BOSTON UNIVERSITY Global Development Policy Center
Economics in Context Initiative

ECI Policy Brief 01 ▪ 04/2026

Fertilizer Overuse and the Case for Legume Cover Crops: A One Health Approach

By Eric Christine*

Executive summary:

- Corn is the primary consumer of synthetic nitrogen (N) fertilizers in the United States (US), averaging approximately 68% of all domestic N fertilizer consumption in the past 20 years.
- Synthetic N fertilizers represent the greatest share of operating costs for US corn farmers (averaging 39.8%) and are often overused.
- Over half of the N used by corn farmers is lost to the environment through leaching, runoff, and air pollution, resulting in $32 billion in annual health and environmental externalities.
- While the US has expanded domestic N fertilizer production, the supply side of the market remains tightly concentrated and geographically constrained.
- Natural gas, which is subject to price fluctuations and supply disruption, is the primary operating cost for ammonia manufacturers.
- Cover cropping with legumes can increase yields and soil health, but adoption is hindered by a lack of alternative markets for leguminous crops.
- Over 97% of domestic livestock feed relies on corn. Legumes offer a more sustainable and affordable protein source relative to meat—particularly beef.
- Farmer profitability, consumer affordability, and cross-sectoral health goals are optimized under a One Health policy framework that incentivizes leguminous cover crop diversification coupled with a demand-side protein transition.

Bottom Line: Corn's heavy reliance on synthetic fertilizers exposes farmers to energy price volatility and a consolidated supply chain while harming public health and the environment. Federal policies incentivizing legume cover crops as well as a transition in protein consumption are essential for ensuring agroeconomic resilience and better health outcomes.

*Eric Christine, MPH, is a research assistant and graduate student at BU studying the connection between food system practices, One Health, and economic policy.

I. Introduction

Synthetic fertilizers are central to the United States (US) agricultural economy, facilitating the production of core cereal grains that underpin meat affordability, biofuel production, and global export markets. Yet the production and consumption of these technologies have generated numerous adverse externalities spanning economic sectors and ecological systems, ultimately affecting public health and climate change.[1] Fortunately, alternative and more sustainable methods for farming the most fertilizer-dependent crops have been proposed and may be feasible on a wide scale.

This policy report analyzes the domestic market for nitrogen (N) fertilizer as an input to cereal grain production—specifically corn (aka maize or *Zea mays*). It reviews the economic and scientific literature and presents an evidence-based approach to incentivize leguminous cover crop adoption at the federal and state level. By diversifying crop rotations, corn farmers across the nation can reduce their reliance on N fertilizers while also strengthening soil ecosystems.

Beyond supply-side incentives, this analysis utilizes a One Health framework —an integrated perspective that recognizes the fundamental link between animal health, environmental integrity, and human nutrition—to evaluate the systemic shifts necessary for a sustainable agroeconomic future. By contextualizing corn as the definitive nexus between animal, human, and environmental health, the following brief examines how domestic production practices are inherently linked to consumer demand for animal-based protein. Ultimately, a holistic approach targeting both agricultural production and dietary patterns is required to mitigate the economic and ecological challenges of N mismanagement.

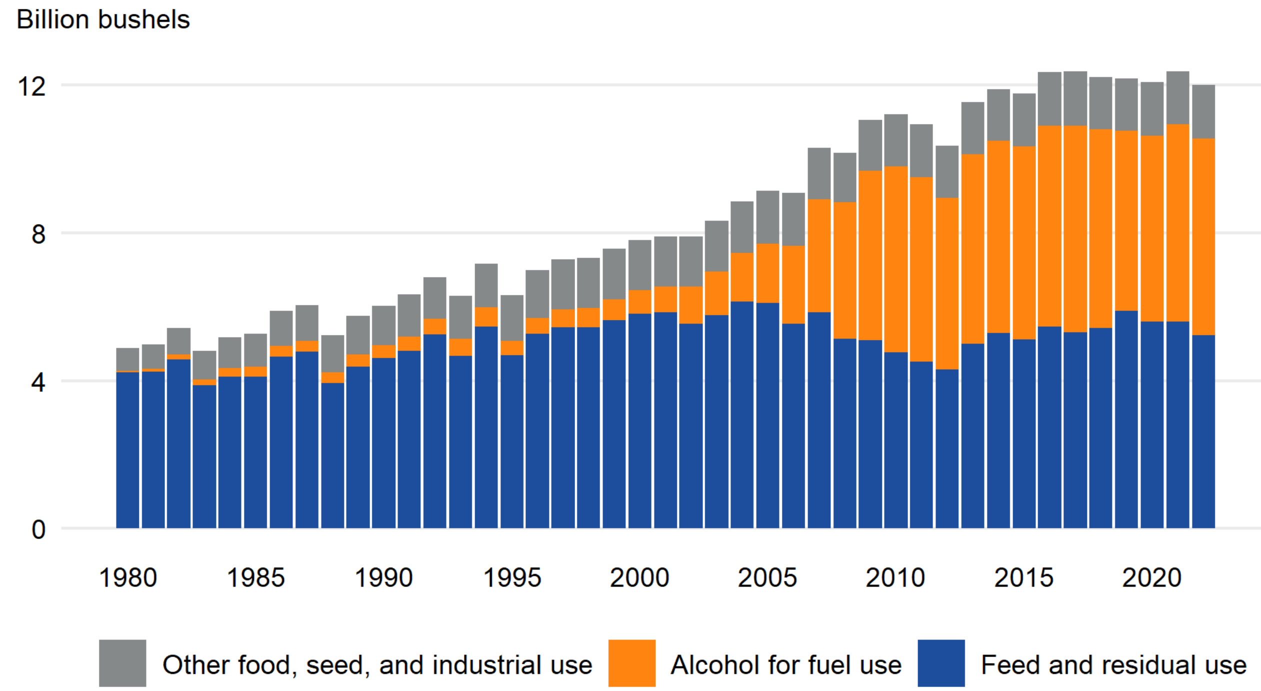
II. Corn in Context: The Macroeconomics of Macronutrients

The US produces the most corn in the world by volume, holding approximately 33% of the global market share from 2025 – 2026 (US Department of Agriculture [USDA] Foreign Agriculture Service [FAS], 2026). In 2025, domestic corn production reached a record high at 17 billion bushels (USDA, National Agriculture Statistics Service, 2026).

Corn serves a crucial economic function not merely as a human food source but also as livestock feed (~40 percent of total domestic corn use) and as an input to industrial manufacturing processes including ethanol production (~45 percent; see Figure 1). Corn ethanol is the most produced and consumed biofuel in the US (Ramsey et al., 2023). In 2024, it was estimated that corn generated $123 billion in economic output across 506 industry sectors and all 50 states (Swanson, 2025).

[1] In economic theory, the concept of externalities refers to impacts of an economic transaction that affect parties outside of the transaction, including environmental impacts.

Figure 1. Historical Domestic Corn Use (1980 – 2022)



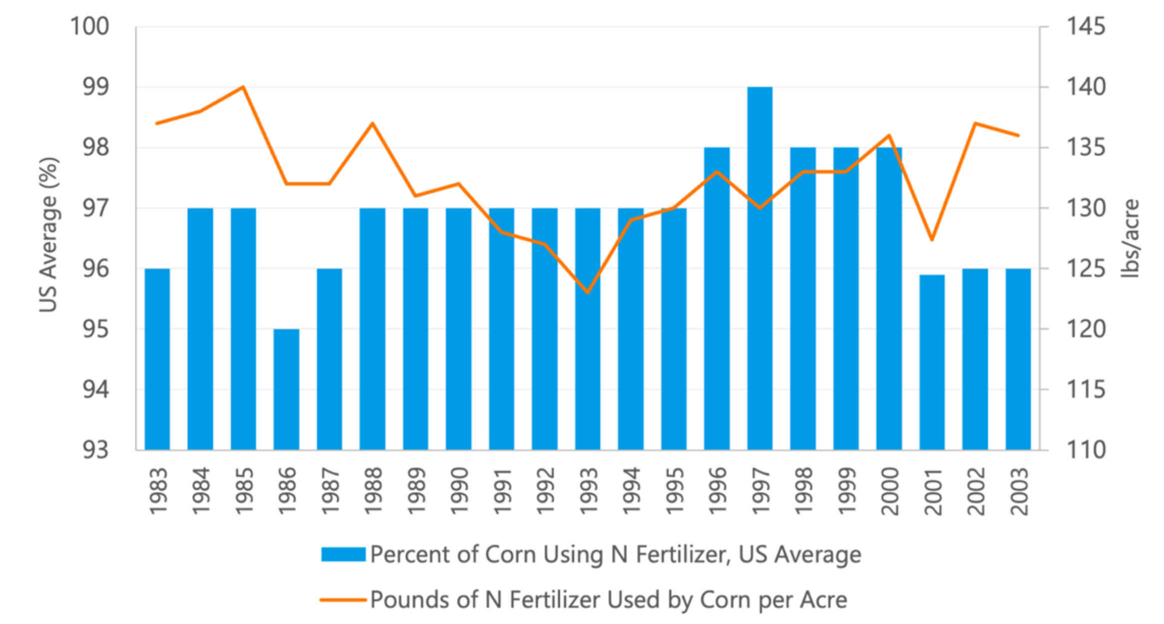
Source: *USDA Economic Research Service (ERS), 2025a*
Note: *1 bushel equals 56 pounds of shelled corn.*

Despite USDA projections for 2026 estimating a seven percent decline in overall production, corn is expected to remain the single most extensively produced crop in the US, followed closely by soybeans (USDA, 2026). In international trade, corn will be the most heavily exported US crop by volume, with USDA forecasts estimating record-setting levels of exports for fiscal year 2026 (USDA ERS & FAS, 2026). Given its immense scale, the environmental sustainability and financial solvency of corn production are called into question, particularly due to the overuse and high costs of N fertilizers (Goswami, 2025; Swanson & Kuck, 2026).

The primary limiting nutrient for corn, along with most cereal grains (wheat, oats, rice, etc.), is N—an element essential to plants like corn due to its incorporation into genes, proteins, and pigments like chlorophyll (Nafziger, 2021; Bayer Crop Science, 2024). Most of the N on Earth is contained within the atmosphere in an inert form, leading microorganisms to adapt early on to "fix" this N through catalytic enzymes called nitrogenases (Pi et al., 2022). These organisms, such as *Rhizobia*, interact symbiotically with crops like legumes (e.g. beans, peas, alfalfa) to stimulate plant growth in exchange for other essential nutrients (Ladha et al., 2022). Given the physiological limitations of corn relative to legumes with respect to N fixation, its production has historically heavily depended on synthetic N fertilizers (Figure 2).

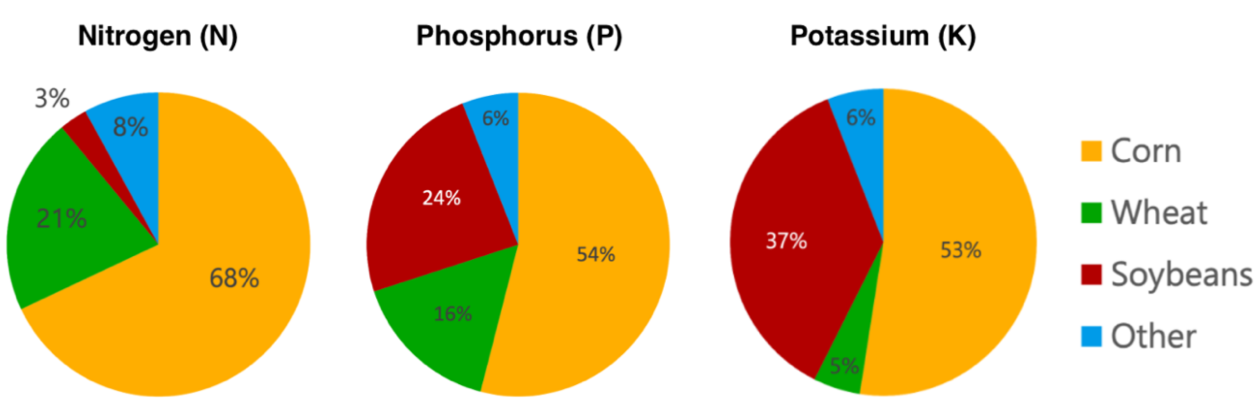
The Haber-Bosch process is an energy-intensive yet convenient way to convert inert atmospheric nitrogen into ammonia via high heat and pressure (Williams et al., 2025). The process is heavily dependent on natural gas inputs, which means that N fertilizers require significantly more energy to produce than those that are phosphate or potassium-based (Mingolla & Rosa, 2025; Daramola & Hatzell, 2023). According to the University of Illinois's Department of Agricultural and Consumer Economics, corn's prevalence in US agriculture has made it the dominant consumer of all synthetic fertilizers (see Figure 3).

Figure 2. US Corn Crop Nitrogen Fertilizer Use (1983 – 2003)



Source: *USDA ERS, 2025b*

Figure 3. Estimated Share of Total Fertilizer Applications by Type and Crop Variety in the US (2002 – 2023)

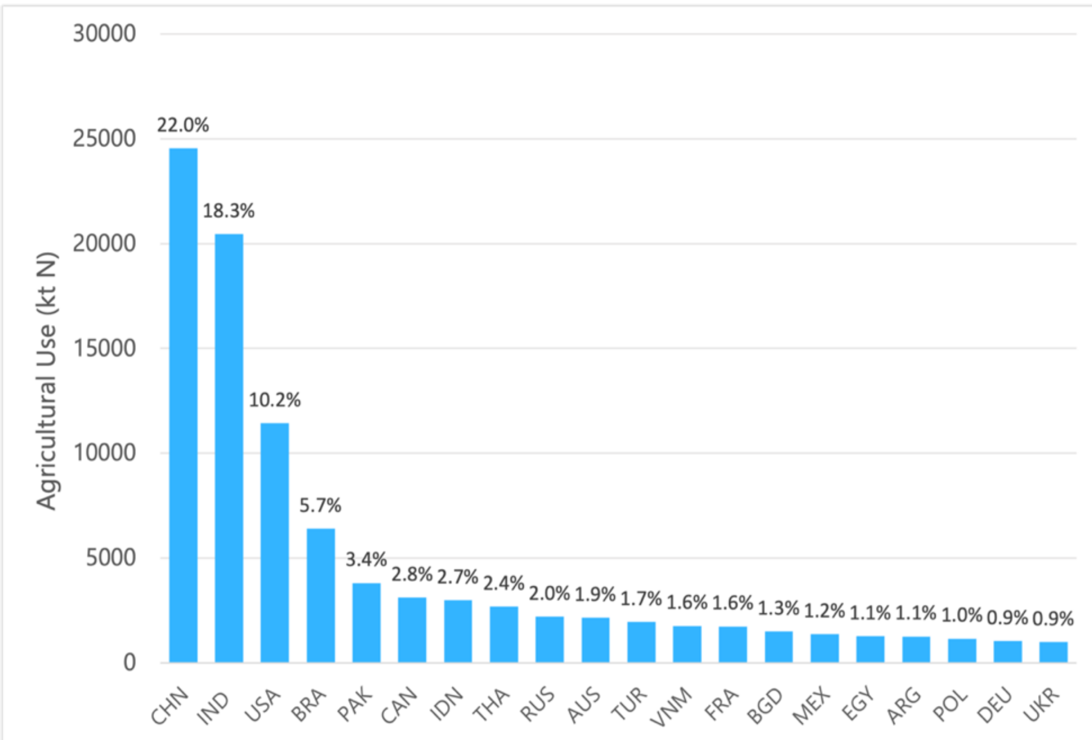


Source*: Monaco et al., 2025*

Note: *Percentages may not sum to 100 due to rounding.*

Globally, the US ranks third in aggregate N fertilizer consumption for agricultural use, with a large share of its consumption coming from domestic production (see Figure 4). From 2006 to 2022, while total fertilizer production in the US declined by approximately 5 percent, N fertilizer's share of that production increased from 34 percent to 61 percent (Williams et al., 2025). This shift toward domestic supply is reflected in recent trade data, with N fertilizers comprising a significantly larger share of exports and a reduced share of imports by 2022. Overall, domestic N fertilizer consumption from 2006 to 2021 was greater than both phosphate and potash fertilizer combined (see Figure 5).

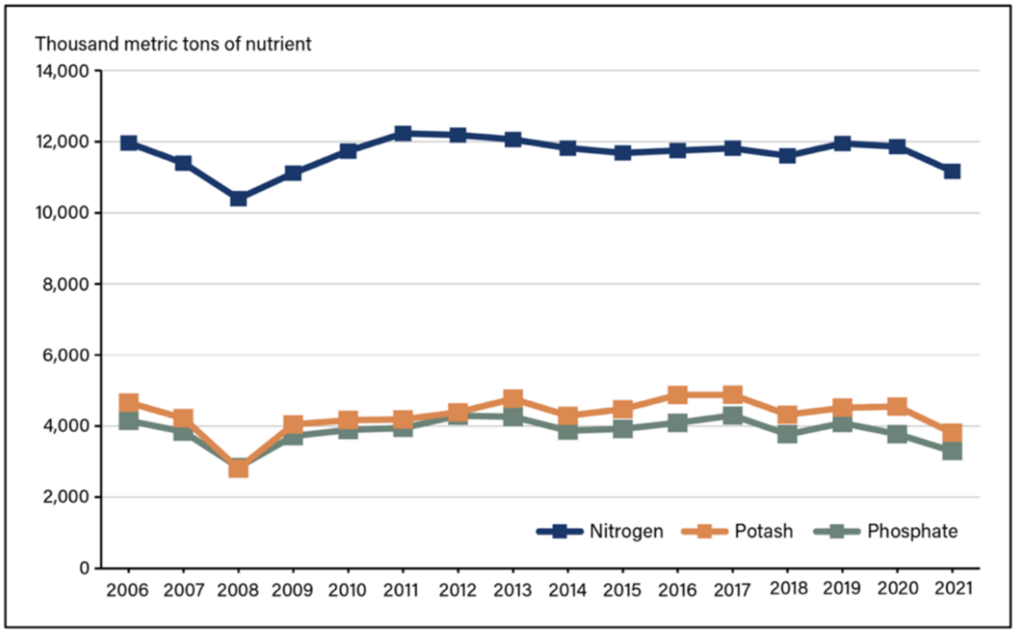
Figure 4. Top 20 Countries Consuming Nitrogen for Agricultural Use (2023)



Source: *Food and Agriculture Organization (FAO), 2025.*
Note: *Aggregate agricultural use is measured in kilotonnes of nitrogen (kt N) for the year 2023. Percentages represent the country-specific share of global N consumption for agricultural use.*

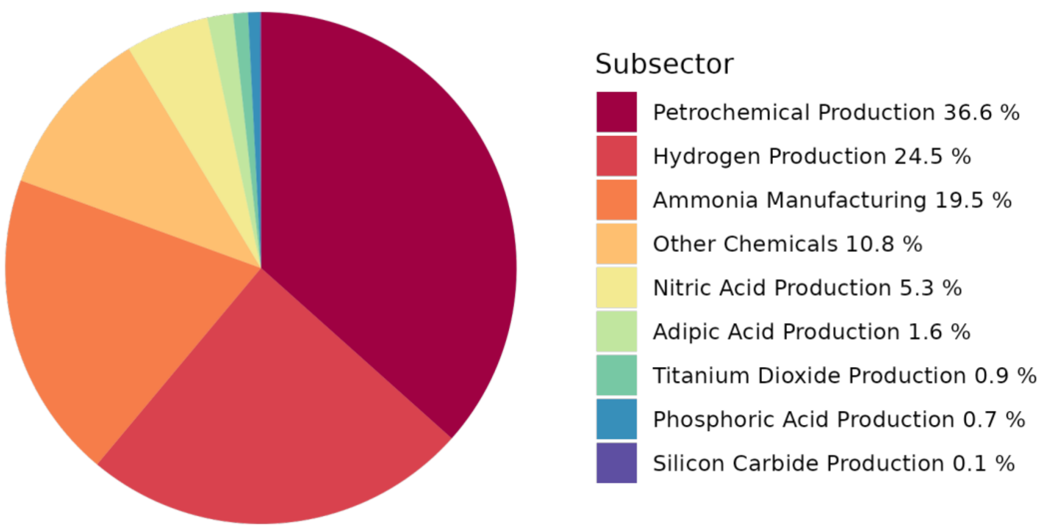
From 2006 to 2022, domestic ammonia production increased by 84%, urea by 62.4%, and ammonium nitrate by 32.9% (Williams et al., 2025). From 2011 to 2023, seven new ammonia production facilities were built in the US, with the industrial manufacturing process emitting about 20% of the total greenhouse gases (GHGs) emitted by chemical manufacturing sector in 2023 (see Figure 6).

Figure 5. US Fertilizer Consumption (2006 – 2021)



Source: *Williams et al., 2025*

Figure 6. Total Reported Emissions from Chemicals Sector, by Subsector (2023)



Source: *US Environmental Protection Agency, 2024*

Besides production emissions, N application rates for corn often exceed what is absorbed by the crop; surplus nitrogen is lost to the environment through both aquatic runoff and atmospheric emissions (Natural Resources Defense Council, 2025). The latter takes the form of gases such as nitrous oxide, ammonia, and nitrogen dioxide, with nitrous oxide comprising the largest share. Over 90% of all crop-related GHG emissions from agriculture come from nitrous oxide—a compound with approximately 270 times the heat-trapping potential of carbon dioxide—due to lost N from soil fertilization (Congressional Budget Office, 2025). This issue is particularly costly in the Corn Belt, where producers frequently overapply the resource (see Table 1).

III. The Corn-Cost Continuum

A. The Negative Externalities of N Fertilizer Overuse

A recent report by the Union of Concerned Scientists explains how corn producers—where most of the demand for US-produced N fertilizer is derived—overuse the resource, often causing environmental pollution and subsequent health harms as a result (Goswami & Tshabalala, 2026).

Given corn's high reliance on N fertilizer, Table 1 represents a proxy for fertilizer overapplication on US corn farms, providing insight into the drawbacks of large-scale corn monoculture systems. A 2022 study found that corn alone was responsible for over two-thirds of direct soil nitrous oxide emissions across the contiguous US since 1900 (Lu et al., 2022). Meanwhile, the UCS report estimates that approximately $12 billion are lost nationally as a direct result of nitrous oxide emissions from N fertilizer overuse. For the Midwest, N-related health and environmental externalities were estimated to surpass $32 billion. Finally, the authors conclude that 30 to 50 percent of fertilizer applied in the Corn Belt is wasted, costing not only society but corn farmers themselves in lost land productivity.

Table 1. Estimates of Fertilizer Overuse in the Corn Belt

Region	Nitrogen Fertilizer Use (Metric Tons)	Estimated Nitrogen Fertilizer Overuse with 50% NUE	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

Source: *Goswami & Tshabalala, 2026.*

Note*: Assuming a 50 and 70% nitrogen use efficiency (NUE), the authors estimated excess nitrogen fertilizer applied in the Corn Belt and the US. The authors chose the three midwestern states above due to their high fertilizer use and corn-soybean production. Fertilizer use is based on corn and soy, with numbers adjusted to the nearest 10,000 for formatting simplification.*

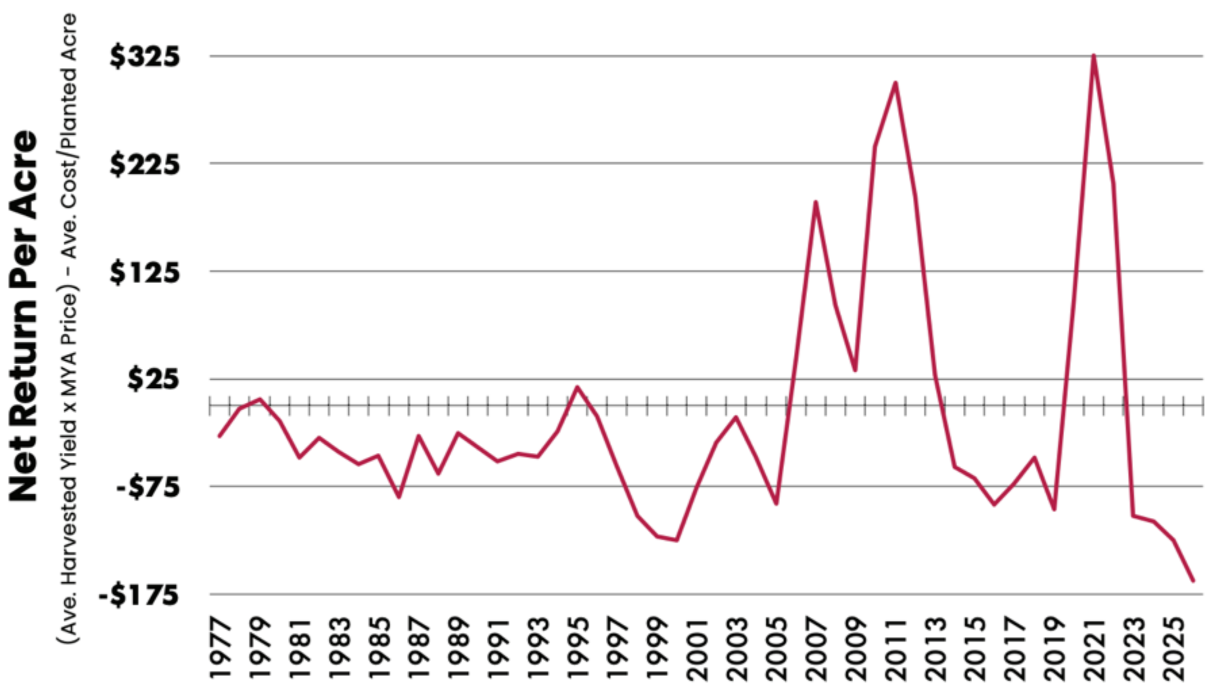
B. Cost Burden on Corn Farmers Amidst Global Supply Chain Disruption

For US corn producers, the largest portion of operating costs comes from fertilizer expenditures, affecting not only farm profitability but the sustainability of the US agricultural economy. The USDA ERS (2025) found that from 2006 to 2023, fertilizer costs represented an average of 39.8% of all operating costs for corn producers (Williams et al., 2025).

Moreover, in a 2026 report, the National Corn Growers Association (NCGA) claimed that the future of America's farms is at risk—approximately 80% of corn growers (out of over 1,000 surveyed) say that the next generation of farmers will not succeed without some form of support (Swanson, 2026).

Projections are that corn farmers—for the fourth consecutive year—will be operating at a loss, with profitability showing extreme volatility in recent years (see Figure 7). As of March 2026, projections by the University of Illinois at Urbana-Champaign estimate that supply chain disruption caused by the US-Israel war with Iran will increase the price of natural gas, thus exacerbate the high costs of N fertilizers and put further strain on the financial security of US corn farmers (Schnitkey et al., 2026).

Figure 7. US Corn Profitability Per Acre (1977 – 2025)



Source: *Swanson, 2026*

The NCGA report posits that one of the primary reasons corn producers have faced rising input costs in recent years has been the market consolidation of suppliers of key inputs like fertilizer. This assertion is corroborated by recent evidence demonstrating that the market for domestically manufactured fertilizers is particularly consolidated. A 2024 briefing paper published by the Agricultural and Food Policy Center at Texas A&M University concluded that the US markets for major fertilizers are all either moderately or highly concentrated (see Table 2).

Table 2. US Fertilizer Market Concentration Estimates

Concentration Metric	HHI	CR4	Concentration Classification
Nitrogen	2,382	77%	Moderate to High
Potash	3,455	100%	High

Source: *Fischer et al., 2024*
Technical Note: *The Herfindahl-Hirschman Index (HHI) is calculated using the market shares of all firms in the industry. Values between 1500 and 2500 mean the market is considered moderately concentrated; markets above 2500 are considered highly concentrated. The four-firm concentration ratio (CR4) is the sum of the market shares (in percent) of the four leading producers within an industry.*
Table Note: *The authors acknowledge that this is a rough measure of the domestic market concentration, as the fertilizer market is globally integrated. Including information on global trade data would provide insight for a more comprehensive analysis. Nonetheless, these findings reveal that the domestic market for fertilizer production is notably consolidated.*

As of March 2026, the US Department of Justice opened an investigation into the domestic fertilizer market for anti-trust policy violations among manufacturers (Milligan, 2026), illustrating the oligopolistic nature of the industry (Morão, 2025). Given the highly concentrated nature of the fertilizer market, it follows that corn fertilizer costs are correlated with the price of the commodity.

Moreover, since natural gas represents a significant portion of operating costs for domestic ammonia manufacturers, fluctuations in natural gas prices can result in stark, immediate increases in N fertilizer prices (Wongpiyabovorn & Hart, 2024). The ongoing supply chain disruption from the 2026 Iran war will have downstream economic effects on cereal grain prices and feedstock consumers such as biofuels and meat.

Another contributor to total N fertilizer costs is the centralized nature of the ammonia manufacturing industry. The geographic mismatch between ammonia production (centralized in the Gulf Coast) and demand (centered in the Corn Belt) results in high transportation costs (Mingolla & Rosa, 2026). While the median production cost of natural gas-based ammonia is $326 per metric ton, transportation adds a median of $40 per ton, leading to a total delivered cost of approximately $343 per metric ton.

Extrapolating this result using total N fertilizer consumption data from Table 1 produces an estimated aggregate cost of natural gas-based ammonia that approaches $4 billion. Transportation—accounting for approximately $465 million in added costs—partly explains the regional variation in fertilizer costs as a share of total operating expenses, as operations in the Corn Belt (Heartland/Eastern Uplands) often lie a significant distance from many of the 33 large ammonia production complexes housed in the US (Williams et al., 2025; Mingolla & Rosa, 2026).

Given that the interstate transportation of ammonia primarily utilizes freight rail (in addition to barges, pipelines, and trucks) as well as refrigerants for storage—all of which consume fossils fuels for energy—ammonia transit costs will rise in 2026 due to fossil fuel price inflation (Bureau of Transportation Statistics, 2025; Paulson et al., 2026; USDA Agricultural Marketing Service [AMS], 2026a). This effect will compound against the base price of ammonia rising, increasing the expected total delivered cost for producers in the Corn Belt.

Cutting costs for US corn farmers means reducing total N fertilizer use. At present, approximately 36% of US corn growers intended to reduce fertilizer use in 2026, presenting a window for US federal policy to intervene (Swanson, 2026). Fortunately, such a reduction in use produces a double-dividend effect: excess N fertilizer application could be attenuated while farmers could be directly supported through the implementation of evidence-based policy initiatives.

Considering the health and environmental externalities associated with N fertilizer overuse, including health conditions arising from nitrous oxide air pollution and the environmental damage caused by the continuous release of GHGs, incentivizing regenerative alternatives is a national imperative (McKnight Foundation & Regenerative Agriculture Foundation, 2025).

IV. Supply-Side Policy Interventions

A. The Case for Legume Cover Crops

A comprehensive 2026 global review analyzing the capacity of integrating legumes to enhance cereal production found that diversifying corn with legumes decreases GHG emissions relative to N-fertilized cereals during growth (Peoples et al., 2026). The analysis suggests that cropping with legumes improves soil structure, nutrient and water availability, and N availability for cereal grains across diverse geographic regions. Contemporary evidence suggests that legume-cereal intercropping benefits soil health and water retention, among other metrics of ecosystem robustness (Motsomane & Magadlela, 2026).

According to Peoples et al., 2026, wheat and maize comprise the top two cereals most reliant on N fertilizer, as the top 15 producers (>70%) of these crops consume over 80% of the world's N fertilizer supply. Meanwhile, Juneja et al. (2026) conducted a global meta-analysis reviewing 20 studies to analyze the N dynamics of 55 arable soil environments. Focusing primarily on US-grown corn, they found that when managed effectively, leguminous cover crops grown prior to planting significantly enhanced crop growth and reduced the need for synthetic N fertilizer. At all N levels, legumes were shown to boost corn yields, with the most substantial increase shown for corn grown without N fertilizer application relative to other cover crops.

B. The Crux for Corn Farmers

While leguminous cover crops are a scientifically proven mechanism for reducing N fertilizer dependency (Juneja et al., 2026), their implementation remains drastically underutilized.

The Heartland region, responsible for approximately 60% of total U.S. corn production, exhibits a cover crop adoption rate of around 10% across owner-operated and rented fields (Szmurlo & Burnett, 2024). Therefore, targeting federal or state-level financial incentives specifically toward the Corn Belt presents the highest potential return on investment for reducing aggregate domestic N demand given that fertilizer costs are typically higher in the region (USDA AMS, 2026b).

Examining the US Midwest from 2006 to 2015, Park et al. (2023) found that federal cost-sharing investments via the Environmental Quality Incentives Program (EQIP) were significantly associated with county-level cover crop adoption. Conversely, the Conservation Stewardship Program (CSP) exhibited a statistically significant negative effect, as its longer time horizons and focus on maintaining existing practices act as a short-term disincentive to implementing newer, costlier conservation practices like cover cropping.

Nonetheless, the authors suggest that the expansion of the CSP through the 2018 Farm Bill could reverse these findings and actually play an important role in increasing cover crop adoption, particularly for the US Corn Belt. These results are especially relevant in light of recent evidence suggesting that cover crop rotations can be as profitable for corn farmers as conventional monoculture systems after the initial transition period (Datta et al., 2025).

A recent USDA ERS 2025 report analyzing the economics of soil health management practices in the US (Bowman et al., 2025) found that generally, cover crops are less profitable and only offset transition costs over longer time horizons. However, when paired with cost-sharing government payments, or if fertilizer costs are high, adoption of cover crops could prove profitable. The dynamics of time, climate, soil, and crop type all create substantial nuance and uncertainty regarding the decision to integrate greater diversity into yearly cash crop rotations.

For corn farmers in particular, the evidence indicates that robust policy support is necessary to increase cover crop adoption; the market cannot sustain monocultures amidst looming energy-driven inflation combined with the cumulative social and environmental costs of N overapplication. By scaling up the EQIP and CSP administered through the USDA, producers could reduce N fertilizer overuse, ensure efficient crop yields, and attain sufficient profits to guarantee sustainable financial futures (Goswami & Tshabalala, 2026).

Shifting to more regenerative practices like cover cropping alone may not sustain the Midwestern farm. Roesch-McNally et al. (2018) reviewed thousands of survey responses from Corn Belt farmers and conducted 159 in-depth interviews, finding that many respondents expressed a general dissatisfaction with the dominant monoculture corn cropping system and a desire to diversify. Despite this desire to increase the number of crops in their annual rotation, the perceived lack of markets for alternative crops also seemed a significant barrier to profitability for corn growers.

Coon et al. (2025) also conducted a series of interviews with Corn Belt farmers, investigating the motivations and barriers for regenerative practice adoption. In 16 in-depth interviews with early adopters, the authors found that while motivations for regenerative practice adoption stem mostly from environmental priorities (e.g. land stewardship, biodiversity enhancement, climate change mitigation), barriers to adoption were primarily economic (e.g. lacking financial resources, big agribusiness influence, and lack of marketing knowledge). Modernizing the political infrastructure for climate-smart agriculture is essential; a national transition toward plant-based protein provides the necessary market signals to make these conservation investments economically viable.

V. One Health Policy Solutions: The Protein Transition

Despite the significant supply-side challenges facing the US food system, a comprehensive policy response must account for the systemic impacts on consumer nutrition and food affordability. One Health is a systems-level approach that attempts to unify the health of the environment, animals, and humans across economic sectors and geographical regions (FAO et al., 2022). Due to its intersection between various supply chain pathways—influencing fossil fuel consumption via N fertilizers, farmer health through nitrous oxide emissions, and animal nutrition—corn can be usefully analyzed through a One Health lens.

According to the USDA ERS (2026), over 97% of domestic livestock feed comes from corn, meaning the aggregate demand for N fertilizer is fundamentally a derived demand for animal protein. While corn provides the bulk energy for livestock, soybeans provide the bulk protein, acting as a functional complement as an industrial input in animal agriculture.

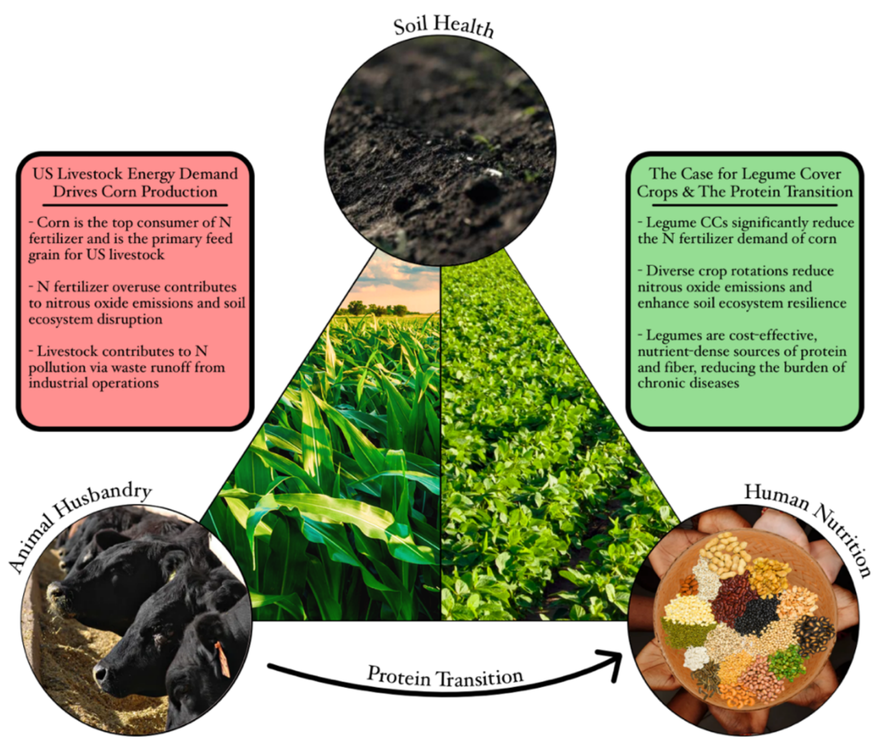
In the context of the national food system supply chain and One Health, a shift in dietary choices toward plant-based protein sources could reduce N pollution and generate healthier outcomes for Americans (Aidoo et al., 2023; Duarte et al., 2024; Lisciani et al., 2024). Relative to red and processed meat, which are environmentally taxing to produce (Rockström et al., 2025; Siegrist et al., 2024), legumes are substantially less energy-intensive and healthier for consumers (Yanni et al., 2024).

Despite these benefits, a pronounced consumption gap exists in the US, where levels of legume intake fall below the established dietary recommendations (Drewnowski et al., 2025; Hughes et al., 2022). This gap can be successfully filled by increasing agricultural diversification and the development of value-added products, such as legume-based flours, snacks, and meat alternatives (Affrifah et al., 2023). Legumes can be integrated into a wide variety of culinary settings ranging from traditional regional dishes to modern plant-based dairy and meat analogs, demonstrating their versatility throughout the national food system (Affrifah et al., 2023; Rockström et al., 2025).

Furthermore, legumes are affordable for most Americans, yet perceptions surrounding protein quality and flatulence limit consumer preferences (Semba et al., 2021). Given the high costs of natural gas, which directly influences N fertilizer prices and subsequently meat costs, encouraging a protein transition to legumes is crucial since increased input costs are likely to further inflate consumer prices for protein foods.

Increasing consumption of legumes can enhance the nutritional quality of the American diet while mitigating the substantial socioeconomic and healthcare burdens associated with chronic diseases. Shifting the national protein demand would reduce the need for industrial-scale animal husbandry and subsequently corn inputs, creating benefits across the One Health spectrum (see Figure 8).

Figure 8. One Health Graphical Abstract: The Protein Transition and Corn-Legume Connection



Note: *Created in Pixelmator Pro v3.7.1.*

European food policy provides an important precedent for this integrated One Health approach. Many European countries have updated national dietary guidelines to prioritize plant food consumption, such as Denmark and the Netherlands (van Dooren et al., 2024). A comprehensive 2023 European assessment demonstrates that a transition toward plant-based diets is central to increasing the N use efficiency of the food system—simultaneously reducing N pollution and GHG emissions (Leip et al., 2023).

A primary lesson from this European evidence is that promoting N-resilient food systems requires agricultural policies that are explicitly nutrition-sensitive. Central to this transition is the reduction of red and processed meat consumption, which the report identifies as a critical lever for achieving both positive health outcomes and environmental sustainability.

This model is further supported by a recent European report advocating for a $3.5 billion (€3 billion) investment over the next decade to support the European protein transition to make sustainable dietary patterns more financially feasible for farmers and consumers alike (The European Alliance for Plant-Based Foods, 2026). The report details how such investments strengthen the One Health approach, emphasizing crop diversification to make the planetary health diet more financially feasible for Europeans, a central solution to N-related externalities discussed in depth by the latest 2025 EAT-Lancet Commission report (Rockström et al., 2025).

The Scientific Report of the Dietary Guidelines Advisory Committee (2024) explicitly called for prioritizing plant-based sources of protein over those from animals, especially red and processed meat. However, the 2025-2030 Dietary Guidelines for Americans (2026) advocates a variety of protein from animal sources, including red meat. More explicit messaging, paired with fiscal policy interventions such as meat taxes or subsidies for sustainable protein alternatives, can elicit climate and public health co-benefits (Bonnet & Coinon, 2024; Bryant et al., 2024; Rockström et al., 2025).

VI. Conclusion: A Dual-Pronged Strategy for Efficient N Use

The US dominance in corn production has led to immense gains across economic sectors, but the current system is untenable in the face of the externalities of N fertilizer overuse. Fertilizers represent the greatest share of costs for corn producers, while N overapplication has been demonstrated to create environmental and health harms via nitrous oxide emission—the leading driver of nearly all crop-derived GHG emissions in the US agricultural sector. Between the natural gas price increases due to global supply chain disruption, a tightly concentrated domestic fertilizer industry, and a need to expand legume availability, there is a multi-faceted benefit to US policy intervention:

- Using the Farm Bill as the legislative vehicle, the US government should increase funding for EQIP and the CSP to guarantee greater technical and financial assistance necessary for corn farmers to adopt leguminous cover crops. At present, the One Big Beautiful Bill Act has expanded funding for these USDA-operated programs, yet the removal of stipulations for "climate-smart" practices may affect the allocation of funding provisions (An act to provide for reconciliation pursuant to title II of H. Con. Res. 14, 2025). Supporting small economies and crop diversification is essential moving forward.
- National dietary guidelines should prioritize plant-based proteins such as beans, peas, and lentils. While the new guidelines mention legume consumption, more comprehensive guidance and direction is needed to facilitate the incorporation of more plant-based protein into the diet.

References

An act to provide for reconciliation pursuant to title II of H. Con. Res. 14, H.R. 1, 119th Cong. (2025). https://www.congress.gov/bill/119th-congress/house-bill/1/text

Affrifah, N. S., Uebersax, M. A., & Amin, S. (2023). Nutritional significance, value-added applications, and consumer perceptions of food legumes: A review. *Legume Science, 5*(4), Article e192. https://doi.org/10.1002/leg3.192

Aidoo, R., Abe-Inge, V., Kwofie, E. M., Baum, J. I., & Kubow, S. (2023). Sustainable healthy diet modeling for a plant-based dietary transitioning in the United States. *npj Science of Food, 7*, Article 61. https://doi.org/10.1038/s41538-023-00239-6

Bayer Crop Science. (2024, August 19). *Corn nutrition 101*. https://www.cropscience.bayer.us/articles/bayer/corn-nutrition-101

Bonnet, C., & Coinon, M. (2024). Environmental co-benefits of health policies to reduce meat consumption: A narrative review. *Health policy (Amsterdam, Netherlands), 143*, 105017. https://doi.org/10.1016/j.healthpol.2024.105017

Bowman, M., Ferraro, P. J., Binzen Fuller, K., Gramig, B., Mosheim, R., Njuki, E., Pratt, B., Rejesus, R., & Rosenberg, A. (2025). *Economic outcomes of soil health and conservation practices on U.S. cropland (Report No. ERR-353)*. U.S. Department of Agriculture, Economic Research Service. https://www.ers.usda.gov/publications/pub-details/?pubid=109425

Bryant, C., Couture, A., Ross, E., Clark, A., & Chapman, T. (2024). A review of policy levers to reduce meat production and consumption. *Appetite, 203*, 107684. https://doi.org/10.1016/j.appet.2024.107684

Bureau of Transportation Statistics. (2025). *Freight facts and figures*. U.S. Department of Transportation. https://data.bts.gov/stories/s/Freight-Transportation-Energy-Use-Environmental-Im/f7sr-d4s8/

Congressional Budget Office. (2025, August). *Emissions of greenhouse gases in the agriculture sector*. https://www.cbo.gov/system/files/2025-08/61467-ghg-agriculture.pdf

Coon, J., Easley, M., Williams, J., et al. (2025). Farmer perceptions of regenerative agriculture in the Corn Belt: Exploring motivations and barriers to adoption. *Agriculture and Human Values, 42*, 1847–1864. https://doi.org/10.1007/s10460-025-10735-y

Daramola, D. A., & Hatzell, M. C. (2023). Energy demand of nitrogen and phosphorus based fertilizers and approaches to circularity. *ACS Energy Letters, 8*(3), 1493–1501. https://doi.org/10.1021/acsenergylett.2c02627

Datta, A., Wilke, B., Charles, C., Hasenick, M., Ulbrich, T., Singh, M., Sears, M., & Robertson, G. P. (2025). Crop performance and profitability for the initial transition years of a regenerative cropping system in the Upper Midwest United States. *Journal of Environmental Quality, 54*, 1572–1585. https://doi.org/10.1002/jeq2.70084

Drewnowski, A., Zavela, C., Tran, V., Mallya, G., & Conrad, Z. (2025). Pulse consumption trends in the US in the context of 2025-30 Dietary Guidelines for Americans: Analyses of NHANES data for 1999-2018. *Frontiers in Nutrition, 12*, Article 1638519. https://doi.org/10.3389/fnut.2025.1638519

Duarte, R. D. C., Iannetta, P. P. M., Gomes, A. M., & Vasconcelos, M. W. (2024). More than a meat- or synthetic nitrogen fertiliser-substitute: A review of legume phytochemicals as drivers of 'One Health' via their influence on the functional diversity of soil- and gut-microbes. *Frontiers in Plant Science, 15*, Article 1337653. https://doi.org/10.3389/fpls.2024.1337653

The European Alliance for Plant-Based Foods, Plant-Based Foods Europe, EUVEPRO: European Vegetable Protein Association, & FoodConNext Foundation. (2026, January). *The plant-based opportunity 2026-2035*. https://plantbasedfoodalliance.eu/wp-content/uploads/2026/02/The-Plant-Based-Opportunity-2026-2035.pdf

Fischer, B. L., Outlaw, J. L., Bryant, H. L., Raulston, J. M., & Knapek, G. M. (2024, March). *Concentration and competition in the U.S. fertilizer industry (Briefing Paper 24-1)*. Agricultural and Food Policy Center, Texas A&M University. https://afpc.tamu.edu/research/publications/725

Food and Agriculture Organization of the United Nations. (2025, July 11). *Fertilizers by nutrient*. https://www.fao.org/faostat/en/#data/RFN

Food and Agriculture Organization of the United Nations, United Nations Environment Programme, World Health Organization, & World Organisation for Animal Health. (2022). *One Health Joint Plan of Action (2022–2026): Working together for the health of humans, animals, plants and the environment*. https://doi.org/10.4060/cc2289en

Goswami, O. (2025, November 19). *Half wasted: Fertilizer overuse, pollution, and the global nitrogen cycle*. Union of Concerned Scientists. https://blog.ucs.org/omanjana-goswami/half-wasted-fertilizer-overuse-pollution-and-the-global-nitrogen-cycle/

Goswami, O., & Tshabalala, P. (2026, February). *Less fertilizer, better outcomes: USDA conservation programs benefit both farmers and the planet*. Union of Concerned Scientists. https://doi.org/10.47923/2026.16101

Hughes, J., Pearson, E., & Grafenauer, S. (2022). Legumes—A comprehensive exploration of global food-based dietary guidelines and consumption. *Nutrients, 14*(15), 3080 . https://doi.org/10.3390/nu14153080

Juneja, P., Baath, G. S., Brar, J. S., Flynn, K. C., Yost, J. L., & Rajan, N. (2026). Corn responses to nitrogen fertilization as influenced by cover cropping: A meta-analysis.

Agronomy for Sustainable Development, 46(3). https://doi.org/10.1007/s13593-025-01067-6

Ladha, J. K., Peoples, M. B., Reddy, P. M., Biswas, J. C., Bennett, A., Jat, M. L., & Krupnik, T. J. (2022). Biological nitrogen fixation and prospects for ecological intensification in cereal-based cropping systems. *Field Crops Research, 283*, Article 108541. https://doi.org/10.1016/j.fcr.2022.108541

Leip, A., Wollgast, J., Kugelberg, S., Costa Leite, J., Maas, R. J. M., Mason, K. E., & Sutton, M. A. (Eds.). (2023). *Appetite for change: Food system options for nitrogen, environment & health. 2nd European Nitrogen Assessment Special Report on Nitrogen & Food*. UK Centre for Ecology and Hydrology. https://zenodo.org/records/10406450

Lisciani, S., Marconi, S., Le Donne, C., Camilli, E., Aguzzi, A., Gabrielli, P., Gambelli, L., Kunert, K., Marais, D., Vorster, B. J., Alvarado-Ramos, K., Reboul, E., Cominelli, E., Preite, C., Sparvoli, F., Losa, A., Sala, T., Botha, A.-M., & Ferrari, M. (2024). Legumes and common beans in sustainable diets: nutritional quality, environmental benefits, spread and use in food preparations. *Frontiers in Nutrition, 11*, 1385232. https://doi.org/10.3389/fnut.2024.1385232

Lu, C., Yu, Z., Zhang, J., Cao, P., Tian, H., & Nevison, C. (2022). Century-long changes and drivers of soil nitrous oxide (N_2O) emissions across the contiguous United States. *Global Change Biology, 28*(7), 2505–2524. https://doi.org/10.1111/gcb.16061

McKnight Foundation, & Regenerative Agriculture Foundation. (2025). *Nitrous oxide—a hidden threat: Pathways for industry & agriculture to reduce emissions from synthetic fertilizer*. https://www.mcknight.org/wp-content/uploads/Nitrous-Oxide-A-Hidden-Threat-Pathways-for-Industry-Agriculture-to-Reduce-Emissions-from-Synthetic-Fertilizer.pdf

Milligan, L. (2026, March 17). *U.S. Department of Justice opens investigations into U.S. fertilizer market*. CropLife. https://www.croplife.com/crop-inputs/fertilizer/u-s-department-of-justice-opens-investigations-into-u-s-fertilizer-market/

Mingolla, S., & Rosa, L. (2025). Low-carbon ammonia production is essential for resilient and sustainable agriculture. *Nature Food, 6*, 610–621. https://doi.org/10.1038/s43016-025-01125-y

Mingolla, S., & Rosa, L. (2026). Techno-economic feasibility of centralized and decentralized ammonia production in the United States. *Renewable and Sustainable Energy Reviews, 226*, Article 116486. https://doi.org/10.1016/j.rser.2025.116486

Monaco, H., Paulson, N., & Schnitkey, G. (2025, May 29). Trends in fertilizer use and efficiency in the U.S. *farmdoc daily, 15*(98). Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign. https://farmdocdaily.illinois.edu/2025/05/trends-in-fertilizer-use-and-efficiency-in-the-us.html

Morão, H. (2025). The economic consequences of fertilizer supply shocks. *Food Policy, 133*, Article 102835. https://doi.org/10.1016/j.foodpol.2025.102835

Motsomane, N., & Magadlela, A. (2026). Legume-grass intercropping systems improve soil health and plant nutrition. *Plant and Soil*. https://doi.org/10.1007/s11104-026-08380-3

Nafziger, E. (2021). *Nitrogen management for corn (Agronomy Handbook Chapter 9)*. Illinois Extension; Illinois Fertilizer & Chemical Association. https://extension.illinois.edu/sites/default/files/iah_-_nitrogen_management_for_corn_v4.pdf

Natural Resources Defense Council. (2025, September). *Too much of a good thing: Overapplication of nitrogen fertilizer endangers human and environmental health* (Fact Sheet No. FS: 25-09-B). https://www.nrdc.org/sites/default/files/2025-09/too-much-of-a-good-thing-fs.pdf

Park, B., Rejesus, R. M., Aglasan, S., Che, Y., Hagen, S. C., & Salas, W. (2023). Payments from agricultural conservation programs and cover crop adoption. *Applied Economic Perspectives and Policy, 45*(2), 984–1007. https://doi.org/10.1002/aepp.13248

Paulson, N., Schnitkey, G., Monaco, H., & Zulauf, C. (2026, March 24). Nitrogen prices remain in focus after Iran conflict. *farmdoc daily, 16*(49). Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign. https://farmdocdaily.illinois.edu/2026/03/nitrogen-prices-remain-in-focus-after-iran-conflict.html

Peoples, M. B., Li, X., Kirkegaard, J. A., Armstrong, R. D., Ciampitti, I. A., Franke, A. C., Giller, K. E., Hunt, J. R., Jeuffroy, M.-H., Ladha, J. K., Lemaire, G., Li, L., Palmero, F., Reckling, M., Salvagiotti, F., Sida, T. S., Swan, A. D., Zhang, S., & Herridge, D. F. (2026). Integrating legumes to enhance cereal production: The relative inputs of fertiliser nitrogen and legume biological nitrogen fixation in major wheat and maize producing countries. *Plant and Soil*. https://doi.org/10.1007/s11104-025-08245-1

Pi, H.-W., Lin, J.-J., Chen, C.-A., Wang, P.-H., Chiang, Y.-R., Huang, C.-C., Young, C.-C., & Li, W.-H. (2022). Origin and evolution of nitrogen fixation in prokaryotes. *Molecular Biology and Evolution*, *39*(9), Article msac181. https://doi.org/10.1093/molbev/msac181

Ramsey, S., Williams, B., Jarrell, P., & Hubbs, T. (2023, February). *Global demand for fuel ethanol through 2030 (Report No. BIO-05)*. U.S. Department of Agriculture, Economic Research Service. https://ers.usda.gov/sites/default/files/_laserfiche/outlooks/105762/BIO-05.pdf?v=19326

Rockström, J., Thilsted, S. H., Willett, W. C., Gordon, L. J., Herrero, M., Hicks, C. C., Mason-D'Croz, D., Rao, N., Springmann, M., Wright, E. C., Agustina, R., Bajaj, S., Bunge, A. C., Carducci, B., Conti, C., Covic, N., Fanzo, J., Forouhi, N. G., Gibson, M. F., . . . DeClerck,

F. (2025). The EAT–Lancet Commission on healthy, sustainable, and just food systems. *The Lancet, 406*(10512), 1625–1700. https://doi.org/10.1016/S0140-6736(25)01201-2

Roesch-McNally, G. E., Arbuckle, J. G., & Tyndall, J. C. (2018). Barriers to implementing climate resilient agricultural strategies: The case of crop diversification in the U.S. Corn Belt. *Global Environmental Change, 48*, 206–215. https://doi.org/10.1016/j.gloenvcha.2017.12.002

Schnitkey, G., Zulauf, C., Paulson, N., & Baltz, J. (2026, March 17). The Iran conflict: Potential impacts on 2026 corn and soybean returns. *farmdoc daily, 16*(45). Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign. https://farmdocdaily.illinois.edu/2026/03/the-iran-conflict-potential-impacts-on-2026-corn-and-soybean-returns.html

Semba, R. D., Rahman, N., Du, S., Ramsing, R., Sullivan, V., Nussbaumer, E., Love, D., & Bloem, M. W. (2021). Patterns of legume purchases and consumption in the United States. *Frontiers in Nutrition, 8*, 732237. https://doi.org/10.3389/fnut.2021.732237

Siegrist, M., Michel, F., & Hartmann, C. (2024). The shift from meat to plant-based proteins: Consumers and public policy. *Current Opinion in Food Science, 58*, Article 101182. https://doi.org/10.1016/j.cofs.2024.101182

Swan, T., McBratney, A., & Field, D. (2024). Linkages between Soil Security and One Health: implications for the 2030 Sustainable Development Goals. *Frontiers in public health, 12*, 1447663. https://doi.org/10.3389/fpubh.2024.1447663

Swanson, K. (2025, June). *A study of the economic contribution of corn farming in the United States for 2024*. National Corn Growers Association. https://dt176nijwh14e.cloudfront.net/file/800/Economic%20Contribution%20Summary%206-2025.pdf

Swanson, K. (2026, February). *America's farms: Past, present, and future*. National Corn Growers Association. https://ncga.com/stay-informed/media/the-corn-economy/article/2026/02/americas-crop-at-risk-the-future-of-corn-and-family-farms

Swanson, K, & Kuck, G. (2026, January). *Economic outlook – 2026 Q1*. National Corn Growers Association. https://www.ncga.com/stay-informed/media/the-corn-economy/article/2026/01/economic-outlook-2026-q1

Szmurlo, D., & Burnett, J. W. (2024, August 19). *Cover crop adoption rates vary across regions and tenure in corn production*. U.S. Department of Agriculture, Economic Research Service. https://www.ers.usda.gov/data-products/charts-of-note/chart-detail?chartId=109750

2025 Dietary Guidelines Advisory Committee. (2024). *Scientific report of the 2025 Dietary Guidelines Advisory Committee: Advisory report to the Secretary of Health and Human Services and Secretary of Agriculture*. U.S. Department of Health and Human Services.

https://www.dietaryguidelines.gov/sites/default/files/2024-12/Scientific_Report_of_the_2025_Dietary_Guidelines_Advisory_Committee_508c.pdf

U.S. Department of Agriculture. (2026, February 19). *Grains and oilseeds outlook for 2026*. https://www.usda.gov/sites/default/files/documents/2026AOF-grains-oilseeds-outlook.pdf

U.S. Department of Agriculture, Agricultural Marketing Service. (2026a). *Fertilizer transportation dashboard*. Open Ag Transport Data. https://agtransport.usda.gov/stories/s/Fertilizer-Transportation-Dashboard/dtqv-e4ux/

U.S. Department of Agriculture, Agricultural Marketing Service. (2026b). *Fertilizer prices by region (using data from Green Markets, a Bloomberg Company)* [Data set]. Open Ag Transport Data. https://agtransport.usda.gov/Fertilizer/Fertilizer-Prices-by-Region/8bgf-5mdv/about_data

U.S. Department of Agriculture, Economic Research Service. (2025a, April 17). *Corn and other feed grains - feed grains sector at a glance*. https://www.ers.usda.gov/topics/crops/corn-and-other-feed-grains/feed-grains-sector-at-a-glance

U.S. Department of Agriculture, Economic Research Service. (2025b, November 13). *Fertilizer use and price: Documentation and data sources* [Data set]. https://www.ers.usda.gov/data-products/fertilizer-use-and-price/documentation-and-data-sources

U.S. Department of Agriculture, Economic Research Service. (2026, March 11). *Feed grains yearbook tables* [Data set]. https://www.ers.usda.gov/data-products/feed-grains-database/feed-grains-yearbook-tables

U.S. Department of Agriculture, Economic Research Service & U.S. Department of Agriculture, Foreign Agricultural Service. (2026, February 27). *Outlook for U.S. agricultural trade: February 2026* (Report No. AES-135). https://ers.usda.gov/sites/default/files/_laserfiche/outlooks/113912/AES-135.pdf?v=83719

U.S. Department of Agriculture, Foreign Agricultural Service. (2026). *Production – Corn*. https://www.fas.usda.gov/data/production/0440000

U.S. Department of Agriculture, National Agricultural Statistics Service. (2026, January). *Crop production 2025 summary*. https://esmis.nal.usda.gov/sites/default/release-files/795725/cropan26.pdf

U.S. Department of Agriculture & U.S. Department of Health and Human Services. (2026, January). *Dietary Guidelines for Americans, 2025–2030*. https://cdn.realfood.gov/DGA.pdf

U.S. Environmental Protection Agency. (2024, October 3). *2011–2023 greenhouse gas reporting program sector profile: Chemicals sector (non-fluorinated)*. https://www.epa.gov/system/files/documents/2024-10/chemical_profile_ry2023-10-03-2024.pdf

van Dooren, C., Loken, B., Lang, T., Meltzer, H. M., Halevy, S., Neven, L., Rubens, K., Seves-Santman, M., & Trolle, E. (2024). The planet on our plates: approaches to incorporate environmental sustainability within food-based dietary guidelines. *Frontiers in Nutrition, 11*, 1223814. https://doi.org/10.3389/fnut.2024.1223814

Williams, A., Collins, L. A., & Boline, A. (2025). *Drivers of fertilizer markets: Supply, demand, and prices* (Economic Research Report No. 354). U.S. Department of Agriculture, Economic Research Service. https://ers.usda.gov/sites/default/files/_laserfiche/publications/113324/ERR-354.pdf?v=56658

Wongpiyabovorn, O., & Hart, C. (2024). Examining the factors of fertilizer pricing. *Journal of the Agricultural and Applied Economics Association, 3*, 572–583. https://doi.org/10.1002/jaa2.133

Yanni, A. E., Iakovidi, S., Vasilikopoulou, E., & Karathanos, V. T. (2024). Legumes: A vehicle for transition to sustainability. *Nutrients, 16*(1), Article 98. https://doi.org/10.3390/nu16010098