PREFACE

Ecosystems can be predictable, or they can change in surprising ways. Ecological research may appear to make rapid progress when it focuses on scales at which ecosystems seem predictable. The art of experimentation is to simplify systems so that they behave in transparent, interpretable, and ultimately predictable ways. The same could be said of modeling. But too much emphasis of predictable scales may cause us to neglect big, surprising changes. Long-term ecological research and landscape ecology show that big changes sometimes occur. The most important of these garner public attention. Yet the massive changes are infrequent, so it is difficult to study them in repeatable, statistically significant ways. Consequently, prediction of big changes remains difficult or impossible. This book is about ecological phenomena that are often at the edge of statistical significance, yet are at the forefront of significance to ecologists and the public.

If big changes were readily reversible, they would be easier to study and less problematic for ecosystem managers. But often the big changes are not reversible, or can be reversed only slowly, with long time delays. The big changes punctuate longer periods of modest variability, called regimes. While regimes are probably not truly stable, they are persistent. The processes that cause regimes to persist, and those that cause them to break down, pose challenges for ecological research and management.

Better understanding of regime shifts requires sustained, long-term ecological research at multiple spatial scales. Comparative studies of similar ecosystems, such as lakes, islands and watersheds, also broaden our knowledge of ecosystem regimes. Experimentation on whole ecosystems is perhaps the most powerful and rapid method for understanding regime shifts. However, where people depend on ecosystems for their livelihoods, such experiments may be risky. Ironically, these are the ecosystems for which we most need information about regime shifts. In these situations, there are creative possibilities for ecosystem studies and safe experiments that can build our understanding of regime shifts.

Ecologists frequently point out the value of species, ecosystem, and landscape diversity. The discipline of ecology has an analogous need for diverse models. Providing these models is the job of ecological theory. Ecology seems to oscillate between the demand for new models of unexplained phenomena and the deductive processes that winnow models. Both theory and experiments limit our understanding of regime shifts. We sorely need new empirical work to address important models that have been neglected, or in some cases rejected prematurely, due to inadequate data. We also need better theory, framed in terms of observables and parameters that can be identified using ecological field data. I have attempted to provide some bridges between theory and field observations in this Excellence in Ecology book.

I am grateful to many friends and institutions for their role in the creation of this work.

The Ecology Institute of Oldendorf/Luhe awarded me a prize for Excellence in Ecology that led to this book. To Otto Kinne and his colleagues I am deeply grateful. Funding for a leave of absence to write the book was provided by a Kellett Mid-Career Award from the Graduate School of the University of Wisconsin-Madison.

The U.S. National Science Foundation and the Andrew W. Mellon Foundation have generously supported my research. NSF support for various ecosystem experiments and the North Temperate Lakes Long-Term Ecological Research site has provided a solid foundation for my field programs. Sustained, rigorous field data are crucial for research on regime shifts, and NSF has made it possible to gather such data. The Mellon Foundation has provided unusually flexible support that allowed novel explorations of models and time series data. Bill Robertson at the Mellon Foundation has been willing to support my intuitive guesses over the years, some of which were rather vague in their initial expressions. Some of those guesses paid off in the form of insights reflected in this volume.

The Center for Limnology, University of Wisconsin-Madison, is a superb place to do science. This book could have been written nowhere else. John Magnuson, and now Jim Kitchell, manages a magnificent institution dedicated to creative ecological research. The operating definition of limnology at CFL extends beyond fresh waters to embrace landscape ecology, theoretical ecology, ecological economics and applications of ecology to societal issues. The resulting environment encourages broad thinking.

I have had the good fortune to be affiliated with three outstanding field stations. Trout Lake Station provided a haven for much field work, but more importantly it was home to the intellectual contributions of Tom Frost and Tim Kratz. I deeply miss the insight of Tom Frost, who died in a tragic accident before we were able to discuss the work reported here. The University of Notre Dame Environmental Research Center (UNDERC) has provided a venue for my research since 1979. UNDERC's capacities for whole-lake experiments are unparalleled in the United States, and were crucial for the data analyzed in Chapter IV. The Laboratory of Limnology in Madison, Wisconsin is the base station for work on Lake Mendota and other nearby lakes. In Madison I am fortunate to work with Dick Lathrop, an energetic and productive collaborator who knows more about Lake Mendota than anyone ever has, or likely ever will.

Whole-lake experiments on trophic cascades first prompted my interest in hysteresis and regime shifts. I am grateful to Jim Kitchell for more than 20 years of collaboration on theories, models and field experiments addressing trophic cascades. Mike Pace and Jon Cole joined us in this work over a decade ago. They have taught me a lot. Jim Hodgson has anchored the fish work for the whole-lake experiments from the beginning. The Cascade Collaboration brings together creative people from several disciplines to learn from whole-lake experiments and collaborative models. It is remarkably productive, and fun. Long may it run.

The Resilience Alliance (sometimes known as the “island-hopping crazy herd of nerds”) developed ecological theory that has infiltrated this book in many ways. My focus on regime shifts owes a great intellectual debt to C.S. (Buzz) Holling, founder of the R.A. Much of what I know about models for regime shifts was learned through collaborations with R.A. friends, especially W.A. (Buz) Brock, Don Ludwig, Garry Peterson, and Marten Scheffer.

I’m grateful to Bill Feeny for drawing figures 21 and 32.

Many colleagues provided helpful reviews of the book draft. Craig Stow read the whole draft, and provided perceptive advice throughout. Several people wrote useful reviews of one or more chapters. For this valuable service I thank Darren Bade, Elena Bennett, Jeff Cardille, Paul Hanson, Buzz Holling, Pieter Johnson, Genkai Motomi-Kato, Garry Peterson, Greg Sass, Emily Stanley and Jake Vander Zanden. Liz Levitt helped with all aspects of the manuscript.

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