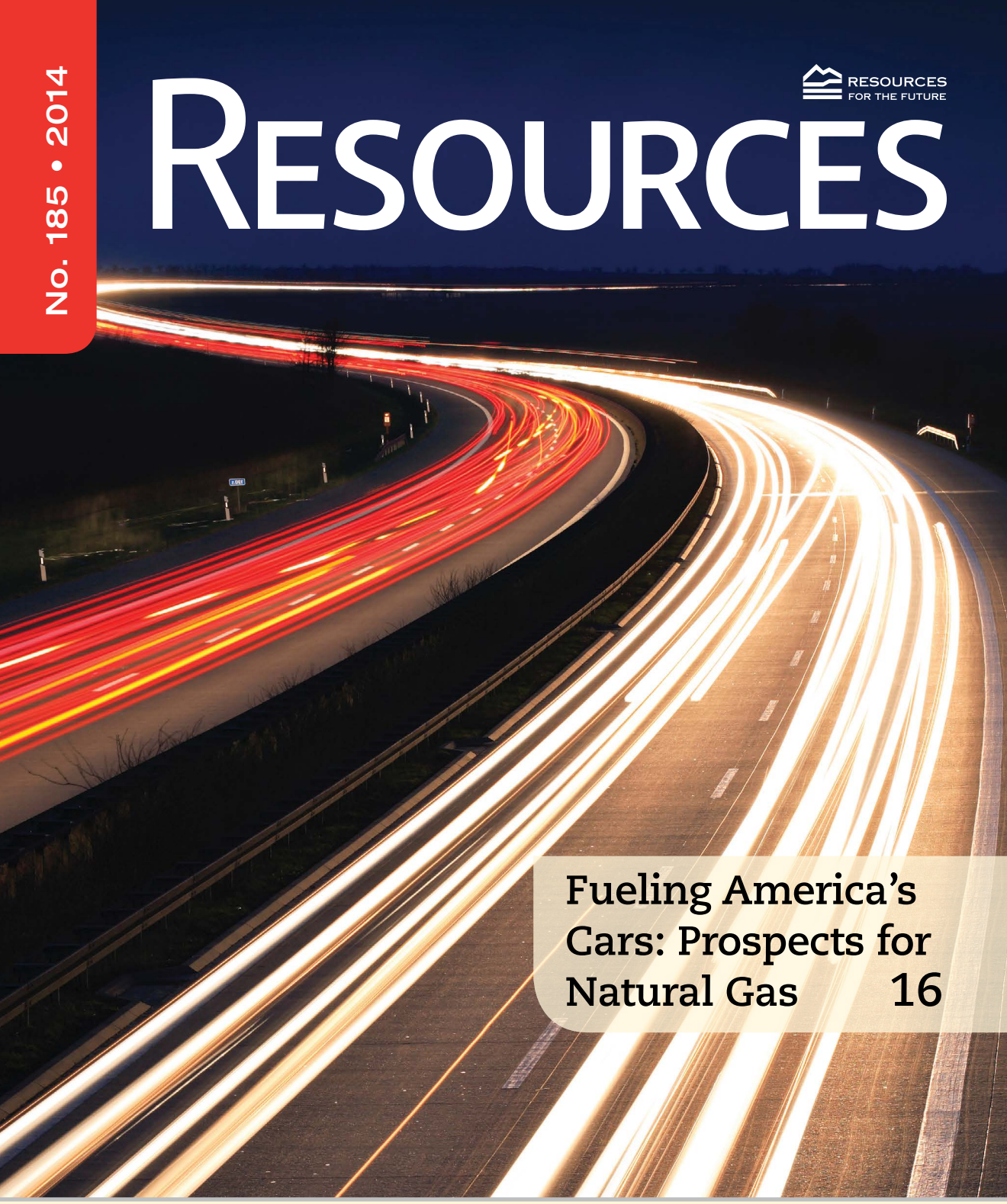
No. 185 • 2014

Resources

Resources for the Future



Resources

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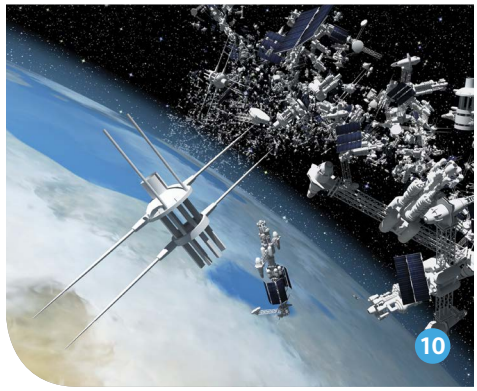

features

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In This Issue

Boyd

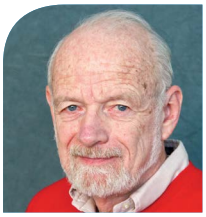
James W. Boyd is the director of RFF's Center for the Management of Ecological Wealth and a senior fellow at RFF. His research lies at the intersection of economics, ecology, and law, with a particular focus on the measurement and management of ecosystem goods and services. Boyd emphasizes the need to better coordinate economic and ecological research to improve the practical performance of green incentives, markets, and investments.

Burtraw

Dallas Burtraw is the Darius Gaskins Senior Fellow at RFF and an associate director of RFF's Center for Climate and Electricity Policy. He is one of the nation's foremost experts on environmental regulation in the electricity sector. For two decades, he has worked on creating a more efficient and politically rational method for controlling air pollution. He also studies electricity restructuring, competition, and economic deregulation.

Flannery

Jared Carbone is an associate professor of economics at the University of Calgary. His research focuses primarily on evaluating the economy-wide impacts of environmental regulations. He has written about international trade and regulatory responses to global warming, environmental taxation and fiscal reform, and models of demand for environmental quality and health in economy-wide benefit–cost assessments.



Fraas

Brian Flannery is a center fellow in RFF's Center for Climate and Electricity Policy. He also participates in the international climate and energy arena, serving as chair of the Business Engagement Task Force of the Major Economies Business Forum and of the Green Economies Dialogue project. He previously served as science, strategy, and programs manager in environmental policy and planning at Exxon Mobil Corporation, which he joined in 1980.

Arthur G. Fraas joined RFF as a visiting fellow in April 2009 after a distinguished career in senior positions within the federal government. In 2008, he retired after 21 years as chief of the Natural Resources, Energy, and Agriculture Branch of the Office of Information and Regulatory Affairs within the Office of Management and Budget. Much of his work has examined the federal regulatory process, with a particular focus on the impact of environmental regulations.

Harrington

Winston Harrington is an RFF senior fellow. His research interests include urban transportation, motor vehicles and air quality, and problems of estimating the costs of environmental policy. He has worked extensively on such topics as the economics of enforcing environmental regulations, the health benefits derived from improved air quality, and federal rulemaking procedures.

Krupnick

Alan J. Krupnick is the director of RFF's Center for Energy Economics and Policy and a senior fellow at RFF. His research focuses on analyzing environmental and energy issues, in particular, the benefits, costs, and design of pollution and energy policies, both in the United States and in developing countries. His primary research methodology is in the development and analysis of stated preference surveys.

Macauley

RFF Vice President for Research and Senior Fellow **Molly K. Macauley's** research interests include space economics and policy, the use of economic incentives in environmental regulation, climate and Earth science, and recycling and solid waste management. She serves on numerous special committees of the National Academy of Sciences and federal agencies.

Morgenstern

RFF Senior Fellow **Richard D. Morgenstern's** research focuses on the economic analysis of environmental issues with an emphasis on the costs, benefits, evaluation, and design of environmental policies, especially economic incentive measures. His analysis also focuses on climate change, including the design of cost-effective policies to reduce emissions domestically and abroad.

Siikamäki

Juha Siikamäki is an associate research director and fellow at RFF. His research focuses on evaluating the benefits, costs, and cost-effectiveness of different environmental policy options, concentrating on natural ecosystems, such as forests, agricultural landscapes, and coastal ecosystems. He also has a broad interest in public policy evaluations, especially in the context of empirical assessments of consumer preferences and choices.

Williams

Roberton C. Williams III is the director of academic programs and a senior fellow at RFF. He studies both environmental policy and tax policy, with a particular focus on interactions between the two. In addition to his role at RFF, he is an associate professor at the University of Maryland, College Park, and a research associate of the National Bureau of Economic Research.

Pushing the Boundaries of Environmental Economics

At RFF we strive to be an active resource for policymakers, providing them with information they need to resolve current policy questions. But that is just one part of our mission. We also strive to look over the horizon—which is why RFF's anniversary year was built around the theme of *Resources 2020*, an examination of the developments that will shape the world in the decade ahead.

The year included a series of public events highlighted by addresses from three Nobel Laureates. It was an investment in our ability to push the boundaries of thought on difficult problems.

Out of these activities, we've identified four areas that we are excited about exploring over the next year. They call for RFF-style creative thinking and the nonpartisan space we provide to convene government officials, business groups, and NGOs.

» *The future of our coasts and oceans.* Urbanization of coastal areas around the world—and energy development in offshore waters and the Arctic—hold new promise but create interrelated social and environmental concerns. Better stewardship of these precious resources is critical.

» *Risk and resilience.* Societies are still not very good at thinking about public policy when it involves significant risk and uncertainty. The quantification and communication of risk and catastrophe represent large gaps of knowledge in much of the environmental economics research—and even larger gaps in public understanding and policymaking.

» *The link between macroeconomics and traditional environmental economics.* We need a stronger grasp of the interplay among economic growth, public fiscal challenges, and environmental regulation—especially as the globe faces climate change and fast-growing economies confront resource challenges and severe pollution. In short, how can we best sustain economic growth during our generation without fouling the environment for the next?

» *Big data.* With the exception of some scholars who incorporate physical climate process models or newly available energy efficiency data into their research, few environmental and natural resource economists have yet to fully access or explore the use of the extremely large data sets that have emerged from the massive increase in computing power in the information age.

Reviewing past predictions is often a humbling experience. Many of the most important developments of the previous decades caught everyone off guard. We have no illusions about our ability to predict the future, but our experience as an organization also has shown that forward thinking can have huge returns. This year holds exciting promise for RFF, and we look forward to sharing our progress with you.

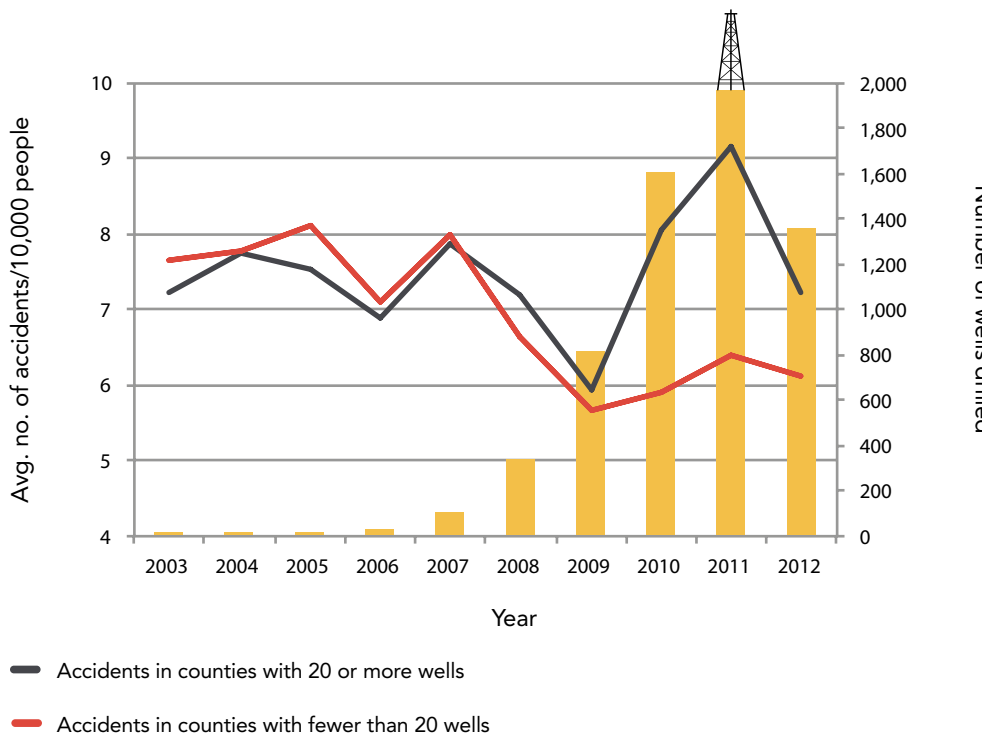
Phil Sharp, President
sharp@rff.org

Shale Gas Development Linked to Traffic Accidents in Pennsylvania

More than 7,000 shale gas wells have been drilled in Pennsylvania since 2004. The fracking process requires a large amount of water, which is primarily brought to and from a well via tanker trucks. Sometimes developing one well will require more than 1,000 such trips—mostly along rural roads and through small towns.

New analysis by RFF Fellow Lucija Muehlenbachs and Senior Fellow Alan Krupnick, director of RFF's Center for Energy Economics and Policy, links shale gas well development activities to traffic-related accidents in Pennsylvania. They used data on accidents from the Crash Reporting System maintained by the Pennsylvania Department of Transportation, which provides detailed information, such as the types of vehicles involved in an accident, the exact location and time of the accident, and the severity of the accident. They cross-referenced that data with information

Figure 1. Number of Truck-Related Accidents in Pennsylvania Counties With and Without 20 or More Shale Gas Wells, per Year



on shale gas wells from the Pennsylvania Department of Environmental Protection and the Department of Conservation and Natural Resources.

They find a significant increase in the number of accidents involving a heavy truck in counties with a relatively large degree of shale gas development, as compared with counties with less (or no) development. Figure 1 shows the average number of accidents involving a heavy-duty truck in counties with 20 or more shale gas wells, the same information for counties that have fewer than 20 shale gas wells, and the number of shale gas wells drilled over the same time period throughout the state.

There is a high degree of variation in accident rates from year to year, but the lines for both groups of counties move together until shale gas development takes off in 2009–2010. At this point the two accident rates diverge, with far higher accident rates in the counties with more than 20 wells.

They also find that one additional well drilled per month raises the frequency of such accidents by approximately 2 percent. These results control for changes in county population, county characteristics, and state-level trends in accident rates over time. With one additional well drilled in a county, the number of accidents involving a fatality increases by 0.6 percent (Figure 2).

There are reasons why increased shale gas truck traffic specifically could increase the probability of an accident: there are oil field exemptions from highway safety rules created in the 1960s that allow truckers in the oil and gas industry to work longer hours than drivers in other industries. A study by the Centers for Disease Control and Prevention finds that 27 percent of fatalities among oil and gas extraction workers in the United States from 2003 to 2006 were from highway motor vehicle crashes. Furthermore, it has been shown that an increase in the number of light-duty trucks also increases annual traffic fatalities. A better understanding of the extreme costs (such as accidents and fatalities) associated with shale gas development activity could catalyze attention and resources toward prevention of such accidents in the future.

Figure 2. Predicted Effects of One Additional Well Drilled per Month per County

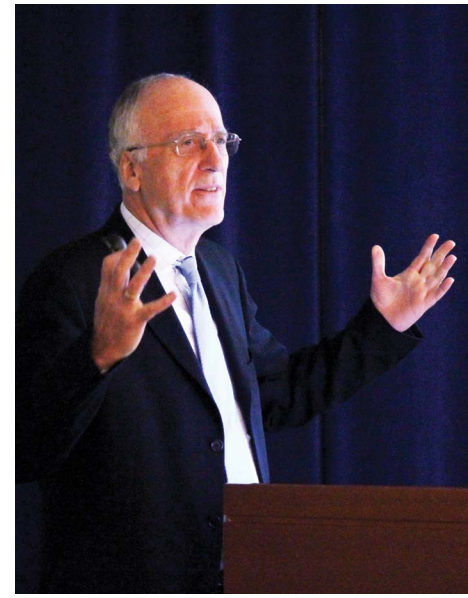
Impacts on frequency of heavy-duty truck accidents and accidents involving a fatality

Highlights of RFF's Recent Contributions to Shaping Environmental Policy

A Retrospective Analysis of US Climate Policy

September 19

"The prospect of overestimating or underestimating the impacts of regulation can lead to a misallocation of resources, misinformation delivered to the public, skepticism of economic analysis—and it can even undermine the regulatory system in question."
—Richard D. Morgenstern, RFF senior fellow, on the importance of understanding climate policy impacts when considering new regulations.
www.rff.org/retrospective



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The Future of US Water Supply
October 2

RFF's Center for the Management of Ecological Wealth hosted a dialogue to discuss the findings of two significant federal agency reports evaluating the future of US water supplies. Panelists, including RFF Fellow Yusuke Kuwayama and Resident Scholar Leonard Shabman, explored the potential for economic mechanisms, such as water pricing, trading, and ecosystem service valuation, to help reduce gaps between supply and demand.
www.rff.org/uswatersupplies

Carbon Tax
October 8

RFF researchers showcased new analysis of a federal carbon tax in a half-day workshop in Washington. The new research examined options for revenue recycling, ways to address vulnerable industries, and scaling carbon tax rates to the new social cost of carbon estimates.
www.rff.org/taxupdate

Clean Air Act
October 28

RFF hosted representatives from the electric utilities sector to discuss the detailed architecture and state-level implementation of the existing source rule for greenhouse gas regulation under the Clean Air Act.
www.rff.org/caa

presentation article or paper video

Roger Sedjo

FOSSIL FUEL VERSUS BIOMASS EMISSIONS REVISITED

Due to an editing error, Roger Sedjo's piece on biofuels in the last issue of *Resources* ("Regulating Emissions from Bioenergy: What Life-Cycle Assessments Tell Us," pp. 16–17) included an erroneous claim that carbon emissions from fossil fuels cannot be recaptured. The text should have stated, "Unlike fossil fuels, which have the disadvantage of releasing carbon into the biosphere that can never be recaptured *back to its original source*, wood chips or pellets, biofuels, and other forest energy products are renewable, and the carbon released in energy production can be recycled indefinitely through a regenerated forest" (italics ours).

We asked Sedjo to elaborate on the difference between fossil fuel and biomass emissions in this issue.

RESOURCES: Some have argued that carbon emissions from biomass are identical to those of fossil fuels—that the atmosphere cannot tell the difference.

ROGER SEDJO: It is correct that the emissions of both are identical and both can be sequestered by biological growth. In the case of fossil fuels, however, additional biological growth must occur. Biomass, by contrast, requires only that the utilized biomass be replaced or regenerated. So, sustainable biological stocks are adequate for biomass energy offsets, whereas fossil fuels require net increases in biological stocks to offset their emissions.

RESOURCES: Are these differences really important for carbon control?

SEDJO: Yes. For biomass energy, the maintenance of existing stocks is sufficient to offset their carbon releases. In the United States, biomass stocks are normally regenerated and thus maintained by market forces. This is the case for agricultural waste and commercial forests. No special efforts need to be undertaken to maintain biological stocks. However, offsetting fossil fuel emissions does require a special effort to generate net increases in biological stocks.

One problem with the application of cap-and-trade programs that allow forest offsets is the determination of whether a proposed offset is, in fact, a net addition rather than simply the replacement of a forest in some other location.

RESOURCES: US forests have been exhibiting net stock increases for at least 50 and probably for the last 100 years. What difference does this make to the question of emissions from biomass versus fossil fuels?

SEDJO: US forests have been sequestering a significant portion of gross US carbon emissions. The substitution of some biomass from sustainable portions of the forest for fossil fuels would reduce net emissions into the atmosphere. Only if forests were not regenerated would the effects of biomass and fossil fuels on the atmosphere in the long term be similar.

Forever Ours?

The Challenges of Long-Lived Environmental Problems

Pharmaceutical residues in waterways, industrial waste lingering in soils, space debris in orbit for hundreds of years, nuclear waste requiring management for thousands of years, and greenhouse gases affecting carbon cycles subject to geologic timescales: these pollutants are the potentially long-lasting side effects of modern, growing economies and the attainment of ever-better standards of living.

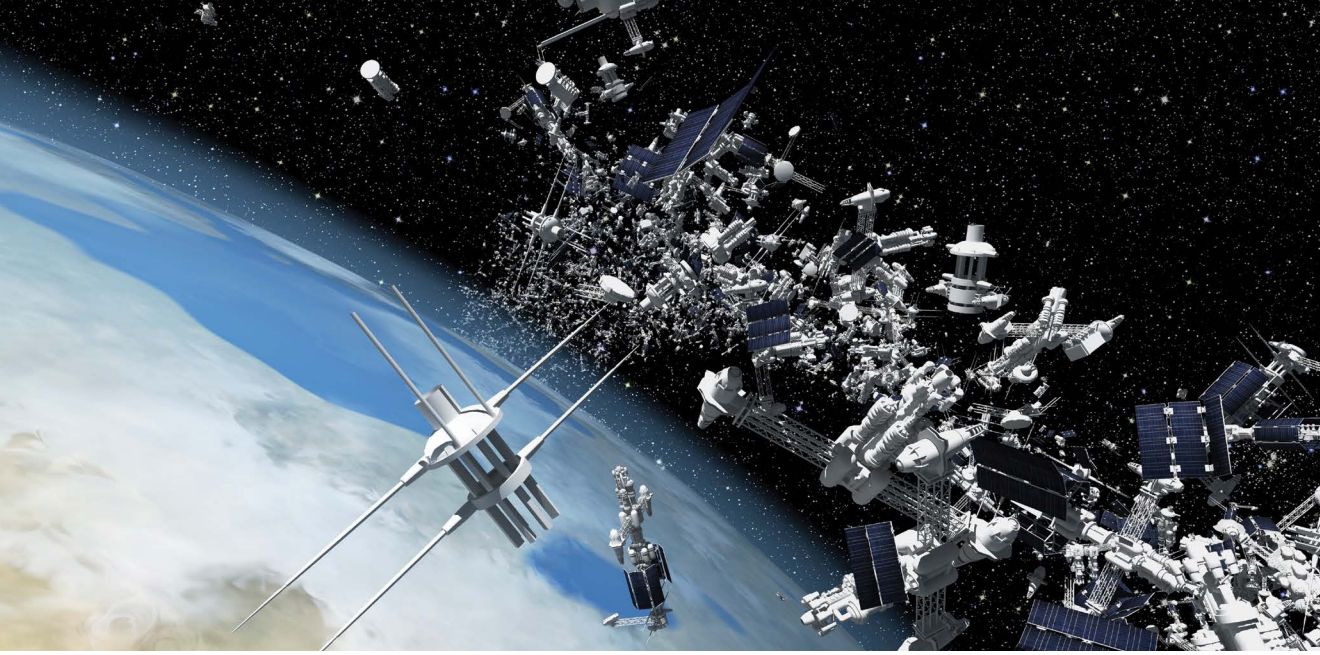
Policymakers seek to protect the public by balancing the costs and benefits of mitigation, remediation, and other strategies to control these problems. Unlike the case of many shorter-lived pollutants, however, these long-lived contaminants are particularly vexing for regulators and citizens alike. Indeed, these long-lived environmental issues could be thought of as a class of problems that are "forever ours," unique because of their almost unrestrained temporal scale. The contaminants may be present in trace amounts or have other effects that cause only small damages today; thus the public may not feel urgency to take action. But the contaminants may persist and, even worse, accumulate over time to create much greater damage, although in a perhaps very distant future. Some pharmaceutical residues, certain greenhouse gases, and space debris that self-collide to produce yet more debris are examples of pollution with cumulative effects that can worsen to create significant future harm.

In most cases, technical fixes can mitigate damages of forever-ours problems. For instance, technologies are available for chemical and other special treatments of contaminants in wastewater or soils, underground sequestration of some greenhouse gases, storage of nuclear waste, and the vacuuming of in-orbit space debris. But these solutions are costly, some have yet to be fully tested, and some have met with public resistance. In the case of greenhouse gases and space debris, solutions require global cooperation.

> Certain greenhouse gases and space debris that self-collide to produce yet more debris are examples of pollution with cumulative effects that can create significant future harm.

Solutions also include public policies—such as taxes or fees—to capitalize the harm, discourage generation of these pollutants, and possibly help to underwrite the cost of technological fixes.

For long-lived problems, the usual point of departure for deciding what to do, when to do it, and how much to spend on technological solutions or specific social policies centers on the practice of discounting. It is widely recognized, however, that discounting can fall well short as a relevant metric



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for very-far-into-the-future timescales. A much shorter duration, such as 30-year mortgages for homeownership, is empirical evidence of just how far into the future many citizens are willing to manage their own assets. (Longer-lived transactions, such as bonds with maturities of up to 100 years, are infrequent although not unheard of.)

Some experts suggest that the discount rate should be the same as the rate of per capita economic growth, interpreting this rate as a measure of how well off society is. Others point out that the discount rate probably changes over time—it may be constant, declining, or even quasi-hyperbolic. Some experts find the act of discounting—or market-like thinking more generally—to be acceptable for buying a home or car but wholly inappropriate in decisions about future human lives or the environment. Others expect future generations to be wealthier, smarter, and more innovative than current generations.

Even if the discounting issue could be resolved, the intergenerational nature of forever-ours problems strains the capacity of effective governance. Most governing institutions are subject to harsh myopic pressures. Regulators are stretched thin by the short-run pressures of fiscal year budgets and immediate concerns, with little capacity to address long-lived problems. In the United States, only the Supreme Court has been endowed with the capacity to think far into the future on behalf of the nation. And, although the Supreme Court has weighed in on a variety of environmental issues, its role is not a regulatory one or necessarily one giving primacy to the effects of pollutants on future generations.

This problem of managing some types of intergenerational environmental issues suggests that the nation may benefit from institutional innovation in capacity to think long term—maybe something like a "science court." Might a Supreme Court for Intergenerational Resource Allocation make sense?

In 1967, the physicist and engineer Arthur Kantrowitz proposed establishment of a group of independent, neutral, and technical experts that would hear opposing viewpoints publicly. A presidential task force supported the idea—which the media had dubbed a "science court"—and noted that "in almost all cases, the boundary between knowledge and ignorance will continuously shift and revisions to take account of new knowledge may have to be made frequently when issues of great national importance are at stake." The idea of a science court has since been studied by experts in law, science, and technology policy (see Further

Reading). These studies have focused on other rationale for a science court, however, not on its possible advantages in hearing cases centered on the problem of long-lived environmental concerns.

Since Kantrowitz's idea, the National Research Council and science advisory boards of government agencies have evolved to offer some advice on a host of national problems, including environmental concerns. But these efforts lack the continuity inherent in a standing body of tenured judges and remain stove-piped among agencies, thus unable to treat long-lived concerns as a unique class of problems. A science court could be a solution to provide sustained capacity for objective, dispassionate, consistent, and forward-looking environmental stewardship that is otherwise not practicable among existing institutions.

The potential attributes would be that the court judges would not be subject to election cycles, would enjoy appointments for life, and would hear evidence and make decisions on the basis of science and reasoned argument. The court also would be the body entrusted to adjust decisions in light of new science—such as evidence of greater accumulations of pharmaceutical residues, growing concentrations of greenhouse gases, the propagation of space debris, and so forth. And importantly, the court would keep latent environmental problems prominent before the public.

The court could insist on use of such state-of-the-art tools as structured expert judgment and expert elicitation and require the collection of information critical to decisions about long-term problems. This would benefit scientists and the public alike because few of these data are routinely collected despite their critical role in understanding the effects of long-lived pollutants.

The court could be established by an act of Congress (just as Congress recently created the US Foreign Intelligence Surveillance Court), with members appointed by the president and subject to Senate confirmation.

Shy of this step, another action that seems particularly suited to help in coping with long-term pollutants is more routine use of sunset provisions in public policies to make explicit that rules will terminate (with new ones put in place), forcing an "on ramp" for both the collection and admitting of new scientific data about mounting environmental problems. Another step could be greater use of price signals, such as taxes and fees, established with explicit dates at which prices will be adjusted in light of new information.

These actions fully complement a science court, should one be instituted. No doubt there are other approaches to be considered. Rethinking long-lived environmental concerns as a unique class of problems could in fact make them less "forever ours," enabling us to assure our great-great-grandchildren that these concerns will not be theirs. ● —Molly K. Macauley

This article draws partly from the Carolyn and Edward Wenk, Jr. Lecture in Technology and Public Policy given by Macauley at The Johns Hopkins University on April 27, 2012.

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Goeschl, Timo, Daniel Heyen, and Juan Moreno-Cruz. 2011. Long-Term Environmental Problems and Strategic Intergenerational Transfers. Working paper WP2011-009. Atlanta, GA: Georgia Tech School of Economics. www.econ.gatech.edu/research/workingpapers/2011.

Jurs, Andrew W. 2010. Science Court: Past Proposals, Current Considerations, and a Suggested Structure. *Virginia Journal of Law and Technology* 15(1): 1–42.

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Putting a Price on Carbon: Who Gets the Revenue?

One of the many questions governments must answer when setting a price on carbon is how to allocate the potentially very large revenues that a cap-and-trade or carbon tax program would generate. RFF Darius Gaskins Senior Fellow Dallas Burtraw argues that two perspectives are emerging based on property rights: one views the atmosphere as property of the government, the other as a common-pool resource shared by its citizens. *Resources* sat down with Burtraw to discuss how this choice affects the efficiency and fairness of a given carbon-pricing program, and what these consequences mean for the political economy and likelihood of climate policy.

RESOURCES: One of the first and most notable cases of using incentives to manage pollution in the United States was the regulation of sulfur dioxide emissions through a cap-and-trade program under the Clean Air Act Amendments of 1990. In that case, the emissions allowances were given to firms based on their historical levels of pollution. You've pointed out that using the same strategy for greenhouse gas regulation could have some very important distributional implications.

DALLAS BURTRAW: The situation for carbon dioxide is very different than it was for sulfur dioxide in 1990, because carbon dioxide is ubiquitous through our economy. If we have a system that gives emissions allowances for free to firms in a competitive economy, we can expect them to forward those costs to consumers through a change in product prices, just in the same way they would a change in their cost for fuel or labor. So it puts industry in a situation of being able to charge consumers for something they themselves have received for free. The consequence can be the prospect for "windfall" profits—that is, changes in revenues that are greater than the changes in costs that the firms actually have to incur in order to reduce their emissions. This has occurred already in Europe.

RESOURCES: So when we create property rights in the environment and acknowledge this common property resource, are we actually creating a source of wealth?

BURTRAW: I would make the observation that the introduction of a price on carbon in the US economy would constitute the greatest creation of a federally enforced property right since the opening of the Great American West in the nineteenth century. The land obviously existed previously and was inhabited by Native Americans, just as our atmosphere exists already, and we all breathe it.

RESOURCES: You've identified two emerging paradigms for framing how we should treat this new wealth that's created.

BURTRAW: The two perspectives have to do with who receives this significant asset value. Is it inherently the property of government? That would justify using the

revenue to address fiscal problems and other resources problems. Or is it inherently the property of individuals? In this case, compensation could take the form of dividends paid directly back to households.

These represent two different world views: One is that the resource is the domain of government, belongs to government, and should be managed by government. The other is that the atmosphere is the common property of individuals even though government plays a role in how to manage it.

RESOURCES: This is no longer an abstract discussion. We're seeing governments around the world employing carbon pricing and having to decide what they'll do with the revenue. You and Samantha Sekar looked at six existing carbon-pricing programs in a recent paper: What are some of your insights?

BURTRAW: What we see is a clear trend away from free allocation to industry and toward auctioning or direct introduction of emissions fees. This creates a large sum of revenue to be allocated. We find a variety of examples in the six programs of how the revenues are used, and we were able to quantify the results of the policies.

In some programs, investments are being made that complement the goals of the program—for instance, investments in energy efficiency. But we also see two extremes taking form in terms of the different philosophical perspectives I just mentioned. One approach is that the revenues are used as part of a tax swap, essentially helping to contribute to general revenue and address the fiscal challenges of the state. The other is that dividends are paid directly back to individuals.

The best examples of this latter approach come from California, British Columbia, and Australia. Under California's cap-and-trade program, nearly half the revenue that's being collected in 2013 will be returned to individuals as dividends. In British Columbia, about 20 percent of the revenue collected under their carbon tax is returned as dividends to households. And in the Australian carbon tax program—which just began to take shape and now is in limbo because the country has just voted in a new prime minister—about 70 percent of revenues would be returned to households as dividends.

> The introduction of a price on carbon in the US economy would constitute the greatest creation of a federally enforced property right since the opening of the Great American West.

RESOURCES: How does the way we use the money from these kinds of programs affect the overall economic efficiency of the programs?

BURTRAW: The major lesson from public finance in looking at how we might introduce a price on carbon is that using the revenues to reduce distortionary taxes can lower the overall cost of the program. If you use the revenue created by introducing a price on carbon dioxide to reduce preexisting taxes, you can then essentially get a bounceback in economic growth and stimulate the economy. So that's one reason why a public finance economist will suggest a tax swap. Introducing a tax

on dirty goods, such as carbon dioxide, and using the revenue to offset preexisting taxes on things that we want to see—like more labor and more capital investment—can be good for the economy.

RESOURCES: It's interesting to see how this will play out because, even leaving aside the ethical and philosophical questions, these approaches play into questions of political economy.

BURTRAW: That's exactly the point the proponents of a dividend approach embrace—the notion that it's politically reinforcing to give dividends because it has the prospect of making climate policy popular. People may not like to pay more for gas at the pump or more in their electricity bill, but it appears from the social science literature that getting checks back in the mail is what really lingers with us. People really look forward to that dividend as a special windfall in its own right.

But the other problem we face is that carbon is a ubiquitous pollutant in our society, and to address the challenges of climate change, it's going to be a very expensive venture. We're going to need to find a way to do it that poses the least cost on our economy and helps the economy to grow—because to the extent that the economy grows, that's good for everyone. The efficiency benefits of using revenues to reduce preexisting taxes can be substantial compared to other approaches.

This frames a central dilemma in having to choose between two options that each have their downsides. The more efficient approach of using revenues to reduce preexisting taxes may be perceived to have unfair distributional outcomes. A dividend approach, which seems eminently more fair, may have large efficiency costs compared to the alternative.

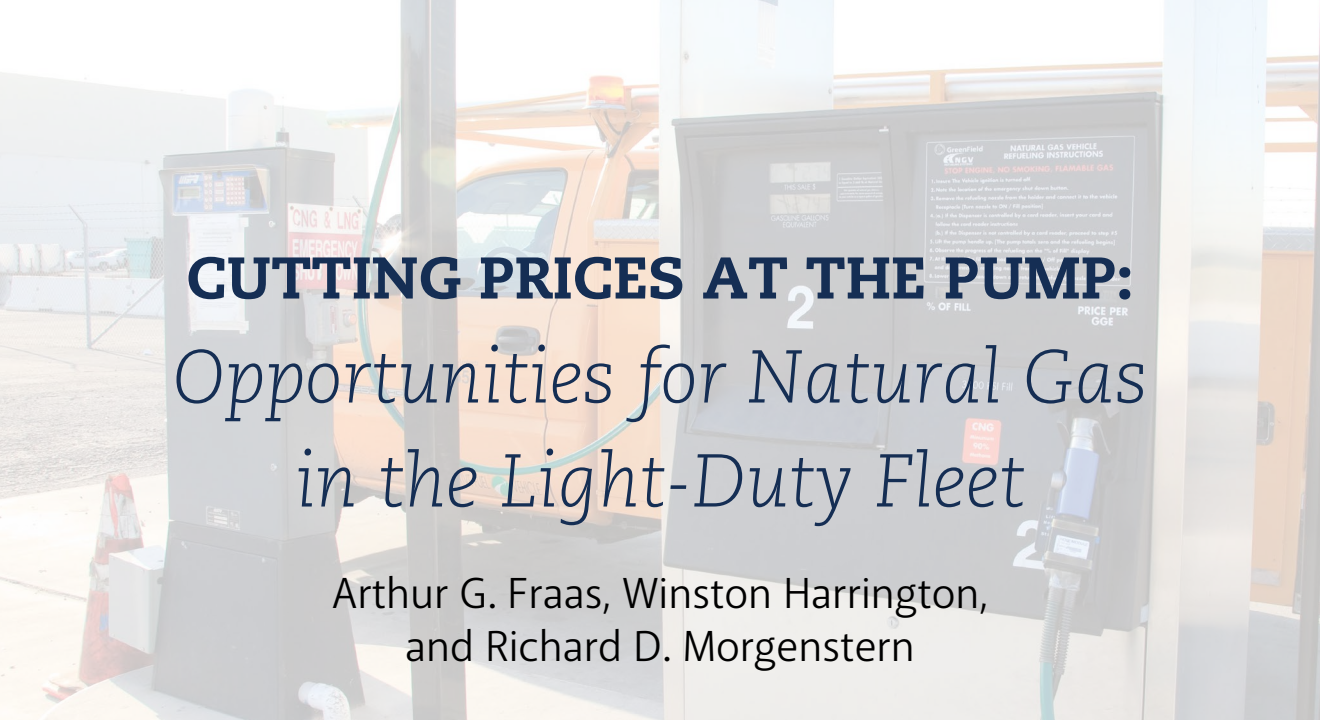
RESOURCES: Another point you touch on in the paper is that carbon is a global pollutant—and it's also a stock pollutant. Particularly when you have a situation where the stock has been added to by developed countries, is there an ethical property right case to be made that the revenue should be recycled to countries outside the developed world on a per capita basis?

BURTRAW: You can take the reasoning of introducing dividends in the domestic economy and say, "Shouldn't that apply internationally? Shouldn't everybody get an equal share of the atmosphere?" There's strength to that logic, but I think it's undermined by the fact that different parts of the world exist under different property rights regimes, and many parts of the developing world have not bought into a climate policy regime under which they take on obligations for reducing their own carbon emissions. So in the absence of a legal framework for shared property rights, I think it's unreasonable to make the leap from using dividends in the domestic economy to using dividends on an international basis. But somewhere down the road, under optimistic scenarios about international agreements, that conversation may be had. ●

Listen to a podcast of the full interview at www.rff.org/BurtrawQA.

FURTHER READING

Burtraw, Dallas, and Samantha Sekar. 2013. Two World Views on Carbon Revenues. Discussion paper 13-32. Washington, DC: RFF.



CUTTING PRICES AT THE PUMP:

Opportunities for Natural Gas in the Light-Duty Fleet

Arthur G. Fraas, Winston Harrington, and Richard D. Morgenstern

Natural gas prices in the United States have dropped almost 50 percent over the last decade thanks to the shale gas revolution. Oil prices, on the other hand, have more than doubled during that time. The change in the relative prices of these two fuels—combined with significant advances in both fuel and vehicle technologies—creates an opportunity to expand the use of natural gas in the light-duty fleet of cars and trucks and lower prices at the pump. Ethanol, methanol, compressed natural gas (CNG), and liquid petroleum gas (LPG) are four natural gas–based fuels that may be able to do just that.

Although these fuels could yield significant cost savings relative to conventional gasoline in the light-duty fleet, the principal beneficiaries of these fuel and technology trends are currently limited to the estimated 250,000 owners of CNG- and LPG-capable vehicles.

Another 10 million flex-fuel vehicles on the road today are capable of burning E85, a blend of 85 percent ethanol and 15 percent gasoline. Although E85 is not currently cheaper on an energy-equivalent basis at the pump than conventional gasoline in most areas, newly developed technologies offer the promise that low-cost, natural gas–derived ethanol can be produced in the future.

In our recent research, we compared the costs of E85 produced using these new technologies with conventional gasoline, estimating the volume of fuel required to propel a vehicle the same distance (expressed in gasoline gallon equivalents). For the most favorable case, E85 could be produced and sold for $0.31 to $0.59 per gasoline gallon equivalent below the current price of gasoline in selected urban areas across the United States. This amounts to annual savings ranging from $157 to $439 for a vehicle driven 15,000 miles per year, depending on a range of assumptions. Based on 2015 fuel price projections by the US Energy Information Administration, these savings could increase substantially in later years.

Significant opportunities exist to convert conventional gasoline vehicles to E85. The US Environmental Protection Agency (EPA) has certified just one E85 conversion kit, costing $1,300. However, there appears to be considerable potential to expand the number and type of approved kits and drive down the price substantially, perhaps

by 75 percent or more. Payback for such a conversion could be as short as six months, depending on location, timing, vehicle fuel economy, and miles driven.

For methanol, the information is less precise. Based on a range of assumptions, however, including those about the development of a methanol fuel network, we find that the development and production of methanol-capable vehicles could be an attractive economic proposition.

For both CNG and LPG, the conversion costs are considerably higher, on the order of $5,000 to $10,000 per vehicle. For these fuels, conversion makes economic sense only for large, heavy vehicles with high usage rates.

In our research, we assumed that the regulatory landscape will remain unchanged for the foreseeable future. However, one can imagine regulatory changes that could either help or hinder the development and deployment of natural gas fuels. An example of the former would be an expedited, simplified process for obtaining EPA certification of conversion kits, which would probably drive down kit prices. An example of the latter would be an expanded mandate for the sale of biogenic ethanol, which could operate to bring more cellulosic-based E85 into the market and shrink demand for the natural gas–based product.

Despite our general optimism about the future for natural gas fuels in the light-duty fleet, there is clearly a chicken-and-egg issue of bringing the fuels to market and developing a sizable fleet of flex-fuel or dedicated vehicles capable of using them. We are at the beginning of a potentially long, complex, and highly uncertain process of market transformation. Success hinges on many factors, not the least of which are the ability and willingness of firms to produce and market E85 and other natural gas–based fuels at the forecast prices. Other uncertainties include the interest of conversion kit manufacturers in developing low-cost kits, as well as trends in natural gas and oil prices. ●

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The Social Benefits of Natural Gas–Based Fuels

Apart from bringing down fuel prices, the use of natural gas fuels also may improve energy security and benefit the environment. For example, sharp increases in world oil prices can reduce US aggregate consumption and demand, potentially triggering a recession. Substituting inexpensive natural gas fuels for gasoline made from crude oil shields us from this effect. Put into monetary terms, this energy security benefit could be on the order of $0.20 per gallon of gasoline saved.

With respect to air pollution benefits, current estimates indicate that (with a few exceptions) the emissions of light-duty vehicles using conventional gasoline and their natural gas–based alternatives are comparable. And although the shift to alternative fuels may decrease emissions of certain gasoline-related air toxics, such as benzene, it is likely to increase aldehyde emissions. More research is needed on the potential trade-offs between these pollutants.

The situation remains similarly murky regarding local environmental consequences of shale gas development, as well as the uncertain greenhouse gas emissions resulting from leakage during the production and transport of the gas.

Business Motivations

FOR CONSERVATION

Conservationists can stimulate pro-environment business practices, ***James W. Boyd*** *argues, particularly if they learn to think like companies —and beyond regulation.*

Business decisions have a huge impact on natural resource use and environmental quality, so the ability to influence these decisions presents an opportunity for significant conservation gains. How can conservationists tap into the range of factors that drive business behavior and motivate businesses to invest in conservation efforts?

Not surprisingly, most theories of business behavior emphasize financial motivations. A powerful, but incomplete theory is that businesses do not care about the environmental costs they impose on others because "externalized" costs do not affect profitability. The corollary is that environmentally beneficial behavior can be motivated by the imposition of those costs on firms. The need to internalize otherwise external social costs justifies most modern environmental laws and regulations.

Conservationists can focus their advocacy around new, reformed, or expanded government policies to internalize a broader suite of environmental costs on businesses, regulate or prohibit activities at odds with conservation goals, or subsidize desirable conservation behaviors. This strategy resulted in landmark policy and legal innovations in the 1960s and 1970s, and it continues today. But lobbying government to enact such policies is not the only strategy available to conservation advocates.

Businesses routinely engage in environmentally beneficial behaviors that are not motivated directly by statutes or regulations. They take a variety of actions that go beyond compliance with environmental regulations and can loosely be described as voluntary. But while voluntary, these actions are not necessarily altruistic; profits do rule the day. However, pro-environment business behaviors are driven by a range of consumer, business partner, and community factors—all of which are points of leverage for conservation advocates.

How Consumers Motivate Business Decisions

Most obviously, businesses sell their products to consumers who may desire—and be willing to pay for—environmentally beneficial products and services. In some cases, the products and services themselves may be less environmentally damaging, such as biodegradable packaging or low-emissions vehicles. In other cases, the environmental benefit may arise from the product's broader ecological footprint, related to its production processes or resource demands—think shade-grown coffee. In addition, marketing surveys and some economic analyses suggest that consumer perceptions of firms' social and environmental sustainability influence consumer choices and behavior.

The degree to which consumer motivations are environmentally effective and good for business depends in large part on how well consumers can assess a product's or company's environmental performance. If "green" features are fairly clear, companies can market those features directly to consumers. However, it is often difficult for consumers to observe and verify a product or company's environmental features, performance, or footprint. For example, the

Pro-environment business behaviors are driven by a range of consumer, business partner, and community factors—all of which are points of leverage for conservation advocates.

environmental features of many products are associated with their production, by-products, recycling, or disposal rather than anything directly experienced by the consumer. And many consumer products involve vast supply chains where the environmental performance of a given link is nearly impossible to observe.

This situation can lead to consumer skepticism about green marketing claims, which reduces the price premium that a business can charge for environmentally beneficial products. In turn, this means that businesses may not be able to recoup the costs of green products or profit sufficiently to make their development worthwhile from a business perspective. The public, environmentalists, and businesses have a collective interest in addressing this market failure.

Harnessing individual consumer motivations sometimes requires intervention via information-based programs. Labeling and certification programs, if properly executed, provide consumers with an independent, and thus presumably credible, signal of the environmental quality of a product, process, or company. If consumers can rely on this signal, their willingness to pay a premium and businesses' subsequent willingness to provide high-quality products are restored.

A variety of voluntary information-related programs are also closely linked to environmental performance. Consumers can rely on a range of green signals provided by government certification programs, such as the Energy Star label, recycled content information, and fuel-efficiency

ratings. In general, these programs operate as partnerships between government and businesses. In exchange for salutary environmental behavior, businesses are able to brand themselves as environmentally advanced, using the government program and its imprimatur as evidence.

In some cases, the private sector establishes its own programs for certification and standards, primarily to deal with supply chain information issues. An example is the American National Standards Institute that, via the International Organization for Standardization, developed the ISO 14000 environmental certification program. The Forest Stewardship Council, which certifies sustainable forest products, is another example. Web-based applications also are being created by independent firms to provide consumers with easily accessible product ratings (GoodGuide.com is one notable example).

Studies suggest that the firms most likely to participate in voluntary programs tend to be larger, produce final consumer goods (where public values are likely to be most influential), and be exposed to pressure from advocacy groups and the public.

Partnering for Environmental Branding

A related tactic involves partnerships between environmental groups and businesses. Some prominent examples include the following:

» the Sierra Club's endorsement of Clorox's Green Works line of biodegradable cleaners,

» the National Audubon Society's partnership with Monsanto to develop protection plans for waterfowl habitat near the company's industrial farms,

» the Wildlife Conservation Society's certification of forestry products from Congolaise Industrielle des Bois, and

» the environmental assessments provided to BP by Conservation International and The Nature Conservancy.

Environmental NGOs can provide businesses with technical assistance due to their expertise with environmental analysis and planning. Several of the above examples (such as the partnerships with BP) take this form. But the NGOs also are providing businesses with powerful branding tools. In some cases, a branding relationship can take a particularly direct form—as when Clorox placed the Sierra Club's logo on its Green Works products. But even without logo placements, the relationship itself is publicized in other ways, such as through advertising campaigns, websites, and annual environmental reports.

NGO–business partnerships are controversial within the environmental community. In part, this reflects the environmental community's differences of opinion over political tactics—specifically, whether it is better to work "with" or "against" the business community. But critics also note that when money changes hands (as it did in some form for all of the examples listed above), this undermines the NGO's independence and credibility as a certifier.

"Political" Motivations for Overcompliance

Because politics can determine changes in law and regulation, businesses and other stakeholders have an incentive to influence

Positive environmental behavior today can influence politics, regulation, and stakeholders in ways that improve future business profitability.

the political process. Most of the related insights ahead follow a basic intuition: positive environmental behavior today can influence politics, regulation, and stakeholders in ways that improve future business profitability.

Some firms or whole industries may position themselves as environmental leaders by overcomplying in order to reduce the incentive of environmental interests to organize and lobby for tighter regulatory standards. Similarly, because monitoring and enforcement resources are limited and regulators lack compliance information prior to monitoring, they may target firms considered more likely to be noncompliant.

Firms also often require contentious local approvals—such as zoning permits—in order to site their facilities. Corporate reputation can be important to the success or failure of these political deliberations, as well.

Firms understand that regulation can have a differential effect on competitors in an industry. For example, DuPont supported a ban on chlorofluorocarbons, at least in part because it had developed a substitute, a non-ozone-depleting chemical that would be in demand once the ban was in place. The regulatory ban, in effect, gave it a competitive advantage over technologically lagging rivals.

Supply Chain and Business-to-Business Motivations

The production of almost all consumer goods and services involves "chained" business relationships among suppliers, manufacturers, distributors, and retailers. Walmart is estimated to have 57,000 suppliers in the United States alone, with tens of thousands more internationally. The average automobile is composed of 20,000 different parts, produced by thousands of different suppliers. Apple, a far more vertically integrated company, has supplier relationships with 156 different companies (and each of those has its own supplier relationships).

Large global brands are increasingly concerned not only with their own reputations and environmental performance but also with the reputations and practices of their suppliers. Apple doesn't make its own logic boards; Tiffany & Co. doesn't mine its own diamonds; Walmart doesn't make its own T-shirts; and Starbucks doesn't grow its own coffee. But consumers understand that when they purchase from those companies, they are indirectly supporting those supply chains. For example, consumer reaction to the labor practices of Nike suppliers in the 1990s created a crisis for the company, as its brand became associated with unaccept-

ably low wages and abusive factory conditions in the developing world.

Many of the supply chain impacts of greatest concern involve suppliers in different countries, in the developing world in particular. In general, it is very difficult—if not impossible—for US law and regulation to directly affect international environmental behavior. Supply chain incentives are therefore more likely to be driven by more "informal" profit motives.

Earlier, I mentioned third-party certification as an informational device in the context of end-product consumers. But certification is arguably of greater importance between business partners. Firms wishing to purchase green inputs from suppliers and other business partners may find it difficult to judge the environmental quality or impacts of their suppliers' products. The certification of wood products is a good example. Lumber retailers are far removed (geographically and contractually) from the forest managers and landowners, many of them in the developing world, responsible for harvesting practices. A firm whose reputation is vulnerable to charges of poor environmental stewardship therefore benefits greatly from an intermediary certifying institution.

A related strategy is for firms to audit supplier conduct and transparently disclose supplier information. For example, in 2012, Apple joined Nike, Intel, and Hewlett-Packard in publicly disclosing a list of its major suppliers. Alone, such disclosure is no guarantee of environmental performance. But it makes identification (and oversight) of these companies easier for stakeholders.

These kinds of supply chain initiatives are fairly recent, not particularly widespread, and often the result of external pressure, like boycotts and bad publicity, rather than more proactive strategies. It is also not a coincidence that supply chain behaviors tend to be associated with large, well-known brands. Branding is a competitive strategy to generate consumer loyalty, awareness, and publicity. The flip side of this strategy is that valuable brands are particularly sensitive to stakeholder pressure and negative publicity: they have more to lose if that brand is tarnished and inherently draw more public attention. These same factors also make valuable brands particularly desirable targets for advocacy pressure.

Valuable brands are particularly sensitive to stakeholder pressure and negative publicity: they have more to lose if that brand is tarnished and inherently draw more public attention.

Concluding Thoughts

Businesses are strategic and sophisticated when it comes to the richer social and political factors that affect their long-run profitability, routinely using "beyond-compliance" strategies to gain competitive advantage. Understanding the motivations for these strategies can inform the conservation community's own strategies.

A concluding thought relates to the investment community's unique power to affect business behavior. "Corporate social responsibility" is a generic term used for many of the business behaviors I've described. Over the past several decades, there has been significant growth in so-called socially responsible investment vehicles. As of 2012, 11 percent of dollars

under professional management in the United States were in such funds (representing $3.31 trillion, compared to $639 billion in 1995). The most obvious explanation for such funds is that they identify portfolios that outperform comparable investments that are not socially responsible. Given the various profit motivations for beyond-compliance products, investments, and practices described above, a reasonable hypothesis is that firms adopting them, particularly in aggregate, would see above-average market performance.

In fact, the ultimate test of whether the environmental motivations described above do, in fact, explain business behavior is whether or not they can be related to a firm's profitability. Here, I must admit that the evidence is mixed (see the box below). This is due in part to the difficulty of defining and measuring environmentally responsible behavior. It also suggests that conservationists should interact directly with the investor community to better understand profit-driven points of leverage. ●

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Are Environmentally Responsible Firms More Profitable?

Studies show that socially responsible investments underperform or are statistically indistinguishable from conventional investments. A meta-analysis of such studies by Harvard Business School's Joshua Margolis and colleagues found that, for a significant majority of firms, the relationship between corporate social responsibility and profitability was not statistically significant. However, a more positive spin on that study's findings is that socially responsible behavior reduced profitability in less than 2 percent of the companies in the sample.

One problem is that corporate social responsibility is often defined and quantified in ways that are more cosmetic than substantive. For these reasons, the findings of the literature on social responsibility and financial market performance leave something to be desired.

A recent study by Harvard Business School professor Robert Eccles and colleagues looks more concretely at firm-specific practices. The study stratified firms into two samples based on managerial and environmental practices. Interestingly, the study found that "high-sustainability" firms, defined as those exhibiting such practices, significantly outperformed their "low-sustainability" counterparts over an 18-year period ending in 2010. Specifically, $1 invested in the former portfolio would have grown to $22.60 over the period, compared with $15.40 in the latter.

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Negotiating a **POST-2020 CLIMATE AGREEMENT** *in a Mosaic World*

As we approach the end game of serious negotiations for a post-2020 international climate regime, ***Brian Flannery*** *describes the difficult road ahead.*

Architects of the 1997 Kyoto Protocol believed it would usher in a long-term, top-down process for mitigating climate change, with a growing set of nations taking on increasingly ambitious greenhouse gas emissions targets and carbon markets playing a central role. That has not happened.

Instead, the world has moved to a bottom-up approach, where nations take on self-determined obligations based on national priorities and circumstances—an approach that I characterize as a "mosaic world." In the mosaic world, for many developed and developing nations, carbon markets play no role. Though it promises less, proceeding under a mosaic approach may ultimately accomplish more than insisting on a top-down approach, which runs the very real risk of reducing participation by many countries that account for significant emissions globally. Without their participation, ambitious goals will never be met.

Tension over these approaches are on display as nations commence serious negotiations to develop a post-2020 agreement to be concluded in Paris in late 2015, at the 21st meeting of the Conference of Parties (COP-21). Since the very visible failure to reach an agreement in Copenhagen in 2009 (COP-15), nations have grown increasingly frustrated and concerned over the viability of negotiations under the United Nations Framework Convention on Climate Change (UNFCCC). In part, this arises from a growing legacy of unmet expectations.

As the negotiations become increasingly complex, fundamental differences continue to grow and separate various coalitions of nations. Groups have yet to resolve central issues, including the following:

» the magnitude of national emissions commitments, and whether they should put the world on track to limit warming to less than 2°C;

» the means of implementation—particularly finance, but also technology and capacity building;

» how the agreement will reflect differences between developed and developing nations based on common but differentiated responsibilities, equity, and historical responsibility; and

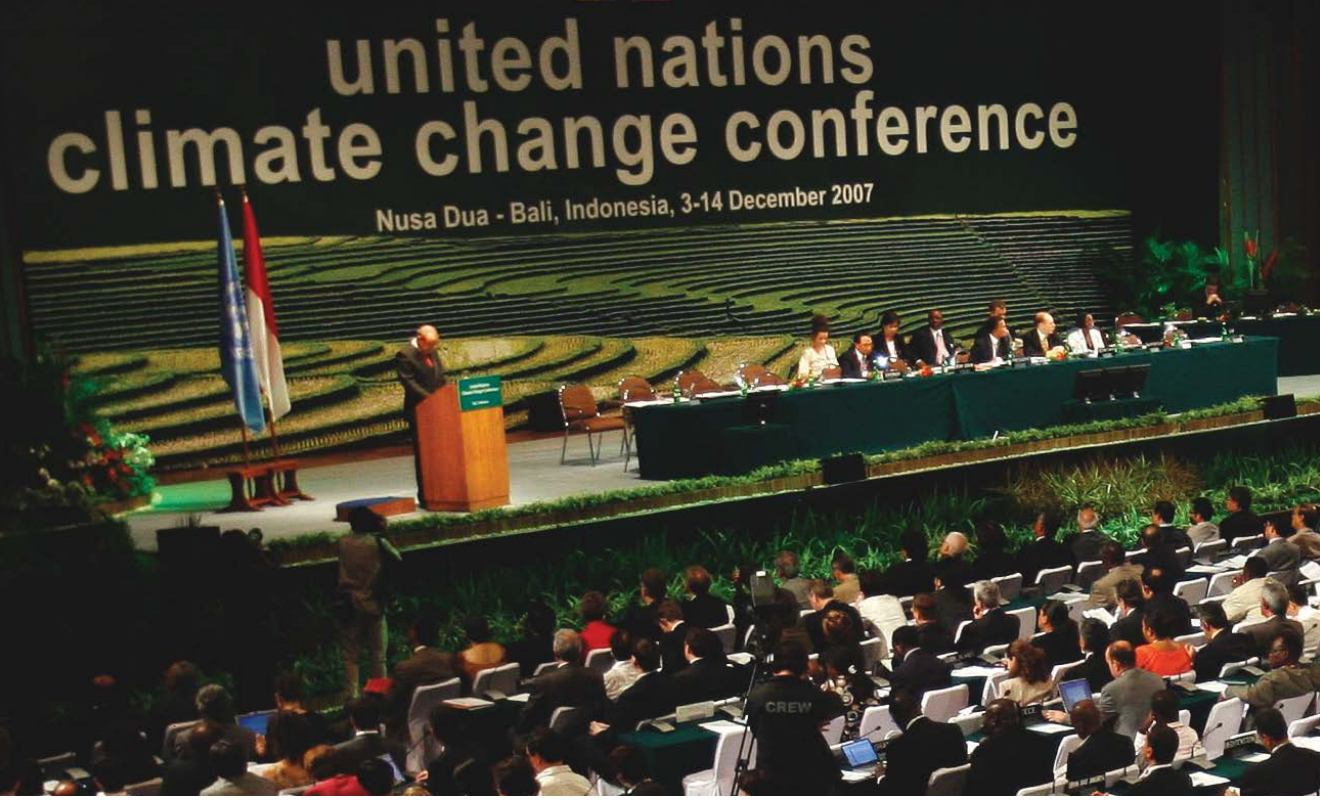
» whether the ultimate agreement will be legally binding.

Given these differences and the realities of today's mosaic world, progress in Paris may depend on whether nations can embrace bottom-up commitments in lieu of a more ambitious top-down, legally binding approach.

Demise of the Top-Down Climate Process

The Bali Action Plan, adopted in 2007 at COP-13, was framed to address progress after Kyoto's first commitment period ended in 2012. It created huge expectations for an agreement in Copenhagen in 2009. Many anticipated a deal with both significant financial aid and ambitious emissions commitments, not only from developed nations, but also from major developing nations. However, developing nations never embraced the idea that such obligations would apply to them. In their preferred approach, embodied in the principle of common but differentiated responsibilities, legally binding commitments only obligated developed nations, which should take action through the Kyoto Protocol.

Bali was potentially significant in other ways as well. For the first time, it created a framework in which developing countries were also expected to take on meaningful commitments to reduce emissions—a significant break with the tradition of the UNFCCC and the Kyoto Protocol. It remains to be seen whether this break will manifest in the post-2020 agreement.



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Tensions climaxed in Copenhagen. Advocates for the top-down approach rallied considerable pressure and media attention, trying to force an ambitious outcome. Yet major developed and developing nations recognized the lack of support for a formal deal. Consequently, even before Copenhagen, they announced their intention to reach a political agreement, rather than the legally binding one called for in Bali. Leaders from a handful of major developed and developing nations established the Copenhagen Accord outside the COP process. Ultimately, the accord led to voluntary emissions pledges through 2020 by most nations. But many of the pledges are hedged with caveats and framed using vague concepts, such as promising improvements relative to a business-as-usual baseline.

Besides mitigation, discussions along the way to Copenhagen raised hopes for hundreds of billions of dollars in secure, additional financial aid to assist developing countries in mitigating emissions and adapting to climate change. At Copenhagen, the developed world pledged "to mobilize" $100 billion per year of new aid by 2020, but funding of this scale seems politically unlikely to be forthcoming, depending on how politicians ultimately resolve the meaning of "to mobilize."

Developing nations were not the only ones to refuse emissions-reductions obligations under Kyoto. The United States never ratified the protocol; Canada never implemented it; and Japan, later joined by New Zealand and Russia, withdrew at the end of the first commitment period.

Challenges for the Post-2020 Agreement

Following the public disagreements at COP-15, attention to the UNFCCC waned, and many observers and participants lost interest. Little has changed to quell frustration, with seemingly endless delays and failure to make meaningful progress. Nonetheless, COP-21 in Paris in 2015 is certain to draw increased interest and scrutiny, especially coupled with the ongoing rollout over the next several months of the 5th Assessment Report of the Intergovernmental Panel on Climate Change.

Since Copenhagen, meetings of the COP in Cancun (2010), Durban (2011), and Doha (2012) sought to restore trust in the multilateral UNFCCC process. They succeeded to a degree, but confidence remains fragile. Doha managed to adopt a second Kyoto commitment period (though without participation by Canada, Japan, New Zealand, Russia, or the United States) and progressed the work of the Ad Hoc Working Group on the Durban Platform for Enhanced Action (ADP), the body responsible for negotiation of the post-2020 agreement. ADP's ambitious mandate calls for progress in two areas: negotiating the post-2020 agreement by 2015 and, in the period before 2020, closing what ADP calls the "ambition gap" between the aggregate effect of mitigation pledges and the emissions cuts likely to hold the increase in global average temperature below 2°C.

The post-2020 agreement faces daunting substantive and procedural challenges. Indeed, limiting global temperature rise to 2°C would require major emitting nations to reduce emissions by 50 to 80 percent by 2050. Many, including rapidly growing developing countries, are unwilling to accept such stringent targets. In addition, estimates of the financial aid required to assist developing countries indicate that needs would rise from hundreds of billions of dollars per year in the near future to trillions of dollars per year by 2050.

Financial aid poses many other complex matters, fueling open-ended arguments for aid and compensation to address adaptation, adverse impacts on developing nations of response measures in developed nations, and loss and damages from the impacts of climate change. These are serious issues, but electorates and politicians in developed nations seem broadly unaware of and unlikely to support moves in these directions. Nonetheless, UNFCCC debates over funding now encompass mitigation and adaptation as well as the impacts of policies and of climate change itself. Each carries a price tag arguably in the hundreds of billions of dollars per year—and each has contentious political and technical aspects.

Besides the amount of funding itself, establishing procedures to decide which activities to fund remains a challenge. For example, developing nations are formulating proposals for nationally appropriate mitigation actions (NAMAs). However, it remains unclear whether adequate resources will be available to fund such actions or what process will be used to match funding to individual NAMAs.

Complexity also hampers progress. A typical COP meeting lasting 10 days must find space and time to accommodate dozens and dozens of meetings and contact groups, with no more than two official meetings occurring at one time. Procedural complexity makes it difficult for any nation or observer group to be aware of or understand all that is happening. Many agenda items inextricably link to others. This is not only confusing—it provides ample opportunity for nations wishing to stall or create

pressure to use complexity and linkages to slow the process. Nothing is decided until everything is decided as a package.

As an example, negotiators of the post-2020 agreement are contemplating an array of new mitigation approaches, such as new market mechanisms; nonmarket mechanisms; approaches involving agriculture, land use, and forestry; sectoral approaches; and a catchall umbrella topic: the framework for various approaches. No one is at all clear how these new approaches will work individually or in combination. Matters are further complicated by how they interact with the Clean Development Mechanism and NAMAs; the potential for double counting; and whether there will be common, accepted international norms for measurement, reporting, and verification (MRV).

Developing nations also stress the importance of addressing the means of implementation in the new agreement. Besides finance, this includes access to technology and capacity building. Over the past few years, intellectual property rights (IPRs) have become a particularly thorny issue. Led by India, many developing nations claim they should have unfettered access to climate-related IPRs as a public good. At a minimum, this would include access to any technology that produces or uses energy, such as power plants, fuels, and technologies that increase energy efficiency. Developed nations, led especially by the United States and Japan, have declared protection of these rights to be nonnegotiable. In their view, the UNFCCC should not become a forum for such discussions because competent international forums already exist. Business groups strongly oppose such a far-ranging assault on intellectual property, pointing out that this threatens the incentive for companies to invest in research and development, and that IPRs can promote technology deployment.

Differences exist over the even more fundamental issue of whether the ultimate agreement will be legally binding, with comparable mitigation commitments by all nations, and with compliance and common international rules for MRV. The United States and some others call essentially for an international pledge-and-review process, with compliance and many aspects of MRV governed by domestic, not international, laws and rules. This view is at odds with that of the European Union and developing nations, who insist that the agreement must impose legally binding consequences and internationally agreed-upon rules.

Important coalitions of nations also have grown as issues proliferate. Most fundamentally, the Alliance of Small Island States sees achieving the 2°C goal as a matter of their survival, yet the BASIC nations (Brazil, South Africa, India, and China) refuse to acknowledge that this would require significant emissions reductions not only by the developed world but also on their part. Splits exist within the developing world on questions involving IPRs and carbon capture and storage, among others, and between developed and developing nations on the use of border taxes.

Combining Bottom-Up and Top-Down Approaches

While many divisions exist, some shared views are emerging. All parties seem to agree that a hybrid approach will be necessary to develop ultimate commitments. This starts with bottom-up, voluntary, self-determined pledges brought forward by individual nations. Parties seem to agree that this will be followed by an ex ante period for discussion and assessment of national proposals and analyses of implications for global outcomes.

Disagreement exists over whether the next top-down step consists solely of

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an analytical element, or whether it also involves a forced reconciliation to achieve global goals. In particular, those favoring a top-down approach insist that the new agreement should put the world on track to limit global warming to less than 2°C. In any case, the process of making pledges, exchanging views, and analyzing global impacts will be complicated and require a significant amount of time. It is unclear whether all this is to occur before adoption of the agreement in 2015 or whether the analysis and later phases might occur between now and 2020.

Prospects

With stark differences among key groups on a variety of issues and constraints from the lingering economic downturn, it is difficult to see how significant progress can occur in the next 24 months. On the other hand, negotiators have been adept over the last several years at "kicking the can down the road," delaying agreements now with the promise of progress later. Perhaps they will find a way to do so again. But failure to conclude an agreement will not be the fault of the negotiators. The differences are fundamental and require a political deal at the level of heads of state.

In this mosaic world, it seems that the ultimate climate agreement is more likely to reflect bottom-up pledges based on national priorities and circumstances than a forced, top-down reconciliation designed to meet nonbinding, aspirational global goals.

With COP-19 in Warsaw just concluded, the basic messages in this article require no change as it goes to press. Indeed, developments in Japan and Australia underscore the challenge of unmet expectations. However, two additional factors are worth notice. First, unlike the period of vigorous public debate leading to Kyoto in 1997, to date there has been surprisingly little analysis or dialogue regarding what commitment the United States may make for the post-2020 period. Second, as discussed, the ADP seeks more ambitious mitigation efforts and clarity on finance before 2020. Nations continuing in the Kyoto Protocol have an explicit opportunity, by April 30 of next year, to increase the ambition of their commitment. Those, like the United States, outside the Kyoto Protocol also are being challenged to do more now on mitigation and finance. In considering their participation and contributions post-2020, developing nations will be looking for signs of “good faith” that developed nations will make greater efforts now. ●


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GETTING TO AN EFFICIENT CARBON TAX

How the Revenue Is Used Matters

Results from an innovative model run by ***Jared Carbone****,* ***Richard D. Morgenstern****,* ***Roberton C. Williams III****, and* ***Dallas Burtraw*** *reveal the most efficient uses of the trillions of dollars in revenue a carbon tax could raise over the next decade.*

Despite the widespread view among economists and policymakers that the US federal tax system needs reform over the long term, there is little consensus on the specifics. The system is inefficient, excessively distorting the economy for the amount of revenue raised. The notion of lower marginal tax rates and a broader base has wide appeal, but no politically feasible path to achieve such goals is apparent. Further, short of substantial cuts in federal programs at a scale and scope not being seriously considered, the need for at least some more tax revenue over the long term seems almost inevitable. How those revenues should be raised is an open question.

Accounting for recent tax hikes, the sequester, and other spending cuts, current projections by the Congressional Budget Office (CBO) show a substantially lower near-term federal deficit, now projected at $560 billion for 2014 and $378 billion for 2015. Nonetheless, the long-run fiscal forecast is quite gloomy. CBO expects

the federal deficit to start rising again in 2016—with debt levels reaching 73.6 percent of gross domestic product (GDP) by 2023, almost twice the 2000 ratio—and to continue growing thereafter.

At the same time, the world faces the challenge of reducing emissions of carbon dioxide (CO_2) and other greenhouse gases to limit the effects of global climate change. Introducing a carbon tax as one element of tax reform can both provide revenue and reduce carbon emissions.

To analyze these scenarios, we created a new modeling framework (see About the Model) that enables the consideration of the budgetary, economic, distributional, and environmental implications of including such a measure as part of a fiscal reform initiative. Our focus is strictly on federal tax policy and the effects that alternative sources of revenue have on economic activity. The analysis does not consider the benefits of reducing greenhouse gas emissions. We examine three general directions for tax and deficit changes involving a carbon tax at three levels: \$20, \$30, and \$50 per ton of CO_2 (in 2012 dollars), beginning in 2015, and remaining constant in real terms thereafter.

In a first set of modeling simulations, we generate "revenue-neutral tax swaps," by substituting a carbon tax (in a revenue-neutral manner) for existing capital, labor, and consumption taxes or by returning carbon tax revenues via lump-sum rebates to households. In a second set of simulations, we study the effect of including a carbon tax in a package of measures to reduce the budget deficit. In a third set, we look at the carbon tax as a deficit-reduction tool by itself, with the tax revenue serving as a down payment on deficit reduction.

The results of our analysis show that holding all other taxes in the economy constant, the imposition of a carbon tax represents a potentially substantial revenue source for the United States, on the order of \$160 to \$360 billion in gross revenues per year, or \$1.6 to \$3.6 trillion over the decade (2012\$). How these revenues are used has a huge effect on the efficiency and fairness of a carbon tax policy.

About the Model

To run this analysis, we built a dynamic general-equilibrium, overlapping-generations (OLG) model of the US economy, which includes detail on government taxes and expenditures and substantial energy-sector information. As described in a previous *Resources* article on early results of this model (see Further Reading), a key feature is its more realistic depiction of households' decisions about work, savings, and consumption over their lifetimes. It contrasts other frameworks, which either model people as living forever or involve a one-time snapshot of households.

The OLG model has several advantages. First, it is well suited to examining the effects of changes in the timing of taxes or spending because, unlike most other models, which imply that government borrowing is fully offset by private-sector saving, this is not the case here. Second, the OLG model enables a more realistic analysis of the effects of tax policy on capital accumulation. Third, it lets us examine how different generations—baby boomers, new workers, and even future generations—are affected by policy reforms, including how they respond to those changes. No other model combines these three features, as is needed to address key questions about carbon taxes and fiscal policy.

A Revenue-Neutral Tax: Using the Revenues to Cut Other Taxes

Among the revenue-neutral tax reform options (which ignore the growing debt burden), we find that using the carbon tax revenues to cut noncarbon taxes has a range of effects.

Cutting capital taxes—corporate taxes or personal income rates on interest, dividends, or capital gains—produces the largest economic efficiency benefits, roughly offsetting the economic cost of the carbon tax. Without considering the environmental benefits from CO_2 emissions reductions, the net social costs are close to zero, depending on which measure of cost is used. We find that GDP rises slightly, but a more comprehensive measure shows a slight cost. Either way, the net costs are close to zero.

Another approach is to recycle the revenues by reducing labor taxes—in the form of payroll or personal income tax reductions. This option is less economically efficient than recycling via capital tax cuts, though the differences are relatively modest.

Recycling the revenues via lump-sum rebates to lower-income households (which are likely to be the most disadvantaged by a carbon tax) is worse for economic efficiency than any of the options that involve tax rate cuts. At the same time, as we discuss later, such rebates are most progressive in terms of their income distribution impacts.

Impacts on Different Generations

We also consider how the different options for revenue recycling affect individuals in different generations.

We find that using carbon tax revenues to fund lump-sum transfers or cuts in sales tax rates benefits older generations at the cost of younger generations. Using the revenues to fund cuts in labor tax rates has the opposite effect: younger generations do better than older generations under this option. And using carbon tax revenues for capital tax cuts yields net costs that vary relatively little across generations.

Impacts on Households

Distributional impacts in the near term are especially important to understand because the citizens alive today are the ones who will decide the policy. Looking across the different policies, the outcome for any given expenditure quintile varies significantly.

Part of the effect of a carbon tax on households comes through higher product prices. For those price increases, roughly half of the cost increase can be attributed to direct consumption of natural gas, heating oil, gasoline, air travel, and electricity. The rest comes from the purchase of products that require energy to manufacture and increased costs of services provided by institutions, such as those by government agencies and hospitals.

The largest category of spending on energy is for gasoline, for which the diversity across states appears to be relatively small. The diversity in electricity expenditures is somewhat greater, and it is greatest in the categories of natural gas and other fuels (primarily heating oil). On a per capita basis, the greatest level of spending on direct energy consumption occurs in the northeastern states.

Cutting capital taxes produces the largest economic efficiency benefits, roughly offsetting the economic cost of the carbon tax.

Authors Roberton Williams of RFF and Jared Carbone of the University of Calgary were among the presenters at RFF's seminar on the role of a carbon tax in tax reform and deficit reduction held on June 26, 2013.

Many of the states with the greatest use of coal in electricity generation currently have electricity (and overall energy) costs that are less than the average for the nation. They might expect to see a relatively large increase in energy costs with a carbon tax, but the net effect is a price leveling across the nation.

Lower-income households spend a greater portion of their income on direct energy consumption and may be especially adversely affected by the carbon tax. The carbon tax also may affect household incomes by changing wages and returns to capital (particularly in energy-intensive sectors of the economy). These changes are important, though they are more difficult to model than changes in product prices.

The effects of revenue recycling on households are likely to be more important than the effects of the carbon tax itself. Using revenues to fund capital tax cuts (or to prevent capital tax increases) disproportionately helps higher-income households. Returning revenue via per capita rebates disproportionately helps lower-income households. Cutting labor or consumption taxes falls somewhere in between.

The effects of revenue recycling on households are likely to be more important than the effects of the carbon tax itself.

Generating Revenue for Deficit Reduction

In the revenue-neutral scenarios we just described, we assume that federal expenditures will be cut and federal revenues increased in equal amounts, matching the 50–50 split embodied in the widely discussed Domenici–Rivlin Debt Reduction Task Force Plan 2.0. But the simulations focus strictly on revenue-side options: the use of carbon taxes versus capital, labor, or consumption taxes or lump-sum rebates to raise the required revenues.

The key difference in our next set of deficit-reduction scenarios is that we

compare a carbon tax to various noncarbon taxes and rebates as alternative means of raising revenues, recognizing the need for additional revenues. Unsurprisingly, the general pattern of results is very similar to that of the revenue-neutral scenarios.

Offsetting capital tax hikes provides the most economic benefits, followed by labor and consumption taxes and the provision of lump-sum dividends.

In terms of intergenerational impacts, using carbon tax revenues to offset increases in consumption tax rates benefits older generations at the cost of younger generations, using the revenues to offset hikes in the labor tax rate aids younger generations the most, and using carbon tax revenues to offset capital tax hikes yields net costs that vary relatively little across generations.

Parallel distributional impacts also arise in terms of distribution across income groups and regions of the country, although in the absence of household-level reductions in marginal rates or the provision of lump-sum dividends, the economic welfare impacts are all likely to be negative.

Paying Down the Deficit Earlier

Finally, we present initial results for a somewhat different approach, which might be described as an early down payment on debt reduction, involving an initial round of carbon taxes, which is followed by smaller increases in other taxes than would otherwise have been required to meet long-term deficit-reduction goals.

The results are quite striking: the carbon tax is consistently better for economic efficiency in this down-payment case than it is in the revenue-neutral case. Indeed, if the carbon tax down payment results in less need to increase capital taxes later, then the net cost of the carbon tax is negative (even ignoring any environmental benefits). This shows the substantial efficiency gains from addressing the budget deficit sooner rather than later. The intergenerational consequences may make this politically difficult, however: although this case is good for economic efficiency, it also makes every generation old enough to vote today worse off, on average, while benefiting all future generations.

Using a Carbon Tax to Lessen Trade-Offs

Tax policy has various competing goals, such as generating sufficient revenues for government while promoting economic growth and fairness. Tax policies also can be used to enhance the environment. So far, despite recent efforts, calls for broad-scale tax reform and deficit reduction have failed to yield substantial results.

Introducing a carbon tax adds a new element to the mix, unambiguously augmenting revenues and reducing CO_2 emissions. How the new revenues are used matters a great deal. Some options can enhance economic welfare and GDP growth; others impede it. At the same time, some options, if not well designed, may introduce inequities across generations, income groups, or regions of the country. In fact, decisions on the use of the revenues can have bigger effects on the distribution of outcomes across households than would substantial changes in the carbon tax rate. But even though it comes with its own set of difficult decisions, a carbon tax arguably lessens the trade-offs among the multiple goals and unambiguously advances environmental objectives. ●

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Would You Pay to Reduce Risks from Shale Gas Development?

Public Attitudes in Pennsylvania and Texas

A new survey brings an important stakeholder—the public—into the policy debate over shale gas development. ***Alan J. Krupnick*** *and* ***Juha Siikamäki*** *report the surprising results.*

In 2011, RFF's Center for Energy Economics and Policy (CEEP) launched an initiative to conduct an independent, broad assessment of the environmental risks associated with the shale gas development process. One key part of that project—our survey of experts from government agencies, industry, academia, and nongovernmental organizations—elicited rich information on the views of experts about understanding and prioritizing risks associated with shale gas development. However, the general public, which is an important stakeholder in the policy debate, may not be aware of experts' opinions or agree with them. To

help better understand public opinion and bring it into the policy debate, researchers at CEEP conducted a survey involving random sampling of the adult populations of Pennsylvania and Texas. The survey was designed to answer several questions:

» How much does the public know about shale gas development and fracking?

» How much does the public support shale gas development?

» How concerned is the public about the associated environmental and health risks?

» How much is the public willing to pay to reduce those risks?

» How does the type of information that people receive about shale gas development and its risks affect their beliefs and support?

By asking about participants' knowledge about the shale gas development process and risks, we hoped to determine how such knowledge affects support. We also experimented with giving survey respondents one of three different information "treatments" about the risks of shale gas development, to examine how malleable attitudes are in general and with respect to the type of information provided. Besides helping understand what drives public opinion, this information could facilitate development of improved communication and public education strategies.

Given the extensive oil and gas development in Texas relative to Pennsylvania, the former's dependence on the industry for much of its economic development, and the political differences between the two states, we might expect that Pennsylvanians would be less supportive of shale gas development than Texans, and that they would be willing to pay more to reduce environmental risks, all other things equal.

Contrary to this expectation, we found that a majority of people in both states support shale gas development—despite their serious concerns about potential damages—and that they are generally willing to pay similar amounts to reduce risks to the environment.

About the Survey

We conducted an online survey of 1,716 adults drawn from a randomly selected panel, representative of adult Pennsylvanians and Texans. First, respondents were asked about their knowledge of shale gas development. Then they received an explanation of the process. Next, we gauged their attitudes toward shale gas development and the risks. The participants were provided one of three alternative descriptions of the risks—one from the website of the American Petroleum Institute (API), another from websites of several environmental organizations, and a neutral description written by RFF researchers designed to be the "rational middle."

To elicit willingness to pay, we asked respondents to vote for potential government programs to reduce risks to groundwater, surface water, air pollution, community disruption, and habitat fragmentation. The survey explained to respondents that mitigating risks will be costly, and these costs will result in higher natural gas and electricity prices.

In the voting questions, respondents could vote for one of two optional risk-reduction programs, each with specified costs and risk reductions, or select the status quo without a new risk-reduction program or additional cost to the household. Each respondent went through a series of such voting questions. By asking respondents about different environmental risk reductions and program costs, we could identify willingness to pay for specific types of risk reductions.

The voting questions required that we describe current environmental risks as

a baseline. But because the actual levels of risk have not yet been conclusively determined, the survey varied these risks across respondents, examining the public's preferences under low, medium, and high baseline risks.

Toward the end of the survey, respondents' attitudes toward risks and shale gas development were reengaged to assess whether the information they were given in the survey affected their attitudes. Finally, participants were given a long list of debriefing questions to gauge whether they understood the survey, accepted it as real and unbiased, and interpreted the questions using logic we intended.

Attitudes toward Shale Gas Development and Risks

By and large, the survey responses indicate that a considerable fraction of the general public in both states is concerned about the environmental risks associated with shale gas development. Groundwater and surface water risks generated the most concern; 41 and 34 percent of all respondents said they are extremely concerned or very concerned about these two risks, respectively. In contrast, only 14 and 19 percent responded that they are not at all concerned or only minimally concerned.

However, despite these worries, there is also a surprisingly broad base of support for shale gas development. Fifty-nine percent of the respondents said they are supportive, while only 20 percent are against development (leaving 11 percent indifferent and 10 percent responding that they have no opinion or don't know). This distribution of support differs little across the two states, although Texans have a more positive view (Figure 1).

Taking these two findings together, we concluded that the public in these two very different states is generally supportive of sustainable shale gas development.

Willingness to Pay to Reduce Risk

As all economists know, attitudes are one thing and willingness to pay is another.

Figure 1. Public Support for Shale Gas Development

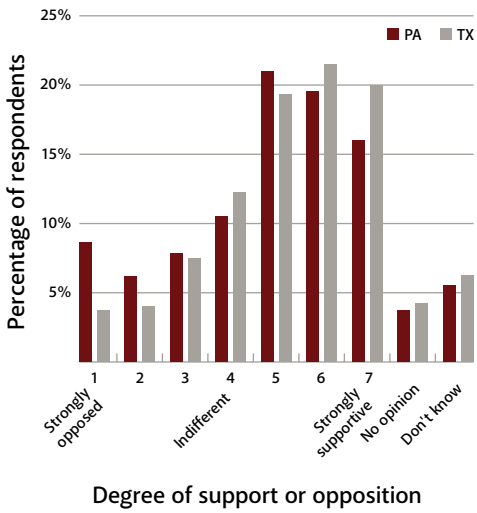
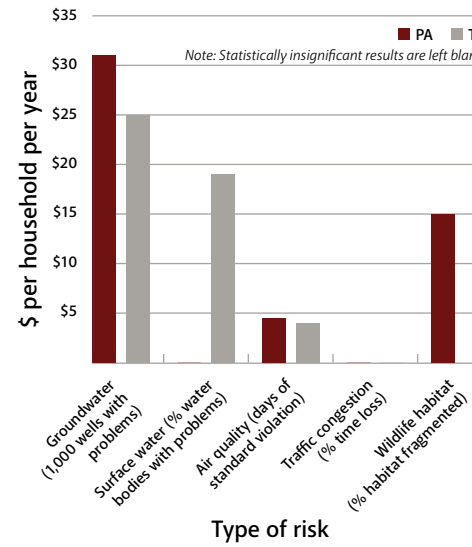


Figure 2. Willingness to Pay, on Average, for Shale Gas Risk Reductions



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Just because the survey respondents are concerned about the environmental risks of shale gas development doesn't mean that they will be willing (or able) to pay.

However, we found that the survey respondents in both states are clearly willing to pay to reduce risks (Figure 2). For instance, on average, their willingness to pay per household per year falls approximately as follows:

» $25 to $30 to eliminate problems with 1,000 drinking water wells,

» $20 in Texas to eliminate problems in 1 percent of surface water bodies with problems, and

» $15 in Pennsylvania to reduce 1 percent of habitat fragmented.

Reducing risks to air quality (reduced days of violations of the National Ambient Air Quality Standards) also generates a willingness to pay, on average about $4 per day of violation reduced in both states. Neither Texans nor Pennsylvanians are willing to pay to reduce time lost from increased truck traffic and road congestion, possibly because the population-weighted sample primarily includes urban dwellers, or possibly because these aspects of community effects are viewed as unimportant. In Pennsylvania, we found that although willingness to pay, on average, for reduced surface water risks is not statistically different from zero, a portion of the

general public is willing to pay to avoid those risks. The same is true for habitat fragmentation in Texas.

These results are averaged over different risk baselines. In designing the study, we had two countering hypotheses—that lower baselines give respondents the impression that the problem is not that severe and makes them less willing to pay for further risk reductions, or that because a given absolute reduction in risk is larger in percentage terms for a lower baseline, people are willing to pay more for a given change when the baseline is lower. We found weak support for the latter hypothesis but conclude that generally, willingness to pay on a per-unit basis (for example, per 1,000 drinking water wells, or 1 percent of surface water bodies) is not sensitive to the risk baseline.

The Role of Information

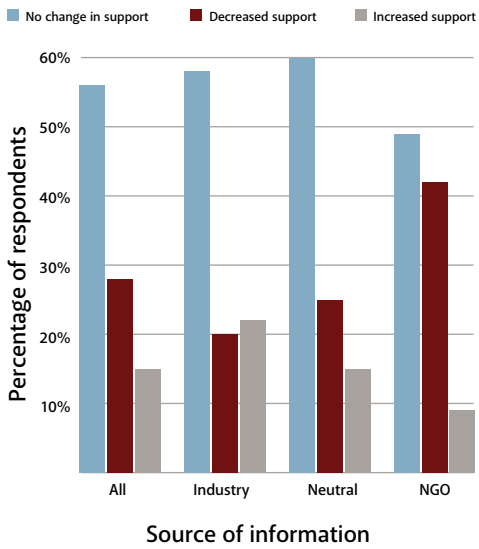
The findings above use the RFF neutral risk information as reference and control for the two other explanations of risks from the API and environmental organizations. An examination of the willingness-to-pay estimates by each explanation revealed that the effect of risk information depends, in part, on whether the respondent holds a predisposed attitude toward supporting or opposing shale gas development. For those with such opinions already formulated, risk information affects willingness to pay as expected: API information reduces willingness to pay for risk reductions, whereas the NGO information increases it. For the small fraction of the sample not holding a preexisting view about shale gas development, the results are more difficult to interpret, and the effects of the treatments may even reverse.

The different risk explanations also influenced stated support for shale gas development (Figure 3). We hypothesized that RFF's neutral information would be least effective in changing attitudes, that the API information would increase support for shale gas development, and that the environmental groups' information would reduce support.

Only the last of these hypotheses was borne out: the environmental groups' information is three times more likely to erode support as increase it. Although information provided by industry changes attitudes as well, it is as likely to lose supporters as increase support. Our neutral information induces a bit more opposition and a bit less support than that of industry.

The results suggest that industry has a communications problem. Unfortunately, careful examination does not reveal any characteristics that differentiate the people who become less supportive in response to the industry script from those who become more supportive, as industry intended. The only robust finding we can make is a very general one: people who are unfamiliar with fracking and other terms associated

Figure 3. How Different Information Affects Support for Shale Gas Development



with shale gas development are more likely to be moved by the information we provide them, irrespective of the source.

Implications for Regulation and Messaging

The public in two very different states is supportive of sustainable shale gas development and willing to pay, through higher natural gas prices, to reduce some of the risks that sustainability implies. The government can use this information to examine how stringent its regulations should be by comparing these monetary benefits of risk reductions as the public sees them to regulatory costs.

In spite of the enormous flow of messages, news stories, blog posts, reports, and the like, most of the public is largely ignorant of the details of shale gas development and the risks it might impose. Therefore, their beliefs and preferences may be malleable. Our findings suggest that environmental NGOs have been more successful than industry in persuading the public of their views. Ultimately, industry and environmental groups need to get better at communicating accurate information. For this to happen, experts need to agree on what the risks of shale gas development actually are, and this will require more and better research. Until this happens shale gas development will continue to be an example of social polarization. ●

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Krupnick, Alan, Hal Gordon, and Sheila Olmstead. 2013. *Pathways to Dialogue: What Experts Say about the Environmental Risks of Shale Gas Development*. Washington, DC: RFF.

Olmstead, Sheila, Lucija A. Muehlenbachs, Jhih-Shyang Shih, Ziyan Chu, and Alan J. Krupnick. 2013. Shale Gas Development Impacts on Surface Quality in Pennsylvania. *Proceedings of the National Academy of Sciences* 110(13): 4855–4856.

What Respondent Characteristics Drive Support or Opposition?

Because the survey collects demographic and other personal information, it is possible to understand how individual characteristics drive attitudes on shale gas development. This understanding can help target public education and communication, and may even help target regulations that address grievances of specific groups.

We collected demographic data, such as respondent's age, income, gender, and so forth. Looking at each variable, we found that men, older people, political conservatives, non-Hispanics, middle-income earners with an annual salary of $50,000–$70,000, and those who lease land for shale development are more likely to support shale gas development. We saw no effect associated with race, unemployment, familiarity with fracking, or higher earnings, and we found that support is significantly driven by political conservatism.

For Pennsylvania, we also have information about where the respondent lives. Using data on shale gas well locations, we examined geographic designation, distance of home from the nearest well, and the well density within a certain radius from the home. Our most robust finding is that respondents who live in Philadelphia or Pittsburgh are less supportive of shale gas development than the rest of the state, even when political views are held constant.

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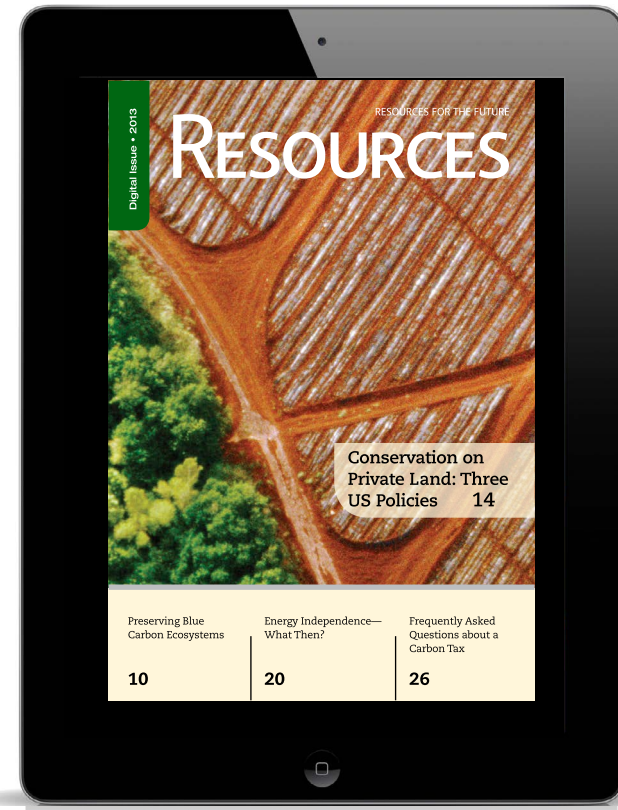

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A Look at What's Happening

Inside RFF

RFF University Fellow **Lawrence Goulder** of Stanford University was named a 2012 fellow of the Association of Environmental and Resource Economists in recognition of his outstanding contributions to the advancement of the profession.

RFF Fellow **Carolyn Kousky** is serving on the Adaptation and Hazards Indicators Technical Team for the US Global Change Research Program's National Climate Assessment. In addition, she was awarded the Tartufari International Prize in the Field of Socio-Economic Assessment of Natural Disasters for 2013 from Italy's Accademia Nazionale dei Lincei.

RFF awarded Senior Fellow **Allen Blackman** the 2013–2015 Thomas Klutznick Chair in Environmental Policy. With the award, he will examine the costs of programs in developing-country megacities that aim to cut traffic congestion and air pollution by prohibiting cars from being driven one or two days per week depending on the last digit of their license plates.

RFF Fellowship Awardees for the 2013–2014 Academic Year

RFF named the following **academic fellowship, stipend, and internship awardees** to conduct environmental and energy research during the coming year:

Gilbert F. White Postdoctoral Fellowship

» **Daniel Shawhan**, an assistant professor at the Rensselaer Polytechnic Institute, will spend the year in residence at RFF, working to develop and implement improved models of the US power grid.

Joseph L. Fisher Doctoral Dissertation Fellowships

» **Adrian Lopes**, a student of applied economics and management at Cornell University, is conducting dissertation research on poaching and species protection, with an application to elephants in southern Africa.

» **Lala Ma**, an economics student at Duke University, is completing her dissertation on improving estimates of the value of brownfields cleanup by taking into account how much information households have about the site and anticipated future cleanup.

» **Erica Myers**, a student of agricultural and resource economics at the University of California, Berkeley, is focusing on the energy efficiency gap, specifically looking at asymmetric information between landlords and tenants and between home buyers and sellers.

» **Ashwin Rode**, an economics student at the University of California, Santa Barbara, is conducting research on lobbying and permit allocations in the EU Emissions Trading System. He is also studying institutions and the resource curse—a

paradox wherein countries with an abundance of natural resources tend to have less economic growth and worse development outcomes than countries with fewer natural resources.

» **Richard Sweeney**, a student at the John F. Kennedy School of Government at Harvard University, is pursuing dissertation research on the effects of environmental regulations in the oil refining industry, testing whether they spur efficiency and innovation and looking at dynamic firm decisionmaking.

John V. Krutilla Research Stipend

» **Derek Lemoine**, an assistant professor at the University of Arizona, is working to update and improve the damage functions used in integrated assessment modeling of climate change policy.

Walter O. Spofford Memorial Internship

» **Xu Liu**, a student of environmental science at the Yale School of Forestry and Environmental Studies, is working with RFF researchers to study the online retail of green products in China and what the Beijing car registration lottery tells us about demand for automobiles in China.

Meet RFF's Newest Fellows

Two of RFF's newest research fellows—**Marc Hafstead** and **Ariel Ortiz-Bobea**—describe their past, present, and future research interests.

Marc Hafstead
Assessing Solutions to Climate and Energy Challenges

I became interested in environmental economics because of the issue of climate change. There have been many policies proposed (and some passed) at local, state, regional, and national levels to address this challenge, but I realized that environmental economics can be used to identify the policies that can deliver the greatest good for the smallest cost.

My most recent research is on the cost-effectiveness of clean energy standards and similar regulations relative to emissions pricing policies, such as a cap-and-trade program. With RFF University Fellow Lawrence Goulder and RFF Senior Fellow Roberton Williams, director of academic programs, we show that a well-designed clean energy standard can be more cost-effective than cap and trade when calling for relatively minor reductions in emissions. To achieve maximum cost-effectiveness, the standard must give partial credits to electricity generated from natural gas to reflect the differences in emissions generated from both non-fossil electricity and coal-fired electricity.

One of the questions that environmental policymakers frequently ask is how regulations affect jobs. This is not an easy question to answer, but in the coming months I will begin working with Williams to develop an economic model that will allow us to examine the impacts of environmental regulation on employment.

Ariel Ortiz-Bobea
Examining the Effects of Climate Change

I didn't really plan to become an economist.

Following a field experience in Ethiopia, I started to apprehend the key role for policy in influencing the interactions between conservation and development. That led me to a degree in public policy and an appointment as special assistant to the minister of the environment of the Dominican Republic. The policy challenges I witnessed there helped crystallize my interest in this field.

My dissertation focused on developing an econometric approach for assessing potential climate change impacts on agriculture in the United States. Many insights can be gained from carefully unpacking climate change impact mechanisms. For instance, key climatic factors affecting the sector tend to be confounded, like extreme temperature and drought. If you don't measure one of these factors well, you end up attributing the effects to the other. This can bias impact estimates.

During my first week at RFF, I was contacted by two separate teams to submit research proposals to the National Science Foundation to explore water quality and sustainability issues related to agriculture under climate change. I also plan to work on issues related to the value of environmental information and to environmental risk and agricultural biotechnology.

Highlights from Recent Journal Articles by RFF Researchers

Uncertainty Analysis Comes to Integrated Assessment Models for Climate Change ... and Conversely

Roger M. Cooke

Climatic Change | April 2013 | Vol. 117, Issue 3 | 467–479

The author traces the development of uncertainty analysis through three generations punctuated by large methodology investments in the nuclear sector aimed at strengthening the scientific basis of uncertainty quantification.

Strategically Placing Green Infrastructure: Cost-Effective Land Conservation in the Floodplain

Carolyn Kousky, Sheila M. Olmstead, Margaret A. Walls, and Molly Macauley

Environmental Science & Technology | DOI: 10.1021/es303938c

The authors examine the costs and benefits of avoiding flood damages and preventing development of floodplain land in the East River Watershed of Wisconsin's Lower Fox River Basin.

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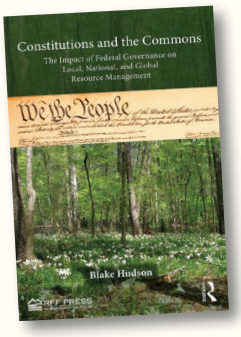

Constitutions and the Commons

The Impact of Federal Governance on Local, National, and Global Resource Management

By Blake Hudson

Constitutions and the Commons looks at the critical but little-examined issue of the degree to which the federal constitution of a nation contributes toward or limits the ability of the national government to manage its natural resources (or commons). Furthermore it considers how far the constitution facilitates the binding of constituent states, provinces, or other subnational units to honor the conditions of international environmental treaties. While the main focus is on the United States, there is also detailed coverage of Australia, Brazil, Canada, India, Russia, and other nations.

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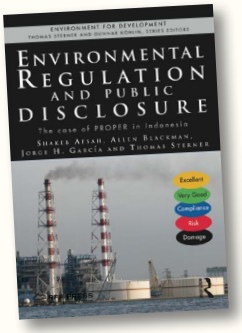

Environmental Regulation and Public Disclosure

The Case of PROPER in Indonesia

By Shakeb Afsah, Allen Blackman, Jorge H. García, and Thomas Sterner

This book is a remarkable case study of an environmental policy initiative for a national environmental regulatory system in the information age. The authors provide a multidisciplinary analysis of how the PROPER program harnessed the power of public disclosure to abate the problem of industrial pollution. The combination of institutional history and detailed economic analyses sheds light on the role of policy entrepreneurs who laid the foundation for disclosure and transparency, despite the constraints of the Suharto regime.

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