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CLIMATE CHANGE CONFUSION AND THE SUPREME COURT: THE MISGUIDED REGULATION OF GREENHOUSE GAS EMISSIONS UNDER THE CLEAN AIR ACT

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INTRODUCTION

In the spring of 2007, the U.S. Supreme Court ruled in *Massachusetts v. EPA*[1] that the U.S. Environmental Protection Agency (EPA) must promulgate automobile tailpipe carbon dioxide (CO_2) emission standards under section 202 of the Clean Air Act (CAA).[2] American environmentalists hailed the Supreme Court's decision as an important victory in the battle to curb global warming. It is not. The majority opinion in *Massachusetts v. EPA* resonates with the alarmist rhetoric that has come to dominate the climate change policy debate and its reasoning reflects fundamental misunderstandings regarding the likely impact of global warming on the health and welfare of the people of the United States that climate change alarmism has created. An

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1 127 S. Ct. 1438 (2007).

2 42 U.S.C. § 7521 (2000).

extensive and very well established body of systematic empirical economic evidence shows that in the short-to-medium run, a warmer climate will be predominantly beneficial, rather than harmful, to the United States. In the longer run, investments to reduce greenhouse gas (GHG) emissions may pay off in a lessened probability of harmful climate change, but whether they do so will depend almost entirely upon the actions taken by other countries, in particular by China.

In apparent ignorance of these basic facts about climate change, and in an almost hysterical frenzy to do something about the supposedly imminent demise of our blue planet, the Supreme Court majority in *Massachusetts v. EPA* interpreted the CAA—intended by Congress to reduce largely localized air pollution and thereby provide the local public good of improved health—as requiring EPA to impose GHG emission limits. Not only will such limits likely be ineffective, but by requiring EPA to regulate greenhouse emissions, the Court has effectively forced a change in the status quo that makes economically sensible and environmentally sound federal climate change legislation much less likely. Moreover, unlike the air pollution that Congress intended to regulate under the CAA, even if the United States were to immediately implement effective GHG reduction strategies, those efforts might have little or no impact in reducing harm from global warming. It is the atmospheric stock of CO_2 and other GHGs that is contributing to global warming, and the flow of GHG emissions from the United States is only a fraction, and a likely declining one at that, of the total global flow. It is China, and not the United States, that is the world's largest GHG emitter, and it is China that now accounts for the majority of the growth in global GHG emissions.[3] Paradoxically, it is possible that the more effective present day U.S. GHG emission limits are, the lower the future incentive for rapidly industrializing, dominant CO_2 emitters such as China to themselves curb such emissions.

This Article begins in Part I by briefly summarizing the Court's opinion in *Massachusetts v. EPA*. In Part II, I then set out a general

the United States, not net costs. One cannot fault the Supreme Court opinions in *Massachusetts v. EPA* for failing to even acknowledge the existence of this evidence; the government apparently did not produce it, and none of the reports of the ostensibly authoritative Intergovernmental Panel on Climate Change (IPCC) thoroughly discuss this or any other economic work on climate change. But the economic evidence is extensive and extremely important: it shows that temperature increases in the two to three degree centigrade range are likely to provide many regions of the United States with large benefits in the form of the amenity value of a warmer climate, increased agricultural productivity, reduced deaths and disease due to cold weather, and increased value from warm weather recreational pursuits.

To be sure, this same body of empirical work shows that some regions in the United States may be net losers from a warmer climate (even prior to 2100). But the costs of reducing GHG emissions fall disproportionately not on those states and regions that have the most to lose from a warmer climate and therefore potentially the most to gain from GHG emission reductions, but rather on states and regions that would actually likely be benefited by a warmer climate. The CAA imposed federal air pollution reduction requirements on some places that did not have a serious air pollution problem at the time and its costs were not uniformly felt (auto industry states likely bearing more costs). These interstate variations in the distribution of costs and benefits were well known by federal legislators, and legislative bargaining over their allocation is in large part responsible for the complexity of the CAA. But overall, the CAA mandated costly nationwide air pollution reduction that generated nationwide health and welfare benefits. To interpret that statute as covering GHG emissions, as the Supreme Court did in *Massachusetts v. EPA*, is to presume that legislators who voted to impose costs on some of their constituents so that all of their constituents would get present and future benefits from cleaner air would also have voted to impose even larger costs on all their constituents so that people in other states or districts could perhaps someday get benefits from a stabilized climate. To take this view, which comprises the Court's core holding in *Massachusetts v. EPA*, is not to interpret the CAA, but to rewrite it.

As I explain in Part IV, one cannot instrumentally justify this core holding by pointing to the desirable incentive effects that it will have in spurring Congress to take action on climate change. By effectively forcing EPA to regulate GHG emissions under a statute that was never intended to cover the very different problem of climate change, the Court has changed the policy status quo in a way that makes socially desirable climate change legislation at the federal level much less

potentially very harmful, long-term consequences to the United States. In the short-to-medium run, global warming may cause significant harm in developing countries. A sensible formulation of U.S. climate change policy would involve measures to respond both to the long-term threat to the United States and the short-term threat to developing countries. There are policy instruments appropriate to these goals. Large increases in subsidies for research and development into clean coal and alternative fuels are a sensible way for the United States to respond to the long-term threat to the United States. Redirecting foreign aid to fund climate change adaptation in developing countries is a sensible way to respond to the short-term threat to developing countries. But neither these nor other sound responses to climate change can be pursued within the framework established by the 1970 CAA.

I. The Supreme Court and Climate Change: An Overview of *Massachusetts v. EPA*

The litigation in *Massachusetts v. EPA* began in 1999, when the State of Massachusetts (along with several other state and local governments and environmental groups) filed a rulemaking petition requesting that the federal EPA regulate "'greenhouse gas emissions from new motor vehicles'" under section 202(a) of the federal CAA.[4] After receiving thousands of comments, and requesting a special report from the National Research Council, EPA denied the petition for rulemaking.[5] EPA explained that it either lacked the authority to issue climate change regulations under section 202(a) of the CAA, or if it did have such legal authority, then as a policy matter, it would choose not to exercise that authority. More precisely, on the first point, EPA argued that Congress had considered and decided against regulating greenhouse gases under the CAA, and that greenhouse gases were not "air pollutants" subject to regulation under section 202 of the CAA.[6] On the second point, EPA found that there was too much uncertainty over the causal relationship between global mean

4 *EPA*, 127 S. Ct. at 1449 (quoting Int'l Ctr. for Tech. Assessment, Petition for Rulemaking and Collateral Relief Seeking the Regulation of Greenhouse Gas Emissions from New Motor Vehicles Under § 202 of the Clean Air Act at 1 (Oct. 20, 1999), *available at* www.icta.org/doc/ghgpet2.pdf).

5 *Id.* at 1449–50.

6 *Id.* at 1450–51 (citing Control of Emissions from New Highway Vehicles and Engines, 68 Fed. Reg. 52,922, 52,925–29 (Sept. 8, 2003)). In pertinent part, section 202(a) of the CAA states that "[t]he [EPA] Administrator shall by regulation prescribe . . . standards applicable to the emission of any air pollutant from any class or classes of new motor vehicles . . . which in his judgment cause, or contribute to, air

the State Department and has "nothing to do"[14] with whether regulating greenhouse gases under the CAA would impair the President's ability to negotiate with developing nations to reduce their emissions.

The bulk of the majority's opinion is devoted to justifying its holding that the plaintiffs have standing to sue and that EPA has statutory authority to regulate. The Court easily concluded that EPA has the authority to regulate GHGs as air pollutants under CAA section 202. According to the Court, there was no ambiguity at all in the statutory definition of "air pollutant"—as "any air pollution agent or combination of such agents, including any physical, chemical . . . substance or matter which is emitted into or otherwise enters the ambient air"[15]—which clearly encompassed CO_2 and other GHGs.[16] Moreover, for the Court, congressional action and inaction during the 1980s—in failing to amend the CAA to explicitly include emissions limits for GHGs but instead merely encouraging interagency collaboration and research—"tells us nothing about what Congress meant when it amended § 202(a)(1) in 1970 and 1977."[17]

In finding that the constitutional requirements for standing were met, the Court relied on two rather different theories. On the one hand, the majority said that Massachusetts had met the traditional (albeit not very old) three-pronged test requiring (on summary judgment) that the plaintiff produce affidavits and similar evidence (1) of a concrete and particularized injury that is either actual or imminent; (2) that the injury is fairly traceable to the defendant; and (3) that it is likely that a favorable decision will redress that injury.[18] As to the first requirement—that the plaintiff suffer a "concrete and particularized injury"—the Court relied almost entirely on the affidavit opinion of climate scientist Michael MacCracken to the effect that "'qualified scientific experts involved in climate change research'" have reached a "'strong consensus'"[19] that global warming had caused an increase of global sea levels of "between 10 and 20 centimeters over the 20th century," and that these "rising seas have already begun to swallow Massachusetts' coastal land"[20] and "[i]f sea levels continue to rise as predicted, one Massachusetts official believes that a significant frac-

14 *Id.*

15 42 U.S.C. § 7602(g) (2000).

16 *See EPA*, 127 S. Ct. at 1461.

17 *Id.* at 1460.

18 Summarized, for example, in *Lujan v. Defenders of Wildlife*, 504 U.S. 555, 560–61 (1992).

19 *EPA*, 127 S. Ct. at 1455–56 (quoting declaration of Michael C. MacCracken ¶ 5).

20 *Id.* (citing declaration of Michael C. MacCracken ¶ 5).

tion of coastal property will be 'either permanently lost through inundation or temporarily lost through periodic storm surge and flooding events.'"[21] Having found that such sea level rise constituted a "concrete and particularized injury" to the State of Massachusetts, it was not difficult for the majority to go on to find that the other two prongs of the standing test were met. The MacCracken affidavit also established causation, for according to that affidavit, CO_2 emissions from the United States transportation sector alone would make the United States the third largest emitter of CO_2, so that "[j]udged by any standard, U.S. motor-vehicle emissions make a meaningful contribution to greenhouse gas concentrations and hence, according to petitioners, to global warming."[22] Finally, as to remedy, for the majority of the court, even if developing countries such as China and India increase greenhouse gas emissions "substantially" over the next century, "[a] reduction in domestic emissions would slow the pace of global emissions increases, no matter what happens elsewhere,"[23] so that federal

large body of economic work that overwhelmingly shows that in the climate change world's short-to-medium term—out to 2100—few if any regions of the United States are likely to suffer serious harm from global warming, while many regions and industries may well realize modest benefits. The naïve literalist interpretation of the CAA adopted by the majority thus effectively decides that Congress also intended the CAA to require Americans to incur highly uncertain but potentially severe economic costs—the cost of reducing GHG emissions—in exchange for little or no benefit to them during this century. It is difficult to see how such a result could be squared with any reasonable construction of congressional intent in passing the CAA.

Here, therefore, I adopt the purposive approach, asking whether the interests, purposes, and policies that supported regulating conventional air pollution under the CAA would also support the regulation of GHGs under that statute.

A. Traditional Air Pollution Regulation Under the Clean Air Act

In deciding that CO_2 may constitute an air pollutant within the meaning of the CAA, the Supreme Court majority argued that the broad statutory definition of "air pollutant" as "'*any* air pollution agent or combination of such agents, including *any* physical, chemical . . . substance or matter which is emitted into or otherwise enters the ambient air'"[36] was so broad as to include "all airborne compounds of whatever stripe."[37] The Supreme Court majority in *Massachusetts v. EPA* gave this very general, vague statutory provision a very broad reading, so as to include CO_2 and other GHGs within the statutory definition of air pollution. Taking the purposive approach to

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development, and the increasing use of motor vehicles, has resulted in mounting dangers to the public health and welfare, including injury to agricultural crops and livestock, damage to and the deterioration of property, and hazards to air and ground transportation . . . ."); *id.*

topography.[44] Across vast areas of the United States, air pollution is not a problem. Indeed, many of the criteria pollutants—sulfur dioxide, carbon monoxide, and oxides of nitrogen—are a problem only in the most urbanized areas of the country. For example, in the vast areas encompassed by the U.S. plains states, the only criteria air pollutant that is a problem is particulate pollution in the form of dust from agriculture.[45]

Just as the levels of traditional air pollution vary greatly across different regions and metropolitan areas in the United States, so too do the benefits and costs of pollution reduction. At least in terms of health effects, places with very little pollution generally suffer lower harm from pollution, and therefore benefit less from pollution reduction, than places with lots of pollution, where the adverse health effects and benefits from pollution reduction are greater.

Of course, pollution reduction is not generally free. It is costly. In understanding the CAA, what is important is not just the total cost of achieving pollution reduction goals, but also the geographic distribution of the costs. Most importantly, the geographic distribution of the cost of pollution reduction is very different for stationary sources (industry) than for mobile sources (automobiles). This difference in the distribution of cost is a basic determinant of the structure of the CAA, explaining the way in which the CAA tries to reduce pollution from these two different types of sources.

For industrial pollution, both the benefits and costs of pollution reduction are primarily local. That is, if it is local industry that is responsible for the air pollution problem, then it is local industry and local communities that will bear the cost of pollution reduction. Given the highly localized concentration of both benefits and costs from reducing stationary source air pollution, the CAA's NAAQS are set by the federal regulator and are nationally uniform, but the states were given the job—through what are called State Implementation

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44 *See* U.S. Envtl. Prot. Agency, National Ambient Air Quality Standards, General Conformity, Frequent Questions, http://www.epa.gov/air/genconform/faq.htm (last visited Nov. 5, 2008) ("The Clean Air Act identifies six common air pollutants that are found all over the United States. These pollutants can injure health, harm the environment and cause property damage. EPA calls these pollutants criteria air pollutants because the agency has developed science-based guidelines as the basis for setting permissible levels.").

45 *See* U.S. Envtl. Prot. Agency, National Air Quality and Emissions Trends Report 59 (2003), *available at* http://www.epa.gov/air/airtrends/aqtrnd03 (showing how, as of September 2002, in the States of North Dakota, South Dakota, Nebraska, Minnesota, Iowa, Oklahoma, Kansas, Montana, and Wyoming there were only a handful of air pollution control areas in non-attainment with National Ambient Air Quality Standards, and then only for coarse particulates, PM_{10}).

Plans—of determining how to lower stationary source emissions so as to meet the NAAQS.[46] Notably, while EPA is not allowed to consider costs in setting NAAQS[47] (the national ambient air quality standards are supposedly based purely on health considerations), the states are allowed to consider costs in setting emission standards for existing industrial facilities that are necessary to meet NAAQS.[48]

For new industrial facilities, the CAA has since its inception required technology-based emission standards that are ostensibly uniform within particular industrial categories.[49] But neither the NAAQS nor the technology-based standards under the CAA are in fact nationally uniform. Before the law was even fully implemented, the courts construed and then Congress amended the statute to require that even areas of the country with relatively clean air (areas that were in attainment with the national ambient standards) had to meet (different) technology-based air pollution control standards (so that they could not simply pollute up to the ambient standard level).[50] And

46 *See* U.S. Environmental Protection Agency, *supra* note 44 ("Through [State

of combustion and post-combustion controls designed to reduce emissions of carbon monoxide, nitrogen oxides, unburned hydrocarbons (or a subset thereof, volatile organic compounds), and particulate matter from diesel engines.[58]

The CAA is thus an enormously complex statute whose complexity in large part reflects the varying costs and benefits of reducing criteria air pollutants in different states and localities. In the CAA, Congress' intent was indeed to improve ambient air quality by reduc-

preted to apply to GHGs, the relevant question (from the point of view of purposive statutory interpretation) is: does the magnitude and interstate distribution of costs and benefits from reducing GHGs so resemble that from reducing conventional air pollutants that it is reasonable, or even plausible, to think that the federal legislators who voted in favor of incurring present-day costs in order to reduce traditional air pollution and thereby confer health benefits upon the present generation of Americans (the CAA "deal") would have also voted to regulate GHG emissions under that statute?

B. The Geographic and Intertemporal Distribution of U.S. Costs and Benefits from Global Warming Is Radically Different from the Costs and Benefits from Traditional Air Pollutants: Congress Could Not Have Intended to Regulate GHGs Under the Clean Air Act

The answer the question posed at the end of subpart A is, I believe, clearly "no," for the simple reason that the pattern of costs and benefits from regulating GHGs under the CAA is likely to be radically different from the pattern of costs and benefits generated by the regulation of traditional air pollutants under that Statute. The impact of GHGs on American society is strikingly different from the traditional pollutants regulated under the CAA. Greenhouse gases are to be regulated not because of any direct local health effect, but because their accumulation at various concentrations in the atmosphere is causing the global climate to warm, and it is believed that this warmer global climate will in turn have adverse impacts for particular places both within and outside of the United States. Aside from its separate treatment of the stratospheric ozone problem,[60] the CAA is not concerned with international air pollution.[61] Therefore, if one is to jus-

60 Title VI of the CAA, "Stratospheric Ozone Protection," is found at 42 U.S.C. §§ 7671–7671q (2000). As lucidly explained by RICHARD ELLIOT BENEDICK, OZONE DIPLOMACY 111–13 (1991), U.S. companies such as DuPont did not actively oppose the phase-out of the most serious ozone depleting refrigerants, at least relative to their European competitors, in large part because they achieved leadership in producing substitutes.

61 Indeed, it was only after Congress added a separate and quite different program—the Title IV acid rain trading program—that the CAA successfully addressed even a regional air pollution problem. *See* BAILEY, *supra* note 50, at 230–38. The acid rain problem was not even discussed by Congress until after the 1977 amendments. *See id.* at 210. In Congress, acid rain control starkly pitted the interests of some regions of the country against others, with politicians from northern and northeastern states recounting the damage acid rain had done to their states' lakes rivers and forests, while those from midwestern and Appalachian coal-producing states argued that there was not sufficient evidence that coal was the problem. *See id.* at 214–27. Support for tougher sulfur dioxide emission limits came from representatives and

tify the regulation of GHG emissions as a form of air pollution under the CAA, then it must be because of the adverse impact on the United States from global warming. However, unlike traditional air pollutants, which are a local public bad everywhere, GHG emissions are not an economic bad everywhere within the United States. Indeed, there is a large body of economic evidence which suggests that in the short-to-medium term (up to at least 2050), for many regions within the United States, the climate changes induced by the accumulation of CO_2 and other GHGs in the atmosphere (troposphere) will generate net benefits, rather than net costs.[62] For such regions, climate change will be an economic good, not an economic bad. The CAA has nothing to do with the regulation of "pollution" that is likely to be a short-to medium-term economic good for many regions of the United States.

It is of course true that if in the longer term (late twenty-first century and beyond), GHG emissions do not decline or at least stabilize, climate changes are possible which will in fact harm most regions of the United States.[63] However, there is so much uncertainty associated with such long-term climate change that it is very0.9301 Tstabi-States.

mates. It is well known that both wages and salaries and home prices vary a great deal with location. For example, in 2006, the median price of an existing single family home in the most expensive U.S. markets, such as San Francisco and Boston, was many, many times what the median price was in midwestern and Rocky Mountain metropolitan areas such as Cincinnati, Cleveland, Denver and Des Moines.[66] Now, of course, locations vary in lots of dimensions other than climate that economists predict would determine median home prices and wages, such as median income and wealth, unemployment rate, and the quality of local schools.[67] Some of these predictions—such as the prediction that metropolitan areas with higher median income should also have higher median home prices—have been difficult for economists to empirically corroborate.[68] But what the studies have consistently found is a result of striking importance for the normative evaluation of alternative climates: that people have a strong and robust willingness to pay for local climates that are mild.[69]

66 As reported by the National Association of Realtors, median sales prices of existing single family homes as of 2006 for the exemplar cities in the text ranged from $753,000 and $402,000 for San Francisco and Boston, respectively, to $250,000 for Denver, $145,000 for Des Moines, $143,000 for Cincinnati, and $134,000 for Cleveland. *See* Nat'l Ass'n of Realtors, Metropolitan Median Prices, http://www.realtor.org/Research.nsf/Pages/MetroPrice. For data on interurban wage variation, see Jennifer Roback, *Wages, Rents, and the Quality of Life*

(OAGCM) used by the IPCC is correct in predicting that climate change will mean that many regions of the United States will be warmer, especially in the winter, then for such regions, climate change may bring precisely the kind of climate that people like. Rather than being places to flee from, northern regions of the country may instead be places that people migrate toward. Moreover, those regions that are predicted to become both warmer and much more subject to drought (such as the Southeast) may indeed suffer declines in agricultural yield, but they will also resemble more the desert metropolitan areas that, as the economic literature predicts, are currently the fastest growing areas in the entire United States.[82]

It is true that people in regions with warmer and hence more desirable climates will not enjoy a free lunch. On the margin, areas with warmer, more desirable climates will attract more immigrants (and lose fewer emigrants), and therefore housing prices in such places will tend to rise relative to places with worsening climates.[83] Of course, insofar as global warming may mean that most places in the United States will have milder winters, the value of a mild winter will tend to fall (by the basic law of supply and demand). Moreover, the effects of a warming climate are not expected to be positive everywhere: places that are now quite cold would increase in value by more than average, whereas hot places could decrease in value.[84] Still, moderate (two degree centigrade) climate change will have generated what is essentially a large scale local public good: a "free" warming of local climates (free in the sense that it was not paid for in local taxes) that may be worth as much as $75 billion.[85]

And even this number may be an underestimate. Recent evidence shows that over time, the value of climate (as with other public goods) has been increasing.[86] Between 1940 and 1990, the U.S. popu-

82 The most recent census data reveals that nine of the ten U.S. counties with the biggest population gains over the 2000 to 2006 period were in the South or West, with half of those with the biggest gains located in Texas; the biggest absolute population increase was in Maricopa County in Arizona (growing by 700,000 people since 2000, or by more than the population of all but fifteen American cities), and the largest growth rate was in Flagler County in northeastern Florida, with growth of sixty-seven percent since 2000. *See* Sam Roberts, *Census Reports Arizona County Still Has Biggest Growth*, N.Y. TIMES, Mar. 22, 2007, at A18.

83 A point made by Matthew E. Kahn, *Environmental Valuation Using Cross-City Hedonic Methods* 5 (Draft of June 2004), *available at* http://ssrn.com/abstract=556739.

84 Robert Mendelsohn, *A Hedonic Study of the Non-Market Impacts of Global Warming in the U.S.*, *in* THE AMENITY VALUE OF THE GLOBAL CLIMATE 93, 104 (2001).

85 *Id.* at 105.

86 *See* Dora L. Costa & Matthew E. Kahn, *The Rising Price of Nonmarket Goods*, 93 AM. ECON. REV. 227, 227 (2003).

lation moved south and west, and wealthier and older people with the means to "buy" warmer climate through their locational choices clearly did so.[87] Cragg and Kahn find that whereas in 1960 and 1970 places with warmer February temperatures actually had lower real estate rental prices, by 1990, warm February temperatures were capitalized into higher real estate rents.[88] In related work, Dora L. Costa and Matthew E. Kahn find that whereas in 1970 a person would have had to pay $1288 (in 1990 dollars) to buy San Francisco's climate instead of Chicago's, by 1990 this differential had increased to $7547.[89] In summary, recent empirical findings indicate that over the time period 1940 to 1990, the price of warm climate (measured by February average temperatures) has been increasing in terms of both rising rental prices and falling earnings.[90]

2. Health and Recreational Benefits to the United States from a Warming Climate

The relationship between climate—and especially temperature—and human morbidity and mortality is not a new topic, having been studied for over a century.[91] In industrialized countries, mortality peaks in the winter, mainly from noncommunicable diseases (such as heart disease).[92] This suggests that the warmer, wetter conditions pre-

87 *See* Michael I. Cragg & Matthew E. Kahn, *Climate Consumption and Climate Pricing from 1940 to 1990*

dicted for the northern region of the United States will not only mean enhanced agricultural productivity for that region, but also (as with El Niño events discussed below) a likely substantial reduction in lives lost due to severe winter weather.[93]

That a warmer climate, with milder winters, will bring clear health benefits to the United States is buttressed by recent work showing how in the United States, heat-related mortality has steadily declined over the period from the 1960s to the late 1990s, with an average number of excess deaths on hot and humid days dropping (in a sample of twenty-eight major American cities) from forty-one during the 1960s to 1970s to a little over ten in the 1990s.[94] A number of factors seem to account for the secular decrease in heat-related mortality in the United States since the 1960s: improvements in medical care and technologies, improved public health systems that warn people about coming heat waves, and even human biophysical acclimatization to high temperatures.[95] Perhaps most striking and significant, however, has been the impact of air conditioning. By the 1980s, many cities in the southern United States (such as Houston, Miami, and Charlotte) had no elevated mortality on hot and humid days, and over the entire period from the 1960s to the 1990s, the impact of hot and humid days on mortality was weakest in cities in the southern United States—the warmest and most humid cities, but also places where air conditioning use is most widespread.[96] Indeed, reflecting the huge

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manifest themselves and to spread. *See* COMM. ON SCI., ENG'G, & PUB. POLICY, *supra* note 91, at 616 (citing Wolf H. Wiehe, *Climate, Health and Disease*, *in* PROCEEDINGS OF THE WORLD CLIMATE CONFERENCE, 311, 336–48 (World Meteorological Org. ed., 1979)); Robert E. Davis et al., *Changing Heat-Related Mortality in the United States*, 111 ENVTL. HEALTH PERSP. 1712, 1713 (2003). For some specific studies, see, for example, G. Laschewski & G. Jendritzky, *Effects of the Thermal Environment on Human Health: An Investigation of 30 Years of Daily Mortality Data from SW Germany*, 21 CLIMATE RES. 91, 93–100 (2002); Alexander Lerchl,

impact of air conditioning in allowing people to consume warm winters without suffering so much from hot and humid summers, Cragg and Kahn find that while in 1960 workers were compensated in the form of higher earnings for living in places with hot summers, by 1990 there was no compensating wage differential for living in such hot and humid places.[97]

Of course, to accurately measure the impact of weather on health in the United States, one must control for the massive population shift to the better-adapted southern states that has occurred over the last thirty years.[98] Even using two General Circulation Models (GCM) that predict a huge increase over the 2070 to 2099 period in very hot days[99] but very little decline in the number of very cold days,[100] a recent study that does precisely this finds that for most demographic groups in the United States, there will be no statistically significant increase in mortality due to such temperature increases.[101] Moreover, the estimated mortality functions in this study are U-shaped, with mortality highest at the very warmest and coldest daily (mean) temperatures.[102] The estimated temperature-mortality relationship implies that under alternative but plausible climate change scenarios, where warming is concentrated most in the coldest months, warming would lead to a "substantial" reduction in mortality.[103]

This evidence does not imply that everyone can equally adapt to a warming climate,[104] nor does it imply that adaptation is costless.[105]

1995 Chicago heat wave. These studies found that moving from an unventilated indoor location to an air conditioned location reduced the individual mortality risk by a factor of five or six (that is, 500–600%). *See, e.g.*, Nathan Y. Chan et al., *An Empirical Mechanistic Framework for Heat-Related Illness*, 16 CLIMATE RES

What it shows is that for the average resident of developed, industrialized countries, a warmer climate will bring net health benefits rather than any significant health costs.[106]

In the United States, a warmer climate will likely not only bring health benefits, but also quite sizeable recreational benefits. Early studies of the impact of climate warming in the 2.5° centigrade range focused on skiing and unsurprisingly found that a warmer climate would mean a potentially large decrease in ski days and a correspondingly large welfare loss.[107] But skiing is of relative economic insignificance compared to summertime recreational activities such as boating, camping, fishing, golfing, hunting, and wildlife viewing, with only $2.5 billion spent annually on skiing, compared to $76 billion on the summertime activities.[108] With either a modest 2.5° centigrade increase, or an even larger 5° centigrade increase in temperature, recent economic work estimates very large net recreational benefits from global warming in the United States, with net benefits perhaps reaching over $25 billion under the five degree increase scenario.[109]

3. Market Adaptation to Extreme Weather Events and the Continuing Increase in Value of and Decreased Human Risk in U.S. Coastal Locations

As just discussed, air conditioning has proven to be an enormously effective adaptation in allowing residents of very warm southern and southwestern regions of the United States to enjoy the benefits of a warm climate while lessening the adverse health consequences from heat waves. It may well be pointed out that many models of climate change predict that in most parts of the United States, a warmer and wetter climate will also be much stormier, with an increase in the frequency of torrential rains, tornadoes, and similar severe weather. The models do not predict future widespread Mediterranean mildness in the United States, but rather something like a

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there will be a statistically significant increase in energy consumption of between fifteen and thirty-five percent. *Id.* at 34.

106 It has been estimated that a 2.5° centigrade rise in average U.S. temperatures would cut annual deaths by between 37,000 and 41,000. Thomas Gale Moore, *Health and Amenity Effects of Global Warming*, 36 ECON. INQUIRY 471, 475, 478 (1998) (researching these numbers based on studies of mortality in Washington, D.C. and in 89 large

much stormier and more unpredictable version of the climate that now prevails in the southeastern United States. Finally, critics may stress that global warming will also entail rising sea levels (due both to the direct effect of a warmer atmosphere, and hence oceans, and to melting ice caps) and increasingly severe hurricanes—developments that will make the mild, coastal climates that Americans now seem to most prefer much less attractive places to live.

Let us assume that the criticism stated a moment ago is correct: that even if climate change makes much of the United States warmer and less snowy and therefore more attractive to many people, it will also make ocean coastal areas much more subject to hurricanes and coastal storms. A very basic economic prediction is that as people come to expect increased storms in certain locations, they will come to subtract the expected loss due to such storms from the price they are willing to pay for homes.[110] There is evidence for such rational discounting of home prices.[111] There is also evidence for the related and equally plausible conjecture that even for hurricanes, one or two occurrences of such a storm event does not cause people to immediately evaluate upward their expected loss. Rather, it may take a somewhat sustained increase in the number of such random natural disasters before people decide that the probability of such a disaster has increased and for them to consequently increase their estimated expected losses, and to (permanently) discount the price they are willing to pay for homes in locations that have been subject to such repeat strikes.[112]

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110 *See* Colin F. Camerer & Howard Kunreuther, *Decision Processes for Low Probability Events: Policy Implications*, 8 J. POL'Y ANALYSIS & MGMT. 565 (1989) (arguing that hurricanes and other catastrophic natural disasters are precisely the sort of low probability–vast harm events that people have difficulty in rationally and quantitatively evaluating). This is an alternative explanation of empirical findings, discussed below, that people do not discount by much the price they are willing to pay for housing in locations subject to such risks.

111 *See, e.g.*, Don N. MacDonald et al., *Uncertain Hazards, Insurance, and Consumer Choice: Evidence from Housing Markets*, 63 LAND ECON. 361, 369–70 (1987).

112 *See* J. Edward Graham, Jr. & William W. Hall, Jr., *Hurricanes, Housing Market Activity, and Coastal Real Estate Values*, 69 APPRAISAL J. 379, 385–86 (2001). Graham and Hall use different measures of market reaction (the spread between listing and selling price, average days on the market, and monthly sales), when looking at the same natural hazard realization—the series of hurricanes and storms that struck the Cape Fear Region of North Carolina ending in 1999. J. Edward Graham & William W. Hall, *Catastrophic Risk and Behavior of Residential Real Estate Market Participants*, 3 NAT. HAZARDS REV. 92, 96 (2002). This study's main result, that the spread between asking and selling prices increased by eight percent after the fourth and final hurricane strike, *id.*, also tends to support the earlier finding that this series of storms eventually caused people to revise upward their perceived probability of such storms.

set of natural disasters, Kahn found that the average number of deaths per disaster fell an average of 4.6% per year over the period 1970 to 2001.[117] Just as air conditioning reduced the discomfort from the South's warm and humid climate, stimulating labor productivity in and hence migration to the southern United States,[118] so too have advances in weather forecasting, communications, construction, and transportation infrastructure significantly decreased the cost, and hence increased the expected net value, from living in warm, humid, but storm-prone coastal locations.[119] Given both the increasing value

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> [E]arly warning systems and large-scale evacuations; . . . disaster insurance; . . . reforestation, soil conservation, mangrove replantation, and other natural defenses; strengthen[ing of] docks, harbor facilities, and telecommunication and satellite systems; build[ing of] protective barriers for sea surges and water diversion channels; fortif[ication of] drainage, irrigation, water supply, and sanitation infrastructure; organiz[ation of] relocation efforts and "managed retreats"; smooth recovery for firms and sectors suffering serious losses; enforce[ment of] efficient zoning regulations; administ[ration of] public health and educational services; and . . . emergency treatment for victims.

J. Timmons Roberts & Bradley C. Parks, A Climate of Injustice 111 (2007).

117 Matthew E. Kahn, *Two Measures of Progress in Adapting to Climate Change*, 13 Global Envtl. Change 307, 309 (2003). Kahn's list of natural disasters included earthquakes, extremes of heat and cold, floods, and a broad "wind storm" category that included hurricanes, storms, tornadoes, tropical storms, typhoons, and winter storms. *Id.* at 308.

118 For evidence of adaptation to warmer climates, see Cragg & Kahn, *supra* note 87, at 534–35 (showing that while people's willingness to pay for a warm climate has increased over the period 1960 to 1990, southern earnings have not fallen (as would be expected from rising demand for warm climate, as people accepted lower earnings in order to live in warm climates)). The coincidence of both rising earnings and employment in the South is generally ascribed to the adoption of the air conditioner, a form of adaptation to hot and humid summers that had a remarkably large impact in increasing labor productivity. Walter Y. Oi, *The Welfare Implications of Invention*, *in* The Economics of New Goods 109, 127–28 (Timothy F. Bresnahan & Robert J. Gordon eds., 1997) (recounting how air conditioning rates in the South rose from fifty-eight percent to ninety-one percent over the 1970 to 1990 period versus only from forty-four percent to seventy percent nationally).

119 Especially with federally subsidized coastal flood insurance programs, for the individual coastal property owner, the amount risked per dollar invested has almost surely fallen over the time period 1960 to 1990. How much of this decrease in individual loss exposure is due to subsidized insurance, versus adaptive construction standards, is difficult to determine. Note that there is no inconsistency between a reduction due to adaptation in an individual coastal property owner's risk of loss from floods and hurricanes and the increase in the total losses from hurricanes and other coastal storms so clearly documented by Roger A. Pielke, Jr. & Christopher W. Landsea, *Normalized Hurricane Damages in the United States: 1925–1995*, 13 Weather & Forecasting 621, 630–31 (1998). Indeed, by lowering individual cost, programs like

where in the world), lower agricultural prices are predicted to make American consumers better off to the tune of between $2.5 and $13 billion in 2090.[123] Even more strikingly, under the widely used Hadley Center GCM, agricultural production is predicted to increase for all regions of the United States in both 2030 and 2090.[124] Finally, with agricultural production predicted to shift to regions that will not only be warmer but also much wetter, Reilly finds a very strong shift in comparative economic advantage away from irrigated cropping and toward dryland, and with a much smaller yield advantage to be gained from irrigation, they find that irrigation is no longer economically viable in many areas.[125] With many areas of the country historically drawing down groundwater supplies at unsustainable rates to supply the water demand of both agriculture and growing urban populations, the decrease in agricultural demand for groundwater predicted by Reilly is a significant potential environmental benefit.

The ability of farmers to adapt quickly to changing climate conditions is indeed a crucial factor in deriving U.S. agricultural benefits from global warming. The best way to empirically estimate how farmers will adapt to generally warmer conditions is by looking at how they have already adapted to the very large existing climatic variations in the United States. Such studies—which are based on real, cross-sectional data and estimate statistically the actual relationship between agricultural land prices, climatic, economic, and soil variables—essen-

clearly increasing farm value, higher temperatures in July and January reducing farm value, and higher precipitation increasing farm value only if it comes in January and April (versus July or October).[126] Moreover, this study finds that even in the United States, interannual climatic variation reduces farm values. Climate change is predicted to have clearly beneficial effects for increases of 2.5 degrees centigrade—with the amount of cropland increasing a little but crop revenue increasing significantly (between seventeen percent and twenty percent, depending upon how much additional rainfall comes with increased temperature)—but somewhat more ambiguous effects for a five degree centigrade increase—with cropland down somewhat, while crop revenue increases enormously (between twenty-six percent and twenty-eight percent).[127]

Another approach that has been used to estimate the impact of changing climate on U.S. agriculture is to examine how year-to-year fluctuations in temperature and precipitation have influenced agricultural profits.[128] Using state-level climate change projections from the

harmful. However, this critical work can itself be criticized on various grounds.[131] For example, increases in wine quality and the number of varieties that can be produced in certain regions of both the United States and Europe[132] and an increase in the productivity of northern European agriculture and forestry.[133] The evidence shows that wealthy developed countries such as the United States almost surely have agricultural benefits from a warmer global climate.[134]

131 Perhaps the most dedicated economist critic is the German economist Wolfram Schlenker. *See* Wolfram Schlenker et al., *Will U.S. Agriculture Really Benefit from Global Warming? Accounting for Irrigation in the Hedonic Approach*, 95 AM. ECON. REV. 395 (2005). Schlenker and his colleagues show that the hedonic climate gradient is different as between counties that rely on irrigation and those that do not (so-called dryland counties). *Id.* at 397–98. However, the significance of their results for predicting the impact of climate change depends upon their assumption that subsidized irrigation will not be provided on the same terms as today if and when global warming increases the demand for it in current dryland counties. *See id.* at 396–97. A more recent work uses a novel dataset that uses regression methods to interpolate daily summer maximum temperatures on 2.5 mile square grids and finds that yields for corn, soybeans, and cotton fall steeply when surface air temperatures exceed a threshold daily maximum. *See* Wolfram Schlenker & Michael Roberts, *Estimating the Impact of Climate Change on Crop Yields: The Importance of Nonlinear Temperature Effects* 10–12 (Nat'l Bureau of Econ. Research, Working Paper No. 13799, 2008), *available at* http://www.ssrn.com/abstract=1092849. This is an interesting result, but it is subject to the general criticism of regression interpolation techniques for surface air temperature made by Roger Pielke, Sr. and his colleagues. *See* Roger A. Pielke, Sr. et al., *Unresolved Issues with Assessment of Multidecadal Global Land Surface Temperature Trends*, J. GEOPHYSICAL RES., Dec. 2007, at D24S08, at 2–12; *see also* Schlenker & Roberts, *supra* at 10 fig.1 (depicting actual surface temperatures during the growing season and comparing this distribution to various future climate scenarios generated by the Hadley Center Coupled Ocean-Atmospheric GCM, ultimately revealing that the Hadley model predicts not a single-peaked, symmetric temperature distribution, but rather something quite different and very unusual).

132 *See* Gregory V. Jones et al., *Climate Change and Global Wine Quality*, 73 CLIMATIC CHANGE 319, 338–39 (2005). Somewhat differently, Orley Ashenfelter and Karl Storchmann take the hedonic approach one step further by estimating the impact of climate change on solar radiation and hence on the amount of solar radiant energy collected by vineyards in the Mosel region of Germany. Orley Ashenfelter & Karl Storchmann, *Using a Hedonic Model of Solar Radiation to Assess the Economic Effect of Climate Change: The Case of Mosel Valley Vineyards* 17–18 (Nat'l Bureau of Econ. Research, Working Paper No. 12380, 2006), *available at* http://www.ssrn.com/abstract=921546.

133 *See*

5. Global Warming May Increase the Frequency of Beneficial El Niño Events

Should global warming increase the frequency of El Niño events, then there will be a reduction in the frequency and severity of U.S. losses from hurricanes. In general, El Niño events generate positive net benefits for the United States as a whole. However, climate change models are unlikely ever to have the capability of predicting the impact of global warming on El Niño event frequency and severity. As neither of these points seems very well understood—neither the beneficial effects of El Niño events in the United States nor their inherent unpredictability—it is worth spending a bit of time to explain why.

The current set of GCMs is not very good at all in predicting the impact of global warming on El Niño frequency and intensity.[135] While several GCMs do indeed predict warming sea-surface temperatures (SST) in the equatorial eastern Pacific, this is not El Niño warming but a relatively simple and direct consequence of higher CO_2, and according to climate scientists, there is "still an open question" as to whether such increases in average SSTs due to CO_2 buildup will cause changes in El Niño Southern Oscillation (ENSO) amplitude, whether the changes in averages are statistically independent of ENSO, or whether they are just a "nonlinear residual."[136] As for ENSO frequency, GCMs are all over the map: in a run of twenty-one such models, eight predicted much shorter ENSO cycles than observed, five much longer cycles, with only eight of twenty-one doing a "relatively good" job at predicting ENSO oscillations.[137] Most seriously and quite intuitively, among the biases in GCMs (which are "as big as the signal

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135 *See* Michael J. McPhaden et al., *ENSO As an Integrating Concept in Earth Science*, 314 SCIENCE 1740, 1744 (2006). As McPhaden and colleagues explain, while the "consensus outlook from the current generation of global climate models suggests no significant change in ENSO characteristics under various greenhouse gas emission scenarios that presume a doubling of atmospheric CO_2 from preindustrial levels over the next 100 years," ultimately, however, because "climate models have known flaws that compromise the reliability of future projections in the tropical Pacific . . . . [W]e cannot say with confidence at present how global warming will affect either ENSO variability or the background state on which it is superimposed." *Id.*

136 *See* Sang-Wook Yeh & Ben P. Kirtman, *ENSO Amplitude Changes Due to Climate Change Projections in Different Coupled Models*, 20 J. CLIMATE 203, 207 (2007) (hypothesizing that disagreement among the climate models in predicting ENSO amplitude is caused by varying degrees of nonlinearity in the models).

137 Jia-Lin Lin, *Interdecadal Variability of ENSO in 21 IPCC AR4 Coupled GCMs*, GEOPHYSICAL RES. LETTERS, June 2007, at L12702, at 2.

one is trying to predict"[138]) is a tendency to systematically underestimate tropical Pacific SSTs and hence to overpredict weakened easterly winds and—as such wind anomalies are precisely the condition that immediately precedes El Niño events—to overpredict the frequency of El Niño events.[139]

Still, suppose that the climate models that predict an increase in El Niño frequency due to global warming actually turn out to be correct: would this be a bad thing for the United States? The answer is almost surely "no." To see why this is so, it is important to briefly describe El Niño and the ENSO cycle of which it is a part. ENSO is a cycle between unusually warm (El Niño) and unusually cold (La Niña) sea surface temperatures in the tropical Pacific.[140] Under normal conditions, the easterly trade winds in the tropical Pacific cause the accumulation of warm surface water in the western Pacific and a corresponding upwelling of cold water in the equatorial eastern Pacific and coastal South America. Additionally, the sea surface west-

brings drought to Australia, Indonesia, and other parts of the western Pacific while inundating islands in the central Pacific and the west coast of South America in torrential rain.[143] Although the impacts of strong El Niño and La Niña events at higher latitudes and in oceans other than the Pacific are more attenuated and therefore less predictable, it is known that Atlantic hurricanes "tend to be reduced in number and intensity during moderate-to-strong El Niño events but stronger and more numerous during La Niña events," and that "[t]hese year-to-year changes translate into a 3-to-1 greater likelihood of a major Atlantic hurricane striking the United States during La Niña versus El Niño years, with correspondingly higher losses during La Niña years."[144]

El Niño events are currently (and may be inherently) unpredictable in advance of the weakening of trade winds that bring them on.[145] However unpredictable in advance they may be, as one leading

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ENSO having a noticeable impact on the whole lower stratosphere and upper tropical troposphere—affecting both the subtropical jet stream and the polar vortex—only during solar minima. *See* Vladimir N. Kryjov & Chung-Kyu Park, *Solar Modulation of the El-Niño/Southern Oscillation Impact on the Northern Hemisphere Annular Mode*, GEOPHYSICAL RES. LETTERS, May 2007, at L10701, at 3.

143 McPhaden et al., *supra* note 135, at 1741 (noting that weaker events such as the El Niño of 2004 to 2005 "may have impacts that are muted or even undetectable above the background weather noise of the atmosphere").

144 *Id.* The larger vertical shear that accompanies an El Niño has its greatest effect on storm patterns in the area between ten degrees and twenty degrees North from North Africa to Central America. Roger A. Pielke, Jr. & Christopher N. Landsea, *La Niña, El Niño, and Atlantic Hurricane Damages in the United States*, 80 BULLETIN AM. METEOROLOGICAL SOC'Y. 2027, 2028 (1999). Hence the larger vertical shear associated with El Niño tends to reduce the number of Atlantic tropical storms. *Id.* at 2028. When Pielke and Landsea looked at normalized hurricane damages over the period 1925 to 1997 (damages indexed to take account of inflation, wealth, and population), they found a large difference in the probability of hurricanes generating more than $1 billion in damages between El Niño versus La Niña or neutral years, with a 0.77 probability in La Niña years and 0.48 probability in neutral years versus only a 0.32 probability in El Niño years. *Id.* at 2029–31. It is true that Pielke and Landsea found that the frequency of very damaging hurricanes, with losses exceeding $5 billion, did not vary as much between La Niña and El Niño years, but there were relatively few such storms even over their long sample period; for this reason they found no statistically significant difference in the probability of such very large storms in La Niña versus El Niño years. *Id.* at 2031.

145 There are actually now two different theories of the Southern Oscillation of which El Niño is a component: the first holds that it is a "weakly dampled oscillator that needs to be triggered by a random disturbance. Westerly wind bursts in the western equatorial Pacific appear necessary [on this theory] at the onset of El Niño"; the second theory views the "Southern Oscillation . . . as a lower frequency self-sustaining mode of oscillation in the tropical Pacific." David J. Stephens et al., *Differences in Atmospheric Circulation Between the Development of Weak and Strong Warm Events in the*

meteorologist has recently commented, "all weather conditions produce winners and losers, and in general, less is known about the winners than about the losers."[146] This is perhaps especially true of ENSO, as "it is often the adverse impacts of ENSO variations that receive the most publicity, whereas the benefits, at least for some regions of the globe, are much less understood and appreciated."[147] For example, although the strong 1997 to 1998 El Niño brought devastating drought and fire to areas of the western Pacific and Central America, it generated both costs and benefits for the United States. As predicted, the 1997 to 1998 El Niño brought coastal storms and heavy rains to California and an increased number of severe rainstorms (and accompanying tornadoes) to Florida, Texas, and other southern states.[148] By the end of May, 1998, 189 deaths nationally had been attributed to the El Niño conditions.[149]

Yet the 1997 to 1998 El Niño also generated clear benefits for the United States. The mild, virtually snow-free winter it caused in the northern United States was estimated to have reduced by 828 the number of deaths due to extreme low temperatures and to snow and ice storms, and to have saved almost $14 billion in reduced heating costs and losses due to spring snowmelt floods.[150] By eliminating major Atlantic hurricanes, the 1997 to 1998 El Niño not only elimi-

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Southern Oscillation, 20 J. CLIMATE 2191, 2192 (2007). On the latter theory, the quasi-periodicity of the ENSO cycle is understood as an aspect of a natural oscillator in the

nated the $5 billion in property damage that hurricanes had been causing on average in the United States during the 1990s, but also saved an expected twenty lives that would have been lost in hurricanes.[151]

with the regional distribution of the costs of air pollution reduction.[154] When it comes to the goal of reducing GHG emissions from automobiles, the basic structure of the CAA simply does not give EPA the authority to pursue the range of policies needed to achieve the goal. A more general program of reducing GHG emissions from power plants and other sources—as the Court's decision in *Massachusetts v. EPA* almost surely requires—likewise entails new and as yet unavailable technologies and a potentially massive national redistribution of costs and benefits of control. The complex bargain among

duction to combustion in cars).[156] Although Congress has in fact recently increased auto fuel economy standards,[157] such fuel economy standards are not set by EPA, but rather by the Department of Energy.[158] Congress has also mandated the use and subsidized the production of ethanol as an alternative fuel that may have the potential to be a cleaner fuel—in terms of total CO_2 emissions—than gasoline.[159] Once again, however, Congress has mandated biofuel use in separate energy legislation that has nothing to do with EPA.[160] Another alternative path to reducing the amount of gasoline burned and CO_2 emitted is to subsidize consumer purchases of high mileage and hybrid gas-electric vehicles. In the Energy Policy Act of 2005,[161] Congress provided such subsidies to purchasers of hybrids—in the

156 *See* Press Release, European Union, Questions and Answers on the EU Strategy to Reduce CO_2 Emissions from Cars 1, 4 (July 2, 2007), *available at* http://europa.eu/rapid/pressReleasesAction.do?reference=MEMO/07/46.

157 For a discussion of the new Corporate Average Fuel Economy (CAFE) standards found in the Energy Independence and Security Act of 2007, Pub. L. No. 110-140, 121 Stat. 1492, see *infra* notes 158–163.

158 The Department of Energy acts in this way under the authority of the Energy Policy and Conservation Act as amended by the Energy Independent and Security Act. Energy Policy and Conservation Act § 1(e), 49 U.S.C.A. § 32902 (West 2007), *amended by* Energy Independence and Security Act of 2007, Pub. L. No. 110-140, § 102, 121 Stat. 1492, 1498–1501 (codified at 49 U.S.C.A. § 32902 (West Supp. 2008)).

159 *See* Faulk & Gray, *supra* note 155, at 63 (discussing the renewable fuel standard program created by the Energy Policy Act). As I discuss below, *infra* notes 160–163, the ethanol requirement has been massively increased by the Energy Independence and Security Act of 2007. The corn-based ethanol currently being subsidized and used in the United States to the tune of over 250,000 barrels per day is a net source of CO_2, and the federal government is currently funding research into cellulosic ethanol, which has the potential to be a carbon negative fuel. *See* Katharine Sanderson, *A Field in Ferment*, 444 NATURE 673, 673 (2006) (explaining the challenges surrounding the development of ethanol). Recent work strongly suggests that this potential is very unlikely to be realized, because when account is taken of the lost carbon sequestration due to the conversion of forests and grasslands to biofuel crop production, moving to ethanol as a fuel involves massive net increases in CO_2: as much as fifty percent if the fuel is switchgrass and between 17 and 420 times current CO_2 emissions if the fuel is corn or sugarcane. *See* Joseph Fargione et al., *Land Clearing and the Biofuel Carbon Debt*, 319 SCIENCE 1235, 1235 (2008); Timothy Searchinger et al., *Use of U.S. Croplands for Biofuels Increases Greenhouse Gases Through Emissions from Land Use Change*, 319 SCIENCE 1238, 1238 (2008).

160 In the Energy Policy Act of 2005, Congress tripled the ethanol requirement in automobile fuel, § 1501, 42 U.S.C.A. § 7545 (West Supp. 2008), and in the Energy Independence and Security Act of 2007 Congress increased the ethanol requirement even further, quadrupling ethanol requirements over the 2009 to 2022 period, § 202, 42 U.S.C.A. § 7545 (West Supp. 2008).

161 Energy Policy Act of 2005, Pub. L. No. 109-58, 119 Stat. 594.

ments for reducing GHG emissions in automobile exhausts, the only one that EPA has authority to adopt under the CAA is to require a change in the composition of automobile fuel.[172] One must ask whether a Congress that intended for EPA to regulate GHG emissions from automobiles would have so severely limited the regulatory tools available to the agency to accomplish this goal.

2. Cost Distribution Issues in Reducing GHG Emissions from Non-auto Sources

As other legal scholars have clearly explained, the Court's broad reading of "pollutant" under the CAA will have the effect of compelling EPA to regulate not only automobile tailpipe GHG emissions, but also GHG emissions from stationary sources—directly for new stationary sources (which must comply with federal new source emission standards) and indirectly, through NAAQS, for existing stationary sources.[173] Issues regarding the magnitude and distribution of cost of reducing GHG emissions from automobile tailpipe emissions are just as severe when it comes to policies to reduce GHG emissions from stationary sources.

As for the distribution of emission reduction cost across income levels, studies indicate that the distribution of the cost of reducing GHG emissions from stationary sources may be just as regressive as is the cost of reducing automobile tailpipe GHG emissions. The only currently available method of reducing CO_2 emissions from coal-burn-

172 Under section 211 of the CAA, EPA has the authority to regulate automobile fuel and fuel additives. 42 U.S.C. § 7418 (2000). Under draft legislation introduced in the U.S. House of Representatives in June, 2007, EPA would be given the express authority to regulate the carbon content of automobile fuels. *See* STAFF OF H.R. SUBCOMM. ON ENERGY AND AIR QUALITY, 110TH CONG., ALTERNATIVE FUELS, INFRASTRUCTURE AND VEHICLES (Discussion Draft 2007), *available at* http://energycommerce.house.gov/energy_110/Title%20I%20-%20Fuels%20060107_xml.pdf.

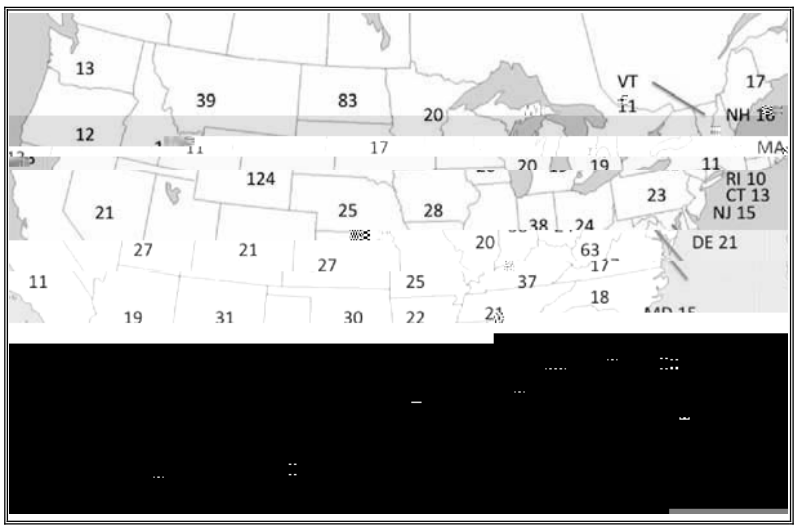
173 *See* Jonathan H. Adler, Massachusetts v. EPA *Heats Up Climate Policy No Less Than Administrative Law: A Comment on Professors Watts and Wildermuth*, 102 NW. U. L. REV. COLLOQUY 32, 37–39 (2007) ("Whatever impact *Massachusetts v. EPA* has on administrative law, one thing is certain: Barring congressional intervention, this decision will cause the EPA to regulate the emission of greenhouse gases from new motor vehicles, as well as from other sources . . . . Once the EPA makes the required finding under section 202 [the automobile tailpipe provision], it will be child's play to force greenhouse gas emission regulation under other Clean Air Act provisions."); Faulk & Gray, *supra* note 155, at 66–74. For the same conclusion, but from the perspective of the plaintiffs in *Massachusetts v. EPA*, see Heinzerling, *supra* note 32, at 5 ("[T]he legal reasoning behind EPA's decision not to control greenhouse gas emissions in setting New Source Performance Standards for power plants has been upended by the Court's decision.").

ing power plants increases a typical customer's utility bills by forty-four percent.[174] Given that poor households are well known to spend disproportionately more on energy than wealthier households,[175] unless offsetting measures are taken, the cost of reducing GHG emissions from power plants will clearly fall disproportionately on the poor.[176] And not just the poor, but especially poor minorities may disproportionately bear the burden of reducing GHG emissions. In opposing the Kyoto Protocol, a study commissioned by minority organizations

174 Eli Kintisch, *Making Dirty Coal Plants Cleaner*, 317 SCIENCE 184, 186 (2007). This method involves passing treated flue gas through an absorber with the solvent monoethanolamine (MEA); the solvent bonds with CO_2 molecules, the CO_2/MEA complexes are then separated out, and, finally, the CO_2 is purified for ground storage. *Id.* at 185. A model Energy Department–sponsored plant called Future Gen that uses a newer and more advanced technique, integrated coal gasification, has greatly increased in cost (from $1 to $1.8 billion) and the Energy Department is now requiring private utilities to bear a greater share of the cost of the project. *See* Andrew C. Revkin, *A 'Bold' Step to Capture an Elusive Gas Falters*, N.Y. TIMES, Feb. 3, 2008, § 4, at 4.

175 *See* JAMES P. STUCKER, THE IMPACT OF ENERGY PRICE INCREASES ON H,

FIGURE 1[180]



PER CAPITA CO_2 BY STATE 2005

distances—systematically have higher per capita CO_2 emissions.[181] Fundamental differences in primary power plant energy source, population density, climate, and size have led to large and enduring differences in CO_2 emissions across different U.S. regions.

E. Implication: The Regional and Socioeconomic Distribution of Costs and Benefits from Reducing GHG Emissions Is So Radically Different From the Pattern of Costs and Benefits from Reducing Conventional Air Pollutants That the CAA Cannot Reasonably Be Interpreted to Mandate GHG Emission Reduction

By detailing how global warming is likely to actually benefit many regions of the United States in the short-to-medium term while GHG emission reduction will likely entail significant costs to many regions and to many poor people in the United States, my discussion thus far may well have made the reader wonder why Massachusetts or any

California, Connecticut, Illinois, Maine, Massachusetts, New Jersey, New Mexico, New York, Oregon, Rhode Island, Vermont, and Washington.[182] My discussion thus far has already revealed a major characteristic that all of these states have in common and a major reason that they sued EPA to compel GHG emission regulation: with the exception of New Mexico, all of these states already have relatively low per capita CO_2 emissions[183] and therefore stand to gain an economic comparative advantage relative to other, higher emitting states from federal regulation of GHGs. Given the relatively low costs and potential economic gain to the plaintiff states from federal GHG regulation, the attorneys general who actually represented the plaintiff states clearly felt no great need to find additional tangible benefits to justify a lawsuit that for them personally probably held the potential for very real political benefits.[184] To satisfy standing requirements, however, Massachusetts alleged, of course, that it would benefit from federal regulation of GHGs today because it would suffer harm from possible twenty-first century sea level rise due to global warming. The *Massachusetts v. EPA*

industry in states such as Vermont is generally projected to lose from global warming.[188]

Thus, the plaintiff states in *Massachusetts v. EPA* were a group that—at least from the point of view of their attorneys general—were likely to receive net benefits regulating GHGs under the CAA. But in asking whether it would be reasonable or even sensible to interpret the CAA broadly to regulate GHGs, the question to ask is not whether the plaintiffs might possibly benefit from such an interpretation, but whether such an interpretation can possibly be seen as consistent with the overall purposes and structure of the CAA. It cannot be. What is most strikingly clear, from both the textual structure and legislative history, is that the CAA represented a series of complex compromises among different regions and interests within the United States.

Consider first stationary source air pollution. Here, the basic structure of the CAA anticipated that places with the dirtiest air would incur the biggest costs, but probably also get the biggest health benefits, from reducing air pollution.[189] Through its scheme of coopera-

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warming are in fact not predicted as a consequence of La Niña events becoming more frequent or severe due to global warming. Instead, these drought predictions are derived from computer predictions of changes in global atmospheric circulation patterns caused by warmer surface temperatures. Notably, climate scientist Richard Seager and his colleagues have found support for the hypothesis of a more drought-prone southwestern United States in a GCM prediction that global warming will move the Hadley cell circulation and mid-latitude westerlies poleward, thus robbing the southwestern United States of ocean moisture and subjecting it to very stable drying descending air. *See* Richard Seager et al., *Model Projections of an Imminent Transition to a More Arid Climate in Southwestern North America*, 316 SCIENCE 1181, 1183 (2007). Ironically, such drying is caused by the fact that a warmer atmosphere will also be a more humid one. Basically, the warmer the global mean temperature, the higher the latitude necessary to get cool enough temperatures for water to precipitate out as rain. Seager and his coauthors conclude that "[t]he most severe future droughts will still occur during persistent La Niña events, . . . they will be worse than any since the medieval period, because the La Niña conditions will be perturbing a base state that is drier than any state experienced recently." *Id.* at 1183–84. Of course, emphasizing the impact of possible poleward-shifting westerlies while ignoring the drought-destroying impact of possibly more frequent and/or severe El Niño events would seem at the very least to give a very incomplete and somewhat slanted picture of what a warmer climate may mean for the southwestern United States. For more on this and other troubling rhetorical strategies that have come to characterize the climate change science/policy world, see Jason Johnston, The IPCC as Expert Witness: Piercing the Rhetoric of Climate Change Advocacy Science to Reveal Fundamental Questions and Uncertainties About CO_2 and Climate Change (September 2008) (unpublished manuscript, on file with author).

188 *See supra* note 107 and accompanying text.

189 Economic studies have consistently found that since the passage of the Clean Air Act, pollution levels have fallen more in counties with poor air quality (non-attain-

Pacific coast, northeastern, and New England regions are looking at a very uncertain mix of costs and benefits from global warming, but are likely to have relatively low costs of reducing GHG emissions.

The pollutants regulated under the CAA presented a relatively clear pattern: developed parts of the country with high pollution incurred relatively big costs but also got big benefits from reducing air pollution.[191] Regulation of GHG emissions presents a more complicated but still obviously different pattern: many, perhaps most, of the U.S. regions that have the least to lose from global warming would have the highest cost of reducing GHG emissions; the regions that would gain the most—such as the wealthy Northeast—also have relatively low costs of reducing GHG emissions. In deciding whether to vote for the CAA's regulation of conventional pollutants, federal legislators from a very large number of then relatively less developed states and districts voted for something that cost their constituents relatively little while bringing them some benefits. Had they been voting on a CAA that regulated GHG emissions, federal legislators from many of those same states would have to decide whether to vote for a law that cost their constituents an enormous amount while not only not bringing them big benefits, but probably costing them the benefits of a warmer and milder climate. If anything, one would expect that the latter vote could only be obtained through a complex compromise that gave such states and districts something in exchange for their otherwise altruistic support for curbing GHG emissions. But such speculation is unnecessary to my argument. Because of the dissimilarity in the interstate and interregional pattern of costs and benefits from GHG emission regulation, there simply is no basis for concluding that

ever, every year in which predictions of the models fail to be validated represent a data point indicating that the models are lacking and in important ways incorrect. Now suppose that a super rational member of Congress believes model predictions of serious climate change in the far distant future, say one hundred years. At the same time, however, legislation requiring costly actions to reduce GHG emissions cannot get majority support unless Congress is persuaded that some very severe harm from climate change will occur much sooner. Such relatively imminent harms will then be the official justification for passing GHG reduction legislation. But if legislation is passed with the express purpose of preventing imminent harm from global warming, and in fact temperatures increase very slowly (or not at all) in the near future and the near-term harm that justified costly legislative GHG reduction requirements does not occur, there will be enormous pressure on Congress to amend the law to weaken its GHG reduction requirements (a very similar story in fact took place with the CAA itself).[196] Once weakened by future amendment, it may be very difficult, if not politically impossible, to return to a statute that adequately protects against the predicted long-term consequences. In short, by passing legislation based on predicted short-term consequences, Congress may drastically increase the stakes in the accuracy of short-term predictions from climate models. But climate models cannot make accurate short-term (five-to-ten year) predictions.[197] Hence, the justification for legislation imposing present day costs for the far-off future will likely fail, leading to legislative repeal and a worsened status quo than if GHG emission requirements were postponed.

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albedo, leading to higher surface temperatures, more melting, and so on), then such models will always attach some positive probability to very high potential temperature increases. Perhaps most importantly, "foreseeable improvements in the understanding of physical processes, and in the estimation of their effects from observations, will not yield large reductions in the envelope of climate sensitivity." *Id.* at 631.

196 *See* BAILEY, *supra* note 50, at 167–74.

197 This is because, among other reasons, they cannot predict ENSv gg9hAO-event,n

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2007,[202] Congress: (1) set a new target for automobile and light truck fuel economy of thirty-five miles per gallon, to be achieved by 2020; (2) mandated a large increase in the minimum annual level of renewable fuel in U.S. transportation fuel, rising from nine billion gallons in 2008 to thirty-six billion gallons by 2022; and (3) set new efficiency standards for light bulbs and several other consumer household appliances. None of these policies are new[203] and none are focused specifically on reducing greenhouse gas emissions. Although they may have that effect, such an impact is hardly guaranteed. Meeting the new auto fuel efficiency standards by shifting fleets to diesel could, for

with biofuels derived from sources other than corn.[206] While there is evidence that biofuels made from grasses, wood, and waste biomass generate large net GHG emission reductions, the magnitude of these reductions is unclear.[207]

It would thus be fanciful to argue that what Congress has done in the Energy Independence and Security Act of 2007 is to take dramatic and effective action on the problem of GHG emissions and climate change. Instead, Congress has, if anything, simply used the general panic over climate change as an excuse for passing legislation that benefits certain special interest groups while quite possibly *increasing* GHG emissions. As for legislation actually focused on the climate change problem, it is true that over the past several years, there have been a number of bills introduced in Congress that would set up comprehensive climate change regulatory regimes.[208] Virtually all of these are what economists would call market-based in that they would create GHG cap and trade regimes (the vast majority) or a carbon tax.[209] As I discuss below in the Conclusion of this Article, the widespread preference for cap and trade global warming regulatory regimes is, in my view, based on an overly facile belief that a policy instrument that has seemed to work relatively well for some air pollutants (in the United States, sulfur dioxide and nitrous oxides) will also be appropriate for a radically different set of air emissions whose reduction involves virtually every sector of the U.S. economy.[210]

It is true that in the spring of 2008, the Senate came close to voting on the Lieberman-Warner Climate Security Act of 2007,[211] which would have implemented a greenhouse gas cap and trade scheme.[212] Lieberman-Warner was a gargantuan and enormously complex piece of legislation, with complicated provisions setting up an entire new system of transfer payments and greenhouse gas offsets to cushion the impact on the poor and various U.S. regions and industrial sectors (for example, agriculture). The radical and fundamental differences between the Lieberman-Warner greenhouse gas cap and

206 *See* Energy Independence and Security Act of 2007 §§ 201–202, 42 U.S.C.A § 7545 (West 2003 & Supp. 2008) (effective Jan. 1, 2009).

207 *See* BILL JACKSON ET AL., THE BOUNTY OF BIOFUELS 2 (2008), http://www.boozallen.com/media/file/Bounty_of_Biofuels.pdf; Roger A. Sedjo, Commentary, *Biofuels: Think Outside the Cornfield*, 32 [illegible] se to207wFedt sevrneindus-15.2646w0629 -1.2222 TD0.0898r

trade program and the Clean Air Act provide further support for my argument that Congress simply could never have contemplated regulating greenhouse gas emissions under the CAA. My prediction that EPA regulation under the CAA will, counter-intuitively, lessen the chance that Congress will pass something like Lieberman-Warner remains to be tested. Although over a year and a half has passed since the Court's decision in *Massachusetts v. EPA*, EPA has not acted to promulgate greenhouse gas emission regulations under the CAA. What EPA has done instead is to issue an Advance Notice of Proposed Rulemaking in which it sets out a variety of reasons—in many cases paralleling parts of my argument—as to why it would be difficult or even impossible to sensibly regulate greenhouse gas emissions under the CAA's regulatory structure.[213] As EPA has not yet acted to regulate GHGs under the Clean Air Act, we do not yet have a test for my hypothesis.[214]

It must be stressed that the foregoing analysis has been concerned with the impact of EPA regulation of greenhouse gases under the Clean Air Act on the likelihood of federal global warming legislation. I have been concerned with the case where EPA does in fact promulgate greenhouse gas regulations under the Clean Air Act. EPA has not yet promulgated such regulations. Instead, the current situation is most accurately described as one where regulation is *threatened*. On the analysis of legislative costs and benefits set out above, threatened legislation is likely to have political incentive effects that are opposite to those created by promulgated regulation. The reason is quite straightforward: the threat of regulation means that federal legislators who support global warming legislation see a risk of losing some of the political benefits available to them from acting on global warming. Rather than allowing the agency to act first, and reducing the benefit to them from legislating, supporters of federal legislation may see a reason to act quickly, to beat the agency to the punch, as it were. As for members of Congress whose constituents are likely to be net losers from global warming, early congressional action gives them

213 *See* Regulating Greenhouse Gas Emissions Under the Clean Air Act, 73 Fed. Reg. 44,353, 44,362–71 (July 30, 2008) (to be codified at 40 C.F.R. Ch. I) (discussing the potential transportation costs, agricultural burdens, disparate regional impacts, questionable effectiveness, and various collateral effects of regulating GHGs under the CAA).

214 There has been widespread speculation, however, that an Obama administration would move quickly to promulgate such regulations, and thus such an administration would likely generate a test of my hypothesis regarding the likelihood of congressional reaction to costly and sub-optimal regulations. *See* Editorial, *Obama's Carbon Ultimatum*, WALL STREET J., Oct. 20, 2008, at A18.

an opportunity to attempt to at least lessen the cost of global warming regulation to their constituents. Still, if they believe that regulation under the Clean Air Act will likely prove to be unworkable and easily stymied in practical implementation, then they may well oppose legislation which is superior on cost-benefit grounds to regulation under the Clean Air Act precisely because such legislation is likely to result in actual compliance costs far sooner than under Clean Air Act regulation.

IV. The International Nature of the Global Warming Problem Not Only Justifies

the emission to make such a finding. Had Congress specifically and explicitly told EPA to regulate GHG emissions, then the agency would obviously have lacked authority to defer regulation on the ground that the effects of GHGs are too uncertain.[219] But there is no such command to the agency to regulate GHGs anywhere in the CAA, and the legal question under the *Chevron* test is then whether the agency's decision to defer its consideration of GHG emission regulation could be understood as a reasonable exercise of its statutory discretion.

For Justice Scalia writing in dissent, the reasons given by EPA for its deferral—its desire to avoid a fractured, piecemeal approach to GHG emission regulation, and to avoid interfering with executive branch climate change programs and international negotiations—were eminently reasonable, precisely the kinds of "considerations executive agencies *regularly* take into account (and *ought* to take into

rios, such as the potentially catastrophic flooding along the American Atlantic and Gulf coasts and severe drought in the Southwest discussed earlier.[230]

Now as with any regulatory decision, if EPA decides to regulate GHGs because of these projected harms, two types of error are possible. A Type I error occurs when the regulator incorrectly takes action: the regulation was either not needed or is ineffective.[231] In the case of global warming, a Type I error means that GHG emissions are reduced and the harms do not occur—for example, the American climate becomes warmer and everywhere wetter, and there is adaptation to sea level rise, with people on balance being better off as they migrate to the upper Midwest—and the agency has inflicted a gigantic loss across the economy, which would not be approved of by Congress at the time. Crucially, for federal regulation of GHG emissions, there is another potential source of Type I error: EPA could regulate U.S. GHG emissions, but China, India, and other developing countries could fail to control GHGs, in which case the harm from global warming would occur despite U.S. costs to cut GHG emissions, so that regulation would have generated costs but no benefits.[232] With global warming there are two types of Type I error: regulating when global warming in fact generates little harm to the United States, and regulating when global warming is indeed harmful to the United States but occurs despite U.S. GHG emission reductions.

Type II error arises when the agency fails to regulate GHG emissions and harm occurs.[233] Such an error would arise when global warming is harmful, and when other nations or subnational governments fail to implement regulations that are sufficient to offset the American failure to regulate.

Now consider the regulation of traditional air pollutants. Type I errors for traditional air pollution regulation arise when EPA regulates—meaning levels of air pollution are reduced by some amount—but the existing levels were not actually harmful. In this case, there is an economy-wide wasted cost of pollution reduction. In the case of

230 *See supra* notes 185–87 and accompanying text.

231 *See* Mark A. Hall & Ronald F. Wright, *Systematic Content Analysis of Judicial Opinions*, 96 CAL. L. REV. 63, 95 n.133 (2008).

232 *See* Reimund Schwarze, *Liability for Climate Change: The Benefits, the Costs, and the Transaction Costs*, 155 U. PA. L. REV. 1947, 1951 (2007) ("If the United States were to establish a crushingly expensive regime ascribing liability to individual polluters, there would be a serious incentive to relocate GHG-intensive industries to countries such as China and India, which have no or almost no restrictions on GHG emissions and no liability for climate-related damages.").

233 *See* Hall & Wright, *supra* note 231, at 95 n.133.

All of this is to say that at the best, the power of EPA is extremely limited in the case of taking effective action to reduce the harm from global warming relative to its power to reduce the harm from traditional pollution. But matters may in fact be worse than this. It may be that the more effective EPA is in reducing GHG emissions, the weaker the incentive will be for other countries to do the same. Such scenarios are in fact very easy to imagine.

Suppose that the United States reduces its GHG emissions but global warming seems not to be accelerating as predicted. Under such circumstances, there will be less pressure on late movers to act. Suppose somewhat differently that the United States reduces its GHG emissions and the atmospheric stock level of CO_2 begins—for whatever reason—to stabilize or even decline. In this scenario, there is once again less pressure on other countries to act.[237] Suppose finally that the United States reduces GHG emissions but there is no

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in estimates of China's CO_2 emissions. However, allowing for this uncertainty, two recent, independent studies estimate that China's CO_2 emissions exceeded those of the United States in 2006. Jay S. Gregg et al., *China: Emissions Pattern of the World Leader in CO_2 Emissions from Fossil Fuel Consumption and Cement Production*, GEOPHYSICAL RES. LETTERS, April 2008, at L08806, at 1; NETH. ENVTL. ASSESSMENT AGENCY, GLOBAL CO_2 EMISSIONS (2008), http://www.mnp.nl/en/publications/2008/GlobalCO2emissionsthrough2007.html. Given the uncertainty in estimates of Chinese CO_2 emissions, and the likelihood that annual data underestimate emissions (due to incentives to overstate end-of-year production, so as to meet quotas, and hence understate early year production), Gregg and colleagues point out that it is possible that Chinese emissions could have passed U.S. emissions as early as 2004. Gregg et al., *supra* at 4. Auffhammer and Carson also estimate that China CO_2 emissions surpassed those of the United States in 2006. Maximilian Auffhammer and Richard T. Carson, *Forecasting the Path of China's CO_2 Emissions Using Province-Level Information*, 55 J. ENVTL. ECON. & MGMT. 229, 229 (2008). In addition, using models that accurately capture the cost of replacing old, dirty capital, they forecast that by 2010, China's carbon emissions will increase by 600 million metric tons relative to 2000, dwarfing the 116 million ton reduction that Kyoto signatories are committed to bringing about by 2010. *Id.* at 245.

237 This particular scenario is a version of the general game modeled by Michael Hoel who presumes that the higher the emissions reduction by one country, the lower the marginal benefit—in terms of reduced harm—to reductions by another country. Michael Hoel, *Global Environmental Problems: The Effects of Unilateral Actions Taken by One Country*, 20 J. ENVTL. ECON. & MGMT. 55, 59–60 (1991). Hence although total emissions must decline, late movers free-ride off the emissions reductions of early movers. Moreover, under such conditions, a unilateral commitment to reduce emissions by one country unambiguously harms its position in negotiating with the other country for an emissions reduction treaty. *Id.* at 63–64. Erling Moxnes and Eline van der Heijden provide evidence demonstrating that investments to reduce a public bad by leaders reduces subsequent investment by later movers. Erling Moxnes & Eline van der Heijden, *The Effect of Leadership in a Public Bad Experiment*, 47 J. CONFLICT

new apparent harm from global warming. Once again, there will be less pressure on late movers to act.

There are, on the other hand, scenarios under which unilateral action by the United States could increase the incentives for other nations to act to reduce GHG emissions. If the atmospheric stock of CO_2 continues to increase despite U.S. GHG reductions, and global average temperature and harms from such temperature changes also continue to increase, then unilateral U.S. action could increase the incentive of late-moving countries to act by revealing that the cost of action is lower than expected. In other words, were U.S. action to generate effective and unexpectedly cheap technologies for GHG reduction, and were late-moving countries such as China to perceive that they had become pivotal—in the sense that by reducing their emissions, they could in fact reduce harms suffered by their own populations[238]—then early U.S. action could sufficiently lower the cost of emission control that would spur action by late movers.[239] Still, even if unilateral U.S. action revealed unexpectedly cheap and effective technologies for reducing GHG emissions, and late moving countries would realize a self-interested benefit from reducing their own GHG emissions, whether such late movers would take still costly action to reduce GHG emissions would depend upon how quickly they are growing, how high their per capita income has grown, and in general on the whole set of factors determining the domestic demand for and supply of pollution reduction efforts. For pollutants such as sulfur dioxide, there is evidence of an environmental "Kuznets Curve," whereby emissions at first increase with industrialization and national per capita income but then eventually fall for sufficiently high levels of wealth.[240] There is no evidence of a consistent relationship of this sort between national income and CO_2; instead, CO_2 emissions mono-

example as opposed to a situation with no leader. *Id.* This produces benefits also to the leaders but not enough to recover all the costs of taking a leading position.

238 Note that the existence of a treaty could significantly enhance the positive impact of early-moving behavior by essentially reducing the potential harm from treaty defection to treaty adherents. *See* Jean-Christophe Pereau & Tarik Tazdait, *Cooperation and Unilateral Commitment in the Presence of Global Environmental Problems*, 20 ENVTL. & RES. ECON. 225, 237 (2001). This, of course, is a further argument that a purposive Congress would not have intended to mandate U.S. GHG reductions without a treaty in place.

239 *See* Urs Steiner Brandt, *Unilateral Actions, Case of International Environmental Problems*, 26 RES. & ENERGY ECON. 373, 389 (2004).

240 The "Environmental Kuznets Curve" refers to the observed tendency for ambient pollution to at first increase but then decrease as national per capita GDP increases, thus giving rise to an inverted U-shaped relationship between per capita income and pollution. *See* Arik Levinson, *Environmental Kuznets Curve*, *in* 2 NEW PAL-

tonically increase with national income for some countries but exhibit an inverted U-shaped relationship for others.[241] To assume that in the case of, for example, China, there will someday suddenly appear a new demand for GHG reduction merely because other nations have previously discovered relatively cheap and effective ways to reduce their own GHG emissions would be to ignore the striking lesson of the present day, when Chinese conventional pollution has soared with its industrialization. Since China has largely eschewed the emission reduction technologies for conventional pollutants made available by pollution control efforts in already industrialized countries, why would one expect China to adopt at some future point the GHG reduction technologies made available by present-day GHG emission reduction requirements in such countries?

This may be overly pessimistic.[242] China, India, Brazil, and other rapidly industrializing countries may indeed someday provide a lucrative market for GHG reduction technologies—most especially carbon capture and storage—developed by virtue of unilateral U.S. GHG emission reduction requirements.[243] And there are other potential

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GRAVE DICTIONARY OF ECONOMICS 892, 892–93 (Steven N. Durlauf & Lawrence E. Blume eds., 2d ed. 2008).

241 Elbert Dijkgraaf & Herman R.J. Vollebergh, *A Note on Testing for Environmental Kuznets Curves with Panel Data* 16–17 (Fondazione Eni Enrico Mattei Working Paper No. 63.2001, Sept. 2001), *available at* http://papers.ssrn.com/sol3/papers.cfm?abstract_id=286692. The inconsistent relationship for CO_2 is perhaps predictable, given the more general finding in the Environmental Kuznets Curve literature that the more dispersed is the externality from a particular pollutant, the higher the turning point in national income at which levels of the pollutant begin to decline; for pollutants with the most dispersed negative impacts, there often is no turning point. *See* Levinson, *supra* note 240, at 892–93.

242 But it is unlikely. *See* Jon Hovi et al., *The Persistence of the Kyoto Protocol: Why Other Annex I Countries Move on Without the United States*, 3 GLOBAL ENVTL. POL. 1, 20–21 (2003) (analyzing an existing case of early moving on climate change policy—the European Union's early leadership in pursuing (superficially at least) a GHG reduction policy despite the failure of the United States to participate in the Kyoto Treaty—and rejecting the hypothesis that such behavior is motivated by rational strategic gain and believe that it is instead explained by the bureaucratic inertia of EU climate institutions and the desire of EU actors to strengthen the European Union as a foreign policy force).

243 For discussions of the potential for profitably transferring such technologies if they are indeed developed, see Scott Barrett, *Proposal for a New Climate Change Treaty System*, ECONOMISTS' VOICE, Oct. 2007, at 1, 4, *available at* http://www.bepress.com/cgi/viewcontent.cgi?article=1240&context=ev, and Gwyn Prins & Steve Rayner, *Time to Ditch Kyoto*, 449 NATURE 973, 974 (2007). Brian R. Copeland and M. Scott Taylor have demonstrated that international trade is likely to play a significant role in determining the impact of developed country GHG emission reductions. They show that by increasing developing country income from the production of "dirty" (that is,

justifications for unilateral action that have not been formally modeled by economists. For example, by acting unilaterally, the United States could at the very least alter somewhat the rate of change in global CO_2 emissions, and such a change in the global rate of change in CO_2 could provide more information on the actual impact of changing CO_2 stocks on the crucial regional impacts of increasing global average temperature. Further exploration of these and other possible justifications for the United States to take costly actions now to reduce GHG emissions is beyond the scope of this Article. The important and concluding point for present purposes is that none of these very complex and indirect benefits from present-day GHG reduction make GHG reduction even remotely similar in its anticipated impact to the kind of pollution reduction that Congress intended to cover under the CAA. That statute mandated federal, state, and local regulations that if effectively enforced, would be successful in reducing conventional pollutants, and improving ambient air quality, *regardless* of the present or future actions of other countries. Such effective unilateral action is at the best extremely unlikely in the case of climate change.

Conclusion: The CAA Does Not Cover GHG Emissions, but This Does Not Mean That Climate Change Is Not a Problem Requiring a Policy Response

It is important to understand the limits to the scope of the argument that I have made in this Article. My argument is that the distribution of short-to medium-term costs and benefits to the United States from taking costly action to reduce GHG emissions is so very different than the distribution of costs and benefits from regulating air pollutants under the CAA that it is completely unreasonable to interpret the CAA as covering GHG emissions. This argument does not imply that climate change is not a problem for the United States, nor does it imply that the United States should do nothing to reduce its GHG emissions. There is credible scientific evidence that if GHG emissions continue to increase, then in the very long run—beyond 2100—there are a variety of severe harms that might befall people in

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GHG emitting) goods, reduction in the developed country GHG emissions could actually stimulate the demand for GHG emission reduction in the developing countries by enough to offset both the shift of dirty good production to such countries (so-called leakage) and also free-riding by such countries. Brian R. Copeland & M. Scott Taylor, *Free Trade and Global Warming*, 49 J. Envtl. Econ. & Mgmt. 205, 229–31 (2005).

the United States.[244] There is also credible scientific evidence that even in the short-to-medium term—up to 2100—many developing countries are likely to suffer harm as a result even of moderate changes in climate.[245] Hence as a matter purely of national self-interest, the United States has an interest in adopting policies designed to lessen the likelihood of harmful far-distant climate change. And for a variety of foreign policy reasons—ranging from a concern with international equity to a concern with the possible impact of climate change in developing countries in prompting mass immigration and exacerbating the international terrorist threat—the United States has an interest in taking costly action to lessen harmful near-to medium-term climate change impacts in developing countries.

The optimal U.S. response to climate change depends upon why the United States is acting: to attempt to avert short-to medium-term harm in developing countries, or instead to prevent very distant and uncertain and yet also potentially very costly harm to the United States. From the long-term point of view, clearly a program of significant government subsidies for research and development into clean coal (carbon sequestration), as well as non-carbon-based energy sources, makes sense. If and when such technologies are developed, their adoption can also be subsidized. Such a pattern of expenditure would acknowledge an obligation of the present generation to do something now—the U.S. government of today should spend far, far more than it has thus far in directly funding and indirectly rewarding

244 The economic studies of the impact of climate change cited *supra* notes 107, 121–34, for example, clearly show that temperature increases above seven degrees centigrade inflict large net losses on American agriculture.

245 Consider, for example, Africa. As the IPCC notes, climate is a "significant control on day-to-day economic development of Africa," with agriculture and water-resource sectors especially vulnerable to climate fluctuations. INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, *supra* note 121, at 436. Under a variety of future climate scenarios, the IPCC predicts that there will be by the 2080's a "significant decrease in suitable rain-fed land extent and production potential for cereals," with an increase in arid (desert) and semi-arid land in Africa of five to eight percent and the likely disappearance of wheat production from Africa. *Id.* at 448. For an Asian example, see Jonathan T. Overpeck and Julia E. Cole, *Lessons from a Distant Monsoon*, 445 NATURE 270 (2007) (opining that if the Indian monsoon intensifies, as some climate models predict, then Indonesia in particular will have more severe and longer droughts, imperiling rural livelihoods and natural resources). Not only is developing world agriculture more susceptible to drought, increases in sea level that cause a loss of coastal agricultural land are much more damaging in poor countries that cannot as easily substitute for land loss by increasing fertilizer use and in which agriculture is a much larger share of the national economy. *See* Francesco Bosello et al., *Economy-Wide Estimates of the Implications of Climate Change: Sea Level Rise*, 37 ENVTL. & RES. ECON. 549, 557 (2006).

research and development into technologies that generate no or low CO_2 emissions—while also shifting to future generations a good share of the cost of widespread adoption of whatever technologies are developed.

There is no guarantee that such technologies will come online quickly enough, however, to help developing countries deal with adverse short-to medium-term consequences of a warming climate. But given the very long half-life of atmospheric CO_2,[246] it is far from clear that anything but an immediate and drastic decarbonization of the economy of the United States and other large CO_2 emitting countries will do anything to slow or reverse global warming in time to prevent harmful impacts on developing countries. Even with drastic decarbonization, such countries may well suffer harm from a warming climate. That is, the short-to medium-term harm from climate change is due not to current emissions, but primarily to atmospheric CO_2 that was emitted over the last thirty-five or so years, most of which will remain in the atmosphere for decades to come. Radical decarbonization—such as a wholesale conversion to nuclear power—might well drastically cut current CO_2 emissions,[247] but it will not prevent short-to medium-term harm to developing countries. Such harm can be averted only by either large-scale adaptation in such countries, or by moving people out of harm's way: that is, by large-scale immigration from hazardous developing countries to safer developed countries. The choice among these and other alternatives, and in particular the question of how much developed countries should pay to help developing countries cope with climate change, involves questions of relative efficacy, efficiency, and fairness. These issues are important, but their consideration is beyond the scope of this Article and best left to future work.

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246 Of any given exogenous increase in CO_2 input into the atmosphere, a substantial fraction is absorbed relatively quickly by the oceans, while in the very long run of hundreds of thousands of years, only about seven percent remains. In the centuries in between, CO_2 is slowly absorbed by the oceans and biosphere. *See* David Archer, *Fate of Fossil Fuel CO_2 in Geologic Time*, J. GEOPHYSICAL RES., Sept. 2005, at C09S05, at 5. For the classic analysis, which shows the importance of the assumed rate of oceanic and biosphere absorption to the time path of atmospheric retention, see U. Siegenthaler and H. Oeschger, *Predicting Future Atmospheric Carbon Dioxide Levels*, 199 SCIENCE 388, 391–92 (1978).

247 Even many committed climate change scientist advocates end up recommending at least some conversion to nuclear power, *see, e.g.*, R.T. Pierrehumbert, *Climate Change: A Catastrophe in Slow Motion*, 6 CHI. J. INT'L. L. 1, 18 (2006) ("[S]olving the problems of nuclear power is arguably more tractable than solving the problems of burning coal safely—especially safely sequestering the highly mobile carbon dioxide that is the inevitable consequence of coal burning.").