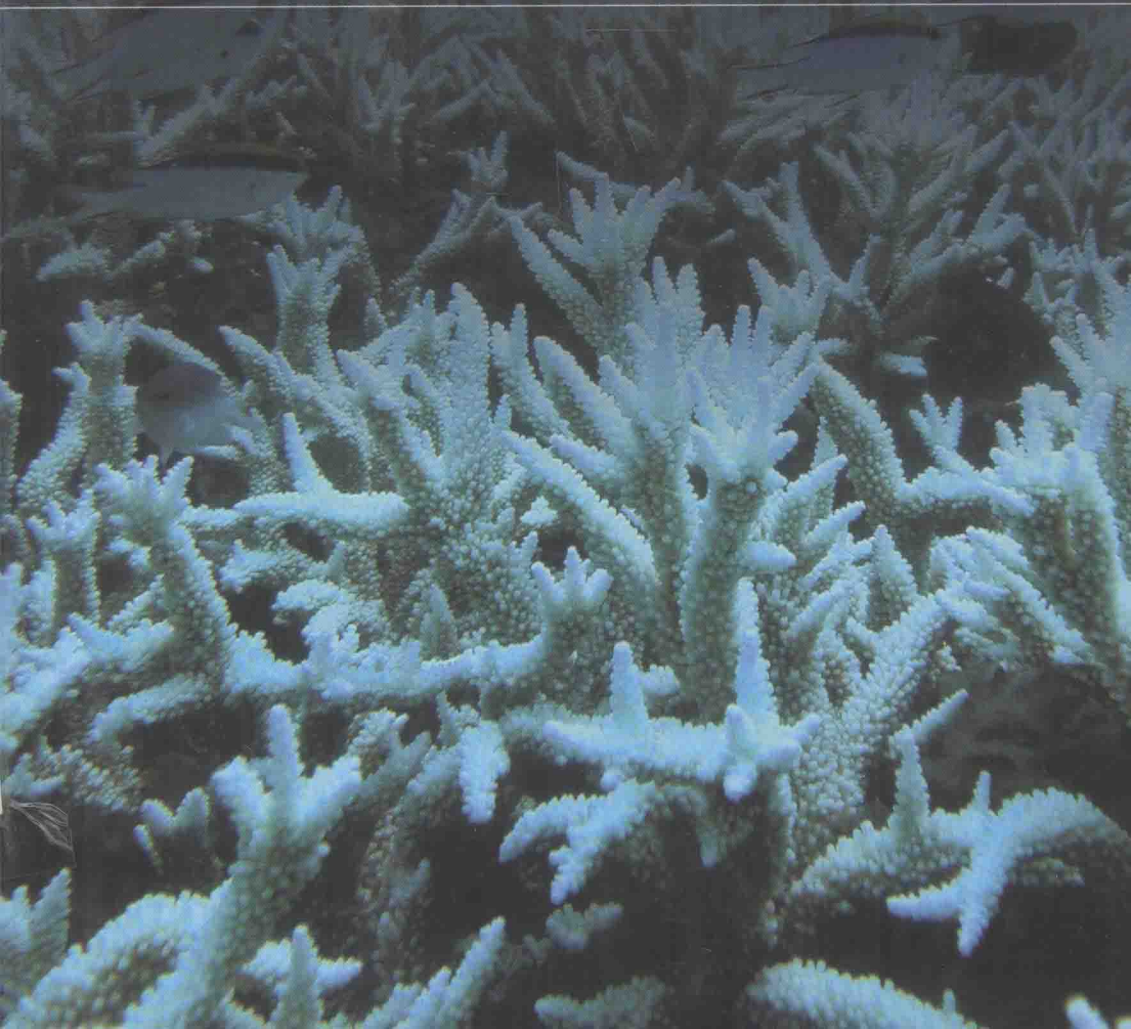
OUR DYING PLANET

PETER F. SALE

AN ECOLOGIST'S VIEW OF THE CRISIS WE FACE



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PREFACE

My neighbor and I were mowing our lawns one morning in the spring of 2005. We paused to talk. It was an early spring; the grass was growing furiously. I commented that unusual weather is what we should come to expect with climate change. His response floored me—climate change was nothing to worry about, and humans weren't responsible anyway. When I pressed, he replied that from what he could deduce from the newspapers, the overwhelming majority of climate scientists were convinced there was nothing serious going on. I tried to suggest he had it backward, that the great majority thought the problem was serious. I realized then that intelligent members of the public were not well informed on the matter. That same spring, while teaching a new community ecology course to senior undergraduates, I saw that even life science majors were frequently ill informed. Most were either naively committed conservationists or sublimely comfortable in a worldview that admitted no concerns about environmental matters. That spring, I decided to write this book.

Since that time, there has been enormous growth in information and interest about climate change, although many people remain unconvinced. Books on climate change tend to deal with it in isolation from all the other things we are doing to the environment, and this tendency to avoid confronting the full spectrum of problems makes our situation seem less critical than it really is. As I wrote

recently[1] with reference to the global decline of coral reefs, they "are not becoming degraded because of over-fishing, or pollution, or inappropriate coastal development, or global warming, or ocean acidification, or even because of an increase in intensity of storms. It is the synergy of all these impacts which is causing the progressive collapse of coral reef ecosystems." It's possible that as a marine scientist I am particularly attuned to the importance of multiple impacts, because ocean processes do merge and blend. In any event, I do not think the issue of the multiplicity of impacts—our ecological footprint—is getting nearly enough attention.

Although I began my studies at the University of Toronto, I have spent most of a rewarding academic career doing marine ecological research in the tropics. I spent nearly twenty years at the University of Sydney, doing research on the Great Barrier Reef, before I moved in 1988 to the University of New Hampshire and subsequently the University of Windsor, Canada, continuing tropical research in the Caribbean. I am now based at the United Nations University's Institute for Water, Environment, and Health, located in Hamilton, Canada. UNU–INWEH is a small U.N. agency where I seek to use the best available science to advance environmental management of tropical coastal environments.

Coral reefs, the ecosystem I know best, have been clichéd as the canaries in the environmental coal mine, and they seem very likely to disappear this century—the first ecosystem we will have eliminated from the earth. That staggers me: we are likely to eliminate a whole ecosystem from the planet. What science is learning about coral reefs and our impacts on them is truly alarming, and this book is in part an attempt to let the public know about that. However, as an ecologist, I reach beyond my own special system to look at our impacts in other areas, and I see lots of other bad news—bad news that still has not caught the attention it should. By focusing on several of our different negative impacts on the global environment rather than on just one, this book is my attempt to educate without preaching. I want people who read the book to understand, better than they did before, the seriousness of our situation and to subjectively appreciate it. I use coral reefs as a motif, a link that quietly ties the various chapters together,

1. P.F. Sale, *Marine Pollution Bulletin* 56 (2008): 805–809.

but the book is really about us, about what we are doing to our world, and about what we must do to repair our damage and create a better future. I hope that my research background and particular perspective will permit some new examples, alternative metaphors, and novel linkages that will make the messages fresh, distinctive, and compelling.

While the book deals with what may seem like an overwhelming amount of bad news, the overall message is positive. There still is time for us to salvage most of what we are destroying, and there are ways to transition toward a future that combines a high quality of life and a sustainable environment that is biologically diverse. The choice is not between economic progress and environmental conservation, or even between civilization and the natural world—it is between an intelligently managed, low-impact but advanced civilization and the widespread disaster that will come if we continue business as usual. The final chapter sets out the changes that have to occur very soon if we are to avoid the abyss we have been digging for ourselves.

I owe a number of people thanks for their help in making this book possible. My colleagues Jon Lovett Doust and Jake Kritzer read early versions of some chapters and provided needed encouragement when progress was slow. Donna, my wife, and Michelle, my daughter-in-law, read most chapters, helping me to see where I was in danger of losing the reader. Donna also provided numerous examples of our environmental impacts from her own active reading of the media. Randy Olson, Bob Steneck, and Jake Kritzer commented "anonymously" on later drafts, and while I did not make it more detailed, as Bob wanted, or less like "science-talk," as Randy wanted, I did take their advice very seriously as I rewrote, while also incorporating the comments that Jake provided. I know it became better with their input. Yvonne Sadovy, Terry Donaldson, Meg Lowman, Bob Steneck, Ove Hoegh-Guldberg, and Andy Hooten were all generous with photographs. At University of California Press, Chuck Crumly, science publisher, was immediately positive when I approached him about the book. He was involved in the publishing of my first book through Academic Press in 1991 and has been a supporter since. The UC Press team, including Chuck, Lynn Meinhardt (who never lost a file I sent), Jacqueline Volin (who took the book through production), and copy editor Jimmée Greco (who worked diligently to make my text clear), made the tasks of putting the book together almost fun. Along the way, Eric Engles of

Editcraft Editorial Services used his expertise as a developmental editor to turn what I thought was a good book into something a whole lot better and taught me a lot in the process. My son, Darian, and my wider family have been uniformly supportive, but Donna, in particular, has consistently provided that love and steady understanding that she has always provided throughout our lives together. Living with a scientist must have its lonely moments, and I am always grateful (and even a bit surprised) that she chose to be with me. Needless to say, all the errors in this book are mine alone.

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INTRODUCTION

April 1984, Heron Island, southern Great Barrier Reef. The helicopter landed in a swirl of sand on the circular pad near the resort. I grabbed my gear, walked across the island to the research station for a hasty hello, then headed down the beach to the waiting skiff. Fifteen minutes after landing, I boarded the *MV Hero,* joining my research team. They had just spent a week under trying circumstances of high winds, rough seas, and cold rain doing scuba surveys of the Capricorn Group on the southern Great Barrier Reef. Naturally, on my arrival, the seas had flattened and the sun had come out. I was regarded with some suspicion mixed with irritation: once again Sale had avoided the bad weather. We steamed north through the night to the Swains Reefs, a vast labyrinth of mostly unnamed reefs that lies 200 to 300 km off the Queensland coast.

Over the next nine days, under sunny skies and glorious starlit nights, with continuing calm seas, we surveyed some fifteen reefs, searching for ones with a northwestern face of relatively uniform slope and high coral cover, chiefly of platelike and branching corals. This was the first year of a new project, and we wanted to choose five reasonably similar reefs that we could visit late each summer for the next three years. We saw many amazing places—steep drop-offs, isolated coral pinnacles ris-

Facing page: Agaricia tenuifolia, Glovers Reef, Belize, 2003. Photo courtesy of R. S. Steneck.

ing nearly to the surface, narrow passes between reefs with tidal waters surging through, dense forests of soft corals, and the gently sloping reefs covered with platelike corals that we wanted to find. One reef held the densest population of sea snakes I had ever encountered—snakes up to five feet long, on the bottom, in mid-water, and at the surface—and I learned which members of the team carried that deep-seated fear of serpents that is, unfortunately, so common. On each reef that proved suitable, we conducted counts of fish using standard transect methods. We set out tape measures 30 meters long, then swam along them, counting fish of each species and tallying them on underwater slates. We focused on juveniles, fish that had been hatched and recruited to that reef during the past summer season. We also described the habitat along each transect, recording coral forms and other structural elements. During the week in the Swains, we encountered only one other vessel. It appeared on the horizon and then disappeared fifteen minutes later. Otherwise it was us, a brilliant bowl of a sky, a circular ocean world, and the reefs.

At the end of the trip, I flew home to Sydney, and less than a week later I was in the Florida Keys, where I met Jim Bohnsack, a reef fisheries scientist based at NOAA's Southeast Fisheries Science Center on Key Biscayne. Bohnsack knows the Keys intimately and took me to Looe Key, which at that time was one of only two protected portions of the Keys and one of the best examples of reef development in Florida. It was my first visit to Florida, and he wanted to show me the best.

We headed south by car to Key Largo, and then by boat south along the curving chain of islands. When we arrived at Looe Key, we tied up to a convenient mooring, suited up, and got in the water. I saw several other small boats in the vicinity, and during my dive I almost bumped into two other divers as we came around a massive coral head from opposite sides. I do not know who they were, but that was the first time in years that I had nearly run into a stranger underwater. Things got worse. At the end of my dive, I was on the surface, about to throw my mask and snorkel over the gunwale and haul myself aboard, when I realized I had surfaced at the wrong boat. I discreetly retreated and swam over to the right boat. Moorings to tie up to, lots of boats, and diver traffic jams: although Looe Key was a fascinating example of a Caribbean reef and a pleasure to visit, it was definitely not the picture of isolation I had experienced at the Swains Reefs.

The close juxtaposing in time of these two field trips jolted me into recognition of something I had thrust to the very back of my mind since my graduate student days in the late 1960s: people and the things they do are a significant factor in most natural environments, and thinking about ecology without also thinking about people is unrealistic. Until then, my research had centered on reefs in a "natural" condition, meaning "without people," or more accurately, "with so few people that human impacts could be ignored." In taking that approach, I was like most other ecologists at the time, but fewer and fewer reefs were like that. A quarter century later, ecologists like me think frequently about people and the impacts they have on natural ecosystems. The problem is that most of our impacts are far less benign than what's caused by divers swimming past, watching and enjoying a coral reef.

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It is now widely accepted that humans affect the natural environment deleteriously through overfishing, deforestation, release of greenhouse gases, and in many other ways, including anchoring small boats near reefs and bumping into reefs while diving. What is not broadly appreciated is that these many impacts are linked in multiple ways, both in the causal factors leading to them and in their consequences. They are not suited to a solve-one-at-a-time strategy, nor can they be ignored, because they each are becoming more serious every day. Also not fully appreciated is the seriousness of the changes these impacts are causing in the functioning of the natural world—seriousness for the ecosystems concerned and seriousness for us. In the West, our wealthy civilization's ability to import resources from far afield and protect us from bad outcomes has become an enormous, warm, and fluffy duvet that we have pulled over ourselves—a duvet that keeps us from seeing what is really happening outside. Our wealth protects us from reality, and that reality is one of serious jeopardy.

We remove too many fish from the sea and too many trees from the forest. We replace grasslands with agricultural fields and fields with towns. We divide land into patches separated by concrete barriers we call highways. And we poison natural systems (and sometimes ourselves) when we send the by-products of our technology (not to mention our used and unwanted items), into landfills, waterways, and the air around us. Now our impacts are so large that we are altering the

chemistry of our atmosphere and oceans in ways that change the climate on a global scale. One consequence is a mounting loss of biodiversity around the world. We are causing what might become the greatest of all the mass extinctions that have occurred since organisms first roamed the earth, certainly the most rapid of the mass extinctions on record. Yet while we recognize these varied impacts, we still do not really see what is happening to our world, nor do we comprehend what the consequences might be for us.

People may know a lot about each different impact but less about their full significance. We all know of extinctions that have occurred in the recent past and of species that might be on the edge. We take steps to conserve threatened species, even to the point of flying ultralights to guide threatened birds on their annual migrations. But few people understand the consequences of biodiversity loss. We know of instances of overfishing (usually after the fish are all gone), but we are less familiar with the reasons why fisheries keep on failing one after another, and we do not see the long-term consequences for our food supply or for ocean ecology. We appreciate the fact of deforestation but not its scale or its significance to the global water cycle or the climate. Desertification, the process by which productive lands turn into arid wastelands, is seen—if it is thought of at all—as something that happens to other people and not as the natural endpoint of years of mismanagement of forests, grasslands, and water resources. We know that pollution can have consequences for human health as well as environmental health. We even sense that recycling can make economic as well as environmental sense, but we do not appreciate the growing scale and complexity of pollution or its subtle ramifications. We generally understand the greenhouse effect and the fact that our carbon-intensive economy is changing the atmosphere and thereby altering the climate, but we mostly think of climate change as merely a slight increase in average temperature rather than a radical reordering of the ocean–atmosphere climate engine. Having lots of facts does not build a visceral appreciation of our various impacts on this planet.

We also tend to examine each of our deleterious impacts separately and out of context when we should be seeing them as interconnected, mutually reinforcing parts of a larger problem. And living under our duvets, we in the West like to keep the separate parts of that larger problem at arm's length. Sometimes we treat them as problems of spe-

cific regions, as if the dead zone in the Gulf of Mexico were a unique phenomenon unrelated to the four hundred other dead zones we have created around our shores. Or as if the desertification in West Africa shares nothing with the 1930s dust bowl of the American Midwest. But the separate problems are really one problem, a global problem, our problem.

Some parts of the natural world are more sensitive to our impacts than others. As a coral reef ecologist, I study one of the most sensitive systems on Earth. Worldwide, reefs have deteriorated measurably in my lifetime, and it is not an unrealistic prediction to say that we risk having no reefs that resemble those of today in as little as thirty or forty more years. None. Although many of us have never seen a coral reef and do not live anywhere near one, our activities have still degraded this marvelous ecosystem almost everywhere it occurs. An understanding of how our impacts interact to affect this particularly sensitive system could go a long way toward helping us anticipate the kinds of problems we are likely to face as our impacts begin to have major consequences for less-sensitive ecosystems. In this way, the coral reef can serve as an important sentinel, an early warning of the problems to come, a canary in the environmental coal mine. As a scientist, I am certain that a deeper understanding of the ecology of all natural systems, and of the details of how our activities modify that ecology, is an important and fundamental element in preparing ourselves for the tasks we now face. More sensitive ecological systems—the canaries—can help us gain that knowledge sooner.

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In his 1994 autobiography, the Harvard University biologist E. O. Wilson advised us to "keep in mind that ecology is a far more complex subject than physics." Unfortunately, this counsel does not seem to have permeated very far into our communal psyche. Instead, we tend to think of ecology as something like advanced nature study—all notebooks, binoculars, and funny sun hats. Most of us know little about this science, having gleaned what we could from half-remembered high school or college courses, supplemented by information in the media. While there are sophisticated treatments of this discipline in the better universities and in some excellent textbooks on the subject, there also exist quite weak texts and university courses taught with little excite-

ment and no imagination. Ecology in high school courses tends to be kept very simple, and the media usually do a poorer job of reporting on this field than they do on many other areas of science. I often find that otherwise informative "educational" videos dealing with ecological subjects are best viewed with the mute button depressed, because of the misinformation in the narration. The result is that the great majority of people, if they know much at all about the science of ecology, have a very superficial sense of what this science is about, and a rather simple picture of its central concepts—the population, the community, and the ecosystem. Just at the time our growing impacts require that we really understand the nature of ecological communities, our educational systems become even less effective in providing the necessary knowledge than they had been, bogged down by the widespread misconception that the only growing points in the biological sciences are at the molecular level.

To fully understand human impacts on ecological systems, we need to understand the systems' normal functioning. What world leaders, policymakers, and average citizens need today is a crash course on the nature of ecological communities—how they function, how they change over time, and why they change in the ways they do. Unfortunately, the conventional wisdom on these subjects can be pretty far from the truth. Conventional wisdom relies heavily on an out-of-date, early-twentieth-century understanding of ecology that is at odds with what we now know to be the case. A profound revolution in ecological thinking took place in the latter years of the twentieth century, which revealed a world that is very different from—and far less capable of self-regulation and repair than—the world we believed in until then. I'll take up this topic in a later chapter, but for now remember that we live in a world we need to understand correctly if we are going to be able to anticipate the likely consequences of our impacts on it. And believe me when I say that our world is far more fragile ecologically than our conventional wisdom would suggest. We cannot assume it will always be able to repair itself when we carelessly damage it.

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The human footprint on the natural world is unsustainable already, but it is becoming larger every day because of the growth of human

population and per capita[1] consumption. We do not have the option of ignoring this problem for much longer. The ecological underpinnings of our way of life are rapidly deteriorating, so the sooner we peek out from under our duvet and recognize that there is a problem we have to attend to, the greater our opportunity to make wise choices and create a good future.

Our apparently separate impacts all trace back to the growing number of people and each person's growing use of natural resources and environmental services.[2] The most obvious difference between now and past times is that there are many more of us than there used to be, and given that each of us requires a certain amount of food, water, shelter, and other perquisites of life, we are requiring more from the earth than we used to. As well as becoming much more numerous, we have, in many countries, become more profligate in our use of things the earth provides, consuming far more food, water, energy, and other resources per capita than our ancestors did.

Consider our use of energy. Humans used to be like other animals, deriving all our energy from the food we ate. Sometime during the Pleistocene, we first harnessed fire, using wood as the source of fuel, thus increasing our per capita use of energy about 2.5 times. With the invention of agriculture, we had more work to be done, and we harnessed additional sources of energy to do it. Horses, oxen, and camels were domesticated as additional muscle power, increasing per capita use of energy another 2.5-fold. Adding use of wind and water power doubled energy use, and the harnessing of coal at the start of the Industrial Revolution brought the total increase in per capita use to 37.5 times that of pre-fire hominids. Our per capita rate of consumption has increased more or less exponentially since that time, and our increase in numbers makes the increase in total energy used enormous. While per cap-

1. Since I will use this term frequently, remember that *per capita* means "the rate per individual." If population size is growing, use of resources will also grow, even if the per capita rate of use remains constant.

2. The environment provides us with both goods, such as foods and building materials, and services, such as degradation and recycling of wastes, protection from storms, and cycling of nutrients and energy. We tend to treat the goods as ours for the taking and to take the services for granted. It is relatively easy to see our growing use of goods (resources), but our use of services is also important. Frequently, our overexploitation of resources leads to changes in the environment that impact its capacity to provide these critical services.

ita use of energy has grown most rapidly, our use of other resources has also tended to grow substantially as our civilization has become more sophisticated.

Some people point to the differences among nations in resource consumption, as if this is the problem that needs to be solved. In fact, the differences among nations in per capita use of resources are substantial and important, but the overall growth in average per capita consumption is also real—it's not only Americans who like to own cars. This increasing average individual rate of consumption means that the growth of our population has a far greater impact on the earth than it would otherwise have. In many cases, we are using resources at rates that are unsustainable, either because these are nonrenewable resources that exist in finite amounts or because these are renewable resources that cannot be renewed at rates any faster than they are at present. In still other cases, there are ample supplies of these resources, but they cannot be transported to the places where people need them with sufficient rapidity to meet the growing demand. As a consequence, there are many instances in which we are running out of important natural resources either locally or globally. It is also the case that our use of resources impinges upon the use made by other organisms, with the result that our growing demand for resources leads to other radical changes within the ecosystems of the earth. Our growing demand is capturing more and more of what the earth produces, to the detriment of other species and of the ecosystems on which our lives depend.

As we consume more resources than we did in the past, we also produce more waste products, and their impacts on the ecosystems of which we are a part are correspondingly greater. To complicate matters, our advanced civilizations have created many new materials, so that our waste products include items that were not part of the natural world before the development of civilized societies. Some of these items can be toxic to people or to other organisms that may be important to us.

Some of our effects upon the earth may seem quite subtle at first, but they can have a way of turning out to be much more serious than initially suspected. On land, because of our recently developed capacity and apparent enthusiasm for broad-scale terraforming, literally reshaping the physical environment in which we live, we have tended to chop up ecological systems such as forests and grasslands into ever smaller