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RESOURCES FOR THE FUTURE

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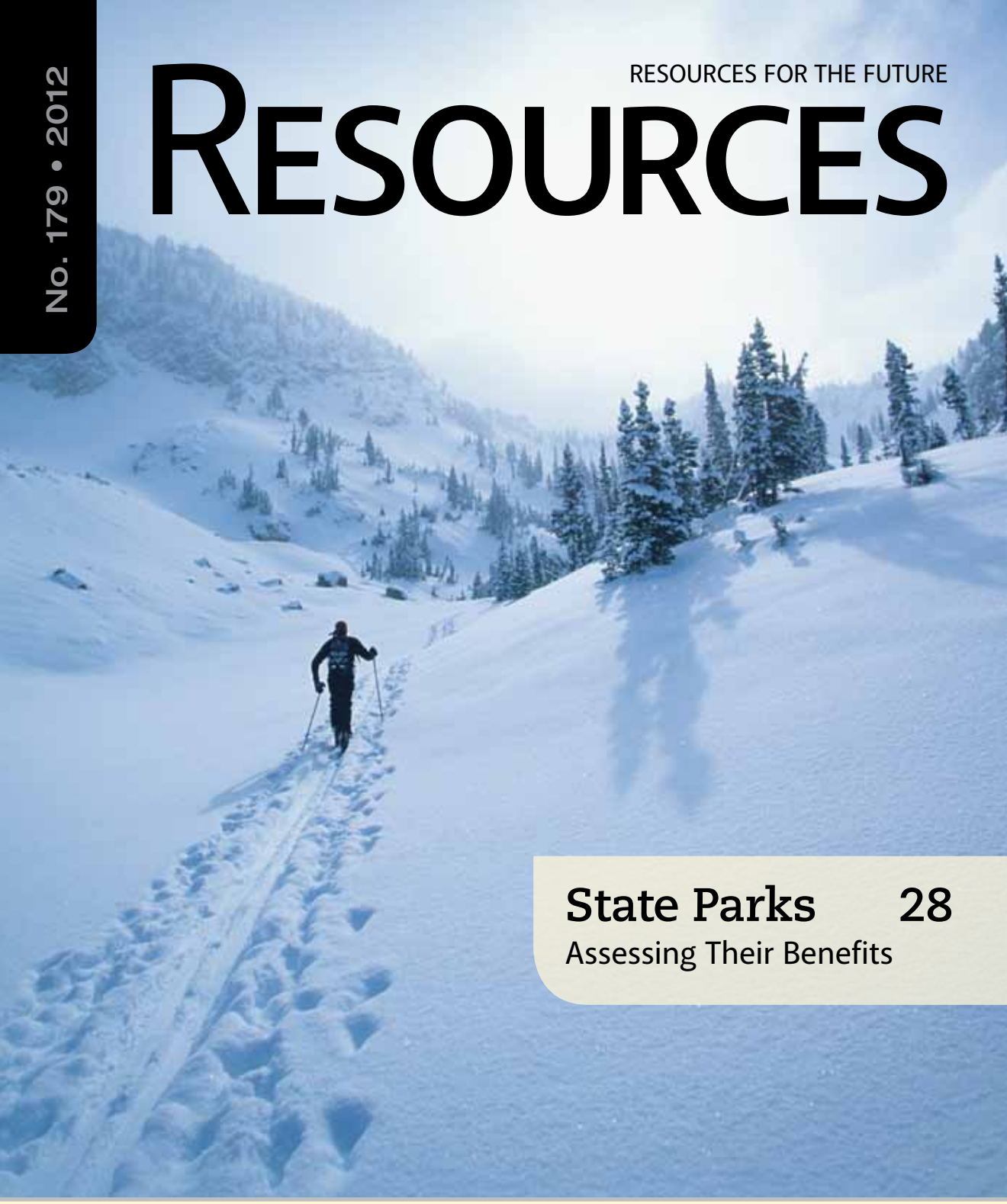

Resources

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In This Issue

RFF Senior Fellow **James W. Boyd** is co-director of RFF's Center for the Management of Ecological Wealth. His research lies at the intersection of economics, ecology, and law, with a particular focus on the measurement and management of ecosystem goods and services. He has served on National Academy of Science and other advisory panels, including most recently the U.S. Environmental Protection Agency's Committee on Valuing Ecological Systems and Services.

Boyd

In his four decades at RFF, Senior Fellow **Joel Darmstadter** has conducted research centered on energy resources and policy. His recent work addresses issues of energy security, renewable resources, and climate change. Darmstadter has served on numerous National Research Council bodies and has contributed to their studies. He also was part of a team that evaluated the performance of the U.S. Department of Energy's National Institute for Global Environmental Change.

Darmstadter

Winston Harrington is a senior fellow at RFF. His research interests include urban transportation, motor vehicles and air quality, and problems of estimating the costs of environmental policy. He has worked extensively on the economics of enforcing environmental regulations, the health benefits derived from improved air quality, the costs of waterborne disease outbreaks, endangered species policy, federal rulemaking procedures, and the economics of outdoor recreation.

Harrington

RFF Senior Fellow **Raymond J. Kopp** is director of RFF's Center for Climate and Electricity Policy. His current research interests focus on the design of domestic and international policies to combat climate change. During his career, he has specialized in the analysis of environmental and natural resources issues with a focus on federal regulatory activity. He led the first examination of the cost of major U.S. environmental regulations in a full, general equilibrium, dynamic context by using an approach that is now widely accepted as state-of-the-art in cost–benefit analysis.

Kopp

Kousky

Linn

Olmstead

Siikamäki

RFF Fellow **Carolyn Kousky's** research focuses on natural resource management, decisionmaking under uncertainty, and individual and societal responses to natural disaster risk. She has examined how individuals learn about extreme event risk, the demand for natural disaster insurance, and policy responses to potential changes in extreme events due to climate change. She also is interested in ecosystem services policy and has examined the design of incentive-based mechanisms to supply ecosystem services and the use of natural capital to reduce vulnerability to weather-related disasters.

Joshua Linn is a fellow at RFF. His research centers on the effect of environmental regulation and market incentives on technology, with particular focus on the electricity sector and markets for new vehicles. His work on the electricity sector has compared the effectiveness of cap and trade and alternative policy instruments in promoting new technology, including renewable electricity technologies.

RFF Fellow **Sheila Olmstead's** research focuses on natural resource management and pollution control, with a particular emphasis on water resource economics, including urban water demand management, market-based approaches to water conservation, drinking water quality regulation, access to drinking water among low-income populations, and the efficient allocation of water across sectors. Her recent work investigates the impacts of information disclosure on drinking water quality violations, regulatory avoidance under the U.S. Safe Drinking Water Act, the influence of federal fire suppression policy on land development in the American West, and key components of a post-2012 international climate policy architecture.

Recent work by RFF Fellow **Juha Siikamäki** has examined nature recreation in the United States, global options for preserving forest carbon and biodiversity, potential for improving the cost-effectiveness of biodiversity conservation, and households' preferences for energy efficiency. His research focuses on evaluating the benefits, costs, and cost-effectiveness of different environmental policy options. His work concentrates on natural ecosystems, such as forests, agricultural landscapes, and coastal ecosystems. He has broad interest in public policy evaluations, especially in the context of empirical assessments of consumer preferences and choices.

60 Years of Investing in Ideas

In the long run, economic growth and environmental protection must go hand in hand. But achieving both requires innovative and tough-minded thinking. This has been at the heart of our work at Resources for the Future since 1952.

This year RFF celebrates its 60th anniversary. The organization was created in response to fears that scarce natural resources eventually could jeopardize economic growth and national security. *Resources for Freedom,* the presidential commission report that recommended the creation of RFF, was truly a landmark in the analysis of environmental and natural resource scarcity.

We've come a long way. Yet 60 years later, some of the same concerns are still on people's minds, particularly with rising prices in many commodity markets. It's important to keep some perspective, however. As Senior Fellow Joel Darmstadter's piece in this issue of Resources reminds us, we've been down this path before.

That isn't to say that past experience is an infallible guide for the future. The world has changed markedly and scarce minerals such as rare earths have joined the roster of traditional concerns like oil and copper. Darmstadter suggests that today may be an opportune time to conduct a systematic and comprehensive assessment of U.S. and global resource prospects.

While some questions from the past remain with us, we are also faced with a whole set of new ones. Perhaps none is more challenging than reconciling sound environmental protection with the imperative for robust economic growth. In particular, the stakes around the climate change issue are large, for both the economy and the planet.

With the world economy in the midst of tenuous recovery from economic crisis and the fiscal situations of many national governments looking bleak, there is now an intense focus on what government costs us, either directly in the form of expenditures or indirectly in terms of reduced economic growth. Against this backdrop, governments, nongovernmental organizations, and the private sector are emphasizing getting the most out of environmental investments.

It's no surprise that this means an important role for RFF's brand of rigorous economic analysis. RFF has been at the

When it comes to the critical global challenges of today and tomorrow, we believe the best long-run rate of return comes from unbiased research, innovative thinking, and a commitment to practical solutions.

forefront of measuring the costs and benefits of environmental and natural resource policies and has pioneered approaches to including hard-to-measure values. In this issue, you'll find numerous examples of how RFF experts are identifying and measuring the real return of approaches to environmental and natural resource policy:

» As Director of RFF's Center for the Management of Ecological Wealth Jim Boyd notes, the challenge with measuring return on investment for conservation efforts is that many of the returns—improved air and water quality, more abundant biodiversity, and improvements in other ecosystem services—are difficult to measure.

» RFF Fellow Juha Siikamäki's innovative research finds that state parks contribute roughly one-third of all nature recreation in the United States and produce billions of dollars' worth of benefits each year.

» Ray Kopp, director of RFF's Center for Climate and Electricity Policy, argues that governments should think like the private sector in seeking out carbon reductions—look for the best deals out there.

» When Senior Fellow Dick Morgenstern and his RFF colleagues Jhih-Shyang Shih and Billy Pizer looked at the impacts of environmental regulations on employment over ten years ago, their work was mainly noticed in academic circles. That's changed recently, and as Morgenstern's interview in these pages makes clear, the policy community is beginning to take a keen interest in this very complicated issue.

These are just some of the ways that RFF is interacting with the public and private sectors to address new problems and account for new realities. The fundamentals, however, have remained constant throughout the life of our organization: research excellence, independent analysis, and meaningful policy recommendations.

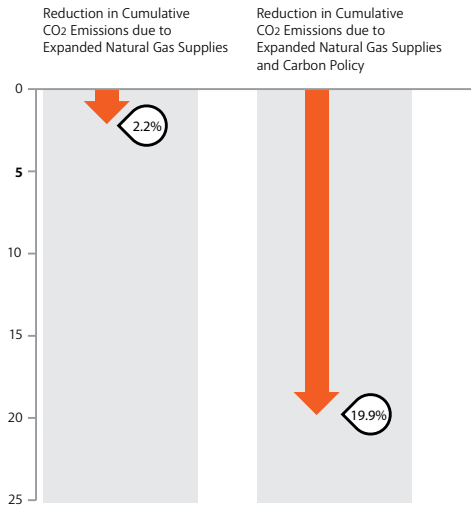
Clear thinking about the costs and benefits of environmental protection and resource management is no longer a luxury; it's a necessity. When it comes to the critical global challenges of today and tomorrow, we believe the best long-run rate of return comes from unbiased research, innovative thinking, and a commitment to practical solutions.

Philip R. Sharp, President
sharp@rff.org

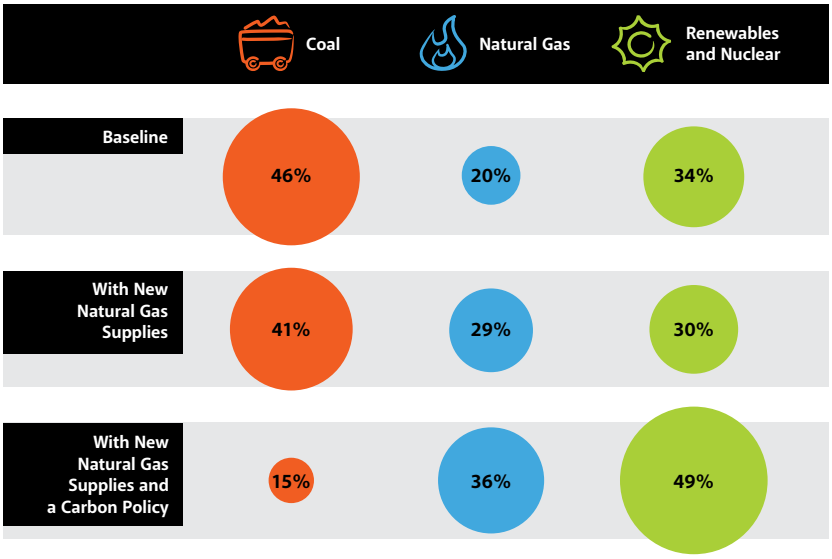
Natural Gas: A Bridge to a Low-Carbon Future?

Because the emissions from natural gas are about 45 percent lower per Btu than coal, some have suggested that newly revised estimates of U.S. shale gas reserves could mean that gas will be a "bridge" to a low-carbon future. Research from RFF's Center for Energy Economics and Policy indicates that while natural gas may substitute for coal, it won't substitute for a carbon policy. The reason: gas also competes with low-carbon energy sources, like renewables and nuclear power. Without a carbon policy, the greenhouse gas emissions from greater use of natural gas are modest, although new natural gas supplies will lower the cost of climate policy. So natural gas is a bridge, but a flimsy one.

CUMULATIVE (2010-2035) CO_2 EMISSIONS FROM TWO POSSIBLE FUTURES



SHARE OF ELECTRICITY GENERATION IN 2035 FOR THREE POSSIBLE FUTURES



Source: Brown, Stephen P.A., and Alan J. Krupnick. 2010. Abundant Shale Gas Resources: Long-Term Implications for U.S. Natural Gas Markets. Discussion paper 10-41. Washington, DC: Resources for the Future.

Highlights of RFF's Recent Contributions to Shaping Environmental Policy

Flood Risk Management
September 14
In this seminar presented by RFF and the Royal Netherlands Embassy, Netherlands' Delta Commissioner Wim Kuijken offered thoughts on what his country has learned about floodplain and flood risk management. He also discussed new policies his country is adopting. Other panelists provided commentary in the context of U.S. issues and emerging policy options going forward. www.rff.org/FloodRisk

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CONVENING THOUGHT LEADERS

Census of Marine Life
October 4
At this seminar, RFF University Fellow Jesse H. Ausubel, vice president of programs at the Alfred P. Sloan Foundation and director of the Program for the Human Environment at The Rockefeller University in New York City, offered the most comprehensive and authoritative answer yet to one of humanity's most ancient questions: "what lives in the sea?" www.rff.org/MarineCensus

Creative Financing for Energy Efficiency
October 5
Panelists at this First Wednesday seminar discussed the role that financing can play in improving the energy efficiency of buildings and offered insights on the importance of financing as a tool for closing the energy-efficiency gap. They addressed opportunities for private financing and evaluated recent government initiatives. www.rff.org/Financing

How Climate Change Impacts Voting
October 14
RFF University Fellow Jon Krosnick, of Stanford University, presented the results of a new study examining whether candidates' positions on climate change policy have influenced their electoral success. www.rff.org/Voting

Sustainable Forest Products
November 2
Panelists at this First Wednesday seminar discussed the impacts of illegal logging,

the changing regulatory regime, and tools available to help avoid buying illegal forest products. www.rff.org/ForestProducts

Risks of Shale Gas
November 14
RFF's Center for Energy Economics and Policy hosted a public launch of a new initiative to identify the priority risks associated with shale gas development and recommend strategies for responsible development. Turn to page 16 to read more about this initiative. www.rff.org/ShaleGasRisks

Greenhouse Gas Regulation under the Clean Air Act
December 7
At this First Wednesday seminar, speakers discussed Clean Air Act rules and regulations as pathways for climate policy in the absence of congressional action. The three panelists presented results of recent RFF research on how such regulations would affect power plants in particular. www.rff.org/GHG

BUILDING PARTNERSHIPS

Clean Energy Standard (CES)
July 27
RFF's Center for Climate and Electricity Policy and the U.S. Environmental Protection Agency co-hosted a workshop to present current analysis of CES policies—drawing upon recent empirical modeling and conceptual thinking by RFF, other independent and government research institutions, industry, and various stakeholders. www.rff.org/CES

Shale Gas and Groundwater
September 27
RFF Fellow Sheila Olmstead discussed RFF's new research on managing the risks of shale gas development at the Groundwater Protection Council Annual Forum.

Energy Policy Options
September 28
Alan Krupnick, director of RFF's Center for Energy Economics and Policy, presented at an event in Portugal co-sponsored by the Universidade de Coimbra and the U.S. Embassy in Portugal.

Carbon Tax
October 18
RFF's Center for Climate and Electricity Policy and the Peterson Institute for International Economics co-hosted a workshop to discuss the design, implications, and prospects of a federal carbon tax. www.rff.org/CarbonTax

Climate Economics and Policy
October 27
This conference, presented by the Stanford Institute for Economic Policy Research and RFF, with support from the U.S. Environmental Protection Agency, brought together a group of research economists and policy leaders to take stock and help provide guidelines for future climate policy. www.rff.org/NextRound

Climate and Energy
November 9
RFF President Phil Sharp and other experts discussed critical energy and climate challenges as part of the launch of the Center for Climate and Energy Solutions, the successor to the Pew Center on Global Climate Change.

Environmental Infrastructure
November 10
RFF, in partnership with the University of Maryland and TU Berlin/DIW Berlin, hosted the Fifth Annual Trans-Atlantic INFRADAY Conference on Applied Infrastructure Modeling and Policy Analysis, focusing on the environmental impacts of infrastructure.

Loan Guarantees Reconsidered

Early in September 2011, Solyndra, which manufactured a new type of solar photovoltaic module, declared bankruptcy, and about 1,100 workers lost their jobs. The company had been awarded a $535 million loan guarantee from the U.S. Department of Energy's (DOE) Loan Programs Office (LPO), and many politicians and industry advocates had previously touted Solyndra as a positive example of the "green economy." DOE's press release announcing the award in September 2009 predicted that Solyndra would "accelerate job creation and ... introduce into large-scale commercial operation a new and highly innovative process for manufacturing a breakthrough design for photovoltaic panels."

Solyndra's collapse and the resulting cost to taxpayers have generated a flurry of media coverage. While some of that coverage delved into issues related to loan guarantees in general or Solyndra in particular, most of the media attention has focused rather narrowly on the loan approval process, largely ignoring the bigger policy questions. As the quote above reflects, loan guarantee programs such as DOE's have rather broad aims: encouraging commercialization of brand-new technology, promoting U.S. manufacturing of green technologies, and stimulating the stagnant economy. Are loan guarantee programs a good way to achieve these objectives, and how can this approach be improved?

Three Loan Guarantee Programs in One Office

The basic workings of a loan guarantee are fairly simple. A private company borrows money for a project, and the government agrees to repay all or most of the loan if the project fails and the company has to default. By reducing the risk to the lender, the guarantee reduces the cost to the company of obtaining the loan. Effectively, the government is subsidizing the cost of the project.

DOE's LPO oversees three programs that have overlapping objectives. The first program aims to encourage the commercialization of significantly new or improved technologies that reduce carbon dioxide emissions. The second program aims to create jobs in the current weak economy and includes, in particular, projects that began construction before the end of 2011. The third program specifically focuses on vehicle technologies. All told, the programs have guaranteed almost $40 billion in loans for 42 projects. The expected federal liability depends on the projects' successes and will almost surely be less than $40 billion.

Common Rationales for Loan Guarantees

Three primary arguments commonly support the goals of loan guarantees.

Bridging the "valley of death." Investment in new technologies tends to be highest in the earliest stages (think venture capital or public funding of basic R&D) and in the latest stages (private funding after commercialization); in the "valley" between these stages, new technology has trouble attracting private investment. Investors may not want to back a start-up because there is too much uncertainty about the quality of its product, for example, or

Despite receiving a $535 million DOE loan guarantee, Solyndra shut down its manufacturing operations on August 31, 2011, and filed for bankruptcy a week later.

because the time horizon required for payback is too long.

Providing immediate economic stimulus. Because of poor and presumably transitory economic conditions like the current economic downturn, many otherwise successful businesses—particularly environmentally innovative ones—may fail; loan guarantees would help support such businesses.

Supporting green industry in the long term. Many supporters of loan guarantees argue that because of either future carbon policy or depletion of exhaustible resources, the United States will have to transition to low-carbon technologies sometime in the future. U.S. citizens would be better off developing and manufacturing these technologies rather than importing them from China and elsewhere.

Some Important Economic Considerations

Using loan guarantees to meet the stated objectives, particularly regarding the commercialization of new technology, means facing several challenges. We turn to those now.

Risk. Investing in new technology is inherently risky—moving from the pilot-project stage to commercialization is extremely difficult, and there is always uncertainty over finding sufficient customers. That doesn't necessarily mean that the projects shouldn't receive subsidies, but it does mean that loan guarantees for new technologies should be recognized as risky. Projects may fail because technologies turn out not to perform as expected, because demand drops unexpectedly, or for a number of other reasons. If few of the projects fail, they might not have been risky enough to justify a loan guarantee.

Learning-by-doing and market failures. Loan guarantees and other investment subsidies are often justified based on a learning-by-doing argument: basic economic theory says that firms invest in learning less than is socially optimal when others profit from it. The important lesson for the government is that subsidies are only justified when there are learning spillovers. If learning stays within the firm, the firm profits from it privately, and subsidies are not justified.

Information. In a successful loan guarantee program, the government supports projects that private investors have decided not to back, but that nonetheless are beneficial to society. In other words, the government needs to figure out why the private market isn't financing the project. Is it because the project is a bad idea? Or because the social benefits of the project outweigh the private benefits? The LPO addresses this information problem by conducting a detailed review of each proposed project, a policy that places a large burden on the government.

Is a Loan Guarantee Program the Best Policy for the Job?

One detail that sets apart loan guarantee programs from other federal subsidies, such as tax credits, is that loan guarantees directly promote the commercialization of new technologies. (Imposition of a carbon dioxide emissions price might be an important complementary policy, reinforcing the loan guarantee promotion of new technologies.) Even so, it is not clear why loan guarantees are the best form of investment subsidy, much less the best policy for meeting the broader objectives of promoting new technology, green industry, and employment. A particularly challenging task for the government is to acquire enough information to identify the projects that have the greatest social value and that the private sector would not invest in otherwise. Identifying learning spillovers is very difficult, as is gathering sufficient information to evaluate a project's risk and societal benefit.

It is not clear why loan guarantees are the best form of investment subsidy, much less the best policy for meeting the broader objectives of promoting new technology, green industry, and employment.

If loan guarantees are to continue despite their shortcomings, they should be subject to ex post evaluation of their effectiveness. The programs are advocated for correcting market failures related to the commercialization of new green technologies, and it should be possible to assess the extent to which the programs achieve that goal.

Other options include an innovation or commercialization prize offered to a project that successfully meets certain criteria, or a production subsidy offered for each unit of output. In both cases, the subsidy can depend on the social value of the project, so the government no longer has to identify the best projects. Instead, private investors can consider the value of the subsidy and any additional profits they may earn from selling the resulting products—and then choose accordingly. ● – Joel Darmstadter and Joshua Linn

Read more:
www.rff.org/PolicyCommentary.

How Does Regulation Affect Employment?

An Interview with Richard Morgenstern

At the end of 2011, with unemployment at 8.6 percent and a growing number of critics focused on "job-killing" environmental rules, *Resources* sat down with RFF Senior Fellow Richard Morgenstern to discuss the impact of government regulation on employment.

RESOURCES: Why might we think regulations would have an impact on employment? What's the theory behind that?

MORGENSTERN: Regulation imposes costs on firms, and these costs typically get passed along in the form of higher product prices. Consumers, in turn, respond by purchasing less and/or searching for alternative suppliers. Reduced sales, combined with additional outsourcing by firms for their material inputs, can lead to job losses.

But that is only part of the story. Regulation is also likely to result in some new investments in pollution abatement or other facility upgrades, which could create jobs in the initially regulated firms or in those firms that are producing the pollution control equipment.

A further impact could be that consumers may shift their buying patterns in a way that creates jobs in domestic industries beyond the initially regulated ones and/or those supplying pollution abatement equipment. Overall, the potential impacts of regulation are complicated. It is difficult to pin down a single unambiguous impact of regulation.

RESOURCES: So that's the theory for why regulation may have a negative impact on employment and why some of that impact might be offset with spillovers to other aspects of the firm or the economy as a whole. What does the evidence show?

MORGENSTERN: That's the most interesting question. Despite the strong policy interest in this question right now, there has been remarkably little study of the issue. Until recently, a paper I wrote more than 10 years ago with colleagues Billy Pizer and Jhih-Shyang Shih was little known outside academic circles because the impact of regulation on jobs wasn't seen as a major policy issue back then. Even now it remains one of the few rigorous studies of the regulation–jobs issue.

RESOURCES: Let's delve into that particular paper. What did you look at, and what did you find?

MORGENSTERN: The analysis is based on confidential plant-level data we obtained from the Census Bureau. Our measure of regulation is reported environmental spending, a widely used, albeit imperfect, metric of regulatory burden.

The paper's strength is that the modeling, using advanced econometric methods, is quite detailed, linking regulation to changes in output and, ultimately, to employment. We explicitly modeled the possibility of added employment at the industry level in response to regulation. The weaknesses are that we studied only four industries—pulp and paper, plastics, petroleum, and steel—and all the data are from the 1980s and early 1990s.

Our results suggest that regulation has multiple impacts, both creating and destroying jobs. The higher costs are definitely a negative factor, but they tend to be offset by gains in pollution abatement activities. Although there is important variation across sectors, when we look across all four industries studied, we see a small, statistically *in*significant *net* gain in employment. We interpret the results as indicating the absence of a clear-cut impact of regulation on total employment in the four industries during the 1980s and early 1990s. Recognizing the uncertainties, we calculate that environmental spending may have accounted, at most, for 2 percent of the total jobs lost over the period of the study. At the same time, it is also plausible that environmental spending actually had a net job-creation effect, offsetting as much as 4 percent of the total jobs lost over the period. Note that we are talking about total employment, not the protection of particular jobs. Clearly, some individuals have lost jobs, and some have gained jobs.

One of the key challenges is to interpret these results for a broader set of industries, operating in the current U.S. economy. While some may see pulp and paper, plastics, petroleum, and steel as good representatives of heavy industry, our results do not reflect the important differences between those sectors relying on control technologies, such as baghouses, scrubbers, or other end-of-pipe treatments, versus those that change their production processes in response to regulation. Similarly, the 1980s and early 1990s may not reflect the realities of today's economy.

RESOURCES: How do you differentiate your study from the few others out there that show large impacts on employment, at least in regional areas?

MORGENSTERN: MIT economist Michael Greenstone wrote an excellent paper that also has attracted a lot of attention. He finds a significant job *shift* over the period of the late 1970s and 1980s that corresponds to the U.S. Environmental Protection Agency (EPA) attainment designations for air quality. Specifically, after adjusting for a wide range of factors, he finds that several hundred thousand jobs have moved from non-attainment to attainment areas.

Notwithstanding the high quality of his paper, Greenstone does not specifically address the question of job *loss.* Rather, his focus is on job *shifts* from non-attainment to attainment areas. Although individuals

Regulation has multiple impacts, both creating and destroying jobs. Higher costs are a negative factor, but they tend to be offset by gains in pollution abatement activities.

may lose particular jobs, the limitations of his model prevent him from determining whether these jobs are made up by gains elsewhere in the economy. For example, an auto plant in Michigan that shifted production to Tennessee would show up in Greenstone's analysis as a job shift—that is, a negative impact. In our study, such shifts in production would show up as having no net impact on jobs if the same number of people were employed in Tennessee as in Michigan.

RESOURCES: Especially in these times, we might say "a job is a job," but does a manufacturing production job pay more or less than jobs that are geared toward reducing emissions or limiting environmental impacts? Has anyone looked at the impact of these regulations on wage levels?

MORGENSTERN: I'm not aware of specific studies of the impact of regulation on wage levels, but it is certainly true that manufacturing jobs tend to be highly paid, capital-intensive jobs. To the extent that regulation encourages less capital-intensive jobs—for example, in the service industries—they may well involve lower pay. It is plausible that changes of that type are occurring. Other impacts also may be important. For example, there is some evidence that people who go through a transition lose some of their skills before they are rehired.

Up to this point, EPA and other government agencies have generally considered the job impacts of regulation in the context of a full-employment economy. Recently, some have called for a more pragmatic approach that recognizes the difficulty of finding new jobs for people who are displaced by regulation. In the days of low unemployment, this was not a priority issue. Understandably, with an outlook of extended unemployment, some change may be necessary in the way we think about these issues.

RESOURCES: If you were to examine this issue again, what sort of things would you want to study in particular?

MORGENSTERN: That's a really good question. In fact, RFF Fellow Josh Linn and I are starting to do some new work on this issue in collaboration with other researchers outside of RFF. We are attempting to regain access to the confidential census data that I mentioned, to update the earlier analysis. We also are trying to look at a broader set of industries.

RESOURCES: Terrific. When your study is completed, we hope you will come back and share your results with us.

MORGENSTERN: I'd be happy to. Thanks. ●

Hear the full interview at www.rff.org/MorgensternQA.

The Risks of Shale Gas Development

How RFF Is Identifying a Pathway toward Responsible Development

In November, several hundred people came to RFF—and even more joined the audience via live webcast—to listen to RFF experts and outside consultants discuss the opportunities and risks of extracting natural gas from shale. The turnout for the event was a testament to the keen interest in the shale gas development process—and to the strong opinions and confusion that the issue generates.

Depending on whom you ask, natural gas extracted from shale is the path to U.S. energy independence or the road to environmental destruction. The information available about the risks and value of shale gas and hydraulic fracturing is scattered and

often contradictory, making it difficult for policymakers and regulators to determine how to take advantage of this promising energy resource while addressing the risks to the environment and the public.

RFF is working to remedy that. The November event, "Managing the Risks of Shale Gas: Charting a Pathway to Responsible Development," marked the public launch of an 18-month initiative by RFF's Center for Energy Economics and Policy (CEEP) to identify the risks of shale gas development and recommend strategies for responsible development. This analysis, made possible by a $1.2 million grant from the Alfred P. Sloan Foundation, will be the first independent, survey-based assessment of the key risks associated with the shale gas development process.

The project is led by Senior Fellow and Director of CEEP Alan Krupnick, and the team includes experts and scholars at RFF and around the country specializing in water management, natural gas drilling, risk management, cost–benefit analysis, hydrology, engineering, and geology.

"The ultimate goal of this project is to identify the perceived and potential burdens that shale gas development might impose on the environment and on the community, and to think about how industry and government might address those,'' said Krupnick.

To get a clear inventory of the risks, RFF is surveying experts to identify the burdens of shale gas development and polling the public to understand its perception of those risks. Both surveys will challenge respondents to make explicit choices and tradeoffs to determine how people understand and prioritize risk.

The CEEP team developed a matrix that follows the activities involved in producing shale gas—from site preparation to drilling to well abandonment—through to their potential impacts on people and the environment. These "impact pathways," combined with the results of the public and expert surveys, will highlight which specific shale gas development activities are associated with the risks that people care about the most. The team will then identify how regulations and voluntary industry activities are working to address those risks as well as how both groups can do a better job in the future.

"The idea is to map out for each activity the full set of potential burdens, the intermediate impacts, and the final impacts," said RFF Fellow Sheila Olmstead, a primary researcher on the project, at the November event. "The final impacts matter in an economic sense to people and could be monetized in a benefit–cost framework."

The CEEP team has visited shale gas drilling and production sites in the Marcellus Shale natural gas play in Pennsylvania to get a firsthand look at each stage of the development cycle. The tours—one on November 3 of Anadarko Petroleum Corporation's Bull Run drilling sites and one a week later of Chesapeake Energy Corporation's drilling operations near Towanda—provided a detailed view of the development process, from permitting to water use to drilling and fracturing.

Water management is at the center of much of the controversy. The CEEP team learned that Anadarko spent more than $100 million a year to transport water to its Pennsylvania sites until it invested in large-scale freshwater impoundments and pipelines, which lowered those costs by 30 percent. Chesapeake Energy said it uses as much as 5.6 million gallons of water in drilling, fracturing, and completing each well. Both companies are taking steps to eliminate the hundreds of truck trips required in this process. According to Olmstead, RFF already has begun a statistical analysis of

surface water quality and its relationship to nearby shale gas wells, based on data from the Pennsylvania Department of Environmental Protection.

The expert consultants who presented their views at the November event had divergent opinions about shale gas development's safety and environmental impact, especially on water.

"There have been no documented cases of groundwater contamination due to fracturing itself," said Mukul Sharma, a professor and the "Tex" Moncrief Centennial Chair in Petroleum and Geosystems Engineering at the University of Texas at Austin.

James Saiers, a professor of hydrology at the Yale School of Forestry and Environmental Studies, said public worry that shale gas development could contaminate groundwater is not misplaced, as hydraulic fracturing can open pathways from the shale to the surface, such as through old abandoned wells. "I believe that in its heart of hearts, industry does not think this is an issue. But there hasn't been a single study to test their hunch," he said.

There is less debate about whether methane can reach the surface or groundwater through leaks in the borehole. Karlis Muehlenbachs, a professor at the University of Alberta in Edmonton, said he has used carbon isotope fingerprinting of methane, ethane, and propane to show that gas from shale formations has reached the surface. Muehlenbachs presented data suggesting that nearly 60 percent of natural gas wells show flaws in their casings and cements by the time they have been operating for 17 years or more. A buildup of sustained gas pressure within various casings surrounding the well bores can pose risks of casing failure and hydrocarbon leakage to groundwater, soils, or the air.

RFF's project will help to illuminate the facts about the risks of shale gas development. For more information on this project, and for the November event video and slides, visit www.rff.org/ShaleGasRisks. ●

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Fuel Consumption Standards

FOR HEAVY-DUTY VEHICLES

***Winston Harrington** urges regulating agencies to keep other options on the table.*

In August 2011, the National Highway Traffic Safety Administration and the Environmental Protection Agency jointly published the first-ever federal regulations mandating improvements in fuel economy and reductions in carbon dioxide (CO_2) emissions by heavy-duty commercial vehicles. While the standards are arguably models of their kind, questions remain about the overall effectiveness and efficiency of even the best such regulations.

The Regulations

Heavy-duty vehicles range from pickups to combination truck trailers. For regulatory purposes, the agencies developed a simplified, three-way classification that aligns with how vehicles are manufactured and used, and thus, with the technological opportunities for fuel savings. Overall, heavy-duty vehicles account for about 17 percent of total greenhouse gas emissions from all transport sources.

The first category is heavy-duty pickups and vans, used for moving relatively small loads of people and goods for short distances. Vehicles in this category account for about 60 percent of the total heavy-duty fleet but just 20 percent of CO_2 emissions. The new standards call for an average fuel intensity of 5.2 or 6.3 gallons per 100 miles, depending on whether they use diesel fuel or gasoline, representing a 17 or 12 percent reduction from the baseline.

Vehicles in the second category, combination trailers, are used in intercity freight hauling. These vehicles are estimated to account for 65 percent of fuel use and CO_2

emissions from the heavy-duty fleet, even though they make up only about 20 percent of the fleet. The new standards for 2018 call for an average fuel intensity of 6.5–11.8 gallons per 1,000 ton-miles, representing a 10–24 percent reduction from the baseline.

The third category, vocational vehicles, is defined as all vehicles that are not in the other two categories. This category is enormously varied by size, use, and body design, and includes fire trucks, cement mixers, dump trucks, and school buses, among others. These vehicles range in size from 8,500 to 80,000 pounds. The new standards call for an average fuel intensity of 21–36 gallons per 1,000 ton-miles, representing a 6–9 percent reduction from the baseline. In general, achieving reductions in fuel intensity is more difficult and expensive in this category. The predominant use of these vehicles at low speeds in urban and off-road settings makes aerodynamic improvements a wasted effort. The great variety of designs implies low volumes and small rewards for fuel-saving innovations.

Some Concerns

The work done by the agencies in developing these standards is admirable. Yet a basic problem arises: like the CAFE (corporate average fuel economy) standards for light-duty vehicles, the new standards regulate the design and initial performance of vehicles rather than their use. Once the vehicles leave the showroom floor, the regulations have no further influence on them. As a result, the standards affect fuel use only by improving fuel intensity in new vehicles and, with appropriate design, the availability of fuels and engines that use fossil fuels less intensively. The current standards do nothing for fuel consumption rates in existing vehicles, vehicle miles traveled, fleet mix, or fleet turnover rates. Worse, they can affect these other margins perversely.

For example:

The rebound effect. Better fuel use will lower cost per mile or ton-mile, potentially increasing the demand for transport and attracting traffic from more energy-efficient modes, such as barges and railroads. This is a mixed blessing; more transport increases wealth, but it is counterproductive with respect to the policy goal.

Fleet turnover effect. While the price per mile traveled is decreasing, the initial price of the vehicle is going up. Potential buyers will have second thoughts and may decide to postpone new vehicle purchases, delaying fuel intensity improvements. This effect could be stronger in heavy-duty vehicles than in light-duty vehicles simply because their expected lifetimes are longer.

Class shifting. Because costs per vehicle can vary considerably, buyers have an incentive to substitute a vehicle in another category for their first choice. Use of vehicles in other categories may produce cost savings for users but could raise CO_2 emissions substantially. And manufacturers may design and build vehicles that do not now exist but that could, with relatively minor alterations, have multiple uses.

Each of these perverse effects is well understood by the agencies, and in their discussion of the regulations, they minimized their significance. The agencies could be right, or not. Policies such as emissions taxes, focusing directly on vehicle use rather than vehicle design, are likely to be at least as efficient without suffering from the unintended consequences described here.

In addition, the percentage improvement in CO_2 emissions reductions is modest compared to the 50 percent cut thought to be technologically possible. This suggests we are now at the very beginning of a long regulatory process. It makes sense to try to keep all options on the table, including emissions fees and fuel taxes. ●

Unnatural Disasters?

The climate may be changing, but human nature isn't. **Sheila Olmstead** and **Carolyn Kousky** explain.

Fueled by the worst drought in a century, the 2011 fires in Texas torched nearly 4 million acres of land—an area the size of Rhode Island, Connecticut, and New York City combined. The fires consumed more than 7,000 structures and took several lives.

Add this to the blizzards, floods, tornadoes, and hurricanes that racked up tens of billions of dollars' worth of damage across the Northeast, Midwest, and Mid-Atlantic in 2011. And if the most recent forecasts of the U.N. Intergovernmental Panel on Climate Change are correct, extreme weather is likely to become more frequent and even more extreme.

But Mother Nature isn't the sole culprit for last year's string of billion-dollar disasters. A big part of each natural disaster isn't

Induced Development in Risky Locations: Fire Suppression and Land Use in the American West

RFF Fellows Sheila Olmstead and Carolyn Kousky are completing research testing the hypothesis that federal efforts to suppress wildfires in the western United States since 1970 have acted as a development subsidy, drawing new residential and commercial development into risky regions. The analysis exploits a natural experiment—a major shift in federal fire suppression policy that occurred in the aftermath of catastrophic fires in Yellowstone National Park in 1988. Results suggest that during periods when the federal government has intensified its expected suppression efforts on public lands, private residential and commercial development has accelerated on nearby land that would benefit from that suppression.

"natural" after all. Federal policy plays its role, and if we are indeed headed into a new era of wild weather, it's time to make some changes.

An important driver of rising disaster costs is not climate but the presence of more people and structures in harm's way. Certain disasters, such as wildfires and floods, occur largely, if not exclusively, in identifiable high-risk areas. Moving out of these areas reduces your chances of being flooded or losing a home to a wildfire. Less drastic measures, such as fire-proofing your roof or clearing trees near your house, can also reduce that risk.

Hazardous areas like coasts and dry forestland often are nice places to live: they have great views, access to recreation, and little noise and pollution. Floodplains can be fertile agricultural areas. There will always be development in these risky locations, and for much of this development,

the benefits surely will outweigh the costs of disaster damages.

But certain public policies potentially are leading to too much development in some places we know are dangerous and too little investment in risk reduction, increasing losses when disasters do occur.

U.S. wildfire suppression, for example, is largely funded by federal and state taxpayers, not homeowners in fire-prone places, creating an implicit incentive to develop these areas. Our research confirms that in the western United States, development is greater on lands benefiting from federal suppression efforts, all else equal. (See "Induced Development in Risky Locations" on page 22.)

In a similar vein, subsidized crop and flood insurance can encourage farming or development in areas that individuals may have avoided, were it not for federal funds. (See "Improving the Corps of Engineers' Contribution to National Flood Risk Management" below.) There may be distributional or other benefits arising from these subsidies, but we need to be more discriminating about when and which development costs are borne by the general taxpayer.

Federal polices can alter the incentives individuals face to locate in hazardous areas, purchase disaster insurance, or invest in risk-reducing measures. But to date, there is only a small amount of empirical evidence on the magnitude of the intended and unintended influences of federal policies on individual and community decisionmaking vis-à-vis natural hazards. Researchers at RFF are beginning to fill this gap.

With forecasts of extreme events increasing, it is time to look at the impacts of federal disaster risk management policies before tragedy strikes. RFF research will inform the development of disaster policies that consider not just the climate but also human nature. ●

Certain public policies potentially are leading to too much development in places we know are dangerous and too little investment in risk reduction.

Improving the Corps of Engineers' Contribution to National Flood Risk Management

Leonard Shabman, a resident scholar at RFF, is leading a study on flood risk management policy with Carolyn Kousky and colleagues at other institutions. The study recommends replacing the federal focus on projects and programs to secure flood damage reduction with a more decentralized approach. At the heart of this new approach are two objectives. The first is to improve individuals', businesses', and local communities' understanding of their flood risk. To do so, the federal government must clarify the capabilities and limits of its programs to reduce and manage such risk. The second goal is to assure that nonfederal interests take responsibility for the consequences of their decisions to locate in areas that may flood—and for implementation of any risk-reducing measures.

MEASURING CONSERVATION'S RETURN ON INVESTMENT

Cleaner air, reduced flooding, beautiful vistas: ***James W. Boyd*** *gives a five-point plan for quantifying conservation's benefits to human well-being.*

Each year, conservation organizations disburse vast sums of money on the important task of protecting the world's natural areas. In fiscal year 2010, the Nature Conservancy alone spent around $550 million on conservation programs and land purchases. The year before, it spent just over $1 billion. Beyond protecting biodiversity, these investments produce a portfolio of other socially valuable returns: cleaner air and water, healthier soils, reduced risks of flooding and disease, and aesthetic, cultural, and recreational benefits. But how do such organizations quantify this suite of "returns" on conservation investments?

RFF has joined with the Nature Conservancy to answer that question. In this new partnership, experts will work together to assess how the conservation community can apply return on investment (ROI) analysis to its investments.

ROI's Appeal to the Conservation Community

ROI analysis is a formal procedure used to depict the amount and timing of an investment's costs and compare those costs to the investment's upside. ROI analysis also can be used after the fact to evaluate the success or failure of a given investment. Businesses use this tool to help choose new products, develop markets to enter, and identify assets to acquire.

Conservation organizations are starting to pay attention to ROI analysis, too, as a way to quantitatively measure the costs, benefits, and risks of investments so they can rank or prioritize them. Their interest in these methods is motivated by the need to wisely deploy scarce financial and institutional resources, make evidence-based decisions, and evaluate and communicate the relevance of conservation to a wider

spectrum of stakeholders and supporters.

Credible, quantitative ROI analysis of most conservation projects will challenge even the most technically sophisticated conservancies because conservation's effects on water quality and availability, air quality, and other ecosystem services are not yet straightforward to measure. Investments in such measurement are beginning at conservancies but, with a few exceptions, do not yet permit the quantification of ecosystem service outcomes. Also, the social and economic benefits of ecosystem service improvements are rarely evaluated.

Yet among conservation practitioners, there is a near-universal appreciation of conservation's contributions to these "beyond-biodiversity" benefits, a hunger to engage in measurement of those benefits, and numerous efforts to begin building that capacity, including RFF's partnership with the Nature Conservancy.

Five Core Elements

Identification of the returns to be considered is the first step in any ROI analysis. Currently, a commonly identified beyond-biodiversity return is greenhouse gas reductions associated with forest conservation. These reductions are easier to measure than some other returns because they are well studied and their "market price" is relatively easy to describe. Returns like improved water quality and availability from up-watershed reforestation connect conservation even more directly to social benefits.

The second core component of ROI analysis is **empirical analysis of the relationship**

The Gulf of Mexico: An Opportunity to Apply ROI Analysis

The Gulf of Mexico's ecosystems are the site of an ongoing and slow-motion environmental disaster. Over 2,000 square miles of coastal wetlands (an area larger than the State of Delaware) have been lost to the Gulf since the expansion of massive levees along the lower Mississippi River in the wake of the Great Flood of 1927. A "dead zone" reaching nearly 8,000 square miles along the Gulf's bottom waters has been created, largely due to increased nutrient loads carried down the Mississippi and Atchafalaya Rivers from fertilizer use in upstream agriculture. Added to this is damage from oil and gas exploration, most notably the millions of barrels of oil that spilled following the Deepwater Horizon tragedy of 2010.

Addressing the Gulf's declining environmental quality has proved to be an overwhelming challenge, complicated by a lack of both funding and political consensus. Ironically, the Gulf spill has provided a chance to jump-start environmental restoration in the Gulf. A federal–state partnership to restore its vitality has emerged since the Deepwater Horizon accident, with potentially over a billion dollars of funding from fines levied because of the accident.

With a once-in-a-generation opportunity at hand, it is crucial that the investments in Gulf restoration are expended wisely for the benefit of nature and the diverse communities dependent on its goods and services. But how will success and failure be measured? How can the conservation community apply return on investment analysis to these investments? RFF and the Nature Conservancy are working to answer that question.

between conservation investments and desired returns. Over the past decades, conservation organizations have developed and applied methods to quantify conservation's impact on biodiversity. An analogous effort is required to quantify conservation's impact on beyond-biodiversity outcomes. Empirical studies of these relationships are already being conducted by the Nature Conservancy and the academic community focused on ecosystem services. Examples include efforts to quantify the relationship between land use and water quality, aquifer recharge, surface and groundwater availability, pollination, and flood risk reduction.

The return on conservation investments also critically depends on **the risk and magnitude of biophysical losses if conservation investment does not occur**. Often, conservation benefits arise from maintaining current ecological conditions rather than improving them. Thus, conservation's returns in such cases require prediction of future losses.

To do this, both biophysical and economic analyses of threats are necessary. Biophysical analysis can predict losses associated with such threats as invasive species, climate change, and drought. Economic analysis can predict losses associated with changes like population growth, land conversions to agriculture or urbanization, and road construction. It also deserves emphasis that each return captured by an ROI analysis is subject to its own, unique risks. The risks to biodiversity, for example, are not necessarily the same as the risks to water quality degradation.

Beyond-biodiversity biophysical returns are an important step toward assessment of social benefits. But it is also necessary to **translate biophysical returns into their associated social benefits**. One of RFF's traditional strengths is the development and application of tools to measure just such "nonmarket" benefits of nature. A range of social outcome evaluation methods is available, many associated with the basic valuation tools of environmental economics—for example, hedonic analysis, travel cost studies, and stated preference methods. But other approaches are available, too, including arguably more practical methods based on basic sociodemographic data and survey-based methods involving affected households and communities that target outcomes related to physical and human health, subjective well-being, and socioeconomic status.

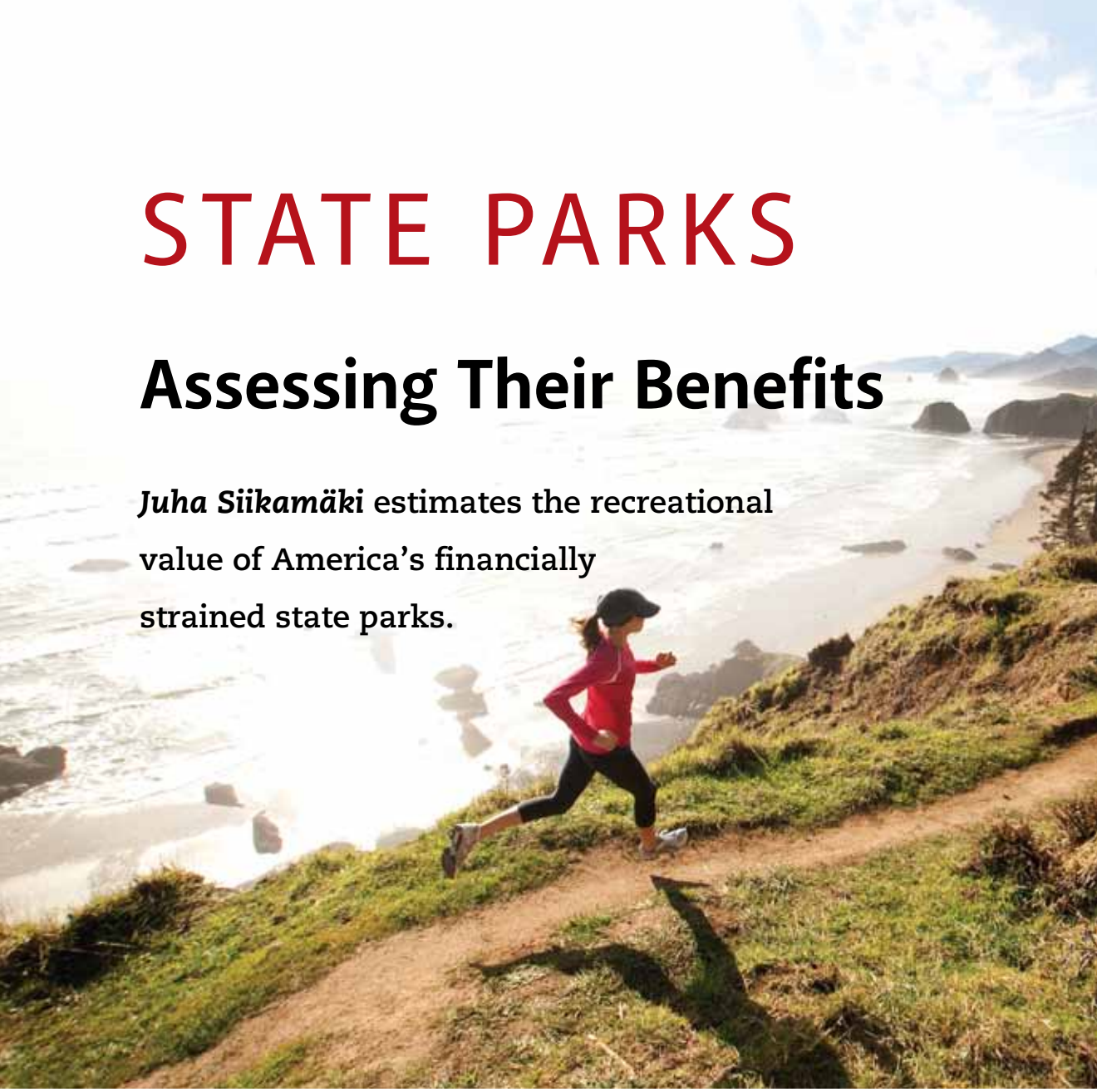
Finally, any multi-objective ROI analysis requires **ways to describe, communicate, and resolve trade-offs among the objectives**. One way to resolve trade-offs is to assign returns different weights that reflect their importance. Nonmarket valuation studies can uncover relative social preferences and express them in a consistent unit: dollars. But conservancies do not necessarily need to use monetary weights derived from economic analysis to weight their own returns. A conservancy may want to weight the importance of its goals to be more reflective of its own mission, values, and strategy. ROI analysis also can be designed to communicate trade-offs in a transparent way, leaving resolution to the discretion and judgment of decisionmakers.

RFF's ongoing work with the Nature Conservancy is devoted to concrete applications of the data and methods needed to develop these five core elements of ROI analysis. Using these methods, the conservation community can continue improving its ability to target the highest-value conservation opportunities, better communicate the social benefits of its missions, and advance evidence-based conservation practices. ●

STATE PARKS

Assessing Their Benefits

Juha Siikamäki **estimates the recreational value of America's financially strained state parks.**



Each year, more than 700 million visits are made to America's 6,600 state parks. Despite the popularity of these areas, Arizona, California, Nevada, New York, and many other states are considering or already have decided to temporarily close some or even all of their parks to reduce expenses. The scale of proposed budget cuts is massive: In 2009, the State of Washington roughly halved the operating budget of its parks—from $100 million to $48 million—with further cuts scheduled for 2011–2013. Arizona legislature cut $72 million from the state parks budget over the past three years, and California has announced a plan to close 70 state parks to help meet a $22 million budget cut. The federal government, also an important supporter of outdoor recreation, similarly is under pressure to reduce spending.

While spending cuts and park closures may be inevitable, we don't know enough about their overall impact on nature recreation. Will the popularity of nature recre-

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ation drop as state parks are closed, or will people simply find alternative locations to explore nature? And does setting up nature parks encourage outdoor recreation? If it does, by how much?

Answering these questions is important from a policy and economic standpoint. Expenditures and investments in support of outdoor recreation are large, so it is worth knowing whether they achieve their intended societal goals and if their impacts translate into economic benefits or losses. Closing parks may not look like such a good idea if they generate larger benefits than the expenditures required to keep them open.

There is a large, rigorous literature assessing outdoor recreation behavior and benefits, but most of it is focused on specific recreation activities, such as angling, hiking, or hunting. Most of the studies further concentrate in a specific geographic region, such as a state or a sub-region within a state or a set of states. I recently completed a study that expanded the scope to include broad categories of recreational activities and examined their popularity relative to the entire U.S. park system.

My research indicates that state parks contribute roughly one-third of all nature recreation in the United States, measured in hours of nature recreation per capita. Using conventional economic approaches to estimate the value of recreation time combined with relatively conservative assumptions, the estimated annual contribution of the state park system is around $14 billion. That value is considerably larger than the annual operation and management costs of state parks.

Study Overview

Examining the amount of time Americans use for nature recreation was the focus of my study. Historical data on time use were available from five different surveys conducted between 1975 and 2007, and with the help of those data I could measure the impacts of changing access to nature on the popularity of nature recreation. Time-use surveys offer detailed descriptions of the daily activities elicited from individuals, and their data comprise a sample from the annual national time budget.

Each surveyed individual was requested to provide a minute-by-minute listing of activities during a 24-hour recall period. Nature recreation was defined broadly

to include many different kinds of physical recreation activities that take place in nature, including fishing, hunting, hiking, camping, skiing, boating, canoeing, recreational walking, and so forth. Using broad categories also made it possible to combine data from multiple surveys.

slightly increased. Note that these participation estimates refer to the percentage of the population for whom time use for nature recreation was not zero during the 24-hour survey recall period. Though such data well predict the relative popularity of nature recreation over time, participation rates would be higher had the recall period been a month or a year.

Between 1975 and 2007, about 3,000 new state parks were established. This expansion is estimated to contribute annually about 600 million additional hours of nature recreation.

As shown in Figure 1a, in 1975, Americans spent, on average, 0.79 hours per week per person on nature recreation. Nature recreation declined to about 0.59 and 0.57 hours per week per person by 1985 and 1992, respectively, and then dropped to 0.48 and 0.51 by 2003 and 2007. Although a consistent, moderate downward trend is apparent in Figure 1a, the estimates of average time use are not statistically significantly different between different years.

Figure 1b shows that the percentage of the population active in nature recreation steadily declined between 1975 and 1993 but has since stayed relatively constant or

Geographic variation in estimated time use per capita for nature recreation is illustrated for 2003–2007 in Figure 2. Nature recreation is especially popular in the Northwest and Northeast. Parts of the Southeast and south-central United States also stand out.

Uncovering the Contributions of U.S. State Parks

Data on time use for nature recreation are informative but do not reveal what drives nature recreation and what role access

Figure 1a. Time Use for Nature Recreation (hours/week/person)

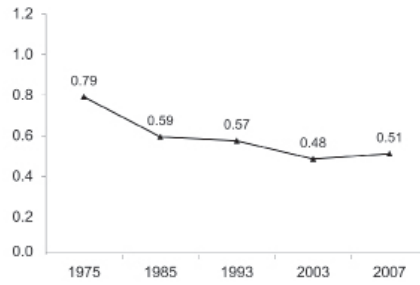

Figure 1b. Percentage of Population with Non-zero Time Use for Nature Recreation

to nature has in the popularity of nature recreation. To examine these questions, I constructed state-level estimates of nature recreation for the survey years between 1975 and 2007 and then matched those estimates with state-level data on the availability of state parks and other potentially important drivers of nature recreation. This approach allowed me to separate out state-specific innate differences in recreation and focus directly on how changes over time in the availability of state parks influenced the popularity of nature recreation in various states.

The statistical methods I used in this study are designed to extensively control for potentially important and possibly confounding factors within and among states, including baseline differences among the different states, time trends, and state-level variation in the socioeconomic characteristics of the population. The model also takes into account the availability of other potential recreation areas, such as access to federal lands and state parks in neighboring states.

Changes over time in the availability of state parks have a robust effect on nature recreation per capita. Between 1975 and 2007, about 3,000 new parks totaling about 2 million acres were established in the United States, increasing the total area of the state park system by nearly one-quarter. This expansion of the state parks is estimated to contribute about 9 percent of all current time use for nature recreation (Table 1). Overall in the United States, this equals annually about 600 million additional hours of nature recreation, or about 2.7 hours of nature recreation per capita.

Valuing recreation time monetarily requires determining the opportunity cost of time. To illustrate the potential magnitude of recreation's time value, I used a conventional and commonly adopted approach where recreation time is valued at

Figure 2. Time Use for Nature Recreation by State, 2003–2007 (hours/week/person, on average)

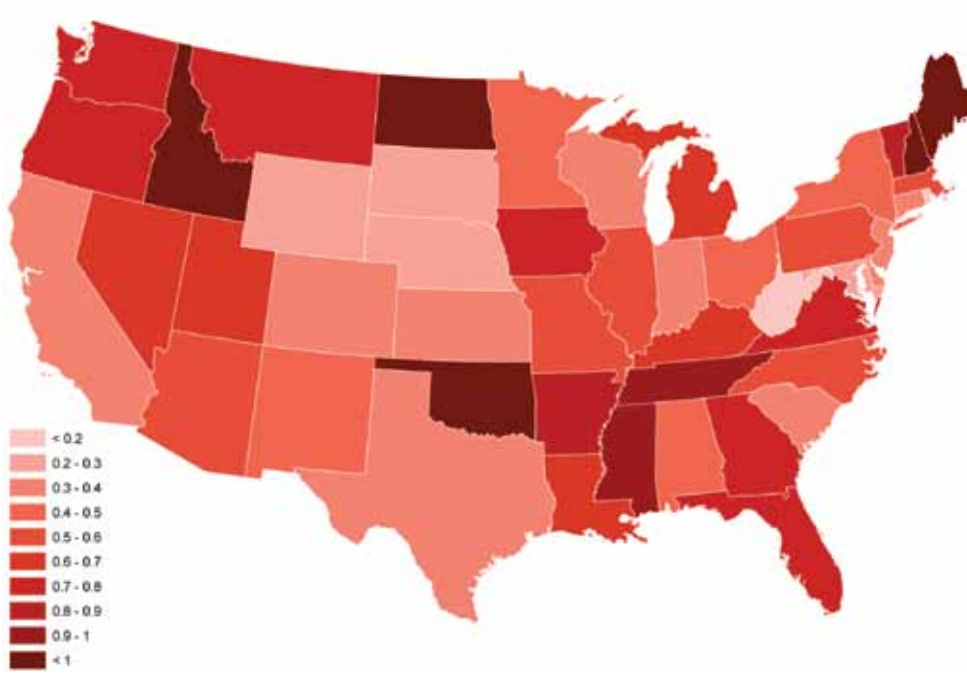

Table 1. Estimated Nature Recreation Services Provided by U.S. State Parks

Estimated effect	Expansion, 1975–2007 (about 1.9 million acres)	All parks (about 10.4 million acres)
Share of all current nature recreation contributed	9.2%	33.4%
Per person, annually		
Hours of nature recreation	2.7	9.7
Estimated time value	$17	$62
In the United States, annually		
Hours of nature recreation (millions), total	602	2,194
Estimated time value (millions), total	$3,851	$14,037

Source: Siikamäki 2011.

one-third the wage rate. The estimated time value of the nature recreation generated by the expansion of state parks between 1975 and 2007 is about $3.85 billion, or $17 per person, annually.

Extrapolating from the above results, I estimate about 33 percent of current time use for nature recreation can be attributed to the U.S. state park system (Table 1). This equals annually about 9.7 hours of nature recreation per capita, or about 2.2 billion hours of nature recreation in total in the United States. The estimated time value of nature recreation generated by the entire U.S. state park system is about $14 billion annually (about $62 per person annually, on average).

Park Benefits Exceed Recurring Costs

This research shows that providing the public with access to nature generates discernible and measurable impacts on the popularity of nature recreation. The estimated nature recreation services provided by the U.S. state park system are considerable. For example, the estimated recreation services from the two million acres of state parks established between 1975 and 2007—about one-fifth the total acreage of state parks—already exceed the currently reported operation and management costs of the entire U.S. state park system ($3.85 billion versus $2.3 billion, annually). In total, the entire U.S. state park system is estimated to generate about 2.2 billion hours of nature recreation, worth an estimated time value of about $14 billion, annually. Although the capital cost sunk in park real estate is not included in this calculation, it is unlikely that adding it to the assessment would make the overall costs of state parks greater than their benefits.

These estimates denote the annual flow of nature recreation attributed to the U.S.

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state park system. The net present value of these annual flows is required to project the total contributions of state parks. For example, using a 10 percent discount rate and an infinite horizon (because parks typically are permanent), the estimated total net present amount of nature recreation associated with the entire U.S. state park system equals about 22 billion hours and has an estimated total time value of about $140 billion.

It is also worth noting that the effects of a specific park on nature recreation may be smaller or greater than the average, even considerably. The existing literature on outdoor recreation also suggests this, providing many examples of how the characteristics of a recreation area influence its attractiveness to people.

Nature recreation represents only a partial assessment of the full range of ecosystem services produced by natural areas. Examples of other potentially relevant ecosystem services include carbon sequestration and storage through biological processes, contributions to surface and groundwater services, and benefits from preserving endangered and threatened species. A full assessment of ecosystem services from state parks should consider these nonrecreation contributions, yielding an even more comprehensive—and presumably larger—estimate of the value of America's state park system. ●

FURTHER READING

Siikamäki, Juha. 2011. Contributions of the U.S. State Park System to Nature Recreation. *Proceedings of the National Academy of Sciences* 108: 14031–36.


horjus

IF WALMART WERE IN CHARGE

Sourcing CO_2 Emissions Reductions at Least Cost

Raymond J. Kopp *gathers shopping lessons for the U.S. government from a price-cutting pro.*

Seemingly everyone has an opinion of Walmart, and quite often these opinions diverge. But just about everyone would agree that Walmart sources its products in a manner that permits it to sell them at very low prices. The primary reason is that Walmart is itself a great shopper—for any given product, the company looks globally for the best price and encourages suppliers to compete with one another.

In late 2009, the United States pledged to the international community that it would substantially reduce its carbon dioxide (CO_2) and other greenhouse gas emissions by 2020, and the president restated this goal in the 2011 *Economic Report of the President*. Now that U.S. policymakers are in the market for CO_2 reductions, it would behoove them to take some shopping lessons from Walmart.

Always Shop for the Best Price

Although the U.S. Senate did not follow the House of Representatives in 2009 in passing comprehensive climate legislation to reduce CO_2 emissions, the U.S. Environmental Protection Agency (EPA) is moving ahead with the regulation of CO_2 under authority contained in the Clean Air Act (CAA). Despite its 2009 rejection of an overarching climate policy, the Senate now is considering energy legislation in the form of a clean energy standard that would reduce emissions (primarily from the electric utility

sector) by requiring a growing percentage of the nation's electricity to be generated from zero or low CO_2-emitting electricity generation technologies.

Each of these actions—regulatory and legislative—is essentially equivalent to buying reductions in CO_2 emissions, and the price being paid is the cost CO_2 emitters (and eventually the general public who purchase and use energy) must pay to comply with these new regulations and standards. And either way, the more cheaply emitters can comply with the regulations, the lower will be the energy price increases faced by U.S. households and businesses, and the greater will be the growth of the U.S. economy and jobs.

The Importance of Supplier Flexibility

The effect of a reduction in a ton of CO_2 emissions on the global climate system is the same no matter where that reduction takes place, whether from a power plant in Ohio or across the border in Mexico. The irrelevance of the emissions location gives rise to an important feature of well-designed climate policy—*supplier flexibility.* A policy with supplier flexibility is one that enables reductions in CO_2 emissions to take place where they are the least expensive.

In the marketplace for CO_2 reductions, the cost of the reduction can vary a great deal, so shopping for the least-cost option can have a significant effect on energy prices, economic growth, and employment. For example, the Energy Information Administration (EIA) conducted a series of economic analyses of the House-passed climate legislation—the American Clean Energy and Security (ACES) Act of 2009. In one analysis, EIA allowed reductions in emissions to take place wherever they were least expensive, whereas in a second case, reductions could take place only within the United States.

A comparison of the results is striking. As Figure 1 portrays, the cost of complying with the requirements of the ACES Act in 2020 for the last ton of CO_2 reduced would have been $52 if all reductions had to take place in the United States, compared to $31.75 (a savings of more than $20) when emitters of CO_2 could shop the global market for reductions. EIA estimated the cost savings gained though global shopping to be worth $19 billion in 2020 in terms of enhanced U.S. gross domestic product.

These cost savings are not the result of arcane and dubious economic analyses but rather common sense known to every American consumer—you can find a deal if you shop around.

The Importance of Source Flexibility

Just as it does not matter where CO_2 emissions are reduced, it does not matter how they are reduced. The effect is the same whether a ton of reductions is from a U.S. power plant or a fleet of automobiles. The result is *source flexibility*. Well-designed policies incorporating source flexibility consider all sources of emissions as candidates for reductions and then choose those sources with the lowest cost.

The importance of source flexibility in controlling the cost of CO_2 reductions is best exemplified by the releases of CO_2

The more cheaply emitters can comply with CO_2 regulations, the lower will be the energy price increases faced by U.S. households and businesses.

Figure 1. Cost of Reducing Emissions with and without Supplier Flexibility

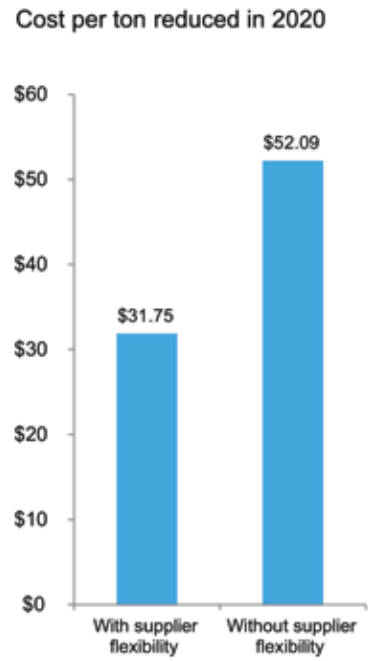
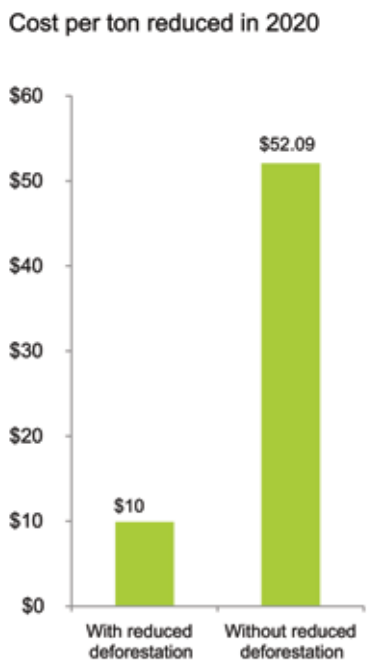


Figure 2. Cost of Reducing Emissions with and without Source Flexibility



from the clearing of tropical rain forests for agriculture and timber production. Using conservative assumptions, a recent RFF study by Erin Myers Madeira and colleagues finds that 100–125 million tons of these deforestation-related CO_2 emissions can be reduced annually at $10 per ton. Figure 2 compares the cost of CO_2 reductions from reduced deforestation in tropical countries to the estimates provided by EIA of reducing CO_2 emissions solely in the United States. The deforestation costs are one-fifth the domestic U.S. cost—like buying a $1,000 plasma TV for $200.

Empowering the Shoppers

The greater the reductions we demand from our energy sector, the greater will be the cost—an economic fact of life. The way to contain the cost within reasonable bounds is to exercise supplier and source flexibility, and by far the best way to do that is to purchase emissions reductions generated through reductions in tropical deforestation.

Regulation of CO_2 emissions is now the law of the land in the United States under the CAA. As it traditionally has been applied, it generally lacks source and supplier flexibility; however, legal scholars and CAA experts are split in their opinions regarding EPA's flexibility under the act. Some argue that EPA might have flexibility in its interpretation of the CAA and could provide regulated entities with the ability to purchase CO_2 reductions from overseas forestry projects.

As Congress continues to develop policies to promote clean energy within the United States, it has the ability to empower CO_2 emitters to reduce their emissions at the least cost globally. Clean energy standards, such as those proposed by the president and under discussion within Congress, would require increasingly greater portions of U.S. electricity to be generated from

Beyond Price

In addition to cost-effectiveness, reducing tropical deforestation is a preferred emissions reduction policy for three reasons:

» An estimated 18–25 percent of annual global greenhouse gas emissions come from deforestation, so reduced deforestation offers a way to substantially cut emissions.

» Although it takes a very long lead time and huge sums of capital to transform our energy infrastructure, policies to reduce deforestation can be implemented quickly, and emissions reductions can be achieved just as fast. Although we are investing in new, low-carbon energy systems to reap carbon dioxide reductions in the future, we can thus meet our immediate emissions reduction commitments now by investing in policies to reduce deforestation.

» Tropical forests are home to the bulk of the world's biodiversity. Reducing tropical deforestation not only reduces carbon dioxide emissions and protects the global climate, but it carries with it the side benefit of maintaining plant and animal habitat.

sources that emit low amounts of CO_2. Such standards could easily accommodate supplier and source flexibility by allowing the purchase of CO_2 reductions from overseas forestry projects in lieu of investments in prohibitively expensive low-carbon energy projects.

Perhaps most importantly, the fiscal policy debate now under way in Washington quite likely could result in fundamental U.S. federal tax reform. It is a well-known economic fact that lowering distortionary taxes (such as payroll taxes) has tremendous benefits in terms of enhanced economic growth and job creation. Putting a price on CO_2 emissions and using the resulting revenue to lower labor taxes on a neutral dollar-for-dollar basis would both enhance growth and reduce CO_2 emissions. Building in a tax credit system based on CO_2 reductions from reduced tropical deforestation would lower revenues a bit but enhance the economic efficiency of the CO_2 pricing policy.

CO_2 regulatory regimes are available in many flavors. To get the most environmental protection for every dollar spent, the regimes need to be flexible in where and how emissions reductions are achieved. Currently, the least-cost reductions come from reduced rates of deforestation in tropical counties. If Walmart were in charge, that's where it would be shopping. ●

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MEETING THE WORLD'S NATURAL RESOURCE NEEDS

Confrontation Ahead?

Will scarcity threaten our future?
Joel Darmstadter *looks to the past for answers.*

In today's conversations about oil and other natural resources, a common worry is whether the world is "running out" and will soon begin a confrontational scramble to gain access to what's left for the picking. Before such visions become mainstream thinking, a reminder that we've been down this path before might provide some useful perspective. Every few decades, it seems, an event or conjunction of events creates enough anxiety to prompt these questions.

Such anxiety sometimes arises from circumstances that are anything but trivial. The Paley Commission's 1952 report, *Resources for Freedom,* for example, looked at the nation's resource needs and adequacy at a time when the memory of World War II shortages, the ongoing Korean War, and the intensifying Cold War did not allow policymakers to take a relaxed view of what might be in store for the country amid growing international tensions.

Like many others, a U.S. gas station in 1973 faced fuel shortages during the Arab oil embargo.

Yet in retrospect, volatility often does not justify the overreaction and policy excesses it engendered. The Arab oil embargo of 1973–1974 and the Iranian revolution of 1979–1980 were invoked to support the perversely damaging control of oil markets and lay the groundwork for a multibillion-dollar government-sponsored effort—mercifully abandoned—to augment conventional oil resources with synthetic fuels. But the steep oil price increases of the 1970s were followed by sharply lower prices in the mid-1980s. This experience offers a chastening reminder to distinguish between transitory events—however disruptive—and genuine discontinuities in trends that may signal a need for policy course corrections.

It's not yet clear whether this decade's renewed increases in prices for oil and other natural-resource commodities find us at such a soul-searching juncture. I'll start with oil and then look at several other resources.

The Oil Conundrum

During the last six months or so, world oil prices have remained high amid persistent conditions of high unemployment and sluggish economic growth in the major industrial countries; less demand and lower prices would have been the typical course of events. But let's also take note of demand-heightening political upheavals in the Middle East and continuing fast growth in both GDP and energy consumption in industrializing economies—most notably, China and India, with energy growth averaging 7–8 percent annually during 2006–2010.

This recent surge in demand for oil is driving price increases (plotted in Figure 1). In response, T. Boone Pickens pronounced, "A global race for energy is on—and China is way out in front." And the usually more restrained *New York Times* characterized a Chinese stake in an Argentine offshore oil venture as a "beachhead." But is the increase in demand potent enough to justify these claims? This sort of language easily can lead to an alarming evocation of "resource wars" and suggests a zero-sum state of affairs: success in an effort to "lock in" energy resources would presumably occur at the expense of other countries.

This rhetoric risks conflating two distinct phenomena: the enduring or transitory scarcity of a resource, signaled by real costs and market prices, and a threatened shortage of such magnitude as to prompt a consuming country to seek dominant command over that resource. Continuing, rapid, and spreading economic growth could strain global oil supply, necessitating higher real prices to bring demand and supply into balance (by both restraining

Figure 1. U.S. Average Value of Petroleum, 1870–2010

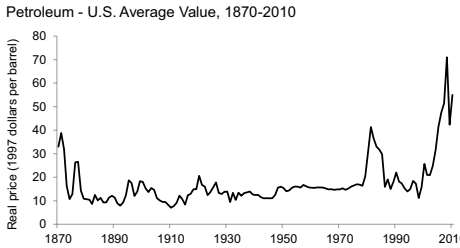
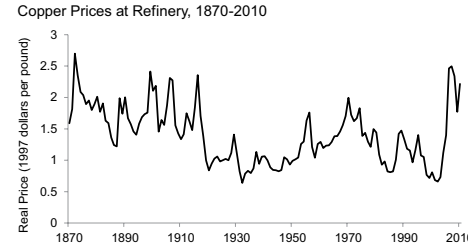


Figure 2. Copper Prices at Refinery, 1870–2010



Source: Data compiled from Tilton 2003, the U.S. Energy Information Administration, and the U.S. Geological Survey.

consumption and encouraging new supply development). But oil is traded in an international marketplace. Higher prices would confront *all* consuming countries—China included—whether or not their oil needs are satisfied by domestic production or imports and such imports originate in their own overseas assets.

Consistent with that observation, in a 2010 study of Chinese natural resource procurement arrangements, international business professor Theodore Moran concludes that "Chinese efforts predominantly help expand and diversify the global supplier system" and that rather than keeping oil supplies for itself, the country has sold them. Still, the notion of preemptive control persists: a recent *Washington Post* editorial characterizes China's Canadian investments as "locking up more of the world's oil production."

Even though China no doubt has many objectives behind its quest for offshore oil and other properties—and even if the world does find itself on an extended upward path in oil prices—the terms chosen by Pickens (and the *New York Times*) still seem sensationally hyperbolic.

Nonfuel Minerals

Two cases illustrate how some of the issues considered in the oil discussion apply to nonfuels. The first and more conventional example is copper; the second, "rare earths," is the subject of intense current disputation.

Copper

As a general proposition, copper—a nonrenewable commodity whose ease of extractability, absent technological progress, recedes with time—shares attributes of oil, including the questionable feature of "peaking." In an admirable 2003 RFF Press book, *On Borrowed Time? Assessing the Threat of Mineral Depletion,* John Tilton, of the Colorado School of Mines and an RFF university fellow, shows how the real price of copper has been on an unmistakable downward path for the past 130 years, never mind periodically sharp volatility along the way (Figure 2). Over the course of more than a century, he explains, the cost-reducing effects of technological progress to sustain copper's availability more than compensated for any pressures from depletion to drive up costs. But even more important to our future welfare, in Tilton's words, is "whether society will be able in the future to provide the needs currently being served by these high-quality mineral deposits from other resources at real prices close to or even below those that currently prevail."

In the case of copper, industry is rising to the challenge: not only did fiber-optic transmission replace reliance on copper wire in telecommunications, but by now,

microwave towers have replaced much of the fiber optic infrastructure. Recycling is another, if less glamorous, strategy. Still, a look at the most recent period charted in Figure 2 signals caution. As with oil, copper shows a price boom that appears not yet to have run its course. And, as with oil, the prudent catchphrase should be "stay tuned."

Rare Earths

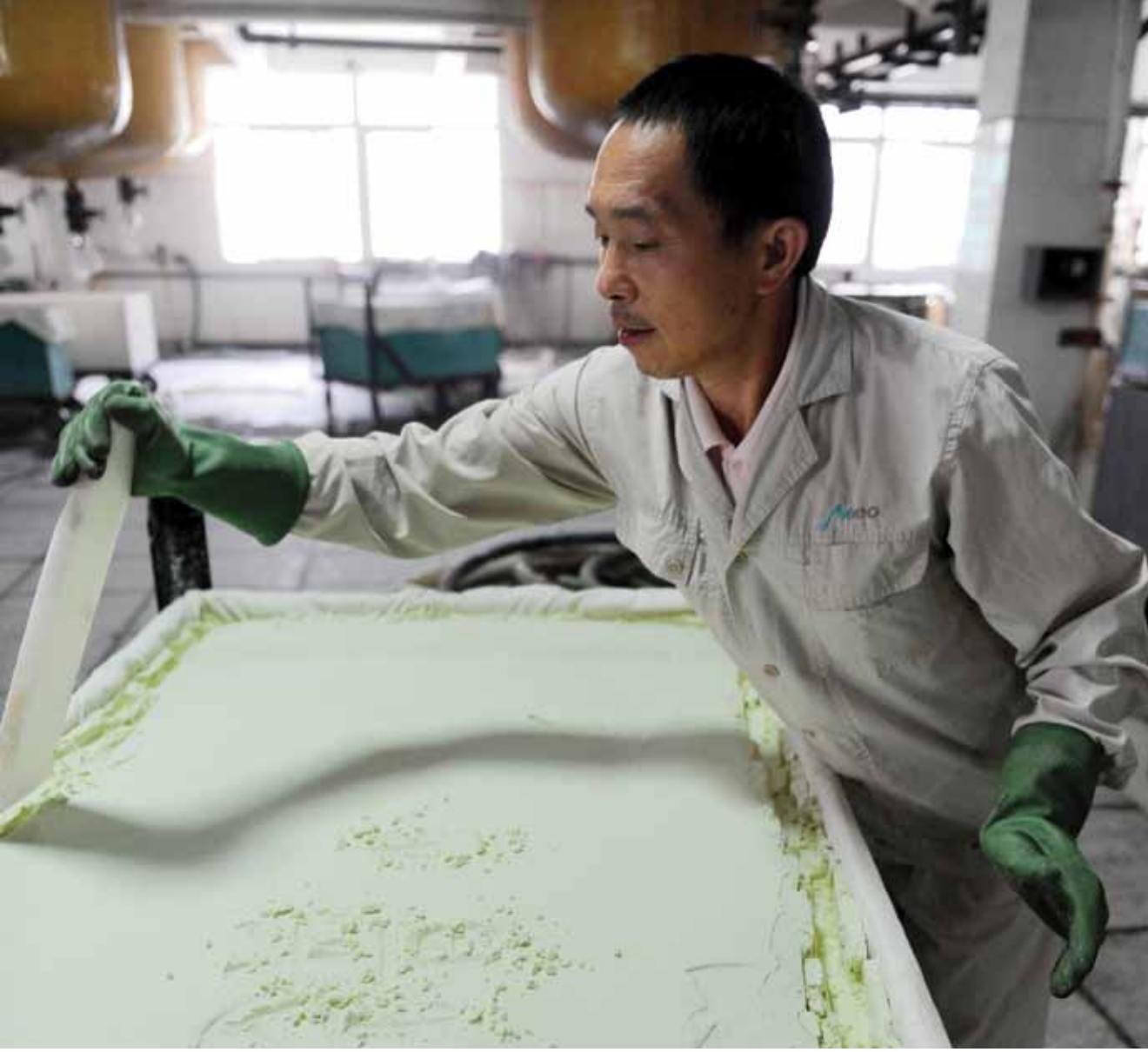
Many people were alerted to the topic of rare earths only in October 2010, when Japan detained a Chinese trawler captain and China retaliated by suspending rare earth exports to Japan. However isolated an example, rare earths raise issues of natural resource markets, trade and investment policy, and—not far removed—effects on other countries, including the United States. Although rare earths can't begin to match international oil transactions in quantitative and economic significance, their potential for stirring conflict and tension may be as real.

Rare earths are more than a dozen elements in the periodic table, primarily spanning atomic numbers 57–71, with magnetic and other properties. Their names—neodymium and dysprosium, to give two particularly important examples—hardly enjoy everyday familiarity. But they are critical inputs to energy and other systems and products that couldn't be more familiar: batteries, lasers, computer memory, medical equipment, and photographic lenses are just a limited sampling. They have an especially vital role in energy applications, such as wind turbines. Although their worldwide geologic occurrence is abundant, China is the only significant producer of certain of these important materials. Moreover, the country is moving aggressively to gain a dominant stake in the finished products embedding these resources—a topic addressed in a recent RFF analysis conducted at the request of the U.S. Department of Energy. (See "Rare Earths: Valuable Resource and Political Challenge" on page 44.)

In an idealized market paradigm, China's status as a quasi-monopolist would be competed away as other rare earth producers revived or started up extraction. But China seeks to foreclose that outcome through subsidization, along with an apparent willingness to tolerate some of the marked environmental impacts associated with rare earth mining. Export controls come into play as well, and at the high-value, manufacturing stage of rare earth–dependent equipment, imposition of domestic content requirements (which limit the investment stake of foreign firms) is yet another means of securing economic advantage for domestic industry.

In principle, claimed violations of World Trade Organization (WTO) rules can be filed with that body, but WTO intermediation and resolution can be a lengthy and frequently inconclusive process. Though hardly an antidote, international firms facing competitively restrictive practices have a strengthened incentive to counter with strategies of their own: development of substitutes for uncertain inputs; recycling of materials; and aggressive pursuit of technological progress. (Recall the copper example.) One

As with oil, copper shows a price boom that appears not yet to have run its course. The prudent catchphrase should be "stay tuned."



A worker at a factory in China's Ganzhou City processes yttrium, one of some 17 rare earth elements.

thing is certain: a plunge into prolonged trade conflicts—with few, if any, winners—would be an unfortunate consequence of this story.

Concluding Comments

Looking to the past to learn about the future of our natural resource supply, we see that over more than a century, the real petroleum price trend has been close to flat, despite the volatility surrounding that trend (see Figure 1). Recurrent and confident predictions of early exhaustion (or its flip side, runaway price increases) repeatedly have been negated by new reserve additions. As one example of a formerly economically unrecoverable resource, the Williston-Bakken shale oil formation stretching across the Dakotas and Montana has added at least an estimated billion barrels to U.S. oil reserves, with production these days running at around 200,000 barrels a day.

But these reassuring lessons from the past are not preordained to hold for the future. Consider: we probably face recourse to less hospitable and costlier producing regions; there looms the imperative of mitigating greenhouse gases and other

Rare Earths: Valuable Resource and Political Challenge

Rare earths have a variety of significant applications, including batteries, lasers, and computer hard disks, and the focus of a recent RFF study for the U.S. Department of Energy is their importance in the production of onshore and offshore wind turbines. The entire multistage supply chain begins with the extraction of rare earth ores and ends with the production of the turbines (along with key ancillary components, principally rare earth–dependent magnets).

Rare earth reserves are widely distributed around the world, with the U.S. portion estimated at around 11 percent. But China's production in recent years has accounted for close to 100 percent of the global total. With wind-generated electricity growing rapidly around the world, there is keen rivalry—not least on the part of China—in supplying the turbine market. As examined in the RFF study and attracting increasing attention by U.S. policymakers, observers have expressed concern about the prospect of a Chinese state-directed effort to parlay the country's current tight grip on the rare earth commodity market into dominance in the "downstream" segment of the supply chain as well.

For now, according to the RFF study, the U.S. economy "does not appear to be vulnerable to the exercise of market power along the supply chain." But in the longer run, the picture could be more disturbing "if wind power deployment were to significantly exceed" the modest "baseline" growth projections of the Energy Information Administration.

For more information, see Brennan et al. 2012.

environmental risks; and a progressively more skewed geographic concentration of oil resources and reserves—hence market dominance in production capacity—seems likely. With all such factors playing out amid rapid economic growth in many parts of the world, the situation could presage a global oil profile significantly different from that of the past.

In the face of concerns over the perceived threat Chinese rare earth policies pose to U.S. competitiveness and national security, growing numbers in Congress are considering policy initiatives to blunt such impacts. The stakes associated with choosing wisely are large. It is worth asking whether it's time to update the findings of the Paley Commission by undertaking another major reconnaissance of U.S. and global resource prospects and problems. ●

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A Look at What's Happening

Inside RFF

RFF named **Molly Macauley** as its new vice president for research. Macauley, an RFF senior fellow and former research director, brings more than 25 years of economic research expertise and leadership to her new role. Macauley now oversees all research and educational programs at RFF and guides efforts to expand RFF's contributions to environmental, energy, and natural resource policy research and analysis.

Alan Krupnick, director of RFF's Center for Energy Economics and Policy, was named president-elect of the Association of Environmental and Resource Economists (AERE) during its winter meeting in Chicago. Krupnick was selected and recognized for his work on air quality, health valuation, and integrated interdisciplinary environmental assessments as well as his contributions to the field through mentorship, leadership, and extensive community involvement outside RFF.

Yusuke Kuwayama joined RFF as a new fellow. Kuwayama, who received a Ph.D. in agricultural and applied economics from the University of Illinois at Urbana-Champaign, focuses on tradable groundwater permits, adjusting for time lags and uncertainty in marketable permit design, and optimal groundwater policy in the case of contaminant dispersion.

RFF Fellow **Carolyn Kousky** was selected to attend the National Academies Keck Futures Initiative Conference on Ecosystem Services. Kousky was one of the approximately 100 applicants selected, based on their active professional involvement, the breadth and depth of their experience, and the diverse perspectives they bring to the topic of ecosystem services.

Elisheba Beia Spiller joined RFF as a new post-doctoral researcher after completing a Ph.D. in economics at Duke University. Her research focuses on energy and transportation issues, with a particular emphasis on estimating vehicle and gasoline demand.

RFF Senior Fellow and Chauncey Starr Chair in Risk Analysis **Roger Cooke** received the 2011 Distinguished Achievement Award from the Society for Risk Analysis. He was also honored as the 2011 Best Reviewer.

James Boyd, co-director of RFF's Center for the Management of Ecological Wealth, launched a new RFF partnership with the University of Maryland to establish the National Socio-Environmental Synthesis Center (SESYNC). Funded by a grant from the National Science Foundation, SESYNC will initiate, support, and coordinate transdisciplinary research across the social and physical sciences to address policy and stakeholder needs.

RFF named the following **academic fellowships and special stipend awardees** to conduct environmental and energy research during the coming year:

Gilbert F. White Postdoctoral Fellowships

» **Jintao Xu**, chair of the Department of Environmental Management at Peking University, is studying China's collective forest tenure reform.

» **Jared Carbone**, professor of economics at the University of Calgary, is examining benefit–cost assessments of environmental policies related to human health outcomes.

» **James L. Smith**, Cary M. Maguire Professor of Oil and Gas Management at the Edwin L. Cox School of Business at Southern Methodist University, is researching various oil market issues, including the impact of financial trading on oil prices.

Joseph L. Fisher Doctoral Dissertation Fellowships

» **W. Reed Walker**, a Ph.D. candidate in the Department of Economics at Columbia University, is completing his dissertation on market and nonmarket valuation as it pertains to the costs and benefits of environmental policy.

» **Michael Madowitz**, a Ph.D. candidate in the Department of Economics at the University of California, San Diego, is finishing his research on the fiscal effects of environmental taxation at the state level.

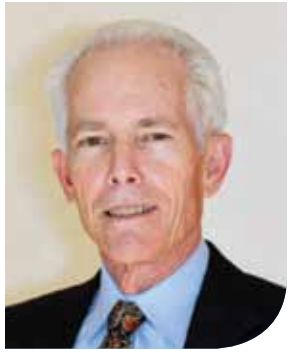
» **Alison Sexton**, a Ph.D. candidate in the Department of Applied Economics at the University of Minnesota, is continuing her research on the impacts of air-quality information on consumer health risk–avoidance behavior.

John V. Krutilla Research Stipend

» **Junjie Zhang**, an assistant professor of environmental economics in the School of International Relations and Pacific Studies at the University of California, San Diego, is examining wind power development in China.

Welcome New RFF Board Members

RFF is pleased to announce the appointment of four new members to its Board of Directors. Each brings a wealth of experience and leadership to help RFF improve its research and outreach in the coming years.



Anthony Bernhardt, *Co-Director, Northern California Chapter, Environmental Entrepreneurs (E2)*

Tony Bernhardt had a 30-year career as a physicist at Lawrence Livermore National Laboratory, where he served as director of the Center for Microelectronics and Optoelectronics. In that position, he earned the Department of Energy Federal Laboratory Consortium Award for Excellence in Technology Transfer. Currently, Bernhardt is a northern California co-director of Environmental Entrepreneurs, an organization of business volunteers advocating environmental legislation from a business perspective. He was part of the core E2 team that successfully advocated passage of the California Global Warming Solutions Act of 2006 (AB 32), and he continues to work on clean energy technology and policy. Bernhardt is a member of the Global Leadership Council of the Natural Resources Defense Council.

Red Cavaney, *Senior Vice President, Government Affairs, ConcoPhillips*

Red Cavaney is responsible for the government affairs efforts of ConocoPhillips as well as its communications and public affairs activities. Previously, Cavaney was president and CEO of the American Petroleum Institute. He also has served as president and CEO of the American Paper Institute, founding president and CEO of the American Plastics Council and the American Forest & Paper Association, and president of Ericson Yachts, Inc. He also served on the senior staffs of Presidents Ronald Reagan, Gerald Ford, and Richard Nixon. Cavaney was honorably discharged as a lieutenant from the U.S. Navy following three tours of combat duty in Vietnam. He is a member of the boards of directors of Buckeye Technologies and the Gerald R. Ford Foundation, among others.

Richard G. Newell, *Gendell Associate Professor of Energy and Environmental Economics, Nicholas School of the Environment, Duke University*

Richard G. Newell is the director of Duke's university-wide energy initiative. From July 2009 through June 2011, he served as the seventh administrator of the U.S. Energy Information Administration. Newell also served as the senior economist for energy and environment on the President's Council of Economic Advisers. He is a research associate of the National Bureau of Economic Research and a university fellow at RFF, where he also served previously as a senior fellow. Newell has published widely on the economics of markets and policies for energy, the environment, and related technologies, including incentives for technological innovation and adoption. He has served on numerous National Academy of Science committees, including Energy R&D, Innovation Inducement Prizes, Energy Externalities, and Energy Efficiency.

Lisa A. Stewart, *Chief Executive Officer, Sheridan Production Partners*

Lisa Stewart became CEO of Sheridan Production Partners in September 2006, after serving as the president of El Paso Exploration & Production Company. At El Paso, Stewart oversaw restructuring to focus on capital efficiency and returns, as well as the exit from international power and other unregulated businesses to bring focus to the company's two main business segments. Previously, she worked for Apache for 20 years, where she had responsibility for sourcing and negotiating mergers and acquisitions transactions, environmental health and safety, reserves reporting, land administration, and purchasing. Stewart began her professional career with Cities Service Oil and Gas (now Occidental Petroleum) as a reservoir engineer. She is a member of the Society of Petroleum Engineers and the Independent Petroleum Association of America.

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In 1951, a presidential commission called for an independent organization to inform the nation's natural resource planning. In 1952, RFF was created to do just that. Today, RFF enjoys a broad base of support from government, individuals, foundations, and corporations. Through this continuing support, RFF is able to help decisionmakers develop policies that work.

RFF relies on those who have the vision to see the role rigorous, objective research plays in formulating sound public policies. Contributors to RFF receive a wide variety of benefits, including invitations to special events, targeted research reports, and briefings with RFF experts. For a complete listing of these benefits, visit www.rff.org/support.

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