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New Study Distorts Health Benefits of Greenhouse Gas Reduction

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Air pollution is a serious problem in many cities around the world, accounting for significant damage to human health. The World Health Organization estimates that air pollution kills as many as 3.3 million people per year, mostly in the developing world. Millions more suffer air pollution-related disability, such as aggravations of asthma and other respiratory diseases.[1] A recent paper, "Hidden Health Benefits of Greenhouse Gas Mitigation" by Luis Cifuentes and four co-authors (hereafter *Cifuentes*), published in the August 17, 2001 issue of the journal *Science*, purports to show that reducing greenhouse gases, in addition to fending off global warming decades from now, will also yield significant near-term health benefits by reducing air pollution.[2]

When researchers make far-reaching policy recommendations in a respected scientific journal, one might expect those recommendations to rest on a firm scientific foundation. But that is not always the case. Though published in the "Policy Forum" section of the prestigious journal *Science*, the *Cifuentes* study does not meet minimal standards of scientific validity, and the available evidence does not support its findings and recommendations. These flaws make the *Cifuentes* study of limited usefulness for policymakers and others interested in either greenhouse gas or air pollution policy.

There is little doubt that reducing air pollution in regions with high air pollution levels would provide substantial human health benefits. However, the key policy questions, largely ignored by *Cifuentes*, are the following:

- Given the world's limited resources to deal with a wide range of threats to human health and safety, how do reductions in greenhouse gases and air pollution fit into an overall policy that maximizes health and safety for any given level of investment?
- What measures will provide the most air pollution reduction per dollar spent?
- How clean is "clean enough," in terms of air quality standards that adequately protect human health?

Unfortunately, the *Cifuentes* paper skips over these key issues and simply assumes that greenhouse gas reductions are an efficient and cost effective way to address ozone and particulate air pollution problems.

I. Summary of the *Cifuentes* Study

Global warming studies generally focus on the predicted effects of carbon dioxide and other greenhouse-gas reductions on climate. The main source of human-caused carbon dioxide emissions is fossil fuel combustion, such as the burning of coal, oil, or natural gas for electricity generation, or the burning of gasoline or diesel in cars and trucks. *Cifuentes* argues that reducing carbon dioxide will have the ancillary benefit of causing reductions in ozone and airborne particulates—local pollutants that also result from burning fossil fuels.

Cifuentes attempts to estimate the health benefits of such ancillary pollution reductions for four cities: New York, U.S.A.; São Paulo, Brazil; Santiago, Chile; and Mexico City, Mexico. The study asserts that "adoption of [greenhouse gas] mitigation technologies would reduce particulate matter and ozone ambient concentrations by about 10 percent." It also estimates the health benefits produced by this level of pollution reduction to be the avoidance of 64,000 premature deaths, 65,000 chronic bronchitis cases, and 37 million person-days of restricted activity during the next 20 years for the four cities studied.

II. Problems with the Cifuentes Study

A. *Cifuentes* Employs an Invalid Carbon Dioxide-Reduction Cost and Feasibility Scenario

The *Cifuentes* conclusions rest on four projections: (1) carbon dioxide emissions between now and 2020 with and without greenhouse gas reduction measures, (2) the cost of the carbon dioxide reduction measures, (3) ozone and particulate reductions between now and 2020 due to the carbon dioxide reductions, and (4) health benefits due to the ozone and particulate reductions. Each of these projections must rest on a firm foundation for the paper's conclusions to be valid.

Unfortunately, *Cifuentes* provides no easy way to assess the validity of the first two projections. Since *Cifuentes* is mainly a summary of previous work along with policy recommendations, the reader is referred to other articles for the details of the *Cifuentes* analysis. The main analysis supporting *Cifuentes* can be found in a paper published by the same authors in the June 2001 issue of the journal *Environmental Health Perspectives* (*EHP*).[3] The *EHP* paper states that "the scenarios used in this article are based largely upon a recent estimate of the potential reductions in [particulates and ozone] ambient concentrations that have been estimated as achievable in Chile through the use of readily available technologies to mitigate greenhouse gas emissions in energy, transport, residential, and industrial sectors." The article also claims that a 13 percent reduction in carbon dioxide emissions could be achieved at "little or no cost" and would result in the 10 percent reduction of ozone and particulates claimed by *Cifuentes*.

Although the *EHP* paper discusses the health effects estimates in detail, the carbon dioxide-reduction feasibility and cost estimates are sourced to a separate paper from an August 2000 United Nations Intergovernmental Panel on Climate Change (IPCC) conference entitled "Ancillary Benefits and Costs of Greenhouse Gas Mitigation Strategies."[4] But this paper also does not describe the methodology for deriving the

carbon dioxide reduction measures and costs, and instead cites yet another paper as the source of the details.[5] Unfortunately, this last paper, originally published in Chile, is not available on the World Wide Web or at the University of California Library, and could not be obtained in time to be considered for this article.

Even without scrutinizing these supporting details, there are at least three problems with the *Cifuentes* carbon-dioxide-reduction scenario:

- It doesn't come from a peer-reviewed source, so it has not been vetted by independent experts and found to meet at least minimum standards for scientific validity;
- The scenario was developed solely for Chile, and regardless of its validity for Chile, it might not be valid for other developing countries due to regional socio-economic differences; and
- The Chile example certainly won't be applicable to New York City and other developed areas, because the economies of developed nations are more energy-efficient, less polluting, and more technologically advanced than those of developing countries.

Nevertheless, *Cifuentes* misleadingly implies that its overall results are applicable to the vast majority of the world's urban areas. Without seeing the details of the carbon dioxide reduction assumptions, it is not possible to evaluate whether the assumed magnitude and costs are reasonable.

B. Greenhouse Gas Reductions are Neither Necessary nor Desirable as an Air Pollution Reduction Strategy

Cifuentes leads the reader to incorrectly believe that (1) increased fuel combustion necessarily means increased ozone and particulate air pollution, and therefore (2) carbon dioxide reductions, achieved through reductions in fuel combustion, are a necessary and desirable way to reduce air pollution. *Cifuentes* unilaterally states "For every day that policies to reduce fossil fuel combustion are postponed, deaths and illness related to air pollution will increase."

There are two ways in which this statement is false. First, in the industrialized world, local air pollution is no longer an inevitable result of fuel combustion. Ozone levels dropped 24 percent in the U.S. between 1980 and 1999, even as vehicle use increased more than 75 percent.[6] Likewise, particulate levels dropped by 18 percent between 1990 and 1999.[7] Based on California Air Resources Board and California Bureau of Automotive Repair data and projections, an average model-year 2002 vehicle will emit 90 percent fewer pollutants than the average vehicle currently on the road, even though newer cars burn about as much fuel per mile as older cars.[8] Turnover of the fleet to these low-polluting vehicles will ensure even more rapid pollution reductions in the future.

Similarly, advancements in pollution control also allow power plants to drastically reduce emissions when compared with older technologies. For example, new natural-gas power plants in California emit 90 percent less nitrogen oxide pollution per kilowatt-hour of energy when compared with the average California plant, and 98 percent less than a gas-fired plant with no pollution controls.[9] Modern technologies can also reduce nitrogen-

oxide emissions from older coal-fired power plants by 35 to 80 percent, depending on the technology chosen.[10] Directly addressing air pollution problems is not only more effective than attacking them indirectly through carbon dioxide reductions, it is also far cheaper. For example, the U.S. Energy Information Administration recently estimated that a 75 percent reduction in nitrogen oxides and sulfur dioxide emissions from U.S. power plants would cause about a 2 percent increase in electricity costs. However, reducing power plant carbon dioxide emissions by only 7 percent would increase electricity costs by 25 to 30 percent.[11]

Technological advancements have thus provided the means to slowly but surely decouple air pollution from energy production. *Cifuentes* projects a mere 10 percent reduction in local air pollution during the next 20 years from a 13 percent carbon dioxide reduction. But diffusion of modern pollution control technologies to the developing world would provide much larger, cheaper, and more rapid pollution reductions by directly addressing the causes of air pollution.

Second, according to the World Health Organization, roughly half the world's people use wood, cow dung, or other solid biomass as their main source of fuel for home heating and cooking, resulting in dangerously high levels of indoor air pollution.[12] As a result, researchers estimate that somewhere between 2 and 2.8 million people per year are killed by indoor air pollution, mainly in India, China, and sub-Saharan Africa. When comparing the damage from indoor and outdoor air pollution, researchers estimate that indoor air pollution is responsible for at least 85 percent of air pollution's worldwide health toll.[13]

The irony here is that a key way to improve the health of the world's poor would be increased use of cleaner fuels such as kerosene, gas, and electricity for home heating and cooking—exactly what the *Cifuentes* authors hope to prevent.

In sum, reducing fossil fuel use for energy generation is likely to be minimally effective and very costly as an air pollution control measure in the developed world, and would likely be counterproductive to the health of many people in the developing world.

C. Cifuentes Overestimates the Health Benefits of Ozone and Particulate Reductions in New York City

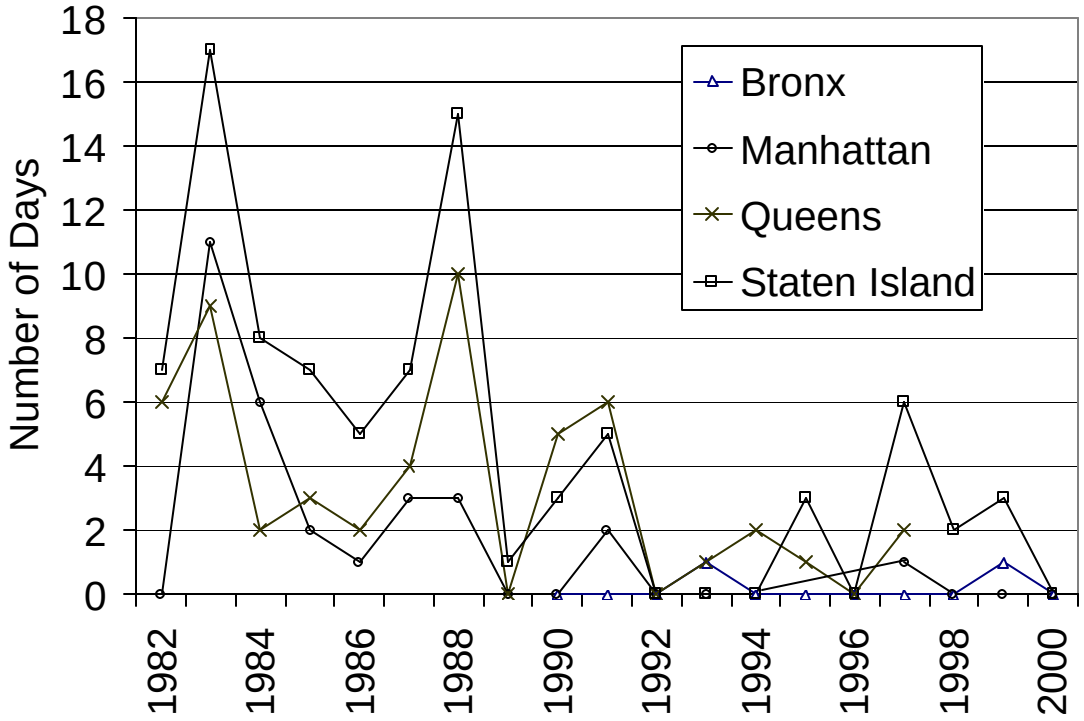
Cifuentes predicts that a 10 percent reduction in ozone and particulate levels will result in substantial health benefits for many New York City residents. For some health effects, the projected benefits for New York are of similar magnitude to those projected for cities in the three developing countries. For example, according to *Cifuentes*, New York would attain benefits similar to at least one developing country for several health effects, including overall mortality, chronic bronchitis, asthma attacks, work-loss days, and restricted activity days. These results are odd because New York already has some of the cleanest air among the world's large urban areas, and much lower air pollution levels than the other cities in the study.

Figure 1 displays the trend in the number of high ozone days in New York during the last 18 years.[14] Note the sharp downward trend in high ozone days from the 1980s to the 1990s. Table 1 summarizes recent ozone air quality in New York. Note that few locations ever exceed the current U.S. Environmental Protection Agency (EPA) ozone standard of 120 parts per billion (ppb), and that New York is also closing in on EPA's

new, tougher 80 ppb standard. Table 1 also displays annual mean ozone levels. Note here that half of monitoring locations have average concentrations of 40 ppb or less, which is about the same as the natural background ozone level.[15]

Figure 1. Trend in New York City's Number of Days Per Year with Ozone Greater than the EPA 120 ppb 1-Hour Standard, 1982–2000

(only locations with long-term data included)



Source: Chart based on EPA air monitoring data, www.epa.gov/aqspubl1/annual_summary.html.

The news is even better for particulate pollution. From 1998 to 2000, New York City never exceeded the federal daily particulate standard. More than 80 percent of locations never exceeded even half the standard. For the annual standard, 13 of 14 locations never exceeded the standard, while one location exceeded the standard in one of the last three years. More than 50 percent of locations never exceeded even half the annual standard, which effectively puts these areas near background levels.[16]

EPA pollution-monitoring data thus show that New York City meets or exceeds federal standards for particulates everywhere, meets federal ozone standards in portions of the city, and is close to meeting federal ozone standards in other areas. Given the ongoing downward trend in ozone levels, it is likely that New York City will meet the federal 80 ppb, eight-hour ozone standard within a few years—a standard set by EPA to protect human health with an adequate margin of safety.

The ozone and particulate standards are set to protect even sensitive individuals from the negative effects of air pollution. This means that New Yorkers are likely suffering few

effects of ozone and particulates now, and will suffer even fewer effects in the future, as ozone levels drop below the health standards at all monitoring sites. Many areas of New York even have ozone and particulate levels that are near background levels. One might therefore ask how *Cifuentes* was able to predict similar benefits for some health effects for pollution reductions in New York when compared with cities that have much higher pollution levels.[17] *Cifuentes* and its associated references do not address this issue, so it is not possible to determine how the authors arrived at their conclusions.

Table 1. Summary of New York City Ozone Pollution, 1998–2000
(Eight Monitoring Locations)

	Days Per Year Above 120 ppb Standard	Days Per Year Above 80 ppb Standard	Annual Mean Ozone Level (ppb)
Best Location	0	0	29
Median Location	0	2	41
Worst Location	2	12	58

Notes: ppb = parts per billion. Parts per billion is a measure of the concentration of ozone in air. 120 ppb daily standard and annual mean are based on one-hour average daily ozone levels. 80 ppb daily standard is based on an eight-hour average daily ozone level. The "median" is the value such that half of monitoring locations have values less than the median, while half have values greater than the median. All monitoring locations in New York City are included except for the ozone monitoring site at the top of the World Trade Center. This location was excluded because it does not measure ozone at or near ground level, where people spend their time outdoors.

Source: Analysis of air quality data from EPA, www.epa.gov/aqspubl1/annual_summary.html.

Table 2. Summary of New York City Particulate Pollution, 1998–2000

New York City Daily PM_{10} Monitoring (Daily federal PM_{10} health standard is 150 micrograms per cubic meter, 24-hour average)	Number of New York City monitoring locations exceeding daily PM_{10} standard: 0 of 17 14 of 17 locations never exceeded half the daily PM_{10} standard
New York Annual Average PM_{10} Monitoring (Annual federal PM_{10} standard is 50 micrograms per cubic meter, annual average)	Number of New York City monitoring locations exceeding annual PM_{10} standard: 1 of 17 The one monitor that exceeded the annual PM_{10} standard was a Manhattan location that averaged 56 micrograms per cubic meter in 1998, or 12 percent over the standard. Most sites were less than half the standard.

Note: PM_{10} signifies particulate matter of less than 10 micrometers in diameter.

Source: Analysis of air quality data from EPA, www.epa.gov/aqspubl1/annual_summany.html.

D. Focus on Climate Change Distracts Policymakers from the Real Factors that Determine Future Human Health and Safety

The biggest challenge to human health and safety in this century will not come from global warming, but from pre-existing environmental problems. Table 3, which is based on the *Second Assessment Report* of the IPCC, compares baseline environmental problems with additional effects predicted to occur as a result of climate change. As the table shows, the IPCC estimates that baseline problems are much larger than the additional effects projected to occur as a result of global warming.[18]

Table 3. Projected Climate Change Impacts Compared to Baseline Environmental Problems

Indicator	Year	Baseline (Includes all Effects Other than Climate Change)	Effects of Climate Change on Top of Baseline
Agricultural Production	2060 (for baseline) >2100 (for climate change)	Must increase 83% relative to 1990	Net global production would change –2.4% to +1.1% but could substantially redistribute production from developing to developed countries
Global Forest Area	2050	Decrease 25% – 30%	Reduced loss of global forest area
Malaria Incidence	2060	500 million people	25 to 40 million additional people
	2100	500 million people	50 to 80 million additional people
Sea Level Rise	2060	Varies	Less than 10 inches
	2100	Varies	Less than 20 inches

Source: Based on Indur M. Goklany, "Potential Consequences of Increasing Atmospheric CO_2 Concentration Compared to Other Environmental Problems," *Technology*, Issue 7S (2000) pp. 189–213.

Based on the IPCC projections, as a result of global warming malaria incidence will increase by 5 percent to 16 percent, forests won't decline as rapidly, and global food production will change hardly at all. In addition, the cost of protecting people and buildings against a 20-inch sea level rise by 2100 has been estimated to be about $1 billion per year—about 0.005 percent of the world's economic output.[19] As policy researcher Indur M. Goklany of the U.S. Department of Interior points out:

> "Stabilizing greenhouse gas concentrations immediately, even if feasible, would do little or nothing over the next several decades to solve those problems that are the major reasons for concern about warming, except, possibly, sea-level rise.
>
> Specifically:
>
> – Land and water conversion will continue virtually unabated, with little or no reduction in the threats to forests, biodiversity, and carbon stores and sinks;

- The feeding, clothing, and sheltering of a larger world population will not have been substantially advanced, if at all;
- Incidence rates of infectious and parasitic diseases will be virtually unchanged; and
- Poorer nations, which by virtue of their poverty are deemed to be most vulnerable to the adverse impacts of climate change, will continue to be vulnerable to all kinds of adversity, natural or man-made."[20]

How should the world address these challenges? Goklany points out the importance of economic development for a healthier and safer society:

"Economic development, which creates wealth, helps increase food supplies per capita, which reduces hunger and malnutrition. Economic development also makes basic public health services more available. Working together, improved health services and higher food supplies help reduce mortality rates. Thus, as levels of economic development increase, infant mortality rates decline and life expectancies increase."[21]

There is a direct relationship between income and health for both individuals and societies. Two decades of peer-reviewed studies have shown that people use their disposable income to weave a personal safety net around themselves and their loved ones. The more disposable income they have, the more steps they can take to increase their safety by, for example, buying more nutritious food, seeking medical care, or driving a safer car.[22] Ralph Keeney, a professor at the University of Southern California, has analyzed how policymakers can actually make people less safe if they pass regulations that reduce people's income without providing benefits that more than offset costs:

> "Regulatory costs are paid by individuals, which leaves them with less disposable income. Since individuals on average use additional income to make their lives safer and healthier, the regulatory costs lead to higher mortality risks and fatalities. Based on data from the National Longitudinal Mortality Study relating income to risk of dying, approximately each $5 million of regulatory cost induces a fatality if costs are borne equally among the public. If costs are borne proportional to income, approximately $11.5 million in regulatory costs induces a fatality."[23]

Measures that would, for example, increase fuel prices in an effort to reduce global warming would exacerbate all of the negative consequences of poverty. As noted earlier, an estimated 2 to 2.8 million people die annually from indoor air pollution. Increasing prices for fossil fuels would only make it more difficult for people to switch to cleaner home energy sources that would improve their health.

Increased fuel prices would also slow economic growth by making almost everything else more expensive. This would reduce the ability of developing countries to deal with urgent problems, such as the 300 to 500 million people infected with malaria, and the more than 1 million people who die of the disease each year.[24] While stabilizing greenhouse gases might reduce future malaria cases by up to 15 percent, the only thing stopping developing countries from completely eradicating malaria today (as the U.S. and Europe did half a century ago) is the economic wherewithal to afford the necessary public health measures. Wasting limited resources on smaller or less urgent problems reduces a society's ability to deal with bigger and more urgent risks.

If we devote scarce resources to climate change now, we won't see any benefits, if at all, until several decades hence. On the other hand, we could address serious and urgent health and safety concerns now to both solve current problems, and at the same time reduce humanity's vulnerability to the potential effects of global warming in the future.

E. *Cifuentes* Makes Several Exaggerated or False Claims

Based on the above analysis, we can see that many of the claims made by the authors of *Cifuentes* are exaggerated or simply false. Here are a few examples:

***Cifuentes*:** "There is little doubt that air pollution from current patterns of fossil fuel use for electricity generation, transport, industry, and housing are already killing millions throughout the world."

Reality: Researchers estimate that up to 3.3 million people die each year due to air pollution. But at least 85 percent of the health damage due to air pollution appears to be caused by *indoor* air pollution as the result of burning solid biomass fuels for heating and cooking, rather than due to outdoor air pollution caused by transportation, industry, or energy production. This is not to trivialize the dangerously high levels of outdoor air pollution found in many cities around the world. Outdoor air pollution does threaten health in these places. However, the solutions to that problem lie in measures that directly address the causes of outdoor air pollution, rather than indirect surrogates such as greenhouse gas emissions. Technologies already exist to reduce sources of outdoor ozone and particulate air pollution, and developing countries have begun to adopt them as they become wealthy enough to afford them. Indeed, because many pollution-reduction technologies have already matured in the developed world, developing countries have been able to adopt them at much lower income levels when compared to the income levels of developed countries at time they began their pollution cleanup efforts.[25]

***Cifuentes*:** "Increasing power generation by conventional fossil-fuel combustion further threatens human health and welfare by increasing air pollution."

Reality: The U.S. experience of decreasing air pollution along with increasing energy use belies this claim. Furthermore, for the billions of people in the developing world who now rely on health-threatening biomass fuels for home heating and cooking, "conventional fossil fuel" power generation would be a tremendous boon to their health and well-being.

***Cifuentes*:** "Reductions in greenhouse gas emissions can similarly reduce associated co-pollutants that affect human health, providing these reductions are based on lowered fossil-fuel combustion."

Reality: Ozone and particulate air pollution can be reduced far more effectively and cheaply by direct measures to reduce the pollutants of concern. Furthermore, the key to greater health and safety for the world's poor is a greater level of prosperity that allows both individuals and societies to choose safer ways of living. Artificial reductions in energy use will subvert the economic growth necessary for people in developing countries to create safer, more resilient, more adaptable societies.

***Cifuentes*:** "If climate change is avoided as a result of mitigation efforts, then related air-quality shifts, such as rising ozone air pollution from higher temperatures, can also be avoided."

Reality: Higher temperatures do favor more ozone generation. But ozone can't form without nitrogen oxide and hydrocarbon precursors from fuel combustion. It's already clear that technological progress in industrialized countries will result in substantial reductions in these precursors during the next 10 to 20 years, further reducing ozone and particulate levels. Developing countries will see similar reductions as they also adopt new, cleaner technologies. Without the precursor pollutants, there won't be much ozone, regardless of temperature increases.

***Cifuentes*:** "For every day that policies to reduce fossil-fuel combustion emissions are postponed, deaths and illness related to air pollution will increase."

Reality: Air pollution is more effectively and cheaply reduced by measures that directly address pollutant emissions. Developing countries are already adopting pollution control measures at much lower income levels than those of the U.S. and other industrialized countries when they began their pollution cleanup efforts. The surest way to help developing nations reduce air pollution further is to help their economies grow so that they will be able to devote more resources to pollution reduction and other health and safety improvements. Encouraging artificial reductions in energy consumption would likely subvert this process.

***Cifuentes*:** "Policies to mitigate greenhouse gases can yield substantive and immediate benefits to the three billion people currently residing in urban areas throughout the world."

Reality: Policies that directly reduce indoor and outdoor air pollution could significantly improve the health and safety of billions of people in developing countries. On the other hand, policies that reduce greenhouse gas emissions by reducing energy use, as *Cifuentes* recommends, will slow economic growth in developing nations, reducing their wherewithal to address urgent health and safety concerns.

III. Conclusion

This analysis has detailed a number of serious problems with *Cifuentes*, including:

- Reliance on a carbon dioxide-reduction scenario that is not detailed in any of the available papers cited by *Cifuentes*, has not been subjected to independent peer review, and is invalid for many regions of the world;
- Asserting that greenhouse-gas reductions are a good way to solve ozone and particulate air pollution problems, even though such reductions are far more expensive and less effective than directly addressing the causes of air pollution;
- Predicting large air pollution reduction health benefits for New York City as a result of greenhouse-gas reductions, even though New York City's air already meets federal particulate health standards, and is on the verge of meeting federal ozone standards;

- Asserting that increased fuel combustion necessarily results in increased health damage due to air pollution, even though the United States has achieved large reductions in air pollution along with large increases in fossil-fuel use by implementing cost-effective pollution-reduction measures; and
- Recommending that the world try to improve human health and safety by reducing greenhouse gas emissions. Instead, the world should focus on solving the problems (such as infectious diseases) that might be exacerbated by global warming, and avoid policies that will slow economic growth and thereby increase humanity's vulnerability to environmental threats and reduce its ability to improve people's health and safety.

As a result of these shortcomings, the *Cifuentes* study is of limited usefulness for policymakers and others interested in either greenhouse gas or air pollution policy.

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[1] World Health Organization, *Air Quality Guidelines* (Geneva, Switzerland, 1999).

[2] Luis Cifuentes, Victor H. Borja-Aburto, Nelson Gouveia, George Thurston, and Devra L. Davis, "Hidden Health Benefits of Greenhouse Gas Mitigation," *Science*, Vol. 293 (2001), pp. 1257–59.

[3] Luis Cifuentes et al., "Assessing the Health Benefits of Urban Air Pollution Reductions Associated with Climate Change Mitigation (2000–2020): Santiago, São Paulo, Mexico City, and New York City," *Environmental Health Perspectives*, Vol. 109, Supplement 3 (2001), pp. 419–425.

[4] Luis Cifuentes et al., "Preliminary Estimation of the Potential Ancillary Benefits for Chile," from IPCC Worshop: Assessing the Ancillary Benefits and Costs of Greenhouse Gas Mitigation Strategies (Washington, D.C., August 2000), available at http://www.oecd.org/env/cc/ancillary_workshop.htm.

[5] Programa de Investigaciones en Energía, "Mitigación de Gases de Efecto Invernadero: Chile 1994–2000," (Santiago, Chile: University of Chile, 1999).

[6] Environmental Protection Agency, *Air Quality Trends 1999* (Washington, D.C., 2000), available at http://www.epa.gov/oar/aqtrnd99/. Vehicle-use trends come from the U.S. Bureau of Transportation Statistics (www.bts.gov/btsprod/nts/Ch1_web/1-29.htm) and the Federal Highway Administration (www.fhwa.dot.gov/ohim/hs99/tables/vm1.pdf).

[7] Ibid.

[8] Projected emissions for 2002 vehicles from California Air Resources Board, *Zero-emission Vehicles and Clean Air* (Sacramento, CA, 2000) available at www.arb.ca.gov/msprog/zevprog/evfacts.pdf; current emissions based on average vehicle emissions calculated from California Bureau of Automotive Repair random roadside emissions test data.

[9] California Air Resources Board estimates.

[10] Energy Information Administration, "Analysis of Strategies for Reducing Multiple Emissions from Power Plants: Sulfur Dioxide, Nitrogen Oxides, and Carbon Dioxide" (Washington, D.C., 2000), available at www.eia.doe.gov/oiaf/servicerpt/powerplants/.

[11] Ibid.

[12] World Health Organization, *Air Quality Guidelines*.

[13] K. R. Smith and S. Mehta, "Estimating the Global Burden of Disease from Indoor Air Pollution," from *Methodology for Assessment of Environmental Burden of Disease*: *Report on the ISEE Session on Environmental Burden of Disease* (Washington, D.C.: World Health Organization, August 2000), available

at www.who.int/peh/Burden/methodologyhtm.htm; and World Health Organization, *Air Quality Guidelines*.

[14] Data summarized in Figure 1, Table 1, and Table 2 were downloaded from U.S. Environmental Protection Agency's online database on pollution monitoring at www.epa.gov/aqspubl1/annual_summary.html.

[15] Environmental Protection Agency, *Review Of National Ambient Air Quality Standards For Ozone Assessment Of Scientific And Technical Information* (Durham, North Carolina, 1996).

[16] Ibid.

[17] Air pollution in cities in developing countries is generally much higher than in New York City and other cities in developed countries. See, for example, Mexico City data at sma.df.gob.mx/sma/gaa/tendencies/tendencia.htm; for Chile, see B. Ostro, *Air Pollution and Mortality: Results from Santiago, Chile* (Washington, D.C.: World Bank, 1994).

[18] The table is based on Indur M. Goklany, "Potential Consequences of Increasing Atmospheric CO_2 Concentration Compared to Other Environmental Problems," *Technology*, Issue 7S (2000) pp. 189–213.

[19] Ibid.

[20] Ibid.

[21] Ibid.

[22] Kenneth Green, *Rethinking EPA's Proposed Ozone and Particulate Standards*, Policy Study No. 224 (Los Angeles: Reason Public Policy Institute, 1997), available at www.rppi.org/environment/ps224.html.

[23] Ralph Keeney, "Estimating Fatalities Induced by the Economic Costs of Regulations," *Journal of Risk and Uncertainty*, Vol. 14 (1997), pp. 5–23.

[24] World Health Organization, *Malaria*, Fact Sheet #94 (Geneva, Switzerland, October 1998), available at www.who.int/inf-fs/en/fact094.html.

[25] Indur M. Goklany, Department of Interior, interview with author, August 20, 2001.