APPENDICES

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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Appendix A

Fertilizer Use and Heat-Trapping Gas Emissions

The objective of this analysis is to estimate how much excess fertilizer is applied in the US agricultural system and to determine resulting emissions of heat-trapping gases. Two commodity crops, corn and soybeans, occupy the most planted acreage and hence were selected to be included in this research (Ribaudo et al. 2011). Corn is the most-grown crop in the United States and receives the highest share of fertilizers in the country, and soybeans are grown in rotation with corn (Glibert 2020).

All calculations and analyses were done in R (version 4.4.1), using the tidyverse and dplyr packages, MS Excel, and STATA (version 18.5). The R code, STATA code, and data files are available online at https://dataverse.harvard.edu/dataset.xhtml?persistentId=doi%3A10.7910%2FDVN%2FUGIVGN&showIngestSuccess=true&version=DRAFT

Data and Methodology

We obtained national fertilizer use data for all crops grown across the United States from the International Fertilizer Association database (IFA 2025). In 2023, 11.62 MMT of nitrogen fertilizer were applied on US agricultural cropland. Nitrogen fertilizer use accounted for about 58 percent of all fertilizer consumption in the United States, with phosphorus fertilizer accounting for 19 percent and potassium fertilizer accounting for the remaining 23 percent (IFA 2025). Nitrogen inputs to soil are also influenced by fertilizer formulations for other nutrients such as phosphorus, and this is especially true for soybeans, which have a higher demand for phosphorus. For example, phosphorus fertilizer formulations such as diammonium phosphate and monoammonium phosphate both contain nitrogen and when added increase reactive nitrogen in the soil (Kaiser and Pagliari 2018).

We extracted fertilizer use data for corn and soybean in Illinois, Iowa, and Minnesota from the USDA National Agricultural Statistics Service (NASS) Chemical Use Survey Program (2025), which collects data from producers regarding on-farm fertilizer applications and agrichemical use. Data pertaining to fertilizer applied across specific states for corn and soybeans were available for 2021 and 2023, respectively. This data was accessed using the query links available for corn and soybeans and is in Table A1 below. Units were converted from pounds (lbs) to metric tons using the conversion factor of 0.00045 for consistency across calculations and alignment with literature. This data was downloaded on August 11, 2025.

Exact conversions and calculations are available in the accompanying R code. To ensure consistency across reporting, simplification of formatting and ease of reading, total fertilizer use data in tables have been adjusted to the nearest 10,000, and emissions data has been adjusted to the nearest 1,000 where possible. We adjusted the results only in this report and not the input variables used in calculations.

Table A1. Quantity of Nitrogen Fertilizer Used on Corn and Soybeans in Our States of Focus and in the United States

States	N Fertilizer Used on Corn (Metric Tons)*	N Fertilizer Used on Soybean (Metric Tons)*	N Fertilizer Used (Metric Tons)#
Illinois	855,900	27,600	883,000
Iowa	757,200	23,500	781,000
Minnesota	540,200	25,600	566,000
National/US	N/A	N/A	11,620,000

**Adjusted to the nearest 100 to simplify formatting. #Adjusted to the nearest 10,000 to simplify formatting.*

Heat-Trapping Gas Emissions

Heat-trapping gas emissions of nitrous oxide (N_2O) and carbon dioxide (CO_2) from the application of nitrogen fertilizers in managed agricultural soils come from five different sources.

1. Direct N_2O emissions ($E_{directN_2O}$) from the application of fertilizers.
2. Indirect N_2O emissions resulting from the conversion of fertilizer into gaseous ammonia (E_{GASF}), which is deposited into soils and indirectly converted to N_2O.
3. Nitrate leaching (E_{LEACH}) resulting from fertilizer runoff, which ends up in surface water and is partially reconverted to N_2O leading to indirect N_2O emissions.
4. CO_2 emissions resulting from the decomposition of urea ($E_{decomposition}$), which is the most frequently applied nitrogen fertilizer (Roy et al. 2006).
5. CO_2 emissions from the application of limestone used to neutralize soil acidification ($E_{limestone}$) from nitrogen fertilizers.

We calculated the release of heat-trapping gases from these five sources following the method described in Gao and Serrenho (2023) and Intergovernmental Panel on Climate Change (IPCC) Chapter 11: N_2O Emissions from Managed Soils, and CO_2 Emissions from Lime and Urea Application (2019). In this report, we use the following equations to calculate the mass flow of nitrogen fertilizer and the resulting heat-trapping gas emissions in the United States and separately for Illinois, Iowa, and Minnesota. Direct emissions of N_2O are calculated based on fertilizer-specific emissions factors listed in Bouwman, Boumans, and Batjes (2002) and Gao and Serrenho (2023) (equation 1). Additional indirect emissions are estimated using the IPCC 2019 refinement to the 2006 IPCC greenhouse gas inventories, using the Tier 1 approach (equations 2– 5).

$$E_{directN_2O} = F_N \times EF_1 \times \frac{44}{28} \times 273 \quad (1)$$

$$E_{GASF} = F_N \times Frac_{GASF} \times EF_4 \times \frac{44}{28} \times 273 \quad (2)$$

$$E_{LEACH} = F_N \times Frac_{LEACH} \times EF_5 \times \frac{44}{28} \times 273 \quad (3)$$

$$E_{decomposition} = F_N \times EF_{decomposition} \quad (4)$$

$$E_{limestone} = F_N \times LT \times 0.12 \times \frac{44}{12} \quad (5)$$

$$\text{Total} = E_{directN_2O} + E_{GASF} + E_{LEACH} + E_{decomposition} + E_{limestone} \quad (6)$$

Table A2. The Description, Value, and Source of Equation Variables

Term*	Description	Fixed Value/Calculation	Source
F_N (Metric Ton)	Amount of applied nitrogen fertilizer	Calculated	IFA 2025; NASS 2025
EF_1 (Metric Ton N)$^{-1}$	N additions from mineral fertilizers, organic amendments and crop residues, and N mineralized from mineral soil as a result of loss of soil carbon	0.01	IPCC Chapter 11, Table 11.1
$Frac_{GASF}$ (Metric Ton N)$^{-1}$	Fraction of applied nitrogen fertilizer that degrades to form ammonia and NO_x	0.11	IPCC Chapter 11, Table 11.3
EF_4 (Metric Ton N)$^{-1}$	N volatilization and redeposition factor	0.01	
$Frac_{LEACH}$ (Metric Ton N)$^{-1}$	Fraction of applied nitrogen fertilizer that leaches as nitrate	0.24	
EF_5 (Metric Ton N)$^{-1}$	Leaching/runoff factor	0.011	
$EF_{decomposition}$ (t^{-1} N)	Conversion factor of embedded carbon in urea	1.57	Gao and Serrenho (2023)
LT (t^{-1} N)	Amount of limestone required to neutralize the soil per ton of applied nitrogen	6.5	
273	The 100-year global warming potential of N_2O		
44/28	Conversion factor for mass of nitrogen to N_2O		
44/12	Conversion factor of embedded carbon to CO_2		
0.12	Fraction of carbon from calcium carbonate ($CaCO_3$)		

**For consistency we are assuming all units in metric ton. Uncertainty range of each variable is available in the original data source.*

Table A3. Estimated Amount of Heat-Trapping Gases from Fertilizer Use (CO_2 Equivalent)

Region	In CO_2 Equivalent (Metric Ton)#					
	(1) Direct N_2O	(2) N_2O from Ammonia	(3) N_2O from Leaching	(4) CO_2 from Urea	(5) CO_2 from Limestone	(6) Total
Illinois*	3,790,000	417,000	1,001,000	1,387,000	2,527,000	9,121,000
Iowa*	3,349,000	368,000	884,000	1,226,000	2,233,000	8,061,000
Minnesota*	2,428,000	267,000	641,000	888,000	1,618,000	5,842,000
Total US	49,850,000	5,484,000	13,160,000	18,244,000	33,233,000	119,971,000

**For states, emissions calculations are based on fertilizer use on corn and soy. #Adjusted to the nearest 1,000 to simplify formatting.*

All tables have been adjusted to the nearest 1,000 for consistency. We found that direct N_2O emissions dominated the heat-trapping emissions from fertilizer use, accounting for nearly 40 percent of total N fertilizer-related emissions across the United States (Table A3). It is important to remember that N_2O is 273 times more potent than CO_2 in its heat-trapping capacity and hence has a much higher impact on global warming.

Nitrogen Use Efficiency (NUE)

As described previously, we assumed NUE equal to 50 to 70 percent; that is, we assumed 30 to 50 percent of applied fertilizer is unused by crops and is therefore excess. Using these 30 and 50 percent values, we estimated the amount of fertilizer overapplied nationally and separately for three Midwestern states. We used equations (1) through (6) to calculate emissions that could be attributed to the quantity of excess fertilizer in agricultural systems at the national and state levels (Table A4 and Table A5). While assuming NUE of 50 to 70 percent is a simplified approach to estimating fertilizer excess—in reality, NUE varies from crop to crop and is dependent on a wide range of factors such as climate—we believe that this estimate is supported by current literature as described previously (Kirk et al. 2024; Govindasamy et al. 2023; Ritchie 2021; Roy, Wagner, and Niles 2021; Zhang, Cao, and Lu 2021; Omara et al. 2019; Swaney et al. 2018).

Table A4. Estimated Amount of Heat-Trapping Gases from Excess Fertilizer Use, Assuming 50 Percent NUE

Region	In CO_2 Equivalent (Metric Ton)#					
	(1) Direct N_2O	(2) N_2O from Ammonia	(3) N_2O from Leaching	(4) CO_2 from Urea	(5) CO_2 from Limestone	(6) Total
Illinois*	1,895,000	208,000	500,000	694,000	1,263,000	4,561,000
Iowa*	1,675,000	184,000	442,000	613,000	1,116,000	4,030,000
Minnesota*	1,214,000	134,000	320,000	444,000	809,000	2,921,000
Total US	24,925,000	2,742,000	6,580,000	9,122,000	16,617,000	59,986,000

**For states, emissions calculations are based on fertilizer use on corn and soy. #Adjusted to the nearest 1,000 to simplify formatting.*

Table A5. Estimated Amount of Heat-Trapping Gases from Excess Fertilizer Use, Assuming 70 Percent NUE

Region	In CO_2 Equivalent (Metric Ton)#					
	(1) Direct N_2O	(2) N_2O from Ammonia	(3) N_2O from Leaching	(4) CO_2 from Urea	(5) CO_2 from Limestone	(6) Total
Illinois*	1,137,000	125,000	300,000	416,000	758,000	2,736,000
Iowa*	1,005,000	111,000	265,000	368,000	670,000	2,418,000
Minnesota*	728,000	80,000	192,000	267,000	486,000	1,753,000
Total US	14,955,000	1,645,000	3,948,000	5,473,000	9,970,000	35,991,000

**For states, emissions calculations are based on fertilizer use on corn and soy. #Adjusted to the nearest 1,000 to simplify formatting.*

Sensitivity Analysis

We undertook a sensitivity analysis to assess how uncertainties in the model input parameters may affect emission estimates. The input parameters we used in our primary analyses are based on global averages of limited datasets. However, real-life emissions vary according to soil type, area, location, and other factors (Borzouei et al. 2022).

To estimate a range of possible outcomes under different assumptions, we re-ran our models using low and high estimates of heat-trapping gas emissions from fertilizer use (Table A6). For both low and high scenarios, we used parameter values found in Table 11.3 of the IPCC 2019 refinement to the 2006 IPCC greenhouse gas inventories, Chapter 11. Low and high parameter values for $EF_{decomposition}$ and LT were not available, so we estimated these using +/- 20 percent.

Table A6. Low and High Estimates of Emissions Parameters

Term	Low-Estimated Parameters	High-Estimated Parameters
EF_1	0.002	0.018
$Frac_{GASF}$	0.03	0.3
EF_4	0.002	0.05
$Frac_{LEACH}$	0.1	0.8
EF_5	0.0005	0.025
$EF_{decomposition}$	1.256	1.884
LT	5.2	7.8

Table A7 shows the estimated amount of heat-trapping gases from fertilizer use using the low-estimated values for model parameters from Table A6. This low estimate is more than two times less than our estimate of 120 MMT (Table A3 vs. Table A7).

Table A7. Low Estimate of Heat-Trapping Gases from Fertilizer Use

Region	In CO_2 Equivalent (Metric Ton)#					
	Direct N_2O	N_2O from Ammonia	N_2O from Leaching	CO_2 from Urea	CO_2 from Limestone	Total
Illinois	759,000	23,000	19,000	1,110,000	2,022,000	5,842,000
Iowa	670,000	21,000	17,000	981,000	1,787,000	5,163,000
Minnesota	486,000	15,000	13,000	711,000	1,295,000	3,743,000
Total US	9,971,000	300,000	250,000	14,595,000	26,587,000	76,817,000

#Adjusted to the nearest 1,000 to simplify formatting.

Table A8 shows the estimated amount of heat-trapping gases from fertilizer use using the high-estimated values for model parameters from Table A6. This shows that the total US fertilizer-related emissions could be as high as 326 MMT of CO_2, almost three times higher than our estimate of 120 MMT (Table A3 vs. Table A8).

Table A8. High Estimate of Heat-Trapping Gases from Fertilizer Use

Region	In CO_2 Equivalent (Metric Ton)#					
	Direct N_2O	N_2O from Ammonia	N_2O from Leaching	CO_2 from Urea	CO_2 from Limestone	Total
Illinois	6,823,000	5,686,000	7,581,000	1,665,000	3,033,000	46,539,000
Iowa	6,029,000	5,024,000	6,699,000	1,471,000	2,680,000	41,125,000
Minnesota	4,370,000	3,642,000	4,856,000	1,067,000	1,943,000	29,809,000
Total US	89,731,000	74,760,000	99,701,000	21,890,000	39,881,000	612,080,000

#Adjusted to the nearest 1,000 to simplify formatting.

Limitations

Aggregated data for fertilizer use at the US level and for states were not available from the same source. The IFASTAT data is aggregated across all crops, whereas USDA NASS Chemical Use Survey reports data on a rotational basis (every few years) for certain row crops across certain states. We used aggregate fertilizer application data from IFASTAT and USDA NASS for corn and soy in our analysis. However, we are cognizant that fertilizer application is crop specific and is often dictated by individual producer behavior, with the rate of application and quantity of fertilizer used varying depending on the type of crop, underlying environmental conditions, moisture and irrigation, and environmental factors such as soil health.

Nitrous oxide emissions depend on complex interactions between soil microbes and plants and are influenced by factors such as soil type, climate, temperature, and moisture (Fuchs et al. 2019). Previous research has identified nonlinearity of N_2O fluxes from soils across different temporal and spatial scales (Butterbach-Bahl et al. 2013). Even though the IPCC emissions factor approach that we use in this study is a commonly applied and generally accepted tool to estimate N_2O emissions across national scale, it does not account for spatial and temporal variability such as variation in land management practices that may reduce N_2O emissions from agriculture, nor does it capture the impact of changing environmental conditions on N_2O emissions.

Our findings deviate from what EPA reports in the Inventory of US Greenhouse Gas Emissions and Sinks: 1990–2022 **(**EPA 2024**).** Our analysis estimated emissions using the IPCC 2019 refinement to the 2006 IPCC greenhouse gas inventories, using the IPCC Tier 1 approach. EPA uses a mixed-model approach, using a combination of IPCC Tier 1 and 3 approaches, along with application of a splicing method (EPA 2024). Furthermore, EPA uses the DayCent model to estimate direct emissions from crops grown in mineral soils and grasslands with country specific model parameters, which we are unable to access (EPA 2024). EPA's emissions estimates are not crop specific, whereas our analysis estimates emissions from fertilizer use on all crops for the United States, and specifically for corn and soybean in our states of focus. For the specific states, our analysis also excluded fertilizer use on grassland. In our analysis, we used global parameters (Table A5) as our input and included a sensitivity analysis (Tables A6–

A8) to understand the robustness of our emissions estimates, and to identify which parameters have the greatest influence on our results.

The purpose of this report is to offer a contribution in discussing the scientific consensus on the problem of fertilizer overapplication, and to use a simplified analytical approach in estimating the quantity of fertilizer overapplied in the US and associated emissions of heat-trapping gases. When discussing fertilizer and nutrient management, several complementary topics, such as yield, soil health, and underapplication of fertilizer, remain outside the scope of this report. We do not intend to be prescriptive with the solutions we offer here but rather pose them as an example of the multitude of ways in which the problem of overapplication can be addressed.

Appendix B
A Scenario Experiment of the Impact of Changing Funding for CSP and EQIP

The objective of this analysis is to estimate the potential economic and climate emission impacts of decreasing or increasing funding for the US Department of Agriculture's (USDA) federal voluntary conservation programs, such as Conservation Stewardship Program (CSP) and Environmental Quality Incentives Program (EQIP).

All analyses were done in IMPLAN using 2023 data, the most recent available at the time, and adjusted for inflation to reflect 2025 prices. IMPLAN is an input–output (I–O) modelling system that uses industry- and region-specific data on production, consumption, employment, and trade to model the ripple effects of a given economic activity—such as increased conservation spending—throughout the broader economy (IMPLAN 2023). At its core, IMPLAN is based on I–O tables that capture the flow of goods and services between industries, households, and government entities. The model uses fixed coefficients (not regressions) to trace how a direct change in demand leads to indirect and induced effects—such as supplier purchases and household spending. In this case, we are interested in how increased spending in conservation programs can generate ripple effects throughout the economy.

IMPLAN's environmental data can also shed light on the associated impacts on heat-trapping gas emissions. IMPLAN estimates environmental impacts—such as greenhouse gas emissions—by applying predetermined emissions factors to the economic activity it models. Specifically, for each industry, IMPLAN includes environmental coefficients that represent the amount of emissions (e.g., kilograms of CO_2-equivalent) produced per dollar of output. When spending is modeled—for example, government funding for conservation—IMPLAN multiplies the amount spent in each industry by that industry′s emissions factor to estimate total emissions.

These coefficients are developed from national data sources such as the Environmental Protection Agency, Department of Energy, United States Geological Survey, and USDA, and are fixed values that do not change with behavior, technology, or efficiency improvements. IMPLAN uses them to estimate emissions across direct, indirect, and induced economic effects, providing a static but consistent picture of how economic activity influences environmental outcomes.

Importantly, IMPLAN does not model actual emissions reductions from conservation practices (e.g., reduced fertilizer use or methane capture). To estimate the benefits of those changes, users would need to combine IMPLAN with biophysical models like COMET-Farm or apply custom adjustments to spending patterns or emissions factors.

Data and Methodology

We extracted data on Nutrient Management (Ac.) (590) Conservation Practice Standard financial assistance, as well as the acres on which it was implemented, from the Natural Resources Conservation Service Financial Assistance Program Practices Data and from the NRCS Selected Conservation Practices Applied by Land Use, Program, and Fiscal Year (USDA n.d.; NRCS NPAD 2023.). Funding for both CSP and EQIP programs was provided through allocations from the farm bill and the Inflation Reduction Act (IRA). Table B1 shows significant variation in both funding and implementation scale across states, with Minnesota leading in both metrics. Minnesota received far more NRCS funding for Practice 590 than Iowa and Illinois, although these three states receive roughly similar amounts of total CSP and EQIP funding. This difference reflects clear program priorities. Minnesota redirected millions towards best management practices, driven by groundwater nitrate concerns, strong state water-quality rules, and a large livestock sector that depends on manure-nutrient planning. Minnesota also used some of its IRA climate-smart funds to expand Practice 590 contracts.

Practice 590 is part of NRCS's voluntary conservation programs that provide cost-sharing funds to producers for them to develop and implement nutrient management plans. Cost-sharing programs work by reimbursing participants for a percentage of the cost of implementing a nutrient management plan. Cost sharing for Practice 590 can range between 10 and 90 percent of implementation expenses, depending on the state, practice scenario, and producer (Pereira 2024; Wonpiyabovorn and Plastina 2023). We assumed a cost-share payment rate of 50 percent as a simplifying assumption, a mid-bound of potential program support, which makes the total cost of implementing twice the value of financial assistance (Table B1). NRCS estimated that producers who adopt Practice 590 spend on average $29.28 less on fertilizer costs per acre (Knight and Pierce 2022). We used this estimate, along with the acreage of Practice 590 data from the USDA, to estimate the total fertilizer cost savings by state (Table B1).

Table B1. Funding, Acreage, Implementation Costs, and Cost Savings Associated with Nutrient Management Practice 590

State	Practice 590 Financial Assistance (2023)	Acres Implemented (2023)	Total Cost of Implementation	Total Fertilizer Cost Savings
Illinois	$525,756	48,063.69	$1,051,512	$1,407,304.84
Iowa	$128,648	44,968.81	$257,316	$1,316,686.76
Minnesota	$3,073,143	144,554.19	$6,146,286	$4,232,546.68

Sources: USDA n.d.; NRCS NPAD 2023.

Practice 590 can be implemented in six different ways, depending on farm size, nutrient sources, and management needs (NRCS 2023a; NRCS 2023b; NRCS 2023c). For this analysis, we modeled the most basic NRCS option—Scenario 1—which applies to cropland parcels larger than 40 acres and assumes no manure is used. We chose this scenario because the average farm size in Illinois, Iowa, and Minnesota exceeds 40 acres (Katchova et al. 2024). This simplification allowed us to focus the study on the direct effects of synthetic fertilizer, which constitutes the dominant source of potentially polluting nitrogen inputs to agricultural systems in Illinois, Minnesota, and Iowa, with numerous studies showing nitrogen from synthetic fertilizer far exceeds nitrogen from manure in these states (Jones et al. 2018; Bierman et al. 2012; David and Gentry 2000).

Table B2. Practice Scenario 1 Costs and Corresponding IMPLAN Industry Code

Cost Category	IMPLAN Industry Code
Equipment installation: Truck, pickup – equipment, and power unit costs. Labor is not included.	252 - Farm Equipment and Machinery manufacturing
General labor performed using basic tools, power tools, shovels, and other tools; e.g., pipe layer, herder, concrete placement, materials spreader, flagger, etc.	50 – Construction of new commercial structures, including farm structures
Specialist labor requiring specialized skills; e.g., agronomists, foresters, biologists, etc. to provide technical assistance	19 – Support activities for agriculture
Materials: Soil tests (includes materials, shipping, labor, and equipment costs)	450 – All other miscellaneous professional, scientific, and technical services
Fertilizer	159 - Nitrogenous fertilizer manufacturing

Sources: NRCS 2023a; NRCS 2023b; NRCS 2023c.

According to NRCS Practice Scenarios data for fiscal Year 2023, the average cost of implementing Scenario 1 Practice 590 per acre varies by state: $10.39 in Illinois, $9.42 in Iowa, and $10.08 in Minnesota (NRCS 2023a; NRCS 2023b; NRCS 2023c). We used the total cost of implementing Practice 590 in Table B1 as IMPLAN input. State-level practice scenario data disaggregates the cost of implementing Scenario 1 into four categories of expenses. We matched each cost category with the most relevant IMPLAN industry, using the North American Industry Classification System (NAICS) to determine how funding for Practice 590 through expenditure in each industry translates into economic benefits.

Table B3 outlines the percentage allocation for each cost category by state, based on NRCS's state Practice Scenarios (NRCS 2023a; NRCS 2023b; NRCS 2023c). We used these proportions to distribute the total Practice 590 funding across the four relevant industries. This allocation allowed us to estimate the spending patterns by industry, which IMPLAN then uses to calculate the resulting economic and environmental impacts resulting from implementing Practice 590.

Table B3. Cost Proportions for Scenario 1 in Percentage, By State

Category	Illinois	Iowa	Minnesota
Equipment	6.4%	6.7%	6.4%
General Labor	29.5%	27.8%	28.4%
Specialist labor	56.8%	57.2%	57.4%
Materials	7.4%	8.2%	7.7%

Sources: NRCS 2023a; NRCS 2023b; NRCS 2023c.

Following the NRCS Conservation Practice effects network diagram (NRCS 2014), we modeled reductions in fertilizer costs due to the implementation of Practice 590 as both a disinvestment in the nitrogen fertilizer manufacturing industry (NAICS 159) and as proprietary income for grain producers (NAICS 2) due to reduced fertilizer applications. Since this is a cost-sharing arrangement, we accounted for the producers' contribution by subtracting half of the total implementation cost from the total fertilizer savings. The resulting net fertilizer savings were considered as retained income for producers. We allocated this income to grain producers, which includes corn producers, because corn prices significantly influence N application rate decisions (Monaco, Paulson, and Schnitkey 2025). We also assumed that corn is typically grown in rotation with soybeans, which is a common practice in the Midwest (Quinn 2025; Hussain et al. 2019).

To assess the impact of various funding levels, we created scenarios representing three tiers of change: 10 percent, 20 percent, and 50 percent increases or decreases in funding.

Our results suggest that investments in Practice 590 have the potential to generate economic and environmental impacts (Tables B3 and B4). The results reported in Table 3 aggregate the direct, indirect, and induced effects of Practice 590 implementation at the state level across different funding scenarios. Direct effects include spending that comes directly from implementing Practice 590, as shown in Table B2. Indirect effects include the spending by suppliers who provide services and products to the four industries in Table B2, for example, what the equipment manufacturer spends. Induced effects reflect the household spending of employees working in both the directly affected industries and their suppliers.

Limitations

We assumed a cost share of 50 percent for all three states, although in reality EQIP and CSP cost shares vary between 10 percent and 75 percent by state, practice, and producer eligibility, with historically underserved producers receiving up to 90 percent (Benami et al. 2024).

IMPLAN is a static I–O model that estimates economic and environmental impacts by tracing how interindustry and household expenditures flow through the economy. It assumes constant returns to scale and no substitution effects and thus fails to capture the nonlinear patterns of adoption rates and environmental outcomes. In the real world, N2O emissions are nonlinear; therefore, the IMPLAN results possibly underestimate reductions in emissions with increases in funding (Borzouei et al. 2022). IMPLAN's fixed-proportions I–O model assumes producers and institutions respond rationally to incentives, but in reality, behavior may not be rational and is often shaped by disparities, culture, and institutional inertia (Mayne 2023).

We assumed homogeneity of Practice 590 implementation Scenario 1, which may mask how adoption rates and costs vary across farms and states. This may fail to acknowledge several equity-relevant differences in Practice 590 adoption capacity, costs, and outcomes across states. Larger, well-capitalized farms have the resources to afford the planning, recordkeeping, and technology required for Practice 590 compliance, while historically underserved producers may face higher relative costs. This inequity could mean that an increase in funding for conservation programs may not translate to an increase in adoption of these programs among historically underserved producers who currently do not participate in NRCS programs at the same rate as other producers (Guynn, Player, and Burns 2024; Osmond et al. 2015).

This analysis focused solely on Practice 590, one of many practices funded through EQIP and CSP. As such, the results presented here demonstrate only a fraction of the potential economic and environmental benefits generated by federal funding for conservation programs. Moreover, while this investigation assessed only the impact of federal funding for conservation programs on heat-trapping gases, the overall environmental impact of funding these conservation programs includes benefits to soil health, air and water quality, and biodiversity (Liu, Yuan, and Koropeckyj-Cox 2021). Therefore, the results shown here are only a fraction of the anticipated benefits resulting from funding USDA conservation programs.

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