THE WORLDWATCH INSTITUTE

Special 20th Anniversary Edition

# STATE OF THE WORLD 2003

Chris Bright Christopher Flavin Gary Gardner Mia MacDonald
Anne Platt McGinn Danielle Nierenberg Payal Sampat Janet Sawin
Molly O'Meara Sheehan Linda Starke Howard Youth

# STATE OF THE WORLD 2003

A Worldwatch Institute Report on
Progress Toward a Sustainable Society

Gary Gardner, Project Director
Chris Bright
Christopher Flavin
Mia MacDonald
Anne Platt McGinn
Danielle Nierenberg
Payal Sampat
Janet Sawin
Molly O'Meara Sheehan
Howard Youth

Linda Starke, Editor

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# Acknowledgments

This twentieth edition of *State of the World* is the product of the shared vision and effort of the entire Worldwatch staff, as well as the Institute's friends and supporters. Authors, editors, marketers, administrative and communications support, researchers, librarians, and funders all deserve a round of applause for their various contributions.

To begin with, many chapter authors were assisted by a willing and able group of colleagues. The 2002 research interns—Elizabeth Bast, Cheng Chang, Megan Crimmins, Arunima Dhar, Vanessa Larson, Uta Saoshiro, and Dave Taylor—brought new ideas and enthusiasm to the book. While Dave was diligently retrieving data on mining for Chapter 6, Elizabeth was busy collecting data and information for Chapter 7. Arunima channeled her energies into ferreting out obscure statistics and verifying sources for Chapter 3. Staff researcher Radhika Sarin contributed data and analysis for Chapters 1 and 3, research associate Brian Halweil provided instrumental editorial comments and input on structure for Chapter 3, and staff researcher Erik Assadourian collected material for and provided valuable feedback on Chapter 8. Research librarian Lori Brown helped out in numerous ways, from tracking down articles, journals, and books to keeping researchers up to date on the latest information in their fields.

The initial research and writing were followed by a grueling day-long internal review process in which current Worldwatch staff and alumni gave chapter authors detailed feedback. Also receiving chapter comments this year were former Worldwatcher Howard Youth, now a Madrid-based writer on birds and other conservation topics, and Mia MacDonald, a New York–based consultant who works on issues of gender, environment, and development. To ensure that findings were accurate and explanations succinct, authors were critiqued, complimented, and challenged to strengthen arguments and clarify details. Special thanks go to senior researcher Michael Renner and to Institute alumni John Young and David Roodman for their incisive comments. Magazine editor Ed Ayres helped refine many ideas in Chapter 2 that were presented in an earlier magazine feature article. The director of Worldwatch's Global Governance Project, Hilary French, who is on sabbatical for six months, was sorely missed during the staff review process, but we look forward to her return.

We are also grateful to the experts outside the Institute who generously gave us their time and reviewed portions of the manuscript. For their thoughtful comments, advice, and information, we would like to thank: Saleem Ali, Kelly Alley, Christine Auclair, Mohammed Awer, Leslie Ayres, J. Kevin Baird, Suprotik Basu, Maria Becket, John Beier, Stan Bernstein, Sally Bingham, Henk

Bouwman, Joel Breman, Yves Cabannes, Cassandra Carmichael, Julie Church, Nigel Collar, Mario Coluzzi, Chris Curtis, Sue Darlington, Roger-Mark De Souza, Robert Desowitz, Steve D'Esposito, Daniel Edelstein, Robert Engelman, Emilio Escudero, Richard Foltz, Bronwen Golder, Brian Greenwood, John Grim, Simon Hay, Benjamin Hensler, Steve Herz, Walter Hook, Alvin Hutchinson, Jose Galindo Jaramillo, Norman Jennings, Ragupathy Kannan, Rachel Kyte, Annette Lanjouw, Michael Lippe, Rich Liroff, Socrates Litsios, Michael Macdonald, Birger Madsen, Jack Makau, Eric Martinot, Bill McKibben, Julie McLaughlin, Chandana Mendes, Kamini Mendis, David Milborrow, Glenn Miller, William Moomaw, Jay Moor, James O'Meara, Michelle Ozrech, Janice Perlman, Jonas Rabinovitch, Donald Rogich, Mary Rojas, Martha Rosen, Horst Rutsch, Jeffrey Sachs, David Satterthwaite, Vinod Prakash Sharma, Courtney Ann Shaw, Joseph Sheehan, Keith Slack, Robert Snow, Andrew Spielman, Alison J. Stattersfield, Richard Stren, Mary Evelyn Tucker, Andreas Wagner, Kathleen Walker, Rasna Warah, and Chris Williams.

Through careful edits and polishing of individual chapters, independent editor Linda Starke, more accurately known at the Institute as "the enforcer," made sure authors reached the finish line gracefully. The Institute is fortunate to have on board a new art director, Lyle Rosbotham, whose talent at design brought to life the text, tables, and figures of each chapter. He also designed the stunning new cover. As the final step, the page proofs were sent to Ritch Pope, who created the index.

As the authors' work was ending, that of our communications team was just beginning. Leanne Mitchell, Susan Finkelpearl, and Susanne Martikke, along with senior advisor Dick Bell, worked closely with researchers to craft their messages for the press and the public. Talea Miller pitched in as communications intern, and Sharon Lapier helped keep the department running, staffing the front desk and tracking the thousands of press clips we receive during the year. Patrick Settle, our IT systems administrator, kept all cyber-activities flowing smoothly. Stephen Conklin joined us in the fall as an intern to help with the Web site.

Thanks are also due to our superb development team. Kevin Parker and Mary Redfern strengthened existing relationships with foundations, while forging ahead into uncharted territory. Adrianne Greenlees focused her energies on expanding the Institute's major donors, with the help of Cyndi Cramer. On the business development side, Elizabeth Nolan tackled our marketing and sales efforts and coordinated activities with all our publishers. Tina Soumela played a jack-of-all-trades role, assisting with research, communications, and business development activities.

Senior editors Tom Prugh and Curtis Runyan kept *World Watch* magazine on schedule amid pressures on authors to meet too many overlapping deadlines. We also want to extend our gratitude and best wishes to several staff members who left Worldwatch during the past year: Janet Abramovitz, Niki Clark, Elizabeth Doherty, Seth Dunn, Jonathan Guzman, David Roodman, and Denise Warden.

A strong administrative staff forms the backbone of the Institute. Suzanne Clift kept Worldwatch President Christopher Flavin on track while also helping researchers organize speaking engagements and travel plans. Director of Finance and Administration Barbara Fallin assured the journey was smooth sailing, and Joseph Gravely kept things moving in the mailroom.

Amy Cherry, Bill Rusin, Andrew Marasia, and Lucinda Bartley are our energetic col-

leagues at W.W. Norton & Company, our long-time U.S. publisher. Thanks to their efforts, Worldwatch publications can be found at bookstores throughout the United States. This year we look forward to working with Leo Weigman on some new projects for the college market.

On the international front, we would like to thank the many Worldwatch supporters and international publishers who provide advice as well as translation, outreach, and distribution assistance around the globe. *State of the World* is regularly published in more than 20 different languages. Without the dedication of a host of publishers, nongovernmental organizations, and individuals who work to spread the Institute's message, we would not be able to live up to our name.

Special thanks for their efforts on the 2002 edition of *State of the World* go to our longtime partners Eduardo Athayde of Universidade Livre da Mata Atlantica in Brazil, Gianfranco Bologna of WWF Italy and Anna Bruno of Edizioni Ambiente in Italy, Michael Baumann and Klaus Milke of Germanwatch in Germany, Soki Oda of Worldwatch Japan, Sang Baek Lee and Jung Yu Jun of the Korean Federation for Environmental Movement, Magnar Norderhaug and Oystein Dahle of Worldwatch Norden in Norway, Jose Santamarta and Marie-Amelie Ponce of G.A.I.A. in Spain, and Jonathan Sinclair Wilson of Earthscan Publications Ltd in the United Kingdom.

Thanks also go to our newly established partners, Gulay Eskikaya and Yesim Erkan of the TEMA Foundation in Turkey and Yiannis Sakiotis of the Greek Society of Political Analysis Nikos Poulantzas in Greece. We are deeply appreciative of the dedicated work of our many international publishers and partners who make it possible for us to continually reach readers and decisionmakers throughout the world.

The Worldwatch Institute relies on philanthropic funding to provide more than 70 percent of its operating budget. The largest sources of support are the private foundations that have an abiding commitment to an environmentally sustainable and socially just world. This year, we would like to express our special appreciation to The John D. and Catherine T. MacArthur Foundation for providing grants specifically for *State of the World 2003*. We also want to thank the other foundations that have generously supported our work in the past year: The Ford Foundation, the Richard & Rhoda Goldman Fund, The George Gund Foundation, The William and Flora Hewlett Foundation, The Frances Lear Foundation, Steve Leuthold Foundation, Charles Stewart Mott Foundation, the Curtis and Edith Munson Foundation, The David and Lucile Packard Foundation, the NIB Foundation, The Overbrook Foundation, The Shared Earth Foundation, Surdna Foundation, Inc., Turner Foundation, Inc., Wallace Global Fund, Weeden Foundation, and The Winslow Foundation.

Behind every successful nongovernmental organization is a group of leaders who contribute a combination of prudence and foresight to strategic leadership of the organization. The members of Worldwatch's Board of Directors have increased their involvement this past year through their committed participation in strategic planning, organizational development, and fundraising. We are especially indebted to their extraordinary financial leadership this year through the creation of a "Board Matching Gift Challenge" of nearly $600,000, aimed at inspiring increased individual giving to the Institute.

We are also grateful to the thousands of individual contributors who are members of the Friends of Worldwatch. We have been proud to learn that many of our members are active at the local level in creating sustainable

communities around the world. Thank you for your support and for your personal efforts to make the world a better place.

Our profound gratitude is extended to Worldwatch Council of Sponsors members—Adam and Rachel Albright, Tom and Cathy Crain, and Robert Wallace and Raisa Scriabine Wallace—who provide annual support of $50,000 or more to Worldwatch.

Robert Wallace is a shining example of an individual who was dedicated to fostering a better world. This past October, Bob passed away, and Worldwatch lost a longtime friend who was deeply devoted to international sustainable development work. In 1996 Bob, who was President of the Wallace Global Fund, inspired the creation of the Worldwatch Council of Sponsors, which continues to provide core support to the Institute on an annual basis.

We are proud to have had such a lasting relationship with Bob, and are grateful for the legacy that he and his wife, Raisa, together with his children and the Wallace Global Fund, have left at Worldwatch. We dedicate this twentieth anniversary *State of the World* to Bob Wallace.

Finally, in July 2002 the entire staff of the Institute welcomed the latest additions to the Worldwatch family—Samuel Carlos and Clara Lucia Gardner. When Sally and I traveled to Bolivia to adopt Sam and Clara, we knew that this lively pair was going to change our lives forever. Since we returned, we have discovered they are a daily reminder of why our work here at Worldwatch matters.

Gary Gardner
*Project Director*

# Contents

# List of Boxes, Tables, and Figures

## Boxes

**8 Engaging Religion in the Quest for a Sustainable World**



## Tables

**2 Watching Birds Disappear**



**4 Combating Malaria**



**5 Charting a New Energy Future**



**6 Scrapping Mining Dependence**



**7 Uniting Divided Cities**



**8 Engaging Religion in the Quest for a Sustainable World**

# Figures

## 3 Linking Population, Women, and Biodiversity



## 4 Combating Malaria



## 5 Charting a New Energy Future



## 6 Scrapping Mining Dependence



## 7 Uniting Divided Cities

# Preface

In late August 2002, several colleagues and I flew from Washington to Johannesburg, South Africa, to participate in the World Summit on Sustainable Development. The journey is a long one, and not only in terms of the seven time zones, 65 degrees of latitude, or the disconcerting seasonal transition—from a damp northern summer to a refreshing southern winter. In moving this far from North to South, we entered a different world.

While *State of the World 2002* focused on the agenda for the Johannesburg World Summit, *State of the World 2003* is informed by our experiences in being there. The Summit showed us much about where the world is politically in dealing with the vast problems related to sustainable development, but it also showed us in a more immediate way how a large part of the world lives—and how deeply people are affected by the intersection of poverty and environmental decline.

The upscale Sandton Convention Center in which the official Johannesburg negotiations took place would nestle easily into the suburbs of Washington, DC, or even Beverly Hills. But that splendor gives a misleading perception of life in South Africa and the rest of the region.

Some of my colleagues saw firsthand the squalor of Johannesburg's urban slums, as Molly O'Meara Sheehan describes in Chapter 7, where life has improved little in the decade since apartheid ended. Payal Sampat, author of Chapter 6, met with mine workers at an abandoned gold mine—gold mining is the reason that Johannesburg exists at all—and was able to see the enormous human and environmental price that was paid to extract the precious metal embedded in the jewelry of millions of people around the world.

From its vast human inequality to the coal soot in its air and the falling water tables beneath its surface, Johannesburg is a living, breathing example of why sustainable development is imperative—and of how far we still must go to achieve it. But South Africa also provides the world with one of the all-time object lessons about the possibility of dramatic change. In his speech opening the Summit, President Mbeki drew on South Africa's precipitous overturning of apartheid as a metaphor for what the world must do to achieve sustainable development.

Other examples of rapid change are more ancient. In Chapter 1 this year, entitled "A History of Our Future," Chris Bright describes a remarkable advance in human tool-making among a group of people in the Middle East some 40,000–50,000 years ago that led to rapid human social evolution—a critical step toward the development of human civilization and everything that followed. The change seems to have occurred relatively quickly. And like many subsequent human innovations, it demonstrates humanity's seemingly limitless potential for change

in response to outside pressures.

Both of these transformations demonstrate that while dramatic transitions are possible, they only set the stage for continuing cultural, economic, and technological evolution that unfolds after a breakthrough is made. Our ancestors did not move directly from fashioning blades from stone to working on personal computers, but this Aurignacian technology, as it is known, does seem to have set the stage for a surge in social evolution, leading in due course to settled agriculture, cities, and the Industrial Revolution. South Africa's experience with change has only begun to unfold, but it shows similar patterns: ending apartheid was a historic first step in addressing South Africa's social, economic, and environmental problems. But it will take decades to overcome the legacy of racial inequality and improve the lives of all South Africans.

From our perch in Johannesburg, looking back on the Earth Summit in Rio a decade earlier, we saw many parallels between the initial euphoria that followed that breakthrough conference and the sense that all things were possible that accompanied the formal ending of apartheid. The Rio agreements provided formal recognition that global trends were not sustainable—and laid out a long-term road map for the creation of a sustainable world—but it did not by itself solve all the problems that stand in the way. Amid predictable diversity of views, the Johannesburg Summit marked the beginning of a shift from agreements in principle to more modest but concrete plans of action that are needed to move the world in a new direction.

The Johannesburg agreements do not have the historic resonance of the Rio treaties, nor do they meet all the tests that we laid out in the last edition of *State of the World*. Indeed, according to most assessments of the official 54-page Plan of Implementation, including the World Summit Policy Brief written by my colleague Hilary French, the Johannesburg agreement is something between a modest step sideways and a small step backwards. But her analysis of the World Summit also indicates a more profound significance, one with encouraging implications for the future.

One of the first things to be agreed to by World Summit negotiators was that the world still has a long way to go to achieve the substantial ambitions of the historic Rio treaties of 1992. Unlike at the earlier Earth Summit, there were no major treaties up for negotiation in Johannesburg. Instead, the focus was on concrete steps for moving the Rio agenda forward.

Much of the debate in Johannesburg revolved around whether the Plan of Implementation should include new targets and timetables related to sustainable development—complementing and building on the Millennium Development Goals adopted by heads of state in 2000. Despite opposition from the United States, the Johannesburg plan did in the end include several date-specific targets, including halving the proportion of people without access to sanitation by 2015, restoring fisheries to their maximum sustainable yields by 2015, eliminating destructive fishing practices and establishing a representative network of marine protected areas by 2012, reducing biodiversity loss by 2010, and aiming by 2020 to use and produce chemicals in ways that do not harm human health and the environment.

The lack of detail in these commitments and the acrimony that preceded them left many Summit participants pessimistic about the world's ability to move forward on the most important issues facing humanity in the twenty-first century. The severe North-South splits on financial and trade-related issues seemed deeper than ever, and the U.S. government's opposition to virtually any sub-

stantive multilateral commitments led some to wonder whether a half-century of progress in forging a cooperative global community was about to dissolve in chaos.

These well-founded concerns can hardly be dismissed, but they capture only part of what was going on in Johannesburg. The government negotiators who were niggling over the wording and grammar of deliberately ambiguous paragraphs were literally and figuratively surrounded by one of the largest collections of civil society organizations in U.N. history—ranging from environmentalists and farmers to human rights activists, local officials, and labor union representatives.

More than 8,000 nongovernmental participants were officially accredited to the Summit. In addition to participating in the official summit meetings, nongovernmental groups sponsored a broad range of parallel events, such as meetings of parliamentarians, Supreme Court justices, local government officials, and trade unionists. An estimated 20,000 people representing Africa's dispossessed marched from one of Johannesburg's poorest areas to the posh neighborhood where the conference was held to protest what they saw as the meeting's failure to address the concerns of the poor.

The corporate world was also vigorously present in Johannesburg. According to Business Action for Sustainable Development, an estimated 1,000 business representatives participated in the Summit—with 120 of them being CEOs or Board Chairmen. In comparison, there were 104 world leaders in attendance.

The substantial presence of nongovernmental organizations (NGOs) at an official meeting of governments may have pointed to a strategy for accelerating the process of global change. Because of their scale and because of the politics that surround them, governments and international institutions are often influenced by archaic ideologies or beholden to entrenched economic interests. Outside groups with fresh ideas and representing new political pressures are often required to overcome the momentum of the status quo.

The coming together in Johannesburg of NGOs committed to social betterment, environmental progress, and the creation of new economic opportunities represents a powerful force for change. And the fact that a large portion of these groups came from the South is an even more profound indication that the world is changing. In response to the failure of governments to agree on any clear principles regarding access to information, NGOs set up a voluntary code of conduct that nongovernmental groups, international institutions, and even governments can elect to join.

This example of NGOs stepping in to fill a gap left by governments provides guidance for how the world can one day get beyond the sort of impasse that has blocked international progress on many economic, social, and environmental issues in the past decade. In his recent book, *High Noon*, J. F. Rischard argues that the sheer scale and complexity of many problems have reached the point where traditional nation-states and intergovernmental processes can no longer cope with them, let alone get ahead of the avalanche of problems now rushing toward us. Rischard goes on to suggest that traditional hierarchical processes at the international level should be supplemented by what he calls "global issues networks"—voluntary alliances of governments and NGOs working under the auspices of U.N. bodies such as the U.N. Environment Programme or U.N. Development Programme on specific challenges that face the world today.

It is in this area that Johannesburg may have yielded its most significant results. In addition to the official agreements, the Summit produced roughly 280 "partnership ini-

tiatives"—agreements among national governments, international institutions, the business community, labor groups, NGOs, and other actors to carry out sustainable development activities. These agreements were a significant departure from earlier approaches, where the emphasis was on accords among nation-states. Examples of the new initiatives include a partnership for cleaner fuels and vehicles announced at the Summit that will involve the United Nations, national governments, NGOs, and the private sector, and a European Union "Water for Life" project that will help provide clean water and sanitation in Africa and Central Asia.

The growing role of developing countries in setting the international agenda was also clearly evident at the Johannesburg Summit. While that fact made North-South gaps more prominent, it also provided a needed focus on the fact that we live in a world where growing inequality is one of the most pronounced and disturbing global trends. To paraphrase U.S. President Lincoln on a similar division a century and a half ago, a world divided against itself cannot be sustained.

South Africa, itself a hybrid of North and South, provides a signal example of a country that is striving to bridge such gaps. But it is also emblematic of one of the biggest advantages our globalized world presents today: diversity. Diversity in South Africa is represented not only by its highly complex racial and cultural mixes but by one of the world's great "hotspots" of biodiversity. The Cape Floral Kingdom in the southwest, as described in Chapter 3 of this year's book, is home to 9,000 plant species. Diversity creates tensions and conflicts, but if those are successfully managed, diversity also spawns innovation and resilience that will ultimately make South Africa a stronger country—and has the potential to make the world sustainable.

It is far too early to know whether the diversity and innovation that marked the Johannesburg World Summit will ultimately fill the gaps left by governments. But as you will see in *State of the World 2003*, it is clear that the world is changing. Slowly, and sometimes chaotically, humanity is responding to stress—and is changing its ways, just as our ancestors did 40,000–50,000 years ago. Daily and powerfully, our fellow *Homo sapiens* remind us that it is far too early to give up on the human race.

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*November 2002*

# State of the World: A Year in Review

The first chapter of *State of the World* this year is about innovation—and we appropriately have an innovation of our own in this edition. As a result of a brainstorming session earlier in the year on how to convey better the many developments and setbacks along the road to sustainable development, we decided to add a timeline called "State of the World: A Year in Review." This germ of an idea was turned into a fascinating final product by Research Associate Lisa Mastny and Art Director Lyle Rosbotham.

Each year, the timeline will cover significant announcements and reports during the 12 months before *State of the World* goes to press. Assembling such a chronicle of global events can be a challenge—particularly in today's accelerated age of information and mis-information. But we have done our best to present an accurate yet engaging mix of both encouraging and sobering signs of planetary change.

Although we made no attempt to be comprehensive, we hope that this timeline will boost your awareness of the connections between specific global events and ideas and the broader, often less tangible, trends that influence and shape our planetary future—from climate change and biodiversity loss to new milestones in global governance and public health. As always, we welcome your feedback on this *State of the World* innovation.

**STATE OF THE WORLD: A YEAR IN REVIEW**

**FORESTS**
UN reports that tropical countries lose more than 15 million hectares of forests a year to agriculture, logging, and other threats.

**HEALTH**
Study links nearly 2,000 cases of thyroid cancer to the 1986 Chernobyl nuclear accident—the largest group of human cancers associated with a known cause and date.

**CLIMATE**
Report says US carbon emissions jumped 3 percent in 2000 and are up 17 percent from 1990.

**BIODIVERSITY**
Study estimates that 38 million animals are smuggled from Brazil's forests each year for sale on the black market.

**FISHERIES**
Study says inflated fish catch reports from China—the largest producer—have masked a decade-long decline in the global fish harvest.

**WATER**
UN warns that the world's reservoirs are losing storage capacity as deforestation causes erosion and sedimentation behind dams.

**CLIMATE**
UN says 2001 is expected to be the second warmest year on record since measurements began in 1860.


**OZONE LAYER**
Scientists say Antarctic ozone hole has not grown significantly over the past three years and could recover fully in 50 years.

**BIODIVERSITY**
116 countries vote for new global treaty giving farmers the right to save, trade, and sell seeds and limiting biotech patents on plant genes.

**GOVERNANCE**
Trade ministers from 142 countries meeting in Doha, Qatar, agree to a new round of world trade talks.

**BIODIVERSITY**
Scientists warn that native maize in Mexico has suffered genetic pollution through contact with US bioengineered corn.

**FORESTS**
Satellite imagery shows Mexico's deforestation rate is nearly twice as high as previously thought—and the second highest in the world.

**FISHERIES**
Pathbreaking international agreement on conservation and management of global fish stocks enters into force.

**BIODIVERSITY**
Study says half of North America's most biodiverse regions are degraded, and 235 mammal, reptile, bird, and amphibian species are now threatened.

**ENERGY**
Germany sets a goal of meeting at least a quarter of its domestic electricity needs with wind power by 2025.

**CLIMATE**
Study finds that the global ice melt rate has more than doubled since 1988 and could raise sea levels by 27 centimeters by 2100.

**TOXICS**
Report says up to 80 percent of US computers and electronics collected for recycling is sent to Asia, where it threatens worker health and the environment.

**POPULATION**
UN projects that fertility in many developing countries is likely to fall below the replacement level of 2.1 children per woman by mid-century.

**CLIMATE**
Some 3,250 square kilometers of Antarctica's Larsen B ice shelf collapse as regional temperatures warm.

J A N U A R Y F E B R U A R Y M A R C H

2002 Compiled by Lisa Mastny

2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 2 4 6 8 10 12 14 16 18 20 22 24 26 28 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30

**TOXICS**
UK study finds that babies born within 3 kilometers of hazardous waste landfills are 40 percent more likely to have chromosomal defects.

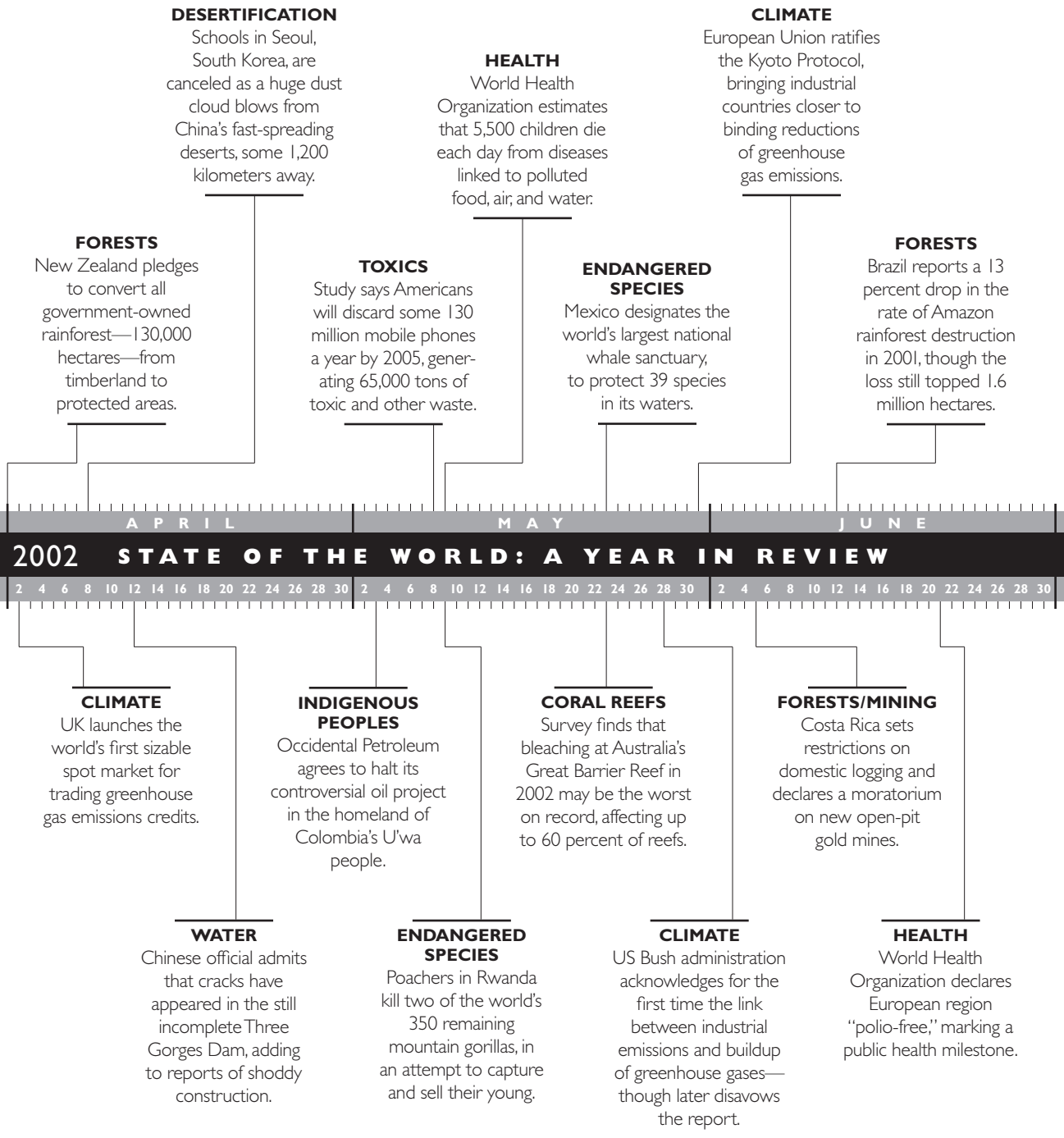
**MINING**
The Provincial Board of Mindoro Province in the Philippines votes for a 25-year moratorium on all forms of mining.

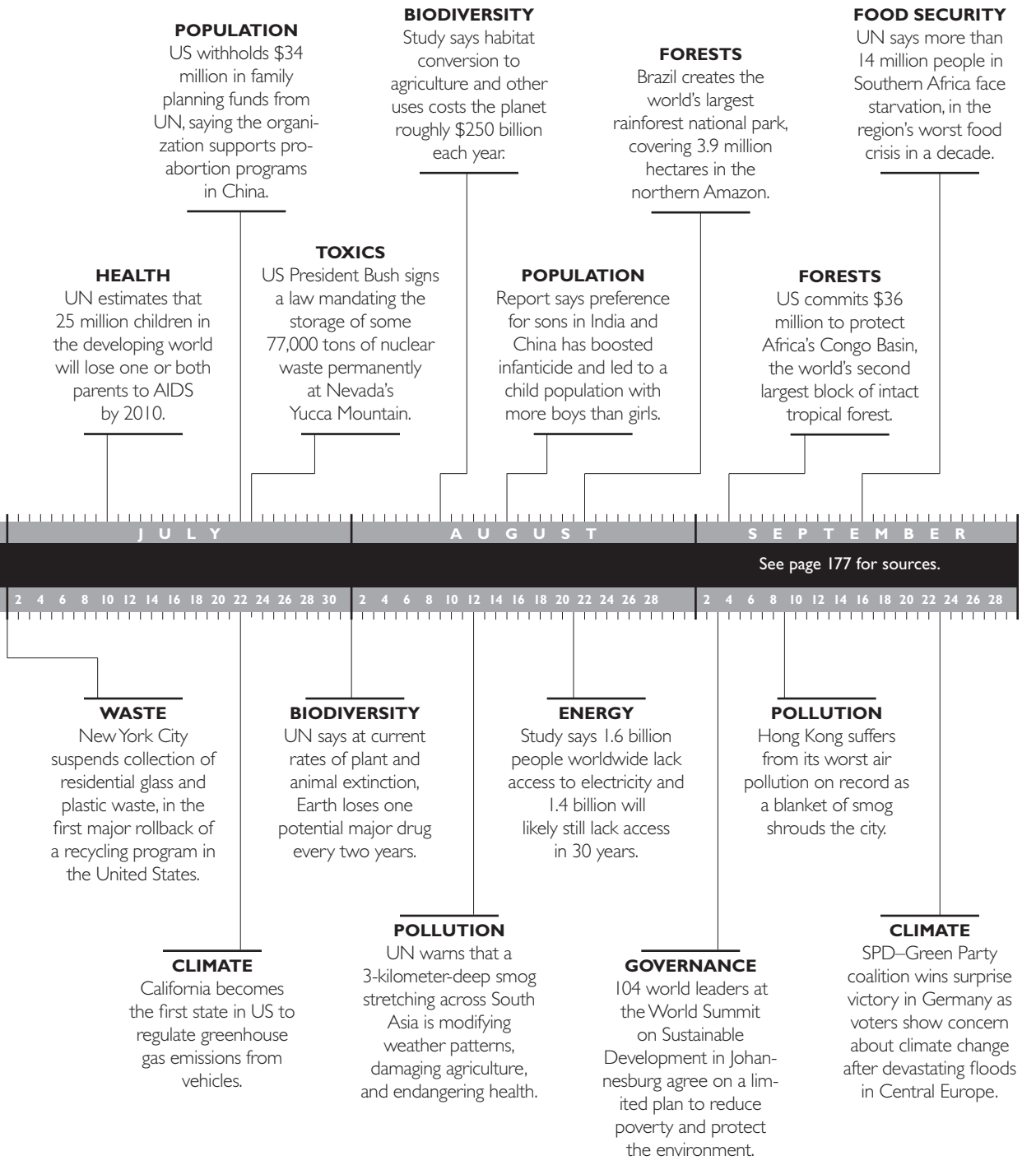
**CLIMATE**
A week of incessant rain causes the worst flooding in decades in Indonesia, killing at least 84 people and inundating up to one fifth of Jakarta.

**FISHERIES**
Scientists warn that precision mapping, satellite navigation, and other new fishing methods are decimating global fish populations.

**URBANIZATION**
UN projects that nearly all 2.2 billion people to be added to world population by 2030 will be in urban areas of the developing world.

**GOVERNANCE**
Aiming to reverse a decade-long downward trend, world leaders gathered in Monterrey, Mexico, pledge to boost aid to developing countries.


DESERTIFICATION
Schools in Seoul, South Korea, are canceled as a huge dust cloud blows from China's fast-spreading deserts, some 1,200 kilometers away.
HEALTH
World Health Organization estimates that 5,500 children die each day from diseases linked to polluted food, air, and water.
CLIMATE
European Union ratifies the Kyoto Protocol, bringing industrial countries closer to binding reductions of greenhouse gas emissions.
FORESTS
New Zealand pledges to convert all government-owned rainforest—130,000 hectares—from timberland to protected areas.
TOXICS
Study says Americans will discard some 130 million mobile phones a year by 2005, generating 65,000 tons of toxic and other waste.
ENDANGERED SPECIES
Mexico designates the world's largest national whale sanctuary, to protect 39 species in its waters.
FORESTS
Brazil reports a 13 percent drop in the rate of Amazon rainforest destruction in 2001, though the loss still topped 1.6 million hectares.
APRIL
MAY
JUNE
2002 STATE OF THE WORLD: A YEAR IN REVIEW
2 4 6 8 10 12 14 16 18 20 22 24 26 28 30
2 4 6 8 10 12 14 16 18 20 22 24 26 28 30
2 4 6 8 10 12 14 16 18 20 22 24 26 28 30
CLIMATE
UK launches the world's first sizable spot market for trading greenhouse gas emissions credits.
INDIGENOUS PEOPLES
Occidental Petroleum agrees to halt its controversial oil project in the homeland of Colombia's U'wa people.
CORAL REEFS
Survey finds that bleaching at Australia's Great Barrier Reef in 2002 may be the worst on record, affecting up to 60 percent of reefs.
FORESTS/MINING
Costa Rica sets restrictions on domestic logging and declares a moratorium on new open-pit gold mines.
WATER
Chinese official admits that cracks have appeared in the still incomplete Three Gorges Dam, adding to reports of shoddy construction.
ENDANGERED SPECIES
Poachers in Rwanda kill two of the world's 350 remaining mountain gorillas, in an attempt to capture and sell their young.
CLIMATE
US Bush administration acknowledges for the first time the link between industrial emissions and buildup of greenhouse gases—though later disavows the report.
HEALTH
World Health Organization declares European region "polio-free," marking a public health milestone.




See page 177 for sources.

# STATE OF THE WORLD

2003

Chapter 1

# A History of Our Future

*Chris Bright*

Some 40,000–50,000 years ago, a group of Middle Eastern people developed a type of tool that seems to have precipitated a radical expansion of the human mind. Or to put it more cautiously, the tool alone may not have done this—the critical factor may have been a new way of thinking about tools. Or maybe even a new way of thinking in general. Whatever it was, these Stone Age, preagricultural people apparently touched off the first episode of rapid, large-scale social change in the history of our species.[1]

Until their innovation set them apart, these people shared in the general culture that prevailed over most of the inhabited Old World. The principal technologies of this general culture were the use of fire and a relatively simple kit of stone flake tools. This tool kit was the product of nearly 2.5 million years of development. Improvement in it had come at a pace that is, by our standards, excruciatingly slow—so slow that it could be likened to evolutionary change. You might even argue that the kit evolved slower than we did, since it passed through the hands of at least two of our precursor species (*Homo habilis* and *H. ergaster*) before it arrived in the hands of our own.

During all that time, the kit underwent only one major revision: the transition about 1.7 million years ago from the rudimentary choppers and scrapers fashioned by *H. habilis* to the larger, more specialized stone tools of *H. ergaster*. One more major revision, about 250,000 years ago, introduced the stone-flake technology that those Middle Eastern people inherited. Three hominid species, 2.5 million years, and only two major bouts of refinement: doesn't sound like much of a program for mastering the planet, does it?

What those Middle Eastern people did was to break that slow, evolutionary tempo of technical development and create an opening for accelerating change. They did this, essentially, by fashioning blades from stone. In general, these new blade-like tools were larger than the flake tools, and they showed a much

Units of measure throughout this book are metric unless common usage dictates otherwise.

greater investment of design. This new technology is known as the Aurignacian, after the Aurignac rock shelter in the French Pyrenees, where anthropologists first identified it. Aurignacian blades are simple artifacts of modest dimensions—a good-sized blade might be 15 centimeters (about 6 inches) long. But they are beautiful, efficient, and occasionally somewhat menacing.[2]

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For reasons that remain obscure, this technology broadened rapidly, to create a vast expansion of social and cultural life. The tool kit itself came to include more and more novel, specialized equipment like ivory needles, reindeer horn spear points, and rope. More sophisticated tools encouraged more extensive trade. Sea shells from the Black Sea arrived in the Don River valley, 500 kilometers to the north; Baltic amber traveled to southern Europe. Flutes were carved out of bone; music had evidently become a part of life. Complex visual art appeared for the first time as well, in the form of bone pendant jewelry, cave paintings, and carvings in bone, stone, and ivory. It became a widespread practice to include some of those carvings and pendants in human burials—strong evidence for the emergence of complex religions. All these developments got their start in a span of fewer than 10,000 years, which amounts to less than one half of 1 percent of the entire previous life of the stone tool kit. In an evolutionary instant, without any obvious precedent, humanity had reinvented itself.[3]

The development of the Aurignacian technology, which marks the transition from the middle to the upper Paleolithic, is arguably the greatest transformation that our species has ever been through. All the major transformations that followed—the development of metal tools, agriculture, and the various industrial revolutions of more recent times—all these transitions may look more dramatic, but none seems to contain as profound a psychological fault line as does the Aurignacian transition. The people on the far side of these other transformations are all recognizably human in the fullest sense of the term. But the apparently very simple, nearly static way of life in pre-Aurignacian times appears to lack at least one characteristic essential to the makeup of all modern people: the habit of innovation. In this fundamental respect, the Aurignacian transition created us—not biologically, but culturally.[4]

Because it was a kind of cultural equivalent to the primordial Big Bang, the Aurignacian transition may offer important perspectives on our basic psychology—and especially on our capacity for change. Unfortunately, however, the causes of the transition remain obscure, although not for lack of theories. (One explanation, for example, invokes environmental stress: it is known that the transition occurred during a period of climatic instability, and climate change might have challenged the ingenuity of societies in areas where resources were dwindling.)

But turn from causes to consequences, and it is possible to draw some broad conclusions, which might be useful for understanding constructive social change in general. Consider the following three characteristics of the transition as a whole. First, the transition seems to have paid an immense "solution dividend": it improved aspects of life that probably had little to do with whatever caused the initial wave of innovation. Second, the transition moved from the merely technical to become profoundly cultural: it apparently began as a way of making better tools, but it progressed into the arts, trade, and religion. And third, the transition magnified the world:

it created new ways of interpreting the world—new ways of building "deep context" for social and individual life, as is apparent, for example, from the magnificent cave paintings that the peoples of the upper Paleolithic era have left us.

## The Challenges We Face

The people who set the Aurignacian transition in motion lived perhaps 2,500 generations ago. Fewer than 500 generations later, the world's first great culture was well established and *Homo sapiens* had become something more than merely a large, common primate. It took only an eyeblink of evolutionary time. We, the generations who share the planet today, are facing a challenge to innovate on a level that may be as profound as the achievement of our distant ancestors. But we do not have 500 generations' worth of time to accomplish the task. Depending on the degree of misery and biological impoverishment that we are prepared to accept, we have only one or perhaps two generations in which to reinvent ourselves. An eyeblink of an eyeblink. Consider five of the most serious threats that future historians might use to define our era.[5]

First, ours is a world in which increasing numbers of people lack the means for a decent life. Global population now exceeds 6.2 billion, more than double what it was in 1950, and is currently projected to rise to between 7.9 billion and 10.9 billion by 2050. Nearly all of that increase will occur in the developing world, where resources are already under serious strain. In these countries, nearly 1.2 billion people—almost a quarter of the world's population—are classed by the World Bank as living in "absolute poverty." These people are surviving on less than the equivalent of $1 a day, and they are generally very vulnerable to additional misfortune—whether in the form of disease, drought, or food shortage.[6]

Worldwide, about 420 million people live in countries that no longer have sufficient cropland per capita to grow all their own food. These nations must rely on imported food—a risky form of dependence for the poorer countries in this group. By 2025, the population of countries that must import food could exceed 1 billion. The quality of cropland in many poor countries is also declining; about one quarter of developing-world cropland is thought to be significantly degraded, and over the past 50 years the rate of degradation has accelerated. But in many places, the biggest threat will not be a shortage of land; it will be a shortage of water. Already, more than a half-billion people live in regions prone to chronic drought. By 2025, that number is likely to have increased at least fivefold, to 2.4–3.4 billion. It is true that there are enormous and largely avoidable inefficiencies in the current food and water supply systems, but a probable minimum population increase of 27 percent over the next half-century is hardly likely to foster either social or ecological stability.[7]

A second threat: our world is in profound geochemical flux. Certain forms of pollution are altering the global chemical cycles that "regulate" key ecosystem processes. The carbon cycle is the best known of these. A vast quantity of carbon that had been removed from circulation millions of years ago—by being absorbed by plants, which were in turn converted to coal and oil—is now being reinjected into the atmosphere. Annual carbon emissions from fossil fuel combustion reached a record 6.55 billion tons in 2001, driving the atmospheric concentration of carbon dioxide to 370.9 parts per million, the highest level it has reached in at least 420,000 years, and probably in 20 million years. Because carbon dioxide traps heat, its increasing concentration is likely to provoke rapid climate change.[8]

The nitrogen and phosphorus cycles, both important regulators of plant growth, are undergoing a similar amplification. Nitrogen becomes biologically available when it is converted from its inert elemental form by being "fixed" into molecules that also contain hydrogen and oxygen. This happens naturally, through the actions of certain soil microbes and through lightning strikes. But human activities have greatly increased the rate of fixation, primarily through fertilizer production, fossil fuel combustion, and the widespread cultivation of plants in the bean family, which often have colonies of nitrogen-fixing microbes on their roots. The destruction of forests and wetlands releases a great deal of additional, already-fixed nitrogen, which had been sequestered in plants and soils. All told, human activities appear to have at least doubled the annual release of fixed nitrogen, to 350 million tons per year. (That figure does not account for changes in the marine portion of the nitrogen cycle, which is not yet well understood.)[9]

The phosphorus cycle is being augmented primarily through fertilizer production. The phosphorus in fertilizer generally comes from mining—a radical amplification of the natural process of phosphorus release, which results from the weathering of rock. The annual release of phosphorus appears to have increased from its natural rate by a factor of 3.7, to 13 million tons per year.[10]

Since both phosphorus and fixed nitrogen are plant nutrients, their presence in vastly greater than natural quantities is liable to cause pervasive ecosystem change. In aquatic ecosystems, this nutrient pollution leads to eutrophication—dense algal growth that chokes out sunlight and causes dissolved oxygen levels to crash. On land, nutrient pollution can homogenize diverse plant communities by encouraging an overgrowth of the weedy species best able to use the excess nutrient. Too much nitrogen also apparently predisposes many plant species to disease and insect attack. (Plants, like people, can "overeat.") In certain forms, excess fixed nitrogen is also a major component of acid deposition, better known as acid rain (even though much of the pollution arrives in the form of gases and dust, rather than as rain or snow). The immediate effect of acid rain is to acidify soil and water, but it also works long-term change in soil chronically subjected to it: it leaches out calcium and magnesium, essential plant nutrients, and it frees aluminum from the mineral matrix that keeps it biologically inert. Free aluminum is toxic to plants and aquatic life.[11]

A third threat: our world is increasingly burdened by the long-term risks associated with toxic chemicals. By a very conservative estimate, for example, global production of hazardous waste has reached 300–500 million tons per year. Depending on what the waste consists of, disposal may involve condensing (the usual first step for contaminated wastewater), incineration, recycling, or neutralization through chemical or biological treatment—all with varying degrees of thoroughness. Or the waste may be injected into deep wells or dumped into landfills in the hope that it will stay put—at least long enough to become somebody else's problem. Of course, many materials not classified as hazardous waste—or as waste at all—are also major pollutants. Pesticides, the antifreeze compounds used to de-ice the wings of airplanes, the chromated copper arsenate in lumber treated for outdoor use: we call such materials products, not wastes, but from an environmental perspective, that's false accounting. They are all destined for the Great Outdoors at some point, either in their original form or as their (sometimes equally noxious) breakdown products.[12]

Our capacity to track the materials moving

through our economies is too sketchy to convey more than a vague idea of the chemical insult that we are inflicting on the natural world—and on our own bodies. But there are good reasons for thinking that this insult is enormous and growing. There is, for example, widespread evidence of the pollution of aquifers (underground water deposits) with petrochemicals, heavy metals, nitrates from fertilizer, and other toxics. Aquifer pollution is a serious concern because aquifers frequently contribute more than half the volume of lakes and rivers; they are also a major source of irrigation and drinking water. And because water circulates through most aquifers very slowly—complete renewal generally takes centuries—such pollution is effectively irreversible.[13]

The composition of the pollutants themselves, especially the synthetic ones, is also a matter of concern. Some 50,000–100,000 synthetic chemicals are thought to be in production, as plastics, pesticides, lubricants, solvents, and so forth. Others are created unintentionally, as manufacturing byproducts or as breakdown products of manufactured materials. Many synthetics are not known to be harmful, but others have been found to be extremely dangerous even in trace quantities. Cancer, immunodeficiency, hormonal abnormalities, and birth defects are among the risks associated with them—in wildlife and in people. Some of these toxics bioaccumulate—that is, they contaminate living things in increasing concentrations at higher links of the food chain, a tendency that poses special dangers to high-level predators like eagles, porpoises, and us. Many synthetics are now pervasive in trace quantities, and many have half-lives that are measured in hundreds of years. So for centuries to come, living things themselves will be a reservoir of contamination.[14]

A fourth threat: our world is subjected to an unprecedented degree of biotic mixing. Growing numbers of organisms of virtually every type are moving through the global trading system and emerging into regions where they are not native. These exotic species travel in the ballast water of ships, in packing material, in raw wood products, in crop shipments, and in many other ways. Most exotics do not survive in their new homes, but a small portion succeed in establishing colonies. If an established exotic finds nothing in its new home to keep its population in check, it may go on a reproduction binge. Depending on what it is, an invasive exotic may outcompete native species for some essential resource, or launch an epidemic, or prey on natives directly.[15]

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The result often goes beyond the suppression of the exotic's immediate victims to include other species that depend on those victims in some way. For example, the highly invasive Argentine ant is displacing many native ant species in dry areas of the tropics and warm temperate zones; the loss of the native ants, in turn, suppresses the plant species that rely on them for pollination or seed dispersal. Eventually, a cascade of ecological effects may work profound change in the invaded community by simplifying its structure, altering its nutrient cycles, and homogenizing its species composition. Even though comprehensive statistics on the problem are not available, the growth of the trading system virtually guarantees that the rates of invasion are increasing. More and more of the world's diverse natural communities are in danger of being dominated by a relatively small number of highly inva-

sive organisms.[16]

And finally, a fifth threat: by virtually every broad measure, our world is in a state of pervasive ecological decline. Primary tropical forests, in general the most diverse ecosystems on the planet, are disappearing at a rate probably exceeding 140,000 square kilometers per year—an area nearly the size of Nepal. Total global forest cover, which now accounts for about a quarter of the planet's land surface excluding Greenland and Antarctica, may have declined by as much as half since the dawn of agriculture. About 30 percent of surviving forest is seriously fragmented or otherwise degraded, and during the 1990s alone, global forest cover is estimated to have declined by more than 4 percent. Wetlands, another highly diverse ecosystem type, have been reduced by more than 50 percent over the past century.[17]

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Coral reefs, the world's most diverse aquatic ecosystems, are suffering the effects of overfishing, pollution, the spread of epidemic disease, and rising sea surface temperatures that many experts link to climate change. By the end of 2000, 27 percent of the world's coral reefs were thought to be severely damaged, up from just 10 percent in 1992. Throughout the oceans, overfishing is taking an ever greater toll: some 60 percent of the world's marine fisheries are now being exploited at or beyond capacity—an invitation to extensive ecological disruption. And according to the IUCN–World Conservation Union, about one quarter of the world's mammals are now in danger of extinction, as are 12 percent of the world's birds. Comprehensive figures do not exist for other major groups of organisms, but in samples of other vertebrate classes, levels of endangerment were similarly high: 25 percent for reptiles, 21 percent for amphibians, and 30 percent for fish.[18]

## Ordinary Miracles

These damage assessments often have an air of unreality about them because they bear little obvious relation to life as it is ordinarily lived—at least by the likely readers of this book. There are several reasons for this disconnect. In the first place, large economies tend to displace the ill effects of behavior from the behavior itself. Few of us ever encounter the toxic waste, soil degradation, or unsustainable mining and logging that support our collective consumption patterns. There may be a basic psychological problem at work here as well, since a great deal of environmental degradation cannot be readily seen. Human beings understand their worlds largely on the basis of sight; invisible threats, especially long-term ones, do not appear to play to our evolutionary strengths.

More generally, it's conceivable that our own inherent adaptability is to some degree working against us—preventing us from recognizing the gravity of the situation. *Homo sapiens* is the ultimate all-terrain animal, as is apparent from the successes of our distant ancestors. Fire and a few simple stone tools were all the equipment they needed to colonize entire continents. We are a generalist species, not a specialist species. We're not like pandas, tanagers, or orchids. We are much more like dandelions, starlings, and rats. We don't need a high state of natural integrity in order to thrive—and apparently, we are not predisposed to react with alarm at its loss.

But the biggest obstacle to reinventing ourselves may simply be a kind of paralysis of

hope. It is possible to see very clearly that our current economies are toxic, destructive on a gargantuan scale, and grossly unfair—to see all this and yet still have difficulty imagining effective reform. It's not that it is hard to envision the paths that reform would have to take; at this point, we have a fairly clear sense of where we need to go (on a technical level, at least, if not always on a cultural one). In the energy economy, for example, the path of reform leads away from fossil fuels and toward renewable energy sources, like wind and solar. In materials production, it leads away from a primary reliance on mining and toward cycles of continual reuse. In trade, the path would presumably lead to meaningful engagement of ecological issues like bioinvasion, and social ones like the loss of local production. And in international relations, the path might begin with a recognition of the obvious: we have built a global economy that assigns one quarter of humanity to the misery of absolute poverty, while the wealthiest 20 percent of the world's people account for 86 percent of total private consumption. Even apart from the offenses to reason and ethics, it is hard to see how "secure" such a world could ever be.[19]

And yet despite the obvious need for change, and despite our obvious technical competence, it can still be hard to believe that real, fundamental change is possible. We are used to constant flux in the daily details of existence, yet the basic structure of the status quo always looks so unalterable.

But it's not. Profound change for the better does occur, even though it can be difficult to see because one of the most common effects of success is to be taken for granted. What looks perfectly ordinary after the fact would often have seemed like a miracle before it. Or sometimes maybe more than a miracle: the results of the Aurignacian transition would probably not even have been comprehensible before the fact. Consider two ordinary miracles from our own era—two changes in which technical effort has created vast cultural opportunity, and in which benefits are accruing far out of proportion to costs.

Consider first the eradication of smallpox. In January 1967, when the World Health Organization (WHO) announced a program intended to eliminate smallpox within a decade, the disease was infecting 10–15 million people every year, primarily children. It killed 1.5–2 million of them and left many of its survivors blind or covered with disfiguring pockmarks. More than 1 billion people, 29 percent of the world's population at the time, lived in countries where the disease was endemic (that is, continually present). Even in industrial countries, where comprehensive vaccination programs had eliminated it as an endemic threat, smallpox remained a chronic security problem because of infection risks from abroad.[20]

When it was announced, the WHO program looked naive at best to many scientists and public health officials. It had grown out of an agreement reached at the Twelfth World Health Assembly in May 1959, which had also called for the elimination of smallpox but had achieved almost nothing. The precedents with other diseases were similarly discouraging. Eradication campaigns had often yielded promising results in particular regions, but always seemed to founder when scaled up to the global level. The first of these efforts, a campaign to eradicate the hookworm parasite, had been launched in 1913 on the strength of a successful control program in the U.S. Southeast. But by the early 1920s it was clear that the parasite was not well enough understood to be eliminated everywhere. The global campaign against yellow fever, begun in 1918, had grown out of early successes in Panama and Cuba, but the eradication objective had to be abandoned in the early 1930s

after researchers in South America discovered yellow fever in wild mammals—reservoirs of the pathogen that they had no way of eliminating.[21]

Malaria eradication had taken a similar course. In northeastern Brazil in the late 1930s, a campaign against a newly arrived African mosquito, *Anopheles gambiae*, completely eradicated it in less than two years. This mosquito is Africa's most important malaria vector. Its removal from Brazil was an astonishing achievement, but that success also turned out to be a deceptive precedent: global malaria eradication, begun in 1955, was running out of steam by the mid-1960s. It was abandoned in 1969 with the recognition that, in most areas with endemic malaria, it was not possible to suppress the mosquitoes long enough to clear human populations of the parasites that cause the disease. (See Chapter 4.) By the mid-1960s, the concept of disease eradication as a policy goal was falling into disrepute. In his 1965 book, *Man Adapting*, the distinguished scientist and philosopher René Dubos caught the prevailing attitude: "eradication programs," he wrote, "will eventually become a curiosity item on library shelves, just as have all social utopias."[22]

Lack of credibility was not the smallpox program's only problem. It was also chronically starved for funds; it lacked any authority other than moral; and it was not always seen as a priority in developing countries, where smallpox was often just one among many serious threats to public health. But despite all the obstacles, the program succeeded—thanks to persistence, a willingness to adapt to varying conditions, and a thorough understanding of the pathogen's weaknesses. (Smallpox was a good target for eradication because it is not "vectored"—it has to be transmitted directly from one person to another—and because there was a reliable vaccine for it.) The world's last "natural" (nonlaboratory) case of smallpox was discovered in Somalia, on October 26, 1977, just 10 months beyond the original target date for eradication. The total cost of the WHO program probably amounted to less than $300 million (equivalent to $700–800 million today). Even in the crudest economic terms, every country benefited because preventative measures against the disease were no longer necessary. The United States, the largest single donor to the campaign, is estimated to make back its total contribution every 26 days. Barring the release of the pathogen from one of its artificially maintained stocks, smallpox is a problem solved and the world is a better place because of that.[23]

Smallpox eradication required the cooperation of thousands of officials and fieldworkers—and millions of parents of unvaccinated children. But as a WHO program, it was still essentially change from the top down. On many fronts, however, constructive change will likely depend much more heavily on public initiative—on a sense of direction supplied by nongovernmental organizations and large numbers of individual people. Change from the bottom up is likely to be more diffuse and less "focused," but here too there are encouraging precedents.

Consider population growth, one of the biggest environmental problems of all, yet in a sense one of the least "public." The increase in our numbers is an aggregate consequence of personal attitudes toward sex and procreation—subjects that are just about as private as you can get. Significant change on this front is a fundamental type of cultural change, and in the usual view, that is not something that is likely to happen quickly. In societies that value large families, we might hope to see ideal family size shrink, but only gradually.

And certainly this view has some strong evidence to support it. The baseline precedent for such change is the European demographic transition, a complex development in which improvements in sanitation, nutrition, education, and general standards of living accompanied declines in child mortality and in the average number of births per woman (known as the total fertility rate, or TFR). The European demographic transition took over 100 years. In the late nineteenth century, the continent's TFR was around 4 or 5; today, the continental average has dropped below the 2.1 "replacement rate." (Over the long term, a population that maintains a 2.1 TFR will stabilize: the number of births will eventually come to equal the number of deaths.)[24]

To demographers, the lesson from the European experience seemed clear: the decline to replacement rate is gradual because the necessary social changes are complicated, expensive, and slow to mature themselves. But by the late 1980s, the experts were beginning to see a pattern that did not fit the European precedent. Several East Asian countries were undergoing the "classic" transition (that is, declining TFRs and rising standards of living), but they were doing it in a radically compressed time frame. In Indonesia, Japan, Singapore, South Korea, Taiwan, and Thailand, TFRs had been dropping at least since the 1960s; today, all these countries have reached the replacement rate or will soon do so. Their transitions, most of which took only 25–30 years, are usually credited to rapid economic growth accompanied by several technical and administrative advances, primarily well-developed family planning programs and substantial improvements in health care and education.[25]

Demographers did not, however, see these East Asian transitions as a reason for major revisions in the global population projections. Nor, in retrospect, should they have: world population nearly quadrupled over the twentieth century, and while it is true that industrial-country TFRs now average 1.6, the vast majority of humanity is not living in places that are likely to undergo classic demographic transitions, accelerated or otherwise. South Korea is no model for India, China, or Nigeria. So as recently as the first half of the 1990s, the standard estimates held that global population was increasing by 86–90 million per year, and that it would continue to grow at that rate for years to come. For example, the report of the International Conference on Population and Development, held in Cairo in 1994, cited current U.N. projections for its estimate that "annual population increments are likely to remain close to 90 million until the year 2015."[26]

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But once again, reasonable expectations have been ambushed by unanticipated change. Eight years after the Cairo conference, the annual increment of population increase is now estimated at around 77 million. In part, this lower number results from a sort of accounting restatement: demographers now think that the annual increment at the time of the Cairo conference was probably around 81 million, not 86–90 million. But the rest of the difference is believed to reflect an actual decline in the increment, on the order of 4 million people. (Note that the population as a whole is still increasing; the decline is in the number of people added to it every year.) This drop in the increment marks a new trend. Until the early 1990s, the increment had been growing; it is now declining, and the decline is projected to continue.[27]

The new trend results from a couple of unexpected developments, one of which is very bad news: the death toll from AIDS is now large enough to influence global population statistics. But the main reason for the decline is not more deaths; it is fewer births. In about a dozen heavily populated developing countries, TFRs have declined substantially, even without significant improvements in standards of living. Iran, for example, reduced its TFR from 5.6 in 1985 to 2.0 in 2000, despite a long, debilitating war with Iraq from 1980 to 1988, economic stagnation, and the Revolutionary government's initial hostility to birth control—a position that was reversed in 1989.[28]

**Organic farming is now the fastest-growing sector of the world agricultural economy.**

Even where the declines have still not brought the TFR to the replacement rate, they are nevertheless remarkable. For example, Bangladesh, a very poor country, has seen its TFR decline from 7 in the 1970s to 3.3 between 1996 and 2000. Neither Bangladesh nor Iran has seen major improvements in most living standards, but they do share one important social feature: both have managed to develop extensive family planning programs that enjoy strong official support and broad public acceptance.[29]

A looser example of such change can be found in Latin America and the Caribbean, a region that now has an overall TFR of around 2.5, down from 6.0 in the first half of the 1960s. It is not surprising that here too the drop in TFR often correlates with increased availability of family planning services, particularly contraception. It is somewhat surprising, though, that the trend is apparent even in some of the region's poorer countries—Peru, for instance. In the *2002 Human Development Index* prepared by the U.N. Development Programme, Peru ranks eighth among the 12 South American countries, yet this nation has seen its contraceptive usage rate rise from around 40 percent of married women in the late 1970s to 64 percent by 1996. Peru's TFR fell from over 5 to 3 during the same period.[30]

Of course, these partial "transitions on the cheap" were well under way at the time of the Cairo conference. And in a sense, they were in plain sight. But it was very difficult to see them because the pattern had not been recognized.

Do these various TFR declines mean that population growth will soon cease to be a major social and environmental concern? Hardly. In fact, the U.N. medium projections for global population growth have recently been revised slightly upwards. The medium projections are often considered the "best bet" about where population trends are headed. (See Chapter 3.) There are several ways in which current TFRs factor into those projections. For one thing, there are still countries, primarily in sub-Saharan Africa, where TFRs remain high and where demographers do not anticipate significant declines anytime soon. And of course in highly populated countries, even "moderate" TFRs can yield enormous increases in population size. India is by far the most dramatic example of this: with a population of a little over 1 billion and a TFR of 3.2, India is currently growing by 17.6 million people a year. Nor is it inevitable that "moderate" TFRs will just keep dropping at a steady rate: unfortunately, over the past few years TFR declines have slowed in several densely populated countries, including Bangladesh, India, and Nigeria. And even after a country's TFR drops below the replacement rate, its population may continue to expand for decades—a phe-

nomenon called "population momentum." China, for instance, has a TFR of only 1.8, but its population of nearly 1.3 billion is still increasing by 11.5 million per year.[31]

Population momentum is easier to understand if you think in terms of the age structure of the population. Societies that have just arrived at the replacement rate tend to be disproportionately young: there are usually many young people but far fewer older ones. Since most deaths occur among older people, there are not initially enough deaths to compensate for the births, even at the 2.1 TFR. The compensatory deaths occur later, as that young demographic bulge moves into middle age and beyond. In the meantime, the population keeps growing. Overall, the developing-world TFR is now a little less than 3, about half of what it was as recently as 1970. The current projection, for whatever that is worth, puts the average TFR in developing countries at 2.17 in 2050.[32]

These unexpected demographic transitions offer no grounds for complacency, but they do offer reason for hope. We are not inevitably destined for the demographic worst-case scenario—a crowded, denatured planetary dystopia of war, poverty, and disease.

There are reasons for hope in many other fields as well—developments that are broad-based although often only partially realized, and that are not yet well integrated into the predominant views of the world. Such change can be seen, for instance, in organic farming, which is now the fastest-growing sector of the world agricultural economy and which could rejuvenate rural communities in countries as varied as the Philippines, Sweden, and the United States. It can be seen in renewable energy technologies, where rapid technical advances and declining production costs are driving increases in wind and photovoltaic generating capacity on the order of 25 percent a year or more. (See Chapter 5.)[33]

Some grounds for hope can be found even for that most famous and least successful cause on the environmental agenda: the conservation of tropical nature. The park—a concept that has often been maligned as politically unrealistic in much of the tropics—has over the past several decades quietly proved its worth. Parks contain almost all that is left of nature on a grand scale in Cuba, the Dominican Republic, Ghana, India, Madagascar, the Philippines, South Africa, and Thailand; they contain most of what is left in many other Latin American, African, and Asian countries. Major investments in this simple approach—essentially, setting places aside for nature—are as critical to the well-being of the planet as investments in renewable energy or family planning.[34]

Roughly 50,000 years after innovation became a human trait, we live in a world that is increasingly of our own making. But it is no less mysterious and challenging than was the world inhabited by those Stone Age authors of innovation. By many measures, the distance between those people and ourselves is so vast that it would be difficult to measure. Our technologies and social consciousness would hardly seem to have a parallel in their culture. And yet in some fundamental respects, our struggles echo theirs. We too rely on technical achievement to catalyze cultural change. We too have a habit of creating "solution dividends." And who knows? Maybe 50,000 years from now, our distant descendants will wonder how we managed to magnify their world in ways that we ourselves could not have imagined.

Chapter 2

# Watching Birds Disappear

*Howard Youth*

In the year 2000, Spix's macaws vanished from northeast Brazil. The large, powder-blue birds' disappearance was no fluke. Farmers and timber cutters cleared their wooded river forest habitat. Bird traders bagged the birds, and hunters shot them. Today, only 40–60 Spix's macaws still live in aviaries, where most of them were born. None remain in riverside woodlands where the birds were "discovered" just 183 years ago.[1]

While scientists puzzle over the prospects for breeding these birds and releasing their progeny back to the wild, many wonder how re-introduced birds would learn to locate food. With little habitat left, they would need to fly to other scattered habitat "islands" to find enough fruit and seeds to survive. Even if all of this worked out, the birds' young would be threatened by an invasive introduced insect—the "Africanized" hybrid honeybee—that inhabits 40 percent of remaining tree cavities suitable for macaw nesting.[2]

The demise of the Spix's macaw resonates far beyond one tiny Brazilian region, for this is far from an isolated incident. According to a 2000 study published by the global conservation organization BirdLife International, the Spix's macaw and almost 1,200 additional species—about 12 percent of the world's remaining bird species—may face extinction within the next century. Most struggle against a deadly mixture of threats. Although some bird extinctions now seem imminent, many can still be avoided with a deep commitment to bird conservation as an integral part of a sustainable development strategy. For many reasons, such a commitment would be in humanity's best interests.[3]

As the growing popularity of bird-watching, or birding, highlights, people have long been inspired by the beauty, songs, and varied behaviors of birds. Central America's Mayas and Aztecs worshipped Quetzalcoatl, a dominant spiritual character cloaked in the iridescent green feathers of the resplendent quetzal, a bird now sought by binocular-toting birders. Ancient Egyptians similarly revered the falcon god Horus, while many ethnic groups around the world still ascribe strong spiritual powers to various bird species,

as well as deriving protein and ornaments from local birds. Native American tribes continue to incorporate eagle feathers into their rituals, while East African pastoral tribes do the same with ostrich feathers. Birds' powers of flight inspired our flying machines and continue to draw the attention of artists and photographers worldwide.[4]

But more important, people benefit from invaluable goods and services that birds provide in habitats worldwide. Scientists are just now starting to quantify these "behind-the-scenes" contributions. Many birds, for example, feed on fruits, scattering seeds as they feed or in their droppings as they flap from place to place. Recent studies revealed that black-casqued, brown-cheeked, and piping hornbills are among tropical Africa's most important seed distributors. In tropical Central and South America, toucans and trogons provide this vital service.[5]

On plains and other open areas, vultures provide natural sanitation services by scavenging animal carcasses. Hummingbirds, orioles, and other nectar-feeding birds pollinate a wide variety of wildflowers, shrubs, and trees, including many valued by people, while thousands of insect-eating species and hundreds of rodent- and insect-eating raptors keep pest numbers in check. In Canadian forests, for instance, populations of wood-warblers and evening grosbeaks surge to match outbreaks of spruce budworm, an insect that can severely damage forests of spruce and fir. Losing these birds and others tears the natural fabric of ecosystems. As conservationists learned from species like Spix's macaw, conserving healthy bird populations early would prove far simpler than trying to reconstruct them later.[6]

In addition, many bird species are easily seen or heard, making them perfect environmental indicators. In many cases, they provide scientists with the best glimpse at how humanity's actions affect the world's ecosystems and the more elusive wildlife that share their habitats. In Europe, biologists consider dippers, which are round-bodied stream-living songbirds, valuable indicators of clean water because they feed on sensitive bottom-dwelling insects such as caddisfly larvae, which disappear in sullied waters. Disappearance of dippers and their prey also follows water acidification brought on by acid rain or the replacement of native deciduous forests with pine plantations. Other species are important indicators of threats to humanity, including chemical contamination, disease, and global warming.[7]

Ornithologists are compiling status reports for all of the world's approximately 9,800 bird species, but what they already have tallied is alarming. (See Box 2–1 for some examples.) Human-related factors threaten 99 percent of the species in greatest danger. Bird extinctions are on the increase, already topping 50 times the natural rate of loss, with at least 128 species vanishing over the last 500 years—103 of which became extinct since 1800. (See Table 2–1.) On islands, human-caused bird extinctions are not new: by sleuthing bits of bone found on far-flung archipelagos, scientists recently concluded that even before European explorers sailed to the region, human colonization of Pacific islands wiped out up to 2,000 endemic (that is, only found in one place), often flightless bird species. Today, however, people are crowding out bird populations on the mainland as well.[8]

Birds are by no means the only class of animals at risk, of course. Prominent scientists now consider the world to be in the midst of the sixth great wave of animal extinctions. The fifth wave finished off the dinosaurs 65 million years ago. Unlike previous episodes, however, people are the cause of most of the sudden die-offs. One quarter of the world's

**BOX 2–1. SIGNS OF BIRDS IN DECLINE**

- A 1994 study revealed that 195 of 514 European bird species—38 percent—had "unfavorable conservation status." In Great Britain alone, 139 of 247 breeding bird species (56 percent) are in decline, according to annual surveys.
- Based on the North American Breeding Bird Survey's records between 1966 and 1998, some 28 percent of 403 thoroughly monitored species showed statistically significant negative trends.
- A BirdLife International study of Asian birds published in 2001 found a quarter of the region's bird species—664—in serious decline or limited to small, vulnerable populations.
- Some Australian ornithologists claim that half of their island nation's land bird species—including many endemic parrots—could become extinct by the end of the century, although recent breeding bird surveys chronicled little difference in status for most species over the past 20 years.

SOURCE: See endnote 8.

mammal species are threatened or nearly threatened with extinction; of the other well-surveyed species, 25 percent of reptiles, 21 percent of amphibians, and 30 percent of fish are threatened.[9]

But if we focus solely on the prospects of extinction, we partly miss the point. From an ecological perspective, extinction is but the last stage in a spiraling degeneration that sends a thriving species slipping toward oblivion. Species stop functioning as critical components of their ecosystems well before they completely disappear.[10]

Although birds are probably the best-studied animal class, a great deal remains to be learned about them—from their life histories to their vulnerability to environmental change. In the tropics, where both avian diversity and habitat loss are greatest—in top biodiversity countries such as Colombia, the Democratic Republic of the Congo (formerly Zaire), and Indonesia—experts just do not know the scope of bird declines because many areas remain poorly, if at all, surveyed. Species and some distinct populations that may later be considered separate species may vanish even before scientists can classify them or study their behavior, let alone their ecological importance. Several new bird species are described every year. One of this century's earliest was an owl discovered in Sri Lanka in 2001, the first new bird species found there in 132 years. These scarce and newly described birds sit at a crossroads, as does humanity. One path leads toward continued biodiversity and sustainability. The other heads toward extinction and imbalance.[11]

## Habitat Loss: The Greatest Threat

Many of the problems faced by birds and other wildlife stem from how we handle our real estate. The human population explosion from 1.6 billion to 6 billion during the last century fueled widespread habitat loss that chiseled once-extensive wilderness into wavering habitat islands. Today, loss or damage to species' living spaces poses by far the greatest threat to birds and biodiversity in general.[12]

Timber operations, farms, pastures, and settlements have already claimed almost half of the world's forests. Between the 1960s and 1990s, about 4.5 million square kilometers of the world's tropical forest cover—20 percent—were cut or burned. Estimates of annual deforestation vary widely, from 50,000 to 170,000 square kilometers. Per-

**Table 2–1. Ten Recently Extinct Bird Species**

| | |
|---|---|
| Atitlán Grebe | Gone by 1986, this flightless aquatic bird lived only in Guatemala. Introduced bass, habitat loss, disturbance, and gill nets contributed to its demise. |
| Colombian Grebe | Last seen in 1977 in Colombia, where a combination of introduced trout, pesticide poisoning, wetland loss, and hunting finished it off. |
| Wake Island Rail | A casualty of World War II, between 1942 and 1945 this island endemic was likely captured and eaten into extinction by starving Japanese soldiers. |
| Canary Islands Oystercatcher | Seen perhaps as recently as 1981, this shorebird succumbed to loss of its mollusk prey due to overharvesting by humans, probable predation by introduced cats and rats, and disturbance by people frequenting its coastal habitats. |
| Paradise Parrot | Probably extinct by 1927, this colorful Australian parrot likely died out due to combined factors including overgrazing, drought, fire suppression, invading exotic prickly pear cacti, disease, trapping, egg collection, introduced predators, and loss of eucalyptus trees. |
| Bush Wren | A ground-nesting bird rousted from New Zealand by introduced predators by 1972. |
| Grand Cayman Thrush | Last seen in 1938, this wetland songbird disappeared with its habitat. |
| Aldabra Warbler | Discovered in 1967, this bird was gone by 1983 from its namesake Indian Ocean island due to rat predation and habitat degradation wrought by introduced goats and native tortoises. |
| Guam Flycatcher | Along with the island's other native birds, this bird was eaten out of its Pacific island home by introduced brown tree snakes by 1983. |
| Kaua'i 'O'o | Last reported in 1987, this Hawaiian forest bird suffered from habitat loss, predation by introduced black rats, and diseases introduced by exotic mosquitoes. |

SOURCE: Alison J. Stattersfield and David R. Capper, eds., *Threatened Birds of the World* (Barcelona: Lynx Edicions, 2000).

haps easier to track are dwindling populations of creatures that must live beneath the trees: habitat loss jeopardizes 1,008 (85 percent) of the world's most threatened bird species, with recent tropical forest destruction affecting 74 percent.[13]

Foresters herald the regrowth of temperate forests as an environmental success story, and in recent decades substantial reforestation did take place in, for example, the eastern United States, China, and Europe. Forest management profoundly affects diversity and natural balances, however, and satellite images of tree cover do not tell us how much of the regrown habitat is indeed quality habitat.[14]

In the southeastern United States over the last five years, for instance, more than 150 industrial chip mills have chewed up vast tracts of natural forest to produce paper, rayon, and pressboard. Foresters replace the clearcut area with rows of same-age, same-species pine saplings. For many native animals and plants, simplified plantation monocultures are no substitute for more complex natural forests, with their old, young, living, dead, deciduous, and coniferous trees and

their lush, varied undergrowth.[15]

Even without plantations, the consistent loss of some forest components can cause birds to abandon areas. For example, studies in intensively managed Finnish forests, where foresters remove older and dead trees, revealed marked declines in large forest birds such as a peacock-sized grouse called the capercaillie and the crow-sized black woodpecker.[16]

Losses of other habitats important to birds and other wildlife have been less heralded, but no less dramatic. Grasslands, which cloak more than a third of Earth's surface, sustain bird populations found nowhere else, but they also host almost one sixth of the human population. Few large, undisturbed grassland areas remain. In North America, the great grasslands that once stretched from the Mississippi to the base of the Rocky Mountains are largely gone, including the tallgrass prairie, of which less than 4 percent remains.[17]

Following this widespread landscape change, many North American grassland bird populations continue to shrivel, according to the U.S. Geological Survey's annual North American Breeding Bird Survey. Between 1966 and 1998, 15 of 28 characteristic grassland bird species steadily declined. The victims include the burrowing owl and other birds that maintained ecological relationships with once-abundant prairie dogs. After the colonial rodents' populations plummeted by 98 percent, the owls, which nest in old prairie dog burrows, are gone from much of their former breeding range. Even in the largest remaining swath of tallgrass prairie—the Flint Hills region of Kansas and Oklahoma—the once-abundant greater prairie-chicken is rapidly losing ground due to recently intensified burning and cattle grazing methods.[18]

In Europe, agriculture covers about half of the land. Most of this excludes grassland birds because intensive, modern cultivation often requires higher chemical inputs such as harmful pesticides, while weedy growth or hedgerows—once wildlife-hospitable components of more traditional, smaller farms—vanished to make way for large machinery and larger areas of cropland. The last strongholds for many grassland species, including large areas in Portugal, Spain, and central and eastern European countries, are under or will soon be under severe pressure from increased irrigation and modernization programs subsidized by the European Union's Common Agricultural Policy.[19]

Grassland remains on about 60 percent of its original span in Asia, Africa, and Australia, although much of it is degraded. One widespread threat is overgrazing. In many areas, light grazing helps maintain healthy grasslands. But the picture quickly changes when a threshold, which varies by region, is passed. And overgrazing is often but one of several threats to these ecosystems.[20]

For example, 10 of the world's 25 bustard species are either threatened with extinction or close to it due to widespread overgrazing, collisions with fog- or darkness-shrouded power lines, and hunting. The turkey-sized great bustard, once found from Britain to China, has just a few Spanish, Russian, and Chinese strongholds and is disappearing from widely scattered populations elsewhere.[21]

A close relative, the Australian bustard, no longer stalks most of the southeastern part of its namesake country due to introduced rabbits and livestock, which chew down habitat, and to fire restrictions, which allow the intrusion of acacias and other woody plants into grasslands. Argentina's grasslands face a similar onslaught brought on by "exotic" trees—pines and eucalyptus introduced at nearby tree plantations invade grasslands to the detriment of native birds and other wildlife.[22]

Many birds flourish where land and water

mix—in wooded swamps, marshes, mangrove forests, coastal mudflats, and other wetlands. Until recently, humanity saw these areas as disease-ridden wilderness asking to be conquered. Draining, filling, and conversion to farmlands or cities destroyed an estimated half of the world's wetlands during the twentieth century. Estimates within individual countries are often much higher. Spain, for instance, has lost an estimated 60–70 percent of its wetland area since the 1940s.[23]

Even wilderness areas such as Everglades National Park, in the United States, and Spain's Doñana National Park have not been spared humanity's heavy hand. In and around these two greatly compromised protected areas—both of which are classified as Biosphere Reserves, World Heritage Sites, and Ramsar wetlands of international importance—hydrology has been disrupted, exotic plants and animals have invaded, and pesticides and other pollutants wash in from nearby farms and industries.[24]

One of Spain's greatest environmental disasters occurred in 1998, when a mine reservoir just north of Doñana burst, flushing 1.58 million gallons of heavy metal–laden water down the Guadiamar River, reaching well into the park's buffer zone. Thousands of birds and fish died, and reproduction will likely be impaired in birds and other aquatic life for years to come.[25]

Declining bird populations followed habitat degradation in both parks. For example, bird census-takers counted 5,100 white ibis in the Everglades between 1997 and 1999—more than 45 times fewer than were estimated to nest there in the 1930s. In Doñana National Park, the once-abundant but now-threatened marbled duck barely breeds within the park's borders most years because increased demand for irrigation, among other factors, means that marshes dry up by August, before these wetland birds finish nesting.[26]

Outside protected areas, changes have been far more dramatic. Over the last 70 years, Armenia's Lake Sevan suffered dramatic lowering due to water diversion, and Lake Gilli was drained entirely. With their vital wetlands destroyed, at least 31 locally breeding bird species abandoned the lakes, including the sensitive black stork and the more adaptable lesser black-backed gull.[27]

**Wetlands serve as key stopover sites for millions of transcontinental migrants.**

A 1999 survey of 47 wetland sites in Morocco found that only 10 had protected status and that most faced threats from development, habitat alteration, and exotic fish introductions. Researchers compared descriptions from a similar survey of 24 of these sites in 1978 and found that 25 percent of the wetlands were destroyed in two decades.[28]

Aside from being vital nesting grounds for birds, wetlands also serve as key stopover sites for millions of transcontinental migrants, particularly on coasts, along rivers, or in bays where birds pause to rest and refuel before or after transoceanic journeys. Major examples of these rest spots include China's Deep Bay, Surinam's coastal mudflats, Alaska's Copper River Delta, and Australia's Gulf of Carpentaria.[29]

Other concentration points favored by migrating storks, hawks, and myriad songbirds include narrow land corridors such as those at Gibraltar, Turkey's Bosporus Strait, Eilat in Israel, Point Pelee in Canada, and the coastal Mexican city of Veracruz. At many of these sites, development shrinks wetlands and other habitats. This means that more migrating birds must pack into smaller and smaller spaces, increasing the likelihood of botulism and other outbreaks that can kill thousands of birds.[30]

In many parts of the world, flat lowland areas have been the first to be exploited for timber or farming. More difficult to clear and cultivate, mountains often hold their habitats longer against human endeavors. In many countries, including Jamaica and Mexico (in terms of the country's dry forest), much of the remaining habitat is found only in prohibitively steep terrain.[31]

Once targeted, though, mountain habitats and wildlife are extremely vulnerable. Altitude and moisture levels dictate vegetation and wildlife occurrence there, creating narrow ribbons of habitat. Humans and migrant birds alike particularly favor temperate and rain-soaked middle elevations. In the Andes, Himalayas, and Central American highlands, among other areas, middle-elevation forests are highly degraded, creating severe erosion problems, fouling watersheds vital to human populations, and providing less and less area for wintering and resident birds.[32]

The blazing orange-and-black blackburnian warbler is one bird affected by the widespread loss of mid-elevation Andean forests. Weighing just a third of an ounce, this colorful insect-eater nests in North American spruce and hemlock forests but winters 8,000 kilometers away in northwestern South America. Conservationists expect a dip in blackburnian warbler populations, a scenario faced by many of the 200 or so other Neotropical migrant birds—species that nest north of the Tropic of Cancer but winter in Mexico, the Caribbean, or Central or South America.[33]

A recent study of another warbler, the American redstart, used carbon isotopes to determine wintering habitats of birds migrating to New Hampshire to breed. The findings suggest that earlier-arriving, healthier birds winter in humid tropical forests, while weaker, less competitive individuals settle for degraded, drier habitats. This is a likely indication that optimal redstart wintering areas are already saturated and limited, and implies that although birds can winter in compromised habitats, they may be less fit to compete and breed.[34]

In many cases, Neotropical migratory birds' winter ranges are more compact than their nesting areas, putting concentrated wintering populations at greater risk from habitat loss. For instance, the Oklahoma state bird—the scissor-tailed flycatcher—nests throughout that state, in most of Texas and Kansas, and in portions of Arkansas, Missouri, and Louisiana. During the winter, however, most of the population packs into an area of northwestern Costa Rica about the size of one Texas county.[35]

Quite a different situation exists for many tropical birds that do not migrate, many of which live year-round in small areas. All told, just over a quarter of all bird species—2,623—have ranges that are at most the size of Costa Rica or Denmark (about 50,000 square kilometers). More than half of these species are threatened or near-threatened; 62 are now extinct. Within their limited ranges, many of these localized species are pigeonholed into only those prime habitats that remain. Even in these last havens, other factors often come into play, nudging populations closer to extinction.[36]

## Falling to Pieces

Ecologically speaking, what happens around a habitat is as important to its denizens as what happens inside it. In recent years, this revelation began guiding conservationists, who now view protected areas as part of larger landscapes that function together to support or thwart species. When habitats—and mosaics blending different habitats—are diced into smaller and smaller pieces, they often suffer from edge effect, or the negative

influences of an edge on a habitat's interior.[37]

For instance, when loggers remove a large swath of trees, light-tolerant plants move into the clearing and the adjacent forest's edge. Sunlight penetrates farther into the forest than before, raising temperatures, drying out the forest floor, and increasing the likelihood of fires or of wind or drought damage. Edge effect stresses or kills shade-adapted plants, leaving them to dry up or to become more susceptible to disease or invading competitors. Researchers studying forest fragments in central Brazilian Amazonia found that the amount of above-ground vegetation was greatly reduced, especially within 100 meters of fragment edges, due in good part to increased tree mortality.[38]

After trees fall, remaining forest fragments may no longer provide an ideal habitat for forest interior birds, which must contend with the invasion of creatures that thrive in more open areas. In forest fragments, North American forest birds face larger predator populations and brown-headed cowbirds. Rather than building their own nests, cowbirds lay their eggs in nests of host bird species, often to the detriment of the hosts' young. In some highly fragmented forests, cowbird eggs turn up in up to 90 percent of wood thrush and 80 percent of warbling vireo nests.[39]

When isolated in small forest patches, many southeastern Australian birds decline because aggressive, edge-favoring birds called noisy miners out-compete them for food and nesting places. Conservationists now recommend setting aside large forest reserves as one of the only ways to protect smaller, less aggressive species, including many insect-eating birds that live within the miners' breeding range. A similar recommendation is made for wood thrushes in highly fragmented midwestern U.S. forests. Specialized insectivorous birds also suffer from fragmentation in other parts of the world, including Japan.[40]

Roads and power lines frequently cut through forests, increasing the chance of fatal collisions and providing pathways for edge predators, competitors, and exotic plants. Traffic noise may also interfere with birds' attempts to mark territory through song. Via roads, humans and their livestock gain easier access to forest fragments, removing undergrowth and dead, standing trees important to parrots, woodpeckers, and other cavity-nesting birds.[41]

In equatorial Africa, Amazonia, tropical Asia, and other regions where forestry roads cut into large remaining tropical forests, intensive hunting—made easier thanks to roads—is also widespread. In equatorial Africa and some other areas, hunters shoot wildlife not only for subsistence but to supply burgeoning urban delicacy markets. On the island of New Guinea, increasing hunting pressure, aided by recent road construction, threatens a growing number of endemic bird-of-paradise species.[42]

Coming at the fragmentation issue from the other side, some researchers highlight the importance of intact "source" areas—refugia that produce surplus birds that may later disperse to take up slack in more stressed, less productive "sink" areas such as woodlands carved up by suburbs. A 1996–98 survey that took place mostly within Cherokee and Nantahala-Pisgah national forests in the southeastern United States compared results with surveys done at the same sites 50 years earlier. Researchers found that this extensive area "retained and probably regained functional integrity for forest birds during the latter half of the 20th century." Opportunistic, nest-robbing blue jays declined during this time, while nest-parasitizing cowbirds, lacking open feeding areas nearby, were virtually absent. Neotropical migrants declining in many other places held steady or increased in these large forest reserves.[43]

## An Alien and Danger-Filled Ark

Visit a Hawaiian garden, and you'll likely see Brazilian red-crested cardinals and Asian common mynas, but you will be hard-pressed to find a native bird. Stroll city streets in North America, South Africa, and Australia, and you may find introduced European starlings, house sparrows, and feral pigeons at your feet. What's happening here? Even in otherwise-undisturbed wildlife habitats, a new order is taking hold as exotic, or non-native, species—from pathogens to mongooses—are introduced through human blunder, curiosity, or in hopes of providing food or other goods and services, including control of other rampaging exotics. Over the past century, the pace of introductions greatly accelerated in parallel with the rise in global trade and travel.[44]

**Due to their apparent lack of immunity, North American birds today factor as key indicators of the spread of West Nile virus.**

Today, exotics threaten birds and their ecosystems in myriad ways, constituting the second most intense threat to birds worldwide, after habitat loss and degradation. (For threatened species, however, exotics rank third, behind exploitation, particularly hunting and capture for the cage bird trade.) Introduced species contributed to most bird extinctions since 1800, and they now menace a quarter of globally threatened bird species.[45]

Once introduced, some exotic predators became all the more lethal on islands, where endemic species evolved with few or no defenses against such hunters. To date, 93 percent of bird extinctions (119 out of 128) have occurred on islands, where extremely vulnerable endemic species succumbed to habitat loss, hunting, and, in most cases, exotic species. In many cases, introduced mongooses, rats, pigs, and other non-native animals have unsettled unique island ecological balances.[46]

One reptilian invader, the brown tree snake, ate 12 of Guam's 14 land bird species into extinction by the 1980s after its accidental release following World War II. In recent years, this snake has also turned up at Hawaiian airports, raising fears that it could become the latest—and one of the greatest—threats introduced there.[47]

Introduced rats plague many island-nesting seabirds, including albatrosses and petrels. Having found their way to islands via explorers' or colonists' ships, or more recently fishing boats, the opportunistic rodents now dine on bird eggs and young. A recent study on New Zealand's northern offshore islands revealed that rats not only threaten the islands' nesting petrels, they also eat native plants' seeds, stifling the distribution of 11 out of 17 coastal trees and bringing some close to local extinction.[48]

One of humanity's constant companions is another nemesis of wild birds. On far-flung islands, house and feral cats have contributed to the extinction of 22 or more endemic birds. Their effect on mainland wildlife populations is also great. Studies in Australia in the early 1990s documented domesticated and feral cats killing members of almost a quarter of the country's 750 bird species. Annually, cats kill an estimated 1 billion birds in the United States, where at least 40 million house cats regularly roam free and another 60–100 million cats live in a feral state. U.S. cats kill at least nine federally listed species, among many other victims, including beach-nesting least terns and piping plovers.[49]

Tiny predators plague other birds. The yellow crazy ant, a frenetic, fast-multiplying insect, is marching across the Australian ter-

ritory of Christmas Island following its introduction there during the twentieth century. Recently, biologists documented the insects killing the islands' abundant land crabs. Like many other ant species, crazy ants "farm" scale insects—herding and protecting these forest-damaging insects and drinking a sweet secretion they extrude while destroying rainforest trees.[50]

As they spread across the island, crazy ants will likely kill young native birds, including those of two critically endangered species—the endemic Christmas Island hawk-owl and Abbott's booby, a seabird that nests nowhere else but in the island's forest canopy. In coming decades, both species are expected to decline 80 percent due to the ant invasion. Introduced crazy ants also threaten birds on the Hawaiian and Seychelles islands and on Tanzania's Zanzibar.[51]

In North American forests, sap-feeding insects called hemlock and balsam wooly adelgids are changing habitats' ability to support birds and other flora and fauna. These accidentally introduced insects now spread by wind and via birds' feathers and mammals' fur. First a threat to western forests, the hemlock wooly adelgid, originally from Asia, moved east by the 1950s and is now eradicating Carolina and eastern hemlocks, important components of eastern woodlands. Meanwhile, the European balsam wooly adelgid attacks balsam and Fraser firs in northeastern and Appalachian forests. Heavy loss of Fraser firs leaves intermingled red spruce more vulnerable to wind damage, changing the face of forests in such important bird breeding "source" areas as the Great Smoky Mountains National Park. A recent study in a fir-damaged area found that the combined density of all breeding birds declined by half and that 10 of 11 common breeding birds had declined.[52]

Sometimes introduced dangers are invisible. On the Hawaiian Islands, mosquitoes, which originally landed in the archipelago in ship-carried water barrels in 1826, unleashed a pair of deadly diseases—avian pox and avian malaria—upon the island's non-immune native birds. These diseases arrived via introduced birds and were injected into natives by the mosquitoes, contributing to at least 10 extinctions and potentially fueling dozens more. Weakened, native Hawaiian birds become even more vulnerable to introduced birds that compete with them for food and habitat.[53]

Whether introduced, naturally occurring, or strengthened by unnatural conditions, other diseases threaten birds. India's once-abundant long-billed and white-rumped vulture populations have crashed—plummeting more than 90 percent country-wide during the last decade—most likely due to a virus or other contagious illness. A decade ago, these birds swarmed over abundant cow carcasses that litter fields and dumps around Indian cities and towns. Now they are listed as critically endangered. In their sudden absence, feral dog, crow, and rat populations have exploded, taking up the slack in scavengers and posing great health risks to people nearby.[54]

Due to their apparent lack of immunity, North American birds today factor as key indicators of the spread of West Nile virus, which first appeared in New York in 1999. This mosquito-borne disease, present in Africa and Eurasia for decades, has killed scores of people in the United States so far. West Nile virus has taken a far higher toll on birds, killing thousands of birds in more than 100 species and putting endangered species breeding programs in peril. To date, no one knows if transported pet birds, humans, or—less likely—trans-Atlantic migrant birds brought the illness.[55]

Predators and pathogens aside, native birds also face both genetic and direct competition from exotic birds. For example, people around

the world have dumped familiar domesticated mallard ducks into ponds and other wetlands. In various countries, these green-headed waterfowl vigorously interbreed with closely related species, "swamping" or undermining the native species' genetic variability. Such hybridization affects South Africa's yellow-billed ducks, endangered Hawaiian ducks, American black ducks, and mottled ducks. A similar problem occurs in Spain. There, threatened white-headed ducks—already pinched by habitat loss—now mingle and hybridize with North American ruddy ducks, which were introduced to England in the 1940s but have since flown over to the continent. New European legislation aims to curb ruddy duck numbers through hunting.[56]

Introduced plants create their own, very different dangers, changing birds' habitats until they are eventually uninhabitable. Whether brought over as nursery stock, planted with the blessing of farm programs, or seeded by accident, exotic plant species have gone wild in many parts of the world—at the expense of birds and other wildlife. One of North America's worst plant invaders illustrates the point. Brought over from Eurasia, rapid-growing cheatgrass has spread far and wide since its introduction to North America in the late 1800s. As it overtakes sagebrush and bunchgrass habitats, cheatgrass fuels the decline of such sage-dependent birds as the sage grouse, which nests among sagebrush shrubs and depends on their leaves and shoots for food. Cheatgrass is now found on more than 40 million hectares, an area larger than Germany, and dominates much of that grassland and pasture.[57]

Unknowingly, birds use their formidable seed-distributing abilities to further spread invasive exotic plants. This is happening, for example, on the Pacific island of Tahiti and in the Hawaiian islands, where birds distribute seeds of the fast-spreading miconia tree, a South American ornamental that now runs amok, shading out native plant life in more than half of Tahiti's forests. Many scientists consider this striated, broad-leafed plant to be one of the greatest threats to Hawaii's remaining native forests as well; there it covers about 4,400 hectares.[58]

In Florida, millions of wintering American robins and other native birds eat Brazilian pepper berries and scatter their seeds across the Everglades and other wild areas. Brazilian pepper, one of the most widespread exotic plants in the state, is now found on at least 324,000 hectares, including 40,400 hectares of mangrove forest in Everglades National Park. Similarly, the introduced common myna is dispersing pervasive South American lantana bush's seeds in Asia.[59]

Although overlooked by novice nature-lovers, exotic plants now dominate many landscapes. Controlling well-established exotics is neither cheap nor easy. For example, perhaps 5 percent of 283 million hectares (700 million acres) of public land is "seriously infested" in the United States, where at least 400 exotic plant species have gone out of control. No longer can we think that nature can right itself if left alone.[60]

Dealing with exotic introductions often requires active management, including hunting, poisoning, herbicide spraying, and in some cases introducing natural predators of the out-of-control exotic—activities that can also potentially disturb or harm native birds and other wildlife. In the United States alone, the annual cost of damage caused by exotics and the measures to control them reaches an estimated $137 billion.[61]

## Bullets, Cages, Hooks, and Chemicals

It is hard not to marvel at tiny birds' mighty migratory abilities and delight in their return

each year. In some regions, however, human attention to migrants poses an environmental problem: unregulated hunting along migration routes kills huge numbers of birds each fall and spring. The Mediterranean island nation of Malta has long had one of the most publicized problems. There, throughout spring and fall migration, hunters take aim at island-hopping birds during their flights north to mainland European nesting grounds and south to African wintering areas.[62]

Officially protected birds, from swallows and bee-eaters to harriers and herons, fall to Maltese shooters in staggering numbers. Most of this hunting is just target practice, and hurts already declining European nesting bird populations. Birds, mainly finches, are also illegally trapped as cage birds: in 2001, the nongovernmental organization (NGO) BirdLife Malta used aerial photography to identify more than 5,300 trapping sites, mainly along the coastlines of the country's two largest islands, Malta and Gozo. Thanks in good part to NGOs' efforts, public outcry has grown in recent years, and the Maltese government recently passed more stringent hunting laws. Enforcement remains lax, however, and the hunting lobby is strong. As of October 2002, the government was wavering as to whether to loosen hunting restrictions. BirdLife Malta estimates that 3 million birds are shot or trapped in Malta each year.[63]

Meanwhile, illegal hunting and trapping of protected birds of prey and songbirds remain problems in other parts of Europe, including Cyprus (another important migration stopover), Greece, France, Spain, and Italy, although growing public support for conservation efforts has helped reduce this threat, particularly in the latter two countries. On the other side of Eurasia, an upswing in commercial hunting of Chinese songbirds raises concerns that migratory and resident species, including yellow-breasted buntings and Eurasian tree sparrows, are being unsustainably killed for bite-sized snacks. Despite a government ban on killing these birds, since the early 1990s more than 100,000 a year have been caught, killed, frozen, and then fried and sold—from Beijing to Guandong.[64]

While many small species are targeted, robust species attract even more attention. Among the first wildlife species to disappear from Central and South American forest fragments are turkey-like birds called curassows, chachalacas, and guans, 15 of which are threatened with extinction. Large, nonmigratory, and palatable, these herbivores feed on forest fruits, seeds, leaves, and flowers, and some are important seed dispersers.[65]

**Almost a third of the world's 330 parrot species are threatened with extinction due to habitat loss and collecting pressures.**

Even where hunting laws protect rare guans, such as in Mexico in the case of the horned guan, there is insufficient enforcement. Large, roadless forest tracts provide the best refuge for these birds, but such real estate is now hard to come by in Central America and parts of South America. Elsewhere, unregulated hunting threatens other large birds, including 22 localized Asian pheasant species.[66]

Hunting is less of a threat for parrots, long loved by people the world over for their colorful plumages, potential affection toward their owners, and, in many species, adept "talking" abilities. For these attributes, wild parrot populations suffer greatly from the wild bird trade. Almost a third of the world's 330 parrot species are threatened with extinction due to habitat loss and collecting pressures, part of a burgeoning illegal wildlife trade valued at billions of dollars a year.[67]

Over the last decade, protection measures helped reduce the international trade in wild parrots. These initiatives include the Convention on International Trade in Endangered Species of Wild Fauna and Flora, which protects rare species from the wildlife trade (see Table 2–2), and wild bird export bans in Australia, Guyana, and other countries. The 1992 Wild Bird Conservation Act in the United States, which limits or prohibits exotic wild bird imports, greatly reduced wild bird imports and fueled a growing U.S. captive-breeding industry.[68]

But protection laws in many parrot-rich countries often go unheeded, and parrot poaching and smuggling remain widespread, due to both domestic and international demand. In addition to parrots, bird traders seek many other colorful species, including South America's yellow cardinal and a cherry-red bird called the red siskin, both of which have been collected almost to extinction in their remaining habitats. Without concerted in-country efforts to stem unbridled collecting, these and other species will likely disappear.[69]

Far from South American forests, another threat looms. Seemingly endless ocean expanses provide an undulating backdrop for large-scale seabird die-offs brought on by commercial longline fishing. At least 23 seabird species now face extinction largely due to this industry, which became dominant worldwide following the 1993 ban on drift-nets, hulking devices that scooped up enormous quantities of untargeted sea creatures. Today, longline boats set their lines, which can be 130 kilometers long and stud-

**Table 2–2. Some International Agreements That Help Conserve Birds**

| |
|---|
| Ramsar Convention on Wetlands (1971) |
| Nearly 1,200 wetland sites in 133 countries, totaling 103 million hectares, have been designated for protection and monitoring under this international agreement to conserve wetlands and use them sustainably. |
| Programme on Man and the Biosphere (1972) and World Heritage Convention (1972) |
| Under UNESCO, these initiatives set a framework for designating, protecting, and monitoring some of the world's most important biodiversity and cultural hotspots. As of May 2002, 94 countries had established a total of 408 biosphere reserves under the Man and the Biosphere Programme. |
| Convention on International Trade in Endangered Species of Wild Fauna and Flora (1975) |
| An international agreement by 160 countries to monitor international trade in wild animals and plants and ensure that trade does not put wildlife in jeopardy. |
| Convention on the Conservation of Migratory Species of Wild Animals (1983) |
| Eighty countries have signed this agreement, also known as the Bonn Convention, to protect migratory wildlife species, including birds, throughout their international migratory, breeding, and wintering areas. |
| Convention on Biodiversity (1992) |
| A total of 185 countries have signed on to this agreement, which was introduced at the Earth Summit in Rio in 1992. Signatories promise to set up strategies for protecting their biodiversity, including habitat protection and restoration. Fewer than 40 have drawn up formal plans so far. |

SOURCE: Convention and program Web sites.

ded with up to 12,000 baited hooks, later hauling them in to collect commercial fish such as tuna, swordfish, cod, and halibut. Unfortunately, hundreds of thousands of seabirds drop down on the lines before they sink, grabbing at bait and becoming hooked, only to be submerged and drowned.[70]

Among the birds hard-hit by this activity are 17 of the world's 24 albatross species. These slow-breeding, slow-maturing ocean-wanderers—many already under pressure at their remote nesting sites from introduced predators—are suffering staggering losses. For instance, from 1997 to 2000, illegal or "pirate" longlining in southern oceans killed an estimated 333,000 seabirds, including 67,000 albatrosses. An estimated 10 percent of the black-footed albatross's breeding population perishes each year on longlines set in the North Pacific.[71]

To date, no adjustments have been made in fishing practices, despite recent findings that simple measures can reduce bird bycatch by more than 90 percent. Such measures include installing bird-scaring streamers, setting nets at night, and adding weights to lines so that they sink faster. At least 33 countries have longline fleets plying the world's waters; prominent players include Canada, China, Japan, Russia, South Korea, Taiwan, and the United States.[72]

This situation may soon change, however. In 2001, seven countries—Australia (which initiated the plan in 1997), Brazil, Chile, France, New Zealand, Peru, and the United Kingdom—signed the Agreement for the Conservation of Albatrosses and Petrels, under the Bonn Convention. When ratified, this treaty will legally bind signatories to reduce longlining bycatch of seabirds and to implement other seabird conservation measures. One challenge will be to get boats to use these measures uniformly. And then there is the problem of regulating and policing illegal fishing, which depletes not only bird but also fish stocks. The U.N. Food and Agriculture Organization encourages countries to draw up their own national plans of action for voluntarily reducing longlining bird kills.[73]

The specter of oil spills also hangs over many seabird populations. An unprecedented volume of oil crosses the seas these days, providing a human-transported disaster waiting to happen at any time. African, Magellanic, Galápagos, and five other penguin species are among the many seabirds affected by oil spills near their nesting and feeding areas.[74]

Large-scale spills highlight oil's effects on ecosystems and birds. The 1989 Exxon Valdez spill, for instance, perhaps killed more than 250,000 birds, and a 1999 spill off of France's Brittany Coast killed an estimated 100,000–200,000 birds of at least 40 different species. But small, less-publicized, daily tanker leaks also kill birds.[75]

The Galápagos Islands—a cradle of endemic species and inspiration for Darwin's evolutionary theories—were similarly threatened by oil in 2001, when 150,000 gallons leaked from an Ecuadorian tanker. The spreading spill seemed likely to mire many of the archipelago's aquatic species, including sea lions, unique marine iguanas, the world's rarest gull, and Galápagos penguins. Fortunately, the current swept much of the slick clear of the islands, so dozens rather than thousands of birds and sea lions died. Some scientists believe, however, that small quantities of oil killed the bacteria in the algae-eating iguanas' guts, causing many to starve. If that proves true, this incident highlights the impacts that even smaller amounts of spilled oil can have on wildlife.[76]

Trade in oil is but one industry that pollutes the environment, as can be seen in bird populations' reactions to the poisoning of their habitats. Effluents released by factories into surrounding waters leave telltale marks

on bird populations. A recent study of tree swallows breeding in the PCB-contaminated Hudson River seemed to show that young females there molt into adult coloration earlier, a possible sign that the birds' endocrine systems have been disrupted by contaminants.[77]

In the 1970s and early 1980s, biologists and toxicologists monitored severe deformities and breeding troubles in fish-eating Great Lakes birds. Since Canadian and U.S. efforts to stem industrial contaminants such as PCBs and DDE began in the late 1970s, the populations of herring gulls and double-crested cormorants have grown, and the bald eagle returned to the region. But scientists continue to keep tabs on birds and fish to assess industrial threats not only to wildlife but also to human health. They still note bird deformities and breeding troubles in heavily industrialized parts of the Great Lakes.[78]

**Even within protected wetland areas, thousands of birds die each year from lead poisoning.**

Chemicals also threaten birds far outside heavily industrialized zones. Worldwide, both in water and on land, pesticides kill millions of birds. For example, the persistent organochlorine pesticide DDT builds up in predatory birds' tissues and causes widespread nesting failure—as was seen in the United States and Britain during the 1950s and 1960s. After U.S. law banned DDT in 1972, the country's peregrine falcon, bald eagle, osprey, and brown pelican populations rebounded. Similar rebounds occurred in Britain in such raptors as sparrowhawks after a ban was initiated there. In 2001, 120 countries signed a pesticide treaty that included a phaseout of DDT except for limited use in controlling malaria. (See Chapter 4.) But DDT has not gone away even where it is now banned: this pesticide persists in soil and water even in places where its use was discontinued 30 years ago.[79]

Although not as persistent, some of the new generation of pesticides, including organophosphates and carbamates, are more toxic to birds. One of the most dramatic recent examples of pesticides' danger to birds came from the Argentinean pampas, where, in the winter of 1995, an estimated 20,000 Swainson's hawks—about 5 percent of the population—died after feeding in alfalfa and sunflower fields sprayed with the insecticide monocrotophos.[80]

In autumn, these western North American nesters fly 6,000–12,000 kilometers south to feed in flocks on field insects during the southern spring and summer. Due to public outcry from NGOs and government agencies in the United States, Canada, and Argentina, a major manufacturer of the organophosphate insecticide, Ciba-Geigy (now Novartis), agreed to phase out its sales in areas where the hawks winter. The Argentinean government also banned its use there.[81]

Pesticides also affect birds indirectly, either killing off their prey or destroying vegetation they need for shelter and nesting. British gray partridges, for example, declined after insecticides reduced their chicks' invertebrate prey and herbicides withered wild plants among which they nest and feed. Bustards, skylarks, and other birds living on agricultural lands suffer similar effects.[82]

Even within many protected wetland areas, thousands of birds die each year from another form of chemical threat—lead poisoning. Carefully regulated hunting is frequently an integrated part of bird conservation efforts. In fact, hunters continue to be instrumental in setting aside vital conservation lands in North America, Europe, and elsewhere. But one traditional hunting tool—lead shot—

poses grave threats not only to waterfowl but to eagles and other wildlife. Waterfowl are most at risk because they guzzle down spent shot either instead of the pebbles they seek as grit or by accident when rooting underwater for food. Several weeks after ingesting the shot, the slowly poisoned birds die. Eagles and other scavengers feeding on shot ducks also succumb to lead poisoning.[83]

A growing number of countries, including the United States, Canada, and many in Europe, have banned lead shot. But many others have not. The U.S. Fish & Wildlife Service estimates that in 1997 alone, the nationwide ban on lead shot used for waterfowl hunting prevented 1.4 million duck poisoning deaths. In 2001, a partial ban began in Spain, where conservationists estimate that up to 70,000 birds die of lead poisoning each year. A similar fate awaits waterfowl ingesting lead fishing sinkers, a leading cause of death for loons breeding in the northeastern United States.[84]

## Modern Conveniences and Climate Change

As technologies advance and human settlements spread, we tailor the landscape to outfit our needs for communication, electricity, modern office space, and other amenities. Some of these advances are setbacks for birds, which evolved in far different surroundings.

Strung across open country, power lines are a leading cause of mortality in Europe's white storks, threatened great bustards, and raptors. Birds taking off in foggy or dark conditions run into the obscured lines. Others are electrocuted when they land on exposed cables atop poles. Studies conducted in Spain, Norway, and elsewhere indicate that putting markers on wires can cut collisions at least in half. This measure is taken by some companies, but it is not yet widespread in most of the world.[85]

Skyscrapers and television, radio, and cellphone towers kill millions of night-flying migrants each year, especially during cloudy or foggy nights. In the United States alone, communications towers may kill up to 40 million birds annually. The structures' pulsing red lights distract the birds, which use light as one of their migratory cues. Many collide with towers or their guy wires while circling the lights. Depending upon weather conditions, the death tolls can be staggering: During just one cloudy night in January 1998, between 5,000 and 10,000 lapland longspurs—sparrow-like birds that breed on tundra but winter far south on farms in the United States—died after hitting one 420-foot-tall Kansas tower. Between 1957 and 1994, 121,000 birds of 123 species turned up dead beneath one 960-foot television tower in Wisconsin.[86]

These threats increase as tall towers and buildings continue to spread across landscapes. More than 40,000 towers above 200 feet are found the United States, and this figure may double over the next decade due to the proliferation of towers needed for mobile phones as well as new digital television technology. Weather is not the only consideration—location is important. Towers placed along migration corridors or hilltops increase the risks to birds. Few companies or governments have addressed this growing problem, which requires more study to determine the best measures to minimize the effects of light, towers, and guy wires, as well as tall buildings. Some suggested alternatives include replacing pulsing red lights with white strobe lights that might be less confusing to migrants and building lower towers that do not require deadly guy wires for support.[87]

To the threats posed by these human-made structures must now be added the dangers of human-caused global warming, which

is hastened by many of the same activities that destroy habitat—forest clearing, rampant forest fires, road building, and urban expansion. Scientists estimate that Earth's climate warmed 0.3–0.6 degrees Celsius over the past century, and that temperature change will continue and possibly intensify. Already, ecological changes seem to be under way in ecosystems around the world.[88]

For one thing, temperate fauna and flora seem to be changing their schedules. Over the past few decades, scientists have documented earlier flower blooming, butterfly emergence, and frog calling—and earlier bird migration and egg-laying dates in Europe and North America. Many temperate bird species' ranges are creeping northward. While this might sound exciting to bird-watchers, it is unclear whether some earlier migrations and northward range extensions match rapid habitat changes. It is unlikely that all natural components will shift simultaneously, adjusting quickly to rapid climate change. Many probably will not. Habitats may change too quickly for many species to adapt. Park boundaries may be rendered useless, and many localized species may have no place to go as their habitat changes around them.[89]

The Kirtland's warbler, an endangered, localized songbird, may prove to be one such victim. This small, lemon-breasted bird builds its grass-and-leaf nest beneath young stands of jack pine, a tree found from northern Michigan through much of the lower half of Canada. The well-draining sand under the warblers' nests is not found far outside of Michigan, however, and the birds nest in only a few of that state's counties. If global warming erases the southern extent of jack pines, northward-moving birds might be left without well-draining nesting substrate, and nesting may fail.[90]

Global warming would endanger more than just temperate-zone songbirds. Vegetation and climate models testing moderate climate change scenarios predict that globally threatened spoon-billed sandpipers and red-breasted geese may lose respectively 60 and almost 70 percent of their remaining nesting habitat as tundra turns to forest.[91]

Global climate change will also likely increase the frequency and severity of weather anomalies that pound bird populations. El Niño events, when ocean temperatures rise and fish stocks fall near many important seabird breeding islands, could finish off such rare, localized, and declining species such as the Galápagos penguin, which has evolved and thrived on an equatorial archipelago flushed by cool, fish-rich currents. In addition, intensified and more-frequent droughts and fires could accompany El Niño and other cycles, both in the tropics and as far north as Canada's boreal forests.[92]

"Additional threats will emerge as climate continues to change, especially as climate interacts with other stressors such as habitat fragmentation," wrote biologist John P. McCarty in the journal *Conservation Biology* in 2001. With climate change upon us, conservationists and planners must now think of landscapes and protections as more dynamic than previously supposed. Barriers created by human landscape changes will likely stifle species' movements, and conservation plans will have to take such dangers into account and be flexible enough to accommodate distribution shifts. Some species that are found only in cold regions or on mountaintops may have no place to go as climate changes.[93]

## Flying Straight: For Birds and Humanity

In 1998, conservation biologists Russell A. Mittermeier, Norman Myers, and Jorgen B. Thomsen wrote in *Conservation Biology*: "If

we are to have a real impact on biodiversity conservation worldwide, it is essential that we place great emphasis on the biologically most important regions regardless of their political or social situation and do whatever possible to overcome social and political obstacles."[94]

Decades of field work, computer modeling, and satellite imagery analysis have pinpointed "hotspots"—areas that harbor disproportionately high diversity and high numbers of imperiled bird species. (See also Chapter 3.) BirdLife International has been instrumental in working with organizations, agencies, and biologists around the world, creating a global partnership that coordinates conservation efforts. Increasingly, the efforts of this NGO and many others have focused not only on affecting government action but also on working with other NGOs and involving local communities in protecting and learning about endemic birds and other wildlife.[95]

Among BirdLife's most significant accomplishments in this area has been the identification of 7,000 important bird areas (IBAs) in 140 countries—critical bird breeding and migration spots—and 218 endemic bird areas (EBAs), which are places with the highest numbers of restricted-range and endemic species. While not conferring formal protection, these designations offer a framework from which to set international, national, and local protection priorities. Some IBAs and EBAs are already designated protected areas. Some have active programs to involve local people in protecting the areas. (See Box 2–2.) Many, however, remain

**BOX 2–2. SAVING BLUE SWALLOWS: LOCAL INVOLVEMENT IS KEY**

Glossy and streamer-tailed, the blue swallow catches the eye as it sweeps over moist, montane grasslands in search of insects. But getting a look at this African species grows harder each year. Only 1,500 pairs survive in scattered parts of eastern and southern Africa. In 2001, a network of conservation groups and government agencies from 9 of the 10 nations home to blue swallows drew up an action plan for saving the birds. Such international efforts are increasingly common, as birds are recognized as knowing no boundaries. One difference with the swallow plan is an effort to train local guides who involve not only tourists but local communities in learning about, saving, and benefiting from the blue swallow's presence.

In South Africa, where the blue swallow is critically endangered, BirdLife South Africa and the Endangered Species Trust Blue Swallow Working Group initiated a development program for local blue swallow guides. In 2001, its first guide, Edward Themba, began work in the Blue Swallow Natural Heritage Site, a designated important bird area in the village of Kaapsehoop, close to Kruger National Park.

Visiting tourists hire Themba to show them the birds, although swallow nesting sites are kept secret. After spotting swallows, tourists often patronize local businesses, some of which provide Themba with essential marketing and business support. But birds, tourists, and local businesses are not the only beneficiaries of this effort: Themba also leads trips for underprivileged students and communities, so that they can appreciate the unique beauty that survives in their area. "The success of this project is inspiring," says BirdLife South Africa project coordinator Duan Biggs, "and we are using it as a basis model for the expansion of these types of initiatives to other parts of the country and possibly even beyond."

SOURCE: See endnote 96.

unprotected and poorly surveyed.[96]

Linking IBAs and other key habitats and striking a balance between developed and undeveloped areas will be key in saving birds in our ever-more-crowded world. Over the past 20 years, the emergence of the multidisciplinary field of conservation biology—a blending of biology, conservation science, economics, and social integration—has changed the focus of biodiversity protection efforts from the park to the landscape level, incorporating not just protected areas but adjacent lands and water resources and the people who inhabit and use them. This landscape focus increasingly brings conservation goals alongside—instead of in confrontation with—business plans.[97]

**Growing awareness that biodiversity protections can be combined with money-making ventures seems to be bringing enterprise and environmentalism together.**

The approach is not only progressive but also pragmatic, since most of the world's remaining wild areas remain in private hands or are managed by no one at all. All told, between 6.4 and 8.8 percent of Earth's land area falls under some category of formal habitat protection. These areas are sprinkled across the globe, and many are quite small. Their management varies from protection only on paper to a mixed strategy that includes core areas closed to visitors surrounded by buffers that allow recreational and commercial activities. In general, the largest and most biologically diverse parks, including Peru's Manu National Park—where up to 1,000 species, about 10 percent of the world's bird species, have been recorded—are the least well staffed and protected, as they are in some of the world's poorest regions. Local support for these areas—and the buffer zones and green corridors needed to protect them adequately—is critical.[98]

But park protection measures aside, most of the world remains open to alteration, and people who are hungry and lack alternatives cannot embrace or focus on efforts to protect natural resources unless they clearly benefit in the bargain. Boosting economic prospects and educational opportunities—that is, empowering communities to rise above poverty—will allow local people to focus on saving birds and other natural resources for the future. These conditions are still lacking in many parts of the world, yet an increasing number of efforts highlight the potential for conservation and poverty-fighting measures to work in tandem.[99]

The growing awareness that biodiversity protections can be combined with money-making ventures seems to be bringing enterprise and environmentalism together. Nowhere are marriages between commercial and conservation interests more apparent than within the realm of agriculture, the main employer and source of income in many developing nations.[100]

Shade-grown coffee is increasingly popular, for instance. This crop is grown the traditional way, beneath a tropical forest canopy that also shelters resident and migratory birds. Shade-grown coffee requires far fewer chemical inputs than coffee grown on pesticide-heavy "sun coffee" farms. Some large coffee shop chains now sell these specialty varieties, but the largest brand-name companies have yet to dabble in more environment- and bird-friendly coffees.[101]

In addition, cultivations of various fruits, cork, cacao (for cocoa), and other crops support many bird species, although they do not fully substitute for natural forests. Farm operations that minimize use of harmful pesticides, such as organic farms and those using

integrated pest management, provide more diverse food sources and safer habitats for birds.[102]

Some successful incentive programs pay farmers to set aside land for wildlife, water, and soil conservation purposes. From 2002 to 2007, for example, about 15.9 million hectares (39.2 million acres) will be enrolled in the U.S. Department of Agriculture's Conservation Reserve Program (CRP). Hundreds of thousands of farmers enroll land for 10–15 years—taking it out of production, planting grasses and trees, restoring wetlands, or grazing or harvesting hay in a way compatible with wildlife and erosion control. Although some grasses used in this program are invasive exotics, since its inception in 1985, the CRP has helped many declining grassland birds regain ground, including sharp-tailed grouse, dickcissels, and Henslow's sparrows.[103]

Across the Atlantic, some British farmers—inspired in part by conservation-oriented subsidies that began in the 1990s—started preserving hedgerows and wet meadows, and not planting crops that need harvesting at peak nesting season for field birds.[104]

In the Netherlands, a program set up by Dutch biologists offers dairy farmers payments to protect and encourage nesting birds as a farm product. An experiment conducted between 1993 and 1996 found that it was cheaper to pay farmers to monitor and manage breeding wild birds as if they were a crop rather than compensate them for restricting farming practices for the sake of bird protection. The project resulted in increased breeding success of meadow-nesting lapwings, godwits, ruffs, and redshanks, while not interrupting the dairy business. By 2002, about 36,000 hectares (89,000 acres) of Dutch farmland were enrolled in this program.[105]

When the California state government restricted rice growers from burning their stubble in the fall, the farmers joined with conservationists to flood their fields and augment available waterfowl habitat in the Sacramento Valley, allowing their stubble to biodegrade instead of going up in smoke. From a pilot project in 1993, the program grew to embrace about 61,000 hectares (150,000 acres) by 1998. The valley is an important wintering and migration area for thousands of ducks, geese, ibis, herons, gulls, sandpipers, and other wetland birds.[106]

Meanwhile, in 2001 the Spanish conservation group SEO/BirdLife established an organic rice-growing farm adjacent to one of Spain's most important remaining wetlands at the Ebro River delta to augment bird habitat there, showcase organic agriculture, and promote compatible bird-oriented tourism.[107]

Ecotourism, which first arose in Costa Rica and Kenya in the early 1980s, is loosely defined as nature-oriented travel that does not harm the environment and that benefits both the traveler and the local community being visited. Most nations now court ecotourists. Although nature-oriented tourism is not always light on the environment, this industry shows signs of improving and is often an economically viable alternative to resource extraction. Unfortunately, a good deal of the ecotourism revenue is often earned outside the country being toured, limiting the economic gains that trickle down to local people. Increasingly, however, NGOs, tour operators, and governments are trying to boost community involvement, as local residents are recognized as critical to the success of conservation programs.[108]

To balance human activities with nature protection, we must ratchet biodiversity protection up to rank high among development priorities such as housing, sanitation, and municipal water supply—as part of a sustainable land use strategy. The increasingly

crowded peninsular state of Florida, although not directly comparable to many developing nations, provides a compelling example of how local, state, federal, and private concerns set priorities on and commercialize conservation while struggling with relentless development and population growth. Florida is at once one of the most biologically diverse and environmentally challenged states. Fortunately, since the 1980s, careful study and planning have been hallmarks of growing conservation efforts there.[109]

One study published by three University of Florida biologists in *Conservation Biology* in 2000 plotted out an interconnected web of wildlife habitat called the Florida Ecological Network, which embraces the state's most diverse remaining habitats and wildlife. More than half of the network is already under protected status, while some of the rest is targeted for acquisition. With the most critical areas mapped out and many of them targeted, planners should be better able to steer and concentrate development into the many areas outside the park and corridor network and incorporate protected lands into landscapes that combine compatible forms of agriculture.[110]

Another study by two Florida Fish and Wildlife Conservation Commission biologists plotted private lands needed to ensure a secure future for the most threatened wildlife, including the state's 117 rare and endangered listed animals. The researchers deduced that a specifically targeted 33 percent of the state's land area would need protection to lower significantly the chances of rare species extinctions. They included the 20 percent of the state that already falls under protection. Florida has identified at least 6 percent more land for future acquisition or protection through easements.[111]

As prime wild real estate becomes more expensive and hard to find, conservationists have stepped up efforts to secure targeted Florida lands. In 2001, the nonprofit organization The Nature Conservancy announced that it had helped protect its 1 millionth Florida acre. This organization secures funding to buy acreage that is later turned over to government protection or kept as private preserves.[112]

Meanwhile, the Florida state government runs a land-buying program called Florida Forever, an aggressive 10-year effort that targets properties most in need of conservation. Under this, the state spends about $105 million each year to acquire critical conservation lands, protect watersheds, restore polluted or degraded areas, and provide public recreation. Some properties are held in conservation easements, under which property owners receive state payments or tax incentives in return for managing property as wildlife habitat.[113]

A good part of Florida's economy derives from tourism revenue, and more than 40 million people flood into the state each year on vacation. Meanwhile, almost 20 percent of the state's population is over 65 years of age, many of whom are retired and are frequent visitors to state tourist attractions. Combining its huge tourism infrastructure and highway system with a newly honed focus on wild places, the state identified nature watching as vital tourism with The Great Florida Birding Trail, which received federal aid and cooperation from the U.S. Department of Transportation and the U.S. Fish & Wildlife Service. Slated for completion in 2005, but already up and running in the state's center, this sign-marked driving route of some 3,000 kilometers winds its way past most of the state's bird hotspots, including county parks, ranches, state forests, private preserves, an alligator farm or two, and federal lands.[114]

Texas pioneered the first such driving route

in 1996, including 300 sites where birders may find up to 600 bird species. At least 19 other states and several Canadian provinces followed suit over the last seven years. Local towns benefit from nature tourists, a point not lost on local chambers of commerce in cash-strapped areas of southern Texas and elsewhere.[115]

The birding trails follow decades of growing interest in birding, a hobby that turns most of its participants into supporters of conservation efforts that protect birds and other wildlife. Two nationwide surveys underscore birding's rising popularity, listing it as one of the fastest-growing outdoor hobbies in the United States.

The preliminary findings of the 2001 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation by the U.S. Departments of Interior and Commerce note that more than 66 million Americans aged 16 or older observed, fed, or photographed wildlife (particularly birds) during the year, spending an estimated $40 billion on birdseed, binoculars, field guides, and other equipment and travel expenses. In comparison, 13 million hunters and 34 million anglers were reported pursuing their hobbies in the country that year, spending $20.6 billion and $35.6 billion, respectively.[116]

Another report, the National Survey on Recreation and the Environment, is conducted by government and private organizations and last ran in 2001. It estimated that at least a third of U.S. residents 16 or older—or about 70.4 million people—go outdoors to watch birds sometime during the year, and that these numbers more than doubled between 1983 and 2001. Surveys conducted in Britain by the Royal Society for the Protection of Birds yielded similar results.[117]

Economic impact aside, the burgeoning ranks of birders also provide a powerful infusion of eyes and ears that assist scientists in monitoring bird and other wildlife populations around the world. For example, more than 50,000 volunteers participated in the 100th annual National Audubon Society Christmas Bird Count, the largest and probably longest-running bird census. These knowledgeable birders identified and tallied birds wintering at more than 1,800 local census sites throughout North America and in an increasing number of Central and South American, Pacific island, and Caribbean countries as well. The century's worth of wintering bird data gives ornithologists a telling picture of bird abundance and distribution.[118]

**Two nationwide surveys underscore birding's rising popularity, listing it as one of the fastest-growing outdoor hobbies in the United States.**

Each year since 1987, birders have conducted similar January surveys across Asia, as teams of local volunteer birders pool their observations in the Asian Waterbird Census. And during the spring nesting season, other large-scale monitoring efforts take place in North America, Europe, Australia, Japan, and elsewhere to canvas bird breeding. Other "citizen science" programs target declining bird species, backyard birds, plants, insects, amphibians, and even stream-living invertebrates to test stream water quality.[119]

As bird surveyors note, many bird species are in decline and prospects remain bleak for many of the world's most-threatened bird species. Governmental and private efforts to save some, however, are bearing fruit, setting good examples for future endeavors elsewhere:

- The Seychelles magpie-robin is rebounding after being reintroduced to predator-free islands and after reductions in pesticide

use in its habitat.[120]

- The Canada-nesting, Texas-wintering whooping crane has been a hallmark of conservation efforts between Canada and the United States—up to about 200 birds after a low of 14 adults in 1938. A non-migratory population was reintroduced to Florida, providing an extra hedge against extinction (and an added ecotourism attraction).[121]
- In 1999, the peregrine falcon was lifted from the U.S. Endangered Species list following the ban on DDT in the 1970s and decades of protection, captive breeding, and reintroduction programs. The bald eagle may soon follow.[122]
- Protection combined with apparent adaptability to changed landscapes enabled red kites to return to former haunts in the United Kingdom, Sweden, Germany, and France.[123]
- Four threatened parrot species on three Caribbean islands—St. Vincent, St. Lucia, and Dominica—are inching back from the brink thanks to government and NGO protections, public education campaigns, and some captive breeding efforts.[124]
- On the fabled dodo island of Mauritius, habitat protection and exotic plant and animal eradication efforts benefit now-growing populations of the endemic Mauritius cuckoo-shrike and Mauritius kestrel, a species that also benefited from captive breeding and release programs until the early 1990s.[125]
- The bright blue Lear's macaw, a rare parrot of northeast Brazil, appears to be steadily rising in number, from about 170 in the late 1990s to about 250. A local landowner, Brazilian conservation organizations, the World Parrot Trust, and funding from the Disney Conservation Initiative help conservationists plant licurí palms (essential food plants for the birds), monitor the population, and protect nest sites.[126]

The actions needed to ensure a secure future for birds are the very same ones needed to achieve a sustainable human future: preserving and restoring ecosystems, cleaning up polluted areas, reducing the use of harmful pesticides, reversing global climate change, restoring ecological balances, and controlling the spread of exotic species that knock such balances askew. (See Box 2–3.) Wildlife conservation must be worked into and be compatible with rural, suburban, and urban planning efforts that improve the prospects for the world's poor while making our cities and industries safer for all living beings.

Canadian Wildlife Service biologist F.L. Filion once wrote about birds: "it is difficult to imagine another resource capable of contributing as fully and as completely to mankind's diverse needs." Birds provide us with food, inspiration, a link to nature, and security—in this case as indicators of environmental ills. Today, this feathered resource is in great need of human attention. As we work toward a more sustainable future, keeping an eye on the world's 9,800 bird species helps us keep ourselves in check—if we care to heed the warnings. Along the way, birds' colors, songs, and activity will continue to inspire us, reminding us that in protecting the world's biodiversity, we are doing the right thing for flora, fauna, and ourselves.[127]

**BOX 2–3. A DOZEN STEPS TOWARD A SUSTAINABLE FUTURE FOR BIRDS AND BIODIVERSITY**

- Involve local communities in conservation efforts.
- Where possible, combine compatible commercial activities with conservation goals.
- Study bird and other wildlife populations thoroughly and set aside areas most in need of protection.
- Include biodiversity protection as a key goal when planning development, industry, or agriculture.
- Control harmful introduced species.
- Ban chemicals dangerous to birds, other wildlife, and people.
- Improve protections against chemical spills, including oil spills.
- Reign in uncontrolled hunting of birds, particularly along migration routes and in areas inhabited by localized, threatened species.
- Mitigate harmful fishing techniques, particularly longline nets, which needlessly kill many thousands of seabirds.
- Address and mitigate threats posed to birds by communications towers, tall buildings, and power lines.
- Stem the causes of global warming.
- Within communities, raise environmental awareness through bird-watching and other activities.

Chapter 3

# Linking Population, Women, and Biodiversity

*Mia MacDonald with Danielle Nierenberg*

Travel north by boat from the island city of Lamu on Kenya's coast toward the Kiunga National Marine Reserve and a scene of intense beauty unfolds. Stands of slender mangroves form leafy barrier islands in the Indian Ocean, vibrant swaths of green in the blue-gray waters. Pelicans and terns nest on beaches exposed by retreating tides. Just south of the Somali border, the Lamu Archipelago, with the Kiunga Reserve at its top, is part of a rich marine ecosystem that stretches thousands of kilometers along the East African coast from Somalia to Mozambique. Coral reefs and sea grasses provide homes for many species of fish and crustaceans, and Olive Ridley, Hawksbill, and Green turtles lay their eggs on Kiunga's beaches. The dugong—a rarely seen sea cow, cousin to the manatee—forages among the sea grass in these waters. A few small villages, with homes constructed of mangrove and palm, also hug the coastline, quiet but for the sounds of children playing and donkeys braying and drinking at the water's edge.[1]

But spend some time in the Kiunga Reserve and the picture becomes more complicated. Brightly colored plastic bags and human flotsam mar many of the village beaches, including large numbers of plastic sandals carried on Indian Ocean currents from as far away as Malaysia. These are visible clues that this remote corner of Kenya, like so many places throughout the world, is subject to the forces of demographic and environmental change, even if the evidence of such changes is not always immediately apparent. Although the human population of the Lamu Archipelago is small—about 75,000—it is growing by some 2.2 percent a year. All along the East African coast, population continues to grow 5–6 percent a year, a result of relatively large family size and significant migration to coastal cities where job opportunities are more abundant. The growth rate is well above that for Kenya (about 1.9 percent) and for the world overall (now just above 1.2 percent a year).[2]

Nearly all of the 14,000 people living within the boundaries of the Kiunga Reserve or just outside them rely heavily on its nat-

ural resources. Salaried job options for men are few, and for women, they are practically non-existent. Just beyond the verdant coastal mangroves, large numbers of trees have been reduced to stumps—slashed and burned to make way for agriculture or cut for sale in coastal cities. Their loss contributes to soil erosion and to silt being deposited in the ocean waters, and will make it harder in future years for women to find wood for cooking and heating.[3]

Kiunga is just one illustration of the ways in which people are transforming Earth's natural systems. In and around this reserve, as in many parts of the developing world, local residents and migrants are intensifying their use of resources in a bid to meet their needs. In other parts of the world, including industrialized regions, migration—by choice, not desperation—in tandem with poor land use planning and overconsumption risks destroying ecosystems or so degrading them that they can no longer provide the services people depend on for daily life.

In Kiunga's waters, the fish, crustaceans, ocean-dwelling coral, and turtles are showing signs of stress as people pushed by poverty apply new fishing methods to increase their catch. Much of Kenya's coastal waters south of Kiunga have been "fished out," meaning that each year seasonal migrants—fishers seeking to engage in the only livelihood many of them know—enter the reserve, intensifying the pressures on sea life.[4]

As with the ecosystem, pressures on the human inhabitants of Kiunga are also increasing. Poverty is deepening and privations like a lack of electricity or running water remain unaddressed. Access to health services or education beyond primary school is limited, especially for women and girls. Like mothers in many rural regions of the developing world, most mothers in Kiunga say they hope their children will leave the reserve and make a better life for themselves somewhere less remote and less poor, where choices are more plentiful.[5]

An ocean away, in Florida, a sub-tropical marshland known as the Everglades that is a riot of biodiversity also makes the population-environment link clear. Here 25 species of orchid, 300 species of birds, and thousands of plants and trees from oaks to mangroves share habitat with panthers, crocodiles, and alligators. But as in the Kiunga Reserve—and at a larger scale and with greater speed—the need to accommodate a rising human population is transforming natural systems and squeezing other species into ever-smaller spaces. For more than a hundred years, the Everglades wetlands were drained, diverting water to agriculture or providing a dry plain on which to build homes, businesses, and highways. Roads, housing developments, golf courses, and a university have all been built in prime habitat for the highly endangered Florida panther, whose population hovers at about 60.[6]

**In Florida, the Everglades is a riot of biodiversity that makes the population-environment link clear.**

But even with a $7.8-billion Everglades restoration plan in place in the southeast, new development in the southwest of the state is taking off, often following the pattern of sprawl seen in other parts of the United States. As the human population grows, and with it demands for resources, threats to the unique ecosystems in the Everglades are gathering strength. Population is rising fast as a result not of high fertility but of migration into the area from other parts of the country and the world. Between 1990 and 2000, Florida's population grew by nearly a quarter;

in two counties at the edge of the western Everglades, the annual growth rate hovers at or just above 5 percent.[7]

World population is now estimated to be over 6.2 billion and growing by 77 million a year, equivalent to the combined 2001 populations of Mozambique, Paraguay, Poland, Portugal, and Singapore. The rate of growth is slowing, however. Globally, women now have about half as many children as their mothers did (an average of just under three children each). But this trend is not guaranteed. Between 1998 and 2000, the United Nations had to revise its medium population projection (the one most likely to occur) for 2050 up by more than 400 million people. Fertility rates are not falling as fast as previously projected in 16 poor countries or in a handful of countries with large base populations, including Bangladesh, Nigeria, and the two most populous countries in the world—China and India, both of which are home to more than a billion people. (See Figure 3–1.) The United Nations now suggests that by 2050 about 9.3 billion people will be alive—50 percent more than today. The United Nations will soon issue new projections. While these may include slight changes in overall population estimates, they will still show that substantial population growth is expected over the next half-century, especially in the world's poorest countries.[8]

The interplay among population growth, gender roles, and biodiversity loss is complex and can be addressed from several different entry points. But at the core we know that gender inequity tends to exacerbate population growth, and that population increases tend to put pressure on the natural environment, including biological resources. Through a series of global agreements hammered out over the past decade, governments around the world have acknowledged the need to include population realities in sustainable development planning and vice versa. These agreements have also noted the central role that increasing women's status and achieving gender equity—balancing relations between women and men—play both in lowering fertility and in ensuring the sound management of natural resources. Indeed, women's roles in the sustainable use and conservation of natural resources and the need for women to participate fully in policymaking and program delivery are among the principles guiding the Convention on Biological Diversity that was signed in 1992. And *Agenda 21*, the plan of action agreed to that year at the Rio Earth Summit, includes a whole chapter on women and natural resources.[9]

Even though the importance of gender in shaping the use of biological resources is acknowledged in these international agreements, women's roles have often been neglected in the global discussion about biodiversity. The links between biodiversity and gender are especially strong in rural areas of the developing world, where women often experience the immediate effects of environmental degradation. Unfortunately, they also usually have limited control over access to resources and decisions on how they are used. According to the *2002 Human Development Report*, while progress has been made on closing gender gaps in recent years, there is no country in the world where women have obtained equal political and economic power or human development with men—making gender equity a considerable goal for the industrial world as well as for countries in the fast-growing developing regions as they wrestle with how to best protect biodiversity and meet human needs.[10]

Despite the decade-long existence of goals and even, in some cases, strategies for integration of population, biodiversity conservation, and gender, most efforts remain

in the early stages. Still, throughout the 1990s, increasing numbers of conservation and development professionals, government agencies, and people in decisionmaking or educational arenas have begun to see and to act on the connections between population, biodiversity, and gender. This work, in the shape of a number of small initiatives under way in a range of biologically rich areas of the world, provides fertile ground for nurturing larger-scale, more robust actions. And it comes none too soon, for as Nobel prize–winning economist Amartya Sen points out, "The population problem is integrally linked with justice for women in particular.…Advancing gender equity, through reversing the various social and economic handicaps that make women voiceless and powerless, may also be one of the best ways of saving the environment, working against global warming and countering the dangers of overcrowding and other adversities associated with population pressure. The voice of women is critically important for the world's future—not just for women's future."[11]

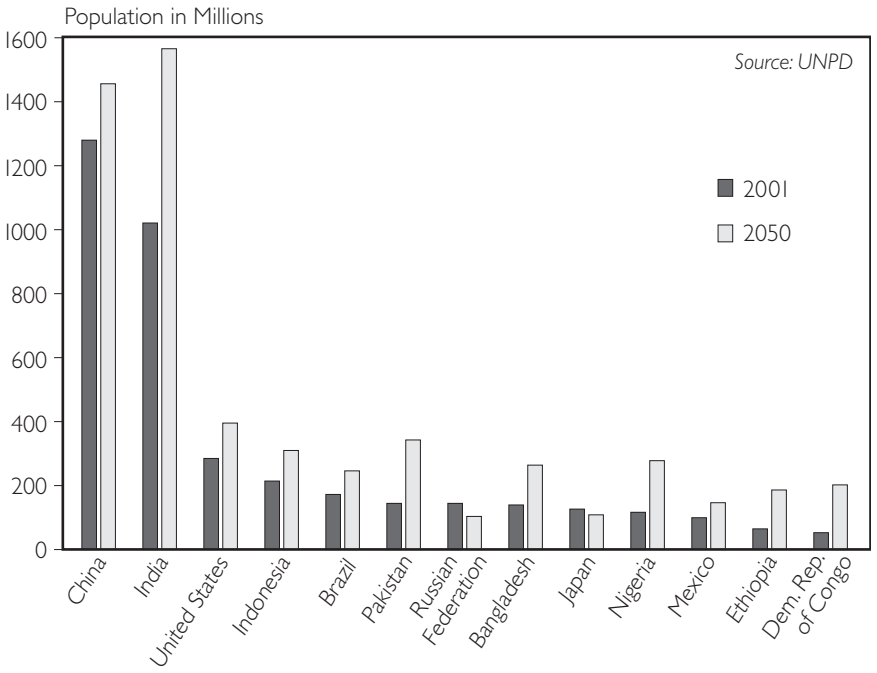


**Figure 3–1. World's Most Populous Countries, 2001 and 2050**

## Exploring the Linkages

From the mountains of southwest China to the Eastern Himalayas, from the forests of central Africa to Eastern Europe's Danube River basin, species, habitats, and ecosystems in a number of biologically rich areas are under stress as a result of human activities. Biologists and conservation practitioners now accept that changes in human population dynamics—including growth, migration, and density—and in patterns of resource consumption are among the root causes of biodiversity loss. Combined with social and economic realities like integration of global markets and the creation of new wealth alongside persistent poverty, demographic and resource use trends demonstrate the vast power humans have to reshape the natural world. They also make clear the need for new policies and programmatic approaches—sustainable over the long term—that protect biodiversity for ourselves and other species, that advance human development, and that redress long-standing inequities between women and men.[12]

Each new person who joins the planet, even someone at the very low end of the consumption scale, ratchets up the net demands on Earth's natural systems. And each new person born in an industrial country has a disproportionate effect on those demands. The toll is becoming increasingly visible as the biotic communities on which life depends exhibit symptoms of decline, the most obvious being the retreat of plants and animals from parts of Earth both large and small. (See Box 3–1.)[13]

As in the Everglades and the Kiunga Reserve, the losses tell us just how the disruption of delicate and biologically diverse ecosystems—whether in tropical jungles or the suburbs of major cities—can affect human and nonhuman lives. Commercial cutting of India's forests has undermined traditional systems of village forest management and has caused shortages in fuelwood and building materials for millions of rural villagers. And when overfishing caused the collapse of cod stocks off Canada's coast in the early 1990s, it threw 30,000 people out of work and decimated the economies of 700 communities in Newfoundland.[14]

More people are using more resources, and with more intensity, than ever before. But numbers alone do not capture the impact of the interactions between human populations and biodiversity. The size and weight of the

**BOX 3–1. THE VALUE OF BIODIVERSITY**

Biological diversity, or biodiversity, is the total number of genes, species, and ecosystems in a region and the variability between them. Biodiversity makes life itself possible. Not only do plants and animals provide actual and potential sources for human medicines and food, biodiversity has additional benefits that reach far beyond straightforward economic evaluations of utility. Scientists have shown that rich and diverse ecosystems improve water quality, reduce flooding, and absorb and clean wastes. They are also more resistant to environmental shocks and quicker to recover than regions depleted of genetic and species diversity. A group of scientists recently estimated the value of the services provided to humanity by the world's ecosystems—the pollination provided by insects, for example, and the water-cleaning capacity of healthy soils—as up to $61 trillion, which is twice the size of the world economy.

But around the world, plants and animals and the ecosystems that are their homes are being degraded or disappearing, largely as a result of human actions. Over the past 100 years, 20–50 percent of Earth's original forest cover has been lost. The U.N. Food and Agriculture Organization (FAO) estimates that during the 1990s, about 146,000 square kilometers of natural forest were lost each year. The vast majority of this was in tropical forests, with losses running at about 142,000 square kilometers a year (an area just about equal to the size of Nepal). The Central American dry tropical forests have practically disappeared. And in many countries, half or more of the mangroves (costal forests) have been cleared. Such loses are particularly damaging since forests contain about half the Earth's total biodiversity and have the highest species diversity of any ecosystem. Wetlands have also shrunk by 50 percent, and in some places only 10 percent of grasslands remain. Species loss is also increasing. About 24 percent of mammals (1,137 species) and 12 percent of birds (1,192 species) worldwide are currently under threat of extinction, and many species—the exact number is not known—have already disappeared.

SOURCE: See endnote 13.

"ecological footprint" each person plants on Earth is determined by the ways people use resources, which affects the quantities they use. The difference between the footprints of individuals can be vast. For instance, a vegetarian who uses a bike as a major mode of transportation has a much smaller impact than someone who eats meat and drives a gas-guzzling sport utility vehicle.

Similarly, the differences in average footprints across regions can also be huge, and the combined footprints of people in a given region determine the prospects for saving or permanently losing the biological diversity found there. The ecological footprint of an average person in a high-income country is about six times bigger than that of someone in a low-income country—comparable to wearing either a size 7 shoe or an outsized 42. The one fifth of the world who live in the highest-income countries drive 87 percent of world's vehicles and release 53 percent of the world's carbon emissions.[15]

Although family size has declined in most wealthy nations, the U.S. population is growing at the fastest rate of any industrial country. Between 1990 and 2000, the U.S. population increased by 32.7 million people (13.1 percent), the largest number in any 10-year period in U.S. history. At about 280 million people, the United States is now the third most populous nation in the world and its population is expected to reach nearly 400 million by 2050. And fertility rates in the United States are at their highest level in 30 years, at about 2.1 children per woman. A recent study suggests that if every person alive today consumed at the rate of an average person in the United States, three more planets would be required to fulfill these demands. "Because we live so large," writes environmentalist Bill McKibben in a recent book on the need for Americans to consider having only one child, "North Americans (and Europeans and Asians of the quickly growing industrial powers) will largely determine what shape the world is in fifty years from now."[16]

While consumers in the wealthiest countries can and do have vast power to reshape the natural world through their use of resources and products, population growth rates themselves remain highest in the poorest, least-developed countries. Here, biodiversity is often high and environmental degradation already widespread. These are the same places where women's status—a key determinant of population growth rates—is low and where governments are least equipped to provide health care, education, and job opportunities for the vast numbers of people added to the population each year or to moderate the direct demands placed on resources.[17]

Poor populations in many biodiversity-rich regions—largely rural areas where good health facilities, schools, and basic infrastructure are frequently absent—often have no other options but to exploit their local environment to meet subsistence needs. In these settings, rapid growth in human numbers can lead to collisions between traditional practices that were ecologically viable when population size was small but that are becoming increasingly less so for species and ecosystems as population grows and demands rise. The trade in bushmeat in Central Africa, for instance, has accelerated to such a degree that the future of forest-dwelling animals, including primates, is in jeopardy. (See Box 3–2.)[18]

As a way of focusing conservation efforts, British ecologist Norman Myers and Washington-based environmental group Conservation International (CI) defined 25 biodiversity "hotspots" around the world—places that are extremely rich in different plant and animal species and are also threatened significantly by human activity. These

**BOX 3–2. THE BUSHMEAT TRADE: POPULATION, BIODIVERSITY, AND WOMEN IN THE CONGO BASIN**

Gorillas, chimpanzees, forest buffalo, elephants, and a huge variety of other animal and plant life inhabit the forests of Central Africa's Congo Basin, designated as one of only three remaining major tropical wilderness areas in the world. But rising demand for bushmeat (the meat of wild animals, including elephant, gorilla, chimpanzee, monitor lizard, and forest antelopes), the main source of protein for a rapidly growing and urbanizing population, is contributing to loss of species at a breakneck pace. As much as 1 million tons of bushmeat—the equivalent of 4 million cattle—are sold in Central Africa each year. Urban areas are centers of demand, and logging operations expanding into the region's forests provide not only new markets (the logging camp workers), but also new means of transport on logging trucks and along logging roads. If current rates of hunting continue, the commercial bushmeat trade will decimate, if not eliminate, some endangered species such as great apes, forest elephants, and other fauna from the Congo Basin in coming decades. Conservationists increasingly warn of "empty forest syndrome," where tree cover survives but forest species are almost wholly absent.

Ecological and socioeconomic conditions combine to make bushmeat an attractive option. The prevalence of the tsetse fly and sleeping sickness generally precludes cattle raising, and declining global prices for cash crops like coffee and cocoa leave rural families with few ways to earn an income. In addition, poverty and hunger are widespread: a recent FAO study classified half of all people living in Central Africa as "undernourished." Hunters can earn up to $1,100 a year from bushmeat alone—well beyond average household incomes. Despite the fact that most of this hunting is illegal, it continues due to persistent demand and lax enforcement of anti-hunting laws. Poor women, relying on resources at hand to provide a livelihood, play important roles in the trade, processing, and marketing of the meat. About 24 million people live in the Congo Basin and population growth rates are among the highest in the world. Moreover, less than a fifth of girls in the Democratic Republic of the Congo attend secondary school, and almost half the women over the age of 15 are illiterate.

*—Arunima Dhar*

SOURCE: See endnote 18.

hotspots, found in both the industrial and the developing world, contain just over half of all land-dwelling plant and animal species. Together, hotspots once covered nearly 12 percent of Earth's land surface; now, the undisturbed original cover in these hotspots is just 1.4 percent of the world's total land surface area. A study by CI and Washington-based Population Action International found that in 1995 about 1.1 billion people—nearly one fifth of the world—lived inside hotspot boundaries. In all but one of the hotspots, the human population is growing, due to a combination of high fertility and migration. On average, populations in the hotspots are increasing by about 1.8 percent a year, nearly 50 percent above the current global average. (See Figure 3–2.) Many hotspots also have high population densities, generally linked to significant losses of biodiversity. (See Figure 3–3.)[19]

Why are population growth rates in hotspots and many other biodiversity-rich areas often high? Researchers point to several reasons: local populations often live in extreme poverty, and since the areas are

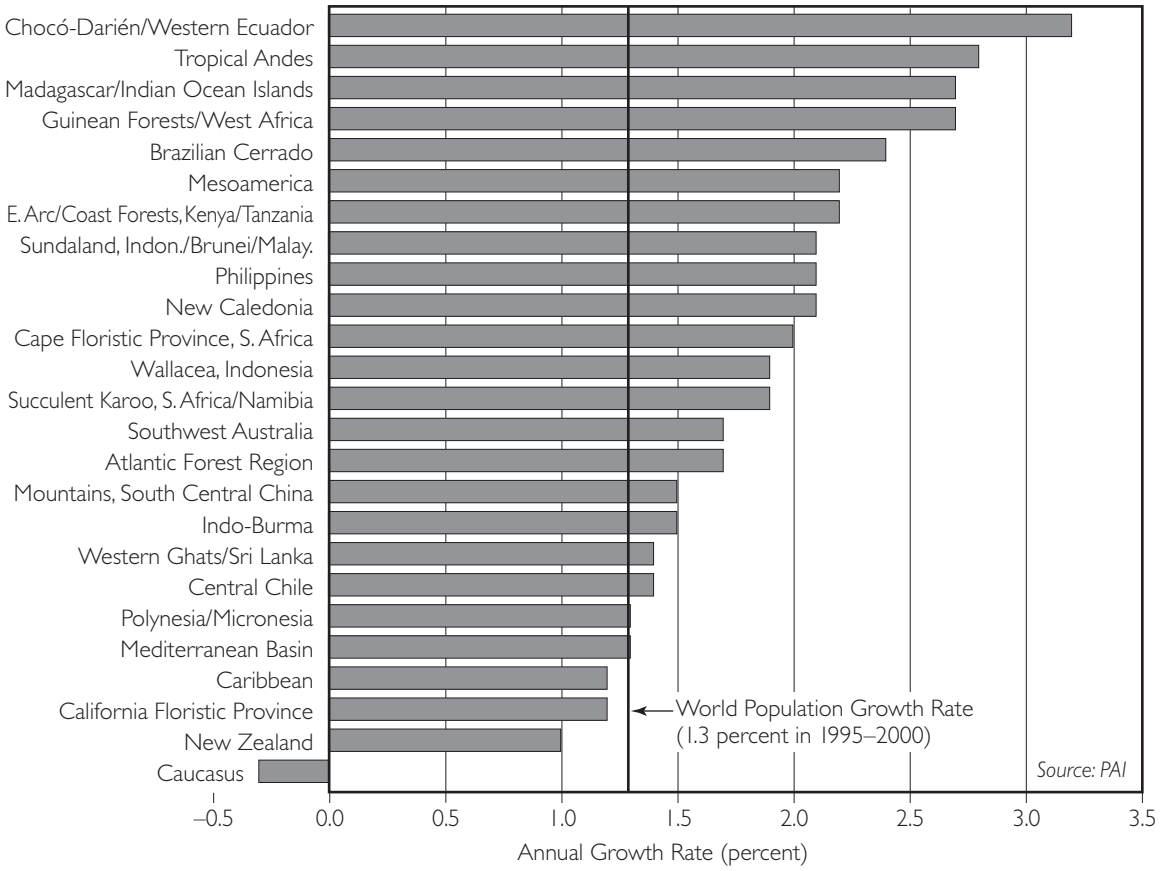


**Figure 3–2. Population Growth in 25 Biodiversity Hotspots, 1995–2000**

remote, health services, schools, and job opportunities for women are all scarce, contributing to higher fertility. Migration into the often fragile ecological zones that hotspots occupy may be the last resort for those who lack other options—landownership or livelihoods elsewhere—or the result of government agricultural or forest policies, rapid urbanization, or civil conflicts. In addition, in countries where a majority of the population is rural, rural-to-rural migration is still common.[20]

Of course, population growth is only one aspect—albeit a crucial one—of the full range of population dynamics that needs to be explored when trying to understand the impacts of human numbers on biodiversity. In many regions, migration, increasing population densities, and consumption patterns are the most immediate pressures. Studies of the links between population density and biodiversity loss have not been extensive, but research suggests that as the number of people in an area increases, lower levels of biodiversity result. As habitats are reduced, animals and plants may be crowded increasingly into the spaces where human activity is less extensive.[21]

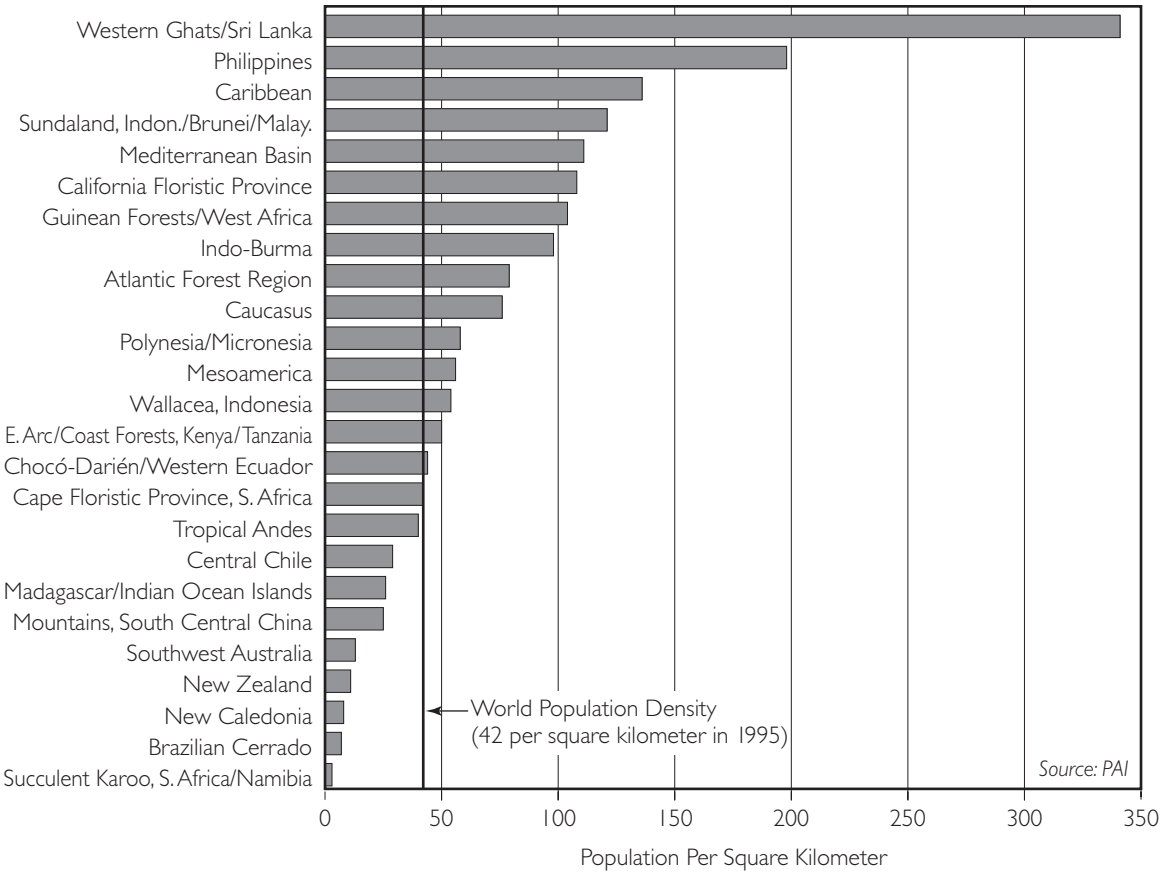


**Figure 3–3. Population Densities in 25 Biodiversity Hotspots, 1995**

In Madagascar, about 30 percent of the people now live in cities, and the pace of migration to urban centers and larger towns is increasing. This migratory pattern, combined with rapid increases in human numbers, is leading both directly and indirectly to increased deforestation. Over 90 percent of Madagascar's urban population in the southwest of the country still relies on wood or charcoal for energy, using up the equivalent of about 10,000 hectares of forest a year. If the urban population in this island nation continues to grow at its current rate of 5–6 percent a year, and if no alternatives become available, it is estimated that 42,500 hectares of forest will be needed annually by 2010 to meet urban demands for fuelwood and charcoal alone. Even more forest will be lost as rural dwellers also seek to meet their daily needs for fuel for heating and cooking.[22]

This pattern of migration in southwest Madagascar is mirrored throughout the developing world. Each day, about 160,000 people move from rural to urban areas, often as a result of poverty, landlessness, or degraded rural environments that are losing their productive capacity. In 1950, 30 percent of people lived in urban areas; by 2000, that

number had risen to 47 percent; by 2007, urban dwellers will make up half of the world's human population, although it will be at least two more decades before a majority of people in developing regions live in urban areas. Population growth from migration is fastest in smaller cities, where infrastructure to absorb the new arrivals is often lacking, leading to helter-skelter patterns of development, slums, pollution, and disease. It is often men who move to the cities in search of paid labor, leaving women behind to provide for children by farming or taking on a job themselves, often in the informal sector, to make ends meet. In some rural areas, gender ratios are highly skewed, with many more women present than men. In rural areas of the world's least developed countries, nearly a quarter of households are headed by women. This often reinforces women's dependence on the natural resources they have access to, and at times increases their burden of labor.[23]

Cities, too, consume vast amounts of resources, even if these are out of residents' sight. Urban dwellers rely heavily on watersheds, fuel sources, and waste processing. In addition, rapid growth of urban populations often limits cities' abilities to develop infrastructure adequate to demand, and it outstrips available supplies of clean water, electricity, and systems for treating or clearing wastes. And when cities sprawl, through planning or the lack of it, they can consume considerable amounts of open land or forests, often home to a diverse array of species.[24]

Unfortunately, the massive movement into cities does not mean there is going to be more space in rural regions for ecosystem and species recovery in the near future. Rural populations themselves grew from 2 billion in 1960 to 3.2 billion in 2000. Between now and 2030, some regions of the world will see their rural populations grow, including south-central Asia and all of Africa except the southern region, although the net increase in the rural population of the less developed regions will be less than 200 million.[25]

As trading borders have opened, with greater integration of markets and with pressure for poor countries to export raw materials, ecosystems and species have felt the effects. The world's farmers, for example, a majority of whom are women, are shifting from cultivating a variety of crops for sale in local markets or to be consumed within households to growing one crop that is in demand from world commodity markets. Along with many of these "mono crops" comes pressure on producers to maximize yields in the short term, often at the expense of plants and animals and overall ecosystem health.[26]

Once exposed to the world trading system, producers in poor countries have to adapt to the volatility of markets that may threaten their livelihoods. As markets respond to shifting tastes, and as increasing numbers of people enter these markets as producers, biodiversity can often get trampled. This exchange of resources is not solely on a North-South axis. Somalia's acacia forests—or what remains of them in this heavily desertified country—are being chopped down, converted to charcoal, and exported to rapidly growing neighboring countries on the Arabian peninsula to fuel cooking stoves.[27]

At the same time, market forces are creating new middle classes around the world whose preferences are more closely aligned with consumers in industrial nations. As they consume more and more when their incomes rise, pressures on resources are likely to increase exponentially. With mass media making its way into the most remote regions, the lifestyle of the industrial world is being relayed to more and more people. People

see how others in the world's wealthiest countries live—and they want to live that way too. Practicality and equity mean that such aspirations cannot go unheeded.

Fortunately, conservation groups are beginning to recognize that if biodiversity decline is to be reversed successfully, programs that previously focused on small areas of land or water in or near national parks or reserves will have to operate at much larger scales. At the same time, these groups are beginning to include in their planning and programming the socioeconomic realities that affect biodiversity, including population dynamics, relationships between women and men, and the often-distinct ways men and women use and control resources. Lorena Aguilar, senior gender advisor at IUCN–The World Conservation Union, sees gender equity as the "unavoidable current" determining the impact of conservation policies and programs, and therefore as deserving more focused attention than it has received to date. Still, even as awareness increases, very few women currently hold key decisionmaking positions in the global conservation community.[28]

## Why Gender Matters

At least since the 1994 International Conference on Population and Development, held in Cairo, the global community has recognized that greater equality between men and women is an essential component of advancing social and economic development and slowing population growth. Where women are free to determine when and whether they will have children, fertility rates fall. Research also shows that the more education a woman receives, the fewer children she has and the healthier and better educated those children are. Other studies suggest that if women have the right and ability to manage childbearing, they can manage other areas of their lives more effectively too, including available resources. And a recent World Bank report found that the lack of gender equality stymies the ability of developing-country governments to promote economic growth and reduce poverty.[29]

Throughout the developing world, in particular, gender plays a strong role in how resources are used, controlled, and developed and in how people respond to environmental challenges. These connections are particularly strong in rural areas, where people depend directly on resources on a daily basis, but there is evidence that they persist in urban settings and in wealthy nations as well. For the most part, though, men still decide how the world's natural resources are used through, for example, mining, livestock grazing, logging, and land tenure. By some estimates, women around the world hold title to less than 2 percent of the land that is owned.[30]

In much of the developing world, millions of people's lives are structured by their relationship with natural resources. In particular, though, it is women who rely heavily on trees, grasses, and water for livestock production, fuelwood, fibers for clothing and mats, roofing materials, basket making, and a variety of plants for medicines—whether to earn income or to meet household needs. Because of their direct dependence on resources, when ecosystems become degraded through human activity, women are often the first to feel the effects. They are often the first line of adaptation as well. It is they who most frequently are responsible for making up for declining capacity in the environment, by, for example, walking farther to get fuelwood as hillsides become denuded. They venture farther from home to reach clean water as soil erosion decreases water retention, and to find new

sources of food as customary supplies are overharvested. They must also make existing resources go further and often are the first to initiate efforts to reverse degradation—for instance, raising seedlings, planting trees, or practicing soil conservation.[31]

For example, deforestation in the Sudan has quadrupled the amount of time women spend gathering wood for cooking, and the energy used to tote water from rivers and other water sources accounts for one third of a woman's daily calorie intake, according to the World Health Organization. Throughout rural parts of the developing world, a common sight as days begin is women and young girls venturing out, alone or in small groups, to gather fuelwood or water, and later—sometimes much later—returning laden with bundles or heavy plastic water canisters on their heads.[32]

In addition to their responsibilities within households to ensure daily supplies of fuel, water, and food, women are also responsible for many agricultural tasks, including raising small livestock and generating income from the sale of food. According to FAO, women constitute 51 percent of the world's agricultural labor force. In Southeast Asia, they provide up to 90 percent of the labor for rice cultivation, while in Africa 90 percent of the wood and water gathering is done by women. In Africa and Asia, women work on average 13 more hours per week than men, and in many regions women spend up to 5 hours a day collecting fuelwood and water and up to 4 hours preparing food. This work is unpaid and does not appear in any national accounts of productive labor. [33]

Too often, however, governments and development agencies still see women solely as "housewives," with men defined as "workers" (income earners)—categories that reinforce false distinctions. Researchers looking into the threats to biodiversity from gold mining and the collection of Brazil nuts in the Bahuaja Sonene, a protected reserve in Peru, did not consider the meaning of the terms "housewife" and "miner" as applied to women and men. But the director of a local nongovernmental organization (NGO) did, and discovered that women also moved with men into the forest to collect nuts and then worked to dry, peel, and often sell them. Many contracts for collecting the nuts are in women's names. Women also join men in setting up gold mining camps in the forest and, in addition to cooking and managing the temporary household, often sell the gold that men dig up and process. Without this understanding of both women's and men's roles in the mining and nut trades, any campaigns of public education or promotion of alternative, less environmentally destructive livelihoods are unlikely to include women and therefore less likely to be effective.[34]

**For the most part, men still decide how the world's natural resources are used through, for example, mining, livestock grazing, logging, and land tenure.**

Women without independent resources are more vulnerable to poverty. In the developing world, women's ability to stay on the land is often tied to the presence of a father or husband and is often reduced if the man dies or a couple divorces. In addition to the natural resources on the land, owning property can provide an important safety net for women as collateral to gain credit to improve land stewardship. It can also be used as an asset to be sold or mortgaged during a time of crisis, including drought, war, or ecosystem decline. In addition, financial security allows women to make long-term investments in resources—planting trees, for instance, building terraces to halt erosion, or investing in effi-

cient irrigation.[35]

But low levels of literacy and education among women—still widespread in poor countries—can constrain productivity and limit women's ability to manage land effectively. And despite women's multiple and strong ties to natural resources, agricultural extension workers, development practitioners, and even conservation field-workers (still mostly men) have too often ignored the ways that gender shapes resource use and the prospects for sustainability and biodiversity protection. But this situation is beginning to change, with increasing numbers of conservation field workers being exposed, slowly, to information about gender dynamics and resource use, and including women in efforts to protect biodiversity and secure livelihoods from natural resources. As they do so, they are learning to provide training when women are not busy with child care or other responsibilities and to be sensitive to the different spheres that women and men inhabit. Without such training, opportunities are lost to make resource use more equitable and efficient both within communities and at higher levels, where district or national planning takes place.[36]

**Many women have acted to protect natural resources by mobilizing their communities against environmental and health hazards.**

In certain settings there is evidence of greater on-the-ground recognition of the inequalities between men and women and how these affect resource use. For example, in a network of locally managed conservancies in Namibia, men serve as game guards. But the conservancies have made a commitment to gender equity, so women have been hired to monitor use of non-wildlife resources as well as to provide a conduit for bringing women's input to conservation decision-makers. Parallel with this, the number of women on local conservancy committees has continued to rise, with some previously all-male committees amending their charters to include women. Program managers report that communities have, over time, embraced these moves toward gender equity and see the value in having diverse perspectives channeled into decisions about resource use and conservation.[37]

"Since rights to natural resources are so heavily biased against women," reasons Agnes Quisumbing of the International Food Policy Research Institute, "equalizing these rights will lead to more efficient and equitable resource use." When government officials or community leaders fail to recognize the different ways that women use natural resources—growing vegetables for family consumption in the spaces between male-managed cash crops, for example—the resources are easily destroyed. To protect fragile mangroves in El Salvador, for instance, community officials placed restrictions on fishing and collecting fuelwood. The community's women, who depended on both the wood and the fish from the estuaries to feed their families, were not consulted—but they were most affected by the ban because performing their role as caretakers became a criminal act. Such a lack of fairness and common sense is no longer tolerable in view of the increasing stresses on croplands and other resources imposed by rising populations.[38]

But women are not only victims of environmental degradation; they are activists as well, and many have acted to protect natural resources by mobilizing their communities against environmental and health hazards. (See Box 3–3 for one example of this.) Women in India, for instance, are resisting large-scale agricultural methods that require

**BOX 3–3. WOMEN, TREES, AND EMPOWERMENT: KENYA'S GREEN BELT MOVEMENT**

"It is ironic that the poor people who depend on the environment are also partly responsible for its destruction. That's why I insist that the living conditions of the poor must be improved if we really want to save our environment," says Wangari Maathai, founder of the Green Belt Movement. Established in Kenya on Earth Day in 1977, the Green Belt Movement has created a nationwide network of 6,000 village nurseries that have worked to avert desertification by encouraging tree planting and soil and water conservation in rural communities. In 1999, it was estimated that Green Belt's 50,000 women members had planted more than 20 million trees, and that while some had been harvested, millions more were still standing.

The network encourages zero-grazing (keeping livestock penned to control manure) and organic farming as a means of improving soil fertility and food production. It also encourages farmers to plant native crop varieties, like millet, groundnuts, and sweet potatoes that are adapted to local conditions and can weather drought and other shocks that threaten food supplies. Many of these crops had been put aside in favor of coffee, tea, and flowers for export. Because members of the group sell seedlings from their nurseries, they gain not only a source of firewood but also a source of independent income. Green Belt also works to build women's self-confidence and create the conditions for greater gender equality in households and the public sphere. "Implicit in the action of planting trees," says Maathai, "is a civic education, a strategy to empower people and to give them a sense of taking their destiny into their own hands, removing their fear…[so women] can control the direction of their own lives."

*—Arunima Dhar*

SOURCE: See endnote 39.

heavy inputs of chemicals by promoting sustainable agriculture in rural communities. In the Ogoni region of Nigeria, women have come together to fight the toll that oil exploration and refining—fires, oil waste dumping, and pipe explosions—have taken on the health of their families and the environment. Their demands have included protection of women environmental activists and compensation for health damages from the oil industry. In a region of Louisiana known as Cancer Alley, African-American women are educating one another and their communities about the connections linking industry, environment, and human health.[39]

In order to raise awareness of the links between gender and biodiversity and the actions that can address them, a few conservation organizations are now providing gender training to headquarters and field-based staff, as well as to government extension workers and local community leaders. Others are promoting the use of gender analysis, a tool that helps illuminate the power dynamics that shape the control and use of resources and that eliminates blind spots. In 2001, a number of conservation organizations came together to form the Conservation and Gender Alliance, an informal group organized to look at the role of gender in conservation and to share experiences and tools that advance the inclusion of gender issues in the mainstream of conservation activities. Members include IUCN, The Nature Conservancy, Conservation International, and the World Wide Fund for Nature (WWF). And in

the run-up to the 2002 World Summit on Sustainable Development, women from governments and the NGO community met to consider women's roles in the transition to sustainability. (See Box 3–4.)[40]

## Continuing Gaps, Integrated Approaches

In the 1950s and 1960s, a number of developing-country governments adopted national plans designed to reduce rapid rates of population growth that strained their abilities to provide enough health care, schools, and jobs for their citizens. Even more governments adopted population policies in the 1970s and 1980s. But few of these policies sought to link reducing population pressures with expanded protections for biological resources or efforts to raise incomes within a framework of sustainability. This situation largely persists today: while the linkages between poverty, environmental degradation, and rapid population growth are noted in many policies, they are rarely elaborated. And few environment or population policies address issues of women's status and gender equality.[41]

Although government thinking has evolved away from numbers and toward improving lives, the conditions contributing to continued high fertility have not been dealt with adequately. Poverty remains a huge challenge, as does gender inequality, high rates of death for children under the age of five, and shortcomings in the systems for providing reproductive health care and edu-

**BOX 3–4. WOMEN AND THE ENVIRONMENT**

In most of the industrial world, the relationship between women and the environment is perhaps more subtle than elsewhere, partly because women tend to be more removed from the natural resources they depend on. Some advocates note, however, that women's roles as mothers and as the prime caregivers to children make them more likely to have a greater awareness of and interest in avoiding environmental hazards, such as pesticides in food and chemicals that can increase reproductive risks. Most women around the world, including in industrial nations, still do the majority of household shopping and cooking. This is why some environmental groups in these countries have targeted women for campaigns around issues of food safety. There are also some indications that women may be more receptive to efforts that encourage shifts in consumption practices. For example, a recent study in the United States showed that women tended to enroll in a green electricity program at a higher rate than men.

In March 2002, women environment ministers and representatives from 19 industrial and developing countries, along with women NGO leaders, met in Helsinki to develop a common statement on the environment. The participants noted that "women bring a unique voice to the challenges and opportunities of sustainable development." They called for, in part, equal rights; access to and control of natural resources for women, including land tenure; policies that give women stronger voices in decisions about sustainable resource use; better consumer education, especially for women, on the environmental impacts of products; support for women's consumer initiatives, through recycling, product labeling, and promotion of organic foods; and development of "policies, legislation and strategies towards gender balance in environmental protection and in the distribution of its benefits."

SOURCE: See endnote 40.

cation, particularly in rural areas. For instance, 60 percent of the 113 million children not in primary school around the world are girls. Yet numerous studies over the years have documented the impact that education has on the number of children a woman bears in her lifetime, particularly secondary schooling. (See Figure 3–4.) And women still account for two thirds of the people worldwide who cannot read. A 2002 study estimated that 549 million women in the world are illiterate. There is some good news, however. According to UNESCO, in all the world's regions women are gaining access to literacy and education, and at a faster rate than men. (Although given how far women have lagged behind, this is perhaps not surprising.) The U.N. Development Programme (UNDP) found that 90 countries, home to 60 percent of the world's people, are likely to meet global goals for ending gender inequalities in primary schooling by 2015.[42]

More women than ever are using modern methods of contraception today: 62 percent of those who are married or in a stable union globally (about 650 million women), including 60 percent of those in less developed regions. But significant differences exist between regions. In Africa, only 25 percent of married women use contraception, while in Latin America and the Caribbean, 69 percent do, a rate very similar to the industrial-country average of 70 percent. Still, vast needs go unmet: overall, according to the United Nations Population Fund (UNFPA), 350 million women lack access to a range of contraceptive services, a number that can be expected to grow as populations increase. And an estimated 125 million women do not want to be pregnant but are not using any type of contraception. Millions more women would like to avoid pregnancy but are using the wrong type of birth control because they lack information about the best method for them.[43]

Overall, progress toward the goal agreed to at the Cairo Conference of universal access to reproductive health care—which includes family planning information and services, maternal and infant health care, and prevention and treatment of sexually transmitted diseases, among other services—by 2015 has been slow. Funds to realize this goal have fallen short. In 2000, the support that inter-

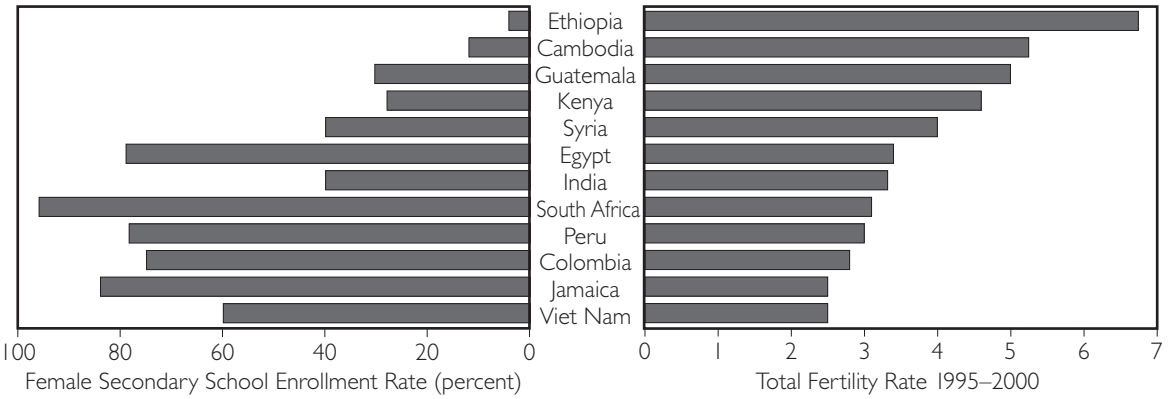


**Figure 3–4. Education Levels and Fertility Rates for Women and Girls in 12 Developing Countries, Late 1990s**

national donors promised at the Cairo conference was running at about half the promised level. And although developing countries are contributing most of their agreed portion, significant differences exist between countries and regions.[44]

Some population researchers contend that the deficiencies in harnessing political will and sufficient budgets mean the declines in fertility witnessed over the past 35 years may well stall. "Many biodiversity-rich areas are among the last places on Earth for average fertility to fall from its historic high levels," observes Robert Engelman of Population Action International, "probably because such places tend to be farthest from the reach of cities, services, and the electronic media. But these also are often the places where fertility is falling fastest," he continues, "precisely because the modern world is just reaching them, and traditional ideas of childbearing and women's roles are changing rapidly." He notes that governments' and NGOs' inability or unwillingness to provide good-quality reproductive health services in remote areas often slows down this process altogether. And in the industrial world, national policies remain largely silent on the interaction of population trends with overconsumption of natural resources. Taken together, these realities suggest that collisions between human populations and biological resources in developing and industrial regions alike will only intensify.[45]

Still, since the Cairo conference and the global women's conference in 1995 in Beijing, governments have acknowledged—at least rhetorically—that nations suffer when they neglect the needs and rights of women. Few leaders have made the needed additional leap in thinking, however, to see clearly and act on the links between growing population and resource consumption, gender inequality, and the loss of biodiversity. But at the community level, programs that seek to address the commonalities among the three areas have been put in place, often as a result of the initiative of conservation and development agencies and the participation of local NGOs and communities—actors that are increasingly working in tandem. In some programs, governments themselves have been important partners. While a few of these programs began before the Cairo conference, most have been launched since 1994 and reflect its principles and objectives.

Some programs have health or population as their entry points. Others stem from concern about long-term threats to species or habitats. In some cases, conservation groups have taken the lead; in others, development organizations working on health or poverty alleviation have discovered that community needs are better served when reproductive health care is provided along with environmental inputs, or vice versa. But all are based on the premise that integrated service delivery leads to greater success in improving human health, expanding livelihood options, and protecting the environment. For several programs, gender equity and increases in the power that women have to make decisions—whether about their fertility or their use of resources—are important goals. Most of the current set of programs reach relatively small numbers of people, tens of thousands at the most, but in many can be found the seeds for a "scaling up" of the efforts' reach and scope.[46]

In the state of Chiapas, Mexico, for instance, Conservation International has recently begun working with a family planning NGO, Mexfam, and the Mexican Social Security Institute to expand access to reproductive health care, including family planning, and to halt the clearing of forests in and around the Montes Azules Biosphere Reserve. Lying within the Mesoamerican biodiversity

hotspot, this reserve contains some of North America's last large tropical rainforest. CI provides natural resource management services—techniques for improving soil conservation and increasing crop yields, for example, and a forest fire prevention program—while its partners deliver health services. CI also provides information on small loans and income-generating opportunities to women who participate in the program's health or environmental activities, and is working to promote ecotourism in the region.[47]

In the mountainous provinces of central Ecuador, where most women want reproductive health services but cannot get them, fertility is high and soil erosion is widespread. World Neighbors, a development organization, has joined with a local NGO, the Center for Medical Guidance and Family Planning, to deliver reproductive health care and to promote improvements in local management of natural resources to more than 4,000 families. Among the services provided through five clinics in 60 rural provinces are family planning and maternal and child health care and training, along with inputs for sustainable agriculture, animal husbandry, and food security. Successful efforts have been made to expand women's participation in all program activities, despite high rates of female illiteracy and gender roles that limit women's say in community decisions.[48]

Three government departments in South Africa—Water Affairs and Forestry, Environmental Affairs and Tourism, and Agriculture—rolled out a Working for Water Programme in 1995 to meet two goals. The first was to remove alien trees and shrubs, brought to South Africa by successive waves of immigrants and colonizers, that compete with and crowd out indigenous plants and animals. The second was to create employment options for still-marginalized members of society, including women and young people. The program employs about 20,000 people, 60 percent of them women, in 300 projects throughout South Africa. One area where Working for Water is active is the Cape Floral Kingdom in the southwest, a global biodiversity hotspot and home to 9,000 plant species. To address high rates of unwanted and unplanned pregnancies among staff, as well as the HIV/AIDS crisis gripping South Africa, Working for Water has incorporated an AIDS awareness training program and offers its workers reproductive health information and services, including condom distribution and management of sexually transmitted diseases.[49]

**Governments have acknowledged—at least rhetorically—that nations suffer when they neglect the needs and rights of women.**

In nearby Tanzania, responding to serious deforestation outside the borders of the Gombe National Park, in 1994 the Jane Goodall Institute established the Lake Tanganyika Catchment Reforestation and Education (TACARE) program. TACARE now works in 30 villages to address the combined pressures of high population growth, limited economic development, and ecosystem decline—specifically soil erosion and the effects of deforestation. Gombe itself now contains the only forested area left in the region. TACARE delivers conservation education in local schools and villages and has supported the creation of village forest reserves (for fuel and cooking wood) and tree nurseries, as well as the planting of nearly 750,000 new trees. With regional government health authorities, TACARE supports community-based health promoters and contraceptive distributors who are trained to deliver reproductive health care, preventive

health services, and HIV/AIDS awareness. Central to TACARE's activities is developing the capacities of women for improved household and resource management. Training is provided to women in the cultivation of fruit and palm oil trees, savings and loans programs support women who launch environmentally friendly small businesses, a girls' scholarship program is in operation, and legal support is offered to make women's rights better known and to protect them.[50]

Yet another example of this integrated approach, and at a larger scale, is found in the Solomon Islands in the South Pacific, where marine biodiversity is rich. WWF has recently launched a public education and media initiative on the connections between population trends, resource use, and the health of land and sea ecosystems, including intact rainforest. Migration patterns combined with population growth (average fertility is above five children for each woman) are threatening communities' livelihoods, which largely consist of subsistence farming and fishing. A central goal of the campaign is to expand awareness and use of family planning services. Partners in this effort include provincial and national government agencies, health and family planning organizations, educational institutions, and community-based organizations, as well as women's groups. WWF-Solomon Islands has also adopted a gender equity policy to guide its internal operations and provide a potential model of best practices for other organizations working in the Solomons, which is still a highly patriarchal society.[51]

These initiatives, just a handful of those under way around the world, demonstrate that incorporating improved access to contraception and a broader range of other reproductive health services can increase women's participation in natural resource conservation, education, skills training, and small business programs and vice versa. They also show that addressing health and livelihood needs—and gender realities—can be an important means of successfully protecting biodiversity. And they illustrate the roles that conservation and development organizations, government agencies, and communities have to play in addressing population and biodiversity challenges. As the connections between conservation, resource use, and population projects become clearer, the environmental community and environment ministers can become an important new constituency for reproductive health and women's rights.

As UNFPA executive director Thoraya Obaid has said: "Ten years after the adoption of *Agenda 21*, the primary challenge remains: to ensure that access to resources for human development is in balance with human numbers; to end extreme poverty; and to advance equality between men and women.…Many women in developing countries still lack access to resources, services and the opportunity to make real choices. They are trapped in poverty by illiteracy, poor health and unwanted high fertility. All of these contribute to environmental degradation and tighten the grip of poverty. If we are serious about sustainable development, we must break this vicious cycle."[52]

## Nurturing the Next Revolution

As the linkages among population, gender, and biodiversity become better known, there are more opportunities to take actions in holistic ways that work for people and nature. But time is critical. Collisions between population and biodiversity can be expected only to intensify as human numbers and resource use expand. If we do not address the bonds that tie population, gender, and biodiversity together through large-scale, more compre-

hensive, more equitable programs and policies, we will miss an opportunity that may not arise again. Species and habitats lost today as a result of rapid population growth and consumption will not be recreated anytime soon. Several principles can guide this effort. (See Box 3–5.)

First, policymakers need to target areas of high biodiversity. In areas particularly rich in animal and plant species and especially threatened, efforts should be made not just to protect biodiversity but also to improve women's lives and rights. Concrete steps should be taken by governments to expand the availability of reproductive health care and information in threatened landscapes or marine areas with high population growth. There is ample opportunity here for partnerships between government agencies and international, national, or regional health, development, or conservation NGOs. Conservation International, for instance, has integrated reproductive health activities into its conservation programs in four countries in biodiversity hotspot zones—Guatemala, Madagascar, Mexico, and the Philippines. When government reproductive health services are available, CI seeks to expand communities' access to them; when they are not, as is often the case, CI works with local NGOs to establish services.[53]

It will also be important for governments and conservation and development groups to ensure that the impact of gender realities on resource use and control is understood and addressed. They should take steps to ensure that women fully participate in, and benefit from, programs to improve natural resource management or conserve biodiversity on an equal basis with men. In Nepal and Tanzania, among other places, women's membership in community resource management bodies is mandated by the government. Conservation practitioners note that not only has this advanced gender equity and women's status in communities, it has also led to improvements in management of forests and other ecosystems.[54]

**BOX 3–5. PRINCIPLES FOR INTEGRATED PROGRAMS ON POPULATION, WOMEN, AND BIODIVERSITY**

- Target areas of high biodiversity for improvements in reproductive health, in education, and in women's rights to participate in natural resource management.
- Increase capacity of key actors to do cross-sectoral work.
- Encourage sustainable consumption patterns in all countries.
- Introduce policy changes that will encourage scaling up of successful local programs.

In addition, supporting improvements in girls' education—in enrollment levels and available facilities—can promote future conservation of biodiversity-rich areas and improve women's lives. Nearly 1.2 billion adolescents are now entering their reproductive years—the largest generation in history. The choices they make today will determine the population-biodiversity balance of the twenty-first century. The government of Bangladesh, with World Bank support, has just launched the second phase of a national effort to improve secondary school enrollment rates for girls in rural areas by providing stipends for tuition costs. Although not geared specifically for areas of high biodiversity, the effort is laudable for its ambition and concrete gains. Girls' enrollment levels doubled in areas where the program operated in its first phase, and rates of early marriage (strongly linked to early child-

bearing and continued high rates of maternal death in Bangladesh) have begun to fall. About 1.5 million girls are expected to participate in this new phase, which also includes measures to improve the quality of schooling, at an astonishingly low cost—about $20 a year for each girl.[55]

**At the community level, productive partnerships need to be nurtured among health and population organizations, community groups, and key stakeholders.**

The World Wildlife Fund in the United States is supporting a small number of primary and secondary school scholarships for girls, along with environmental education, in seven countries in priority biodiversity conservation regions: Bhutan, Colombia, Kenya, Madagascar, Nepal, the Philippines, and Tanzania. Scholarships are awarded in rural communities where girls rarely complete high school, where women's literacy levels lag well behind men's, where fertility rates remain high, and where women's roles in resource use and its protection are often ignored.[56]

In schools in the Kiunga Reserve in Kenya, it is not unusual for eighth-grade classes to have no girls in them. But in a sign of change, some lower grades have more girls than boys. This trend toward valuing girls' education is growing, partly as a result of local communities' efforts. At weekly *barazas* (community meetings), teachers report urging parents to send girls to school and keep them there. Nineteen year-old Fahima is a World Wildlife Fund scholarship recipient from Kiunga who attends a girls' boarding school in the city of Lamu. "If you are a girl who is educated, you will be a very important person in society. You can uplift yourself and your family," she says.[57]

Efforts in Kiunga to get more girls into school have naturally been paired with efforts to get conservation education into schools as well. And girls, along with boy scholarship recipients, attend a week-long conservation camp. Here they get hands-on conservation experience—restoring coral, counting turtle eggs, tagging nesting turtles—as well as conservation education. They also learn to snorkel, with many seeing live coral for the first time, even though they have lived on the shore of the Indian Ocean all their lives. Girls and boys leave with a better understanding of the conservation challenges in Kiunga, and in many cases a greater commitment to taking action to reduce the pressures placed on marine resources. Swabra, a 16-year-old girl living in Kiunga, says, "In our area, people were eating turtles. Now I know the importance of conserving turtles. If we eat all of them there will be no species of turtles.... They will not be able to save them....I've educated the whole community by telling them it is not good to eat turtles."[58]

The second key principle is to increase the capacity of organizations large and small—from governments and the World Bank to international conservation and development agencies and local family planning clinics—to undertake cross-sectoral work on population, gender, and biodiversity, and to make this work part of the way they do business. A great deal of interest exists in better understanding and acting on these linkages, but uncertainty on how to move forward is slowing efforts on the ground. In many agencies, government and nongovernmental alike, it is rare to find expertise that crosses sectors. Even in large development agencies, with many experts on staff, managers and divisions in an area such as health may have limited contact with those working on biodiversity protection. Such divisions will need to be broken down through, for example, building awareness within environment

departments of the gender dimensions of natural resource management. Another potentially useful strategy, particularly for large international agencies or government ministries, is creation of policy and program working groups with representation from population, biodiversity, and gender or women's divisions. Such groups, called for in the Cairo agreement, could also usefully be created at more local levels, within government structures and across NGOs, as a means of joining efforts in separate sectors.[59]

Actions are also needed to improve the understanding and skills of NGOs, community-based organizations (like women's groups), and field-based line managers who oversee government- or donor-funded programs. Conservation and development organizations have important roles to play here in spurring capacity development by supporting or providing training, for example, in the areas of gender and population. Development of partnerships between NGOs and government agencies can also increase their ability to act on population, gender, and biodiversity linkages, from local to district to national levels.

At larger scales, strategic partnerships among these various agencies and groups may be most useful, though it may take some time to develop and sustain joint ventures among international development agencies that provide health or education services; conservation groups; research institutes that work on population and that have useful technical skills, such as mapping population and biodiversity variables; gender and development organizations with analysis or program expertise; institutes with proficiency in technical skills or demography analysis; and regional health or development NGOs. At the community or district level, productive partnerships need to be nurtured among health and population organizations; community groups, including women's groups and associations; and key stakeholders in communities, such as teachers and elders. One place to create such partnerships is through the district development committees that are increasingly common local policymaking bodies in developing countries; their membership generally includes government as well as community representatives.

Building the steps for gender equity and environmental sustainability at many levels is also likely to create the grounding from which to launch future actions. Moreover, strong partners at national, regional, and local levels can facilitate more strategic thinking, action, and follow-up. They can also share tools and information or provide an entry point for further work. For example, IUCN is in the midst of a multiyear project with environmental ministries in the eight Mesoamerican countries to integrate gender equity into natural resource policies and the action plans to implement them. Four U.N. agencies—UNFPA, UNDP, UNESCO, and FAO—are planning to work with national governments and IUCN on a comprehensive program to manage and conserve biodiversity in the Sundarbans region of India and Bangladesh. The Sundarbans is the largest mangrove ecosystem in the world—home to the Bengal tiger and Ganges dolphin—but ecological degradation there is gathering speed as human activities expand. When launched in mid-2003, the program will support skills development for sustainable livelihoods for women and men, promote communities' participation in conservation activities, and improve the capacity of governments to provide reproductive health services.[60]

A third area for action is encouraging more sustainable consumption, given local and global impacts of current choices—and necessities—on biodiversity and equity. As personal action has been fairly limited to date,

widespread change is unlikely to come without government and institutional policies—and without more public information and guidance on the effects of consumption choices. Many countries have already taken steps in the right direction. In Brazil, for example, ethanol produced from fermented sugarcane juice is used as a gasoline substitute to power 10 million cars with high-compression engines. This has reduced gasoline use by 50 percent and prevents nearly 10 million tons of carbon dioxide emissions a year. Another significant benefit has been the creation of more than 700,000 jobs at the processing plants used for ethanol production. Other countries could adopt similarly or even more ambitious fuel-saving measures if the political leadership existed.[61]

**Population growth is slowing and the status of women is improving—two hopeful trends in an otherwise rather dismal picture.**

Many private nonprofit groups, however, including those working for environmental protection and sustainability, are not waiting for governments to act. For instance, the U.S.-based Center for a New American Dream has launched a Web-based Turn the Tide campaign that asks North Americans to take nine actions—from skipping a car trip or a meal of beef once a week to replacing four standard light bulbs with energy-efficient compact fluoresents—that produce measurable impacts on global warming, water and energy conservation, and wildlife and forest habitat protection. It is worth noting that about two thirds of those who have signed up so far are women. And the Women's Environmental Network in the United Kingdom has a local foods program and other campaigns to encourage women and, by extension, men and children to change the way they consume.[62]

In the developing world, it is also important to raise public awareness and provide alternatives that shift or reduce consumption of resources that may put biodiversity under pressure. Prime areas for further action include reducing the cutting of forests for wood and charcoal and the hunting of forest mammals or marine species for household consumption or sale. Also important is development of alternative livelihoods that are less resource-dependent, especially for women, and skills and entrepreneurship training to make this possible; needs for these remain vast and will only increase as populations grow. An area of considerable interest and action is expanding use of solar cookers and fuel-efficient stoves that require less wood. Of course, significant pressures on developing regions' biodiversity as well as on the livelihoods of the poor, who rely heavily on local environments, stem from the operations of extractive industries like logging, mining, and oil exploration and refining; their impacts will also need to be acknowledged and addressed within the consumption equation.

A final guiding principle is to use policy changes to transform current programs into national or regional-level initiatives, drawing on the lessons learned from smaller-scale efforts. Most on-the-ground programs addressing population, gender, and biodiversity operate in relatively small geographic areas and reach only a fraction of those who could benefit. Few are backed up by policies that call for coordination between ministries of health or natural resources, or that make women's participation or gender equity operational principles. Such policy innovation—as endorsed in the series of international agreements that stretches from Rio to Cairo to Beijing—is an important component of scaling up current efforts and increasing

their reach and impact. "Even if there is a lot of emphasis on population and gender at local levels, without attention to this at policy levels, we are wasting our time," says Daniel Mavella, project manager for a national park program in Tanzania. "Policies are the frameworks that give us the room and the confidence [to work]."[63]

Policies could help spur big-picture thinking by policymakers on the population trends most forcefully affecting biodiversity and the means of dealing with the underlying conditions driving them—such as limited access to reproductive health care and education in rural areas, women's low status, high levels of illiteracy, intense use of resources at subsistence level, and women's low levels of landownership and poor access to agricultural extension services or credit. They can also ensure that integration of sectors, such as population or health, with environment happens on the ground, at the district and municipal levels, where operational decisions are often made. Policies can and should make gender equity and women's full and equal participation bedrock principles. The Ministry of Population and Environment in Nepal, for instance, may well ease the way for integrated actions across sectors and, potentially, at larger scales. Its mandate is to coordinate government activities in the areas of population, reproductive health, and environment.[64]

Policy changes may also redirect money streams so that they, too, cross sectors. A test case in coming years will be funds spent on population programs by the U.S. Agency for International Development. Due to recent changes in the legislation guiding U.S. spending, some of the population funds are to be used in areas where population growth "threatens biodiversity or endangered species."[65]

There is no question that much remains to be done to reverse the ecological degradation that has been experienced around the world because of unsustainable population growth and consumption. But population growth is slowing and the status of women is improving—two hopeful trends in an otherwise rather dismal picture. And efforts are under way to protect areas rich in biodiversity across the world by recognizing the links between gender equity, population realities, and environmental protection. These efforts set an example for all nations to recognize that what is good for women—improved access to reproductive health care and family planning, increased access to education, greater economic opportunities and decisionmaking on natural resource use—is also good for biodiversity. Current actions need to be nurtured and accelerated if we are to have a real chance of creating a more secure, equitable, biologically rich world, both for ourselves and for the rest of nature.

Chapter 4

# Combating Malaria

*Anne Platt McGinn*

No other disease in the course of human history has had as profound an effect on human development and well-being as malaria. Africans in Neolithic times, ancient Chinese and Greeks, Roman emperors, and hundreds of millions of other people—rich and poor—have died from this disease. For centuries, Africa was known as the White Man's Grave because so many Europeans who went there lost their lives to malaria. During the early stages of World War II, General Douglas MacArthur lost more soldiers in the Pacific arena to malaria-carrying mosquitoes than to the Japanese. Today, up to 7,000 people, primarily children in sub-Saharan Africa, die from this disease every day. "There is no doubt that malaria has caused the greatest harm to the greatest number," notes Sir Frank Macfarlane Burnet, a Nobel Prize–winning immunologist.[1]

Malaria is still known as the King of Diseases in Hindi, and with good reason: for each person who dies from malaria itself, another three who have it succumb to more mundane problems such as malnutrition, anemia, or diarrhea. The death toll from malaria and malaria-related illnesses exceeds that of AIDS, which now kills about 3 million people annually.[2]

Despite its unrelenting grip on humanity and the fact that about 2.5 billion people are at risk of contracting the disease, malaria is a relatively low public health priority on the international scene. It rarely makes the news. Between 1975 and 1999, only 4 of the 1,393 new drugs developed worldwide were antimalarials.[3]

The low priority assigned to malaria would be easier to understand if the threat were static. Unfortunately, it is not. Although the geographic range of the disease has contracted substantially since the mid-twentieth century, over a few decades malaria has been gathering strength in several different dimensions. The parasites now resist most antimalarial drugs, making treatment vastly more complicated and expensive. Poverty, war, and civil strife make it hard for governments to implement preventive and curative measures. Environmental change and human migra-

tions have always exacerbated the potential for this disease to spread, but the global scale of these factors today makes malaria even more difficult to contain.[4]

Like so many problems that are especially acute in developing countries, malaria costs more to ignore than to treat. Malaria costs Africa some $3–12 billion a year, but it could be controlled with available prevention and treatment measures for much less. By 2007, about $2.5 billion a year will be needed to control malaria globally, according to recent estimates. Although such an investment would pay off in human and economic terms, it is not being made. International funding for malaria research currently comes to about $150 million annually, only about 5 percent as much as proposed U.S. government funding for AIDS research in 2003.[5]

The reality is that malaria is a disease of poor countries. If it were a constant threat in industrial countries, the story would be completely different. Although the funding situation looks much better today than it has in years, the newly created Global Fund to Fight AIDS, Tuberculosis & Malaria and the Medicines for Malaria Venture are still vastly underfinanced compared with the scale of the problem. Moreover, money alone is not enough to fight malaria. It will take political will and concerted international cooperation to confront this global threat. And it will take a change in mindset: people must appreciate that human and environmental health are intimately linked on a local and global scale. Adopting this thinking is perhaps the greatest challenge—and the greatest opportunity—for curbing malaria.

## A Modern and Growing Threat

Malaria is predominantly a disease of the tropics (see Figure 4–1), but as recently as 60 years ago it was found throughout the more temperate regions of southern Europe, North Africa, East Asia, and the southeastern United States. Although the disease's geographic reach has shrunk, more than 40 percent of the world's population now lives in areas where malaria transmission occurs regularly. Elsewhere, people are at risk from the occasional outbreak of "airport malaria," when infected mosquitoes hitchhike on international aircraft and bite people living near airports.[6]

By virtue of ecology, demographics, and climate, sub-Saharan Africa is home to some 90 percent of the world's malaria cases and deaths. In the early 1990s, outpatient clinics throughout the region routinely treated more people for malaria than for any other disease. (The rapid spread of HIV/AIDS has undoubtedly altered the resources dedicated to malaria, but not the absolute burden from the disease.) The mosquito species most closely adapted to human blood and the most debilitating malaria parasites are common in these areas, taking an especially high toll on pregnant women and the very young. Children may have as many as five different strains of malaria in their bodies at once. In many areas of Africa, the parasite is almost always circulating in people's blood, though not always at levels high enough to be detected by a microscope. Whether or not these parasites cause severe, debilitating disease depends on the person's immunity and genetic susceptibility, among other factors.[7]

In Africa, the typical person infected with malaria lives where a large share of the population gets the disease each year, where infected people are disabled, weakened, or occasionally killed by it, and where people suffer from many bouts of the illness during their lifetimes. In contrast, environmental and human factors and the mosquito species that carry malaria are all quite different in much of Asia and the Americas, manifesting

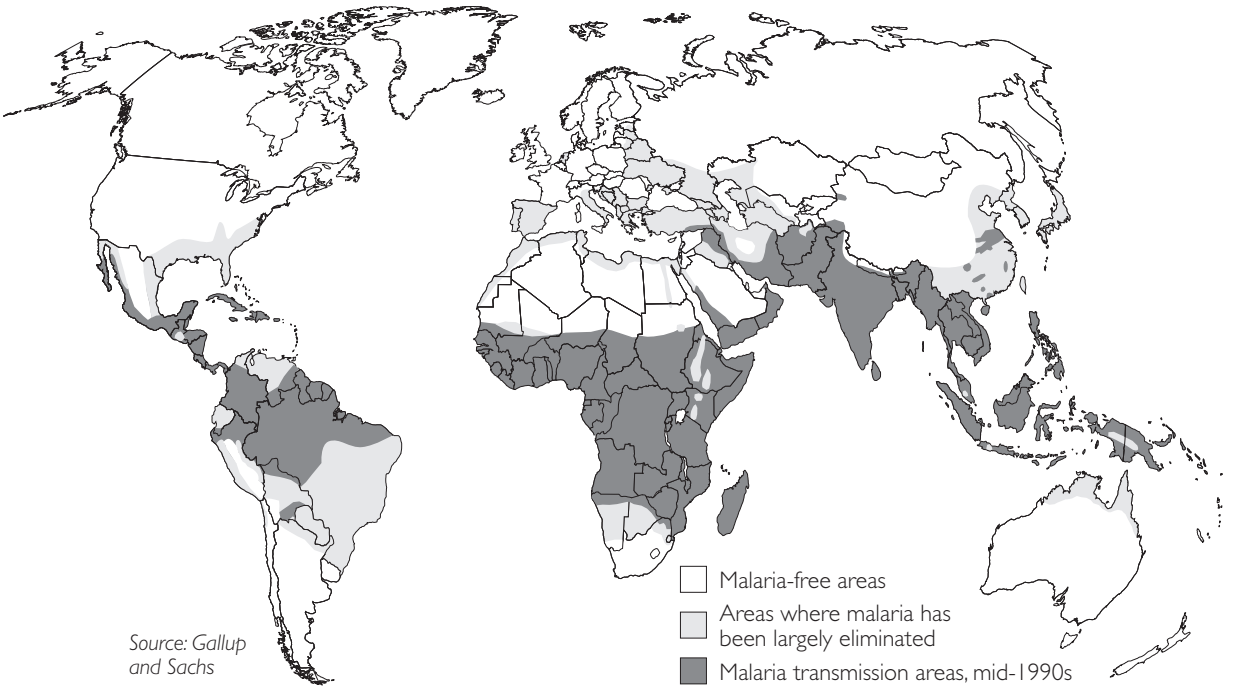


**Figure 4-1. Prevalence of Malaria**

a different disease. (See Table 4–1.) In these areas, people of all ages are affected by malaria, but they rarely die from it.[8]

A severe bout of malaria can trigger prolonged, repeated illness and chronic anemia and can have life-long effects on cognitive development, behavior, and educational achievement. In Kenya, one in 20 children is so anemic from repeated bouts with malaria that in the United States the child would be rushed to a hospital for an emergency blood transfusion. In sub-Saharan Africa, children suffer about 600,000 attacks of cerebral malaria—a severe infection in the brain—each year, with one in five patients dying. Those fortunate enough to survive suffer from a range of neurological difficulties, including learning disorders, behavioral problems, speech disorders, hearing impairment, paralysis, epilepsy, and cerebral palsy.[9]

Pregnant women are especially vulnerable to malaria. In sub-Saharan Africa, as many as 400,000 pregnant women contracted severe anemia induced by malaria in 1995. Up to 10,000 of them died. Pregnant women with malaria are at higher risk of miscarriages, stillbirths, and having babies with low birth weight. In sub-Saharan Africa, malaria is directly responsible for about 30 percent of childhood deaths and is a contributing factor in up to 60 percent of infant and child deaths.[10]

Where infant and child mortality rates are high, parents often react by having more children. Higher fertility rates, in turn, prompt lower investments in education per child. Moreover, children who are sick with malaria have higher rates of school absenteeism, which increases the chances they will fail classes, possibly repeat a school year, or drop out

entirely. In Kenya, primary school students miss up to 11 percent of school days per year because of malaria.[11]

The problem with malaria is not just medical, but also the way it deepens the poverty of people who are just barely scraping along. Many of the 1.2 billion people who live on $1 a day in developing countries are at risk for malaria. In some areas, malaria-stricken households spend up to $40 a month on malaria prevention and treatment. Devoting as much as one third of their total income to fighting this plague, families also suffer a loss of income when a wage-earning member is home sick.[12]

**Table 4–1. Malaria in Asia and the Americas Versus Africa**

| Characteristic | Asia and Americas | Africa |
|---|---|---|
| Risk of infection | Very low | Very high |
| Acquired immunity | No | Yes |
| Case fatality following infection | High | Low due to immunity |
| Population at risk of death | All ages | Infants, young children, and women pregnant for first time |
| History of vector control | Effective | Not widely applied |

SOURCE: J. Kevin Baird, "Resurgent Malaria at the Millennium," *Drugs*, April 2000, p. 734.

A country that is branded high-risk for malaria is essentially isolated from the global economy. It typically loses potential foreign investment, tourism revenue, and trade because companies, governments, and travelers are reluctant to be in areas where people could contract malaria. This isolation strengthens the cycle of disease and poverty. As noted earlier, malaria costs Africa some $3–12 billion each year, an estimated 1–4 percent of the continent's collective gross domestic products. Over the past 35 years, this one disease has led to nearly $100 billion in losses from Africa's economy, roughly five times as much as the continent received in international development aid in 1999.[13]

After progress against the disease in the 1960s, malaria is now staging a strong global comeback. (See Figure 4–2.) From 1970 to 1997, global mortality rates from malaria (the number of deaths per 100,000 population) increased by 13 percent. Death rates in sub-Saharan Africa jumped by 54 percent during this time. By 1997, Africa's death rate from malaria stood at 165 per 100,00 people, nine times the global average that year. Children are now suffering even more from malaria. From mid-century to the 1990s, mortality rates from all diseases among African children under the age of five declined by 34 percent. But malaria-specific death rates among children have increased 30 percent since the 1960s, offsetting nearly all the gains made in other childhood illnesses.[14]

Despite our long history with this disease, malaria remains one of the world's leading health threats. Officially, some 300–500 million cases of clinical malaria occur each year, and at least 1 million people die from malaria, but these data are vast underestimates. Because many illnesses and deaths occur at home and are never formally registered, the actual number could be as much as three times as high. Recent studies show, for example, that people in malarious areas suffer at least 1 billion high-fever episodes each year that resemble malaria and should be considered for malaria treatment. If effective control strategies are not introduced, the number of malaria cases could double in the next 20 years, simply due to population growth in

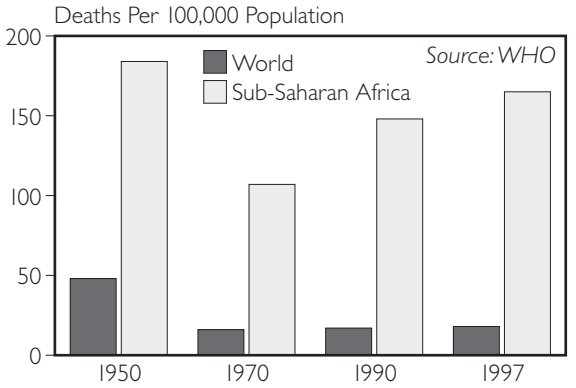


**Figure 4–2. Malaria Mortality Rate, 1950, 1970, 1990, and 1997**

areas with high rates of this disease.[15]

Three key factors explain why malaria is getting worse. First, virtually all areas where the disease is endemic (native) have seen drug-resistant strains of the parasite emerge. Chloroquine was the drug of choice for fighting malaria for generations. It was long added to table salt to dose entire populations and prevent malaria. But overuse and misuse have promoted the survival of drug-resistant strains. Now chloroquine is useless in virtually all malaria-ridden areas of the world—more than 100 countries.[16]

The loss of chloroquine is especially great because it is cheaper and easier to administer than other anti-malarial drugs. It is also fast-acting: patients normally feel better within 24 hours. These characteristics contributed to both its usefulness and, more recently, its downfall. *Plasmodium falciparum*, the deadliest of the four malaria parasites, has become even tougher and more expensive to treat after decades of exposure to chloroquine and other anti-malarial drugs. Consequently, death rates are rising.[17]

Replacement drugs are suffering a similar fate. In parts of Southeast Asia and East Africa, for example, multi-drug-resistant parasites have already developed from the heavy use of the second-line anti-malarial drug, sulfadoxine/pyrimethamine. And in northwestern Thailand, local parasites are becoming resistant to every known anti-malarial drug.[18]

While the available medical arsenal shrinks, some scientists have concentrated on genetic blueprints to find clues for new therapeutic agents. In 2002, a group of international scientists decoded the genome sequences for the most dangerous malaria parasite and mosquito. Although such information will be useful for developing new anti-malarial medicines and narrowing the search for a reliable vaccine, widespread application of such tools is still years away.[19]

Second, malaria is gaining ground because of environmental and social changes. The disease occurs where people are poor and the environmental conditions are right. Irrigation, dam building, deforestation, and other activities can boost the chances that malaria will spread, particularly in the world's "malaria belt." In countries as varied as Afghanistan and Sierra Leone, the lack of basic sanitation and medicines in areas disrupted by war has helped spread the disease, as has the interruption of health coverage in places like North and South Korea and Tajikistan. Even though malaria is regarded as predominantly a rural disease, people living in rapidly expanding tropical cities are not immune to its spread, especially as some mosquitoes now show signs of adapting to the urban landscape.[20]

To make matters worse, climatic instability may allow malaria parasites and mosquitoes to survive in places that have been free of them for years. By 2050, for example, some experts predict a return of malaria to the southern United States, southern Brazil, western China, and regions across Central Asia due to climate change.[21]

The third reason for the global resurgence of malaria is the scant use of safe, effective, and affordable means to control the mosquito that carries the disease. Given the absence of a reliable way to kill the parasite, controlling, repelling, or simply killing mosquitoes that bear it—a practice known as vector control—remains fundamental to controlling malaria today. This has led to the use of toxic insecticides, including one of the most notorious—DDT. (See Box 4–1.)[22]

While the use of DDT may seem necessary, especially in light of the global resurgence of malaria, there are good reasons for thinking that progress against the disease may allow us to minimize this approach. Insecticide-treated bednets, indoor spraying of less persistent insecticides, and carefully designed environmental measures to control larval breeding, for example, all help reduce the burden of malaria. Despite their proven benefits, these measures are not widely applied in regions that desperately need protection. Ensuring that these and other tested tools are available and adopted and that outside funding is secured to purchase and distribute them is a central challenge to combating malaria in the world's poorest regions.

## The Biology and Evolution of the Disease

Malaria is principally a vector-borne disease (one carried by an intermediary, in this case a mosquito) that is caused by four protozoan parasites in the genus *Plasmodium*. The malaria parasite is a highly complex organism that goes through four distinct stages in its lifecycle that cannot be completed without access to both a mosquito and a mammal. These parasites are spread exclusively by certain mosquitoes belonging to the genus *Anopheles*. Understanding the interplay between parasite, vector, human host, and environment is important to appreciating why it is so difficult to control the various forms of malaria. Indeed, malaria is not a single disease, but a disease complex, a host of illnesses that are related by ecology.[23]

A malaria infection begins with a single mosquito bite. (See Figure 4–3.) A female *Anopheles* mosquito needs blood from a human (or other mammal) to make eggs. She repeatedly probes the skin with her mouthpiece, basically a pair of sharp, needle-like tubes. With each exploratory prick, one tube sends a mix of anti-coagulation compounds and other chemicals into the bloodstream, ensuring a steady supply of human blood up into her body. When she hits a capillary, the other tube sucks up a microliter or two of blood, which triples the mosquito's body weight. Sometimes her saliva contains thousands of thread-like sporozoites, the infective form of malaria parasite. Only about 1 percent of a mosquito's sporozoites are deposited with each meal. Within minutes of being transferred from mosquito to person, the sporozoites move from the bloodstream to the liver, well before the body can muster an effective defense.[24]

In the second stage of the parasite's life, sporozoites multiply asexually in the liver. Each one matures into tens of thousands of merozoites, a round form of the parasite, that are contained in a schizont, which is like a hard capsule. In about a week's time, the schizonts rupture, spewing forth millions of merozoites that invade the body's red blood cells, where they feed on the oxygen-carrying hemoglobin.[25]

At this stage, some 7–20 days after the initial mosquito bite, a person will feel the first signs of infection: high fever, chills, and profuse sweating. These symptoms come in waves as the merozoites continue to reproduce in cycles. By the time the body's immune system responds to these symptoms, the process of

**BOX 4–1. THE ENVIRONMENTAL AND HEALTH IMPACTS OF DDT**

DDT (dichlorodiphenyl trichloroethane) is a persistent organic pollutant—one of a group of synthetic compounds that share four common properties: they are toxic, they bioaccumulate in the food chain, they persist in the environment, and they have a high potential to travel long distances from their source. Animals and people bioaccumulate DDT in their bodies, primarily from the food they eat. As the chemicals move up the food chain, each link or species takes up the previous link's exposure, adding it to their own and magnifying the effects. Arctic cod and turbot, for example, have up to 1,000 times higher concentrations of DDT per gram of fat than the zooplankton they consume. One of the most commonly detected synthetic chemicals in humans is DDE—a highly persistent breakdown product of DDT.

Most of the problems with DDT relate to environmental contamination and its effects on animals. In 1999, the U.S. National Academy of Sciences stated that "it is now well-established that the DDT metabolite, DDE,…causes eggshell thinning" and that the bald eagle population in the United States declined "primarily because of exposure to DDT and its metabolites."

In its 2000 toxicological profile of DDT and DDE, the U.S. Agency for Toxic Substances and Disease Registry (ATSDR) cited studies of the hormone-disrupting impacts of DDT and DDE in wildlife and laboratory animals. It noted that "key endocrine processes can be profoundly affected by exposure to extremely small amounts of active chemicals during critical windows of embryonic, fetal, and neonatal development." ATSDR also noted that these studies raise concerns about human health effects.

DDT has already been linked to human disorders. In a 2001 study, researchers focused on samples of mothers' blood that had been stored when babies were born during the 1950s and 1960s. They used new chemical techniques to measure DDE levels, and then looked at the relationship between these and the likelihood of premature birth. They found a strong association. The higher the contamination level, the more likely a preterm birth was. They also showed that contamination was linked to the baby's size, with babies more likely to be small for their gestational age if their mothers had higher DDE levels. Premature babies not only have a higher death rate, they are also more likely to suffer from neurodevelopmental handicaps, chronic respiratory problems, and infections. The authors warn that "in tropical countries, where DDT is used for malaria control, blood concentrations of DDE can greatly exceed the range observed" in the sample they studied.

Workers in DDT production facilities and malaria control programs have also developed chronic health effects. For example, retired DDT-exposed malaria control workers in Costa Rica performed, on average, up to 20 percent worse on a series of tests than a control group of retired drivers and guards. The longer the malaria control worker had been on the job, the greater the decline in their performance. Their reaction times were slower, they had lower verbal attention and visual motor skills, and they showed more problems with dexterity and sequencing. They also experienced more psychiatric and neuropsychological symptoms than the control group.

SOURCE: See endnote 22.

amplification is well under way. The parasite load increases 20-fold every 48 hours. As the parasite infects red blood cells, it starves the brain and other tissues of oxygen and blood, triggering severe anemia, coma, and sometimes death.[26]

Some of the parasites in red blood cells do not stay in the body, however. Instead, they

develop into a sexual, egg-like form known as a gametocyte. Gametocytes are taken up by other mosquitoes when they bite an infected person, prompting the fourth and final stage in the life of the malaria parasite. Once inside *Anopheles*, gametocytes spend about 9–12 days maturing into another crop of infective sporozoites. These are then transmitted to other victims via a mosquito bite, continuing the cycle of disease.[27]

Of the roughly 380 mosquito species in the genus *Anopheles*, about 60 are able to transmit malaria in people. Many of these same species are widespread throughout the tropics and warm temperate zones and are very efficient at spreading the disease. Species in the *An. gambiae* complex are the most important vectors in Africa.[28]

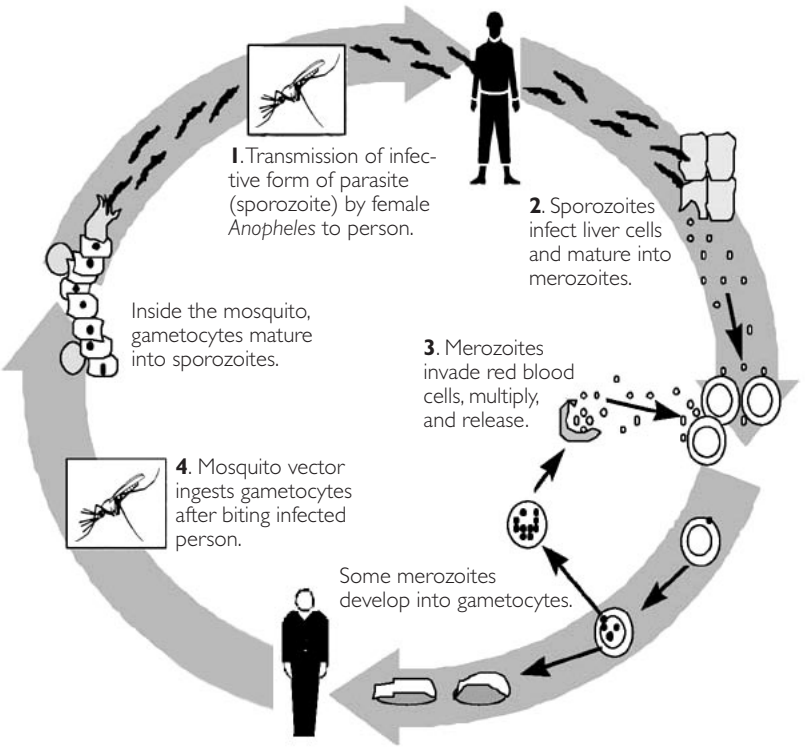


**Figure 4-3. Lifecycle of the Malaria Parasite**

Malaria has an extremely high potential for transmission, as is apparent from a measurement that epidemiologists call the basic reproduction number (BRN). The BRN indicates, on average, how many new cases a single infected person is likely to cause. For example, among the diseases caused by pathogens that travel directly from person to person without an intermediary like a mosquito, measles is one of the most contagious. The BRN for measles is 12–14, meaning that someone with measles is likely to infect about a dozen other people. (There is an inherent limit in this process: as a pathogen spreads through any particular area, it will encounter fewer and fewer susceptible people who are not already sick, and the outbreak will eventually subside.) HIV/AIDS is on the other end of the scale: it is deadly, but it moves through a population slowly. On average, each AIDS patient infects one other person. Its BRN is just above one, the minimum necessary for the pathogen's survival.[29]

With malaria, the BRN varies considerably but is generally higher in sub-Saharan Africa than elsewhere. Malaria can have a BRN as high as 100: conceivably, an infected person can be bitten by more than 100 mosquitoes in one night, each of which can become infected and able to transmit the infection.[30]

To comprehend why malaria has such a strong hold on sub-Saharan Africa, it helps to understand the evolution of the disease.

Before the introduction of agriculture, people contracted malaria on the continent but never in large numbers. Movement to and from areas with mosquitoes offered some relief for victims. Then people began to settle down and clear areas of the rainforest to grow yams and other root crops. These islands of cultivation within forests became ideal breeding grounds for mosquitoes. They were sunlit and had clean water. With a semi-permanent population of people to feed on, the mosquito vectors developed a strong preference for human blood. As the landscape changed and human population increased, malaria became more entrenched. Mosquitoes that fed almost exclusively on people rather than cattle, birds, or primates emerged as the primary vectors.[31]

Africa is home to the mosquito that is best suited to spreading malaria, one of the most deadly and efficient malaria vectors, *An. gambiae*. Unlike other mosquitoes, *An. gambiae* have a high affinity for human blood and bite people rather than animals 95 percent of the time. Thus, they can maintain disease transmission at extremely low mosquito population densities. These efficient vectors encouraged the emergence of a more virulent species of the malaria parasite, *P. falciparum*. During epidemic bursts of disease, a fast-growing, more aggressive parasite had an advantage over slower-growing ones. It could complete development to disease faster and take advantage of frequent transmission.[32]

Additional evidence of malaria's long and deadly history in Africa comes from the persistence of the sickle-cell trait, a defective form of hemoglobin in the blood. People living throughout the tropics may have this genetic mutation because it confers partial immunity to the most lethal forms of malaria. But people who live in areas of highly endemic malaria, such as tropical sub-Saharan Africa, India, and the Middle East, are most likely to have it. Experts believe that sickle-cell hemoglobin causes red blood cells to "sickle" (collapse) when oxygen in the bloodstream is low.[33]

In the absence of sickle-cell hemoglobin, a person experiences the worst effects of malaria. If a child inherits the sickle-cell hemoglobin gene from one parent and a normal hemoglobin gene from the other, the child gains the advantage of a partial genetic defense: a single dose of the gene does not prevent the child from acquiring malaria infections, but it fends off the worst effects and virtually guarantees the survival of the child, despite numerous bouts with the disease. If a child inherits the gene from both parents, however, he or she will die from sickle-cell anemia before reaching reproductive age. The evolution of this trait underscores the fact that malaria was an ancient killer of immense proportions. (Other, milder forms of blood diseases, such as thalassemia, persist in populations of southern Europe and Asia, conferring some protection against the less virulent forms of malaria found in those areas.)[34]

Malaria transmission in Africa is highly variable. Depending on where people live in endemic areas of Africa, they receive anywhere from 1 to 1,000 infective bites per person a year. In contrast, people in Southeast Asia and South America generally suffer 1 infective mosquito bite at most each year. The average Tanzanian gets bitten more each night than the average Thai or Vietnamese does in a year because the vector and humans are so closely associated. (Not every bite by an infected mosquito results in malaria; the process has about a 10 percent success rate.) The less efficient vectors that are common in Asia and the Americas mean that the risk of infection is low and infrequent for people. But the infections that do happen can take a stiff toll, quickly progressing to severe forms of dis-

ease that are sometimes life-threatening.[35]

In Africa, frequent infectious mosquito bites manifest a very different picture of disease and health. In much of sub-Saharan Africa, malaria is a chronic infection that causes recurring bouts of devastating fever, life-draining anemia, and general weakening of the body. But older children who manage to survive repeated cases of malaria early in life acquire partial immunity. Unlike immunity to other diseases, which confers total protection from illness, people who are immune to malaria are protected only from the worst effects of the disease; they remain susceptible to the illness throughout life and will lose this protection if infections stop recurring. Children are especially vulnerable, as their bodies have not had time to develop even this partial immunity. Most children in this area battle several bouts of the illness each year and become weaker, until they finally succumb to it.[36]

The course of infection has a direct bearing on control measures. For example, children who are exposed to fewer infective bites experience a lower level of parasites in their blood. Even in the absence of complete elimination, effective, locally tailored control efforts can save many lives and reduce the burden of disease. The critical point is that in highly endemic areas such efforts need to be maintained over the long term to have any hope of keeping the ever-evolving *Anopheles* and malaria parasite in check.[37]

## The False Promise of Eradication

"Malaria" comes from the Italian term "mal' aria." For centuries, European physicians had attributed the disease to "bad air." Apart from a tradition of associating bad air with swamps—a useful prejudice, given the amount of mosquito habitat there—early medicine was largely ineffective against the disease. It wasn't until the mid-1890s that scientists identified the parasites and mosquitoes that transmit malaria and began to understand how the disease works.[38]

These discoveries had an immediate impact. The U.S. administration of Theodore Roosevelt recognized malaria and yellow fever (another mosquito-borne disease) as perhaps the most serious obstacles to the construction of the Panama Canal. (An earlier and unsuccessful French attempt to build the canal is estimated to have lost between 10,000 and 20,000 workers to disease.) So American workers put up screens, filled in swamps, dug ditches, poured oil into standing water to suffocate air-breathing larvae, and swatted adult mosquitoes. This intensive effort worked: the incidence of malaria declined. On average, just 2 percent of Americans were hospitalized with malaria, compared with 30 percent of workers during the French project. Malaria could be suppressed, it turned out, with a great deal of mosquito netting and by eliminating as much mosquito habitat as possible. But such elaborate and labor-intensive campaigns were difficult and costly to sustain, especially in poor and often remote areas of the tropics.[39]

That is why DDT proved so appealing. In 1939, Swiss chemist Paul Müller discovered that dichlorodiphenyl trichloroethane was an extremely potent pesticide. First used in World War II as a delousing agent, DDT was later used to kill malaria-carrying mosquitoes before Allied soldiers moved through southern Europe, North Africa, and Asia. In 1948, Müller won a Nobel Prize for his work, and DDT was hailed as a miracle chemical. For the control of mosquito-borne diseases, it was seen as a panacea.[40]

A decade later, DDT had inspired another kind of war—a global assault on malaria. For the first time, malaria eradication seemed not

only feasible but imminent. With DDT in hand, the recently formed World Health Organization (WHO) launched a global program to eliminate malaria. In 1957, more than 66 nations enlisted in the cause. Funding for DDT factories was donated to poor countries, and production of the insecticide climbed, as did distribution of anti-malarial medicine, chloroquine.[41]

The goal of the global program was not to kill every single mosquito but to reduce the daily rate of survival for mosquitoes and thereby reduce the frequency of bites and transmission. By suppressing the mosquitoes, human populations were relieved of new infections and had an opportunity to cleanse their bodies of the parasite in circulation. Once a local human population was cleared of infection, mosquitoes could go about biting people without picking up the parasite—at least, that was the theory.[42]

Rather than spraying DDT outdoors, as in the 1940s, mosquito control experts fine-tuned their approach. They used DDT selectively indoors. After mosquitoes take their blood meal, they usually rest in the vicinity, on a wall inside a house. If those walls were coated with a thin film of insecticide, the mosquitoes would absorb a lethal dose. (DDT is also known to have a repellent effect, prompting mosquitoes to quickly flee outdoors or avoid biting people indoors at all.) Unlike other insecticides that can lose their potency in a matter of days, DDT is long-lasting: one dousing could protect a family for six months. In the early euphoria, DDT did not seem to cause any harm to other species. And it was cheap.[43]

Relying heavily on DDT, the global program saved millions of lives. The islands of Taiwan, Jamaica, and Sardinia were soon declared malaria-free. Tropical countries such as Sri Lanka and India witnessed stunning declines in the incidence of malaria. Temperate countries rooted it out entirely. By 1961, malaria had been eliminated or dramatically reduced in 37 countries.[44]

But the strategy relied on a centralized approach that proved difficult to maintain over time. Logistical problems were hard to overcome, and local variations in mosquito behavior and patterns of disease transmission were often ignored. At the same time, mosquitoes evolved resistance to the pesticide. This was reported as early as 1948, only one year into a major public health campaign to use DDT (an effort to suppress mosquitoes and flies in Greece). This knowledge was, in large part, why the global campaign became so urgent. Time was of the essence, given the estimated three years that was needed to clear the protozoan from human circulation and the four to seven years it seemed to take mosquitoes to become resistant to DDT.[45]

By the late 1960s, the urgent campaign ground to a halt. The political landscape had shifted considerably with respect to DDT, thanks in large part to Rachel Carson's influential book, *Silent Spring*, which was published in 1962. No longer were people willing to accept protection for human health at such a high ecological cost. Thus in spite of initial successes, the global program was abandoned in 1969. That year, WHO significantly revised its strategy from malaria eradication to control. While control was a far more realistic and achievable goal, it had far less appeal to countries and health agencies with limited financial resources and many other pressing health concerns. Eradication had been sold as a time-limited opportunity; controlling malaria required maintaining a solid effort almost indefinitely.[46]

In many ways, the global program of the 1960s has made the modern malaria problem far worse. It introduced the dynamics of insecticide and drug resistance, it encouraged some vectors to change their behavior,

it virtually eliminated malariology as a specialty, it created a void in interest and funding for malaria control that is only now turning around, and it engendered the idea of DDT as a first resort against mosquitoes. While most countries experienced a decline in the prevalence of malaria between 1965 and 1994, tropical countries actually registered an increase. (See Table 4–2.)[47]

## Environmental and Social Changes Alter the Balance

During the mid-twentieth century, indoor spraying with DDT helped eradicate *An. darlingi* in Guyana and, along with it, the fear of malaria. Aided by disease control measures, Guyanese society slowly developed. Trade improved and the economy began to grow. Horses, donkeys, oxen, and other work animals were replaced by motorized vehicles. But as the society gradually modernized, malaria came back.[48]

Officials responded by spraying DDT, as it had worked in earlier campaigns. It did not work this time, however, because the primary vector was a different species—one that bit people outdoors. *An. aquasalis* had always been present in Guyana, but it had never been a serious problem because it fed on animals. Once the vectors lost their primary source of food, the mosquitoes adapted to human blood and started spreading the infection to city-dwellers. By this time people had lost their previous immunity, so the health risks were much greater.[49]

Thus some of the projects and trends that have been central to rural economic development ironically can make malaria a more formidable foe. Human-induced environmental changes create new habitat areas for mosquitoes to breed in and expand their range, and the overuse of anti-malarial drugs can affect the severity of the disease. When irrigation is introduced, when dams or roads are built, or when certain crops are cultivated, mosquitoes are often not far behind.[50]

**Table 4–2. Level and Changes in Malaria Prevalence Between 1965 and 1994, by Climate Zone**

| Predominant Climate | Malaria Index, 1965[1] | Average Change, 1965–94 |
|---|---|---|
| Temperate | 0.2 | –0.2 |
| Desert | 27.8 | –8.8 |
| Subtropical | 61.7 | –5.0 |
| Tropical | 64.9 | +0.5 |

[1]Index ranges from 0 to 100.

SOURCE: John Luke Gallup and Jeffrey D. Sachs, "The Economic Burden of Malaria," *American Journal of Tropical Medicine & Hygiene*, January/February 2001 (supp.), p. 88.

There is also a direct human element: such changes attract people looking for work. Often these workers and their families have little or no previous exposure to malaria and are susceptible to the full-blown disease. Migrating human populations carry the malaria parasite with them to new areas and inadvertently infect others. Interactions between mosquitoes, people, and the environment determine the opportunities for *Anopheles* to develop more lethal fangs, so to speak, because more infective mosquito bites translate into more new cases of human disease. But as Guyana's experience demonstrates, the consequences of a changing environment are often difficult to predict.[51]

In Sri Lanka, for example, the Mahawehli River project of the late 1970s brought water to seasonally dry areas, increasing the amount of land under cultivation. But malaria became prevalent again in areas where it had been nearly eradicated. In Ethiopia's northern province of Tigray, children living near recently constructed small dams showed a

sevenfold increase in malaria incidence compared with children living in villages far from the dams. Moreover, Ethiopian researchers found that the dams strengthened malaria's grip, extending its season from a brief period just after the rains to a nearly year-round occurrence.[52]

Between 1974 and 1991, Brazil witnessed a 10-fold increase in malaria cases, largely due to logging in the Amazon. Expansion into frontier areas brought non-immune, susceptible people into newly disrupted forest areas. Health services were largely nonexistent. The people were poor and often had little education or access to political power. Housing consisted of temporary shelters made from palm fronds, so indoor spraying was out of the question. The vector, *An. darlingi*, thrived in the newly exposed forest fringe areas because it prefers partial shade and deep, sunlit water to the rainforest, where there is too little sunlight and the water is too acidic for its tastes. Breeding on the forest edge also gave this mosquito easy access to human blood.[53]

Gold mining in the Amazon also contributed to the spread of malaria. Miners use mercury to extract the gold from ore, washing the mix in pits filled with water. Once the pits are abandoned, they collect rainwater that is less acidic than streams in the region and therefore attractive to *An. darlingi*.[54]

In addition to changes in the landscape, mosquitoes are also sensitive to their microenvironment. Malaria patterns often vary from one part of a village to another, depending on the mosquito species, sources of standing water, and characteristics of the built environment, for example. Throughout rural Africa, mud bricks are the most common choice of housing materials. A mixture of water and easily crumbled soil provides an almost endless source of construction material and malaria-bearing mosquitoes. The problem is that mud brick houses require frequent replastering and repair, so people create pits adjacent to or very close to their home for when they need more construction materials. Because the pits are so close to people, the source of *Anopheles'* fuel for reproduction, they are quickly inhabited by mosquito larvae. Based on field research in Ethiopia and Namibia, scientists have recently shown that windblown pollen from nearby corn fields settles in these pits and serves as a ready source of food for mosquito larvae.[55]

Changes in water flow can limit the spread of malaria by altering or removing larval habitats. In Karnataka, India, for example, *An. fluviatilis* (one of six epidemiologically important vectors in India) disappeared as coffee plantations, deforestation, and dams virtually eliminated the streams where this species bred. During the 1950s in the southeastern United States, the Tennessee Valley Authority (TVA) built a series of dams and flood control projects. Conscious of the need to control *Anopheles* larvae, engineers constructed the sides of the artificial canals with carefully angled slopes, so periodic changes in water levels would leave the mosquitoes high and dry.[56]

Urban areas have long been free from endemic malaria because of better housing, access to medical treatment, and water pollution. *Anopheles* typically do not lay their eggs in water bodies that are contaminated with high organic content or chemical pollution. They usually prefer clean, still or slowly moving fresh water, not the polluted water found in crowded urban areas. A notable exception is *An. stephensi*, which is endemic in some cities in South Asia, where it lays its eggs in household water storage tanks and cement rooftop cisterns. However, the urban landscape is changing in favor of other mosquitoes. In Accra, Ghana, for instance, researchers have found *An. gambiae* breeding

in household water containers, a sign that these species can adapt to the urban environment.[57]

Recent evidence also shows that malaria is gaining ground in densely populated settlements surrounding urban areas in Africa. People migrating from rural areas to the edges of cities typically retain rural activities and habits for a time, such as household gardens, irrigation, and informal housing materials. These bring with them the pattern of rural transmission, and disease consequently spreads. Over time, as these areas become more settled, they become less susceptible to local malaria transmission because the water is usually too polluted to support *Anopheles*.[58]

As in Guyana, environmental factors also interact with economic circumstances in unpredictable ways. This was the case in several farming communities in Tanzania. Scientists who analyzed entomological data predicted that the incidence of malaria would be higher in villages where people grew rice and where paddies provided breeding grounds with higher rates of vector survival and density than where farmers grew sugarcane or savannah crops. What these researchers initially failed to appreciate, however, is that the villagers growing rice had more income and were able to buy bednets and arm themselves with anti-malarial drugs, so they had less exposure to malaria.[59]

The growing problem of drug resistance is complicating the malaria picture worldwide even further. This is especially true in Africa. Chloroquine-resistant strains of *P. falciparum* first appeared in East Africa in 1978. Within 10 years, authorities reported chloroquine resistance in virtually every country in sub-Saharan Africa. The effects of this development were immediate. In the 1980s, several African countries showed a two- to threefold increase in deaths and hospital admissions for severe malaria, a trend that coincided with the spread of chloroquine resistance. Health officials in Kinshasa reported that not only were children getting more severe forms of the disease and dying more frequently, but the incidence of related health problems, especially anemia and HIV/AIDS, was higher too. (Children who have severe anemia require frequent blood transfusions, which raises the risks of HIV transmission.) Today, hundreds of thousands of African children succumb to malaria each year because *P. falciparum* is no longer susceptible to chloroquine.[60]

Despite these failures, most African countries have yet to change their drug policies. Chloroquine is still widely used as a first step in treating malaria because most people cannot afford other drugs, which can cost 5–10 times more per dose, because it is widely available without a prescription, and because decades of chloroquine use have made it difficult to phase in alternatives. Even if such drugs were readily available, parasites in some areas already resist them. Complicating the situation is the fact that many patients who receive chloroquine become asymptomatic: they show no outward signs of illness, but they still have drug-resistant strains of the parasite circulating in their blood. These people become a reservoir of the more complicated form of the disease.[61]

## Mexico's Approach

Communities struggling to counteract the effects of malaria, whether from environmental, economic, or social changes, may benefit from an approach to disease control that Mexico has successfully developed. It is based on community involvement, widespread prevention, locally tailored treatments, and use of the least toxic option first.

As recently as the mid-twentieth century,

malaria was one of the top 10 causes of death in Mexico; roughly 2.4 million people were infected annually. The country began an indoor spraying program with DDT in the late 1940s, well before the WHO effort was launched. In 1955, Mexico expanded the program into a National Eradication Campaign, which continued through the early 1960s. The campaign did not achieve its ostensible goal, but it did push the number of cases down to about 20,000 annually, a level that remained relatively constant throughout the 1970s. The campaign also largely eliminated the most dangerous species of the parasite, *P. falciparum*.[62]

**By 2000, Mexico had achieved its goal of phasing out DDT seven years ahead of schedule.**

Mexico could well have continued using DDT had the chemical not become a major trade liability. In 1972, the United States banned DDT and began to reject shipments of imported Mexican produce that were contaminated with the chemical. At first, the Mexican response was confined largely to farmers in the northern part of the country. They were heavily dependent on exports, so they switched to other pesticides to get their crops into the United States. Farther south, farmers relied on crops for local consumption rather than for export income, so DDT remained in use as an agricultural pesticide through the mid-1980s.[63]

But by the early 1990s, DDT had become a domestic issue as well. The Mexican public was growing increasingly uneasy about the high levels of DDE (a breakdown product of DDT) in the milk of nursing mothers. These domestic concerns reinforced the trade issue: in the 1994 North American Free Trade Agreement, Mexico, the United States, and Canada agreed to develop a regional approach to persistent pollutants. DDT became the first order of business; in 1997, Mexico agreed to a 10-year plan to phase out the pesticide entirely.[64]

In the meantime, however, malaria was re-emerging. In the early 1980s, annual infections rose to 133,000. The timing was unfortunate: a severe economic recession cut into production and supplies of DDT; financial resources for malaria control evaporated. Another outbreak occurred in 1988. The following year the federal government delegated malaria control to the states, which revived the rural networks set up decades ago under the eradication program. Over the next eight years, certified community volunteers collected blood samples, which were sent to regional laboratories for testing. The presence of parasites triggered visits from medical teams and from mosquito control personnel. DDT was sprayed on the inside walls of houses to kill adult mosquitoes; outside, less persistent insecticides were sprayed on standing water to kill larvae.[65]

Because it was highly targeted and sensitive to environmental conditions, this new mosquito control strategy was a vast improvement over the old, broadcast spraying techniques. But as concerns about pesticides spread, mosquito control came under greater scrutiny. The pesticide teams were called "cat killers" because so many neighborhood cats died after their visits. In some areas, poor people complained that the teams washed their equipment in streams, killing the fish they depended on for food. And in the state of Oaxaca, organic farmers and environmentalists categorically opposed the use of DDT.[66]

As a result of this public pressure, reliance on DDT diminished greatly by the mid-1990s, replaced by less persistent pyrethroid

pesticides. (Indoors, deltamethrin was used instead of DDT; outdoors, permethrin replaced malathion.) These were incorporated into an "integrated vector management" approach that includes the occasional application of pyrethroids but no DDT. Local officials now reserve indoor repellant spraying for areas where the need has been carefully determined. They use a combination of remote sensing maps, geographic information systems, and on-the-ground sampling to pinpoint areas to target spraying and larvicides. Other environmental management techniques, such as water removal and personal protection measures, are also used. Mosquito habitat is reduced without using pesticides at all, by removing algae that serves as a breeding site and source of food for some mosquitoes, for instance.[67]

Since the 1988 outbreak, malaria has been largely confined to several "hotspots" on the Pacific coast of Mexico—poor parts of the states of Oaxaca and Chiapas. These areas are common destinations for immigrants from Central America. Blood screening and mosquito control programs are now largely limited to these areas.[68]

Mexico's approach has worked. In 2000, the only Mexican manufacturer of DDT, Tekchem, halted all production. Mexico had achieved its goal of phasing out DDT seven years ahead of schedule. And despite the 1988 outbreak, no one is known to have died from locally acquired malaria in Mexico since 1982.[69]

Mexico's experience offers several lessons for malaria control efforts in other parts of the world. Environmental management is a central focus of the program, with several interventions acting at once (such as different combinations of larvicides, vegetation clearance, drainage of standing water, house screening, and surveillance of mosquito larvae). The malaria control strategies rely on a wide range of expertise, including people knowledgeable about entomology, hydrology, epidemiology, ecology, and clinical aspects of malaria. Community participation and local knowledge about malaria and the environmental impacts of control measures are highly valued and help tailor solutions. Last, the program has been fine-tuned over a number of years, adjusting to changing demographics, public perceptions, and scientific knowledge.[70]

## The Challenge in Africa

In December 2000, representatives of governments, environmental groups, and industry associations from more than 100 countries met in Johannesburg, South Africa, for the final round of negotiations on the Stockholm Convention on Persistent Organic Pollutants (POPs). One of the remaining sticking points in the treaty talks was DDT, which had been banned from agricultural use in nearly 90 countries. Its role in disease control was highly controversial, especially in light of South Africa's recent experience with malaria.[71]

South Africa had stopped using DDT to fight malaria in 1996—a move that was not questioned at the time, since decades of DDT use had greatly reduced *Anopheles* populations and largely eliminated one of the most troublesome vectors, the appropriately named *An. funestus* ("funestis" means death-bearing or funereal). Like Mexico, South Africa seemed to have beaten the DDT habit: the chemical had been used to achieve a worthwhile objective; it had then been set aside. Mosquito control could henceforth be accomplished with pyrethroids. And the plan worked—until a year before the POPs summit.[72]

In 1999, malaria infections in South Africa rose to 61,000 cases, a level not seen in decades. *An. funestus* reappeared as well, in

KwaZulu-Natal, in a form resistant to pyrethroids. In early 2000, the authorities reintroduced DDT in an indoor spraying program. By the middle of the year, the number of infections had dropped by half. Initially, the spraying program was criticized. But what reasonable alternative was there? This is said to be the African predicament, although the South African situation is hardly representative of sub-Saharan Africa as a whole. What happened in South Africa suggests that DDT will remain an important tool for malaria control in epidemic situations in parts of Africa where the mode of transmission is susceptible, such as an outbreak that occurred in Madagascar in the late 1980s.[73]

Since its first use in the 1940s, DDT has saved countless millions of lives, and under specific conditions it still helps to reduce the transmission of malaria. But to imply that routine—let alone increased—use of DDT is key to controlling malaria today, especially in Africa, where human suffering and the need for treatment and control are greatest, is misleading. As the Pan-American Health Organization recently concluded, indoor insecticide spraying is inadequate in much of the developing world because of changing environmental conditions, migrating human populations, and informal housing and shelters. Even at the height of the global program in the 1960s, WHO planners limited efforts to Ethiopia, South Africa, and southern Rhodesia (now Zimbabwe), where eradication was thought to be feasible.[74]

Although the global campaign largely passed Africa by, DDT has not. Many African countries have attempted mosquito control during particularly severe outbreaks, but the primary use of DDT on the continent has been as an agricultural insecticide. Consequently, in parts of West Africa especially, DDT resistance is now widespread in *An. gambiae*. But even if it were possible to reduce *An. gambiae* populations substantially, that alone would not effectively control malaria because *An. gambiae* is such a highly efficient vector that it challenges the theoretical underpinnings of house spraying and vector control. This mosquito can bite people up to 2,000 times more frequently than is needed to maintain endemic malaria.[75]

In Africa, the key to progress includes the general suppression of mosquito populations in their larval and adult stages, a shortening of mosquito longevity, and the reduction of human-vector contact. To this end, a very promising option is bednets—mosquito netting or other material that is treated with a pyrethroid insecticide, such as deltamethrin or permethrin, and that is suspended over a person's bed or hammock.[76]

Bednets alone cannot eliminate malaria, but they can deflect some of the burden. Because *Anopheles* generally feed in the evening and at night, a bednet can radically reduce the number of infective bites that a person is subjected to. The individual would probably still have the parasite in his or her blood, but most of the time it would be at a level low enough for normal functioning.[77]

Even though bednets do not prevent infection, they can in a sense prevent a good deal of disease. Children who sleep under bednets have shown declines in malaria incidence of 14–63 percent and in overall mortality of up to 25 percent. Pregnant women who use bednets tend to give birth to healthier babies. Treated bednets also have a significant communal benefit. People sleeping near a treated bednet in the same bedroom, house, or even neighborhood benefit from a "herd effect" as the nets reduce the number of mosquitoes, the number of infections, and the number of severe cases.[78]

In parts of Burkina Faso, Chad, Mali, and Senegal, bednets are becoming standard household items. In the tiny West African

nation of The Gambia, somewhere between 50 and 80 percent of people have bednets. Sadly, these places are notable exceptions. In much of Africa, where transmission rates are high, people have only begun to learn or hear about bednets, let alone use them regularly.[79]

And bednets are hardly a panacea. They have to be used properly and re-treated with insecticide occasionally. Many people cannot afford to buy the net or insecticide. And the insecticides themselves pose a risk to human and environmental health. Plus, there is still the problem of insecticide resistance, although the nets themselves are hardly likely to be the main cause of it. (Pyrethroids are used extensively in agriculture as well.) Nevertheless, a recent U.S. Agency for International Development study concluded that the public health benefits from these materials justify their "apparently modest risks." Quite simply, bednets can help transform malaria from chronic disaster to manageable disease.[80]

So it is unfortunate that in much of central and southern Africa, the nets are a rarity. It is even more unfortunate that as recently as 1998, 28 African countries levied import tariffs on bednets; most people in these countries would have trouble paying for a net even without the tax. This problem was addressed in the Abuja Declaration, a plan of action to control malaria signed by the Heads of State from 44 African countries in April 2000. The Declaration included a pledge to remove "malaria taxes." Since then, 15 countries have acted on the pledge, although in some cases only by reducing rather than eliminating the taxes. In the meantime, several million Africans have died from malaria.[81]

This failure to follow through with the Abuja Declaration casts the concern about DDT in a rather poor light. To date, 28 of the countries that have signed the POPs treaty have indicated that they are reserving the right to use DDT as a public health measure; 18 of these countries are in Africa. And of those, 10 are apparently still taxing or imposing tariffs on bednets. (Among the African countries that have not signed the POPs treaty, some are almost certainly both using DDT and taxing bednets, but the exact number is difficult to ascertain because the status of DDT is not always clear.) A strong case can be made for the use of DDT in situations like the one South Africa encountered in 1999—an infrequent flare-up of the disease in a context that lends itself to control. Throughout most of sub-Saharan Africa, however, routine spraying of DDT for malaria control is difficult to imagine given the vertical, top-down structure needed to implement it.[82]

**Bednets alone cannot eliminate malaria, but they can deflect some of the burden.**

In recent years, some scientists have presented the use of DDT as an all-or-nothing situation for malaria control. They argue that rich, northern countries successfully abolished endemic malaria 40 years ago by using DDT, and are now trying to convince other countries not to use it. Without DDT, proponents argue, millions of people in poor countries will die.[83]

The justification for such use sets up a false dichotomy—DDT or disease—thereby perpetuating both. This line of argument also oversimplifies the complexities of malaria control and trivializes the efforts of malariologists, public health officials, and vector control experts who carefully adjust solutions to local conditions. Moreover, it fails to acknowledge that in northern, temperate countries, public health applications of DDT coincided with overall improvements in housing, water drainage, and economic development—con-

ditions that have yet to be met in much of the tropical South.[84]

The most effective programs today rely on a range of tools, including drug policies, environmental management, strengthened health systems, community involvement, and the selective and appropriate use of methods for vector control and personal protection, such as bednets. In some areas, controlling the larvae and vector will require a change in housing materials. This, in turn, requires investment in other materials that are sometimes less convenient and costlier. Real prevention in Africa requires combining anti-malaria measures with anti-poverty programs that can reinforce economic development so that people and governments can afford adequate health care, education, and social services that help interrupt the cycle of poverty and disease.[85]

## Improving Public Health, Engaging People

Malaria is complex, but combating it does not have to be complicated. (See Box 4–2.) When simple, easy-to-use, low-tech preventive tools are made available, their benefits are undeniable. Just as condoms have proved effective in preventing HIV/AIDS and oral rehydration salts have helped ameliorate diarrheal diseases, malaria control through a combination of insecticide-treated bednets, better case detection and treatment, elimination of mosquito habitat, and insecticide spraying as a last resort will reduce malaria's human toll.

Not only does a multifaceted approach make sense from a public health perspective, it is a wise economic course as well. "One healthy year of life is gained for every $1 to $8 spent on effectively treating malaria cases, which makes malaria treatment as cost-effective a public health investment as measles vaccinations," according to Dr. Ann Mills of the London School of Hygiene and Tropical Medicine. An annual investment of $2.5 billion—just 1¢ for every $100 of the gross domestic product in industrial countries—would go a long way toward combating malaria in Africa. And its rewards would be reaped many times over in human, social, and economic benefits.[86]

One of the first steps is to make the most of simple solutions and technologies and adjust them to local conditions. In Namibia, for example, irrigation water is a necessity for agriculture and nourishment, but it also serves as a catalyst for malaria. Farmers in this semiarid nation have found that fixing leaky pipes is sometimes all that is needed to keep malaria in check. In Chennai, India, public health specialists have worked with community representatives to design better lids on water tanks to stop *Anopheles* from breeding.[87]

A second area for action is for policymakers to abolish malaria taxes. As noted earlier, many African countries still have taxes or tariffs on imported nets and insecticides, which is undercutting disease control efforts. In Senegal, for example, foreign net manufacturers have refused to enter the market until the government eliminates taxes and tariffs on bednets, despite a proven need and demand for such products.[88]

Health economists have shown that insecticide-treated nets are as cost-effective as childhood vaccinations, arguing that nets should be provided for free or at least at a subsidized price. China has the largest insecticide-treated net program in the world. In Viet Nam, users buy their own nets and the government provides insecticide for free in regular net treatment services. In Zambia, the government is creating a voucher system to help the poor buy into the system. People who qualify would pick up vouchers in health clinics to be redeemed at a local store for nets.[89]

Many tropical disease experts argue that malaria eradication eradicated the malariologists. Research since the 1960s has focused heavily on vaccines, genetically modified mosquitoes, and genome sequencing, sometimes at the expense of research on the environmental aspects of malaria transmission. Given the scale of tropical ecosystem degradation today, it is imperative that funding for such research is increased. Monitoring the mosquitoes and characteristics of malaria transmission before projects are approved and during the implementation phase can sensitize agricultural officials, urban planners, economists, and health officials to the nature of malaria and offer an early warning system for outbreaks of disease. Increased awareness, in turn, sparks greater responsiveness to its control and better preparedness.[90]

**BOX 4–2. ESSENTIAL STRATEGIES FOR DEALING WITH MALARIA**

- Make the most of simple, cost-effective tools.
- Abolish so-called malaria taxes and distribute insecticide-treated bednets.
- Fund research on the environmental dimensions of malaria.
- Fund demonstration projects on and further the use of integrated vector management strategies.
- Provide financial assistance to poorer countries.
- Engage public-private partnerships to reach people.
- Use more targeted diagnosis and treatment.
- Slow drug resistance.
- Incorporate malaria treatment into existing programs.
- Invest in malaria drug and combination therapy development and distribution.

Although it is difficult to predict the effect of environmental changes on the spread of malaria, officials can better anticipate the spread of disease and adopt some basic safeguards in their work. To offset the negative effects of dams, for example, authorities and engineers can site them at higher altitudes or away from communities and can manage water levels carefully, much as U.S. authorities did with TVA dams. Irrigated rice paddies have long been associated with malaria, but draining paddies intermittently will kill mosquito larvae that hatch there. As shown in many Asian countries, this practice has the additional benefit of raising rice yields by bringing more oxygen to the plants' roots.[91]

Researchers with the Kenya-based International Centre for Insect Physiology and Ecology are forging new ground in the search for natural insect repellants. They have studied the chemical defense tactics that plants use to repel insects and to deter feeding and reproduction. Researchers have now identified at least a dozen plants native to East Africa that proved successful in lab tests at fending off *An. gambiae*, the primary vector in Africa. Biologists and ethnobotanists are also testing native plants in South Asia and the Amazon basin.[92]

Paying for research and the implementation of costly alternatives is an enormous challenge. The United States and other well-off nations need to invest in the research and assistance programs critical to helping poorer nations combat malaria in a healthier way. The highest priority for existing funding mechanisms is to build stronger capacity in developing nations for delivering malaria control services, including case detection and management and focused vector control.

Public-private partnerships also have an important role to play. In the mid-1990s, for example, public authorities teamed up with the private sector in the Ifakara district of rural Tanzania to promote insecticide-

treated bednets. Health officials educated people about their use and maintenance, and the local government subsidized their purchase. The private sector focused on publicizing the benefits of using nets, marketing them, and distributing them widely. By encouraging market competition and footing part of the bill for the cost of nets, the government was able to leverage its resources to bring prices down. Between 1997 and 1999, there was a sixfold increase in net ownership, a 60-percent drop in severe anemia, and a 27-percent increase in survival rates among children who slept under a net.[93]

**Even with new programs in place, malaria has continued to kill one child every 30 seconds in sub-Saharan Africa.**

Greater public education is vital in order to target malaria diagnosis and treatment more effectively. In the Tigray region of northern Ethiopia, for instance, nearly half of the population is at risk of malaria, yet most people have no access to formal health services. Mothers in the local community started a network in 1992 to teach each other how to diagnose and treat malaria at home. Today, more than 700 volunteers work to use proper drugs to treat malaria early on, before it becomes life-threatening. Nearly a half-million people are protected by this network of mothers each year in Ethiopia.[94]

People on the frontlines who dispense drugs and determine treatment protocols also need education and better information on drug efficacies and the spread of drug-resistant parasites. In 1998, health officials and researchers from Kenya, Rwanda, Tanzania, and Uganda teamed up to create the East African Network for Monitoring Antimalarial Treatment to share data, monitor drug resistance, develop more effective treatment policies, and reduce malaria. Based on improved communication, this new approach has been vital to detecting the presence of drug-resistant cases and selecting the appropriate treatment. Other countries could develop similar online, publicly available databases to monitor drug resistance.[95]

To reach the youngest victims of disease, the Integrated Management of Childhood Illness program now includes malaria as one of its five key health conditions. Health care providers and staff learn to diagnose and treat malaria as part of their basic training. A new important tool to protect children is artemisinin suppositories. (Artemisinin and related compounds come from an ancient Chinese herb known as qinghaosu. Artesunates have proved to be among the safest, most effective, fastest-acting of all anti-malarials.) The suppositories could significantly reduce deaths in children, who often develop severe malaria quickly and commonly are unable to get the necessary hospital-based care in time.[96]

In Tanzania, health researchers recently established a program to dispense anti-malarials with routine vaccinations. Combining intermittent, preventive malaria treatment with vaccines reduces the number of clinical cases of malaria and the rate of severe anemia and is a good way to reach children who would otherwise receive no treatment. The vaccine programs are already in place and the malaria component can be added on easily. Similarly, intermittent drug treatment and the provision of free bednets for pregnant women are important low-cost ways to prevent the effects of malaria in pregnancy, and they can be readily added to existing prenatal care programs.[97]

In Southeast Asia, it makes sense to invest in better diagnosis methods because the drugs for drug-resistant malaria are expensive and

few fevers are actually malarial. One of the latest tools in Cambodia's fight against malaria is a rapid diagnostic kit that is similar to a home-based pregnancy test. The person using the rapid diagnostic test (known as a dipstick) pricks the patient's finger, swipes the blood on a reactive strip, and in a matter of minutes has results that are easy to interpret. Because there is no need for costly equipment, dipsticks are especially useful in areas far from clinical settings or where power supplies are unreliable, and they can reduce the reliance on presumptive treatment, with its unintended results.[98]

Recently, Cambodian authorities joined with private marketers to supply dipstick tests and the latest anti-malarial combination therapy (mefloquine and artesunate) to treat multi-drug-resistant strains. This combination therapy is effective even when the malaria parasite has developed high levels of resistance to mefloquine because it takes longer for genes to resist two different drug compounds at the same time. These efforts have reduced significantly the number of severe cases of malaria, as people are diagnosed earlier and have effective treatments readily available. In frontier areas with seasonal outbreaks and low transmission rates, such as the Brazilian Amazon, or in emergency situations, packets of dipsticks and prepackaged anti-malarial drugs are now proving extremely useful.[99]

Minimal investment in malaria drug development is still a major roadblock. The malaria parasite is about 100 times more complex than the virus that causes AIDS, but it receives only about one tenth as much funding for research. While most pharmaceutical companies have turned a blind eye on malaria because it is seen as a money-losing venture, there are a few notable exceptions. In May 2001, for example, WHO announced a partnership with Swiss-based Novartis AG to distribute the company's new combination therapy anti-malarial drug, Coartem, at greatly reduced cost to poor countries.[100]

In May 1998, Gro Harlem Brundtland became Director-General of WHO. One of her first priorities was to address malaria and other diseases of poverty. Under her leadership, WHO has taken a more active role in advocating for renewed attention and funding for malaria. In the past five years, four major international initiatives were launched to raise the profile of malaria control and to tackle issues of funding, research coordination, and public and private cooperation. (See Table 4–3 on page 84.) All represent a new infusion of political interest and financial commitments.[101]

Even with these new programs in place, malaria has continued to kill one child every 30 seconds in sub-Saharan Africa. The new visibility that this disease has achieved is just a first step in dedicating resources and taking action to stop malaria. But these programs signal a much needed move away from the view of malaria as strictly a health issue, and as a poor person's disease at that, and toward an understanding that malaria is a truly global challenge of improving public health, securing economic and social well-being, and advancing sustainable development.[102]

### Table 4–3. Recent International Malaria Programs

| Global Fund to Fight AIDS, Tuberculosis & Malaria |
|---|
| Launched in 2002, the fund was created to attract, manage, and disburse financial resources through a new public-private partnership to reduce the impact of HIV/AIDS, tuberculosis, and malaria and to contribute to poverty reduction. Total budget confirmed: $1.2 billion; $72 million in multiyear grants for malaria control approved in April 2002. |
| Roll Back Malaria (RBM) |
| Launched in 1998 by WHO, the World Bank, UNICEF, the U.N. Development Programme, and other partners, RBM aims to cut malaria burden by half by 2010 and to distribute insecticide-treated bednets to all pregnant women and children in sub-Saharan Africa by then. RBM is not a financing mechanism. It works by encouraging others to dedicate resources to malaria control, to strengthen health systems, and to use a variety of tools through existing networks and partnerships. Budget: $24 million in 2002. |
| Medicines for Malaria Venture (MMV) |
| The joint public-private venture was initiated in 1998 by WHO, the World Bank, and several drug companies. The goal is to develop at least one new anti-malarial drug or drug combination every five years and to make them available in poor countries. Seven drug discovery projects and five development projects now in progress, making MMV "the largest anti-malarial drug pipeline since World War II." Budget: $15 million in 2002; goal of $30 million per year. In 2001, the program received $5 million per year from the Bill and Melinda Gates Foundation for the next five years. |
| Multilateral Initiative on Malaria (MIM) |
| Launched in 1997, this international effort coordinates malaria research funding and promotes greater malaria research and control capacity in Africa. Scientists, funding agencies, governments, pharmaceutical companies, and other members of public and private sector are involved. MIM provides training and research grants. Budget: $2 million per year. |

SOURCE: See endnote 101.

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## State of the World: A Year in Review

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## Chapter 3. Linking Population, Women, and Biodiversity

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## Chapter 4. Combating Malaria

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