Ronald D. Brunner and Amanda H. Lynch

Adaptive Governance and Climate Change

AMERICAN METEOROLOGICAL SOCIETY

"The science is abundantly clear that global climate change is the great environmental crisis of our age. However, the current 'top down' approach to scientific management is yielding mostly policy gridlock that thwarts the needed mitigation and adaptation action. This book advocates a change of thinking, a 'bottom up' approach in which actions are pragmatically achieved at the local level (adaptive governance). Successful outcomes from such local experiments will show what can work politically, and it is by 'scaling up' from these successes that policies will evolve that can respond globally to the very real threat to our habitable world posed by rapidly changing climate."

—VICTOR R. BAKER, Regents Professor, Department of Hydrology and Water Resources, The University of Arizona

"While science has made enormous contributions to understanding the nature of climate change, can it play a major role in finding and implementing solutions? Are we missing something important by focusing primarily on global-scale, science-driven solutions via international negotiations? This book provides some provocative suggestions on how to deal with the most complex threat to humanity in the 21st century."

—WILL STEFFEN, Executive Director, The Australian National University Climate Change Institute

"There is unfolding a global tragedy of our planetary commons: national leaders are risking the future of the earth for short-term benefits. Brunner and Lynch show how, by listening to the advice from scientists about the seriousness of climate warming risks and adopting adaptive governance, the global challenge we share can be turned into smaller, tractable problems with real solutions."

—A. HENDERSON-SELLERS, Former Executive Director of the UN's World Climate Research Programme and Australian Research Council Professorial Fellow in Climate Risk at Macquarie University

"As societies seek ways to avoid the unmanageable and manage the unavoidable from climate change, federal, state, and local governments need viable adaptation cases to inform their decisions but also effective policy framings so that 'bottom up' actions and 'top down' institutional support lead to adaptive solutions that can be communicated peer to peer."

—JOSH FOSTER, Climate Adaptation Manager, Urban Leaders Adaptation Initiative, Center for Clean Air Policy

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American Meteorological Society

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PREFACE

Major initiatives to mitigate global warming are pending as we write. One is the Waxman-Markey bill in Congress, officially called the American Clean Energy and Security Act. The goal is to reduce the 2005 level of greenhouse gas emissions in the United States by 17% by 2020, and 83% by 2050. The primary means is a national cap-and-trade system, which would create a market for trading a decreasing total of emission permits to be allocated free and auctioned by the federal government. Another is the Carbon Pollution Reduction Scheme, with similar goals and means, being debated in the Australian Parliament. A third is the United Nations Climate Conference scheduled for December 7–18, 2009, in Copenhagen, to clarify emissions reductions targets for industrialized nations and other issues that stand in the way of an ambitious successor to the Kyoto Protocol, which expires in 2012. The Conference is the 15th meeting of the Conference of the Parties to the U.N. Framework Convention on Climate Change and the 5th meeting of the Parties to the Kyoto Protocol.

Like others concerned about climate change, we hope such initiatives will succeed quickly in reducing the danger of increasing concentrations of greenhouse gases in the atmosphere. At the same time, we fear that these initiatives may be stymied by a continuing lack of political will. During the last two decades, a lack of political will in addressing the danger of climate change has been manifest in the substitution of scientific assessments and technology R & D for actions that deploy existing knowledge and technology; in the official proclamation of long-term goals that defer the costs of realizing them to future office holders and their constituents; in the negotiation of emissions-reduction targets and timetables lacking sanctions severe enough to be enforceable; in limited capabilities to measure compliance and otherwise enforce those regulations that do have some teeth; and in the neglect of appraisals to terminate policies that have not worked and to improve those that have. Progress in mitigating dangerous concentrations of greenhouse gases in the atmosphere has been disappointing so far, especially given the magnitude of the task ahead. Meanwhile, there is growing concern that we are running out of time; irreversible changes in climate may be imminent according to some scientists.

In this context it would be prudent to complement such major initiatives with adaptive governance. This approach to reducing net losses from climate change depends on factoring the global problem into thousands of local problems, each of which is more tractable scientifically and politically than the global one and somewhat different. From intensive case studies by ourselves and others it is clear that some local communities have developed and implemented innovative policies that effectively reduce their vulnerability to climate change or their greenhouse gas emissions while accommodating other community interests. Indeed, other community interests often have been enough to justify decisions and actions that mitigate or adapt to climate change; these are "no regrets" policies that make sense regardless of climate change projections. Through networks these communities have made the more successful adaptation and mitigation policies available for voluntary adaptation by local communities elsewhere, and have set aside policies that failed. They have also clarified shared needs for external resources from those central authorities who are interested in supporting what has worked on the ground.

In short, adaptive governance is an opportunity for field-testing in series and in parallel thousand of policies for adapting to those climate changes we cannot avoid, and for mitigating those we can. If our hopes for more effective national and international agreements on climate policy are realized, adaptive governance practiced on a broader scale can expedite and improve their implementation. If our fears turn out to be warranted, adaptive governance nevertheless can build on existing resources, including pockets of political will, to field-test policies and to diffuse and adapt on a broader scale those policies that succeed in reducing net losses from climate change. Under either contingency, there is more to be gained at the margin by encouraging adaptive governance than by relying *exclusively* on business as usual. This book provides an introduction to adaptive governance, as an opportunity for those concerned about climate change to expand the range of individual choices and collective decisions under consideration. Major initiatives like those pending have dominated attention for more than two decades, but they have not produced progress commensurate with the magnitude of the task ahead.

Collaboration on this book began at the University of Colorado at Boulder more than a decade ago, when Amanda Lynch and her colleagues invited Ron Brunner to participate in an assessment of climate change on the North Slope coast of Alaska. The invitation was prompted by Brunner's lecture on a paper in progress, "Science and the Climate Change Regime." It was accepted on assurances by Lynch and her colleagues that helping the people of the North Slope adapt to climate change was the project's top priority; contributing to the scientific literature was an important but secondary goal. The project proposal was informed by an exploratory grant and funded as "An Integrated Assessment of the Impacts of Climate Variability on the Alaskan North Slope Coastal Region" by the National Science Foundation. Our field research began in August 2000 in Barrow, the center of the North Slope Borough government, and concluded there in February 2008. During the field research it gradually became apparent that what we were learning about climate change adaptation, and reporting periodically to people in Barrow, could be significant to scientists and policy makers well beyond the North Slope.

Consequently, we began exploring beyond the project's boundaries to clarify the larger significance of the project's findings. In other case studies, in other climate-related literature, and in general theoretical literature, we found many corroborating observations and insights. But typically they were scattered, addressed exclusively to other scientists or to national and international policy makers, and marginalized by the mainstream quest to reduce greenhouse gas emissions through mandatory targets and timetables, legally binding on all nations with significant emissions. It seemed appropriate to pull together in a book what we learned on the ground in Barrow and in the literature. Early in 2007 we began to focus on writing this book to clarify adaptive governance and draw attention to it; the manuscript was substantially completed two years later. We conclude that adaptive governance is an emerging pattern of science, policy, and decision making, and so far a missed opportunity for reducing net losses from climate change on larger scales at all levels in the international system, from local to global.

Nonetheless, we expect adaptive governance to be controversial in some quarters (but not in others) because it is a departure from dominant ways of thinking about climate change. Moreover, specific steps toward adaptive governance are sometimes in conflict, sometimes complementary, with business as usual in various policy arenas. Any issues that arise are best engaged, we believe, through the comparative evaluation of specific action proposals—from business as usual, from adaptive governance, and from other promising approaches—in the light of explicit criteria and evidence that is detailed and comprehensive within practical constraints. This is nothing more than an affirmation of good practice in science, policy, and decision making.

ACKNOWLEDGMENTS

We would like to express our gratitude to the other principal investigators on the Barrow project: Jim Maslanik, who took over as lead investigator when Lynch returned to Australia; Judy Curry, who provided the initial inspiration as well as crucial ideas early in the design of the project; James Syvitski, who contributed to our understanding of coastal processes in the region; and Linda Mearns, an important connection to current thinking in regional climate change who also proved a doughty collaborator when faced with two hungry polar bears. Our hopes for the Barrow project would not have been realized without the contributions of Liz Cassano and Leanne Lestak in particular, for their research, their support, and their good humour. Other research contributors and project supporters based in the lower 48 states or in Australia were Ruth Doherty, Sheldon Drobot, Cinda Gillilan, Klaus Görgen, Melinda Koslow, Bill Manley, Christina McAlpin, Jon Pardikes, Scott Peckham, Matt Pocernich, Matthew Rothstein, Cove Sturtevant, Claudia Tebaldi, Casey Thornbrugh, Petteri Uotila, and Jason Vogel. Eric Parrish helped with graphics after conclusion of the project.

Of course the Barrow project would not have been possible without the openness, good will, and cooperation of the people of Barrow. In Barrow, project personnel included archeologists and long-time Barrow residents Anne Jensen, Senior Scientist at the Ukpeaġvik Iñupiat Corporation Real

Estate Science Division, and Glenn Sheehan, Executive Director of the Barrow Arctic Science Consortium (BASC). They guided us through the culture and the community, including its relevant past, and reviewed an earlier draft of Chapter 3 focused on Barrow and the North Slope. We received invaluable logistics support from Glenn and others at BASC, including Lewis Brower, Alice Brower Drake, Linda Fischel, Henry Gueco, Matt Irinaga, Lollie Hopson, Scott Oyagak, and Dave Ramey. We received important observations and insights on various occasions from Barrow residents Mike Aamodt, Tom Brower III, Rob Elkins, Dan Enders, Richard Glenn, Bob Harcharek, Edward Itta, Curt Thomas, Kenneth Toovak, and Chastity Olemaun.

Other residents of Barrow also contributed through meetings, interviews, and documentation, including Sheldon Adams, Bart Ahosagak, Johnny Aiken, Tom Albert, Dave Anderson, Summer Arnhart, Leslie Boen, Arnold Brower Sr., Eugene Brower, Fred Brower, Price Brower, Ronald Brower Sr., Frank Brown, Paul Bush, Marie Adams Carroll, Mike Donovan, George Edwardsen, Terri Ekalook, Earl Finkler, Ben Frantz, Craig George, John Gleason, Arlene Glenn, Allison Graves, George Leavitt, Doreen Lampe, Dave Logan, Andrew McLean, Ben Nageak, Charlie Neakok, Lars Nelson, Allen Nesteby, Joe Nicely, George Olemaun, Marvin Olson, David Ongley, Jerry Painter, Crawford Patkotak, Pat Patterson, Donovan Price, Delbert Rexford, Tim Russell, Dorothy Savok, Joe Stankowitz, Joe Stepak, Gina Sturm, Jim Vorderstrasse, Mary Ann Warden, and Laurie Wing. Additional insights on Barrow came from former residents or frequent visitors, including Karen Brewster, Forrest Brooks, Steve Chronic, Hajo Eichen, Owen Mason, Dave Norton, Grace Redding, Paul Schuitt, Dale Stotts, Jesse Walker, Charles Wohlforth, and Bernie Zak. Luci Eningowuk from Shishmaref, Earl Kignak from Point Hope, and Tom Brower III of Barrow reviewed initial ideas for organizing a network of Native villages vulnerable to coastal erosion and flooding in the Arctic.

Michael Ledbetter at the National Science Foundation gave us tremendous encouragement in getting the project on Barrow and the North Slope off the ground, first by providing an exploratory grant and then guiding us through the funding of a 5-year project (NSF OPP-0100120) as part of the Human Dimensions of the Arctic component of the Arctic Systems Science program. Neil Swanberg of NSF provided crucial continuing support. Amanda Lynch also received substantial support from the Australian Research Council (FF0348550). Rachelle Hollander supported Ron Brunner's earlier project on capitalizing the policy sciences for climate change research (NSF SBR-95-12026). Any opinions, findings, and conclusions or recommendations are those of the authors and do not necessarily reflect the views of the Australian Research Council or the National Science Foundation.

But this is a book on adaptive governance and climate change. As such it goes well beyond Barrow and the North Slope, the focus of just one of five chapters. For helpful comments or discussions on other parts of the manuscript as it evolved, we are especially grateful to Cheryl Anderson, Kate Auty, Josh Foster, Joe Friday, Mike Hamnett, Søren Hermansen, Susan Iott, Eileen Shea, John Thwaites, Will Steffen, Henk Tennekes, and Jason Vogel. Of course our gratitude does not imply that they agree with any of our arguments. We are also grateful for feedback from participants at various workshops, meetings, and conferences where either or both of us presented parts of the manuscript in progress. These included the workshop of WAS*IS (Weather & Society*Integrated Studies) at Mt. Macedon, Australia, January 2007; the International Workshop on Dialogue Between Social and Natural Sciences sponsored by a consortium of Japanese universities, IR3S (Integrated Research System for Sustainability Science), in Honolulu, February 2007; the workshop on Arctic Coastal Zones at Risk sponsored by four scientific organizations (LOICZ, AMAP, IASC, and IHDP) in Tromsø, Norway, October 2007; a symposium on extreme events held by Emergency Management Australia in Melbourne, November 2007; the 87th and 88th General Meetings of the American Meteorological Society in San Antonio, January 2007, and New Orleans, January 2008, respectively; the annual Science at the Shine Dome meeting of the Australian Academy of Sciences in Canberra, May 2008; the 27th Annual Institute of the Society of Policy Scientists and a lecture at the National Center for Atmospheric Research, both in Boulder, CO, in October 2008; and the Climate Change Congress in Copenhagen, February 2009. Sarah Jane Shangraw at the American Meteorological Society shepherded the manuscript supportively and efficiently though the review and publication process.

Finally, we would both like to express a deep and abiding gratitude to our spouses, for all that they have done in support of us and this book.

ACRONYMS

AAAS	American Association for the Advancement of Science
ACIA	Arctic Climate Impact Assessment
AEC	Atomic Energy Commission
AEWC	Alaska Eskimo Whaling Commission
AFN	Alaska Federation of Natives
AGGG	Advisory Group on Greenhouse Gases
APEC	Asia-Pacific Economic Cooperation
ASNA	Arctic Slope Native Association
ASRC	Arctic Slope Regional Corporation
AUD	Australian dollars
BIA	Bureau of Indian Affairs
BTS	Barrow Technical Services
CARB	California Air Resources Board
CCAP	Climate Change Action Plan
CCP	Cities for Climate Protection
CCSP	U.S. Climate Change Science Program
CCTP	U.S. Climate Change Technology Program
CEI	Competitive Enterprise Institute
CES	Committee on Earth Sciences
CIPM	Capital Improvements Project Management, NSB

CND	Canadian dollars
CMDL	Climate Monitoring and Diagnostics Laboratory
CO_2	carbon dioxide
DEW	Distant Early Warning
ENSO	El Niño–Southern Oscillation
EA	Environmental Assessment
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
ERDA	Energy Research and Development Administration
ESSP	Earth Systems Science Partnership
ETS	Emissions Trading System
EU	European Union
EUA	EU Allowance
FAR	First Assessment Report of the IPCC
FEMA	U.S. Federal Emergency Management Administration
GAO	U.S. Government Accountability Office (formerly General Accounting Office)
GHG	greenhouse gases
ICAS	Iñupiat Community of the Arctic Slope
ICC	Inuit Circumpolar Conference
ICLEI	International Council for Local Environmental Initiatives
ICSU	International Council of Scientific Unions
IGBP	International Geosphere–Biosphere Programme
IHDP	International Human Dimensions Program
IPCC	Intergovernmental Panel on Climate Change
IWC	International Whaling Commission
NAP	National Allocation Plan
NAPA	National Adaptation Programmes of Action
NARL	Naval Arctic Research Laboratory
NAST	National Assessment Synthesis Team
NFIP	National Flood Insurance Program
NOAA	National Oceanic and Atmospheric Administration
NSB	North Slope Borough
NWS	U.S. National Weather Service (formerly Weather Bureau)
OGP	Office of Global Programs
OSTP	Office of Science and Technology Policy in the White House
OTA	Office of Technology Assessment, formerly a research arm of the U.S. Congress
PEAC	Pacific ENSO Applications Center

RGGI	Regional Greenhouse Gas Initiative
RISA	Regional Integrated Sciences and Assessments program
RSWG	Response Strategies Working Group
SAPs	Synthesis and Applied Products
SRES	Special Report on Emission Scenarios
UIC	Ukpeaġvik Iñupiat Corporation
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific, and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
USD	U.S. dollars
USGCRP	U.S. Global Change Research Program
WCRP	World Climate Research Program
WERI	Weather and Energy Research Institute, University of Guam
WMO	World Meteorological Organization

BOXES AND FIGURES

“Knowing is not one thing that we do among many others, but a quality of any of our doings. . . . To say that we know is to say that we do rightly in the light of our purposes, and that our purposes are thereby fulfilled is not merely a sign of our knowledge, but its very substance.”

Abraham Kaplan, *The Conduct of Inquiry*

1

CLARIFYING THE PROBLEM

In *An Inconvenient Truth*, an award-winning documentary film, Al Gore used startling graphs and dramatic photos to summarize the scientific consensus on global warming and its past and projected impacts on planet Earth and its inhabitants. Along with human population growth and more powerful technologies, he cited "our way of thinking" as a third major factor that has transformed humanity's relationship to the earth. Supporting our way of thinking are certain misconceptions the former vice president of the United States attributed to special interests. For example, he reported a leaked internal memo that advised lobbyists and public relations specialists for a group of companies including ExxonMobil to "reposition global warming as theory, rather than fact." And they succeeded to the extent that 53% of the 623 news stories in a random sample from influential newspapers did raise doubts about global warming. But in the end, Gore's message about meeting this planetary emergency, as he called it, was upbeat in view of the array of technologies available to curb global warming and its impacts: "We already know everything we need to know to effectively address this problem. We've got to do a lot of things, not just one." But he concluded with an important qualification: "We have everything we need, save perhaps *political will*."[1]

The film emphasized the more extreme climate changes and adverse impacts projected within the mainstream scientific consensus.[2] But the balance of evidence supports enough of the inconvenient truth dramatized in the film to underscore the need for action to mitigate global warming and other climate changes and to adapt to the changes we cannot prevent. The evidence also supports the former vice president's emphasis on the influential role of political opponents in propagating misconceptions that inhibit if not block individual and collective action. But those of us who are dissatisfied with the outcomes of climate change mitigation and adaptation efforts to date, or who are concerned about the magnitude of the task ahead, might go beyond blaming political opponents to reconsider our own roles. Have we done all that we can to reduce past losses from climate change and future vulnerabilities? Will persistence in business as usual be sufficient to contain losses from climate change? In response to such questions a bit of introspection suggests another inconvenient truth: We need to open the established climate change regime to additional approaches to science, policy, and decision making.

An Appraisal

The United Nations Framework Convention on Climate Change (UNFCCC) was opened for signature at the Earth Summit in Rio de Janeiro in June 1992. The climate change regime was formally established in March 1994 when the 50th national government ratified the convention. Since then, at least 189 national governments have ratified it and joined the Conference of the Parties to the UNFCCC. The ultimate objective of the convention, as stated in Article 2, is "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference in the climate system."[3] As a first step toward meeting the ultimate objective, the UNFCCC itself included Article 4(2), a nonbinding commitment of 36 industrialized countries specified in Annex I to the convention to reduce their emissions of greenhouse gases to 1990 levels by the year 2000. In December 1997, the Conference of the Parties to the convention negotiated a successor policy, the Kyoto Protocol. The protocol went into effect in February 2005, after ratification by the Russian Federation met the prescribed threshold, ratification by 55 parties to the convention, including Annex I countries accounting for at least 55% of the total carbon dioxide (CO_2) emissions of Annex I countries in 1990. Each of the parties to the protocol formally committed itself not to exceed a specified amount of emissions of six greenhouse gases, calculated as CO_2-equivalent emissions and averaged over the five-year period 2008–2012. In the aggregate, the parties overall would reduce their emissions by at least

5% below 1990 levels using whatever joint and national means they deemed appropriate.[4] Australia ratified the protocol late in 2007, leaving the United States as the only Annex I country *not* party to it. As early as 2004, attention turned to negotiating another emissions-reductions policy to follow termination of the Kyoto Protocol in 2012.[5]

The significance of these and other policies in light of the ultimate objective depends on the standards applied. To be sure, some progress has been made in reducing greenhouse gas emissions by the counter-factual standard—the level of emissions that would have occurred without the UNFCCC—but this standard is relatively difficult to estimate as a gauge of progress. A more widely used standard is the level of greenhouse gas emissions that occurred in 1990 when measurements became available for most industrialized countries and climate change was still a relatively new issue. Using this standard, the UNFCCC reported in 2009 that the country with the most emissions, the United States, *increased* its emissions of greenhouse gases by 14.0% from 1990 to 2006, the lastest year for which data are available.[6] The United States and 25 other industrialized countries *increased* their aggregate emissions by 9.1% from 1990 to 2006. However, when 14 industrialized countries in transition to market economies are folded in, aggregate emissions *decreased* by 4.5% during the same period. This reflects primarily the depth of economic decline in the former Soviet bloc after the end of the Cold War, not policies implemented under UNFCCC auspices. These percentage increases and decreases in emissions vary with statistical adjustments in the 1990 baseline and to a lesser extent in annual emissions reported since then.[7] Meanwhile, developing countries not included in the Kyoto Protocol or Annex I to the UNFCCC have significantly added to global greenhouse gas emissions, but their reporting capabilities are not sufficient to gauge aggregate emissions trends.[8] However, in November 2006 the International Energy Agency in Paris projected that China, with soaring coal consumption fueling rapid economic development, would surpass the United States in CO_2 emissions in 2009.[9] In June 2008 the Netherlands Environmental Assessment Agency reported that China's CO_2 emissions had in fact exceeded the United States's by 7% in 2006 and 14% in 2007.[10]

These outcomes are especially disappointing in light of the magnitude of the task implied by the ultimate objective of the UNFCCC. What stabilization level would prevent "dangerous" anthropogenic interference in the climate system? That depends on judgments of facts and values. European Union sources recommend limiting average global warming to no more than 2°C above our best estimate of the preindustrial "equilibrium" temperature.

The atmospheric greenhouse gas concentration that would allow this outcome is not well understood. Current scientific analyses confirm that *cumulative* emissions determine the likelihood of keeping warming below 2°C. Current estimates suggest that a stabilization level of no more than 450 parts per million in the concentration of CO_2-equivalent greenhouse gases in the atmosphere could achieve an even chance, at best, of constraining warming to this level. Even this level would require emissions to peak earlier than 2020, and then decline to 50% of 1990 emissions by 2050. This implies that the world will use less than half the current economically recoverable fossil fuel reserves prior to 2050.[11] Different assumptions lead to different projections, of course. But to put the magnitude of the task ahead in broader historical context, global greenhouse gas emissions are estimated to have increased 70% from 1970 to 2004, and they are expected to continue to increase *under current policies and practices*.[12] It is worth emphasizing that all policy-relevant climate change research is justified on the premise that current policies and practices are subject to change. Meanwhile, global emissions appear to be growing at a faster rate than any of the emissions scenarios considered in the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) in 2007.[13] And global mean temperature and sea level since 1990 are rising at a rate in the upper range or above that projected in the IPCC scenarios.[14]

Already, concentrations of greenhouse gases in the atmosphere are sufficient to force significant changes on natural and human systems.[15] And perhaps losses from climate change have already arrived through extreme weather events. Munich Re, a global reinsurance company, estimated that the number of great natural catastrophes worldwide increased nearly threefold from the 1960s to the 1990s, while economic losses from these same catastrophes increased ninefold during the same period.[16] Using more recent data from Munich Re, the Earth Policy Institute at Columbia University reports that economic losses from major hurricanes worldwide increased from $24 billion in the 1980s to $113 billion in the 1990s and $272 billion in this decade through 2005.[17] Included in the estimate for this decade are losses from Hurricane Katrina, which struck New Orleans and the Gulf Coast of the United States in late August 2005. From another source we calculate that nearly 12,000 lives were lost and over 153 million lives were impacted by wind storms, wildfires, floods, temperature extremes, and droughts worldwide in 2005 alone.[18] However, it should be emphasized that many other factors interact with extreme weather events to cause losses. These include the location of people, property, and other things of value with respect to extreme weather, as well as response capabilities before, during, and after extreme weather. Moreover, while changes in the frequency of extreme weather events have been observed, scientists still debate the physical and statistical linkages between the frequency and intensity of extreme weather events and global climate change.[19]

Underlying these disappointing outcomes and possibilities for improving upon them are two patterns of governance. One is scientific management, the foundation of the climate change regime established by the UNFCCC and a major reason why progress under the regime has been so modest. In *Seeing Like a State,* James Scott traced parts of this pattern back to the origins of modern states in Europe, when monarchs standardized measures and practices to extract more revenues, conscripts, and control more efficiently from diverse subject communities. In a more pungent critique, John Ralston Saul underscored the rise of *Voltaire's Bastards* who separated the Enlightenment emphasis on reason from common sense morality. Parallel to developments in Europe, Frederick Winslow Taylor formally introduced American engineers to principles of scientific management in 1895. From such origins, "Scientific Management has worked its way into the fabric of all modern industrial societies, where it is now so common as to go unnoticed by most people."[20] In the United States not long after the turn of the twentieth century, "Scientific Management aspired to rise above politics, relying on science as the foundation for efficient policies made through a single central authority—a bureaucratic structure with the appropriate mandate, jurisdiction, and expert personnel."[21] But during the last century it became increasingly clear, in the United States at least, that effective control is dispersed among multiple authorities and interest groups; that efficiency is only one of many interests to be reconciled in policy decision processes; and that science on important issues is politically contested. Amid such twenty-first-century realities, scientific management typically leads to policy gridlock.

Adaptive governance emerged more or less spontaneously here and there at the local level as a loosely coordinated array of pragmatic responses to manifest failures of scientific management. Not surprisingly, recognition of the pattern in the last decade or two and the term itself followed innovations in practice. Adaptive governance is characteristically more responsive to differences and changes on the ground; often but not always it proceeds from the bottom up rather than the top down.[22] From intensive case studies it is clear that some local communities working separately can integrate scientific and local knowledge into policies that advance their common interest on contested issues; in the process, politics and profound uncertainties are unavoidable. Similar communities working together can harvest their collective experience to make successful innovations anywhere in a network available for adaptation elsewhere on a voluntary basis. They can also clarify their common needs for national authorities, who typically control the resources necessary to move ahead, including knowledge and information, funding, and legal authority. This pattern of governance has been documented in natural resource policy in the American West, but it is *not* limited to that sector or region; it appears to be an adaptation to twenty-first-century realities more generally.[23] Adaptive governance suggests factoring the global climate change problem into thousands of local problems, each of which is more tractable scientifically and politically than the global problem. Insights from research on adaptive governance turned out to be constructive, if not essential in our project to assist one local community, Barrow, AK, in adapting to climate change. Since the project initiated field work in August 2000, we have found aspects of adaptive governance scattered through climate change and related literatures, corroborating our experience on the ground in Barrow.

This book integrates what we have learned about adaptive governance as a set of proposals for opening the established regime to accelerate progress on climate change problems. It is intended primarily for those scientists, environmentalists, administrators, policymakers, and other citizens of the world who are sufficiently dissatisfied with disappointing outcomes to date, or sufficiently concerned about the magnitude of the task ahead, to consider changes in business as usual. The next section provides a brief historical overview and comparison of scientific management and adaptive governance in climate change, deferring most of the substantive details to later chapters. Building on these constructs, the final section introduces normative considerations that also have a bearing on understanding disappointing outcomes to date and what might be done to improve them.

It should be understood at the outset that scientific management and adaptive governance are simplified constructs that frame inquiry on, and action in, a much more complex reality that lies beyond anyone's complete or completely objective understanding. But we can improve our understanding through inquiry and action even if no one is omniscient. Scientific management, the established frame, has for the most part restricted attention to only part of the relevant picture.[24] Adaptive governance is a means of directing attention to otherwise neglected parts that can help reduce our vulnerability to climate change.

Constructing the Context

The framing of climate change as a global problem recognizes that CO_2 and other greenhouse gases, regardless of their geographic origins, are dispersed more or less uniformly in the atmosphere through the global circulation. These gases absorb and reirradiate heat that would otherwise escape into space, warming the earth and making life as we know it possible. But increases in concentrations of greenhouse gases in the atmosphere force temperature increases and other climate changes. These in turn force changes on natural and human systems, mostly adverse changes because these systems evolved under different climate conditions. The basic physics of the greenhouse effect are neither new nor controversial. In 1896, building on the work of others, "the Swedish scientist Svante Arrhenius was the first to make a quantitative link between changes in CO_2 concentration and climate."[25] For a doubling of CO_2 concentrations in the atmosphere, he predicted a global temperature increase of 5° to 6°C.

Scientific interest in global warming increased in the late 1950s with direct measurements of atmospheric CO_2 at Mauna Loa in Hawaii, confirming the Revelle–Suess hypothesis that concentrations were on the rise (Fig. 1.1). In a famous framing of the hypothesis, Roger Revelle and Hans Suess wrote in 1957 that "human beings are now carrying out a large scale geophysical experiment of a kind that could not have happened in the past nor be reproduced in the future. Within a few centuries we are returning to the atmosphere and oceans the concentrated organic carbon stored in sedimentary rocks over hundreds of millions of years. This experiment, if adequately documented, may yield a far-reaching insight into the processes determining weather and climate."[26] Two years later, Swedish atmospheric scientists Bert Bolin and Erik Eriksson identified a bottleneck in the transfer of carbon dioxide from the atmosphere to oceans, and they suggested that the burning of fossil fuels would lead to an accumulation of carbon dioxide in the atmosphere. They linked the accumulation with the energy balance of the earth and global warming.[27]

Other scientific developments included improvements in climate records, recognition that gases in addition to CO_2 contribute to the greenhouse effect, and improvements in global circulation models of the atmosphere that increased confidence in predictions of global warming. In 1987, discovery of a depleted ozone layer in the atmosphere over the Antarctic (popularly known as "the ozone hole") underscored the unintended consequences of human activities for the atmosphere. Such developments added credibility

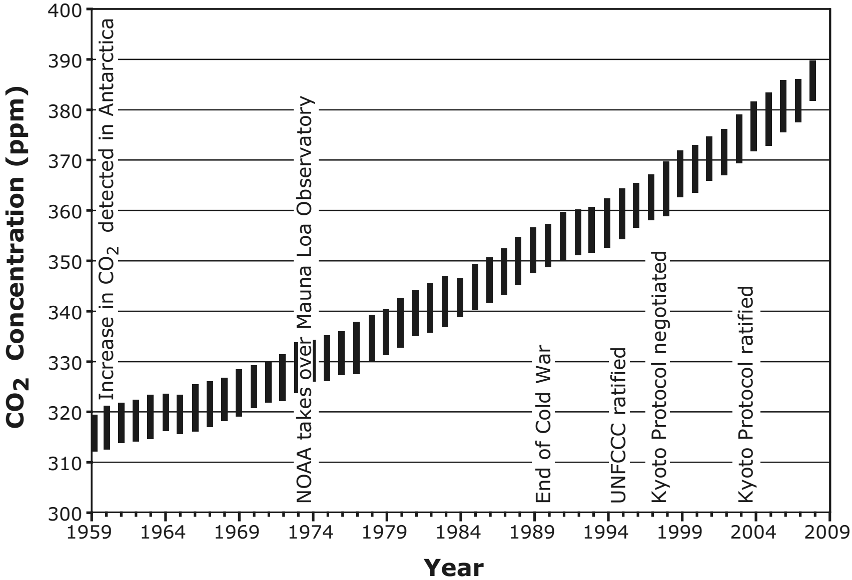

Fig. 1.1. Concentrations of CO_2 in the atmosphere. The range of monthly averages, 1959–2008. Source: Data from Mauna Loa Observatory, Hawaii.

to scientists' predictions of climate change and intensified demands for action to mitigate it. This led to establishment of the climate change regime. But the footprint of the regime in the Mauna Loa measurements (Fig. 1.1) is less evident than economic decline in the former Soviet bloc after the end of the Cold War.

Scientific Management

Scientists and their allies put climate change on the political agenda and took the lead in policy initiatives.[28] Daniel Bodansky reports that "a number of scientists and non-governmental organizations [NGOs] acted as entrepreneurs, promoting the climate change issue through conferences, reports and personal contacts" beginning in earnest early in the 1970s.[29] Among the most important initiatives was a conference held at Villach, Austria, in October 1985. It approved the establishment of a small group of independent scientists as the Advisory Group on Greenhouse Gases (AGGG) to advise the UN Environment Programme (UNEP), the World Meteorological Organization (WMO), and the International Council of Scientific Unions (ICSU). It was set up to ensure that "periodic assessments are undertaken of the state of scientific understanding and its practical applications and to initiate, if deemed necessary, consideration of a global convention, and to advise on further mechanisms and actions required at the national and international levels."[30] The AGGG "remained a major influence and organizing force behind the dissemination of the climate threat after 1985."[31] At the time of the Villach Conference, ICSU had just finalized its International Geosphere–Biosphere Programme (IGBP); an Ad Hoc Planning Group for this program of research met under ICSU auspices in Bern, Switzerland, in September 1986 and published Report No. 12 in 1990.[32] We summarize this major research plan in the next chapter.

Perhaps "the high-water mark of policy declarations on global warming" came from the World Conference on the Changing Atmosphere: Implications for Global Security, held in Toronto in June 1988.[33] The Toronto Conference Statement called for a 20% reduction in CO_2 emissions, a provocative demand that "caused considerable unease among governments and industry."[34] Also in June 1988, NASA scientist James Hansen testified before a U.S. Senate committee that he was 99% certain that global warming was under way.[35] Concurrently, an extreme heat wave and drought in eastern North America attracted attention to Hansen's testimony and the Toronto Conference Statement and amplified their influence. As climate scientist Stephen Schneider observed, "In 1988, nature did more for the notoriety of global warming in 15 weeks than any of us [scientists] or sympathetic journalists or politicians were able to do in the previous fifteen years."[36] Nature was assisted by Sen. Tim Wirth and colleagues who scheduled Hansen's testimony for the day with the maximum expected temperature for Washington in that period and who opened the windows of the hearing room the night before to make the atmosphere inside sweltering during the hearings.[37] With or without such political support, nature in this role penalizes inaction and sometimes forces action. This is an underutilized resource in compensating for a lack of political will—a critical limiting factor in Al Gore's appraisal, our appraisal, and others.[38]

Built on climate science foundations, such highly visible initiatives toward mitigation policy attracted the attention of officials and nonofficials who perceived their interests to be threatened and provoked political backlash. "By June 1987, the U.S. State Department had become unhappy about the AGGG as representing little more than 'free wheeling academics.' Governmental bodies therefore began to wrest the policy initiative from the AGGG network by replacing parts of it and extending others to include governmental research bodies, especially those close to WMO."[39] In 1988, the United States and allied governments requested that WMO and UNEP establish an organization which became the IPCC and effectively replaced the independent AGGG. "Through the WMO, governments gained the power to veto participants to the IPCC and influence its brief."[40] But "there was considerable bitterness in some quarters about the fate of the AGGG, which was disbanded under pressure from the U.S. State Department. . . ."[41] The Executive Council of the WMO, which had taken the lead, endorsed the IPCC and its brief in June 1988, just before the Toronto Conference and after many changes had been made.[42] The formal mandate of the IPCC was to "(i) assess available scientific information on climate change, (ii) assess the environmental and socio-economic impacts of climate change, and (iii) formulate response strategies."[43] The informal mandate was "in part to reassert governmental control and supervision over what was becoming an increasingly prominent political issue."[44] The IPCC's First Assessment Report was completed in 1990; we summarize the results of its Working Group III on response strategies in the next chapter. The report was updated in 1992 to provide the scientific foundation for negotiation of the UNFCCC by the International Negotiating Committee.[45]

Meanwhile, in the United States, threatened industries organized against taxes and other policies proposed to reduce greenhouse gas emissions. The Global Change Coalition, for example, spun off from the National Association of Manufacturers in 1989 to lobby on behalf of utility, oil, coal, and automobile interests. As established around that time, U.S. policy effectively substituted research for action to mitigate greenhouse gas emissions.[46] At an international conference in Noordwijk, the Netherlands, in 1989, the head of the U.S. Environmental Protection Agency (EPA), William Reilly, "spoke mainly of scientific uncertainties and declared that 'the United States is substantially increasing its budgets for scientific research into the causes and consequences of climate change.'"[47] The chief beneficiary was the U.S. Global Change Research Program (USGCRP), an initiative of the interagency Committee on Earth Sciences.[48] The committee's first major research strategy and research plan, both published in 1989, prompted substantial budget increases for global change research. In the next chapter we summarize the Fiscal Year 1990 Research Plan for the USGCRP. Participants in USGCRP and in the national research programs of other countries cooperated formally and informally through various scientific organizations, including the IGBP and IPCC.[49] In the division of labor, the IPCC assesses original research funded for the most part by national research programs, while the IGBP and the World Climate Research Program (WCRP), among others, organize research at the international level.