Statement of

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on

The EPA Renewable Fuel Standard Mandate

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Chairman Smith, Ranking Member Johnson, Chairman Weber, Chairman Loudermilk, Ranking Member Grayson, Ranking Member Beyer, and Members of the Subcommittees, good morning and thank you for inviting me to testify before you today. I am Jason Hill, Associate Professor of Bioproducts and Biosystems Engineering at the University of Minnesota and Resident Fellow of the University of Minnesota's Institute on the Environment.

My research focuses on understanding the environmental effects of the world's energy and food systems, and especially where they intersect in the emerging bioeconomy. My work is funded by grants from the U.S. Dept. of Energy, the U.S. Dept. of Agriculture, the U.S. Environmental Protection Agency, and the State of Minnesota. I recently served on the National Research Council's Committee on the Economic and Environmental Impacts of Increasing Biofuels Production.

I am pleased to describe, as you have requested, my ongoing research into the environmental impacts of biofuels, in particular the effects of corn ethanol, cellulosic ethanol, and gasoline on air quality. Much of the research that I will discuss today was conducted together with my colleagues Prof. Julian Marshall and Dr. Chris Tessum. I offer this testimony entirely on my own behalf.

One of the goals of the Renewable Fuel Standard (RFS2) is to reduce the negative environmental effects of transportation by increasing the use of biofuels, but is this an effective approach? Are biofuels truly "cleaner" than conventional fuels?

To answer this question, we need to compare these fuels over their full life cycle. That is, we need to consider the damage caused by producing them in addition to using them.[1] For gasoline, the life cycle includes extracting and refining crude oil, and distributing and combusting the gasoline itself. The life cycle of corn ethanol includes growing and fermenting grain, and distilling, distributing, and combusting the ethanol itself.

Just how important is this life cycle approach? If we were to ignore the pollution that is released when producing these fuels, as many others have done, we would underestimate their impacts.[2,3] For corn ethanol, for instance, most of the pollution that contributes to increased fine particulate matter ($PM_{2.5}$) and ozone (O_3) levels is emitted when it is produced, not when it is burned. We focused our analysis on these two pollutants as they cause the overwhelming majority of air pollution health impacts.

Corn ethanol has higher life cycle emissions than gasoline of five major pollutants that contribute to $PM_{2.5}$ and O_3 levels. (**Fig. 1**). Cellulosic ethanol, which is considered here as derived from corn stover, emits greater amounts of some pollutants than gasoline and lower amounts of others. It is also worth noting that using gasoline more efficiently, such as in a hybrid vehicle or other vehicle with improved fuel economy, reduces life cycle emissions of all five of these pollutants.

What is the effect of these emissions on human health? The answer depends in part on where these emissions occur and where they travel, since what we care about is how many people breathe dirty air and how much pollution they inhale.

To determine the effect of these fuels on human health, my colleagues and I first estimated how levels of $PM_{2.5}$ (**Fig. 2**) and O_3 (**Fig. 3**) change as a result of producing and using each fuel.[4] We then calculated the damage to human health that would result from these changes in air quality (**Fig. 4**) and monetized those costs (**Fig. 5**).

We found that producing and using a gallon of gasoline in a conventional vehicle results in air quality-related health costs of approximately $0.50 per gallon. For corn grain ethanol, the cost is nearly double. This difference is largely due to ethanol production having greater pollutant emissions than gasoline production and not due to differences in tailpipe emissions, which are relatively small. Increased mortality from ethanol production and use occurs largely in the Midwest and Eastern U.S. For both fuels, nearly all of the damage to human health is caused by $PM_{2.5}$ rather than by O_3.

We also found that producing and using a gallon of corn stover ethanol results in damage costs comparable to gasoline, again around $0.50 per gallon. Although increased mortality occurs in the Corn Belt and areas downwind, areas where coal is mined benefit from improved air quality. This is because corn stover ethanol production generates excess electricity that can offset electricity from coal.

Let us return to our original question of whether RFS2 reduces the negative environmental effects of transportation. Our research shows that, at least with respect to air quality, the answer is no. In fact, because RFS2 has been met almost entirely with corn grain ethanol, it makes the air worse. This finding is consistent with the U.S. EPA's own findings, which estimated RFS2 to increase average $PM_{2.5}$ and O_3 concentrations leading to up to 245 cases of premature mortality annually.[5,6]

What role could cellulosic biofuels play in cleaning the air? We found that they have the potential to be no more damaging than gasoline and perhaps somewhat better.[7] Still, because cellulosic biofuels are not yet produced on a large commercial scale, their effects are less certain than those of corn grain ethanol. There is, in fact, tremendous uncertainty about how the cellulosic biofuels industry will develop.[8,9] My colleagues and I recently showed that federal agencies differ dramatically in their projections of the types of biomass feedstocks that would be used to meet RFS2 (**Fig. 6**) and where these feedstocks would be produced (**Fig. 7**).[10]

RFS2 will continue to damage air quality as long as it supports corn grain ethanol regardless of how the cellulosic biofuel industry develops. Increasing the efficiency of corn grain ethanol production may lessen its negative health effects, but even dramatic improvements would be unlikely to make it a less damaging alternative to gasoline. Likewise, even ideal development of the cellulosic biofuel industry would likely result in only marginal improvements in the health impacts of transportation.

Alternatively, we know that other options are likely to improve air quality, including increasing vehicle efficiency, electrifying vehicles with low-emission and renewable sources of electricity, promoting public transportation, and redesigning infrastructure.[4] These are the options that we should pursue should we wish to make meaningful gains in reducing the damage that transportation causes to air quality.

Thank you again, Messrs. Chairmen, Ranking Members, and Members of the Subcommittees for the opportunity to be here today. I am happy to answer any questions you might have.

References

1. Hill, J. (2013) Life cycle analysis of biofuels. In S. Levin (ed.) *Encyclopedia of Biodiversity, 2nd Edition*. Academic Press, Waltham.
2. Tessum, C., J. Marshall, and J. Hill (2012) A spatially and temporally explicit life cycle inventory of air pollutants from gasoline and ethanol in the United States. *Environ. Sci. Technol.* **46**: 11408–11417.
3. Wagstrom, K., and J. Hill (2012) Air pollution impacts of biofuels. In A. Gasparatos and P. Stromberg (eds.) *Socioeconomic and Environmental Impacts of Biofuels: Evidence from Developing Nations*. Cambridge University Press, England.
4. Tessum, C., J. Hill, and J. Marshall (2014) Life cycle air quality impacts of conventional and alternative light-duty transportation in the United States. *Proc. Natl. Acad. Sci. USA* **111**: 18490–18495.
5. Cook, R., *et al.* (2011) Air quality impacts of increased use of ethanol under the United States' Energy Independence and Security Act. *Atmos. Environ.* **45**: 7714–7724.
6. U.S. EPA (2010) Regulatory Announcement: EPA Finalizes Regulations for the National Renewable Fuel Standard Program for 2010 and Beyond. EPA-420-F-10-007.
7. Hill, J., S. Polasky, E. Nelson, D. Tilman, H. Huo, L. Ludwig, J. Neumann, H. Zheng, and D. Bonta (2009) Climate change and health costs of air emissions from biofuels and gasoline. *Proc. Natl. Acad. Sci. USA* **106**: 2077–2082.
8. Tilman, D., R. Socolow, J. Foley, J. Hill, E. Larson, L. Lynd, S. Pacala, J. Reilly, T. Searchinger, C. Somerville, R. Williams (2009) Beneficial biofuels – The food, energy, and environment trilemma. *Science* **325**: 270–271.
9. National Research Council (2011) The Renewable Fuel Standard: Potential Economic and Environmental Effects of U.S. Biofuel Policy.
10. Keeler, B., B. Krohn, T. Nickerson, J. Hill (2013) U.S. Federal agency models offer different visions for achieving Renewable Fuel Standard (RFS2) biofuel volumes. *Environ. Sci. Technol.* **47**: 10095–10101.

Summary of major points

- The environmental effects of fuels must be compared on a life cycle basis, which means that we consider the consequences of both their production and their use.
- Corn grain ethanol has higher life cycle emissions than gasoline of five major pollutants that contribute to reduced air quality. These are primary fine particulate matter ($PM_{2.5}$), sulfur oxides (SO_x), nitrogen oxides (NO_x), volatile organic compounds (VOCs), and ammonia (NH_3).
- Corn grain ethanol worsens air quality in the Midwest and Eastern U.S. relative to gasoline by increasing levels of fine particulate matter ($PM_{2.5}$) and ozone (O_3) in the air.
- The air quality-related human health cost of producing and using gasoline is approximately $0.50 per gallon. For corn grain ethanol, it is nearly double.
- The air quality-related human health cost of producing and using cellulosic ethanol from corn stover is similar to that of gasoline.
- The monetized damages to human health from increased levels of $PM_{2.5}$ greatly exceed those of O_3 for each of the fuels considered.
- The Renewable Fuel Standard (RFS2), because it is currently dominated by corn grain ethanol, is responsible for reduced air quality over much of the U.S., which leads to increased mortality.
- Uncertainty in how the cellulosic biofuels industry will develop complicates projections of whether cellulosic biofuels will be better or worse for human health than gasoline or corn grain ethanol as relates to air quality.
- Improved vehicle efficiency, vehicle electrification using low-emission or renewable sources of electricity, public transportation, and redesign of infrastructure are better options for reducing the air quality impacts of transportation.

Figures

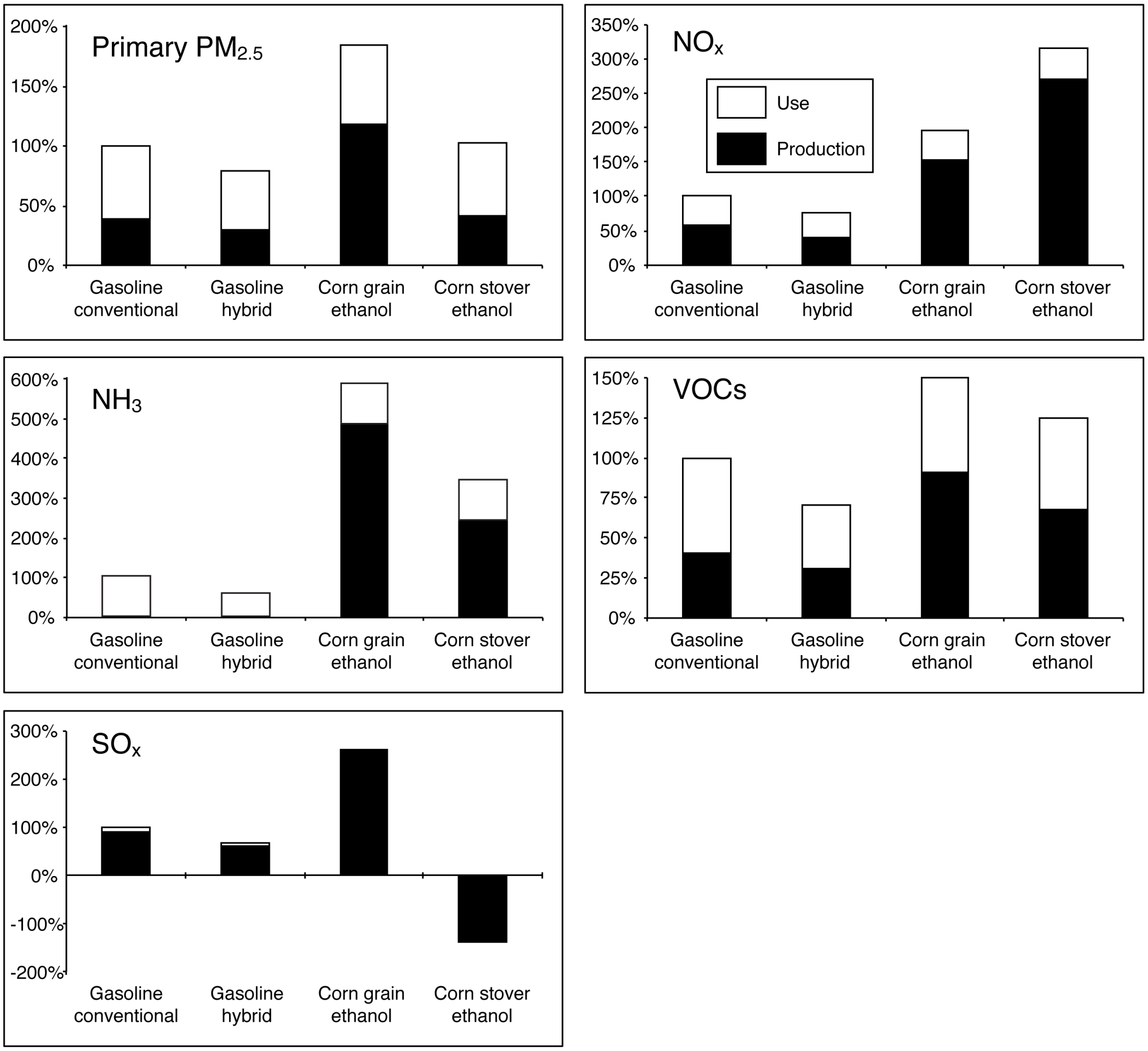

Figure 1. Life cycle emissions from fuel production and use. Values are indexed to gasoline.

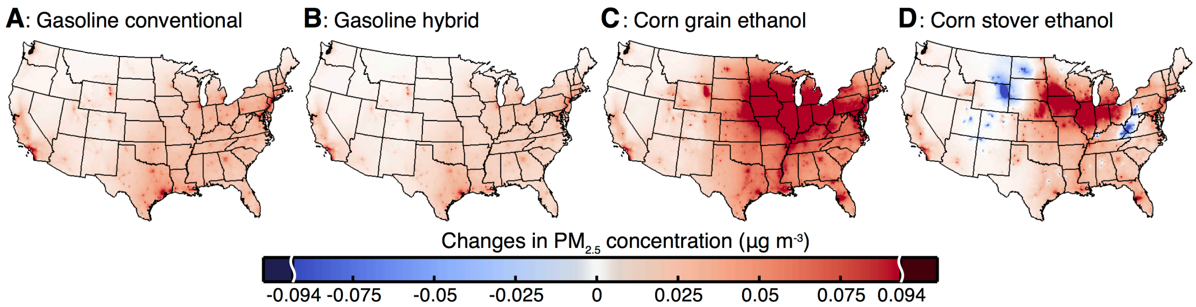

Figure 2. Changes in $PM_{2.5}$ concentrations from 10% of vehicle miles traveled by fuel.

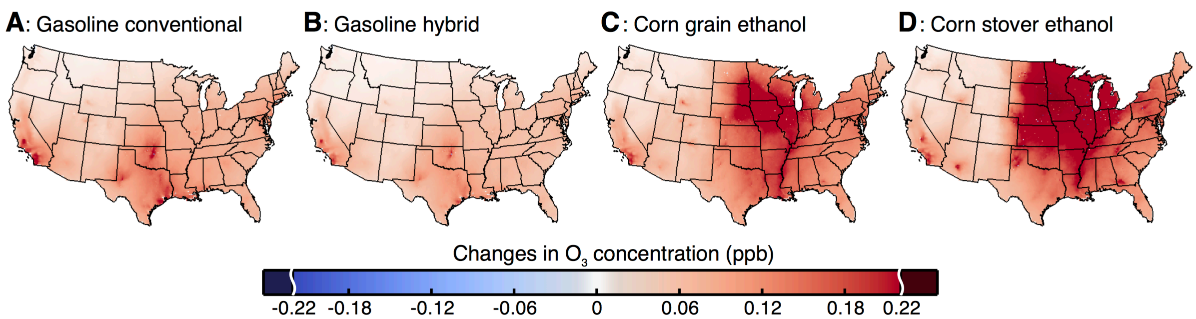

Figure 3. Changes in O_3 concentrations from 10% of vehicle miles traveled by fuel.

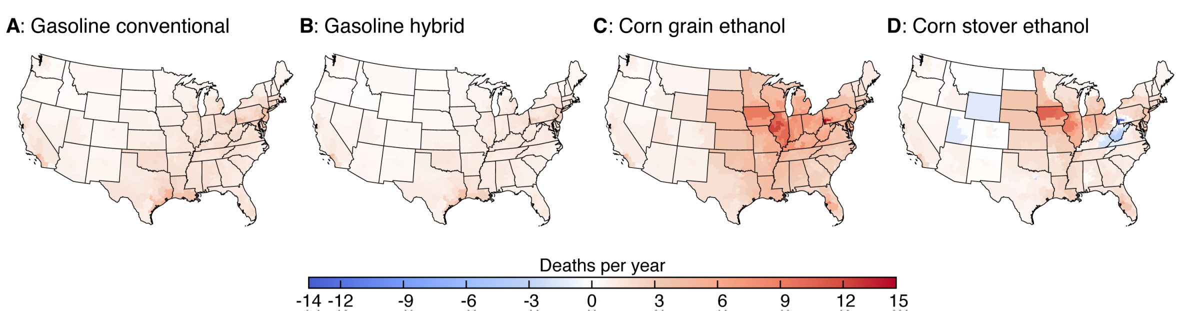

Figure 4. Annual human health damage from $PM_{2.5}$ aggregated by congressional district by fuel.

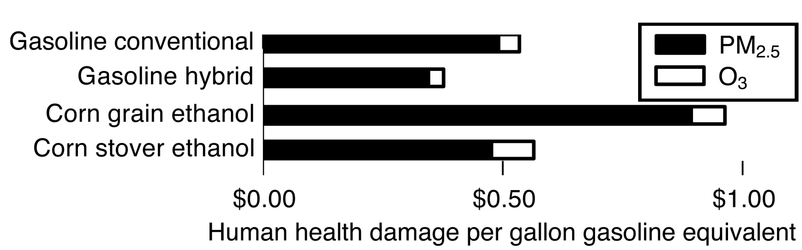

Figure 5. Monetized damage costs of fuel production and use by fuel.

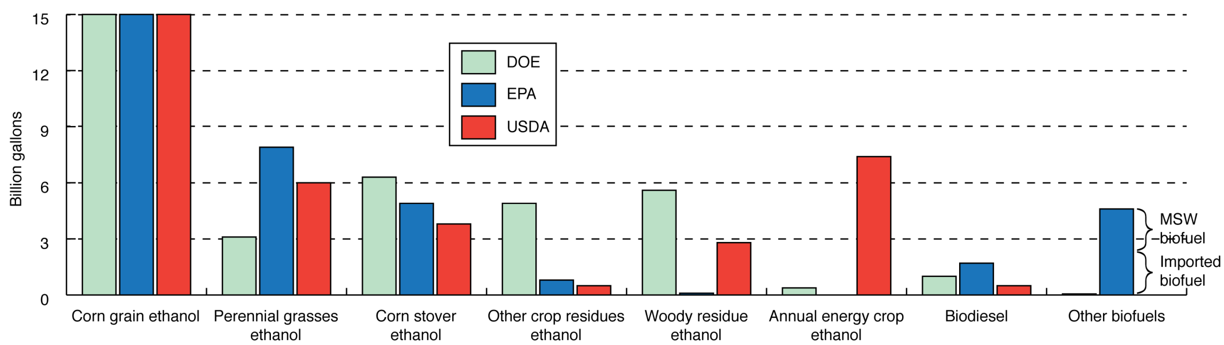

Figure 6. Federal agency projections of types of biomass produced to satisfy RFS2 in 2022.

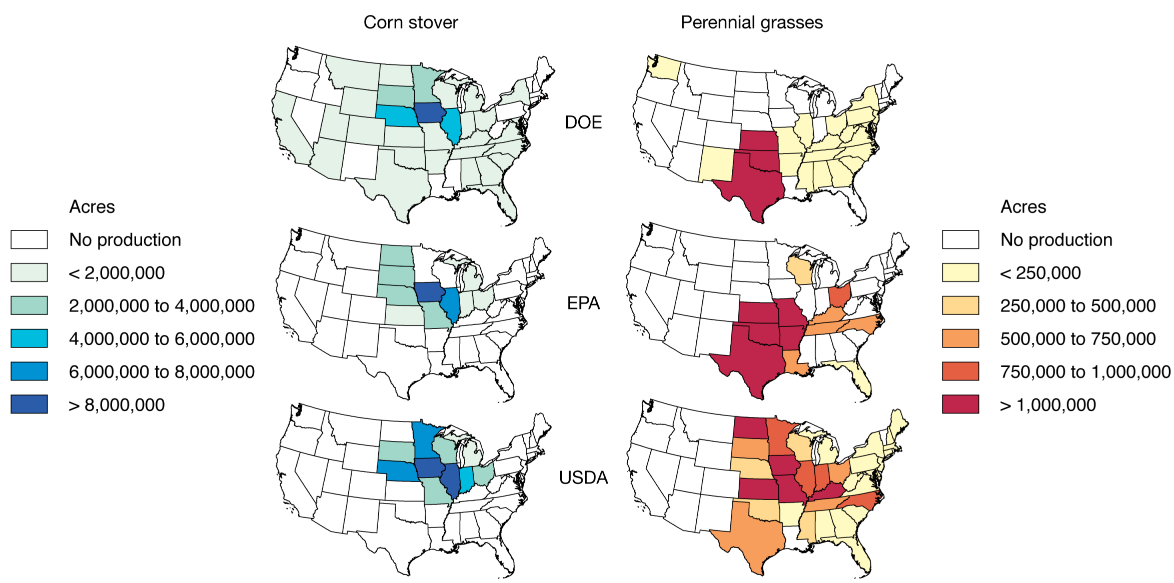

Figure 7. Federal agency projections of biomass production areas to satisfy RFS2 in 2022.