

# Fragmentation in Semi-Arid and Arid Landscapes

# Fragmentation in Semi-Arid and Arid Landscapes

Consequences for Human and Natural Systems

edited by

**Kathleen A. Galvin**

*Colorado State University,  
Fort Collins, CO, U.S.A.*

**Robin S. Reid**

*International Livestock Research Institute,  
Nairobi, Kenya*

**Roy H. Behnke Jr.**

*Macaulay Land Use Research Institute,  
Aberdeen, Scotland, U.K.*

and

**N. Thompson Hobbs**

*Colorado State University,  
Fort Collins, CO, U.S.A.*

A C.I.P. Catalogue record for this book is available from the Library of Congress.

ISBN 978-1-4020-4905-7 (HB)

ISBN 978-1-4020-4906-4 (e-book)

---

Published by Springer,  
P.O. Box 17, 3300 AA Dordrecht, The Netherlands.

*www.springer.com*

Photo Credits:

East Africa (cattle, wildebeest, factory)

Photo by Cathleen J. Wilson

Central Asia (mountains with yurt and livestock) - Kyrgyz nomads' summer camp,  
Pamir mountains, Tajikistan

Photo by Carol Kerven, June 2005

*Printed on acid-free paper*

All Rights Reserved

© 2008 Springer

No part of this work may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, microfilming, recording or otherwise, without written permission from the Publisher, with the exception of any material supplied specifically for the purpose of being entered and executed on a computer system, for exclusive use by the purchaser of the work.

## DEDICATION

‘the marble index of a mind for ever  
Voyaging through strange seas of Thought, alone.’

That was William Wordsworth’s response to a statue of Sir Isaac Newton, and I suspect that Wordsworth got it right about Newton. This book is dedicated to Jim Ellis, who also took some voyages of scientific discovery. In comparison to a colossal mind like Newton’s, these were modest trips, but real ones nonetheless, and Jim remains the best creative scientist I have known or am ever likely to know well.

The remarkable thing about Jim was that he didn’t travel alone; he took a lot of us with him a lot of the way. He had the ability to see the unexpected and the simple, and the character to lead people in investigating these possibilities. The authors of the chapters in this book are just a few of the people who worked with Jim, were personally influenced by him, and regarded him with affection and admiration. That we reside on five continents tells you something about the breadth of the man’s intellectual ambitions, and his ability to assemble diverse people to match those ambitions.

As always in Jim’s work, many have willingly contributed, especially Kathy Galvin who did the practical things that got this book into print. But this is Jim’s book. He identified the research issues, got the funding, assembled the collaborators and, in the weeks before his death, brought us together to agree to produce this book. I hope that what follows does justice to his scientific legacy. Despite our efforts, this work necessarily lacks the final leavening, that unexpected insight into the significant and obvious, which was Jim’s special kind of contribution. I know that there are thoughts I will not think without him.

A provincial Ethiopian hotel is a good place from which to write this dedication. It’s the kind of place where you pay when you check in, but it has pretensions: The sheets are clean and every room has a telephone that never works. At dusk on a Sunday evening the whole parade is here – the kids on the play equipment in front of the bar, the lovers at the bar, the business man and the plump girl in the rooms behind. Jim travelled well. We

travelled together in Asia, but I think he would have smiled on this African scene. Alert, judging but not judgmental, amused – a good field man and companion.

So forget Wordsworth's strange and lonely seas. There is, I believe, a children's book with the title 'Science Can Be Fun.' Jim proved it could be so.

Good scientist, good friend, good friend in science, missed.

Roy Behnke  
Awassa, Ethiopia

# TABLE OF CONTENTS

Dedication	v
Foreword	ix
List of Contributors	xi
Acknowledgements	xv

## PART I. INTRODUCTION AND FRAMEWORK

1. Global Significance of Extensive Grazing Lands and Pastoral Societies: An Introduction 1  
*Robin S. Reid, Kathleen A. Galvin, and Russell S. Kruska*
2. Fragmentation of Arid and Semi-Arid Ecosystems: Implications for People and Animals 25  
*N. Thompson Hobbs, Robin S. Reid, Kathleen A. Galvin, and James E. Ellis*
3. Causes and Consequences of Herbivore Movement in Landscape Ecosystems 45  
*Michael B. Coughenour*

## PART II. CASE STUDIES

### Australia

4. Changing Patterns of Land Use and Tenure in the Dalrymple Shire, Australia 93  
*Chris J. Stokes, Ryan R. J. McAllister, Andrew J. Ash, and John E. Gross*

### North America

5. From Fragmentation to Reaggregation of Rangelands in the Northern Great Plains, USA 113  
*Jill M. Lockett and Kathleen A. Galvin*
6. Land Use, Fragmentation, and Impacts on Wildlife in Jackson Valley, Wyoming, USA 135  
*Jill M. Lockett and N. Thompson Hobbs*

**Asia**

7. Ideology, Land Tenure and Livestock Mobility in Kazakhstan 151  
*Iliya I. Alimaev and Roy H. Behnke, Jr.*
8. Policy Changes in Mongolia: Implications for Land Use  
and Landscapes 179  
*Dennis Ojima and Togtohyn Chuluun*

**Africa**

9. Fragmentation of a Peri-Urban Savanna, Athi-Kaputiei  
Plains, Kenya 195  
*Robin S. Reid, Helen Gichohi, Mohammed Y. Said,  
David Nkedianye, Joseph O. Ogutu, Mrigesh Kshatriya,  
Patti Kristjanson, Shem C. Kifugo, Jasphat L. Agatsiva,  
Samuel A. Adanje, and Richard Bagine*
10. Processes of Fragmentation in the Amboseli Ecosystem,  
Southern Kajiado District, Kenya 225  
*Shauna B. BurnSilver, Jeffrey Worden, and Randall B. Boone*
11. Ngorongoro Conservation Area, Tanzania: Fragmentation  
of a Unique Region of the Greater Serengeti Ecosystem 255  
*Kathleen A. Galvin, Philip K. Thornton, Randall B. Boone,  
and Linda M. Knapp*
12. North-West Province, South Africa: Communal  
and Commercial Livestock Systems in Transition 281  
*Kathleen A. Galvin, Randall B. Boone, Philip K. Thornton,  
and Linda M. Knapp*

**PART III. ISSUES OF FRAGMENTATION  
AND COMPLEXITY: A SYNTHETIC PERSPECTIVE**

13. The Drivers of Fragmentation in Arid and Semi-Arid  
Landscapes 305  
*Roy H. Behnke*
14. Comparing Landscape and Infrastructural Heterogeneity  
within and between Ecosystems 341  
*Randall B. Boone, Shauna B. BurnSilver, and Russell L. Kruska*
15. Responses of Pastoralists to Land Fragmentation: Social  
Capital, Connectivity and Resilience 369  
*Kathleen A. Galvin*

- Index** 391

## FOREWORD

Casual readers of the title of this book might be forgiven for thinking that it is a little esoteric, far-removed from the pressing day-to-day concerns of humans and wildlife in the drylands of the world. But they could not be more wrong. It addresses an issue of the utmost practical importance in the world today, yet does so on the basis of exciting new theory about how the world operates.

Of the billion or so human beings who now live in the world's arid and semi-arid lands, a majority depend on natural resources for their livelihoods. These natural resources include livestock and their forage, as well as the wild biota that creates opportunities for tourism or subsistence harvesting. Arid and semi-arid lands are spread over a third of the world's land surface, from Colorado to the Kalahari, the Sahel to the Simpson, the Altai Steppe to Amboseli. Notwithstanding their diversity, these lands are broadly characterised by low productivity, management at large scales, and great climate variability – in short, by high spatial and temporal heterogeneity.

This book is about the implications of that high spatial and temporal heterogeneity for life, management and policy in arid and semi-arid lands. Over centuries, these lands have been subjected to colonisation and development modelled on experiences from centres of human power in less heterogeneous regions, particularly Europe. The result has been institutions and infrastructure imposed without appreciating that heterogeneity might cause arid and semi-arid lands to function in a fundamentally different way. In particular, the widespread paradigm of subdivision and intensification has fragmented the landscapes, and, with them, the capacity of both humans and wildlife to take advantage of variation in space to help cope with unavoidable variations in time. The fragmentation caused by intensified land use is presumed to benefit net regional productivity. The time has come to understand where this is a legitimate trade-off, and where it is an imposed prejudice which is undermining the future of a vast chunk of the world.

So this is a very practical book for the drylands. But the analysis of fragmentation also demands a fascinating and cutting-edge collusion between the ecological and social sciences. It forces us to think beyond the straitjacket of averages to concentrate on the impacts of variability about the mean; and not just in one dimension while the rest “are held constant”, but in space and time simultaneously.



Taken together, the papers that follow face up to this challenge in a wide variety of different systems across the world, with a variety of disciplinary foci, and linking field data with modelling and theory. They summarise results from an international effort to learn from case studies across the world in regions with different levels of spatial and temporal heterogeneity, combined with different social, environmental and historical contexts. This, the biocomplexity ‘SCALE’ project, was the original brainchild of Jim Ellis, sadly no longer with us, ably carried through by the project team represented in the following pages. Jim’s work sought to determine whether (and which) arid and semi-arid lands really function in a different way to other regions of the world; he carried the banner for the idea of non-equilibrium ecosystem dynamics. Today, in this book and elsewhere, the question of whether there is a truly differentiated ‘science of desert living’ to be uncovered is being taken up more generally, to speak to the future of these regions.

Faced with global change – in climate, in economic systems, in governance – at an ever-increasing pace, at least 200 million inhabitants of drylands are believed to be vulnerable to losing their livelihoods and even their lives over the coming decades. With confidence and coherence, this book contributes theory, understanding and implications to help reduce this vulnerability in relation to the poorly-grasped threats arising from fragmentation.

It is a pleasure to recommend this excellent and thought-provoking read.

Mark Stafford Smith,  
Australia, July 2006

## LIST OF CONTRIBUTORS

**Adanje, Samuel A.** Kenya Wildlife Service, P.O. Box 40241, Nairobi, Kenya

**Agatsiva, Jasphat L.** Department of Resource Surveys and Remote Sensing, P.O. Box 47146, Nairobi, Kenya

**Alimaev, Iliya I.** Department of Pasture and Fodder, Scientific Centre for Animal Production and Veterinary Research, 51 Jandosov St., Almaty, Kazakhstan

**Ash, Andrew J.** CSIRO Sustainable Ecosystems, 306 Carmody Rd, St Lucia, Q 4067, Australia

**Bagine, Richard** Kenya Wildlife Service, P.O. Box 40241, Nairobi, Kenya

**Behnke, Roy H.** Macaulay Institute, Craigiebuckler, Aberdeen AB15 8QH U.K.

**Boone, Randall B.** Natural Resource Ecology Laboratory, Colorado State University, Fort Collins, CO 80523, USA

**BurnSilver, Shauna B.** Natural Resource Ecology Laboratory and Department of Anthropology, Colorado State University, Fort Collins, CO 80523, USA

**Chuluun, Togtohn** Environmental Remote Sensing and Geographic Information System Laboratory, National University of Mongolia, Ulaanbaatar 210646, Mongolia

**Coughenour, Michael B.** Natural Resource Ecology Laboratory, Colorado State University, Fort Collins, CO 80523, USA

**Ellis, James E.** deceased

**Galvin, Kathleen A.** Department of Anthropology and Natural Resource Ecology Laboratory, Colorado State University, Fort Collins, CO 80523, USA

**Gichohi, Helen** African Wildlife Foundation, P.O. Box 48177, Nairobi, Kenya

**Gross, John E.** National Park Service, 1201 Oakridge Drive, Suite 150, Fort Collins, CO 80525-5589, USA

**Hobbs, N. Thompson** Department of Forest, Rangeland, and Watershed Stewardship and Natural Resource Ecology Laboratory, Colorado State University, Fort Collins, CO 80523, USA

**Kifugo, Shem C.** International Livestock Research Institute, P.O. Box 30709, Nairobi, Kenya

**Knapp, Linda M.** Department of Anthropology and Natural Resource Ecology Laboratory, Colorado State University, Fort Collins, CO 80523, USA

**Kristjanson, Patti** International Livestock Research Institute, P.O. Box 30709, Nairobi, Kenya

**Kruska, Russell S.** International Livestock Research Institute, P.O. Box 30709, Nairobi, Kenya

**Kshatriya, Mrigesh** International Livestock Research Institute, P.O. Box 30709, Nairobi, Kenya

**Lackett, Jill M.** Natural Resource Ecology Laboratory, Colorado State University, Fort Collins, CO 80523, USA

**McAllister, Ryan R. J.** CSIRO Sustainable Ecosystems, Davies Lab, PMB PO Aitkenvale, Q 4814, Australia

**Nkedianye, David** International Livestock Research Institute, P.O. Box 30709, Nairobi, Kenya

**Ogutu, Joseph O.** International Livestock Research Institute, P.O. Box 30709, Nairobi, Kenya

**Ojima, Dennis** Natural Resource Ecology Laboratory, Colorado State University, Fort Collins, CO 80523, USA

**Reid, Robin S.** International Livestock Research Institute, P.O. Box 30709, Nairobi, Kenya

**Said, Mohammed Y.** International Livestock Research Institute, P.O. Box 30709, Nairobi, Kenya

**Stokes, Chris J.** CSIRO Sustainable Ecosystems, Davies Lab, PMB PO Aitkenvale, Q 4814, Australia

**Thornton, Philip K.** International Livestock Research Institute, Nairobi, Kenya and Institute of Atmospheric and Environmental Sciences, School of Geosciences, University of Edinburgh, Edinburgh, UK

**Worden, Jeffrey** International Livestock Research Institute, P.O. Box 30709, Nairobi, Kenya

## **ACKNOWLEDGEMENTS**

We would like to thank the US National Science Foundation for funding the project, Biocomplexity, Spatial Scale, and Fragmentation: Implications for Arid and Semi-arid Ecosystems (SCALE) - Grant No. DEB-0119618, which supported much of the research that forms the basis for the chapters in this volume.