REPORT

Less Fertilizer, Better Outcomes:

USDA Conservation Programs Benefit Both Farmers and the Planet

HIGHLIGHTS

Every year, US farmers apply between 30 and 50 percent more synthetic nitrogen fertilizer than their crops can actually absorb, and the excess that runs off farm fields does harm to people, ecosystems, and the climate.

Voluntary conservation programs administered by the US Department of Agriculture offer scientifically proven ways for farmers to break this cycle of fertilizer dependency, but they are not sufficiently funded to meet demand, and disadvantaged farmers often can't afford the up-front investment. The next food and farm bill should make these programs accessible to more farmers, and prioritize practices that improve soil health without chemicals—which will also reduce the emissions that drive climate change.

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Union of Concerned Scientists

Introduction: The Fertilizer Overapplication Crisis

Every year, producers apply millions of metric tons of synthetic fertilizer to agricultural farmland. In the United States in 2022, approximately 236 million acres—roughly 78 percent of the total 301 million cropland acres in the country—were treated with synthetic commercial fertilizers, lime, and soil conditioners (NASS 2024c). Today's agricultural systems focus on growing commodity crops such as corn and soybeans at high density, which demands vast amounts of nitrogen to support crop development and yield (Ribaudo et al. 2011). In large-scale industrial agricultural systems, synthetic fertilizers such as urea, nitrate, anhydrous ammonia, potash, and ammonium phosphates supply essential macronutrients like nitrogen (N), phosphorus (P), and potassium (K) (Kaiser and Pagliari 2018; Kaiser and Rosen 2018; Mengel n.d.). Although the nitrogen and other nutrients in these fertilizers are essential for plants to grow, most of the applied nutrients are not absorbed by plants and end up polluting the environment and surrounding communities (de Vries 2021).

This report calculates the quantity of fertilizer applied in excess of the amount crops can use across the United States and estimates the emissions of heat-trapping gases resulting from this overapplication. In addition to this national assessment, we also conduct separate analyses for three major Corn Belt states—Illinois, Iowa, and Minnesota—which rank among the top states in fertilizer-treated acreage and crop-related heat-trapping emissions (Rabine and Schechinger 2025; NASS 2024a; EPA 2023a; NASS 2024b). Our analysis focuses on the dominant corn–soybean rotation system, which occupies substantial acreage in the United States. Corn has a particularly high demand for nitrogen fertilizer, and soybeans grown in rotation with corn influence soil nutrient dynamics and fertilizer requirements (Hoss et al. 2018).

To illustrate how federal programs help address fertilizer-related impacts, this report also presents an illustrative estimate of the potential economic and environmental benefits of assisting producers in developing a nutrient management plan in accordance with the Natural Resources Conservation Service (NRCS) Nutrient Management (Ac.) (590) Conservation Practice Standard.

Estimating Fertilizer Use and Overuse

In 2023, producers in the United States used about 11.62 million metric tons (MMT) of nitrogen fertilizer on all crops (IFA 2025). In Illinois, Iowa, and Minnesota, corn and soybean fertilizer application ranged between 565,856 and 883,462 metric tons, according to US Department of Agriculture (USDA) surveys (Table 1; NASS 2025).

Table 1. Nitrogen Fertilizer Use

Region	Nitrogen Fertilizer Use (Metric Tons)
Illinois[a]	880,000
Iowa[a]	780,000
Minnesota[a]	570,000
Total US[b]	11,620,000

The quantity of nitrogen fertilizer used in the United States and in Illinois, Iowa, and Minnesota. These states rank among the top states in fertilizer-treated acreage and crop-related heat-trapping emissions. The data have been adjusted to nearest 10,000.
Note: Aggregated NASS and IFA values carry about 1 to 5 percent uncertainty. See Appendix A for detailed methodology.
Sources: a = NASS 2025 for fertilizer use on corn and soy; b = IFA 2025.

The problem is not the use of fertilizer; the problem is fertilizer overapplication. Fertilizer overapplication is an element of a broader system consisting of fertilizer manufacturing and overuse in agricultural production systems with overall negative impacts such as nutrient losses, pollution, and emissions. Producers often apply fertilizer in quantities far greater than crops need or can absorb (Ritchie 2021). Despite significant advances in fertilizer management and uptake efficiency, research shows that overapplication and subsequent surplus nitrogen is still a prevalent problem, and often as much as 50 percent of applied nitrogen fertilizer is excess and remains unused by plants (Ritchie 2021; Byrnes, Van Meter, and Basu 2020). This excess use directly contributes to nitrogen loss from agricultural systems, because unused soil nitrogen runs off to surface water bodies, leaches to groundwater, or reconverts to gases such as nitrous oxide (N_2O), nitrogen oxides (NO_x), ammonia (NH_3), and carbon dioxide (CO_2), which are released into the atmosphere (Almaraz et al. 2018). Direct emissions of N_2O result after the application of nitrogen fertilizer, as soil microbes convert reactive nitrogen into N_2O through processes such as nitrification and denitrification (Gao and Serrenho 2023). A second set of emissions—indirect emissions—arise from processes that generate additional N_2O, NH_3, NO_x and CO_2. Indirect emissions of N_2O and NO_x arise from the conversion of fertilizer into NH_3 and transformation into N_2O; the leaching of nitrates from fertilizer runoff releases additional N_2O (Gao and Serrenho 2023). CO_2 emissions arise from breakdown of urea (one of the most common fertilizers applied) and from degradation of limestone used to neutralize soil acidification resulting from the addition of nitrogen fertilizers (Gao and Serrenho 2023).

Fertilizer application beyond optimal levels is damaging to soil and environmental health. For instance, it depletes soil's ability to absorb water and to store, use, and replenish essential soil nutrients (Pahalvi et al. 2021; Tripathi et al. 2020; Green, Blackmer, and Horton 1995). As soils become less efficient in their ability to replenish their own nutrient reserves, producers are pushed onto a "fertilizer treadmill," requiring ever higher applications simply to maintain yields (Silverman 2021; Wertz 2020; Houser and Stuart 2020). Fertilizer overapplication leading to wasted fertilizer is also expensive for producers, increasingly so as fertilizer prices rise (McCracken 2024).

Nitrogen use efficiency (NUE) is a science-based metric that expresses how much applied nitrogen crops actually use. It is calculated as the ratio of the nitrogen taken up from the soil by the crop over the amount of nitrogen input and is usually expressed as a percentage (Congreves et al. 2021; Lassaletta et al. 2014). For example, an NUE of 60 percent means that only 60 percent of applied nitrogen is converted into nitrogen in harvested products, while 40 percent is not and may result in runoff, leaching, and breakdown into N_2O (Congreves et al. 2021). NUE can be optimized by practices that increase yield and reduce fertilizer application, or by increasing the efficiency of fertilizer application to improve nitrogen management, reduce wasted resources, and subsequent detrimental environmental impacts (Langholtz et al. 2021).

In an ideal world, the amount of nitrogen applied would be dictated by crop requirement to maximize crop production while minimizing nitrogen loss. But, in reality, rates of fertilizer application far exceed the rate of plant absorption (Glibert 2020). According to the US Department of Agriculture (USDA), in 2010, about 47 percent of planted corn acres in the United States received at least 25 percent more nitrogen fertilizer than plants require (ERS 2025a). Research has shown that NUE has decreased in a majority of regions in the United States, even as total nitrogen inputs to agricultural acres have steadily increased (Swaney, Howarth, and Hong 2018). NUE estimates vary widely, with national estimates often ranging between 40 and 70 percent. NUE also varies by crop, and some studies have estimated NUE of corn to be lower than 40 percent (Kaur et al. 2024; Omara et al. 2019; Griesheim et al. 2019). In addition to crop variation, there is also regional NUE variation.

Despite scientific findings indicating a range of values, all NUE estimates unequivocally show that a substantial amount of nitrogen fertilizer remains unused by the plants it is supposed to benefit. For example, previous studies focused on the US Corn Belt have estimated NUE ranges from 50 to 70 percent (Kirk et al. 2024; Zhang, Cao, and Lu 2021; Roy, Wagner, and Niles 2021; Swaney, Howarth, and Hong 2018). Using this NUE range, we estimated that US producers apply about 3.5 to 5.8 MMT more fertilizer than plants can absorb (Table 2). As we explain in the next section, this unused nitrogen creates significant climate and environmental risks.

Table 2. Fertilizer Overuse in the Corn Belt

Region	Nitrogen Fertilizer Use (Metric Tons)	Estimated Nitrogen Fertilizer Overuse with 50% NUE (Metric Tons)	Estimated Nitrogen Fertilizer Overuse with 70% NUE
Illinois*	880,000	440,000	270,000
Iowa*	780,000	390,000	230,000
Minnesota*	570,000	280,000	170,000
Total US	11,620,000	5,810,000	3,490,000

*Assuming 50 and 70 percent NUE, we estimated excess nitrogen fertilizer applied in the Corn Belt and in the United States and three midwestern states. A third to half of fertilizer applied in the Corn Belt is wasted and ends up polluting the environment including surrounding waters and the atmosphere. *For states, fertilizer use is based on corn and soy, and numbers have been adjusted to the nearest 10,000 to simplify formatting.*

How Excess Fertilizer Use Creates Heat-Trapping Gas Emissions

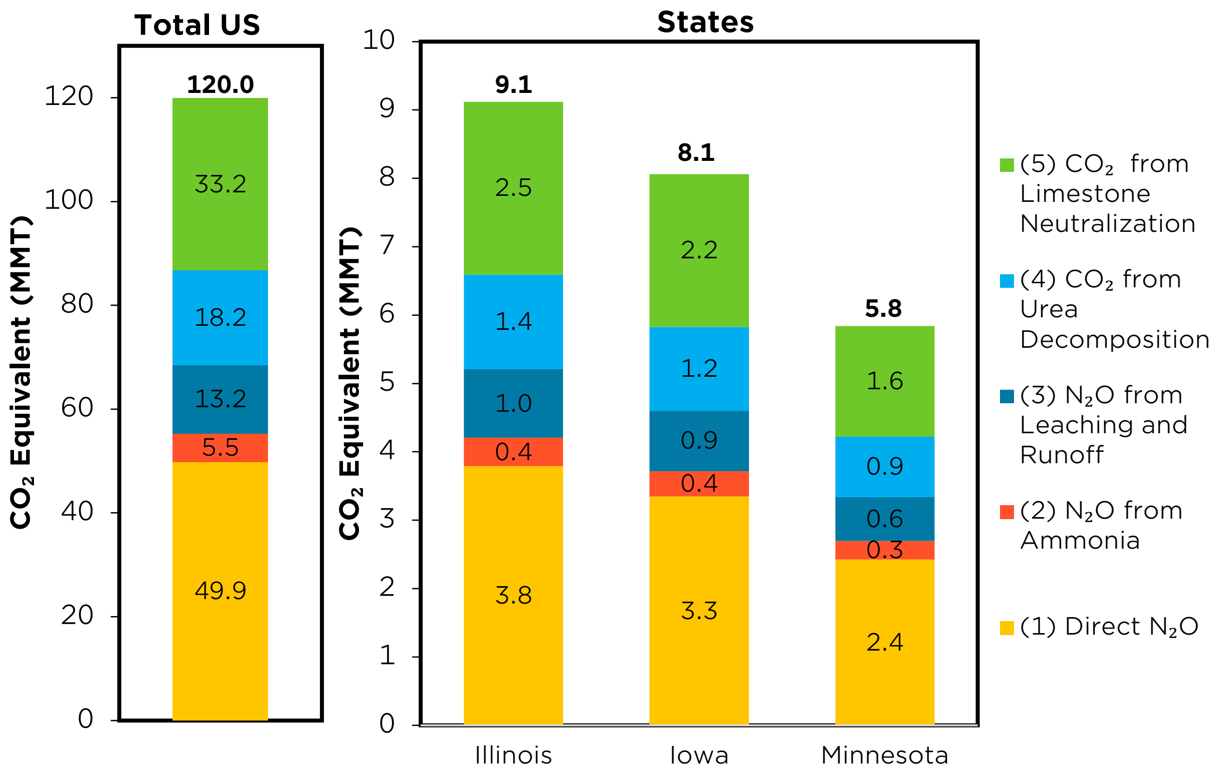
The nitrogen cycle in the environment is complicated. Nitrogen shifts through many chemical forms using various pathways (Badzmierowski 2025; Goswami 2025b; Stein and Klotz 2016). Humans intervene in the nitrogen cycle by adding synthetic nitrogen fertilizers; this intervention has resulted in a vast soil, water, and atmospheric reserve of nitrogen that can create environmental havoc, including nutrient pollution, emission of heat-trapping gases, and negative impacts on human health (Fields 2004; Erisman et al. 2013).

The Environmental Protection Agency (EPA) estimates that in 2022, the agriculture sector was cumulatively responsible for emissions of 593.4 MMT of heat-trapping carbon dioxide (reported in units of CO_2 equivalent, or CO_2e as per scientific nomenclature), comprising about 9.4 percent of total heat-trapping gas emissions in the United States (EPA 2024). Our analysis shows that for the entirety of the United States, in 2023, use of nitrogen fertilizer was responsible for emitting about 120 MMT of heat-trapping gas calculated as CO_2e (Figure 1). Using the EPA Greenhouse Gas Equivalencies Calculator, our calculated emissions of 120 MMT CO_2e is equivalent to emissions from about 28 million gasoline-powered cars driven for a year (EPA 2025b). Using our emissions estimate of 120 MMT CO_2e, fertilizer use alone accounts for about 20 percent of these agriculture sector emissions.

The portion of unused fertilizer that microbes transform into gaseous N_2O is released into the atmosphere. N_2O is 273 times more powerful than CO_2 in capturing heat and is considered a superpollutant (EPA 2025f; UNEP and FAO 2024). As of 2022, in the United States, N_2O comprised approximately 6 percent of all heat-trapping gas emissions (EPA 2025c). According to the EPA, agricultural soil management is far and away the largest unmitigated source of N_2O, responsible for emitting about 75 percent of total direct N_2O emissions, totaling about 290 MMT CO_2e (EPA 2025d; EPA 2024). N_2O emissions are dependent on various factors, including temperature, soil conditions such as moisture, and drainage (Wang et al. 2021), but excessive amounts of available nitrogen means a higher chance of increased emissions (de Vries 2021).

As per our analysis, of the total emissions of 120 MMT CO_2e, 50 MMT was direct N_2O (in CO_2e) alone, accounting for about 41 percent of overall emissions. With the average cost of societal damages associated with N_2O estimated at $67,000 per metric ton, the direct N_2O emitted nationally from fertilizer overuse translates into an economic burden of nearly 12 billion in 2025 dollars (EPA 2023b; BLS 2025). In Illinois, Iowa, and Minnesota, total heat-trapping gas emissions from the application of fertilizer on corn and soy specifically ranged between 5.8 and 9.1 MMT of CO_2e (Figure 1). Cumulatively, corn–soybean rotation systems in these states are responsible for emitting almost 20 percent of heat-trapping emissions resulting from fertilizer use in the United States.

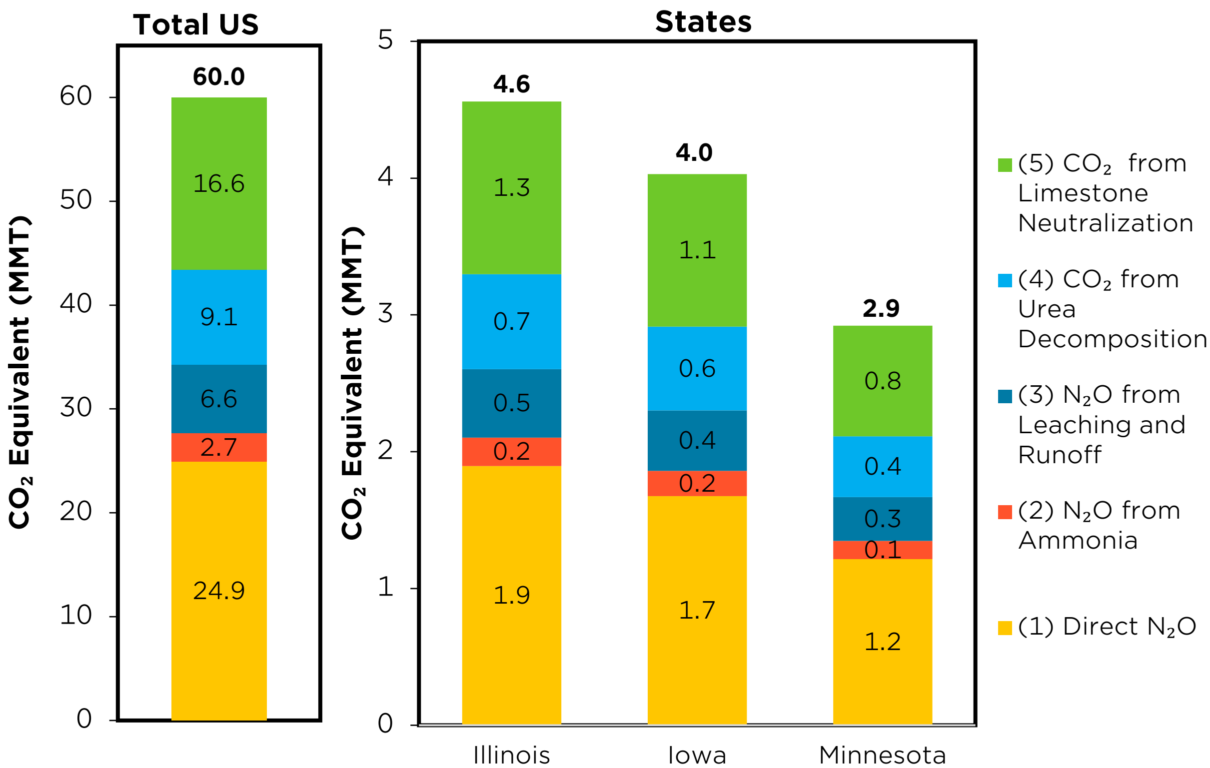
Figure 1. Emissions from Total Nitrogen Fertilizer Applied



Fertilizer use leads to heat-trapping emissions through a number of means, including both direct soil N_2O emissions and indirect emissions from ammonia volatilization, nitrate leaching, urea decomposition, and limestone neutralization. Stacked segments in this figure represent five emission pathways. Reducing fertilizer overuse will lead to reducing such emissions. Estimated fertilizer-associated heat-trapping gas emissions in 2023 for the entire United States was 120 MMT CO_2e for all crops, and estimated fertilizer-associated heat trapping emissions from fertilizer use on corn and soybeans ranged between 5.8 and 9.1 MMT CO_2e for the three states. See Appendix A for methodological details.

We also estimated the emissions resulting from *excess* fertilizer use (that is, the fertilizer that was applied but not used by crops). Using our estimated range of 3.5 and 5.8 MMT of excess nitrogen fertilizer, we calculate that excess fertilizer may be responsible for emitting between 36 and 60 MMT of heat-trapping gas (in CO_2e) in the United States, equivalent to emissions from about 13 million gasoline cars driven for a year (Figure 2; see Appendix A for details). Direct N_2O emissions ranged between 15 and 25 MMT CO_2e for the entirety of the United States. In Illinois, Iowa, and Minnesota, heat-trapping gas emissions from the overapplication of fertilizer on corn and soybeans (assuming range of 50 and 70 percent NUE) ranged between 1.7 and 4.6 MMT CO_2e.

Figure 2. Emissions from Excess Applied Nitrogen Fertilizer Assuming 50 Percent NUE



Estimated fertilizer-associated heat-trapping gas emissions (CO_2e) in 2023 attributable to excess nitrogen fertilizer—the portion of applied fertilizer not taken up by crops assuming an NUE of 50 percent. Bars show emissions for the entire United States (all crops) and for fertilizer applied specifically to corn and soybeans in Illinois, Iowa, and Minnesota. Stacked segments represent five emission pathways. Total excess-fertilizer emissions are estimated between 36 and 60 MMT CO_2e for the United States, and between 1.7 and 4.6 MMT CO_2e across the three states. See Appendix A for methodological details.

In this section and in Figures 1 and 2, we use the term *fertilizer-associated emissions* to describe the full set of heat-trapping gases linked to nitrogen fertilizer use, which includes both *direct and indirect soil N_2O emissions*. The use of *fertilizer-associated* is to clarify that these emissions are connected to nitrogen fertilizer use, even if they do not all represent emissions from nitrogen fertilizer itself as a standalone category. Figure 1 represents emissions from total nitrogen fertilizer use, reflecting the full climate footprint associated with current application levels of nitrogen fertilizer. Figure 2 represents emissions from ***excess*** fertilizer and offers a simplified estimate of the potentially avoidable share of total emissions, based on assumed NUE. We do not imply that all fertilizer-related emissions come only from overapplication of nitrogen but rather provide an approximation of emissions that could be reduced by avoiding overapplication. Indeed, nitrogen as a natural element circulates in the environment, it is moving and transforming across chemical forms all the time, and some N_2O will always be produced even when fertilizer is applied at agronomically required application rates.

Further Consequences of Fertilizer Overapplication: Water Pollution

Nitrogen loss through runoff and leaching of nitrates is a major pathway by which nitrates end up in water systems. This has significant negative environmental impact on freshwater systems, impairing surface water quality, critical habitats for aquatic plants and animals, and public health (Camargo and Alonso 2006; Wang and Li 2019; Woods 2025a). Nitrate runoff accelerates the overgrowth and bacterial decomposition of algae. These processes consume the dissolved oxygen in water (a process called eutrophication), leading to low-oxygen zones in aquatic ecosystems and early death of aquatic life such as fish and plants (EPA 2025e; Goswami 2025a; MSU n.d.; NOS 2024).

Nitrogen loss is particularly high in the US Corn Belt (Ribaudo 2014). Research has shown that in the corn–soybean rotation systems dominant in the Midwest, in which monocultures and simple two-crop rotations prevail, annual loss of nitrogen as nitrate is particularly high and can vary within a wide range; this variation is contingent on soil type and cultivation conditions (Shrestha, Mararik, and Kucharik 2023; Hussain et al. 2020; Hussain et al. 2019; Syswerda et al. 2012; Strock, Porter, and Russelle 2004; Power, Wiese, and Flowerday 2001). There are both economic and environmental costs associated with this loss of nitrogen. Nationally, the cost of nitrogen loss from all sources in the early 2000s averaged about $210 billion per year (ranging between $81 and $441 billion per year) when considering potential resulting health and environmental damages; almost 75 percent of this cost was attributable directly to loss from agricultural sources (Sobota et al. 2015). In today's dollar equivalent, the annual average loss would be approximately $323 billion (BLS 2025).

Nitrogen runoff from Midwestern farms (carried down the Mississippi River) has an enormous pollution footprint and is directly responsible for the "dead zone" that appears in the Gulf of Mexico every summer (Boehm 2020). The dead zone is an area within the Gulf where waters contain little oxygen and no aquatic life can survive. In 2025, this dead zone measured 4,402 square miles, an area approximately the size of Connecticut (Rabalais, Glaspie, and Turner 2025; NOAA 2025; Osterman, Swarzenski, and Poore 2006). Previous Union of Concerned Scientists (UCS) analysis determined that nitrogen losses from agriculture cause as much as $2.4 billion in damage annually to fisheries and marine habitat in the Gulf of Mexico alone (Boehm 2020).

Groundwater contamination by leached nitrates is a widely reported problem in states such as Iowa and Wisconsin and results in contaminated drinking water (Volzer et al. 2025; Waldman 2025). Several states regularly report groundwater sources exceeding the EPA's 10 milligram per liter maximum contaminant level for nitrates (EPA 2025a). Studies have linked exposure to high levels of nitrates in drinking water with higher rates of various types of cancer, including colon cancer, bladder cancer, and ovarian cancer (Ammons et al. 2025; IEC 2024). In addition, infants fed formula prepared with nitrate-contaminated drinking water are at risk for a potentially fatal blood condition known as methemoglobinemia, or blue-baby syndrome (Essien et al. 2022; Ward et al. 2018), in which a lack of oxygen in the bloodstream can cause organ damage, as well as turning the skin blue (WDHS 2025).

Overcoming Dependency on the Fertilizer Industry

According to USDA data, in 2023, producers spent approximately $35.8 billion on fertilizer, which accounted for about 7.8 percent of overall farm expenditure (ERS 2025b; NASS 2024d).

The price of fertilizer has increased substantially and has fluctuated dramatically due to global geopolitical impacts on the nitrogen supply chain (Abay et al. 2025; Parum 2025).

Overapplication of fertilizers means producers spend more money on fertilizers upfront as an investment and then lose a portion of that investment to nitrogen loss. Research by Basso et al. (2019) showed that in 2017, producers in the Midwestern states experienced fertilizer losses of about $485 million (ranging between $350 and $920 million) on average. This estimate would likely be much higher today because both fertilizer costs and application quantity have increased since this research finding. A recent study has shown that between 1991 and 2021, optimum economic nitrogen fertilizer application rates at which a Corn Belt producer maximizes return and profit, not crop yield, have been steadily increasing by about 1.2 percent every year (Baum et al. 2025). In other words, they are having to apply more and more fertilizer in order to turn a profit.

Producers overapply fertilizer as an insurance policy to make sure their crops have enough when needed. Yield expectations embedded in current production and market systems pressure them to apply more fertilizer, and there are no penalties, besides higher costs, associated with overapplication (Woods 2025a; Ogburn 2010). Moreover, the costs associated with environmental and public health impacts are borne not by agribusiness corporations (such as those manufacturing and selling fertilizers), but rather by producers, communities, and taxpayers (UCS 2008).

The overapplication problem has also been aggravated by decades of farm consolidation. These agribusiness corporations, whose profits rise when more fertilizer is sold and when producers are dependent on high application rates, aggressively lobby to influence agriculture policy (Fakhri 2025; Goswami and Stillerman 2024). Most fertilizer application recommendations in the Midwest come from retailers who sell fertilizer, creating a system whereby recommended application rates are set by those who stand to profit, not by independent institutions that have no conflict of interest (Badzmierowski et al. 2025). Between 2020 and 2022, fertilizer prices skyrocketed and the cost of agricultural inputs in general increased for producers, reducing their profit margins.

During that same time period, the largest fertilizer manufacturers filled their coffers with billions (Dhumal 2025; Nutrien 2025; IATP 2022; Zahn 2023). According to an Institute for Agriculture and Trade Policy (IATP 2022) analysis, the combined profits (from all business lines that include fertilizer) of nine of the world's biggest fertilizer companies were just under $13 billion in 2020 and reached $49 billion in 2022 (IATP 2023). Agribusiness corporations have fed producers a carefully crafted narrative that more fertilizer equates to higher yield (Gillam 2023). A UCS analysis found that between 2019 and 2023, giant agribusiness companies and industry associations spent more than half a billion dollars lobbying to keep an open door policy with Congress in order to influence legislation such as the farm bill, which touches on all aspects of the food and farming system (Goswami and Stillerman 2024). Organizations like the American Farm Bureau Federation, National Corn Growers Association, and agrichemical industries claim to represent producer interests, but in reality they align with the giant agribusiness corporations that have collectively hijacked US food and farm policy (Hall 2024; Goswami and Stillerman 2024).

The most straightforward way to reduce nitrogen pollution and lower N_2O emissions is to reduce overapplication of nitrogen fertilizer. Lower but correctly timed fertilizer applications will decrease environmental loss without decreasing agricultural productivity (MOFCB 2021). This can be achieved through practices such as applying fertilizer only where and when crops need it and avoiding practices such as blanket field applications several months before plants can use it (Coppess, Ruppert, and Skidmore 2024; Adika 2024; Wade and Claassen 2016). Scientifically proven practices such as timing fertilizer applications to spring, using precise soil testing measures to determine application placement, and carefully managing irrigation (because wet soils increase N_2O emissions) are all proven ways to reduce fertilizer overapplication (Badzmierowski 2025; Hassan et al. 2022; Millar, Doll, and Robertson 2014).

Annual cropping systems that include practices such as excessive tillage and uncovered fields lead to soil degradation, compaction, erosion, and runoff (Basche 2017). To reduce overall fertilizer need and application, the focus should be on moving away from the harmful two-crop (corn and soy) rotation systems, which do little for the soil and leave it hardened and depleted of essential nutrients. Expanding agroecological practices has proven to bring tangible benefits to soil health and to producers. Practices such as expanded crop rotations and diverse rotation systems have been shown to improve soil structure, increase soil organic matter, lower soil erosion, and reduce nitrogen loss, allowing producers to reduce fertilizer dependence (Mulik 2017).

USDA Programs Can Reduce Fertilizer Overuse, but They Need Funding

On-farm nutrient management involving interventions such as controlled application of nitrogen fertilizers has been shown to improve nitrogen efficiency and reduce nitrogen's detrimental impact on the environment (Ali et al. 2025). Several conservation-focused practices, such as no-till and cover crops, could also reduce fertilizer use on farms and build soil health (Srivastava et al. 2024; NRCS 2025). However, we need robust policy instruments to ensure producers have the right financial and technical incentives to adopt and implement practices that improve nitrogen management on farms.

Voluntary USDA conservation programs such as the Environmental Quality Incentives Program (EQIP) and Conservation Stewardship Program (CSP) provide financial and technical assistance to producers to implement conservation practices such as cover crops, buffer strips, restored wetlands, and managed grazing, which all help keep nutrients in place and build long-term soil health. These programs are backed by decades of scientific evidence and producer experience and allow producers to implement practices that have measurable environmental health benefits and that improve soil health, protect habitat, and safeguard water and air quality, while reducing the need for costly synthetic fertilizers (Stanley 2018).

Several of these programs also have high return on investment. For example, UCS research has found that for every dollar of taxpayer money invested in CSP, about $3.95 is returned in value (Stanley and DeLonge 2018). Practices supported by EQIP and CSP that can influence NUE include nutrient management (NRCS 2025). Research has linked conservation programs to the adoption of conservation practices, reduction in fertilizer use, and, consequently, positive impact on heat-trapping gases in the United States. For example, Reimer, Denny, and Stuart (2018) found that conservation programs incentivized risk-averse producers to experiment with nitrogen management practices. Kwon et al. (2021) found that optimizing fertilizer inputs through ensuring the right amount, right source, right placement, and right timing of plant nutrients and soil amendments applications, jointly referred to as 4R, played a major role in reducing both direct and indirect N_2O emissions.

Implementing a nutrient management plan involves the 4 Rs of nutrient stewardship (MSUE 2019; NRCS 2025). But while the fertilizer industry widely promotes 4R nutrient stewardship as the best management practice, it is only a baseline approach, and it is focused on optimizing chemical inputs rather than on transforming farming systems (TFI 2024). A more holistic alternative is agroecology, which prioritizes the integration of biodiversity, soil health, scientific practices, and producer knowledge (Carlile and Garnett 2021). The integration of agroecology principles offers a systemic approach to reducing reliance on synthetic inputs (Blesh and Schipanski 2024). Programs like EQIP and CSP could also incentivize agroecology practices.

Although evidence demonstrates positive outcomes, participation in voluntary conservation programs remains lower than needed to achieve sustainable agroecological outcomes, particularly from farms producing row crops (Du, Feng, and Arbuckle 2025). Enrollment in these programs is limited primarily because demand for financial assistance far exceeds available funding. In 2021, fewer than half of the producers who applied for EQIP and CSP received contracts. EQIP faced the highest rejection rate, with only 31 percent of applicants securing funding (Happ 2021). Current funding levels are already inadequate, and ongoing budgetary constraints, combined with disincentives erected by agribusiness activities, pose a risk of further investment reductions. These trends threaten the long-term viability of conservation efforts and underscore the need for sustained and increased funding commitments (Wang and Gammons 2025; Robinson 2012).

We have conducted a scenario analysis to explore the potential impact of increased USDA conservation funding on heat-trapping emissions and whether this funding leads to associated economic effects.

A Scenario Analysis Shows Potential Benefits of Increased USDA Funding

This section presents an illustrative estimate of the potential economic and environmental effects of increasing support for producers in developing and implementing a nutrient management plan under NRCS's Nutrient Management (Ac.) (590) Conservation Practice Standard (hereafter, "Practice 590") through CSP and EQIP. We do this by using an input–output model to estimate how changes in federal support for Practice 590 plans might translate into short-term effects on household earnings, value added, grain and oilseed industry output, and potential reductions in heat-trapping gas emissions in Illinois, Iowa, and Minnesota.

Practice 590 is part of the NRCS's voluntary conservation programs that provide cost-sharing and technical assistance for producers to develop nutrient management plans (NRCS 2025). It is not a single on-farm practice; it includes producer support for developing a nutrient management plan tailored to each producer's fields, focused primarily on nitrogen and phosphorus from fertilizer and manure, and for implementing plan-specific practices. It supports farm producers in managing the sources of manure and fertilizer and then the amount, placement, and timing of their application; help with managing other soil amendments is also provided. Practice 590 emphasizes soil testing and dividing fields into management units by soil type so that operators can apply nutrients more precisely based on each unit's nutrient needs (NRCS 2023). This practice aims to optimize NUE, thereby protecting natural resources while optimizing farm profitability (Zhang, Li, and Bovay 2025).

We estimated the impacts of various funding scenarios for Practice 590 on fertilizer usage and the resulting economic implications using the IMPLAN economic model (see Appendix B for detailed methods). In Illinois, Iowa, and Minnesota, Practice 590 was funded by both EQIP and CSP in 2023. We chose Practice 590 for this scenario analysis for a few reasons. First, it is specifically designed to enhance fertilizer use efficiency while minimizing environmental impacts. Second, there are documented potential economic benefits for producers: producers who implement Practice 590 spend approximately $30 less per acre on fertilizer costs (NRCS 2025). Third, data is available to estimate the economic and environmental impact of funding and implementing this practice. We use Practice 590 as an illustrative example because it combines nutrient-management planning with a set of coordinated practices that improve fertilizer efficiency and reduce emissions. Although this analysis focuses on one NRCS standard, it represents only a small piece of what we need to achieve meaningful and lasting environmental benefits. In reality, achieving this goal would require a broader, more integrated approach—one that goes beyond individual practices and addresses whole-farm management and, ultimately, also leads to larger systemic changes in how agricultural landscapes are designed and supported.

Potential Economic Impacts

Our scenario experiment suggests that conservation programs like EQIP and CSP, that fund Practice 590, have the potential to positively affect the economy, measured by labor income, value added, local and federal taxes, and industry output. Value added is defined as the difference between an industry's or establishment's total output and the cost of its intermediate inputs; it is a measure of the contribution to Gross Domestic Product (GDP). Industry output is defined as the total value of goods and services produced by an industry.

The scenario experiment found that the magnitude of economic impacts varied by state depending on the level of funding and how many acres received Practice 590 implementation. Economic returns are higher in states that tie higher financial assistance to Practice 590 adoption, as seen in Minnesota, where the impacts far exceed those in states with lower Practice 590 funding and fewer acres receiving implementation (Table 3; NRCS 2025). Spending $3.07 million implementing Practice 590 in Minnesota in 2023 generated $8.57 million of labor income and added $11.42 million of value to Minnesota's GDP. Tax revenue generated through producers implementing Practice 590 totaled $2.23 million for federal, state, and local governments. The resulting added Industry output produced by grain and oilseed farming was $11.56 million. Similarly, Illinois and Iowa showed promising potential for positive economic impacts from the adoption of Practice 590. These results are consistent with the findings of De Laporte et al. (2021), who established that the adoption of nitrogen management strategies such as 4R has both financial and environmental benefits on corn farms in Canada.

Scaling the model to different funding levels (10 percent, 20 percent, and 50 percent of the 2023 financial assistance obligations) shows proportional changes (for both increase and decrease) in estimated impacts. That is, a 10 percent increase in 2023 funding for Practice 590 would result in a 10 percent increase in income, value added, industry output, and tax revenue, and the converse is true. This proportionality, which reflects IMPLAN's fixed-proportions assumptions, demonstrates that greater federal investment in Practice 590 through conservation programs like CSP and EQIP could potentially increase farm household incomes and positively affect local economies. Conversely, reducing this funding could have a detrimental effect on farm household income as producers spend more on fertilizer. Producers identified surging fertilizer costs as one of the primary factors influencing their operations and prompting the adoption of best management practices (Wang et al. 2023). Consequently, reducing funding for cost-sharing conservation programs may adversely affect producers' ability to adopt nutrient management strategies such as Practice 590 (Adhikari et al. 2023). While environmental concerns and financial incentives from these programs often encourage the adoption of conservation practices, barriers remain. High perceived risks of reduced yields and substantial upfront costs, particularly for socially disadvantaged producers, can discourage producers from participating in conservation practices, despite the potential long-term benefits (Christopher 2024).

Table 3. Estimated Economic Impacts of Funding Practice 590 at Different Funding Levels

State	Funding Scenario for Practice 590	Labor Income	Value Added (GDP)	Industry Output Impact (Grain and Oilseed Farming)	Tax Revenue (Federal, State, and Local)
	In Millions				
Illinois	2023 funding = $0.53	$3.01	$3.82	$4.89	$0.83
	10%	$0.30	$0.38	$0.49	$0.08
	20%	$0.60	$0.76	$0.98	$0.17
	50%	$1.51	$1.91	$2.45	$0.42
Iowa	2023 funding = $0.13	$3.90	$6.16	$12.68	$1.04
	10%	$0.39	$0.62	$1.27	$0.10
	20%	$0.78	$1.23	$2.54	$2.08
	50%	$1.95	$3.08	$6.34	$5.20
Minnesota	2023 funding = $3.07	$8.57	$11.43	$11.56	$2.24
	10%	$0.86	$1.14	$1.16	$0.22
	20%	$1.71	$2.29	$2.31	$0.45
	50%	$4.29	$5.71	$5.78	$1.11

This table shows the potential economic impacts of funding Practice 590 at varying levels across Illinois, Iowa, and Minnesota. Scaling conservation funding yields positive economic benefits in terms of labor income, GDP, industry output, and tax revenues. See Appendix B for details on methodology. Source: (IMPLAN 2023).

Climate Emissions Impacts

In addition to economic benefits, conservation programs like EQIP and CSP have the potential to deliver environmental benefits by reducing fertilizer use and its associated emissions of heat-trapping gases such as CO_2, methane (CH_4), and N_2O. For this scenario analysis, we used

IMPLAN's environmental data to explore how funding Practice 590 through federal conservation programs could potentially affect heat-trapping gas emissions in Illinois, Iowa, and Minnesota (see Appendix B for detailed methodology) (IMPLAN 2023).

Just as with economic impacts, emissions impacts of conservation programs like Practice 590 vary by state. For example, some states, like California, have leveraged USDA conservation incentive programs to specifically address nutrient losses and agricultural threats to water quality and quantity, as well as other environmental challenges such as heat-trapping gas emissions, indicating that some areas are using these programs to help reduce nitrogen losses (Lenhardt and Egoh 2023).

Our scenario experiment found that at 2023 funding levels, implementing Practice 590 showed the potential to decrease heat-trapping gas emissions in all three Corn Belt states (Table 4). Minnesota, in particular, exhibited the greatest potential reduction due to the extensive acreage where Practice 590 was applied and to higher funding levels. These results are consistent with the findings of Adusumilli, Dikitanan, and Wang (2020), who established that cost-sharing incentives such as EQIP and CSP positively influence producers' decisions to adopt nutrient management practices, and those of Zhang et al. (2015), who demonstrated that nutrient management practices have the potential to enhance nutrient efficiency and reduce environmental pollution.

Table 4. Estimated Changes in Emissions as a Result of Different Practice 590 Funding Levels

State	Funding Scenario for Practice 590*	Heat-Trapping Gases in CO_2e (kg)
	In Millions	
Illinois	2023 funding = $0.53	-1.20
	10%	-0.12
	20%	-0.24
	50%	-0.60
Iowa	2023 funding = $0.13	-0.04
	10%	-0.004
	20%	-0.008
	50%	-0.02
Minnesota	2023 funding = $3.07	-3.94
	10%	-0.39
	20%	-0.79
	50%	-1.97

This table shows the potential climate benefits of funding Practice 590. We show that even small increases in funding could significantly reduce heat-trapping gas emissions, with higher funding levels producing substantially greater climate benefits.
*Source: (IMPLAN 2023). *Data available from NRCS (2025) and rounded to the nearest dollar.*

When modeled under alternative funding scenarios, the reduction in heat-trapping gas emissions scales linearly with changes in funding (Table 4). For example, a 50 percent increase in funding yields an estimated 50 percent decrease in emissions of heat-trapping gases. Although this proportionality is consistent with IMPLAN's fixed-proportions production function, it is important to note that real-life emissions responses can be nonlinear and context dependent, as seen in N2O emission sensitivity to fertilizer application rates, timing, and field conditions (Borzouei et al. 2022).

Practice 590 requires meticulous management of the right rate, right time, right site, and improved balance in nutrient inputs, while factoring in soil and climatic conditions. This is essential because improving NUE often narrows the margin for error and, if these practices are mismanaged, they can reduce yields. Therefore, achieving environmental benefits without compromising crop yield requires a careful balance between nutrient management and keeping farming profitable (Andualem et al. 2024).

Key Insights and Policy Implications: Toward Systemic Solutions

Although our scenario experiment looked at just Practice 590, USDA programs like CSP and EQIP support hundreds of conservation practices. Many of these conservation practices are bundled together and funded by NRCS to scale up economic and environmental benefits (NRCS n.d.). While this analysis focuses on a single practice, it offers a glimpse of the enormous economic and environmental effects possible, thanks to CSP- and EQIP-supported conservation practices. Our scenario experiment looking at Practice 590 in just three states sheds light on increased conservation funding's potential to mitigate public health costs, environmental damage, and economic disruptions. In the Midwest alone, nitrogen-related environmental and health impacts are estimated at $32.23 billion annually (2025 dollars), nearly six times total producer profits. Implementing strategies such as reducing fertilizer application rates could lower these costs by $11.96 billion per year (2025 dollars) (Goodkind et al. 2023).

Our scenario experiment shows that federal dollars invested in conservation programs like EQIP and CSP have potential to translate into economic benefits for producers who implement Practice 590 and for rural economies by supporting local livelihoods and local businesses beyond farms. Conversely, underfunding nutrient management—which can lead to inadequate adoption of conservation practices—not only limits economic gains, including potential near-term revenue and other losses for producers, but also heightens producers' exposure to greater climate-related risks as continued fertilizer overapplication contributes to ongoing environmental degradation (CAFE n.d.; EDF 2021).

Programs like CSP and EQIP make it easier for producers to adopt conservation practices that reduce fertilizer use, enabling the US agriculture sector to reduce its reliance on excessive fertilizer inputs. Our analysis shows that the 11.62 MMT of fertilizer applied far exceeds US cropland needs, and that 3.4 to 5.8 MMT of fertilizer application occurs in excess. Not only does fertilizer overapplication pose additional economic burdens on producers, but also it contributes directly to the climate crisis by emitting heat-trapping gases. Our analysis shows that, assuming 50 to 70 percent use efficiency, fertilizer use is responsible for emitting 36 to 60 MMT of heat-trapping gases (in CO_2e) in the United States.

Although conservation practices are essential for reducing nitrogen pollution, and increasing funding to encourage adoption may appear an obvious solution, producers' reluctance to apply nutrient management plans often stems from a complex interplay of economic, behavioral, and structural factors. These include limited trust in university-recommended application rates, reliance on fertilizer dealers for rate decisions, viewing excess nitrogen as a form of yield insurance, the red tape involved in implementing Practice 590, and perceived financial risk (Davidson et al. 2016; Christopher 2024). These facts necessitate a shift from isolated interventions toward a systemic approach that integrates economic incentives, producers' operational contexts, and behavioral insights to ensure that conservation investments deliver measurable and cost-effective outcomes. Additionally, issues such as the fact that many producers rent the land they farm make them hesitant to invest in long-term soil health improvements that, for example, may not yield immediate or direct benefits within the span of their rental agreements (Bezner Kerr et al. 2022). Continuing to increase funding for conservation programs in the form of voluntary, piecemeal approaches risks perpetuating inefficiencies such that resources are spent without achieving meaningful environmental improvements at scale (Ngoc et al. 2025; Chiles et al. 2023).

Reducing Barriers to Equity

Accessing USDA conservation programs remains a challenge for small and other socially disadvantaged producers (Happ 2021). USDA's long history of discrimination against producers of color, especially Black producers, has meant that access to these funds has been skewed toward White producers running large operations. These producers tend to have better access to technical assistance that helps them apply for EQIP and CSP grants. Additionally, the recent removal of formerly public race-based and equity-focused data from USDA and other federal agency websites and a lack of detailed data at the state level present a significant challenge to gauging these programs' effectiveness for small and socially disadvantaged producers (Woods 2025b). Despite this challenge, research conducted prior to the removal of race-based data indicates that funding like the Inflation Reduction Act (IRA), which made historic investments in USDA's conservation programs, allows more producers, especially producers of color, to access financial assistance to implement on-farm conservation practices that improve soil health and build resilience (NSAC 2024; Stillerman 2023; Happ 2021).

Roadblocks to accessing USDA conservation program financial assistance that promotes on-farm land management practices have multiplied severalfold. The future of these programs, especially programs that bring tangible soil health and climate benefits, remains extremely uncertain with several USDA programs on the chopping block, including the IRA climate-focused funding (Bergen 2025; UCS 2024). In 2025, USDA has either frozen or cancelled programs and grants that allowed producers to implement these beneficial on-farm practices (Horn-Muller and Gilpen 2025). Coupled with this financial insecurity is the loss of technical knowledge resulting from the mass firing of USDA staff, in particular NRCS staff in field offices, who served as producers' first contact point (Schewe 2025). These programs and financial assistance opened doors to conservation programs for producers of color, who mainly run small and medium sized farms. Bigger farms, which already have more access to resources, are still largely controlled by wealthy and White owners and corporations, and these farms generally follow commodity crop monoculture practices that include fertilizer overapplication. These bigger farms still have a leg up and will continue to receive larger payouts, thereby perpetuating fertilizer waste and the resulting financial and environmental damages.

Policy Recommendations

Financial assistance for implementing practices that manage synthetic fertilizer use on farms (such as Practice 590) is funded through voluntary conservation programs, including CSP and EQIP, which are written into legislation like the Farm Bill—which is supposed to be passed approximately every 5 years, although the last Farm Bill was signed into law in 2018 and expired in 2023 and has now been extended twice; additional discretionary funding for conservation programs is appropriated annually by Congress. To ensure that producers have the financial and technical assistance needed to implement practices that promote soil health and build resilience while reducing reliance on synthetic fertilizers, lawmakers should support conservation programs and climate resilience in the next Food and Farm Bill, whose future currently remains uncertain. UCS recommends that the next Food and Farm Bill supports producers in implementing climate resilience initiatives by increasing funding for the following programs (Kamrath and Kaplan 2023):

- **Conservation Stewardship Program (CSP)**
  Since the last Farm Bill was signed into law in 2018, there has been a dramatic increase in producer applications to CSP, but the program remains chronically underfunded and oversubscribed. As a result, only about a quarter of producers who apply have received contracts (Happ 2021). UCS is advocating for the next Food and Farm Bill to provide at least $4 billion per year to CSP for new contracts that will allow more producers to implement these beneficial conservation practices.

- **Environmental Quality Incentives Program (EQIP)**
  UCS is advocating for the Food and Farm Bill to provide at least $2 billion per year for the EQIP program for new producer contracts. Furthermore, the bill should reduce financial barriers for producers and improve access to EQIP by providing the full 100 percent cost share for qualified producers to enhance EQIP's climate and environmental benefits.

- **Prioritize Soil Health and Resilience Practices in USDA Conservation Programming**
  In addition to increased funding for CSP and EQIP, these programs should prioritize practices that improve soil health, reduce emissions of heat-trapping gases, and focus on climate resilience.

- **Sustainable Agriculture Research Program (SARE)**
  The SARE program is a producer-driven agriculture research and education program that focuses on sustainable agriculture, upholding the principles of agroecology (SARE 2026). Funding producer-led programs is important to allowing producers to become stewards of their land, and we recommend the SARE program be reauthorized with mandatory funding of at least $100 million per year. Moreover, climate change mitigation and adaptation should be established as a new priority within SARE's mission.

Catalyzing a Meaningful Shift toward Agroecological Systems

Land and fertilizer management practices alone cannot catalyze the scale of change we need to see to lessen nitrogen loss from farms and subsequent impact on climate. Even with soil and land management practices, some nitrogen will always degrade into air and run off into water through processes such as leaching and denitrification. Diversifying farming systems by integrating livestock and adopting an agroecological approach, reducing total acreage of commodity crops (including continuous corn and soybean cultivation), and moving away from subsidies that encourage overproduction of commodities (including corn and soybeans) can reduce runoff from fields (Ansari et al. 2023; Blesh et al. 2023; Franzluebbers and Hendrickson 2024; Martínez-Mena et al. 2020; Peterson et al. 2020; Liebman and Schulte 2015).

The benefits of conservation programs like CSP and EQIP can be multifold when sustainable practices are bundled and financial assistance is expanded to allow more producers (and new producers) to participate. But it is also clear that we need to transition away from the current monopolistic model of agriculture that values corporate profits over people and the environment. We need to diversify farming operations by moving away from corn-and-soy monoculture and toward incentivizing best practices instead of maximum production of commodity crops (Fernandez-Bou et al. 2025). Adoption of farming practices that build soil health, replenish nutrients without harmful agrichemicals, help to clean water and air, protect soil biodiversity, and build resilience to extreme weather and other climate change impacts can increase economic and environmental bottom lines for producers (Kamrath and Lavender 2021).

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