

Richard C. J. Somerville

This is a remarkable and timely book by a scientist who is well known internationally both for her research on climate and for her innovations in education. In straightforward and accessible language, Catherine Gautier introduces the reader to a complex variety of interlinked issues. The theme that unifies this book is that the seemingly disparate topics of oil, water, climate, and population are in fact inexorably bound together by powerful interconnections. As a result, at the dawn of the 21st century, humanity is confronted with a set of urgent challenges. It is no exaggeration to say that these challenges put the very future of civilization at risk.

It is paradoxical that these challenges should arrive at a time when the human race has made remarkable strides in overcoming long-standing obstacles. For millennia, humanity struggled to maintain population growth in the face of the ancient threats of starvation, disease, and war. Recent decades, however, have seen an explosion in human numbers and, in some countries, extraordinary increases in prosperity.

Two thousand years ago, the entire earth supported a population of only about 300 million people. It took until about 1800 for global population to pass 1 billion, and the doubling of that figure to reach 2 billion was not achieved until around 1930. In retrospect, we can now see that, at about that time, a dramatic population surge began to occur, and the global population rose to about 6.5 billion people by 2006. There was thus more than a three-fold increase in worldwide population in only about 75 years, roughly one human lifetime.

In the United States, a country with an exceptionally high level of prosperity and also of resource consumption per capita, the nation's population reached the 300 million mark in 2006, as contrasted with 200 million only about 40 years earlier. These rates of increase, both in the United States and globally, are unprecedented and unsustainable. Population is a potent multiplier for the issues treated in this wide-ranging book.

The prosperity that has characterized developed countries in the modern era has been fueled by abundant and cheap energy. In modern times, about 80% of that energy has been generated by the combustion of coal, oil, and natural gas, the so-called fossil fuels. These fuels constitute a finite resource, and that fact itself has many implications explored in this book. Furthermore, we have begun to realize that the exploitation of these ancient stores of energy, found buried in the earth's crust and extracted in immense quantities, has come at great cost.

Part of that cost occurs in the form of environmental degradation, and an especially important aspect of the environment is the climate system. Our climate is the product of many delicate balances, and one of these in particular has turned out to be vulnerable to the unintended consequences of fossil fuel use. This, of course, is the famous "greenhouse effect," a natural phenomenon in which heat-trapping gases in the atmosphere have warmed the climate since early in our planet's history, creating the conditions necessary for evolving and maintaining the abundant variety of life on Earth, including ourselves.

Now, however, humankind has unwittingly modified that natural greenhouse effect by adding large amounts of carbon dioxide and other greenhouse gases to the atmosphere. Carbon dioxide, the most significant climatically of these

gases affected by human activities, is a natural byproduct of the combustion of fossil fuels and also is produced by deforestation and other human activities. The atmospheric abundance of this gas has increased so much that today about one out of every four molecules of carbon dioxide in the atmosphere is there because we humans put it there. We have thus dramatically altered the chemical composition of the global atmosphere.

The Fossil Fuel Age will surely end, and it will end sooner rather than later, if we are wise. Sheikh Yamani, a former Saudi oil minister, was fond of saying, "The Stone Age did not end because we ran out of stones." Science has clearly shown that continuing to generate 80% of the world's energy from fossil fuel, and using the atmosphere as a free dump for waste products, will ultimately produce a different and damaged planet, a bitter legacy for our children. Catherine Gautier demonstrates in this book that the complex story of humanity's addiction to oil and other fossil fuels has profound consequences through the intricate interdependence of oil, water, and climate.

The story of the depletion of the ozone layer by man-made chemicals has many useful parallels to the story told in this book. F. Sherwood Rowland, later a Nobel laureate, was frustrated in 1984 that humankind was so slow in dealing with the ozone issue. He said, "After all, what's the use of having developed a science well enough to make predictions, if in the end all we're willing to do is stand around and wait for them to come true!" Science and business and governments worked together then, and the ozone layer is on track to heal.

Rowland's remark is apt for the topics treated in this book. Once again, powerful technology with unanticipated side effects has brought us a Faustian bargain: great economic and societal benefits, but at a steep environmental price. Once again, the world finds itself at a point where difficult decisions must be made. Once again, doing nothing, or too little, will lead to dire consequences. Refusing to recognize what scientists have learned about climate change, its causes, and its linkages to water and the environment, in the vain and naive hope that the problem will somehow solve itself, is simply irresponsible. Action is needed, meaningful action, and soon.

We already have impeccable settled science that demonstrates the reality of global warming and its origin in human activities. We fully understand the fundamental physics behind the greenhouse effect. We also have persuasive observational evidence of the dramatic changes now taking place in the climate system. These changes are not small. Humankind's fingerprints on the climate can now be distinguished clearly from natural variability.

We scientists have constructed computer models that are powerful tools to predict the future climate with considerable confidence. We take into account the other important factors, including the sun, volcanoes, and pollution particles. Some of our forecasts have already come true. The Intergovernmental Panel on Climate Change (IPCC), in a series of authoritative reports published in 2007, summarized key aspects of climate science, as follows. Warming of the climate system is unequivocal, based on many kinds of observations. Our knowledge of ancient climates tells us the warmth of the last half-century is unusual in at least the previous 1,300 years.

Most of the observed increase in globally averaged temperatures in recent decades is "very likely" due to the observed increase in human-caused greenhouse gas concentrations in the atmosphere. Here "very likely" is calibrated language that means the odds are better than 9 chances in 10 that this conclusion is correct. A continued warming at the current rate or slightly higher is inevitable for about the next 25 years. Beyond that, the future course of climate

change depends strongly on how much more carbon dioxide humanity dumps into the atmosphere.

Global warming since the 1800s has already produced an increase of about three-quarters of a degree Celsius or more than a degree Fahrenheit. Of the 12 warmest years since the 19th century, 11 of them have occurred in the most recent 12 years. Globally, 2006 was the sixth warmest year in this period. For the United States, 2006 was the warmest year on record.

Arctic temperatures in the last 100 years increased twice as much as the global average. Since 1950, the number of heat waves globally has increased. The heat wave in Europe in 2003 that killed more than 30,000 people was unprecedented in modern times. Intense tropical cyclone activity has increased in the North Atlantic region since about 1970.

The global ocean down to a depth of about 3,000 meters or 10,000 feet has been warming since the early 1960s. This warming contributes to sea-level rise. Sea level rose some 7 inches (or 18 centimeters) over the 20th century, and the rate of rise has apparently increased recently. Water vapor in the atmosphere is increasing as the world warms. This additional water vapor is itself a greenhouse gas that feeds back and amplifies the warming. Snow cover and mountain glaciers are decreasing markedly. These sobering conclusions of the IPCC illustrate the bedrock science that should inform the making of wise public policy.

None of these observed climate changes has been a great surprise to the scientists who study climate. They are just about what we had predicted. We have long been expecting measurements like these. The question is simply, How much worse do we intend to let these trends become? The science warns us that continuing to fuel the world using present technology will bring dangerous and possibly surprising climate changes by the end of this century, if not sooner. Business as usual implies more heat waves, higher sea levels, disrupted rainfall patterns, vanishing glaciers, and much more.

Limiting atmospheric carbon dioxide amounts to any reasonable level will take large cuts in human-caused emissions of carbon dioxide into the atmosphere. At present, however, these emissions are increasing, not decreasing. It takes time to change the gigantic and expensive global energy infrastructure based on fossil fuels. To have a meaningful effect by mid-century, we will need to start soon. The question is whether we, all six-and-a-half billion of us, can muster the collective determination to act. The economic case can be made convincingly, once people understand the cost of doing nothing, or too little. Technology can accomplish great things, once society is committed to a goal. Humanity has already increased atmospheric carbon dioxide by some 35% above natural levels. Humanity will now decide, either intentionally or by neglect, what level it wants to tolerate. Then nature will have its say, and the climate system will change in response to the level of greenhouse gases in the atmosphere. Nature is supremely indifferent to politics and spin. Nature will have the last word.

Climate and its dependence on the greenhouse effect are not the only issues confronting humankind, and they are not the only ones treated in this book. The entire world indeed has a number of critical choices to make in the immediate future. One of them -- in many ways the paradigm decision -- is whether to continue on the present path of adding more and more carbon dioxide and other greenhouse gases to the atmosphere, or whether to seek and find another path. Science tells us that the path we choose will largely determine the kind of Earth that our children and grandchildren will inherit. A key aspect of the solution is a well-informed population. Making sound choices will require critical thinking

and a basic familiarity with the issues and what science can teach us about them. We are all entitled to our own opinions, but we are not entitled to our own facts. Learning the facts and understanding their consequences pose fundamentally an educational challenge. In writing this book, Catherine Gautier has made an important contribution to educating those who will confront these issues and make these choices.

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