Global environmental change is caused by, and affects, all humanity. *Leaving Eden* examines the causes and consequences of global change, with particular emphasis on the interaction of nature and human behavior. The book begins with a discussion of the natural Earth, focusing on the physical and chemical processes that have hitherto controlled our environment and climates. The author then turns to the effects of human disruption of these natural systems, arguing that human beings are now taking over the management of the Earth from nature. Issues such as the greenhouse effect, acid rain, deforestation, ozone depletion, chlorofluorocarbons, air pollution, nuclear waste, agricultural subsidies, and population management are addressed. Fossil fuels, nuclear energy, hydroelectricity, and solar power are compared and assessed. In addition to providing a comprehensive account of the development of the current environmental crisis, the book offers an extensive discussion of the ways in which the environment can be protected and restored.

Leaving Eden

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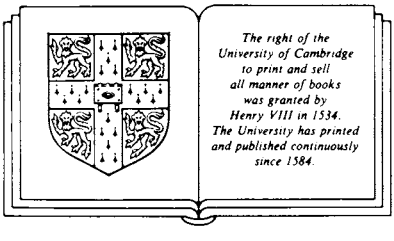
Leaving Eden

To protect and manage the Earth



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To my family,
for whom this book is written

This goodly frame, the Earth, seems to me a sterile promontory; this most excellent canopy, the air, look you, this brave o'erhanging firmament, this majestical roof fretted with golden fire, why it appears no other thing to me than a foul and pestilent congregation of vapours. What a piece of work is a man! how noble in reason! how infinite in faculty! in form and moving, how express and admirable! in action how like an angel! in apprehension how like a god! the beauty of the world! the paragon of animals! And yet, to me, what is this quintessence of dust? man delights not me; no, nor woman neither.

Shakespeare
Hamlet: Act II, Scene II

Contents

Preface

Our home is small and limited. The argument of this book is based on self-interest, that it is to our advantage to protect and to manage the Earth. Western society today exists without governing faith or purpose, and can only be swayed by the perception of advantage. My personal belief is that self-interest should not be our only guide: our first duty is spiritual; our task on Earth is to enjoy our home and to obey the commandment to love our neighbor. The biblical writings are filled with joy in creation and with love for the poor and the oppressed. We are told not to muzzle the ox, not to overuse nature. Our society is heedless of this. Its actions are based largely on short-term self-interest and the maximization of profit.

For all scientists, truth is the only arbiter of research, though truth may be elusive. Society, in contrast, often values interest more highly than truth. Wrong actions may be taken deliberately, simply because there is immediate profit in them. Truth frequently fails against self-interest. Truth alone seems unable in our society to change the world, not even if the Four Horsemen of the Apocalypse were to gallop by. Truth, however, is surely unassailable when allied with self-interest. Here lies my purpose, which is to convince not on the basis of the truth that we are devastating our planet and its beauty, but by an appeal to the

self-interest of nations. The book first details the scientific concerns about the state of the planet and then outlines some possible consequences of the changes brought about by the policies of humanity. If my argument is correct, it is in the strong self-interest of nations to turn away from their present behavior. If they do not, they risk disruption, insurrection, war, famine, and pestilence. Moreover, there is profit in good environmental behavior, if the profits are counted over a decade, not over a year.

Oliver Cromwell once pointed out that "it is interest that keeps peace." Environmentalists may well win a battle or two in defense of the Earth, but a lasting solution can be achieved only if there is strong interest in sustaining it. We need to devise a global economy that recruits self-interest on the side of environmental peace. It is not an impossible task. On a smaller scale, this is how the democracies operate, using coalitions of self-interest groups to sustain constitutional peace.

We stand at a unique moment in human history. Though unaware, we now manage the Earth. We have the power to make or unmake the planet. We can see the future. Before the battle of Sedan in 1870, the French general, Ducrot, surveyed the end of what was called the Liberal Empire, a great, prosperous state. His despairing comment as he rolled up the map on his nation could fit us all today: "Nous sommes dans un pot de chambre, et nous y serons emmerdés." Our environmental laws and regulations today, for the most part, are simply exercises in putting up umbrellas as the first dollops fall into the chamber pot. Yet it is by no means too late to climb out of the pot. Perhaps it might even profit us to do so.

Saint Paul, in his letter to the Romans, commented that in a rightly based society all things work together for good. This is a doctrine of optimism, more difficult to believe and to act upon than easy despair or cynicism. The same letter carries the hope that the whole creation may be freed from the bonds of corruption. In understanding the Earth we will take a few temporal steps toward that freedom. We may also be able to bequeath that freedom, and peace, to our children.

Acknowledgments and apologies

Science in the late twentieth century is set in a reductionist structure. It is both difficult and dangerous to attempt a work of synthesis. Rutherford wrote up his results in books that were accessible to any educated person, but today science is communicated only within interest groups, from peer to peer, by scientific papers, abstracts, and talks at meetings of specialists. Only rarely, if the results are important or wished to be seen to be important, is the research more widely communicated, often in a partial or inadequate context, by means of a press release. Within science, the barriers between disciplines are almost as high as those that bar science as a whole from the broader intellectual community. Those barriers are very difficult to climb. A work of synthesis such as this is perilous, because it is nearly impossible to reach the research literature in so wide a range of fields as global change covers. Inevitably, the synthesis must be guided by colleagues. Errors will be common, either by being out of date and not aware of the latest paper in the *Journal of Tittlebats,* or from a lack of that intuition possessed by all good scientists when judging work within their field, or simply by getting things wrong and not understanding the arcane language of another discipline. Atmospheric chemists make mistakes when talking to foresters, foresters

do not understand the economics of the commons, economists are baffled when faced with atmospheric chemistry. Geologists comprehend none of the above.

Perhaps this book should have been written by a committee. To that committee, and to all specialists and reductionists, I apologize. I ask them to forgive with gentle hearts my errors and omissions, which I hope are not too great; the Earth is a whole, and we need to see that whole, even if the vision is imperfect. I ask them also to write a better book that more accurately guides our decision makers. We need that book: this is not it, but my hope is that it will help to bring about a climate favorable to such a synthesis.

A work of synthesis is not only difficult, it is also not part of the pattern of a career in modern science, and I thank my colleagues who have willingly guided me in so perverse a project. In particular, Mike Keen of the Bedford Institute of Oceanography provided strong criticism and support. I also thank the community of soil scientists, hydrologists, biologists, and atmospheric modelers at the University of Saskatchewan, who have so bravely attempted to create a group outlook on global change that is unique in its integration. Various atmospheric chemists at NCAR and NOAA in Boulder and at DSIR, New Zealand, have been immensely helpful, welcoming an outsider with kindness and teaching an amateur with patience, as have Cathy Law and John Pyle in Cambridge and Jim Lovelock at Coombe Mill. Similarly, the gentle help given me by the limnologists and aquatic biologists in the Department of Fisheries and Oceans in Winnipeg has been invaluable. Canada's leading generalist, Bill Fyfe, has encouraged my global-change interests and given much enthusiasm to those around him. S. H. Alexander's attack on my poor writing style has saved the reader from torture as has Peter-John Leone's (Cambridge University Press) rigorous and uncompromising editing. Kathleen Zylan, Sophia Prybylski (both of CUP), and W. M. Havighurst turned a jumble of paper into a book, very professionally. For criticism, advice, or general encouragement, I am most grateful to Rodney Davenport, Sir Crispin Tickell, A. Barrie Pittock, Charles Caccia, Henry S. Caplan, W. David Hopper, John Hartwick, John Stewart, Hugh Hendry, Peter Fowler, Paul Lowman, Tim O'Riordan, G. H. Miller, E. Ripley, Simon Rippon, and especially Roger Jones. Gordon Wells is thanked for his help with space imagery, and Lindsay Embree for preparing diagrams. Hazel, Hermann, and Aline tolerated a crowded shared office filled with unruly piles of books and papers, and, for all their help, I thank the Earth Science Department in Cambridge, especially Jane Shears, Sam Lal, and Andy Buckley. I thank Angie Heppner, who has created a manuscript out of a pile of sheets scribbled upon by a fountain pen with a bent nib. Author's royalties from this edition all go to the Zimbabwe Scientific Association; however, the Association is in no way responsible for any opinions expressed or errors made, has exerted no editorial control, and is not aware of the views discussed.

Finally, my thanks to C.M.R.F., descendant of Prometheus, who has given up so much for this and borne so much of the load. Perhaps the work will be worth it, for the next generation.

Some decades ago, the British writer C. P. Snow drew attention to the rift

between the sciences and the liberal arts. In his view, the intellectual community had divided into two cultures, each battling for the leadership of society. Today it is apparent that neither culture has prevailed: both have been swept aside by a dominant new culture of social management, as represented by the economists, psychologists, lawyers, and business administrators. Science, the humanities, and also religion, the older source of leadership, have all become the domestic animals of modern society, pets fed their scraps with varying degrees of indulgence but no longer playing any important role in the direction of humanity. Religion, which has nourished and guided our world view over the centuries despite its internal conflicts, is now unheard and almost mute; the voices of science and the humanities are also little regarded and becoming faint and shrill. In the corridors of power the social managers reign unchallenged.

To these social managers, my apologies. Among those natural scientists who deal with environmental issues the commonest attitude toward economists, lawyers, and business administrators is a deep aversion, even often the prejudicial contempt of an old aristocracy for a new. Scientists like myself, especially those in field disciplines who have traveled widely in poor nations, find most economic texts or management plans almost impossible to read, because the basic axioms so often seem to be wrong, possibly describing another planet but with no validity on ours. It is perhaps not accidental that one of the most influential of the economic appraisals of the actions of humanity, Garrett Hardin's thoughts on the tragedy of the commons, was published in a scientific journal. However, as a consequence of the rift between environmental scientists and social managers, our prejudice in the scientific community may have blinded us to the real successes of economic thought. It is for this reason that I apologize: any scientist attempting to put forward a unified picture of global change inevitably risks falling victim to prejudice against social managers and to ignorance of their valid contributions.

To the politicians, too, I must apologize. Many of us can tell stories of politicians who have not listened. Environmental issues are too commonly misunderstood, or exploited for political gain, even if the result is harmful to the community or nation. There is rarely a long-term view, and few politicians are willing to study the issues in the sort of depth that they are prepared to accord to economic and fiscal policy. In consequence of this type of behavior, there is now in the scientific community a widespread mistrust of political leaders. But this too is prejudice on the part of the scientists: my own experience of giving evidence to a parliamentary committee is that the minister could spare us virtually no time, but attending that same committee were many thoughtful backbenchers who asked searching and intelligent questions whether or not they believed us. To them, then, my apologies if I have suggested politically impossible steps in the latter chapters of this work: I look to them to suggest better.

Science has itself changed as it has lost influence. In the Western nations we no longer attract the best minds in the student population: they have left for more rewarding occupations. In exchange, we recruit our graduate students from the poorer countries – wonderfully gifted people, some of them, and an asset to

cherish, but their world view is different, and their loss an enormous burden to their homelands: China, India, Africa. Some of them, though, do share the deeper vision that characterized the early leaders of modern natural science: that insight into the reality below the surface which Rutherford and his school possessed. Among the modern leaders of science, the professors and heads of research teams, that insight is now of little value. In response to the political and managerial onslaught, the demands for productivity and commercial results, we have retreated into what has been termed the excellence of mediocrity: practical, safe science, seeking small solutions to little well-defined problems of immediate piecemeal benefit, and to this path we guide our students. As we shorten the range of our vision, we become ignorant of the ground around us, and grow unaware of the doings of fellow scientists in other disciplines. Ignorance is the breeding ground of isolation and then of prejudice: each of us in science has prejudice against other disciplines, as less pure, or less factual, or less mathematical, or less relevant, or whatever. To my scientific colleagues in other disciplines, then, my apologies where I have omitted or misrepresented the significance of their work through prejudice or unjustified ignorance.

The diversity of these apologies illustrates the width of the global problem. Lord Rayleigh, who was one of the founders of the modern dairy and milk industry, and also a most distinguished physicist when he had the time, commented of his predecessor as Cavendish Professor, J. C. Maxwell, that he had always endeavored "to keep the facts in the foreground." Grand ideas or deep emotions will not of themselves rescue our planet: we need to base our world view on facts. But which facts? Each community that makes up society, in the rich countries and in the poor, needs to search out those facts and to examine its basic axioms of behavior and understanding. My hope is that this book can stimulate that work, however slightly.