farmdoc DAILY

Agricultural, Consumer & Environmental Sciences | University of Illinois Urbana-Champaign

# Conservation & Risk, Part 4: Approaching the Nitrogen Application Question

**Jonathan Coppess, Menglin Liu, Emily Judith Diaz-Vallejo and Natalie Loduca**

**Department of Agricultural and Consumer Economics**
**University of Illinois**

**September 10, 2026**

***farmdoc daily* (16): 162**

**Gardner Policy Series**

Recommended citation format: Coppess, J., L. Menglin, E. J. Diaz-Vallejo, and N. Loduca. "Conservation & Risk, Part 4: Approaching the Nitrogen Application Question." *farmdoc daily* (16): 162, Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign, September 10, 2026.

Permalink: https://farmdocdaily.illinois.edu/2026/09/conservation-risk-part-4-approaching-the-nitrogen-application-question.html

From fertilizer costs to nutrients lost, the issues and challenges of nitrogen continue for row crop agriculture. They are magnified in the moment by the conflict in Iran and the closure of the Strait of Hormuz, adding complications at a difficult time for farmers—higher prices going into harvest and the time when many will be booking fertilizer purchases for the next crop year (*farmdoc daily*, August 25, 2026; August 11, 2026; June 9, 2026; May 26, 2026; May 5, 2026; April 29, 2026; March 31, 2026; March 24, 2026; March 23, 2026; April 18, 2024; January 15, 2024; January 4, 2024; Draper, June 16, 2026; Wong, Crowley and Schmitt, July 12, 2026; Baker, July 13, 2026). To date, much of the impact on fertilizer has been felt more globally than domestically, but the continued instability and chaos in that critical region of the world is not likely to remain outside American shores for long (Hernandez, July 3, 2026; Cullen, June 3, 2026; Hebebrand et al., April 1, 2026; Clayton, June 12, 2026; Webster and Burnett, March 23, 2026). Concerns acknowledged, this article continues the discussion of work under a cooperative agreement with USDA's Natural Resources Conservation Service (NRCS) to explore questions of risk and conservation practices (*farmdoc daily*, May 28, 2026; May 21, 2026; May 7, 2026). Below, we discuss applying research to develop a risk framework for nitrogen application and management.

## Background

From the vast (and it is quite vast) literature on nitrogen use, management, and loss in row crop farming a common theme is easily discernible (*farmdoc daily*, April 18, 2024; December 7, 2023; January 4, 2024; January 15, 2024). Nitrogen is critical to crop production, especially corn; crop production is critical to meeting food demand from a growing population; nitrogen applied but not consumed by the crop, however, is at high risk of being lost to waterways, becoming a form of pollution. From this, the focus turns immediately to farmers and generally narrows to whether farmers are overapplying nitrogen, especially synthetic forms of nitrogen produced using fossil fuels.

Recommendations for nitrogen (N) application rates have evolved from yield-based methods to profit-maximizing approaches (Camberato, 2015). The latter aims to improve farmer profitability while reducing

N losses to the environment by suggesting a lower rate. Regionally uniform rates, recommended by university research in six major corn belt states, are expected to maximize the average return to N based on multi-site-year field trials and the prices of corn and N (Corn Nitrogen Rate Calculator; Sawyer et al., 2006). Although these rates have long been promoted, many farmers still apply N at rates exceeding recommendations or follow yield-goal approaches (Arbuckle and Rosman, 2014; Houser, 2022; Sellars, Schnitkey and Gentry, 2020; Wade, Claassen and Wallendar, December 2015).

The agronomic and economic optimal N application rates are uncertain due to uncertainties in weather and soil conditions and in market prices for inputs and outputs (Correndo et al., 2021; Lobell, 2007; Morris et al. 2018; Palmero et al. 2026; Sawyer et al., 2006). Farmers are aware of these uncertainties and tend to apply rates higher than those based on average weather and soil conditions. Farmers apply for good weather years, believing that a higher rate is required in those years to achieve yield potential, and expect to receive higher multi-year average profits (Babcock, 1992). This aligns with many farmers' behavior of not changing N application rates over the years. However, this could lead to fertilizer losses in some years.

**Discussion**

Any discussion about nitrogen application in corn fields should begin and end with yields; everything else, from farm revenue and profits, etc., is downstream from crop yields. To the farmer's management, in other words, bushels in the bin might be worth more than dollars in the bank. Accordingly, the application of research to the nitrogen question in this overall effort is focused on the risk to the farmer of a conservation practice, primarily the potential yield risk of implementing a practice. For this article, the question is the risk to yield from reductions in the application rate of nitrogen.

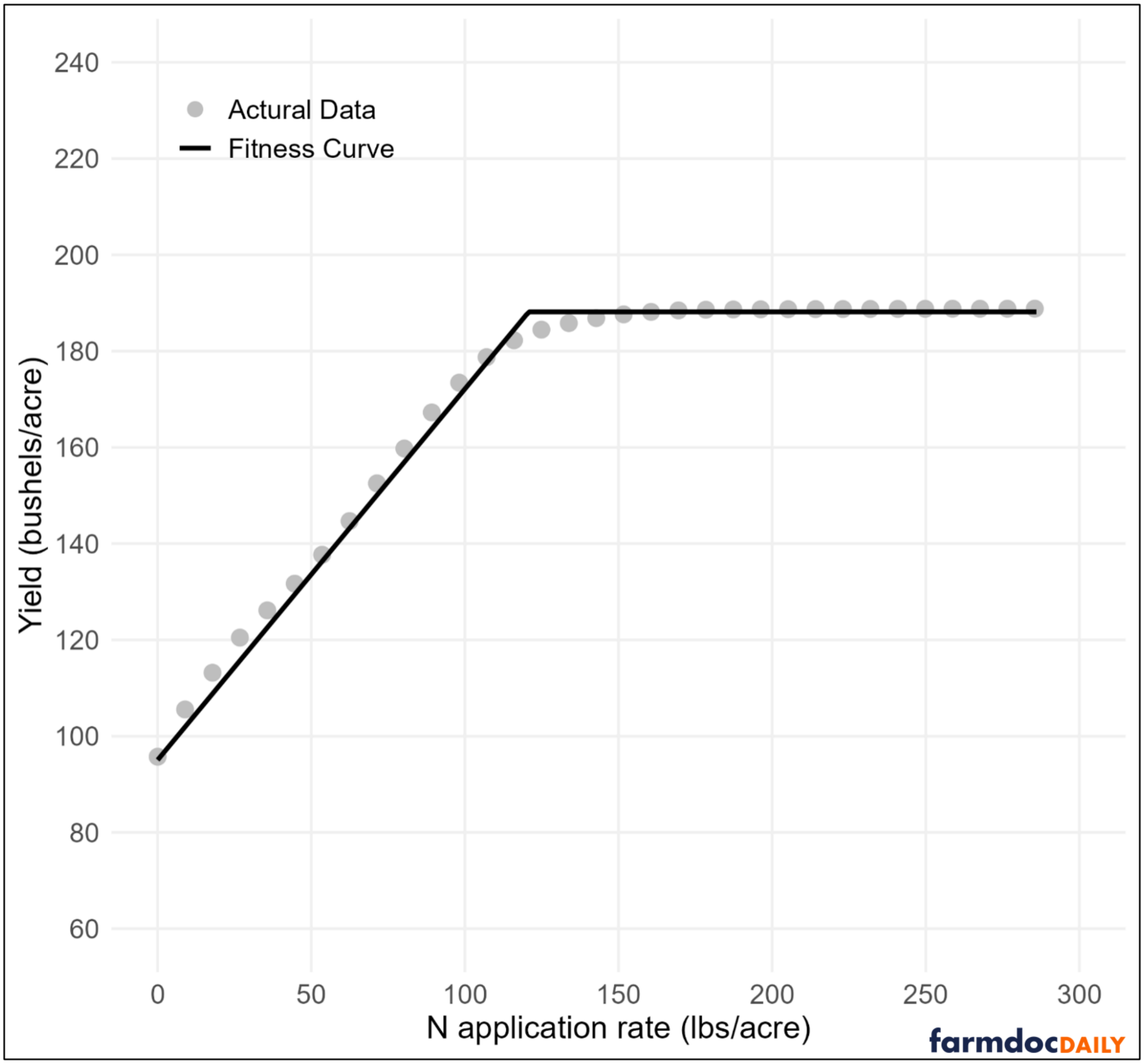
From that perspective, consider that the farmer's yield expectations are unlikely to match county or other area averages, which tend to be used by researchers and others. In fact, the farmer's expectations are most likely to be higher and planning is likely to be based on yields above what crop insurance would cover. For example, the 2027 yield expectations on high productivity farm ground in central Illinois for corn following soybeans is 245 bushels per acre (*farmdoc daily*, September 1, 2026). The average yield for the 10 previous crop years, which would roughly approximate an APH (Actual Production History) used for crop insurance is 219 bushels per acre (*farmdoc*, "Historic Crop Budgets: Budgets For All Regions." Management). An insurance policy at 85% coverage would insure yields at 186 bushels per acre, with the farmer responsible for the first 33 bushels per acre of any loss, known as the deductible range.

It would be the rare farmer who seeks to add risk to the operation by experimenting with fertilizer applications, and the rare banker who wants to lend to such risk-taking. Crop insurance is also built upon yield histories, mostly the ten-year APH with trend adjustments (*farmdoc daily*, March 15, 2022; April 29, 2025). The fertilizer industry certainly knows this well, and any advice to farmers, as well as all marketing and pricing plans, would undoubtedly account for these realities. The only matter that does not, importantly, is the financial assistance offered by conservation policy.

To begin constructing a risk framework for nitrogen application practices (i.e., reductions in rates), we applied existing research, using data produced by a biophysical model (APSIM), validated across hundreds of field trials, to chart the relationship between yield and applied N (Liu, 2026; Mandrini et al., 2022). In the APSIM model, the crop management practices are held constant (e.g., tillage, crop variety, plant population, planting date, and fertilizer application timing). This way, the yield variations across the years are the modeled results due to weather and weather-induced soil conditions at the different N application rates along the curve. As is well known, and similar to field trials, model simulations can often yield results that deviate from the observational data. The model assumptions may not reflect all the real-world matters, such as increased yield trends attributed to genetic improvements (*farmdoc daily*, June 25, 2025). For example, the model simulations use the corn hybrid widely used in research around 2014 – 2015, and the modeled yield is most likely higher than the reported historical yield before this timeframe but lower after it. Other differences in the model simulations include soil quality and characteristics, which would differ at the subfield level used in the model compared to all fields in a county or even the average of the county.

With those matters in mind, Figure 1 illustrates the model simulated data points for an example subfield (one soil type) within a 100-acre field in McLean County, Illinois, in 2018. To those data points, the line illustrates the estimated relationship between yield and applied N (fitted curve). The curve used to fit the data is obtained by estimating a stochastic linear plateau production function that allows parameters to vary across weather conditions (years) and then substituting actual 2018 weather data back into the estimated function. The linear plateau production function is the best-fitting function across the entire dataset compared to the quadratic and quadratic plateau production functions. The yield response curves at the field level are obtained by aggregating the linear plateau production functions estimated at the subfield (soil-type) level, using the subfield areas as weights. Finally, note that the actual McLean County, Illinois average yield for corn in 2018 was reported at 229 bushels per acre (*farmdoc daily*, April 9, 2019; USDA-NASS, Quickstats).

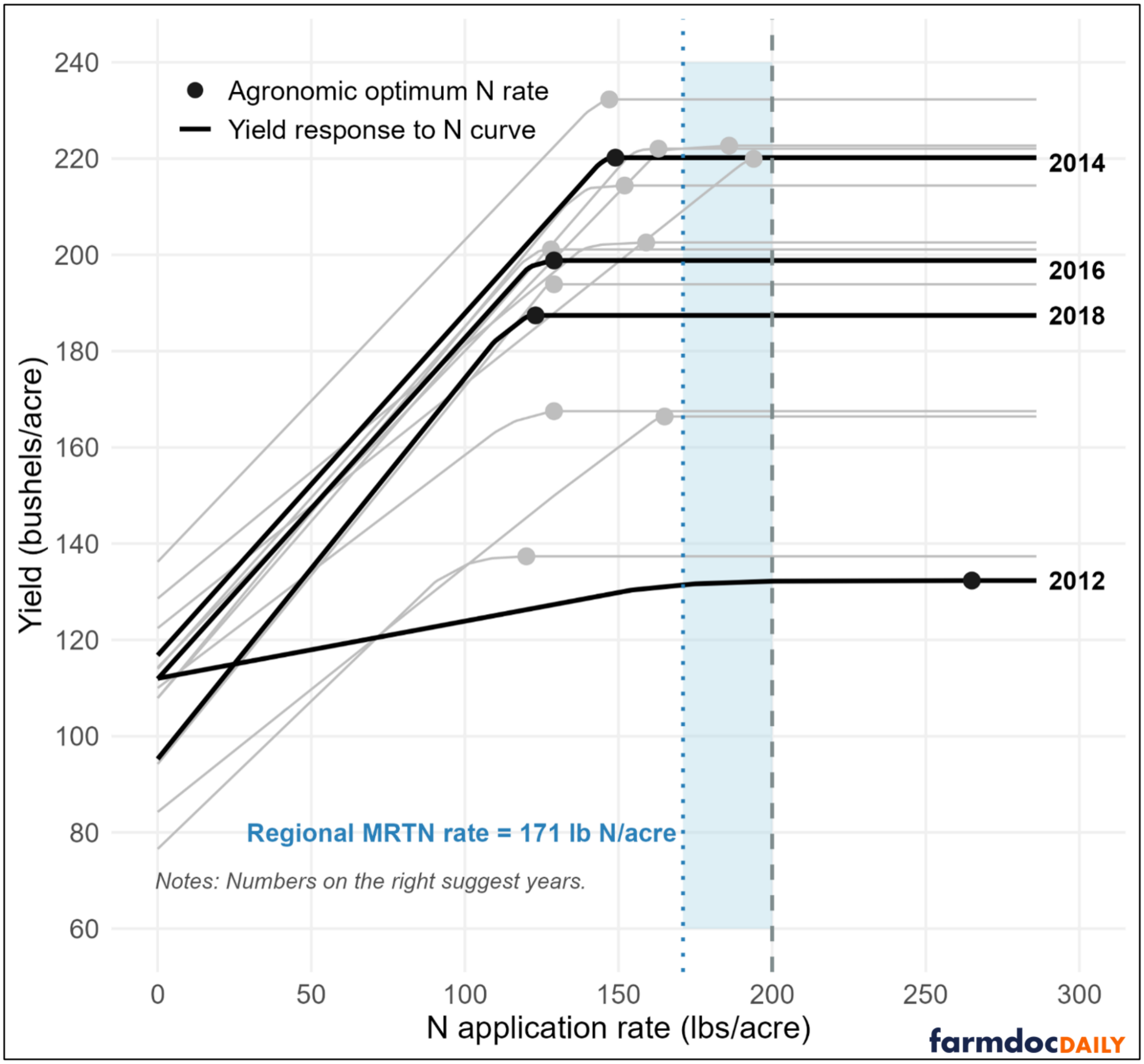
**Figure 1. Model Simulated Corn Yield Response to Varied Nitrogen Application Rates in a Subfield in McLean County, IL, Using 2018 Weather Conditions.**




Using that methodology, Figure 2 illustrates the uncertainty in determining the optimal N application rates under weather uncertainty. The lines are the yield response to N application rate curves for every other year between 1990 and 2018 at the same example field as in Figure 1. As noted above, the yield variations across the years are the modeled results based on the weather in those years, and the weather-induced soil conditions. The dots in Figure 2 represent the agronomic optimum N application rate, the N application rate at which the yields plateau and stop increasing with increased rates of N. Overall in Figure 2, modeled corn yields ranged from 77 to 136 bushels per acre without any N fertilizer application, while yield potentials range from 132 to 232 bushels per acre and the agronomic optimum N application rates (shown as points) ranged from 120 to 265 lb. N/acre.

Figure 2 also includes two lines and a shaded region between two N application rates. The dotted line is at 171 lb. N/acre, representing the Maximum Return to Nitrogen (MRTN) calculator for central Illinois at current prices (https://www.cornnratecalc.org/calculator). The regional MRTN rate was calculated based on anhydrous ammonia price ($1057.5/ton or $0.645/lb N) on June 26, 2026 (USDA-AMS) and corn price ($4.56/bushel) in May 2026 (USDA-NASS).

**Figure 2. Model Simulated Corn Yield Responses to Varied Nitrogen Application Rates for a Field in McLean County, IL, with N Curves and Agronomic Optimum N Rates Under Observed Weather Conditions, 1990-2018.**




The curves and points in Figure 2 suggest that the optimal N application rate is not necessarily higher in more favorable weather years or in years with higher yield potential. Applying N above the optimal rate has costs to the farmer based on the additional pounds of N not consumed by the plant. To demonstrate this point, Table 1 uses reported anhydrous ammonia prices to estimate the excessive N costs based on the modeled agronomic optimum rate for a farmer who applied 200 lb. N/acre every other year from 1990 to 2018. The national average prices in and before 2014 are obtained from the Fertilizer Use and Price summary from USDA-ERS, while prices in 2016 – 2018 are calculated based on March prices published in the Illinois Production Cost Report from USDA-AMS. The price of anhydrous ammonia fluctuates year over year, but the general trend is upward. The costs are affected by both fertilizer prices and the agronomic optimum N application rate, or the difference between that rate and 200 lb. N/acre. The estimated cost of excessive N application varies from $1 to $26/acre across the years, with the highest costs in 2014, 2016, and 2018 when N prices were relatively high.

**Table 1. The costs of the excessive N vs. Yield losses**

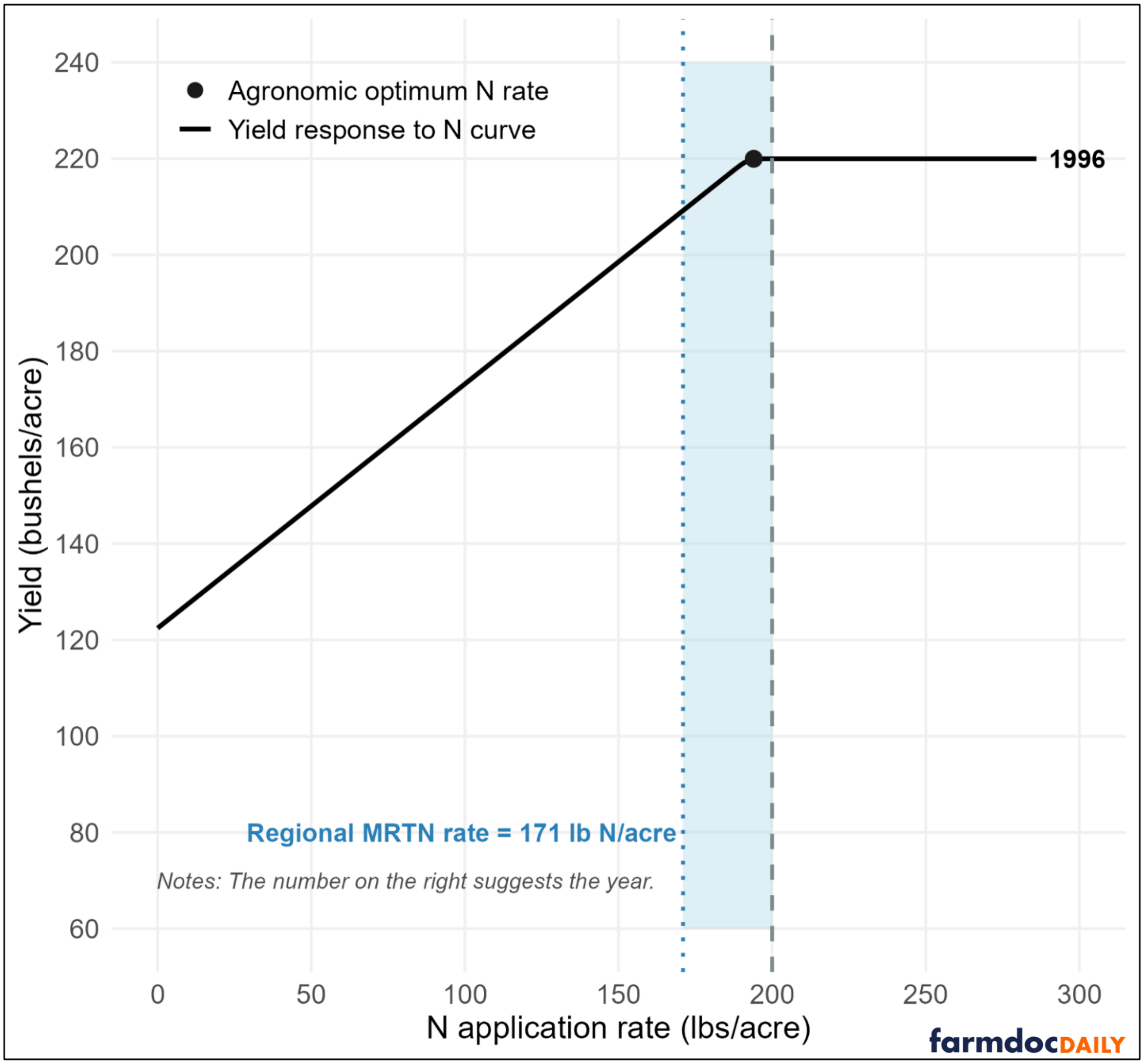
| Year | Anhydrous ammonia price used ($/ton) | Estimated costs of the excessive N if applied 200 lb N/acre ($/acre) | Yield losses if applied 171 lb N/acre (bushel/acre) |
|---|---|---|---|
| 1990 | 199 | 6 | 0 |
| 1992 | 208 | 9 | 0 |
| 1994 | 243 | 12 | 0 |
| 1996 | 303 | 1 | 10.8 |
| 1998 | 253 | 11 | 0 |
| 2000 | 227 | 2 | 0.6 |
| 2002 | 250 | 5 | 0 |
| 2004 | 379 | 12 | 0 |
| 2006 | 521 | 23 | 0 |
| 2008 | 755 | 17 | 0 |
| 2010 | 499 | 12 | 0 |
| 2012 | 785 | 0 | 0.9 |
| 2014 | 851 | 26 | 0 |
| 2016 | 563 | 24 | 0 |
| 2018 | 519 | 24 | 0 |

The potential excessive costs in Table 1 are one component of the risk to the farmer in the N application decision. The primary risk, however, is that reducing N applications may result in yield losses, especially from budget expectations or crop insurance APH. As noted above, any yield loss in the deductible range, before crop insurance indemnities kick in, is absorbed by the farmer and Table 1 includes estimated yield losses at the MRTN rate of 171 lb. N/acre.

Ultimately, the risk of yield loss depends on both weather conditions and the reduced N application rate. Notably, there was not an estimated yield loss in 2018 from the lower MRTN rate because favorable weather conditions estimated an optimal rate below MRTN, which was estimated to be 123 lbs. N/acre. Yield losses in relatively favorable weather years can occur, however, and can be significant to the farmer.

To further examine the risk framework, Figure 3 illustrates the 1996 model simulated yield curve. That year, the optimal rate is estimated to be much closer to 200 lb. N/acre and the expected yield loss that year from reducing the N rate to 171 lb. N/acre is nearly 11 bushels per acre. Based on the weather conditions in 1996, these results suggest that applying more nitrogen—more pounds above the 171 MRTN rate—would have produced more bushels of corn and a higher yield.

**Figure 3. Example of yield loss risk due to N rate reduction, 1996**




As has been well documented, excess N leads to N leaching and greenhouse gas emissions, causing water contamination, hypoxia, and contributing to climate change (see e.g., Gu et al., 2023; Houser, Irvine and Marquart-Pyatt, 2023; Houser, 2022; Houser and Stuart, 2019; Rabotyagov et al., 2014; Peel et al., 2013; Savci, 2012; Townsend and Howarth, 2010; Almasri and Kaluarachchi, 2004; see also, *farmdoc daily*, April 18, 2024; Rose et al., May 15, 2026; Calderon, November 30, 2021). Research continues to find that reducing N application rates could reduce the farmer's costs, as well as reduce the consequences that follow from having excess nitrogen in farm fields (see e.g., *Precision Conservation Management*, 2026; Kim et al., 2021; Eagle et al. (2013). Designing conservation policy to account for the risk of yield losses could be an effective way to achieve a reduction in the consequences, while avoiding an additional burden on the farmer who lowers rates.

## Concluding Thoughts

Reducing nitrogen application rates for corn presents a very real risk of reduced yields in any crop year and should be understood as the major obstacle for farmers. Even a relatively small yield loss can have real cost consequences to the farmer—11 bushels on a field averaging 220 bushels per acre is a 5% yield loss but falls squarely in the deductible range for crop insurance and could cost the farmer between $44 and $55 per acre, depending on the price of corn. Not only are these costs not covered by crop insurance, they are also not a factor in the financial assistance for reducing N application rates from conservation programs like the Environmental Quality Incentives Program (EQIP). The potential costs of reducing N application rates will vary from year-to-year, mostly depending on the weather. This article discussed efforts to quantify the probability and severity of yield losses under varying weather conditions and N application rates. This application of research to the yield risk question is part of an ongoing effort to build a risk framework for conservation policy design as part of a cooperative agreement with USDA's Natural Resources Conservation Service (NRCS) (*farmdoc daily*, May 28, 2026; May 21, 2026; May 7, 2026).

The farmer's framework for managing risk is likely to consider that bushels in the bin could be worth more than dollars in the bank. In other words, the risk that some amount of N application costs fails to produce higher yields is substantially outweighed by the risk that reduced N application rates could result in lower yields. It all depends on the weather and the year, matters which cannot be known when fertilizer is purchased and applied. Every other influence on the farmer's application rate decision knows this and applies it, from crop insurance to the banker and the fertilizer industry. Conservation policy, to be effective in this reality, will need to be designed so that financial assistance also responds to the yield risk of the practice. The next article in this series will look closer at the gap between that financial assistance and the yield risks or costs to the farmer from implementing a nitrogen reduction practice.

**References**

Almasri, Mohammad N., and Jagath J. Kaluarachchi. "Assessment and management of long-term nitrate pollution of ground water in agriculture-dominated watersheds." *Journal of Hydrology* 295, no. 1-4 (2004): 225-245. https://www.sciencedirect.com/science/article/pii/S0022169404001775.

Arbuckle, J. Gordon and Hanna Rosman. "Iowa Farmers' Nitrogen Management Practices and Perspectives." Iowa State University Digital Repository. May 1, 2014. https://dr.lib.iastate.edu/entities/publication/0feef8f6-274a-44a5-b720-72682342ecd8.

Arita, S., M. Wang, J. Kim, R. Chakravorty and S. Steinbach. "Strait of Hormuz Disruption Scenarios and Fertilizer Purchasing Risks for U.S. Crop Producers." *farmdoc daily* (16):75, Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign, April 29, 2026.

Arita, S., R. Chakravorty, J. Kim, W. Y. Lwin and S. Steinbach. "Strait of Hormuz Closure and Fertilizer Supply Risks for U.S. Agriculture." *farmdoc daily* (16):48, Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign, March 23, 2026.

Bruce A. Babcock, The Effects of Uncertainty on Optimal Nitrogen Applications, *Applied Economic Perspectives and Policy*, Volume 14, Issue 2, July 1992, Pages 271–280, https://doi.org/10.2307/1349506.

Baker, Peter. "Trump Says Fighting With Iran Has Resumed as He Orders Blockade and Tolls." *The New York Times*. July 13, 2026. https://www.nytimes.com/2026/07/13/us/politics/trump-iran-ceasefire.html.

Baum, M.E., Sawyer, J.E., Nafziger, E.D. et al. "The optimum nitrogen fertilizer rate for maize in the US Midwest is increasing." *Nature Communications* 16, 404 (2025). https://doi.org/10.1038/s41467-024-55314-7.

Calderon, Ignacio. "Fertilizer washes off Midwest farm fields and taints communities' drinking water, poisons Gulf of Mexico." *Investigate Midwest*. November 30, 2021. https://investigatemidwest.org/2021/11/30/excess-fertilizer-washed-from-midwestern-fields-is-slowly-poisoning-the-gulf-of-mexico//.

Clayton, Chris. "Fertilizer Concerns Remain Over Strait." DTN/Progressive Farmer. June 12, 2026. https://www.dtnpf.com/agriculture/web/ag/columns/washington-insider/article/2026/06/12/mosaic-executive-warns-fertilizer.

Coppess, J., E. J. Diaz-Vallejo, Y. Qin and K. Guan. "Conservation & Risk, Part 2: Examining the Spring Planting Window in Illinois." *farmdoc daily* (16):89, Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign, May 21, 2026.

Coppess, J., S. Ruppert and M. Skidmore. "A Menace Reconsidered, Part 4: Losing Nitrogen." *farmdoc daily* (14):74, Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign, April 18, 2024.

Coppess, J., S. Ruppert and M. Skidmore. "A Menace Reconsidered, Part 4: Losing Nitrogen." *farmdoc daily* (14):74, Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign, April 18, 2024.

Correndo, Adrian A., Jose L. Rotundo, Nicolas Tremblay, Sotirios Archontoulis, Jeffrey A. Coulter, Dorivar Ruiz-Diaz, Dave Franzen et al. "Assessing the uncertainty of maize yield without nitrogen fertilization." *Field Crops Research* 260 (2021): 107985. https://doi.org/10.1016/j.fcr.2020.107985.

Cullen, Maximo Torrero. "The Clock Is Ticking: Fertilizer, Food, and the Fragility of Global Agriculture." Council on Foreign Relations. June 3, 2026. https://www.cfr.org/articles/the-clock-is-ticking-fertilizer-food-and-the-fragility-of-global-agriculture.

Draper, Kevin. “War Hangs Over American Farmers as Fertilizer Prices Rise.” *The New York Times*. June 16, 2026.
https://www.nytimes.com/2026/06/16/business/fertilizer-farming-iran.html.

Eagle, Alison J., Lydia P. Olander, Lucy R. Henry, Karen Haugen-Kozyra, Neville Millar, and G. Philip Robertson. “Greenhouse Gas Mitigation Potential of Agricultural Land Management in the United States: A Synthesis of the Literature (Third Edition).” Nicholas Institute for Energy, Environment & Sustainability. Duke University. January 2012.
https://nicholasinstitute.duke.edu/ecosystem/land/TAGGDLitRev.

Gu, B., Zhang, X., Lam, S.K. *et al.* “Cost-effective mitigation of nitrogen pollution from global croplands.” *Nature* **613**, 77–84 (2023). https://doi.org/10.1038/s41586-022-05481-8.

Hebebrand, Charlotte, Joseph Glauber, Rob Vos, and Brendan Rice. “The Iran war’s impacts on global fertilizer markets and food production.” *IFPRI*. April 1, 2026.
https://www.ifpri.org/blog/the-iran-wars-impacts-on-global-fertilizer-markets-and-food-production/.

Hernandez, Joe. “How a fertilizer shortage caused by the Iran war could affect U.S. food prices.” *NPR.org*. July 3, 2026.
https://www.npr.org/2026/07/03/nx-s1-5877344/fertilizer-shortage-food-prices.

Hosen, M.H.A., Das, S., Burns, G.L. *et al.* Nitrogen fertilizer use in agroecosystems: current practices, policies and recommendations for efficiency improvement. *J Soils Sediments* **26**, 225 (2026). https://doi.org/10.1007/s11368-026-04423-5.

Houser, M. (2022). Farmer motivations for excess nitrogen use in the US Corn Belt. *Case Studies in the Environment*, *6*(1), 1688823. https://doi.org/10.1525/cse.2022.1688823.

Houser, Matthew, Rachel Irvine, and Sandra Marquart-Pyatt. "How Row-Crop Farmers Adapted Nitrogen Management in Response to Market Volatility: Evidence from Interviews in the United States Midwest." *Society & Natural Resources* 38, no. 9 (2025): 985-1002.
https://doi.org/10.1080/08941920.2025.2494016.

Houser, Matthew, and Diana Stuart. "An accelerating treadmill and an overlooked contradiction in industrial agriculture: Climate change and nitrogen fertilizer." *Journal of Agrarian Change* 20, no. 2 (2020): 215-237. https://doi.org/10.1111/joac.12341.

Kim, Taegon, Zhenong Jin, Timothy M. Smith, Licheng Liu, Yufeng Yang, Yi Yang, Bin Peng et al. "Quantifying nitrogen loss hotspots and mitigation potential for individual fields in the US Corn Belt with a metamodeling approach." *Environmental Research Letters* 16, no. 7 (2021): 075008.
https://iopscience.iop.org/article/10.1088/1748-9326/ac0d21.

Liu, Menglin. “Three Essays on the Adoption of Sustainable Agricultural Production Practices.” Ph.D. Dissertation, University of Illinois Urbana-Champaign, 2026.

Lobell, David B. "The cost of uncertainty for nitrogen fertilizer management: A sensitivity analysis." *Field Crops Research* 100, no. 2-3 (2007): 210-217.
https://doi.org/10.1016/j.fcr.2006.07.007.

Loduca, N., J. Coppess, E. J. Diaz-Vallejo, Y. Qin and K. Guan. "Conservation & Risk, Part 3: Exploring the Risk-Payment Gap." *farmdoc daily* (16):93, Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign, May 28, 2026.

Mandrini, German, Eric A. Davidson, Emerson D. Nafziger, Alison J. Eagle, Cameron M. Pittelkow, Laura F. Gentry, Gary D. Schnitkey et al. "A market-based insurance approach aligns environmental and economic outcomes in maize nitrogen management." *Communications Earth & Environment* (2025).
https://www.nature.com/articles/s43247-025-03008-3.

Monaco, H., N. Paulson, G. Schnitkey and C. Zulauf. "Consolidation Trends in the U.S. Nitrogen Fertilizer Industry." *farmdoc daily* (16):91, Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign, May 26, 2026.

Morris, T.F., Murrell, T.S., Beegle, D.B., Camberato, J.J., Ferguson, R.B., Grove, J., Ketterings, Q., Kyveryga, P.M., Laboski, C.A.M., McGrath, J.M., Meisinger, J.J., Melkonian, J., Moebius-Clune, B.N., Nafziger, E.D., Osmond, D., Sawyer, J.E., Scharf, P.C., Smith, W., Spargo, J.T., van Es, H.M. and Yang, H. (2018), Strengths and Limitations of Nitrogen Rate Recommendations for Corn and Opportunities for Improvement. Agron. J., 110: 1-37. https://doi.org/10.2134/agronj2017.02.0112

Palmero, F., Davidson, E.A., Guan, K. *et al.* Environmental and societal costs of maize production decrease by addressing the uncertainty in nitrogen rate recommendations. *Nature Communications* 17, 2375 (2026). https://doi.org/10.1038/s41467-026-68988-y.

Paulson, N., G. Schnitkey, C. Zulauf and B. Zwilling. "Illinois Crop Budgets for 2027." *farmdoc daily* (16):157, Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign, September 1, 2026.

Paulson, N., G. Schnitkey, C. Zulauf and A. Dhakal. "Sulfur and Increasing Phosphate Fertilizer Prices." *farmdoc daily* (16):152, Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign, August 25, 2026.

Paulson, N., G. Schnitkey, R. Batts, B. Zwilling and C. Zulauf. "Fertilizer and Fuel Prices Higher Heading into Fall 2026." farmdoc daily (16):143, Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign, August 11, 2026.

Paulson, N., H. Monaco, G. Schnitkey and C. Zulauf. "Impacts of Consolidation in Ag Inputs: Evidence from a Farmer Survey." *farmdoc daily* (16):100, Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign, June 9, 2026.

Paulson, N., G. Schnitkey, C. Zulauf and L. Gentry. "High Fertilizer Prices Suggest Reconsidering Application Rates." *farmdoc daily* (16):54, Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign, March 31, 2026.

Paulson, N., G. Schnitkey, H. Monaco and C. Zulauf. "Nitrogen Prices Remain in Focus After Iran Conflict." *farmdoc daily* (16):49, Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign, March 24, 2026.

Paulson, N., G. Schnitkey and C. Zulauf. "2024 Corn and Soybean Yields." *farmdoc daily* (15):80, Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign, April 29, 2025.

Peel, J.L., Haeuber, R., Garcia, V. *et al.* Impact of nitrogen and climate change interactions on ambient air pollution and human health. *Biogeochemistry* **114**, 121–134 (2013). https://doi.org/10.1007/s10533-012-9782-4.

Quitzow, Rainer, Margarita Balmaceda, and Andreas Goldthau. "The nexus of geopolitics, decarbonization, and food security gives rise to distinct challenges across fertilizer supply chains." *One Earth* 8, no. 1 (2025). https://www.cell.com/one-earth/fulltext/S2590-3322(24)00603-1.

Rabotyagov, Sergey S., Todd D. Campbell, Michael White, Jeffrey G. Arnold, Jay Atwood, M. Lee Norfleet, Catherine L. Kling et al. "Cost-effective targeting of conservation investments to reduce the northern Gulf of Mexico hypoxic zone." *Proceedings of the National Academy of Sciences* 111, no. 52 (2014): 18530-18535. https://doi.org/10.1073/pnas.1405837111.

Rose, J.P., Dr. Daniel Rath, Arohi Sharma, Maya Korb, and Matthew Kaplan. “The Nitrogen Pollution Crisis: Fertilizer overuse is poisoning America’s water, air, and ecosystems.” NRDC. May 15, 2025. https://www.nrdc.org/resources/nitrogen-pollution-crisis.

Savci, Serpil, "An Agricultural Pollutant: Chemical Fertilizer," *International Journal of Environmental Science and Development* vol. 3, no. 1, pp. 73-80, 2012. https://www.ijesd.org/show-35-736-1.html.

Sawyer, John, Emerson Nafziger, Gyles Randall, Larry Bundy, George Rehm, and Brad Joern. "Concepts and rationale for regional nitrogen rate guidelines for corn." *Iowa State University-University Extension, Ames, Iowa* 28 (2006). https://www.cornnratecalc.org/files/PM2015.pdf.

Schnitkey, G. "2018 County Corn and Soybean Yields: Exceptional Yields in Central Illinois and the Eastern United States." *farmdoc daily* (9):63, Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign, April 9, 2019.

Schnitkey, G., C. Zulauf and N. Paulson. "Fertilizer Cost Increases Resulting from the Iran Conflict." *farmdoc daily* (16):78, Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign, May 5, 2026.

Schnitkey, G., C. Zulauf, N. Paulson, K. Swanson and J. Baltz. "Trend-Adjusted Yield Endorsement." *farmdoc daily* (12):32, Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign, March 15, 2022.

Schnitkey, G., C. Zulauf, N. Paulson, K. Swanson and J. Baltz. "Trend-Adjusted Yield Endorsement." *farmdoc daily* (12):32, Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign, March 15, 2022. https://ageconsearch.umn.edu/record/304617/files/19311.pdf.

Sellars, Sarah C., Gary D. Schnitkey, and Laura F. Gentry. "Do Illinois farmers follow university-based nitrogen recommendations?." (2020). https://ageconsearch.umn.edu/record/304617/files/19311.pdf.

Skidmore, M. and J. Coppess. "When It Rains, It Pours: Extreme Precipitation & Nutrient Loss, Part 2." *farmdoc daily* (14):3, Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign, January 4, 2024.

Skidmore, M. and J. Coppess. "When It Rains, It Pours: Extreme Precipitation & Nutrient Loss, Part 3." *farmdoc daily* (14):10, Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign, January 15, 2024.

Townsend, Alan R., and Robert W. Howarth. “FIXING THE GLOBAL Nitrogen Problem.” *Scientific American* 302, no. 2 (2010): 64–71. http://www.jstor.org/stable/26001899.

Wade, Tara, Roger Claassen, and Steven Wallander. "Conservation-practice adoption rates vary widely by crop and region." Economic Research Service, U.S. Department of Agriculture. Economic Information Bulletin, No. 147. December 2015. https://www.ers.usda.gov/sites/default/files/_laserfiche/publications/44027/56332_eib147.pdf?v=65360.

Webster, Joseph and Kate Burnett. “The Strait of Hormuz crisis will ripple across plastics and food supply chains, helping Beijing and Moscow, hurting Americans.” *Atlantic Council*. March 23, 2026. https://www.atlanticcouncil.org/blogs/energysource/the-strait-of-hormuz-crisis-will-ripple-across-plastics-and-food-supply-chains-helping-beijing-and-moscow-hurting-americans/.

Wong, Edward, Michael Crowley, and Eric Schmitt. “How Trump Failed to Secure the Strait of Hormuz in His Iran Deal.” *The New York Times*. July 12, 2026. https://www.nytimes.com/2026/07/12/us/politics/trump-strait-of-hormuz-iran-deal.html.

Zulauf, C., G. Schnitkey, J. Coppess and N. Paulson. "Declining Yield Variability and 2025 US Corn and Soybean Yield Distribution." *farmdoc daily* (15):116, Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign, June 25, 2025.