Natural Resource Management Reimagined

The systems ecology paradigm (SEP) incorporates humans as integral parts of ecosystems and emphasizes issues that have significant societal relevance such as grazing land, forestland, agricultural ecosystem management, biodiversity, and global change impacts. Accomplishing this societally relevant research requires cutting-edge basic and applied research. This book focuses on environmental and natural resource challenges confronting local to global societies for which the SEP methodology must be utilized for resolution. Key elements of SEP are a holistic perspective of ecological/social systems, systems thinking, and the ecosystem approach applied to real-world, complex environmental and natural resource problems. The SEP and ecosystem approaches force scientific emphasis to be placed on collaborations with social scientists and behavioral, learning, and marketing professionals. The SEP has given environmental scientists, decision makers, citizen stakeholders, and land and water managers a powerful set of tools to analyze, integrate knowledge, and propose adoption of solutions to important local to global problems.

Robert G. Woodmansee is Professor Emeritus and former Director of the Natural Resource Ecology Laboratory (NREL) at Colorado State University (CSU). He is also a former Program Director for Ecosystem Studies at the US National Science Foundation, and a founding member of the Long-Term Ecological Research (LTER) Program. His research interests are in biogeochemistry and landscape ecology, including spatial and temporal scaling in ecosystems.

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Laurie Richards serves as a pre-award research administrator for approximately eighty-three research scientists and graduate students from both the NREL and Department of Ecosystem Science and Sustainability (ESS). She also acts as the publication editor and manager assisting NREL/ESS scientific staff with manuscript submission to many scientific journals.
ECOLOGY, BIODIVERSITY AND CONSERVATION

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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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Natural Resource Management Reimagined

Using the Systems Ecology Paradigm

Edited by

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Preface

ROBERT G. WOODMANSEE, JOHN C. MOORE, DENNIS S. OJIMA, AND LAURIE RICHARDS

This book is dedicated to Dr. George M. Van Dyne, founder in 1967 and first Director of the Natural Resource Ecology Laboratory (NREL) and the Grassland Biome of the US International Biological Program. Dr. Van Dyne was editor of the book *The Ecosystem Concept in Natural Resource Management* (Van Dyne, 1969). The NREL and its network of collaborators throughout the world evolved to become one of the epicenters of development of ecosystem science and systems ecology. This book, *Natural Resource Management Reimagined: Using the Systems Ecology Paradigm*, commemorates more than 50 years of excellence in ecosystem science initiated by Van Dyne, one of the “fathers” of systems ecology.

The concept for this book evolved after co-editor Dr. Robert G. Woodmansee presented a paper, “The Rise of Ecosystem Ecology and its Applications to Environmental Challenges,” at a symposium (Celebratory Symposium for ESA Century Anniversary) organized by Dr. Jill Baron at the European Ecology Federation annual meeting in Rome in September 2015. Dr. Woodmansee was approached by Dr. Michael Usher, series editor for the *Ecology, Biodiversity, and Conservation* series of books published by Cambridge University Press, about developing a book exploring ecosystem ecology based on the Rome presentation. Earlier co-editor Dr. John C. Moore had talked with Dominic Lewis of Cambridge University Press about developing a book celebrating the 50th anniversary of the NREL at Colorado State University. Woodmansee and Moore decided to combine these efforts.

Ecology (the study of the interactions of organisms and their environment) is a wonderful way to explain how the natural world works. But understanding the natural world is not enough as we face both current and future threats to our environments, natural resources, and societies. These threats require considerations of spatial scales ranging from nanometers to the globe, temporal scales of minutes to centuries or more, and institutional scales from households to multinational enterprises.
Scientific approaches and collaboration among many individuals, disciplines, and world views are critically needed to integrate vast amounts of knowledge in systematic ways and produce beneficial management options now and for the future. The editors of this book present the systems ecology paradigm (SEP) as the right science and analytical approach at the right time for resolving many of the Earth’s natural resource, environmental, and societal challenges. The “go-to” SEP integrates mathematical simulation modeling, field and laboratory research, and transdisciplinary collaboration to accomplish its goals. SEP embodies two major components. First, the systems ecology approach is the holistic, systems perspective and methodology developed for the rigorous study of ecosystems. Second is the use of ecosystem science, the vast body of scientific knowledge much of which has been assembled using the “ecosystem approach” first envisioned in the book *The Ecosystem Concept in Natural Resource Management* (Van Dyne, 1969). SEP evolved at Colorado State University since the NREL’s founding.

The editors all “grew up” professionally in the culture of the NREL. Robert G. Woodmansee began at the NREL as a graduate student in 1969 and became its third director from 1984 to 1992. He is a plant ecologist, range and soil scientist, ecosystem scientist, and systems ecologist. He was a member of the original USIBP Grassland Ecosystem Model (ELM) modeling team. He has practical ecosystem management experience having grown up on a farm in rural New Mexico and operating a farm/ranch in northern Colorado. John C. Moore joined NREL as a graduate student in 1982 and became its current director in 2006. John is a zoologist, soil ecologist, theoretical ecologist, and ecosystem scientist. Dennis S. Ojima became involved with the NREL as a graduate student in 1982 and was an interim director in 2005–6. He is a systems ecologist with training in plant ecology and soil science and a background of farming in rural California. Laurie Richards has proofread and edited the majority of publications, research proposals, and project reports generated by NREL staff over the past two decades.

As students of biology and ecology, each had learned about the natural world and how management might affect farmlands, ranches, and forests. Studying at Colorado State University in their PhD programs in systems ecology and ecosystem science, joining the NREL, and working on various derivatives of the ELM, all learned that knowledge and expertise about the natural world is essential but insufficient to explain ecosystem functioning, especially when humans are introduced as components of those systems. Their careers have been spent attempting to utilize systems
thinking and the ecological knowledge base generated by researchers and practitioners around the world to explain how the world works. This book represents a benchmark in that quest and argues that the SEP is essential for understanding and resolving many critical real-world, complex environmental and natural resource challenges (sometimes called “wicked problems”) facing societies around the world (e.g., changing climates; food and water security; loss of biodiversity; and pollution of our lands, air, and waters).

Material presented in this book emphasizes the work of NREL scientists and their extensive network of national and international collaborators. The authors have attempted to recognize other ecosystem scientists and systems ecologists who have contributed to this science. They have not attempted to write a definitive review of all ecosystem science and systems ecology.

The general organizing principles of the application of SEP and steps involved in its application are presented throughout the book. Underpinning the fundamental philosophy of SEP is the belief that all members of society, both present and future, should have the right to conduct activities to meet their needs and all are entitled to live in a world that offers good health, well-being, dignity, and food and water security. Simultaneously, people are responsible for minimizing the known negative impacts of their activities. Science, policy making, management, and human behavior must be integrated to insure human and environmental needs are met.

The editors hope that non-ecosystem scientists, policy makers, land managers, science and academic administrators, enlightened community thought leaders, and students will take advantage of the 50 years of historical knowledge and philosophy of systems ecology depicted in here. Beyond gaining an historical overview of the evolution of a scientific discipline, systems ecology, the editors hope readers will gain knowledge of current groundbreaking research addressing critical real world, complex problems confronting the Earth’s ecosystems and societies. All stakeholders with varying viewpoints will need to work collaboratively to resolve very complex societal and environmental problems.

Ecosystem science and systems ecology emerged as legitimate branches of science in the late 1960s when societies everywhere were beginning to recognize that our environment and natural resources were being threatened by human activities. Management practices in rangelands, forests, agricultural lands, wetlands, and waterways were inadequate to meet the challenges of deteriorating environments. Scientists recognized
an immediate need to develop a knowledge base about how ecosystems function (dynamic interactions of processes), not just how they are physically structured (appear). Two decades were needed for this approach to develop and concluded with the acceptance that humans were integral components of ecosystems, not simply controllers and manipulators of lands and waters. Ecosystem science and systems ecology have flourished because of their fundamental contributions to our understanding of natural resources and the environment. Scientific knowledge about the structure and functioning of ecosystems, the services ecosystems provide to people, and the roles people play therein have become commonplace.

As ecosystem science matured, management options based on the systems approach began shifting solely from production of commodities to practices supporting sustainability, resilience, ecosystem services, biodiversity, and interconnections of ecosystems. Today’s concepts of ecosystem management and related ideas such as sustainable agriculture, ecosystem health and restoration, consequences of and adaptation to climate change, and many other important challenges are a direct result of the systems thinking and methodology expressed in SEP. Emerging from the new knowledge about how ecosystems function and the application of the ecosystem approach is the realization among scientists, managers, policy makers, and key stakeholders that collaboration is needed and essential. SEP is meeting this need.

SEP incorporates human behavior as an integral part of ecosystems and emphasizes issues that have significant societal relevance such as management of grazing land, forestland, agricultural, and aquatic ecosystems. Application of the SEP is needed by societies to confront and resolve threats to global well-being.

Systems ecologists and ecosystem scientists know what challenges face Earth’s environments and they know many of the solutions available to resolve them. Yet, scientific knowledge alone cannot implement change. Transfer of reliable scientific knowledge to people who manage our lands, waters, and other natural resources is essential. Land and water managers must become engaged in implementing solutions to major natural resource and environmental challenges because they are the people who ultimately determine what management practices are applied to the land and waters. Adoption of new concepts and technologies (best management practices) by managers of vast areas of lands and waters are needed to resolve many challenges (e.g., carbon sequestration, water quality and quantity in river basins, nitrogen loading in land and aquatic...
ecosystems, and soil loss in watersheds). Overcoming the barriers to adoption of best management practices is critically needed, and soon. Some barriers to adoption are clearly pragmatic such as economic constraints, cost of conversion, labor availability, age of manager or owner, and access to reliable knowledge. Other barriers are created by adherence to detrimental and dogmatic cultural norms and ideologies by landowners, managers, and policy makers. Overcoming detrimental barriers requires behavioral change in individuals and groups.

Behavioral, organizational, learning, and marketing professionals study behavioral change. Further application of SEP will require incorporating behavioral, organizational, learning, and marketing professionals as partners with systems ecologists. All are needed to implement the concept and technology of adoption and community-based social marketing to solve real world, complex management problems.

George Van Dyne’s vision, shared by the editors of this volume, of inclusiveness and collaboration across disciplines, organizational status, and nationality makes it impossible to acknowledge all those individuals who made major contributions to the systems ecology paradigm and this book. You know who you are. Thank you!

Special thanks go to Dr. Michael Usher for his guidance and review of early drafts of chapters. Also, special acknowledgment is given to Sarah R. Woodmansee for patience, invaluable ideas and suggestions, support, and critical editing.

References
