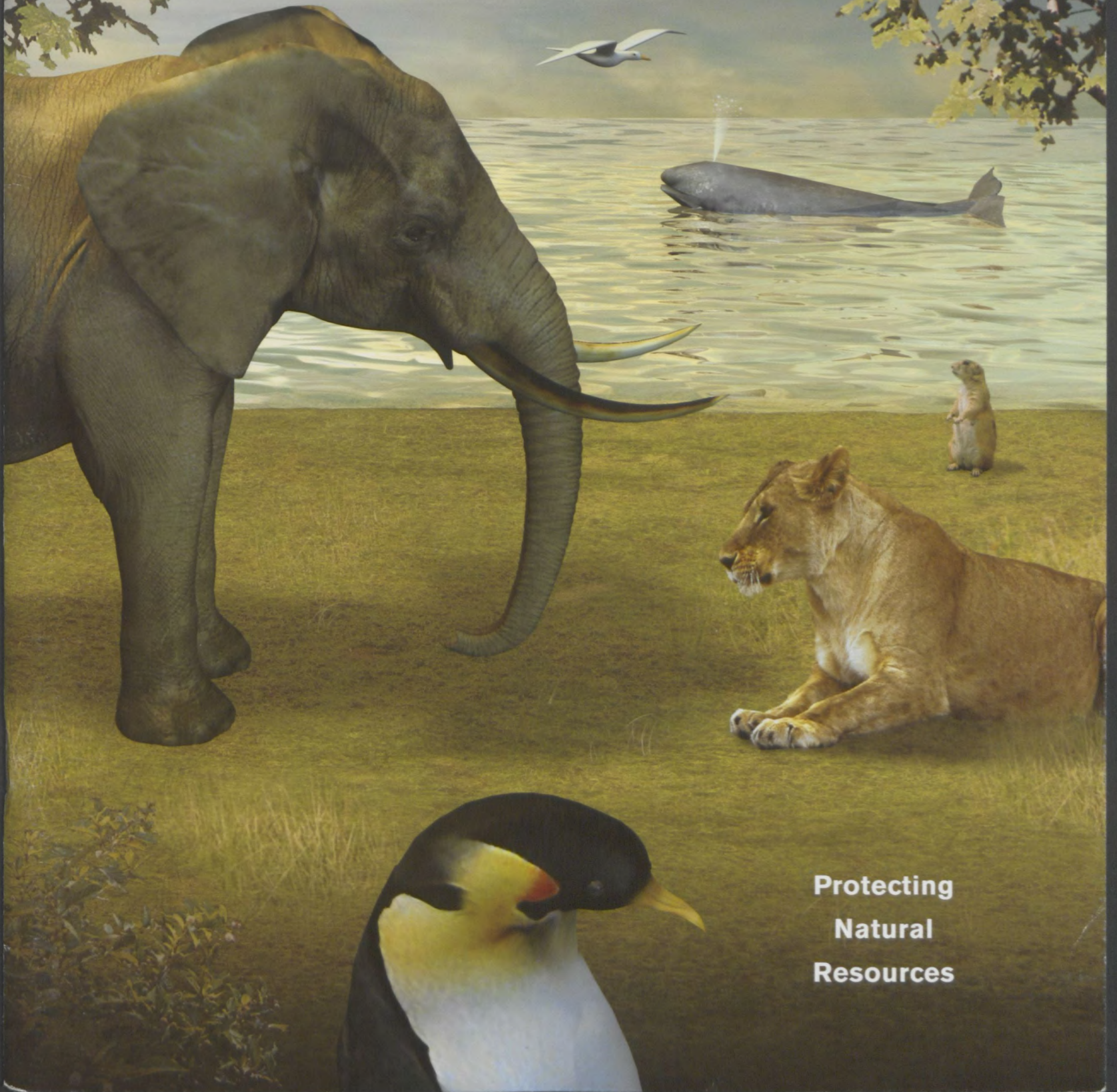


# RESOURCES

RESOURCES FOR THE FUTURE  $\cong$  SUMMER 2005 · ISSUE NUMBER 158



Protecting  
Natural  
Resources

## "I Have Stood on the Shoulders of Giants..."

It was the great scientist Isaac Newton who coined this memorable phrase: "If I have seen further, it is because I have stood on the shoulders of giants..."

The quote seems especially apropos in describing the history of Resources for the Future. For more than 50 years, scholars of legendary insight and creativity have made RFF their academic home. And during all that time, RFF has been blessed to have leaders at the helm that must surely be added to this pantheon of giants.

As RFF's Chair for the past three years, it has been my privilege to watch an already solid organization emerge as the most robust and respected think tank on energy and environmental issues in the country. The visionaries who have led RFF have possessed skills and personal characteristics informed by discipline, deep analytic insight, policy understanding, competence, and civility.

Fortunately, at every point when new leadership has been needed, RFF has found the right person to extend and expand our mission. At a time when so much substantive discussion on important public policy issues is clouded by intense partisanship, RFF stands out as a source of independent and objective analysis—a source more needed than ever.

As RFF prepares to begin the transition to its next president, certain constants remain.

The articles in this edition of *Resources* themselves convey the strength and breadth that have been developed in RFF's research enterprise over the past half-century—and these qualities will endure. Researchers are asking relevant questions about what's missing from current policies, what is often ignored or overlooked, how natural resources—from terrestrial species to outer space—are managed, and how Americans value environmental resources they may never even visit. Such reflections constantly seek the real-world lessons to be gleaned from past practice.

And so, at this period of interregnum in RFF's leadership, we certainly suffer no loss of momentum. In fact, I am confident that RFF's best work still lies in its future. This research organization is at the center of debates on energy policy, wild forests, land use, traffic congestion, and many other areas—and they reflect RFF's true legacy: the thoughtful leadership embodied in its continuing and vital work.

Robert E. Grady  
Chair

# RESOURCES

SUMMER 2005 · ISSUE NUMBER 158



## RESOURCES FOR THE FUTURE

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EDITOR'S NOTE: An editing error on page 15 of the spring issue of *Resources*, number 157, resulted in the inclusion of the parenthetical phrase "nearly 36 degrees Fahrenheit" and omission of the sentence, "The consensus was that above a rise of 3 degrees Celsius there is a serious risk of irreversible system disruption."

### Rep. Sherwood Boehlert: Real Progress on Environment Comes from Arguing Facts, Not Retreating to Ideological Corners

Congressional inaction and lack of public awareness on key environmental issues such as energy, land, and water use, and global climate change color the state of environmental politics, according to Rep. Sherwood Boehlert (R-NY), in his remarks at RFF on June 23. Boehlert, chairman of the House Science Committee, spoke as part of RFF's Policy Leadership Forum series.

"The state (of the political environment) is worse than what I would like and not so dire as some would suggest," Boehlert noted. "But all is not well, either. Some on the right act as if we have infinite resources and we have been granted unlimited license to exploit the earth for our immediate pleasure."

With Congress in the middle of a contentious debate on both the energy bill as a whole and various climate change provisions, he noted that the rancor over these issues is not unique to this era. "It's not as if our nation has been distinguished through most of its history by its sensible and farsighted energy policies," Boehlert acknowledged. "We're a big country and we like to live big—and we've repeatedly ignored energy issues until they've reached crisis proportions."

Boehlert criticized his House colleagues for their reactions to climate change, while noting that the politi-

cal tide on the issue seems to be turning. "The House may be the ultimate lagging indicator on climate; it probably has the highest population density of climate skeptics of any spot on the entire planet," he said. "But the general direction of the debate in Washington and nationwide is toward recognizing climate change as a serious challenge." Only time will tell, he said, if the tide will turn soon enough to make a difference.

The road to such change is littered with stumbling blocks including inattention or insufficient response to several specific policy issues. Boehlert cited an unwillingness by Congress to

raise the Corporate Average Fuel Economy (CAFE) standards, despite studies showing that such action would reduce oil consumption in the United States and could be done without compromising vehicle safety.

"To me, it's sad and distressing and foolhardy that we aren't going to impose the kind of standards that I believe, based on expert opinion, are feasible," he lamented. "But there are positive signs as well—we got more votes this time around for raising CAFE standards than we ever have before." He noted that national security concerns around dependence on foreign oil are bringing new allies,

*It's not as if our nation has been distinguished through most of its history by its sensible and farsighted energy policies ... We're a big country and we like to live big — and we've repeatedly ignored energy issues until they've reached crisis proportions.*

— SHERWOOD BOEHLERT

including conservatives and corporate executives, to the table.

Boehlert clarified that while this is a step in the right direction, it is not close enough. Pointing out that ideological divisions won't help anyone, he called on environmentalists to reach out to moderate conservatives in an effort to build consensus on key environmental issues. He sees progress among conservatives on environmental issues, noting that Congressional votes on opening the Arctic National Wildlife Refuge (ANWR) to drilling were close, and that "those wanting to open ANWR framed many of their arguments in environmental terms."

"A close vote does nothing to protect an acre of land or a herd of caribou," he clarified. "But a close vote can lead to a different strategy and can portend a different future."

To move closer to this future, Boehlert said the public needs to be better informed on environmental issues. He called on the media to provide more coverage, on the scientific community to offer guidance on the best and latest research conclusions, and on his fellow policymakers to work together to make wise choices.

"The moderate approach, I think, is still the way to move ahead on environmental issues," he concluded. "That means getting the best science, arguing the facts, and doing the hard work of cobbling together practical solutions rather than retreating to ideological corners." ■

## ENERGY 2050

# The Future of Renewable Energy

### Briefing Series Begins with Examination of Renewable Energy Sources for Electric Power Generation

**D**iversifying the United States' energy portfolio is a critical step in ensuring America's continued economic growth, national security, and environmental quality. An important component of this effort is the advancement of clean, renewable energy—a sector whose future remains very uncertain.

Renewable energy sources for electric power generation was the focus of a June 21 briefing on Capitol Hill, launching a six-part series titled "Energy 2050." Focused on the primary energy sources that fuel U.S. transportation and power, the series will

examine one of the most pressing issues on the country's policy agenda today—meeting our future energy needs. Energy policy decisions made in the next several years could affect the nature of the U.S. system for at least the next four decades.

"I think the single quickest, least expensive thing we can do to solve energy problems is to improve energy conservation and, above all, energy efficiency," commented Representative Vernon J. Ehlers (R-MI), chair of the Subcommittee on Environment, Technology, and Standards of the House Science Committee, during his



opening remarks at the briefing. "If we went on a concerted drive to improve our energy efficiency, we could deal with most of our energy problems for the next decade, and do it probably within a year or two—it's that simple, it's that quick, and it's not that expensive."

Panelists discussed a variety of renewable energy options, noting that costs have declined in recent decades, but that many technologies are still not catching on in large numbers. According to the Energy Information Administration, renewable energy sources accounted for 6.1 percent of total U.S. energy consumption in 2002, while fossil fuels made up 86 percent. The implications of this situation have global impacts, and the panelists pointed out that a variety of factors and options will be necessary to further the prospects for renewable energy generation.

"These challenges are not just U.S. challenges—they are international and global challenges," commented Dan Arvizu, director of the National

Renewable Energy Laboratory. "We need a whole host of technology options to draw from. There's no one silver bullet—we need to use as much of renewable energy resources as we can."

Karen Palmer, Darius Gaskins Senior Fellow at RFF, pointed out that the future of renewable energy depends on a number of other factors, including public policy and developments in other energy areas.

"It's important to recognize that the future of renewables in electricity is going to depend on what happens to the cost of other ways of generating electricity," she said, "particularly using fossil fuels and nuclear generation."

Representative Roscoe Bartlett (R-MD), a senior member of the House Science Committee, added that educating the public, as well as policymakers, is a critical step in furthering renewable energy options. He stressed that this must be done in order to create a more secure energy future for the United States.

"The average citizen in this country has no idea the emphasis that needs to be placed on renewables," he stated. "[We need to convince] our country and the world of the importance of renewables and to make the investment."

The discussion of renewable energy sources for electric power generation laid the groundwork for further discussion on other aspects of energy policy in briefings to follow. The series, convened by RFF, GLOBE USA (Global Legislators Organization for a Balanced Environment USA), and the Henry M. Jackson Foundation, will continue to bring together legislators, scholars, and representatives from the corporate and public sectors to discuss how we can meet our energy needs in the years ahead. ■

From left: Dan Arvizu, NREL, Paul Portney, RFF, and Rep. Roscoe Bartlett

## ENERGY 2050

### Predicting Natural Gas Prices: The Old Rules No Longer Apply

Not so long ago, natural gas was seen as a panacea for many of America's energy demands. It had none of the environmental problems associated with petroleum; domestic reserves were available, if not abundant; and the price was certainly right. Today, all of that has changed. The price of natural gas is now roughly as high as oil when calculated in equivalent units of energy.

"The price of natural gas is now primarily an oil problem," said Hillard Huntington, executive director of the Energy Modeling Forum at Stanford University. Global efforts to address climate change and domestic efforts to deal with the potential security threats posed by our dependence on Middle East oil are putting comparable pressures on the natural gas market, he said.

Huntington spoke at a July 13 Energy 2050 briefing on Capitol Hill, sponsored by RFF, GLOBE USA (Global Legislators Organization for a Balanced Environment USA), and the Henry M. Jackson Foundation.

While the two fuels are basically not interchangeable, Huntington said, the correlation in price stems in part from the similar cost factors involved in exploration, production, and transport from offshore sources. The reasons for this are twofold: U.S. natural gas reserves are dwindling



and the bulk of the world's proven resources lie in politically sensitive regions, including Iran, Iraq, and Russia. Moreover, intense state and local opposition to the siting of new production and transport facilities, both on and offshore, further complicate the process.

Huntington suggested that an organization like RFF with extensive experience in resource valuation studies could take on the question of western gas reserves and evaluate the tradeoffs between exploration, exploitation, environmental costs, and economic benefits.

Existing federal and state regulations also are keeping the price of natural gas high, thereby driving up electricity costs, Huntington said. "What we need to do is improve market efficiency without causing long-term harm." Power generators need to have greater flexibility in meeting peak demand requirements and substituting other fuel sources as needed, he said. And much more effort needs to go toward providing states and local communities with appropriate incentives to allow new facilities to come online.

Robert Fri, an RFF visiting fellow and former RFF president, said, "The best way to encourage a well-functioning power market will be to adapt to changing circumstances." Global climate change and national security issues are only going to grow in importance over the next 10 to 20 years, thereby increasing demand and keeping prices high, he said. Many utilities and big companies are already planning for eventual domestic greenhouse gas controls. ■

## Environmental Law: The Little Movement That Could

In theory, environmental law should never have happened, began Richard Lazarus, professor of law at Georgetown University, when he spoke at a May 4 RFF First Wednesday seminar. The challenges of passing radically redistributive laws for disparate interests—combined with a lack of political return, both in the marketplace and at the ballot box—should have kept environmental law from happening but it did. Lazarus's comments were drawn from his new book, *The Making of Environmental Law*, which looks at the legal, political, cultural, and scientific factors that shaped—and sometimes hindered—their evolution.

Because it is defined by the very problem it seeks to address—where, when, how fast, and whether ecosystems should be transformed—environmental law is necessarily complex, dynamic, and interdependent. However, Lazarus explained, the ecosystems and human activity affected by this branch of law are also complex and dynamic—and all of these components affect one another.

Because people have different ideas about how the environmental world should be managed, making appropriate and fair laws is challenging. When changes are made to an ecosystem by the mandates of law, Lazarus noted, it is difficult to measure their impact, in large part because the results of

actions taken are spread out over enormous time and space distances. Moreover, making reliable measurements of the impact of legal judgments is critical to formulating beneficial policies in the future.

In many ways, Lazarus continued, environmental law also goes against the guidelines set for the establishment of laws in the Constitution. Ecosystems cross boundaries and therefore require broad regulations, which promote federal oversight and policing—powers the federal government does not have. States can enforce the laws, but the federal government can only authorize and appropriate funds for them. The resulting conflicts come from clashes between lawmaking institutions on different levels, as well as between legislative branches, and intersections with other branches of government.

In laying out an historical perspective on support for, enactment of, and resistance to environmental law at the federal level, Lazarus noted that presidents since the 1970s have struggled to promote environmental policies in

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the absence of any notable political benefit for backing such measures. According to Lazarus, Nixon once said of environmental policy, "It has to be done, but is not worth a damn."

While members of Congress from both sides of the aisle once could agree on natural resource and pollution control policy issues, such as the creation of Superfund in the early 1980s, growing partisanship in the legislative branch makes any environmental action taken up today difficult to pass, Lazarus said. Although the "legal friction" created by environmental issues is arguably necessary to create change, the courts today are skeptical, seeing this friction as a problem rather than a result of a complex issue needing careful consideration and overarching action.

Despite these challenges, environmental law not only continues to exist, but to thrive, Lazarus stated. This is a potentially historic moment in the field, he said, with a lot to celebrate and the architecture firmly in place to accomplish even more. However, the challenges are compounded by a loss of some vitality in the movement and an increased ambiguity in defining goals, he said.

In the discussion following Lazarus's remarks, Jonathan Wiener, the William R. and Thomas L. Perkins Professor of Law at Duke Law School, noted that people tend to care about effects from a distance. In order to move environmental law forward, he said, proponents must demonstrate a combination of broad appeal and public benefit while dealing with the wishes of special interests. He encouraged greater use of economic incentive instruments to determine and quantify costs and benefits, while both speakers urged organizations conducting objective studies on the matter to continue that work. ■

## Short-Term Solutions: Short-sighted for Long-Term Eco-Problems

Washington operates on short-term time frames, punctuated by Congressional calendars and election cycles. Yet some situations—such as Superfund site cleanup, spent nuclear fuel disposal, and remediation of DOE nuclear production facilities—require analysis and planning for decades or even centuries. At an RFF First Wednesday seminar June 1, a panel of experts discussed the options and trade-offs that policymakers confront when facing such dilemmas.

Titled "Environmental Problems That Won't Go Away," the seminar was moderated by RFF Visiting Scholar Robert Fri, a former deputy administrator at EPA. In his opening remarks, Fri noted that the right solution to these problems is not always readily apparent or easy or quick to implement, citing DOE's 20-year struggle to create a nuclear waste repository at Yucca Mountain in Nevada.

Panelist Richard Meserve, president of the Carnegie Institution, picked up this example in his remarks. "The modeling would suggest that the peak dose from Yucca Mountain would occur 300,000 years in the future," he noted. Existing judicial and regulatory systems are simply not designed to accommodate that timescale or to allow for flexibility down the road.

The basic dilemma with the legislative regulatory framework is that "it

envisions right at the outset that one will define a precise, long-term solution that is going to be adequate to deal with the problem," Meserve said. "The real world doesn't allow that certainty."

Kate Probst, a senior fellow at RFF and an expert on Superfund issues, pointed out that while site cleanup is a problem for both nuclear waste and Superfund, a key difference between the two is that the Superfund law has no specific deadlines for cleanup. "The only deadline in the statute was that EPA had to identify the 400 worst sites in the early '80s when the law was passed. This law gives tremendous flexibility to the agency," she said.

The difficulty, according to Probst, was that EPA underestimated both the time required and the technical skills needed to clean up a site. In many cases, contamination can be contained, but will nonetheless remain for decades if not hundreds of years in some situations.

Probst argued that EPA needs to be honest with people who live near Superfund sites about a cleanup project's timeline and progress, and provide assurances that an institution will be around to monitor contamination at these sites. That institution needs authority and credibility, but also some kind of interim deadlines combined with a degree of flexibility to account for what cannot be known at the outset.

Milton Russell, senior fellow at the Joint Institute for Energy and Environment, University of Tennessee, echoed Probst on challenges for DOE site remediation, which he characterized as "perhaps the largest, most complex environmental cleanup in history." Noting that there had been some success in site cleanup, he said other sites are likely to be forever contaminated and can only be contained. He also

pointed out that long-term flexibility for solving these problems must extend beyond existing policy to include possible changes in risk. He wondered if it was even appropriate for policymakers in this generation to try to lock in standards for future generations, not knowing what changes may arise in the future or who would share the burden of stewardship at that time.

"We want to distribute the burden equitably, both among people living today and between us and those who will come after us," he remarked. "We want to protect future generations from some specific, foreseeable potential outcomes... and we want to prepare for change."

Though the situations are different, the panelists' comments indicate that there is a class of these long-term, difficult-to-solve problems, Fri concluded. "The hazard exists... there is not at least easily or economically available technology that will quickly morph the contaminant involved into some benign substance... the hazard must be managed over a very long period," he commented. "It's a problem of multiple generations... [posing] some serious challenges for current practices in environmental regulation."

"Action is required whether a standard is met or not. We can't do nothing," Fri concluded. "We like deadlines, but a deadline for 'solving the problem' once and for all may not mean anything in the case of these very long-lived issues. Our political and regulatory institutions must adapt to new information over many, many decades." ■

## Developing Hydropower and Protecting Biodiversity in Chilean Patagonia

**I**ncreasing national and international pressures for hydroelectric development and ecosystem protection are presently on a collision course in Chilean Patagonia, the southernmost region of South America. Water rights and river management are issues that traditionally have gotten little attention from people and organizations concerned about sustainable development in the region. Recently, however, Patagonia has attracted dramatically increased international interest thanks to the region's wild landscapes, rich biodiversity, unique wildlife and ecosystems, and booming ecotourism.

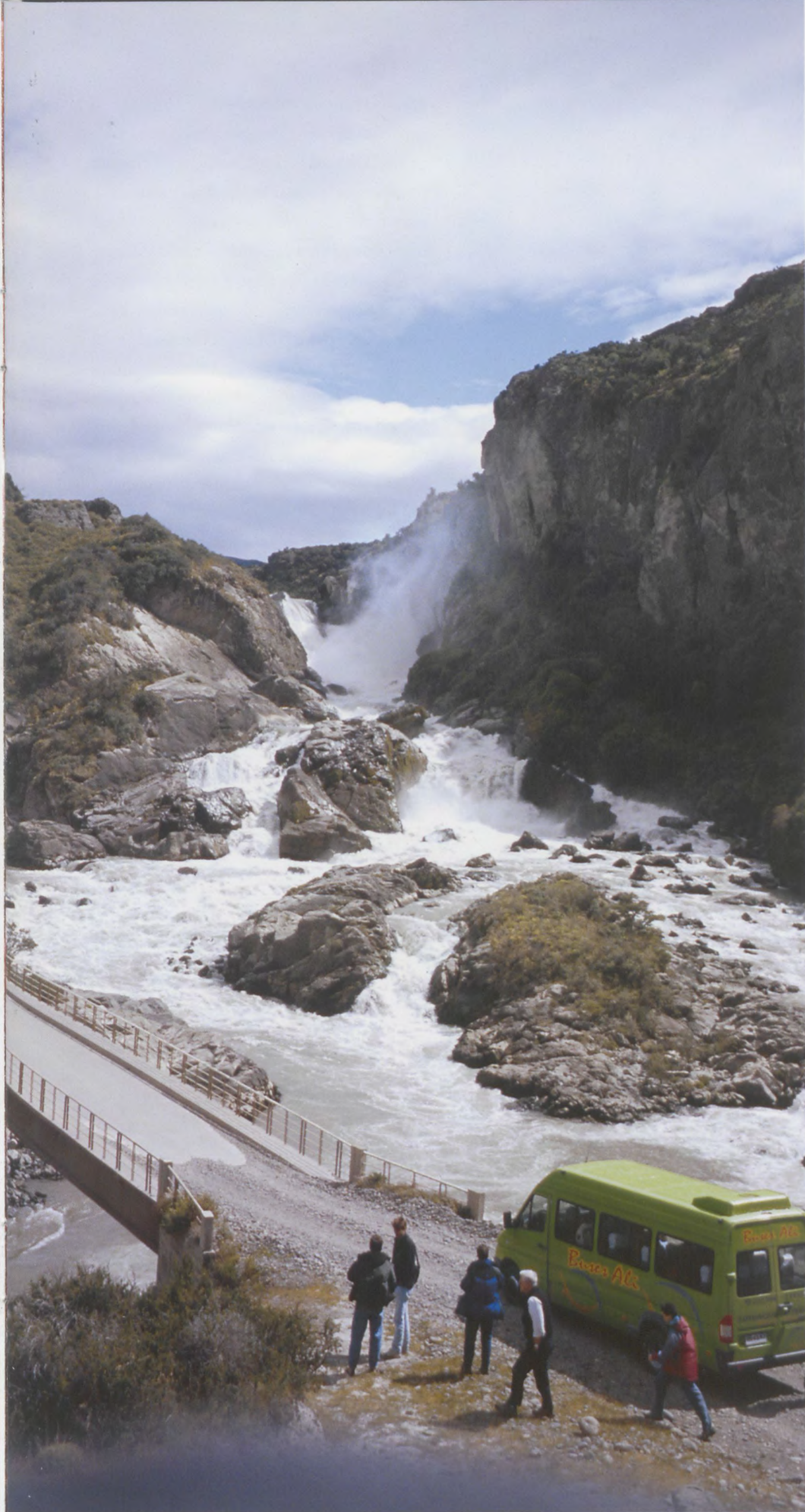
A variety of U.S.-based environmental organizations and private foundations have started programs to preserve Patagonia's ecological assets, including purchasing large areas of land to create private and public parks. At the same time, Chile's growing national demand for electricity, together with the reduction of natural gas imports from Argentina due to that country's economic crisis, means that large-scale hydropower development is looming for Patagonian rivers.

In addition to international efforts, there is growing interest within Chile itself in building a greener model of regional economic development in Patagonia—a model based on ecotourism and environmental amenities, rather than the pattern of exploitation

and export of natural resources that dominates the rest of the country.

RFF Fellow Carl Bauer was in Chile earlier this year to participate as a lecturer in a Pan-American Advanced Studies Institute (PASI). This took the form of a three-week workshop funded by the U.S. National Science Foundation, which brought together U.S. and Latin American scientific experts and graduate students to compare hydropower development and biodiversity in the Columbia River basin (U.S.) and southern Chile/Patagonia. The workshop was organized by the Universities of Idaho and Montana, and the University of Concepción in Chile.

The PASI workshop's basic idea was to compare the two geographic regions as "before and after" examples of the environmental impacts of large-scale hydropower development. In the Columbia River basin, large-scale hydropower development dates back to the 1930s and transformed the economy of the Pacific Northwest in the subsequent decades. The Grand Coulee and Bonneville Dams are only two of the several dozen major federal dams in the basin. Hydropower has generated major regional economic benefits as well as lasting environmental problems, including the impact on salmon populations. In Patagonia, in contrast, hydropower development has yet to begin.



The need to evaluate Patagonian ecosystems in their current condition, in order to improve the laws and policies affecting future development, has led the Chilean government and two Chilean universities to establish a new Center for Research on Patagonian Ecosystems. The new center, called CIEP in Spanish ([www.ciep.cl](http://www.ciep.cl)), is supported by an international consortium that includes the Universities of Idaho and Montana, the University of Córdoba in Spain, and the University of Siena in Italy. A primary focus of CIEP's work will be on aquatic ecosystems and water resources.

CIEP was formally inaugurated in January 2005. At the ceremony, Bauer gave a keynote lecture about water rights and environmental protection in Chile, which was attended by some 200 scientists, politicians, and government officials. Bauer hopes to join other PASI participants in future proposals to the National Science Foundation for collaborative research in Patagonia. ■

## Can Telecommuting Drive Down Emissions?

**T**elecommuting as a concept has been around since the early 1970s. As envisaged, telecommuting would be an antidote to traffic congestion: society would move work, not the workers.

In the past 30 years, telecommuting has been transformed from a futuristic dream into a household word. Thanks to rapid developments in information technology, the range of workplace tasks that can be performed remotely has dramatically increased. While improving workers' lifestyles by increasing flexibility and cutting down on wasteful commuting, telecommuting can also be attractive to employers.

Since telecommuting arrangements tend to reduce worker turnover, lower real-estate costs, and sometimes even increase productivity, many employers have embraced the concept by institutionalizing companywide telecommuting programs. Although telecommuting is not for everyone, for some it can be a win-win situation, even without active government intervention. However, since telecommuting promises to reduce several social problems, there is a case for public policy initiatives in this area. Currently, policymakers hope to encourage more telework because it reduces air pollution.

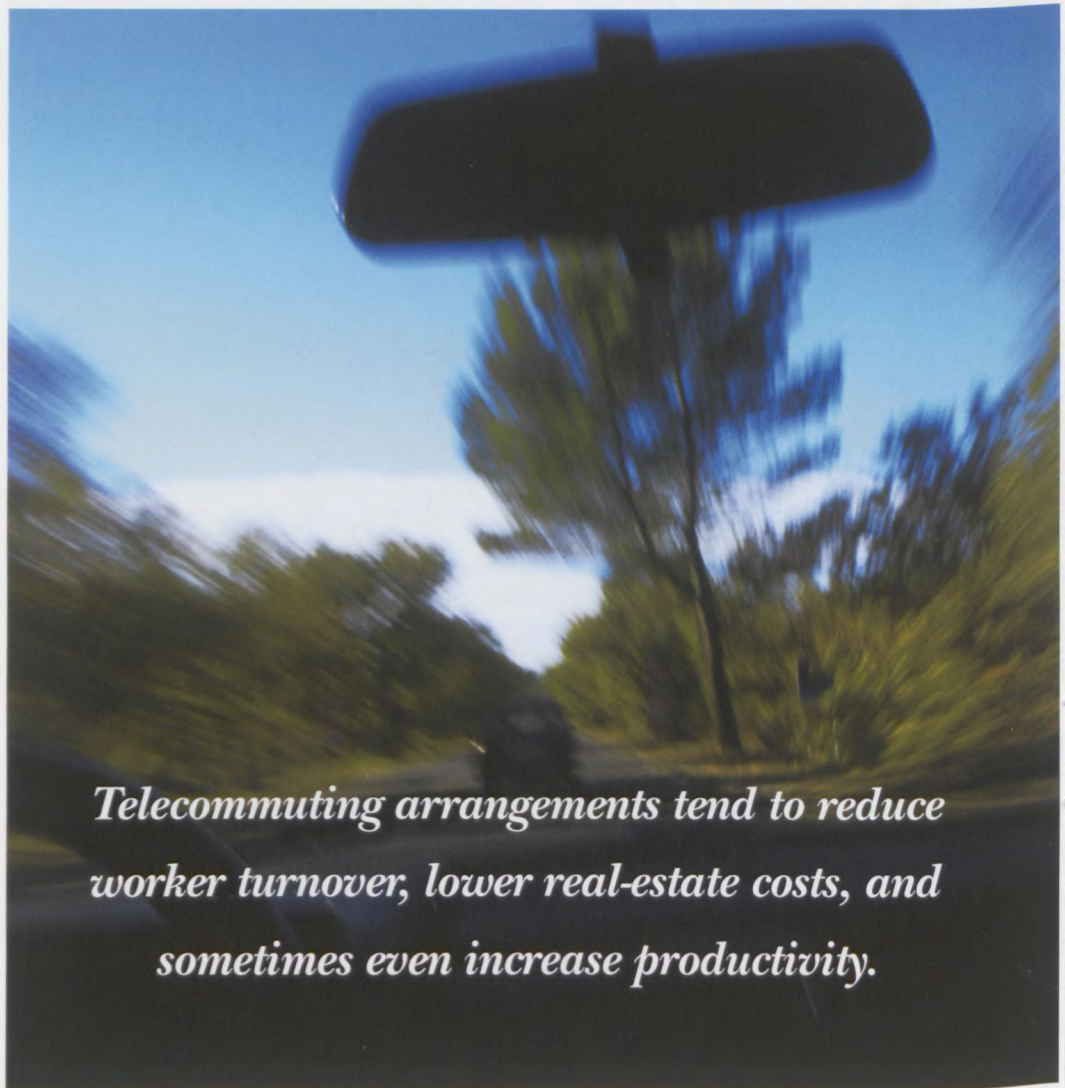
Who telecommutes? And how much of an impact can the practice have on emissions reduction? RFF

scholars have studied the subject and come up with interesting results. Resident Scholar Margaret A. Walls, Fellow Elena Safirova, and Research Associate Peter Nelson outlined their findings in a series of four papers published late last year. Their research was part of a larger program that looks at telecommuting in five metropolitan areas in the United States—Denver, Los Angeles, Houston, Philadelphia, and Washington, DC. This research on the “ecommuter” program, a pilot telecommuting program funded by the 1999 National Air Quality and Telecommuting Act, was funded by EPA. RFF researchers worked through a subcontract with the Global Environment and Technology Foundation.

### Who Is Working at Home?

In order to be effective, government policy should target the part of the population that is most likely to work remotely. The existing telecommuting experience should be able to suggest which industries, geographic areas, and demographic groups are more likely to engage in telework.

The RFF team looked at existing literature on telecommuting and found that there were many pieces of the puzzle, but not a complete picture as yet. Some commonalities did emerge from their review. Certain factors increase both the likelihood and frequency of telecommuting, including having children in the household, being female, having more education, facing a longer commute, working



*Telecommuting arrangements tend to reduce worker turnover, lower real-estate costs, and sometimes even increase productivity.*

longer at one's position, and being in a job that does not require face-to-face contact with coworkers or clients. Also, telecommuters appear to significantly reduce both daily trips and vehicle miles traveled. However, most results were obtained in small studies within government agencies or a handful of firms. In order to see a more complete picture, Walls, Safirova, and Nelson believe there is a need for more research using bigger and more broadly based datasets, containing data on telecommuters across a wide variety of employers.

An interesting anomaly showed up in a broad-based survey conducted by the Southern California Association of Governments (SCAG), which logged telecommuting information for the greater Los Angeles metro area. SCAG's findings indicated that, contrary to popular belief, telecommuters tended to be more often male than female and were less likely to have children in the household. The SCAG survey also showed that many people called themselves telecommuters but in fact worked at home part of the day and in the office part of the day—thereby still driving their cars to work.

#### **Will Telecommuting Reduce Air Quality Problems?**

One piece of the puzzle Walls, Safirova, and Nelson examined was the potential of telecommuting to improve air quality. They looked at this in two ways: Would emissions of pollutants be reduced and by how much? Would a system of trading emissions reductions from vehicles work as efficiently as the system of trading in sulfur dioxide has been working with electric utilities?

The answer to the first question appears to be positive. The team estimates that a 25-ton-per-year reduc-

*In the greater Los Angeles metro area, telecommuters tended more often to be male rather than female and were less likely to have children in the household.*



tion in volatile organic compounds could be achieved in a large metropolitan area, such as one of the ecommute pilot cities, with approximately 4,500 telecommuters working at home, on average, one and a half days a week. However, questions remain about the permanence of telecommuting activity. In the ecommute program, RFF researchers found that many workers appeared to drop out of the program after a period of time. More research is needed into the factors that lead to stability in telecommuting activity among workers.

As far as an emissions trading system is concerned, the outlook seems less encouraging. Several regulatory and institutional barriers exist to using telecommuting in an emissions trading program. The most important may be that emissions reductions from telecommuting have weak envi-

ronmental integrity—in other words, any reductions cannot with certainty be tied to telecommuting by particular workers. In addition, the approach is unlikely to be cost-effective because the reductions from an individual telecommuter are small.

The picture of telecommuting that the team has drawn so far shows mixed benefits for the United States in the upcoming years. Although telecommuting programs can produce air quality benefits, they have to be looked at in comparison with other approaches that could potentially produce even more emissions reductions at lower costs. On the other hand, telecommuting programs can produce large co-benefits, particularly reduced traffic congestion, and therefore may be an attractive alternative for transportation and air quality planners. ■

# Shall We Gather 'round the CAMPFIRE?

## ZIMBABWE'S APPROACH TO CONSERVING INDIGENOUS WILDLIFE

*Carolyn Fischer, Edwin Muchapondwa, and Thomas Sterner*

**W**hen the bald eagle, revered symbol of the United States, was threatened with extinction 40 years ago, the problem turned out to be relatively easy to solve. The greatest threat came from a widely used pesticide, DDT, which interfered with the bird's ability to reproduce by weakening the shells for its eggs, causing them to break during incubation or fail to hatch. It was banned in 1972 and bald eagle numbers have risen steadily ever since.

But for the great animals of the African plains currently facing extinction, the remedies are hardly so clear-cut. The reasons why, however, are not: habitat loss and poaching have taken their toll for decades, despite regulations, bans, and treaties. Recent conservation efforts have focused not only on enforcement of trade restrictions, such as bans on ivory, but also on mitigating the economic consequences of human-wildlife conflicts. In particular, major international and non-governmental conservation organizations are supporting initiatives to promote and share the economic benefits of wildlife conservation with local communities. Some examples in East Africa include channeling commercial forest product royalties and forest-based tourism fees from Mount Kenya Forest to the community level; assistance with marketing activities to help sell natural woodland products in Kibwezi, Kenya; and a voluntary levy by outfitters of 10 percent of trophy fees on tourist hunting in the Serengeti, Tanzania, with the revenues directed to the villages on whose land they operate.

At first glance, profit sharing, by making wildlife a valuable resource, seems sure to encourage wildlife conservation and

benefit poor rural communities. But wildlife management problems in developing countries are rife with complicated questions of governance and human conditions, not to mention biological processes. An important policy question is how the design of benefit-sharing initiatives might affect both wildlife and community welfare.

Zimbabwe offers an interesting case study. The establishment of national parks, game reserves, and safari areas in the late 1920s may have helped avert biodiversity loss, but it also displaced rural communities from land that was traditionally theirs. Cultivation and grazing land was expropriated, and subsistence hunting became illegal. Wildlife from the parks roamed freely in surrounding areas, destroying crops and threatening livestock and people.

To make matters worse, more than 90 percent of communal land in Zimbabwe is located within agriculturally marginal regions plagued by persistent drought and poor soil. So people relying on parklands to graze livestock suffer doubly by the creation of wildlife parks.

The Department of National Parks and Wildlife Management has owned the wildlife in trust for the country and originally reaped all the benefits—by selling licenses for hunting and charging fees for wildlife services, like tourism. Hunting is ordinarily forbidden in national parks, but the country has 17 safari areas—comprising 1,892,724 hectares—that allow limited hunting. Illegal poaching grew problematic, and since wildlife posed a nuisance, locals would often turn a blind eye or even collaborate with poachers.

In 1989, Zimbabwe instituted a wildlife benefit-sharing program, the Communal Areas Management Programme for

Indigenous Resources (CAMPFIRE). It focuses on communal areas adjacent to national parks, where wildlife intrusion is most severe. CAMPFIRE gives communities co-ownership of natural resources, which generate income through trophy hunting concessions, natural resources harvesting, tourism, live animal sales, and raising animals for meat.

### **ANTIPOACHING EFFORTS IN ZIMBABWE**

Most of the economic value of wildlife throughout much of Africa comes from poaching. In Zimbabwe, local communities themselves engage in small-scale subsistence poaching, mainly for small game such as spring-hare, bushbuck, and guinea fowl. Poaching for the pot has often been overlooked by the park agency, which finds it difficult to enforce the law in any case.

Commercial poaching, on the other hand, mainly targets larger game for trophy sales and is usually carried out by professionals with automatic weapons. The ultimate customers are international and wealthy. Poachers usually hire a few local informers and accomplices; however, little income from commercial poaching actually reaches the local community.

Under the 1982 Parks and Wildlife Act, authority over wildlife resources devolved to democratically elected rural district councils. The CAMPFIRE program was created to integrate the local communities into decisions about wildlife conservation and give them shares of the benefits. Absent such benefits, the local communities consider wildlife, particularly large game, to be a nuisance and tolerate poaching. Once they were integrated into the process, local communities began to perceive game as a resource and frown on activities that harm it. This change in local norms along with peer enforcement alienates accomplices and makes poaching more difficult for the outsiders.

Poaching was rampant prior to CAMPFIRE but has since been drastically reduced in some areas, as the neighboring communities started reaping economic benefits from legal use of wildlife and making public arrests of commercial poachers. However, in other areas, poaching subsided only temporarily. Unfortunately, since controversial land reform began in 2000, CAMPFIRE has fallen into disarray.

### **BUILDING A MODEL TO STUDY POACHING**

To understand both the successes and the shortcomings of the program, we have analyzed how community income and conservation incentives respond to resource profit sharing in a typical rural area in Zimbabwe where wildlife is abundant (though our analysis is relevant to wildlife revenue-shar-

ing programs in general). We employed a bioeconomic model to study poaching by outsiders, antipoaching efforts of local communities, and interactions between park managers, the communities, and the poachers. Our model has two agents, the park agency and a local community; two control variables, hunting quotas and antipoaching efforts; and a stock variable representing wildlife. The revenue from wildlife conservation—from hunting licenses and tourism fees—may be shared between the park agency and the local community; agricultural production solely benefits the community. Income from agriculture is negatively affected by larger wildlife stocks, which graze and trample crops.

The local community receives a hunting quota and consequently a share of the hunting profits. It may also get a share of the profits from tourism fees. The remaining profit goes to the park agency. Revenue from both consumptive (hunting) and nonconsumptive (tourism) uses will increase with the stock of wildlife.

The community can engage in antipoaching activities—discouraging accomplices, monitoring and protecting wildlife, reporting poachers and informants, and employing antipoaching units—and can also collaborate with poachers. Engaging in antipoaching efforts entails costs, such as the value of time lost and wages for private enforcement agents.

### **MODEL RESULTS: PROPERTY RIGHTS AND CONSERVATION INCENTIVES**

How does the reallocation of the benefits from wildlife resources affect a community's incentives for conservation?

The community knows that the allocation of hunting licenses may be influenced by the strength of wildlife stock, which the community, in turn, can influence through antipoaching efforts. With profit sharing, the local community can augment its income from agriculture with profit shares from hunting and tourism, less the costs of antipoaching activities. Naturally, the community will engage in active antipoaching efforts if more wildlife benefits them, and it will collaborate with poachers if wildlife is a nuisance. Note that the community does not directly choose harvesting levels; rather, it influences the offtake (hunting plus poaching) through how it responds to poaching.

Given this indirect influence on the wildlife stock—and the revenues it generates—how should we expect conservation incentives to respond to the allocation of the benefits from the two sources of wildlife profits, hunting and tourism? More wildlife generates more tourism, so raising the community's tourism shares always improves incentives for conservation and antipoaching efforts—or at least it makes

wildlife less of a nuisance on balance and reduces incentives to collaborate with poachers. However, raising hunting quota shares increases conservation incentives only if having more wildlife generates more quotas. Therefore, an important question is the extent to which the community thinks that its efforts will result in an increase in quotas, which are set by the park agency.

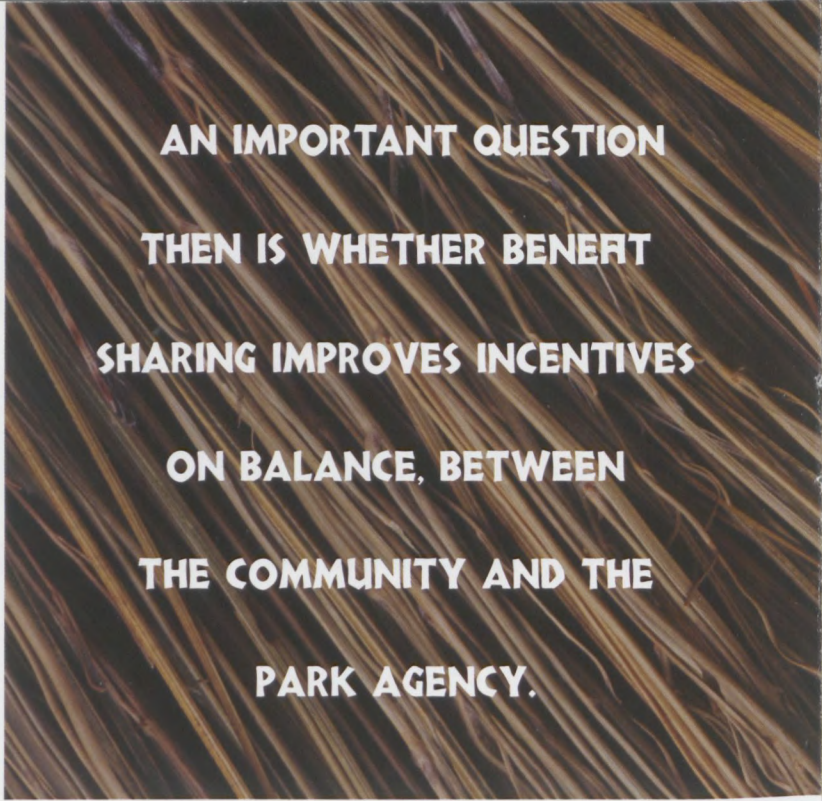
Less poaching does not necessarily mean more hunting quotas because the number of quotas depends both on population growth rates and on the park agency's response. If the community has little faith that the park agency will raise quotas, its incentives will be considerably weakened. In the extreme case—if the community believes the quota allocation to be fixed—increased hunting shares will yield a lump-sum increase in income, with no impact on conservation incentives.

Next we explore the effect of how the hunting quotas are determined. Taking the extremes, we first assume that the park agency bases its decision on biology alone, then see what happens if the park agency seeks to maximize its own profits.

Under a biologically determined decision rule, the park agency determines a sustainable harvest. When the wildlife population increases, the park agency accordingly can afford to raise the hunting quotas. In this scenario, an increase in the share of hunting revenues increases antipoaching efforts, since communities know additional quota revenues will be forthcoming.

However, conservation incentives do not go hand-in-hand with the responsiveness of the park agency. When communities perceive wildlife to be a nuisance, the park agency's response of granting additional hunting licenses when there is less poaching generates two benefits: it raises revenues for the community and reduces nuisance wildlife. Conversely, when communities want more wildlife (and the tourism revenue it generates), the responsiveness of the park agency can raise or lower antipoaching efforts. On the one hand, the community receives additional revenue; on the other hand, additional quotas reduce the stock of wildlife that now has a net positive value to the community. In other words, the quota increase can dampen community efforts.

Now let's say that the park agency is out to maximize profits. In this case, the park agency's concern for conservation depends on its own share of the benefits. It is more concerned with conservation—and less willing to allocate hunting licenses—the higher the marginal return to tourism and the lower the marginal return to hunting, after profit sharing. As a result, changing the relative hunting and tourism revenue shares can change the manager's incentive for setting quotas.



**AN IMPORTANT QUESTION  
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An important question then is whether benefit sharing improves incentives on balance, between the community and the park agency. For example, if the park agency retained all the hunting profits while the communities reaped all the tourism revenue, any decrease in poaching would merely be offset by additional hunting licenses. If the community recognizes this response, it would have little incentive to engage in antipoaching efforts. Consequently, wildlife stocks would become more depleted under this kind of profit sharing, benefiting communities by fewer wildlife conflicts rather than by large tourism revenues.

Suppose instead the park agency reaped all the tourism revenue while the community received the hunting quotas. In this case, the park agency would want to keep the wildlife stock as large as possible and would refrain from issuing hunting licenses. Communities would then be worse off: not only would they receive little or no hunting revenue, but they would suffer more wildlife incursions.

More generally, when the park agency controls the target wildlife stock through hunting quotas, the community can only influence the portion of the total offtake that is harvested through hunting rather than poaching. When the community receives a share of the hunting quotas, it combats poaching to secure a share of those licenses for itself, not to manage the wildlife stock. Tourism benefits, however, have no effect.

In Zimbabwe, tourism revenues from CAMPFIRE have been small compared with hunting revenues. However, if the incentive from tourism shares is sufficiently strong—as perhaps it could be in Kenya and other countries with more wildlife



tourism—the community may engage in less effort, recognizing that on the margin it affects only hunting licenses rather than the wildlife stock.

## CONCLUSION

The CAMPFIRE program in Zimbabwe directed shares of the profits from hunting and benign tourism toward the local community, in part to offer direct compensation for the nuisance suffered from wildlife and in part to induce antipoaching effort. In many respects, CAMPFIRE seemed successful, at least initially. Poaching, seen as rampant before the program, fell drastically afterward, with evidence of community help. However, in some areas poaching subsided only temporarily, and the situation deteriorated again when communities did not receive the promised benefits and rural district councils did not generate enough money to support the antipoaching units.

Mere resource sharing does not automatically confer benefits and conservation incentives on local communities, according to our analysis. Those incentives depend critically on the type of resource activity that generates the shared profits, the extent to which these shared profits outweigh agricultural losses, and also how profit sharing and community responses affect the resource management practices of the park agency.

Our findings reveal the importance of the park agency's management strategy and its interaction with the community. If less poaching merely translates into more licenses—and the community knows this—the incentives to resist poaching then derive primarily from the hunting revenues. If, on the other hand, additional licenses do not completely crowd out reductions in poaching, the community will expend more effort against poaching (or at least collaborate less) to the extent that it receives more revenues from tourism.

When the community does not expect the park agency to change its allocation of hunting quotas, additional efforts to promote tourism through more conservation can be tempered after a while—or even undone completely—if the agency does not itself have enough incentive to protect the wildlife stock for tourism. The consequences have been felt in recent years, as political instability has hobbled the tourism industry; reports of rampant hunting and poaching on game parks seized as part of the land reform evoke little surprise.

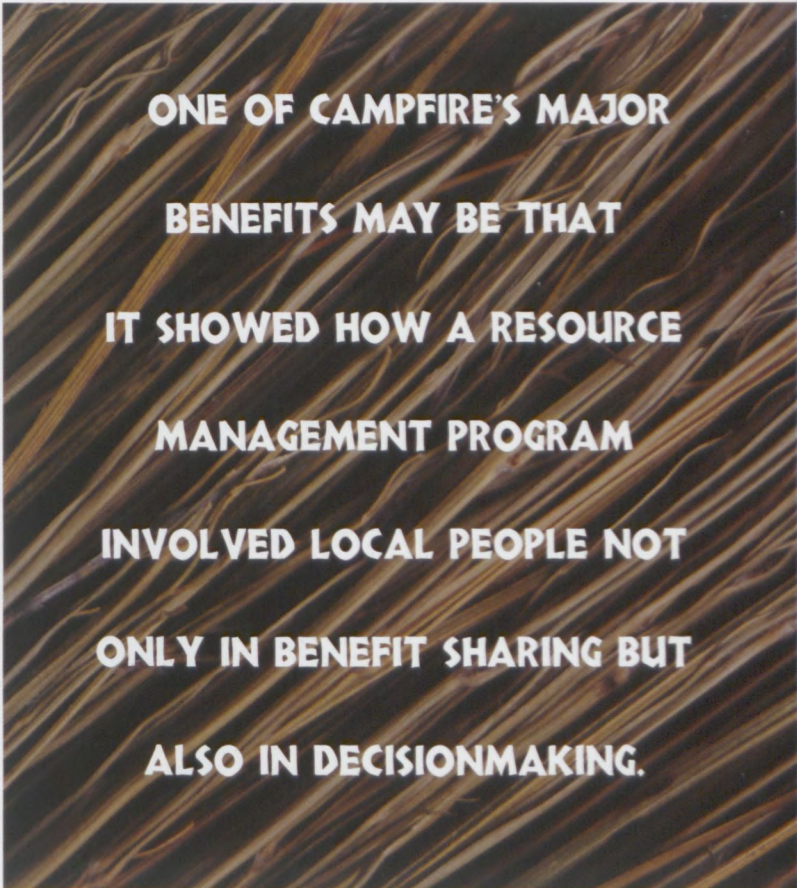
Recent troubles aside, the experience of CAMPFIRE in the 1990s was largely positive, although the success was fragile. The details of program design are important: one of CAMP-

FIRE's major benefits may be that it showed how a resource management program involved local people not only in benefit sharing but also in decisionmaking. If allowed to evolve, these kinds of institutions could open up avenues for correcting problems in the design of wildlife conservation programs and ensuring that the application of benefit sharing lives up to its laudable intentions. ■

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**ONE OF CAMPFIRE'S MAJOR  
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# Ecosystem Services and Government Accountability: The Need for a New Way of Judging Nature's Value

*James W. Boyd and H. Spencer Banzhaf*

Ten years ago environmental policy discussions became flooded with the term "sustainability." Books, articles, conferences, grant competitions, even entire organizations, took sustainability as their focus. No doubt the word took off because it evoked environment-friendly concepts like balance and stewardship. Its success may also have been due to the fact that it could mean almost anything. Now a new term—ecosystem services—threatens to dethrone sustainability as the ultimate environmental buzzword.

Like its predecessor, the term "ecosystem services" is increasingly attached to all manner of public and private environmental endeavors. Recent examples include the UN-sponsored Millennium Assessment, National Research Council reports, and numerous advisory boards to the government and the private sector. As the term gets more and more use, there is a danger it will become a soft, generic label signifying everything, yet nothing.

What follows is a brief guide to what ecosystem services really are, what they are not, and why we need a system of measuring them.

## **A definition and a distinction**

*Ecosystem services are the end products of nature that yield human well-being.* Three necessary conditions define an ecosystem service. First, and most obvious, the service has to emerge from the natural environment. Second, a service must enhance human well-being. Third, a service is an end product of nature directly used by people. The last two parts of the definition deserve further explanation. Before doing so it is important to emphasize a distinction: ecosystem services are not the same thing as ecosystem functions. Functions are the biological, chemical, and physical interactions associated with ecosystems. These functions are the things described by biology, atmospheric science, hydrology, and so on. Services depend on these functions but are different: they are the aspects of the ecosystem valued by people. For the purposes of our article, we use the word biophysical to define this complex interplay between the inhabitants of the natural world and their environment.

## **Services are about human well-being**

The term services conveys a basic truth: human welfare is dependent on natural systems. The study and measurement of services tell us about how welfare can be enhanced via stewardship of the environment. It is the emphasis on welfare and human well-being that sets the economic analysis of services apart from purely biophysical analysis.

There are two reasons—one philosophical, one pragmatic—to emphasize nature's economic characteristics. As a matter of philosophy, economists believe that the objective of social policy is to maximize human well-being. The well-being nature provides can be interpreted quite broadly to include nonmaterial, even spiritual experiences. When we measure ecological conditions alone, it is certainly far better than doing nothing, but it neglects deeper inquiry into what is socially beneficial about ecosystems. The second reason to assess benefits is that it illuminates and disciplines how priorities are set and trade-offs are calculated.

Indicators of pure ecological conditions, such as the presence of a contaminant in a stream, do not help a policymaker forced to choose between conflicting interventions or operate under a tight budget. To say that better ecological conditions are better for society is true, but unhelpful. In practice, policymakers struggle with much more difficult questions, such as *which* ecological conditions are better than others? For economists, measures of social well-being are an effective way to come up with the answers.

It deserves emphasis, however, that all of nature's benefits can be and should be measured, including nonmaterial, even spiritual, benefits.

### Services are the “end products” of nature

Nature is composed of a swirling multiplicity of processes, functions, and interactions. The oceans affect climate, climate affects plant life, plant life affects habitat, and on and on. All of these linkages are fundamental to life on Earth and thus to human well-being. And all are therefore valuable. But being valuable is not the same thing as being a service.

The metaphor of nature as a factory, although possibly jarring, is powerful and illustrative in this context. To an economist, a factory is nothing more than a set of inputs and a way of combining those inputs to create a set of things people want (the end products). To apply the metaphor, ecosystem services are the things people want from nature, like the beauty of a forest and fish from the sea, not the equally important processes or components on which services depend. These services can be enjoyed directly (such as outdoor recreation) or indirectly, via an additional economic process (such as the fertility of soil, which contributes to the production of food).

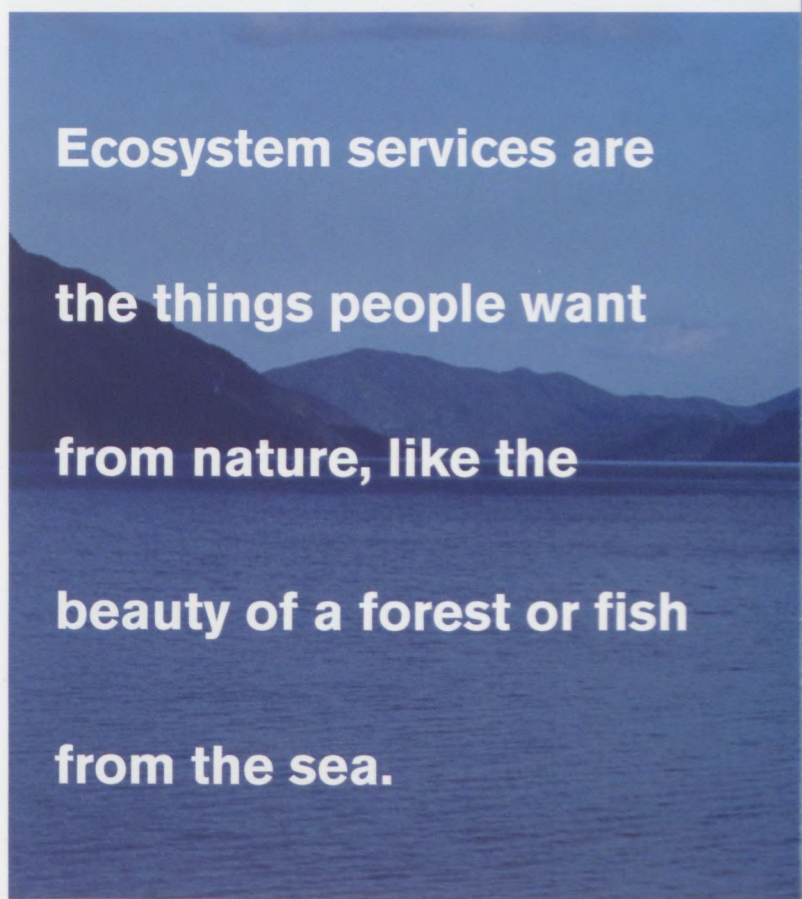
Like a factory, nature represents the processes and components that give rise to these services. To be sure, nature is an extremely complicated factory. While we can inventory the inputs and processes involved with a real factory, depicting the full range of biophysical relationships will occupy

science for centuries to come. But the earth sciences, broadly defined, are already doing this. Another term for this factory is the ecological production function. If you believe in climate change you believe in a biophysical production function.

Confusion between inputs and outputs muddies thinking about ecosystem services. Most inventories of ecosystem services include both the end products people want and the biophysical inputs or processes on which end products depend. For example, inventories of ecosystem services include such things as photosynthesis and nutrient cycling, which are functions, not services. One imperfect test is whether an average person knows what nutrient cycling is (probably not). Nutrient cycling is a valuable ecosystem function because it leads to things people want: clean water, in this case. It is not something people intrinsically value as an end in itself.

### Services are the bridge between economics and ecology

Truly interdisciplinary work between economists and biophysical scientists is the Holy Grail in environmental analysis. Each group can conduct productive academic activities in isolation, but real progress in public decisionmaking demands



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integration. Given the definition of services as end products of nature that yield human well-being, the biophysical sciences tell us what kinds of end products we can expect from nature. Take drinking water for example, clearly something from nature that benefits human beings. How much additional clean water can we expect if we apply less pesticide to farms? This is a question for the biophysical sciences. How valuable is that change in clean water? That is a question for economists. The link between the two inquiries—that is, the units nature provides and that enter into consumption or economic production decisions—is the service. But ecologists and economists must agree on the definition of services or their analyses will never effectively integrate.

A corollary to this is that ecologists need to buy into the economic conception of services. To deep ecologists, services' focus on human well-being may be an insuperable hurdle to acceptance. But there are positive reasons for ecologists to embrace the concept, as well as a few misconceptions to clear up. We start with a misconception.

### **Services will usually not be bought and sold**

Proponents of market-oriented environmental policies have seized on the language of ecosystem services because some services can—in principle—be exchanged and priced. This enthusiasm is somewhat unfortunate because it can lead skeptics of market-oriented policies to equate the services mindset with market policies. In reality, a commercial approach to ecosystem services provision is a dim dream for all but a small set of environmental benefits. This is because most ecosystem services are common resources or public goods in economic terminology.

Like the other classic sets of public services—defense and public safety—ecological services tend to benefit large groups of people and resist ownership. A corollary is that people, even if they were somehow allowed to buy ecosystem services, would not buy enough of them. Altruism is not a strong enough motivation for citizens to pay for ecosystem services. We don't even pay for fuel-efficient vehicles and clean fuels and we still apply too much fertilizer and pesticides on our lawns. All of these problems arise for the same reason: our private incentives do not align with the public interest. When it comes to the environment this will always be so because of a fundamental reality: the environment is shared, not owned.

Misplaced excitement over the commercial provision of ecological services arises from one of two mistakes: The belief that private parties will pay for public goods when they clearly don't. Or that someone else—in particular, the gov-

ernment—will pay for them. Theoretically, governments are the solution to public good provision. But it is a misconception to assume that governments know how to provide ecosystem services.

### **Services demand expertise in procurement**

The procurement of public goods is a challenge. Consider public safety and defense. Because private markets do not provide these services we rely on governments to purchase them. Unfortunately, governments are not immune to mispending money. Scandals in defense contracting—such as thousand-dollar toilet seats and armored vehicles that don't perform as they should—provide regular examples of the difference between a government purchase and one where an individual's own money is on the line.

Because ecosystem services are public goods, this problem is inevitable. What it suggests, however, is that governments need a way to measure the quality of services they are buying. With public safety, the public gets some form of feedback on the quality of its investment when the crime rates rise and fall. With ecosystem services, the feedback by which we judge the performance of government in providing these services is much more ambiguous. Was trout fishing better this year than last? Is property better protected from flooding?

### **We should demand quality services**

If the public can be educated about what ecosystem services are, it will be easier to convey the importance of maintaining their quality. There are cars and then there are good cars. The same is true of ecosystem services.

The notion of services prompts two kinds of inquiry into quality. First, what is the environmental quality of the services? Is there more clean water, are there wetlands capable of cycling nutrients, is the visual beauty of the landscape improving? Second, what is the economic quality of these services? Economic quality relates to the degree to which a service creates well-being. For example, the location of ecosystem services can strongly affect their value. The value of flood or hurricane damage prevention, recreation, and aesthetic enjoyment are all strongly dependent on their location.

Economic quality also relates to things like the availability of substitutes. Many ecosystem services have no substitutes. For example, there is no clear substitute for the existence value of wilderness or an endangered species. Other services do have substitutes, however. Consider drinking water. Purchased filtration of unclean water is a partial substitute for

clean water. Are we indifferent between the two? Of course not, because clean drinking water is a signal of many other things: clean rivers and lakes, a sense of personal safety, and trust in institutions delivering the water, to name a few. But there are substitutes for naturally occurring clean drinking water. Mechanically filtered water, for example, is an imperfect substitute for pure natural water. From a procurement standpoint, the substitutability of these services—and their relative cost—should be made a part of public process.

### **The immediate challenge: measure, track, and communicate services**

Measurement of ecosystem services is a first step to their better procurement. Such measurement will require the use of both biophysical and economic data, to capture both the ecological production function and the contribution of services to human welfare. How to go about this is the subject of ongoing research at RFF.

We have been developing a set of tools based on ecological benefit indicators (EBIs), which are quantitative, transparent measures of ecological and social conditions usually gleaned from geospatial information and other public data sets. The depiction of these indicators—both quantitatively and visually—provides a basis for public learning about the ways in which natural systems create well-being. They are also designed to overcome the typical bifurcation of analysis into separate economic and ecological components.

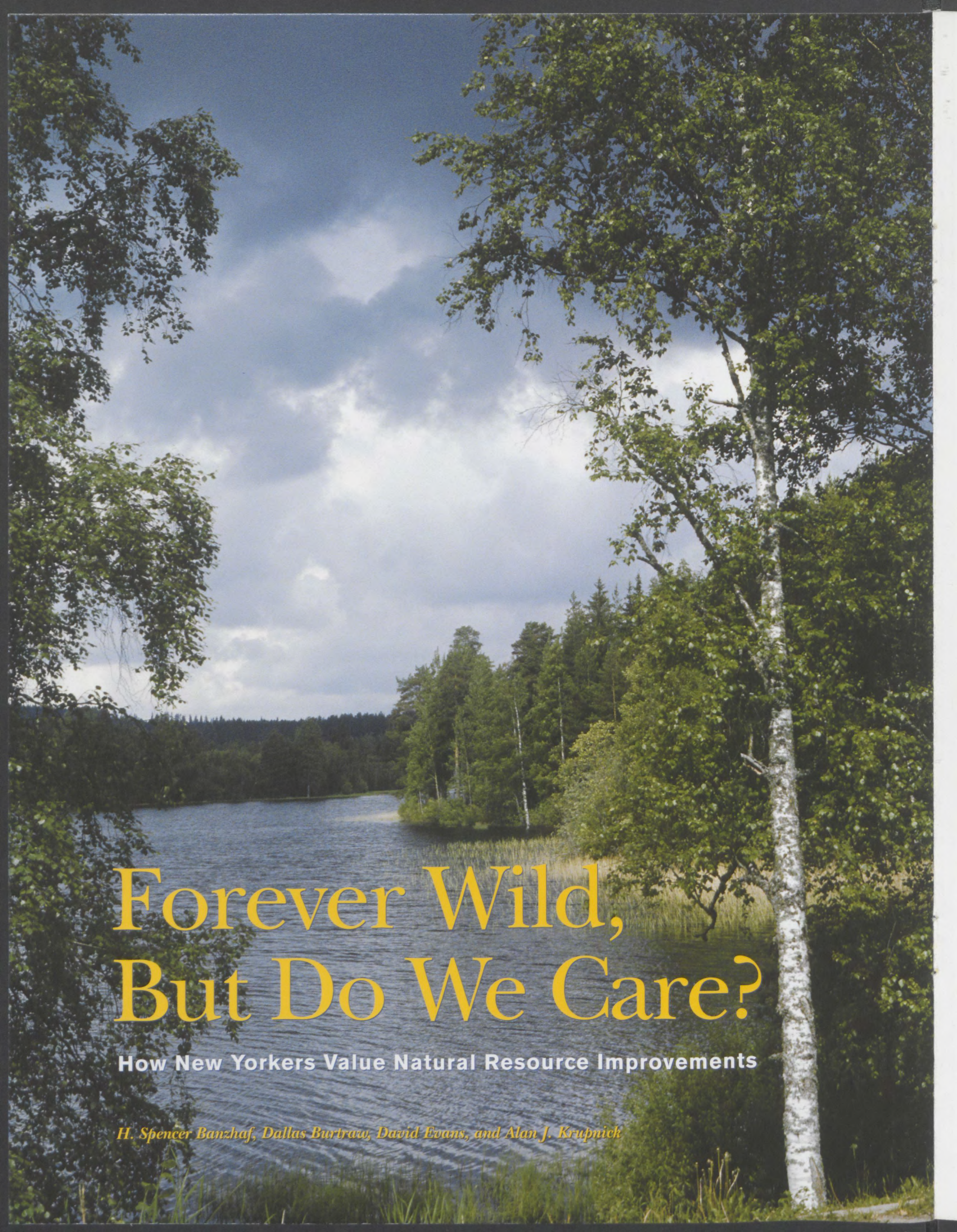
Several products have emerged from this line of thinking. First, for a set of case studies, indicators were collected, displayed, and used to analyze the value of different natural resources. Second, we have been studying the integration of these indicators into a formal index of ecosystem services. Consider an index like the gross domestic product (GDP). We trust such an index because it is constructed transparently and rooted in sound economic science. An index of ecological benefits requires those same properties and one other: it must be based on production function analysis derived from sound biophysical science.

Any such index can be challenged in terms of what it really represents. But a reason to embark on such a project is to begin the development of a rigorous, systematic measurement of ecosystem services. The way we measure GDP has changed over the last 100 years. The way we account for ecosystem benefits will also change over time. But it is important to start. Governments make decisions every day that affect the sources of well-being we derive from nature. The public needs a way to think about, systematize, and track these changes. ■

**If the public can be educated about what ecosystem services are, it will be easier to convey the importance of maintaining their quality.**

**There are cars and then there are good cars.**

**The same is true of ecosystem services.**



# Forever Wild, But Do We Care?

How New Yorkers Value Natural Resource Improvements

*H. Spencer Banzhaf, Dallas Burtraw, David Evans, and Alan J. Krupnick*

# T

he very name “Adirondacks” conjures up the image of the famous wood-slatted outdoor chair first made around the turn of the last century, connoting scenic vistas, clean and healthy lakes, and fresh air. Certainly, the Adirondack Park features an abundance of vistas and lakes. Simply put, the park is huge. It covers 20 percent of New York State and is nearly three times the size of Yellowstone National Park. The park encompasses six major river basins, contains almost 3,000 lakes, and is the largest area of old-growth forest east of the Mississippi. One-sixth of the park is designated as wilderness and its status as a “forever wild” forest preserve is enshrined in the New York Constitution.

But the park’s protected status has not made it immune to the effects of pollution. About one-half of the park’s lakes are affected by acid deposition resulting from emissions from power plants and other sources. While the clarity of their water gives the impression that they are clean, the lakes’ ability to support plant and animal life has been greatly diminished. Forest health, particularly at high elevations, and bird populations may also be compromised by acid rain.

Federal and state initiatives to reduce air pollution, including the 1990 Clean Air Act Amendments and the recently promulgated Clean Air Interstate Rule, have cited reduced acid precipitation as a benefit of further reductions in sulfur dioxide (SO<sub>2</sub>) and nitrogen oxides (NO<sub>x</sub>). But, in fact, these policies have proceeded without making the link between the ecological science and the social science necessary to enable economic valuation of the benefits of these emissions reductions. In particular, no one knows how much people value improving the quality of the Adirondacks ecosystem. This knowledge is a necessary step for determining how much to reduce these pollutants.

Our study is the first to examine values people place on improving this resource. A 1990 study—part of the National Acidic Precipitation Assessment Program (NAPAP)—examined values for recreation opportunities. However, only a relatively small fraction of New Yorkers actually spends time in the park and the political saliency of acid rain damage in the Adirondacks suggests that nonusers may value the park highly.

We found that New Yorkers (users and nonusers alike) place significant value on rectifying damages from acid rain in the park. Depending on the improvement scenario in our survey, they would be willing to pay from \$48 to \$159 per

household each year. With 7 million households in the state, this amounts to benefits of \$336 million to \$1.1 billion annually. The values of nonusers are a large percentage of these totals.

### Details of the Study

Our study, entitled *Valuation of Natural Resource Improvements in the Adirondacks*, targeted households living in New York State because they likely would hold a large share of the benefits of any park improvements. To develop an estimate of social willingness to pay (WTP) for improvements to the park we used contingent valuation, a method perhaps best known for estimating the damages after the 1989 Exxon Valdez oil spill. Contingent valuation is done by surveying households to determine whether they are willing to pay various amounts of money for a specific hypothetical project or intervention that, in this case, would lead to improvements in the health of the Adirondacks.

To ensure that the resource changes being valued mapped closely to the current and expected future condition of the park, we initially developed a “summary of the science.” Armed with this information, we conducted numerous focus groups to identify ways to accurately and meaningfully distill this complex information in the survey. Understandably, there is considerable scientific uncertainty as to what the level of pollution at the park will be and how it may change with further emissions reductions. In response, we developed two versions of the survey to span the range of scientific opinion about the future status of the park both with and without further emissions reductions. These two versions also permitted a “scope” test, that is, whether greater improvements to the

resource generate a higher willingness to pay.

One version of the survey depicts the future status of the park as constant in the absence of any interference and as improving with an intervention. In this version, the intervention yields the improvement of 600 lakes over a 10-year period (of about 1,500 currently damaged), and small improvements in the populations of two bird species and one tree species. The other version depicts the situation as worsening without any interference and with greater ecosystem benefits should the intervention be adopted. In contrast, this second version indicates an improvement of 900 lakes and greater benefits to four bird species and three tree species over the same time period.

We convened 31 focus groups and conducted two major pretests to develop and extensively assess alternative text, debriefing questions, and graphics. For example, in explaining the acidity of the lakes, we needed appropriate language that would convey that environmental consequences, not human health, are at issue. To do this, we likened the acidity of the affected lakes to that of orange juice—possibly affecting wildlife relying on the lakes, but harmless to humans. Similarly, in proposing improvements, we needed to ensure that the intervention be plausible and understandable to respondents. They also needed to be reasonably convinced that they would have to pay for this improvement, if the majority of voters agreed. This was a major challenge as the way the park is likely to be improved—through national policy for emissions reductions at eastern and Midwestern power plants—would be mostly paid for by other people. So we introduced an intervention where New York State would run a tax-financed program to drop lime from airplanes onto lakes and affected forests to neutralize the acidity, a necessary ruse that was accepted by respondents.

### Hypotheticals and Overestimates

A common criticism of contingent valuation studies is that the hypothetical nature of the exercise tends to yield overestimates of WTP. That is, respondents vote for the hypothetical increase as a sign that they generally care about the issue, not whether they would expect to be better off if the intervention were adopted and their taxes rose accordingly. In response, we followed a cautious or conservative approach in designing the survey and applying statistical methods so that our estimates of social WTP are likely less than the true WTP for the improvements described.

A related concern about overestimates of WTP is the observed tendency of respondents to vote “yes” for a program in a pro forma way, perhaps out of a sense of obligation or

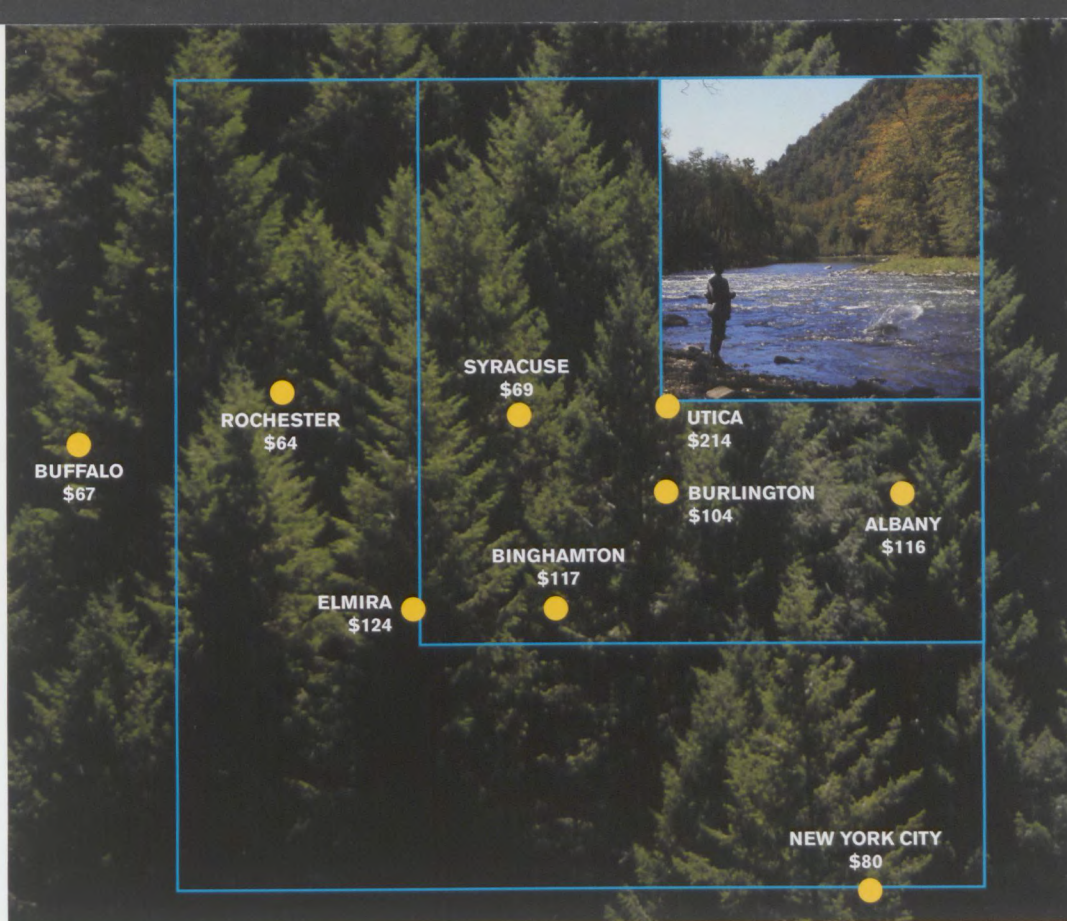
desire to please the survey administrator, but in any case without truly registering the economic trade-offs involved and hence without truly stating preferences. In particular, we wanted to prevent what has been termed a “warm glow,” by which households approve of the policy to satisfy their desire to be generous, rather than out of desire for a better park as such. To avoid this, we purposely reminded respondents of the costs involved, used line drawings rather than more evocative photographs, and otherwise sought to avoid emotional triggers.

Conversely, another potential challenge for measuring WTP is those respondents who vote “no” automatically and reject a program for reasons extraneous to its benefits and costs—for example, because they are reflexively opposed to raising taxes or distrust the government on principle. We were concerned about respondents of this type because the survey elicits WTP by proposing an increase in their New York State income taxes. We used questions about respondents’ feelings toward the government and taxes to eliminate or control for this “cold gloom” effect.

One novel feature of our study is that the survey was administered through several modes. A private research firm administered it from August 2003 through February 2004 to more than 1,800 New York residents. Some of these respondents belong to a panel of regular takers of marketing surveys obtained through techniques designed to obtain a representative sample of the population. Another group consisted of panel dropouts. Both of these groups took the survey on a computer via the web. A third group took it by mail. While there were some differences across the samples (for example, the mail sample had the oldest average age), in general they displayed fairly similar average income, political attitudes, and other characteristics. More importantly, their WTP for the improvement to the Adirondacks was not sensitive to being on the panel or how they took the survey.

So who tended to value the environmental improvements most highly? Households with the highest WTP included those with the highest incomes, those that expected their future income to increase over the next 10 years, and those with children. Measures of personal stake were also important, with households who frequently visit the park (23% of our sample) willing to pay 70% more than those who visit less frequently or not at all. Those living farther from the park were willing to pay less, with WTP falling by about \$.08 per kilometer from the household’s closest vehicle entrance to the park (see figure on page 23). Self-classified environmentalists were more likely to vote for the intervention, just as self-proclaimed conservatives and those who think taxes are too high were more likely to vote against.





**Median Willingness to Pay per Year to Protect Adirondack Park, by Region**

### From Survey to Policy

How can the results of this survey be used by policymakers? Clearly, these numbers have some political value, showing that benefits extend not only to those who live near the park, but also to residents of New York City and elsewhere who have never visited there.

Beyond their political value, these numbers can help guide air pollution policy. For instance, these numbers can be compared against established abatement cost benchmarks to help decide if further emissions reductions are worthwhile. EPA has estimated the costs of its Clean Air Interstate Rule to be \$4.3 billion in 2010, rising to \$6.3 billion by 2020. Given that we excluded populations outside of New York State and made very conservative estimates of benefits, it is clear that the ecosystem benefits are a sizable fraction of costs. Further, we excluded health benefits that would be directly realized from the improvement in air quality. EPA analyses of these benefits find that they are at least 10 times the costs, although uncertainties and controversy about these estimates abound.

### Next Steps

Damage to the Adirondacks has been the focus of decades-long debates regarding air pollution control. Further strategies to reduce emissions are being justified, in part, by how they will improve this unique resource. For the

first time, results have been produced that show the value people place on ecological improvements to the park.

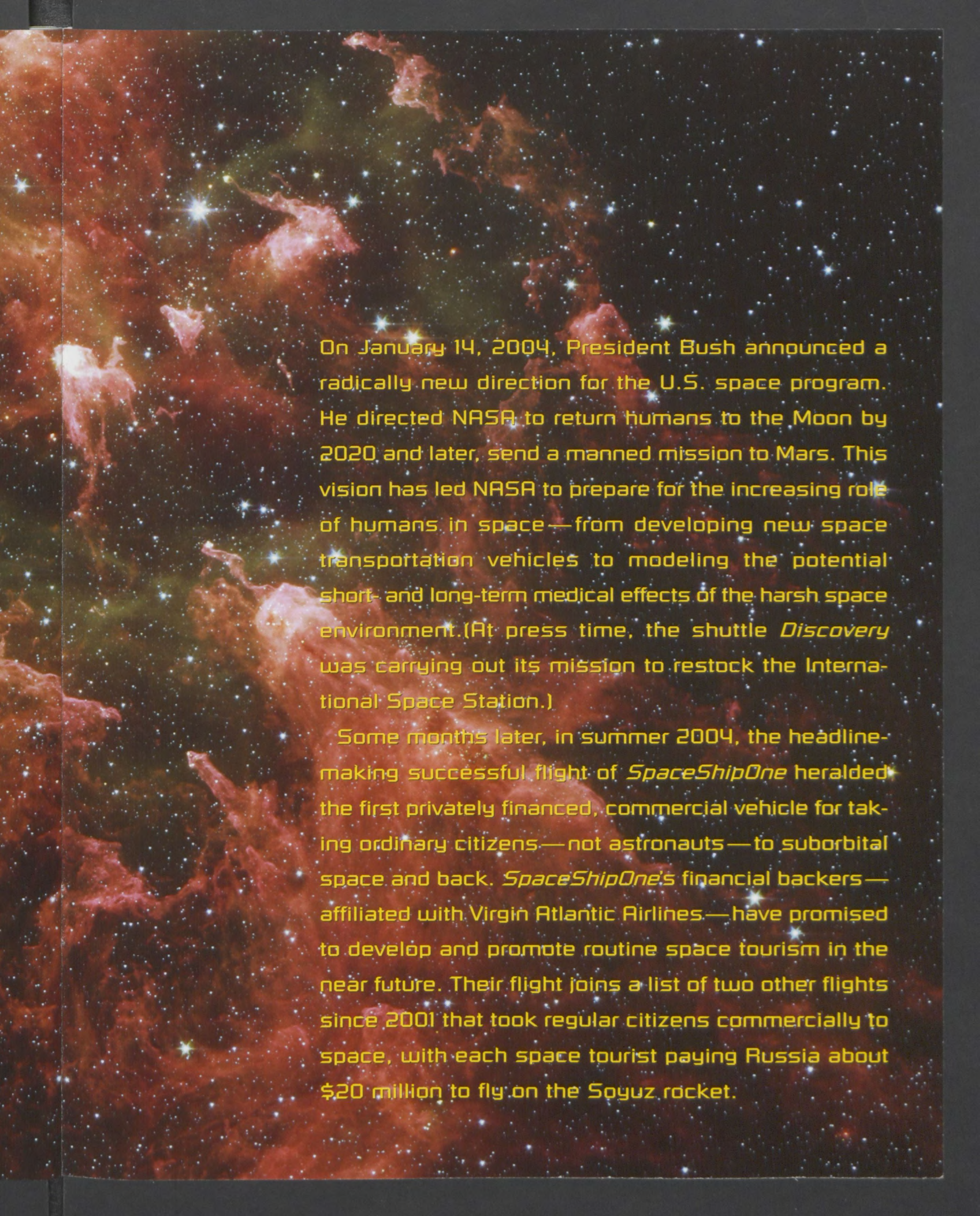
As we have discussed, we adopted a careful interpretation of the natural science and made cautious survey design and analytical decisions to measure the value of an ecological outcome that would be achieved at a minimum by forthcoming emissions reductions. The resulting estimates of WTP are, in turn, cautious and therefore very defensible. Our results, we believe, provide long-sought and valuable information about the benefits of air pollution policy.

RFF has won a new grant to extend this work by comparing different methods and applying them in different regions. The exercise will be repeated for the Adirondacks using a "conjoint" survey design, in which respondents are asked to consider different environmental scenarios in a way that enables the researchers to estimate the relative importance individuals place on different aspects of acidification damage. This approach enables us to develop estimates that are more readily transferable to other geographic areas. As part of the project extension, both the contingent valuation and conjoint surveys will be applied to similar problems in the Smoky Mountains of Tennessee and North Carolina. Crosschecking the comparability of benefits in the two regions using different methods can serve as a test of the ability to extrapolate them to still other regions, for purposes of national policymaking. ■



*TAKING  
RISKS  
ON THE  
SPACE  
FRONTIER*

MOLLY K. MACAULEY



On January 14, 2004, President Bush announced a radically new direction for the U.S. space program. He directed NASA to return humans to the Moon by 2020 and later, send a manned mission to Mars. This vision has led NASA to prepare for the increasing role of humans in space—from developing new space transportation vehicles to modeling the potential short- and long-term medical effects of the harsh space environment. (At press time, the shuttle *Discovery* was carrying out its mission to restock the International Space Station.)

Some months later, in summer 2004, the headline-making successful flight of *SpaceShipOne* heralded the first privately financed, commercial vehicle for taking ordinary citizens—not astronauts—to suborbital space and back. *SpaceShipOne's* financial backers—affiliated with Virgin Atlantic Airlines—have promised to develop and promote routine space tourism in the near future. Their flight joins a list of two other flights since 2001 that took regular citizens commercially to space, with each space tourist paying Russia about \$20 million to fly on the Soyuz rocket.

In order to build a foundation for future analyses, it is important to note that zero risk in space activity is unattainable and an obviously unreasonable policy objective.

Accompanying this significant infusion of public and private capital underwriting humans in space is a looming public policy problem: managing the risk. Risk is borne by the first parties—the actual space travelers themselves. Perhaps less obvious, risk is also borne by third parties, including persons on the ground beneath the flight path of a space vehicle and even the general public. Sound risk management calls for appropriate application, balancing, and coordination of regulation, legislation, and other forms of potential policy intervention. While government self-insures (that is, taxpayers underwrite the risk of NASA's space activities), the increasingly large private-sector role in space also calls for greater consideration of the advantages and disadvantages of relying on conventional practices such as tort liability and insurance as alternatives to government intervention in designing public policy.

In order to build a foundation for future analyses, it is important to note that zero risk in space activity is unattainable and an obviously unreasonable policy objective. The objective is not “no” risk but accepting risk; managing it through a combination of incentives, regulation, and legislation; and rationally deciding how much to accept based on the expected benefit.

## THE HUMAN FACTOR

The most notable examples of risks to humans involved in space activity are the fatal accidents that occurred with *Apollo 1* and with the shuttles *Challenger* and *Columbia*. The policy response to these events is illustrative of as-yet-unresolved problems in risk management.

After each incident, investigations by Congress, presidential commissions, and NASA itself led to engineering redesigns—in short, technological fixes. These reviews also recommended changes in how space activities are conducted, largely with respect to how safety concerns are communicated in large organizations like NASA. The history of these accidents repeatedly illustrates that spaceflight remains risky even after exhaustive, painstakingly detailed and careful investigation, extensive re-engineering, and changes in communication.

Another pattern evident with these accidents is the extraordinarily long amount of time that has elapsed between each accident and subsequent return to flight. This trend harbors important implications for the degree to which the risk of flight might be more readily accepted. These long “stand-downs” after an accident will make it difficult for NASA to meet the timeline set forth in President Bush's plan for sending humans to the moon by 2020.

In the case of *Apollo 1*, the three-man crew of the *Apollo* command module died in a fire on the launch pad during a preflight test at Cape Canaveral on January 27, 1967. Twenty months elapsed before the next manned *Apollo* mission (an unmanned mission was flown in November 1967). First NASA and then Congress conducted exhaustive investigations of the accident. The reviews concluded that the most likely accident cause was a spark from a short circuit.

Other factors materially contributed to the *Apollo 1* accident, including the absence of emergency equipment or personnel on the launch pad because the test was a simulation and not considered hazardous, the lack of emergency exits or procedures for the crew, and problems that prevailed in communicating safety concerns between NASA and its contractors.

The space shuttle *Challenger* accident on January 22, 1986, was attributable to flawed engineering design, poor management and accountability, and a host of oversights. The presidential commission investigating *Challenger* cited the cause of the disaster as a failure of an “O-ring” seal in one of the shuttle's solid-fuel rockets.

The commission found fault not only with the failed sealant ring but also with the NASA officials who allowed the shuttle launch to take place despite concerns voiced by engineers.

The entire space shuttle program was grounded during the investigation and did not resume flying for 32 months—returning only after shuttle designers made several technical modifications and NASA management implemented stricter regulations regarding quality control and safety.

The *Columbia* Accident Investigation Board (CAIB), established to investigate the February 1, 2003, accident cited physical failures in the spacecraft design and underlying weaknesses in NASA's organization as the principal contributors to the incident. The physical cause was a breach in the thermal protection system on the wings. The organizational causes ranged from schedule pressures to characterization and management of the shuttle as operational rather than developmental. The CAIB said there was inadequate testing to fully understand the shuttle's performance, organizational barriers that prevented effective communication about safety and stifled differences of opinion, and informal, poorly documented decisionmaking within the regular chain of command. The shuttle system resumed flying in July 2005—about 18 months after the accident.

In addition to its detailed review of the *Columbia* event, the CAIB offered a broader conclusion: “[O]peration of the Space Shuttle, and all human spaceflight, is a developmental activity with high inherent risks.” These words are worth bearing in mind, as future spacecraft that are developed to ferry humans to the moon and Mars will be radically new types of vehicles that must meet even more challenging flight conditions than did *Apollo* or the shuttles. The new spacecraft will need to be able to withstand extreme hot and cold, radiation, and long-duration requirements that will be encountered on future missions. With each successive mission, vehicles are expected to evolve, with each stage incorporating increasingly more demanding physical capabilities. The program timing is likely to make each vehicle and each flight a unique experiment with new, unknown risks.

## LEAVING IT UP TO ROBOTS

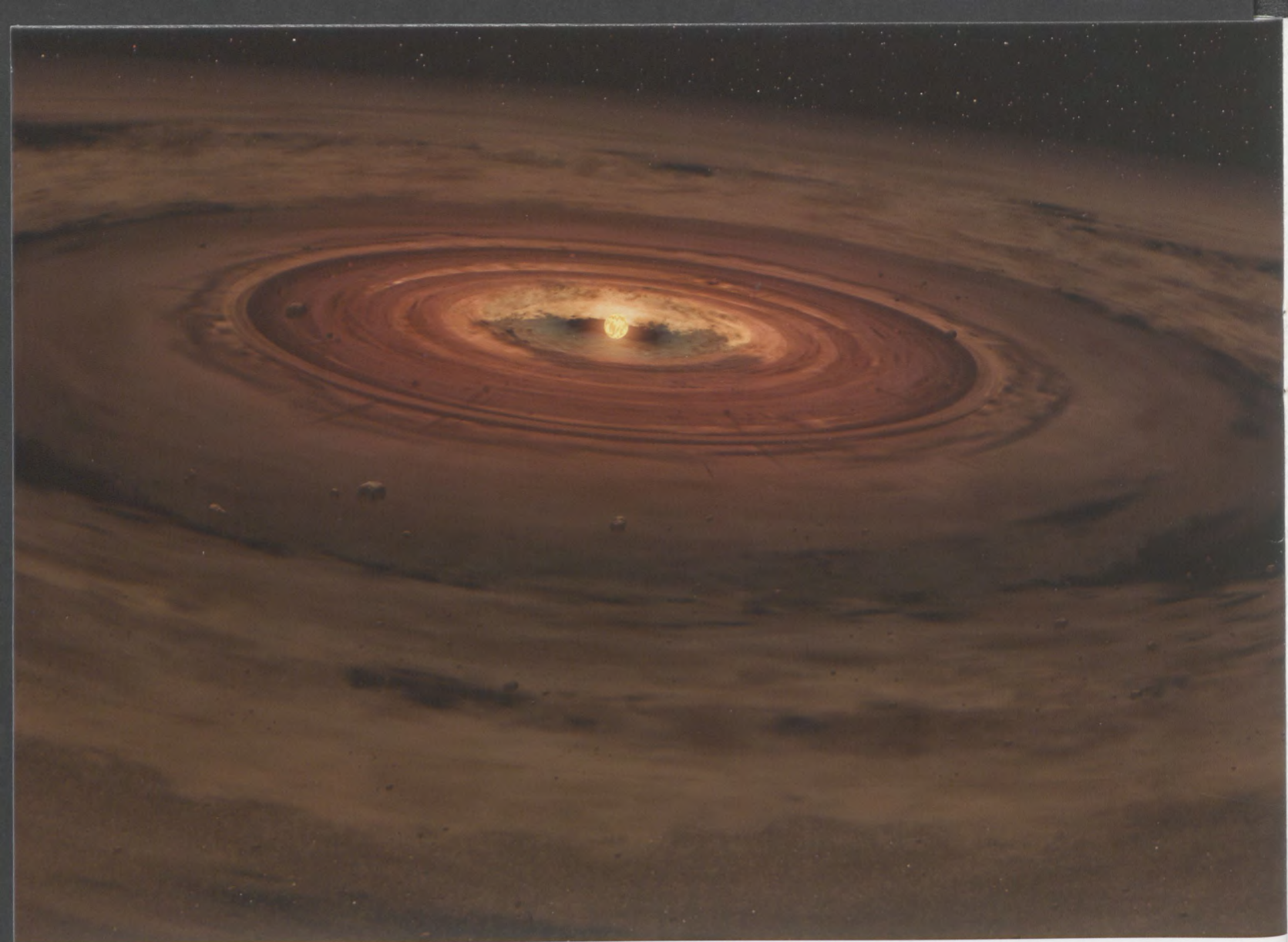
Advances in computing and robotic technology since the *Apollo* and shuttle programs make unmanned exploration a potentially very close substitute for human exploration. High-resolution, high-speed, and high-quality animation and graphics of computerized virtual reality can readily be combined with the truly fantastic data sent back by unmanned probes.

For those who want to see and even touch Mars, interplanetary robots can do this, too, by gathering samples and returning them to earth. Years ago, unmanned spacecraft brought back moon rocks. In 2004, a low-cost NASA spacecraft, *Stardust*, collected samples of comet and interplanetary dust and will return them to earth via parachute in 2006. Advances in unmanned data collection from space and other innovations in information technology are improving so rapidly that robotic success could even undo human exploration and enable sophisticated, “stay-at-home” explorers. Robots in the near future are likely to be capable of making split-second decisions and displaying the spirit of inquiry that human explorers bring. As the NASA probe *Spirit* began its journey on Mars, British scientists reported the first robot capable of theorizing, reasoning, and actively learning.



**Above:** An artist's concept of a possible newfound planet spinning through a clearing, detected around the star CoKu Tau 4 by the Spitzer Space Telescope, in a nearby star's dusty, planet-forming disc. The possible planet is theorized to be at least as massive as Jupiter, and may have a similar appearance to what the giant planets in our own solar system looked like billions of years ago. (NASA/JPL-Caltech/R. Hurt; ssc-Caltech)

**Opening spread:** Picture taken by NASA's Spitzer Space Telescope, reveals a mix of embryonic stars in the Eta Carinae neighborhood of the Milky Way galaxy. (NASA/JPL-Caltech/N. Smith; Univ. of Colorado at Boulder)



This artist's concept shows a brown dwarf surrounded by a swirling disk of planet-building dust. NASA's Spitzer Space Telescope spotted such a disk around a surprisingly low-mass brown dwarf, or "failed star." Astronomers believe that this unusual system will eventually spawn planets. If so, they speculate the disk has enough mass to make one small gas giant and a few Earth-sized rocky planets. (NASA/JPL)

Balancing manned and robotic exploration based in part on a comparison of human risk is only part of a much larger and much-needed discussion about future space activities. While spaceflight accidents may never be taken in the stride of auto or aviation accidents, the pursuit of human spaceflight requires greater acceptance of the outcome that lives will be lost. According to NASA data, the number of fully qualified candidates for the astronaut corps has stayed the same or even increased after shuttle accidents, clear proof that applicants are comfortable with their perceived level of the risks that come with manned space flight (see table on page 29). For policymakers, this finding can serve as a useful benchmark in many policy decisions: when evaluating the trade-off between using robots or involving humans, in conducting accident reviews to ascertain "how safe is safe enough," and in technological fixes for safer spacecraft.

## FLY AT SOME RISK

After the success of the privately built and financed spacecraft, *SpaceShipOne*, British businessman Richard Branson, who founded Virgin Atlantic Airlines, quickly entered into a licensing agreement with the owners to build five spacecraft for passengers. Branson's business plan within the next three years is to fly 50 passengers a month, charging \$200,000 each, for a two-hour flight. Shortly after the agreement, a hotel magnate offered another prize, for \$50 million, for the first private manned mission to orbit the earth.

In the wake of *SpaceShipOne's* success, the U.S. Congress entered into debate about how to regulate commercial human spaceflight, arguing at length about how to handle crew and passenger safety and the appropriate scope of authority to be vested with the government. Some legislators supported allowing privately owned and operated spacecraft to carry paying passengers on a "fly at your own risk" basis. This perspective would make private spaceflight relatively free from regulation, much like the early aviation barnstorming era. As one expert opined, passengers should be able to board their vehicles with the same freedom as the stunt pilots who pioneered commercial aviation.

Several draft bills before Congress proposed regulating the training and setting standards for the medical condition of crews, the extent to which passengers would have to be informed of the risks of their participation, and whether passengers would be required to supply written, informed consent to safety-related risk associated with the flight. Another topic of debate during the hearings was the use of mutual waivers of liability with licensees and the federal government as well as the extent of the government's role. Industry wanted loose oversight, claiming that federal authority should be limited to safeguarding the uninvolved public (such as populations living under the flight path of the spacecraft).

While the final version of the legislation for regulating space tourism has a preamble statement recognizing that space transportation is inherently risky, the specific provisions only loosely regulate passenger safety. The Commercial Space Launch Amendments Act of 2004 allows private spacecraft to be licensed on an experimental basis and establishes liability guidelines. The bill provides a legal basis for allowing private and commercial passengers to undertake space travel and establishes the concept of informed risk for space passengers. For the next eight years, the government can also restrict or prohibit design features or operating practices that have resulted in or could have contributed to a serious or fatal injury to crew or passengers during a licensed flight. This sunset provision is intended to allow safety standards to evolve in the industry and to permit revision of the standards.

## PLANETARY PROTECTION

Yet another category of risk—potentially including risk to the population as a whole—looms ahead as humans play an ever-increasing role in space and particularly as we begin to bring samples back from robotic exploration of Mars in preparation for sending humans there. "Planetary protection" refers to two situations: protecting Earth from microorganisms that may be brought back in samples of soil, rocks, and other materials collected from other solar system bodies during scientific space exploration; and protecting the solar system—planets, moons, asteroids, and comets—from Earth life introduced when spacecraft land on or impact with these bodies. Contaminating other bodies is known as "forward contamination," and contaminating Earth is known as "backward contamination." Samples themselves can also become contaminated and must be collected and handled in a manner to protect them from terrestrial organisms in order to preserve their integrity.

Planetary protection has long been a concern in space exploration. For example, to prevent backward contamination, the lunar samples collected by the *Apollo* astronauts as well as the astronauts themselves were quarantined upon return to earth. To prevent forward contamination, before launching the U.S. *Viking* missions to Mars in the 1970s, NASA cleaned the Mars landers to reduce bacterial spores on them, packaged the landers in a protective shield, and baked the packaged spacecraft to sterilize them. The rationale at that time was to avoid contamination in introducing life from earth into the Martian environment and thereby confounding analysis of the soils on the surface of Mars in looking for evidence of life.

## Total Applications to Join Astronaut Corps and Number Selected

04/1959	508	7
09/1962	250	9
10/1963	720	14
06/1965	909	6
04/1966	510	19
08/1967	900	11
08/1969	*	7
07/1978	8079	35
07/1980	3465	19
07/1984	4934	17
08/1985	166	13
08/1987	2061	15
07/1990	2424	23
08/1992	2236	19
03/1995	2962	19
08/1996	2451	35
08/1998	2621	25
08/2000	3015	17
05/2004	2882	11

\*Application data missing for 1969

Source: Aaron Manka et al. 2003. Improving Management of Astronaut Corps. June 27 Memo to Associate Administrator for Space Flight. G-01-035. (Data for 1959–2003.) ([www.hq.nasa.gov/office/oig/hq/old/inspections\\_assessments/index.html](http://www.hq.nasa.gov/office/oig/hq/old/inspections_assessments/index.html), accessed July 2005); The Baltimore Sun. 2004. May 7, p. 1b. (data for 2004).

Human risks associated with planetary contamination are wide ranging. They include risks to the general public when samples are returned to earth from space, risks to astronauts who may collect samples during space missions, risks to scientists and others who handle samples for analysis, and risks to life that may exist on other planets. NASA is now considering protocols for sample return and the appropriate design of laboratories where samples from Mars missions would be taken. The Space Studies Board of the National Research Council has recommended that laboratories housing Mars samples should match the strictest security requirement established by the U.S. government for facilities dealing with biological agents and infectious diseases. In another study, *Safe on Mars: Precursor Measurements Necessary to Support Human Operations on the Martian Surface*, the board points out the many environmental, chemical, and biological hazards involved in a human mission to Mars and some steps to take to mitigate these concerns. For example, dust on Mars could contain large amounts of sulfur, chlorine, and hexavalent chromium.



Discovery's cargo bay over Earth's horizon was photographed by one of the seven crew members as the shuttle approached the International Space Station on July 28, 2005. (NASA)

## LOOKING AHEAD

International treaties and agreements, government safety regulation of space tourism and space transportation, and government indemnification of commercial space transportation currently exist for addressing some of the human risks in space activities. That said, however, many unresolved issues remain.

If the lengthy stand-downs in spaceflight following the loss of life are to be the rule rather than the exception, human missions to the moon and Mars are light-years away. Because space activity will always be risky, unduly long delays are likely to be meaningless. In the early days of aviation, fatal accidents occurred almost routinely, but aviators flew again immediately. Provided those who fly—astronauts or passengers—give informed consent, and provided the financial consequences to the government or the private sector are acceptable, a return to the barnstormer approach to risk may make sense.

Finally, robotic missions and the ability to return samples to earth—although not riskless—are increasingly viable alternatives to humans in space. Unless or until policymakers change their attitudes toward space-related risk, real change and the appropriate balance of humans and robots in space is not likely to come in the near future. ■

*This article is drawn in part from "Flying in the Face of Uncertainty: Human Risk in Space Activities," in the summer 2005 issue of the Chicago Journal of International Law.*

### Further Readings

- Columbia Accident Investigation Board Report, executive summary at <http://caib.nasa.gov> (all sites accessed July 2005)
- Return to Flight report, executive summary at <http://returntoflight.org>
- Safe on Mars: Precursor Measurements Necessary to Support Human Operations on the Martian Surface. National Academy of Sciences Press, 2002, summary at [www.nap.edu/catalog/10360.html?onpi\\_newsdoc050102](http://www.nap.edu/catalog/10360.html?onpi_newsdoc050102).



## Inside RFF

### Espinosa, Economist and AmEx VP, Joins RFF Board

**J**. Andres Espinosa, vice president and international head of consumer lending for American Express, was elected to the RFF Board of Directors in April. Espinosa has a background in environmental economics, international trade, and statistics, but the initial focus of his education was dairy science.

A native of Ecuador, Espinosa studied tropical agriculture and earned a degree as an agronomist from the Pan-American School of Agriculture in Honduras before coming to the United States. He majored in animal science and industry at Kansas State

University, where he also earned his master's degree in agricultural economics. A deepening interest in how markets work led him to the Ph.D. economics program at North Carolina State University.

Espinosa's dissertation research, on a general equilibrium model of air pollution in the European Community, was supported by an RFF Joseph L. Fisher dissertation fellowship, awarded in 1993. Named in honor of the president of RFF from 1959 to 1974, this fellowship supports doctoral dissertation research on issues related to the environment, natural resources, or energy.

His Ph.D. thesis "transformed environmental economists' understanding of the subtle interactions between international trade policies and environmental amenities," says V. Kerry Smith, University Distinguished Professor, agricultural and resource economics, and director of the Center for Environmental and Resource Economics Policy at NC State and an RFF University Fellow.

Espinosa's skills in innovative analysis made him valuable to American Express, where he began his career as an econometrician in risk management. Several steps later, he was promoted to vice president in International Risk and Information Management for Latin America and Canada, then vice president and regional marketing head in the International Consumer and Small Business Services Group; he was named to his current position in that division in January.

"The same concepts used to describe how people make choices outside the market," observes Smith, "can be used to understand their prospects for making disciplined financial decisions."

Having been a beneficiary of RFF, Espinosa says, "I feel a strong connection to the organization and want to give something back. And being a board member will help me stay informed about RFF's important research on important issues." ■



RFF sponsors a summer internship program that brings students from across the country to work with the research staff on ongoing projects or to assist them in developing new areas of research and analysis. RFF also offers an internship in the name of Dr. Walter O. Spofford, Jr., who helped establish RFF's China program. Pictured here are some of this year's interns:

Bottom row, from left: Francisco Aguilar, Bidisha Lahiri, Honglin Li, and Hui He (Spofford).

Middle row, from left: Brock Howell, Jennifer Hanson, Eleanor McCormick, RFF Acting President Ted Hand, and Yi Jiang.

Top row, from left: Mike Springborn, Momodou Fanneh, Madeleine Baker, and Erik Johnson.

Not pictured: Jonathan Basile, Indivar Dutta-Gupta, Elizabeth Leavy, Cameron Speir, and Sarah Wise.

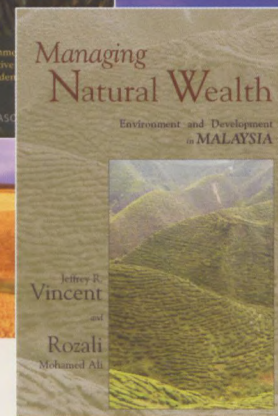
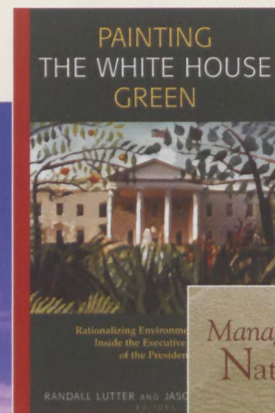
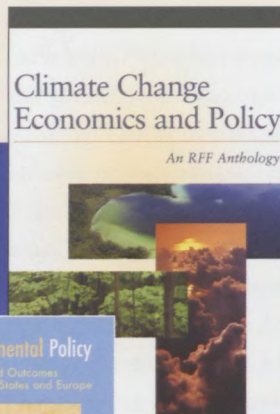
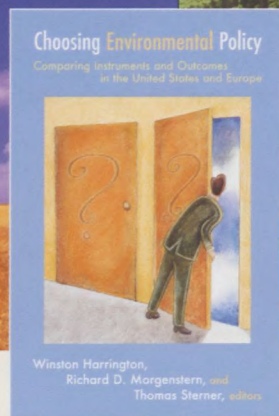
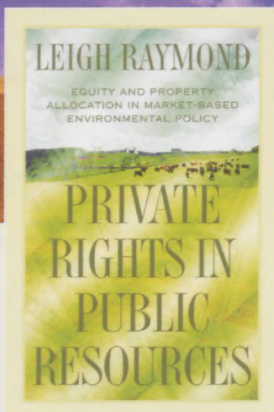
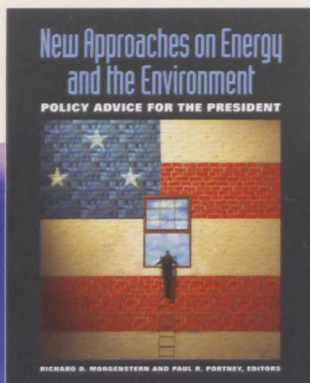
## Resource Links

Interested in learning more about the feature stories in this issue? The following links will take you to special pages on the RFF website, where you will find additional resources:

- [www.rff.org/shallwegatherroundthecampfire](http://www.rff.org/shallwegatherroundthecampfire)
- [www.rff.org/ecosystems-services-and-governments-accountability](http://www.rff.org/ecosystems-services-and-governments-accountability)
- [www.rff.org/forever-wild-but-dowecare](http://www.rff.org/forever-wild-but-dowecare)
- [www.rff.org/taking-risks-on-the-space-frontier](http://www.rff.org/taking-risks-on-the-space-frontier)

Also, RFF events are videotaped—you can turn to [www.rff.org/rff/Events/index.cfm](http://www.rff.org/rff/Events/index.cfm) for more information.

# RFF Press changing the policy climate



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*Richard D. Morgenstern and Paul R. Portney, editors*

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Paper, ISBN 1-933115-01-7 / \$16.95

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*Michael A. Toman, editor*

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## **Private Rights in Public Resources Equity and Property Allocation in Market-Based Environmental Policy**

*Leigh Raymond*

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Paper, ISBN 1-891853-62-7 / \$46.95

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## **Painting the White House Green Rationalizing Environmental Policy Inside the Executive Office of the President**

*Randall Lutter and Jason F. Shogren, editors*

Cloth, ISBN 1-891853-73-2 / \$55.00  
Paper, ISBN 1-891853-72-4 / \$25.95

## **Common Waters, Diverging Streams Linking Institutions and Water Management in Arizona, California, and Colorado**

*William Blomquist, Edella Schlager, and Tanya Heikkila*

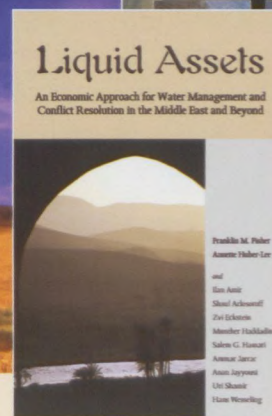
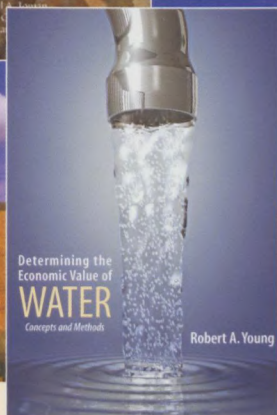
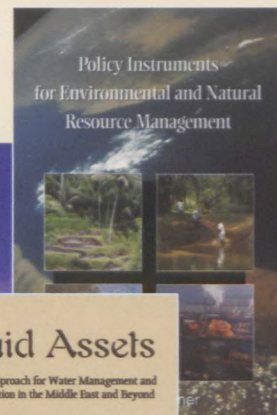
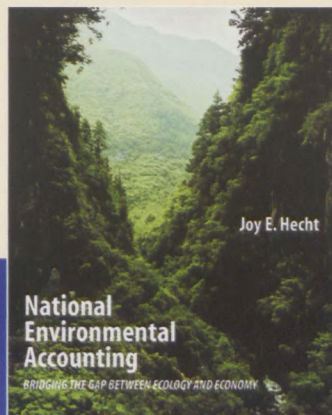
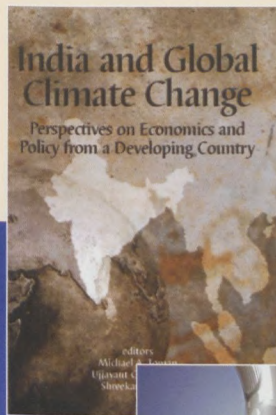
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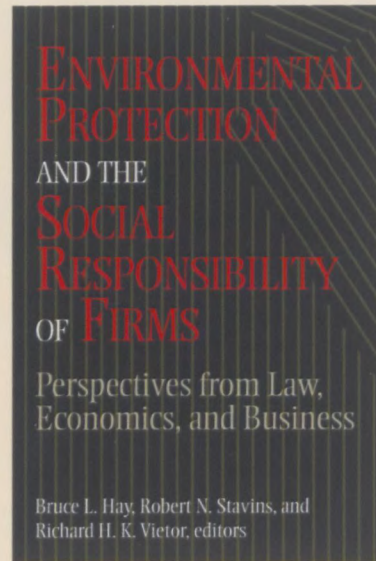
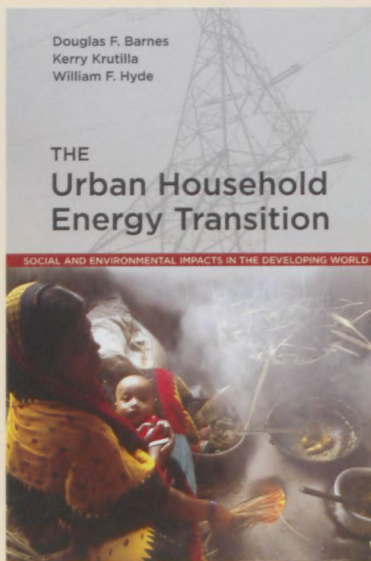
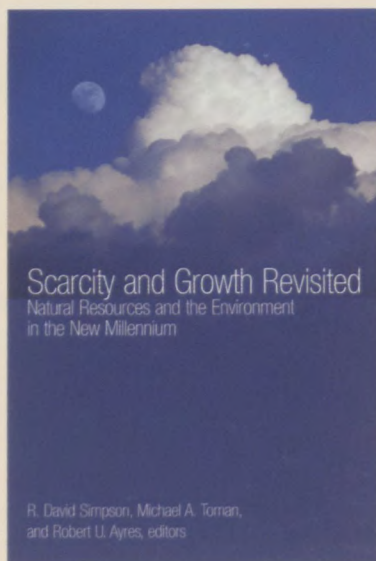
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