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REPORT

THE NITROGEN POLLUTION CRISIS:

HOW FERTILIZER OVERUSE IS POISONING AMERICA'S WATER, AIR AND ECOSYSTEMS: CALIFORNIA

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EXECUTIVE SUMMARY

Fertilizing crops with nitrogen made modern agriculture possible by replenishing nutrients in the soil and increasing crop yields. But this important tool is now routinely overused. In fact, studies across multiple states show that many farmers apply significantly more nitrogen than is recommended by land grant universities while making limited use of practices minimizing nitrogen runoff.[1] As a result, nearly half of the nitrogen fertilizer applied to croplands is not even used by plants; instead it washes into rivers and groundwater or is released into the air. In some places and for certain crops, the proportion rises to more than half.[2]

This lost nitrogen is not harmless. Nitrate-contaminated groundwater has been linked to blue baby syndrome, certain cancers, and thyroid disorders, while gaseous nitrogen emissions contribute to fine-particle air pollution and smog precursors that exacerbate asthma and other respiratory diseases.[3] Excess nitrogen can devastate aquatic ecosystems by fueling harmful algal blooms and creating low-oxygen "dead zones" that suffocate aquatic life. And it contributes to the climate crisis through emissions of nitrous oxide (N_2O), a greenhouse gas roughly 273 times more effective at trapping heat than carbon dioxide.[4]

Nitrogen mismanagement costs the U.S. economy billions of dollars, shouldered predominantly by rural and low-income communities. Nitrogen fertilizer (defined in this report as either synthetic nitrogen fertilizer or manure) can account for a small or large share of a farm's operating budget, depending on the crop grown. But the 40 to 60 percent of applied nitrogen that crops don't use is more than just an unnecessary expense for farmers, especially when it comes to water pollution.[5] Small and rural water systems, which make up the vast majority of U.S. water providers, face disproportionate treatment costs to remove excess nitrogen because they lack the resources to finance filtration upgrades or switch to unpolluted water sources.[6] Nitrogen pollution can require states to spend heavily on interim bottled-water programs, emergency responses to algal blooms, and habitat restoration. Recreational economic losses due to harmful algal blooms caused in part from nitrogen pollution run into the tens of billions of dollars annually when beaches close, boat ramps sit idle, and fisheries falter.[7]

VOLUNTARY NITROGEN REDUCTION PROGRAMS ARE NECESSARY BUT NOT SUFFICIENT

States have leaned heavily on education, technical assistance, and incentives to encourage best management practices to reduce nitrogen pollution in water. For example, California's premier sustainable agriculture grant initiative, the Healthy Soils Program, has awarded more than $162 million to farmers for practices that reduce the potential for nitrogen loss, such as cover cropping, reducing tillage, using hedgerows and windbreaks, rotating diverse crops, and applying compost.[8] While these voluntary efforts have resulted in some practice uptake and increased awareness of nitrogen overuse, they cannot deliver the needed improvements in water quality by themselves. After decades of voluntary efforts, many waters are still impaired, more waters are becoming polluted, more drinking water wells are testing high for nitrate, and treatment costs continue to rise.[9]

STATES MUST SET MEASURABLE LIMITS TO STEM NITROGEN POLLUTION

Successful pollution-control frameworks contain clear, measurable limits that align incentives with outcomes. Where regulators set numeric targets, track performance, and enforce against outliers, progress follows. Where they do not, communities, taxpayers, and ecosystems keep paying the price.

States must set clear goals to address nitrogen over-application and discharge that degrades water quality. They can require robust data collection that enables them to target help where it matters most and to measure progress. They can also pair enforceable, outcome-oriented limits with technical assistance and incentives, ensuring that both small and large farms can comply and thrive. And they can require shared accountability for results so that fertilizer companies and retailers that profit from overapplication are, alongside farmers, part of the solution.

Communities should not be forced to choose between having clean water and growing food. The status quo is inequitable, expensive, and unsustainable. We have the responsibility to change it. The good news is that we also have the tools to do so.

INTRODUCTION

Having enough available nitrogen in the soil is crucial to plant growth. Prior to the 20th century, human nitrogen inputs to soil were available only from sources such as manure and crop residue from legumes, which made its presence one of the main determinants of what an acre of farmland could produce.[10] When scientists discovered how to produce synthetic nitrogen fertilizer through the energy-intensive Haber–Bosch process in the early 20th century, farmers finally had a reliable source of nitrogen to scale crop production and harvest unprecedented yields. However, cheap and reliable access to nitrogen fertilizer quickly led to overapplication. Between 1960 and 2000, the amount of nitrogen fertilizer applied to agricultural systems more than tripled and the amount of nitrogen lost to the environment similarly skyrocketed.[11]

Mismanagement of nitrogen fertilizer wreaks havoc on local ecosystems, threatens human health, contributes to the climate crisis, and costs the U.S. economy billions of dollars per year. There is a clear solution: Reduce overapplication and implement practices to minimize nitrogen runoff. The good news is that farmers are proving it's possible and profitable to grow healthy food for communities without polluting water with excess nitrogen. Across the country, they are dramatically cutting nitrogen pollution without sacrificing productivity by reducing overapplication and adopting sustainable farming practices like adaptive nitrogen management, cover cropping, edge-of-field pollution control, and diverse crop rotation. However, current policies create an uneven playing field where industrial agricultural interests face no accountability for continued pollution while sustainable farming practices are not properly rewarded.

Harmful algal bloom in Lake Okeechobee.

This report explains the scale and sources of the nitrogen pollution crisis, who pays for it, and why current approaches to reduce nitrogen pollution have fallen short. It also proposes practical steps policymakers and stakeholders can take now to turn the tide. It is not intended to be a comprehensive overview of the environmental or economic harms of other agricultural practices.

Nitrogen policy reform is pro-farmer, pro-community, pro-health, and pro-technology. It will reward farmers who are already utilizing effective nitrogen management practices, guide other farmers toward those solutions, and save their communities from pollution. The payoff is cleaner, safer, and more affordable water; healthier rivers, lakes, and coasts; less air pollution; and meaningful climate gains from lower nitrous oxide emissions. Below is an overview of the remainder of this report.

- **Section II** details how the nitrogen pollution crisis is not a niche farm-policy issue but a pervasive problem that endangers human health, damages ecosystems, threatens biodiversity, and fuels climate change.
- **Section III** quantifies the economic burden of the nitrogen pollution crisis, including the costs of drinking water remediation, cleanup of harmful algal blooms, and diminished recreational opportunities.
- **Section IV** evaluates the shortcomings of major existing federal tools that could be used to reduce nitrogen pollution, including the Clean Water Act, Safe Drinking Water Act, and federal conservation programs.
- **Section V** presents case studies of mixed success in nitrogen management from Minnesota and California. Minnesota illustrates how investments in voluntary practices have resulted in only marginal reductions in pollution. California shows how rigorous data collection can form the foundation for smarter, more targeted policy and illustrates the consequences of failing to pair that data with enforceable limits on overapplication and runoff.
- **Section VI** lays out solutions that states can adopt now, including outcome-based monitoring and reporting paired with numeric limits on nitrogen overapplication and runoff.
- **Section VII** highlights the need for better tracking of nitrous oxide, the "forgotten superpollutant"—a primary driver of climate change from excess fertilizer.
- **Section VIII** contains a brief conclusion.
- The **Appendix** addresses frequently asked questions about the nitrogen pollution crisis, offering evidence-based responses.

CASE STUDY: CALIFORNIA

BACKGROUND

Excess nitrogen fertilizer has been a major pollutant in California for 70 years.[12] In a 1988 report prepared for the state legislature, the State Water Resources Control Board found that a growing number of drinking water sources were exceeding the MCL for nitrates.[13] The report recommended that the State Water Board centralize nitrate data collection and explore regulatory actions, including limiting fertilizer applications in vulnerable areas to address nitrogen pollution.[14] However, the Water Board did not take any regulatory action and instead continued allowing agricultural operations to unconditionally discharge nitrogen pollution into waterways.[15]

In 1999, the California legislature passed Senate Bill 390 (SB 390), which directed the State Water Board to cease its unconditional permitting and regulate agricultural discharges, including nitrogen pollution.[16] Shortly after passage of SB 390, the board created the Irrigated Lands Regulatory Program (ILRP) to protect water quality by reducing nitrogen pollution from irrigated croplands.[17] However, the regulatory program consists only of data collection and does not set numeric limits or maximums for nitrogen application or discharges.

Unsurprisingly, nitrogen pollution continues to harm communities and ecosystems and is increasing in some parts of the state.[18] In the Central Coast region, 14,039 residents were served water from systems that exceeded the nitrate MCL in 2025.[19] In the San Joaquin Valley, between 2003 and 2017, approximately 1.5 million people received drinking water from systems that tested at or above the MCL.[20]

CALIFORNIA'S DATA COLLECTION EFFORTS

Despite ongoing challenges with reducing nutrient pollution, the ILRP's reporting requirements offer a starting place for nitrogen fertilizer data reporting that can help guide and inform other states. The State Water Board sets baseline requirements for the ILRP that each of nine regional boards can adapt according to each region's growing conditions, hydrology, and crop types.[21] This flexibility has resulted in varying data quality, variable reporting standards, and a fragmented picture of nitrogen pollution across California.

The State Water Board issued a precedential Water Quality Order in 2018 to improve the ILRP, including adding new data reporting requirements.[22] The 2018 order requires farmers to report their fertilizer applications, nitrogen removals, crops grown, projected yields, volume of irrigation water applied, and acreage, among other items. Unfortunately, because of some regional variation in ILRPs, not all the data reported by farmers is shared with the State Water Board or the public, particularly acreage data.

In at least one regional water board's ILRP, field-level acreage values are reported by farmers, but these values are removed before being submitted to the State Water Board and regional water boards, owing to privacy concerns.[23] This undermines the State Water Board's ability to identify farms that are overapplying nitrogen, because it is impossible to know if the overapplications or discharges are happening at rates above the limits without knowing over how many acres the overapplications and discharges are occurring. For example, discharging 50 pounds of nitrogen per acre over 10 acres (potentially 500 pounds of nitrogen lost) has different public

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health, environmental, and policy implications than that same discharge over 1,000 acres (potentially 50,000 pounds of nitrogen lost).

If field-level acreage data were made available, the data in these reports could reveal the scale of fertilizer overapplications in California and which cropping systems contribute the most nitrogen pollution. The data could also help resource-strapped regulators efficiently target outreach and education to farmers who are consistently overapplying nitrogen fertilizers. Additionally, the data could allow regulators to design more precise regulations and measure the impact of those regulations, which could help build long-term trust in the program.[24]

THE RISE AND REMAND OF AGRICULTURAL ORDER 4.0

By 2021, one of the regional water boards, the Central Coast Water Quality Control Board, observed that simply requiring farmers to report their nitrogen application was not reducing nitrogen pollution.[25] In fact, water quality in some parts of the region kept getting worse. The Central Coast Board's experience is consistent with the viewpoint that voluntary, nonnumeric efforts to reduce nitrogen pollution are inadequate by themselves to protect water quality.[26]

In response, the Central Coast Board issued Agricultural Order 4.0, a regulation that would have set numeric limits and targets on nitrogen fertilizer applications and discharges. The order was designed to reduce nitrogen pollution over a 28-year period so that, ultimately, nitrogen use would be compatible with safe drinking water quality thresholds.[27] It would have been the first regulation to set numeric limits on general nitrogen applications and discharges in the United States. The order was remanded by the State Water Board before it had a chance to take full effect.

The initial limits in Agricultural Order 4.0 were aimed at growers who were applying nitrogen fertilizer at levels that were orders of magnitude above recommended rates, meaning that most farmers would have already been compliant. According to the Central Coast Board's nitrogen data reporting dashboard, only 3 percent of farmers who reported their nitrogen data in 2021 would have had to change their behavior to meet the first nitrogen discharge target of 500 pounds per acre.[28]

Agriculture Order 4.0 would have also rewarded farmers for using sustainable nitrogen management practices such as planting cover crops or using compost. Interestingly, on the basis of anecdotal evidence from local researchers, the numeric limits in Agriculture Order 4.0 combined with the rewards for sustainable nitrogen management practices prompted more farmers to experiment with cover crops, organic amendments, and compost before the order was remanded.[29] Regulation drove adoption of sustainable nitrogen management practices.

The State Water Board set aside the numeric limits in Agricultural Order 4.0, claiming that the Central Coast Board had violated a previous order issued by the State Water Board.[30] As of 2025, the State Water Board had not implemented any numeric limits on nitrogen application and discharge. Instead, state agencies continue to prioritize reporting, technical assistance, and education, which by themselves have not solved the nitrogen pollution crisis.

A harmful algal bloom in California's San Luis Reservoir.

APPENDIX: FREQUENTLY ASKED QUESTIONS ABOUT THE NITROGEN POLLUTION CRISIS

WHAT IS THE PRIMARY SOURCE OF NITROGEN POLLUTION IN THE UNITED STATES?

Excess nitrogen from agricultural systems is the primary source of nitrogen pollution in the atmosphere, and in many watersheds across the United States.

Nitrogen runoff from agriculture is the primary source of nitrogen pollution in the atmosphere as well as in many of the watersheds experiencing degraded water quality across the United States. In the atmosphere, agricultural nitrogen inputs account for 50 to 70 percent of anthropogenic nitrous oxide emissions globally.[31] These agricultural nitrous oxide emissions are a major reason why nitrous oxide is currently the most abundant stratospheric-ozone-depleting substance.[32]

There are many potential sources of aquatic nitrogen pollution—synthetic and organic fertilizers, municipal wastewater, biological nitrogen fixation, and atmospheric nitrogen deposition—and the specific mix of sources that impact a particular watershed will often depend on the location of that watershed. Studies using both modeling and stable isotopes to track the sources of nitrogen in ground and surface water confirm that agricultural nitrogen inputs are the main source of nitrate in groundwater in watersheds across the globe.[33] In ground and surface water, agricultural systems can contribute 56 to 88 percent of nitrogen pollution, depending on the watershed, largely through the runoff of nitrogen from synthetic fertilizers and manure.[34] Even small increases in fertilizer application can have an impact, with a 10 percent increase in the use of nitrogen fertilizer (kg) across a watershed estimated to lead to a 1.525 percent increase in the concentration of nitrogen (mg/L) in surface water.[35] Across the United States, synthetic nitrogen fertilizer is the largest nitrogen source in 41 percent of watersheds, and agriculture is the dominant source of runoff to coastal estuaries on the East Coast and the eastern Gulf of Mexico.[36]

IS FERTILIZER OVERAPPLICATION REALLY OCCURRING?

Yes. Numerous studies demonstrate that more nitrogen fertilizer is applied to agricultural fields than plants can use, particularly in hot spot areas, with actual overapplication amounts varying by location and crop type.

Fertilizer overapplication has been recognized as a global problem for decades.[37] An estimated 40 to 60 percent of the nitrogen applied to U.S. fields is not used by crops and instead runs off into the environment.[38] Many studies have shown that a significant number of farmers in the United States apply nitrogen in excess of recommendations from land grant universities. In 2006, one USDA study found that 64 percent of U.S. fertilized crop acres did not meet nitrogen management criteria, including rate, timing, and placement of nitrogen fertilizer. Of those, approximately 32 percent were applying more nitrogen than recommended.[39]

However, not all agricultural land contributes to nitrogen runoff equally. A 2021 study found that nitrogen hot spots in only about 24 percent of U.S. cropland area, most of which was dominated by animal feed crops, collectively account for approximately 63 percent of total surplus nitrogen balance.[40] Another 2021 study found that approximately 2 to 8 percent of the land area within the contiguous United States accounted for 75 percent of the estimated nitrogen pollution to rivers and lakes.[41] These studies highlight how the lack of accurate fertilizer application data can make it difficult to understand the full scope of nitrogen pollution in the United States and also underscore how most agricultural nitrogen pollution in this country originates in nitrogen hot spots.

There is a documented history of nitrogen overapplication occurring within U.S. nitrogen hot spot areas. In 2014, a study of three midwestern states found that an estimated 37 percent of the 134 farmers interviewed overapplied nitrogen by five pounds per acre or more.[42] The average farm size was 1,615 acres, translating to an estimated overapplication of at least 400,000 pounds of nitrogen per year, just for that study area. A 2020 study of Illinois corn acres showed that 67 percent of sampled acres were applying nitrogen above the maximum return to nitrogen value, with 33 percent of fields applying at least 20 pounds of nitrogen per acre over the recommended rate.[43] Finally, in a 2014 study of Iowa farmers, more than half of those surveyed agreed that "farmers apply too much nitrogen to ensure yield."[44]

Overapplication is likely to continue. Applying more nitrogen fertilizer is one of the documented farmer responses to the increased potential for irregular rainfall patterns and extreme weather events linked to climate change.[45] The idea is that extra nitrogen will be left behind to support crop growth after a rain event diminishes nitrogen levels in the soil. While this response is seen as a quick fix, it can actually exacerbate climate change and nitrogen pollution issues and is projected to be a key factor in increased nitrogen runoff from susceptible agricultural fields in the next few decades.[46]

WHY DO FARMERS OVERAPPLY NITROGEN FERTILIZER?

Farmers often apply more nitrogen fertilizer than plants need to manage risk, maximize yields, and take advantage of insurance policies and supply contracts that incentivize overapplication.

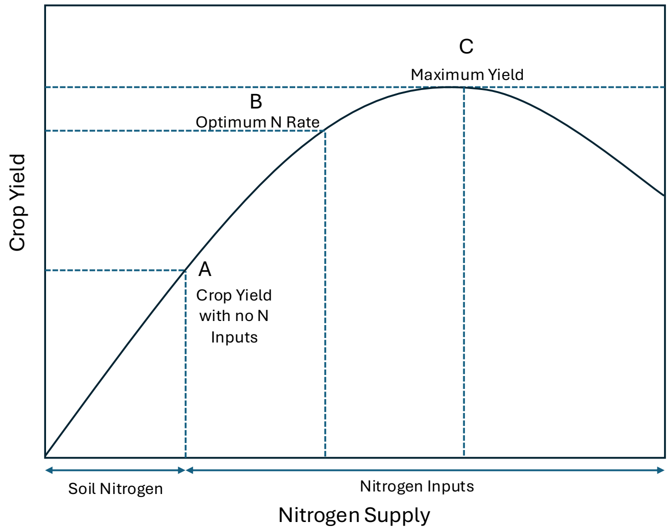
There are two major reasons why farmers may be motivated to overapply nitrogen fertilizers: boosting yields and reducing risk. Higher nitrogen application is assumed to result in greater yields, and greater yields help farmers maintain their crop insurance rates, obtain bank loans, and secure contracts with larger-scale industrial buyers.[47]

Crop yield increases with the amount of nitrogen applied, up to an optimum point ("B" in figure A1). Past this point, farmers see only marginal improvements to yield with increased nitrogen applied, but this increase still creates a perverse incentive to overapply nitrogen fertilizers past what is economically optimum, to avoid falling short of the maximum.[48] Past the optimum rate, a greater proportion of the nitrogen applied is not being used by the crop and is wasted. However, the combination of operating on small profit margins and the low cost of nitrogen fertilizers (relative to other farm costs) mean that farmers still opt for reaping the marginal profits associated with diminished yields.[49]

Overapplication also doubles as a risk management strategy.[50] Some farmers apply excess nitrogen to provide a buffer against yield losses that might occur or to reap benefits from ideal weather conditions. Ironically, climate change driven in part by emissions from cropland nitrogen increases unpredictable weather patterns and may make those ideal growing conditions less likely.[51] The practice of overapplication to mitigate risk has become so commonplace that many farmers believe that any reduction in their nitrogen applications will lead to yield or profit losses.[52] However, studies show that in some situations nitrogen use can be cut by up to half without reducing agricultural productivity, and that overapplication is driven largely by perceptions of risk.[53]

FIGURE A1

Nitrogen fertilizer can be economically beneficial and improve yield, but only up to a certain point.



Insurance policies can incentivize overapplication of fertilizer.[54] To receive crop insurance payments, the U.S. Federal Crop Insurance Program requires farmers to prove that they were not at fault for crop failures by demonstrating they were following "good farming practices."[55] Farmers can be denied insurance payouts for under-fertilizing their crops, which encourages them to err on the side of overapplying nitrogen fertilizer. Crop insurance coverage is also often a prerequisite for farmers to apply for bank loans.[56] Farm insurance coverage depends on actual production history (APH), which is calculated using the average of a farmer's previous 4- to 10-year yield records.[57] Higher APHs can improve a farmer's crop insurance coverage and encourage farmers to overapply nitrogen fertilizers to achieve higher yields. In 2023, the USDA took an important step to address the mismatch between crop insurance and sustainable farming practices, aligning crop insurance rules with the NRCS guidelines for practices like cover cropping.[58]

Supply contracts between corporations and farmers also incentivize overapplication of nitrogen fertilizer. Two types of contracts dominate the agricultural sector: tournament and fixed-rate. Tournament contracts pit growers against each other and pay on the basis of farmers' rankings. This rewards farmers who produce the highest yields and penalizes those who do not, sometimes with cancelled contracts.[59] Tournament contracts, which are common for corn seed production, introduce an extreme incentive to overapply nitrogen fertilizer in the hopes of maximizing yield. In one study, farmers who produce seed for both corn seed and commercial corn reported applying four times as much nitrogen per acre on their corn seed acreage as they did on their commercial corn acres.[60]

Fixed-rate contracts, which are used predominantly for fruit and vegetable production, directly influence farmers' fertilizer decisions because of fertilization and quality control practices that are written into the contracts.[61] Under some very specific fixed-rate production contracts, large-scale buyers mandate fertilizer application rates, leaving farmers without any control over their fertilizer practices.[62]

Fertilizer retailers also influence nitrogen fertilizer practices implemented by farmers. Studies reveal that fertilizer retailers are consistently ranked as the most trusted source of nitrogen management information, marking a significant shift away from public sector academics toward private sector sources.[63] Farmers believe that a fertilizer retailer's interest in protecting farmers' output closely aligns with their own profit motives.[64] Unfortunately, fertilizer retailers also have a vested financial interest in selling as much fertilizer as possible.

Finally, government pressure has pushed nitrogen application amounts to higher and higher levels. Today's nitrogen pollution crisis sits atop a policy decision the United States made in the 1970s when the secretary of the USDA, Earl Butz, set a goal to dramatically increase corn and soybean production and pushed farmers and ranchers across the country to "get big or get out" of agriculture.[65] Farmers now operate in an environment where generations of policy have made consolidation and growth among the few survival strategies available to them.

WILL REDUCING NITROGEN FERTILIZER APPLICATION RESULT IN CROPS NOT GETTING ENOUGH NITROGEN?

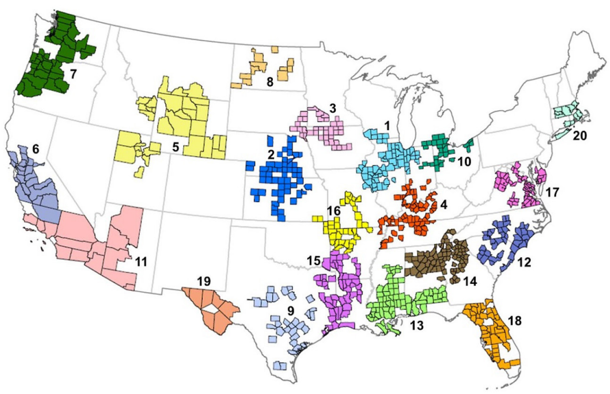
No. Given that 40 to 60 percent of the nitrogen applied to fields is not taken up by crops, nitrogen use, particularly in hotspots, can be reduced without significant impacts on yield.

As discussed earlier in this section, nitrogen hot spots account for a majority of the nitrogen surplus and overapplication across the United States. This means that nitrogen reduction efforts targeted to specific areas and cropping systems (particularly less efficient cropping systems producing animal feed) can have an outsize impact on reducing nitrogen waste with minimal impact on yield.[66]

Studies show that both nitrogen inputs and nitrogen losses from agricultural fields can be significantly reduced without a loss of agricultural productivity, particularly in low-yielding areas.[67] Maintaining productivity under nitrogen rates lower than many farmers currently use is possible both because overapplication is occurring and because the majority of the nitrogen that plants use during the cropping season actually comes from soil organic matter.[68] This is why soil nitrogen tests—which measure the soil nitrogen pool—are important. Increasing nitrogen stored in soil organic matter helps reduce loss, since nitrogen trapped in soil organic matter is less susceptible to leaching.[69] The legacy of nitrogen overapplication in the United States means that soils may contain significant nitrogen reserves that can be used to supply crops and reduce the need for application. However, even though an increasing number of farmers perform soil nitrogen tests, it is not clear whether those test results inform or influence fertilizer management decisions.[70] Neglecting to consider soil nitrogen may be one of the reasons why less profitable farms spend 30 percent more on fertilizer than the most profitable farms.[71]

Farm productivity can also be maintained by increasing the efficiency of nitrogen use via practices that trap nitrogen on fields. Cover cropping can reduce incidences of both nitrogen leaching and soil erosion while trapping nitrogen in crop residues to be released over the subsequent growing season. Riparian buffers and field border strips can trap nitrogen before it runs off to surface water bodies. Crop diversification can ensure that different compartments of the soil are scavenged for nitrogen, and using legumes can improve nitrogen fixation. Setting clear limits on nitrogen application and discharge from fields can accelerate adoption of these practices.[72] Accounting for the nitrogen supplied by the soil and crop residues when planning fertilizer applications is a practice adopted in several other countries. Nitrogen budgets in Germany and Denmark estimate the amount of nitrogen provided by cover crop residue and soil mineralization and reduce recommended nitrogen rates by that amount.[73]

FIGURE A2: A MAP OF N SURPLUS HOT SPOTS ACROSS THE UNITED STATES WHERE BETTER N MANAGEMENT COULD REDUCE LOSSES WITHOUT SIGNIFICANT YIELD IMPACTS. NUMBERS CORRESPOND TO RANKINGS BY TOTAL N SURPLUS (METRIC TONS N YR^{-1}), GREATEST TO SMALLEST[74]



CAN'T WE SOLVE THE NITROGEN POLLUTION CRISIS WITH NEW TECHNOLOGIES?

No. While new technologies and innovations will play an important role, they will not solve the nitrogen pollution crisis by themselves because they can be misused.

While technological solutions will continue to play an important role in reducing nitrogen pollution, relying solely on technology to increase nitrogen use efficiency may not actually reduce nitrogen overapplication. In fact, increasing the efficiency of resource use may actually increase overall resource use. This idea, called Jevon's Paradox, has been observed in other fields such as alternative energy and irrigation technology.[75] A nitrogen-specific example is split application of fertilizer—a practice intended to apply smaller amounts of fertilizer at times when it can be better taken up by plants—which has been found to actually increase overall nitrogen application.[76]

Incremental technical approaches to address agricultural nutrient pollution may not be sufficient on their own because farm nitrogen application decisions are driven not solely by economic concerns, but also by risk management and structural incentives such as crop insurance. Because of this, there is a need to alter the structural, social, and ecological conditions of the modern agricultural system to ensure that food is produced without compromising the natural resources that production depends on. This involves combining technological advances with wider systemic changes, such as limits on overapplication of nitrogen fertilizer and nitrogen runoff, wider food system accountability for nitrogen pollution, accounting for soil nitrogen mineralization, increased crop diversification, insurance and incentive reform, and improved reporting.[77]

There are already promising technologies that could significantly reduce nitrogen pollution when combined with practice changes. Enhanced-efficiency fertilizers (EEFs) and the introduction of new cultivars as well as irrigation and tillage technologies can be combined with organic carbon amendments, crop legume rotation, and buffer zones to great effect.[78]

However, as discussed above in Section VI, technological advances are not a one-size-fits-all approach. For instance, some EEFs are designed to reduce the amount of nitrogen that is lost from fields through coatings that slow the rate at which that nitrogen is released. Slowing nitrogen losses with EEFs can give farmers more time to use any excess nitrogen in a second crop or post-harvest cover crop. These benefits can be lost by fertilizer timing and rate mismanagement. Enhanced efficiency fertilizers currently available also are not necessarily effective in all conditions, including in some humid wheat and corn systems. To create an enabling environment where these technological advances can deliver on their promise, the need to reduce nitrogen fertilizer application rates and nitrogen runoff must be clearly established; the need plainly exists in an environmental sense, but not in an economic or regulatory sense under the current system.

COULDN'T A TAX ON FERTILIZER RESULT IN LESS USE OF NITROGEN FERTILIZER?

No. A tax that increases fertilizer prices will not necessarily reduce nitrogen application but can increase farmer costs because overapplication is also driven by other factors.

A proposed solution to the nitrogen pollution crisis is the institution of taxes or additional fees on nitrogen fertilizer. The logic is that if fertilizer costs more, farmers will need to reduce their application rates to keep input costs stable. However, this would not necessarily bear out in practice, as the drivers of fertilizer application are not purely economic; crop prices matter more than fertilizer prices, and nitrogen costs represent only a fraction of the total cost of running a farm.

As discussed above, farmers often apply more nitrogen than plants need to manage potential risks or to maximize yield. The current market is set up to incentivize yield above all else, which is reflected in the design of producer contracts, crop insurance premiums, and other factors that drive farmer fertilizer choices apart from the price of fertilizer. In cases where crop prices are high, there is a high potential return on investment, making it more economically feasible to apply more fertilizer during the season to maximize potential yield, even if some of it is wasted. Fertilizer expenditure relative to potential income can also be small—often only about 1 to 2 percent of a farm budget in the case of some high-value crops.

For instance, fertilizer costs for lettuce grown in California's Central Coast region are still typically less than 1 percent of gross revenue even under extremely high fertilizer rate scenarios. Because fertilizer costs are such a small fraction of gross revenue, reducing fertilizer application rates by 70 to 100 pounds of nitrogen per an acre does not result in meaningful cost savings for growers—less than $50 per an acre in most years. However, lettuce prices can command up to $21,000 per acre, meaning that the economic cost to farmers from applying an excessive rate can be low while the perceived benefits can be quite high.

Moreover, the presence of subsidies and crop insurance can warp the impact of fertilizer prices. At the average Minnesota corn yield observed over the past five years (184 bushels per acre), the breakeven price of corn ranged from $3.68 to $4.94 per bushel. In 2025 the USDA estimated production costs at $897 per an acre, which would make the breakeven price at average Minnesota yields $4.88 per bushel, well above the August price of $3.72 per bushel or even the September price of approximately $4 per bushel. Even excluding all fertilizer, production costs are approximately $3.97 per acre, making it impossible to raise profitable average-yield corn in Minnesota even if fertilizer were free, given the low corn prices. In this case, fertilizer application would be driven by the yields needed to fulfill contracts or meet crop insurance requirements.

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