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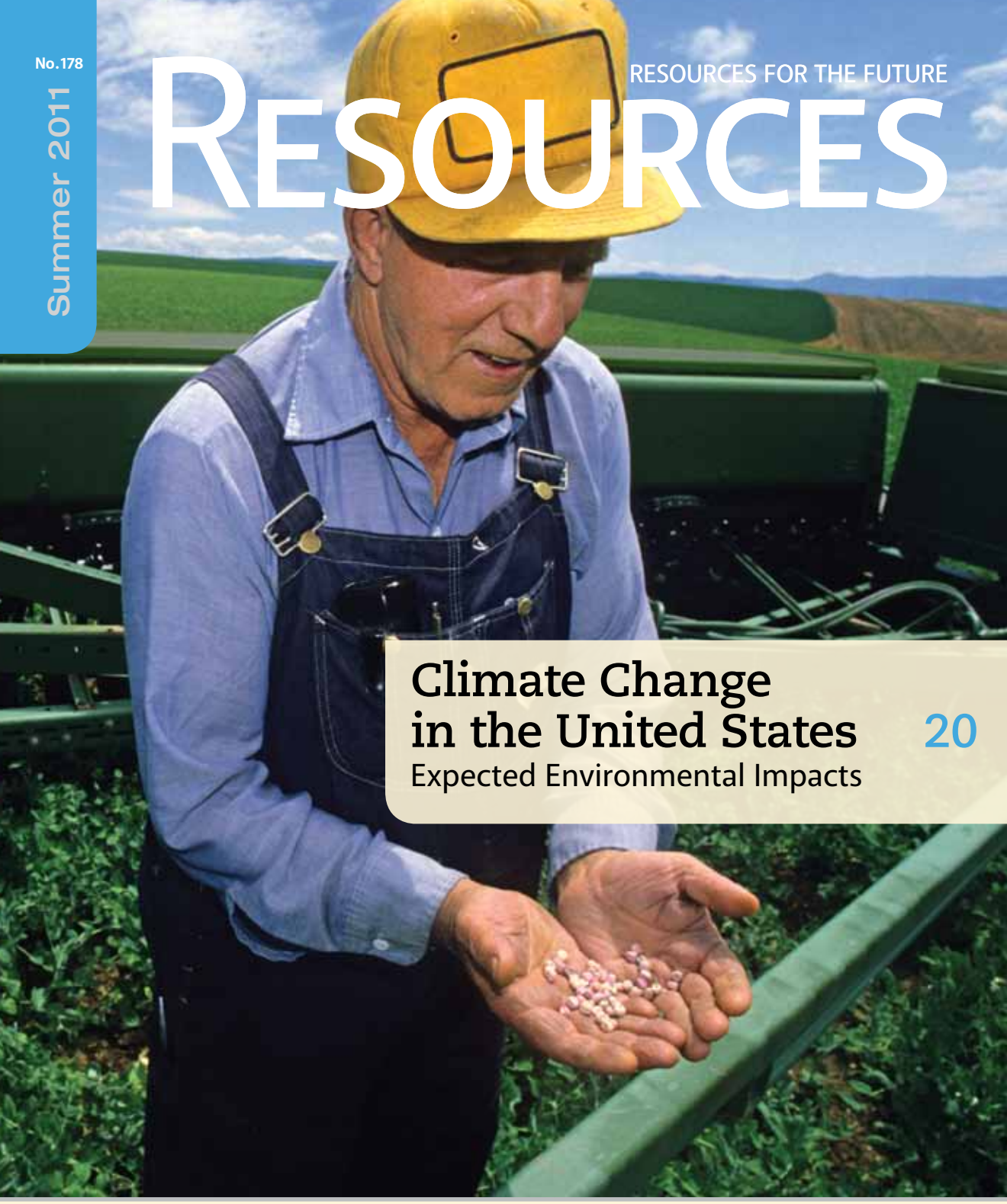
Summer 2011

RESOURCES FOR THE FUTURE

RESOURCES



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Resources

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In This Issue

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Boyd

Alan J. Krupnick is director of RFF's Center for Energy Economics and Policy, as well as director of research and a senior fellow. His research focuses on analyzing environmental and energy issues, in particular, the benefits, costs, and design of pollution and energy policies, in both the United States and developing countries. **p. 38**

Krupnick

RFF Vice President for Research and Senior Fellow **Molly K. Macauley** works on the economics of new technologies, climate policy, space economics and policy, economic incentives in environmental regulation, and recycling and solid waste management. **p. 20**

Macauley

Daniel F. Morris is a center fellow at RFF's Center for Climate and Electricity Policy. His work focuses on domestic adaptation policy, water supply and adaptation, forest resource monitoring and forest carbon modeling, and ecosystem services. **p. 20**

Morris

Ian W.H. Parry is technical assistance advisor on climate change and environmental policy in the Fiscal Affairs Department of the International Monetary Fund and a senior fellow at RFF. His research focuses on climate and environmental policy, transportation policy, and energy policy. **p. 38**

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RFF Nonresident Fellow **James N. Sanchirico** is a professor in the Department of Environmental Science and Policy at the University of California, Davis. He focuses his work on the economic analysis of marine policies, especially the effects of individual transferable quotas and marine protected areas. **p. 18**

Wolfram Schlenker is an assistant professor in the Department of Economics at the School of International and Public Affairs at Columbia University. **p. 08**

Sanchirico

Managing Risks and Mitigating Consequences

The Gulf of Mexico oil spill and the Fukushima meltdown are painful reminders of the risks associated with the technologies that underpin our modern economy. Today, concerns and uncertainties about shale "fracking" to access new energy supplies are at the forefront. In fact, RFF Board Vice Chair John Deutch is leading a new committee for the Secretary of Energy to recommend how to manage those risks.

While the nature and magnitude of the risks associated with these issues are different, our corporations, communities, and governments continue to confront the same questions: How should we assess risks? How can we best mitigate risks? And how much risk is society willing to tolerate to reap the benefits of technological achievement?

RFF specializes in helping decisionmakers identify and tackle such questions. Our experts remain deeply committed to improving the analytical tools that help us better understand and minimize the risks we face—whether in the financial markets, the operation of nuclear power plants, or the flooding of farmlands.

Furthermore, we have focused significant attention on how federal agencies can best manage risks through regulation. Last year, we advised the National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling and the Department of the Interior on such matters. Currently, we are focused on shale gas development: identifying the most critical risks and their drivers, assessing attempts to address those risks, and recommending policies for mitigation and action. Finding pathways to smarter regulation is not an easy task, but it is one to which RFF is committed.

For the past several years, the risks of climate change have caused contentious debates around the country and in Washington. Regardless of the results of global efforts to curb greenhouse gas emissions, there is a strong scientific consensus that global warming is underway and that we will witness its effects in the decades ahead.

In this issue of *Resources*, we examine how the federal government can help communities adapt to the potential risks and emerging effects of climate change. Our scholars offer recommendations on managing and responding to extreme weather events, improving the information provided to citizens and decisionmakers, and reforming institutions to better serve the public in the face of a changing climate.

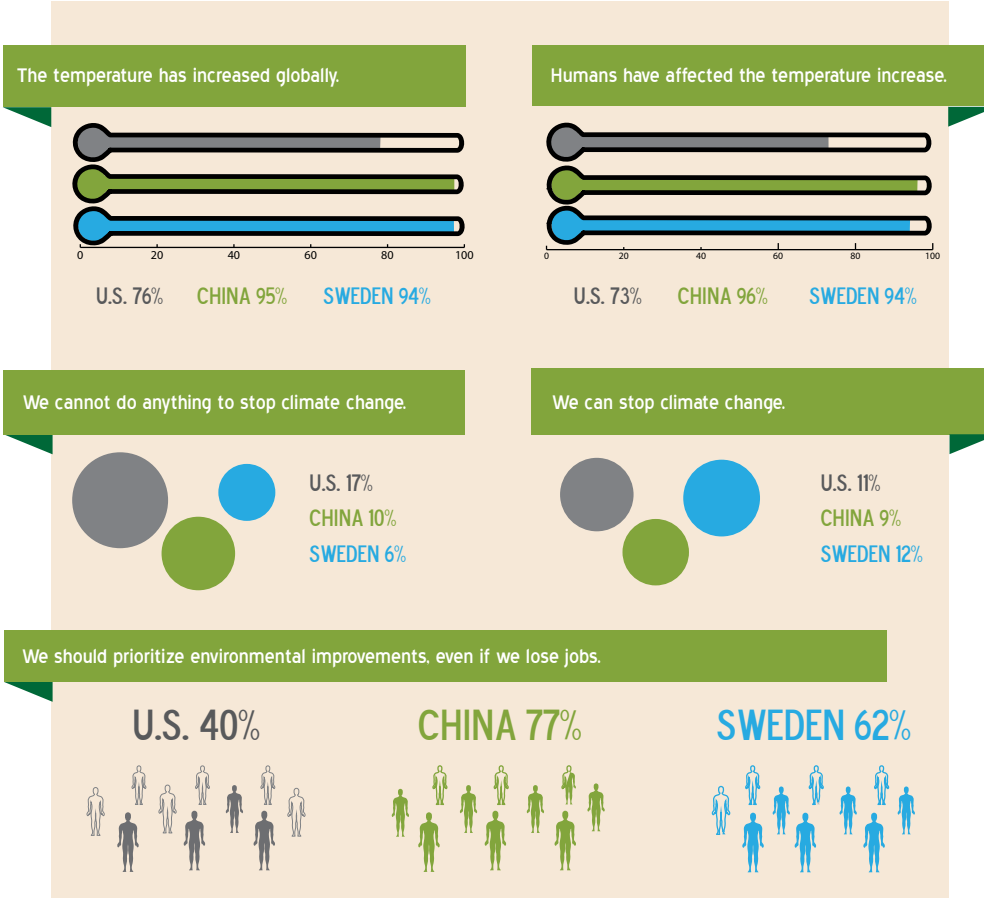
At RFF, we believe that better policy comes from rigorous, independent analysis advanced in tandem with robust conversations across the public, private, and nonprofit sectors. This issue highlights new insights that aim to spark a different kind of dialogue about climate risk, one that is nonpartisan and informed by solid analysis.

Philip R. Sharp, President
sharp@rff.org

ATTITUDES TOWARD CLIMATE CHANGE

A Multiple Country Study

One of the stumbling blocks to curbing greenhouse gas emissions in the United States is that a large fraction of the American public is skeptical about the proposition of human-induced climate change. Research by RFF scholars conducted with colleagues from China and Sweden examined how attitudes on the issue compare across the three countries. In addition to the issues presented below, the research team also looked at respondents' willingness-to-pay (WTP) to avoid the consequences of global temperature increases, and found that Swedes were willing to pay the most and Chinese the least. When measured as a share of income, however, the Chinese and U.S. WTP were comparable. See *Paying for Mitigation: A Multi-Country Study* at www.rff.org/wtp.



Note: Percentages are share of respondents agreeing with each statement.

Highlights of RFF's Recent Contributions

to Shaping Environmental Policy

Deepwater Drilling: One Year Later
May 16
William Reilly, former EPA administrator and co-chairman of the National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling, discussed the future of deepwater drilling at RFF's Policy Leadership Forum.

Ellen A. Walter

ENGAGING WITH CONGRESS

Jobs and the Economy
February 15
RFF Visiting Scholar Randall Lutter testified on environmental regulation, the economy, and jobs before the House Committee on Energy and Commerce Subcommittee on Environment and the Economy.

Deepwater Drilling Technologies
April 5
RFF Vice President for Research and Senior Fellow Molly Macauley testified on offshore drilling safety and response technologies before the House Committee on Science, Space and Technology Subcommittee on Energy and the Environment.

Clean Energy Standard
April 11
RFF scholars responded to questions posed by the Senate Committee on Energy and Natural Resources on the development of a clean energy standard (CES).

June 20
RFF Senior Fellow Karen Palmer presented the impacts of various clean energy standard options at "A Cleaner Way to Power?", a bipartisan congressional briefing hosted by the offices of Reps. Edward Whitfield (R-KY) and Bobby Rush (D-IL).

CONVENING THOUGHT LEADERS

Deepwater Drilling: Looking Back
April 6
Richard Lazarus, executive director of the National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling, presented an overview of the commission's report and RFF's contributions at an RFF First Wednesday seminar.

Regulation at Independent Agencies
April 7
RFF hosted a conference on using economic analysis to improve policy at independent regulatory agencies. Several former OMB, FTC, and FCC administrators participated,

including Alice Rivlin, Sally Katzen, and J. Howard Beales, among others.

Adapting to Climate Change

June 1

At the June First Wednesday seminar, RFF experts presented the results of a major study on policy options for the federal government's role in climate adaptation, titled *Reforming Institutions and Managing Extremes: U.S. Policy Approaches for Adapting to a Changing Climate.*

Saving the Antarctic

June 15

Renowned polar explorer, environmental leader, and motivational speaker Robert Swan (OBE) shared his passion about the environment and experiences from the past 25 years at RFF's Policy Leadership Forum. See page 16 for coverage of this event.

Energy Policies and Markets

June 21

RFF and the University of Chicago hosted, in Washington, the second annual Energy Policy Symposium. The topic of this year's conference was Market Responses and the Effectiveness of Energy Policies.

BUILDING PARTNERSHIPS

Global Climate Policy

May 24

In Milan, RFF President Phil Sharp addressed the U.S. role in global climate policymaking at an event sponsored by the Fondazione Eni Enrico Mattei, which awarded RFF the 20th Anniversary FEEM Prize in Environmental Economics.

Natural Gas Development

May 24

Alan Krupnick, director of RFF's Center for Energy Economics and Policy, participated in a National Press Club Newsmakers Committee panel on the challenges, impacts, and need for natural gas drilling.

June 27

RFF President Phil Sharp participated in a panel discussion on MIT's new report, *The Future of Natural Gas,* at the Brookings Institution.

Energy and Electricity

July 3

RFF President Phil Sharp chaired this year's Aspen Energy Policy Forum, "Changing Currents: Turbulence for the Electricity Industry?"

A Book Note by RFF Senior Fellow Joel Darmstadter

Emery Castle, whose terms as vice president and president of Resources for the Future (1976–79 and 1979–86, respectively) represented an important phase in a distinguished academic career, shares his experiences and insights in a new autobiography, *Reflections of a Pragmatic Economist: My Intellectual Journey* (Oregon State University Press, 2010). Emery's research and writings focused in particular on the economics of rural and agricultural development. At RFF, he not only contended with a wide range of natural resource and environmental issues but also helped chart a course for the then-25-year-old institution as it faced the challenges of newly emerging research needs, policy concerns, and the financial means to address them. Emery's account of his university and RFF years is told with a blend of analytical insight and humanity that will resonate knowingly with his many friends and professional colleagues.

Climate Change and Agriculture

U.S. agriculture supplies a major share of basic calories to the world. Recent research suggests that even with current agricultural technology, climate change could dramatically reduce agricultural productivity in the United States. What would be the impact of such shifts?

Agricultural productivity increased steadily in the second half of the 20th century, with yields of most agricultural commodities increasing threefold. These large gains have caused a general downward trend in agricultural prices and have greatly improved economic welfare—inflation-adjusted agricultural prices are at low historic levels even after recent spikes. As a result of the fall in prices, agriculture now constitutes a small share of GDP in developed countries (2 to 3 percent in the United States).

The effect of climate change on U.S. agricultural productivity is of global importance, however, because demand for agricultural products is highly price-inelastic (that is, demand is not affected by changes in price). The recent past has shown how a shortfall in global production can dramatically increase prices. Because the United States supplies nearly one-fourth of the world's basic calories, any impact on yields in the United States will have global ramifications. Recent research (see Further Reading) suggests that, unless technology changes, climate change could have a large negative effect on agricultural productivity in the United States.

Potential Impacts on U.S. Agriculture

The relationship between temperature and agricultural productivity has been found in recent work to be nonlinear. Yields increase with temperature up to 29°C (84°F) for corn and 30°C (86°F) for soybeans. If farmers could freely choose their growing conditions, a temperature of 84°F or 86°F every day, all year long would be ideal. Temperatures above and below the optimums reduce yields, but the slope of the decline above the optimum is about 10 times greater than the incline below it. In other words, being 1°F above the optimum reduces yields 10 times as much as being 1°F below it.

The strong relationship between temperatures above the optimum and yields implies that roughly half of the year-to-year variation in crop yields can be explained by measuring how often and by how much temperatures exceed the crop-specific optimum. Accounting for extremes gives a much better yield forecast than only looking at average temperature. The commonly used concept of "degree days" captures this piecewise linear relationship between temperature and yield by simply adding all temperatures above the optimum for each day. One day that is 10 degrees above the optimum is as harmful as 10 days that are 1 degree above the optimum. Corn futures markets confirm the nonlinear relationship: futures prices for deliveries at the end of the growing season are highly sensitive to extreme heat events during the growing season, but not to average temperature.

This nonlinearity is important because climate change is predicted to increase both daily minimum and maximum temperatures. During the summer months, the minimum is usually below 84°F in the Midwest, the major agricultural growing

gettyimages

area in the United States. At the same time, there are many days when the maximum temperature is above 86°F. Climate change therefore has countervailing effects: shifting minimum temperatures up toward optimal temperatures improves yields, but increasing the frequency and extent to which temperature exceeds the optimum decreases yields. The latter effect dominates, and most climate scenarios show significantly decreased yields. Looking at current growing regions, average yields are predicted to decline by roughly 40 percent at the end of the century under the slowest warming scenario and up to about 75 percent under the most rapid warming scenario in one of the commonly used global circulation models (Hadley III). The latter scenario predicts significant temperature increases that would lead to desertification of a significant share of today's agricultural areas.

Of course, evidence based on year-to-year weather fluctuations may overstate the effect of climate change if farmers can adapt better to permanent climate shifts than to annual fluctuations. It is therefore instructive to look at the effect of average temperatures on average yields. One would have expected yields in the southern United States to be less sensitive to high temperatures because this region experiences temperatures above 84°F to 86°F more frequently than others. However, the same nonlinear and asymmetric relationship is found across regions, which suggests that there has been limited historical adaptation of seed varieties or management practices to warmer average temperatures. A model using farmland values instead of crop yields finds similar results if one controls for the damaging effects of extreme heat.

These results pertain to the United States, and similar results are found using data from Africa, although the data are "noisier."

While countries in Africa are already hotter and hence more susceptible to further temperature increases, predicted temperature increases are lower than in higher latitudes.

expense of lower heat tolerance, as in the period from 1960 onward.

Genetically modified crops are the biggest hope for improving heat tolerance. To date, most commercially successful, genetically modified crops resist pests or herbicides. But more ambitious efforts exist to develop plants that manufacture their own nitrogen fertilizer and possess more nutrients. Although public funding of basic research has diminished, private donations from charities like the Gates Foundation have increased. Given the public good attributes of research, private sources may not provide enough funding going forward.

● – Wolfram Schlenker

Because the United States supplies nearly one-fourth of the world's basic calories, any impacts on yields in the United States will have global ramifications.

Adaptation to Climate Change: Evolution of Heat Tolerance

Given the large damaging effect of extreme heat on yields for at least two basic food commodities, corn and soybeans, the big question is whether technological innovation can reduce the sensitivity to these extreme temperatures. If changes in climatic conditions reduce yields, prices would rise, giving seed companies a strong incentive to innovate and make seeds more heat resistant. On the other hand, it may be difficult to increase heat tolerance because of biological limitations.

The recent past might give us some guidance: while average corn yields increased continuously in the second half of the 20th century by a total factor of three, heat tolerance of corn in Indiana—the state with the longest detailed daily weather record—increased between 1940 and 1960, yet started to decline again after 1960. The dates coincide with changes in seed varieties: Double-crossed hybrid corn was adopted in the late 1930s and single-crossed hybrids came online around 1960. Corn in Indiana is most sensitive to extreme temperatures at the end of the sample. The big questions are whether the next breeding cycle will increase both average yields and heat tolerance, as in the period from 1940 to 1960, or whether continued increases in average yields will only be achieved at the

FURTHER READING

Johnson, D. Gale. 1997. Agriculture and the Wealth of Nations. *American Economic Review* 87(2): 1–12.

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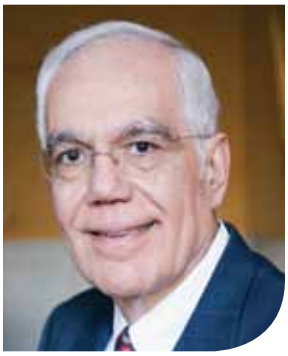
Schlenker, W., and M. J. Roberts. 2009. Non-linear Temperature Effects Indicate Severe Damages to U.S. Crop Yields under Climate Change. *Proceedings of the National Academy of Sciences* 106(37): 15594–15598.

How Communities and Countries Can Adapt to Climate Change

An Interview with Mohamed El-Ashry



Daniel Morris, center fellow at the RFF Center for Climate and Electricity Policy, sat down with Mohamed El-Ashry, RFF board member and retired CEO and chairman of the Global Environment Facility, to discuss international climate negotiations and priorities for adaptation. Below is an excerpt of their conversation. Video from this interview is available online at www.rff.org/ElAshryQA.

MORRIS: How do you define adaptation? When people ask you about it, what do you tell them?

EL-ASHRY: Adaptation is about building resilience and reducing vulnerability. People and natural systems are being affected by climate change. If we do nothing, then the degradation will continue to impact the productivity and health of both. So that's how I present it: building resilience and reducing vulnerability.

MORRIS: How can communities build resilience in order to adapt to climate change?

EL-ASHRY: I'm glad you mentioned communities, because the tendency is to think about this as a global issue—but the impacts are local. We need to think about the institutions that will deal with these issues on the ground.

People need better information. For example, a farmer wants information about the land, wind, and droughts, so that he can adjust. These cycles have happened before, and people have adjusted to them. That's how people build resilience. As for ecosystems, building resilience means reducing the human impact, which is tremendous. The Millennium Ecosystem Assessment in 2005 showed that because ecosystems are already degraded, the impacts of climate change are going to be even greater.

MORRIS: How do you strike a balance between trying to make sure that communities are not as vulnerable to climate change, while ensuring that they're resilient to its effects now and in the future?

EL-ASHRY: I think the best way of looking at this is to talk about upstream interventions that would be valuable regardless of the specific impacts of climate change. For example, we have droughts right now. Farmers suffer. However, crop varieties that are resistant to drought will help right now and will also provide a cushion for when droughts become worse in the future. Vulnerability exists, but it's being reduced. Unless you put forth a serious mitigation effort, that vulnerability remains—and the

impacts are there no matter what.

MORRIS: It seems like there is a distinct connection between adapting to climate change and general development in emerging countries. How do you see that connection?

EL-ASHRY: There's no question about the linkage between adaptation and development. In fact, you cannot adapt without a national framework for economic activity and sustainable development. Otherwise, adaptation efforts become marginalized because designing a few projects here or there isn't sufficient. Adaptation requires a long-term effort that starts with building resilience in communities, so it must be within a country's development framework.

However, if we're talking about development and poverty alleviation, then you have to look at what poor people really need right now. They need access to energy, because without it they will not have an income. They need clean energy, because they can't afford oil.

MORRIS: Is it time to start bringing mitigation and adaptation conversations and efforts together, or are we not quite ready for that as an international community?

EL-ASHRY: Let's talk about why we aren't ready for that. Negotiations related to climate change are between developed and developing countries. Developed countries are interested in mitigation. Developing countries are interested in adaptation. Poor countries contribute only 8 percent of the global greenhouse gas emissions, yet 98 percent of the people who suffer from the effects of climate change live in those countries. Of course, the two are closely linked, because the more we mitigate, the less we have to adapt. However, that's not the nature of the current political debate.

MORRIS: Do you think that international negotiations are moving forward, in terms of the pledges by developed countries to have $100 billion available per year by 2020?

The tendency is to think about adaptation as a global issue—but the impacts are local. We need to think about the institutions that will deal with these issues on the ground.

EL-ASHRY: It's really all talk. Pledges are pledges. Where is the money going to come from? Let's just be honest about it. Even $10 billion, where would it come from? That's really what bothers me about the international negotiations and disappoints the people who are being affected.

MORRIS: Do you think that the UNFCCC processes of the past 20 years are still viable? Or is it time to start moving toward a new model that takes funding challenges into account and begins to focus on helping people adapt to climate change where it's currently most needed?

EL-ASHRY: You cannot disregard the UNFCCC process. It's the only universal approach where all countries are present and have a say. However, experience shows that we need other ways to complement

it. There is no reason why small groups—such as the G20, the G8, or the G8 plus five—can't come up with ideas that can be put forward to the bigger group. When the Framework Convention was being negotiated, there were small groups that developed and shared ideas. However, ultimately, you need to work through the international system, because without that global policy framework, we cannot talk about implementation on a global scale.

MORRIS: It seems that negotiations have been held up by simple questions of economics: Where does money come from? How does it get distributed? Who needs it the most, and who is going to supply it? Are we ready to have a discussion about the economics of climate change and adaptation projects?

EL-ASHRY: We are not there yet—let's back up one step. Where would additional sources of funding come from? There have been proposals for taxing airline tickets for international travel, and it's not a bad idea. For example, you put a $1 tax on economy tickets, a $20 tax on business-class tickets, and a $40 tax on first-class tickets. That can raise between $8 and $10 billion a year. Another option is taxing maritime fuel, or bunker fuel, the only fuel not currently taxed. A small tax will increase the price of the commodity, but only slightly. If you do it in a way that does not impact the developing countries as severely as the developed countries, it can actually raise another $8 to $10 billion. If you combine both strategies, that's $16 to $20 billion. These are good ideas, but people can't really agree on them. The United States is against the airline ticket idea. The Europeans are for it, and they've launched a small pilot project raising money not for climate change, but for vaccinations for the poor. We really need to come together as a global community and agree on some of these things. Let's start small.

MORRIS: If you were able to prioritize discussions on adaptation over the next two to three years in order to address the concerns of developing countries about the impacts of climate change and those of developed countries about spending and transparency—what would be your priority areas?

EL-ASHRY: Ten years ago, when I was leading the Global Environmental Facility, the Framework Convention asked us to fund the preparation of National Adaptation Programmes of Action. Fifty of them were completed. Some are good. Some are not as good. My first priority was to provide funding for implementing those plans. In Cancun, however, the Framework Convention decided that there should be new national adaptation plans, and those previously prepared weren't implemented. But, I am still optimistic. If I weren't optimistic, I wouldn't have been working on environmental issues for all these years.

MORRIS: Do you think that extreme weather events are starting to influence the conversations to some degree?

EL-ASHRY: Not yet. The difficulty is that you cannot really pinpoint any particular event in relation to climate change. Science tells us that with increased temperatures, there is more evaporation and more precipitation, but we can't yet separate what is a natural cycle from what is a result of global warming. However, it seems that what is being predicted in the climate models is what we are seeing now. This realization has not yet reached decisionmakers and policymakers. I think the reason is very simple: because there is a cost that needs to be paid.

Weathervane in Brief

Weathervane, RFF's climate policy blog, was launched in 1997 and is designed to advance and inform debates surrounding the environmental and economic aspects of climate change. Since its inception, Weathervane has fostered a vibrant discussion of current climate change policy research and debate. Below are clips from recent posts, covering topics from climate adaptation to the Green Climate Fund to carbon emissions in China—a small sample of issues covered on Weathervane. *To read more, visit www.rff.org/wv.*

Climate Adaptation in U.S. Policy

One area where the federal government can take action is in reforming institutions and getting incentives right, in order to better incorporate risks from climate into price signals. As one measure, we recommend reshaping subsidy programs (such as the National Flood Insurance Program) to better reflect the actual climate risk that consumers face. ● –Daniel Morris

Clean Energy Standard (CES) in the United States

It is important to note that there are likely no efficiency gains under a CES by crediting existing facilities, but serious regional implications exist because the distribution of existing nuclear and hydro plants is not uniform across the country. For example, the Pacific Northwest has a lot of existing hydropower, and if those facilities aren't credited, they will be treated just as coal under a [CES] program—receiving no credit, despite their "clean" nature. If that were the case, electricity prices in the Pacific Northwest would increase substantially under a CES. But if those hydro plants do get credits, prices would rise by a much smaller amount. In that scenario, however, consumers nationwide will be paying more and so interregional transfers of wealth will occur, depending on whether or not existing facilities are credited. ● –Anthony Paul

Is Bioenergy Carbon Neutral?

Although carbon released by fossil fuels or biofuels has an equivalent impact on the atmosphere, important differences do exist. In the case of fossil fuels, the release of carbon means an irreversible flow of carbon from the fossil fuel stock to the biosphere, resulting in a net permanent addition to the total amount. For biomass, by contrast, the amount of carbon in the biosphere does not change. This lack of equivalence is not without consequence. Only the form has changed—carbon moves over time from being captured in biomass to being released into the atmosphere, from where it might once again be recaptured in biomass. The release of fossil fuel emissions is thus, in principle, completely irreversible, whereas biomass emissions are reversible and can be returned to biomass. Biomass carbon is a zero sum game—in the long run. Over shorter periods of time and for individual sites, however, the question is more complex.

● –Roger Sedjo

Three Responses to U.S. Cap-and-Trade Troubles

Governor Chris Christie has decided to pull New Jersey out of the Regional Greenhouse Gas Initiative (RGGI), the Northeast's carbon cap-and-trade program. New Hampshire's legislature has also voted to leave, though the governor may veto the bill. Other states are considering their positions. Three reactions are possible: 1) Despair (Cap and trade gets a knife in the back to match the one in the front); 2) Indifference ("Wait... New Jersey had a carbon policy?"); and 3) Optimism (Playing the long game). Which of these three is right? Perhaps unsurprisingly, all three are appropriate to some extent. Pricing carbon is the most effective climate policy—so it is troubling to see it lose ground. RGGI itself is largely irrelevant to both the science and politics of climate. And the long view matters most of all.

● –Nathan Richardson

How Big Will the Green Fund Grow?

Unless a truly international mechanism is established that bypasses national coffers, which is possible although it seems unlikely at the moment, this introduces a timing complication in determining the size of the Green Climate Fund. Using the rough estimates above, it is plausible that between $5 billion and $20 billion per year could be available for the Green Climate Fund, given sufficient political will. The first pledging period is unlikely to start for several years because of the slow negotiations around this type of fund and the lag for national contributions. For a notional three-year pledging period that lasts from 2019–2021, however, the size of the fund seems likely to range from $15 to $60 billion (of which only the annual average would be comparable to the $100 billion pledge).

● –Andrew Stevenson

Scoring U.S. Federal Government Emissions Reductions

Significant emissions reductions from U.S. government departments and agencies can lead to a decrease in overall U.S. emissions—without the need for sweeping national congressional legislation or Environmental Protection Agency action. According to the data, overall, the federal government emitted 121.3 million metric tons of carbon in 2010. The majority of this, as we have said before, comes from the Department of Defense (DOD). In 2008, the DOD ranked 47 in the world for carbon intensity—emitting more carbon than Israel, Chile and the Philippines.

● –Lynann Butkiewicz

The Challenge of Reducing Carbon Emissions in China

Carbon taxes and cap and trade are facing similar problems gaining traction in China. As in the United States, the first and perhaps most significant obstacle is political will. Instead of being played out in town halls and talk radio, however, China's debate is mostly within the government. Some believe that the costs of these programs are too high for China's rapidly growing economy to bear. Others see an opportunity to improve the efficiency of China's economy and boost energy security or combat the economic threat of climate change. ● –Andrew Stevenson



RENEWABLE ENERGY IN ANTARCTICA AND THE POWER OF BEING BOLD

RFF Policy Leadership Forum featuring Robert Swan

Renowned polar explorer, environmental leader, and motivational speaker Robert Swan (OBE) shared his passion about the environment and experiences from the past 25 years in a talk punctuated with stunning visuals and humor at RFF on June 15. Swan, who referred to himself as "the only person stupid enough to walk to both the North and South Poles," made pleas for protecting the Antarctic from resource exploitation and making a global commitment to transition the world economy to renewable energy.

The Protocol on Environmental Protection to the Antarctic Treaty currently prohibits drilling and mining there until 2041, when it can be modified or amended. Calling the continent the world's "last great wilderness," Swan said he has made it his mission to make sure it is never opened up for resource exploitation.

Ellen A. Walter

Next year marks the 25th anniversary of Swan's first journey to Antarctica. The original 80-day, 12-miles-per-day walk to the South Pole, inspired by Sir Robert Scott's trek in 1912, became a defining moment in his life, said Swan. Watching the changes occurring on both poles, Swan said he has come to believe they "are like canaries in mines, and we should listen to them."

Swan is planning to return to the South Pole to commemorate the 25th anniversary, this time relying upon only renewable energy for survival. While he noted that the technology to enable such a journey is "not quite there yet," he smiled and said "we're going to do it anyway."

He noted that the long-term solution to the energy question would require a mix of technologies, acknowledging that he would be taking an airline flight that evening, and the ability to take such a trip without relying on fossil fuels is a long way off.

Swan added that "sustainable inspiration" is required to make global environmental progress on sustainable growth. He faulted the current international negotiating framework as fostering cynicism and apathy and called for getting some concrete "wins" to demonstrate progress. He noted that the world had come together to address the threat to the ozone layer through the Montreal Protocol and such achievements tend to be overlooked.

As part of his efforts to increase awareness and inspire young people about environmental issues, Swan has embarked on a Voyage for Clean Energy as well as a series of Antarctic expeditions. Starting in Cape Town, South Africa, Swan's team and his yacht "2041" have traveled almost 120,000 nautical miles since 2002 to connect with and inspire students from around the world. Currently, the yacht is on its way to the June 2012 World Summit in Rio de Janeiro, Brazil, where Swan will address heads of state as he did at the first Rio conference in 1992.

More than 500 corporate leaders, educators, students, and entrepreneurs from around the world have joined Swan's team as part of an annual exploration of the Antarctic Peninsula. The 2012 team will depart from Ushuaia, Argentina to gain first-hand knowledge of Antarctica's ecosystem.

At the RFF event, Swan made the first announcement of his new project—working with the U.S. Marines to help promote and showcase their use of renewable technologies. He noted that renewable energy will help lighten the weight of soldiers' packs and reduce the need for helicopter drops of fuel and batteries.

Watching the changes occurring on both Poles, Swan said he has come to believe they "are like canaries in mines, and we should listen to them."

For more information on Sir Robert Swan's work, visit www.2041.com.

Rising Sea Levels and Coastal Erosion

Policy Options to Help Communities Adapt

James N. Sanchirico

Thermal expansion of the world's oceans and the inflow of freshwater from glaciers as a result of global warming have contributed to a rise in average sea levels during the 20th century. What's more, research suggests that sea level rises are projected to experience greater increases in the years to come.

Along with the changes to marine and coastal natural resources, coastal communities are on the front lines for experiencing the effects of sea level rise, including inundation, coastal erosion, flooding, and saltwater intrusion. These climate change impacts will occur in dense and already stressed environments. Specifically, counties within coastal watersheds, excluding Alaska, contain close to 53 percent of the U.S. population but represent only 17 percent of the total area of the country.

Coastal erosion is expected to threaten a large number of existing properties in the coming decades. Many of these structures are presently armored with seawalls or other hard barriers that disrupt sediment flows to the shore. Although all landowners will probably fight to keep their properties and their rights to protect them, society faces an important question regarding whether and when a property should be abandoned. In some cases, the answer might be never, especially if it is a unique or high value structure, such as a cultural heritage site. Regardless, public policies must be adopted to enhance the resilience of these communities to the impacts of

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climate change. Below are several options to consider.

Disaster insurance: State and federal governments could reduce the amount or type of disaster insurance available to existing coastal landowners to decrease incentives to invest in refurbishing and strengthening seawalls over time. The National Flood Insurance Program (NFIP) insures high risk properties from flood damage. NFIP policyholders are, in some circumstances, required to adopt building practices to reduce flood risk or are required to do so after filing multiple claims. To reduce the likelihood that property owners in high flood risk areas will pursue maladaptive actions in the future, the federal government could tighten standards for new NFIP policies or even stop issuing policies altogether to certain regions.

Armaments and setbacks: Private insurers could also respond to increasing risk to homes and business due to climate change by increasing homeowner rates in anticipation of the damages. In this case, government intervention in the market might be needed for the prohibition of insurance discounts to landowners who reduce their risks through maladaptive practices, such as building larger sea armaments. Some level of government intervention seems warranted because neither insurance companies nor homeowners are likely to internalize the societal costs associated with seawalls and similar structures, including the increase in erosion, the decreased ability of wetlands to adapt to changing conditions, and interference with public access to the coast.

In the case of future development, states have instituted a range of policies for adapting to anticipated erosion without the use of expensive and environmentally damaging barriers. These include bans on armoring and setbacks, which prohibit development seaward beyond a predetermined boundary. One potential issue with the use of setbacks is that once the water level reaches the setback, there is, in essence, an implicit contract that landowners will be able to build seawalls to protect their homes.

Rolling easements: A more flexible approach than seawalls and setbacks, which is tailored toward the dynamic nature of coastal erosion, has been pioneered and successfully defended in the courts by the state of Texas. Rolling easements are intended to induce property owners to yield to advancing shorelines or wetlands. This type of easement prevents property owners from holding back the sea and moves or "rolls" with the rising seas. The advantages of a rolling easement include (1) the lack of disturbance of sedimentation transport; (2) the potential for wetlands and other tidal habitat to migrate unimpeded; and (3) continued public access to the shore.

Abandonment: Although abandonment or the strategic retreat from a place is a politically difficult position to take, with many potential distributional and social justice consequences, the question of if and when to retreat needs to be in the forefront of the dialogue on adaptation policies. This is true for decisions regarding coastal habitat restoration in the face of sea level rise, habitat protections, and development in highly vulnerable locations such as barrier islands. If abandonment is not included as a feasible option, cost-effective adaptation policies will remain elusive.

FURTHER READING

Kling, David, and James N. Sanchirico. 2009. *An Adaptation Portfolio for the United States Coastal and Marine Environment.* Washington, DC: Resources for the Future.

CLIMATE CHANGE IN THE UNITED STATES

Expected Environmental Impacts and Necessary Federal Action

Molly K. Macauley and Daniel F. Morris

There is little doubt that adapting to a changing climate will be necessary in the years ahead. Climate adaptation is generally defined as the range of steps taken to respond to climatic changes such as increases in the frequency of extreme weather, longer and more severe droughts, a rising sea level, and other effects. The term also can include additional steps to shore up resiliency against extremes, by protecting shorelines from ocean encroachment as sea level rises, for instance. Some climatic changes may be beneficial as well, such as longer growing seasons in some regions.

Many actions are likely to be taken by the private sector as businesses and consum-

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Waves explode over a seawall and into Galveston, Texas as Hurricane Ike approaches on September 12, 2008.

ers adapt naturally, perhaps without much problem. Here, insurance for floods and other disasters provides a buffer for economic losses. Actions may also be required of the government, however, including federal, regional, state, and local officials. What role exists for government has received little attention until quite recently, when the U.S. Global Change Research Program, a federal interagency effort established by the 1900 Global Change Research Act, began to include climate adaptation on its list of priorities.

Acknowledging this gap, Resources for the Future in 2008 launched its Domestic Adaptation Project. While climate impacts and adaptation in developing countries had long been recognized and under way, little attention had been accorded adaptation in the United States. This spring RFF released a summary report and findings from the project, containing over 30 specific policy recommendations for the role of the federal government in helping the nation adapt to a changing climate.

What are the expected effects of a changing climate?

The project began with six independently authored reports summarizing the state of scientific understanding of the possible effects of a changing climate on the United States. The reports considered agriculture, coastal and marine resources, freshwater resources, infrastructure, public health, and terrestrial ecosystems. (These sectors were chosen to conform to the sectors on which the efforts of the United Nation's Intergovernmental Panel on Climate Change have long been focused.) The reports highlighted several main findings in synthesizing the scientific literature:

Agriculture

Assessments of agricultural effects vary widely, but many indicate that the U.S. food supply is under little threat from climate changes. Carbon dioxide fertilization may offset some effects of temperature and precipitation changes. Agricultural productivity in the southern part of the country is likely to decline and be more vulnerable to drought and extreme temperatures, whereas northern areas may receive increased precipitation and become more productive. Livestock production may decline overall as a result of higher summer temperatures unless livestock management practices advance to mitigate this risk.

Coastal and Marine Resources

Effects on marine and coastal systems carry a host of concerns, ranging from changes in ocean and air temperatures to acidification, increased freshwater runoff, ice loss in the Arctic, sea level rise, and changes in upwelling and ocean circulation. These

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effects place stress on some marine ecosystems that already suffer from overfishing and land-based pollution. Coral reefs are of particular concern because they are already in decline. Coastal and marine effects will vary widely across the nation, however. Some communities will be more vulnerable than others and in all coastal areas, land use is a closely related concern.

Freshwater Resources

Increased variability in precipitation extremes across the United States will be an issue, including large floods and prolonged droughts. Water availability for both human uses and ecosystems will become less predictable with a changing climate. Moreover, reduced volumes of water in rivers and lakes due to increased evaporation may have long-term hydrological consequences as well as implications for water quality. The frequency and extreme nature of future weather events could push the adaptive capacities of human and natural systems to their limits in the absence of additional action.

Infrastructure

Public infrastructure—such as transportation, energy generation and transmission, water and sewer systems, telecommunications, and coastal defense—will experience climate effects in different ways. Some infrastructure has been engineered to have built-in tolerance to extreme events, including sea level rise, water scarcity, temperature changes, and demand-induced effects such as increased electricity consumption. Public infrastructure often is long-lived with a regular maintenance schedule, which provides an opportunity to routinely improve adaptive capacity. Some costs of improvement, however, may grow too large to sustain over the long term, requiring new investment altogether.

Public Health

Climate change will not introduce new sources of morbidity and mortality in the United States, but may alter the factors that lead to them. Effects include heat stress and heat waves, exacerbation of aeroallergen distribution and allergic diseases, changes in the nature and patterns of epidemic infectious diseases, and increased ambient air pollution. The public health community differs in perspective as to what level of urgency should be used to address climate change, though most practitioners agree that primary prevention and enhanced health surveillance systems are needed.

Terrestrial Ecosystems

Plants and animals will have to adapt to weather extremes, prolonged droughts, and other effects while remaining in the same habitat or migrating outside their current geographic distribution. One of the connections between climate changes and ecosystem response is the life-cycle timing and early season growth of plants due to earlier spring-like conditions. Not only are changes in average temperature and precipitation of concern, but so too is the likelihood of more extremes, as these may be more difficult for ecosystems to accommodate. For instance, some organisms die at even slightly higher or lower sustained or variable temperatures. Similarly, disturbance events (droughts, floods, and wildfires, for example) can stress ecosystems to the point of altering their basic structure, a situation that may be more prominent under new climate regimes. As a result, native species may struggle while invasive species flourish. Because natural ecosystems typically receive little active management from humans, deliberate adaptation actions may be required.

In light of these effects, what might be the roles of the federal government in response?

The RFF project identified three characteristics for a course of federal policy action:

» improving and strengthening incentives to use resources wisely, not only now but especially as climate changes;

» reforming existing institutions to enhance their flexibility to respond to these effects; and

» greatly enhancing the traditional role of government in providing information—particularly about the nature, likelihood, and timing of extreme events—to enable consumers, businesses, and other decision-makers to take appropriate actions.

In brief, the RFF team found the following:

» Markets play a critical role in adaptation, but they can function efficiently only when incentives are correctly in place.

» Some federal actions are likely necessary to help communities adapt, and while most existing management and regulatory structures are not designed to address adaptation, they can achieve a great deal with some basic reforms.

» Climate change will result in extreme events that go beyond current experience and knowledge, so proper adaptation will require better data gathering and more information relayed to decisionmakers.

Incentives

As the climate shifts, prices need to be flexible enough to reflect new levels of scarcity. In some cases, the federal government may need to alter subsidies that inhibit private actors from making necessary adjustments. In other cases, the federal government may be the one setting the price, and it will need to adjust its current practices. In still other cases, there are no existing effective pricing mechanisms and government will need to work to develop them.

Key reforms include revising the nation's approach to pricing insurance for flood protection and reducing existing subsidies of electricity, water, and agricultural commodities (including crop price supports and other distortions in trade policy). Getting incentives right provides a host of benefits that can enable government, resource managers, and consumers to respond more readily to climate change.

Institutions

Adapting to a changing climate is often thought to be local, in that most actions, such as protecting coastal shorelines or

Drought conditions take their toll on the shoreline of Lake Powell in Utah.

MORE READING ON ADAPTATION

The RFF publications listed below address the most compelling and urgent of actions that could frame U.S. climate adaptation policy. They are available at www.rff.org/adaptation.

UNDERSTANDING THE IMPACTS

Adapting to Climate Change: The Public Policy Response—Public Infrastructure, *James E. Neumann and Jason C. Price*

Agriculture and the Food System: Adaptation to Climate Change, *John M. Antle*

An Adaptation Portfolio for the United States Coastal and Marine Environment, *David Kling and James N. Sanchirico*

Emerging Climate Change Impacts on Freshwater Resources: A Perspective on Transformed Watersheds, *Alan P. Covich*

Terrestrial Ecosystem Adaptation, *Steven W. Running and L. Scott Mills*

Adapting to Climate Change: Public Health, *Jonathan M. Samet*

REFORMING INSTITUTIONS AND MANAGING EXTREMES

Promoting Innovative Climate Adaptation through Federalism, *Winston Harrington*

Ecosystem Services and Climate Adaptation, *James W. Boyd*

Pre-Positioned Policy as Public Adaptation to Climate Change, *V. Kerry Smith*

Climate Adaptation and Watershed Transboundary Governance Institutions, *Marc K. Landy*

Adaptations to Sustain High-Quality Freshwater Supplies in Response to Climate Change, *Alan P. Covich*

Climate Adaptation Policy: The Role and Value of Information, *Molly K. Macauley*

Adapting to Extreme Events: Managing Fat Tails, *Carolyn Kousky and Roger M. Cooke*

Climate Dependencies and Risk Management: Microcorrelations and Tail Dependence, *Roger M. Cooke and Carolyn Kousky*

Public Health: Adapting to Climate Change, *Jonathan M. Samet*

Adaptation of Agriculture and the Food System to Climate Change: Policy Issues, *John M. Antle*

Climate Adaptation and Federal Megadisaster Policy: Lessons from Katrina, *Marc K. Landy*

Adapting to Climate Change in Public Lands Management, *Joel B. Smith and William R. Travis*

Encouraging Adaptation to Climate Change: Long-Term Flood Insurance, *Howard Kunreuther and Erwann Michel-Kerjan*

Adaptation to Climate Change: Revisiting Infrastructure Norms, *James E. Neumann*

Better Defined Rights and Responsibilities in the Marine Environment, *James N. Sanchirico*

A Legal Framework for Climate Adaptation Assessment, *Daniel A. Farber*

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sheltering persons during hurricanes, are executed by subnational governments. Yet the federal government can take many steps to improve management efforts and expand the capacity for local governments to act, particularly by coordinating efforts across jurisdictions, and employing innovative options to improve national regulations and management systems for resources such as water and lands, as well as public goods like infrastructure and public health.

the likelihood and extent of these effects can help decisionmakers steer resources toward their most effective use. The supply of information, including that required to enable the public to anticipate extreme events, has long been a role of government. Climate scientists at present collect massive amounts of data on the ground as well as from satellites, aircraft, and ocean buoys to model and measure the physical properties of Earth's climate; evaluating these data and

Getting incentives right provides a host of benefits that can enable government, resource managers, and consumers to respond more readily to climate change.

Institutional reforms that may be needed include the establishment of ocean governance practices through planning and allocating use rights, forming state and federal institutions for transboundary governance of watersheds, and coordinating regional efforts in managing land (such as protecting wildlife corridors). The federal government can play an additional role in promoting coordination between state and local agencies in long-term planning for water scarcity (for example, by providing deep reservoir storage).

Information and Managing Extremes

As the climate baseline shifts, events that were once considered extreme and rare are expected by many scientists to be likely to occur with greater frequency and stronger intensity. If so, formerly reliable buffers against severe events like hurricanes, floods, and droughts could become less effective. Similarly, historical benchmarks would no longer provide useful guidance for at-risk communities to adjust to new climate patterns. New and better information about enhancing them to support decisionmaking for adaptation will be critical. These observing stations can also help to provide "early warning" of possible climate tipping points or abrupt climate changes.

Adaptation policies, in some cases, may also be contentious as regions and demographic groups experience different effects. For example, extreme long-term drought in the Southwest or Southeast may lead to water-rationing that generates significant controversy. Low income communities can be vulnerable to the effects of extreme weather events yet often lack capacity to adapt. Also, sea level rise may eventually overwhelm urban areas such that people will need to relocate and infrastructure will be abandoned. Enhancing national resiliency to a changing climate, then, requires both more effective incentives, institutions, and information, and a means to balance inevitable distributional effects.

NASA

On Sept. 3, 2010, when NASA's Terra spacecraft captured this image over the Indus River in Pakistan, severe flooding was still causing a major humanitarian crisis in Pakistan. The city of Hyderabad is near the middle of the image.

Investing in Information

TO RESPOND TO A CHANGING CLIMATE

Molly K. Macauley

In the 1970s, a severe drought hit the Soviet Union and significantly reduced its grain harvest. As the USSR began quietly purchasing large amounts of world grain inventories, global food prices soared. Learning from the so-called "Great Grain Robbery of 1972," the U.S. Department of Agriculture began increasing its surveillance of global agricultural conditions, regularly forecasting expected crop yields and worldwide agricultural productivity. Today, the forecasts rely on a variety of satellite data, ranging from weather to land-use observations, in combination with official reports from foreign governments, overseas post reports, and other data to provide early warning and critical analyses of major world crop events.

This is just one example of how publicly provided information on global conditions is used to leverage huge financial resources. As the world adapts to a changing climate, the quantity and quality of our information will play a critical role in determining

the effectiveness of public and private responses:

» Information on changes in sea level, variability of temperatures, and the severity of droughts, for instance, will be pivotal in leveraging public-sector resources and managing infrastructure.

» Public-health surveillance systems can incorporate information about vector-borne diseases, extreme weather events, and climate-influenced changes in aeroallergens and other measures of air quality.

» Precipitation, soil moisture, snowmelt, and other indicators will signal when actions may be needed to protect terrestrial ecosystems and manage freshwater resources.

» Data on ocean salinity and temperature will help in understanding and predicting the effects of climate change on marine resources.

» Climate data can assist private industry as well, including agriculture and livestock management and insurance markets.

Collecting these kinds of data comes at a cost. The examples above help show precisely which data and information have value for decisionmaking. To date, large investments in data collection have been made, particularly from the vantage point of space observations.

Already, the United States has invested more than $15 billion in climate-related data collection, modeling, and analysis of fundamental atmospheric, terrestrial, and oceanic processes that together make up the physical climate system. Additional expenditures—on the order of $6 billion—are required annually to operate these systems. The activities involve at least six government agencies: the National Aeronautics and Space Administration, the National Oceanic and Atmospheric Administration, the U.S. Department of Energy, the U.S. Environmental Protection Agency, the U.S. Department of Interior, and the U.S. Department of Agriculture. All these agencies operate climate-related observing systems either in space or on the ground (to measure carbon flux, land use, and so forth).

Other countries have invested additional amounts in their own science-observing networks. Counting just the space systems—since these represent most of the expenditure so far—the entire international effort of the United States and some other 30 countries now includes 78 spacecraft carrying 125 instruments. The cost of these efforts is not readily available, but assuming an average cost of about $500 million per system, some $39 billion of observation infrastructure is in place. And, as noted, additional ground and ocean systems collect data that complement and provide "ground truthing" for the satellites.

Acquiring and developing information is not free—and government expenditures on information collection must compete with many other pressing demands for government services.

Valuing Information

Acquiring and developing information is not free—and government expenditures on information collection must compete with other pressing demands for government services. Understanding this, in what terms should we consider how much public effort to devote to the collection and dissemination of climate-related information?

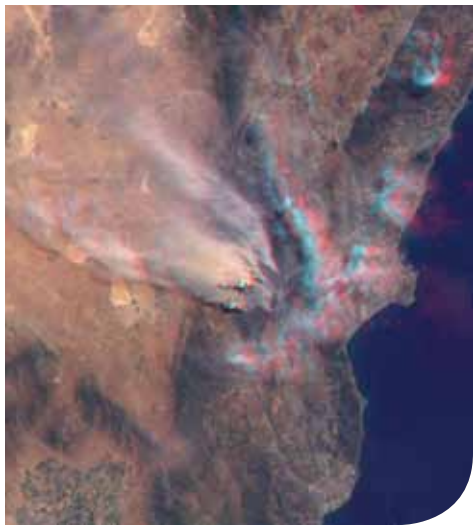
gettyimages

The simple economic answer, of course, is that the benefits of the information should exceed the opportunity costs of acquiring it. But there are wrinkles to this story. Four principles come into play when deciding whether investing in information delivers sufficient bang for the buck.

Perfect information may not be worth its cost of acquisition.

In fact, people typically make decisions with less-than-perfect information—that is, with at least some uncertainty, balancing the chance of a mistake against the cost of more information. With adequate—even if imperfect—information, engineers build bridges with structural tolerances, for instance, and building codes protect other infrastructure from the chance of some extreme events. Comparing the cost of uncertainty with the cost of information acquisition thus sheds some light on how certain is certain enough.

And, in many cases, the "value of information" can be extremely large. For example, research by Jim Neumann and Daniel Hudgens (see Further Reading) finds that the infrastructure required to protect coastal California from one-half meter of sea level rise in 2100 is about $1 billion cheaper than if the sea rises a full meter. Narrowing our uncertainty about the amount of rise would allow for a much more efficient allocation of public and private dollars. Comparing the likelihood of each outcome with the cost of information acquisition and protection can help to describe how certain the information needs to be in a standard value-of-information framework. Economically framed questions such as this will help inform public investment in information.



Smoke from the Station Fire in La Cañada Flintridge blankets Southern California.

Information is less useful if no action can be taken in response.

For instance, flooding and loss during monsoon seasons is a way of life in low-lying developing countries. In many places, however, people can take few precautionary actions in response to flood forecasts. This principle suggests that even data that are spatially and temporally well scaled for a community may serve little use in some situations. (This example also suggests that the value of information is necessarily linked with other actions—such as incentives to change building practices along low-lying coastal areas or the size of premiums charged for flood insurance—that will influence how people adapt in response to information.)

Information may have value if an action deliberately is not taken.

The U.S. agricultural sector, for example, could face an export market in which farmers in another country may decide not to irrigate—even when severe drought is forecast—unless the expected world price for the crop in the longer run is large enough to recoup irrigation costs.

Much like the previous case—incapacity or weak incentives to take action in response to information—deliberately deciding not to take action depends on a host of circumstances additional to the information itself. For this reason, researchers applying value-of-information assessments have pointed out that care needs to be taken if the metric is the action of a person using the information. Failure to observe an action may mask the decision to not take action.

An increase in information may not reduce uncertainty but may still be worth acquiring.

Examples abound in the case of information collected as part of scientific research, where additional data can lead to more questions rather than answers, or medical testing, where additional results may fail to confirm prior diagnoses. An outcome of more uncertainty ex post—that is, after information collection—does not mean that the information lacks value. It simply means we knew less than we thought we did.

Abrupt Climate Change

In an extreme case, if climate was changing so abruptly that adaptation proved ineffective, what information might government provide in an early warning system? Abrupt climate change is defined as a large-scale change in the climate system that takes place over a few decades or less, persists (or is anticipated to persist) for at least two decades, and causes substantial disruption in human and natural systems. Scientists use the paleoclimate record and other information to infer possible causes of rapid, large-scale change to which society may be unable to adapt. Examples include precipitous changes in ice sheets leading to

NASA

a rise in sea level, widespread and sustained changes in the hydrological cycle, abrupt change of the Atlantic meridional overturning circulation, and rapid release into the atmosphere of methane trapped in permafrost and on continental shelves.

A separate concern is cascade-event catastrophes. The simultaneous failure of a large number of integrated systems, such as linked agricultural networks, could constitute another type of abrupt climate change with limited time for response.

The value of information to improve understanding of these types of changes in climate depends in part on the ability to take action in advance of and in response to the information. In his book *Catastrophe*, Richard Posner worries that insufficient resources are devoted to evaluating the costs and benefits of extreme events, including climate tipping points. Bill Travis (see Further Reading) proposes a severe climate early warning system. He points out that such a system would operate on a time scale akin to early warning systems for earthquake hazard, drought, and famine, which are based on long-term probability, and the Torino asteroid threat scale, which is based on the probability of impact and the potential ensuing effects over periods of years to decades. He argues for improvements in information, specifically in the form of enhanced monitoring and more scientific research to better anticipate an abrupt change.

Concluding Thoughts

These observations point to the usefulness of redirecting the nation's significant investment in climate science and data collection to include information specifically to support decisionmaking in a more targeted manner. Adaptation is in many cases a local and regional challenge. The United States needs a more systematic plan than the current piecemeal approach among agencies for balancing information to serve two ends: what people in states and localities need to know, and what scientists who study Earth systems can tell us about global-scale phenomena that affect states and localities.

Principles about the value of information should be adopted to guide data collection and analysis. Not all information has value, nor does the benefit of perfect information necessarily exceed its costs. Filters need to be established to sort through the large amounts of data now being collected by global climate observing networks and some of these efforts may need to be redirected to provide the kind of information necessary for adaptation.

Finally, the specter of tipping points raises additional questions about the provision of information if, despite best efforts, society is unable to adapt to abrupt changes in climate. What information is required to monitor the approach of possible extreme changes in climate? How early is early enough for action to be taken? At present, no U.S. agency has the responsibility to ask and answer questions such as these, despite their relevance to long-term thinking about both adaptation and our recourse if our best efforts to adapt fall short.

FURTHER READING

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THE RISK OF

Ecosystem Service Losses

Ecological Hedging Strategies

James W. Boyd

The supply of ecological goods and services is both economically important and at risk because of climate change and other threats. Although we may not be able to eliminate the risk of climate change—hence the need to adapt—we can make investments in ecological production to reduce the negative consequences of climate change on ecological wealth.

An economic rationale referred to as "option value" is well established for protecting natural resources even when the resource's current benefits are less than the benefits of developing, degrading, or not conserving the resource. This reasoning hinges on uncertainty regarding the social costs of environmental damage and the relative irreversibility of ecological losses.

Option values take two general forms. The first is a risk-aversion premium, where in the option value is like an insurance premium designed to ensure adequate future supply of a resource. The second form reflects the value of information gained from delayed ecological degradation, during which time uncertainty regarding the scale of implied environmental damage is reduced.

The idea of option value in environmental economics is analogous to the value of options contracts in financial markets. In financial markets, it is valuable to purchase an option to some future action, such as the purchase of an asset at a given price. Importantly, options are not obligations. Rather, they give decisionmakers the ability to take

one action over another in the future upon the resolution of current uncertainties.

The Practical Implications of Option Value

If we are to act on the basis of option value, we need to estimate the ways in which ecological and economic uncertainties can be reduced in the future and how we can act on better future information. In general, the larger and more irreversible potential ecological damages are—and the quicker and more successfully we expect the science of ecological prediction to develop—the higher the option value. In these circumstances, the value of information associated with delayed degradation is highest.

Unfortunately, it is nearly impossible today to calculate the option value associated with conservation. Clearly, it is desirable to make some investments in protection, restoration, and management of ecological systems to hedge against the ecological and economic risks associated with systems likely to be altered and disturbed by climate change. And although it is difficult to make a clear argument for the appropriate magnitude of such investment, several principles can and should be applied to the hedging strategy we put in place.

Assessing Ecological Resilience

First, analysis of ecological resilience is the best way to identify the most desirable hedging strategies. The concept of resilience captures the notion that species and ecological systems are able to adapt to shocks, stressors, and threats, but that resilience is itself a depletable feature of natural systems. Certain species, for example, may be able to adapt to elevated temperatures by moving to locations with lower temperatures (such as higher latitudes or elevations), but only if suitable habitats and pathways through which species can migrate exist within those ranges.

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This example highlights that resilience can be managed by protecting the natural landscape's ability to adapt and provide critical forage, reproduction, and migratory resources. The growing discipline of ecosystem-based management emphasizes the need to evaluate the ability of ecosystems to rebound from disturbances. From this line of thought arise two types of ecological hedging: *refuges* and *investments in restoration and management of natural systems and their services.*

In practice, refuges have several general features associated with contiguity and connectivity—at the top of the list are a minimum size and connections or pathways to other resources needed to support migration, reproduction, and forage. Exam-

Volunteers have begun a coastal restoration project in the Pass a Loutre Wildlife Management Area at the mouth of the Mississippi River. The area is still contaminated with oil from the Deepwater Horizon *oil spill, and the restoration project includes planting marsh grass in biodegradable burlap bags, which contain soil mixed with natural oil-eating microorganisms and marsh grasses. They are placed strategically in the marsh in hopes that the grasses will take hold.*

ples of the latter are migratory pathways to allow the free movement of terrestrial species over often very large distances.

Accordingly, ecologists have proposed protected area networks, or refuges, designed with climate resilience in mind. Although they are desirable for ecological reasons alone, refuges also preserve the economic value of that ecological production. As a result, protected-area networks are one of the principle hedging strategies available to preserve ecological wealth.

Other prime strategies for ecological hedging are investments in restoration and management of natural systems and their services. Like protected-area designations, restoration of wetlands, riparian forest buffers, and native plant species can enhance resilience and help ecosystems adapt to climate change. Similarly, water management (such as diversion of flows to stock subsurface aquifers) and land management (selective harvests, cropping practices, and removal of invasive species, for example) are measures by which we can hedge against the loss of ecosystem goods and services.

An Ecological Investment Portfolio

A second key hedging principle is the idea

of a portfolio of investments. Because of the numerous uncertainties associated with ecological change, it is desirable for society to invest in a diversified portfolio of natural resources and systems. Ecological diversification should take place to hedge against the following:

» losses in ecosystem goods we use directly, such as agricultural soils, water, and species we consume for food;

» loss of ecological processes, functions, and inputs necessary to produce those consumed goods; and

» changes in demand for ecosystem goods by demographic changes (population, industrial activity) associated with climate change.

Consider a concrete example. If we wish to hedge against the loss of marine fish populations on which we are dependent for food, we should consider the following forms of diversification: protecting numerous different species whose adaptive responses to climate change are uncertain and protecting the food webs on which these species depend—which themselves will adapt unevenly to climate change.

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Policies to Achieve a Diversified Portfolio of Ecosystem Functions and Services

Given our current lack of information, how should policies be designed to foster investments in ecosystem services adaptation? First, we should realize that current environmental policies—even those designed in the most sophisticated manner—have not been based on climate adaptation objectives. Going forward, environmental policies should be designed and targeted in close collaboration with natural scientists engaged in adaptive ecological management and strategy. Also, policy design should take into account the economic value of ecosystem goods and services for which patterns of production are likely to change in the future. Consider the following policy instruments and ways in which they could facilitate ecological hedging strategies.

Public Lands Management

The current U.S. portfolio of protected lands is large and provides opportunities for the management of water flows, land use, and land cover to facilitate ecological adaptation. The Department of the Interior and other public trustees should experiment with management practices designed to increase the resilience of ecological systems.

Public Lands Designation

U.S. public land holdings are designed to serve many public purposes. However, land acquisitions as well as wilderness and other protected designations have not been made with climate adaptation in mind. A portfolio approach to adaptation may include new

investments in land acquisition and protection and new land use restrictions.

Marine Resource Management and Protection

As in the previous two examples, the designation of new marine reserves and fishery management practices could facilitate the resilience and continued productivity of ocean resources.

Payments for Ecosystem Services

Payments for ecosystem services, from targeted farm conservation payments to schemes that transfer revenues from water users to up-watershed landholders, typically focus on delivery of a single service. Such schemes can facilitate a range of other ecological benefits, including resilience and adaptation benefits. Calculation of—and payment for—these additional benefits will create opportunities for greater investment in ecological resilience.

Greenhouse Gas Markets

Many carbon sequestration practices generate a range of associated biophysical effects that influence the broader delivery of ecosystem services and resilience. For example, reforestation can provide numerous potential ancillary benefits beyond carbon sequestration, including support for species abundance, recreation and subsistence benefits, and enhanced water supply. Greenhouse gas markets and other payments could and should take these differential benefits into account.

Natural Resource Damages

In the United States, responsible parties are liable for natural resource damages under Superfund regulation and the Oil Pollution Act. These laws require injurers to compensate the public for the lost economic value associated with damaged natural resources. Federal agencies, including the National Oceanic and Atmospheric Administration and Department of the Interior, are the designated trustees responsible for the assessment and adjudication of these damages. Natural resource damage practices should be adapted to capture the possibility that resource injuries are degrading resilience and option value.

Many other policies could be adapted to foster ecological resilience, including rules governing wetland loss mitigation, tax laws that affect the incentive to donate conservation easements on private property, local zoning regulations, designated water use determination under the Clean Water Act, and the definition of critical habitat under the Endangered Species and Magnuson-Stevens Acts.

Conclusion

From an economic perspective, the idea that delay has an economic value holds true for *any* decision characterized by irreversible consequences and uncertainties that can be at least partially resolved through delay. This does not necessarily imply that we should always delay an environmentally damaging housing development, fishery, dam, or power plant. It does mean, though, that we should invest in science and economics designed to better understand the option value of ecological protection.

In the meantime, it is economically rational to devise hedging strategies as best we can. For ecosystem goods and services, climate adaptation policies should foster investments in geographically diverse portfolios of species, lands, resources, and ecological systems designed to hedge against future losses in supply or increases in demand brought about by climate change. Creating these portfolios will require coordinated analysis by natural and social scientists.

Decarbonizing the Power Sector

Are Feebates Better Than a Clean Energy Standard?

Alan J. Krupnick and Ian W.H. Parry

Following the failure in 2010 to pass a comprehensive cap-and-trade bill to reduce carbon dioxide (CO_2) and other greenhouse gas emissions, the Obama administration and some in Congress are now focused, in particular, on a *clean energy standard* (CES). Under this approach, electricity producers would be required to meet a rising fraction of their generation using zero-carbon sources or sources with lower carbon intensity (defined as CO_2 emissions per kilowatt-hour [kWh]) than that of coal generation.

Although a CES would lower the carbon intensity of the power sector, it is typically viewed as a second-best approach relative to a well-designed, economywide cap-and-trade policy, as the latter promotes a broader range of behavioral responses to reduce CO_2 emissions across all sectors of the economy.

In some important economic and practical regards, however, a CES may be a better first step than the cap-and-trade proposals floated in Congress. In particular, it can

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FEEBATES AT A GLANCE

What are feebates? This energy policy option has the potential to come out on top in terms of effectiveness and cost-effectiveness when compared to a clean energy standard for significantly reducing carbon emissions from the power sector. Feebates can be understood on a basic level by breaking down the term to its two components: fees and rebates. First, an average emissions level of carbon dioxide per kWh (or a ***pivot point;*** see full story) is determined. Then, put simply, firms that generate power at above-average emissions intensity are charged a fee. Firms that do the job at below-average levels of emissions intensity are given a rebate or subsidy. The feebate option has a number of potential advantages, including its ability to be made (approximately) revenue neutral and facilitate comparison of policy stringency across countries.

be significantly more cost-effective and it avoids, at least initially, large increases in energy prices, which are a major political hurdle for emissions pricing policies. Nonetheless, policymakers should seriously consider a pricing alternative to a CES, known as a *feebate,* which involves fees for generators with above-average emissions intensity and subsidies or rebates for those with below-average emissions intensity. Feebates are a potentially more effective, and cost-effective, policy than a CES for decarbonizing the power sector.

Cap-and-Trade versus CES

As long recognized in the literature on climate policies, a potentially important problem with cap-and-trade systems is that they create a large amount of allowance revenue. It is important that this be used productively, in particular by auctioning allowances and using the revenue to alleviate distortions from the broader fiscal system.

To understand this, consider how broader fiscal instruments affect the economy. Personal income and payroll taxes cause distortions by reducing the overall level of work effort below levels that would maximize economic efficiency, by lowering the returns to labor force participation, effort on the job, accumulation of skills, and so on. Similarly, personal taxes paid on dividend and capital gains income, and taxes at the corporate level on investment returns, cause distortionary effects by reducing capital accumulation. And generous tax preferences in the fiscal system, such as tax exemptions and deductions for employer-provided medical insurance and home ownership, further warp the economy by creating a bias toward tax-favored spending and away from ordinary spending.

Emissions pricing policies potentially interact with these sources of preexisting distortion in two important, but offsetting, ways. First, revenues resulting from an emissions permit auction, or from a carbon tax, could be used to reduce taxes on labor and capital income—offering a relatively large source of economic efficiency gain by alleviating distortions from the broader fiscal system. Second, however, the overall level of economic activity will contract in response to higher energy prices, leading to a (slight) reduction in work effort and capital accumulation, exacerbating the costs of preexisting taxes on labor and capital income.

These linkages with the broader fiscal system have two key implications for ranking different policies on cost grounds.

There is a large cost savings from emis-

sions pricing policies that exploit revenues to reduce tax distortions (what we term "revenue recycling") versus pricing policies that do not take advantage of this effect, for example, by returning the revenues in lump sum transfers to households.

Without the benefits of revenue recycling, emissions pricing policies may not be superior to a CES on cost-effectiveness grounds. This is because emissions pricing policies have a bigger impact on energy prices, and hence can further amplify preexisting tax distortions.

These implications are borne out in a recent RFF study by Parry and Williams (2011). They looked at several policies to reduce domestic, energy-related CO_2 emissions by 8.5 percent (about 0.5 billion tons) in 2020 below levels otherwise projected to occur for that year (this is about the level of domestic reductions projected under federal cap-and-trade proposals). Under cap-and-trade policies with free allowance allocation (or a carbon tax with revenues returned in lump-sum transfers) the estimated average cost per ton reduced is $91 (in current dollars). In contrast, under a carbon tax or cap-and-trade scheme with full allowance auctions, where revenues are used to cut distortionary income taxes, average costs are actually slightly negative (as a result of large gains from cutting other taxes when they distort both factor markets and create distortionary tax preferences). Parry and Williams also examined a CO_2 intensity standard for the power sector, which is similar to a CES in that it promotes fuel switching without a large increase in electricity prices. This policy represents an intermediate case, with average costs of $29 per ton reduced.

In short, the revenues created by carbon taxes or under cap-and-trade are potentially problematic. They need to be used to cut distortionary taxes (or used in other

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ways that yield comparable economic efficiency benefits) for these instruments to be unambiguously better on cost-effectiveness grounds than a CES and similar policies. If not, then well-designed policies to lower the emissions intensity of the power sector could be the better way forward, at least for the scale of energy-related CO_2 reductions envisioned for the medium term.

There are caveats here. One is that a CES may not be well designed in practice (for instance, it could be designed with limitations on credit-trading provisions—see below), with a resulting loss of cost-effectiveness. Another is that the relative differences in the average costs per ton of different instruments, caused by their interactions with the tax system, become less pronounced as the goal for CO_2 reductions becomes more ambitious. A third, related point is that there are limits to the reductions in CO_2 that a CES can deliver compared to a cap-and-trade or carbon tax policy because a CES offers less of an incentive for energy conservation and would only apply to the electricity sector. So, pushing the CES hard could, beyond some point, result in a rapid escalation of costs compared to a cap-and-trade policy.

Nevertheless, important practical obsta-

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cles associated with higher energy prices are holding up emissions pricing policies and the current political environment seems to favor a CES-type approach for the time being. One such obstacle is competitiveness and the related issue of emissions leakage. As energy prices rise in response to climate policy, firms trading in global markets with energy-intensive production processes (steel, aluminum, and cement, for example) suffer a loss of competitiveness and may relocate some of their activities to countries without emissions pricing policies. Measures to address capital flight, however, such as taxes or permit requirements imposed on embodied carbon in imported products (with symmetrical rebates for exported products), are contentious because of problems measuring carbon content and possible conflicts with international trade obligations.

Similar issues arise in the context of distributional impacts. CO_2 emissions-pricing policies are regressive (that is, the burden of higher energy prices, relative to income, is greater for poor households than for wealthy households) because lower-income households tend to spend a relatively larger portion of their income on energy. Under emissions pricing policies, complicated compensation schemes could be designed to address some of these regressive effects (for example, using revenues to fund tax cuts that disproportionately benefit the poor), though these schemes typically lower the economic efficiency benefits from revenue recycling.

In short, to the extent that competitiveness and emissions leakage are concerns for the near term (and until emissions pricing becomes more prevalent in other countries), a CES may be favored over a cap-and-trade or carbon tax policy because the former results in less of an energy price increase. And until carbon taxes can be implemented as part of a broader fiscal package that has some progressive elements (like scaling back tax preferences favoring the wealthy), distributional concerns might be better addressed through a CES or other policy that avoids large increases in energy prices.

A clean energy standard may be favored over a cap-and-trade or carbon tax policy because it results in less of an energy price increase.

CES versus Feebate

Although we have discussed some potential merits of a CES, some potential pitfalls exist in the details of design (rather than the general concept). In fact, a feebate could be a more promising approach.

A feebate—a term taken from the literature on applying rebates to vehicles that more than meet a fuel economy standard and a fee applied to vehicles with fuel economy worse than the standard—would have two elements in the context of the electricity sector. First, a price on CO_2 emissions. Second, a *pivot point* level of CO_2 per kWh. Firms with emissions intensity (averaged across their portfolio of generation plants) in excess of the pivot point would pay a fee calculated based on CO_2 price, emissions per kWh beyond the pivot point, and their electricity generation (in kWh). Conversely, firms with CO_2 per kWh below the pivot point would receive a rebate or subsidy based on a similar calculation. The policy can be made revenue-neutral (approximately) by setting the pivot point in one year equal to the average observed CO_2

per kWh in the previous year. The feebate approach has several potential advantages over a CES.

For starters, the incremental costs of reducing CO_2 are automatically equated across different generators, promoting a cost-effective allocation of emissions reductions within the power sector at a given point in time. Another attraction of the feebate is that it automatically handles changes in the future costs of different generation technologies or fuel prices. If, for example, the future expansion of nuclear power is temporarily held up, firms would be permitted a higher emissions intensity (at the expense of paying more fees or receiving fewer rebates); under a strict CES they would be required to meet a given emissions intensity standard, regardless of costs. Conversely, if the competitiveness of wind power improves, firms are rewarded for exploiting this opportunity and further cutting their emissions under a feebate system; with a CES, they have no incentive to do better than the emissions intensity standard.

By establishing a fixed price on CO_2 emissions, moreover, a feebate facilitates comparison of policy stringency across countries. This price could be set in line with estimates of the (global) environmental damages from CO_2 (currently about $21 per ton, according to a recent review across U.S. agencies and subsequent use in U.S. regulatory impact analyses [U.S. Interagency Working Group on Social Cost of Carbon 2010]) or prices prevailing in the European Union's Emissions Trading. Finally, designing a transitory compensation scheme to improve feasibility by helping coal-intensive generators should be straightforward under a feebate system, where the future emissions price is known, rather than under a CES where the emissions price is revealed later on during credit trading.

Today, without either an auctioned cap-and-trade system or a revenue-neutral carbon tax in place, a serious and reasonably comprehensive effort on behalf of the United States to begin scaling back CO_2 emissions is urgent, not only for its own sake, but also to undermine excuses for delaying emissions-reduction programs in other countries. A CES could, under certain conditions, be more cost-effective and less contentious than a tax or cap-and-trade program. Policymakers would be wise to also consider a feebate applied to power sector emissions, which could strike a better balance between cost-effectiveness and political realities than a CES.

By establishing a fixed price on CO_2 emissions, a feebate facilitates comparison of policy stringency across countries.

FURTHER READING

Parry, Ian W.H., and Roberton C. Williams III. 2011. Moving U.S Climate Policy Forward: Are Carbon Taxes the Only Good Alternative? Discussion paper 11-02. Washington, DC: Resources for the Future.

U.S. Interagency Working Group on Social Cost of Carbon. 2010. Technical Support Document: Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866. Washington, DC: United States Government.

The views expressed in this article are those of the authors and do not necessarily represent those of the IMF or IMF policy.

RFF's Centers of Excellence

Tackling Critical Environmental Issues for Today and the Future

Developing effective environmental policy requires us to do more than simply analyze current issues. We also need to constantly scan the horizon for what's ahead to help set future agendas for the policy community. By engaging with government leaders, industry experts, and academic researchers, RFF's new Centers of Excellence strive to move environmental policy forward in four key areas.

The **Center for Climate and Electricity Policy (CCEP)** conducts research and analysis to inform the development of domestic and international climate mitigation and adaptation policy. Special initiatives focus on energy efficiency measures to achieve climate goals, regulation of greenhouse gases under the Clean Air Act, and development of a clean energy standard. Other policy analyses address reducing emissions from deforestation and degradation (REDD), adapting to and mitigating the effects of climate change, international climate finance, and state and regional policies. For more information, contact RFF Senior Fellow and Director of CCEP Raymond J. Kopp, or visit www.rff.org/ccep.

The **Center for Energy Economics and Policy (CEEP)** builds on decades of energy-related research at RFF to help policymakers understand and consider the economics of energy options. Special initiatives focus on the development of a coordinated national energy policy by examining different policy combinations based on their effectiveness and social costs. Other research explores the costs and benefits of natural gas and offshore oil drilling, links between energy and transportation, and the effects of energy subsidies. For more information, contact RFF Research Director, Senior Fellow, and Director of CEEP Alan J. Krupnick, or visit www.rff.org/ceep.

The **Center for Forest Economics and Policy (CFEP)** provides objective assessments and analyses of critical forest issues, from the role of plantation forests as a source of industrial wood to the size of the carbon footprint associated with biomass energy. In addition, CFEP research includes measuring and monitoring global forests and forest carbon, examining the effects of climate change on forests, and exploring wildfire prevention, suppression, and effects. For more information, contact RFF Senior Fellow and Director of CFEP Roger A. Sedjo, or visit www.rff.org/cfep.

The **Center for the Management of Ecological Wealth (CMEW)** works to build a better understanding of the benefits of ecological wealth, including clean air and water, diverse and plentiful plant and animal life, productive soils, and buffers against floods, fires, and disease. Using that knowledge, CMEW experts help policymakers incorporate ecological science into innovative policy solutions that preserve nature and address the challenges posed by the decline of natural systems. For more information, contact RFF Senior Fellow and Co-Director of CMEW James W. Boyd, RFF Visiting Scholar and Co-Director of CMEW Lynn Scarlett, or visit www.rff.org/cmew.

A Look at What's Happening

Inside RFF

HILARY SIGMAN, noted environmental economist, joined RFF as a nonresident fellow. One of Sigman's main areas of research has been transboundary issues, including federal-versus-state implementation and enforcement of environmental regulations and pollution of rivers that cross national boundaries. She is a professor of economics at Rutgers University and a research associate at the National Bureau of Economic Research.

Vice President for Research and Senior Fellow **MOLLY MACAULEY** was appointed to the U.S. Carbon Cycle Scientific Steering Group, which advises the U.S. Global Change Research Program established by Congress.

ROGER SEDJO, senior fellow and director of RFF's Center for Forest Economics and Policy, received an Honorary Doctorate of Humane Letters (L.H.D.) for his work in natural resources and forestry from the State University of New York (SUNY) and the SUNY College of Environmental Science and Forestry.

PAUL PORTNEY was awarded the 2010 Distinguished Achievement Award by the Society for Risk Analysis. Portney, a former RFF president and current university fellow, was recognized for his "extraordinary achievement in science or public policy related to risk analysis."

Climate Change and Global Poverty, a book edited by Visiting Scholar **NIGEL PURVIS**, Research Assistant **ABIGAIL JONES,** and Lael Brainard, was selected by the American Libraries Association as an Outstanding Academic Title for 2010.

Resident Scholar **LEONARD A. SHABMAN** and coauthors Jonathan Deason, G. Edward Dickey, and Jason C. Kinnell received the American Society of Civil Engineers Journal of Water Resources Planning and Management award for Best Policy Paper for 2010 for their paper "Integrated Planning Framework for Urban River Rehabilitation."

Chauncey Starr Senior Fellow **ROGER COOKE'S** work in high dimensional dependence modeling was featured at the 4th Workshop on Vine Copula Distributions and Applications at the Technical University of Munich.

Several RFF experts were appointed to National Academy of Sciences Committees:

» **J. CLARENCE DAVIES,** senior fellow, is a member of the committee Incorporating Sustainability in the U.S. Environmental Protection Agency.

» **MOLLY MACAULEY,** vice president for research and senior fellow, is a member of the committees Assessment of NASA's Earth Science Program and Assessment of NASA's Orbital Debris Programs.

» **MAUREEN CROPPER,** senior fellow, and **ROBERTON WILLIAMS**, director of academic programs, are members of the committee Effects of Provisions in the Internal Revenue Code on Greenhouse Gas Emissions.

Lester B. Lave (1939–2011)

An Appreciation

Lester B. Lave, one of the nation's leading economists, died May 9, 2011, at his home in Pittsburgh. RFF President Phil Sharp released the following statement: "Lester Lave was a wonderful colleague, mentor, and friend to many of us at Resources for the Future. His pioneering work with Eugene Seskin on the health impacts of air pollution is just one example of the tremendous legacy he leaves. He was a giant in his field and his loss is deeply felt here, as it is among all those who had the good fortune to know him."

2011 Summer Interns

Every summer, interns come from around the world to work with the RFF research staff.
Standing, left to right: Chrystie Burr, Hal Gordon, Ron Chan, Taylor Martin, Brendan Cooper, Samuel Stolper, Jonathan Eyer, Megan Orlando, Davie Nguyen.
Seated, left to right: Beau Wittmer, Xingchen Wang, RFF President Phil Sharp, Rachel Jiang, Xiaohui Tian.

Ellen A. Walter

Ways to Give

Nearly 60 years ago, Resources for the Future pioneered the application of economics as a tool to develop more effective natural resource policy. Today we continue to provide independent, nonpartisan research and analysis to set the future agenda for the environmental policy community. Our supporters help make this possible.

RFF received a top rating of four stars from Charity Navigator because we exceed industry standards and outperform other charities in terms of fiscal responsibility and financial health.
Visit www.charitynavigator.org for more information.

How You Can Help

As a 501(c)(3) organization, our success relies on individuals, corporations, and foundations that have the vision to see the role research plays in formulating sound public policies. If you believe that today's environmental challenges deserve independent investigation and innovative, implementable solutions, become an RFF supporter today. There are various ways to support RFF:

Donate online: You can donate through the secure Network for Good website at www.networkforgood.org.

Donate via mail: If you would like to contribute by mail, please use the enclosed envelope or send your gift to:

Resources for the Future
Attn: Development Office
1616 P Street NW
Washington, DC 20036

Provide matching gifts: Your employer may be one of the many that will support RFF through a matching gift program. Your personnel office can provide the appropriate form to include with your donation. For your employer's reference, RFF's Tax ID number is 53-0220900.

Participate in the Combined Federal Campaign: If you are a federal employee or member of the military, you can support RFF through the 2011 Combined Federal Campaign using the CFC code 19241.

Give gifts of stock: RFF accepts gifts of stock, bonds, and mutual funds. Please contact Barbara Bush at 202.328.5030 or bush@rff.org for assistance.

Consider planned gifts: If you would like information about bequests or deferred giving, please contact Lea Harvey at 202.328.5016 or harvey@rff.org.

Become a corporate or foundation member: Our community of supporters enjoys a wide array of membership benefits, including invitations to special events and individual meetings with RFF researchers. Please contact Key Hill at 202.328.5042 or hill@rff.org for more information.

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