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Josep G. Canadell • Robert B. Jackson
Editors

Ecosystem Collapse and Climate Change

 Springer

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Preface

Concerns about climate-related “collapse” of ecosystems are increasing, including the potential irreversible loss of habitats and species. California’s record fire year of 2020 and high-intensity fires caused unusual mortality among giant sequoias (*Sequoiadendron giganteum*), raising questions about the preservation of these ancient organisms. Likewise, diverse and unconnected terrestrial and marine ecosystems in Australia experienced simultaneous and abrupt collapse in response to the strong El Niño in 2015–2016, on top of long-term warming trends. Those changes triggered the question as to whether we were seeing predicted future climate impacts now with the rapid transformation and loss of ecosystems as we know them.

In this volume, we, and the contributing authors, document cases of ecosystem collapse around the world. In each case, the authors believe that climate change is playing a dominant or, at least, contributing role in the ecosystem’s apparent demise, sometimes interacting with other pressures. The word “collapse” is challenging to apply because in many cases we do not know (i.e., it is too early to tell) whether a given ecosystem may recover through time. In other cases, however, the ecosystem’s prognosis is poor and the chance of recovery to its initial state appears unlikely, particularly so in the face of the continuing intensification of climate change.

Our book covers three broad latitudinal regions encompassing many biome types, including (1) polar and boreal ecosystems, (2) temperate and semiarid ecosystems, and (3) tropical and temperate coastal ecosystems. Examples of ecosystem collapse in polar and boreal systems include an alpine ecosystem on sub-Antarctic Macquarie Island, approximately 650 km southwest of New Zealand, where water stress from a changing climate is interacting with a novel pathogen. The volume also examines forest collapse in southern Siberia, where warming and a lengthening fire season are leading to post-fire recruitment failure and the large-scale replacement of boreal forests with grasslands.

Studies in temperate and semiarid ecosystems include the rapid transition of a relict alpine ecosystem in Tasmania. There, fire killed a paleo-endemic ecosystem characterized by the slow-growing conifer, *Athrotaxis cupressoides*. Other chapters examine forest dieback and forest transitions to grassland and shrublands, with interactions among droughts, heatwaves, and insect outbreaks contributing to the

observed transitions in places like western USA, Northern Africa and the Mediterranean region.

Examples of coastal ecosystem collapses include synchronous mangrove dieback along a 1500-km coastal mangrove ecosystem in northeastern Australia; mass bleaching and mortality in coral reefs of the Great Barrier Reef and Mediterranean Sea; the local extinction of 100 km of kelp forest in western Australia and its replacement by turf algae, attributable to marine heat waves and elevated background ocean temperatures; and the collapse of ~1300 km² of seagrass ecosystems attributable to a marine heat wave in 2010–2011.

The changes observed by the authors often go far beyond the biotic shifts described here. Seagrass and mangrove ecosystem experienced sediment erosion and depleted carbon stocks, and permafrost-driven changes in high latitude ecosystems are rapidly changing emissions of greenhouse gases and carbon stores in soils and vegetation.

One goal of this book is to raise awareness of the transitions that are already occurring through climate change today, and particularly those transitions associated with abrupt dynamics in response to one of the most important manifestations of climate change: the increasing intensity and sometimes frequency of climate variability and extremes. Some of the transitions might be critical, in so far that they may be irreversible or signal the beginning of a new level of abrupt changes that will ultimately lead to an irreversible outcome. Finally, we hope that by documenting such changes, increased awareness will help scientists and managers restore lost or degraded ecosystems, and where possible, their species and ecosystem functioning. In other instances, there may be opportunities to assist in a guided transition toward more resilient ecosystems in the face of rapid changes.

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