

# Ultimate Agents of Global Change

JOEL E. COHEN

**CONSERVATION FACES** one crisis after another. Those who do conservation on the ground are frequently responding to immediate threats such as imminent deforestation or development. When conservationists protect habitats and species under siege, it is too easy to forget the long-term, chronic drivers of global change that lead to continual crises. Among those drivers are demographic, economic, environmental, and cultural forces. These drivers influence regional conservation threats, as well as what types of solutions might work to protect biodiversity.

## A Senegalese Example

The waters off the coast of West Africa have been famous for centuries as rich fishing grounds. Upwelling waters of the North Atlantic nourish the food of large, commercially valuable fish, Senegal's foremost export commodity. Senegal's fishers used to operate wooden canoes called *pirogues*, often brightly painted in blues, yellows, and reds. Now they operate small motorized boats, still called *pirogues*.

Even with motorized boats, Senegalese fishers cannot keep up with the increasing numbers of large, freezer-equipped industrialized fishing boats that have come to Senegal's coastal waters in the past decade from France, Italy, Japan, China, and South Korea, as prime fisheries in the Mediterranean and elsewhere have collapsed. Some of these boats are legally licensed to fish in Senegal's waters through international agreements, and some were not. With the surge in foreign competition and advanced technology from abroad, the stocks of the large fish off West Africa have been rapidly depleted. The catches and profits of Senegalese fishers have fallen. One Senegalese nongovernmental organization devoted to the marine environment estimated that one pirogue now takes a month to catch the same amount of fish it used to catch in four days.

While Senegal's offshore stock of commercial fish has declined, its population of poor, unemployed youths has increased. By estimates made in 2001, the overall unemployment rate was 48 percent, and 54 percent of the population lived below the poverty line. In 2007, Senegal had about 12.5 million people, roughly as many as metropolitan Los Angeles. Unlike the people of Los Angeles, the people of Senegal had average incomes equivalent (by purchasing-power parity) to about \$5 per day, or \$1,800 per year. The population of Senegal was estimated to be growing at well over twice the global population growth rate, with 42 percent of the Senegalese under the age of fifteen and a median age of less than nineteen years.

In recent years, energy prices have also increased. In 2006, an energy crisis caused widespread blackouts in Senegal. As the price of fuel for the fishing boats rose and the yields from fishing fell, more and more fishers sought other ways to earn income from their capital assets and their expertise on the seas. They discovered a more valuable cargo than fish: people.

Many young men were willing to pay fishers to transport them 1,500 kilometers across dangerous seas from Senegal to the Canary Islands, colonies of Spain. Ferrying migrants to the Spanish islands required only enough gasoline to get to the islands and back and two working engines. If the fisher survived, the work was highly profitable.

Canary Island authorities were swamped by more than nine thousand illegal immigrants in the first five months of 2006, versus a total of ten thousand for the entire year of 2002. Immigrants without identification papers could not be repatriated and were flown to Spain from the Canary Islands at no cost to them. In 2006, the Spanish authorities sent an envoy to West Africa to discuss how Spain could give the West African countries economic help to keep people at home.

By August 2007, some dramatic changes were under way. The abrupt rise in sub-Saharan migration to the Canary Islands

prompted Spain to patrol its shores more aggressively and take a tougher stance on immigration. At the same time, the Spanish and Senegalese governments launched a plan to stem the tide of immigration by giving hundreds of Senegalese workers one-year visas and jobs in Spain and bringing them to Spain legitimately—but not if they had migrated to Spain illegally. That same summer, Spain's labor minister signed agreements with the Gambia, Mali, and Mauritania to invest Spanish funds in training citizens of those countries who could be recruited for jobs in Spain.

Such programs for African workers are driven as much by demand from Spain as by desperation for decent jobs on the part of Africans. Spain did not have enough young workers to support its rapid economic growth, and it needed to hire thousands of migrants each year to work in agricultural fields, serve in restaurants, and build buildings. Spain's population was older and growing at only about one-tenth of the global rate. Only 14 percent of the population was under the age of fifteen, and the median age of the population exceeded forty years.

Whether the topic is fish stocks, migration, or rural livelihoods, local challenges and changes are no longer isolated; they are linked to and driven by regional and global trends. The world's fish stocks don't stop at the Mediterranean. The drivers of Senegal's climate don't stop at Senegal's national borders.

## The Key Ingredients

The fabric of this story is woven of four threads: population, the environment, economics, and culture. These are the ultimate agents of global change. Let us focus on these threads, one at a time, and on their interactions.

**POPULATION.** From now to 2050, several billion more people will be added to the populations of developing countries, while the population sizes of most rich countries will stagnate or decline. Population growth will slow everywhere (first in the rich countries, later in the poor). Virtually all population increase



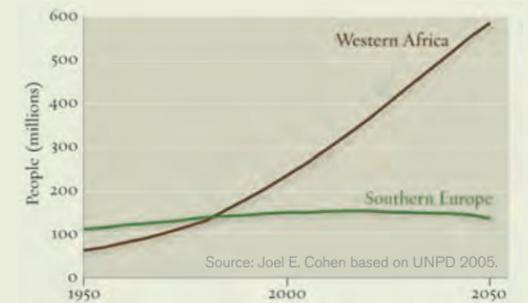
will be in cities, not rural areas. The fraction and number of aged people will increase at unprecedented rates to unprecedented levels (again, first in the rich countries, later in the poor). While the population of West Africa, including Senegal, is predicted to skyrocket, notwithstanding the expected declines in the population growth rate, the population of southern Europe, including Spain and Italy, is expected to rise only slightly, level off, and begin to decline in the next half century (see figure above).

Rural people of West African countries, including Senegal, have flocked to cities, especially coastal cities like Dakar. Such rural-urban migrants were pushed by poverty and environmental problems at home, and pulled by the prospects of a better life in cities. Senegal's environmental problems include coastal overfishing, wildlife poaching, deforestation, overgrazing, soil erosion, and desertification, and these challenges affect poor rural people the most because poor rural people depend more directly on the environment for their incomes than do urban people.

Migrants have always been principally young adults. With the rapid population growth of recent decades in poor countries, the proportion of young adults available to migrate in West African populations is very

**Drivers of global change.** The influence and interaction of population, the environment, economics, and culture should be considered in conservation policies.

**Different trajectories.** Populations grow dramatically in western Africa as they begin to decline in southern Europe.



high. Those migrants fuel demand for food and for jobs.

**THE ENVIRONMENT.** In Senegal and elsewhere in West Africa, high variability in rainfall from year to year and from decade to decade results in extended droughts, which make it difficult for rural farmers to survive, let alone produce a surplus for sale, in the absence of adequate investments. According to studies in central Senegal, poor health, inadequate village infrastructure, and rural unemployment undermine small farmers' capacity to adapt to climate change. Along with economic and institutional limitations, uncertain environmental resources in the interior push the poor to the coastal cities.

Meanwhile, a decline in the abundance and size of coastal fishes pushes people back to the interior or on to Europe. The large, commercially most valuable fish species reproduce at later ages and recover from a dip in population more slowly than do small fish species. The natural environment, through irregular rainfall and the slow population recovery times of large fish species, constrains human options.

**ECONOMICS.** Economics drive human activities in many ways. The estimated gross domestic product per person (after adjusting

for purchasing-power parity) of Spain in 2006 was \$27,400, compared to Senegal's \$1,800—a gap typical of that between the West African region and southern Europe. This inequality is an obvious incentive for fishers to transform fishing boats to vehicles of migration, and for unemployed young men to risk their lives to get to the Canary Islands.

Growing wealth outside West Africa also contributes to the demand for Senegal's fishes. In 2001, the United Nations Food and Agricultural Organisation reportedly estimated that demand for fish had grown at twice the rate of human population growth over the forty preceding years. World fishery production at the beginning of the twenty-first century was more than six times that in the middle of the twentieth century, in part because of growing demand from elsewhere, in part because the technology of fishing evolved. Industrial fishing trawlers may stay at sea for months with built-in facilities for freezing and packing fish. The growing wealth, the changes in technology, and the arrivals of industrialized fishing boats from around the world are signs and symptoms of globalization: the movement of technologies, people, services, credit, capital, and markets wherever opportunities beckon. Globalization permits any industrial country



Henvé Collart/Sygma/Corbis

Senegalese with pirogues, their traditional fishing boats

to focus its fishing fleet wherever the fishing remains good, even if the local stock will be rapidly depleted and the local fishers will be rapidly displaced as a result.

Economic “rationality” drives this process. To simplify, if the global rate of interest is 4 percent, and if the rate of increase of a large fish population is 3 percent, then the economically “rational” thing to do for anyone with access to the fish population is to harvest as much of it as possible immediately and convert the fish into money, which can grow at a higher rate than the fish. In general, whenever the economic interest rate exceeds the population growth rate of a biological resource, the rational decision is to convert the biological resource to faster-growing money. As the BBC’s Tim Judah reported in 2001, “West Africa has to choose between short-term cash and long-term fish... [T]he fish-rich West African countries face agonising choices, not dissimilar from those facing central African countries rich in timber. They need the money now, but once the fish and trees are gone, they are gone.”

**CULTURE.** The links of politics to the collapse of the fisheries off Senegal are surprising. Environmentalists assert that, to allay the political dissatisfaction of Basque separatists in Spain, the European Union (EU) subsidized fishing fleets, including boats that employ thousands of fishermen from Basque country. As a result, the European Union created an overcapacity in its fishing fleets. As the waters legally accessible to the European Union were depleted of fish, the European Commission looked elsewhere for fish. West Africa’s waters were the nearest target.

Africa also has internal politics. In 1975, Morocco occupied the territory of Western

Sahara and controlled the rich waters off the coast. In 1995, Morocco began a lucrative four-year agreement with the European Union to allow EU fishing boats in Western Sahara waters. When the agreement lapsed at the end of November 1999, EU fishing boats were no longer able to fish off Western Sahara, and 4,300 Spanish and Portuguese fishers lost their jobs. Some of these fishers looked to waters farther south, off the shores of Senegal and its neighbors, to continue to make a living at sea. The struggles between and within Europe and Africa for power and money have a strong effect on how many and whose boats fish the waters.

Culture goes beyond politics. A usually unstated source of tension in the relations between Senegal and Spain is that Senegalese look different from Spaniards. While it was difficult for Spain initially to accept immigrant workers from Eastern Europe, it has proved even more difficult to accept immigrant workers, so different in appearance, from West Africa, including Senegal. The latest contracts of Senegalese workers in Spain offer single-year visas, renewable at the will of the Spanish side.

#### **Moral of the Story**

The four threads of population, the environment, economics, and culture are essential ingredients driving every complex global change. It is not enough for conservation policies to be based just on information about the environment. To be successful, they must also take account of the interacting influences of population, economics, and culture.

JOEL E. COHEN IS A PROFESSOR OF POPULATIONS AT ROCKEFELLER AND COLUMBIA UNIVERSITIES.



# The Atlas of Global Conservation

CHANGES, CHALLENGES, AND  
OPPORTUNITIES TO MAKE A DIFFERENCE

**JONATHAN M. HOEKSTRA, JENNIFER L. MOLNAR,  
MICHAEL JENNINGS, CARMEN REVENGA, MARK D. SPALDING,  
TIMOTHY M. BOUCHER, JAMES C. ROBERTSON, AND  
THOMAS J. HEIBEL, WITH KATHERINE ELLISON**

**UNIVERSITY OF CALIFORNIA PRESS** BERKELEY LOS ANGELES LONDON

**THE NATURE CONSERVANCY**

EDITED BY JENNIFER L. MOLNAR



Jennifer Molnar

To future generations, and the planet they will inherit,  
and in recognition of the generous support and vision of  
Bill Barclay and Ofelia Miramontes

Citation: Hoekstra, J.M., J.L. Molnar, M. Jennings, C. Revenga, M.D. Spalding, T.M. Boucher, J.C. Robertson, T.J. Heibel, with K. Ellison. 2010. *The Atlas of Global Conservation: Changes, Challenges, and Opportunities to Make a Difference*. Ed. J.L. Molnar. Berkeley: University of California Press.

University of California Press, one of the most distinguished university presses in the United States, enriches lives around the world by advancing scholarship in the humanities, social sciences, and natural sciences. Its activities are supported by the UC Press Foundation and by philanthropic contributions from individuals and institutions. For more information, visit [www.ucpress.edu](http://www.ucpress.edu).

University of California Press  
Berkeley and Los Angeles, California

University of California Press, Ltd.  
London, England

The mission of The Nature Conservancy is to preserve the plants, animals and natural communities that represent the diversity of life on Earth by protecting the lands and waters they need to survive.

© 2010 by the Regents of the University of California

Library of Congress Cataloging-in-Publication Data

The atlas of global conservation : changes, challenges and opportunities to make a difference / Jonathan M. Hoekstra [et al.] ; edited by Jennifer L. Molnar.

p. cm.

Includes bibliographical references and index.

ISBN 978-0-520-26256-0 (cloth : alk. paper)

1. Conservation of natural resources. 2. Environmental protection. 3. Globalization. I. Hoekstra, Jonathan M.

II. Molnar, Jennifer L.

S936.A75 2010

333.95'16--dc22

2009023617

Project Management: Michael Bass Associates

Cartography: Paula Robbins, XNR Productions

Design and Composition: Nicole Hayward Design

Text: Adobe Garamond Pro

Display: Berthold Akzidenz Grotesk

Prepress, Printing, and Binding: FourColour Imports, Ltd.

Title page photo: Ami Vitale

Manufactured in China

18 17 16 15 14 13 12 11 10

10 9 8 7 6 5 4 3 2 1

This book has been printed on FSC Paper to be environmentally conscientious. The paper used in this publication meets the minimum requirements of ANSI/NISO Z39.48-1992 (R 1997) (*Permanence of Paper*). ♻️

[nature.org/atlas](http://nature.org/atlas)

# Contents

ACKNOWLEDGMENTS	x
FOREWORD • A NEW VIEW OF OUR HOME Mark Tercek, The Nature Conservancy	xii
FOREWORD • CONSERVATION CONNECTIONS Paul R. Ehrlich, Stanford University	xiv



<b>1. INTRODUCTION</b>	1
WHY ECOREGIONS? Taylor Ricketts, World Wildlife Fund	6
<b>Terrestrial Ecoregions, Realms, and Biomes</b>	8
<b>Freshwater Ecoregions and Basins</b>	10
<b>Marine Ecoregions, Provinces, and Realms</b>	12
THE STORIES THAT MAPS TELL Jon Christensen, Stanford University	14

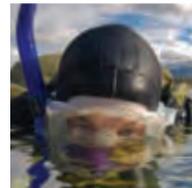


<b>2. HABITATS</b>	19
<b>Forests and Woodlands: Giving Trees</b>	22
<b>Grasslands: Where the Buffalo Roamed</b>	24
<b>Deserts and Aridlands: Hardy Life under Harsh Conditions</b>	26
<b>Rivers and Wetlands: The Planet's Lifeblood</b>	28
<b>Lakes: Fragile Pools of Life</b>	30
<b>Caves and Karst: Treasures of Subterranean Species</b>	32
HOPE IN HABITATS Steven J. McCormick, Gordon and Betty Moore Foundation	34
<b>Coasts and Shelves: The Sea's Sunlit Margins</b>	36
<b>Coral Reefs: Crown Jewels of the Ocean</b>	38
<b>Mangrove Forests: Bridging Land and Sea</b>	40
<b>Seagrass Beds: Marine Meadows</b>	42
<b>Salt Marshes: Living Filters along Our Coasts</b>	44
<b>High Seas and Deep Oceans: Earth's Uncharted "Inner Space"</b>	46



<b>3. SPECIES</b>	49
<b>Plants: A Vital Variety</b>	52
<b>Freshwater Fish: A Diverse Cast</b>	54
<b>Amphibians: Fragile Markers of the Planet's Health</b>	56
<b>Reptiles: Prehistoric Survivors</b>	58

MIGRATIONS	60
Martin Wikelski, Max Planck Institute for Ornithology and Konstanz University, and David S. Wilcove, Princeton University	
<b>Birds: Everyday, Everywhere</b> Wildlife	64
<b>Mammals: Shared Destiny with Our Closest Kin</b>	66
<b>Endemic Species: In the Narrowest Niches</b>	68
<b>Evolutionary Distinction: Branches on the Tree of Life</b>	70
PROMOTING LIVELIHOODS, SAVING NATURE	72
Greg Mock, former editor, <i>World Resources Report</i>	
<b>4. A WORLD OF CHANGE</b>	75
<b>Human Population: Outnumbering Nature</b>	78
<b>Consuming Nature: Running Out of Planet?</b>	80
<b>Climate Change: The Planetary Emergency</b>	82
ULTIMATE AGENTS OF GLOBAL CHANGE	84
Joel E. Cohen, Rockefeller and Columbia Universities	
<b>Habitat Loss on Land: Going, Going,...</b>	88
<b>Coastal Development: Reshaping the Seashore</b>	90
<b>Bottom Trawling and Dredging: Scouring the Seafloor</b>	92
<b>Landscape Fragmentation: Going to Pieces</b>	94
<b>Thwarted Fish Runs: Up against a Wall</b>	96
GLOBAL CONTAMINATION OF THE BIOSPHERE	98
John Peterson Myers, Environmental Health Sciences	
<b>Freshwater Pollution: Clear but Hazardous</b>	102
<b>Nitrogen Pollution: Too Much of a Good Thing</b>	104
<b>Ruin of the Reefs: Fading Jewels, Lost Wealth</b>	106
<b>Into the Wild: The Cost of Expanding Human Access</b>	108
POVERTY AND NATURE'S SERVICES	110
M. Sanjayan, The Nature Conservancy	
<b>Forest Clearing: Uprooting Nature</b>	112
<b>Water Stress: Overused and Undermanaged</b>	114
<b>Overfishing: Emptying the Oceans</b>	116
<b>Wildlife Trade: Sold into Extinction</b>	118
FUTURE OF FISHERIES	120
Jackie Alder, United Nations Environment Programme, and Daniel Pauly, University of British Columbia	
<b>Fire: Healthy Doses of Destruction</b>	122



<b>Dams and Reservoirs: Clogging Earth's Arteries</b>	124
<b>Sediment Flow: Starving Some Habitats, Smothering Others</b>	126
<b>Melting Ice and Rising Seas: Squeezing the Coasts</b>	128
<b>Disappearing Glaciers: Ice Storage on a Slippery Slope</b>	130
NATURE CONSERVATION AND CLIMATE CHANGE	132
Jonathan M. Hoekstra, The Nature Conservancy	
<b>Terrestrial Invaders: Unwelcome Guests</b>	134
<b>Freshwater Invaders: Good Intentions with Costly Consequences</b>	136
<b>Marine Invaders: Stowaways Attacking Our Coasts</b>	138
<b>Terrestrial Animals at Risk: More in Jeopardy Each Year</b>	140
<b>Freshwater Animals at Risk: Are Their Futures Drying Up?</b>	142
<b>Marine Animals at Risk: Sea Life Unraveling</b>	144
<b>5. TAKING ACTION</b>	147
<b>Protected Areas on Land: Triumph for Nature</b>	150
<b>Protecting Rivers, Lakes, and Wetlands: Thinking beyond Park Boundaries</b>	152
<b>Marine Protected Areas: Oases for Fish and People</b>	154
<b>Protecting Nature's Services: Dividends from the Wealth of Nature</b>	156
CONVERGENT CONSERVATION	158
Scott A. Morrison, The Nature Conservancy	
<b>International Cooperation: Saving the Whales—and More</b>	160
<b>Greening the Marketplace: Certifiably Profitable</b>	162
<b>Collaborative Solutions: Problem-Solving Partnerships</b>	164
CONSERVATION ON OUR WATCH	166
Gretchen C. Daily, Marilyn Cornelius, and Charles J. Katz, Jr., Stanford University, and Brian Shillinglaw, New Forests, Inc.	
<b>Rule of Law: Protecting the Commons</b>	168
<b>Individual Action: Parting the Waters</b>	170
<b>Restoring Nature: Mending the Web of Life</b>	172
<b>6. CONCLUSION OUR FUTURE, OUR CHOICES</b>	175
APPENDIX A: ECOREGIONS INDEX MAPS	180
APPENDIX B: TECHNICAL NOTES AND REFERENCES	200
INDEX	229
ABOUT THE AUTHORS	234