Greenhouse gas data deep dive reaches new level of 'reasonable and true'

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Researcher Yushu Xia (pictured) and others from the University of Illinois and Argonne National Laboratory have mapped nitrous oxide emissions from corn fertilizers to the county level, allowing greater precision in life cycle analysis for corn ethanol. Credit: University of Illinois College of Agricultural, Consumer and Environmental Sciences (ACES)

For the most accurate accounting of a product's environmental impact, scientists look at the product's entire life cycle, from cradle to grave. It's

a grand calculation known as a life cycle assessment (LCA), and greenhouse gas emissions are a key component.

For corn ethanol, most greenhouse gas emissions can be mapped to the fuel's production, transportation, and combustion, but a large portion of the greenhouse gas calculation can be traced right back to the farm. Because of privacy concerns, however, scientists can't access individual farm management decisions such as fertilizer type and rate.

Nitrogen fertilizer data are an important piece of the calculation because a portion of these fertilizers wind up in the atmosphere in the form of nitrous oxide, a highly potent greenhouse gas. Corn nitrogen fertilizer data are publicly available at the national and state levels, but scientists argue this level of resolution masks what's really being applied on farms across the country and could lead to inaccurate LCAs for corn ethanol.

In a new study from the University of Illinois and the U.S. Department of Energy's Argonne National Laboratory, researchers developed the first county-level nitrogen application datasets for corn, dramatically improving the accuracy of greenhouse gas calculations for the crop.

"Having good data is really important to foster both a shared discussion and greater confidence in LCAs. We've seen some abuses of life cycle analysis using really crude numbers, downscaling big averages that can really vary a lot. So even though the county level still isn't as precise as we would like, it's a big accomplishment to get to that scale," saysMichelle Wander, professor in theDepartment of Natural Resources and Environmental Sciencesat Illinois and co-author on the study.

Hoyoung Kwon, principal environmental scientist in the Systems Assessments Center at Argonne and co-author on the study, says the protocol and findings will help the agricultural and bioeconomy community better understand the impacts of high-resolution nitrogen

fertilizer data on corn-based biofuel LCAs.

"Nitrous oxide makes up about half of the total greenhouse gases associated with corn farming," Kwon says. "Now we can differentiate nitrous oxide emission associated with corn farming on the county level, and can show how much these emissions vary with location and farming practice."

Yushu Xia, who led the analysis and recently finished her doctoral program with Wander, used two approaches to determine county-level nitrogen fertilizer and manure usage.

The first, which Xia calls the top-down approach, was a bit like putting a puzzle together using different-sized pieces. At the county level, she found data for nitrogen fertilizer and manure inputs, but the numbers were aggregated across all crops, not corn specifically. The state level dataset included fertilized area in corn, so it was a matter of matching county with state. The state dataset also included nitrogen inputs, but aggregated them across fertilizer types. Data validation, or double-checking state and country information, therefore became another puzzle.

"For the top-down approach, we used data derived from fertilizer sales, information compiled by the Association of American Plant Food Control Officials. So we assume these numbers are relatively accurate; somebody actually bought that nitrogen. Yushu went through painstaking effort, basically using that crop data layer like a jigsaw puzzle to figure out how much corn is where and in what rotation over time. And then also for the manure: How many animals are there? Where are they? What kind of animal waste and how much? It's literally a budgeting effort to try to find out what's reasonable and true," Wander says.

Xia's second approach took corn yield, crop rotations, and soil properties

from the county level and estimated nitrogen inputs based on the amount of nitrogen it would take to achieve that yield. Comparing the results of the two approaches told Xia farmers are applying nitrogen in excess of what's needed.

"Nationally, the weighted averages of corn nitrogen inputs based on corn planted area exceeded nitrogen needs by 60 kilograms per hectare, with a nitrogen surplus found in 80% of all U.S. corn producing counties," Xia says.

Excess application was most pronounced in the Midwest, followed by the Northern Plains. The Southeast and Northwest had comparatively low nitrogen application rates and surplus levels. Western states were more variable overall.

Xia says the technique can be useful beyond nitrous oxide emissions estimations.

"Our approach can also be used to estimate nitrogen leaching, ammonia emissions, other greenhouse gas emissions, or the water and carbon footprint. These data improvements can really help to create and utilize better ecosystem models and life cycle analysis."

Kwon indicates the new approach could potentially be used by policymakers at the national level.

"The EPA's national greenhouse gas inventory report currently uses state-level nitrogen fertilizer data to generate national estimates of nitrous oxide emissions from fertilizer. If they apply these high-resolution county-level data, they can refine those numbers on a national scale."

The results could also help farmers make more informed management decisions.

"Fertilizer prices are sky high right now, so since our results suggest some farmers are over-applying up to a third of their nitrogen, they could probably back off a bit and save some money," Wander says.

The article, "Developing county-level data of nitrogen fertilizer and manure inputs for corn production in the United States," is published in the *Journal of Cleaner Production*.

More information: Yushu Xia et al, Developing county-level data of nitrogen fertilizer and manure inputs for corn production in the United States, *Journal of Cleaner Production* (2021). DOI: 10.1016/j.jclepro.2021.126957

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