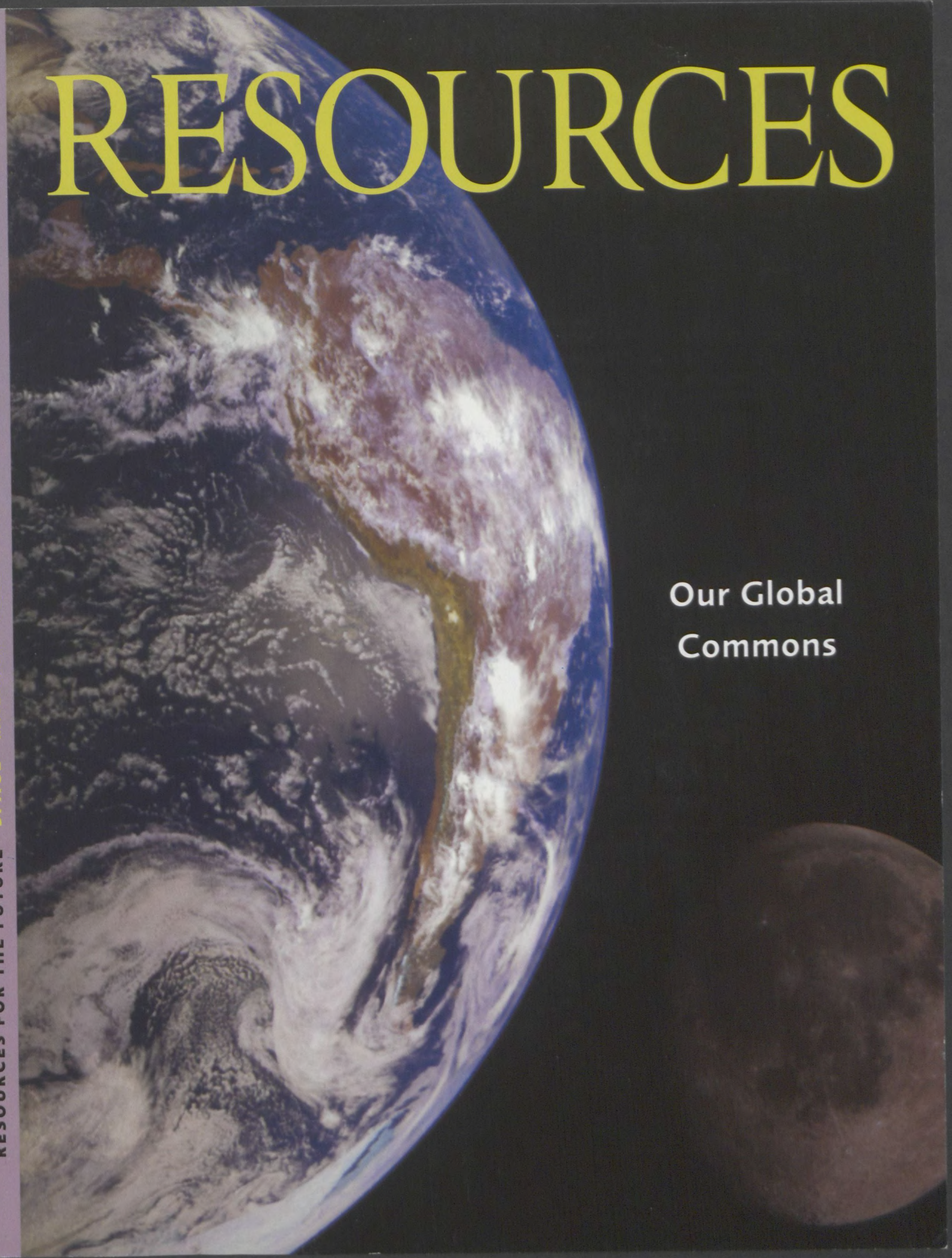
RESOURCES



Our Global Commons

RESOURCES FOR THE FUTURE · SPACE · MALARIA · ECOSYSTEM SERVICES · SPRING 2008 · NUMBER 168

Positive Feedback

PHILIP R. SHARP
PRESIDENT

Here at RFF we invest in new ideas but don't count on immediate, high rates of return. Tracking the growth of an idea can be challenging, as it progresses and evolves through academic channels and on to conversations with policymakers. But we are patient people: building a portfolio of truly workable policy ideas takes time.

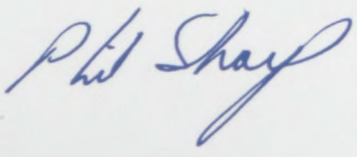
Year after year, we hold seminars and host workshops to bring together scholars, government officials, the press, and the public. RFF researchers disseminate their findings by publishing in journals; attending conferences, often overseas; and writing comprehensive reports that lay out their conclusions in the clearest terms possible.

But lately, more people are recognizing the value of what we do here at RFF. Over the past 12 months, several RFF researchers have received very substantial grants that will allow them to expand their efforts—gathering data, engaging in vital research, and doing greater outreach.

Much of this new support is geared toward addressing various aspects of how to mitigate, and adapt to, climate change. However, RFF researchers have been studying these problems for over 30 years and we view these generous contributions from the Doris Duke Charitable Foundation, the Simons Foundation, and other foundations, government agencies, and corporate donors as a further endorsement of how we work to solve perhaps the most critical environmental problem of our time. The recipients include Senior Fellows Ray Kopp, Alan Krupnick, Molly Macauley, Richard Morgenstern, Billy Pizer, and Fellow Joe Aldy.

But not all of us work on climate change. NASA has awarded a large grant to Senior Fellow Molly Macauley, the author of this issue's cover story, who will conduct three studies on environmental policy directions and earth science valuation techniques. The Robert Wood Johnson Foundation has given Senior Fellow Ramanan Laxminarayan and his colleagues major funding for continuing research on antibiotic resistance. And the Bill and Melinda Gates Foundation has provided support to Laxminarayan for research and an international conference on the scientific merits of a multiple drug regimen to fight malaria.

Recognition can come in many forms, including through the quality of people who serve on our Board of Directors. We are delighted to announce two new additions to our board. Joseph Stiglitz, winner of the 2005 Nobel Prize in Economics, has rejoined the board, an indication of the value placed on RFF from the very top of the economics profession. In addition, Mark Tercek, managing director at Goldman Sachs and head of the Goldman Sachs Center for Environmental Markets, was elected to the board at our April meeting. Mark's innovative work promoting environmental goals through market forces makes him a wonderful fit for RFF, and for his new role as president of the Nature Conservancy, a post he will assume this summer.



RESOURCES

SPRING 2008 · ISSUE NUMBER 168

RESOURCES FOR THE FUTURE
1616 P Street, NW
Washington, DC 20036–1400
202-328-5000
www.rff.org

Resources is available to individuals and institutions at no cost. To subscribe, contact Scott Hase at RFF (hase@rff.org) or 202-328-5006. The publication is also available on the RFF website ▸ www.rff.org.

RESOURCES
Peter Nelson, Director of Communications
Felicia Day, Managing Editor
Adrienne Foerster, Assistant Editor
Marc Alain Meadows, Art Director

Published quarterly since 1959, *Resources* (ISSN 0048-7376) contains news of research and policy analysis regarding environmental, energy, and natural resources issues. The views offered are those of the contributors and should not be attributed to Resources for the Future, its directors, or its officers.

Cover photo courtesy of NASA/JPL-Caltech/USGS. Separate images of the Earth and Moon were combined to generate this view.

Design and production: Meadows Design Office, Inc.

♻ Printed with soy-based inks on 50% recycled (and recyclable) paper containing 15% post-consumer fiber, processed chlorine free, in an FSC-certified plant.

CONTENTS

DEPARTMENTS

Goings On

Inside RFF

FEATURES

CONTRIBUTORS

DALLAS BURTRAW

HILLARD HUNTINGTON

RICHARD MORGENSTERN

JUHA V. SIIKAMÄKI

RFF Senior Fellow Dallas Burtraw is one of the nation's foremost experts on electricity and the environment. His research interests include the design, costs, and benefits of environmental regulation, and the regulation and restructuring of the electricity industry.

Hellen Gelband is an epidemiologist with nearly 30 years experience in domestic and global health policy. At RFF, she works on the Extending the Cure project and innovative strategies for using malaria drugs.

Hillard Huntington is the executive director of Stanford University's Energy Modeling Forum. He conducts studies to improve the usefulness of models for understanding energy and environmental problems. His current research includes modeling electricity competition, energy price shocks, and energy market impacts of environmental policies.

An expert on space economics and policy, RFF Senior Fellow Molly K. Macauley's research interests include the economics of new technologies, recycling and solid waste management, urban transportation policy, and the use of economic incentives in environmental regulation.

Richard Morgenstern, a senior fellow at RFF, is an expert on the economics of environmental issues and on the use of economic incentives to address global climate change. His career includes service at EPA, where he directed the agency's policy office for more than a decade, and at the U.S. Department of State, where he participated in the Kyoto Protocol negotiations.

Juha V. Siikamäki, an RFF Fellow, focuses his research on valuing the environment and evaluating the benefits, costs, and cost-effectiveness of different environmental policy options. He is especially interested in understanding the preferences of consumers, households, and landowners for different policy programs.

RESOURCE LINKS

Selecting an RFF scholar's name above will open a new window in your web browser, displaying their detailed profile and credentials from the RFF website. To learn more about the feature stories in this issue, please enter these links listed below in your web browser or, if reading from our PDF edition, simply select an active link and a new window will open.

▸ This triangular symbol seen throughout *Resources* indicates an active link.

Space as the Canonical "Global Commons" ▸ www.rff.org/ourglobalcommons

Biodiversity ▸ www.rff.org/biodiversity

Malaria ▸ www.rff.org/newmalariaattention

Auctions and Revenue Recycling under Carbon Cap-and-Trade

In January, Senior Fellow Dallas Burtraw testified before the U.S. House of Representatives Select Committee on Energy Independence and Global Warming. This article is drawn from his full testimony.

There are not many viewpoints you can get public finance economists to agree on, but one exception is the role of an auction in the implementation of an emissions cap-and-trade program. Compared to free allocation, auctions are, by far, the most efficient way to allocate emissions allowances.

The primary reason is that auctions satisfy the goals of simplicity and transparency, which are important for the formation of a new market for an environmental commodity. Also, they are administratively simple and preclude regulated parties from seeking a more generous future allocation.

Auctions also have efficiency benefits that apply specifically to the electricity sector, which holds the greatest potential for the largest emissions reductions in the first decades of climate policy. Specifically, auctions can reduce the difference between price and marginal cost for electricity generation, a source of inefficiency that is endemic to the electricity industry.

The second and equally forceful reason that economists favor auctions is that they generate funds that can be used to achieve related goals. Depending on how these revenues are used, they can help reduce the social cost of policy significantly. For the purposes of minimizing the cost of climate policy on the economy and promoting economic growth, economists would favor dedicating auction revenues to reduce preexisting taxes.

Like any new regulation, climate policy imposes costs on households and firms, and that cost acts like a virtual tax, reducing the real wages of workers. This hidden cost can be especially large under a cap-and-trade program because the price placed on the scarcity value of carbon is reflected in the cost of goods that use carbon in their production.

However, one of the most important findings in environmental economics and public finance in the past 15 years is that the use of revenue raised through an auction (or an emissions tax), if dedicated to reducing other pre-existing taxes, can reduce this cost substantially. This so-called revenue recycling would have truly dramatic efficiency advantages compared with free distribution. In a study for the State of Maryland, my colleagues and I found that the dedication of 25 percent of the allowance value to investments in end-use efficiency could offset any increase in retail electricity prices that would occur from the state's joining the Regional Greenhouse Gas Initiative, a cooperative effort by Northeastern and Mid-Atlantic states to reduce carbon dioxide emissions. Investing just a portion of the allowance revenues can offset the impact of the policy on consumers, while also advancing climate policy goals, according to our findings.

Auctions satisfy the goals of simplicity and transparency, which are important for the formation of a new market for an environmental commodity. They are administratively simple and preclude regulated parties from seeking a more generous future allocation.

Auction revenue can also help support the attainment of efficiency in our energy infrastructure more broadly. A small sliver of auction revenues could provide a substantial infusion of support for research and development of new technologies or incentives for investment, such as an investment tax credit aimed at promoting innovative technologies or modernizing industries that are especially vulnerable to the policy.

Finally, a related issue involves adaptation to climate change. Atmospheric scientists tell us that we are already at the point where some climate warming is inevitable and that adaptation will be necessary. Adaptation to climate change will likely involve significant investment by the private and public sectors. An auction provides revenues that can be directed toward these activities. ■

▸ Dallas Burtraw's full testimony can be found at: www.rff.org/rff/Documents/CT-Burtraw-Testimony-08-01-23.pdf.

Climate Change: Addressing Competitiveness Concerns

In March, Senior Fellow Richard Morgenstern testified before the U.S. House of Representatives Committee on Energy and Commerce. This article is based on his full testimony.

Due to the diversity of greenhouse gas (GHG) sources, efforts to address climate change will, of necessity, impact nations, industries, and individuals. In general, pursuing a cost-effective approach that minimizes the overall cost to society of achieving a particular emissions-reduction target will minimize the burden imposed on businesses and consumers.

The first step to addressing concerns about competitiveness should be paying close attention to considerations of cost and efficiency. Broad, market-based strategies—such as an emissions tax or a cap-and-trade program that effectively attach a price to GHG emissions—offer significant advantages. In order to limit hardships on selected industries, however, additional mechanisms to increase flexibility will be required. These could include recognizing offset credits from sectors or gases not included under the cap and from projects undertaken in other countries.

But even with a cost-effective strategy for reducing U.S. GHG emissions, some domestic producers will incur increased production costs and face increased challenges to their ability to remain globally competitive, particularly in trade-sensitive, energy-intensive sectors.

The question will likely be asked: why should U.S. firms be disadvantaged relative to overseas competitors to address a *global* problem? The difficulty, moreover, is not just political: if, in response to a mandatory policy, U.S. production simply shifts abroad to unregulated foreign firms, the resulting emissions "leakage" could wipe out some of the environmental benefits sought by taking domestic action.

As policymakers consider options to lessen these competitiveness impacts, an important caution is in order. As compelling as the argument for protecting vulnerable firms or industries might be, few provisions or program modifications designed to accomplish this can be implemented without some cost to the environment, as well as to the overall economy. Nor are trade-related actions costless: they might raise legality concerns under World Trade Organization rules or risk provoking countervailing actions by other nations.

Efforts to address competitiveness concerns in the context of a mandatory domestic climate policy typically involve one or more of the following options: weaker overall program targets; partial or full exemptions from the carbon policy; standards instead of market-based policies for some sectors; free allowance allocation under a cap-and-trade system; and trade-related policies, such as a border adjustment for energy- or carbon-intensive goods.

These options can also be mixed and matched to some extent. One option would be to start out with a generous allowance allocation for the most severely affected industries, which could then be phased out at a future time, either a certain date or once trade-related measures were in place or other key nations adopted comparable climate mitigation policies. In general, the more targeted policies will be difficult to police and many industries will have strong incentives to seek special protection by taking advantage of these various mechanisms without necessarily being at significant competitive risk. ■

▸ Richard Morgenstern's full testimony can be found at: www.rff.org/rff/Documents/CT-Morgenstern-08-03-05.pdf.

RFF POLICY COMMENTARY

The Oil Security Problem

Hillard Huntington

Today, three of every five barrels sold on the world petroleum market originate from insecure regions: the Persian Gulf, North Africa, Nigeria, Angola, Venezuela, Russia, and the Caspian states. Political, military, or terrorist events could disrupt oil markets and quickly double oil prices. If these events happen at a time when monetary authorities find it difficult to control inflationary expectations, a trend much more likely today than just a few months ago, the world could return to the 1970s and stagflation.

Reducing our vulnerability to such events is the main task for oil security policy. Curtailing imports from sources like our major oil trading partners (Canada and Mexico) is unlikely to benefit us. But reducing our imports is important only if we can reduce the market share of vulnerable supplies. Doing so would mean that disruptions will remove less oil from the market and thus cause severe price shocks.

Our vulnerability also depends upon how closely our infrastructure is tied to petroleum use. When disruptions cause oil prices to double, that price applies to any oil used in the U.S. economy, including domestic oil and ethanol supplies. Therefore, efforts to reduce oil demand may be more valuable than efforts to simply replace vulnerable imported supplies.

Pursuing energy security is relatively simple in conceptual terms. The nation is buying an insurance policy against future recessions caused by unanticipated oil price shocks. Today's insurance policy should cost no more than the value of avoiding these possible damages. Higher avoided damages could be due to either a greater probability of a disruption happening

or to more serious economic impacts from such a disruption.

Stanford University's Energy Modeling Forum recently completed two studies that may help resolve some of the uncertainties related to damage estimates associated with oil insecurity.

In the first, a group of geopolitical and oil-market experts assembled to provide expert judgment on the risks of one or more disruptions occuring over the next 10 years. The experts considered four separate, oil-producing regions and identified specific disruption events and the conditions that could make them more or less likely. From there, they evaluated the probability that certain events could happen and the amount of oil removed from the market in each case.

In their view, another disruption is very likely, given today's conditions. Over the next 10 years, there is an 80 percent chance of at least one disruption of 2 million barrels per day (MMBD) or more that would last one month or longer.

Compared to previous periods, the risks today are greater for disruptions below 7 MMBD. Not only are there more insecure regions today, but fewer opportunities exist to offset any disruption with excess oil production capacity elsewhere. These offsets tend to be highly concentrated in Saudi Arabia and are unlikely to be available if oil is disrupted in that country.

In the second study, macroeconomic experts gathered to discuss the likely economic impacts of oil price shocks. An important distinction concerns the nature of an oil price increase. During the 1970s and early 1990s, oil supply disruptions caused prices to rise suddenly and sharply. These price shocks were fundamentally different from recent price increases, which have been rising more gradually than during the 1970s. Price shocks are likely to create great uncertainty, forcing firms and households to delay investments, producing spillover effects throughout the economy. Gradual price elevation, on the other hand, may anger the driver who fills his gasoline tank, but it is unlikely to delay investment and lead to a recession.

The other unknown is how economic policymakers will respond to disruptions. Over the last few years, inflationary fears around the world have been very low, which has allowed monetary authorities to ease the money supply to offset lost economic output without creating additional inflationary pressures. In recent months, however, inflationary fears have grown and may become more intense yet. These developments would make it much more difficult for governments to intervene and offset lost output without exacerbating future inflation.

If inflationary fears tie Mr. Bernanke's hands, does the nation have a fallback position? Yes, although it seems unlikely that the political process will adopt these policies. First, larger public oil stockpiles would have limited value without a more explicit "trigger" mechanism for releasing oil during emergencies. Second, domestic ethanol or Alaskan oil supplies could replace more vulnerable supplies, but would do nothing for our infrastructure's oil dependence. Third, fuel efficiency may be more valuable because it does both, reducing vulnerable supplies as well as our economy's reliance upon oil. And finally, automobile insurance rates could discourage excessive driving by being based partly on the miles driven.

More than a half century ago, the very possibility of oil vulnerability shocked the western world with the closure of the Suez Canal. Despite other major disruptions since that explosive event, there has been little evidence of "learning by doing" in current oil security policy. ■

▸ see www.rff. org/weeklycommentary.

A NEW "RESOURCE" FROM RESOURCES FOR THE FUTURE

The RFF Weekly Policy Commentary series, a new feature on our website, provides an accessible way for students, academics, journalists, policymakers, and the general public to learn about important environmental, natural resource, energy, urban, and public health problems.

Here's where you can turn to find out more about new ideas and problems that you've heard of, such as congestion pricing, MRSA, the EU Emissions Trading Scheme, and the Gulf of Mexico's Dead Zone. Each week, a leading expert summarizes the current state of analysis or evidence about a particular policy topic, along with recommendations for further reading. These commentaries can be found at www.rff.org/weeklycommentary. Some of the topics covered include:

- Bringing our Food Safety System into the 21st Century
- The Greening of Buildings
- How Should Emissions Allowance Auctions Be Designed?
- Useful Lessons from California's Experiment with Congestion Pricing
- Building Better Housing Policies for the Developing World's Poor
- Why International Natural Gas Markets Matter in Today's Energy and Environmental Picture
- The Effectiveness of Voluntary Environmental Programs
- Addressing Biodiversity and Global Warming by Preserving Tropical Forests
- MRSA by the Numbers
- Inducing Innovation for Climate Change Mitigation
- Evaluating Europe's Plan for Reducing Greenhouse Gases
- Enhancing Productivity While Safeguarding Environmental Quality: The Inherent Challenges in Regulating Pesticides
- FutureGen: How to Burn Coal—Maybe—Without Contributing to Climate Change
- How Advertising for Smoking-Cessation Products Can Help Meet Public Health Goals
- Thinking Beyond Borders: Why We Need to Focus on Global Public Goods
- Which is the Best Climate Policy: Emissions Taxes or Emissions Trading?
- What Do the Damages Caused by U.S. Air Pollution Cost?
- Using the Price System to Reduce Airport Congestion
- Trash Talk
- Congestion Pricing: Lessons from London
- A New Chapter in the History of Malaria Control
- How People Feel, Here and in China, about Reducing Mortality Risks
- The Cost of Protecting Oil in the Persian Gulf
- Does the Federal Government Spend too Much for Highways, or too Little?
- The Political Economy of Addressing Overfishing in U.S. Waters
- What Can Policymakers Learn from Experimental Economics?
- Green Cities and Economic Development
- The Gulf of Mexico's Dead Zone: Mess, Problem, or Puzzle?
- Designing the Next International Climate Agreement
- Should Automobile Fuel Economy Standards Be Increased?
- What are the Biggest Environmental Challenges Facing the United States?

Managing Costs in a U.S. Greenhouse Gas Trading Program: Workshop Summary

With federal action on climate change seen as increasingly likely, debate over the details of a workable legislative proposal has sharpened. Cost containment has emerged as a major point of contention, forcing policymakers and stakeholders to weigh the need for environmental certainty (in terms of confidence in future greenhouse gas reductions) against the need for safeguards to protect the U.S. economy in the event of high costs.

Recognizing the practical and political importance of these concerns, RFF joined with the National Commission on Energy Policy and Duke University's Nicholas Institute for Environmental Policy Solutions to host a workshop devoted specifically to the topic of cost containment. The workshop, held in March, featured presentations from senior RFF researchers and invited speakers with expertise in economics, financial markets, and environmental regulation.

The day began with an attempt to frame overarching issues related to cost containment. Speakers reviewed the recent evolution of this concept and described some of the specific approaches that have been put forward in various legislative proposals. The second part of the workshop focused on the idea of creating an independent board, akin to the Federal Reserve, that could intervene in future carbon markets to respond to cost concerns. Full details of the workshop, including presentation materials and audio and video recordings of the event are available at ▸ www.rff.org/costcontainment.

Several key themes and questions emerged over the course of the workshop:

Is the point of a cost-management mechanism primarily to limit expected costs or to guard against unexpected costs? Many workshop participants agreed that the primary focus ought to be on managing unexpected, short-term costs.

- Cost management has multiple dimensions. Are policymakers chiefly concerned with managing costs in the short term or over the long run? Is the point of a cost-management mechanism primarily to limit expected costs or to guard against unexpected costs?

- There are trade-offs between providing economic certainty and environmental certainty. A hard cap on future costs (as would exist under a simple safety-valve mechanism) would provide absolute certainty about maximum costs but has the disadvantage not only of creating uncertainty about final emissions, but—without a corresponding guard against low costs—of diminishing incentives to invest in technology innovations that could yield major emissions reductions in the future.

- With sufficient inter-temporal flexibility, markets should—in principle—be able to manage short-term cost fluctuations using conventional financial and risk management tools. In practice, however, reliance on banking and borrowing is likely to be constrained by institutional and other concerns (for example, the existence of default risk or the possibility that firms may not always operate rationally or with adequate foresight).

- The concept of an independent entity that could intervene in markets if necessary (a "Carbon Market Efficiency Board") would seem to offer a number of advantages—such an entity could serve an important information-gathering purpose and respond quickly to market developments in a way that Congress cannot. Numerous questions about the specific form and function of such an entity still need to be answered—especially how much discretionary authority it would wield—but independence, transparency, accountability, and an expert staff would all seem to be critical attributes for success.

These and other points generated a lively interchange of questions and comments at the workshop. Several core themes emerged. First, many workshop participants seemed to agree that the primary focus ought to be on managing unexpected, short-term costs. "Uncertainty about whether allowance prices are $15 or $100 over the first five years of the program make it very difficult to reach a consensus," said Billy Pizer, a senior fellow at RFF and moderator of the first panel. Concerns about expected short- and long-term costs, several speakers argued, are better handled through other program design features, such as the choice of targets and timetables, the inclusion of technology provisions, and linking the program to international efforts. Likewise, concerns about the distribution of expected costs within the economy can be handled through allocation. Finally, unexpected long-

term costs will be difficult—and in many ways undesirable—to address through any prescribed mechanism now; future events and decisions by future generations must ultimately weigh in.

Second, there was substantial support for banking and borrowing as an important means—but likely not the only one—for addressing short-term price and volatility concerns. One idea currently under discussion is the establishment of a quantity-limited "reserve" of carbon permits that could be drawn upon when market conditions warrant. Such a reserve could be created by withholding a small percentage of permits from future-year emissions budgets. Other concepts that merit further exploration, in the view of workshop participants, include symmetrical cost management (that is, combining any price ceiling with a price floor), the use of offset credits as a further means of increasing compliance flexibility while simultaneously promoting investment in low-cost mitigation opportunities in the United States and abroad, and the creation of an independent board to oversee future carbon markets. Workshop participants seemed to agree that such a board could serve several important functions, but they also noted that it would likely take some time for any new entity to build the kind of institutional authority and credibility currently enjoyed by the Federal Reserve.

Finally, a recurrent theme throughout the day was the need for policy credibility and confidence in the long-term integrity of underlying regulatory commitments to support a robust emissions market. Several workshop participants emphasized that policymakers need to be constantly mindful of trading political risk against economic risk in devising cost-management mechanisms that attempt to respond to concerns about the impact of mandatory greenhouse gas limits on the U.S. economy. ■

Pennsylvania Environment Secretary Kathleen McGinty Delivers 5th Annual Landsberg Lecture

In February, RFF hosted a presentation by Kathleen A. McGinty, Secretary of the Pennsylvania Department of Environmental Protection, at the Fifth Annual Hans Landsberg Memorial Lecture. The series honors the memory of Landsberg, a pioneer in energy and mineral economics who was a devoted member of the RFF staff for nearly 40 years.

With the reality of mandatory climate policies being crafted at both the state and federal levels, Kathleen McGinty encouraged the audience to keep in mind the old saying of "all things in moderation" when considering three options that could be counted as part of a comprehensive strategy to reduce greenhouse gas emissions: corn-based ethanol, carbon taxes, and cap-and-trade systems.

McGinty acknowledged that while carbon taxes and cap-and-trade systems to control emissions are both enjoying considerable "enthusiasm and exuberance" for their potential, "everyone now seems to love to hate corn-based ethanol." She nudged listeners that "maybe, at least for a time, we could dial up our enthusiasm" for the gasoline alternative that she considers to be an "okay start from an environment point of view," especially when considered along with the need to increase national energy security.

One concern people have about corn-based ethanol is that while it is net-energy positive, it's not dramatically so, especially as compared to cellulosic ethanol, said McGinty. She noted that many feel that "we can't afford the 'whoops' in terms of ethanol in building all that technology and infrastructure—let's wait for cellulosic." But, according to McGinty, "about 78 percent of the capital plant equipment for a corn-based ethanol plant is exactly what you would use for a cellulosic ethanol plant. So to me, it's not a dead end."

Nor is a carbon tax a dead end or the sole answer for McGinty, which she believes to be an elegant solution to the "perfect storm of the Katrinas, the Iraqs, and the $3 per gallon gasoline. To me, there is an essential role for a carbon tax to send a price signal." She also discussed the inherent difficulty in overcoming the fact that a carbon tax alone, in order to make significant reductions in carbon emissions, would have to be set at what she considers to be an unsustainably high level.

The third part of the equation for McGinty is a cap-and-trade system, again emphasizing its role as an "absolutely essential, fundamental building block of an overall climate policy," but acknowledging that it cannot bear the heavy weight of reducing overall emissions alone. "The job is bigger when we see what is unfolding around the world. We might not have the 2°C head room we thought we had. We might not have the 450 ppm head room we thought we had, and we might not have the 2050 head room we thought we had."

There is no panacea or quick answer to the complex issues surrounding climate change, McGinty said. Policymakers will need to carefully craft a blend of policies in order to address the global changes that will be the result of a warming planet. ■

Full coverage of Secretary McGinty's lecture can be found at ▸ www.rff.org/McGinty.cfm

Space as the Canonical "Global Commons"

AN INTRODUCTION TO ITS ECONOMICS

MOLLY K. MACAULEY

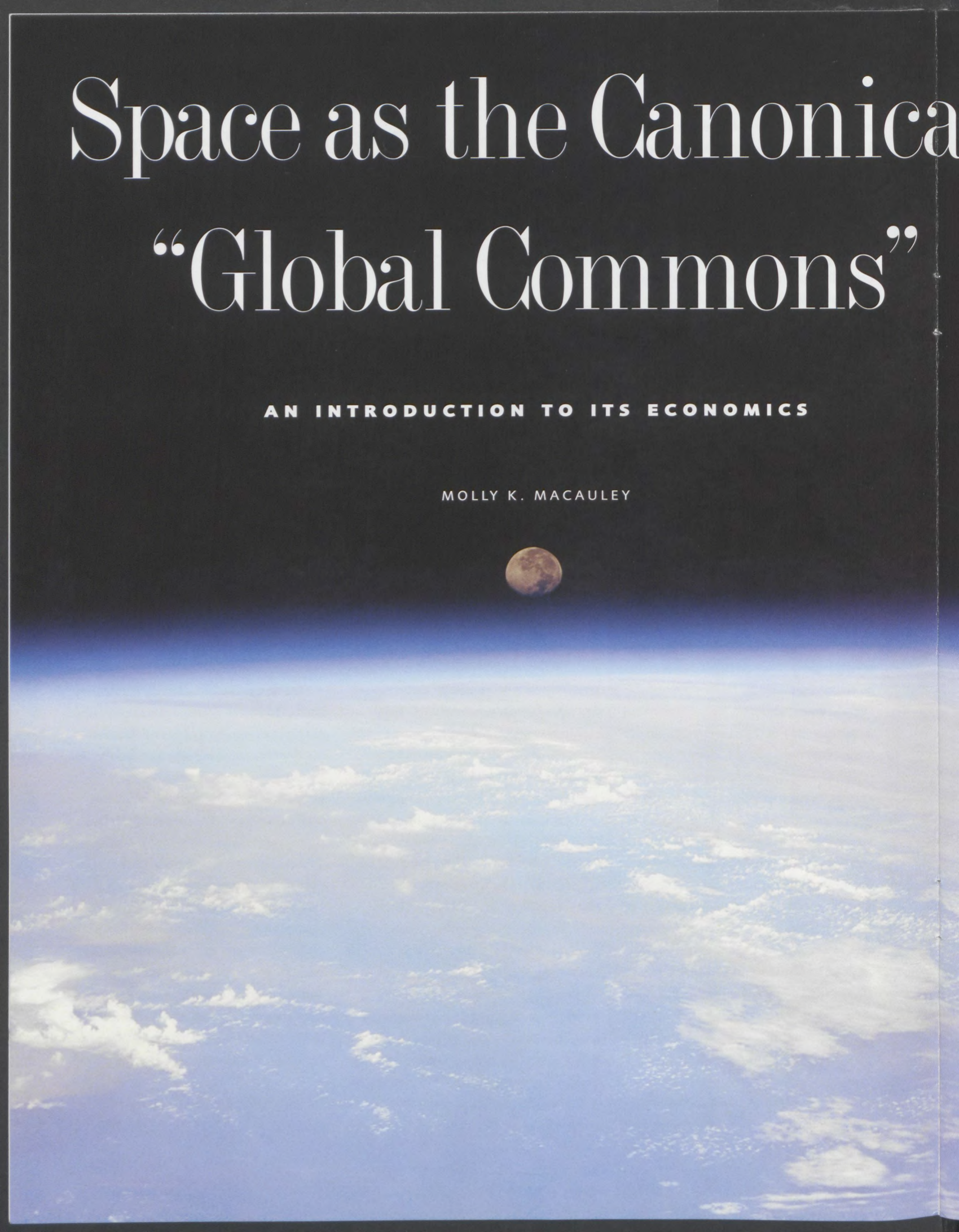


PHOTO COURTESY OF NASA

SOMETHING HAPPENS AT AN ALTITUDE OF ABOUT 60 MILES: we move from "air" to "space." The exact altitude is somewhat arbitrary. It's defined roughly as where the density of the atmosphere decreases so much that a vehicle has to travel faster than orbital velocity in order to get enough lift to support itself—an aircraft becomes a spacecraft. But the point is this: mere altitude does nothing to vitiate the importance of environmental and resource economics in informing public policy on space.

On January 11, 2007, the People's Republic of China successfully destroyed one of its older weather satellites by launching a rocket that traveled at nearly 18,000 miles per hour. It hit the 6-foot long satellite, which instantly shattered into an estimated 35,000 pieces. To many experts in the national defense community, this demonstration of anti-satellite technology was neither alarming nor unprecedented. What was startling, however, was the large amount of space debris generated by the test, the largest single source since the start of the space age. But the problem was already large and growing (see Figure 1).

Space debris includes defunct spacecraft, metal shards, nuts and bolts, and a host of other discards from space activities. Debris is dangerous because it orbits at extremely high velocity; for example, mere flecks of paint have struck quarter-inch deep gouges in windows on the space shuttle. (To protect astronauts, the space shuttle has six layers of windshields.) Communications satellites, the space station, and other spacecraft have extra layers of "shielding" but still remain vulnerable to damage.

And there are no easy ways to avoid it. If a piece of debris is larger than a softball, ground-based radar can detect debris and engineers can send commands to a spacecraft to maneuver it out of the way. (But this solution comes at a cost—it draws on an already limited spacecraft fuel supply.) Smaller debris is also lethal and undetectable. Debris often "begets" debris when it collides with itself to produce even more and even smaller (hence harder to detect) pieces.

To economists, space debris can be seen as one more form of pollution that can be addressed through policy mechanisms like deposit-refunds or tradable permits. For example, fees could be assessed on spacecraft at the time of launch. The size of fees can be large or small depending on the debris-generating potential of the spacecraft. (Is it painted, such that flecks of paint can become debris? Are external devices secured by lanyards? Will excess rocket propellant, which forms pellets and acts like debris, be properly managed?) Under a deposit-refund approach, any deposit payments foregone by the failure to reduce debris could accrue in a compensation fund to reimburse the cost of harm done to operating spacecraft.

Another alternative would be to issue a small number of debris permits to space-faring nations or to companies supplying launch services and spacecraft. Permits could be exchanged among low- and high-cost debris control activities associated with different types of space missions. Flexible strategies offer additional advantages. For example, some regions of space are heavily used for communications satellites or the space shuttle and space station. The stringency of strategies could be adjusted depending on the destination of the spacecraft.

Under any option, whether voluntary, mandatory, or market-like, policymakers must determine an amount of debris growth that can be appropriately managed. They must also take into account costs of complying with, monitoring, and enforcing the rules.

The Petri Dish Problem

There is an even more profound excuse for keeping space clean. One of the reasons to explore space is to pursue truly cosmic questions: Where did we come from? Are we alone? The rationale for planetary exploration is in fact to pursue these questions. But landing a robot on the surface of a planet to look for evidence of life automatically introduces our own germs into that planet's environment. The microbe we find on Mars may be our own.

Experts have long expressed concern about protecting other planets from human contamination. Safeguards, such as assembling spacecraft in high-technology clean rooms and sterilizing all components, can be taken to minimize contamination. Using shrouds, filters, and seals can also reduce the microbes that can hitchhike from Earth. Technicians might prepare inventories to document the kinds and amounts of "bio-burden" associated with spacecraft assembly and launch to provide a background record as a basis for later comparison with the spacecraft's research results.

None of these precautions fully prevents contamination. A recent report by experts engaged in the operation of rovers on Mars points out (but does not endorse) that "the only way to fully eliminate risk is to stop direct-contact missions and go to passive observation." Passive observation means observing planets from a distance—say, by means of a spacecraft orbiting the planet and taking pictures. But even then, the chance remains of an accidental spacecraft crash.

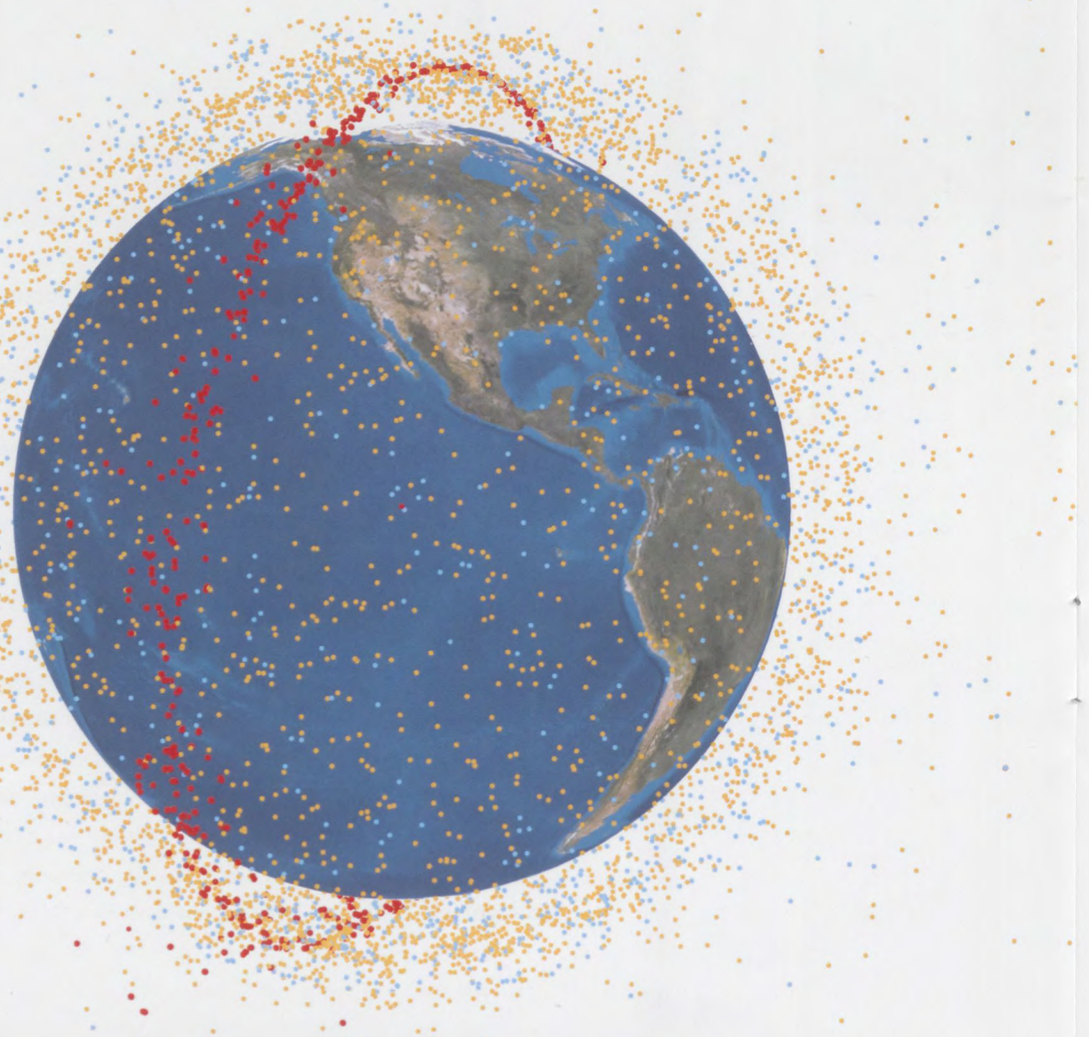


Figure 1: This graphic shows the amount of spacecraft and old and new debris orbiting the Earth. Each dot represents a man-made object larger than four inches.

SPACECRAFT
There are more than 3,100 spacecraft orbiting Earth. Two-thirds of these are no longer active.

OLD DEBRIS
Nearly 7,000 pieces of man-made debris are large enough to be tracked.

NEW DEBRIS
The satellite destroyed by China in January has left nearly 1,000 pieces of large debris.

Graphic reproduced with permission from The New York Times Agency. David Constantine and Monica Evanchik. "Littered Skies." Interactive graphic. *New York Times*, February 6, 2007, online edition.

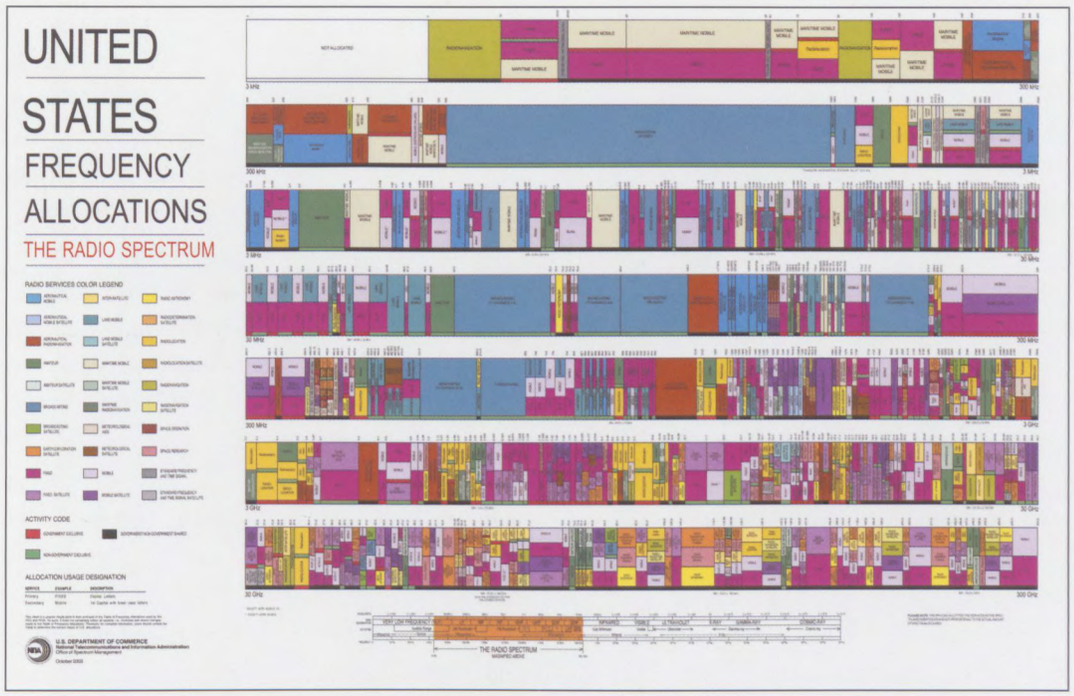
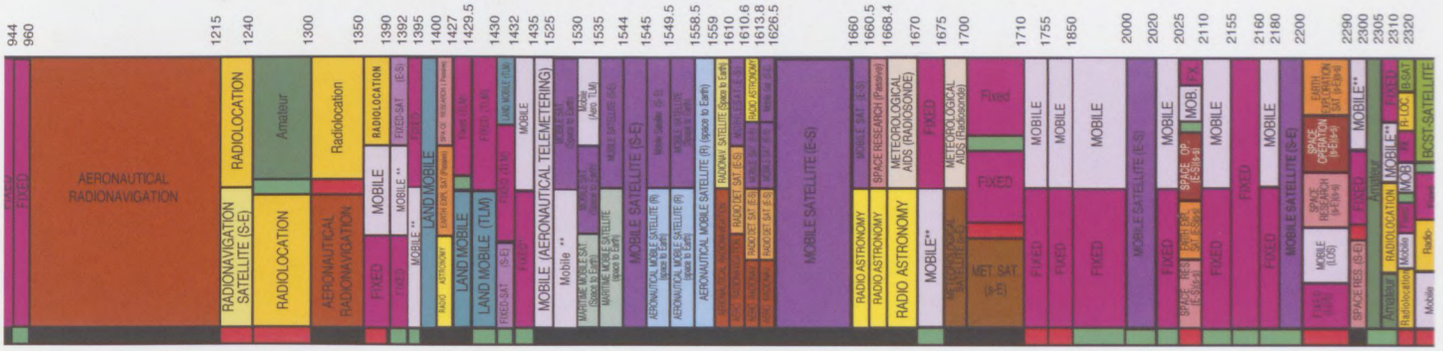


Figure 2: This figure illustrates regions and uses of the spectrum.



How might planetary exploration go forward? Protecting planets and other celestial bodies while exploring space requires the balancing of competing objectives, wholly analogous to the tradeoffs involved in environmental protection on Earth. An example is zoning. On some planets, researchers have identified special regions where there is a high potential for the existence of indigenous life, such as where liquid water may be present (for example, at the Martian polar caps and in areas of hydrothermal activity). International protocols now require additional sterilization requirements for spacecraft making contact in these zones.

Another example of tradeoffs is figuring out how best to time the pace of exploration, given that it is frequently informed by new information about conditions for life elsewhere. The Viking landings on Mars in the 1970s suggested a dry, barren environment hostile to life. Surprisingly, recent data indicate that Mars has multiple environments, with some suitable for life. A related finding is discovery of the diversity and survivability of terrestrial microorganisms in extreme ocean environments previously deemed highly unlikely to harbor life. Given the value of this kind of information, it could be wise to adopt a "go slow" approach in space exploration, if the goal is to have as few regrets as possible about contaminating other environments.

Timing also affects the opportunity handed to future generations; those making decisions today may not be those facing consequences later. The National Research Council's Space Studies Board has urged that new efforts be directed toward research on planetary protection measures. Decisionmaking under uncertainty and discounting for intergenerational effects—long-researched topics in economics—come to the fore on a new frontier.

What's that Crosstalk?

Another emerging issue—for which the economists' toolkit has already proven useful—is allocation of a resource required for all activities in space. The electromagnetic spectrum, or airwaves, is the communications backbone, not only among everyday cell phone users and TV and radio transmission, but it is also how we communicate with space-based activities. And the airwaves are getting ever more crowded.

First, a bit of history. In 1960, University of Chicago economist Ronald Coase wrote about the difficulty of allocating the electromagnetic spectrum, responding to the problem of interference on the radio and TV dials. Coase won the Nobel Prize in Economics in 1991 partly for his argument that under certain conditions, a public good like the airwaves can be managed by conferring property rights on radio and TV stations. Rightsholders would take appropriate care to minimize mutually destructive, interfering signals. Moreover, recognizing the scarcity value of electromagnetic spectrum, they would have strong incentives to pursue innovation to develop new electronic devices capable of using it more efficiently. In 1971, RFF sponsored *The Invisible Resource*, a book by economist Harvey Levin that further outlined systems for and advantages of spectrum rights. By early 1995, first New Zealand, and then the United States had begun to confer property rights by auctioning portions of spectrum to the telecommunications industry.

While the auctions allocate spectrum among commercial companies, the problem has re-emerged in the case of public users. A wholly new demand for interference-free spectrum has come to the fore: satellite data to observe Earth's air, water, forests, crops, and climate. The data from these spacecraft provide early warning of changes in the Earth system, such as ice cover in the polar regions, the status of the protective ozone layer, and sea level. In some cases, experts hope that satellite data can allow monitoring of the extent of forestation, deforestation, and afforestation—measurements deemed necessary for projects such as carbon credits to facilitate forest protection by developing countries. Similarly, assessing the efficacy of the Montreal Protocol to protect the ozone layer and the effectiveness of many other international environmental agreements rely on space-derived information.

What is the connection with Coase? Every natural phenomenon, from a tree to the ocean to clouds, has a unique spectral "signature" or "fingerprint." Each emits energy (light) naturally at the microwave level or other portions of the electromagnetic spectrum. The instruments in space, then, look at Earth to detect the emitted radiation and interpret it to understand environmental parameters as varied as soil moisture, temperature, humidity, ocean salinity, and climate.

When satellites "listen" to the natural emissions, everyday electronic devices can interfere. A single cell phone uses several different transmitting devices operating at as many frequencies, substantially increasing the radio din. Figure 2 shows regions and uses of the spectrum; look hard enough to see the tiny "EEES" (earth exploration and earth science) sections where Earth "speaks" to us. The frustration cell phone callers experience with a bad signal is magnified for natural scientists trying to tune in to a highly specific natural phenomenon. In some cases, scientists aren't sure whether their signal is "real" or "noise." The National Academy of Sciences is presently carrying out a study of spectrum interference for earth science (and radio astronomy, which is also subject to the interference problem).

How best to decide who gets what? How much spectrum for our telecommunications devices, and how much to Earth science? Just as with the problems of managing space debris and planetary environments, the spectrum problem is primed for economists who have the tools with which to value public goods, frame tradeoffs among competing alternatives, and, when appropriate, suggest market-like approaches to allocating natural resources. ■

The National Academy of Sciences urges that scientists plan lunar and planetary studies with great care and deep concern so that initial operations do not compromise and make impossible forever after critical scientific experiments.

—Preventing the Forward Contamination of Mars, Washington, DC: National Academies Press, 2005

Biodiversity

What it Means, How it Works, and What the Current Issues Are

Juha V. Siikamäki

This article is adapted from the author's chapter in a forthcoming book from RFF Press, *Perspectives on Sustainable Resources in America*, edited by RFF Senior Fellow Roger A. Sedjo.

Biological diversity, or biodiversity, denotes the wealth and variety of all living things. Although naturalists have a long history of examining and classifying animals, plants, fungi, and other organisms, the term biodiversity, meaning the total variability of life, dates only from the 1980s. Biodiversity's importance was quickly recognized, and by the early 1990s, it became the subject of international agreements like the Convention on Biological Diversity adopted in Rio de Janeiro in 1992. Now, almost 20 years later, mounting evidence of the potential effects of global warming on different species and ecosystems only heightens the need to integrate biodiversity into the complex policy decisions that lie ahead.

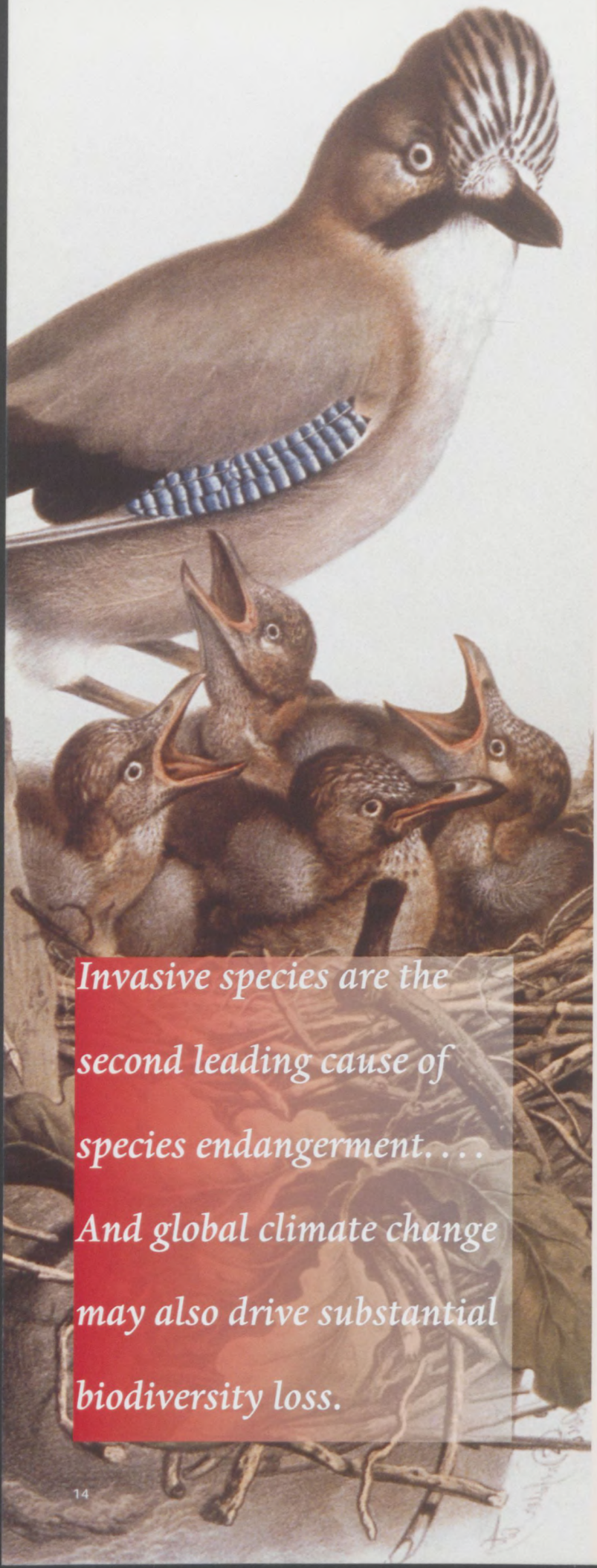
Biodiversity typically is considered at three levels: species diversity, genetic diversity, and ecosystem diversity. The first category refers to the variety and abundance of species in a geographical area; the number of species is the simplest and most commonly used measure of biodiversity. Despite the tendency to focus on species, relying on species and their numbers alone does not go far enough: each species consists of subspecies, populations, and individuals. In fact, many practical conservation decisions target subspecies and populations rather than species.

The second and third categories of biodiversity, genetic and ecosystem diversity, have not garnered as much media coverage. Genetic diversity refers to variation between and within species, both among populations and among individuals within a population. Variations arise from mutations in genes, and natural selection of these characteristics is the primary mechanism of biological evolution. Ecosystem or systems diversity refers to the variation between communities and their associations with the physical environment.

Species have different functions within their communities; some can be substituted while others (keystone species) play determinant roles in the food web and cannot be removed without fundamentally altering the community itself. An example of a keystone species is the grey wolf. The cascading effects of the reintroduction of the grey wolf to Yellowstone demonstrate its disproportionate role in shaping the ecosystem. When wolves were absent, deer foraged in large numbers in riparian areas, removing vegetation and keeping areas open. The wolves' new presence has caused deer to avoid those areas where the risk of being preyed upon is greatest. Consequently, with the re-growth of vegetation, riparian habitat for birds and beavers has increased both in quality and extent. Several plants and trees that were previously overgrazed now flourish in spots that elk and deer avoid because of the presence of wolves. The new vegetation provides food for beaver and habitat for songbirds, and their populations have increased.

How Biodiversity Works

Ecologists generally consider species richness to increases ecosystem productivity, stability, and resiliency. Results from long-term field experiments indicate that although species richness and the resulting



Invasive species are the second leading cause of species endangerment. . . . And global climate change may also drive substantial biodiversity loss.

interspecies competition may cause fluctuations in individual species populations, diversity tends to increase the productive stability of an ecosystem as a whole. This concept is similar to the portfolio theory in economics, which illustrates how diversification of stock portfolios can effectively remove stock-specific risks on returns. Like stocks, the returns (that is, biomass in primary production) generated by different plant species are not perfectly correlated. Rather, changes in the biomass production by some species are associated with dissimilar changes in the biomass production by other species. In other words, a high number of species acts as a buffer against productivity reductions within any single species, and ecosystems with greater numbers of species experience fewer fluctuations in aggregate biomass production.

Diverse ecosystems also generally have relatively high rates of ecosystem processes and produce more biomass than less diverse systems. However, increases in the rates of ecosystem processes are not constant and seem to plateau at relatively low levels of species richness. Additionally, it is difficult to predict the magnitude, or even the direction, of the effects of removing or adding certain species. Experimental analyses also suggest that functional groups—sets of species serving different ecosystem functions such as decomposition, production, and nutrient recycling—are important to the role of biodiversity in ecosystems. Therefore, the distribution of species within and between functional groups also is an important determinant of ecosystem functions. Differential responses by various species and functional groups give rise to ecosystem stability.

Ecosystem resilience has two meanings in ecology. First, resilience can be defined as the magnitude of disturbance that can be absorbed by the ecosystem before it changes to another equilibrium state. Second, resilience is the rate at which the ecosystem returns to equilibrium after a disturbance. Species diversity may play important roles in the resiliency of ecosystems to disturbances. For example, recent research suggests that diverse communities may have a capacity to resist invasions by exotic, non-native species.

Several components of species diversity determine its effects within actual ecosystems. These include the number of species, their relative abundance, the particular species present, the interactions among species, and the spatial and temporal variations of these components. Current knowledge about the consequences of biodiversity loss in actual ecosystems is limited, particularly when considering large ecosystems and changes in biodiversity. Present information about how ecosystem functions relate to diversity comes primarily from simple ecosystems with few species, reflecting small variations in composition and relative abundance.

Where Do Things Stand?

The United States has a rich natural heritage to which the vast size of the nation and the extensive variation of climate, topography, and

biota across different regions all contribute. Most species that live in the United States are well known and have been catalogued, especially macrobiotic ones. Around 140,000 U.S. species are currently described from the well-known taxonomic groups, including more than 96,000 insects, some 15,000 flowering plants, almost 10,000 crustaceans, over 1,100 fishes, over 500 birds, and over 400 mammals (*see Figure 1*).

Within the United States, species richness tends to be greater in southern areas and decreases gradually toward the north. A similar longitudinal gradient is observed in global biodiversity: species richness increases from the poles to the equator. Larger states with boundaries that encompass a diverse array of ecosystems tend to contain a greater number of species. For this reason, California, Texas, Arizona, New Mexico, and Alabama are the five states with the greatest species richness (*see Figure 2 on page 16*). States with the fewest species are geographically small, such as Hawaii (1,418 species), or have relatively uniform ecosystems, such as North Dakota (1,889 species). Despite its vast landmass, Alaska has fewer than 2,000 known species.

Endemic species are those that exist only within a limited region or location. Generally, states with distinct geographical features that are sufficiently isolated from surrounding areas are likely to have many endemic species. The small but geographically isolated Hawaiian Islands have an exceptional number of endemic species; more than 1,000 of Hawaii's 1,418 known species don't exist anywhere else.

Globally, many basic questions related to the current status of biodiversity remain unanswered. For example, fewer than two million species in the world are actually recognized and described. However, they constitute only some fraction of the number of total species in the world, which is unknown and must be estimated. Estimates vary from a few million to more than 100 million species, with current consensus around 14 million species. Species counts and their precision vary considerably across different taxonomic groups, and only the best-known—plants and animals—have species counts with narrow bounds of agreement. For all other groups of organisms, the precision of the estimated species counts is generally considered poor to moderate.

What Is Being Lost?

Species extinction is the most concrete example of biodiversity loss. By definition, a species becomes extinct when its last member dies. When only a few individuals of a species exist, that species may become functionally extinct, meaning that the reproduction and the long-term survival of that species become impossible. A species becomes extinct in the wild when the only living individuals belonging to that species are maintained in unnatural environments, such as zoos.

Ecological theory suggests that several factors contribute to the vulnerability of certain species to extinction. Species that are most susceptible to extinctions include large organisms; species high on the food web; species with small population ranges or population sizes; species that have evolved in isolation; species with little evolutionary experience of disturbances; species with poor dispersal or colonization abilities; migratory species; and species nesting or reproducing in colonies. Many island and locally endemic species share several of the above characteristics.

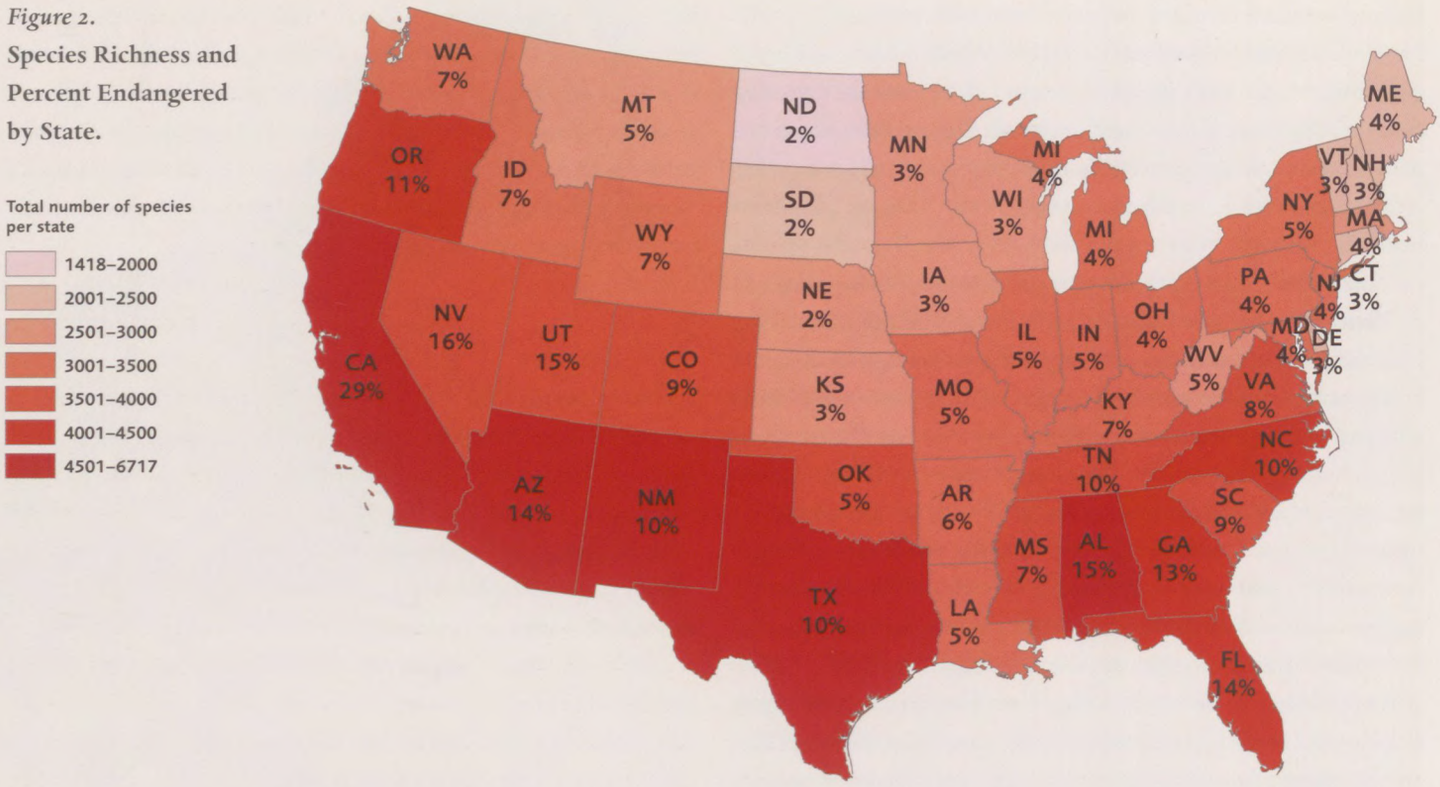
How common are extinctions in the United States? According to records of known species extinctions, approximately 0.2 to 0.4 percent of all described U.S. species have gone extinct. Within certain

***Figure 1.* Extinctions and species endangerment in the United States, by the International Union for the Conservation of Nature (IUCN) Classification**

TAXONOMIC GROUP	EXTINCT, EXTINCT IN THE WILD	CRITICALLY ENDANGERED, ENDANGERED, VULNERABLE	KNOWN SPECIES
Vertebrates, total	51	342	2,680
Mammals	4	40	428
Birds	27	71	508
Reptiles	1	27	360
Amphibians	3	50	283
Fishes	17	154	1,101
Invertebrates, total[a]	185	561	118,595
Molluscs and snails	134	261	7,500
Other invertebrates	51	300	>111,000
Plants and varieties[b]	30	240	17,680
Total	**267**	**1,143**	**>138,955**

[a] *Includes only the following five groups: snails, bivalves, crustaceans, insects, and arachnids.* [b] *Includes only the following four groups: flowering plants, conifers and cycads, ferns and allies, and lichens.*
Compiled from the IUCN database, accessed Nov. 10, 2005.
Note: This figure excludes bacteria and protists (algae, protozoa, etc.) because of the inherent difficulty in finding and describing microscopic species.

Figure 2.
Species Richness and Percent Endangered by State.



taxonomic groups, such as vertebrates, extinction rates are considerably higher. For example, about five percent of all known bird species in the United States are now extinct. Overall, the Hawaiian Islands are the unambiguous hotbed of extinctions, though they have been recorded in every U.S. state. Hawaii comprises only a small fraction (less than 0.2 percent) of the total land area of the United States, but it accounts for about 30 percent of extinctions and 50 percent of possible extinctions.

The Human Factor

The principal cause of contemporary biodiversity decline is habitat destruction and degradation, driven by the expansion of human populations and activities. Habitat loss is the major cause of endangerment for 85 percent of the species listed under the Endangered Species Act (ESA), the primary federal statute governing the protection and management of biodiversity. It often results from urban development, pollution, or fragmentation by small-scale encroachment (urban sprawl).

Invasive species are the second leading cause of species endangerment. Introduction can be intentional—through importation of ornamental plants, livestock, and game species—or unintentional, introduced via ballast water, potted soil, or freight containers. Tolerance of a wide range of environmental conditions, high rates of reproduction and dispersal, and a lack of natural predators within the new community are characteristics that help nonnative species thrive in the new habitat.

Human activities also cause chemical pollution and contamination of natural systems. For example, urban, agricultural, and industrial sources often release large amounts of nitrates and phosphates into aquatic systems, where they cause algal blooms that choke oxygen and shade other species. However, regulation of toxic pollutants in the United States has lowered concentrations of many industrial pollutants from point sources to the lowest levels since measurements began.

Global climate change, caused by the atmospheric accumulation of human-generated greenhouse gases, may also drive substantial biodiversity loss. Although many species have the capacity to adapt to environmental change, climate change likely will occur more rapidly than most previous, natural climate shifts. Shifts in temperature and precipitation could have numerous impacts on biodiversity, including shifts in migration and breeding patterns; expansions or contractions of natural species ranges; rise in sea level, water temperature, and acidity; increase in disease transmission and pest infestations; and unpredictable fluctuations in populations and habitat conditions.

The adaptive power of some species will likely be overwhelmed by these new pressures, especially when combined with fragmentation, decreased connectivity of habitats, and other stresses that already threaten many species and may create additional barriers to adjustment to changing conditions. The best known example of such species are polar bears, which were recently added to the endangered species list, and are seriously threatened by the predicted sea ice change associated with climate change.

Integrating Economics and Ecology to Help Preserve Biodiversity

One certainty in determining appropriate long-term biodiversity policy is that economic and ecological tradeoffs are unavoidable. Identifying successful strategies to preserve biodiversity requires integrating economics and ecology, For example, systematic conservation planning aims to identify the most cost-effective conservation strategies for achieving specific conservation goals such as protecting certain total amount of habitat, species, or populations, under budget constraints. Though cost-effectiveness analyses do not address the broader rationale for conservation—that is, how much societies should invest in conservation—they help improve practical conservation decisions.

Because most biodiversity occupies working landscapes rather than reserves, examining alternative management strategies for multiple-use areas also is centrally important. Understanding the drivers of land use change, as well as landowners' preferences and behaviors relative to alternative biodiversity conservation policies, is helpful in finding practical approaches to protecting biodiversity. For example, preserving biodiversity in working landscapes using easements may be achieved relatively inexpensively compared to full preservation through acquisitions or prohibitive regulation. Augmenting regulatory approaches to conservation with economic incentives to protect biodiversity may therefore prove both economically and ecologically more prudent than relying solely on regulatory approaches.

Valuation of biodiversity highlights its economic importance to societies. However, economic analysis can be controversial and, to some, even fundamentally objectionable. Disagreements are especially common when economic valuation and arguments are used to address species protection and, alternately, extinctions. But in many cases, economic values from biodiversity are related to our everyday life rather than species existence or extinction. For example, many commodities essential to human well-being—such as food, feed, fiber, wood, and pharmaceutical products—originate from and are continually supplemented by ecosystems and their biodiversity. Nature also provides genetic resources for breeding new plant varieties and organisms for the development of biological control and remediation methods. And ecosystems as a whole contribute valuable services through watershed protection, water filtration, carbon and nutrient storage and cycling, pollution breakdown and absorption, replenishment of soil fertility, erosion prevention, and climate stability.

Rather than taking for granted that biodiversity should or should not be preserved, economics provides a systematic framework to assess the various tradeoffs involved in decisions regarding biodiversity preservation. For example, it may be possible to estimate the level of conservation benefits achieved from allocating land for protection and then compare those results the benefits of using the same land for other purposes, such as agriculture or forestry. Depending on the relative benefits and costs, such analysis may suggest that all, none, or just a fraction of the land should be devoted to conservation. When all-or-nothing conservation is not the only option, it may be possible to connect current land uses with conservation goals at relatively low cost by providing landowners with economic incentives.

Assessments of biodiversity conservation options may vary greatly by location, depending on unique economic and natural characteristics. And they obviously are not definitive because of limited knowledge and imperfect methods in both economics and ecology. But these inquiries provide relevant information that, in the context of other considerations, can help decisionmakers identify practical conservation choices. ■

THE HARD NUMBERS

In addition to past extinctions, many species are currently endangered and dependent on conservation measures. According to the World Conservation Union (IUCN), widely recognized as the world's leading conservation network, 1,143 species in the United States—903 animals and 240 plants—are classified from vulnerable to critically endangered, meaning that these are under high to extreme high risks of extinction. In addition, IUCN lists another 292 animals and 27 plants that are either conservation dependent or near threatened. The 903 endangered animal species include 342 vertebrates: 40 mammals, 71 birds, 27 reptiles, 50 amphibians, and 154 fishes. Taking into account the known 51 extinct vertebrates, almost 15 percent of all known U.S. vertebrates, or 393 of 2,680 species, are either extinct or endangered.

Malaria

Hellen Gelband

It's Not Neglected Any More

Public consciousness about malaria is rising in this country. Just a few years ago, many Americans thought that malaria was an ancient plague and were surprised to discover that it still plagues populations in Africa, Asia, and other tropical parts of the globe. Of course, people still have much to learn, but between the President and First Lady visiting malaria control programs in Africa and the Denver Nuggets raising money for bed nets treated with mosquito-zapping insecticide, malaria is harder to miss these days.

Here are the rote statistics: half a billion cases and one million dead each year—most of them African children. What's new—and startling, certainly for the global health community—is the fact that a billion dollars is now pouring into malaria control every year. Less than a decade ago, it was just a few tens of millions. With such an enormous financial commitment and the attention of the world, will this investment pay off? Will we finally be able to change the numbers on the malaria scoreboard? People are talking big: the "e word" is in play again. *Eradication*. Is it a pipe dream or can it be reality?

While scientific advances in the treatment of malaria are cause for optimism, the lack of a unified worldwide plan or vision for malaria control remains a serious concern. More people sleep under protective nets and have access to effective drugs than ever before but malaria-endemic countries tend to be among the world's poorest, which also means they have the weakest healthcare infrastructures. And while malaria may be the most important health problem historically, it is overshadowed by AIDS—which not only makes people vulnerable to other diseases, but also has soaked up the best and the brightest in the healthcare workforce.

Can we control malaria? Or will it continue to control the lives of the people affected? A lot depends on what happens over the next few years: if success can be documented, funding will probably continue to flow. But, if progress is not great enough, despite the large sums devoted to tackling malaria, the disease may win again.

Today's Control Measures Can Work

Clear evidence has emerged, from the places where the current wave of malaria control started earliest, that the tools we have do work. The big three interventions are effective drugs, insecticide-impregnated bednets, and the spraying of indoor walls with insecticide (referred to as indoor residual spraying). Take Kwazulu Natal (KZN), the state that had the highest malaria burden in South Africa up to the year 2000, when the KZN malaria control program conducted house-to-house campaigns of indoor spraying, and

(But It's Not Gone, Either)

switched to the best type of drug. Prior to that, some districts reported 5,000 cases each month during the high season. In 2001, the numbers fell to 1,000 per month. Since 2002, not more than a few hundred cases have been reported. Today, mothers no longer spend their days caring for children in crowded malaria wards. Both the annual number of cases and number of deaths in KZN have fallen 90 percent. Zanzibar, a large island off the Tanzanian coast, and other countries (Rwanda and Ethiopia, for instance) where insecticide-treated nets are integral to the mix, are beginning to yield similar stories.

We still need better drugs and insecticides, and the search continues for the holy grail: a vaccine against malaria. But we know that using current methods will lead to huge declines in the malaria burden. Whether or not they can lead to eradication is still an open question.

Funding Is at an All-Time High

The harsh reality is that the best science and the best intentions will have little impact without funding. That goes for implementing malaria control programs and for carrying out research needed to advance knowledge, both in the laboratory and in the field. Recent progress has been possible because of money. Current funding for malaria control is at an all-time high and still in crescendo mode. Since 2000, three major new funding sources have transformed the scene: the Global Fund for AIDS, Tuberculosis and Malaria (the Global Fund), the World Bank Booster Program for Malaria, and the President's Malaria Initiative (through the U.S. Agency for International Development, USAID). The Department for International Development, the British bilateral aid agency, is also a major donor to malaria efforts and, in smaller amounts, other countries have increased aid as well. The role of the Bill & Melinda Gates Foundation, in money and in visibility for malaria, cannot be overlooked. Overall, it adds up to a billion dollars per year.

The Global Fund has made the biggest financial contribution over the largest number of countries, and has the best chance of maintaining a long-term commitment. The President's initiative is billed as a five-year, $1.2 billion program, and like the President's Emergency Plan for AIDS, funding will likely be renewed if progress is being made. It is difficult to project what priorities may look like in the United States five years from now, however. Clearly, a different president will be in office who may want his or her stamp on some other cause.

The first and only serious attempt to eradicate malaria globally, in the mid-20th century, succeeded in southern Europe and large parts of Asia and South America, but failed in sub-Saharan Africa . . . It was clear that DDT alone could not wipe out malaria in Africa, where intensity of transmission was higher and infrastructure was poor. Some also believe that sub-Saharan Africa was written off as a lost cause for malaria, and that sufficient effort was not made.

Better Tools on the Way

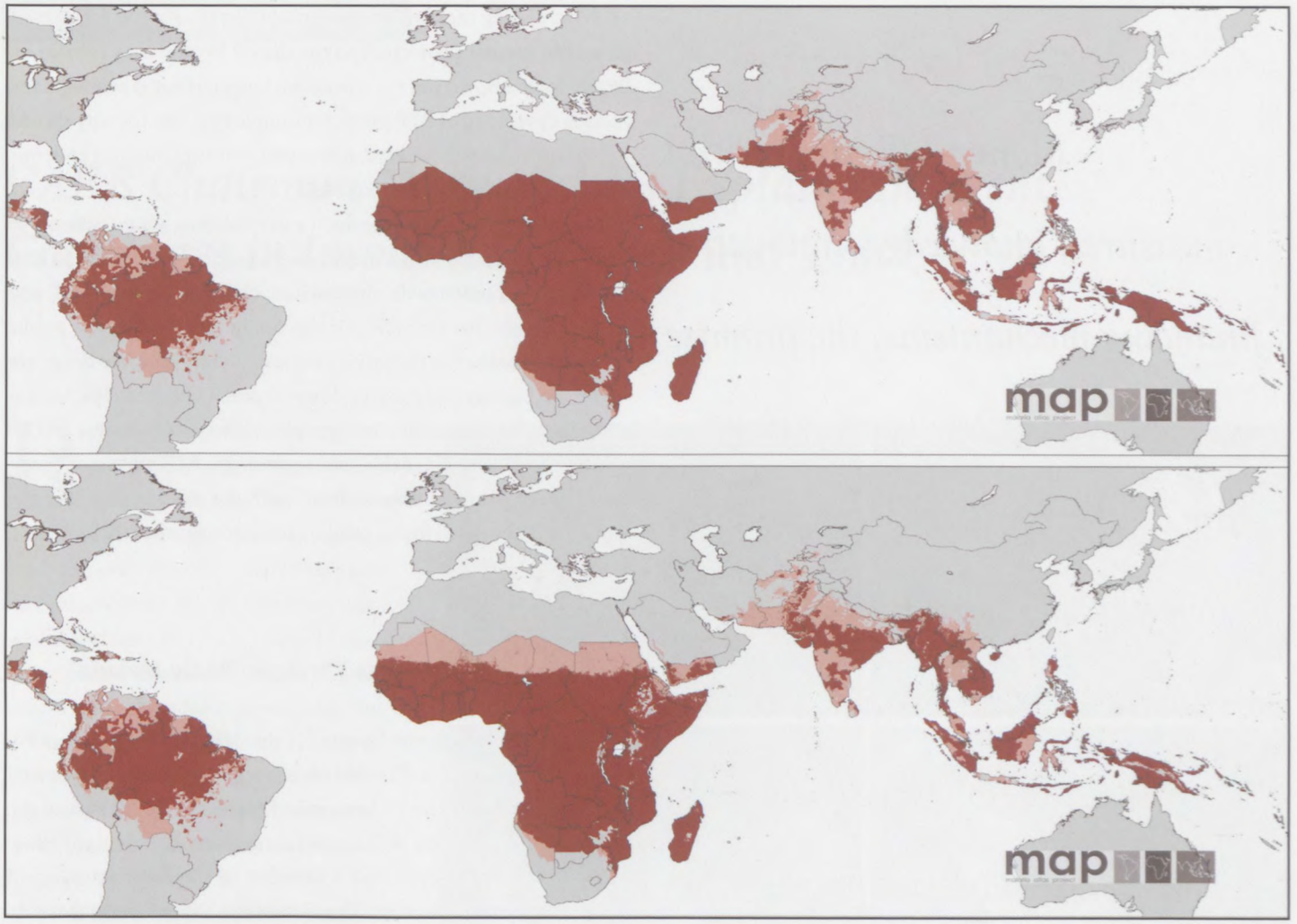
The first and only serious attempt to eradicate malaria globally, which began with much fanfare in 1955, succeeded in southern Europe and large parts of Asia and the Americas, but failed in sub-Saharan Africa. The World Health Organization's (WHO) malaria eradication campaign relied on a single tool—spraying of the then-remarkable insecticide DDT. By 1969, when a halt was called to the campaign, it was clear that DDT alone could not wipe out malaria in Africa, where intensity of transmission was higher (year-round in many areas) and infrastructure was poor. Most obviously, DDT-resistant mosquitoes took over well before the job was done. Where DDT had outlasted the species that spread malaria elsewhere, the African vector (*Anopheles gambiae*) was tougher, and in the end, mosquitoes triumphed. Some also believe that sub-Saharan Africa was written off as a lost cause for malaria, and that sufficient effort was not made.

It could be different this time. We have a bigger and better arsenal of tools and, equally important, a better understanding of how they work. We know from well planned and executed field trials that insecticide-treated bed nets reduce childhood deaths from malaria. Net technology itself has improved: an earlier generation required users to retreat them every three months with insecticide, but the current models incorporate insecticide into the fabric itself. And we have a new generation of drugs—artemisinin-combination therapies, or ACTs—that are even more effective than chloroquine, which was lost to resistant malaria parasites after a decades-long run. Even DDT has been rehabilitated. The years during which it was not used has winnowed out the resistant mosquitoes and DDT is now used more judiciously, by spraying only internal walls, as in KZN. A few other insecticides can also be used, but development of new insecticides has lagged.

For the long term, the malaria drug pipeline is fuller than it's ever been. Although novel drugs may come from a variety of sources, the Medicines for Malaria Venture, a non-profit "public-private partnership," has the deepest and broadest inventory of drugs in development of any organization. Over time, even the best new drugs will need replacement—not in crisis, but as a matter of course. That should now be possible, although it will likely be another decade before the partnership's R&D results in new forms of treatment.

Malaria Knowledge Is Advancing

The breadth and organization of knowledge are also advancing in important ways. Recently, the first results of the Malaria Atlas Project (MAP) were published, combining sophisticated data processing and old-fashioned, shoe-leather epidemiologic detective work. The international Kenya-based MAP team (including David Smith, an



P. falciparum Malaria Risk Defined by Annual Parasite Incidence (PfAPI; top), Temperature, and Aridity (bottom). Areas were defined as stable (dark-red areas), unstable (pink areas), or no risk (light grey). The few areas for which no PfAPI data could be obtained, mainly in India, are in dark grey. The borders of the 87 countries defined as *P. falciparum* endemic are shown. Highland areas where risk was excluded due to temperature appear in light grey. The aridity mask excluded risk in a stepwise fashion, reflected mainly in the larger extents of unstable (pink) areas compared to the top panel, particularly in the Sahel and southwest Asia (southern Iran and Pakistan). Source: Guerra, CA, Gikandi, PW, Tatem, AJ, Noor, AM, Smith, DL, et al. (2008) "The limits and intensity of Plasmodium falciparum transmission: Implications for malaria control and elimination worldwide." PLoS Med 5(2): e38. doi:10.1371/journal.pmed.0050038

RFF visiting scholar) has produced the most detailed malaria map to date. Using records unearthed from around the globe, it shows not just how many people are at risk of malaria, but also their level of risk. MAP could be the basis of a global plan for malaria control, containment, and eventual eradication. Talk is now about "shrinking the map."

Drug Resistance: Liability and Opportunity

One of the biggest threats to malaria control is drug resistance. The world was lucky that chloroquine—the 20th century mainstay—was effective for decades. For reasons not well understood, very few malaria parasites ever maintained genetic mutations conferring true resistance to this drug. But over time, the progeny of a resistant strain from Southeast Asia finally spread throughout Asia and then Africa. In Asia, replacement drugs were used starting in the 1960s. By the 1990s, mortality rates in Africa were rising because chloroquine no longer worked, and African countries, by and large, did not have the resources to switch drugs. The exception was a switch to another remarkably inexpensive drug, sulfadoxine-pyrimethamine (SP). It was very effective initially but, unlike chloroquine, was rendered ineffective in a few short years by drug-resistant malaria.

Chloroquine and SP resistance were both global catastrophes and wake-up calls: malaria drugs are precious, shared resources that must be managed so that they do the most human good, but they also must be protected from loss to drug resistance for as long as possible. The fact that the world is now relying on one drug class—

Money, effective control measures, knowledge, innovative financing mechanisms, the promise of even better interventions—all are on the increase where malaria is concerned.... The key to future worldwide eradication will be a plan with global scope that can shrink the malaria map until it no longer exists.

the artemisinins—as the backbone of malaria drug treatment for at least the next decade makes protection all the more imperative.

Continuing research at RFF is playing a key role in advancing both science and policy for better stewardship of antimalarial drugs. This spring, RFF researchers hosted scientists and policymakers from around the world at a first-of-a-kind conference on antimalarial treatment strategies, held in South Africa. A major theme was that malaria drugs are shared resources, and their effectiveness, a "global public good."

The conference was the culmination of 18 months of work that extended earlier epidemiologic modeling at RFF. The earlier work predicted large benefits from using malaria drugs in combination (rather than as monotherapy, which had been the norm), both in terms of saving lives and prolonging the effectiveness of drugs. The current combinations all include an artemisinin plus a companion drug (ACTs)—each of which should be effective malaria drugs for the locale.

Would using more than one combination in a given population give even greater protection to the drugs? Would they remain effective for years, maybe even decades, longer? That is just what the models developed at RFF predict: multiple first-line therapy should significantly delay the spread of resistant parasites. But can endemic countries implement such policies?

No one expects a clinic or doctor to randomly assign patients to one ACT or another when they come in needing treatment. So RFF has suggested practicable alternatives: children get one ACT and adults another, for example. Or the use of one ACT in the public sector and another in the private sector. Today, multiple drugs are sold from big-city pharmacies down to small village shops. Unfortunately, many are ineffective (people still buy chloroquine and SP because they are affordable and, currently, ACTs are not), substandard, or outright counterfeits. Both the affordability and the quality of drugs sold in the public sector are another focus of RFF work.

Financing Malaria Drugs Through "Radio Malaria"

"Radio Malaria" is the nickname for the Affordable Medicines Facility-malaria—AMFm. The AMFm strategy was born of the central idea in a 2004 study by an Institute of Medicine (IOM, part of the U.S. National Academy of Sciences) committee. RFF Senior Fellow Ramanan Laxminarayan was a member of the committee, and I served as the study director. The committee's idea for a global subsidy has developed into the outlines of an international organization, slated to begin operation in 2009. By the plan's outline, manufacturers of high-quality ACTs (judged, as currently, by the WHO or another international authority) will sell them at "chloroquine" prices to governments and to the wholesalers that supply the private markets in endemic countries. AMFm will then pay the manufacturer a supplemental amount for each dose sold, so that manufacturers will be paid a fair (but competitive) wholesale price.

By taking advantage of a chain of distribution that already exists through the private sector (where more than half of antimalarials are acquired currently), AMFm would expand access to these lifesaving drugs and delay their loss of effectiveness to resistant malaria parasites for years or decades. The title of the IOM report says it all: *Saving Lives, Buying Time.*

Money, effective control measures, knowledge, innovative financing mechanisms, the promise of even better interventions—all are on the increase where malaria is concerned. Thus far, interventions and plans have been approached in nearly all cases on a country-by-country basis. Some countries have seen greater success than others. The key to future worldwide control—possibly even eradication—will be a plan with global scope that can shrink the malaria map until it no longer exists. ■

CARB Chairman Mary Nichols Explains Inherent Challenges in Implementing Cap and Trade

RFF was honored to have Mary Nichols, chairman of the California Air Resources Board (CARB), speak at the recent Board of Directors dinner in San Francisco. Two years ago, AB 32, California's landmark global climate change legislation, was passed, and CARB was put in charge of developing the plans and implementing the program. Nichols spoke about the implementation lessons to be learned from EPA's SO_2 trading program (Title IV of the Clean Air Act) both for California and AB 32, and the nation, with major climate change legislation now moving through Congress.

Clockwise from top left: Phil Sharp, Michael Mantell, Mary Nichols, and Larry Linden; Bob Grady and Dan Esty; Alan Krupnick and Mary Nichols; Steve Percy, E. Lynn Draper, and Peter Robertson.

"What a lot of people don't remember, or may not know, when they talk about how easy it will be to implement cap and trade is that Title IV is not a small section of the Clean Air Act," said Nichols, one of the few people in the country to have run such a program. (Nichols was assistant administrator for EPA's Air and Radiation program under the Clinton administration.)

There's a lot of language in Title IV that people negotiated long and hard about before the bill was ever passed in Congress, she said. Several more years of work went into actually setting up the program and developing the regulations that allowed it to come into effect.

"Creating a market out of nothing in a governmental context, when the goal is not to make more pork bellies, but to have fewer pounds of sulfur dioxide, it's a totally different thing," said Nichols. While it's not surprising that fully implementing the program took as long as it did, she said, what was a little bit surprising—and certainly very gratifying—is that the program was implemented with no major scandals or disruptions and achieved the intended results.

"The only reason for telling this story to people is that I want folks to be realistic," Nichols said. "Given the scope of what we're facing in the climate area—the number of different sources and different issues that we're dealing with and a complicated economy—to act as though the market would march off on its own is just not helpful."

Another factor that many overlook when discussing the feasibility of implementing a cap-and-trade program is the emerging role of groups concerned about environmental justice, an issue that is prominent in California. Just as the SO_2 program required years of careful negotiation, so will AB 32. "Many citizens tend to be quite suspicious about any kind of trading program and they are not persuaded by the arguments of economists," Nichols said.

"We will need to do a lot of work to make sure that if and when we come out with a proposal for a cap-and-trade system, that it contains enough analysis and enough measures to satisfy critics that this is not going to become a way of escaping from the pressures to do more to clean up."

"At the end of the day, I'm actually reasonably optimistic," she said. "Process is the thing that saves you, if you do it right." ■

Meet RFF's Newest Scholar

Harrison Fell joined RFF last September as a fellow in its Energy and Natural Resources Division. His research focuses on marine resource issues, such as rights-based fishery management, a system in which fishing rights are given out at the individual level rather than having an entire fish stock as a common-pool resource for all fishers.

His enthusiasm for environmental issues sparked during his time at the Colorado School of Mines, where he received a B.S. in both economics and engineering. Having completed his Ph.D. in economics at the University of Washington, Fell found marine resource issues a natural fit.

"At the heart of many environmental and natural resource economics problems is the issue of property rights, and this is certainly true for marine resource economics," says Fell. "What is particularly interesting is that there are currently many natural experiments to study as fishery management in some areas moves from common-property systems to some form of rights-based management."

HARRISON FELL

He received a fellowship from Sea Grant, in conjunction with the National Oceanic and Atmospheric Administration (NOAA), and worked to improve understanding of the impacts of rights-based management on the fishing industry, a topic he also addressed in his Ph.D. dissertation. At RFF, he will continue research on the ability of fish processors to react to markets and the bargaining power of fishermen.

Created markets in general—those which wouldn't otherwise exist because of a lack of property rights, but do because of government intervention—are also of interest to Fell. He notes that "knowledge gained studying the property-rights issues surrounding fisheries can be translated into other areas of environmental economics."

Prior to joining RFF, he worked as a contractor for the Pacific States Marine Fisheries Council and as a research assistant for the Alaska Fisheries Science Center, part of the National Marine Fisheries Service. ■

RFF Board Member and University Fellow Leads New AERE Journal

In April 2007, the Association of Environmental and Resource Economists (AERE) launched the *Review of Environmental Economics and Policy* (REEP), the organization's official accessible journal, complimenting its official technical journal, the *Journal of Environmental Economics and Management* (JEEM). RFF Board Member and University Fellow Robert Stavins serves as the editor, overseeing the solicitation and editing of content, which is focused on the broader lessons to be learned from environmental and resource economics.

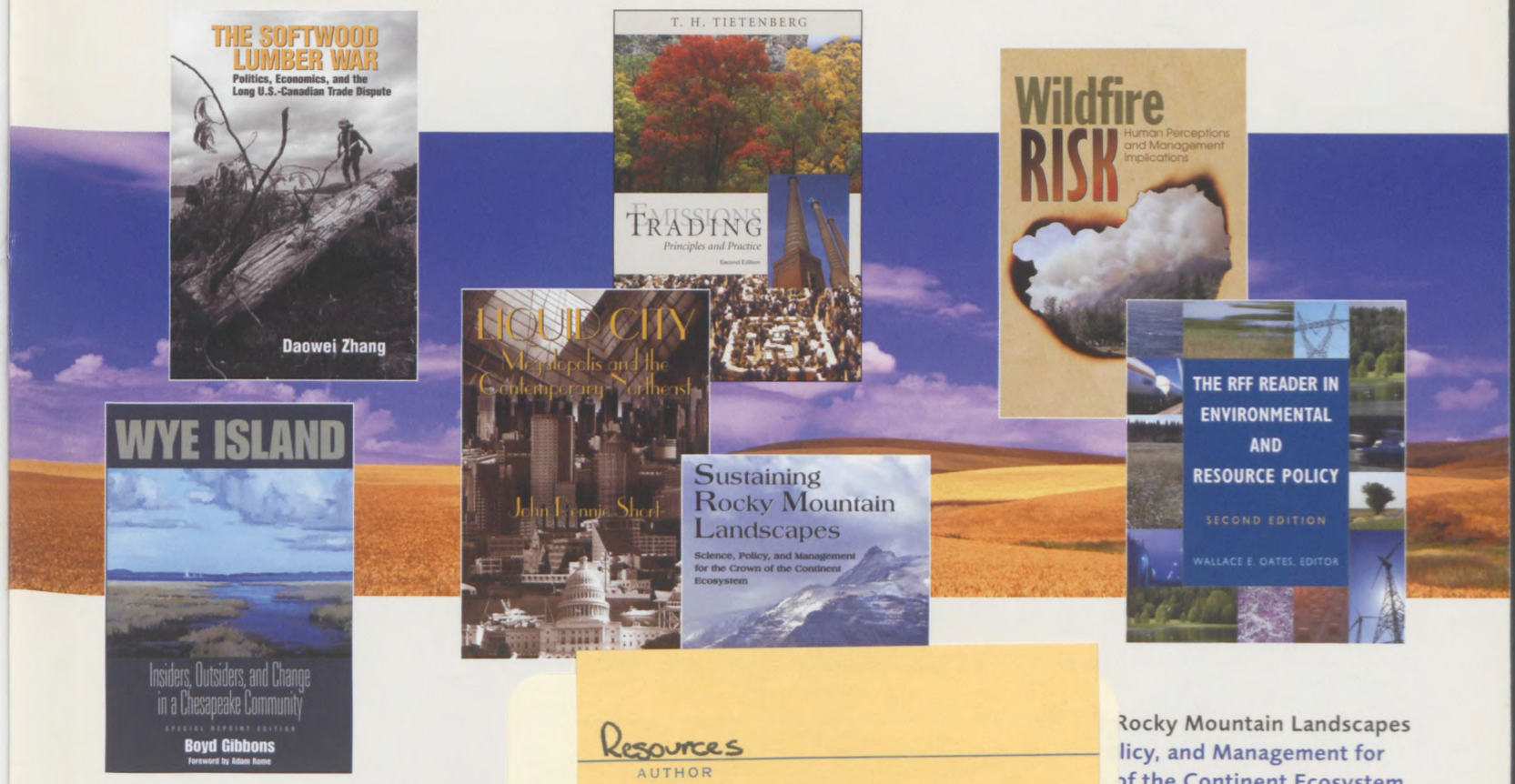
Aiming to fill the gap between traditional academic journals and the general interest press, the inaugural issue included such titles as "A Celebration of Environmental and Resource Economics," "To Tax or Not to Tax: Alternative Approaches to Slowing Global Warming," and a symposium of articles on the European Union's Emissions Trading Scheme. The journal also includes regular features like "Policy Monitor," "Reflections on the Literature," and "Announcements," which provides timely notices of calls for papers, conferences and workshops, and other relevant updates.

AERE was established in 1979 as a means of exchanging ideas, stimulating research, and promoting graduate training in the relatively new field of resource and environmental economics. Researchers at RFF were instrumental in the creation of AERE and leadership at RFF agreed to provide an organizational home to the new association. ■

"COMMON TRAGEDIES" RECEIVES NOD

"Common Tragedies," (http://commontragedies.wordpress.com/) the blog started in September 2007 by RFF Research Assistants Sarah Darley, Daniel Hall, Evan Herrnstadt, Erica Myers, and Richard Sweeney, was noted in February by the Times Online as one of the "Top 50 Eco Blogs" (http://timesonline.typepad.com/environment/2008/02/the-top-50-eco.html) on the internet. The group posts regularly on a range of topics relating to environmental and energy economics and policy.

RFF Press resourceful, policy-relevant books



Emissions Trading
Principles and Practice
Second Edition
T. H. Tietenberg
Cloth, ISBN 1-933115-30-0 / $80.00
Paper, ISBN 1-933115-31-9 / $38.95

From the Corn Belt to the Gulf
Societal and Environmental Implications of Alternative Agricultural Futures
Joan Iverson Nassauer, Mary V. Santelmann, and Donald Scavia, editors
Cloth, ISBN 978-1-933115-47-4 / $85.00
Paper, ISBN 978-1-933115-48-1 / $41.95

.

Resources
AUTHOR
n168
TITLE

Rocky Mountain Landscapes
licy, and Management for
of the Continent Ecosystem
nd Dan Fagre, editors
1-933115-45-0 / $90.00
1-933115-46-7 / $42.00

tsiders, and Change in a
Community
nt Edition
s,
d by Adam Rome
1-933115-42-9 / $45.00
1-933115-40-5 / $22.95

eptions and Management
in, Carol Raish, and
itors
1-933115-51-1 / $85.00
1-933115-52-8 / $43.95

New from RFF Press

Choosing Safety
A Guide to Using Probabilistic Risk Assessment and Decision Analysis in Complex, High Consequence Systems
Michael V. Frank

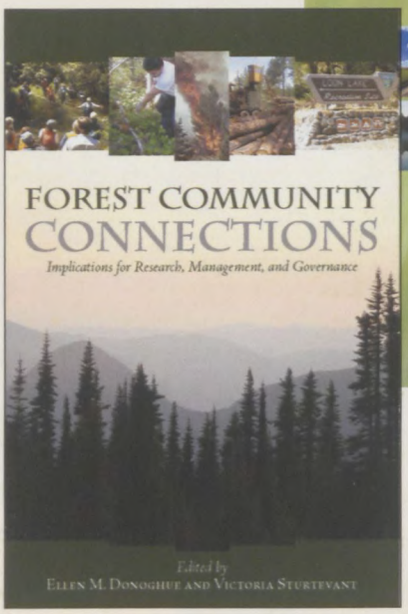
Forthcoming July 2008

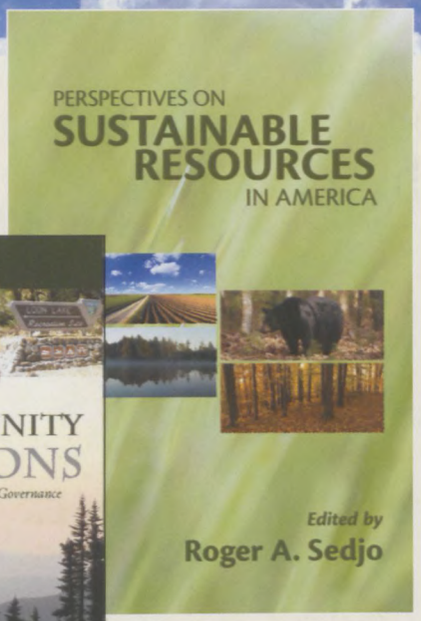
Cloth, ISBN 978-1-933115-53-5 $85.00
Paper, ISBN 978-1-933115-54-2 $41.95

Forest Community Connections
Implications for Research, Management, and Governance
Ellen M. Donoghue and Victoria E..Sturtevant, editors

Forthcoming July/August 2008

Cloth, ISBN 978-1-933115-68-9 $80.00
Paper, ISBN 978-1-933115-67-2 $39.95





Perspectives on Sustainable Resources in America
Roger A. Sedjo, editor

Forthcoming July/August 2008

Cloth, ISBN 978-1-933115-62-7 $80.00
Paper, ISBN 978-1-933115-63-4 $38.95

Frontiers in Resource and Rural Economics
Human-Nature, Rural-Urban Interdependencies
JunJie Wu, Paul W. Barkley, and Bruce A. Weber, editors

Cloth, ISBN 978-1-933115-64-1 $85.00
Paper, ISBN 978-1-933115-65-8 $41.95

PDF QUICK LINK ▶ Selecting a book title, or a cover, will take you to the RFF PRESS website with further information on the publication and its author.

TO ORDER, VISIT WWW.RFFPRESS.ORG OR CALL 800.537.5487 (U.S.) OR 410.516.6965

RESOURCES FOR THE FUTURE
1616 P Street, NW
Washington, DC 20036-1400

RETURN SERVICE REQUESTED

NON-PROFIT
US POSTAGE PAID
PERMIT NO. 3361
BALTIMORE, MD