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# The Ecology of Agricultural Landscapes

## LONG-TERM RESEARCH ON THE PATH TO SUSTAINABILITY

EDITED BY
Stephen K. Hamilton
Julie E. Doll
G. Philip Robertson

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STEPHEN K. HAMILTON, JULIE E. DOLL, AND

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# Preface

Agricultural ecosystems and landscapes are managed to produce food, fuel, and fiber but also have the potential, when managed appropriately, to provide society a host of other benefits known as ecosystem services. Examples include climate change mitigation, clean drinking water, beneficial insect habitat, and various cultural amenities like outdoor recreation and green space. The delivery of these services depends on how agriculture is managed as fields and landscapes, and often involves trade-offs. Historically we have managed agricultural systems more for yield than for other ecosystem services, though evidence in this volume and elsewhere suggests that many of these other services can be promoted without sacrificing yield. And increasingly, we realize how issues of environmental quality that extend well beyond the farm challenge the sustainability of agriculture in the long term.

By taking a systems approach to the study of agricultural ecosystems, it is possible to understand how different parts of the systems interact to enhance or diminish different ecosystem services, and to then evaluate inherent trade-offs. Managing these trade-offs for different outcomes provides the opportunity to make farming more sustainable.

To take such an approach requires taking into account every key part of the agricultural ecosystem: living organisms (crops, weeds, insects, microbes, animals, and humans) as well as their nonliving, physical environment (water, air, minerals, and soil). Understanding how all these parts interact can help to better utilize biological resources to control pests, provide nitrogen to crops, mitigate climate change, and build soil fertility.

This book is a synthesis of over two decades of research in agricultural ecology at the W. K. Kellogg Biological Station Long-Term Ecological Research site (KBS LTER), located in southwest Michigan, U.S. Here, scientists study agricultural ecosystems amid the matrix of unmanaged, successional forests and fields in which they reside, as well as wetlands, streams, and lakes in the broader landscape. Sustained sampling over many years documents the effects of episodic events such as drought or pest outbreaks, and as well allows observation of ecosystem processes that respond slowly, such as changes in soil carbon and microbial communities. Experimentation allows us to identify the organisms and processes responsible for different outcomes, and suggests ways that different systems might be managed to optimize the delivery of the most valued ecosystem services.

A unique aspect of the KBS LTER is the synergistic collaboration of agricultural scientists, ecologists, and social scientists, providing cross-disciplinary exchanges of ideas to generate new knowledge and new avenues of investigation. In this book, we present the current state of our understanding of row-crop agriculture at this site, drawing on comprehensive research extending from field to landscape scales. We show, for example, how KBS LTER scientists traced the cycle of nitrogen through soils, plants, and microbes to reveal how leaching moves different amounts of nitrogen to ground and surface waters in different cropping systems; quantified how different farming practices can reduce greenhouse gas emissions without diminishing crop yields, and why farmers might adopt such practices; and revealed how plant diversity in the surrounding landscape enhances the number of beneficial predators of agricultural pests in farm fields. These are but a few examples of how KBS LTER research can and has informed the design and management of more sustainable farming systems.

Never has the need been greater for an ecosystem approach to agriculture. As our global population grows to over 9 billion in the next 30 years, with a concomitant demand for agricultural products, ever more pressure will be placed on our agricultural systems. Meanwhile, climate change is altering the ecological settings in which agriculture is practiced, demanding adaptation. Knowledge generated by long-term research such as that at KBS will help to address one of the grand challenges of our time: how to meet sustainably the growing world demand for agricultural products—in a way that minimizes environmental harm and enhances the delivery of a diverse array of ecosystem services.

Throughout this book, the authors identify knowledge gaps and suggest new directions for future research to bring us further down the sustainability path. Readers will find chapters that stand on their own, but when read together offer a comprehensive, synthetic portrait of the ecology of row-crop ecosystems and unmanaged lands in agricultural landscapes. We hope this volume enhances readers' understanding of the nexus between agriculture, people, and the environment, and stimulates new research and educational efforts.

Data collected as part of core KBS LTER research activities are maintained online, in a publicly available database. This includes most of the data used in the following chapters. The KBS LTER Data Catalog (http://lter.kbs.msu.edu/datatables) is also incorporated in the LTER Network Information System (https://portal.lternet.edu/nis/home.jsp).

# Acknowledgments

The KBS LTER is one of 26 sites in the national LTER network that spans a broad diversity of climates, biomes, and degrees of human influence. The U.S. National Science Foundation funds the core activities at all LTER sites, enabling observations and experimentation over time scales not addressable in conventional research awards. We are indebted to the foresight and commitment of many at NSF who realized this vision and have acted to sustain it. We particularly thank former and current program directors James T. Callahan, Scott L. Collins, Henry L. Gholz, Nancy J. Huntly, Matthew D. Kane, and Saran Twombly.

Many colleagues have contributed substantially to the success of the KBS LTER. We are particularly indebted to former principal investigators who were not able to author chapters, including Michael J. Klug, Richard R. Harwood, and Christopher K. Vanderpool. George H. Lauff and Bernard D. Knezek were also instrumental in the successful launch of KBS LTER, and James J. Gallagher and Charles W. "Andy" Anderson helped develop our K–12 education program.

Critical to the success of this large, multidisciplinary, long-term project has been the dedicated staff that manages agronomic operations, sampling and data collection, and information management. Past and current project managers Katherine M. Klingensmith, Sandra J. Halstead, Andrew T. Corbin, and Stacey L. VanderWulp; agronomic managers James A. Bronson, Robert L. Beeley, Mark A. Halvorson, and Joseph T. Simmons; information managers John B. Gorentz, Timothy T. Bergsma, Lolita S. Krievs, Garrett R. Ponciroli, Sven Bohm, and Suzanne J. Sippel; and recent science coordinator Justin M. Kunkle all contributed immeasurably to the progress of science at KBS, as did the numerous technicians, graduate students, and postdocs who conducted most of the field and laboratory measurements. We are also indebted to Barbara G. Fox and Jane L. Schuette for their invaluable assistance in producing this book.

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Finally, the editors are grateful to the contributing authors for their chapters, and for their patience with this project.

S. K. H.
J. E. D.
G. P. R.

# Contributors

**Bruno Basso**
W.K. Kellogg Biological Station
Department of Geological Sciences
Michigan State University
East Lansing, MI 48824

**Subir Biswas**
Department of Electrical and Computer Engineering
Michigan State University
East Lansing, MI 48824

**Huilan Chen**
Guangzhou Chengfa Investment Fund Management Co. Ltd.
Guangzhou 510623, China

**Adam S. Davis**
Agricultural Research Service
U.S. Department of Agriculture
Urbana, IL 61801

**Julie E. Doll**
W.K. Kellogg Biological Station
Michigan State University
Hickory Corners, MI 49060

**Sarah Emery**
Department of Biology
University of Louisville
Louisville, KY 40292

**Jordan Fox**
Cerner Corporation
816 SW Country Hill Dr
Grain Valley, MO 64029

**Stuart H. Gage**
Department of Entomology
Michigan State University
East Lansing, MI 48824

**Ilya Gelfand**
Great Lakes Bioenergy Research Center &
W.K. Kellogg Biological Station
Michigan State University
Hickory Corners, MI 49060

**A. Stuart Grandy**
Department of Natural Resources and the Environment

University of New Hampshire
Durham, NH 03824

**Katherine L. Gross**
W.K. Kellogg Biological Station &
Department of Plant Biology
Michigan State University
Hickory Corners, MI 49060

**Stephen K. Hamilton**
W.K. Kellogg Biological Station
Department of Integrative Biology
Michigan State University
Hickory Corners, MI 49060

**M. Christina Jolejole-Foreman**
Department of Global Health and Population
Harvard University School of Public Health
Roxbury Crossing, MA 02120

**Wooyeong Joo**
Department of Integrative Biology
Michigan State University
East Lansing, MI 48824

**Eric P. Kasten**
Global Observatory for Ecosystem Services
Michigan State University
East Lansing, MI 48824

**Alexandra Kravchenko**
Department of Plant, Soil and Microbial Sciences
Michigan State University
East Lansing, MI 48824

**Douglas A. Landis**
Department of Entomology
Michigan State University
East Lansing, MI 48824

**Frank Lupi**
Department of Agricultural, Food, and Resource Economics &
Department of Fisheries and Wildlife
Michigan State University
East Lansing, MI 48824

**Shan Ma**
The Natural Capital Project
Stanford University
Stanford, CA 94305

**Neville Millar**
Great Lakes Bioenergy Research Center &
W.K. Kellogg Biological Station
Michigan State University
Hickory Corners, MI 49060

**Sherri Morris**
Biology Department
Bradley University
Peoria, IL 61625

**Eldor A. Paul**
Natural Resource Ecology Laboratory
Colorado State University
Fort Collins, CO 80525

**Natalie Rector**
Corn Marketing Program of Michigan
Lansing, MI 48906

**Joe T. Ritchie**
Department of Agricultural and Biological Engineering
University of Florida
Gainesville, FL 32611

**G. Philip Robertson**
W.K. Kellogg Biological Station &
Department of Plant, Soil and Microbial Sciences
Michigan State University
Hickory Corners, MI 49060

**Todd M.P. Robinson**
W.K. Kellogg Biological Station
Department of Plant Biology
Michigan State University
Hickory Corners, MI 49060

**Gene R. Safir**
Department of Plant Pathology
Michigan State University
East Lansing, MI 48824

**Thomas M. Schmidt**
Department of Ecology and Evolutionary Biology
University of Michigan
Ann Arbor, MI 48109

**Richard G. Smith**
Department of Natural Resources and the Environment
University of New Hampshire
Durham, NH 03824

**Sieglinde S. Snapp**
W.K. Kellogg Biological Station &
Department of Plant, Soil and Microbial Sciences
Michigan State University
Hickory Corners, MI 49060

**Scott M. Swinton**
Department of Agricultural, Food, and Resource Economics
Michigan State University
East Lansing, MI 48824

**Clive Waldron**
Department of Ecology and Evolutionary Biology
University of Michigan
Ann Arbor, MI 48109

**Wei Zhang**
Environment and Production Technology Division
International Food Policy Research Institute
Washington, DC 20006

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