CLEARPATH

Conservation Innovation Grants: Putting American Farmers First through Fertilizer Innovation

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Executive Summary

The United States (U.S.) has long been a global leader in agricultural innovation. That leadership is built on sustained investment in public research and development (R&D) to improve seed genetics, farm management practices and fertilizer efficiency. Together, these opportunities drive higher yields, greater efficiency and stronger farm profitability. These investments have delivered substantial economic returns, with every federal dollar spent on agricultural innovation generating an estimated $20 for the U.S. economy.[1]

However, warning signs are emerging. U.S. agricultural productivity growth has slowed, and federal R&D investment levels now mirror those of the 1960s. Meanwhile, global competitors such as China and Brazil are accelerating their investments and outpacing the U.S. Without renewed federal leadership, particularly in fertilizer innovation, the U.S. risks falling further behind, when greater agriculture resilience, efficiency and productivity are urgently needed.

Fertilizer innovation represents a strategic opportunity to strengthen both farm economics and environmental performance. Fertilizer is one of the largest crop input costs for producers, and precision tools that improve nutrient management can reduce input expenses, stabilize yields and improve soil health. Emerging technologies, such as enhanced efficiency fertilizers and precision nutrient management systems, can significantly reduce nitrous oxide emissions while protecting farmers from volatile fertilizer prices. In doing so, these investments serve as both an emissions-reduction strategy and an economic growth lever, with the potential to add as much as $4.4 billion annually to U.S. farm receipts.[2]

The U.S. also leads the world in voluntary conservation programs. The recent expansion of the Environmental Quality Incentives Program (EQIP) under the One Big Beautiful Bill Act (OBBBA) creates a timely opportunity to channel fertilizer innovation through proven conservation infrastructure. Within EQIP, the Conservation Innovation Grant (CIG) program is a competitive, cost-sharing accelerator that funds pilots, field demonstrations and applied research to test and validate new technologies. By turning promising approaches into proven, scalable tools that can be incorporated into USDA conservation programs and standards, the CIG program bridges the gap between innovation and widespread adoption.

Programmatic reforms present a clear opportunity for the administration to reverse declining federal investment in innovations that strengthen U.S. agricultural competitiveness and reduce emissions, all while maintaining a strong focus on return on investment for taxpayers and agriculture producers alike.

Key Numbers-at-a-Glance

- $4.4 billion potential annual increase in U.S. farm receipts from adopting precision nutrient management techniques.
- As much as 49% of estimated reduction in nitrous oxide emissions from enhanced-efficiency fertilizers.
- 9 of 1,773 CIG program projects since 2004 that have directly focused on nitrous oxide, less than 0.5% of total awards.

Policy Recommendations

- Prioritize fertilizer innovations in the CIG program, especially enhanced-efficiency fertilizers and precision nutrient management tools that improve farm profitability.
- Modernize Technical Service Provider (TSP) services to increase timely access to nutrient management planning and support grower participation in conservation programs.
- Develop a “CIG-to-EQIP Scaling Pathway” so validated CIG program innovations can inform the EQIP grant selection processes to support technology adoption.
- Implement the SUSTAINS Act and Growing Climate Solutions Act to leverage the CIG program’s role as an incubator for innovative conservation financing solutions.
- Streamline national Conservation Practice Standards by intermittently updating guidance on innovations and establishing a faster national-to-state update process.

Introduction

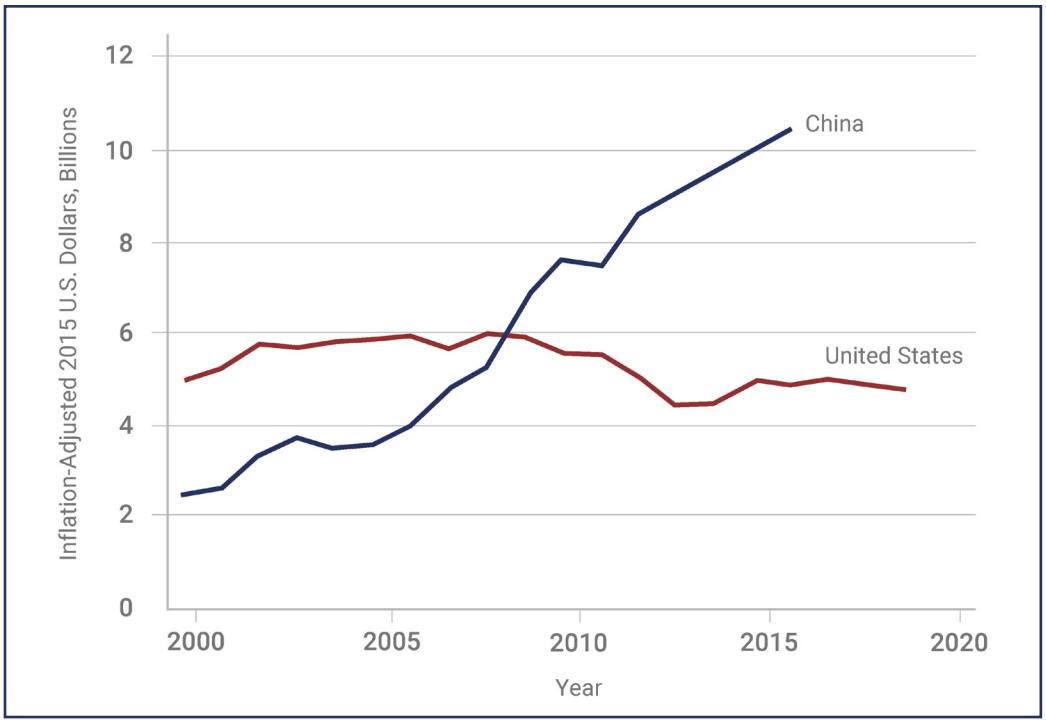
American innovation drives agricultural advancements

America is a historic global leader in agricultural innovation. Foundational advancements, from early mechanization to nitrogen-stabilized fertilizers like urea, anhydrous ammonia and modern pesticides and herbicides, have contributed to steady gains in efficiency and output.[3] These developments helped drive an annual productivity growth rate of 1.49%, much of it linked to sustained agricultural research and development (R&D).[4] Agricultural R&D remains the essential mechanism for moving technologies from concept to lab to on-farm application, where they translate into measurable improvements in productivity and competitiveness.

U.S. agricultural R&D investments are falling behind China

Spending on agricultural R&D contributed to 120% total multifactor productivity gains on American farms from 1950 to 1990.[5] This means that farms produced more than twice as much output with the same amount of inputs (including land, labor, and fertilizer) in 1990 than in 1950, after adjusting for inflation. However, after 1980, public investment declined and the American agriculture industry experienced total productivity growth of only 30% from 1990 to 2020. Meanwhile, China has rapidly increased its investment in agricultural innovation, eclipsing the U.S. funding levels in 2013 and expanding its farm output to nearly a quarter of the global total by 2016. See **Figure 1.**

Figure 1. The United States has been losing ground to China in public investment in agricultural R&D.



Source: adapted from USDA ERS

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The One Big Beautiful Bill Act creates a path for agricultural innovation: Investing over $6 billion in the Environmental Quality Incentives Program (EQIP)

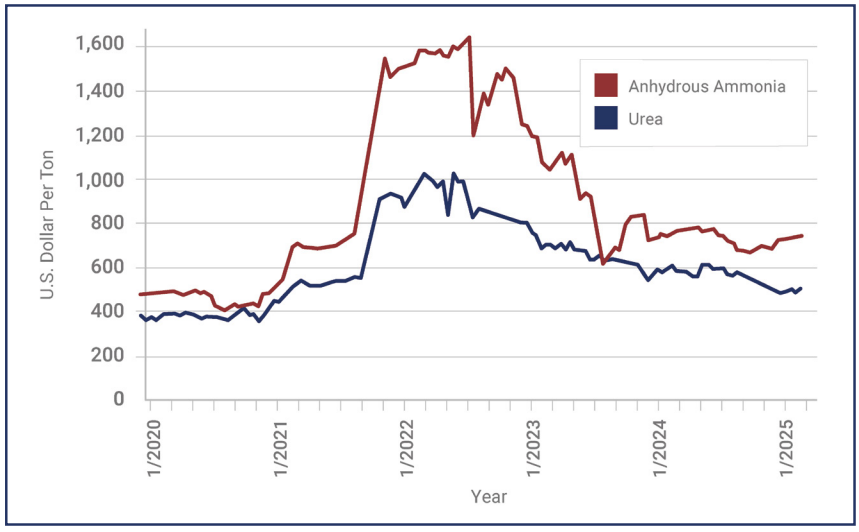
The conservation funding in the One Big Beautiful Bill Act (OBBBA) of 2025 marks an opportunity to reverse this decades-long trend of declining investment in agricultural R&D.[6] OBBBA reauthorized several voluntary conservation programs traditionally included in the Farm Bill, and increased their baseline funding levels for the next five fiscal years, FY26 to FY31, by $11.3 billion in total (see Appendix for detail). The Environmental Quality Incentives Program (EQIP) received the greatest portion of the investment, at $6.4 billion, which provides technical and financial assistance to agricultural producers and forest landowners to address natural resource concerns, including air and water quality, water conservation, soil health and longevity, improved wildlife habitat and drought mitigation.[7] EQIP is administered by the U.S. Department of Agriculture's Natural Resource Conservation Service (NRCS) state offices and, after the expansion under OBBBA, now has more than $18 billion in total budgetary resources to invest in on-farm conservation over the next five years.

EQIP's Conservation Innovation Grants (CIG) program is a promising agricultural innovation incubator for fertilizer innovation

In addition to EQIP's primary function of helping farmers, ranchers and foresters integrate conservation practices, it also supports agricultural R&D through the Conservation Innovation Grant (CIG) program. This program awards competitive grants that stimulate the development and adoption of innovative approaches and technologies for conservation on agricultural lands.[8] The CIG program was first authorized in the 2002 Farm Bill and has since invested $615 million across 1,773 projects in all 50 states.[9] The program has been reauthorized and expanded several times in subsequent legislation on a bipartisan basis.[10]

Though the CIG program funds a variety of projects, one area particularly impactful for farm profitability is innovative technologies for nutrient management. These technologies enable farmers to apply fertilizer efficiently, accurately measure its effectiveness at increasing crop yields and make informed decisions about fertilizer purchases and applications in future years. Fertilizer is often the largest single crop input cost for farmers, and volatile fertilizer prices can cut into farm profits. See **Figure 2.** Precision techniques to reduce fertilizer loss could add as much as $4.4 billion to yearly U.S. farm receipts.[11]

Figure 2. Volatile fertilizer prices can negatively impact farm profitability.



Source: adapted from USDA ERS

By educating farmers on precision techniques and providing on-farm trials of new application and measurement technologies, the CIG program allows farmers to optimize their fertilizer expenditures and improve profitability. Additionally, improving fertilizer efficiency also reduces nutrient runoff and nitrous oxide emissions, which ensures the fertilizer applied goes toward crop yield and is not lost to the environment.

The CIG program presents an opportunity to invest OBBBA conservation funding toward agricultural innovations that will support American farmers, lower emissions and counter China's growing dominance in agriculture. This report will be organized as follows. The first section will describe the nitrous oxide emissions challenge, the second section will describe the CIG program, the third section will show how it can reduce nitrous oxide emissions through precision nutrient management and the concluding section will discuss policy recommendations.

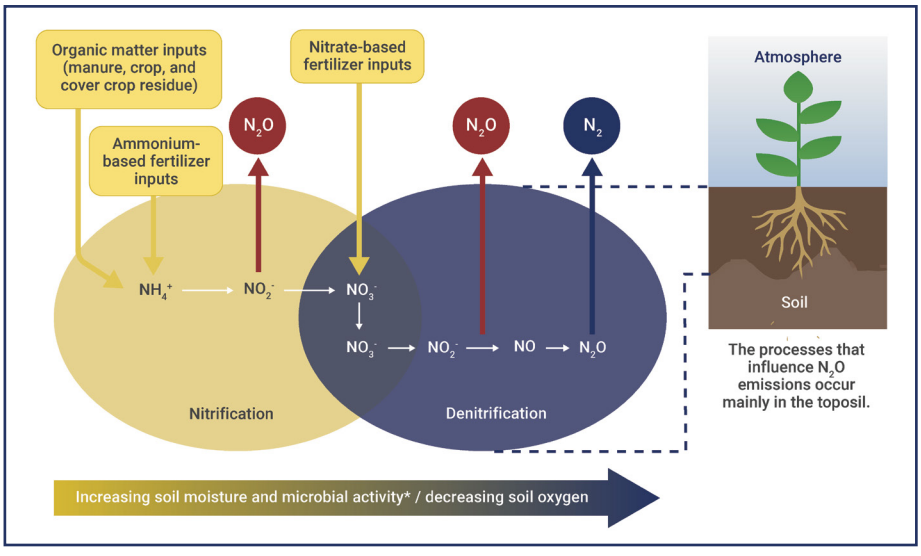
Managing Nitrous Oxide Emissions to Maximize both Farmer Profitability and Nutrient Use Efficiency

Nitrous oxide emissions are 265 times more effective at trapping heat than carbon dioxide, meaning even small concentrations of nitrous oxide have an outsized impact on the environment. In 2024, nitrous oxide accounted for 7% of all U.S. emissions, and its share is expected to increase over the next decade.[12] Agriculture generates an estimated 9% of U.S. emissions, and nitrous oxide represents an estimated 44% of the total agriculture-related emissions. The CIG program can help address this challenge by supporting R&D to help the adoption of innovations that reduce nitrous oxide emissions.

Agricultural nitrous oxide emissions come from excess nitrogen sources in soils

Generally, nitrous oxide emissions occur when excess nitrates from nitrogen fertilizer or other natural sources remain on waterlogged soils or farm fields. The primary cause of nitrous oxide emissions from crop fields is denitrification, a natural process, shown in **Figure 3**, that occurs when soils become saturated, making them anaerobic or oxygen-poor.[13] Anaerobic microbes then convert nitrate (NO_3) to nitrite (NO_2), nitric oxide (NO), nitrous oxide (N_2O) and finally dinitrogen gas (N_2). This process, which can occur when soils are saturated for 36 hours or more, is driven by factors including initial nitrate level, soil moisture, soil temperature, soil organic matter and soil pH. Management decisions that result in an excess of soil nitrate increase the risk of nitrous oxide emissions when conditions are favorable for denitrification (conditions with excess water).

Figure 3. Nitrous oxide emissions result from the nitrification or denitrification of fertilizer inputs.



Source: adapted from Verhoeven et al (2017)

Efficient on-farm management and new technologies can reduce nitrous oxide emissions

There are several ways to reduce nitrous oxide emissions by preventing nitrates from running off with rainwater and keeping them in the soil. The most effective strategy is to retain nitrogen in ammonium (NH_4^+) or other forms that are stable in soil when crops are not taking up large amounts of nitrogen (early crop stages). It is important to manage nitrate levels during the growing season so that they do not exceed crop needs. However, not all forms of nitrogen are available for crop uptake. Nitrate (NO_3^-) and ammonium (NH_4^+) are the two forms of nitrogen available for crop uptake, though crops take up the majority of their nitrogen requirement as nitrate. Therefore, growers must balance applying nitrogen sources that are available for crop uptake while simultaneously reducing the risk for nitrate loss.

In response to this challenge for growers, innovative fertilizer manufacturers have developed enhanced-efficiency fertilizers (EEFs) designed to optimize the timing of nitrate availability to crops. Growers can also use precision agriculture technologies, such as yield zone mapping and crop sensing, to support variable rate application and avoid over-application of inorganic fertilizer or manure.

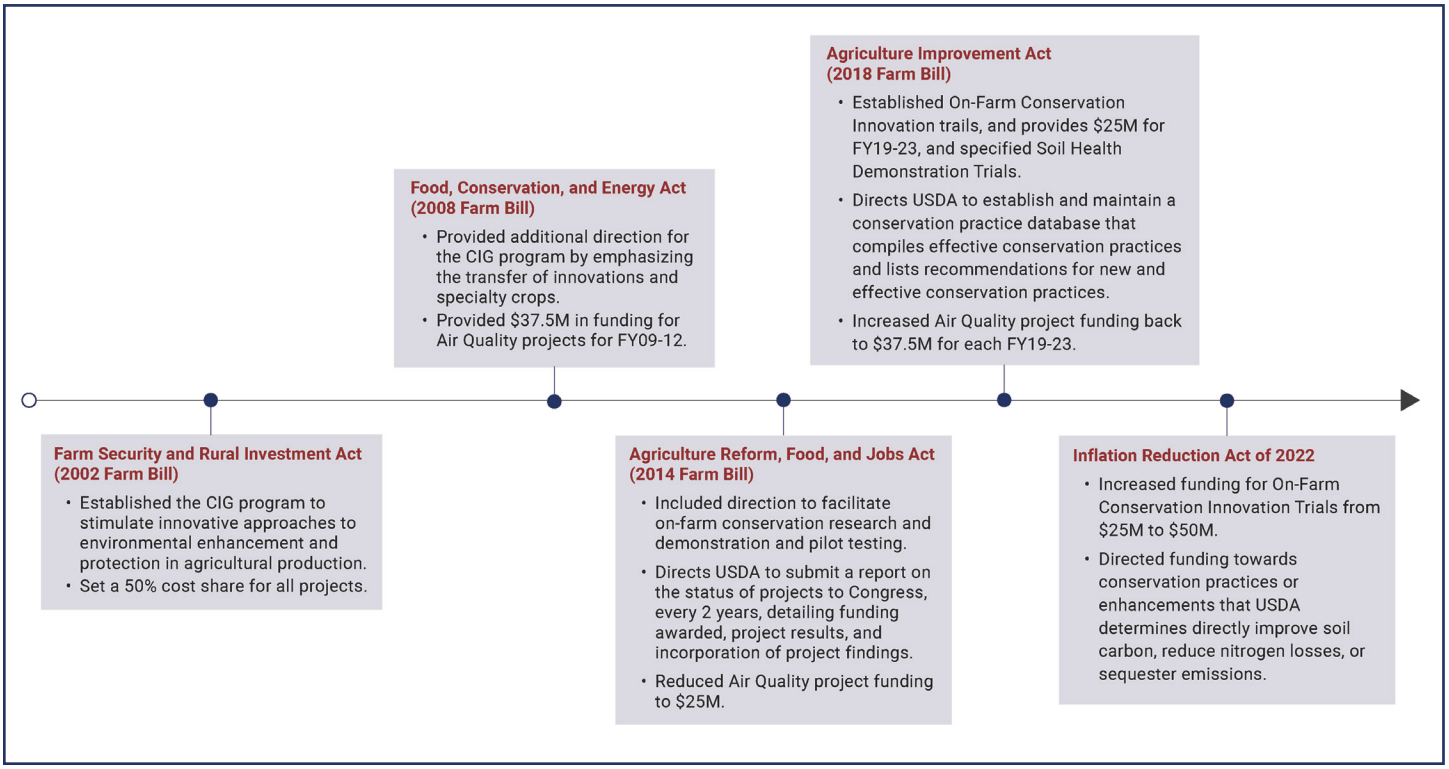
The U.S. Department of Energy's Advanced Research Projects Agency-Energy (ARPA-E) has supported several projects to enhance biological nitrogen fixation to improve cereal and ethanol production. Nitrogen fixation is the process of turning atmospheric nitrogen into ammonia, which can be absorbed by plants, thereby reducing the need for nitrogen fertilizer. The Technologies to Emend and Obviate Synthetic Nitrogen's Toll on Emissions (TEOSYNTE) project, which began in 2024, aims to lower nitrous oxide emissions from the cultivation of corn and sorghum used for U.S. ethanol production by 50% by focusing on plant and microbial bio-design strategies that improve the efficiency of synthetic nitrogen fertilizer on corn and sorghum fields, while maintaining crop yields.[14] Private U.S. manufacturers such as Corteva also produce precision nitrogen applications and nitrogen-fixing bacteria that may increase yields while reducing nitrous oxide emissions.[15]

Nitrous oxide emissions are driven largely by weather conditions and ultimately the water content of soils, but improving fertilizer management on-farm can help dramatically reduce losses. With the right tools, farmers can optimize nitrogen fertilizer delivery to the crop, reducing the risk of nitrous oxide loss and increasing crop uptake of vulnerable nitrates. Federally funded innovation can support new and innovative technologies and strategies to increase nitrogen use efficiency.

The Conservation Innovation Grants (CIG) Program: The USDA's Innovation Accelerator for Agriculture

The CIG program, launched in 2004, is administered by the NRCS to support innovations that enhance conservation on private lands by addressing nutrient management, soil health and water quality, among other conservation priorities, all of which improve agricultural operations and reduce emissions. See **Figure 4** for a brief legislative history, which illustrates continued bipartisan support for federal agricultural innovation through the CIG program.

Figure 4. Legislative history of Conservation Innovation Grants



The focus on innovation differentiates the CIG program from other NRCS programs. Innovation includes new technologies, incentive structures for conservation adoption, such as through market-based and conservation financing and the development or testing of new conservation technologies, practices and systems. The types of innovations that these grants support vary by year and depend on national priorities, which NRCS shares through funding announcements. The priorities for the CIG program from 2020 to 2023 are listed in **Table 1**.

Table 1. List of CIG Program Priorities from 2020 to 2023

CIG Program Priorities (2020-2023)	
2020 • Water Quality • Water Reuse • Wildlife • Air Quality • Energy Conservation	**2021** • Water Resources and Increased Resilience: Climate-Smart Strategies • Soil Health: Climate Mitigation, Adaptation, and Resilience • Nutrient Management • Grazing Lands Conservation • Increasing Conservation Adoption
2022 • Climate-Smart Agriculture: producer adaptation to extreme weather events • Climate-Smart Agriculture: building resilience through emerging production systems for climate-smart agriculture • Combating Invasive Species • Conservation in Urban Agriculture Systems	**2023** • Forestry • Habitat Conservation and Restoration for Wildlife and Invertebrates • Managing Agricultural Lands to Improve Local Water Quality • Energy Conservation • Economics • Strengthening Conservation through Indigenous Knowledge

Source: USDA

The CIG program has an opportunity to support more nitrous oxide emissions reduction with OBBBA investments.

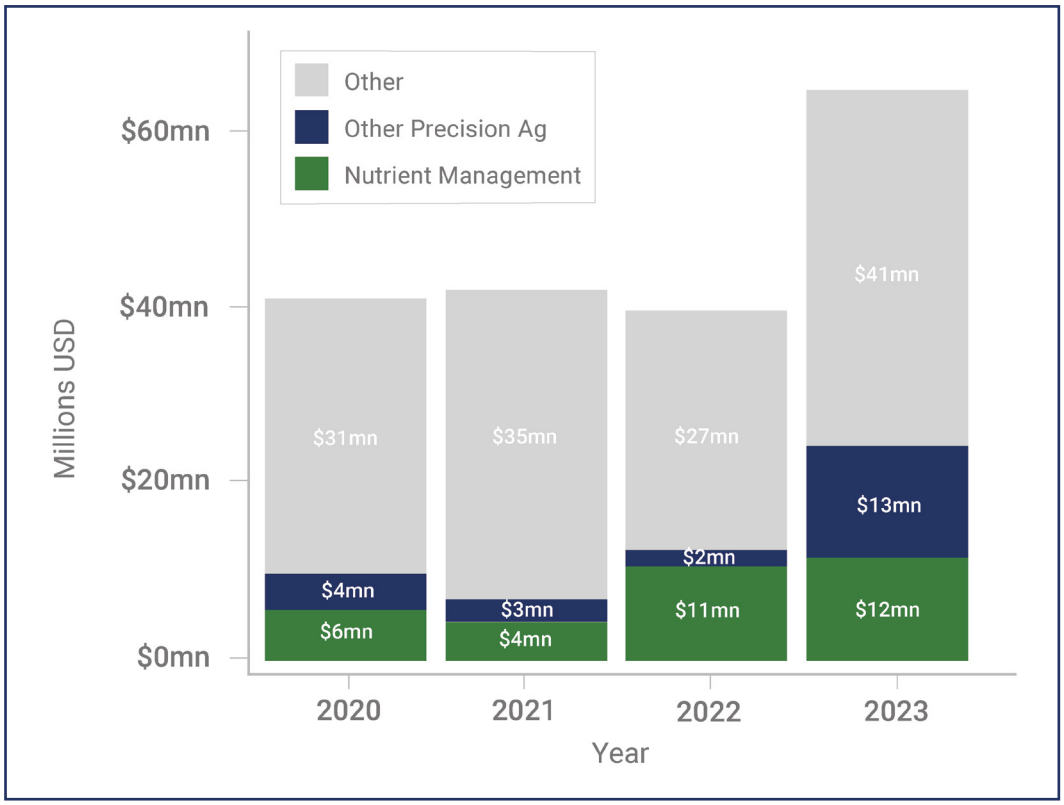
In 2023, nitrous oxide emissions from agricultural soil management, primarily through activities that increase nitrogen availability in the soil, such as fertilizer applications, accounted for 76.6% of U.S. nitrous oxide emissions and 49.8% of emissions from U.S. agriculture.[16]

Despite the central role of nitrogen in both farm economics and emissions, the CIG program has supported relatively few nitrous oxide-focused projects since 2004: nine projects, totaling around $9.2 million, making up less than 0.5 percent of the 1,773 projects funded. This disconnect between the number of CIG program-supported projects and the link between nitrous oxide and agriculture indicates an opportunity for the CIG program to leverage its successful structure to fill the innovation gap in nitrous oxide innovations.

Of these nine projects, six aimed to enable nutrient management, such as by optimizing nitrous oxide emission models and demonstrating efficacy to support the growth of voluntary environmental credit markets. Two of the projects focused on improving livestock manure practices and aimed to reduce nitrous oxide emissions. Though the CIG program has had a limited focus on nitrous oxide in particular, there has been increasing interest in broader nutrient management and precision agriculture topics. **Figure 5** illustrates how CIG program support for these areas has grown from $10 million in 2020 to $27 million in 2023.

New funds from OBBBA can capitalize on the existing expertise within the CIG program at USDA to demonstrate and deploy innovative nutrient management techniques that will benefit American farmers and reduce nitrous oxide emissions.

Figure 5. The CIG program has increased its focus on nutrient management and precision agriculture since 2020.

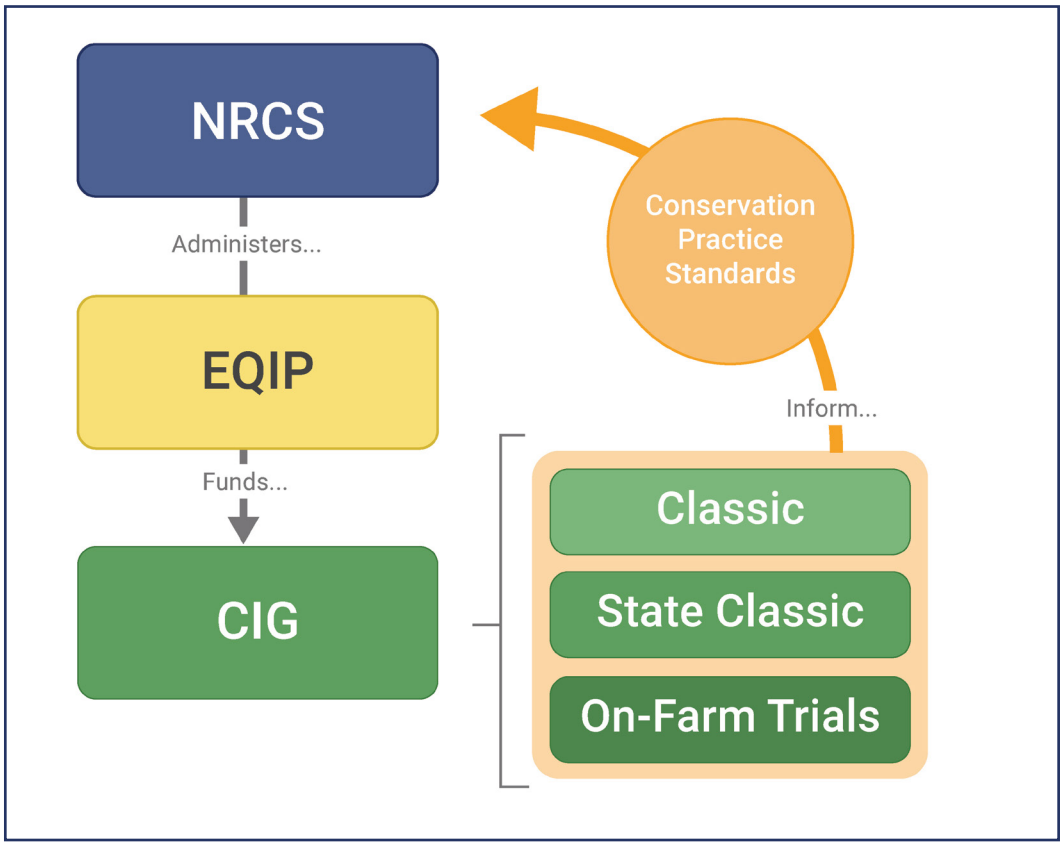


Source: NRCS

CIG Program Components

The CIG program supports agricultural innovations by funding pilot projects, field demonstrations and on-farm conservation research that address different resource challenges. It is a subprogram of the Environmental Quality Incentives Program (EQIP) and it is administered by the Natural Resource Conservation Service (NRCS), diagrammed in **Figure 6**. This is done through three distinct funding opportunities to support agricultural innovation, described in **Table 2**, which compares program components including CIG Classic, State CIG Classic and CIG On-Farm Conservation Innovation Trials (On-Farm Trials).[17]

Figure 6. The CIG program is a subprogram of EQIP, which is administered by the NRCS. The results of CIG-funded research inform NRCS activity through changes to the Conservation Practice Standards.



Source: NRCS

State CIG Classic shares the same goals and approaches as the national CIG Classic. However, NRCS State offices determine if they will administer and manage smaller-scale CIG program competitions, utilizing up to 5% of the state's EQIP allocation. Annually, 20-30 states administer their own CIG program competitions. The NRCS state offices will support projects that target state-identified conservation priorities.

Table 2. Comparison of CIG Program Components

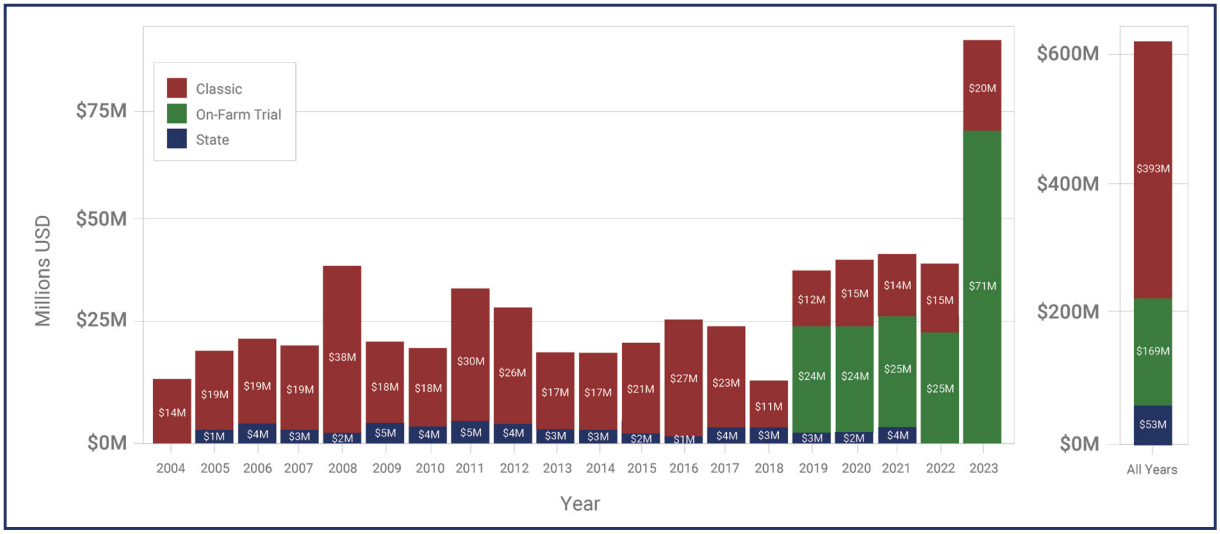
	Classic and State Classic*	On-Farm Trials
Goal	Transfer innovative conservation technologies, management systems, and approaches to EQIP-eligible producers in the form of technical manuals and guides and conservation practice standards, or to the private sector in the form of technical tools, new conservation approaches, or environmental markets.	Support widespread adoption of innovative approaches, practices and systems on working lands.
Program Start*	2004	2019
Awardees	Eligible individuals, nongovernmental organizations, private businesses, tribal organizations, and State and local governments.	Private entities with agriculture-related business, non-governmental organizations with experience working with agricultural producers, and non-Federal government agencies.
Awarded Funding	Up to 50% of total project cost	Up to 75% of total project cost
Length of Projects	Up to 3 years	Up to 5 years

* Figure 4. provides a legislative timeline for the CIG program.

Historical CIG Program Investments

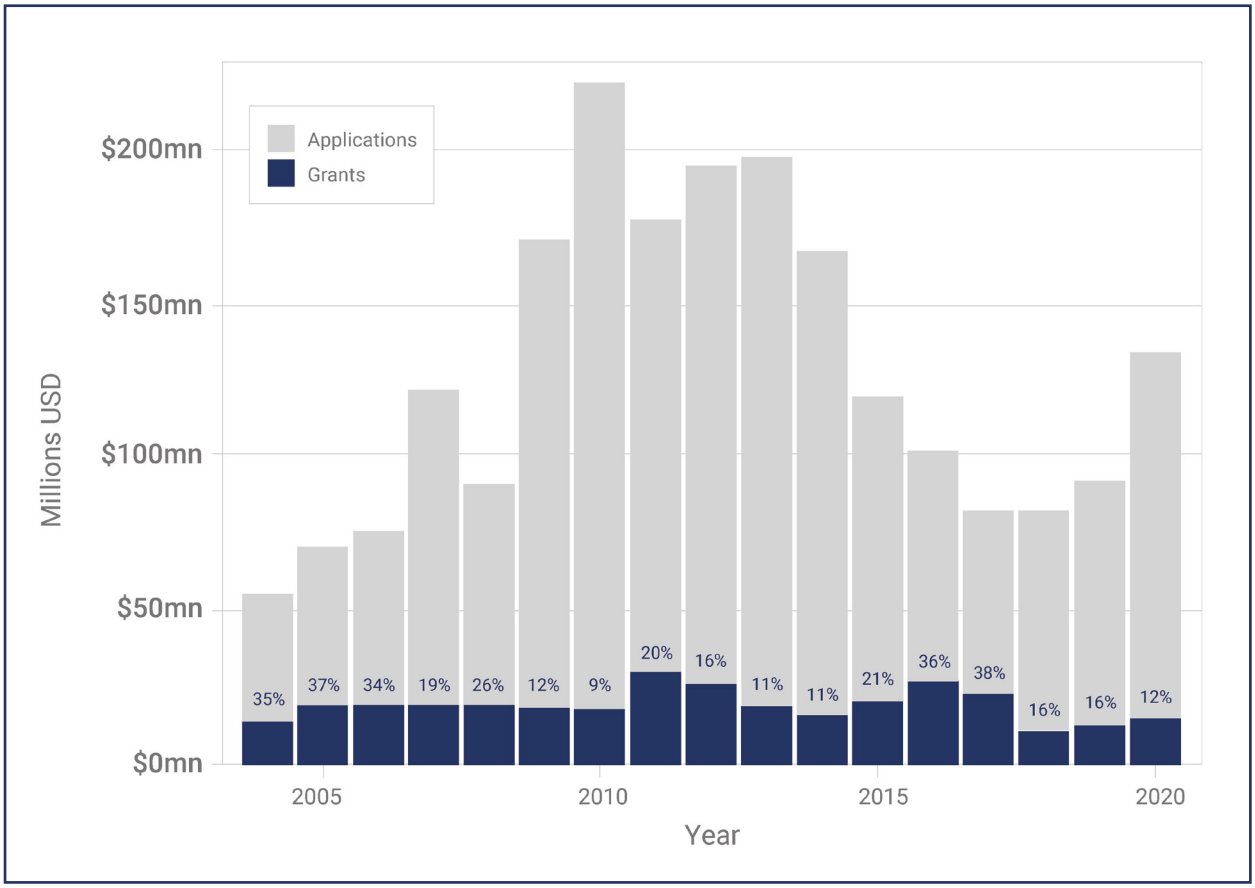
Since 2004, the CIG program has administered $615 million of grants.[18] Both Classic and On-Farm Trial awards are administered via a competitive bidding process, which encourages innovation and impactful federal spending. See **Figure 7**.

Figure 7. CIG program funding by program component, 2004-2023



A 2019 Congressional report collected data on the acceptance rate for Classic grants between 2004 and 2020, finding that the CIG program funded 778 grants out of a total 4,545 applications, or an acceptance rate of 17%.[19] This competitive process incentivizes applicants to make efficient use of federal funds and identify credible sources of private funding to meet the 50% private cost-share requirement. As a result, taxpayer dollars support projects that have been thoroughly vetted and have undergone a highly selective bidding process. See **Figure 8**.

Figure 8. Applications and accepted grants to CIG Classic, 2004-2020



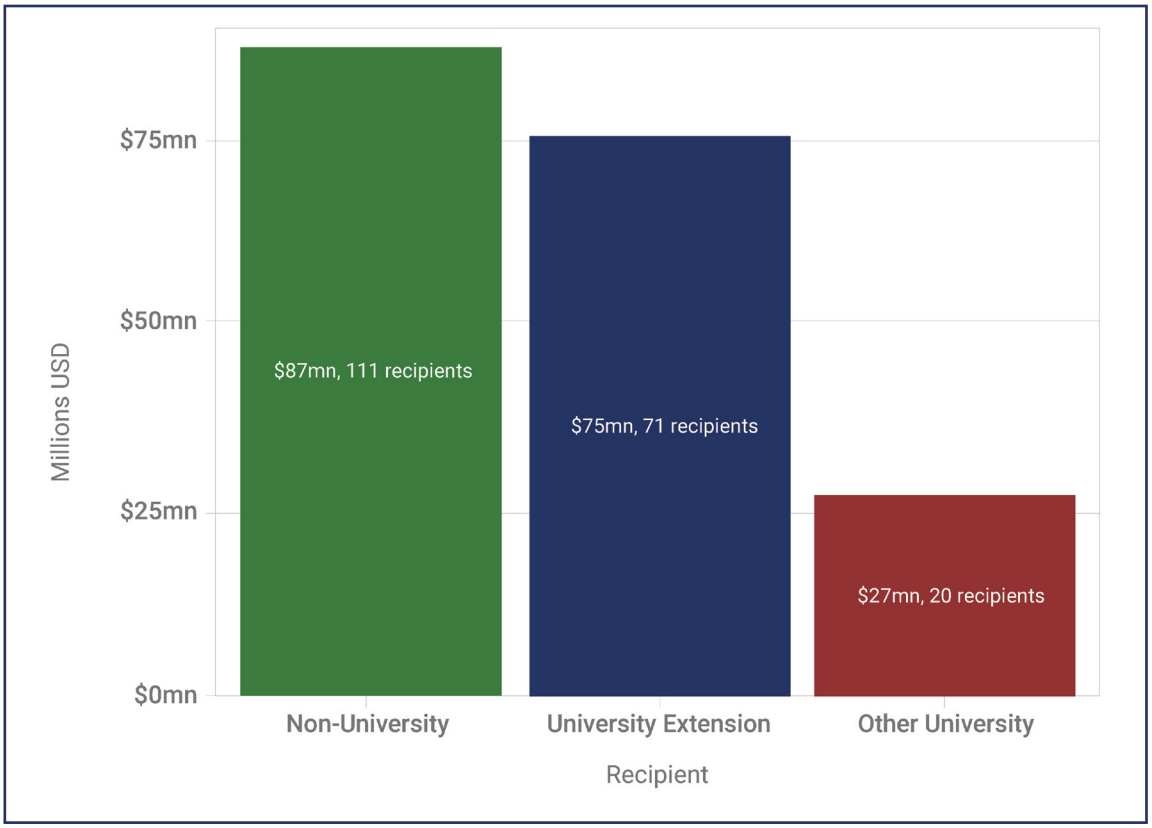
Program Recipients

Since 2020, universities have received a combined $106 million in CIG program dollars, meaning that they have provided at least a matching $106 million of their own support. Of that total, the majority – $79 million– went to university extension programs, trusted research institutions with long-standing relationships with farmers. See **Figure 9**.

CIG Program Nutrient Management Project: Improving the Economic and Ecological Sustainability of U.S. Crop Production through On-Farm Precision Experimentation

The University of Illinois received a grant in 2020 to partner with Washington State University's Extension Program and producers of cotton, corn, soy and wheat, as part of the University of Illinois's Data-Intensive Farm Management Project to conduct site-specific, data-based evaluation of the yield costs of reducing nitrogen losses. This grant aims to deploy a data-intensive crop management system using on-farm precision experiments.[20]

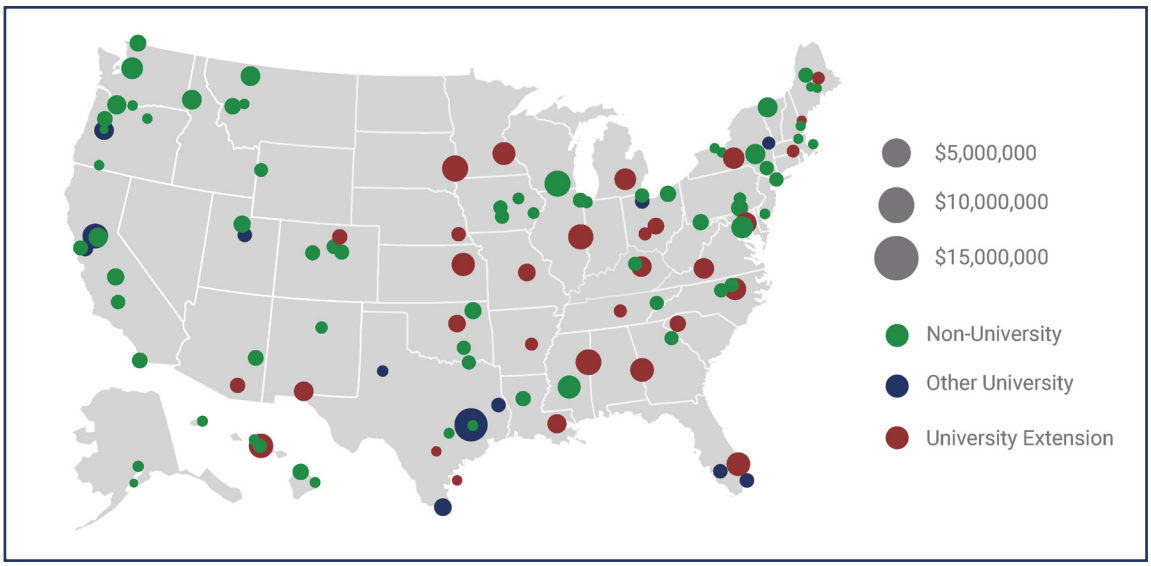
Figure 9. CIG program funding by recipient type, 2020-2023.



Source: NRCS

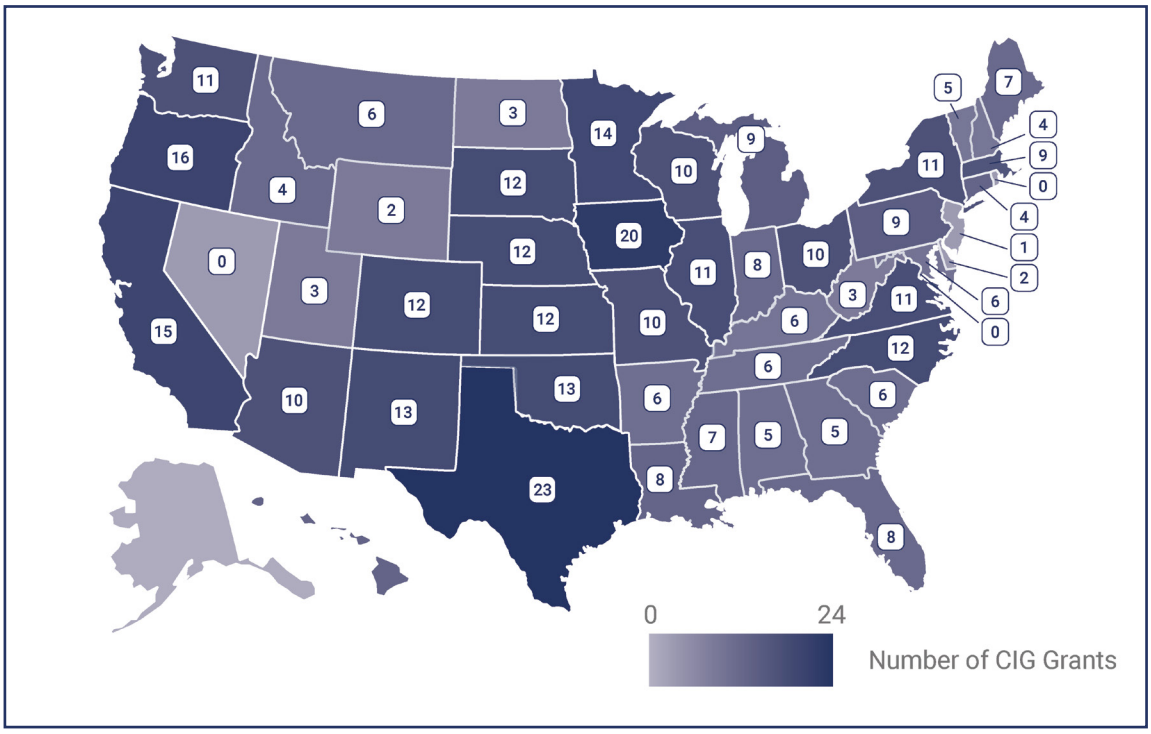
The CIG program has a wide geographic range, reaching institutional recipients in 48 states and farms in 49 states since 2020. Often, an award to an institution in a single state will involve on-farm research and demonstration across several states, ensuring that the educational and technological benefits of the award are dispersed across many recipients and that testing encompasses numerous environments. **Figure 10** shows the locations of all 148 institutions that have received CIG program grants since 2020. The size of the dots corresponds to the total amount of funding received by that institution across its awards. **Figure 11** shows how many CIG program grants have been performed on farms in each state. Texas, Iowa and California have received the most CIG program awards since 2020. Additionally, awards have been evenly distributed across every region of the country.

Figure 10. CIG program funding by recipient type, 2020-2023.



Source: NRCS

Figure 11. CIG program grants have been performed in every state except Nevada and Rhode Island since 2020.



Source: NRCS

Conservation Practice Standards

The CIG program is mandated to carry out projects that "ensure efficient and effective transfer of innovative technologies."[21] One outcome of the CIG program is for the supported innovations to be incorporated into NRCS science-based tools and guidance that influence conservation programs, including the Conservation Practice Standards. Conservation Practice Standards are created by NRCS at the national level and then adapted by states to reflect state-specific conditions and are often more specific than the national criteria.[22]

Private landowners and operators who voluntarily participate in NRCS conservation programs incorporate conservation practices that can improve soil, water, plants, air, wildlife habitat or related natural resources. The following two practice standards consider nitrous oxide emissions reduction: Nutrient Management Code 590 and Soil Carbon Amendment Code 336.

There are an additional seventeen practice standards that could include consideration of nitrous oxide emissions because of the relationship to nutrient management, nutrient cycling, soil health and water quantity, see **Table A2**. Incorporating new and innovative technologies that enhance existing conservation practice standards can be streamlined by seeking state-level recommendations to identify innovations and establishing interim conservation practice standards with stakeholder input. This helps ensure American farmers and ranchers have access to the most up-to-date information and innovations to voluntarily achieve their conservation goals and reduce nitrous oxide emissions.

The CIG Program: A Spotlight for Fertilizer Innovation to Reduce Nitrous Oxide Emissions

Farmers aim to improve their precision nutrient management to enhance profits and reduce environmental impacts. Despite best efforts, global nitrogen use efficiency is estimated to range between 10-60% for corn.[23] The CIG program can improve nitrogen use efficiency and reduce nitrous oxide emissions by helping farmers better utilize fertilizers on their farms. Innovations like enhanced-efficiency fertilizers (EEFs) can further optimize efficiency levels and have been shown to reduce nitrous oxide emissions.[24] Additionally, precision nutrient management techniques allow farmers to track their nutrient inputs and yield outputs of their operation in order to reduce input costs, improve profitability and increase long-term soil health, all while reducing emissions. This section provides an overview of EEFs, explains how farmers implement precision techniques, how these techniques improve farm outcomes and how the CIG program can overcome barriers to implementation by supporting trusted on-farm demonstrations and building evidence to support wider adoption.

Overview of Enhanced Efficiency Fertilizers (EEFs) and impact on reducing nitrous oxide emissions

EEFs are a classification of agricultural inputs that minimize nutrient losses by slowing nutrient availability to crops. This innovation is a solution for farmers who cannot constantly go into their fields to apply nitrogen to their crops when it is most needed, either because of labor or equipment constraints. However,

the greatest amount of nitrogen is needed during later crop growth stages (in particular during grain fill) rather than at initial stages, such as seedling development. Nitrogen applied at planting is often vulnerable to loss to the environment, as the young seedling can only absorb a limited amount of the nutrient. Timing N fertilizer availability with the crop's stage of greatest nitrogen need is an effective way to reduce environmental loss and maximize crop uptake. EEFs are primarily designed to optimize nitrogen release so it is synchronized with crop growth, ensuring crops can utilize this nutrient rather than losing nitrogen to the environment, such as through nitrous oxide losses. A 2022 meta-analysis found that technology-driven solutions like EEFs reduce nitrous oxide emissions by 22%–49%.[25]

The two main categories of nitrogen EEFs are 1) slow-release and controlled-release fertilizers and 2) inhibitors and stabilizers. Slow-release and controlled-release fertilizers are fertilizer coatings that slow the release and delivery of nitrogen over time, which can reduce nitrogen loss from leaching, denitrification and volatilization. The timing of nitrogen release depends on the type of coating used and if it degrades through physical (exposure to water) or biochemical (microbial breakdown) processes. Slow-release fertilizers typically control nitrogen availability through microbial or chemical decomposition of the fertilizer coating, which is affected by moisture, temperature and microbial activity. Controlled-release fertilizers, such as polymer-coated urea (PCU), have a physical coating that takes up water and releases dissolved urea through diffusion, so the time of nitrogen release is more predictable.[26]

Inhibitors and stabilizers are fertilizer additives that temporarily suppress soil microbial communities from converting nitrogen into forms of nitrogen that can be lost to the environment. The two types of inhibitors are nitrification inhibitors and urease inhibitors. Research has shown that urease inhibitors reduced ammonia volatilization by 51% and nitrification inhibitors reduced nitrous oxide emissions by 49%.[27] Nitrification inhibitors slow the conversion of ammonium (NH_4^+) to nitrate (NO_3^-). It reduces denitrification and leaching losses between four and eight weeks. See **Figure 3**, the yellow circle. Urease inhibitors temporarily block the activity of the enzyme urease, a natural enzyme found in soil and plant residues, that is responsible for breaking down urea into ammonium through hydrolysis. Urease inhibitors are helpful in reducing ammonia volatilization for 7 to 14 days.

CIG Program Nutrient Management Project: Beyond Yield: A comprehensive evaluation of enhanced efficiency fertilizers for reducing nitrous oxide emissions and ammonia volatilization in corn systems

North Carolina State University was awarded a CIG program grant in 2022 to measure the efficacy of enhanced efficiency fertilizers (EEFs) containing urease and nitrification inhibitors, to mitigate nitrous oxide and ammonia emissions from nitrogen fertilization of corn fields. The findings will provide critical information on the impact of EEFs on soil health under the hot and humid conditions prevalent in the southeastern United States. The project will also utilize the collected data to refine a nitrous oxide emission model, enabling the creation of estimates for other field sites. This research will perform on-farm trials across six field sites in the primary corn-growing regions in North Carolina.[28]

Implementing Precision Nutrient Management with Innovative Technologies

In the face of volatile fertilizer prices, farmers can leverage precision nutrient management to ensure the optimal amount of fertilizer is used to maximize profitability. Precision nutrient management involves the measurement and optimized application of variable rates of nutrient sources to crops throughout a field, ensuring that farmers maximize crop yield and soil health while minimizing environmental impact.

A typical fertilizer strategy might involve a blanket application across all fields on a farm, with equal distribution regardless of changing conditions across fields. Precision techniques allow farmers to consider the impact of abiotic field conditions, including the field topography, physical and chemical properties and field hydrology, on their crop yields. For instance, field zones only a few meters apart may support a wide range of crop yields. Armed with detailed data taken from their fields, farmers can apply fertilizer in the precise amounts that will lead to the greatest increase in yields, while reducing the potential for nutrient loss. Soil type and quality may vary significantly within a field. Precision nutrient management allows farmers to measure the impact of differing soil types on their crop yields and apply fertilizer where it will be most effective. This precision application approach allows growers to apply nutrients only where there is a crop need and maximize nutrient use efficiency across fields. This, in turn, will decrease input costs and improve farm profitability.

CIG Program Nutrient Management Project: Fertilizer Recommendation Support Tool (FRST)

The FRST project is a nationwide initiative that aims to modernize fertilizer recommendations through an accessible decision support tool. This tool provides unbiased, science-based interpretations of soil testing nutrient values to inform crop fertilization. The tool aims to provide consistency in phosphorus and potassium fertilizer recommendations across state lines, to address variations from soil-testing laboratories across the U.S. that use different analytical methods, interpretations and approaches to fertilizer recommendations.[29] This project is a collaboration of over 100 soil science and agronomic professionals representing universities, USDA and the private sector.[30] FRST received a grant in 2023 to support ongoing development.

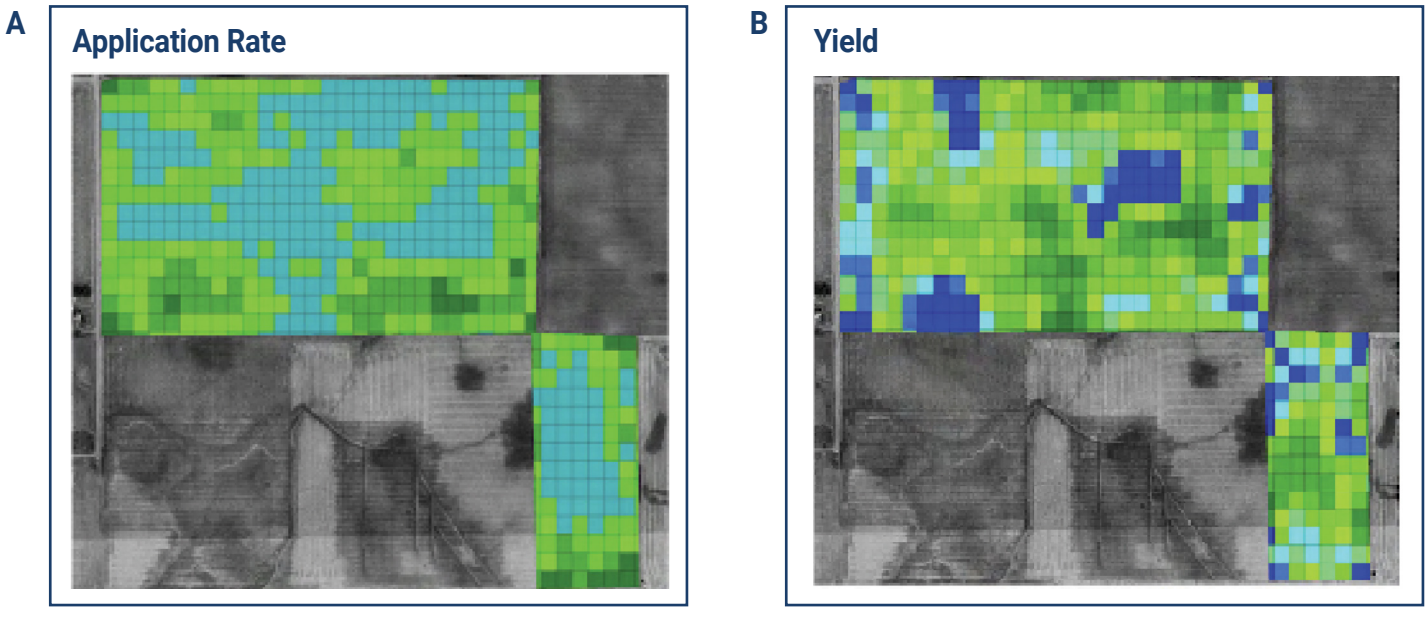
Farmers rely on a variety of innovative technologies to implement precision nutrient management:

1. **Yield Monitors** are used by growers to measure trends in yield stability, both spatially and temporally, allowing for the grower to modify management practices year-to-year to improve yields (e.g., delineate management zones based on crop productivity).
2. **Grid soil sampling** is used to evaluate changes in soil chemistry within a field and to devise nutrient management plans.
3. **Real Time Kinetics (RTK) and GPS Guidance** are GPS systems mounted in tractors and other field equipment to spatially track or guide (auto-drive) field applications, planting and harvest, which allows for spatial data creation that can then be offloaded as data layers for later evaluation.

4. **Precision Geographic Information System (GIS) Software** is used by growers and consultants to build variable rate maps (also known as prescriptions) to load on-board tractors for guidance of precision applications of nutrient, seeding rates etc.
5. **Electro-conductivity monitoring** can be used in conjunction with soil sampling to measure a wider range of soil characteristics, including soil texture, structure, organic matter, drainage, topsoil depth and soil water contents.
6. **Topographic (LiDAR) sensing** is a remote sensing technology that uses laser pulses (light detection and ranging) to measure distances and create 3D maps of land topography that growers can use to measure their field topography.
7. **Land-based optical sensing** is a method that uses cameras and surveying tools to measure vegetative changes that occur within a field.
8. **Multi-spectral satellite imagery or aerial photography** can portray field conditions at a high level of granularity. By compiling historical images taken at various times throughout the season, farmers can measure changes in soil color and vegetative growth.

Farmers can make informed decisions about where and when to apply fertilizer to improve crop yields and protect the farm's bottom line. For instance, the farmer who followed the nitrogen application strategy in **Figure 12** realized $26.64 per acre in savings thanks to reduced fertilizer input costs.[31] In aggregate, estimates suggest that savings from precision techniques to reduce nitrogen loss could total $4.4 billion in yearly U.S. farm receipts.[32] Rather than applying a blanket fertilizer treatment across all fields, they could target specific zones with high crop production potential where fertilizer would have an outsized positive impact on yields and revenues. **Figure 12A** is an example of a recommended fertilizer application strategy for a field and **Figure 12B** shows the resulting variation in yield.[33]

Figure 12. An example of a precision fertilizer application strategy (A) and the resulting yield pattern (B).



Note: (A) shows the recommended distribution of fertilizer on this field, with green areas receiving higher application and blue areas receiving lower application. (B) shows the resulting yield pattern, with green areas producing higher yield and blue areas producing lower yield.

Precision nutrient management also improves long-term ecological health and ensures that farms will maintain the soil fertility necessary to remain profitable for many decades. By taking detailed measurements of soil fertility, farmers can better understand how fertilizer application impacts nutrient distributions from one year to the next and avoid depleting soil health. It is important to note that managing soil nutrient levels is a key tenet for maintaining soil health, as soil nutrients serve as food for both plants (crops) and soil microorganisms.

Education and Demonstration of the 4 Rs: Right Source, Right Time, at the Right Rate and in the Right Place

CIG Program Nutrient Management Project: High Clearance Robotic Irrigation Impacts on Soybeans and Corn Yield and Nutrient Application

Iowa State University, the 360 Yield Center and the Ohio State University received a grant in 2022 for a collaborative project that improves nutrient efficiency and reduces nutrient loss through field demonstrations of a new and innovative high-clearance robotic irrigator (HCRI).[34] This ongoing project assesses the HCRI's ability to align nutrient application timing with row crop nutrient needs within the growing season. Tests consisted of in-season application of traditional and reduced nutrient application rates to understand the amount of nutrients needed to achieve the greatest yields. Additionally, data were also collected to verify nitrate-nitrogen nutrient leaching.

Education and demonstration are essential to encourage the adoption of precision nutrient management. Several extension programs have publicized the "4 Rs" approach to nutrient management: farmers should apply fertilizer only from the "right source," at the "right time," at the "right rate" and in the "right place."[35] This approach is a precision nutrient management approach that strongly encourages the adoption of precision nutrient strategies.

When surveyed about the 4Rs approach, farmers are generally supportive: 68% of Iowa row-crop farmers surveyed in 2022 reported that the 4Rs had some influence on their practice use decisions and as many as 69% had adopted nutrient accounting, the most common precision practice asked about in the survey.[36] A majority of farmers who implemented a 4Rs practice reported measurable increases in soil organic matter, crop yields and water holding capacity.

A 2018 national survey highlighted some of the barriers to adoption of precision nutrient management.[37] Any change to nutrient application involves risk and farmers often default to historical best practices rather than attempt untested application strategies. To adopt new innovations, farmers must be made aware of the associated risks and benefits and see demonstrable proof that the innovation will be effective. Of farmers surveyed, 58% said they take a "wait and see" approach to adopting new technologies, preferring to see proof-of-concept on a neighboring farm before applying the new technique themselves. The survey also found that other farmers, agronomists and fertilizer representatives were the most trusted sources of information about new fertilizer practices. This emphasizes the need to maximize and utilize the trusted relationships between farmers and their advisors.

The CIG program is well-suited to overcome these barriers to agricultural innovation. The data show that a majority of farmers are supportive of precision techniques so long as they are trustworthy. By funding on-farm demonstrations of new technologies, the CIG program can prove to farmers that new techniques are low-risk and beneficial to their bottom line.

CIG Program Nutrient Management Project: Perennial Groundcover: A Scalable Systems Approach to Achieving Soil & Water Conservation with High-Yield, Row Crop Production in Iowa

The Black Hawk Soil and Water Conservation District in Iowa received a five-year grant to work with Iowa State University, Corteva Agriscience and three other counties to gather, analyze and publish data from 10 field sites planting Kentucky Blue Grass as a perennial groundcover to replicate the preliminary field trials conducted by the Iowa Soybean Association, the Iowa Corn Growers Association and Corteva Agriscience.[38] The research is expected to highlight the benefits of using perennial groundcover compared to annual cover cropping, such as reduced management requirements and enhanced soil health, which reduces nitrate leaching, prevents soil erosion, increases water infiltration and enhances soil organic matter.

Conclusion

The Trump administration has a near-term opportunity to provide meaningful benefits to farmers by advancing American innovation, improving farm profitability and reducing emissions through Conservation Innovation Grants. By funding on-farm demonstrations of innovative precision nutrient management technologies, the CIG program shows farmers that cost-saving, profit-generating fertilizer techniques are trustworthy and reliable. CIG program grants will pay dividends to farmers' bottom lines, reduce nitrous oxide emissions and strengthen American agriculture on the global stage.

Policy Recommendations

- **Prioritize fertilizer innovations in the CIG program, especially enhanced-efficiency fertilizers and precision nutrient management tools that improve farm profitability.** Savings to U.S. farmers who implement precision nutrient management to prevent nitrogen loss could total as high as $4.4 billion per year. There is an opportunity to showcase additional benefits of CIG program nutrient management projects by prioritizing demonstration of nitrous oxide emissions reduction innovations. Therefore, innovations to reduce nitrous oxide emissions are essential to reduce global emissions. Nitrous oxide R&D spending is a sub-sector of soil nitrogen R&D, which has received an average of 9.5% of federal agricultural climate mitigation funding between 2017 and 2023.[39] Since the CIG program's inception in 2004, over 1,773 projects have been funded, yet only nine of those projects — less than half a percent — have focused on nitrous oxide. In particular, the administration could focus on promoting research on enhanced-efficiency fertilizers that are specifically designed to reduce nitrous oxide emissions.
- **Modernize Technical Service Provider (TSP) services to increase timely access to nutrient management planning and support grower participation in conservation programs**. Technical Service Providers are essential for educating farmers and ranchers about agricultural conservation practices and can also play

a role in relaying valuable insights from farmers and ranchers to education program developers. Modifying existing regulations and guidances to clarify that Certified Crop Advisor credentials meet the requirement for designation as TSPs for the purpose of developing, writing and approving NRCS Conservation Practice standard 590 Nutrient Management Plans can expand recognition of qualified professionals, which will increase timely access to nutrient management planning services and support grower participation in conservation programs.

- **Develop a "CIG-to-EQIP Scaling Pathway" so validated CIG program innovations can inform the EQIP grant selection processes to support technology adoption.** It is unclear how many innovations supported through the CIG program have translated to updates to the EQIP grantmaking process. Increased coordination between the CIG program and EQIP can help maintain U.S. agricultural innovation and streamline the adoption and commercialization of valuable conservation tools and practices. This can be achieved by utilizing EQIP to demonstrate CIG program successes at a greater scale. For example, a 2018 CIG award to the American Farmland Trust worked alongside the NRCS to improve precision measurement software for soil quality and emissions. These improvements were then scaled to all NRCS projects that use the software. Successful and scalable innovations identified through CIG projects could inform future EQIP grants and targeted financial assistance initiatives, ensuring that farmers and ranchers are familiar with new conservation practices and activities that address natural resource concerns.
- **Implement the SUSTAINS Act and Growing Climate Solutions Act to leverage the CIG program's role as an incubator for innovative conservation financing solutions.** NRCS programs are very popular among farmers, but approximately 50% of eligible projects can receive funding.[40] This creates an opportunity to leverage innovative private-sector financing, such as through the implementation of the SUSTAINS Act, implementation of the Growing Climate Solutions Act and the development of standards for environmental credits that benefit American farmers and ranchers. Additionally, ARPA-E's Seeding Critical Advances for Leading Energy technologies with Untapped Potential (SCALEUP) Program could be used as a model to raise private-sector funding and secure deals with industry.
- **Streamline national Conservation Practice Standards by intermittently updating guidance on innovations and establishing a faster national-to-state update process.** The CIG program was established to support the incorporation of innovations into NRCS science-based tools and guidance that influence conservation programs, including the conservation practice standards. Therefore, the process for updating these practice standards could be streamlined to ensure American farmers and ranchers have access to the most up-to-date information and innovations to voluntarily achieve their conservation goals. Streamlining the incorporation of new and innovative technologies into conservation practice standards could include seeking state-level recommendations to identify promising innovations and establishing interim standards developed with stakeholder input.

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Appendix

Table A1. New conservation funding in OBBBA (all amounts in billions USD).

Program	Pre-OBBBA Total (FY26–31)	Post-OBBBA Total (FY26–31)	Difference
EQIP	12	18.53	6.53
CSP	5.8	8.10	2.3
ACEP	2.7	4.05	1.35
RCPP	1.55	2.68	1.13

Table A2. Seventeen additional practice standards could include consideration of nitrous oxide emissions.

The following conservation practice standards can be implemented to reduce nitrous oxide emissions due to the impact these practices have on nutrient accumulation in water and soil. An analysis of existing research on the impact of these conservation standards on nitrous oxide can be done to consider updating the conditions under which the practice can be applied and the criteria considerations.

Conservation Practice Standard	Code
Alley Cropping	Code 311
Constructed Wetland	Code 656
Conservation Cover	Code 327
Conservation Crop Rotation	Code 328
Contour Buffer Strips	Code 332
Contour Farming	Code 330
Denitrifying Bioreactor	Code 605
Drainage Water Management	Code 554
Hedgerow Planting	Code 422
Irrigation Water Management	Code 449
Pasture and Hay Planting	Code 512
Range Planting	Code 550
Residue and Tillage Management, No Till	Code 329
Residue and Tillage Management, Reduced Till	Code 345
Wetland Creation	Code 658
Wetland Enhancement	Code 659
Wetland Restoration	Code 657

Table A3. Farm Bill Legislation

Year	Title	Public Law Number	Congressional Year
2002	Farm Security and Rural Investment Act	107–171	107th Congress
2008	Food, Conservation, and Energy Act of 2008	110–234	110th Congress
2014	Agriculture Reform, Food, and Jobs Act of 2013	113–79	113th Congress
2018	Agriculture Improvement Act of 2018	115–334	115th Congress
2022	Inflation Reduction Act of 2022 (IRA)	117–169	117th Congress

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