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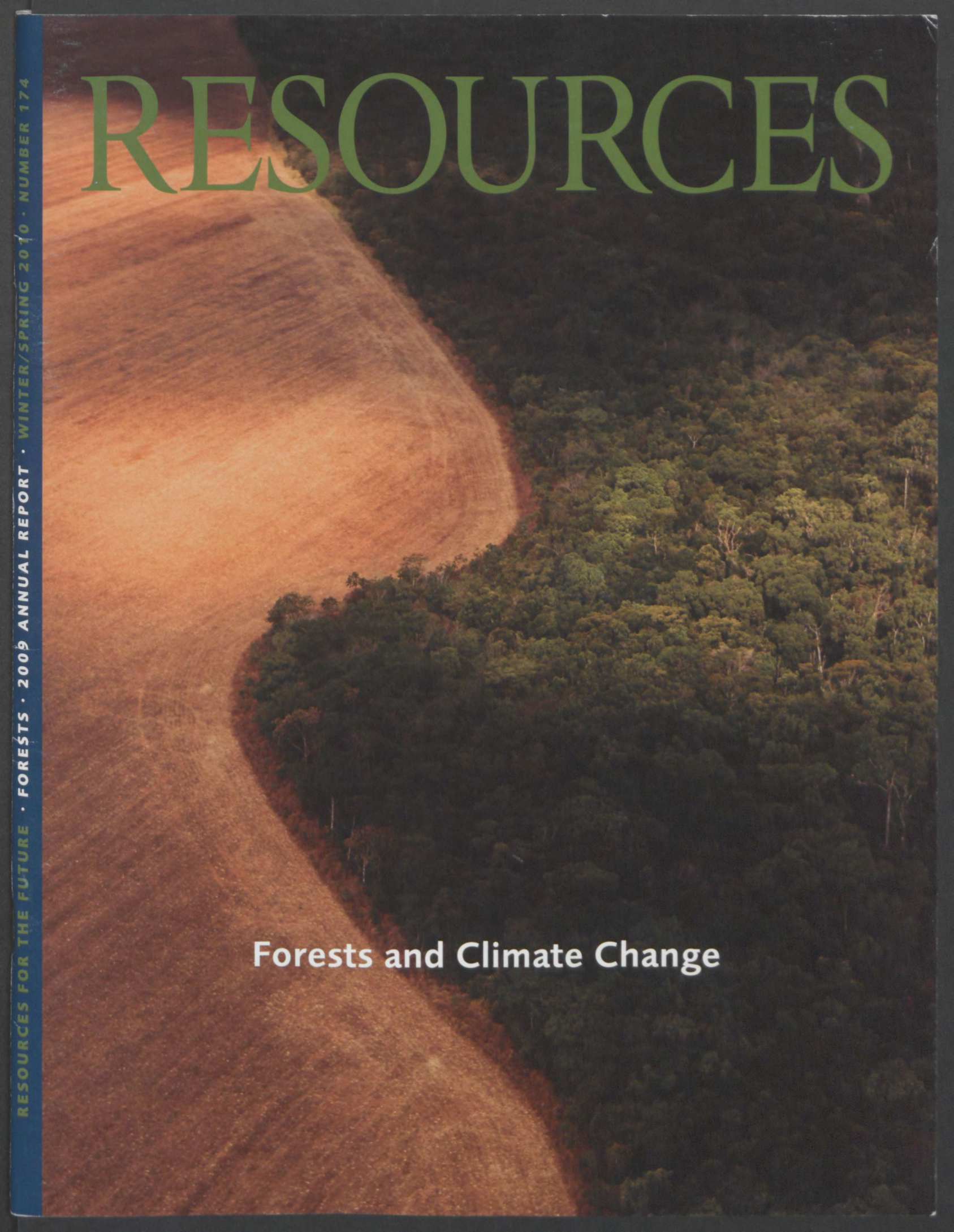


Forests and Climate Change

RESOURCES FOR THE FUTURE · FORESTS · 2009 ANNUAL REPORT · WINTER/SPRING 2010 · NUMBER 174

CONTRIBUTORS

John W. Anderson is RFF's journalist-in-residence. He is a former member of the *Washington Post*'s editorial page staff.

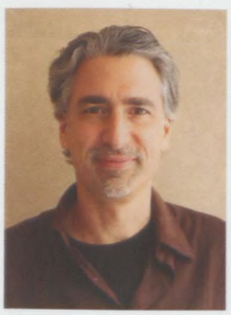
RFF Senior Fellow **Allen Blackman** specializes in the economics of the environment in developing countries. His research has covered topics such as tropical deforestation, clean and climate-friendly technological change, and alternative pollution control policies including public disclosure, economic incentives, and voluntary regulation.

An expert on space economics and policy, RFF Research Director and Senior Fellow **Molly K. Macauley's** research interests include the economics of new technologies, climate policy, and the use of economic incentives in environmental regulation.

Daniel Morris is a research associate for the Center for Climate and Electricity Policy at RFF. His work focuses on a suite of climate change issues, including domestic adaptation policy, water supply and adaptation, monitoring forest resources and modeling forest carbon, ecosystem services, GHG emissions trading system design, climate impacts related to recreation, and current climate legislation.

RFF Senior Fellow **Roger A. Sedjo** has directed RFF's Forest Economics and Policy Center for more than 25 years. His areas of expertise include public and private forestland management, timber supply, and international forestry. Sedjo is a coauthor of three of the Intergovernmental Panel on Climate Change climate assessment reports, has published extensively on forest carbon and climate change, and has examined sequestration incentives and trading mechanisms.

Andrew W. Stevenson is a research assistant at RFF's Center for Climate and Electricity Policy, where he concentrates on U.S. domestic climate policy and international climate negotiations. He completed a Fulbright research fellowship in China on climate change.



ALLEN BLACKMAN

MOLLY K. MACAULEY

DANIEL MORRIS

ANDREW W. STEVENSON

ROGER A. SEDJO

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

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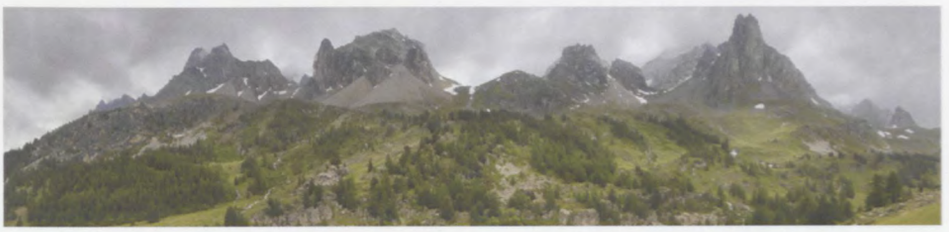
CONTENTS



DEPARTMENTS

FEATURES

RESOURCE LINKS

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.

RFF Policy Commentary

▸ www.rff.org/weeklycommentary

Taking the Measure of Forest Carbon

▸ www.rff.org/measuringforestcarbon

Why We Need Accurate Maps of the World's Forests

▸ www.rff.org/forestmaps

The Future of Trees

▸ www.rff.org/futureoftrees

Report from Copenhagen

Not Your Average Environmental Conference . . .

Andrew W. Stevenson

When the clock struck 8 a.m. on Tuesday, December 15, having already been outside in the 20-degree weather for 2.5 hours, I found myself at the front of a kilometer-long line trying to craft a plan for navigating soon-to-arrive RFF senior scholars through the teeming masses. I realized then this was not your average environmental conference.

There were other telltale signs that the 15th Conference of the Parties to the UN Framework Convention on Climate Change (UNFCCC) in Copenhagen was a once-in-a-generation event. There were the 45,000 civil society observers who registered to attend (including a dozen strong from RFF). There were CEOs who waited in line outside for 10 hours, walkouts and secret meetings galore, and the Greenpeace boat. There were more than 120 world leaders, some of whom huddled around a table to negotiate the most important environmental agreement in decades. And then there was the fallout, scathing op-eds, and ministers sent to early retirement.

But what actually happened in Copenhagen, and what does it mean for the future of international climate cooperation? The answer to both questions is everything and not much.

On the "everything" side, all but 5 of the 192 parties to the UNFCCC endorsed a three-page agreement known as the Copenhagen Accord. The accord includes pledges by all of the signatory countries to implement mitigation actions that limit global temperature increases to less than 2 degrees Celsius above preindustrial levels, to measure and report on these actions, and to participate in international consultations on their progress. It also contains a commitment by developed countries to provide $30 billion in financing before 2012 for climate change mitigation and adaptation in developing nations and a pledge to mobilize $100 billion per year by 2020 in the context of a yet-undefined global agreement. By breaking the Kyoto Protocol divide where developed countries have legal obligations and developing countries have none, the accord could precipitate a dramatic shift in the nature of climate cooperation.

But then there's the "not much." Because 5 countries opposed the accord in the final negotiating session, the parties merely "took note" instead of formally "adopting" the document. This gives the accord no legal status as a basis for future negotiations within the UN, meaning that when countries reconvene, they will pick up where they left off on other documents where little progress had been made prior to or in Copenhagen. Where progress had been made, on issues such as forests and adaptation, the last-minute scramble meant that these texts could not be adopted and that progress could not be solidified. In addition, the negotiations were highly divisive and might have completely collapsed absent the last-minute intervention of world leaders.

Going forward, there are signals that might help negotiators translate these "everythings" and "not muches" into real success. For one, although all major emitters met a January 31 deadline for submitting their proposed actions under the accord, not all indicated that they wanted to be formally associated with the document. This demonstrates that, although the

But what actually happened in Copenhagen, and what does it mean for the future of international climate cooperation? The answer to both questions is everything and not much.

confrence represents a step forward as a high-level political understanding, the existing UN processes remain the only viable way to negotiate a new global agreement in the short to medium term. It is also clear that emerging economies like China and India are willing to act, but they do not see a strong, top-down, multilateral climate regime as serving their national interests and will not agree to one in the foreseeable future.

The United States will not make a binding international commitment unless these countries do as well. Over the next several years, nations are likely to move toward a system where countries pledge actions and consult on their progress internationally, with no compliance penalties. This will place the focus squarely on domestic actions and international financing for least-developed nations, especially for the United States and other major emitters. Although this may seem like a step back from Kyoto, by moving the focus from success in negotiations to success in climate action, it may turn out to be a major step forward after all. ■

ASSOCIATED PRESS

Copenhagen's Achievement: Not a Treaty but an Accord

J.W. Anderson

Because it failed to produce a legally binding international treaty on climate change, a cloud of disappointment and recrimination hangs over the memory of last December's conference in Copenhagen. But that is the result of a peculiar political misunderstanding—a binding climate treaty never was remotely possible.

A binding climate treaty is essentially a European concept, and the great example is the 1997 Kyoto Protocol. In the European view, warmly embraced by many environmental organizations, the primary purpose of the Copenhagen meeting was to write a successor treaty to Kyoto, much of which expires in 2012. But Kyoto imposes limits only on countries that contribute less than one-third of the world's emissions of carbon dioxide, the most prevalent of the greenhouse gases. By a more realistic measure, the first necessity at Copenhagen was to achieve a regime that would include all of the biggest sources of emissions—above all, China and the United States. Neither was limited by Kyoto, China because it was classified as a developing country and the United States because it refused to ratify the protocol.

China had been making it clear for months that it would not accept emissions limits imposed by an international authority. As for the United States, anyone who had watched the struggles in the Senate to find 60 votes for reforms of health care or the financial system can judge the likelihood of getting 67 votes to ratify a climate treaty that, as a practical matter, would have been neither verifiable nor enforceable.

Instead, five big countries—the United States with President Obama at the table, China, India, Brazil, and South Africa—produced a three-page document called the Copenhagen Accord. The conference never formally adopted it and only grudgingly deigned to take note of it. It asks all countries for voluntary pledges to cut emissions and sets up a registry to monitor the pledges. And the accord promises that the rich countries will give the poor ones $100 billion over the next decade to help them deal with changing climates.

Given the accord's nebulous legal status and the absence of any notable action since the conference, it's fair to ask whether the agreement means much. One answer might be that, for the first time, the countries producing the greatest volumes of carbon dioxide now at least acknowledge a responsibility to do something about them.

The accord also suggests a change in the negotiating process. The document was worked out in a meeting of five big countries and reflects a view among the Americans, and perhaps others, that the UN's usual procedures, giving equal votes to all its members—192 of which were represented at Copenhagen—and trying to operate by consensus, is too cumbersome and slow to be useful. But in response, there has been an outcry by small countries that see the UN and its conferences as the only venues in which they can hope to catch the world's attention.

The accord adopts a target of holding global temperature increases to 2 degrees Celsius. That's quite a radical goal and would require a huge worldwide effort beginning in the very near future. The big countries now having at last engaged themselves in the governance of the world's climate, the Copenhagen Accord now must address all the questions regarding how much more they are actually prepared to do. ■

RFF POLICY COMMENTARY

Will REDD Really Be Cheap?

Allen Blackman

An international system that enables countries to earn carbon credits by reducing emissions from deforestation and degradation (REDD) will almost certainly be a prominent feature of whatever post-2012 international climate architecture emerges from ongoing negotiations.

One of the main arguments for creating such a system is that REDD will be inexpensive compared with fuel switching, carbon capture and storage, and other greenhouse gas abatement options. This argument underpins numerous high-profile reports and white papers—including the 2007 Intergovernmental Panel on Climate Change Fourth Assessment Report and the 2006 Stern Review—and has inspired widespread concern about, and research on, a coming deluge of low-cost REDD credits.

Yet the scientific foundation for the hypothesis that REDD credits will be cost-effective is thin, is contradicted by emerging evidence on the effectiveness of forest conservation policies in developing countries, and deserves serious scrutiny before critical REDD policy decisions are made.

Studies that conclude REDD will be inexpensive are often based on simplistic assumptions about how clearing and degradation of forests in developing countries can be prevented. Most assume that the cost of REDD is merely the opportunity cost of the leading activities that result in tree cover loss, sometimes with relatively small transaction costs tacked on. An example is the background paper on REDD used to write the Stern report. The cost of REDD is estimated as the price tag of a hypothetical program applied in eight developing countries with high deforestation. It would identify managers of forested land apt to clear their holdings and pay them the average opportunity cost of retaining tree cover.

A critical assumption is that these payments would result in 100 percent additionality—in short, not a dime would be wasted paying land managers to retain tree cover that is not in real danger of being cleared. A second assumption is that the program would not cause leakage—that is, it would not simply shift deforestation efforts to areas not receiving payments. Using this hypothetical model, the Stern report concludes that "curbing deforestation is a highly cost-effective way of reducing greenhouse gas emissions and has the potential to offer significant reductions fairly quickly."

Opportunity-cost models like this ignore voluminous evidence of the serious constraints to effective forest conservation in developing countries, including weak regulatory institutions, confused property rights, corruption, and an abundance of small-scale drivers of tree cover loss (Chomitz 2007).

Recently, several studies have been published that use accurate forest cover data derived from satellite images along with rigorous statistical methods to develop quantitative estimates of the effectiveness of historical forest conservation policies—the same ones that developing countries would likely use to generate REDD credits. These studies address both additionality and leakage. Unfortunately, they also suggest that REDD is likely to be far more costly than widely believed.

Perhaps most notable is a study of Costa Rica's payments for an environmental services program, now a model for similar initiatives worldwide (Robalino et al. 2008). Much like the hypothetical carbon payments model envisioned by REDD researchers, this program would pay land managers to retain tree cover. The study found that each year, the payments program has prevented deforestation on less than 1 percent of enrolled hectares because virtually all of them are ill suited for productive uses and would have remained forested absent payments. Studies of protected areas in Costa Rica and Mexico reached similar conclusions: these policies prevented only a very small fraction of land from being cleared (Andam et al. 2008; Blackman et al. 2009).

Were these studies alone in concluding that forest conservation policies in developing countries are inefficient, they might be set aside as outliers—but they are not. They put numbers to qualitative findings common in the case study literature.

To be fair, historical experiences with large-scale conservation policies are not necessarily good predictors of the effectiveness of REDD policies. Conservation policies typically serve a number of ends, including preserving biodiversity, protecting hydrological services, and minimizing economic development and cultural trade-offs. Policies specifically designed to preserve tree cover in danger of being cleared would presumably be more effective and efficient at achieving that particular goal. Indeed, some REDD pilot projects appear to have been quite successful.

Still, the gap between the optimistic view of forest conservation in developing countries that underpins the conventional wisdom about the costs of REDD and the more complex and pessimistic perspective afforded by the literature on historical experiences with such conservation should give us pause. REDD policymakers and stakeholders would be well advised to pay at least as much attention to the latter as the former. ■

Further Reading

Andam, K., P. Ferraro, A. Pfaff, J. Robalino, and A. Sanchez. 2008. Measuring the Effectiveness of Protected-Area Networks in Reducing Deforestation. *Proceedings of the National Academy of Sciences* 105(42): 16089-16094.

Blackman, A., A. Pfaff, J. Robalino, and Y. Zepeda. 2009. *Mexico's Natural Protected Areas: Enhancing Effectiveness and Equity.* Interim Narrative Report to the Tinker Foundation. Washington, DC: Resources for the Future.

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Robalino, J., A. Pfaff, G.A. Sánchez-Azofeifa, F. Alpízar, C. León, and C.M. Rodríguez. 2008. *Deforestation Impacts of Environmental Services Payments: Costa Rica's PSA Program 2000–2005.* Environment for Development Discussion paper 08-24.Washington, DC: Resources for the Future.

Taking the Measure of Forest Carbon

Transactions in forest carbon credits could constitute a market of several billion dollars annually and involve potentially large transfers of wealth among nations. This emerging market is generating a demand for reliable information on the size and condition of global forests and forest carbon assets.

Prior to the Copenhagen conference on climate change, scholars at RFF released a major analysis using the best currently available data on global forests. The Forest Carbon Index integrates existing quantitative data relating to biological, economic, investment, and market readiness conditions to illuminate the geography of potential forest carbon offsets.

Weaknesses and data gaps certainly make this process more challenging. But efforts to reduce emissions from deforestation and degradation (REDD) are moving forward because they potentially offer a rapid and cost-effective response to global greenhouse gas emissions.

"The index provides decisionmakers high-level insights regarding how forest offset programs should be targeted, enabling policy to move forward," says Nigel Purvis, an RFF visiting scholar and president of Climate Advisers, who led the project. "As data improve, the potential for the index will increase in kind."

The index brings together, for the first time, 21 datasets at the national scale and six datasets at a gridded subnational scale, integrated and mapped across approximately 1.5 million locations at a resolution of 85.5 square kilometers.

Andrea Cattaneo, a senior scientist at the Woods Hole Research Center who works on tropical deforestation issues, lauded the effort to *Science* magazine. "One of the challenges overcome by the [index] is combining data that are available only at different scales.... This is a welcome addition and is nicely complementary with existing work."

Key Findings

"The average price of forest carbon emissions reductions through 2020 will be slightly more than half of projected carbon prices in developed nations' saving at least $40 billion over this period," says Purvis. "Tropical forests can provide one-quarter of needed climate solutions through 2020."

Based on a rigorous geospatial analysis, the index suggests a range of short- to long-term strategies by which tropical forests can be instrumental in achieving emissions reduction targets:

- In the near term, the focus should be primarily on Brazil, the Amazon-Andes, and Malaysian Borneo, which all have relatively good governance, high profit potential, and significant deforestation.
- By 2020, forest carbon activities should expand to include Indonesia.
- Public-sector investments are needed to build capacity in poorly governed regions and to avoid shifting deforestation to areas of large intact forest, such as nations in the Congo Basin in Africa.

Building Blocks of the Index

The Forest Carbon Index combines estimates of a country's profit potential and risk factors to generate a score of each nation's potential to attract forest carbon investment.

The profit potential is calculated by subtracting the expected cost of managing a piece of land for forest carbon from expected forest carbon revenues. The index measures profit potential by looking at biological and economic factors.

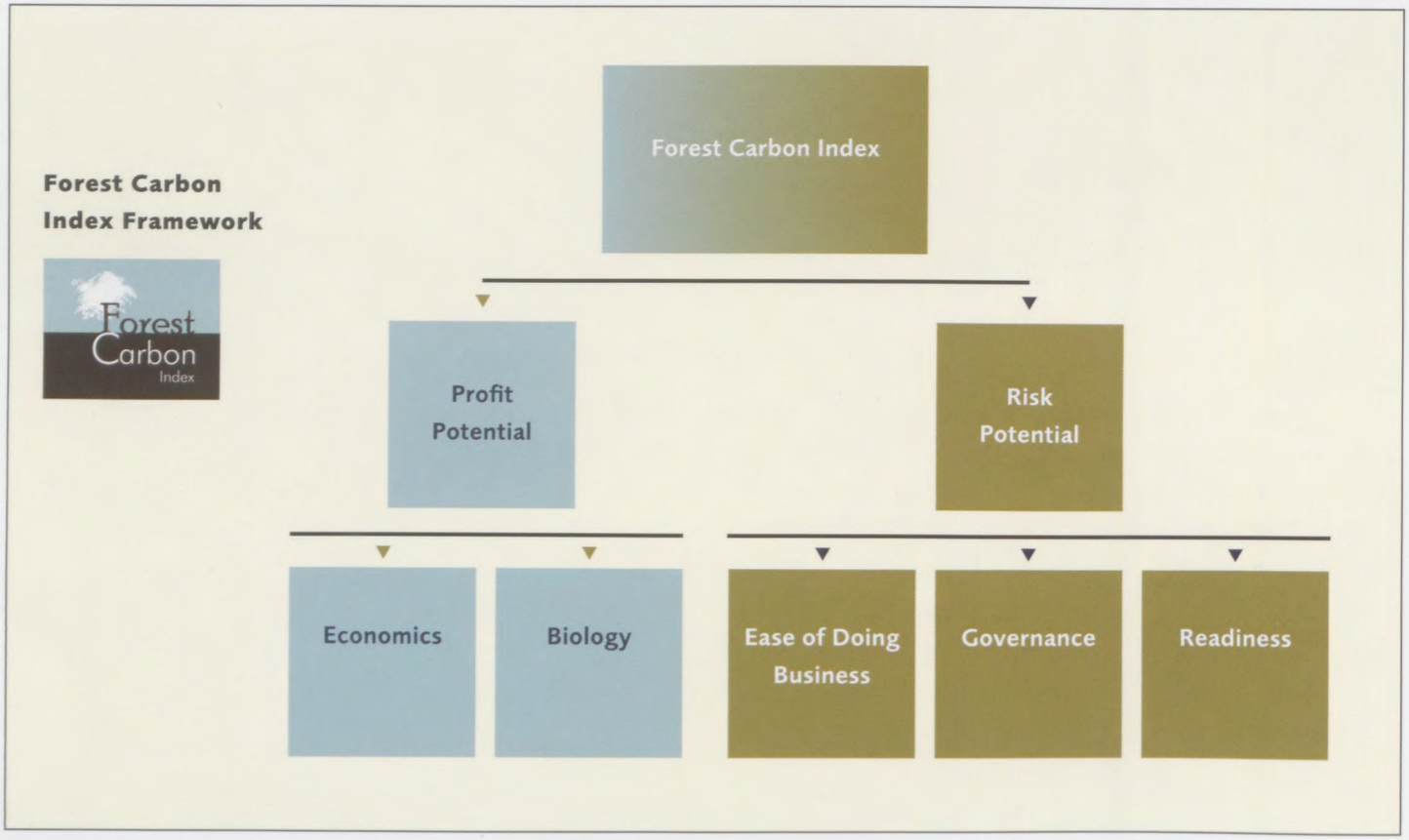
The index discounts raw profit potential by taking into account the institutional, technical, and political risks within a country. It incorporates widely accepted data from the World Bank about governance conditions (including corruption) and the ease of doing business. (The diagram below displays the framework of the index.)

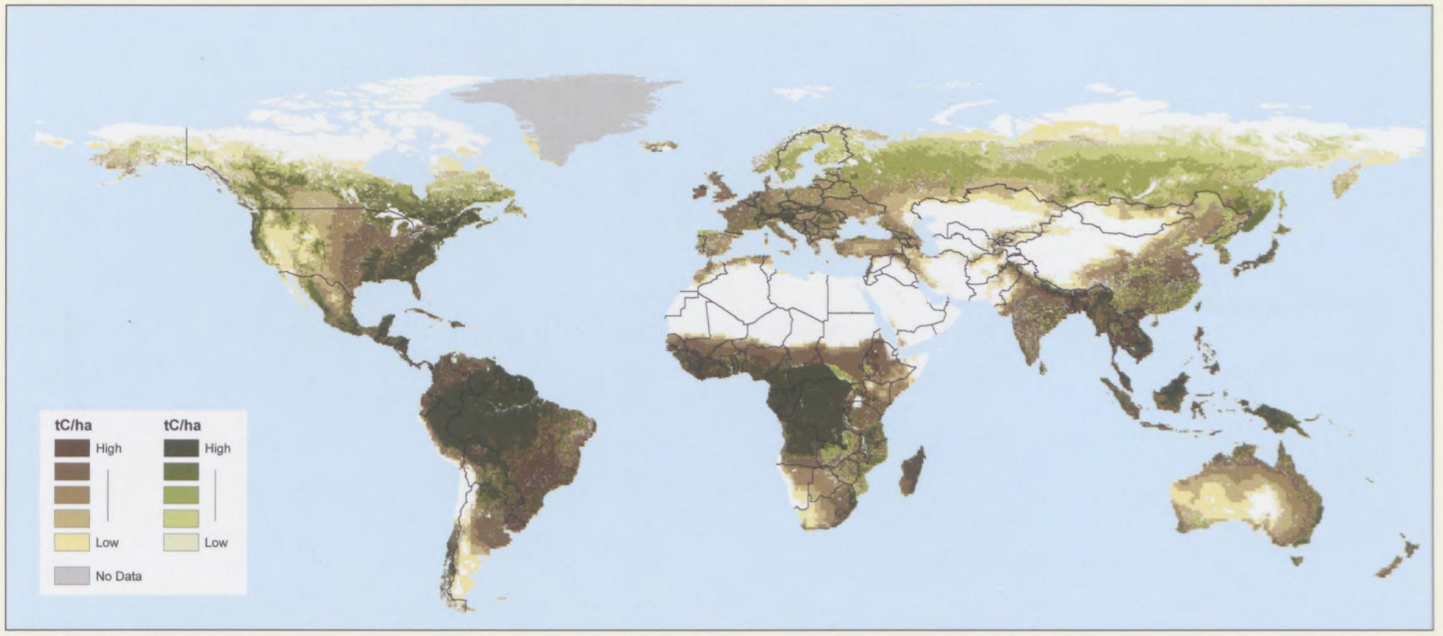
These factors are all combined to create a single index that provides a relative ranking comparing countries and specific locations for their relative capacity to supply forest carbon credits. The results are presented in maps to illustrate the potential geography of forest carbon and in tables to show the estimated costs, quantities, and revenues from forest carbon. ■

To Learn More You can find the *Summary for Policymakers* and the full report, *Forest Carbon Index: The Geography of Forests in Climate Solutions,* at www.forestcarbonindex.org. There, you will also be able to access four interactive maps that allow you evaluate factors like profit potential against location.

The index is part of the Forest Carbon Initiative of RFF's Center for Climate and Electricity Policy, which is funded by contributions from individuals, corporations, government agencies, and foundations.

The center received grants from the Doris Duke Charitable Foundation, the David and Lucile Packard Foundation, and the Simons Foundation, as well as a special gift from the Center for Environmental Markets at Goldman Sachs to support the Forest Carbon Initiative. Support for the dissemination of this research was provided by the United Nations Foundation.





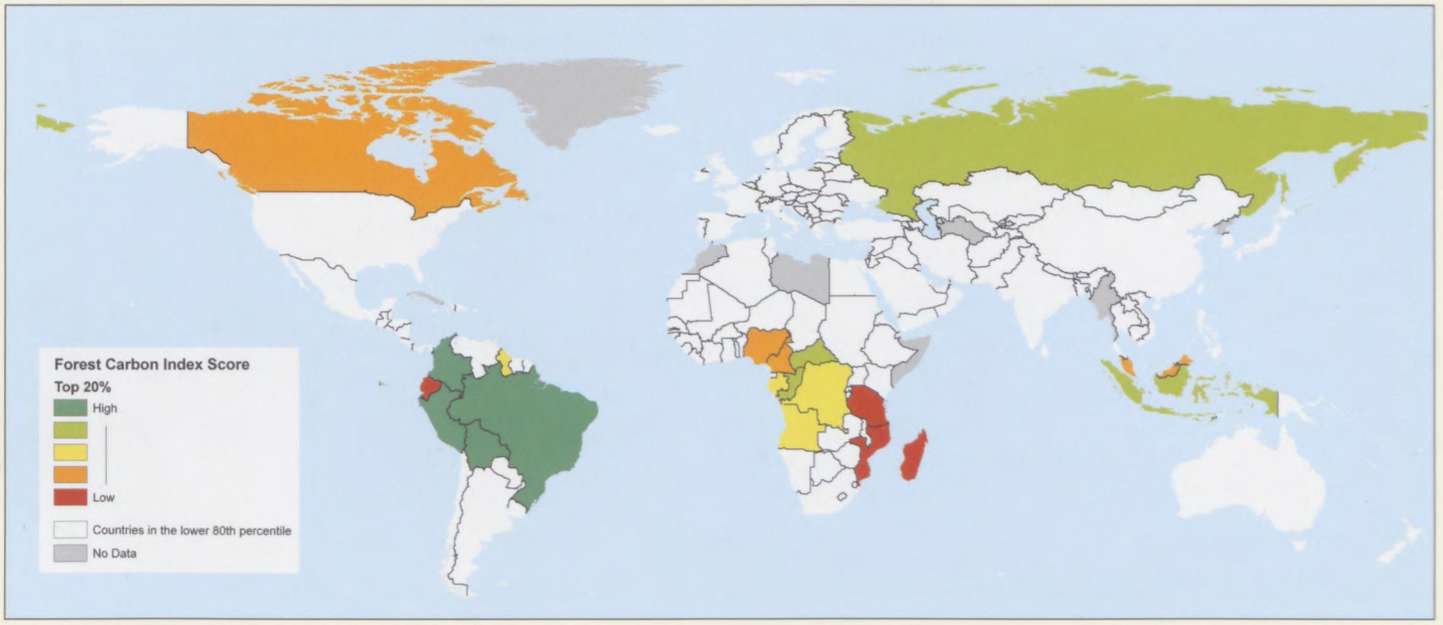
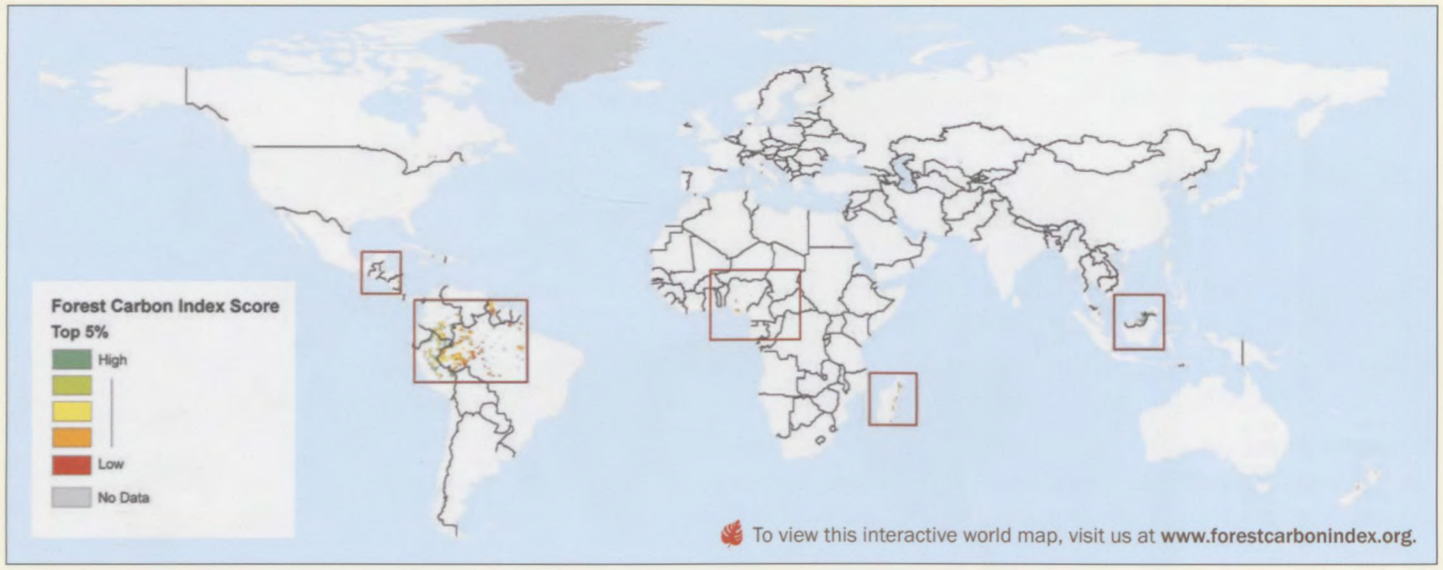


Figure 1. Aboveground Carbon Stocks

Top: Of the Earth's entire land mass, 85 percent has the potential to be managed for forest carbon. The Earth's soils hold great quantities of carbon, methane, and other greenhouse gases and may have the potential to store even more under the right management conditions. Significant uncertainties exist about current soil data.

Figure 2. Country-Level Forest Carbon Index Scores

Bottom: The geography of Forest Carbon Index scores at the national level shows that tropical countries generally do the best, even after taking into account risk factors. The Forest Carbon Index also provides highly site-specific local information to guide decisionmaking.



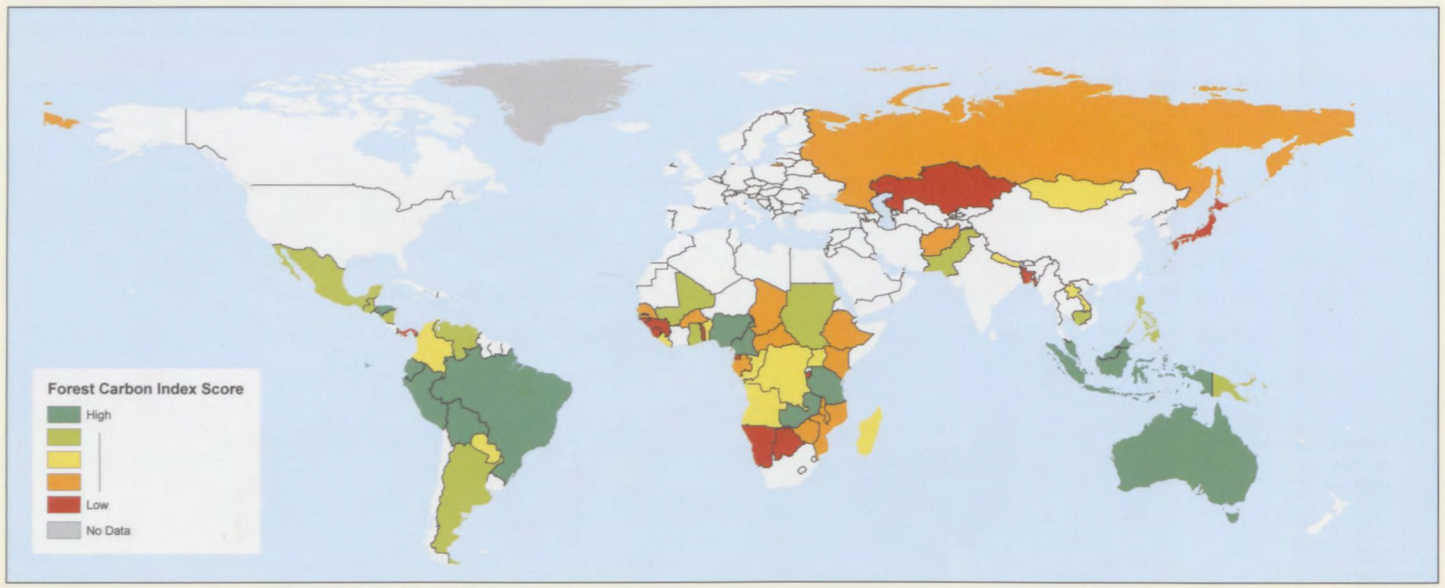
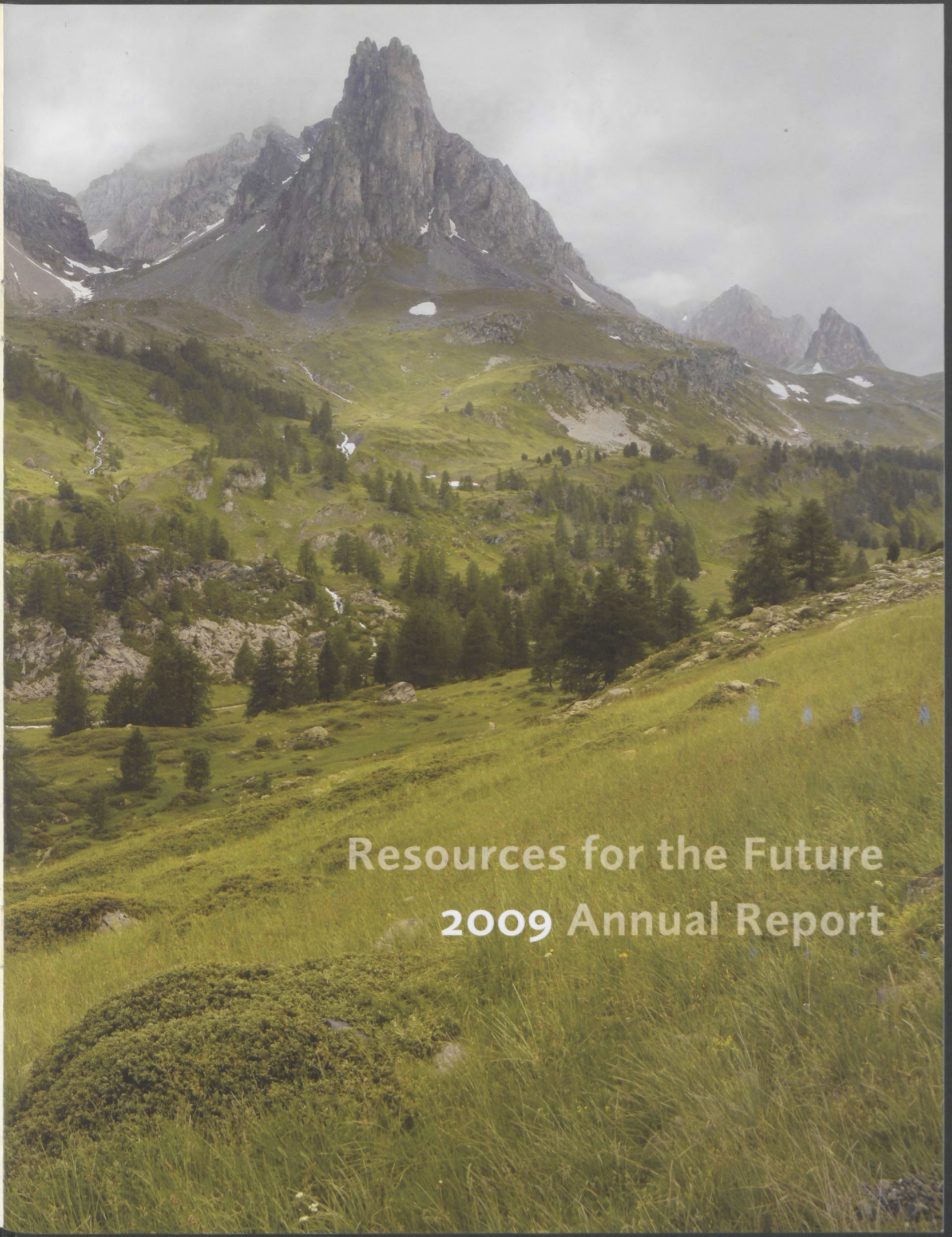


Figure 3. **Best Places for Early Investments at the Local Level**

Top: The Forest Carbon Index predicts how much a country or place will contribute to the global effort to conserve and manage forests to mitigate climate change by discounting theoretical profit potential by risk. This map highlights the 5 best places in the world for early forest carbon returns.

Figure 4. **Taking Deforestation into Account**

Bottom: This map incorporates existing deforestation rates to better predict the geography of forest carbon investment in the medium term. Brazil emerges as the best place for forest carbon investments, and Amazon-Andes countries stand out as well. But Indonesia, as a result of rapid deforestation, moves to second place behind Brazil. Australia has many opportunities to offset its industrial emissions by conserving and growing domestic forests. Countries in West and East Africa with high deforestation rates, from Nigeria and Cameroon to Tanzania and Zambia, also come to the fore.



Resources for the Future
2009 Annual Report

A Message from the President and Chairman

Resources for the Future's unique role in bringing the very best research and scholarship to bear on pressing policy challenges was the common thread in our many successes this year. The value of an institution that can be counted on for ideas and information free of political and intellectual agendas has never been greater. Perhaps most gratifying was to see ideas developed at RFF incorporated into a host of new policy proposals.

- The climate legislation passed in the House of Representatives contains key provisions that draw on RFF research, including the allocation of emissions allowances and the treatment of trade-exposed industries. Additionally, RFF work on price collars and safety valves, two important climate policy tools, influences some of the provisions in the bill and has been adopted in proposals currently being considered in the Senate.

- The Department of Interior announced its "Building a Great Outdoors America" agenda, following the release of *Great Outdoors America,* a report by the bipartisan Outdoor Resources Review Group that was informed by a major RFF research effort.

- In another demonstration that good ideas eventually find their way into policy, the White House's new budget includes competitive grants to support ocean zoning, an idea presented in the RFF book *New Approaches on Energy and the Environment: Policy Advice for the President,* published in 2004.

- The Global Fund to Fight Aids, Tuberculosis, and Malaria committed $225 million to a new international partnership to place affordable life-saving malaria drugs within reach of millions of at-risk citizens worldwide, especially children. The new initiative is designed to delay the rise of resistance to a new generation of antimalarials and is based on work carried out by scholars at RFF's Center for Disease Dynamics, Economics and Policy.

PHILIP R. SHARP
PRESIDENT

LAWRENCE H. LINDEN
CHAIR

In parallel with these milestones, the demand for RFF's research increased, evidenced by growing requests for testimony, participation in government panels, and informal briefings for the legislative and executive branches. Over the past year, we also saw RFF alumni Richard Newell, Joseph Aldy, Michael Taylor, and Shalini Vajjhala take key positions in the federal government. One example of the reach of our work can be found in the most recent *Economic Report of the President,* which cited three RFF studies in the chapter on environmental policy.

RFF also strengthened its convening role with seminars that brought together policymakers, experts, and the interested public. Our First Wednesday Seminars and Policy Leadership Forum series drew capacity crowds for discussions on topics like climate adaptation policy, tensions between the development of renewable energy and the preservation of open space, the link between forests and climate policy, and how to properly account for the risks posed by natural disasters. We also cohosted a highly successful conference with the Society of Risk Analysis on new ideas for risk regulation as well as a confer-

ence on the distributional impacts of energy policy, cosponsored with the University of Chicago and the University of Illinois.

In order to activate the potential of RFF's research, we also moved forward in communicating our research findings and expertise. Our researchers pushed the intellectual frontier with contributions in top scholarly journals. We invigorated Weathervane, RFF's digital forum on climate policy as a blog, and created new stand-alone websites for our Forest Carbon Index and Adaptation Atlas. In addition, we entered into a partnership with the successful publisher Earthscan to increase the reach of RFF Press, our book-publishing arm, and continued an important partnership with Environment for Development, a research consortium with centers in China, Central America, and Africa.

To ensure that RFF maintains a presence and delivers insights on some of the most critical issues of our time, we also made significant investments in our future impact through the creation of three new centers on health, ecosystems, and climate and electricity policy:

- The newly created Center for the Management of Ecological Wealth's mission is to increase well-being though improved management of our ecosystems and other natural resources, given that natural systems are central, complex, and increasingly threatened sources of wealth and well-being to people.
- We have integrated our successful programs on climate policy and electricity policy into the new Center for Climate and Electricity Policy, which will continue to provide analysis and insight on policy options for climate change policy and the ongoing transformation of the nation's electric-power sector.
- The Center for Disease Dynamics, Economics and Policy is bringing together economists, epidemiologists, legal scholars, and experts from other disciplines to develop novel approaches to understanding and crafting policy solutions to urgent global health challenges.

Lastly, we achieved a key institutional goal by exceeding our funding targets for the past year. In the current climate, this is a remarkable achievement, one that everyone associated with RFF can take justifiable pride in. Of course, this success, as with all the others we enjoyed this year, would not have been possible without RFF's many generous supporters. We are extremely grateful for this support and looking forward to the year ahead.

Philip R. Sharp, *President*
Resources for the Future

Lawrence H. Linden, *Chair*
Founder and Trustee
Linden Trust for Conservation and
Retired Partner, Goldman Sachs

At RFF, we like numbers. When you turn the page, you'll see an array of noteworthy 2009 statistics—the extraordinary number of people who now access our findings on the web, the diverse countries we involve in our work, and our steady output of research papers, books, and testimony on current issues.

The rigorous inquiry behind those numbers is driven by the application of tools and methodologies to real-world resource issues through a legacy that inculcates collaboration, innovation, dissemination, and public engagement. Our scholars influence policy and the world of ideas through relevant, cutting-edge research, service on government panels, formal and informal meetings with policymakers, and the communication of our expertise and ideas.

A commitment to quality and relevance

We believe that addressing crucial global challenges requires the very best research and scholarship. We expand the intellectual frontier through contributions to top scholarly journals like the *American Economic Review*, the *Journal of Economic Literature*, *Proceedings of the National Academy of Science*, *Risk Analysis*, and *Science*. Our researchers serve on prestigious scientific panels looking at questions such as social costs associated with the use of fossil fuels, food safety, and the threats from deadly species-crossing microbes.

In 2009, we initiated major research projects addressing key environmental and natural resource issues. At the UN climate negotiations in Copenhagen, RFF unveiled two significant web-based tools—the Forest Carbon Index and the Adaptation Atlas. A major research report, entitled *The State of the Great Outdoors*, delved into the status of America's outdoor resources, the demand for recreational venues, and the financing of conservation, open parks, and open space. And we continued major efforts on U.S. climate and energy policy, climate adaptation, global forests, antibiotic resistance, and improving regulatory policies.

A respected convener

RFF provides a dispassionate setting for policy deliberations—both in public forums and internal workshops. In 2009, our Policy Leadership Forum series hosted Senator Lamar Alexander for an address on energy and open space. The annual Hans Landsberg Lecture was delivered by Rosina Bierbaum, dean of the School of Natural Resources and Environment at the University of Michigan.

RFF's First Wednesday Seminars continue the longest-running environmental policy series in the nation, and this year included sessions on risk regulation, distributional impacts of climate policy, and international trade and climate. The exchanges that occur in these gatherings play an important role in maintaining RFF's reputation as a crucible in which ideas are tested.

Making our voices heard

Our primary goal as a research institution is to improve environmental and natural resource policymaking worldwide. New communication vehicles like Weathervane, RFF's climate policy blog, provide accessible and reader-friendly discussion of important research and policy issues. Of course, one of the most important forums for presenting our findings is before Congress. In 2009, several RFF scholars were asked to testify about critical matters pertaining to proposed and current legislation:

Costs and Benefits for Consumers and Energy Price Effects Associated with the Allocation of Greenhouse Gas Emissions Allowances

Karen L. Palmer

U.S. Senate Committee on Energy and Natural Resources

An Economic Assessment of Eliminating Oil and Gas Company Tax Preferences

Stephen P.A. Brown

U.S. Senate Finance Subcommittee on Energy, Natural Resources and Infrastructure

What We Do

Climate Change Legislation: Allowance and Revenue Distribution
Dallas Burtraw
U.S. Senate Committee on Finance

Addressing Price Volatility in Climate Change Legislation
Dallas Burtraw
U.S. House of Representatives Committee on Ways and Means

Competitiveness and Climate Policy: Avoiding Leakage of Jobs and Emissions
Richard D. Morgenstern
U.S. House of Representatives Energy and Commerce Subcommittee on Energy and Environment

Protecting Lower Income Families While Fighting Global Warming
Dallas Burtraw
U.S. House of Representatives Committee on Ways and Means Subcommittee on Income Security and Family Support

Researchers worked in more than **30** countries during 2009.

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United Arab Emirates
Vietnam

14,000 people receive *Resources*, RFF's free quarterly magazine.

An Index of RFF Activities

23 Issue Briefs, Reports, and Backgrounders were distributed widely at conferences and RFF events.

49 Discussion Papers, on research work in progress, were published.

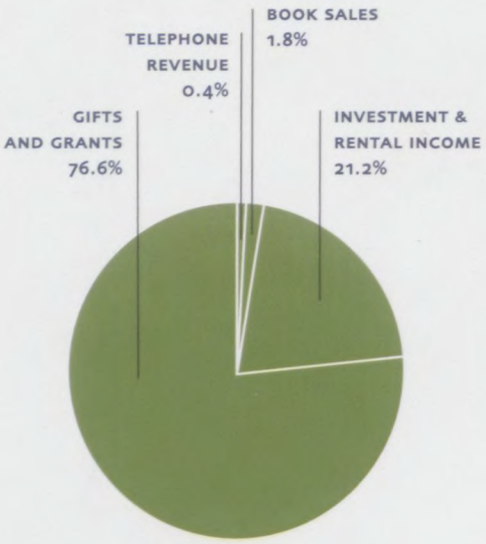
Over **1,600** people came to events held here at RFF and abroad.


45 Weekly Policy Commentaries were posted online.
Nearly 1.5 million page views were logged on the RFF website.
5 new researchers from leading universities joined the research staff and
4 more current and former RFFers joined the administration.
7,000 people receive *RFF Connection*, RFF's monthly e-newsletter highlighting news, publications, and events.
Visitors from 212 countries, ranging from Canada to China, found critical insights on the RFF website.
58 articles were published in peer-reviewed journals.
16 workshops and First Wednesday Seminars were held here at RFF and abroad.
4 books were published by RFF Press.
2 Blogs: WEATHERVANE provides comprehensive coverage of environmental and economic aspects of global climate change policy. EXTENDING THE CURE offers commentary and news coverage regarding antibiotic effectiveness.

Financial Statements

REVENUE

In fiscal year 2009, RFF's operating revenue was $13.1 million, 76.6 percent of which came from individual contributions, foundation grants, corporate contributions, and government grants. RFF augments its income by an annual withdrawal from its reserve fund to support operations. At the end of fiscal year 2009, the reserve fund was valued at $25.3 million.



ASSETS YEAR ENDING SEPTEMBER 30	2009	2008
CURRENT ASSETS		
Cash and cash equivalents	$ 70,171	$ 225,425
Grants and contract revenue receivable	1,658,419	947,390
Contributions receivable	464,850	529,767
Other receivables	103,127	44,058
Other assets	299,614	676,928
Total current assets	**$ 2,596,181**	**$ 2,423,568**
Contributions receivable, net of current portion	**$ 358,370**	**$ 358,370**
INVESTMENTS		
Investments at fair value	25,315,900	26,779,483
Investment in land	8,900,000	8,900,000
Investment in RCC	3,753,475	4,184,876
Total investments	**$ 37,969,375**	**$ 39,864,359**
Fixed assets–net of accumulated depreciation	6,575,400	6,844,776
Assets held under charitable trust agreements	319,122	355,779
TOTAL ASSETS	**$ 47,818,448**	**$ 49,846,852**

LIABILITIES AND NET ASSETS YEAR ENDING SEPTEMBER 30	2009	2008
CURRENT LIABILITIES		
Tax-exempt bond financing, current portion	$ 215,000	$ 210,000
Grants and awards payable	45,000	20,250
Accounts payable and accrued liabilities	2,273,359	2,017,406
Deferred revenue	159,031	106,224
Total current liabilities	**$ 2,692,390**	**$ 2,353,880**
Tax-exempt bond financing, net of current portion	6,130,000	6,345,000
Liabilities under split-interest agreements	347,484	384,810
Funds held for others	37,414	48,899
Total liabilities	**$ 9,207,288**	**$ 9,132,589**
NET ASSETS		
Unrestricted	29,055,717	31,953,005
Temporarily restricted	3,632,536	2,845,763
Permanently restricted	5,922,907	5,915,495
Total net assets	**$ 38,611,160**	**$ 40,714,263**
TOTAL LIABILITIES AND NET ASSETS	**$ 47,818,448**	**$ 49,846,852**

EXPENSES

RFF research and educational programs continued to be vital in 2009, representing 76.7 percent of total expenses. Management and administration, and development expenses combined were 15.4 percent of the total. The balance is related to facilities rented to other nonprofit organizations.

STATEMENT OF ACTIVITIES YEAR ENDING SEPTEMBER 30	2009	2008
	658,570	$ 465,559
	4,643,937	1,993,928
	1,383,377	2,011,001
	1,830,065	2,016,661
	1,521,149	1,451,450
	2,700,292	2,584,937
	81,224	382,165
	51,756	89,680
	231,852	201,386
	3,102,222	**$ 11,196,767**
	10,075,476	$ 8,301,918
	242,606	192,838
	540,524	531,678
	1,216,155	1,071,225
	152,271	203,236
	2,227,032	**$ 10,300,895**
	820,123	649,236
	1,639,529	1,687,278
	1,267,403	1,238,104
	5,954,087	**$ 13,875,513**
	(2,851,865)	(2,678,746)
	748,762	(9,769,996)
	(2,103,103)	(12,448,742)
	40,714,263	53,163,005
	43,611,160	**$ 40,714,263**

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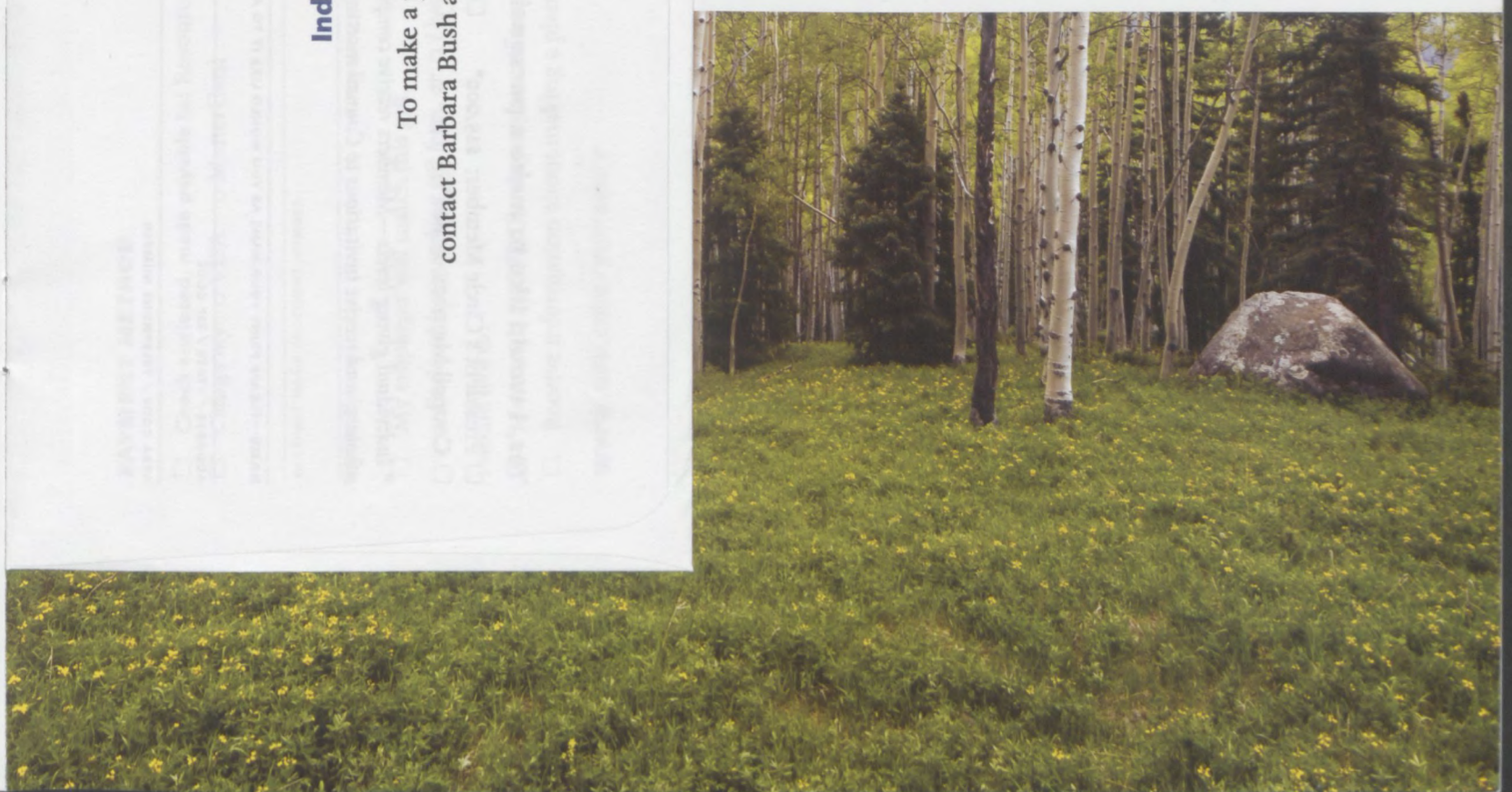

Financial Statements

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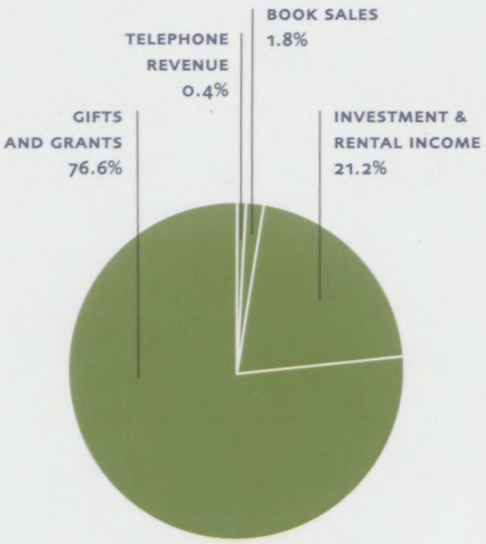

EXPENSES

RFF research and educational programs continued to be vital in 2009, representing 76.7 percent of total expenses. Management and administration, and development expenses combined were 15.4 percent of the total. The balance is related to facilities rented to other nonprofit organizations.

ASSETS YEAR ENDING SEPTEMBER 30	2009	2008
CURRENT ASSETS		
Cash and cash equivalents		
Grants and contract revenue r		
Contributions receivable		
Other receivables		
Other assets		
Total current assets		
Contributions receivable, r		
INVESTMENTS		
Investments at fair value		
Investment in land		
Investment in RCC		
Total investments		
Fixed assets–net of accumulat		
Assets held under charitable t		
TOTAL ASSETS		
LIABILITIES AND NET AS		
CURRENT LIABILITIES		
Tax-exempt bond financing, c		
Grants and awards payable		
Accounts payable and accrue		
Deferred revenue		
Total current liabilities		
Tax-exempt bond financing, n		
Liabilities under split-interest a		
Funds held for others		
Total liabilities		
NET ASSETS		
Unrestricted		
Temporarily restricted		
Permanently restricted		
Total net assets		
TOTAL LIABILITIES AND N		

DEVELOPMENT

BUILDING OPERATIONS 7

MANAGEMENT AND ADMINISTRATION 10

RESEARCH PROGRAMS 76

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1616 P Street, NW
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FIRST CLASS POSTAGE REQUIRED

STATEMENT OF ACTIVITIES YEAR ENDING SEPTEMBER 30	2009	2008
CHANGES IN UNRESTRICTED NET ASSETS		
REVENUE		
Individual contributions	$ 658,570	$ 465,559
Foundation grants	4,643,937	1,993,928
Corporate contributions	1,383,377	2,011,001
Government grants and contracts	1,830,065	2,016,661
Other institution grants	1,521,149	1,451,450
Rental income	2,700,292	2,584,937
Investment income net of fees	81,224	382,165
Telephone revenue	51,756	89,680
Book sales	231,852	201,386
Total operating revenue	**$ 13,102,222**	**$ 11,196,767**
EXPENSES		
Programs		
Research	$ 10,075,476	$ 8,301,918
Academic Relations	242,606	192,838
RFF Press	540,524	531,678
Communications	1,216,155	1,071,225
Other direct	152,271	203,236
Total program expenses	**$ 12,227,032**	**$ 10,300,895**
Fundraising	820,123	649,236
Management and administration	1,639,529	1,687,278
Building operations and maintenance	1,267,403	1,238,104
Total functional expenses	**$ 15,954,087**	**$ 13,875,513**
Change in unrestricted net assets from operations	(2,851,865)	(2,678,746)
Non-operating revenues		
Realized and unrealized losses on investment transactions	748,762	(9,769,996)
INCREASE (DECREASE) IN UNRESTRICTED NET ASSETS	(2,103,103)	(12,448,742)
NET ASSETS AT BEGINNING OF YEAR	40,714,263	53,163,005
NET ASSETS AT END OF YEAR	**$ 38,611,160**	**$ 40,714,263**

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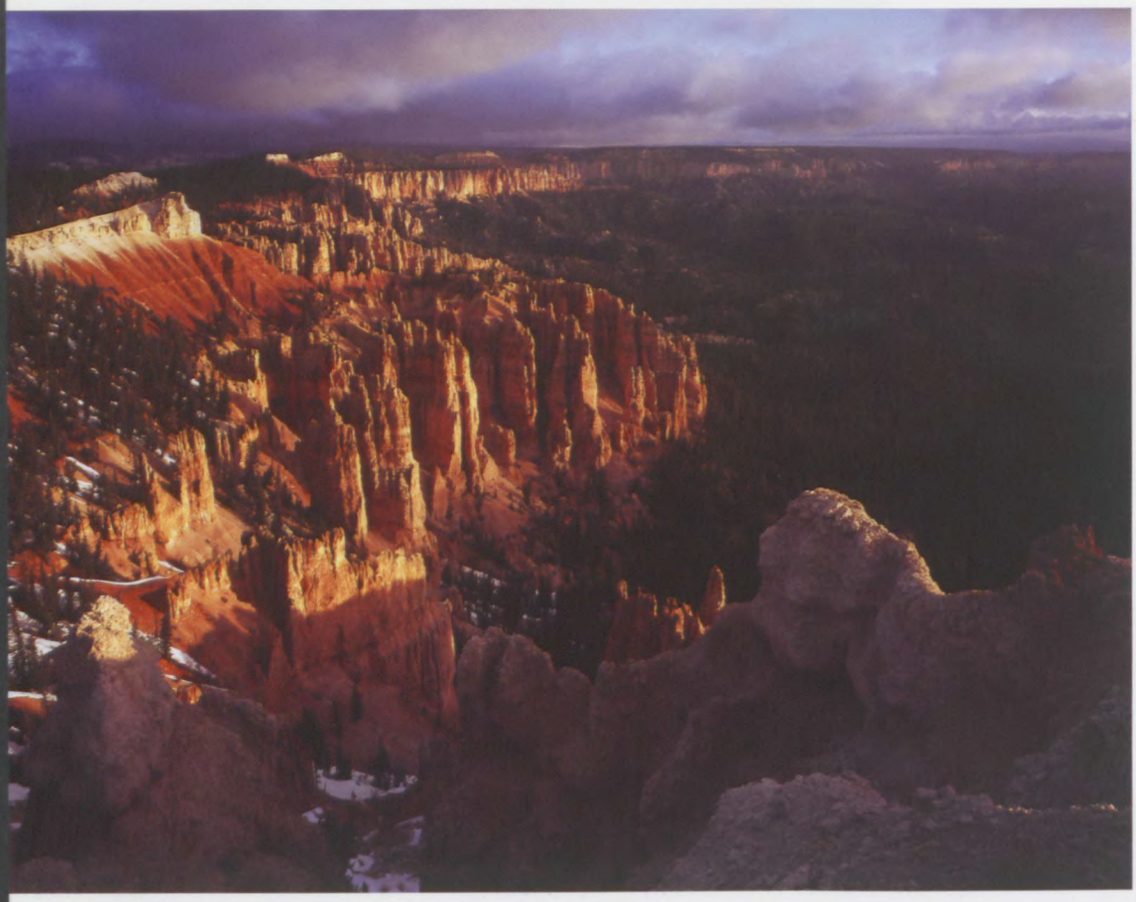

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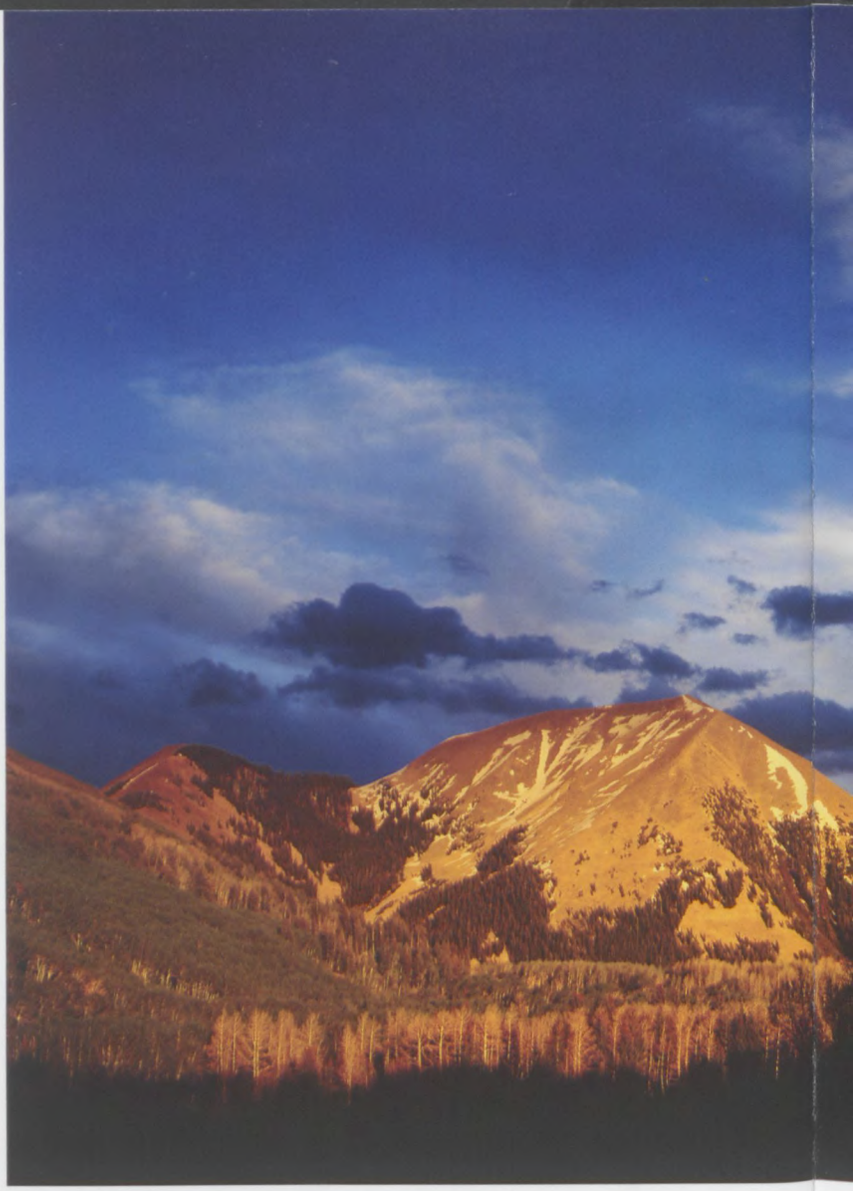

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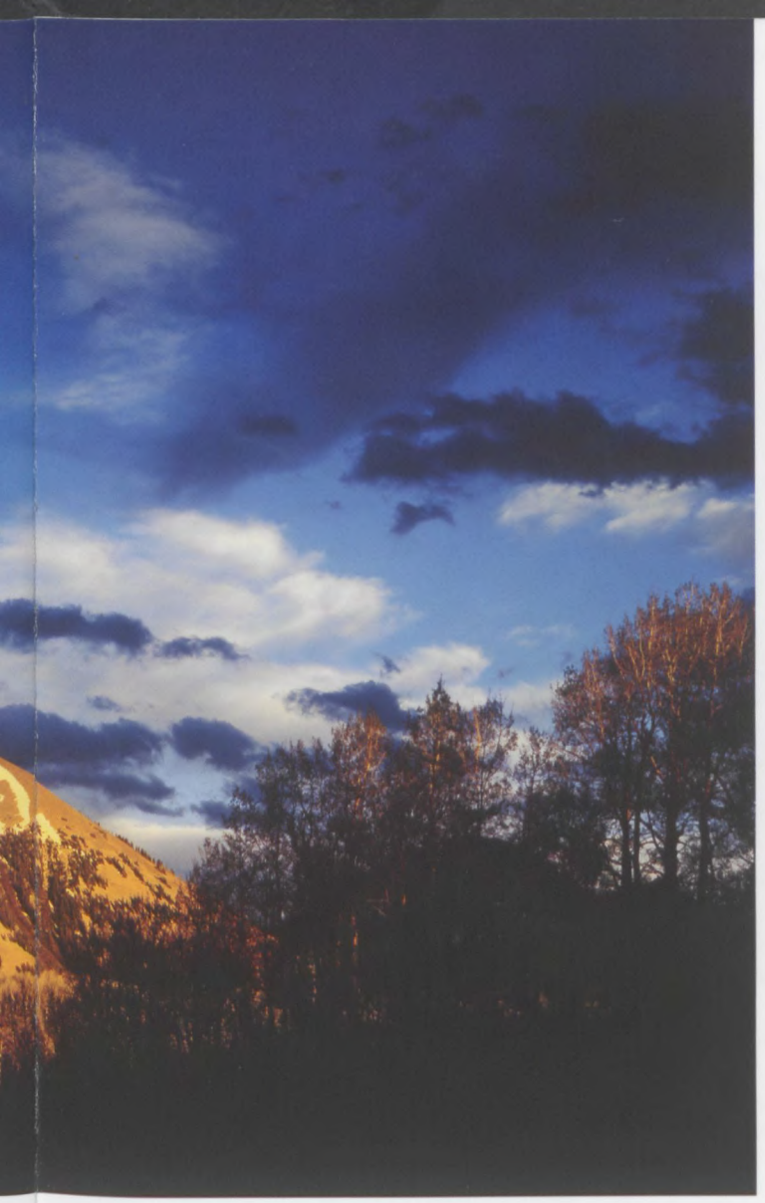

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Why We Need Accurate Maps of the World's Forests

Daniel Morris, Molly K. Macauley, and Roger A. Sedjo

Forests are playing a starring role in ongoing international climate negotiations because curbed deforestation and forest degradation are considered some of the lowest-hanging fruit available to reduce global greenhouse gas emissions. Policymakers, however, have their work cut out for them because data are often ad hoc, imprecise, and inadequate. Today, there are higher-resolution maps of the Moon and Mars than of Earth's forests.

Outlining the total area coverage of forests is difficult because there are myriad definitions of what actually constitutes a forest, while no consensus exists about deforestation rates across the globe. As an illustration, the Intergovernmental Panel on Climate Change (IPCC) estimated that emissions from forests in 2007 represented about 17 percent of total international emissions, whereas studies published in fall 2009 estimated a range from 6 to 17 percent.

While the total deforestation picture in tropical forests remains fuzzy, even less attention is paid to reforestation and forest preservation occurring in boreal and temperate forests. Reducing emissions from deforestation and degradation (REDD)—which is strongly dependent on reliable measurement and monitoring—is a prominent aspect of the Bali Road Map, established by the UN Framework Convention on Climate Change (UNFCCC) processes in 2007. REDD was also prominent on the agenda at the UNFCCC Conference of Parties meeting in Copenhagen in December 2009.

Measurement Error

Ambiguous forest measures are the result of nonstandard reporting methodologies and a patchwork of substandard tools and techniques. Nations self-report these data, differ in their political and fiscal priorities regarding accurate assessment, and vary widely in technical capacity to inventory their forests. Data are updated every five years or so and even then are often extrapolated from past trends.

Most uncertainties in measurement manifest in four variables: forest area, timber volume, forest biomass, and carbon. Because these variables are interrelated, uncertainties in their measures compound and potentially result in a final estimate that has significantly more uncertainty than any single variable. Highlighting these discrepancies can help policymakers and practitioners develop robust measurements

that are good enough and consistent enough for all stakeholders interested in forests.

New RFF research documents major discrepancies in forest measures across the globe. For example, El Salvador's forested land shrank 14 percent from 1990 to 2000 according to a UN Food and Agriculture Organization (FAO) assessment, but another study reported that dense forested land area expanded 25 percent in the same time period. The figures below show disagreements between forest surveys on deforestation hot spots and illustrates the gaps among global forest datasets. Even measurement best practices approved by the IPCC, currently the most authoritative source on climate science, are not without measurement uncertainties.

The purpose of pointing out these discrepancies is not to develop perfect measurement of forests, but rather to develop measurements that are good enough and consistent enough for parties interested in forests. These measurements have to be sound for scientific debates, timber sales, and carbon credits. From there, economical methods for meeting them must be established.

Existing and Emerging Technologies

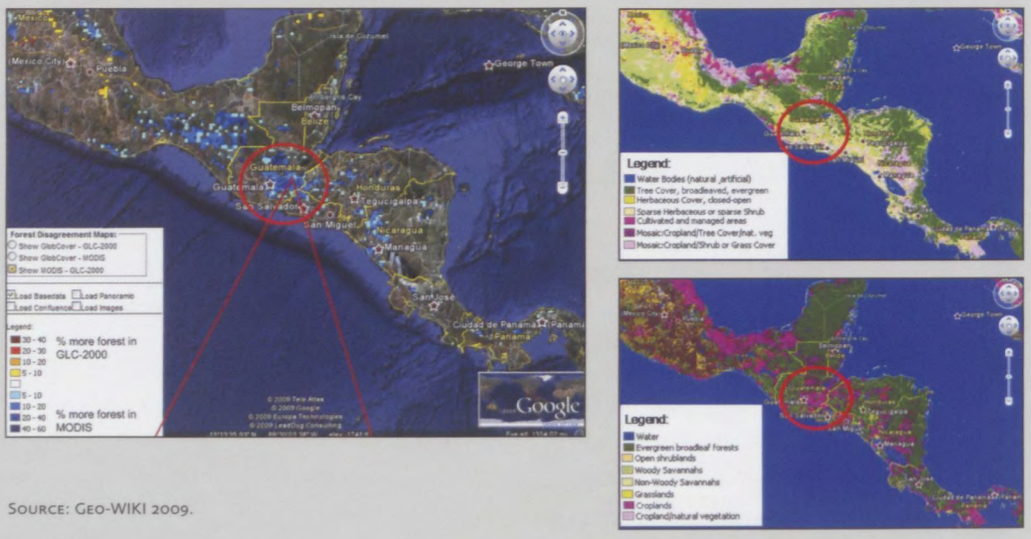
Satellite technology has recently advanced to a point where it can improve the reliability and accuracy of measures of different forest attributes. Monitoring programs have been using satellite data since the U.S. Landsat program got off the ground in the early 1970s. Landsat is the longest continuously operating satellite remote-sensing system in the world, and many organizations, including the UN FAO, incorporate Landsat data into forest assessments, partially

Measuring and Monitoring the World's Forests

One significant lesson from the recent financial crisis is the need for institutions that are transparent and can be monitored effectively. The world's forests, on which many people in poor and developing countries depend, suffer from a similar lack of oversight institutions that can accurately and regularly report their status. As environmental conservation and climate change help focus the international policy community's attention on forest ecosystem issues, the current inability to answer the question "What is the current state of the world's forests?" becomes more troubling.

In 2009, RFF scholars Roger Sedjo and Molly Macauley, with support from the Alfred P. Sloan Foundation, embarked on a project to begin answering that very question. Together with forestry and remote-sensing experts from across the globe, they began a major research initiative to investigate the economic, technical, and institutional issues associated with improving global forest measurement and monitoring.

The project focuses on three major issues: major discrepancies in current forest accounting and measurements, the technical capabilities of remote-sensing technologies, and the level of accuracy and precision required for forest measurements to be useful for scientists, policymakers, and practitioners.



Forest cover from Mexico to Panama classified by GLC2000 (far left) and by MODIS (left, top and bottom) and the disagreement between them. The red circle identifies a hot spot of disagreement in Guatemala and El Salvador.

SOURCE: GEO-WIKI 2009.

because it remains the least expensive option.

Despite Landsat's obvious benefits, the availability of its data in the future is in question due to federal budgetary limits. Additionally, newer technologies can provide more accurate and more complete monitoring coverage, though at present, at a much higher price. Recent improvements in analytical techniques for distinguishing distinct land cover and the combination of different types of satellite imagery can generate forest maps that are 80 to 90 percent accurate.

Encouraging technical progress is not limited to optical satellite sensors, such as those on Landsat. Other technologies, such as radar and LIDAR (light detection and ranging) also show great promise. LIDAR scans are conducted by sending laser pulses to the ground and measuring the returning radiation to penetrate the forest canopy, facilitating three-dimensional accuracy. Such data could provide unprecedented accuracy and understanding of forest area, volume, and biomass. The ability of LIDAR to measure both forest canopy height and ground elevation can increase accuracy in measurement of volume by at least 80 percent.

Unfortunately, LIDAR's potential is limited because at present, the remote-sensing equipment is carried on an airplane. This approach drives up expense and does not guarantee global coverage. Airborne LIDAR can collect only a narrow swath of information on one pass, much smaller than one pass from a satellite; moreover, flights require permission to fly over a country's airspace. Right now, radar technology is only a small part of the satellite fleet, and the first satellite-based LIDAR is not scheduled to be launched until 2015 or later.

Despite some shortcomings, new global satellite measurement and monitoring capabilities hold promise for providing accurate, periodic, and cost-effective global forest datasets. Satellite technology's unique advantages include the potential for improvement in temporal and spatial resolution, standardized measurement protocols, regularly updated global observations, and transparent, replicable methodology. Any regime for advanced data collection will need to be buttressed and validated with extensive "ground-truthing" (through field surveys, for example) and supported by proper institutions to enable accurate global monitoring of forests.

The global reach and frequent coverage enabled by the space-based vantage point of satellites may assist in providing information to monitor several concerns associated with use of forest carbon as part of climate policy. Satellite observations from Landsat may provide a historic baseline from which to measure changes in forested acreage. Accurate baselines are important for addressing additionality, which refers to actions that are taken to preserve forests in addition to actions that might be taken in the absence of any policy. Satellite observations that are periodic, with at least complete yearly coverage, may help monitor permanence or whether forests intended to serve as offsets are indeed maintained. Moreover, satellites provide global coverage to monitor deforestation that may take

Satellite technology's unique advantages include the potential for improvement in temporal and spatial resolution, standardized measurement protocols, regularly updated global observations, and transparent, replicable methodology.

place in one area in response to avoided deforestation elsewhere, a problem known as leakage.

Solutions and New Institutions

To truly gain understanding of the state of the world's forests, measurements must advance beyond the current system of ad hoc, inconsistent data collection. The ultimate goal of RFF's Measurement and Monitoring of the World's Forests project is to construct a potential framework for developing and conducting a global forest "census," which can provide for the first time an accurate, expansive, and universally accessible database of forest attributes.

Advancing a state-of-the-art forest census will require a strong network of expertise, easily understood and achievable standards, and an international coordinating framework to organize many ongoing data collection and ground-truthing efforts. Recognition of the need for an independent, coordinated institution or set of institutions to gather and manage quality datasets is growing. As early as 2002, the G-8 recognized the desirability of coordinating myriad Earth-observing systems to enhance stewardship of the world's natural and environmental resources.

The G-8's response was to form the Global Earth Observation System of Systems (GEOSS), directed by the Group on Earth Observations (GEO), which has over 75 national governments as members. Coordinating and networking the efforts of GEO, which has a draft forest carbon tracking program in place for 2009 through 2011, with international experts and other organizations active in forest monitoring and measurement will result in major advances in observing the state of forests across the globe.

The timing for these efforts could not be more advantageous. In the lead-up to the 15th Conference of the Parties meetings in Copenhagen, British Prime Minister Gordon Brown emphasized the critical role satellite observations will play in monitoring forest carbon systems established by the COP negotiation process. According to Brown, "...satellite navigation systems are going to be very important to the developing of a forest policy. Either you're planting more forests, of course, which is obvious, you can monitor that; or that what is agreed to be protected is actually protected. And I think we're getting better means by which we can have satellite observance of what's going on." ■

Advancing a state-of-the-art forest census will require a strong network of expertise, easily understood and achievable standards, and an international coordinating framework to organize many ongoing data collection and ground-truthing efforts.

Further Reading

This article is based on work by several contributors to RFF's Measurement and Monitoring of the World's Forests initiative, available at rff.org/worldsforests.

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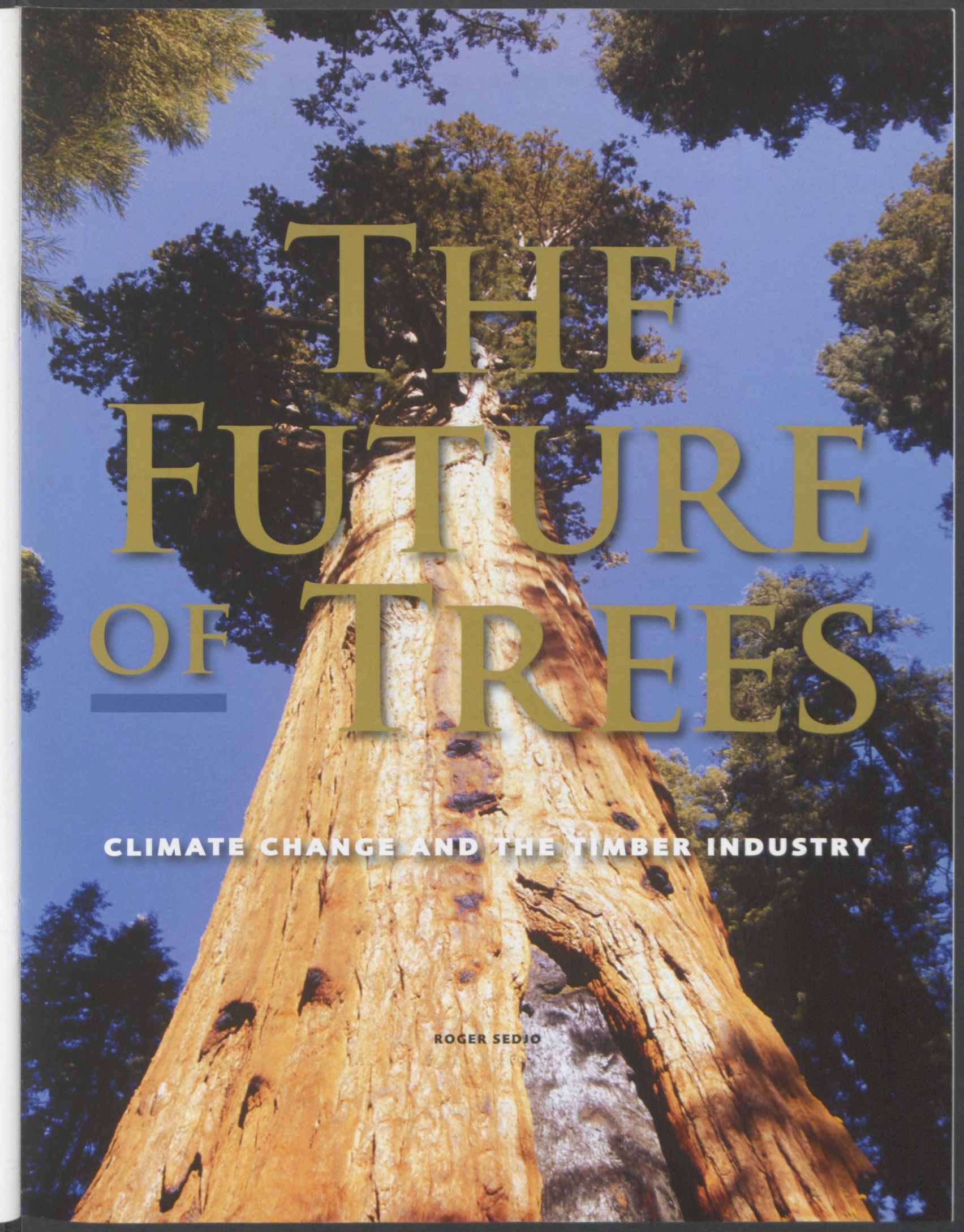
THE FUTURE OF TREES
CLIMATE CHANGE AND THE TIMBER INDUSTRY
ROGER SEDJO

Not all the news on global climate change is gloomy. Global production of industrial timber should increase, even in the face of some regional losses.

In a warming world, global forest area could increase by 5 to 6 percent by 2050. Forest productivity—essentially, the rate at which the trees in the forest grow—is expected to rise. Timber harvests could be 6 percent greater in 2050 than they might have been without warming. In either scenario, forests would colonize unforested regions, and there would be large-scale conversions from some forest types to others. The equatorial region may not change much, but I predict there will be a significant expansion of forests in the high latitudes.

These estimates are based on a report that I recently submitted to the World Bank looking at how the world's forests can be expected to change in a slightly warmer world. My aim was to predict the fate of the worldwide timber industry to the year 2050 if levels of carbon dioxide (CO_2) were to double from those of the late 1990s. To accomplish this, I reviewed the substantial body of climate change literature and used studies that paired two commonly used climate change models (the Hamburg T-106 model and the UIUC model) and an ecosystem model (BIOME$_3$) to provide a starting place for my economic analysis. Although my focus was on global impacts, I also examined some regional cases and suggested steps that the global community might undertake to compensate developing countries for their losses and minimize any future ones they may experience.

Not every forest will thrive, however, and some forests will die back. The fate of individual forests will depend upon the interaction of several variables, including temperature; moisture; and changes in natural disturbances, such as fires and infestations. Some tree species will persist in a region while others will decline.

How Climate Change May Affect Forests

Forecasters predict that the most dramatic increases in temperature will occur in high latitudes. Forests can adapt to undesirable changes in temperature by "migrating" to a more favorable climate. Boreal forests, which prevail in northern latitudes, eventually could possibly replace up to 50 percent of what is now frozen tundra. The temperate forests of the middle latitudes may also expand into lands formerly dominated by boreal forests. These relocated forests will not look exactly like their predecessors, because only some species will thrive and less adaptable species will die off. Temperatures in the equatorial regions should not increase dramatically, so tropical forests will not likely change much if at all.

Migrating forests require more than just an agreeable temperature. They need suitable soil, sufficient moisture, and adequate daily sunlight. They also need time. If temperatures rise too fast or if trees cannot meet their other cultural requirements, some trees, and perhaps entire forests, may die before they can migrate. Some of this dieback is expected at the southern boundary of the boreal forests.

A Quick Botany Lesson

Trees require CO_2 to grow, so the increased levels of CO_2 that are contributing to climate change are a boon to them. This *carbon fertilization effect* may be significant, particularly during the prime growth years. In one study, trees grew 23 percent faster in a high CO_2 environment. Although it will take more research to determine the limits to this beneficial effect, one thing is not in doubt: both CO_2 and forest growth rates have been increasing since the middle of the 20th century.

Changes in precipitation and moisture may have the greatest impact on forests. Climate models are limited in their ability to predict precipitation changes, but they tend to agree that continental interiors will become drier. This could be problematic for some forests; some midlatitude regions may convert to grassland because they are too dry for the forests that live there. We know little about the adaptability of tropical forest species; if they are not resilient, a drier environment may overwhelm them.

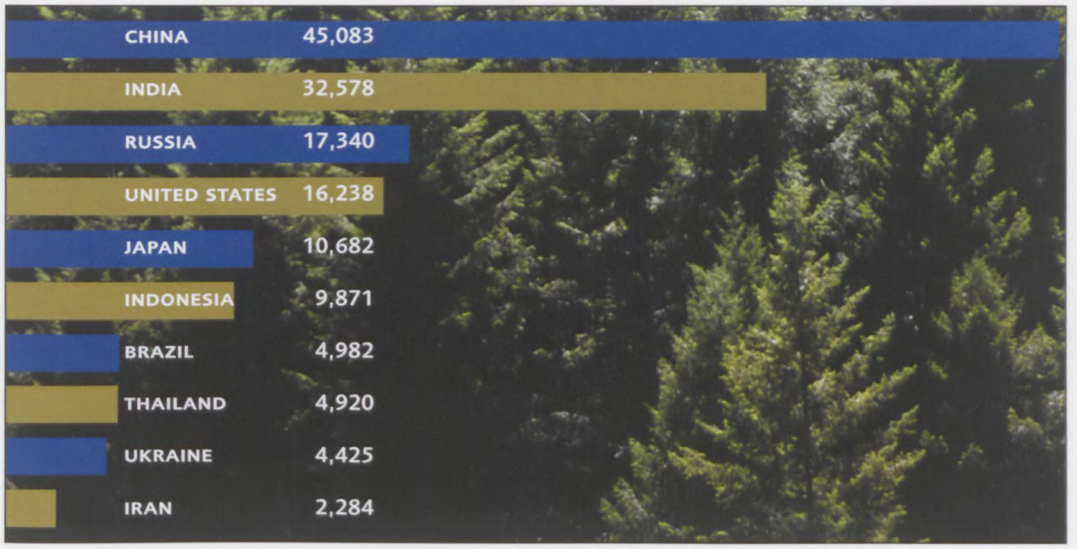

Figure 1.
Forest Plantation Development
Area (1,000/hectares)

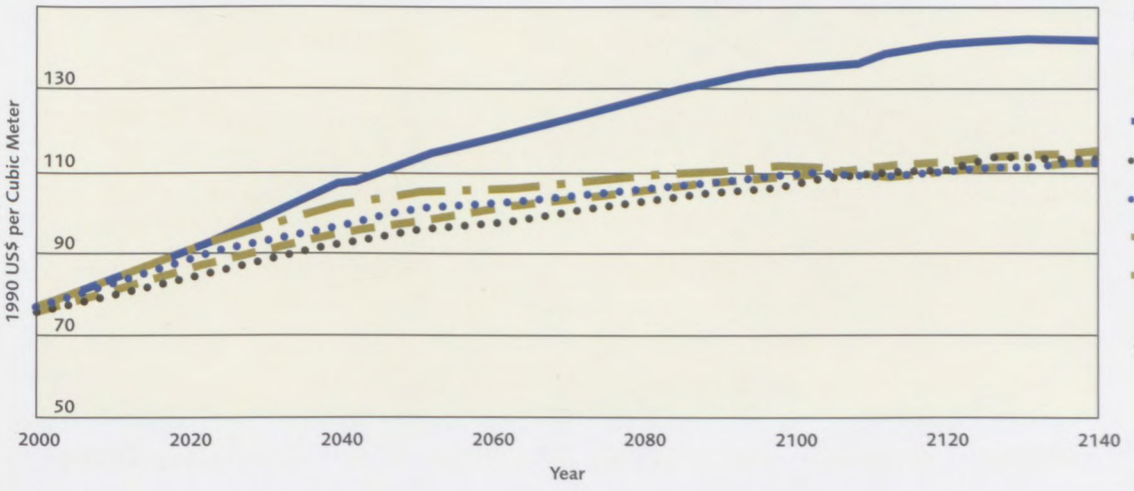

Figure 2.
Global Timber Prices Over Time

Source: Sohngen et al. 2001.

Northern and coastal regions may become wetter. Trees tend to thrive in moist environments, so forests in these areas may succeed, even in the face of higher temperatures.

Healthy forests can tolerate many natural disturbances, such as wildfires, disease, pests, and wind. As trees are stressed by changes in temperature and precipitation, they may be less able to withstand natural disturbances. Climate change is expected to increase the frequency and severity of some disturbances, such as wildfires and pest infestations. Forests that adapt poorly are likely to suffer, and this process may be occurring already. Devastating infestations of beetles have recently threatened forests in western Canada, and many scientists believe it is because warmer winters have allowed the insect population to flourish.

Changes Ahead for the Timber Industry

Historically, wood for industrial use came from the vast natural forests of the temperate regions—North America, Russia, and northern Europe. Gradually, the natural forests of Southeast Asia and the South American and African equatorial regions became major sources of timber. Today, natural stands are being eclipsed by planted forests, which are expected to provide more than half of the world's industrial wood by midcentury. Global change could hasten this transition, as some natural forests die back and are replaced by planted forests in suitable species.

Many of these planted forests reside in regions, such as Asia and Latin America, that did not play a big role in the timber industry before. Figure 1 shows the amount of land devoted to planted forests in various countries. Some of this was planted to restore and conserve forests, but much of it is destined for harvest.

When a resource is abundant, prices fall. Figure 2 presents five scenarios of wood price projections until 2140. The baseline case assumes no climate change. There are two scenarios for each climate model, one anticipating that lost forests will regenerate and one predicting they will not. The striking conclusion is that in either global change scenario, timber will be significantly more abundant than it would be in the absence of climate change.

According to the Hamburg model, near-term losses will be greatest in the middle- and high-latitude regions of North America, the former Soviet Union, China, Oceania, and Europe—regions that currently supply 77 percent of the world's industrial wood. Meanwhile, forests in the lower-latitude regions of South America, India, Asia-Pacific, and Africa will thrive, because temperature changes will be minimal but CO_2 levels will increase. The northern regions will become more productive once valuable species have again taken hold and matured. The UIUC model foretells less dramatic changes in the middle and high latitudes, but greater temperature increases in the tropics, which would mean less dramatic productivity gains in that region.

The Future of Forestry

Although we cannot know what will become of individual forests in the coming decades, managers can prepare for and minimize the effects of climate change. In most areas, little or no adaptation will be necessary. Those who manage natural forests may consider converting some vulnerable natural acreage to planted forests with either current species that have short rotations or new, more sustainable species by providing for the distribution of new seed sources. This could substantially reduce losses that might occur if natural systems adapted on their own.

Where adaptation measures are required, the cost may be high. Any increase in natural disturbances may require higher training and containment costs, at least while trees are adjusting to new environmental conditions. Pest infestations may require managers to replant with different species or to use genetic engineering to create pest-resistant strains of a species already in place. Fires may be more prevalent and require expensive control activities. Forestry may no longer be profitable in some areas, so resource managers may have to plan for alternative land uses. Plantation managers may have to replant other species or relocate, but increased productivity may offset these costs. ■

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THREE CASE STUDIES

Brazil, South Africa, and China have invested heavily in planted forests. Currently, China is the world's leader in the establishment of planted forests, while Brazil ranks seventh. South Africa's contribution is much more modest, but the country is a player in the international pulp and paper industry. I studied the potential effect that climate change could have on the timber industry in each of these countries. In a warming world, they face very different futures.

China

China's forests have made a remarkable recovery in the last 30 years, largely because the government established large areas of planted forest that have increased from 28 million hectares in 1986 to 48 million hectares in 2001. Total forested land area in China has increased from 107.2 million hectares to 158.5 million hectares between 1986 and 2005 and plans to continue expanding its forest area.

China faces only modest challenges to its wood industry from climate change. The main threat appears to be infestations, which have plagued some of the noncommercial poplar forests in the country's interior. China is responding to this threat with pest-resistant genetically engineered poplar trees. If pests begin to attack timber trees, the country could face significant adaptation costs. Overall, however, the outlook for China is positive, particularly because of the country's active policies to establish, manage, and protect its forests.

Brazil

Forest plantations comprise only 1 percent of Brazil's land area, yet they are the core of the country's forest industry. Approximately 50 percent of the total industrial wood now produced by Brazil comes from the 6 million hectares of planted forests and the country plans to plant an additional 500,000 hectares of land annually. The focus is on fast-growing industrially important species that will expand the country's market share by 0.8 percent per year over the next 50 years.

The plantation areas of southern and southeastern Brazil are likely to warm, which would open up new frost-free territory for commercial production of eucalyptus. Pine, another major industrial species, can continue to thrive, although it may be necessary to replace loblolly pine with the more tolerant slash pine or tropical pines if temperatures rise substantially. Pine and eucalyptus are resilient and easily relocated, if necessary. Some forested land may convert to grassland as a result of decreasing rainfall, in which case it would become too costly to try to maintain a forest industry in those areas. Overall, however, climate change should generate more benefits than damages for Brazil's wood-producing industry, at minimal cost.

South Africa

Most of South Africa is arid or semi-arid, with forest plantations concentrated in a swath of relatively moist, frost-free upland. Even today, there are occasional droughts. Compared to other timber-producing countries, South Africa's investment has been small and erratic. In recent years, South Africa has planted an average of 11,000 hectares per year. It had been difficult for the country to locate suitable land in politically stable areas.

Climate change could spell the end of South Africa's timber industry. If the winters become drier, forests may yield to grassland. Irrigation is not economically feasible, and the other regions of the country are already too dry for forests. A small amount of grassland may become wet enough to support forests. Otherwise, the country would need to consider how best to salvage the timber it has before converting the land to grazing or other uses.

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