Science and Policy in Natural Resource Management

Understanding System Complexity

Helen Allison and **Richard Hobbs**

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Understanding System Complexity

Despite many well-intentioned policies and changes to our management practices, our natural resources continue to decline. The roles and interplay between science and policy in the regional broadacre agriculture landscape are examined here, offering readers a thorough understanding of the complex interactions that occur across spatial scales to produce the regional-scale impacts. The fundamental causes of resource degradation, social decline and environmental pollution are addressed, examining the cross-scale drivers from the individual farm level to the global level of commodity systems. Broadacre agriculture is a common land use throughout all continents of the world and is driven by the same type of dynamics, and this case study of the Western Australian agricultural region can be used to clearly demonstrate the principles for other commodity systems. Aimed at academics and researchers through to policy analysts, this book will inspire innovation and action in sustainable natural resource management.

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CAMBRIDGE
UNIVERSITY PRESS

cambridge university press
Cambridge, New York, Melbourne, Madrid, Cape Town, Singapore, São Paulo

Cambridge University Press
The Edinburgh Building, Cambridge cb2 2ru, UK

Published in the United States of America by Cambridge University Press, New York

www.cambridge.org
Information on this title: www.cambridge.org/9780521858830

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First published in print format 2006

isbn-13 978-0-511-24319-6 eBook (Adobe Reader)
isbn-10 0-511-24319-7 eBook (Adobe Reader)

isbn-13 978-0-521-85883-0 hardback
isbn-10 0-521-85883-6 hardback

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Foreword

This is probably the first study that has used resilience, the adaptive cycle and panarchy as a major part of the conceptual foundation for the work. Resilience (as used here) has been explored in the literature for about 30 years, the adaptive cycle originated about 18 years ago and both have been integrated within the panarchy concept for only a few years. The authors combine these concepts with soft systems science conceptual modelling tools to review and assess the character of agricultural development from an integrated perspective of economic, social and ecological changes over about 100 years. They then apply these methods in a strategic analysis of the Western Australian agricultural region.

In the process the authors explore the significance of paradigms of science and policy that come from renewable resource management and practice. These emerge from and create different modes of scientific enquiry, different philosophical foundations of theory, and different modes of management. The latter range over time from traditions of command and control, to integrated management and adaptive management, to the synthetic kind of understanding and action that comes from recent work on complex adaptive systems. The authors find that the earlier approaches of science and management have been part of the cause of the erosion of the system because of their inability to lead to remedial policy and action. They are conceptually limited and too constrained. All elements are necessary but insufficient. The science of complex adaptive systems, however, is very different from traditional disciplinary, reductionist science. It is integrated across disciplines; it assumes non-linearities, multi-stable states and operations interacting over multiple scale ranges. In this case these are over scales from the individual farm to the global market for wheat. It argues for 'just sufficient' parsimony to find the simple sets of explanation for the complex behaviour.

Change is seen as being both regular and abrupt. Uncertainty is high and an integral part of the concepts and methods. Versions of booms and busts are

common, as are continual efforts to partially or wholly recover and redesign. The purpose is not only to reduce uncertainty where possible, but equally, to live with and learn from unexpected results. Models are useful but transient in their usefulness. Systems of people and nature adapt so that an evolutionary change perspective is essential. That is, the system you start with need not be the same as the one you have or will have.

The authors review and assess all that history of approach, science and policy with great clarity, knowledge and sense. They write extremely well and clearly. I really have not seen a better review and assessment than the one they have done. And they do it by vividly exploring the strategic events and processes in the region over a hundred-year period.

Because their analysis is strategic, it aims to define the problems and directions for response. Although any strategic analysis needs data, narrower analysis and models, those do not appear directly in this book. Instead, they are drawn on from the extensive literature available. Therefore few graphs, tables of numbers or graphs from models appear here. Those exist elsewhere in the published literature and reports, allowing the authors to use them and concentrate on their strategic study. I believe they have taken exactly the right course for their strategic purpose.

The authors have extensively reviewed the literature emphasising social and ecological knowledge, and some economic theories and studies as well. Their survey is really admirable. Parts of that survey deal with resilience, adaptive cycles and panarchy. They present an accurate description and assessment of the theories and practices from which the concepts were developed. I find the accuracy of their review to be surprising, since so many such reviews still appearing in the narrower literature are simply wrong, or incomplete or narrowly disciplinary. I found it to be simply excellent.

The authors add to that a review and assessment of economic cycles that, together with the cycles observed in the agricultural developments, clearly shows the degree of influence of internal causes vs. external commodity and international market causes. They show through the use of the adaptive cycle and soft modelling diagrams how the system is dominated by external economic commodity forces outside Western Australia. That is the panarchy in operation. In contrast, endogenous (local) forces that drive other social and ecological elements are not strong enough to be contributing to the evolution of a sustainable system. That has led to progressive resource impoverishment, major destruction of native vegetation, increasing salt concentration of soils, biodiversity loss and social decline. Technological quality and innovation for agriculture has continually advanced and the value of wheat has regularly declined. Some policy reform is possible that might add perennial vegetation,

introduce crop diversity and add new agricultural innovations. Some of these would be useful. But the essential story and analysis leads to the conclusion that the deleterious changes in the agricultural region are irreversible.

The critical change or transformations now needed are global – in trade, in international markets that involve changes in the World Trade Organisation and in geopolitical relations and trade agreements. These need to better integrate economic, social and ecological elements than occurs at present. The authors are right, but such integration occurs so slowly that the beneficiaries will not likely be Western Australia, but other places and other times. It represents a major focus for research, action and policy. That represents a true transformation – partly the double loop learning they refer to, but more transformational learning across scales.

The example of Western Australian agriculture is of great value as the lessons learnt can be applied elsewhere, since the authors end appropriately on questions of institution and governance. The authors do offer a set of actions that are now appropriate. The key ones involve imaginative ways to communicate the story within the region; major changes in education; advances in interactive modelling methods and practices. They offer suggestions for the directions needed in such circumstances – ones that essentially focus on transformation of governance – on institutional reform, on recognition of multiple values on a panarchy of scales across time and space. And they recognise that fundamental change has to wait for the critical time for transformation to be possible. Prepare for it, but wait for it.

C. S. (Buzz) Holling

Preface

‘I strongly advise you to stay within the discipline’ was the advice from the Head of School in the mid 1970s, when the first author Helen Allison was proposing to take a course in History and Philosophy of Science, conducted in another department, as an option in her Zoology Honours year at Aberdeen University. The reason she was told was that timetabling was difficult and it couldn’t be done. In retrospect confining her education to the accepted scientific paradigm would preserve the credibility of the established set of protocols proposed by the zoology discipline thus avoiding any potential for her to ask probing questions on theoretical issues, controversies and paradoxes.

Now 30 years later this book is the result of a course-altering event during the research for a Ph.D. dissertation by Helen, when she discovered an alternative to reductionism. On reading the book *Complexity: The Emerging Science at the Edge of Order and Chaos* (Waldrop, 1992) Helen wondered why she had not been exposed much earlier in her career to the integrating ideas of complexity and self-organising adaptive systems. However, on reflection it is not surprising, given the tacit agreement and protocols of the scientific paradigm. Helen is grateful to the author M. Waldrop who introduced her to the new sciences for the twenty-first century.

Now it is becoming acceptable to talk about diverse epistemologies, different ways of understanding the world, alternative worldviews and different ways of investigation. We now recognise that the complex problems of human societies require new approaches in science to understand the fundamental drivers of their dynamics and to be able to intervene with appropriate policies. Novel approaches and greater integration of the sciences have been advocated by an increasing number of people, including the second author Richard Hobbs. These approaches are receiving much greater attention while still remaining fragmented and marginalised not only within

academic institutions but in the thinking that still informs policy for natural resource management.

In this book we wish to share with the reader what we have learnt about these new sciences integrated with our combined 60 years experience on natural resource management. We also wish to challenge the reader to think both broadly and deeply on the issues that are facing broadacre agricultural systems 'What are the big or distal drivers that are impacting on these types of regions?' To investigate what these drivers might be we have to go beyond the single discipline, and look at relationships between factors and find the tools that can help us investigate these broad integrative relationships.

Acknowledgements

We are greatly indebted to C. S. (Buzz) Holling, Lance Gunderson and Tim Haslett who recognised the importance of this work in its original form, and to Alan Crowden for having the confidence in it to support our approach to Cambridge University Press.

We wish to express our appreciation to two institutions for supporting this research in various ways. Firstly, our thanks to Murdoch University, Western Australia, for financial support by way of a University Scholarship to Helen over the period 2000–3. Secondly, our thanks to Land & Water Australia, in particular Dr Nick Schofield, manager of the Innovation Program, who facilitated our grant approval which provided support for the final transformation of the dissertation into this book.

This book is the result of the generosity of many people who gave their time and contributed in many ways, helping us to integrate the many exciting and new ideas being explored to help understand and manage intractable problems in social-ecological systems.

Helen would like to thank colleagues past and present for their generous contributions of information and time: Associate Professor Frank Murray, Murdoch University, supported my initial proposal, and patiently followed my path of discovery of alternative ways of understanding; Dr Jennifer Robinson, Murdoch University, for her eclectic intellect, robust arguments, forthright approach and discussions on system dynamics; Charlie Nicholson, CALM, a former manager, original thinker and always a systems thinker; Dr Neil Pettit, Washington University, for encouragement and incisive comments on the final draft; Dr Julia Hobson, Murdoch University, who provided positive feedback on drafts of my papers; Dr Bryan Jenkins, Murdoch University, for his participation, energy and interest in conceptualising models; the members of the Task Force for the Review of Natural Resource Management and Viability of Agriculture in Western Australia (Dr Paul McLeod, Dr Libby Mattiske,

Dr George Gardiner, Norman Flugge and Margaret Agnew) for whom I was Executive Officer, for sharing their progressive views on the future of natural resource management and policy; Will Fey for choosing to coach me in system dynamics 'his way'; Dr Tim Haslett, Monash University, and his students who took me under their wing at my first system dynamics conference and who very kindly provided me with his system dynamics modelling course notes 'Mastering ithink'; Professor Nimal Jayaratna, Curtin University Business School, who encouraged the extension of my enquiring mind in the genre of systemic analysis; others include Dr Michael Booth, Dr Frank Harman and Dr David Annandale of Murdoch University; Dr David Egan, Curtin University Business School; Dr Sarah Lumley, University of Western Australia; Dr William Hutchinson, Edith Cowan University; Aldo Zagonel, University of Albany, SUNY; Dr Andrea Hinwood, Edith Cowan University and Deputy Chair of the Environmental Protection Authority; Dr Brian Walker, The Resilience Alliance; Kristen Blann, University of Minnesota; Annie MacBeth, Futurist; Peter Curry and Dr Denis Saunders.

There are also innumerable friends and colleagues who have encouraged me in my endeavour, including Dr Sue Moore, Murdoch University, who gave me the final encouragement I needed to start my Ph.D., and Dr Viki Cramer, who always made herself available for academic, diverse and interesting discussions; friends who reminded me that there was a world outside of my research and provided support in their own ways: Agriculture Breakfast Group (Ross George Agriculture WA, Dr Donald Burnside URS, Martin Wells, John Duff, Nic Watson, Commissioner for Soil Conservation, Dr David Bennett and others mentioned individually elsewhere); Wednesday morning beach swimming group, a constant source of inspiration on summer and winter mornings; Envirodrinks colleagues; my dear friends Lindy Brookes and Joe Tonga who on numerous occasions provided me with dinner, bed and breakfast; Peter Krawec; Kellie and Peter Pendoley; Helen Fordham; Dr Ann Hamblin; and to all those not named individually.

Thanks for support and friendship goes to fellow students in the wind tunnel that we postgraduates called home for the duration of our candidature. I am grateful for the support of the staff in the Division of Science and Engineering: Jeanne Clarke, Frank Salleo, Colin Ferguson, Sarah Xu, Susan Flay, Heather Gordon and Lindsay Lincoln, and in the Division of Research and Development, Ann Randell and Karen Olkowski. Thanks go to Alan Rossow and Kevin Hardman for drafting the maps and some of the more difficult figures and to Ted Lamont and Richard Krumins, Murdoch University, for advice on the tricks to making acrylic moulds when I struggled with a three-dimensional acrylic model of the adaptive cycle.

Finally, special thanks to Jay Whitely, a fellow Ph.D. colleague and friend, who gave so willingly of his time, provided much humour, and guided me in the art of LaTeX for the document preparation, and Dr Iain Allison, Senior Science Adviser, Glasgow University, who supplied me from an early age with his brotherly advice and encouragement, introduced me to *Zen and the Art of Motorcycle Maintenance: An Inquiry into Values* (Pirsig, 1976) and *Sophie's World: A Novel About the History of Philosophy* (Gaarder, 1994) and who holds no responsibility for the consequences of those actions and the content of this work. All errors and interpretation are our sole responsibility.

In addition to the above, Richard would also like to thank the many people who have shaped his thinking in this area and provided him with the confidence to pursue this new and challenging way of working, including Brian Walker, Ted Lefroy, Buzz Holling, Viki Cramer and Sue Moore. I'd also like to thank my wife Gillian and my two children Katie and Hamish for keeping me grounded and reminding me that there is a real world out there, as well as putting up with my long hours holed up in the study and periods away from home.

The original text for the dissertation was proofread by Jan Knight of Flying Edits.

Parts of this book appeared in a paper published in *Ecology and Society* **9**(1): 3, www.ecologyandsociety.org/vol9/iss1/.

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Abbreviations

ABARE	Australian Bureau of Agriculture and Resource Economics
ABS	Australian Bureau of Statistics
AEAM	Adaptive Environmental Assessment and Management
AM	Adaptive Management
CCP	Command and Control Policy
CVA	Competing Values Approach
EPA	Environmental Protection Authority
EPPs	Environmental Protection Policies
ESD	Ecologically Sustainable Development
ESRC	Economic and Social Research Council, UK
EVAO	Estimated Value of Agricultural Output
ICM	Integrated Catchment Management
NAP	National Action Plan on Salinity and Water Quality Australia
NIMSAD	Normative Information Model-based Systems Analysis and Design
OCM	Office of Catchment Management
PRIME	Planning, Research, Implementation, Monitoring and Evaluation Framework
SES	Social-Ecological System
WA	Western Australian

1
Introduction

A common perspective until recently was that our problem-solving abilities have been improving over the years. In the area of resource and environmental management, for example, there was a great deal of faith in our growing scientific understanding of ecosystems, our bag of increasingly sophisticated tools and technologies, and the application of market mechanisms to problems such as air pollution control and fishery management through individually allocated quotas. However, the experience over the last few decades does not support such optimism. A gap has developed between environmental problems and our lagging ability to solve them.

Fikret Berkes, Johan Colding and Carl Folke, 2003

1.1 Introduction and motivation

Despite some impressive progress over the past 30 years, protecting the natural environment is still one of today's top global issues and sustainable use is a widely accepted goal for the management of renewable resources (Rosenberg *et al.*, 1993). The global scale of the negative impacts on the environment from human use are now well documented (Daily, 1997; ESRC Global Environmental Change Programme, 2000; McNeill, 2000). It is believed that these changes are so vast, pervasive, intractable and yet so important that they require our immediate attention (Jasanoff *et al.*, 1997; Lubchenco, 1998). However, global problems are the product of human actions across spatial scales, from the local through the regional and national scales to the global scale, and across temporal scales, in which time delays between cause and effect contribute to fluctuations and instability in the system. Recognition of the increasing number of interacting agents, the inter-relatedness in time and space, across hierarchies, and oscillations in variables