Responses to Comments by John M. Simpson (FTCR), Ethanol Coalition, Roland Huang (NRDC), Gary Whitten (Consultant), an unauthored NRDC document, and the Renewable Energy Action Project (REAP) on the paper,

Jacobson, M.Z., Effects of Ethanol (E85) Versus Gasoline Vehicles on Cancer and Mortality in the United States, Environ. Sci. Technol, 10.1021/es062085v, 2007 (J07) http://www.stanford.edu/group/efmh/jacobson/E85vWindSol

New Measurement Study Supporting the Emission Assumptions in Jacobson (2007)

Graham, L.A., S.L. Belisle, and C.-L. Baas, Emissions from light duty gasoline vehicles operating on low blend ethanol gasoline and E85, Atmospheric Environment, 42, 4498-4516, 2008.

Graham et al. (2008) (G08) concluded, after combining new data comparing E85 versus gasoline emissions of criteria pollutants and air toxics with a literature survey of other results, that (p. 4513) "These changes were generally consistent with those used by Jacobson in a recent assessment of potential health effects of widespread E85 use in the USA (Jacobson, 2007)"

Also shown (under response to NRDC) are comparisons of assumed emission changes in Jacobson (2007) with measurements from recent independent 2006 certification emission data showing a consistency of emission assumptions with data.

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John M. Simpson (Foundation for Taxpayer and Consumer Rights – FTCR)

Press release

The funding for the study came from NASA, for computation program development and support, and Stanford University (salary). This study was not funded or influenced by any oil company, energy company, company of any kind, or special interest group.

John. M. Simpson, through FTCR, issued a press release on April 26, 2007, stating, in its title, “Stanford University Ethanol Study Tainted by Exxon Mobil Ties”, and in its text, “However, the public cannot accept the results at face value when ExxonMobil has funded a major energy research program a the university and research results are in line with giant oil firm’s corporate goals.” Similarly, in a seminar in April, 2007 at Stanford University, Mr. Vinod Khosla, a venture capitalist with investments in ethanol, claimed publicly that this study was funded by Exxon Mobil.

This study had absolutely no funding from Exxon Mobil or other company, as stated. Further, the implication that this study was influenced by Exxon Mobil or other oil companies is completely false and contradicted by its conclusions. The study finds that both gasoline and E85 are bad for U.S. health with E85 causing equal or more damage. Since the implication of this study is that both gasoline and E85 should be eliminated in favor of cleaner technologies (e.g., battery-electric vehicles and hydrogen fuel cell vehicles where the electricity for batteries and for hydrogen production by electrolysis is produced by wind, solar, hydroelectric, geothermal, wave, or tidal power), the suggestion that this study was influenced by oil companies is nonsensical.

In sum, Mr. Simpson, FTCR, and Vinod Khosla were irresponsible in their statements. In the case of FTCR, the statements were intentional smears since Mr. Simpson was informed prior to his press release that there were absolutely no financial or other links between this study and any company. After Mr. Simpson’s press release, he continued the smears in public comments and a newspaper editorial. Mr. Simpson’s statements were untrue.

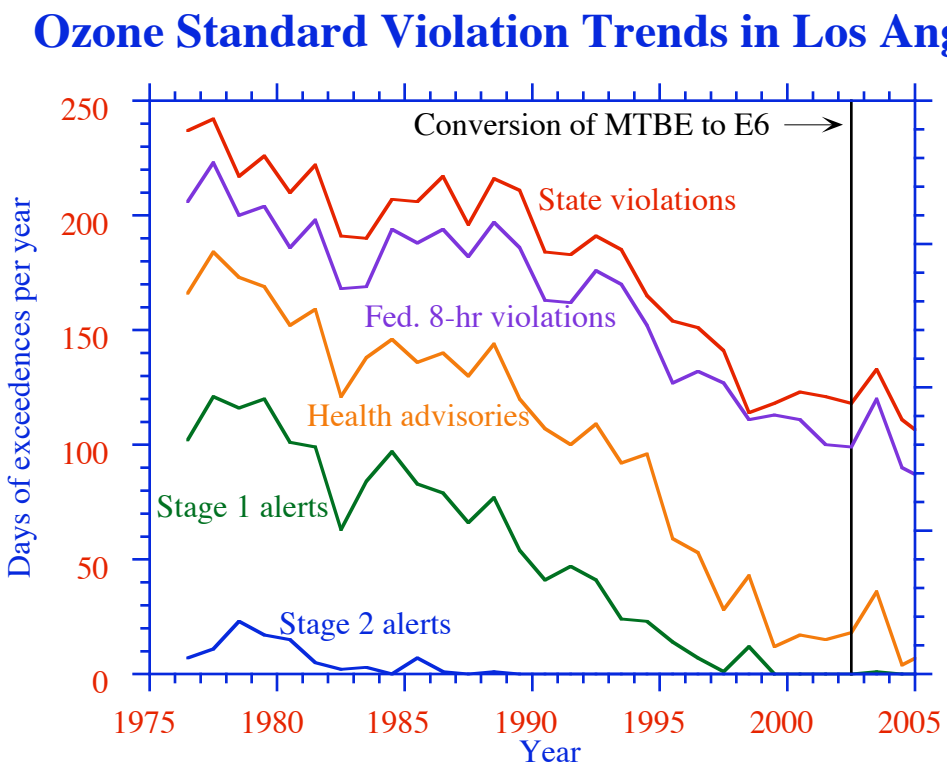
Ethanol Coalition

(http://www.grainnet.com/articles/American_Coalition_for_Ethanol_Responds_to_Stanford_Ethanol_Report-43588.html)

Claim: “Air quality has improved in every city, county, and state that has switched from straight gasoline to ethanol blended fuel"

Response: The implication that the use of ethanol (E6 or E10 in this case) has improved air quality is false. Air quality was improving before E6 or E10 was used in vehicles as well as after, and this has occurred because the 1970 Clean Air Act Amendment required 90% reductions in hydrocarbons, carbon monoxide, and oxides and nitrogen. Such improvements have occurred primarily due to the invention of the catalytic converter, developed as a response to the regulation, and to the year by year removal of older, more polluting cars from the road.

Figure 1. Ozone standard violations in the South Coast (Los Angeles) Air Basin from 1976 to 2005.



Data source: www.aqmd.gov/smog/o3trend.html

Figure 1, shows that when E6 was first introduced into California to replace MTBE, ozone violations in the South Coast Air Basin first increased dramatically before relaxing to their decreasing trend exhibited since 1976. This illustrates that the Ethanol Coalition's claim that "Air quality has improved in every city, county, and state that has switched from straight gasoline to ethanol blended fuel" is misinformation.

Claim: Ethanol reduces carbon monoxide and particulate matter emissions.

Response: This statement is false. Table 2 of J07 shows that of 8 measurement studies, half reported an increase and half reported a decrease of carbon monoxide due to E85. The one particulate matter study showed an increase due to E85.

Roland Hwang, Natural Resources Defense Council

Quotations from various newspaper interviews.

Claim "Ethanol, which cuts one of the key ingredients of smog and produces fewer greenhouse gases, is an important part of reducing all kinds of air pollution."

This statement is misleading. It states that ethanol cuts one of the key ingredients of smog but ignores the fact that it increases other ingredients of smog.

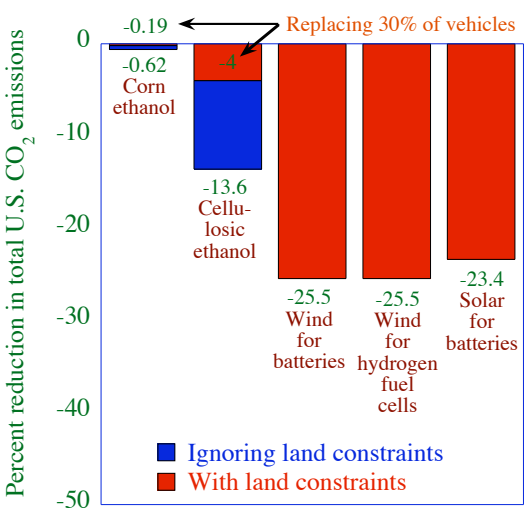
Second, it states that ethanol produces fewer greenhouse gases. However, the latest and most comprehensive assessment to date of the lifecycle emissions from ethanol was carried out by Dr. Mark DeLucchi at U.C. Davis:

www.its.ucdavis.edu/publications/2006/UCD-ITS-RR-06-08.pdf

This study accounts for several factors not previously accounted for in lifecycle analyses. The paper shows, in Table 3 and 8, only a 2.4 percent carbon-equivalent fuel-cycle benefit of U.S. corn-ethanol-E90 over gasoline, and a 17% disbenefit in China, a 10% disbenefit in India, and a 6% disbenefit in Chile. Thus, averaged worldwide, corn ethanol would increase carbon-equivalent emissions over gasoline. In the U.S. the 2.4% needs to be multiplied by 26% (the fraction of U.S. CO2 from onroad vehicles) and 30% (the maximum fraction of the U.S. vehicle fleet likely to be converted to E85 due to landuse constraints (converting all vehicles to corn ethanol would require 10-20% of U.S. land – Figure 3) to obtain a 0.19% difference between corn ethanol and gasoline (Figure 2a). As such, corn ethanol does not, according to current scientific understanding, reduce greenhouse gas emissions beyond a trivial amount. Corn ethanol is the only commercially-developed ethanol available of any quantity in the U.S.

According to Dr. DeLucchi's study, cellulosic ethanol could theoretically reduce greenhouse gas emissions by 52.5% relative to gasoline. Multiplying this number by 26% and 30% (since prairie grass is also land constrained and would require 5-15% of U.S. land to convert all onroad vehicles to E85 – Figure 3), gives a maximum of 4% reduction in U.S. total greenhouse gas emissions from cellulosic ethanol (Figure 2a), which is much less than the 80% reduction needed to address global warming. Further, cellulosic ethanol has not been demonstrated to be viable at the commercial scale.

Figure 2. (a) Potential percent decrease in total U.S. carbon dioxide emissions upon replacing 100% of U.S. onroad vehicles in different ways. Also shown are real percentage reductions possible due to corn and cellulosic E85 due to land constraints. (b) Estimated maximum future U.S. deaths per year from vehicle emissions assuming full penetration of the given vehicle.


Percent reduction in total U.S. CO_2 emissions
0
-10
-20
-30
-40
-50
-0.19
Replacing 30% of vehicles
-0.62
Corn
ethanol
-4
-13.6
Cellu-
losic
ethanol
-25.5
Wind
for
batteries
-25.5
Wind
for
hydrogen
fuel
cells
-23.4
Solar
for
batteries
Ignoring land constraints
With land constraints

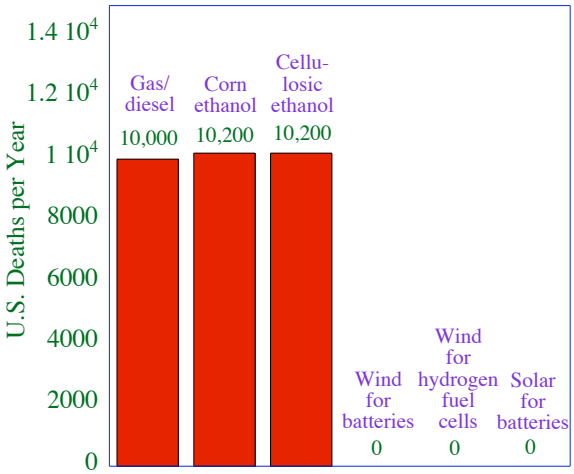

U.S. Deaths per Year
1.4 10^4
1.2 10^4
1 10^4
8000
6000
4000
2000
0
Gas/
diesel
10,000
Corn
ethanol
10,200
Cellu-
losic
ethanol
10,200
Wind
for
batteries
0
Wind
for
hydrogen
fuel
cells
0
Solar
for
batteries
0

Figure 3. Land area required to power 100 percent of U.S. onroad vehicles with corn ethanol-E85 (yellow), cellulosic-ethanol E85 (red), wind-powered battery-electric vehicles (green and pin), and solar-powered battery-electric vehicles. The pink dot is the area touching the ground for wind turbines (exaggerated in size), whereas the green area is the area required for wind turbine spacing.

Claim: "Hwang said he had problems with some of Jacobson's assumptions, such as an entire switch to ethanol by 2020. "

Response: This statement is misleading since the result in the paper applies to any incremental addition of geographically-dispersed vehicles. The only effect of a smaller penetration is a change in the magnitude of the damage, which will be no less than the damage due to gasoline, 10,000 deaths per year (Figure 2b).

Claim: "(Hwang) said that the ozone difference that Jacobson finds is so small that it may be in the margin of error of calculations.

Response: This statement is misleading because the conclusion of the paper is that E85 may cause an equal or greater effect than gasoline, so a zero change is consistent with results from the study. A zero change is equivalent to at least 10,000 deaths per year.

In addition, the direction of the result can be obtained from an ozone isopleth, a second independent verification of the results. Finally, five sensitivity tests were done (four for 2020 and one for present day), and all supported the fundamental conclusion of this study, suggesting that the result was not random noise.

Claim: "Jacobson is also ignoring that ethanol especially the kind made from cellulose, like switchgrass reduces greenhouse gases, which cause global warming. And global warming will increase smog and smog-related deaths, an international scientific panel just found this month"

Response: The claim that reduced air pollution due to reduced warming by cellulosic ethanol would affect the conclusion that E85 damages health through its air pollution effect, is false. First, the carbon benefit of corn ethanol is near zero, so it can have no effective effect on global warming, so its "greenhouse gas" effect cannot ameliorate its air pollution effect.

Second, only one study has been done that examines the potential death rate of global warming due to air pollution, and that was done by M.Z. Jacobson, manuscript in review, 2007. Based on data from that study combined with equivalent CO_2 differences from cellulosic ethanol, the death rate reduction due to lower temperatures resulting from a 100% penetration of cellulosic ethanol would be less than the increase in the air pollution deaths from E85 found in the present study. As such, even if cellulosic ethanol became viable and even if it reduced carbon, any increase in E85 from it would cause equal or greater air pollution deaths than gasoline.

The fundamental point that Mr. Hwang is missing is that cellulosic ethanol cannot reduce carbon by any more than 4% over the U.S. (Figure 2a) and, produces as much or more air pollution as gasoline (Figure 2b). This compares with renewable energies powering battery-electric and hydrogen fuel cell vehicles, which can reduce up to 10,000 deaths per year (Figure 2b) and 25.8% of CO2 emissions (Figure 2a).

As such, every ethanol-fueled car or gasoline-powered car increases death and carbon emissions significantly when it is used instead of a renewable-powered battery-electric or hydrogen fuel cell car.

Dr. Gary Z Whitten, Consultant

From document appearing on Renewable Fuels Association Website
http://www.ethanolrfa.org/objects/documents/1061/smog_reyes-jacobson.pdf

Claim: While the model used in this study by Mark Z. Jacobson is very extensive and sophisticated, the quality of the results from any modeling study always dependant on the quality of the inputs used for the model. In the present case, these

inputs are questionable, mainly due to the time projection out to 2020. The California Air Resources Board (CARB) is currently struggling with an emissions inventory to be used in air quality models that will attempt to predict 2010; yet Professor Jacobson is attempting to predict 2020. Furthermore, the differences in air quality predicted for 2020 between ethanol and gasoline fuels are much smaller than the differences expected in California for just gasoline vehicles in the four years between now and 2010. Thus, even the base gasoline predictions are uncertain for a year so far in the future as 2020, let alone the potential emissions using E85.

Response: Dr. Whitten was not aware that simulations were done for present day conditions as well as 2020, as reported in the paper. Results for the present day were significantly more disadvantageous for E85. Results for 2020 were consistent in direction and lower in magnitude.

Dr. Whitten also was not aware that emission estimates were biased in favor of E85 as overall emission changes between the present and 2020 were lower than estimated by Argonne National Laboratory, and E85 emissions used were lower than from a bottom-up approach.

Further, he was not aware that four sensitivity tests were run examining different possible future (2020) emission scenarios, and for all sensitivities, the future results held. These results were stated in the paper.

Finally, he did not realize that the direction of the results can be obtained from an ozone isopleth.

In sum, results for 2020 were consistent with those for the present day, were conservative, and were not sensitive to large emission changes. As such, his comments have no bearing on the conclusions of this study.

As a group of sensitivity simulations, future expected trends in various emissions categories might be a useful addition to a study comparing gasoline with E85. However, this reviewer believes a more convincing comparison would be based on a simulation of a near term year (e.g. 2006 or 2010) using the latest current gasoline emissions and a compilation of currently available E85 emissions data.

This was done and reported in the paper.

To be sure, as discussed below, this would still be a "fictional" exercise because so few vehicles now can use E85, but it would be based on the best emissions estimates currently available. Even though a total use of E85 might be assumed in one of these near-term scenarios, the results could be used to provide an approximation to the impact of any level of E85 utilization. Trying to project 14 years into the future for all emissions adds too many uncertainties due to changes in gasoline and ethanol technology, let alone potential differences between them.

The number of vehicles selected for the conversion is largely irrelevant. The result applies to the incremental addition of a few or a large number of geographically-dispersed vehicles.

Currently only about 1 percent of vehicles are capable of using E85 nationwide. Thus, any vehicles remaining on the road in 2020 would need to be retrofitted. All new vehicles sold between now and then would have to be either flex-fuel capable between gasoline and E85 (or perhaps even dedicated E85) or they too would have to be retrofitted.

The results apply to a few or a large number of geographically-dispersed vehicles.

There really is a paucity of data now on the emissions of existing E85-capable vehicles. Also new emissions-technology improvements and catalyst formulations are being developed every year. Rapid developing technologies are a major source of uncertainty for the emissions for each fuel themselves, let alone the differences between gasoline and E85 by 2020. Given such uncertainties and the fact that this study by Professor Jacobson showed results that actually were very small (less than 2 ppb ozone) impacts, it is reasonable to state that zero impact could be considered to be within the range of uncertainty for this study.

First, a 2 ppbv change in ozone is not small, as a 1 ppbv change in the 24-hour ozone above 35 ppbv increases the death rate by about 0.92 deaths per 100,000 population (medium case).

Second, Dr. Whitten missed the portion of the abstract of the paper, which states, "However, because of the uncertainty in future emissions, it can be concluded with confidence only that E85 is unlikely to improve air quality over future gasoline vehicles." As a result, E85 will kill as many people in the United States as gasoline vehicles (estimated as 10,000). Because wind, solar, hydro, geothermal, wave, and tidal electricity for batteries and for hydrogen for fuel cells do not kill any people as a result of vehicle emissions (Figure 2b), these are superior options to any form of ethanol combustion or gasoline in terms of public health, and Dr. Whitten, by his comments, implicitly agrees with this conclusion if he agrees that ethanol will kill as many people as gasoline, in the future.

Another problem with this futuristic modeling study is that the methodology used to assemble existing data on E85 emissions is not described in sufficient detail to assess the robustness of that methodology or the range of data variability. As an example, one study well known to this reviewer is the study by the Auto/Oil Air Quality Improvement Research Program released in July 1995, as Technical Bulletin No. 16 entitled "Exhaust Emissions of E85 Ethanol Fuel and Gasoline in Flexible/Variable Fuel Vehicles." In that study three flex-fuel vehicles were tested on gasoline and E85 fuels. Only one of the three had been certified to the emissions standards of the time (the other two were prototypes). The certified vehicle showed favorable comparisons for E85, but the two prototypes did not. Notably, the certified vehicle showed results

that appear to be different than those used by Professor Jacobson. Thus, there must be a range of variation in emissions data between E85 and gasoline that suggests that he could have run his model for both the worst and the most favorable (for E85) sides of that range of variation and thereby address the sensitivity to some of the uncertainty inherent due to the technologies available even today.

Dr. Whitten did not acknowledge Table 2 of the paper, which reports results from 11 independent studies, comparing E85 and gasoline.

Finally, the results of this study by Professor Jacobson do show that most of the air quality "problems" he identified stem from acetaldehyde that is either emitted directly or results from excessive ethanol emissions. If these problems were found to be serious enough, then regulations could quickly be put into place that would require vehicles using E85 (or higher ethanol content fuels) must meet more stringent ethanol and acetaldehyde emissions standards before they could be certified for sale. This reviewer believes that the present study does not show such problems to be serious enough at this time to require changing the existing regulations due to the uncertainties apparent in this study, the long time frame used in the study, and the current rapid changes in vehicle emissions technology.

The 2020 simulations accounted for 60% reduction in E85 and gasoline emissions, and this was an overestimate, in favor of E85, according to the Argonne National Laboratory study.

Unauthored Natural Resources Defense Council (NRDC) Document

Entitled, "NRDC Statement on New Study of Ethanol (E85) Impact on Air Quality", April 26, 2007

Overall response: In this document, NRDC has suppressed information contrary to its argument, misstated assumptions and conclusions in the paper, and failed to comment on the real issue, the comparative disadvantages of both ethanol and gasoline compared with other existing and emerging technologies that nearly eliminate air pollution, climate-relevant gases, and use much less land area than corn or prairie grass for ethanol.

With regard to suppressing information, I will cite two examples up front: NRDC included Figure 3, the change in NO_x emissions from certain certified flex-fuel vehicles in California, but did not include the corresponding change in nonmethane organic gas (NMOG) emissions, which indicate from data provided by NRDC an approximate increase in NMOGs by E85 vehicles of (by eyeball) 50% relative to gasoline from 12 data points for model-year 2004-2006 FFV. Such increases were 2-3 times the increases assumed in the present study. Similarly, with regard to the carbon balance of ethanol, the report cites one study that ignores several emission sources of ethanol but ignores a more comprehensive and recent study that includes such sources. This type of selective use of

data to demonstrate a point occurs throughout the document, as discussed next.

Finally, the emission assumptions going into the model of Jacobson, EST doi:10.1021/es062085v, 2007 (hereafter J07) are consistent (and conservative) based on a comparison with Certification data for 2006 vehicles and other research data. Specifically, results are consistent with an independent set of data,

Certification Data Summary Sheet Data for 2006 MY Flexible Fuel Emissisons/Fuel Economy Comparison Chart, forwarded by the California Air Resources Board.

Data are from six 2006 flex-fuel vehicles. Below is a summary of statistics from the data and a comparison of the statistics with baseline-simulation assumptions in J07.

	City test	Highway test	Avg.	J07
NMOG				
E85	0.0589 g/mi (6 veh.)	0.057 g/mi (2 veh.*)	0.058	
Gasoline	0.0483	0.0323	0.040	
Diff. (E85-gas)	+21.95%	+76.5%	+45.0%	+19.6%
NO_x				
E85	0.0388 g/mi (6 veh.)	0.0151 g/mi (6 veh.)	0.0270	
Gasoline	0.0492	0.0275	0.0384	
Diff. (E85-gas)	-21.1%	-45.1%	-29.7%	-30.0%

*NMOG data for only 2 vehicles were available for highway test.

The comparison shows that the NOx emission changes due to E85 assumed in J07 almost exactly equaled those from the CARB data and the NMOG emission changes underestimated the NMOG changes from the available CARB data by a factor of two. The factor of two lower NMOG emissions in J07 implies that air pollution due to E85 may be worse than determined from J07, considering only these data. Not only were NMOG underestimated relative to CARB data, but the assumptions about speciation of the NMOGs were also conservative, according to 2007 data from

Whitney, K., and T. Fernandez, Characterization of cold temperature VOC and PM emissions from flex fuel vehicles operating on ethanol blends, 17th CRC On-Road Vehicle Emissions Workshop, March 26-28, 2007 (WF07)

	% Difference between E85 and gasoline	
	J07 (Table 1)	WF07 (at 72 ºF)
Benzene	-79%	-64%
1,3-butadiene	-10%	-66%
Acetaldehyde	+2000%	+4500%
Formaldehyde	+60%	+200%

The table above shows that J07 assumed lower increases in acetaldehyde and formaldehyde due to E85 and greater decreases in benzene due to E85 than in this new data set. J07 conversely underestimate the reduction in 1,3-butadiene. Given the relative reactivity of acetaldehyde and formaldehyde at forming ozone (these are two of the top five ozone precursors in Los Angeles, whereas 1,3-butadiene is not in the top 25 (Lurmann et al., 1992, CARB A832-130, 1992)), these results again suggest an underestimate of the air pollution damage due to E85 found in J07.

Specific Responses:

1. Comment: "A high blend of ethanol poses an equal or greater risk to public health than gasoline." This conclusion is at odds with previous studies and emission data from modern vehicles running on E85, and even appears to be at odds with the conclusion from his own study.

Response: The results of the present paper are not at odds with any previous study since no previous study has examined the issue examined in the present study. If NRDC wishes to claim that any previous study has examined the effect on ambient air quality or human health of converting gasoline vehicles to E85 vehicles in Los Angeles or the U.S., the NRDC should provide (a) the reference to the paper, (b) the computer model used, (c) the population distribution used, (d), the health-effects data used, and (e) spatially-distributed emission database used. NRDC is confusing emission studies where authors incorrectly applied health effects information directly to emissions data as an afterthought without considering the concentrations that people are exposed to, the population distribution, or the evolution of the pollution over time, with air quality/health studies, that account for these factors.

Even United States Law, under the Clean Air Act Amendments of 1977, requires that computer modeling be performed to check whether each proposed new source of pollution can result in an exceedence of emission limits in a violation of a National Ambient Air Quality Standard. The type of model NRDC refers to does not satisfy U.S. regulation requirements. The model used for this study does.

The text of the paper (Jacobson, EST doi:10.1021/es062085v, 2007, hereafter J07) states specifically,

"With respect to air pollution, several studies have examined emission differences between gasoline- and ethanol-fueled vehicles (9-19). However, no study has examined the spatially varying effect on cancer or ozone-related illness throughout the United States that might result in a conversion to ethanol."

This statement is true and correct.

To illustrate how misleading it is to suggest that one can use changes in emissions to

extrapolate health effects, one needs only to look at the units of the health effects data. Health effects data are provided in units of, for example, deaths per 100,000 population per ppbv increase in ozone. Emission data give only milligrams per mile of emissions. How is it possible to estimate the ppbv change in ozone if all one knows is the mass of emissions? A mass emission say nothing about the mixing ratio of the pollutant in the air, which depends on dilution, chemistry, deposition, advection, convection, cloud processing, etc. Further, how is it possible to determine how many people were exposed to a mass tailpipe emission? The answer is that it is impossible in the absence of a model that treats the evolution of pollution past the tailpipe.

To bypass these inconvenient details, emission studies in the past merely assigned an ozone formation potential (from a lookup table) to the mass emissions. To illustrate how erroneous this is, one only needs only to recognize that the ozone formation potential estimates are independent of variable conditions such as background mixing ratios. However, from an ozone isopleth, it is clear that the level of ozone depends on the background level of NO_x and hydrocarbons. Thus, the ozone formation potentials used are applicable to one set of conditions only, not the billions of possible sets of conditions that occur in the real atmosphere and that are captured by a three-dimensional model

As such, is irresponsible and misleading for NRDC to imply that air quality decisions can or should be made based on extrapolations of emission data when the extrapolations have no scientific basis and have never been verified to be correct in any study despite the availability of the technique for years. If the method were valid, one could test it against data. But, this has never been done. The 3-D model used in J07 is the most rigorous and tested model worldwide, and has been compared with ambient paired-in-time-and-space data in several peer-reviewed published studies.

The abstract of J07 further states, "Under the base-case emission scenario derived…it was found that E85 may increase ozone-related mortality…However, because of the uncertainty in future emission regulations, it can be concluded with confidence only that E85 is unlikely to improve air quality over future gasoline vehicles."

Nothing in NRDC's document contradicts this conclusion.

2. Comment: Dr. Jacobson fails to explain why his results differ from the published conclusions by scientists at US EPA, US DOE, and NREL. In a study published in the Journal of Air & Waste Management Association, researchers at the US EPA and US DOE found that a flex fuel vehicle running on E85 lowers the smog-forming potential of its emissions. Scientists at the National Renewable Energy Laboratory (NREL) reached the same conclusion. These studies were based on testing of actual vehicles.

Response: This statement is false. The paper, in the third paragraph of the introduction, clearly explains that no previous study has done the same thing as is done here:

"With respect to air pollution, several studies have examined emission differences

between gasoline- and ethanol-fueled vehicles (9-19). However, no study has examined the spatially varying effect on cancer or ozone-related illness throughout the United States that might result in a conversion to ethanol."

Eleven studies, including Black et al. and two NREL studies were referenced in this sentence. These studies were emission studies, not health studies. In some cases, the authors extrapolated emissions to health effects with a back-of-the-envelope approach.

The flaws in the back-of-the-envelope approach were explained under Response 1, above.

The analysis of 2006 California Air Resources data provided at the beginning of this response further confirms the conservative nature of the results found here.

3. Comment First, the law requires vehicles that can run on E85, called flexible fuel vehicles (FFVs), meet the same pollution standards for smog and soot-forming pollutants as gasoline cars. Despite this fact, the study assumes dramatic changes in emission levels from the use of E85, a 30% decrease in NOx and a 22% increase in hydrocarbons. Certification data from modern FFVs show that these vehicles meet the same pollution standards regardless of what fuel they run on.

Response: The federal 8-hour ambient air quality standard for ozone is currently 80 ppbv. However, ozone increases mortality starting at 35 ppbv (Ref. 32 of J07). Emission regulations are designed to keep ozone below the ambient standard. As NRDC knows well, such standards still result in deaths due to ozone. As such, both gasoline and E85 vehicles may meet emission standards with emissions from one higher than the other for some chemicals and lower for others, but in all cases, emissions from both vehicles will still lead to excess mortality. As such, the argument that, just because E85 (or gasoline) vehicles meet standards, we should ignore their health effects, is a poor argument.

4. Comment: Second, the study greatly exaggerates emission impacts by assuming that 100% use of E85 is possible by 2020, a virtual impossibility. It is physically impossible for that much ethanol to be available or for all of the vehicles to transform into FFVs by 2020. Currently ethanol displaces less than 5% of our gasoline fuel supply. To achieve 100% displacement would require well over 200 billion gallons of ethanol compared to today's roughly 5 billion. Under a more likely penetration scenario, E85 would displace about 10% of the gasoline supply by 2020.

Response: The study makes no exaggerations as it does not claim that E85 will or is likely to make a 100% penetration. The only statement in the text referring to possible penetration is "…flex-fuel cars…could substantially penetrate the U.S. vehicle fleet only by 2020." Whereas NRDC estimates 10% penetration above, others have informally estimated 30%.

The purpose of looking at 100% penetration was to determine an upper limit of the effects from which the effects of any smaller addition of geographically-dispersed

vehicles can be examined. Once the 100% effects are known, the effects of incrementally-adding a few geographically-dispersed vehicles can be estimated. It is the direction of the effects, not the magnitude that is important in this case. The study (J07) concludes that "Due to its ozone effects, future E85 may be a greater overall public health risk…However, because of the uncertainty…it can be concluded with confidence only that E85 is unlikely to improve air quality…" This conclusion holds for a few vehicles or full penetration.

5. Comment: Third, the study further magnifies small differences by ignoring the fact that most emission from cars is due to older vehicles that would be incapable of running on E85. By 2020, CARB estimates that less than 25% of the on-road passenger vehicle NOx and hydrocarbons emissions are from cars 16 years and newer (see Figure 1).5 This mistake alone exaggerates the emission impacts by a factor of about four.

The study accounted for the elimination of older vehicles and aging of vehicles in two ways. First, it assumed 60% reductions in 2020 emission of gasoline and E85 relative to today, based on two independent studies. As explained in an earlier response to G. Whitten, such an estimate was conservative. Second, it performed a bottom-up calculation of tailpipe emissions from real aging data modified for future improvements. This approach resulted in more emissions than was actually used in the model, thus the results of this study can only be conservative.

6. Comment: Sensitivity runs by the author make it clear that the changes in the Los Angeles region smog levels are almost entirely driven by his assumption of a 30% NOx decrease (see Figure 2). The small changes in ozone levels appear to be primarily driven by assumption of large changes in NOx. Simple extrapolation of the fairly linear trend shows that there would likely be no change in ozone levels if the author assumed a less than 10% reduction in NOx emissions, a scenario which was not included in the paper. For the primary scenario, the author assumed a very large 30% decrease in NOx.

Response: First, the 2006 California Air Resources Board (CARB) data for six flex-fuel vehicles provided at the beginning of this response show that E85 decreased NO_x by 29.7%, almost exactly equal to the 30% reduction assumed in the present study.

Second, the statement, "…smog levels are almost entirely driven by his assumption of a 30% NOx decrease" is an exaggeration. Table 5 of J07 of the text shows that sensitivity to NOx is important (e.g., the population-weighted ozone difference varies between 0.281 and 1.33 ppbv when NOx is reduced by 10% to 45%), but sensitivity to total organic gas is also a factor (ozone differences from 1.02 to 1.45 when TOG varies from 6% to 38%).

Third, one cannot simply extrapolate NOx changes to -10% and expect zero ozone, although this is one possible scenario, because chemistry is nonlinear. This can be seen from the bottom curve of NRDC's Figure 2 showing an inflection at -30%.

Fourth, because the E85 increase in TOG over gasoline was estimated at 22%, which is lower than all emission studies that reported TOG data, the assumed TOG difference estimate was lower than it is likely to be in reality, and this is confirmed by an additional 12 data points from certification data provided by NRDC which show an approximate increase, on average, of 50% in NMOGs for E85 relative to gasoline.

Fifth, the NMOG data provided by CARB at the beginning of this response shows that E85 may increase NMOGs over gasoline by 45%, which is consistent with the 50% increase found from the data reported by NRDC. Both increases are more than twice the increase assumed in the present study (+19.6% NMOG for E85 relative to gasoline).

Thus, a more realistic higher estimate of NMOG would shift both curves in NRDC's Figure 2 upward.

7. Comment: The study fails to acknowledge that, despite the potential for ozone to increase under certain conditions of NOx decreases, under most circumstances reducing NOx will reduce smog and that the California strategy for the last 25 years to meet ozone and soot (PM2.5) ambient air quality standards has been built around reducing both NOx and hydrocarbons concurrently. Though undesirable, this effect (sometimes known as the "weekend effect") is well known and has been well studied by CARB.6 However since it's impossible to meet clean air standards with hydrocarbons reductions alone, air quality regulators have adopted a strategy to reduce both at the same time. According to CARB: A strategy of concurrent reductions of the major precursors of ozone, VOCs and NOX, has been used for more than twenty-five years to reduce ozone levels in California's ambient air. Concurrent reductions of VOCs and NOX have been very successful at reducing the high ozone levels in southern California. From the mid-1970s into the 21st century, the ozone control strategy implemented in the South Coast Air Basin (SoCAB) included reductions of both VOC emissions and NOX emissions. Early NOX reductions were achieved by statewide controls on emissions from motor vehicles combined with local controls on emissions from industrial sources, such as power plants and cement kilns.

Response: Reducing ozone in Los Angeles by reducing NOx is only possible with a significant NOx reduction (beyond a NOx threshold), and this can be seen from an ozone isopleth (e.g., Fig. S2 of J07). NRDC does not demonstrate whether the VOC or NOx reductions have been reducing ozone, and this is impossible to do from data analysis alone. Certainly, the combination of VOC and NOx reductions should be beneficial, but that is not occurring in the present case, since E85 is clearly increasing TOG.

8. Comment: Even if reducing NOx was a bad idea, emissions data from modern FFVs clearly shows that there is no discernible pattern of differences in NOx emissions when an FFV is running on E85 versus gasoline (see Figure 3).

Response: First, the CARB data shown at the beginning of this response show a 30% NOx reduction and a 45% NMOG increase by E85 relative to gasoline, compared with a

30% NOx reduction and a 19.6% NMOG increase in the present study. As such, NRDC's use of statistics is selective.

Second, NRDC's showing of only this NOx figure is deceptive, since NRDC also has an analogous NMOG figure for 12 cases showing significant relative increases in NMOG from E85 versus gasoline (about 50% on average by eyeball).

Third, the NOx data shown by NRDC are selective since NRDC do not account for many other studies that show decreases. Table 2 of J07 shows that four recent studies (M02, S05, M05, D06) found significant NOx reductions (minimum of 33% and maximum of 59%) between E85 and gasoline. Only one recent study (G06) showed an increase, and that study also showed an NMOG and TOG increase. As NRDC states, it would not be a good policy to increase both NOx and NMOG. All or almost all the studies in Figure 3 of NRDC's document show increases in NMOG and little change in NOx, which cannot mean that E85 will improve air quality over gasoline.

9. Comment: Dr. Jacobson dismisses the substantial potential for E85 to reduce global warming pollution, despite the fact that most researchers agree that when produced from cellulosic feedstocks (e.g., switchgrass, agricultural waste, etc.) ethanol has the potential to dramatically cut global warming pollution. According to a study published in Science magazine by Professors Farrell and Kammen at UC Berkeley, cellulosic ethanol can reduce greenhouse gases by up to 90% compared to gasoline.

Response: NRDC ignores the study by Dr. Mark DeLucchi, discussed early, which is far more comprehensive than any of the other studies published to date. Results from that study shown in Figure 2a here illustrate how E85 could reduce equivalent carbon by at best 4% with 30% E85 penetration. NRDC suggest E85 penetration will be only 10%. This indicates only a 1.33% carbon-equivalent emission benefit of E85 relative to gasoline, a trivial number that illustrates why NRDC's advocacy of E85 at the expense of other renewables is misguided. Figures 2a,b and 3 illustrate clearly the benefits of other methods of addressing air quality and climate that are significantly superior to corn or cellulosic ethanol.

11. Dr. Jacobson fails to account for the fact that rising temperatures due to global warming are predicted to increase smog levels in the US, including California. According to the latest Intergovernmental Panel on Climate Change report by the world's leading experts on global warming, the US can expect "increased frequency of cardio-respiratory diseases due to higher concentrations of ground level ozone related to climate change."

Response: Only one study has ever examined the potential death rate of global warming due to air pollution, and that was done by M.Z. Jacobson, manuscript in review, 2007. Based on data from that study combined with equivalent CO_2 differences from cellulosic ethanol, the death rate reduction due to lower temperatures resulting from a 100% penetration of cellulosic ethanol would be less than the increase in air pollution deaths

from E85 found in the present study. As such, even if cellulosic ethanol became viable and even if it reduced carbon, any increase in E85 from it would cause equal or greater air pollution deaths than gasoline.

Renewable Energy Action Project (REAP)

From document appearing on Renewable Energy Action Project Website
http://www.reapcoalition.org/pdfs/REAPresponse_jacobsonE85.pdf

1) REAP states that the study conflicts with analyses conducted by the U.S. EPA, the California Air Resources Board, and other groups. This statement is false, as no other group has performed a three-dimensional modeling study of the effects of E85 versus gasoline on health in the United States, and this is seen by searching the peer-reviewed (published) and unpublished literature.

2) REAP claims that a complete conversion to E85 is unlikely; thus, it is misleading to imply that more people will perish due to E85 than gasoline. In response, the main implication of the study is that any additional of geographically-dispersed E85 vehicles will either not change or increase the death rate in the United States. This conclusion holds regardless of whether E85 penetration is 1% or 100%. The fact that both gasoline and E85 kill people, just as tobacco smoke does, should be a concern to all those who care about the health and welfare of the population.

3) REAP makes the false claim that the study assumed "vehicles and fuels will not become more advanced in the next 13 years." To the contrary, the study assumed both gasoline and E85 emissions would decrease by 60% between today and 2020.

4) REAP makes the false claim that the assumption of a 30% reduction in NOx by E85 is unsupported. To the contrary, certification data for six 2006 flex-fuel vehicles shown under the response to NRDC, above, indicate a 29.7% reduction in NOx with E85.

5) REAP implies that a reduction in NOx should not increase ozone. Under high NOx conditions, such an effect is well established and embodied in an ozone isopleth (Fig. S2 of J07).

6) REAP claims that the study ignored the role of E85 in reducing evaporative hydrocarbon emissions. This statement is false. The percent changes in emissions between E85 and gasoline assumed in the study applied to both evaporative and direct emissions.

7) REAP claims that the study ignored "recent critical updates to emissions inventories from the California Air Resources Board and other agencies."This statement is false. The study used the latest emission inventory available from the U.S. EPA, and CARB does not produce an emission inventory for the U.S.

8) REAP claims that the study "Assumes acetaldehyde emissions will lead to an increase in PAN emissions, which will thereby lead to greater ozone." First, PAN is not emitted, it forms chemically in the atmosphere, and it does not produce ozone, except incidentally; it is a co-product, along with ozone. Second, no assumptions were made about the effect of acetaldehyde on PAN. The model calculated the production of PAN on its own from first principles.

9) REAP claims that the PAN results found in the study conflict with CARB data and real world experience in Brazil. This statement is false, since no E85 vehicles exist in California today. Further, under high temperatures, such as in Brazil, PAN decomposes, so its mixing ratio is not expected to be high there. Ozone levels in Brazil, though, have been high historically and have been attributed, in the peer-reviewed literature, to ethanol use.

10) REAP claims that modeling inputs are based on outdated vehicle data from 1991. This statement is false. The emission inputs due to E85 were based on 11 studies from many years, up through 2007 certified vehicles. Subsequent to the paper, 2006 data (cited under the response to NRDC) have emerged confirming the assumptions for nearly all important chemical inputs.

11) REAP claims that the study completely ignores life-cycle models, such as the GREET model. This statement is false. One of the 11 input data studies used was a study performed with the GREET model.