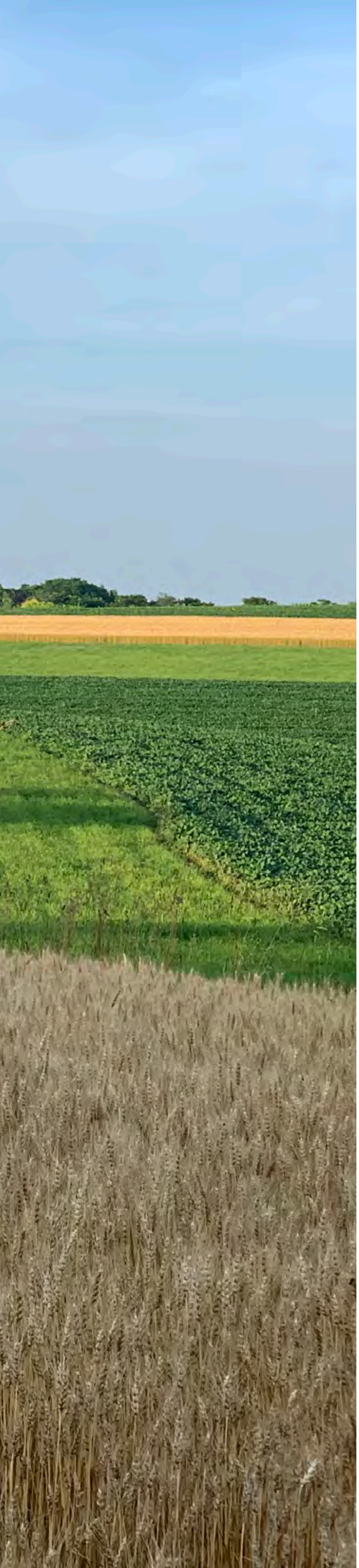
**RH FG#2** - Wisconsin's one of the largest vegetable producers in the country and if we lose those companies and they go away it's just a market that's gone and something else that's got to be replaced is just another knock on rural Wisconsin for jobs and anything else so I think it stretches way beyond individual farms on just how we can rejuvenate Wisconsin

**RG FG#2** - there's some real serious economic disadvantages for the whole the whole region again looking at you know all of our processors I'm sure DelMonte gets all of their crops to supply that plant in stevens point within 30 miles and so if they also have to bump that up number up to 150 miles um how long are they going to leave that plant operating so you get questions like that that are industrial questions not necessarily farm questions that we have to think about too

**RB FG#3** - so what happens to those processors that aren't able to grow here anymore Wisconsin's gonna lose those you have uh you have uh the uh fertilizer companies and everybody that supports agriculture in Wisconsin is gonna be affected by this there's gonna be jobs lost it's uh it's just it's going to be detrimental to ag as a whole the way it's written now it's not doable

**RH FG#3** - if you do this it's literally gonna kill dairy kill vegetables and I don't know how good corn and beans are gonna be with what the rules are going to throw out and everybody's supposed to end up so literally what this is wanting to do is kill all the agriculture in the state

**RI FG#3** - I know some people that are up in the peninsula you know green bay area up there and they got affected by the first round of nr151 um and in door county especially where the soil gets shallow uh there's land rents have gone from 150 175 dollars an acre to between



zero and twenty five dollars an acre because the livestock producers cannot use the ground they cannot mechanically spread manure therefore it is useless

**RB FG#3** - in this type of thing trucking companies are going to lose out big time on this kind of stuff it isn't just ag it's all ag related

**RJ FG#3** - well I think it even goes farther than ag related because once if we lose all these ag operations what happens to all our main street you know our in all our local towns you know we all do a lot of business with our local towns and that business is going to stop

**RH FG#3** - I'll just pick on Lafayette county because I have a nephew that's down there those guys are strictly agriculture there's no manufacturing down there you take that and destroy the agriculture sector of Lafayette county um what's going to happen to everything in the county because that's its lifeblood is agriculture and you destroy that you're going to destroy that whole county

**RB FG#3** - you know society wants cheap food and farmers are doing that you're giving them cheap food and at a good quality and so our margins are small and with this kind of a situation you know you just can't say I'm going to raise my prices because consumers are not going to pay more for their milk and their vegetables so it's going to be a downhill it's going to be downhill fast

**RF FG#4** - I don't like systems that have winners or losers not based on what they do and just by how the map works if certain farms are going to have higher cost production just because where they land and I don't know if that's really very healthy for a rural economy

**RB FG#4** - town roads with spring weight limits we're in a very rural not a lot of you know county highways much less a state highway where our geographical area is those town roads are not made for the heavyweight in um spring so definitely going to be a concern if we move from fall application townships are going to have more heartache with it than what um than what they do now

**RD FG#4** – [road restrictions] it's usually county-based in our area

**RF FG#4** – [road restrictions] in our area it's all township based so each township is different rules so different farms we would be able to and wouldn't be able to do so we wouldn't do all right couldn't do all our applications at one time we might be able to do this township and not down that township it'd be super inefficient and really create lots of problems with windows and efficiency of application

**RB FG#4** - towns are who govern most of our roads that we travel the townships have not gotten the um road aid that they have in the past so you know if this is going to pass um the state better open up some funding for the town roads so these townships can afford to be able to repave or redo roads and you know also handle the weights for those times a year

**RD FG#4** - just putting this proposal into effect I think will have a devastating effect on animal agriculture in the state of Wisconsin I think it will drive smaller producers out and maybe some of the larger producers will be able to stay in because of the economies of scale that they might have but then when you talked about the distance they may have to travel to apply liquid manure in this narrow window we're going to have traffic nightmares we're going to have other issues and with distraught destruction of our roads

**RF FG#4** - we all want the same thing we want good water we want healthy soils but if we do it at the cost of our real farms um you'll never get that back once you lose it and our rural landscape would look quite a bit different then

**RD FG#4** - it affects our rural schools our rural churches and everything when we lose the animal agriculture

**RB FG#4** - whether it's a um 50 cow farm or it's a 5000 cow farm those are all important assets to a real rural economy and real jobs

## Theme 7 - Lack of transparency and explanation behind performance standard provisions and identification of targeted areas

**Summary:** Participants across groups voiced a uniform concern on the lack of transparency or supporting background information to provide and understanding on how the figures, thresholds, and dates in the proposed standards and prohibitions were determined. It was clear that participants did not understanding where the data came from and how those data were used to inform the proposed regulations. In particular, participants drew attention to

how they would measure 2.2lbs/acre/inch, why September 1st was used as a reference date, how the depth to bedrock and soil type were considered in the analysis, how recent were the well testing data, were the contaminated wells found to contain animal or human bacteria, and why was Kewaunee County not included in the targeted area, among others.

Participants voiced their desire to be given the background information that guided development of the standards and prohibitions to better understand and follow the process rather than see only the final proposed restrictions. They also stressed that farmers want science-based research and objective data to better understand the development of any regulatory actions, and without sufficient explanation of methods, the statistical defensibility of the figures in the proposed standards lose their credibility. One area that specifically highlights this concern was the testing process of wells and identification of contaminated wells. Participants were familiar with data from other studies that lack statistical rigor and were requesting more specific information on the dates of testing, the timing between tests, the sample size and selection process, the potential need for resampling, and if construction or structural differences between wells were taken into account.

## Selected Participant Comments

**RB FG#1** - say my farm we had a nitrate sample of one part per million well we're required to go but at my house well I'm not required to sample I'm not really worried about my one part per million nitrate sample so I might not test again for 10 years where if my neighbor has a shallow well that has them they might test every year and rightfully so you know it's a good practice to do but what point does that skew the data that has been presented

**RG FG#1** - I think the main thing is that uh as farmers we want science-based information first of all and when we start questioning the data we have a hard time buying in to any type of regulation and I believe that innovation instead of regulation is the way for our state to move forward on this

**RA FG#1** - my concern with all of it is kind of like I talked about before is once the townships my understanding once the town township's in it's forever in there's no distinction between uh sources of pollution if it's coming from septage like RD was talking about is it coming from animals where is it coming from is it coming from commercial fertilizer

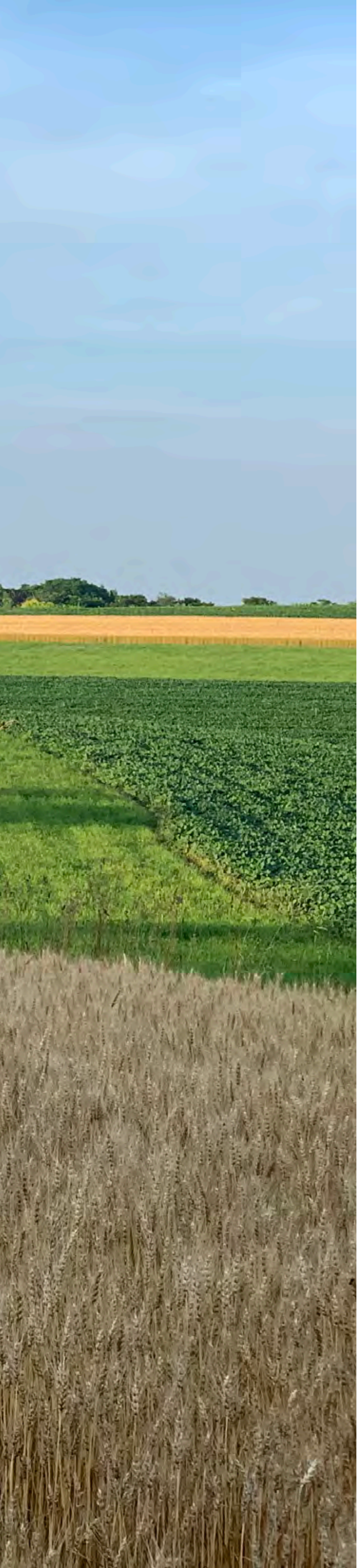
**RA FG#1** - I'm going to make one about the mapping system now I'm on it um everybody kind of knows about the issues that are in Kewaunee county and I'm really shocked that they are not in an area that's restricted on that mapping tool so I really question the legitimacy of how they're doing this because you look at one of the most susceptible areas in the state that's been in the news those type of things and they're not even restricted that that seems crazy to me

**RA FG#1** - so I just want to reiterate my comment on you know that this is going to have a large financial impact on a small percentage of agricultural producers in the state of Wisconsin with a limited amount of control of nutrient management acres and with an administrative person in the white house that's pushing for sustainability and lowering carbon credits we're going to burn more fuel we're going to be less sustainable than we already are we're going to put stress on roads across Wisconsin that already have stress on we're gonna put more stress on um and yeah just at the end it's gonna make dairy less profitable in the state of Wisconsin

**RD FG#**2 - yeah I'm kind of curious where did they come up with some of these dates like September 1st as the last day for hauling there's hardly anybody who's even started chopping up here in the northwest part of the state on September 1st so I'm just kind of curious as to where are they pulling these numbers from I just wanted I'd like to see some of the scientific data on where they're getting it

**RF FG#2** - what we don't have a lot of regulation on or control over as a state and the DNR definitely doesn't is both the well casings that are out there most of which are in terrible shape and the uh house sewage systems that are out there neither one of those are heavily watched regulated or checked we have a lot of abandoned wells we have a lot of poorly cased wells that are many years old that haven't been checked on updated or fixed and there's definitely going to be issues with those and this doesn't do anything to address those kinds of issues I think it's important that ag does its part and we are held to a correct standard I don't know whether or not these numbers are realistic or the correct kind of standard for us though and there's no real good basis that I've seen for how these numbers are derived at or where they should be

**RJ FG#2** - just to provide a little clarification on the uh human versus uh dairy manure source of nitrates and groundwater the study was done in Kewaunee county contaminated wells there 60 percent of it was from dairy cows and Kewaunee county has the highest population



of dairy cows in the united states east of the Rockies so it's a very dairy area but 60 percent of the wells there were contaminated with dairy manure and 40 percent with human fecal material and I have not seen the study yet for south west Wisconsin but what I heard it was 90 percent of it was human fecal material in the southwest Wisconsin and only 10 percent from dairy manure

**RD FG#2** - okay I've got one quick it's kind of a random question but um when the performance standards it says uh establish standards to prevent excessive leaching what would a definition of excessive leaching be that's pretty vague

**RI FG#3** - I just see this as a drastic overreach of their powers and grasping at straws because I haven't seen any ten year long studies that prove what they're telling us to do is actually going to affect the groundwater nitrate concentrations and then lastly I got a problem with the 10 parts per million of nitrate in groundwater being a level of concern um I know for a fact that the world health organization does not get concerned until we get to 50 parts per million um so the whole basis of all of this is flawed from the very beginning

**RF FG#3** - they blocked out um certain townships you know it seems a little restrictive that I think most townships might be six miles by six miles is that can we do field by field if there is certain issues I think we can we should be able to hone in maps from a township basis to more field by field I would think with the technology we have

**RI FG#3** - I uh also wonder about the well data itself if that was sent in by homeowners are they trained properly trained in taking uh accurate well sample I know from personal experience if you don't take your well sample from the right spot you're gonna get false readings um I've had that happen myself

**RI FG#3** - I have a real problem with the map of rock county there's three entire townships that have very few restrictions where the entire townships bordering them are almost all restricted that seems very fishy to me I wonder if it's the way townships enforce well construction

**RI FG#3** - I think we need to go back and retest all the wells again and it needs to be correlated to proper construction and approved construction methods I'm a grade a dairy therefore I am constantly having my water tested and if it doesn't meet spec well that falls on me to build a new well and bring it in spec or I cannot ship my milk so why doesn't that responsibility get shared with the other land owners that decide to live out in the country we should not have to fix their problem um because if they didn't construct an adequate well that's their problem not mine

**RI FG#3** - I could give you a lot more specific numbers data etc. if I could see exactly how they're going to calculate some of these things I could tell you know to the acre how it would change my operation

**RA FG#3** - I guess I would have one more last comment and I would say that uh most farmers don't mind change um but they also like sound reason to make that change and it's got to be a lot of good sound research to back those things up and unfortunately with this I think um like anything when you're told or eventually if you're told you have to comply like this it's really tough to swallow it and once again I'll echo I will say and I'm in the central sands area I believe all the all these farmers in this area are doing everything possible to grow a viable crop with the least amount of expense and doing the best possible practices they can so um you know if we're if you're gonna demand that we change uh you know and do that uh we have to have some science behind it and more research and it you know it may take a lot longer but I don't think implementing this in the near term is the right route to go

**RA FG#4** - it just seems like there's a lot of gray in it right now that's not clearly defined uh like the 2.2 pounds of nitrate uh per inch you know leachable I guess it's hard to know what that translates into you know is that a certain amount that we can put out there every year is that you know where are they going to be measuring that from

**RD FG#4** - I was trying to figure out some of the lines like someone mentioned they stopped at townships what the criteria was to identify uh what's a sensitive area I think it could be more specific to fields or something that would prevent um seepage into the groundwater and I think that would be much more effective than just put something on an entire area

**RF FG#4** - I don't know where the date of September first came from but that could be moved back and coupled with cover crops I think that would be a way better solution a way more economical solution plus then you keep the cover crop growing through the fall have cover for winter and then again it's already established for spring so rather than saying you can't haul any from that date if you could stretch that date out pair it with cover crops that'd be a way more feasible solution while still being very environmentally friendly solution I think so we can think of things like that to add some flexibility I think it'd be a it's often a

blow financially it allows smaller farmers to be more competitive but also still gain a lot of the benefits from an environmental standpoint

**RE FG#4** - the biggest concern I'm looking at right now um so when I when I heard about this proposed rule I start thinking of you know who may be affected and I start thinking of some of our colleagues out east heavier soils um and then up in Kewaunee you know I took a look at Kewaunee I mean the New York Times was reporting on high nitrates and wells I don't see Kewaunee county on this not on this map so the legitimacy of this I don't know where they're getting this information

**RC FG#4** - honestly that was my one of my first impressions was the first thing I looked at was Kewaunee county knowing that they've had issues up there and there there's nothing there that apparently is an issue so there again it's so what is this map really based off of

**RF FG# 4** - it just doesn't make a lot of sense why it's township based in a lot of cases and that just doesn't uh fit with what we're trying to do in the spirit of it I don't think

**RC FG#4** - I think you got to get a little bit more fine-tuned with what fields and areas fall would potentially fall under this rule and what ones maybe don't need to

**RG FG#4** - it just it seems like yeah you really got to put more emphasis on you know depth to bedrock and things like that and soil type rather than um the way it seems the township and uh the way they're developing the map

**RD FG#4** - we also must be mindful of runoff to our streams um the water issue isn't just well water it's flood waters it's rain water it's our streams it's everything and by putting this this into place there are going to be some unintended consequences of those individuals who are looking at this because maybe they're looking at it with blinders on and just talking about well water nitrate levels

## Theme 8 – Challenges of uniform regulations instead of situation-specific collaborative problem solving

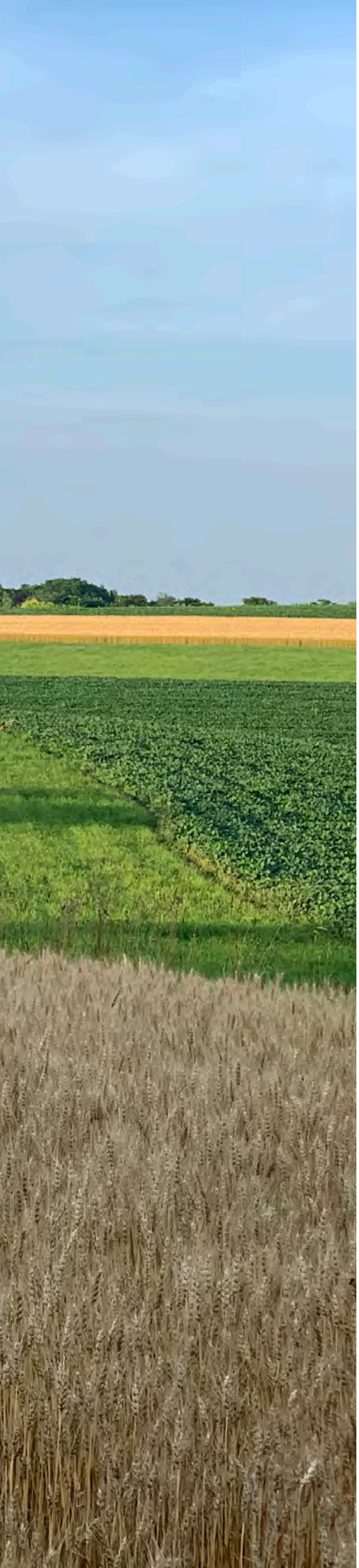
**Summary:** The final general concern that pervaded group discussion was frustration with the application of uniform regulations instead of situation-specific collaborative problem solving. Participants across all focus groups acknowledged the importance of the groundwater quality issue at hand and voiced their desire to be a part of the solution and not the problem. There was prevalent feedback from participants that farmers want clean water too, but they already face a lot of public perception issues and scrutiny in the news and media for their production practices, and these standards felt like one more example of being told what to do instead of engagement and working together towards a solution. Several explicit phrases were used by participants allude to this relationship such as "carrot vs. stick approach", "innovation vs. regulation", and "cooperation vs. handcuffs." Participants communicated that this seemingly one-size-fits-all approach doesn't work on the diversity of Wisconsin farms, and they would want the ability to pilot changes to better understand the impact of new practices rather than being told what to do uniformly and without consideration of their unique settings. Participants requested more research, engagement, transparency, and relationship-building to allow for more flexibility with the proposed targeted standards and prohibitions. Growers opined that a more collegial and collaborative approach would be more effective moving forward and would create locally based options and solutions to work on this complex issue.

### Selected Participant Comments:

**RD FG#1** - other hand I want to be sensitive to the fact that if I am a problem if I'm creating groundwater nitrate issues yeah then I got to solve it we have to get on that we can't allow the consumer to say well we'll give you a pass on this I don't feel that way if I'm a problem I'll man up I'll take ownership of the problem and I'll figure out how to deal with it but to this point I don't have documentation I don't have the science if you will in today's world that helps me understand that I am the problem

**RA FG#1** - I think this problem was created over many years decades if not longer and we're kind of getting forced to solve this over a short time here

**RC FG#1** - I think there's a false premise behind all of this that we do things as farmers just for the heck of it I mean none of us are going to put do anything um to give us more costs and so when they're looking at you know nitrogen application I'm not going to put any more nitrogen on my crops than what's absolutely necessary um just because it doesn't make financial sense and I'm sure if you look at anything that we do if we're not doing it for a specific reason that's going to benefit our crops and our cattle and the way that we do business we



are not going to do it and there's this this kind of false idea out there that we're just randomly doing stuff because we just feel like it you know we do stuff because it's based on science and how we go about doing our business

**RD FG#1** - well somebody once said the world was flat and then uh somebody figured out it wasn't right now I don't know if I have enough information to be able to support this strategy or not support it again as a fellow citizen in my county I do not want to be a bad guy I don't need to make money that bad on the other hand I do have a livelihood I do employ a lot of people I do have a huge economic impact on my county I just don't understand if that if my environmental impact is as great as what I'm being suggested that it is so realistically I would like the opportunity to really dig down sit in a room with the smart people and understand how they develop this knowledge base and really have the opportunity to have the conversation about whether or not the world is flat

**RF FG#2** - so one of the things I've noticed in my other interactions with DNR in the past is vagueness of rules creates ambiguity for the producer and I'm not saying I want very specific I'm not saying I don't but I do know that I've had some pretty bad interactions in the past with uh DNR staff where one says one thing and another says another because it's up to their interpretation of that rule and that creates a pretty big mess for a producer when you're trying to do something and you don't know how the staff is going to come back with their opinion

**RC FG#2** - you know we want to be part of the solution but we need to be justly compensated um for that I mean we're producing food for here and the rest of the country and the world and they want to put the regulations on us but um we're kind of backed into a corner financially so I guess we can't really have one without the other

**RC FG#2** - the second thing would be more of a tiered approach you can't you can't start at a and go right to b you gotta have somewhere in between to allow people time to figure out how you know and what those numbers are you know the guys in the sands are talking about you know and others we don't know what the number actually means and it may not be attainable so I think having more of a tiered approach um would be something that they could do that would help everyone could help everyone figure out what exactly the numbers mean and start taking steps towards achieving better numbers

**RF FG#2** - on a philosophical basis I believe that carrots work better than sticks and when they pass performance standards what I feel happens is people do the absolute minimum and sometimes less than the minimum just enough to get away with passing the rule or passing the bar that's set for them instead of going above and beyond to achieve whereas when you incentivize people to achieve they will go the vast majority of people will go above and beyond to achieve because there's a reward for that and people will chase after a reward but they do just enough to not get hit with the stick and I guess we've seen that in terms of what has been done very successfully by the NRCS more recently since they've kind of changed their tactics to more of a carrot approach with cover crops and no-till we've seen an explosion of use of them in the last few years and all around Wisconsin

**RJ FG#2** - our cover crops were paid for by government grant for the first two years and when they said well there's no more of that money available we say we're not giving up we're gonna keep going even though it's costing us money to put it in now the carrot is much better than the stick

**RC FG#2** - you know that most of the regulations are enforced at the county level so whatever we decide to hand out for carrots should be handed out at the county level to um I think it would better help each county you know it's different soils some the same some different um but each county knows what's best uh for it you know some are vegetables some are dairy some are grain um so I think if you know if we're gonna hand out carrots that they should be channeled through the county

**RE FG#2** - the university of Vermont is what is ahead of Wisconsin and Minnesota on this stuff the university of Vermont has a system somewhat similar to the discovery farms and he actually had research that showed that even with applying manure on their soils and that that they could maintain a good quality water coming out of the tile and university of Vermont you can speak to this too RG if I'm not getting this all right but they want to team up with um Wisconsin and Minnesota and share results and work on projects together so they get more credible data and get it faster

**RA FG#3** - you know the first thing is we always look at the farmer and say he's the polluter he does this because you see him when you're driving down the road but I don't think we put enough emphasis on municipalities and everything else especially small communities that don't take care of what they have in their backyard so and I think we get targeted for that

**RE FG#3** - and it's a pretty common now you know known fact that um you can get better results through cooperation than by applying handcuffs on the producer

**RB FG#3** - I know we made these comments but I just want to reiterate that we have been you know cognizant of nitrates since the 80s and we've been farmers have been doing things to implement better things over the years and I don't think we get credit for that I think we have stopped our nitrogen leaching to a significant point

**RE FG#4** - there's a heavy spring rain everyone's kind of rushing and at the end of the day when there is a mishap you know the news crew is going to be on scene and we're going to be the criminals here you know that's the big that's the biggest thing here on our end is that rules are imposed we get pushed to a corner things don't go our way we're put up with challenges and at the end of the day we're the criminals and that's the hardest part I have with all this

**RD FG#4** - is there a way to pilot some of these things um you see these practices actually what they're talking about actually work to lower the levels of uh nitrates in our well water also agriculture seems to be the target of all this but there are other sources of nitrates that are coming into our groundwater you know the standard one size doesn't necessarily fit all because our state's topography is quite different from north south east and west it's quite different in terms of uh what can be done and the amount of protection for our groundwater

**RH FG#4** - again we want to learn with them and so forth too we just don't want to be dictated to by them

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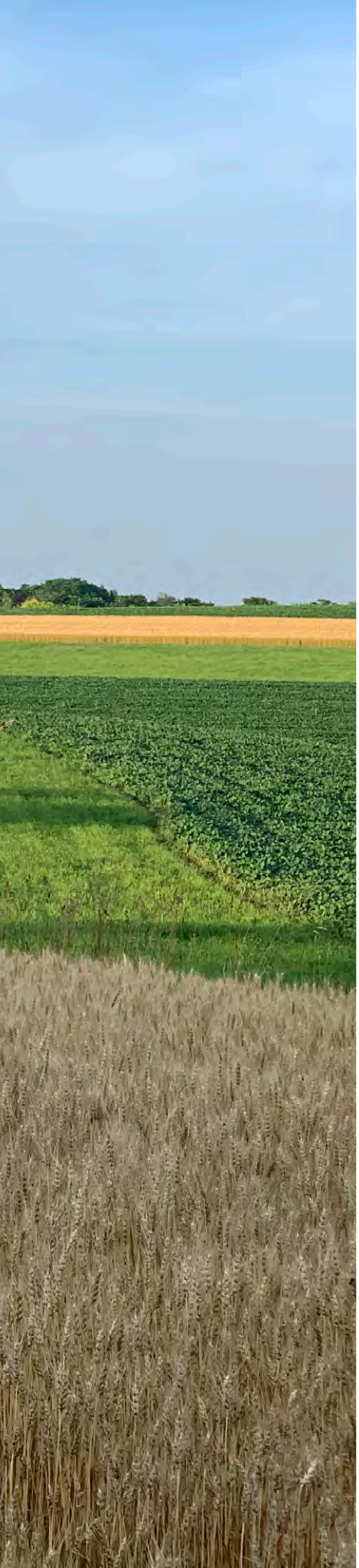


## ADDENDUM 1

## FOCUS GROUP QUESTIONS

### Performance Standards

1. You have all received information regarding the proposed performance standards put forth by the WI DNR. As defined in the document you received from us last week, the intended purpose for these proposed standards is to "Reduce groundwater nitrate pollution in targeted areas of the state that are susceptible to groundwater contamination."

   First, we'd like to learn a little bit more about your first impression of the proposed performance standards. Can you share your thoughts about the standards and how may relate to your individual operation?

   a. Can you tell us a bit more about your current nitrogen management practices on your operation?

   b. If you needed to reduce the amount of nitrogen leaching on your operation in order to be in compliance with a new standard such as the proposed, how would you decide what to do?
      i. What factors would you use to determine how to reduce the amount of nitrogen leaching on your operation?

**2. [If no concerns arise naturally]**
   a. Are there any issues or concerns that you have with these proposed standards?

**3. [If no practices arise naturally]**
   a. Are there production practices that you believe farmers could implement in order to be help them be in compliance with the proposed standards?

### Targeted Areas

4. As you have seen in the (maps within the document we sent out/online mapping tool) the WI DNR is proposing roughly 1.6 million acres of agricultural land be targeted under these proposed performance standards. What is your first impression of the targeted areas for these proposed performance standards?

### Concerns/Issues

**[Depending on which concerns/issues arise naturally]**

5. Can you tell us a bit about how the weather could impact your ability to comply with these proposed performance standards?
6. How do you imagine farm rental arrangements between landowners and land renters would operate under these proposed performance standards?
7. How do you imagine these proposed performance standards might impact the management of a crop with only a portion of the total acreage under the proposed performance standards and another portion not under the standards?

# Appendix 2: Additional Context Regarding Agricultural Nutrient Management

## Introduction

Wisconsin's diverse landscapes and rich water resources are closely intertwined with our state's agricultural history. Agriculture is a critical component of Wisconsin's economy supporting more than $104.8 billion and 437,700 jobs (Deller 2019). Agricultural operations vary considerably, and within their unique operations, growers use many practices and inputs to ensure production quality, profitability and safety. At the same time, management practices across the landscape influence the safety and quality of surface water and groundwater resources. There is currently a sustained focus in Wisconsin on human health concerns associated with nitrate in groundwater, especially in wells that are above the drinking water standard, which in Wisconsin is 10 mg/l of nitrate. The proposed changes to NR 151 relate to connections between agricultural practices and high nitrate levels in groundwater.

Neighboring states and other regions across the U.S. share these concerns around nitrate and have developed (or are currently developing) programs and policies intended to balance agricultural impacts while protecting streams, lakes, and groundwater resources and still maintaining profitable farming operations. As noted in the main body of this report, while the use of commercial fertilizer and/or manure in conventional cropping systems is needed for yield and quality, best management practices (BMP's) to limit nitrate leaching are available to growers. Research, development, and implementation of BMP's and new approaches for growers is necessary to protect water resources while also ensuring profitability, practicality and environmentally sound crop production practices and cropping systems.

Policy approaches are often combinations of government payments and regulatory options. Numerous programs have been developed to promote voluntary adoption of specific practices or principals using cost-share dollars while other efforts include state regulations or standards to mandate practice adoption or input limits to address water quality concerns. Determining the feasibility and mix of approaches depends on understanding the social, economic, and production based impacts these programs have on producers, their farms, rural communities, and water resources. This appendix document highlights the variety of important considerations to provide context for discussions around potential voluntary or regulatory approaches to reducing nitrate leaching from agricultural sources.

## Social Factors

Farms across Wisconsin vary significantly in their combination of soil, topography, and cropping/livestock systems. Just as these farming operations and systems vary in objective measures, their management and approaches to making farm management decisions also vary based operators' individual perceptions, preferences, constraints, pre-existing practices or contractual agreements, and their willingness and/or attitude towards taking on risks and initiating change. This also extends to adoption decisions for conservation practices and programs including those focused on nitrogen management and reduction of nitrate leaching.

The issues are complex, and research has identified many factors influencing adoption decisions for agricultural and conservation management practices (see Prokopy et al. 2019, Mase et al 2015, Reimer et al. 2020). While economic and profit-related factors are clearly important, other nonfinancial considerations are also influential, and with voluntary programs (or even performance based regulatory approaches) farm operators seek to make the best and most-informed decision possible to benefit their operation. For example, it is obvious why a farmer may be reluctant to adopt a technology, for applying N or otherwise, with large fixed costs and uncertain profits (Hite et al. 2002). What may be less obvious though are the internal and social factors influencing a farmer to adopt N-management practices or to enroll in N-reducing conservation programs. Farmers already operate under numerous unpredictable uncertainties as part of their occupation such as weather, input prices, crop prices, etc. (Reimer et al. 2020). It is also this lack of knowledge and unpredictability that influences how farmers experience and process their operation's N management. Farmers must balance social and economic goals without damaging the environment or natural ecosystems. Not only are farmers uncertain about the weather, but they also may lack knowledge about the biophysical systems on their operation and the possibility of underapplying or overapplying N (Reimer et al. 2020). The combination of an individual's risk and uncertainty will likely determine their approach to nitrogen management and application decisions (i.e., when to apply, where to apply, what type to apply, and how much to apply).

Most importantly may be the farmer's self-identity and their perceptions of conservation practices on their own farm (Prokopy et al 2019, McGuire et al 2013). Schwab et al. (2012) found that a farmer's conservation identity was a primary factor in governing their risk perceptions associated with nutrient loss on their operation. Their individual risk perception regarding nutrient loss was mainly driven by their identity as a conservationist and their perceived sufficiency that what they were doing through existing nutrient management practices was good enough (Schwab et al. 2012). The formation of their perception may also be influenced by the source of their knowledge and their age. Kielbasa et al. (2018) found that older farmers drew more from their experiences whereas younger farmers were more likely to draw information from academic or vocational settings to inform their nutrient management perspectives and were willing to incorporate new changes and technology if there was an expected positive outcome (Kielbasa et al. 2018). Mase et al (2015) highlighted varying levels of trust associated with different sources of information provided to farmers related to agricultural management and water quality. Radatz et al (2018) emphasize the importance of developing agricultural and water quality information together in partnership with farmers. Studies have also demonstrated the influence of engaging farmers in outreach and education programs about nutrient management (e.g., Genskow 2012).

Further, Doidge et al. (2020) found that lifestyle choices and land stewardship perspectives of farmers were important in land use change decisions, while Luther et al. (2020) found that farmer preferences for environmental amenities and social status were important adoption criteria for practices that can abate nutrient pollution. As an example of this, the influence and impact of social norms in the decisions of farmers to adopt conservation tillage practices were explicitly pertinent in the results of a survey administered by Wandel & Smithers (2000). Farmer responses when asked about the social barriers to adopting conservation tillage equipment included: "if it isn't broken don't fix it", "peer pressure", "waiting to see what others do", and "afraid to look stupid" (Wandel & Smithers, 2000).

From another perspective, work by Ma et al. (2012) suggests there are actually two separate decisions being made by farmers when deciding to participate in environmental programs for payment. The first and more socially relevant decision depends on the farm and farmer's characteristics informing their willingness to enroll. This decision happens prior to the decision on how many acres to enroll, which is more economically relevant and depends more on the payment offer and marginal cost-benefit criteria (Ma et al. 2012). This scenario stresses the importance of the social factors involved in a farmer's motivation to make conservation-based decisions.

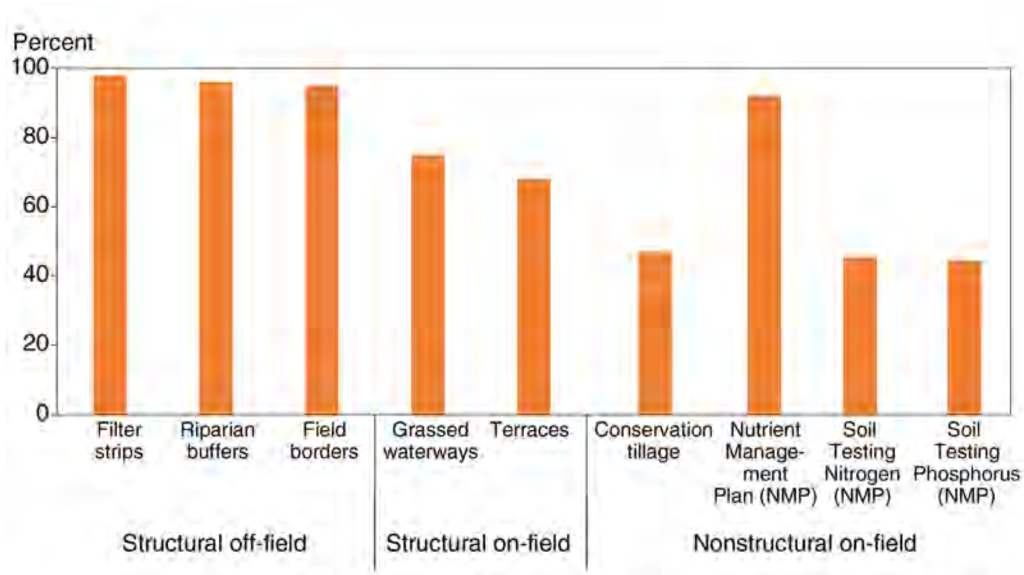
Interestingly, the monetary contribution that Ma et al. (2020) refer to as part of the farmer's secondary decision may vary on the type of conservation practice they are deciding to adopt. As demonstrated in Figure 1., a significantly larger amount of program participants said they would not have adopted a nutrient management plan without a conservation payment compared to other common conservation practices (Claassen & Smith, 2018). Similarly, in Figure 2., "nutrient management" as a conservation practice group resulted in the lowest percent of farm adoption among all conservation practice groups, in addition to the lowest percent of farms adopting with payment across all conservation practice groups (Claassen et al. 2014). This finding may impact the potential cost-share funding made available for nutrient management practices in Wisconsin, requiring a larger cost-share proportion for farmer adoption of nutrient management practices compared to the cost-share amount commonly applied to other conservation practices.

## Economic Factors

As discussed in the previous section, social factors play an equally important role as economic factors in farmer's decisions to adopt or not adopt conservation-based BMP's. Due to the more recent nature of nutrient management practices, and the corresponding economic impact due to their adoption, there is seemingly less literature that includes findings on the quantitative measures associated with these specific practices. Just as the objective measures of farms (e.g., size, topography, cropping system, etc.) and subjective measures of farmers (e.g., identity as a conservationist, land stewardship, risk aversion, social status, etc.) varied significantly, the economic costs and benefits associated with adopting nutrient management practices can also vary significantly from farm to farm.

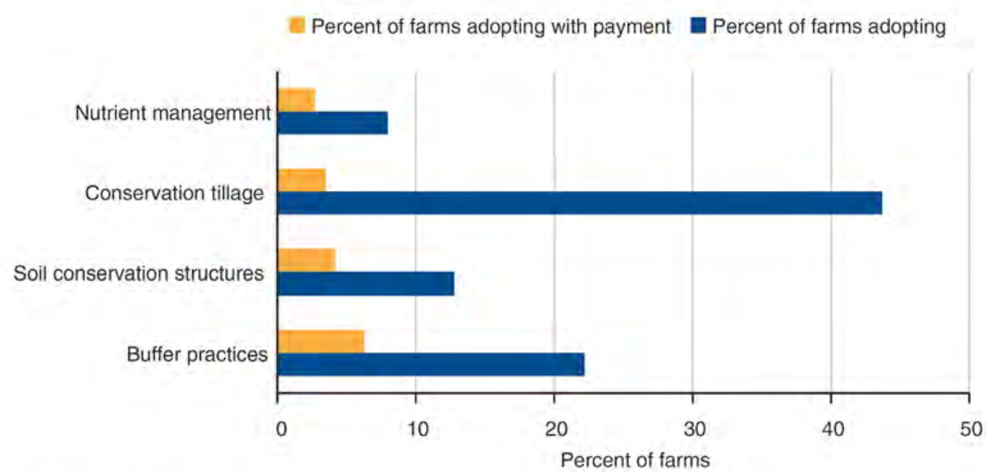
Some of the best available sources of information on the economic costs and benefits of adopting nutrient management practices are from relatively recent initiatives in Iowa and Minnesota. Starting in 2012 with a nitrogen science assessment as its basis, and with many revisions since, the Iowa Nutrient Reduction Strategy outlines a pragmatic framework to assess and reduce nutrients in Iowa waters and the Gulf of Mexico, including targeted practices designed to reduce loads from nonpoint sources such as farm fields (http://www.nutrientstrategy.iastate.edu). Similarly, the Minnesota Nutrient Reduction Strategy, starting in 2014,

**Figure 1.** The percentage of program participants who would not have adopted a practice without a conservation payment (varies by practice)




Note: Conservation payment could come from Federal, State, or local sources. While USDA is the largest single source of conservation payments, many agricultural States also have conservation payment programs.
Source: USDA, Economic Research Service (ERS) analysis using data from ERS and USDA, National Agricultural Statistics Service, Agricultural Resource Management Survey, 2009-12.

**Figure 2.** Conservation practice adoption and payment rates for conservation practice groups




Source: USDA, Economic Research Service and USDA, National Agricultural Statistics Service, Agricultural Resource Management Survey, 2009-11.

outlines specific goals and provides a framework for reducing nutrient pollution in its lakes and streams and reducing the impact downstream (https://www.pca.state.mn.us/water/nutrient-reduction-strategy) These state initiatives continue to track the progress of BMP's for nutrient reduction as well as the implementation of efforts to reduce nutrient pollution.

As the Minnesota Department of Agriculture (MDA) realized through their evaluation of BMP adoption as part of the Minnesota Nutrient Reduction Strategy , each farm is unique and the individual decision to adopt BMP's will depend on the soils, topography, cropping system, in addition to the willingness of economic risk and individual preferences for specific farmers. Recent revisions made to Minnesota's Nitrogen Fertilizer Management Plan in 2015 and Groundwater Protection Rule in 2019 are very similar in nature to the currently proposed WDNR performance standards in Wisconsin (The Current, 2020).

As part of the Iowa Nutrient Reduction Strategy, three categories of nitrate reduction strategies (Nitrogen management, Land use, and Edge-of-field) were evaluated primarily on either corn following corn or corn-soybean rotations. Specific practices within each category were then analyzed in order to estimate the economic cost/benefit impact on the potential implementation at an individual farm level. Estimates of nutrient impact (i.e., Nitrate reduction) and economic impact (i.e., costs to implement conservation practices, costs to change the timing of practice, % change in yield, etc.). Aside from the Iowa initiative, Christianson et al. (2017) found that land use change practices were the most effective type of practice but also required relatively more product system changes compared to agronomic management, and they were also the least cost effective. This was compared to using a single management practice or multiple management practices through "stacking". Overall, stacking a combination of proven management practices may result in the most cost-effective return on conservation dollars without the need to make a change to the overall production system (Christianson et al. 2017).

Similar figures can be found for the Minnesota Nutrient Reduction Strategy. This includes estimates for the lifecycle costs ($/acre/year) and the efficiency of reducing Nitrogen and Phosphorus for a variety of BMP's grouped by category (i.e., nutrient management practices, increase and target living cover, field erosion control, and drainage water retention and treatment). Also included is a summary of strategies to implement along with an estimate of their costs and level of priority. Additionally, though not at a farm level, Professor William Lazarus at the University of Minnesota has developed nitrogen and phosphorus reduction planning tools for watershed-scale decisions (https://wlazarus.cfans.umn.edu/activities-projects-and-interests/water-and-air-quality) as part of the Minnesota Pollution Control Agency's study on ways to reduce nitrogen in surface waters (https://www.pca.state.mn.us/water/nitrogen). These examples and extensions of the prior work completed through both the Iowa and Minnesota Nutrient Reduction Strategies should be used to better understand if Wisconsin farmers are willing to absorb yield loss from year to year in order to maximize the long-term economic return of N-reducing BMP's.

One of the primary hurdles will likely be the economic impact of opportunity costs associated with BMP adoption. Tyndall & Roesch (2014) found that opportunity costs, foregone revenue or rental income due to land removed from production, often times represent the most influential cost factor. Not only are they an added complexity for cost evaluation (Tyndall & Roesch, 2014), the variation from year to year and difficulty to predict into the future increases the potential in serving as a barrier to adoption.

## Conclusion

A review of the Iowa and Minnesota nitrogen reduction strategies provides a good resource of options for nearby states to Wisconsin looking at solutions to similar issues. The cost of implementation, outcomes and approaches could be similar to what could occur in Wisconsin, and as noted in these neighboring states, cost-share options would encourage alternatives. At the same time, more research and new approaches and possibly markets are needed. Overall, farmer adoption of voluntary measures or their selection among multiple practices and field by field options that may meet required performance standards will depend on multiple factors. The practices and options will need to be clearly defined and deemed workable by farmers. Cost share dollars from state and federal partners will help with implementation of specific practices, but since multiple practices and options would need to be implemented to change nitrate groundwater levels, much more than just cost-share dollars would be needed and growers would need to address specific needs on their individual farms and fields.

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