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Cover photo: The average concentration of ozone in Salt Lake City, Utah, greatly exceeds the new national limit of 70 parts per billion. © iStock.com

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Building on Success in Paris

Leaders from around the world have just reached a historic agreement to rein in emissions of carbon dioxide and other greenhouse gases. One feature of the Paris deal that has attracted significant attention is that it articulates a more ambitious goal than previously negotiated—to limit warming to well below 2°C, aspiring to no more than 1.5°C.

Given where we are today, staying within that target represents a Herculean effort. But whether we view that goal as unrealistic or appropriately aspirational, the Paris agreement represents a welcome dose of realism to a process that has long been plagued by significantly more grandstanding than concrete action.

The climate deal includes for the first time emissions mitigation pledges from virtually every country on the planet, reflecting the emergence of a pledge-and-review approach. This new, bottom-up process guarantees that the entire world will take voluntary actions to reduce greenhouse gas emissions—a marked improvement over the Kyoto process.

There is always an urge to make immediate judgments about whether agreements such as this one represent success or failure. In truth, whether this regime proves effective will be determined over the next few years. A cause for optimism is that the key components for success are there. In addition to near-universal participation, countries have agreed to undertake increasingly ambitious actions every five years to reduce emissions, and to report in a transparent manner on those actions.

Critical to the effort is the next phase, the design and implementation of the

review of these pledges—in other words, transparency.

Transparency of commitments in negotiations has been the subject of scholarly research going back to Thomas Schelling 60 years ago and is an area where RFF experts have contributed in recent years. For example, RFF's Joseph Aldy and Billy Pizer have established principles to guide the design of review mechanisms. And at the Paris convention, RFF Senior Fellow Ray Kopp, co-director of RFF's Center for Energy and Climate Economics, in joint work with think tanks in Asia and Europe, presented analyses comparing the first round of commitments made in the lead-up to the negotiations.

The Paris agreement establishes a new path forward in global climate policy. But many of the details, such as when national reviews would begin and how periodic they will be, have yet to be hammered out. Scholarship by RFF researchers and others will inform this effort.

At the end of the day, transparency should help reassure countries that they are not acting alone and push laggards to fulfill their commitments. This global cooperative approach is important, but its success will depend heavily on key countries providing strong leadership, just as the Obama-Xi agreement last year advanced success in Paris by signaling to other nations that real action was possible. ●



PHIL SHARP
President
sharp@rff.org

Exploring the Water–Energy Nexus: Water Use for Fossil Fuel Extraction and Processing

YUSUKE KUWAYAMA

An increase in the production of some fossil fuels in the United States, especially crude oil and natural gas from unconventional sources, has raised concerns about the potential impacts on water resources because producing these fuels can require a significant amount of water.

One way to better understand the water implications of extracting and processing conventional versus unconventional fossil fuels is to analyze their water intensity—the volume of fresh water consumed per unit of energy in the fuel produced (Figure 1). Several insights arise:

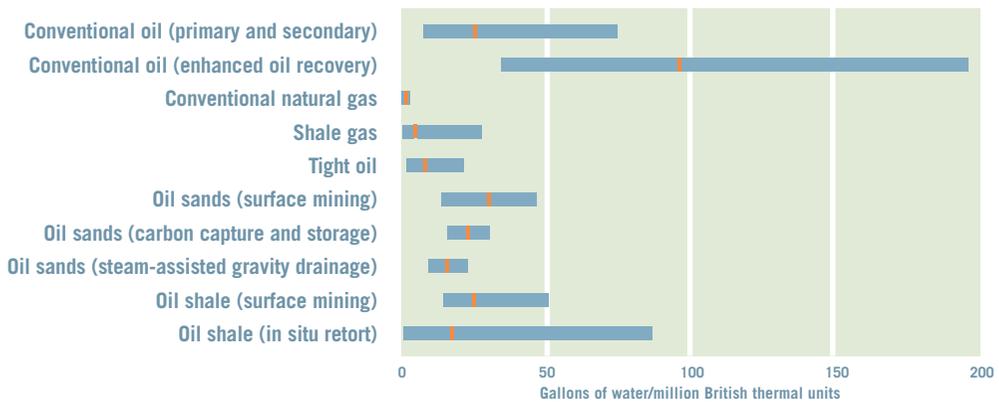
» Some energy sources—such as conventional oil and oil shale with in situ retort—exhibit very wide ranges of estimated water

intensities. This highlights the importance of understanding distinctive factors, such as local geology, in determining the water intensity of individual applications.

» Shale gas is the next-best fuel alternative to conventional natural gas in terms of water intensity, on average. If growth in shale gas can offset oil production, it is possible that total water use in the future may be less than what would have occurred otherwise.

» Production from oil sands and oil shale is less water intensive, on average, than conventional oil production. The expansion of oil sands and oil shale may help reduce the water footprint of economic sectors that may not be able to readily switch to natural gas or renewables. ●

Figure 1. Ranges and Averages of Water Intensity Estimates (Consumptive Use) Available in the Existing Water–Energy Nexus Literature



YUSUKE KUWAYAMA is a fellow at RFF.

FURTHER READING

Kuwayama, Yusuke, Sheila Olmstead, and Alan Krupnick. 2015. Water Quality and Quantity Impacts of Hydraulic Fracturing. *Current Sustainable/Renewable Energy Reports* 2(1): 17–24.

Highlights from Recent Events at RFF

Environmental Policies and Jobs in the Energy Sector

“The three industries that you might think of as most directly hit by environmental policy—logging, mining, and utilities—add up to just 1 percent of the economy. What we need to think about are the whole-economy effects because that’s where most of the jobs are.”

Roberton C. Williams III, Senior Fellow and Director of Academic Programs, RFF;
May 6, 2015

The Responsibility to Take Action on Climate Change

“Scientists are as sure that humans are causing climate change as they are that cigarette smoke causes lung cancer. So unless you want to debate that point, don’t debate about climate change any longer because it is our moral responsibility to act. That responsibility right now is crystal clear. And that is why we have taken action.”

Gina McCarthy, Administrator,
US Environmental Protection Agency;
August 11, 2015

Natural Habitats and Protecting Nature

“We save natural habitats often by not needing the land for any productive uses. We save nature when there is no demand for its exploitation. In this sense, making nature worthless might be a more powerful way of saving nature than valuing its services.”

Linus Blomqvist, Director of Conservation,
The Breakthrough Institute;
September 9, 2015

Low-Income Carbon Pricing Protection

“Well-designed carbon tax legislation can generate enough revenue to fully offset the hit to most vulnerable households’ budgets from higher energy prices, cushion the impact for many other households, and leave plenty to spare for other uses—whether deficit reduction, tax reform, or spending for other public purposes.”

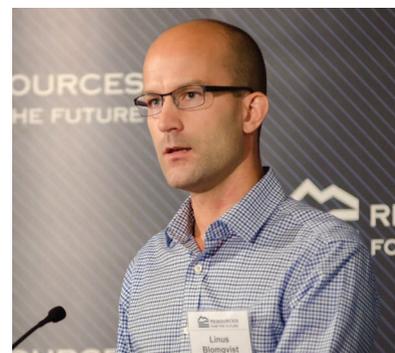
Chad Stone, Chief Economist, Center on Budget and Policy Priorities;
September 22, 2015

Marine Infrastructure in the Alaskan Arctic

“There are no offshore assets [off the port of Nome, Alaska] now that Shell pulled out [of its exploratory drilling activities]. There were—if there was a ship in distress, they had vessels that could go and help. Now there is nothing. I think that’s one important message we need to bring across to folks, and we look forward to working with our congressional delegation and the Army Corps of Engineers to make this improvement.”

The Hon. Denise Michels, Mayor,
City of Nome, Alaska;
October 7, 2015

To view videos and presentations from these events, visit www.rff.org/events.



Clockwise, from top: Gina McCarthy at “The Promise of the Clean Power Plan: A Conversation with Gina McCarthy, Administrator, US Environmental Protection Agency”; Chad Stone at “How Pricing Carbon Impacts Low-Income Households”; Linus Blomqvist at “Reforming Today’s Conservation and Environmental Policies for Tomorrow’s Scarcity (and Abundance)”; the Hon. Denise Michels at “Shipping in the Arctic: Promise, Preparations, and Impacts”; and Roberton C. Williams III at “How Do Environmental Policies Affect Jobs?”

Does Bicycle Infrastructure Reduce Traffic Congestion?

CASEY J. WICHMAN

Bicycle-sharing systems are gaining popularity in the United States, especially in dense urban areas, such as New York, Washington, and Chicago. Proponents tout these programs as cheap, environmentally friendly, healthy, traffic-reducing alternatives to driving a motorized vehicle. But are they? In new research, Timothy Hamilton (of the University of Richmond) and I find evidence suggesting that the Capital Bikeshare program in Washington, DC, does reduce traffic congestion. This finding is particularly salient after Texas A&M University's 2015 Urban Mobility Scorecard ranked DC first in congestion, with 82 hours of delays per commuter.

Bike-sharing systems are a network of bicycle docking stations dispersed throughout the city, which provide easy access to bicycles that can be checked out and returned to any other station in the network for a trip to the store or the last leg of a commute to work. In the case of the Capital Bikeshare, riders can buy memberships of varying lengths, and the cost of an individual trip is based on its duration.

There are many reasons why a city or municipality might adopt a bicycle-sharing system, not the least of which is the promise of reduced traffic congestion and the associated vehicle pollution. Along that line, DC's Capital Bikeshare is funded in part by the US Federal Highway Administration, through a program that typically

backs projects that mitigate traffic congestion and improve air quality.

We recently tackled the question of whether the program delivers on its promises for the metropolitan DC area. It may seem obvious that riding a bicycle rather than driving a car is better for the environment, but that is not quite the right trade-off to be considering. Because DC has an extensive rail and bus system, individuals who use the bike-share might be substituting bike trips for bus trips when the weather is nice. And in the event that there are more bicycles on the road, it is easy to imagine a scenario in which traffic congestion increases, rather than decreases.

We looked specifically at the effectiveness of the Capital Bikeshare system in reducing traffic on urban roads. Because bike-share docks might be located purposely in areas of high congestion, a simple analysis might conclude that bike-share stations actually increase congestion. To account for this, we compared traffic congestion between two observationally similar census block groups in terms of traffic patterns, socioeconomic characteristics, and transit accessibility—the only difference is that one has a bike-share station and the other doesn't.

Using this strategy, we identified a causal effect of the presence of a bike-share station on traffic congestion. The result is a 2 to 3 percent reduction in traffic congestion that can be attributed to the bike-share station within our sample. (For context, a

CASEY J. WICHMAN is a fellow at RFF.



1 percent reduction in congestion results in a roughly 1 percent increase in vehicle miles per hour driven for a representative road segment in our sample.)

A secondary finding, although only suggestive, is that congestion increases in census block groups neighboring those with bike-share stations. This result is a bit more puzzling. It could be the case that motor vehicle drivers seek to avoid streets populated with cyclists. Further, it could be that the cyclist rides through neighboring census blocks on her way to work, thus contributing to congestion increases there.

Looking forward, this research lays a foundation for exploring a suite of questions related to the impact of bicycling on traffic patterns in urban areas. The degree of complementarity or substitutability of cycling for other modes of transit dictates

the degree to which we can stretch transportation funding in an economic climate where investment in infrastructure is critical.

At a minimum, however, our research findings suggest that there are environmental benefits embedded somewhere in each Capital Bikeshare bicycle. And with a \$2.5 million expansion and an additional 435 bicycles planned for the Capital Bikeshare in the District, the interactions among bicycle infrastructure and other modes of transit are only going to become more relevant. ●

This article originally appeared on RFF's blog, *Common Resources* (www.rff.org/blog).

FURTHER READING

Hamilton, Timothy, and Casey J. Wichman. 2015. *Bicycle Infrastructure and Traffic Congestion: Evidence from DC's Capital Bikeshare*. Discussion paper 15-39. Washington, DC: RFF.



The Real Costs and Benefits of Federal Regulations

An Interview with Richard Morgenstern

As part of RFF's Regulatory Performance Initiative, led by RFF Senior Fellow Richard Morgenstern, a number of experts analyzed the actual performance of environmentally oriented regulations throughout the federal government to determine if the realized costs and benefits were consistent with projections. Morgenstern sat down with *Resources* to discuss how such analysis might benefit the development of future regulations.

RESOURCES: You just finished this in-depth project on retrospective performance analysis of environmental regulations. What is the value of such an undertaking?

RICHARD MORGENSTERN: Regulatory analysis is currently done before regulations are issued—at a time when much of the analysis is based on unverifiable assumptions. Retrospective analysis, on the other hand, provides the opportunity to look back and see how rules actually performed, what the goals were, whether they were fully achieved or not, and at what cost. The broad point is to learn from past experiences and improve future rulemaking.

Retrospective analysis is difficult to do because the available data are generally limited. There are not routine ways of collecting information after the fact and, frankly, the incentives are not particularly well structured to do that type of analysis.

RESOURCES: Despite these challenges, you and your colleagues were able to examine the actual costs and benefits of a number of regulations.

MORGENSTERN: That's right. The team, which includes experts from inside and outside RFF, completed nine studies that look at regulations from the US Environmental Protection Agency (EPA), Department of Energy (DOE), Department of the Interior, and Food and Drug Administration. The selection of rules is quite diverse, which creates both challenges and opportunities in drawing conclusions. Because some of the studies involved multiple rules, we have a total of 34 ex ante–ex post benefit or cost comparisons in the group.

RESOURCES: Are the rules providing the benefits or environmental improvements that were forecast originally, and are they doing so at the original cost estimates?

MORGENSTERN: Although it's difficult to generalize from our small sample, one can interpret our results to suggest somewhat of a tendency to overstate both the costs and benefits in the regulatory impact analyses that take place before the rules are issued. Of course, there is no iron law of overstatement, as we have plenty of examples of both underestimates and accurate ex

ante analyses. Now, the next question is, are the benefits overstated more than the costs or vice versa? Unfortunately, we really can't answer that in this study.

RESOURCES: There are some specific issues that can affect the outcomes and costs of regulations. Trading programs, for example, would seem to present opportunities for cost savings, taking the dynamism of the marketplace into account. What did you find with the trading programs that you examined?

MORGENSTERN: We were very fortunate to have a truly outstanding study done of Phase Two of the Acid Rain Trading Program. This is not a new program, but that's part of the reason it was chosen—because it already has a track record.

No one disputes the massive net benefits from this program. However, our team asked a somewhat different question: had the rule been issued as a uniform performance standard rather than one that allowed utilities to trade with each other, what would the results have been? And the findings are quite interesting. On the one hand, the cost savings from trading were considerable. On the other, they were not as great as had been forecasted in the rulemaking. Going forward, the case study authors suggest the textbook case of the least-cost economic solution should be treated as the lower bound of costs rather than the best-case scenario. Such an approach might provide a more realistic estimate of the costs of a new regulation.

The team also looked at the benefits of trading: How did the trading component itself change the overall benefits? They found that because the program moved certain emissions from areas of relatively low population density in the Midwest to

higher-density areas in the East, we ended up with slightly lower overall benefits compared to what would have occurred under a uniform performance standard.

I want to emphasize that this does not undermine the overwhelming success of the acid rain program in terms of achieving enormous benefits at relatively low costs. But there are some important nuances. On the benefits side, the team argues for greater consideration of the potential distributional consequences before a trading-based rule is put in place. In fact, modified designs could have been introduced—for example, zoned trading—to prevent this particular problem from occurring.

RESOURCES: One issue that is often discussed is the costs and benefits of regulations requiring new environmental technologies. Did you examine any such cases, and did these technologies deliver what they had promised?

MORGENSTERN: Two of our case studies feature issues of technology development. One looked at the minimum efficiency performance standards in the DOE regulations for household appliances, and the other looked at the development of new technology under EPA's renewable fuel regulation. And the results of the two studies are opposite of one another.

DOE tended to overestimate the costs of these new technologies. Had its analysis been more accurate, it might have ended up with more stringent standards. EPA, on the other hand, tended to underestimate the costs of renewable fuels. Had it been more accurate, that might have resulted in a less stringent standard than was ultimately adopted. Ironically, EPA has had to soften its standard on more than one occasion since that initial promulgation.

RESOURCES: It seems that technology and the path it takes exemplify the tremendous uncertainties that regulators have to face when they're crafting a rule, but are there other examples?

MORGENSTERN: Uncertainty is prevalent in everyday life, and it's no less prevalent in the regulatory world. For the renewable fuels rule, for example, EPA seemed to have not taken full account of the uncertainty of future energy prices. It assumed that the prices in place at the time the rule was promulgated would continue to rise at healthy levels from that day forward. Failing to recognize the long historical record of volatility in energy prices meant that it didn't understand that the economics of renewable fuels could be adversely affected by a major drop, for example, in world oil prices.

One recommendation from this study is for the agencies to have more explicit considerations of uncertainty. We refer to them as "stress tests," borrowing the popular term from the banking sector, and suggest that stress tests be applied to rules that are particularly vulnerable to such macro-level fluctuations.

RESOURCES: Several experts at RFF are currently conducting a major analysis of EPA's Clean Power Plan, which could include trading, depending on what form of regulation the states adopt. Technology is going to be a big part, as are distributional aspects and uncertainties. What insights do you have for this work, based on the analysis you've just completed?

MORGENSTERN: Evaluating the Clean Power Plan while it's under way would clearly have a great deal of value. Looking at the differences across states and planned requirements deserves careful attention, ex

post as well as ex ante. There are going to be major data issues associated with evaluating this rule—they're going to need to collect information on energy production and costs, greenhouse gas emissions, and the ancillary emissions effects because the co-benefits are an important part of the overall value of the rule as predicted by EPA. Also, coordination with the Energy Information Administration and the states is going to be essential to understanding what's really going on with the Clean Power Plan.

RESOURCES: It seems like this type of analysis is critical to improving the efficiency of regulations, as well as maximizing benefits and reducing costs. What do you think needs to happen to encourage more retrospective analysis of regulations in the future?

MORGENSTERN: A major barrier to this work is the difficulty of obtaining useful data for evaluation purposes. One thing that the agencies could do for new regulations is to build a plan of retrospective analysis into the regulation at the time it's promulgated rather than having researchers piece it together after the fact. Obviously, you can't do it for all rules—especially in times of tight budgets. You should be selective. But the idea of picking out some high-priority rules and having the agencies design retrospective studies up front is an appealing idea. I think the Office of Management and Budget has a role to play in developing guidance for the agencies on how they should be measuring the outcomes of rules. Our study contains some guidance based on our case studies—including many examples of what to do and what not to do. ●

Find the case studies from RFF's Regulatory Performance Initiative and more at www.rff.org/regulatory-performance.



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Shipping in the Arctic: Promise, Preparations, and Impacts

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How Pricing Carbon Impacts Low-Income Households

September 22

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September 9

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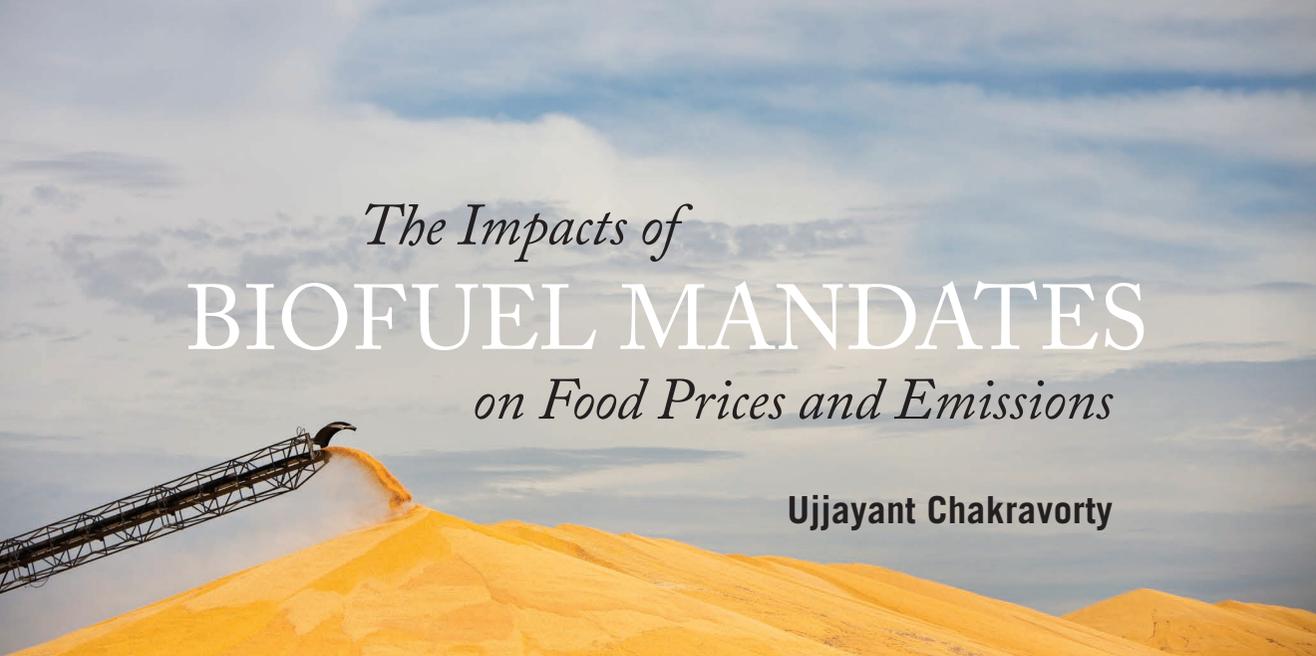
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The Impacts of BIOFUEL MANDATES *on Food Prices and Emissions*

Ujjayant Chakravorty

More than 40 percent of US corn is now used to produce ethanol, which can be a cleaner alternative to gasoline used for transportation. Last summer, the US Environmental Protection Agency (EPA) expanded the Renewable Fuel Standard (RFS), mandating the continued use of ethanol and other biofuels through 2016. While the new standard maintains the current level of ethanol produced from corn, it increases the use of other biofuels. In particular, EPA's target in 2016 for cellulosic biofuel—made from wood by-products and grasses—is six times higher than what was produced in 2014, and the target for total renewable fuels is 10 percent higher.

The European Union has similar mandates in effect. By 2020, it prescribes a 7 percent minimum for biofuels in the transportation sector of every EU nation.

These mandates have been heavily criticized. Environmentalists argue that the related reduction in carbon emissions

is minimal, while hunger groups point to the effects on food prices and poverty. By diverting corn away from traditional uses, food and feed prices may rise, although higher corn prices may induce farmers to bring additional acreage into production—lowering prices but increasing indirect carbon emissions. In a recent study, my colleagues and I examined these long-term effects, focusing on food prices and carbon emissions.

Effects on Food Prices

Our analysis is based on a global model of land use that can help predict which regions are likely to increase agricultural production in response to the US and EU mandates. We also can use the model to distinguish between price increases caused by the mandates and demand shifts caused by increasing per capita incomes, mainly in developing countries.

Accounting for changing dietary habits from rising household incomes is important because many developing nations are going through a dietary transition, moving away from a cereals-based diet to one more dependent on animal protein—specifically meat and dairy products. A classic example

UJJAYANT CHAKRAVORTY is a professor of economics at Tufts University, a research associate at the Toulouse School of Economics, and a 2015–2016 Gilbert F. White Fellow at RFF.

is China, which now consumes half of the world's pork, and where pork consumption has been growing at about 150 percent a year since 2007. On average, eight kilograms of cereals (as feed) produce one kilogram of beef, and three kilograms of cereals produce one kilogram of pork. As more people start consuming animal products, they exert pressure on limited arable land resources, and food prices rise over time.

Given these changes, we find that even if there were no biofuel mandates, food prices would increase—by about 15 percent in 2022 compared to the base year 2007. When we superimpose the US and EU biofuel mandates, world food prices go up by 32 percent.

Our results highlight the impact of increased meat and dairy consumption on the projected growth of food prices. Put another way, if diets were kept constant, food prices would actually fall over time without energy regulation. Then, with the biofuel mandates, they would rise by only 7 percent in year 2022.

Our analysis also predicts the global effects of such mandates; for example, out of the approximately 200 million hectares of new land devoted to agriculture by 2022, 80 million can be attributed to the biofuel mandates. Over the longer time horizon, our research shows that food prices do come down because demand subsides over time and there is learning on the supply side; yields increase, and costs are reduced in the production and processing of biofuels.

The expansion of cellulosic biofuels in the mandate is crucial, since they are less land-intensive than corn ethanol. If cellulose were removed from the RFS, the food price impact of the US and EU mandates combined would be much closer to 40 percent in 2022, rather than 32 percent. Thus, EPA's goal of increasing the quota

“Given changing dietary habits, even if there were no biofuel mandates, food prices would increase.”

for cellulose for 2015 and 2016 is critical to the continued viability of biofuels in the United States. Our analysis suggests that without such a mandate, cellulose will not be adopted at all because of their high cost.

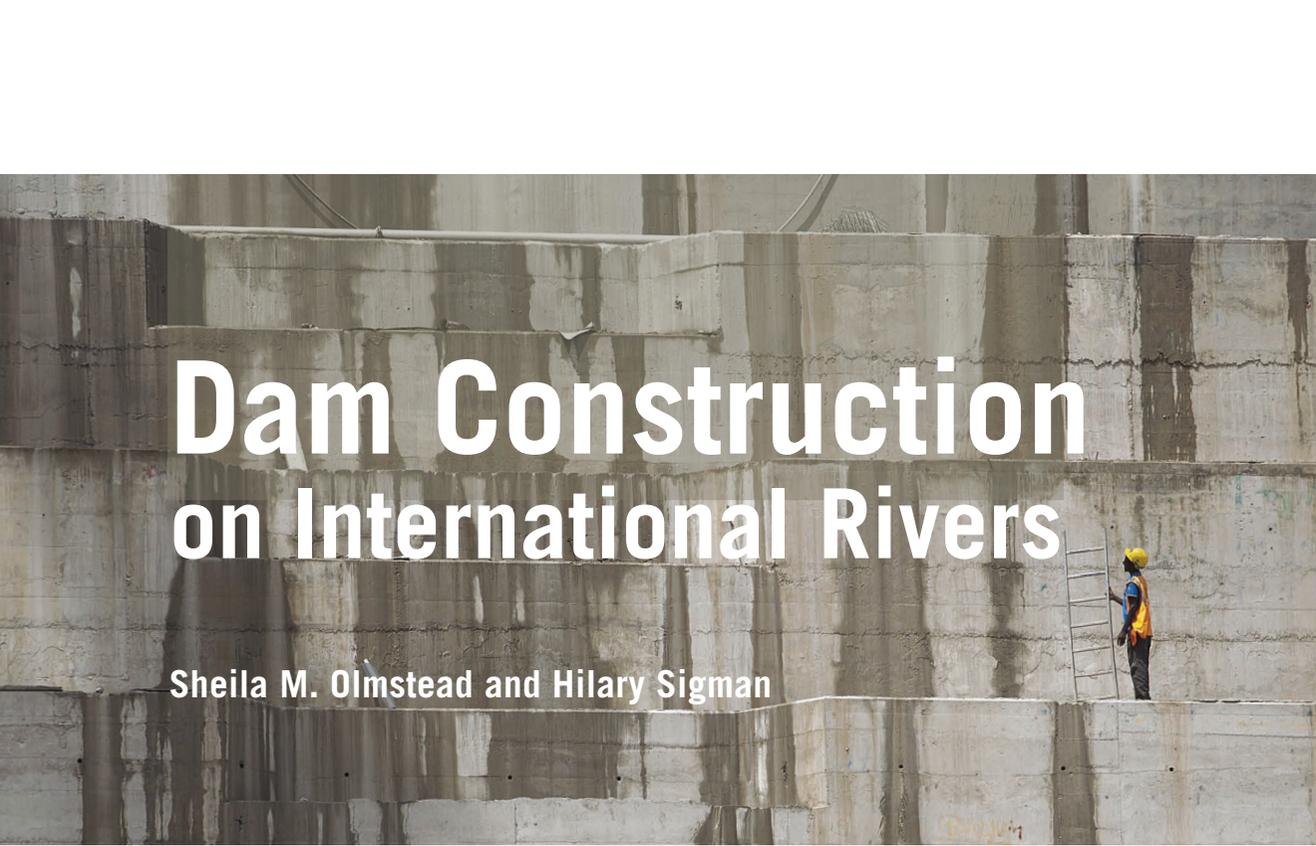
Effects on Carbon Emissions

An important conclusion from our analysis is that under no scenario do we get a major reduction in global carbon emissions. Under the RFS, US emissions fall by about 1 percent; however, that leads to a lowering of global crude oil prices and an increase in oil consumption overseas. Moreover, because of all the new land being farmed, the RFS also causes an increase in carbon emissions. Aggregate global carbon emissions (from both direct burning of fuels and land use changes) increase from 13.4 billion tons of carbon dioxide equivalent to 17.8 billion tons in 2022.

Increased use of cellulose may reduce emissions in the future because they use less land. The use of genetically modified crops may increase yields and trigger less land conversion and indirect carbon emissions. However, these productivity gains may reduce the costs of farming and cause a “rebound” effect that leads to an increase in crop acreage. •

FURTHER READING

Chakravorty, Ujjayant, Marie-Hélène Hubert, Michel Moreaux, and Linda Nøstbakken. 2015. The Long-Run Impact of Biofuels on Food Prices. Discussion paper 15-48. Washington, DC: RFF.

A large-scale photograph of a dam under construction. The image shows massive concrete blocks forming the structure. A worker in a yellow safety vest and hard hat stands on a ledge, leaning against a ladder. The scene is set against a clear sky.

Dam Construction on International Rivers

Sheila M. Olmstead and Hilary Sigman

“We will defend each drop of Nile water with our blood if necessary,” proclaimed Mohamed Morsi, then president of Egypt, in June 2013. He was referring to the Grand Ethiopian Renaissance Dam that Ethiopia has been constructing upstream from Egypt, which may affect the flow of the Nile River into Egypt. The two nations continued to be at a stalemate until signing a Declaration of Principles in 2015 that gives Egypt rights to some of the electricity that will be generated from the dam. Intense negotiations still lie ahead.

Even if countries make efficient decisions about dam construction on domestic rivers,

countries sharing a river may overdevelop it if they are able to pass on some of the costs imposed by dams to other countries. As the Egypt–Ethiopia dilemma shows, these issues can create the potential for conflict across borders.

Managing water in rivers should present a relatively straightforward global resource problem, with a small number of countries sharing a well-defined resource and a natural default allocation of property rights to the upstream country. Many economic models would predict that this sort of problem would readily be solved by bargaining between the upstream and downstream countries. However, based on our examination of the record, even this fairly well-defined issue presents significant challenges for international cooperation.

For years, economists have been concerned that the local benefits of dams may have been overstated and the local costs have been understated. In our

SHEILA M. OLMSTEAD is an associate professor of public affairs at the University of Texas at Austin and a visiting fellow at RFF.

HILARY SIGMAN is a professor of economics at Rutgers University, a visiting fellow at RFF, and a research associate of the National Bureau of Economic Research.

research on international cooperation and conflict surrounding dam construction, recently published in the *Journal of the Association of Environmental and Resource Economists*, we examined what happens when some of the costs of dams are incurred downstream, outside of national borders. We analyzed 382 global river basins and 4,696 dams and concluded that dams are 27 percent more likely to be placed in areas upstream of international borders. Being able to pass some of the inherent cost of the dam to downstream neighboring countries seems to encourage construction of dams on international rivers.

In addition to the number of dams, we examined two other measures of intensity of dam-building activity: the total reservoir capacity and the total height of dams. Like the number of dams, these measures seem to increase upstream of international borders. The total capacity of dammed reservoirs nearly doubles and dam height increases by about 59 percent when an area is upstream of an international border.

Multinational agency involvement and international treaties might help resolve international conflict in the placement of dams. But when we examined projects that were funded by the World Bank or that are in river basins with water treaties, we found only weak evidence that either diminishes free riding. Dams funded by the World Bank do seem to be less subject to the common property problems in international basins than those funded using exclusively domestic resources—but it is possible that the World Bank simply selects less controversial projects.

Meanwhile, the results regarding the presence of a treaty were more complex. The models used for this purpose had to deal with the possibility that treaties might be more likely to appear after conflict over

“Countries sharing a river may overdevelop it if they are able to pass on some of the costs imposed by dams to other countries.”

water allocation has developed between two countries sharing a river. In addition, the small number of international basins around the globe restricts our ability to identify the impact of treaties because only these international river basins are candidates for treaties and the analysis thus compares fairly small groups. Nonetheless, our results offer some evidence that the presence of an international treaty may almost offset the effects of free riding on dam placement.

The need for effective international environmental cooperation will likely grow: a changing climate could have serious impacts on the availability of water resources, causing many countries to look to large dams as potential solutions. Our research indicates that economists and policymakers should consider this important source of inefficiency—the incentive to overexploit shared rivers—in deciding where to place a dam when potential projects are evaluated. ●

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CLEARING THE AIR

How Market-Based
Policies Help Meet the
Tighter US Ozone Limit

The recently strengthened limit for ground-level ozone has stirred controversy over costs, but many existing policies can help states achieve the new standard at a relatively low cost.

Alan J. Krupnick, Joshua Linn, and Kristen McCormack

High concentrations of ground-level ozone, commonly known as smog, pose serious threats to a large and diverse swath of the US population, causing asthma attacks and other respiratory problems and leading to premature mortality. Approximately 123 million people, or 40 percent of the population, live in areas with ozone levels that exceed the standard set by the US Environmental Protection Agency (EPA) that had been in effect since 2008. Now the agency has lowered the limit further, from 75 parts per billion (ppb) to 70 ppb, citing adverse health effects that occur at levels lower than the previous limit.

The costs of meeting pollution standards have always been contentious, and the case of ozone is no exception. Estimates of the costs of the new limits on the US economy were hotly contested before the rule was finalized. In 2014, EPA proposed a new standard in the range of 65 to 70 ppb and estimated that the national costs of reaching 65 ppb in 2025 relative to the then-existing 75 ppb standard would be \$15 billion (2011\$), with benefits 1.3 to 2.5 times greater than costs. (These estimates exclude California, which will have longer to comply with the standard.) In stark contrast, industry reports estimated that the direct costs of achieving a 65 ppb standard would amount to between \$75 billion and \$85 billion in 2025. In the run-up to the final rule, the National Association of Manufacturers led a campaign against tighter ozone standards that claimed cumu-

lative costs over the entire program period would be in excess of one trillion dollars, declaring the proposed tighter standard “the costliest regulation ever.”

Most of the cost controversy circled around the differences between how EPA and industry valued the mitigation measures needed to meet the tighter standard. To calculate the cost of the alternative standard, EPA identified and estimated the cost of a set of well-known technologies that could be used to reduce emissions of nitrogen oxides (NO_x) and volatile organic compounds (VOCs), the two precursors of ground-level ozone. But this set of technologies was not expected to reduce emissions enough to meet the proposed new standards nationwide. To complete its estimate, EPA valued the cost of the remaining unspecified controls that would be needed to meet the proposed standard. Here is where the estimates diverge: EPA valued the cost of these controls (misleadingly termed “unknown”) at a much lower level than did critics of the standards.

Our analysis indicates that EPA’s cost estimates were likely closer to the mark than industry cost estimates. In part, this is due to the more realistic emissions reductions estimates assumed by EPA. In addition, industry critics have ignored the efficiencies of many market-based policies—such as cap-and-trade programs and gasoline taxes—that can achieve emissions reductions at relatively low cost.

EPA announced the new standard of 70 ppb in October 2015. It estimates that an additional 18 counties are expected to violate the new standard, and some of these counties exist in states that have not previously been required to develop implementation plans to comply with the standard. In areas projected to be furthest from meeting the standard, state governments may choose

ALAN J. KRUPNICK is a senior fellow at RFF and co-director of RFF’s Center for Energy and Climate Economics.

JOSHUA LINN is a senior fellow at RFF.

KRISTEN McCORMACK is a research assistant at RFF.

to establish tighter controls on key sources of the precursors to ozone. The potential for these policies to span multiple sectors partially explains the heavy advertising and pointed statements arguing against a tighter ozone standard from the American Petroleum Institute and the National Association of Manufacturers. But state and federal policymakers and regulators working on implementation plans for compliance will have many good options from which to choose. In fact, given the high prices for NO_x offsets and concentration of violating counties in California and Texas, it is especially important to explore other policy options that are likely to prove more cost-effective than current abatement methods.

NO_x Cap-and-Trade in the Power Sector

Both EPA and industry critics analyzed potential technology mandates for the power sector, but, in fact, a cap-and-trade program for NO_x emissions has existed since 1999. The program initially covered power plants and large industrial boilers in the Northeast, expanded to the Southeast and Midwest in 2003, and expanded further in 2009 to cover about half the country.

When implemented efficiently, cap-and-trade programs can reduce emissions at lower cost than other measures—installing emissions-reduction technology at all plants, for example, or retiring coal-fired plants. The cost advantage arises from the fact that cap-and-trade programs encourage emitters to find the lowest-cost opportunities for emissions reductions. For example, the cost of installing selective catalytic reduction technology may vary across power plants, and only the lowest-cost plants would install it under a cap-and-trade program. Other plants would find other ways to reduce emissions.

Existing cap-and-trade programs could serve as a model for a national program to help reduce NO_x emissions. Results from the RFF Haiku electricity model suggest that a national program designed to reduce

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“Industry critics have ignored the efficiencies of many market-based policies—such as cap-and-trade programs and gasoline taxes—that can achieve emissions reductions at relatively low cost.”

.....

emissions by 420,000 tons could do so at an average cost of \$7,100 per ton. These reductions could replace some estimated by EPA to come from the electricity sector and from “unknown” controls—which EPA assumes will cost \$15,000 per ton and industry assumes will cost more, ranging upward from \$29,000 per ton.

Vehicle Retirement Program

A vehicle retirement program that offers individuals money to retire older vehicles would reduce emissions because older vehicles have higher NO_x emissions rates than newer vehicles. A 2013 analysis of the 2009 Cash for Clunkers program, which offered an average subsidy of \$4,400 to retire a vehicle and replace it with a new one meeting certain fuel economy requirements, estimates an average cost of reducing NO_x emissions of \$31,000 per ton. This estimate

“The benefits from a higher gasoline tax would reduce the cost per ton of NO_x and VOC emissions reductions; in fact, the cost could even be zero if the tax revenue were used efficiently.”

does not take into account the benefits of reducing emissions of greenhouse gases and other pollutants, such as VOCs, and includes a dirtier fleet than would be present in 2025.

The purpose of Cash for Clunkers was to provide economic stimulus during the recession and to improve the fuel economy of the on-road vehicle fleet. Reducing NO_x emissions was not an explicit objective of the policy. In principle, targeting a retirement program at NO_x emissions could reduce emissions at lower cost. For example, rather than providing retirement subsidies based on the fuel economy improvement between the new and retired vehicle as under Cash for Clunkers, the subsidy could be tied to the retired vehicle’s NO_x emissions rate and miles traveled to more effectively target high-emitting vehicles.

Fuel Taxes

Vehicle tailpipe standards set limits on grams of NO_x emissions per mile, and states also could reduce emissions by introducing policies to reduce miles traveled. One option is to raise the gasoline tax (and/or diesel tax), which would increase the cost of driving, encourage people to drive less, and

provide an incentive to purchase vehicles with higher fuel economy.

To quantify the effects of fuel tax increases, suppose all states increase their gasoline taxes by \$0.10 per gallon, an increase that could be justified by non-environmental goals, such as reducing congestion and accidents, as economists Ian Parry and Kenneth Small have suggested in their work. Accounting for changes in future NO_x emissions rates of the on-road vehicle fleet, the tax increase might reduce NO_x emissions in 2025 by 17,000 tons and VOC emissions by 12,000 tons. The tax increase would have other benefits, such as reducing distortionary taxes on labor and capital or avoiding the need for other tax increases. These benefits would reduce the cost per ton of NO_x and VOC emissions reductions; in fact, the cost could even be zero if the tax revenue were used efficiently.

California’s Transportation Policies

California recently implemented several programs (some of which are funded by revenues from cap-and-trade auction sales) that may reduce NO_x and VOC emissions. Although many of these programs were created with the goal of reducing greenhouse gas emissions, they also may serve as examples of policies that states can adopt to reduce ozone levels.

Several of these programs focus on reducing emissions from vehicles. California’s Voluntary Accelerated Vehicle Retirement Program offers \$950 to individuals who wish to retire vehicles that failed their last smog check. (Low-income consumers are paid \$1,400.) Although the program is also available for vehicles that passed recent smog checks, it is intended to target high-emitting vehicles. As another example, the Clean Vehicle Rebate Project encourages the purchase or lease of electric, hybrid, and

fuel-cell vehicles by offering up to \$4,800 in rebates per vehicle.

With the passage of California's Senate Bill (SB) 962, 60 percent of future auction revenue from the state's cap-and-trade program has been designated for transportation and sustainable communities programs. These funds support the development of a high-speed rail system, clean vehicle programs, and the expansion of public transit and affordable housing projects, among other goals. In addition, California recently passed a law, SB 350, that is expected to reduce ozone-causing emissions by increasing the use of electric vehicles. By encouraging the use of alternative forms of transportation, these programs and others (such as SB 375, which targets land use) are expected to reduce vehicle miles traveled and NO_x emissions.

Looking Ahead

Existing science suggests that reducing ozone levels will improve public health and the environment. EPA estimates that the benefits expected under the tighter standard will exceed the costs. As outlined here, many cost-effective policy options outside the electric power sector could help states achieve compliance under the new limit at relatively low cost. Additionally, EPA finalized tighter standards for methane emissions last year—a change that will reduce VOC emissions and therefore help reduce ozone levels across the United States.

In considering the costs of meeting the new standard, it is important to also keep technological progress in mind. In its benefit-cost analysis, EPA notes that past regulations have preceded substantial and largely unanticipated technological progress, particularly when the regulations provided strong incentives for innovation. Such unanticipated innovation could cause actual costs

to be lower than current estimates.

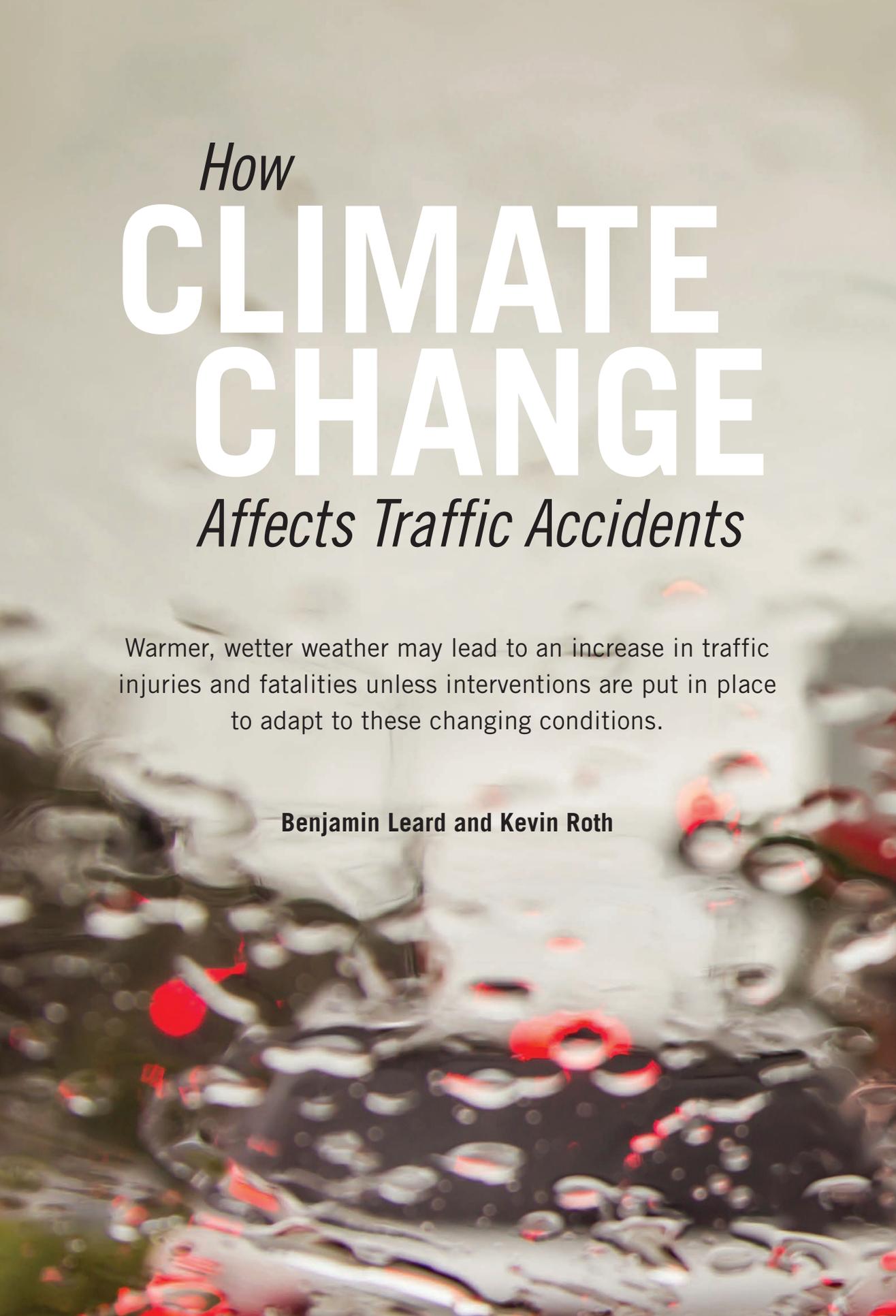
Beyond domestic policy measures, a discussion of ozone levels in the United States would not be complete without a note about China. China contributes to the US ozone problem by emitting pollution that ultimately crosses the Pacific, so it could be a costless part of the solution if the Chinese government follows through on its pledges to reduce urban air pollution. Its carbon cap-and-trade program, for example, would also reduce NO_x emissions.

Finally, as it has with previous air quality standards, EPA may introduce national programs to help states achieve compliance with the new ozone standard. A nationwide approach that reduces NO_x emissions may be necessary because emissions can travel across state boundaries. Control measures taken by upwind states may translate, in fact, to emissions reductions in downwind states. Helping to facilitate a national emissions trading program and tightening tailpipe standards are just two ways that EPA could support the states toward reaching the ultimate goal of improved health outcomes from lower ozone levels. ●

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How
**CLIMATE
CHANGE**
Affects Traffic Accidents

Warmer, wetter weather may lead to an increase in traffic injuries and fatalities unless interventions are put in place to adapt to these changing conditions.

Benjamin Leard and Kevin Roth

Nearly 1.24 million people die in traffic accidents every year around the world. Shifting weather patterns due to climate change, such as warmer temperatures, more rain, and less snow, will exacerbate road safety issues. For example, snowfall and rainfall are widely known to reduce visibility and make braking more difficult, and temperatures may influence the mode, frequency, and types of trips that individuals take. Yet few studies have attempted to document the impact shifting weather patterns will have on traffic accidents, even though the potential costs to society are massive: in 2006, they were the leading cause of death in people between the ages of 4 and 35 in the United States.

To help better estimate the costs of climate change and support the development of appropriate adaptation strategies, we quantified changes in US traffic fatalities, injuries, and property damage that are likely to occur from climate change. We used detailed data from 46.5 million police-reported accidents, daily travel logs of 207,455 households, and weather from 2,607 stations in the United States, covering the years 1990 to 2010. Not surprisingly, we found that drivers are at an elevated risk of an accident when the weather is below freezing and when rainfall or snowfall occurs. However, we also found that fatalities increase significantly when temperatures are warmer. Applying our findings to a “middle-of-the-road” future warming scenario, we estimate that the cost of additional accidents from 2010 to 2099 in the United States will be \$58 billion. This amount is significant: for comparison, it is on the same order of magnitude as expected

changes to agricultural profits under climate change predictions.

Weather and Traffic Accidents

First, we quantified the effect of weather on three types of traffic accidents: those involving property damage only, an injury, or a fatality. Accidents involving just property damage increase by nearly 10 percent on the coldest days relative to a day above 50°F, by nearly 20 percent on a day with more than 3 centimeters (cm) of rain compared to a day with no rainfall, and by 43 percent on a day with more than 3 cm of snowfall compared to a day with none. A similar pattern follows for accidents with an injury but on a smaller magnitude.

The pattern for fatalities looks a bit different. Whereas warm weather has little to no effect on the number of injuries or accidents with property damage only, fatality rates increase by about 9 percent on a day with temperatures above 80°F compared with a day at 50–60°F. Half of this effect is due to exposure to the elements: as temperatures increase, people spend more time outdoors or may use forms of transportation that are exposed, such as walking, biking, or motorcycling, placing them at higher risk of death in the event of a traffic accident. To date, no other study has examined this interaction in depth.

Compared with a day without precipitation, a day with 1.5–3 cm of snowfall will increase fatalities by 15 percent. However, 1.5–3 cm of rainfall will *reduce* fatalities by about 8 percent, suggesting that drivers avoid trips or drive cautiously enough to reduce overall fatality risks on rainy days.

These results present a mixed picture of the effect of climate change on traffic accidents. Warmer temperatures will result in fewer accidents involving property damage and injury—but more fatalities. Meanwhile,

BENJAMIN LEARD is a fellow at RFF.

KEVIN ROTH is an assistant professor at the University of California, Irvine.

an increase in rainfall will reduce fatalities but may increase accidents overall.

Shifting Weather Patterns due to Climate Change

To better understand how these opposing effects could play out over the course of this century, we applied our estimations to a middle-of-the-road future weather scenario developed by the UK Hadley Centre for Climate Change Prediction Research (known as Hadley 3 A1B), which represents balanced growth in fossil and non-fossil energy sources and results in a 4°C rise in global temperature by 2099.

Under this scenario, temperature increases would cause 849 additional deaths—mostly among pedestrians, bicyclists, and motorcyclists—and the shift from snow to rain would save 246 lives annually through 2099 in the United States. From 2010 to 2099, the cost of these additional 603 annual deaths is \$61.7 billion.

The effect on injuries is an additional 1,688 annually, costing \$2.4 billion over the period 2010 to 2099, while warmer weather due to climate change would reduce accidents involving property damage by 51,775, lowering net costs by nearly \$6 billion. From these estimates, we calculate the total discounted accident costs to be \$58 billion from 2010 to 2099.

Adaptation Strategies

One advantage of our model of fatalities is that it allows us to examine the capacity for adaptation. In particular, we looked for evidence that technological change or adaptation to the local climate has weakened the relationship between weather and traffic fatalities over time.

We have data for many safety innovations, including dual front airbags and antilock brakes. To the extent that these

“The impact of climate change on traffic fatalities is largely due to people being drawn outdoors and using forms of transportation that will not protect them in a crash.”

technologies would reduce the effects of weather on fatalities, we might see evidence of a reduced gradient from 2000 to 2009 compared with 1990 to 1999. However, no such reduction has occurred for temperature; if anything, the relationship between temperature and fatalities has grown stronger. This could be a consequence of the so-called Peltzman effect, which asserts that people drive less safely when their cars are equipped with better safety technology.

For rainfall, there may be some support that these technologies have improved safety, although most changes are not statistically different between the two time periods, and the same improvement cannot be found for snowfall.

What about the possibility that drivers or cities may adapt to local conditions? Drivers in warmer locations may know how to avoid heat or be more attentive to features such as air conditioning in vehicles. Cities might adapt through policing, bike lanes, or insurance rates that mitigate these risks. Alternatively, residents in locations with frequent hot weather may not avoid hot days if they suspect the following day is unlikely to see improved conditions, and a warm climate may facilitate choosing a bike or motorcycle over a car.



Yet our study does not find evidence that the hottest and coolest counties have statistically different responses to temperature. If anything, the hottest counties have a larger increase in fatalities on hot days than the coldest counties.

Together these results suggest that adaptation would need to take the form of either migration or dramatically new technology, such as driverless cars, which some hope will remove human error.

Another option is policy intervention. Although 603 additional deaths annually by the end of the century would be costly, those traffic fatalities represent a relatively small fraction of all accidents. As an example, in 2008, the number of fatalities was 34,172, while one year later that number was 30,862, due to reduced driving because of the recession. Thus, policies aimed at traffic reduction are capable of offsetting these losses. For example, a gasoline tax of roughly \$0.27 per gallon would cut miles sufficiently to reduce fatalities.

One broader implication of this research is that exposure is an important mechanism for understanding the impact of climate change on traffic fatalities. Our estimates of these effects are largely due to people being drawn outdoors and using forms of transportation that will not protect them in a crash.

Importantly, exposure will vary across countries. The United States—with highly developed infrastructure, limited access highways, and urban areas designed to channel high-speed traffic away from residential areas—provides significant separation between vehicles and pedestrians, bicycles, and motorcycles. By contrast, developing nations, and even some middle-income countries, have larger fatality rates per capita, many due to vehicles colliding with pedestrians.

That is not to say that reliance on walking, biking, and motorcycling implicitly means large fatality rates. Other developed English-speaking and western European nations have per capita fatality rates that are often less than half that of the United States. Some countries with extraordinarily low fatality rates, such as Sweden, have pursued a variety of legislative and urban design changes, such as replacing intersections with roundabouts to slow vehicles where they are likely to encounter pedestrians. Relatively simple changes like these may prove to be effective, although unglamorous, adaptation strategies to climate change. ●

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Are We Becoming Greener?

Trends in Environmental Desire

The question of whether humanity's environmental attitudes are changing lies at the heart of environmental policy choices.

JAMES W. BOYD AND CAROLYN KOUSKY

Do you care more about the environment now than when you were a kid? Do you care more than your parents did? You may think that the answer to both is an obvious yes. After all, people used to litter, live with dirtier air and water, and not recycle. Our grandparents probably never uttered the word “sustainability.” But does society as a whole, including people in other countries, care more than a generation ago?

The strength of our environmental desires is of central importance to developing efficient and effective environmental policies. Yet the typical assumption in economics is that our desires don’t change over time. We think about our behavior and choices changing as environmental, technological, and economic conditions change. But economists operate as if our deeper environmental desires—our fundamental attitudes, beliefs, and values—are static. Might our hearts and minds be as changeable as those other conditions?

The discussion matters because it goes to the core of basic questions: Are we over- or underprotecting the environment? Are we protecting the right things and doing so in the best ways?

How Do Desires, Behavior, and Preferences Differ?

Our environmental behavior and choices have certainly changed a lot over the last few decades. We recycle, drive hybrid cars, and buy organic food. It’s tempting to view these behavior changes as evidence that something has changed in our desires—that is, our beliefs, psychology, values, or

ethics—that makes us more environmental. But behaviors and preferences can change for other reasons. The distinction between preferences and desires is important because it highlights that preferences and behavior can change—without a change in underlying desires.

Consider people who buy hybrid cars. Many do so out of altruism, a desire to express one’s green values, or to conform to their community’s norms. But others may prefer hybrids simply because they think gas prices will rise.

Technological development is another confounding factor. We may buy hybrid cars, energy-efficient laundry machines, and renewable power for environmental reasons, but technological advancement is what makes those purchases possible. Similarly, people may increasingly buy those things simply because their incomes have risen.

Changing desires can change behavior, but changing preferences, choices, and behavior do not necessarily imply a change in desires.

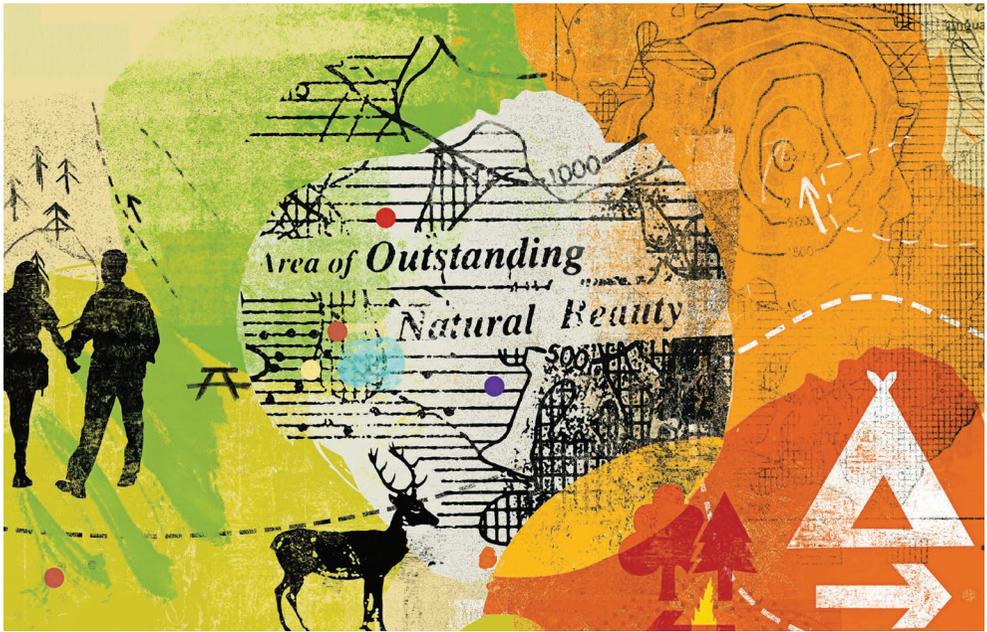
What Makes Desires Change?

What does it mean when our beliefs, psychology, values, and ethics do, in fact, change? To tackle that question, we introduce three related concepts: taste formation, experience and learning, and norms.

Taste formation describes how and why we like or dislike certain things. Half a trillion dollars is spent on marketing every year in the belief that tastes not only change, but that they can be changed deliberately. But unlike fashion and fads, some environmental tastes may be particularly resistant to manipulation because they’re hardwired into our psychology, much like our tastes for certain foods. Several studies have shown that consistently and across cultures, people tend to aesthetically prefer

JAMES W. BOYD is a senior fellow at RFF and director of RFF’s Center for the Management of Ecological Wealth.

CAROLYN KOUSKY is an RFF fellow.



open landscapes dotted with visible water and patches of forest to other types of landscapes. Open landscapes allow us to see predators and prey; water is fundamental to survival; and forests signal shelter and food.

None of this means that our environmental tastes don't change, just that these changes may be harder to spot.

Experience and learning refers to the acquisition of new concepts, facts, and skills. Learning implies change, at least in our knowledge and understanding, but potentially also in our beliefs and values. Does learning about the environment strengthen or change our environmental desires? Does experiencing nature change our desire for it?

Indeed, a number of economic studies and surveys show that direct experience with a natural resource tends to have a positive impact on the value given to the resource. And there is evidence that childhood experiences can condition people's preferences for certain environmental settings. However, our sense is that much

more empirical work would have to be done to make strong causal predictions.

Norms (or "crowd knowledge") relate to collective knowledge and experience as well as a collective understanding of what is right or wrong and desirable or undesirable in a community. They can be thought of loosely as the social version of (individual) tastes and, like tastes, can change over time. Changes in crowd knowledge and environmental norms can drive changes in our environmental desires. For example, a deeper empirical understanding of nature's role in our health, psychology, and economy reinforces our more fundamental environmental beliefs and attitudes.

Can We Measure—and Predict—Changing Environmental Desires?

It seems obvious that desires and tastes change. Taste in art, food and drink, personal aesthetics, and political attitudes suggest that our deeper beliefs and attitudes can and do shift. We've described a variety of ways desires change, but careful empirical

evidence is scant. That's particularly true of environmental desires and tastes. Why?

Economic Measurement

The focus of environmental economics is on the measurement of behavior and choices. People's behavior and choices provide evidence about their preferences for one thing over another. (Do they prefer clean air to cheap energy, or bald eagles to land development?) Economists take this approach because it is relatively easy to get data on behavior and choices and because the goal of most environmental economic analyses is to reveal the trade-offs associated with those behaviors and choices as a guide to public policy.

One explanation for the lack of empirical study of "taste change" within economics is the difficulty of isolating taste change from other factors affecting preferences. Studies must employ methods and data to control for changes over time in supply, scarcity, and substitutes. Illustrative exceptions that prove the rule are studies of changing food consumption patterns. For example, economists have empirically explored changes in US beef consumption and tried to isolate the effect of changes in the taste for beef from other factors affecting consumption, such as prices, household income, and demographic change. When these latter factors are controlled for, the residual change in consumption can be attributed to a change in taste (in this case, perhaps arising from changed attitudes toward health).

Could environmental economists conduct analogous studies to detect environmental taste changes? In principle, yes. In practice, data limitations currently make it nearly impossible. Taste change studies of market commodities like beef can make use of a variety of data on prices and consumption. These data are collected consistently

“A number of economic studies and surveys show that direct experience with a natural resource tends to have a positive impact on the value given to the resource.”

at regular intervals over time (allowing for time-series analysis). Such data are relatively abundant because the goods in question are market goods, and markets generate a great deal of routinely collected information on prices and consumption. Environmental goods and services, however, are usually not market goods and thus lack price and consumption data. To be sure, environmental economists spend much of their time deriving "virtual prices" and gathering data on environmental consumption related to things such as outdoor recreation. But environmental goods lack the routine, consistent collection of data associated with market commodities. As a consequence, environmental economics has, to date, produced few, if any, studies of how virtual environmental prices or consumption change over time—let alone analyses designed to isolate taste change from supply, scarcity, and substitutes.

One way to move forward (which, to our knowledge, has not been attempted) is to create and repeatedly administer over time a national or global environmental preference survey designed to detect environmental taste change. Any such study would require a long-term financial and institutional commitment. It would also require a design that reflects best practice stated preference methods, which are used to get around

the “missing prices” problem associated with nonmarket environmental goods. They involve the construction of realistic, plausible decision scenarios that ask respondents to make (simulated) choices. By comparing people’s choices between nonmarket environmental goods and money or goods with a known market value, the value or preference for environmental goods can be inferred. (For example, would you rather have a new park or a lower property tax bill?) To be clear, such an endeavor would involve more than simply conducting repeated experiments because, as noted earlier, detection of taste change requires careful attention to confounding factors, such as changes in supply, scarcity, and the availability of substitutes.

Another approach would be to examine how environmental desires vary cross-sectionally in response to different conditions. For example, research has been undertaken in experimental economics to examine cross-country differences in variables such as trust and reciprocity. These studies have participants play economic games designed to examine certain types

of behavior and compare how outcomes differ around the world. We could imagine something similar being done to compare environmental desires in different countries. Although it would be challenging to isolate the factors that are the underlying causes for differences, useful patterns could emerge showing correlations between variables such as income, education, or various institutional structures and environmental desires.

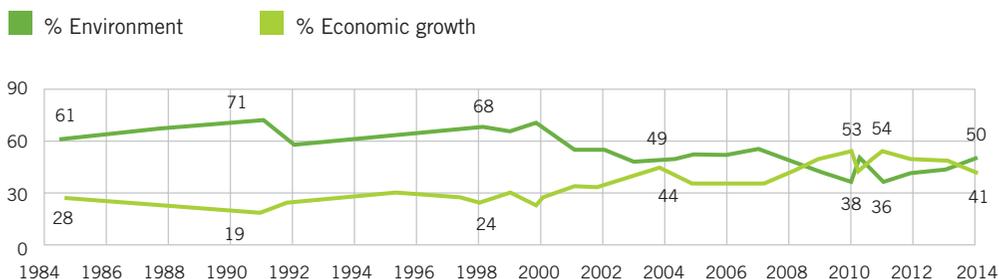
Opinion Polls

Forget about complicated economic methods; can’t we just look at opinion polls to tell us about our changing environmental attitudes? Not really. Although opinion polling has its uses (predicting near-term voting patterns, for example), it does a poor job of revealing our underlying beliefs, desires, and attitudes and how they change over time.

To begin with, it’s rare for environmental polls to be conducted consistently over long periods of time, which makes it hard to see changes. Gallup polls are one exception; several extend back to the 1970s and 1980s (almost no environmental polling existed prior to that time).

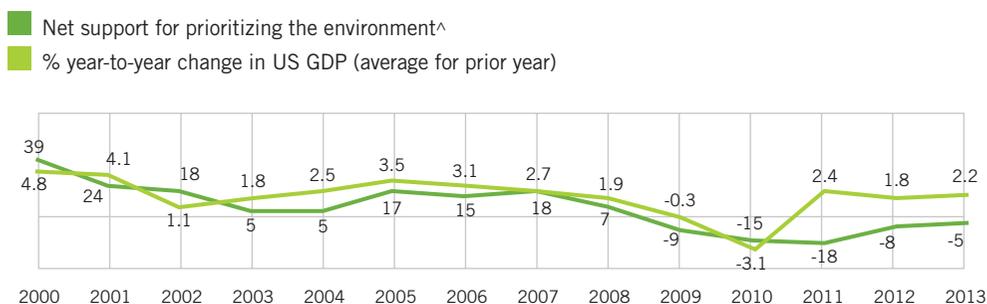
Figure 1. Prioritizing Environmental Protection versus Economic Growth, 1984–2014

With which one of these statements about the environment and the economy do you most agree—protection of the environment should be given priority, even at the risk of curbing economic growth (or) economic growth should be given a priority, even if the environment suffers to some extent?



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Figure 2. Americans' Support for Prioritizing the Environment over the Economy versus Annual US GDP Growth, 2000–2013



^Net = % who would make protecting the environment the priority minus % who would make economic growth the priority.

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Since 1984, Gallup has been asking Americans about whether they place higher priority on economic growth or environmental protection. The results and precise wording of the question are depicted in Figure 1.

Through the 1980s and 1990s a significant majority of respondents favored environmental protection. The gap narrows beginning around 2000 and, in fact, in 2009 and 2011–2013 a majority prefers economic growth. Does this imply that Americans’ environmental preferences are weakening? No, for at least two reasons.

First, legislation, regulation, and investment in environmental protection expanded significantly over the 30-year period. In the 1980s, the major environmental laws in the United States were just beginning to be implemented, following a surge of legislation and regulatory change beginning in the 1970s. In other words, baseline “environmental protection” increased over the period. With status quo levels of environmental protection getting stronger, it’s not surprising for people to give additional environmental protections a lower priority over time. Rather than evidence of weaker

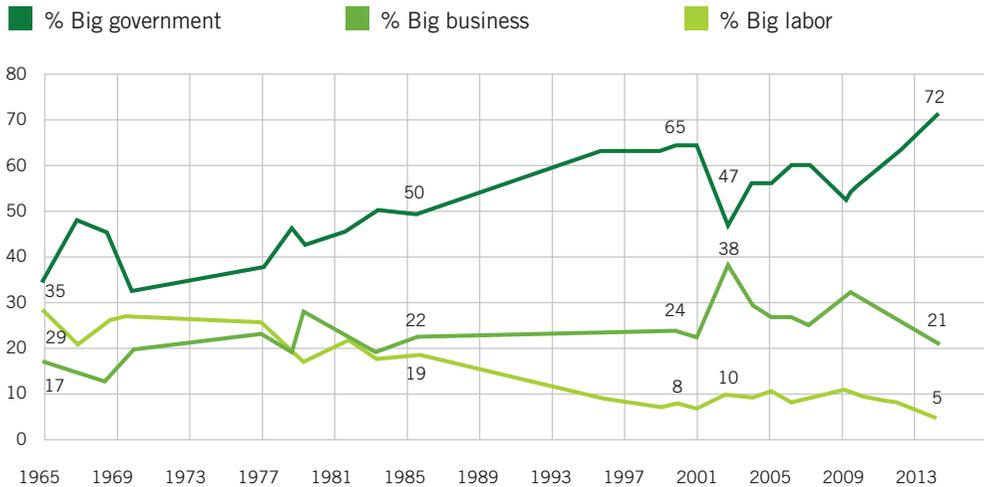
environmental desires, the numbers may just reflect the increased satisfaction of our desires over those 30 years.

Second, the numbers may simply reflect that people’s relative desire for economic growth increases when economic growth falls. Consider Figure 2, which relates Figure 1 (now expressed as “support for prioritizing the environment over the economy”) to changes in US gross domestic product (GDP). The correlation suggests that what’s changing over the period is our desire for economic growth, not our environmental desires.

Another issue with the Gallup polling (which we pick on only because there are so few other examples) is its reliance on the term “environmental protection.” The term is vague and thus subject to various interpretations by respondents and readers alike. Our guess is that many respondents reasonably equate “environmental protection” with “environmental regulation by the federal government.” If so, the survey may conflate attitudes toward the environment with attitudes toward government. Figure 3 shows why that matters to interpretation of the poll. Over the past 40 years distrust

Figure 3. Views of Biggest Threat to US in Future

In your opinion, which of the following will be the biggest threat to the country in the future—big business, big labor, or big government?



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in “big government” (itself a vague term) has grown significantly. This is yet another potential explanation for the decadal decline in the environment versus growth priority ranking.

In fact, viewing the polls together, it is remarkable how strong the preference for environmental protection (Figure 1) remains given the countervailing trends: the improvements over time in baseline environmental protection, dips in economic growth, and increased distrust in government.

Are We Becoming More Environmental?

Given those headwinds, can we conclude that our underlying environmental attitudes have grown stronger over the last 30 years? Yes. Maybe. We hope so. Pertinent data are sparse and over a decadal scale limited to US opinion polling that suffers from a host of interpretive challenges. Although empirical measurement of our underlying envi-

ronmental attitudes and tastes is possible, assessment of long-term, cross-cultural changes in environmental desires would require a fairly heroic commitment to new data and empirical methods.

Our survey, as well as our own personal intuition, leads us to conclude that our desires change, and in some situations can be changed deliberately. The difficulty for prediction, however, is the variety of factors that drive our psychology and attitudes. Do our childhood experiences trump the norms of our adult community? Are our attitudes more affected by learning and social messaging or by institutions that govern the way we interact with one another?

Consider the pronounced global trend toward urbanization and its effect on our environmental desires. One argument is that urbanization is likely to weaken environmental desires, via our increasing detachment from natural experiences in childhood



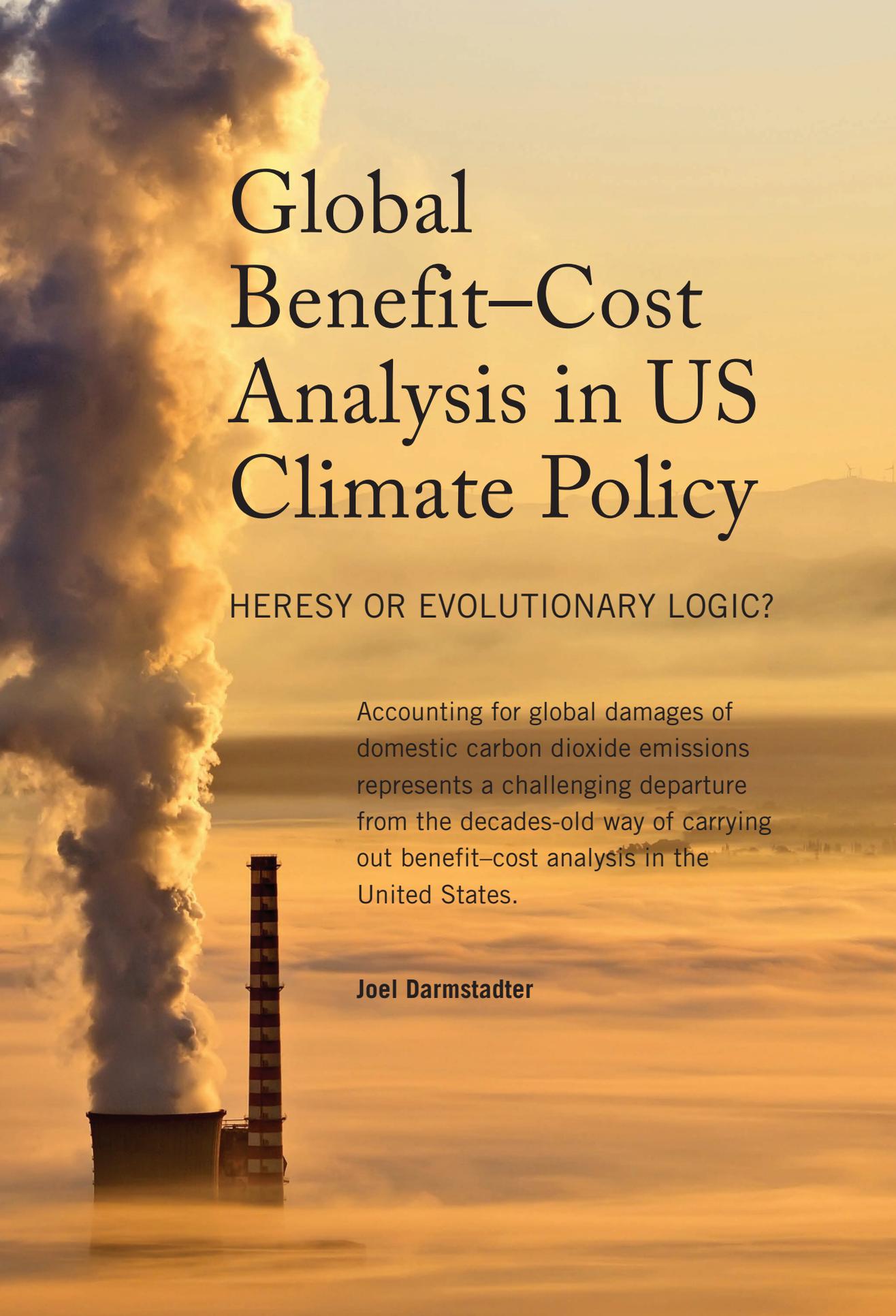
or psychological adaptation to nature's unobtainability. But urbanization is also associated with educational opportunities and social interactions that could strengthen environmental desire.

Given such countervailing winds, prediction requires deliberate strategies to empirically measure trends in our environmental desire. The difficulty of doing so largely explains why the environmental social sciences have so far not provided adequate evidence one way or the other. But difficulty isn't a great excuse for ignoring something so fundamentally pertinent to our environmental policy choices.

Changes in humanity's environmental desires matter. If we predict stronger environmental desires in the future, then policy choices based on our current strength of

desire will tend to underprotect the environment. And conversely, if we expect a weakening, current policy will tend to overstate the benefits of environmental improvement. Our hope is to encourage greater attention (particularly among our colleagues in economics) to the way humanity's deeper environmental desires, values, and attitudes may be changing. ●

This article is excerpted from a related blog series on *Common Resources*. Read the full series at www.rff.org/blog/environmentaldesire.



Global Benefit–Cost Analysis in US Climate Policy

HERESY OR EVOLUTIONARY LOGIC?

Accounting for global damages of domestic carbon dioxide emissions represents a challenging departure from the decades-old way of carrying out benefit–cost analysis in the United States.

Joel Darmstadter

The challenge of reaching a workable accord for greenhouse gas emissions abatement depends on an underlying consensus about numerous critical factors, few more central than the policy issue of how most effectively to control those emissions. That means considering the comparative virtues of a carbon (or carbon-equivalent) tax, a tradable permit system, or some coexisting hybrid of the two instruments. For a tax, determination of its dollar magnitude is critical. Its estimate is commonly derived from the so-called “social cost of carbon”—that is, the monetary deterrent against the damage an incremental ton of carbon dioxide (CO₂) would otherwise inflict on the world.

The prevailing estimate of the social cost of carbon is about \$40 per ton of CO₂ (or around 45 cents per gallon of gasoline), if imposed beginning in the year 2020. Without disputing the size of that number or the methodology on which it rests, I’ll try to illuminate the way in which the social cost of carbon (or any such global estimate) poses a dilemma when folded into an emerging US benefit–cost analytical framework that departs in scope from one that, in its focus on purely domestic impacts, has for decades underpinned the steadily growing field of environmental economics; and, in more recent years, has been reflected in specific cases of US environmental decisionmaking. But now, we see this departure playing out with the benefit–cost analysis underlying the US Environmental Protection Agency’s (EPA’s) recently finalized Clean Power Plan.

Background

A very brief review of the evolution of benefit–cost analysis in the United States

may provide a useful clue to the ongoing, if muted, controversy around which this latest perspective has stirred passions in both academic and policy circles. It is an odyssey that begins as an intellectual tour de force, proceeds through conceptual and institutional refinement, and, at the end, achieves operational and empirical legitimacy in regulatory and rulemaking authority.

Much credit for inspiring this multi-stage evolution should be accorded to Ronald Coase, who, in his 1960 book *The Problem of Social Cost* and follow-on writings, established the intellectual rationale for integrating public goods—with their exposure to nonmarket externalities—into economic orthodoxy. (Its landmark breadth and rigor notwithstanding, Coase’s work was not entirely a bolt from the blue: nearly a century earlier, British economist Arthur Pigou had proposed a tax on externalities.) In its most rudimentary expression, the problem Coase sought to overcome is one where, say, there is a downstream victim of toxic runoff freely discharged upstream—a market failure correctible by providing the downstream party redress through judicial or regulatory relief. (Think of CO₂ releases to the atmosphere instead of upstream pollution and the global climate regime instead of the downstream victim—and you’re practically up-to-date.)

In the years following, Coase’s theoretical foundation segued into a succession of milestones, each of which further strengthened the evolutionary process that led to today’s near fundamental inclusion of benefit–cost analysis in regulatory and environmental policymaking. A 1996 executive order underscored the importance of economic analysis in federal decisionmaking. In line with that presidential advisory, we reached another key juncture when the Office of Management and Budget (OMB) issued

“The Clean Power Plan makes the worldwide benefits of US abatement initiatives very much a part of its analytical architecture, signifying a new conceptual framework.”

its Circular A-4 in 2003. That circular requires, and provides guidelines for the use of, benefit–cost estimates in federal agency rulemaking decisions.

Appropriately, EPA proceeded to apply OMB’s guidelines to its regulatory decisions—exercising its authority under the Clean Air Act and other legislation. The agency’s recently finalized Clean Power Plan, governing emissions from existing coal-burning power plants, is the latest and a major instance of applied benefit–cost analysis. But it is important to note—given the discussion that follows—that Circular A-4 was understood to be exclusively applicable to domestic benefits and costs. The Clean Power Plan relaxes that constraint by making the worldwide benefits of US abatement initiatives very much a part of its analytical architecture. It thereby signifies a new conceptual framework.

The Global Benefit–Cost Dilemma

If what I have sketched out above traces a reasonably faithful and linear time line of development, it means that we’re now at a point of distinct discontinuity in that path. Simply put, a nation that subscribes and is prepared to adhere to an international climate accord is expected to bear the cost

(in the form of the social cost of carbon or its equivalence) of its share of worldwide emissions—irrespective of whether that cost falls short of or exceeds the resulting domestic climatic benefits.

At first blush, this seems like a perversion of accepted analysis. In fact, it represents what is arguably the most effective way forward in confronting a challenge of global dimension. One needs merely to recognize the inherent inability to trace the path among one or more countries’ greenhouse gas releases, their ensuing presence in atmospheric concentrations, and the resultant damages inflicted on identifiable places around the world. It seems hardly necessary to belabor the point: How much Philippine inundation, Australian drought, or heightened African exposure to mosquito-borne disease originates, say, in Indian coal-burning power plants, EU tailpipe emissions, or fugitive US methane leakage is not measurable, even in principle. In short, the only test of a viable multicountry mitigation approach is whether the worldwide sum of each nation’s emissions abatement costs matches the avoidance of worldwide climatic damages resulting from such aggregated emissions declines.

For an instructive quantitative explication of this line of argument as it applies to the United States, consider a useful rundown prepared not long ago by Harvard economist and RFF University Fellow Robert Stavins. Stavins’s tabulation shows that, provisionally, US compliance costs with the Clean Power Plan are estimated to come to around \$9 billion. Against this outlay, domestic climate benefits (that is, the avoidance of US climatic damages that would otherwise occur) amount to about \$3 billion. To be sure, the net domestic climatic “loss” of \$6 billion becomes a net winner if as much as \$40 billion of “co-benefit” health

impacts (for example, reduced respiratory distress from particulate emissions) are thrown into the equation. No doubt, numerous other countries will enjoy such associated benefits as well. Some may even be tempted to make their support for climate policy conditional on those co-benefits. Still, in a purely global-warming context, our \$9 billion expenditure overwhelmingly redounds to the world as a whole to the tune of an estimated global benefit of \$31 billion.

Dissent, Assent

However they may appreciate the extent to which such global warming redress is grounded in ethical arguments, some scholars in both the economics and legal communities take major exception to what they see as an abandonment of established and sound benefit–cost principles—whether in the departure from the strictly domestic dimensions of OMB’s Circular A-4 or from its Coasian intellectual antecedents.

Economic Critique

Most economists appear supportive of the broadened framing of the benefit–cost paradigm. Still, one particularly strong dissent has come from Ted Gayer (of the Brookings Institution) and W. Kip Viscusi (of Vanderbilt University). These two scholars find no justification for US government officials going “outside the typical practice for defining the scope of benefit assessment”—that scope being limited, in their view, to purely domestic benefits. Breaching that limit by granting greenhouse gas reduction benefits to US citizens and noncitizens equally would, in their view, “substantially shift the allocation of societal resources. The global perspective would likely shift immigration policy to one of entirely open borders, as the benefits of granting citizenship to poor

immigrants from around the world would dominate any costs to current US citizens.” One can see how a position so rigidly framed might easily support judicial and policy challenges to regulatory actions such as the Clean Power Plan and thereby blur the thrust and implications of US climate mitigation initiatives.

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“Some scholars in both the economics and legal communities take major exception to what they see as an abandonment of established and sound benefit–cost principles.”

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For what can be taken as a refutation of the Gayer–Viscusi stand—albeit one stated with a touch less certitude—one might usefully refer to the Interagency Working Group (IWG) on the Social Cost of Carbon’s recent response to comments on the social cost of carbon regulatory impact analysis. That document reviews numerous comments—ones both favoring and questioning a global benefit–cost perspective. Yet, even while acknowledging that the IWG departs from strict interpretation of OMB guidelines, the review concludes, “The only way to achieve an efficient allocation of resources for emissions reduction on a global basis is for all countries to base their policies on global estimates of damages and [the IWG] will therefore continue to recommend the use of global SCC estimates in regulatory impact



analyses.” And, in an aside that might well prompt a rebuttal from purists, the IWG describes Circular A-4 as “a living document, which may be updated as appropriate to reflect new developments and unforeseen issues.” Indeed, it describes OMB, an integral participant in the IWG’s work, as supportive of the focus on global damages.

Legal Critique

On the legal front, the underlying—and no longer seriously contested—reality is the Supreme Court’s 2007 decision obliging EPA to limit greenhouse gas emissions under provisions of the Clean Air Act. Predictably, the court did not indicate the specific ways in which EPA was to implement such a broad mandate. This fact has enabled proponents of the Clean Power Plan to cite those parts of the Clean Air Act

(in particular, Section 111(d)) as consistent with the court’s decision and therefore in support of EPA’s finalized Clean Power Plan ruling, while spurring its opponents to seek judicial redress from what they allege to be EPA’s questionable applications of the Clean Air Act.

An excellent guide to that debate is provided in a July 2015 *Common Resources* blog post by Nathan Richardson of the University of South Carolina Law School and an RFF visiting fellow. For example, actual implementation of EPA’s Clean Power Plan emissions rules under 111(d) falls to the states (either individually or in concert with other states) rather than individual power plants. But that devolution of responsibility under the Clean Air Act may be insufficiently tested, in Richardson’s view, to easily forestall legal chal-

lenge. Relatedly, the legitimacy of emissions trading is unclear. Another area of dispute concerns the extent to which—again, with specific applicability to implementation of the Clean Power Plan—Section 111(d) permits recourse to demand-side energy management and the use of renewables. In short, where there is such ambiguity, there is an opening for a litigious contest to assess more precisely the operational features of the Clean Power Plan.

Whether it will turn into an additional challenge is far from clear, but one unique line of argument hostile to the Clean Power Plan deserves to be noted. A widely publicized legal dissent against EPA's proposed rulemaking is contained in a 2014 comment submitted to EPA jointly by Professor Laurence Tribe (of the Harvard Law School) and the Peabody Energy Corporation.

A key feature of the Tribe–Peabody argument is its charge that EPA is in violation of the Due Process and Takings Clauses under the Constitution's Fifth Amendment (which prevent “the government from forcing some people alone to bear public burdens which, in all fairness and justice, should be borne by the public as a whole”). That violation, their comment notes, “is precisely the purpose of the [Clean Power Plan rule], forcing the United States' power plants and energy industry to bear the *global* [my italics] burden of lessening CO₂ emissions EPA's singling out of a mere handful of emitters and limiting (or curtailing) their property is exactly the type of overreaching the Fifth Amendment seeks to prevent.”

One wonders whether US ratification to the 1989 Montreal Protocol—designed to shield the globe from stratospheric ozone depletion—might, analogously, have been challenged on grounds that the cost of its global benefits was disproportionately borne by a handful of US chlorofluorocar-

bon producers. No matter: with respect to final adoption of EPA's Clean Power Plan ground rules, it may take some time for the legal skirmishing to run its course.

To embrace a global benefit–cost approach to greenhouse gas abatement is scarcely to wish away a variety of operational impediments that could impair its smooth implementation. Participation in an international accord by low-income developing countries could spur free-riding impulses by some of those countries. For all participating nations, reporting obligations must be scrupulously defined and observed. Recourse to retaliatory measures must be explicitly acknowledged and codified.

Nonetheless, in these and other respects, transitioning from a domestic to a global perspective hardly qualifies as the indefensible perfidy to established policy practices some critics may continue to claim. ●

This article originally appeared on RFF's blog, *Common Resources* (www.rff.org/blog).

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A Look at

35 YEARS *of*

FLOOD INSURANCE CLAIMS

An analysis of more than one million flood claims under the National Flood Insurance Program reveals insights to help homeowners get the insurance they need.

Carolyn Kousky and Erwann Michel-Kerjan

The historic rainfall and resulting floods that paralyzed South Carolina in October 2015 and claimed several lives served as another tragic example of the toll these disasters can take. In fact, of all natural disasters, floods are the most costly and have affected the most people in the United States. Yet many homeowners remain uninsured against flood damage.

A 2006 RAND Corporation report estimated insurance take-up rates from a ran-

dom sample of homes across the country and found that only about half of single-family homes in 100-year floodplains have flood insurance, although there is substantial regional variation. Even more alarming, a report by the New York City Mayor's Office published after Hurricane Sandy revealed that 80 percent of residents living in areas inundated by storm surge had no flood insurance.

In a recent article in the *Journal of Risk and Insurance*, we look at the history of flood insurance claims from the National Flood Insurance Program (NFIP). This federal program is the main provider of flood insurance nationally and has been since 1968. In the paper, we analyze a database of over one

CAROLYN KOUSKY is a fellow at RFF.

ERWANN MICHEL-KERJAN is executive director of the Wharton School's Risk Management and Decision Processes Center at the University of Pennsylvania.

million claims between 1978 and 2012 made available to us by the Federal Emergency Management Agency (FEMA), looking at factors that lead to higher or lower claims, as well how claims are distributed across time and space.

Some of our findings are surprising. Some are predictable. But they all shed insight on possible reasons for low insurance demand and the challenges the debt-ridden NFIP faces financially.

Most Claims Are Modest, but Some Aren't

It is not clear that individuals living in flood-prone areas understand the damage that they may sustain in the event of a flood. Most outreach on flood risk has focused on the probability of a flood, not the damage that would occur from floods of different magnitudes. Our analysis of claims offers some insight on the damages homeowners may face should they be flooded.

Our results show that the majority of claims are for modest amounts, but a small percentage are for very large amounts. Half of claims are for less than 10 percent of the building's value (see Figure 1). While the majority, then, are not extreme, a small portion of claims exceed three-quarters of a building's value. Across all years, 7 percent of claims are on this higher end, and when the year of Hurricane Katrina is excluded, the share drops to 3 percent. Looking across all 35 years, the mean flood claim is \$33,764 (in 2012\$). This average is pulled up by a few very large claims; the median is much less at \$12,555.

This overall trend is mimicked when looking at NFIP claims by year. Most years had manageable levels of claims payments, but when Hurricane Katrina hit in 2005, NFIP paid out more in claims than it had

over the life of the program, reflecting the catastrophic nature of flooding.

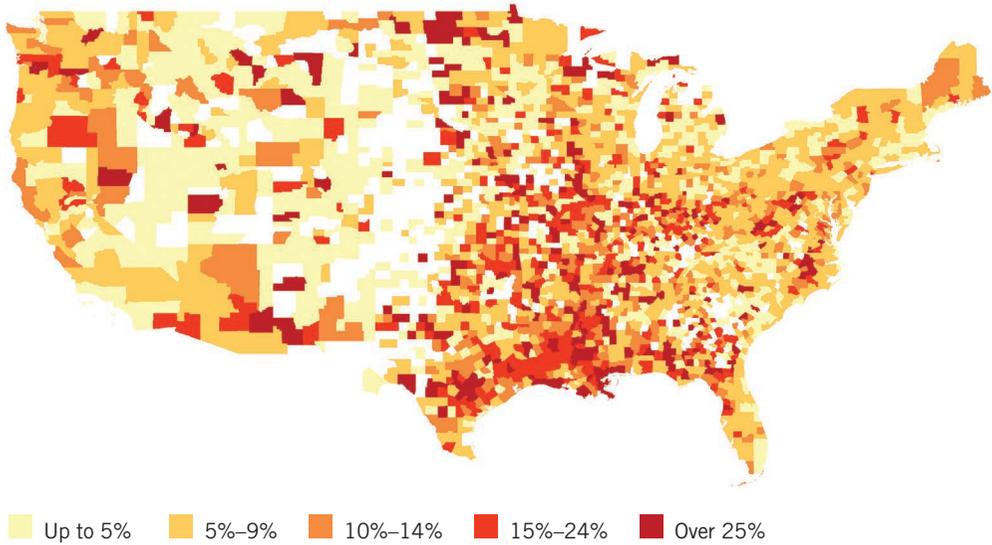
Risky Areas Really Are Riskier, but Better Building Can Lower Damages

FEMA maps different flood zones around the country to meet regulatory and pricing needs. High-risk areas are defined as the 100-year floodplain, where there is a 1 percent chance of a flood in any given year. Within this area, FEMA further differentiates 100-year floodplains that are at risk of storm surge, which can be more damaging. FEMA also maps the 500-year floodplain, where there is only a 0.2 percent chance of a flood in a given year.

We find that claims in 100-year floodplains that are not subject to storm surge are higher than outside the 100-year or 500-year floodplain by 20–25 percent. Claims in 100-year floodplains that are at risk of storm surge are roughly 35 percent higher. As would be expected, claims in 500-year floodplains are higher than outside them, but less than 100-year floodplains, at roughly 13–17 percent. Thus, as intuition would suggest, and as NFIP premiums reflect, floods cause the most damage in areas of storm surge, followed by inland high-risk areas. Areas at risk of moderate flooding see higher claims than areas of low to no risk.

On average, the claim rate in 100-year floodplains should be roughly 1 percent. We find that in FEMA-mapped 100-year floodplains, the average claim rate across all years is a bit higher at 1.55 percent. Surprisingly, outside 100-year floodplains, the average claim rate is 1.27 percent, with no statistically significant difference in these rates. This higher-than-expected claim rate could be due to adverse selection; only the riskiest properties are insuring in these areas. It also could reflect inaccurate and out-of-date maps.

Figure 1. Median Flood Claim as a Percentage of Building Value, by County



The good news is that hazard mitigation works. We find that homes known to be elevated have claims that are 16–18 percent lower than others. And communities that are voluntarily engaging in flood mitigation activities also have lower claims.

High Flood Claims Can Occur Anywhere

NFIP policies are not distributed evenly around the country. Roughly 37 percent of the more than 5 million policies in force around the country are located in Florida. Texas accounts for the second-highest share of policies at 11.5 percent. This is followed by Louisiana. Unsurprisingly, total claims paid are highest where there are many policies in force, such as along the Gulf Coast, and where major flood events have occurred, such as Louisiana, Florida, and the New York/New Jersey region. The largest percentage of paid claims is Louisiana, at 21.5 percent, followed by Texas at 12.5 percent, and Florida at 10 percent—all places that have had major hurricanes hit over the last decade.

When mapping median claims, however, the highest claims are scattered around the country. Sometimes they are on the coast, sometimes inland along major rivers. Although Louisiana has some areas of high median claims, Florida largely does not.

Certain Riskier Properties Continue to Burden the Program

Two groups of properties have proven to be particularly financially burdensome to the NFIP. The first consists of properties that had already been built in high-risk areas when the program was created. These properties were built to lower building standards and have historically received discounted premiums. Because they were built before FEMA created flood insurance rate maps, or FIRMS, the NFIP categorizes them as “pre-FIRM.”

Properties in the second group, which overlaps with pre-FIRM properties, are referred to as “repetitive loss” properties. When a property has two or more losses of at least



\$1,000 over a 10-year period, it obtains repetitive loss status. The US Government Accountability Office reported in 2004 that these properties account for only 1 percent of policies but 38 percent of claims between 1978 and 2004. Unlike a private insurance company, FEMA cannot deny coverage to these properties.

We find that claims from pre-FIRM properties, relative to home value, are 42–45 percent higher than other properties. It was thought that policies categorized as pre-FIRM would phase out over time because these homes must switch to standard policy coverage whenever they are substantially damaged or improved. We find that although pre-FIRM properties represented over 80 percent of NFIP policies through the mid-1980s, they now represent less than 50 percent of policies. The percentage of claims that are pre-FIRM, however, has not fallen as quickly, with over 60 percent still

coming from these properties. Legislation passed in 2014 will slowly phase out the premium discount these properties have been receiving, bringing them closer to paying rates that reflect their higher risk.

We find repetitive loss properties also have higher claims than others, by 5–20 percent. The distribution of repetitive loss properties across flood zones is fairly similar to non-repetitive loss properties. Across all years, Louisiana had the highest insured losses from repetitive loss properties, followed by New York, New Jersey, Florida, and Texas.

Implications for Insurance Demand

For decades, FEMA has concentrated its public communication efforts on the probability of a flood occurring—but research has repeatedly shown that individuals have a hard time fully understanding low-probability events. We believe that information on regional claims should be more widely

discussed with those living in exposed areas to help residents become more knowledgeable about what damages they would suffer after a flood.

As noted earlier, we find evidence that most flood insurance claims are modest but a small number can be quite severe. Homeowners may have different preferences for how to protect themselves against uncertain risks of this kind. To account for these differences, the NFIP could consider two strategies to encourage flood insurance purchases:

Strategy 1. Insurance coverage for small losses only. Some homeowners may prefer insurance coverage against the more likely, moderate, flood damages. This type of policy would cover the vast majority of losses the property is likely to sustain, but would leave homeowners vulnerable to rare catastrophes. Although the probability of those rare events is small, should they occur and homeowners not be protected, they could suffer devastating financial losses.

Strategy 2. Catastrophic coverage only. Other homeowners may prefer coverage for just the most extreme events, choosing to self-insure for lower amounts. Such a catastrophic policy would be cheaper than more comprehensive coverage because the probability of suffering a truly catastrophic loss is very low. It may be challenging for high-risk low- and middle-income families, though, without the liquidity to cover non-catastrophic losses.

Implications for Program Exposure

The concentration of exposure along the Gulf Coast and the possibility for extreme loss years, such as 2005, highlight the challenges faced by the private sector with regard to flood insurance. It is quite expensive to guarantee access to sufficient capital to cover the extreme loss years that are possi-

ble. From a pure cost-of-capital perspective, this constitutes a notable advantage for the federal government. To increase private-sector participation in flood coverage, however, one option is for private insurers to cover losses up to a certain point and have government backstop losses for the very rare events. This is done today for two other types of low-probability, high-impact catastrophes: for terrorism through the Terrorism Risk Insurance Act, established in 2002, and for nuclear accidents through the Price Anderson Act, established in 1957. In both cases, the first layer of losses would be assumed by the private sector, while the second layer would be covered by the government.

The challenge with a public-sector program, however, is that considerations beyond risk influence pricing (see Kousky and Shabman in Further Reading). As noted earlier, in an effort to encourage program participation, some properties historically have been receiving discounted rates. The program also cannot deny coverage to even the riskiest properties. Both of these challenges have led to the program's current debt, which is on the order of \$24 billion. The trade-off is that at higher rates, without a mandate to purchase coverage, many households at risk of floods would simply go uninsured. ●

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RFF Announces Research Chairs, Welcomes New Fellow, and Remembers Wallace E. Oates

RFF University Fellow **Partha Dasgupta** has been awarded the 2015 Blue Planet Prize for scientific achievements in the field of environmental sciences. This prize recognizes outstanding efforts in scientific research or applications of science that contribute to solving global environmental problems.

RFF Senior Fellow **Maureen Cropper** and Board Member **Richard Newell** have been appointed co-chairs of a new National Academies Committee on assessing approaches to updating the social cost of carbon. Committee members also include RFF Board Chair **Richard Schmalensee** and University Fellow **William Pizer**, and RFF Fellow **Casey Wichman** is serving as co-director of the study.

RFF University Fellow **John Antle** is one of four recipients of the 2015 American Society of Agronomy Presidential Award, given to those who have influenced agronomic sciences or crop production practices so greatly that the impact of their efforts will be enduring on future science.

RFF Announces Research Chair Appointments

RFF is pleased to announce the award of the Thomas Klutznick Chair to RFF Senior Fellow and Associate Research Director **Juha Siikamäki** for 2016–2018 and the Darius Gaskins Chair to RFF Senior Fellow **Dallas Burtraw** for an additional year during 2015–2016.

Siikamäki will address trade-offs related to the multitude of services provided by

forests, such as recreation, hydrological services, temperature regulation, carbon sequestration, habitat and species conservation, and alternative uses of forested land. He plans to develop globally comprehensive and geographically consistent estimates of the value of nonmarket forest ecosystem services and then make publicly available the first map of the value of several essential nonmarket forest ecosystem services. He also will use the chair to support his work as the academic leader of a unique eight-country ecosystem services valuation project involving collaboration among the Environment for Development Initiative centers in Chile, China, Costa Rica, Ethiopia, Kenya, South Africa, Sweden, and Tanzania.

As the Darius Gaskins Chair, Burtraw will continue to advance RFF's critical and timely analyses of the implementation of the nation's new Clean Power Plan, including the effects on the market structure and industrial organization of the electricity sector, system resilience to disruption, and energy storage. He also hopes to develop a deeper understanding of the distributional effects of environmental policy.

RFF Awards New Frontiers Funds

RFF has made two awards under its New Frontiers Fund, which encourages RFF researchers to take risks in pursuit of wholly new ideas that tackle difficult problems and to explore unusual approaches to solving today's pressing natural resource and environmental issues.

RFF Fellow **Rebecca Epanchin-Niell** will use the funding to pursue a research project, “Enhancing Policies for Western Rangeland Conservation,” that links ecological dynamics, wildfire and invasive species threats, and ecological and economic outcomes over time and geography to help inform critical decisions about land and species management in the western region of the United States.

RFF Fellow **Benjamin Leard** and Senior Fellow **Joshua Linn** will develop a model of the new light-duty vehicle market, using a rich dataset on consumers’ new vehicle purchases to evaluate public policy. For example, the model will allow comparison of different policies to reduce greenhouse gas emissions, including tighter fuel economy standards and incentives for alternative fuel vehicles.

Meet RFF Fellow Casey Wichman



Casey Wichman joined RFF in summer 2015 as its newest fellow. His research lies at the intersection of environmental and public economics, with an emphasis

on examining the ways in which individuals make decisions in response to environmental policies using quasi-experimental techniques. In his own words, he describes his past, present, and future research interests:

“I began college as an English major and, naturally, found little value in my first economics course. After exploring other options, I decided I wanted to do something related to the environment, reflecting my inclination for the outdoors. I came around to economics when I saw its inherent application to environmental issues. The notion that economics provides structured insight into policy issues was only strengthened for me

by the good fortune of spending a summer as a research intern for former RFF fellow Spencer Banzhaf.

Currently, I am working on a few exciting projects dictated by today’s policy landscape. One examines the effect of bicycle-sharing systems on urban traffic congestion in Washington, DC. The main result is that vehicle traffic lessens in neighborhoods with bike shares. Another project analyzes the effect of water scarcity on electricity generation. Our findings suggest that reductions in clean, renewable hydropower during droughts are countered by increases in electricity generation primarily from natural gas.

Looking ahead, I intend to further my work on water conservation, valuation of public infrastructure, and the intersection of water and energy issues.”

In Remembrance of Wallace E. Oates

The RFF family was saddened to learn of the death on October 30 of **Wallace E. Oates**, distinguished university professor emeritus at the University of Maryland and an RFF university fellow. A scholar of international significance, Oates produced a body of work equal to the very best in the profession and had an enormous impact on both public and environmental economics. His first book, *Fiscal Federalism*, published in 1972, continues to define the research agenda of local public economics to this day. In his numerous environmental writings, he studied the design and implementation of taxes on polluting activities and systems of tradable emissions allowances. In particular, his book *The Theory of Environmental Policy*, written with William Baumol, made environmental economics a core part of economics; it arguably has been the single most influential work in this field. He will be greatly missed by his colleagues here at RFF.



An Economically Sensible Energy Transition

Anthony Bernhardt

I first came to understand the potential for energy technology to address climate change during my years as a physicist at the Lawrence Livermore National Laboratory, where early on I designed and built lasers that would be used for enriching uranium. There I learned about fusion, which is still a major focus of the laboratory today. But when you're working on big technology, you don't really think about the economics. Fusion requires a significant amount of development before it will work, and even then, it will be enormously expensive.

Recognizing this problem, I have since shifted my focus to the economic implications of energy technologies used for electricity and transportation because that's where the rubber hits the road. And that's why I was so interested and thrilled to be involved, both as a board member and supporter, with RFF: it knows economics.

When I retired in 2005, I joined Environmental Entrepreneurs (E2), a nonpartisan group of business leaders who are volunteers. We lobby for environmental legislation that we consider to be beneficial and sensible, which requires making a solid economic argument. We quickly became aware of RFF when its researchers advised California in drafting and then implementing its landmark climate legislation.

Part of my role is to track the development and commercialization of energy technologies with the greatest impact on greenhouse gas emissions, and I'm optimistic

about the transition to clean energy. Clean power technology, which is being manufactured and installed at lower and lower cost, is essentially now at parity with conventional technology. It's cheap compared to nuclear; it's comparable to natural gas.

But with fossil fuels, "externalities," as an economist would say, are still not taken into account. I think that as society becomes more conversant with that concept and sees the consequences of not charging for the lasting damage to the planet and our health from these extractive industries, renewable technologies become essential.

We're just at the tipping point in the deployment of wind and solar. Iowa, for example, is producing more wind energy than it can use and exporting it to its neighboring states. California now produces almost a quarter of its electricity from renewable sources, and it recently passed legislation to extend that figure to 50 percent by 2030. Economically attractive wind and solar resources in the United States are vast.

We need to make this energy transition in the most economically beneficial way that we can. This goal requires a conversation in the political realm based on good data about real policy options and the implications of policy choices. And that's what RFF does better than anyone else. ●

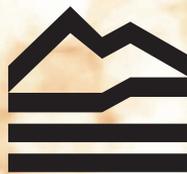
ANTHONY BERNHARDT is a Northern California director of Environmental Entrepreneurs and an RFF board member.

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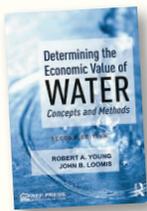
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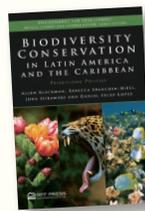
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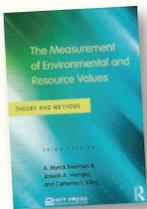
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