

## Ecosystem Collapse and Recovery

There is a growing concern that many important ecosystems, such as coral reefs and tropical rain forests, might be at risk of sudden collapse as a result of human disturbance. At the same time, efforts to support the recovery of degraded ecosystems are increasing, through approaches such as ecological restoration and rewilding. Given the dependence of human livelihoods on the multiple benefits provided by ecosystems, there is an urgent need to understand the situations under which ecosystem collapse can occur and how ecosystem recovery can best be supported. To help develop this understanding, this volume provides the first scientific account of the ecological mechanisms associated with the collapse of ecosystems and their subsequent recovery. After providing an overview of relevant theory, the text evaluates these ideas in the light of available empirical evidence, by profiling case studies drawn from both contemporary and prehistoric ecosystems. Implications for conservation policy and practice are then examined.

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The world's biological diversity faces unprecedented threats. The urgent challenge facing the concerned biologist is to understand ecological processes well enough to maintain their functioning in the face of the pressures resulting from human population growth. Those concerned with the conservation of biodiversity and with restoration also need to be acquainted with the political, social, historical, economic and legal frameworks within which ecological and conservation practice must be developed. The new Ecology, Biodiversity, and Conservation series will present balanced, comprehensive, up-to-date, and critical reviews of selected topics within the sciences of ecology and conservation biology, both botanical and zoological, and both 'pure' and 'applied'. It is aimed at advanced final-year undergraduates, graduate students, researchers, and university teachers, as well as ecologists and conservationists in industry, government and the voluntary sectors. The series encompasses a wide range of approaches and scales (spatial, temporal, and taxonomic), including quantitative, theoretical, population, community, ecosystem, landscape, historical, experimental, behavioural and evolutionary studies. The emphasis is on science related to the real world of plants and animals rather than on purely theoretical abstractions and mathematical models. Books in this series will, wherever possible, consider issues from a broad perspective. Some books will challenge existing paradigms and present new ecological concepts, empirical or theoretical models, and testable hypotheses. Other books will explore new approaches and present syntheses on topics of ecological importance.

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# *Ecosystem Collapse and Recovery*

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People are suffering. People are dying. Entire ecosystems are collapsing. We are  
in the beginning of a mass extinction. And all you can talk about is money  
and fairytales of eternal economic growth. How dare you!  
Greta Thunberg

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## *Preface*

In early 2016, while I was developing plans for this book, a major ecological catastrophe was under way. Australia's Great Barrier Reef, the world's largest living structure, experienced the worst coral bleaching event in its history, with more than 90% of surveyed reefs affected (Hughes et al., 2017a). The researcher who led these field surveys, Professor Terry Hughes of James Cook University in Queensland, summarised the results as follows: 'I showed the results of aerial surveys of bleaching on the Great Barrier Reef to my students. And then we wept' (*The Washington Post*, 20 April 2016).

It is very unusual for a scientific researcher to admit to an emotional reaction such as this. Scientists are supposed to be cool-headed, rational folk, who demonstrate calm objectivity and precision rather than emotional outbursts. In reality, of course, scientists are people too and are subject to the same feelings and emotions as everyone else. What this example illustrates is that some ecologists – perhaps most – are motivated not only by the intellectual pleasures of their chosen subject but also by a love of the natural world. When the ecosystems they study and admire are seriously damaged, perhaps beyond repair, they will suffer grief and a deep sense of loss. I feel the same way about ecosystems with which I am familiar, such as the ancient beech woodlands in southern England, which are currently suffering dieback as a result of climate change.

I mention this because scientific texts typically give scant regard to the emotional import of their subject matter. I have written this book because of growing concern about the condition of ecosystems throughout the world. Everywhere ecosystems are being degraded by multiple environmental pressures, most of which originate from human activity. Human impacts on the biosphere are now so completely pervasive that the functioning of the Earth system itself has been altered profoundly (Crutzen, 2006). Examples such as the bleaching of the Great Barrier

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Reef show us that we cannot take ecosystems for granted: there may come a point at which any ecosystem can no longer cope with the pressures to which it is being subjected. The ecosystem might then collapse.

This text therefore follows scientific convention, by focusing on ecosystem collapse as an ecological phenomenon. I have sought to provide an overview of our current understanding of this phenomenon, and the mechanisms involved, from a purely intellectual rather than an emotional standpoint. Even when considering the implications of ecosystem collapse to human society, I have here focused on socio-economic impacts rather than the potential implications of the loss of aesthetic, cultural or spiritual values associated with nature. This is not to decry such values or undermine their importance: the cultural identity of many human societies is profoundly linked to the ecosystems on which they depend. Even those of us who live in relatively developed or urban societies depend, to a surprising degree, on contact with nature for our health and well-being (Maller *et al.*, 2006). Ecosystem collapse is therefore always a cause for grief.

Or is it? It is a persistent theme in ecological theory that profound ecosystem change can sometimes provide opportunities for innovation and novelty. One needs only to think of our own group of mammals, whose evolutionary diversification is partly attributable to a meteorite strike that eliminated their dinosaur competitors, to recognise the truth in this suggestion. Theories suggest that collapse is part of the natural dynamic of some ecosystems, and further, many ecosystems have demonstrated a remarkable ability to recover after major disturbance events. Perhaps ecosystem recovery is the *yang* to the *yin* of collapse; maybe the two phenomena are complementary and interconnected. At the very least, our growing understanding of how ecosystems can recover following perturbation offers a measure of hope. A focus on such sources of hope coincides with a growing movement encouraging greater optimism in conservation (Balmford and Knowlton, 2017).

I therefore hope that the reader will forgive my focus here on the science of ecosystem collapse and recovery, while neglecting what these phenomena might mean to us as people, either as individuals or collectively. As a scientist, I believe that if we are going to solve a problem, we first need to understand it. As an ecologist, I cannot think of a more important problem to understand than how ecosystems collapse and how they might recover afterwards. When I started thinking about this book, against the background of what was happening to the Great Barrier Reef,

I was struck by many questions, such as: What causes such ecosystems to collapse? Are some ecosystems more at risk of collapse than others? If one ecosystem collapses, might others follow? What happens after an ecosystem has collapsed – can it recover? Do all ecosystems recover in the same way? My main reason for writing this book was to try and answer some of these questions, to help improve my own understanding of the problem. I don't pretend to have come up with all the answers. But I very much hope that this text will encourage others to do so.

A big thank you to everyone who so kindly answered my impertinent questions or who generously sent me literature or other information, particularly Peter Petraitis, Peter White, Sally Keith and Peter Bellingham. Needless to say, the errors are all mine. I also thank the wonderful medical practitioners who helped me through a period of ill health that I experienced while writing this book, especially Bonnie Southgate and Rob Patterson. I'm also deeply grateful to my wife, Lynn, and son, Arthur, for all their love and support. Special thanks to Lynn for checking the manuscript prior to submission and for preparing the index.

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