RENEWABLE FUELS ASSOCIATION

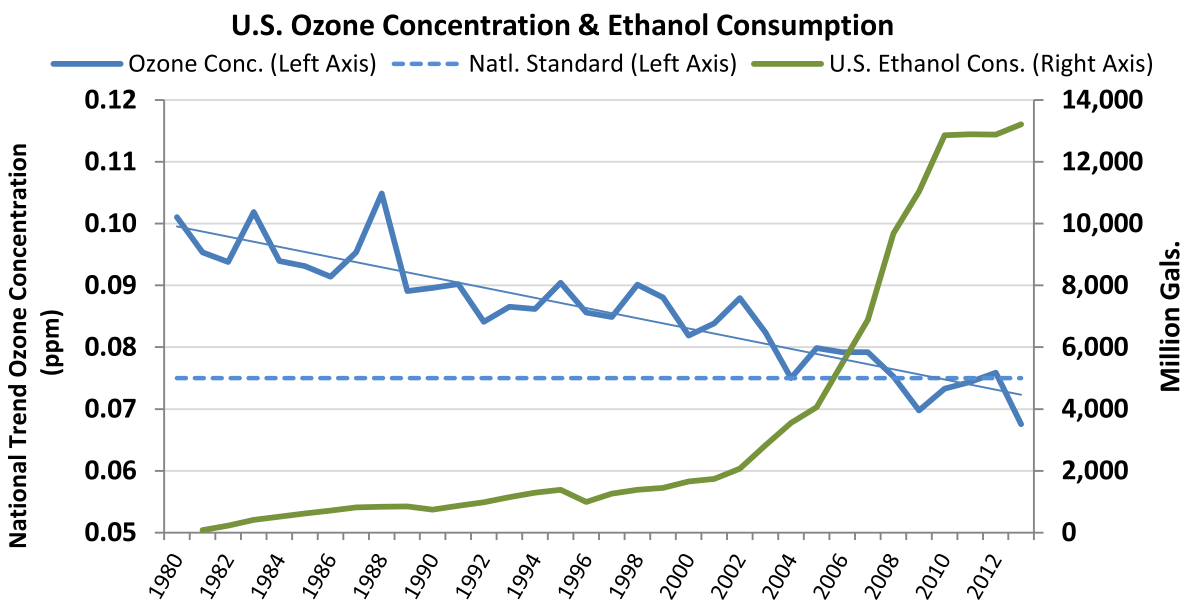
**RESPONSE TO *PNAS* ARTICLE:**

## "LIFE CYCLE AIR QUALITY IMPACTS OF CONVENTIONAL AND ALTERNATIVE LIGHT-DUTY TRANSPORTATION IN THE UNITED STATES"

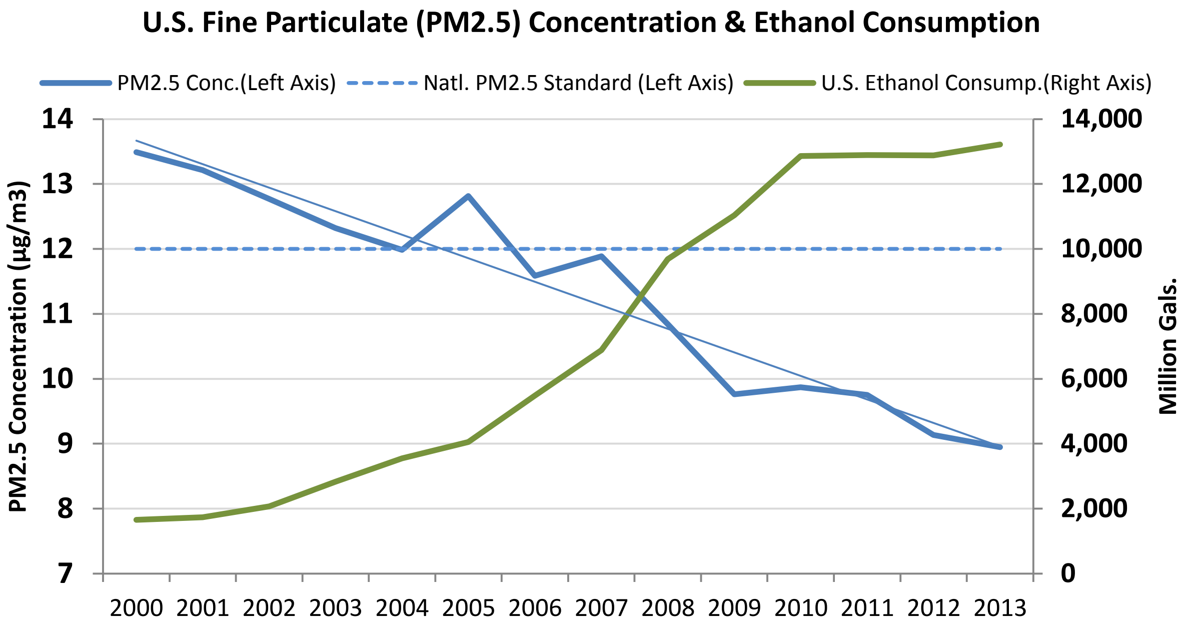
A recent paper by researchers at the University of Minnesota suggests that using corn ethanol in lieu of gasoline would increase emissions of fine particulate matter (PM2.5) and ground-level ozone.[1] The results are based on numerous assumptions (many of which are unclear or concealed from the reader) and a series of complex hypothetical modeling scenarios. Ultimately, the authors' conclusions stand at odds with real-world data showing decreases in ozone and PM2.5 concentrations during the period in which ethanol blending substantially increased in the United States. The findings also run counter to an existing body of research that shows ethanol reduces PM2.5 and emissions that contribute to the formation of urban ozone, including exhaust hydrocarbons and carbon monoxide (CO). Further, the paper is contradicted by the results of the Department of Energy's latest GREET model. Finally, the study omits important emissions sources from the petroleum and electric vehicle lifecycle, resulting in a "stacked deck" against ethanol.

### THE STUDY'S CONCLUSIONS ARE UNDERMINED BY REAL-WORLD OZONE AND PM2.5 TRENDS

The paper's assertion that increased ethanol use would cause higher emissions of ozone and PM2.5 is contradicted by EPA data from actual air sensors. Data from 222 EPA sensing sites show that ozone and PM2.5 concentrations have trended downward during the period in which the use of ethanol-blended gasoline has dramatically increased.[2] Ozone concentrations have fallen 33% since 1980, while PM2.5 is down 34% just since 2000. In recent years, both ground-level ozone and PM2.5 emissions have dropped below their respective national standards, according to EPA. Specific "non-attainment" areas where reformulated gasoline (RFG) is required have shown similar reductions since ethanol was introduced as an oxygenate.




[1] Tessum, C.W.; Hill, J.D.; and Marshall, J.D. "Life cycle air quality impacts of conventional and alternative light-duty transportation in the United States." Proceedings of the National Academies of Science. 10.1073/pnas.140685311.
[2] EPA Air Trends. http://www.epa.gov/airtrends/




**Source**: EPA Air Trends & EIA

**THE STUDY'S FINDINGS ARE AT ODDS WITH EMISSIONS ESTIMATES FROM THE LATEST GREET MODEL**

On a full lifecycle basis (i.e., including the contributions of upstream agriculture emissions), the study's results are contradictory to the results from the Department of Energy's latest GREET model.[3] This is particularly confusing because the authors claim to have used an earlier version of the GREET model for their analysis. It is unclear whether the authors adjusted key inputs in the GREET model, and on what scientific basis such adjustments might have been made.

The most recent GREET model shows **no increase** in PM2.5 emissions or other criteria pollutants when gasoline with 10% corn ethanol is compared to conventional gasoline without ethanol. Further, when E85 from corn ethanol is compared to conventional gasoline, GREET1_2014 shows that using E85 **decreases** urban emissions of volatile organic compounds (VOC), nitrous oxide (NOx), coarse particulates (PM10), fine particulates (PM2.5), and sulfur oxide (SOx).

The high levels of PM2.5 and ozone concentration attributed to corn ethanol in the Minnesota study appear to be mostly related to assumed upstream agricultural practices, such as fertilizer application. However, the paper and the supporting material do not clarify what assumptions were used for fertilizer production and application, or other agricultural activities. Further, the study omits NOx and SOx emissions for other fuels if those emissions occur "far from population centers." Yet, it appears *all* NOx and SOx emissions associated with agricultural production of biofuel feedstocks are included even though most feedstock production occurs in sparsely populated rural areas.

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[3] GREET1_2014. Available at [https://greet.es.anl.gov/](https://greet.es.anl.gov/). See "Results" tab, "Gasoline Vehicle: Gasoline" and "Gasoline Vehicle: Low-Level EtOH Blend with Gasoline (E10, Corn, dry)."

**OTHER RESEARCH SHOWS ETHANOL REDUCES THE POTENTIAL FOR OZONE AND PM2.5**

Urban ozone formation occurs from rather complex atmospheric photochemistry, as volatile organic compounds (VOC) and carbon monoxide (CO) react in the presence of nitrogen oxides (NOx). Both the EPA and National Research Council have recognized that CO is a precursor to ozone formation. There is a substantial body of evidence proving that ethanol reduces both exhaust hydrocarbons and CO emissions, and thus can help reduce the formation of ground-level ozone. Indeed, ethanol's high oxygen content and ability to reduce exhaust hydrocarbons and CO emissions is the primary reason it is used as an important component of reformulated gasoline in cities with high smog levels.

Further, research has shown that increasing the oxygen content in gasoline reduces primary exhaust particulate matter (PM2.5) from the tailpipe. Because ethanol is 35% oxygen by weight, blending ethanol with gasoline increases the oxygen content of the fuel and thus reduces PM2.5 emissions.

**THE STUDY USES QUESTIONABLE ASSUMPTIONS REGARDING OTHER FUELS**

The Minnesota study's lifecycle emissions estimates for electric vehicles (EVs) *do not include emissions associates with battery production*, a glaring omission that creates an inconsistent framework for comparing various fuel/vehicle options. The authors admit that emissions associated with battery production account for **"about half"** of total EV lifecycle emissions—yet those emissions are excluded from the central scenario.

The study also *excludes NOx and SOx emissions associated with crude oil extraction*, a decision that grossly underrepresents the actual lifecycle emissions impacts of gasoline. These emissions were excluded because the authors assume they occur outside the geographical boundaries of their study area. The authors also assumed all crude oil in 2020 is extracted using conventional methods, which entirely ignores the emissions impacts of unconventional extraction techniques. According to the paper, "oil extraction from oil sands occurs outside of our geographic modeling domain," and thus they assume "all oil is extracted conventionally (0% oil sands oil)."

Omitting key emissions sources from the lifecycle assessment of EVs and crude oil inappropriately skews the paper's results for the overall emissions impacts of these fuels and vehicles.