Gary W. Barrett
Terry L. Barrett
Jianguo Wu *Editors*

History of Landscape Ecology in the United States

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Foreword

Three decades after the seminal workshop at Allerton Park, IL, landscape ecology has developed into one of the most vibrant branches of ecological science, with exceptionally strong links between theory and practice. Indeed, it is hard to think of any area in ecology where theory has had a greater impact on application, or where applications have done more to stimulate creative theory. Allerton represented a milestone in launching the field; and this book, by bringing together many leaders in landscape ecology who have done so much to shape the field, represents another milestone.

The editors of this volume have asked me to provide a personal perspective, tracing my own involvement in and perspective on events before and after Allerton. I was fortunate to begin my career at Cornell University in the 1960s. Cornell was a powerhouse in ecology, and indeed in the areas of ecology that were to form a foundation for landscape ecology; but I had no idea of that when I went there. I was a mathematician, with a strong nascent interest in issues like succession, fire, and the linkages between ecological science and the management of parks; but I really knew nothing of the subject. It was my good fortune, however, that my wife, Carole, and I decided to audit lectures by Dick Root as part of his introductory course in ecology, and Dick and we became fast friends. Indeed, I dedicate this foreword to Dick; though he has been in failing health, his contributions to ecology in general and to landscape ecology in particular, through so many of his publications, continue to grow in importance.

I learned a lot from Dick and our interactions; but an added bonus was that he also introduced me to the ecology community at Cornell, and especially to Bob Whittaker. Whittaker was one of the greats of landscape ecology though he preferred to call what he did synecology. Bob revolutionized the application of ordination methods to plant community ecology, but had a broader view that blended ecological and evolutionary theory, and revitalized the subject. His many contributions to ecology, and to biology more generally, are legendary, but we interacted most on understanding the mosaic nature of ecological communities, and on the notion of the ecotope of a species. Gene Likens was another member of the Ecology and Systematics Department, which I joined in 1970, and his integration of population, community, and ecosystem perspectives, together with Herb Bormann, and complemented by

Whittaker, helped build the scientific foundation for addressing the first two of the grand challenges of landscape ecology, “How are fluxes of organisms, of material, and of energy related to landscape heterogeneity?” and “What formative processes, both historical and present, are responsible for the existing pattern in a landscape?” Peter Marks, a Bormann student, also joined the department, and Art Lieberman, a landscape ecology pioneer, was already at Cornell; Zev Naveh spent a sabbatical working with Art. So Cornell was a hotbed of landscape ecology, and the perfect place for me to be.

The richness of Cornell attracted many visitors, but five in particular deserve mention here. Dick Forman, another pioneer and a contributor to this volume, visited Bob Whittaker, and we began discussions that have continued over the years; Dick Levins also visited and shared his ideas on metapopulations, among other things. Metapopulation theory, of course, has become a cornerstone of conservation biology, especially in the work of Ilkka Hanski and others. For me, combining metapopulation theory with island biogeography, which I had started to learn about, perhaps in an explicitly spatial context, helped put community dynamics in a framework where explicit predictions could be made that could aid understanding, and guide conservation.

I had been introduced to island biogeography earlier, through two other visitors. One day, probably in early 1970s, Dick Root told me I really should come to the *Ecology and Systematics Seminar Series* to hear Dan Simberloff, a most recent graduate student of Ed Wilson, speak about his experimental testing of the ideas of MacArthur and Wilson; it was immediately clear that these were critical experiments, and that the ideas of island biogeography had much broader relevance, for example, to islands of vegetation in terrestrial landscapes; so Whittaker and I began to work together on developing these ideas. Robert MacArthur also visited to lecture in Bob Whittaker’s course, and Bruce Wallace and I developed a seminar course on the landmark MacArthur and Wilson book entitled, *The Theory of Island Biogeography*. For me, a number of independent building blocks were fitting together, and an emergent pattern of landscape ecology was taking shape. I became fascinated with spatial processes and patterns, trying to weave these ideas together. Bob Paine was the fifth, and for me the most crucial visitor. Hearing him decorate profound ecological theory with the facts of the intertidal, I knew that this was the system and the collaborator in which and with whom to take these ideas further, which we did. The British Ecological Society presidential lecture given by Alexander Watt was a rich source of ideas for us; Watt was clearly a pioneer of landscape ecology, and helped shape our thinking on two key pillars of landscape ecology: disturbance and patch dynamics.

In the very early 1970s, I paid my first visit to Oak Ridge National Laboratory (ORNL); Bob O’Neill and Hank Shugart came to my talk, and we had great discussions afterward. I became an advisor to the terrific group that Stan Auerbach had built there, through which also passed other pioneers of landscape ecology—Monica Turner, Virginia Dale, Bob Gardner, Don DeAngelis, and Bill Emanuel among them. Many of these have key chapters in this book. My connections with Oak Ridge folks shaped many of my views going forward, but Bob O’Neill was especially key in helping me to appreciate the importance of scale, and the indeterminacy of the definition of an ecosystem. This crystallized in my thinking later, but I owe much to my ORNL interactions for whatever insights I had.

The 1970s and 1980s were key periods in the development of landscape ecology, especially for me. At a conference on ecosystem analysis and prediction I organized in Alta, UT in 1974, a remarkable collection of seminal figures attended. I interpreted that to be evidence of the interest among ecologists and others, coming from different perspectives, to find a unifying framework for what later fused into landscape ecology. Orie Loucks was one who took part, and we developed a strong interaction for a number of years after. Orie did me a huge favor by sending me his student Jianguo Wu to be a postdoc a number of years later, and Jianguo of course has become one of the key players in landscape ecology. Another key conference for me, but one that flies below the radar of landscape ecology, was one organized by John Steele and others in Sicily, focused on pattern formation in the plankton. John was another pioneer, and especially committed to building bridges between the marine and terrestrial ecological communities. That meeting introduced me to ideas, like the Stommel diagram, which have become cornerstones of landscape ecology. John and his co-organizers—Trevor Platt, Gunnar Kullenberg, and my late and dear friend Akira Okubo—decided that they should have a couple of token terrestrial ecologists at the meeting, who turned out to be Bill Clark, now at Harvard, and me. Bill was a student of Buzz Holling, producing a thesis on the dynamics of the spruce budworm, and he encouraged me to come spend my next sabbatical at the University of British Columbia (UBC), which I did with great intellectual profit. The ideas that Holling, Clark, and Don Ludwig were developing, based on the budworm, on resilience, system flips, and critical transitions, have had tremendous influence. They not only profoundly influenced the development of landscape ecology but also have given birth to sister organizations to the International Association for Landscape Ecology (IALE) like the Resilience Alliance, and helped foster the current interest in resilience and in critical transitions. The budworm also was a prime example of how disturbances could spread in landscapes, relevant to the third grand challenge from Allerton Park, IL, "How does landscape heterogeneity affect the spread of disturbance?" Of course, I would be remiss if I did not mention here the keystone meeting that inspired this book and included many of its contributors, the Allerton Park Workshop in 1983, organized by Paul Risser.

Landscape ecology in the United States, as well as globally, is a vibrant science today, as evidenced by the chapters in this book. The IALE and the journal *Landscape Ecology* have played a wonderful catalytic role. The foundational subjects mentioned already will continue to flourish, but I predict expansion in a number of directions that I think are currently underdeveloped and stronger linkages with a number of other disciplines. From a theoretical perspective, great progress is being made and will continue to be made in making connections across scales, especially from the microscopic to the macroscopic and back. This is the essential challenge in dealing with complex adaptive systems; methods from statistical physics, fluid dynamics, and elsewhere are proving invaluable. These considerations relate fundamentally to issues like the robustness and resilience of systems, and the contagious spread of disturbances; but I think that of special interest to landscape ecology are the management issues associated with problems of the commons. For this reason as well as because of increasing attention to ecosystem services, I foresee much greater interactions between ecologists on the one hand, and economists and other social scientists on the other.

Secondly, I think that John Steele's dream of a unification of landscapes and seascapes is here. Approaches such as those of Mick Follows and his colleagues to build up from the individual level to models of the dynamics of marine communities, and complementary approaches of Dan Botkin, Hank Shugart, Dean Urban, Steve Pacala, and others scale from individuals to ecosystems and seascapes/landscapes. Furthermore, the explosion of metagenomic data, mainly currently from marine ecosystems but ultimately clearly from terrestrial ecosystems, together with theoretical advances in evolutionary ecology, will lead to closer linkages between molecular biology and landscape ecology and the ability to address the emergence of ecosystem patterns and nutrient cycling from an evolutionary perspective. Many of these also involve problems of the commons: nitrogen fixation, nutrient retention, and prudent resource use all benefit the collective, but at cost to the individual.

Thirdly, a focus on resilience and robustness has made clearer than ever the potential for systems to lose resilience, and flip from one domain of behavior to another. We have the ability now to combine data from remote sensing and field work with mathematical models to elucidate landscape dynamics, and explore the potential for mechanisms like fire to shift systems from one basin of attraction to another. Critical transitions of systems, from physics to economics to the biosphere, are properly attracting great attention today, and there will be benefits for the science of landscape ecology.

These are just a few of the areas where I predict major advances. Obviously, there will be others, like the linkages to conservation biology and reserve design, to climate change science, and to movement ecology. The connections with management are crucial, and will continue to see positive developments, in accord with the fourth Allerton Park grand challenge, "How can natural resource management be enhanced by a landscape ecology approach?" We have come a long way since the Allerton Park Workshop, but the fun is just beginning.

Simon A. Levin

Preface

The initial premise of this book was an archival account of 25 years of history in landscape ecology within the USA. In 2007, a poster entitled, "USIALE: The First Twenty-five Years of Landscape Ecology in North America (1983–2008)," was presented by Gary W. Barrett and Terry L. Barrett at the Seventh World Congress, International Association for Landscape Ecology (IALE) held in Wageningen, the Netherlands (see Chap. 11). What precipitated this concern was the research of past and at that time present USIALE documents of record found scattered in a loose web of redundancy. This was due to the fact that each consecutive administration had separately recorded its unique contribution to the USIALE records for the most part irrespective of past entries. Accordingly, the continuity of the organizational documents appeared as a trace of interrupted information through no fault of any one administration. The poster was one of the first public attempts to accurately assign USIALE a consistent referent title (United States Regional Association of the International Association for Landscape Ecology), timeline, and ordered accomplishments from selected USIALE documentation. "… The poster will attempt to summarize the themes and sites of the US-IALE annual meetings, award recipients, and officers of the association. In addition, a forthcoming paper will attempt to quantify topics, principles, and advances in the field of landscape ecology based on publications in the journal, *Landscape Ecology*." This volume is in answer to this promised paper.

The inceptive timeframe concerning this volume was drawn from the meeting of USIALE held at the University of Georgia during January 1986 (see Chap. 3) through the 25th year celebration, which took place at the University of Georgia during April 2010. However, when researching the chapters that follow, it becomes apparent that USIALE was conceptualized during the Allerton Park Workshop sponsored by the National Science Foundation (NSF), held in Piatt County, IL from 25 to 27 April 1983. Therefore, the book now describes a 30-year history of landscape ecology in the United States (i.e., 1983 through 2013).

This volume outlines the mission of USIALE, link between IALE and USIALE, and effort to promote transdisciplinary research and training among colleagues across continents and disciplines. Landscape Ecology, as readers will become increasingly aware, is a holistic and an integrative science as scholars in landscape ecology address agrolandscape, environmental education, pollution abatement, resource allocation, or global climate change with a slide rule of scales.

Scientific disciplines typically have a charter, by-laws, annual meeting, journal describing findings for its membership, and approved committees to guide its future. However, landscape ecology is being revalued to address multiple facets of the plane of traditional landscape (see Chap. 8). For example, not only the surface of Earth but the substance of celestial bodies becomes apparent with new technologies. Ecological and anthropological processes linked to Earth can no longer be exclusively juxtaposed with celestial observations. Customary strategy alone can be equally inadequate when approaching the tests of expanding global agendas of governments and individuals—such as planetary mining or bandwidth regulation. Similarly, where inquiry cannot be limited to a preset of questions, refreshed thinking is required to approach ever-increasing complexities in a vignette of economy, politics, security, and society. It is rare during a lifetime to witness a paradigm evolve into a comprehensive and integrative science such as Landscape Ecology.

Gary W. Barrett
Terry L. Barrett
Jianguo (Jingle) Wu

Acknowledgments

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Thanks are extended to each author, or coauthor, of each chapter supplied in this volume. We thank Simon A. Levin for contributing the Foreword to this book. In addition to her contribution as writer and organizer of this volume, Jingle and Gary recognize Terry L. Barrett regarding the initial copyediting, extensive correction of references, and adherence to *Springer* publishing format within each contributing chapter as needed.

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Gary W. Barrett
Terry L. Barrett
Jianguo (Jingle) Wu

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Gary W. Barrett holds the Eugene P. Odum Chair of Ecology in the Eugene P. Odum School of Ecology, University of Georgia (UGA). He is the coauthor of eight books and has published over 190 articles in professional journals. Until 1994, he was Distinguished Professor of Ecology, Miami University, Oxford, OH. At Miami University, he was recipient of the 1986 Sigma Xi Researcher of the Year Award. From 1994 through 1996, Barrett was the Director of the Institute of Ecology, UGA. He was the Ecology Program Director with the National Science Foundation (1981–1983). Barrett is a Fellow of the American Association for the Advancement of Science (1990). He served as President of the United States Regional Association of the International Association for Landscape Ecology (USIALE) (1988–1990), Association for Ecosystem Research Centers (1995–1996), and American Institute of Biological Sciences (AIBS) (1998). He received the 2000 AIBS Presidential Citation Award in recognition of leadership and contributions to the biological sciences, and the prestigious Distinguished Landscape Ecologist Award in 2001 from USIALE. Barrett was the recipient of the 2005 Excellence in Undergraduate Mentoring Award, UGA.

Terry L. Barrett holds an MA in art and an MFA in painting from Miami University, Oxford, OH. Barrett continues to contribute to the field of landscape aesthetics with 12 publications in professional journals, including 2 edited books. She served as Cohost and Program Cochair of the 2010 Twenty-fifth Anniversary Symposium of the United States Regional Association of the International Association for Landscape Ecology (USIALE), University of Georgia, Athens, GA. As independent scholar, she received the 2012 Purple Heart Award given by graduate students within the Eugene P. Odum School of Ecology, University of Georgia, for extraordinary fidelity and dedication to graduate education.

Jianguo (Jingle) Wu is Dean's Distinguished Professor in the Oxford, School of Life Sciences and School of Sustainability, Arizona State University. He received his BS from Inner Mongolia University, his MS and PhD from Miami University, Oxford, OH, and did his postdoctoral work at Cornell University and Princeton University. His current research areas include landscape ecology, urban ecology, and sustainability science. He has published over 250 scientific papers, including 12 books. Wu has been the Editor-In-Chief of *Landscape Ecology* since 2005. He has been the Program Chair and Councilor-At-Large of United States Regional Association of the International Association for Landscape Ecology (USIALE), and was recipient of 2012 USIALE Distinguished Service Award, 2011 IALE Outstanding Scientific Achievements Award, 2010 USIALE Distinguished Landscape Ecologist Award, and 2006 American Association for the Advancement of Science (AAAS) Award for International Scientific Cooperation. He was elected AAAS Fellow in 2007 and Leopold Leadership Fellow in 2009.

Chapter 1
Thirty Years of the United States Regional Association of the International Association for Landscape Ecology: The Evolution of Its Organization and Science

Gary W. Barrett, Jianguo Wu and Terry L. Barrett

Introduction

This book accounts the early history of the United States Regional Association of the International Association for Landscape Ecology (USIALE). In Chap. 1, we describe the revision in mission of USIALE that was influenced by officers during the first 30 years since its conception, recipients of society awards, timelines of annual symposia, and hosts for these annual events.

Chapter 2, prepared by Richard T. T. Forman, traces the USIALE evolution from and early relationship to the International Association for Landscape Ecology (IALE). This chapter describes early meeting sites of IALE, and individual leadership that emanated from the United States during these formative years.

Chapter 3, prepared by Gary W. Barrett, outlines his role as ecology program director with the National Science Foundation during the early 1980s, when he recommended funding for the Allerton Park Workshop held in Piatt County, Illinois from 25 to 27 April 1983. This workshop became the catalyst and a milestone in the establishment of landscape ecology in North America (Risser 1995; Wiens 2008; Risser and Iverson 2013; Wu 2013a).

Monica G. Turner, in Chap. 4, describes the first meeting of USIALE held at the University of Georgia from 15 to 16 January 1986. The late Frank B. Golley

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interacted with Turner in hosting this initial symposium entitled "The Role of Landscape Heterogeneity in the Spread of Disturbance." The USIALE 25th anniversary symposium returned to the University of Georgia from 5 to 9 April 2010 with Gary W. Barrett and Terry L. Barrett as co-program chairs and cohosts. The theme of this 25th symposium was "Is What Humans Do Natural?"

The first volume of the journal *Landscape Ecology* was published in 1987 with Frank B. Golley serving as founding editor-in-chief. In Chap. 5, the current editor-in-chief of *Landscape Ecology*, Jianguo (Jingle) Wu, provides a historical perspective of the evolution of this quintessential transdisciplinary journal.

Chapter 6 provides a glimpse of the numerous challenges faced by several past presidents of USIALE; they also describe benchmark events, policy changes, and administrative directions during their tenure as president. Chapter 7, prepared by Gary W. Barrett and Herman (Hank) Shugart, presents an overview of landscape-level research developments during the past 30 years; they briefly address how landscape-level ecological changes, instrumentation refinement, and large-scale perturbations have changed the field of landscape ecology. They relate these changes to significant theories, principles, and approaches that have emerged in landscape ecology during the past three decades (i.e., since the Allerton Park workshop).

Terry L. Barrett and Gary W. Barrett, in Chap. 8, consider fields of study relevant to landscape ecology, organizational models, and changing parameters of landscape study. John A. Wiens and Richard J. Hobbs in Chap. 9 provided a holistic perspective contrasting the evolution of landscape ecology between two continents—namely, North America and Australia.

Robert V. O'Neill, in Chap. 10, describes how scientists from Oak Ridge National Laboratory (ORNL) have made major contributions to the development and evolution of landscape ecology during these past three decades. O'Neill discusses the leadership, research environment, close collaboration, and interdisciplinary approaches that made ORNL a "hotbed" of advanced theories, integrative research, and holistic approaches in the field of landscape ecology. ORNL perhaps has been one of the leading centers for landscape ecology in training, productivity, and interdisciplinary research; O'Neill describes the history and reasons for this success.

In Chap. 11, the coeditors of this volume discuss a future of USIALE, including collaborative possibilities, research foci, and a broaden universe of landscape.

Mission and Actions of USIALE

Permit us to now note the purpose of USIALE. The purpose of the Regional Association of the IALE shall be to foster landscape ecology in the United States; provide a link among persons concerned with landscape ecology in the United States and IALE, and other Regional associations of IALE; and promote interdisciplinary research and communication among scientists, planners, and other professionals concerned with landscape ecology in the United States and colleagues in other countries under the aegis of IALE.

Table 1.1 USIALE Presidents and terms of service

Name of the president	Term of service
David M. Sharpe	1986–1988
Gary W. Barrett	1988–1990
Joan I. Nassauer	1990–1992
Thomas R. Crow	1992–1994
Monica G. Turner	1994–1996
Louis R. Iverson	1996–1998
Jack Ahern	1998–2000
Virginia Dale	2000–2002
Eric J. Gustafson	2002–2004
Peter August	2004–2006
Robert H. Gardner	2006–2008
Jianguo Liu	2008–2010
Dean L. Urban	2010–2012
Kurt Ritters	2012–2014

The president of USIALE is responsible for the leadership to carry out this mission. Above are the 14 presidents of USIALE who have served this leadership position with distinction (Table 1.1).

Perhaps the next most challenging leadership task is hosting the annual symposia, including selecting the theme for this annual event. Below is the record of USIALE symposia, the location of each symposium, and the local host responsibilities for this special event (Table 1.2).

USIALE presents two annual awards for those individuals who have served with distinction in the field of landscape ecology. The prestigious awards are the Distinguished Landscape Ecologist (Fig. 1.1), and Distinguished Landscape Practitioner (Fig. 1.2). These awards represent the highest USIALE honor bestowed on these recipients. The recipients of these awards are listed in Tables 1.3a and b, respectively.

Other USIALE special awards include the Distinguished Service Award and Outstanding Paper in *Landscape Ecology*, which may be accessed in the *USIALE Executive Committee Handbook*.

We would remiss if we did not recognize the outstanding services contributed to USIALE by Forest Stearns (1995 Distinguished Service Citation), Richard T. T. Forman (1997 Outstanding Book Published in Landscape Ecology) for *Land Mosaic,* Cambridge Press, 1995, Frank B. Golley (1998 Outstanding Service Award), Eugene P. Odum (1998 Distinguished Service Award), Jerry F. Franklin (2001 Leadership Action Award) David J. Mladenoff (2005 Distinguished Service Award), Garik Gutman, William Taylor, Jianguo Liu (2006 Distinguished Service Award), Monica Turner (2010 Distinguished Service Award), and Jianguo Wu (2012 Distinguished Service Award).

Table 1.2 Timeline of USIALE Symposia from 1986 through 2013

Year	Location	Host	Theme of symposium	Program chair
1986	University of Georgia Athens GA	Monica G. Turner	*The Role of Landscape Heterogeneity in the Spread of Disturbance*	Frank B. Golley
1987	University of Virginia Charlottesville VA	William E. Odum	*The Influence of Land-Use Pattern on Landscape Function: Ecological Theory and Management Implications*	Monica G. Turner
1988	University of New Mexico Albuquerque NM	Bruce T. Milne	*Observations Across Scales: The Structure, Function, and Management of Landscapes*	Monica G. Turner
1989	Colorado State University Fort Collins CO	Ingrid C. Burke	*Linking Landscape Structure to Ecosystem Processes*	James F. Thorne
1990	Miami University Oxford OH	John L. Vankat, Gary W. Barrett	*The Role of Landscape Ecology in Public Policy-Making and Land-Use Management*	James F. Thorne
1991	Carleton University Ottawa ON	Gray Merriam	*Farming Landscape and Natural Values* Combined with third IALE World Congress	Louis R. Iverson
1992	Oregon State University Corvallis OR	Robert Lackey, Michael Cairns	*Regional Landscape Change: Impacts of Climate and Land Use*	Louis R. Iverson
1993	Oak Ridge TN	Monica G. Turner	*Pattern and Process in Landscape Ecology*	Margaret M. Moore
1994	University of Arizona Tucson AZ	Guy R. McPherson	*Spatial and Temporal Models for Analyzing Pattern and Process in Landscapes*	Margaret M. Moore, Jeffrey C. Klopatek
1995	University of Minnesota Minneapolis MN	Joan I. Nassauer, Lucinda Johnson	*Working in a World Dominated by Humans*	Jeffrey C. Klopatek, Dean L. Urban
1996	Galveston TX	Robert G. Coulson, Robert Giordano	*Integration of Cultural and Natural Ecosystems Across Landscapes: Applications of the Science*	Dean L. Urban, Kevin Gutzwiller
1997	Duke University Durham NC	Dean L. Urban	*The Pace and Pattern of Landscape Change*	Kevin Gutzwiller, John A. Wiens
1998	Michigan State University East Lansing MI	Jianguo Liu, William Taylor	*The Role of Landscape Ecology in Natural Resource Management*	John A. Wiens, Fred Sklar
1999	Snowmass CO	John A. Wiens	*Landscape Ecology: The Science and the Action* Combined with Fifth IALE World Congress	Fred Sklar

Table 1.2 (continued)

Year	Location	Host	Theme of symposium	Program chair
2000	Fort Lauderdale FL	Fred Sklar, Yegang Wu	*Integration of Societal and Landscape Heterogeneity: Problems and Solutions*	Fred Sklar
2001	Arizona State University Tempe AZ	Jianguo (Jingle) Wu	*Pattern, Process, Scale, and Hierarchy: Interactions in Human-Dominated and Natural Landscapes*	Laura Musacchio
2002	University of Nebraska Lincoln NE	Jim Merchant, Geoff Henebry	*Landscapes in Transition: Cultural Drivers and Natural Constraints*	Geoff Henebry
2003	Banff AB	Marie-Josée Fortin, Bruce T. Milne	*Beyond Borders: Linking Landscapes*	Bruce T. Milne
2004	Las Vegas NV	Nita Tallent-Halsell, K. Bruce Jones	*Transdisciplinary Challenges in Landscape Ecology*	K. Bruce Jones
2005	SUNY-ESF Syracuse NY	Jim Palmer	*Landscape Ecology: At the Intersection*	George Hess
2006	San Diego CA	Janet Franklin	*Linking Landscapes and Seascapes: Conservation and Ecosystem Management at the Land-Sea Interface*	Sarah C. Goslee
2007	University of Arizona Tucson AZ	Don McKenzie, Robert Keane, John Dibari	*Disturbances Across Gradients: From Desert Sears to Mountain Islands*	Robert Keane
2008	University of Wisconsin Madison WI	Monica Turner, Phil Townsend	*Landscape Pattern and Ecosystem Processes*	Sarah C. Goslee
2009	Snowbird UT	John Bissonette, Tom Edwards	*Coupling Humans and Complex Ecological Landscapes*	Tom Edwards
2010	University of Georgia Athens GA	Gary W. Barrett, Terry L. Barrett	*Is What Humans Do Natural?*	Terry L. Barrett, Gary W. Barrett
2011	Portland OR	Anita Morzillo, Rob Scheller	*Sustainability in Dynamic Landscapes*	Rebecca Kennedy
2012	Newport RI	Pete August, Ann Kuhn-Hines	*Informing Decisions in a Changing World*	Jeff Hollister
2013	Austin TX	Wendy S. Gordon, Timothy H. Keitt	*Landscape Dynamics Along Environmental Gradients*	Timothy H. Keitt, Kenneth R. Young

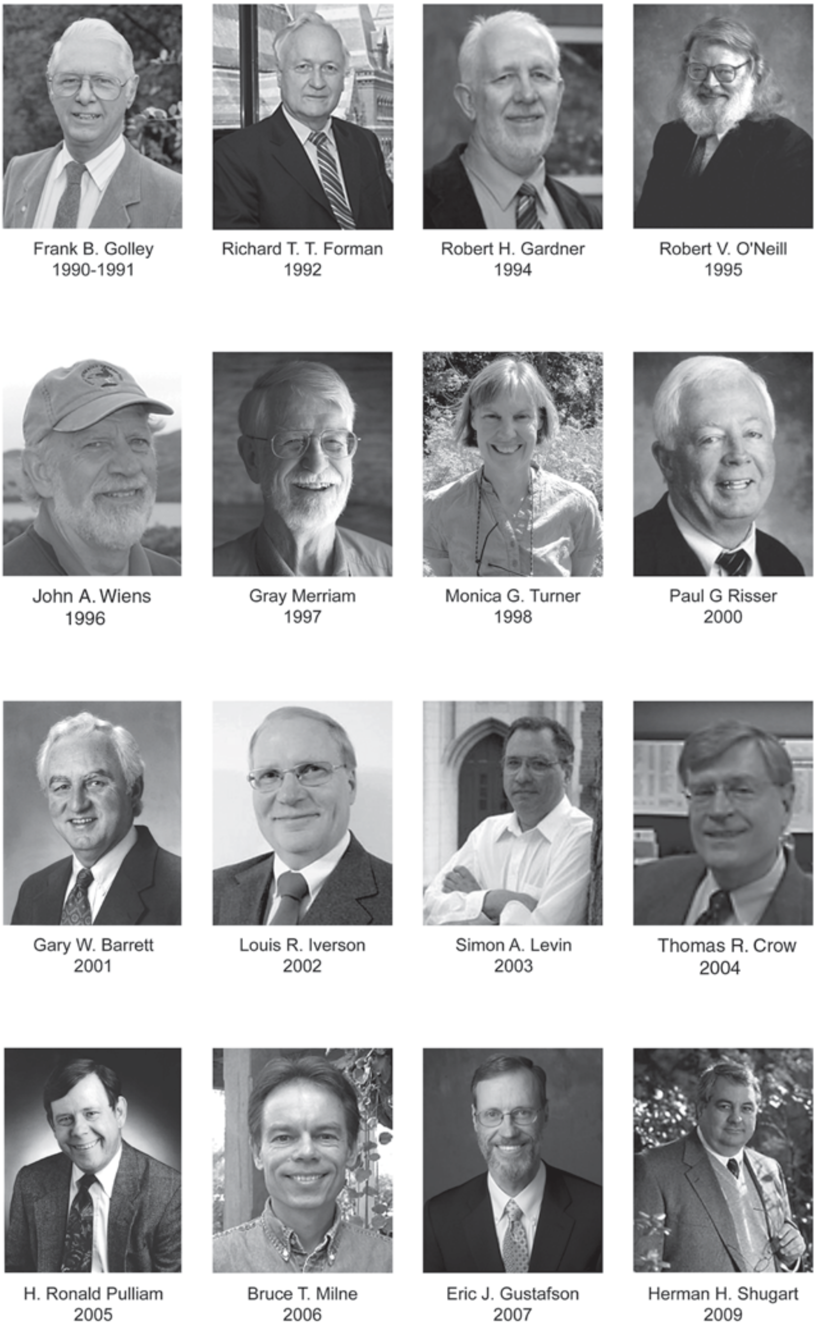

Fig. 1.1 Portraits of USIALE Distinguished Landscape Ecologists from 1990 to 2013. (Images Courtesy of Jianguo Wu)

Fig. 1.1 (continued)

Fig. 1.2 Wes H. Jackson, The Land Institute, Salina, Kansas, 2010 Distinguished Landscape Ecology Practitioner Award recipient (*middle*) shown with friend Robert French (*left*) and invited speaker for the 2010 Awards Dinner Address, Herman H. Shugart (*right*), Athens, Georgia. (Photography by Wingate Downs Photo Courtesy of Terry Barrett)

Table 1.3a USIALE Distinguished Landscape Ecologists

Year of award	Name of recipient
1990	Frank B. Golley
1991	Frank B. Golley[a]
1992	Richard T. T. Forman
1993	No award given
1994	Robert H. Gardner
1995	Robert V. O'Neill
1996	John A. Wiens
1997	Gray Merriam
1998	Monica G. Turner
1999	No awards to avoid conflict with World Congress, Snowmass, UT
2000	Paul G. Risser
2001	Gary W. Barrett
2002	Louis R. Iverson
2003	Simon A. Levin
2004	Thomas Crow
2005	H. Ronald Pulliam
2006	Bruce T. Milne
2007	Eric J. Gustafson
2008	No award
2009	Herman H. Shugart
2010	Joan I. Nassauer
2010	Jianguo Wu
2011	Lenore Fahrig
2012	David J. Mladenoff
2013	Virginia Dale
2013	Marie-Josée Fortin

[a] Second award given due to oversight that this honor had been awarded the previous year

Some Important Works in Landscape Ecology

Numerous benchmark books in the field of landscape ecology deserve mention when one attempts to appreciate early history of this emerging field of study. Indeed, the perspective of landscape ecology is embodied in Aldo Leopold's *A Sand County Almanac: And Sketches Here and There* (Leopold 1949). Ian McHarg (1969) in his book *Design with Nature* outlined the benefits of designing with nature—a precursor of an overlay and a modeling approach to integrating built systems with ecological systems. The edited books entitled, *Pine Barrens: Ecosystem and Landscape,* by Richard Forman (1979), and *Forest Island Dynamics in Man-Dominated Landscapes,* by Robert Burgess and David Sharpe (1981) set the stage for an appreciation of how landscape pattern, and elements (patches, corridors, and matrices) change through time. The now classic book, *Landscape Ecology,* by Richard

Table 1.3b USIALE Distinguished Landscape Ecology Practitioners

Year of award	Name of the recipient
1991	Andropogon Associates
1992	Reed Noss and Tom Atzet, Siskiyou National Forest
1993	No award
1994	Nancy Diaz, Mount Hood National Forest
1995	Mary Jean Huston, The Nature Conservancy-Baraboo Hills Reserve Project
1996	Carl Steinitz, Harvard Graduate School of Design
1997	Michael Hough
1998	No award
1999	No award to avoid conflict with World Congress, Snowbird UT
2000	Larry Harris, University of Florida
2001	The Nature Conservancy
2002	Great Plains Restoration Council for the Buffalo Commons
2003	USGS GAP*
2004	Frederick Steiner, University of Texas at Austin
2005	David Hulse, University of Oregon
2006	No award
2007	No award
2008	No award
2009	Kevin McGarrigal
2010	Wes H. Jackson, The Land Institute, Salina KS
2011	No award
2012	Inventory and Monitoring (I&M) Program, United States National Park Service
2013	K. Bruce Jones

*United States Geological Survey Gap Analysis Program

Forman and Michael Godron (1986) signified the establishment of landscape ecology in North America.

Numerous other books deserve mention regarding an appreciation of the early history of landscape ecology. These include Naveh and Lieberman (1984) focusing on linking landscape theory with application; Turner (1987) reviewing landscape heterogeneity and disturbance; Turner and Gardner (1991) discussing a suite of quantitative methods in landscape ecology; Hanson and di Castri (1992) discussing the relationship of landscape boundaries to biotic diversity and ecological flows; Forman (1995) describing the ecology of landscape regions; Barrett and Peles (1999) reviewing investigations focused on how a model taxonomic group, namely, small mammals, contribute understanding of population dynamics at greater temporal and spatial scales; Klopatek and Gardner (1999) outlining application of landscape ecology methodologies to management issues; Turner et al. (2001) integrating landscape theory to practice and application; Wu and Hobbs (2007) summarizing key topics in this emerging field of study; and Collinge (2009) discussing the ecology of fragmental landscapes. Several books on landscape ecology have served as an underpinning for such topics as forest landscape modeling (Mladenoff and Baker 1999), biological conservation (Gutzwiller 2002), natural resource management (Liu and Taylor 2002), and landscape sustainability (Roe and Benson 2007), and landscape fragmentation (Collinge 2009). From these books and countless publications, one can readily understand how landscape ecology evolved as an emerging field of study that linked basic and applied science—a challenge eluding numerous other fields of study.

The study of causes and consequences of spatial patterns in the landscape was early recognized as a cornerstone of the emerging science of landscape ecology. To comprehend landscape patterns and process, theory and application must be integrated onto a holistic research approach and design. Integrating approaches and concepts include hierarchy theory, ecosystem and landscape services, sustainability, net energy, problem-solving algorithms, cost-benefit analyses, and cybernetic regulatory mechanisms (Barrett 1985; Urban et al. 1987; Ahl and Allen 1996; Daily 1997; Wu 2006; 2013b; Barrett et al. 2009; Risser and Iverson 2013). Landscape ecology provides a scientific basis for the fields that require an understanding of research design, planning, management, protection, conservation, and restoration. Landscape changes during the course of history, not only because of ongoing natural process such as ecological succession, but also because economic, political, and social processes wed these natural systems and environments. Landscape ecology emphasizes these changing relationships, and by focusing on these relationships evolved as an emerging level of organization (see Chap. 7 for details). One develops deeper appreciation for process and phenomena occurring at the levels of organism, population, community, and ecosystem when one more fully understands landscape-level pattern and process (Odum and Barrett 2005).

The chapters that follow provide historical reference for the origin of landscape ecology in the United States; relationship of USIALE with the IALE; and emergence of landscape ecology as dynamic, transdisciplinary, integrative science poised to address questions and changing needs during the twenty-first century.

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Chapter 2
Launching Landscape Ecology in America and Learning from Europe

Richard T. T. Forman

Introduction

When asked to write a history, I have always responded that there is simply too much to do for the present and the future. In this case, I realized that some of the important people were no longer active, and that my accumulated old letters, reports, and published materials would be unintelligible or sterile to outside eyes, or simply discarded.

I am not a historian, using rules for evaluating evidence (Forman and Russell 1983). Thus, I simply present the information in a timeline as objectively and accurately as possible. Inevitably authors are filters, and omissions exist for which I apologize. I wish that this could have been written jointly with Frank Golley (who died in 2006), a key American leader during the period of interest. Gray Merriam (Canada) and his work played a major role during a key phase, and Paul Opdam (the Netherlands) has been a leading figure through most of the period. I hope that each will write a history.

Four periods relative to launching landscape ecology in America are recognized in the following timeline:

- Early landscape ecology approaches in Europe: 1938–1972
- Landscape ecology discovered in America: 1972–1980
- Americans discover Europe, "synergizing" landscape ecology: 1981–1982
- Coalescence of the field internationally and in America: 1983–1987

The timeline for this "emergence phase" of landscape ecology in North America runs from circa 1972 to 1987. After 1986–1987, the field takes off in a "rapid growth phase."

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Overall, people highlighted, considered themselves to be landscape ecologists or recognized their work to be important in landscape ecology. Similarly, cited reports and talks normally have the term “landscape ecology” or something similar in the title or as a prime focus, rather than simply being related to the subject.

Four overviews provided useful background for this historical synopsis: (1) Forman and Godron (1986) and Forman (1995) highlight the roots and foundations of landscape ecology; (2) Schreiber (1990) incisively encapsulates landscape ecology in Europe, especially focusing on Germany. (3) Forman (1990) highlights the 1982–1988 period; and (4) Wiens et al. (2007) select and reprint many of the key articles in and related to the field, and include introductions related to early antecedents, spatial pattern, landscape ecology concepts, scale, landscape pattern, and models. Moss (2000), Bastian (2001), and Wu and Hobbs (2007) provide additional insights.

Finally, following the timelines, I have included two explicitly subjective sections to provide much needed perspective on the litany of facts:

Glimpses of key characters—this introduces 14 important players during the emergence phase of North American landscape ecology; and discoveries of landscape ecology—this highlights three or four times the field developed somewhat independently, and how those developments appear to be related.

Before beginning with the timelines, brief background information on the writer in four areas will greatly enhance the understanding of the timelines and the final sections: (1) *Old field succession and disturbance*—I studied with Heine J. Oosting (1959–1960), worked with Murray F. Buell (1966–1972), and directed the Hutcheson Memorial Forest Center, New Jersey (1972–1984), all icons of old field succession. I worked on patchiness and fire disturbance in the New Jersey Pine Barrens (1979–1982), worked with Steward T. A. Pickett (patch dynamics; circa 1972–1984) (and later in 1985 had a sabbatical with Peter J. Grubb (gap dynamics)); (2) *Island biogeographic theory*—Robert H. MacArthur was on my doctoral committee (1960–1961), and several years later we lived a few blocks apart (1969–circa 1977) (I later wrote part of the *Land Mosaics* book in the library of Edward O. Wilson by his office (1992)); (3) *Gradient analysis*—I worked with Grant Cottam in the University of Wisconsin “Curtis-Cottam school” (1966), and had a sabbatical with Robert H. Whittaker at Cornell University (1971); and (4) *In graduate school at Pennsylvania State University and Duke University (1957–1961)*—I was reasonably familiar with vegetation, climate, soil geography, and zoogeography (including German work), with early work in ecology (e.g., A. Watt), and with vegetation methodology literature (later in the early 1980s, I absorbed the UK quantitative geography literature). Finally, by the early 1970s, I explicitly felt that all of the preceding paradigms were inadequate or misleading to understand readily visible ecological patterns on the land around us.

We now start with the timeline in four phases.

Early Landscape Ecology Approaches in Europe: 1938–1972

(1938–1939) Carl Troll (Germany), geographer and botanist, apparently with newly available aerial photography just before World War II, uses the term "landscape ecology" in passing. Later, he develops it as a concept (1950) and revises it (1966, 1970).

(1967) Ernst Neef (East Germany) publishes the first textbook or handbook on landscape ecology, *Die Theoretischen Grundlagen der Landschaftslehre*, 152 pages (Fig. 2.1).

(Circa 1967) Milan Ruzicka, Czech and Slovakia Socialist Republic (CSSR)—Slovakia, hosts the first of six conferences over a 15-year period on "Problems of Landscape Ecological Research" that apparently mainly focus on land planning, with some ecology included.

Fig. 2.1 Catalytic books during the early period of landscape ecology: (1-5) generally portray the breadth of the field during its emergence phase; and (6) is an early book in the following rapid-growth phase. (1) Ernst Neef (1967), the first text with physical geography strengths; (2) Izaak S. Zonneveld (1979), the second text with land evaluation/planning strengths; (3) S. P. Tjallingii and A. A. de Veer (1982), a breadth of people, disciplines and approaches portrayed under the umbrella of landscape ecology; (4) Zev Naveh and Arthur S. Lieberman (1984), with diverse topics from traditional physical geography to modern ecology; (5) Richard T. T. Forman and Michel Godron (1986), land mosaic approach with the patch-corridor-matrix model for understanding landscapes; and (6) Monica G. Turner (1987), following the First United States Landscape Ecology Symposium, a breadth of American ecological authors and approaches.

(1972) The Netherlands Society for Landscape Ecology is founded perhaps primarily focusing on land planning and evaluation, with some ecology included (600 members by 1981).

(1972) At this point, in addition to physical geography and rural/urban land evaluation/planning, three other fields or perspectives seem to claim at least part of landscape ecology in Europe. "Phytogeography" focuses on mapping, naming, and classifying groups of plant species across the land. Landscape architecture and aesthetics, particularly for small spaces, often incorporates some ecology. Geology, especially geomorphology, analyzes the landscape as a core unit and highlights the key physical dimensions of ecology.

Landscape Ecology Discovered in America: 1972–1980

(Circa 1972–1980) North American ecologists actively publish on the potential applicability of Island Biogeographic Theory (MacArthur and Wilson 1967) on land, especially for protecting nature. An array of valuable studies, for example, J. Brown 1971–1977, J. Terborgh 1974–1980, J. Diamond 1975, Moore and Hooper 1975, D. Simberloff 1976, C. Robbins 1978–1980, M. Usher 1979, P. White 1979, during this period could be labeled pre- or early landscape ecology, but in context seem to be mainly focused on island biogeography and sometimes nature protection. Analogous articles continued on into the 1980s, such as, A. Higgs 1980–1981, G. Peterken 1981, J. Temple 1981–1983, J. Karr 1982, D. Janzen 1983, T. Lovejoy 1983, M. Soule 1985, and D. Wilcove 1985.

(1972) Richard Forman and colleagues at Rutgers University submit a grant proposal to the United States Forest Service to study (surprisingly) "The Effect of Forest Size on the Diversity of Species." The grant is funded for a multidimensional analysis of old-growth oak woods scattered across a New Jersey corn-and-beans landscape.

(1973–1976) John A. Wiens publishes three pioneering studies on pattern and process in patchy grassland bird communities, thus challenging the prevailing population-ecology models assuming spatial homogeneity, and highlighting the importance of a wide landscape perspective.

(1975–1976) The results for avian diversity and tree diversity relative to the size of woods are published (Forman and Elfstrom 1975; Forman et al. 1976; Galli et al. 1976); the first statistically designed study of patch size and biodiversity on land.

(1976 October–December) A "eureka" moment. In this agricultural landscape with dispersed woods, Forman notices that the number and arrangement of land uses surrounding a patch seem to have a major effect on what is in it. In a voracious search, he finds that hardly any ecological literature on the subject exists. From that moment on, intellectually he is a landscape ecologist, though has never heard the term.

(1978) Pickett and Thompson (1978) publish a key article on patch dynamics, extending and making more spatially explicit an earlier shifting mosaic concept.

(1979, January 11) Letter from Forman to Professor Richard Schlatter provides title of talk for Rutgers College Interdepartmental Faculty Lectures (Rutgers Shop Club), "Time, People, and Interactions among Ecosystems, *or* Toward a Landscape Ecology…"

(1979, April) Following 3 years of intensive study and working with authors, Forman publishes his first edited book, *Pine Barrens: Ecosystem and Landscape*, 601 pages, ecologically analyzing a special New Jersey landscape (500,000 ha).

(1979, April) In the preceding book, the final synthesis chapter by Richard Forman entitled, "The Pine Barrens of New Jersey: An Ecological Mosaic," is the initial publication specifically outlining the land mosaic concept with the patch-corridor model.

(1979) Eight Forman letters mention landscape ecology to: Michel Godron (France) on February 28 ("…my interest in landscape ecology has grown…"), May 23, July 14 ("…thinking about the landscape ecology book."), August 25, and October 8; Frederick Schlauch (Long Island, New York) on October 16; and Andrew J. Higgs (UK) September 14, and December 18 ("My major interest currently might be called landscape ecology…").

(1979) Lectures by Forman with landscape ecology in title: February, Rutgers Interdepartmental Faculty Lecture; November, Virginia Polytechnic Institute and State University (Virginia Tech); and November, Torrey Botanical Club, New York.

(1979, May) Michel Godron (France) letter to United States National Science Foundation (NSF) Director, John Brooks, recommending "…to give priority to scientists who work on…landscape ecology…"

(1979) Izaak S. Zonneveld (the Netherlands) publishes the book, *Land Evaluation and Landscape Science,* 134 pages, sometimes considered to be the second landscape ecology textbook (Fig. 2.1).

(1979) A proposed Landscape Ecology Section for the International Congress of Ecology (INTECOL) is discussed at a conference organized by Milan Ruzicka, "Problems of Landscape Ecological Research," in the High Tatra Mountains, CSSR—Slovakia.

(1980, February) Lecture by Forman at the University of Connecticut, "Time, People, and Interactions among Ecosystems, and the Ecological Mosaic."

(1980, September) Steward Pickett and Richard Forman participate in a vegetation dynamics conference in Montpellier (France) where several current and future landscape ecology leaders attend. No session on landscape ecology.

(1980) A *Bulletin of the Ecological Society of America* article by Forman (1980) uses the term "landscape ecology," but probably it is simply copied from a list of ecology research topics in France.

(1980, April–July) A circular by W. Carter Johnson to Richard Forman announcing a 1981 conference held in The Netherlands on “Perspectives in Landscape Ecology.” After these several years of pondering and helping to outline the concept of landscape ecology, this is the first time he notices the term and concept used in Europe, finds it highly appealing, and has an interesting and successful correspondence with the organizers.

Americans Discover Europe, “Synergizing” Landscape Ecology: 1981–1982

(1981, April) An important landscape ecology conference held in Veldhoven, the Netherlands, sponsored by The Netherlands Society of Landscape Ecology, Izaak Zonneveld, host. North Americans present: Canada (Michel Phipps, Robert S. Dorney, Edward B. Wiken) and the United States (Frank B. Golley, David M. Sharpe, Julius G. Y. Fabos, Steven A. Carlson, Richard Forman). Europeans include: East Germany (Ernst Neef, H. Richter), West Germany (Karl-Friedrich Schreiber, Wolfgang Haber, Barbara Ruthsatz), CSSR—Czechoslovakia (Milan Ruzicka, L. Miklos, Hana Rambouskova), Poland (T. Bartkowski), UK (Robert G. H. Bunce, Max D. Hooper), Denmark (Jesper Brandt, Peder Agger), Belgium (Marc Antrop), and the Netherlands (A. P. A. Vink, A. W. L. Veen, E. van der Maarel, Chair G. van Leeuwen, S. P. Tjallingii, Paul Opdam). Frank Golley (the University of Georgia) knows some of the Europeans and helps introduce the North Americans to this array of accomplished international people. Richard Forman gives a lead plenary talk, “Interaction among Landscape Elements: A Core of Landscape Ecology.” Diverse disciplines are welcomed; session on terminology takes place; impressive party is held; forming an International Association for Landscape Ecology is discussed (In January 1982, Forman reviews a draft document).

(1981, April) At the Veldhoven landscape ecology conference, Forman meets the Dutch landscape ecologists, Paul Opdam and colleagues. This group, including Opdam, W. Bert Harms, W. Vos, J. T. R. Kalkhoven, A. Stortelder, D. van Dorp, A. Schotman, publishes from circa 1983 to 1987 a series of articles based on a pioneering large-area, long-term, multidimensional analysis of a heterogeneous agricultural landscape with dispersed woods and hedgerows in the Netherlands.

(1981) Book proceedings of the Veldhoven Conference published, as *Perspectives in Landscape Ecology*, 344 pages (Fig. 2.1), S. P. Tjallingii and A. A. de Veer, editors, which includes articles by North Americans: David Sharpe; Forest Stearns; Robert Burgess and W. Carter Johnson; Julius Fabos and W. Hendrix; Steven Carlson; and Richard Forman (article reprinted in other 1981 and 1982 publications); important book in pinpointing the array of people, disciplines, and approaches for the first time under the umbrella of landscape ecology.

(1981) Edited book by Robert L. Burgess and David M. Sharpe, *Forest Island Dynamics in Man-Dominated Landscapes*, 310 pages, includes articles by Thomas E. Lovejoy, Forest Stearns, Robert M. May, Chandler S. Robbins, W. Carter Johnson, David Sharpe, and Robert Burgess.

(1981, March) Forman and Ralph E. J. Boerner publish a fire ecology article highlighting the concept of a landscape as a mosaic of patches.

(1981) Forman talks on landscape ecology: August, Indiana, Ecological Society of America (ESA) and American Institute of Biological Sciences (AIBS); and November, Washington, D.C., American Society of Landscape Architects (ASLA).

(1981) Preliminary inquiry from a publisher interested in starting a landscape ecology journal to Frank Golley and Richard Forman (subject not pursued).

(1981, November) "Patches and Structural Components for a Landscape Ecology" by Forman and Michel Godron is the first journal article on the subject. Steward Pickett and Mark J. McDonnell (Rutgers University) review the manuscript. Concepts of landscape, edge, patch size/shape/number/origin, configuration, corridor type, network, landscape dynamics, and patch–corridor–matrix model introduced; landscape ecology made more accessible to scientists.

(Circa 1979–1983) A series of important articles by Gray Merriam, Lenore Fahrig, John Wegner, J. D. Middleton, Kathryn E. Freemark, M. Henderson, L. Lefkovitch, and colleagues working in a Southern Ontario agricultural landscape represents the only large-area, long-term, multidimensional landscape ecology work in North America.

(1982, October) Piestany (CSSR—Slovakia) Conference on Landscape Ecological Research Problems, the sixth one, hosted by Milan Ruzicka. East of the "Iron Curtain," attendees come from 15 nations, including: the United States (Frank Golley and Forman), Canada (Michel Phipps and Clayton Rubec), Soviet Union (V. S. Preobrazhensky), and Cuba. Discussion led by I. S. Zonneveld on forming an International Association for Landscape Ecology (IALE). Lively party; also a two-per-nation "ark" evening at Ruzicka's weekend country place (reports on the conference published in 1982 by M. Ruzicka, and 1984 by V. S. Preobrazhensky).

(1982) IALE founded. Statutes and officers approved: President I. S. Zonneveld (the Netherlands); Vice Presidents Karl-Friedrich Schreiber (West Germany) and Richard T. T. Forman (United States); Secretary-General Severin ten Houte de Lange (the Netherlands); and Director of United States Region Frank B. Golley,

(1982, October) Brief report in the *IALE Bulletin* announces the founding of IALE and the *IALE Bulletin*.

(1982) Reports written and distributed by Forman to approximately 50–70 people potentially interested in landscape ecology: January, "The Veldhoven Conference and a Proposed International Association for Landscape Ecology"; and October, "Thoughts about the Piestany Conference."

(1982) Proposal by Paul G. Risser, James R. Karr, and Richard T. T. Forman to the NSF for a United States meeting on landscape ecology (funding approved by NSF Ecology Program Director Gary W. Barrett, January 1983).

Coalescence of the Field Internationally and in America: 1983–1987

(1982, November to 1984, March) Correspondence with Is Zonneveld, Frank Golley, Clayton Rubec, Gray Merriam, and Richard Forman regarding a proposed IALE Region for Canada (inconclusive result).

(Circa 1981–1985) Michel Godron and Forman were intensively working together on a landscape ecology book.

(1983, April) First North American workshop on landscape ecology held at Allerton Park, Illinois, hosted by Paul Risser. Twenty-nine participants including: Gary W. Barrett, Robert Costanza, Richard T. T. Forman, Michel Godron (France), Frank B. Golley, Louis R. Iverson, James Karr, Simon A. Levin, Gray Merriam (Canada), Robert V. O'Neill, David Sharpe, H. Henry Shugart, Carl Steinitz, Jack Ward Thomas, John A. Wiens, Robert Woodmansee. Focus is on spatial pattern effects in large heterogeneous areas, both natural and managed. After years of interactions in Europe and landscape ecology work, Forman learns from the impressive array of people and talents present, encouraging North American colleagues to develop their own flavor of landscape ecology; multidisciplinary perspectives, rather few areas of consensus.

(1983) Reports written and distributed by Forman to people potentially interested in landscape ecology: January, "Description of International Association for Landscape Ecology Founding"; and November, "Information Sources for Landscape Ecology."

(1983, July–November) Frank Golley and Zev Naveh (Israel) correspond in planning a landscape ecology plenary session for a future 1986 INTECOL Congress to be held in Syracuse, New York.

(1983, October) Editorial published in *BioScience* by Richard T. T. Forman, "An Ecology of the Landscape," highlights the field for ecologists and biologists.

(1983, October) IALE Executive Committee meets in Leersum, the Netherlands, host Paul Opdam. President I. S. Zonneveld, Secretary General S. M. ten Houte de Lange; Richard T. T. Forman attends from North America. Group interacts well, creates friendships.

(1983, October) IALE Bulletin, Editor Jesper Brandt (Denmark), includes a brief history of IALE, and landscape ecology in the Netherlands; also, an article by Forman on landscape ecology in the United States.

(1983) Reed F. Noss publishes an article in *BioScience* emphasizing that a landscape/regional perspective and analysis is key to protecting species diversity.

(1983–1984) Richard Forman and Gray Merriam separately publish early articles on the ecology of corridors and connectivity in landscapes.

(1984) Paul G. Risser, James R. Karr, and Richard T. T. Forman publish the results of the 1983 Allerton Park Workshop: *Landscape Ecology: Directions and Approaches,* 18 pages.

(1984, January) Milan Ruzicka is appointed as vice president of IALE.

(1984, August) First contributed papers session on landscape ecology at a professional meeting, ESA at Colorado State University; talks by Wiens and Forman.

(1984) Zev Naveh and Arthur S. Lieberman (United States) publish a book, *Landscape Ecology* (Fig. 2.1), with a new approach of drawing on diverse fields, pinpointing key roots from German geography and phytogeography, highlighting "the total human ecosystem," introducing an array of terminology, and giving some Mediterranean examples.

(1984) Larry D. Harris publishes a book, *The Fragmented Forest,* 210 pages, analyzing the United States Pacific Northwest forest from a landscape ecology, as well as island biogeography, perspective.

(1984, September) Harvard University appoints Richard T. T. Forman, Professor of Advanced Environmental Studies (PAES) in the field of landscape ecology (PAES Professor of Landscape Ecology), which helps to highlight the field.

(1984, October) IALE Conference held in Roskilde, Denmark; Jesper Brandt and Peder Agger, hosts. North Americans present: Gray Merriam and Michel Phipps (Canada); and Mark McDonnell, Vernon Meetenmeyer, and Richard Forman (United States). First IALE General Assembly; ecumenicalism of landscape ecology much in evidence. Good party.

(1984) Editors Jesper Brandt and Peder Agger publish five volumes, Proceedings of the First International Seminar of Methodology in Landscape Ecology Research and Planning, from the IALE Conference Roskilde, Denmark.

(1984, December) IALE Bulletin publishes a list of contact people in IALE regions worldwide, including Frank Golley for the United States.

(1984) IALE Bulletin announces death of Ernst Neef with a description of his contributions.

(1986) Book published by Richard Forman and Michel Godron, *Landscape Ecology*, 619 pages (Fig. 2.1), the first text presenting the "modern" land-mosaic perspective in landscape ecology.

(1986, July) Forman plenary talk on landscape ecology at the Conference on Science in the National Parks, United States National Park Service, Fort Collins, Colorado.

(1986) First landscape ecology conference in North America, hosted by Frank B. Golley and Monica G. Turner at University of Georgia. About 100 registrants, ecumenicalism in landscape ecology continues. Plenary talks given by Paul G. Risser, F. Herbert Bormann, Dennis H. Knight, Eugene P. Odum, Darrel Morrison, Richard T. T. Forman. United States Regional Association of the International Association for Landscape Ecology (USIALE) is established, and officers approved: Chair David Sharpe, Monica G. Turner, Joan I. Nassauer, William H. Romme, Jerry F. Franklin, and Paul G. Risser.

(1986) INTECOL and ESA meet jointly in Syracuse, New York. Presentations focused on landscape ecology include: a plenary talk by Zev Naveh, symposium organized by S. M. ten Houte de Lange, symposium talk by Richard Forman, two contributed papers sessions, and two poster sessions, which together highlight landscape ecology in North America and elsewhere.

(1986) Landscape ecologist Robert V. O'Neill and colleagues (United States) publish a book, *A Hierarchical Concept of Ecosystems,* 253 pages, providing valuable theory in landscape ecology.

(1986) Correspondence with Frank Golley, I. S. Zonneveld, Richard Forman, and two publishers interested in a possible journal on landscape ecology.

(1986, November) Symposium on landscape ecology at an ASLA Meeting held in San Francisco. Speakers include: Gary W. Barrett, "Landscape Architecture in the Rural Landscape."

(1987) The journal, *Landscape Ecology,* is established and published in cooperation with IALE, editor-in-chief Frank B. Golley. Editorial board includes previous landscape ecology leaders plus key people from many allied disciplines: Richard Forman, Michel Godron, Gunter Haase (East Germany), Wolfgang Haber, Simon Levin, Eddie van der Maarel, Gray Merriam, Zev Naveh, M. Numata (Japan), A. F. Ramos, Paul Risser, T. Rosswall, Milan Ruzicka, Karl-Friedrich Schreiber, Henry Shugart, Carl Steinitz, I. S. Zonneveld, and Ervin H. Zube. *Landscape Ecology,* first issue, encompassed articles by Jerry F. Franklin, Richard Forman, Robert H. Gardner, Bruce T. Milne, Robert O'Neill, Monica Turner, Ervin Zube, Carol Johnston, Robert J. Naiman, Dirk van Dorp (the Netherlands), and Paul Opdam.

(1987) Edited book published by Monica G. Turner, *Landscape Heterogeneity and Disturbance,* 239 pages (Fig. 2.1), based on the first United States Landscape Ecology Symposium in 1986.

(1987, April) Second USIALE symposium at University of Virginia, hosted by H. Henry Shugart and William E. Odum. About 200 registrants. John A. Wiens elected to USIALE Council.

(1987, April) Two symposia on landscape ecology at an American Association of Geographers meeting held in Portland, Oregon, organized by Vernon Meentemeyer and R. E. Frenkel. Speakers include: E. R. Hobbs, Jerry Franklin, R. A. Roundtree, Robert G. Bailey, Monica Turner, David Sharpe, and Richard T. T. Forman.

(1987, May) Landscape ecologist job advertised in the *ESA Washington Newsletter*.

(1987) The first government agency in North America to establish an official landscape ecology unit, "Applying Landscape Ecology to Managing Temperate Forests," United States. Forest Service, Rhinelander, Wisconsin, is directed by Thomas R. Crow.

(1987, June) Society for Conservation Biology founded in Montana, with many members learning from and contributing to landscape ecology.

(1987) ESA Annual Meeting includes two landscape ecology symposia, organized by Virginia H. Dale and Robert Gardner and by J. Kolasa.

(1987) Book edited by Denis A. Saunders, G. W. Arnold, A. A. Burbidge, and A. J. M. Hopkins, *Nature Conservation: The Role of Remnants of Native Vegetation,* 410 pages, published highlighting landscape ecology and island biogeography research in Australia.

(1987) Landscape ecology symposium on connectivity held in Munster, West Germany, Karl-Friedrich Schreiber, host. About ten Americans attend, including Monica Turner and Richard Forman. At party, attendees from each nation stand and sing a song.

(1987) Landscape ecology courses are taught at the University of Washington, University of New Mexico, Colorado State University, University of Tennessee, and Harvard University.

Three detailed observations related to the timeline seem useful. First, following the Troll tradition, terminology was of much interest in the European meetings, which always included a session for discussing terms. I avoided these, but should have attended one to understand the process. Second, the European meetings also held great parties to build bridges and enhance friendship among participants from so many nations. Third, only five women are mentioned before 1986 (Lenore Fahrig, Kathryn E. Freemark, Anne E. Galli, Hana Rambouskova, and Barbara Ruthsatz). Monica G. Turner and Joan I. Nassauer, impressive leaders and role models, stepped forward in 1986 at the first United States Landscape Ecology Symposium held in Athens, University of Georgia, thus catalyzing the welcome change evident today.

Glimpses of Key Characters

Following the preceding timeline of facts, I now introduce some of the key players using a more personal lens. I have known almost all of the 14 people here for many years and value them, not only as leaders but also as friends. Introductions are in the rough order I met or most interacted with them, and often highlight the way I knew them in circa 1978–1984.

Michel Godron Director of the major ecological centre of France in Montpellier. Educated as a physicist. Interprets spatial pattern with Information Theory. Incisive ideas. Travels worldwide. Likes working with young scholars from Africa and developing nations. A gentleman. He and his wife with deep ties to a French farmland region. Does not like administrative meetings in Paris, or large conferences. I had a 1977–1978 sabbatical at his centre, and enjoy working jointly on a landscape ecology book with him. We meet in about ten dispersed Euro–North American landscapes.

Steward T. A. Pickett Associate Professor of Botany at Rutgers University. From Kentucky, plus a plant ecology doctorate from Illinois. Reflective approach to science, often looking for frameworks or overarching concepts. Favorite comment for a student groping in research, “What’s the question?” Administration buries him. Friendly. Plays classical music. Office next door to mine. Shortly after hiring him, he gives me an article of his critiquing a piece of my work. As colleagues, we collaborate in countless activities.

David M. Sharpe Associate Professor and Chair of Geography Department, Southern Illinois University. Physical geographer. Collaborates with the Oak Ridge National Laboratory (ORNL) ecologists, including Stan Auerbach, Bob O’Neill, and Bob Gardner. Solid no-nonsense approach, linked with a big smile. We briefly collaborate on some proposals and projects. Among the few North Americans at the beginning 1981 Dutch Conference, we resonate and relish the experience.

Izaak S. Zonneveld Researcher and administrator at the ITC International Institute of Aerospace Survey and Earth Sciences located in Enschede, the Netherlands. Aerial photo interpretation as a foundation for evaluation of land for appropriate land uses. Much work internationally, including Africa. Energizing catalytic person with lots of ideas. Works well with diverse cultures. Loves a good party. Is *the* prime catalyst for promoting landscape ecology in Europe, and establishing IALE. Every year apparently climbs an electric transmission tower (>50 meters) to see and record landscape change. I later edit a book with him.

Ernst Neef Retired landscape ecologist from East Germany. Richard Forman meets and briefly converses with him and his wife only once, in 1981, on a boat in the Dutch polders. He mentions that a few years ago he received in the mail a landscape ecology book in Russian, which turns out to be his own book (Fig. 2.1). Unknown to him, it had been translated into Russian. He shows me three or four Dutch guilders, which is all the Neefs have left on this only (?) trip west of the “Iron Curtain.” I gather that his book is considered to be the only text on landscape ecology. He dies a few months later.

Frank B. Golley Professor at the noted Institute of Ecology, University of Georgia. Research on animal population dynamics. Also, on tropical ecosystem dynamics, with ample time in the American tropics. Sees landscape ecology as a natural broadening of perspective in ecology, and as an effective way to bridge the schism between natural science and social science. Likes to spend time living simply in the Georgia woods (something I often did as a child). A world traveler and diplomatically astute. A ready smile. We share unique memorable experiences together in the CSSR—Slovakia and elsewhere, and frequently interact on international items related to landscape ecology.

Milan Ruzicka Director of the Institute of Applied Biology and Ecology, Slovak Academy of Sciences, Bratislava. Remarkable feat of organizing several landscape ecology conferences during the socialist era, with worldwide participation. A land planner with one client over two decades…the government…, he progressively educates the client so that his later plans become much closer to the optimal. Slightly heavy-set, a strong personality. Plays a home-constructed musical instrument something like a giant vertical banjo, using feet and fingers. Grows orchard fruits, makes brandy. I drove him up Mt. Washington, New Hampshire, and he drove my car down alone.

Karl-Friedrich Schreiber Professor of Ecology, Munster, Germany. A plant physiological ecologist, strong on soil science and mineral nutrients. Studied with noted scientist, Heinz Ellenberg. Research in Germany and the Negev Desert. Tall, friendly person with obvious curiosity. Good at synthesizing subjects. Welcomed me in his home. From atop Mt. Washington, New Hampshire, he wanted to hike down, so this being my daily route during some long-ago doctoral research, I joined him.

Wolfgang Haber Partially retired from the university in Munich, he consults at the highest levels of the German government, for example, with the Foreign Minister. Chaired the Commission to address a huge chemical spill on the Rhine River. Tall, friendly man, diplomatically astute, and with a sincere manner. Helps landscape ecology develop, sometimes working behind the scenes. An enjoyable person to share field trips with. He once did a friendly review of a manuscript I wrote (in English), and detected 12 spelling errors.

Zev Naveh Professor of Environmental Studies, The Technion, Israel. A career committed to and deeply involved in his nation. Research focuses on the land, including soil, fire, afforestation, and developments for people. Short in stature but strong in personality. Attends many international meetings where he regularly challenges speakers and the norm. Argues forcefully for landscape ecology and especially for its human side, including aesthetics, social patterns, and housing. His brand of landscape ecology is especially appreciated in parts of Europe.

Gray Merriam Professor of Biology at Carleton University, Ottawa. Animal population biologist, now mainly working with small mammals. Career apparently has periodically challenged conventional wisdom in population studies. Initiated and effectively runs, with minimal administration, a major long-term, large-area, multidimensional research effort in the farmland-with-woods-and-hedges landscape of Southern Ontario. Stimulates students and others in research collaboration. Most likes to be in a wood-and-canvas canoe on a quiet lake in the North Woods (a lifelong relish of mine). One of the first committed landscape ecologists in North America, whose work I greatly respect.

Paul G. Risser Director of the Illinois Natural History Survey, Champaign, Illinois. From Oklahoma, and ever committed to its grassland. A plant physiological ecologist with a noticeable breadth of perspective. Also, an effective administrator who seems to catalyze activity and interesting initiatives. Sometimes appearing distant or thoughtful, he quickly hones in on the essence of things; he has a future of university presidencies. A stellar ability to summarize a disjointed discussion or activity, and pinpoint key themes. At the initial landscape ecology workshop in 1983, he ran the first dauntingly diverse day, so I volunteered for the second day; he could not wait to do the third wrap-up morning. Came to another landscape ecology meeting with a tennis racquet.

Paul Opdam Director of a government landscape ecology research program at Leersum, the Netherlands. A friendly welcoming person. In an agricultural landscape, he spearheads and runs the only European large-area, long-term, multidimensional ecology program. An animal population ecologist, he and his colleagues study birds and other species relative to diverse spatial patterns created by people and nature. Good productive mainly empirical research scholarship, increasingly in the context of land planning for society. We have visited the home of each other, met at numerous meetings, joined in many field trips, and always had rewarding conversation.

Jesper Brandt Biology professor teaching at Roskilde University in Denmark. A tall, friendly Scandinavian. He cohosts a delightful landscape ecology symposium held in Denmark, which includes a memorable field trip in the largest agricultural commune in Europe. Serves as the ever-dependable editor of the *IALE Bulletin,* which plays a significant role in developing landscape ecology, and keeping the dispersed and diverse characters interacting. Always upbeat conversations with Jesper.

Discoveries of Landscape Ecology

Reviewing the above timeline of events, reports, letters, publications, and key characters listed led to an unexpected or little-known conclusion. Seemingly, landscape ecology as a distinctive paradigm or field has been discovered three times. In the history of ideas, consider the: (1) physical geography approach of Carl Troll; (2) Dutch land mosaic concept of Paul Opdam and colleagues; and (3) land mosaic concept in North America associated with John Wiens, Gray Merriam, Lenore Fahrig, Steward Pickett, Richard Forman, and others in diverse landscapes.

1. Carl Troll, a German geographer and botanist, first mentioned the term landscape ecology in 1938–1939, and then developed and revised the concept from 1950 to 1970. He initially indicated that aerial photo research is the key for understanding geographical landscapes and ecosystems in the landscape, using “ecotope” as the smallest spatial unit practiced by geographers (Schreiber 1990). Troll considered “biogeocoenology” described by a Russian forest botanist, Sukachev

(1944–1953 publications), to be identical to his landscape ecology concept, and "biogeocoenose" equivalent to his ecotope.

Troll (1950) introduces landscape ecology within a terminological and methodological treatise especially for land classification. In this he includes the general concepts of "scale, hierarchy, spatial distribution, integration, natural versus cultural landscapes" (Wiens et al. 2007), as perhaps expected in a physical or cultural geography treatise. Little in the way of a new paradigm or field is evident. Indeed, "Troll (1966) indicated that landscape ecology at that point was not a new science, but merely a special viewpoint for understanding complex natural phenomena" (Schreiber 1990). In the late 1960s, he used the term "geoecology" as synonymous with landscape ecology.

Throughout his work, Troll remained focused apparently on natural landscapes, mainly analyzing vegetation, climate, and soil patterns. Also in Germany, the leading figures H. Ellenberg and R. Tuxen (1950s–1970s) emphasized plants and vegetation in natural landscapes, while extending their work in ecosystem, physiological, and gradient analysis directions. In contrast, E. Neef and colleagues, as well as H. Leser, often analyzing agricultural landscapes, focused more on physical geography and abiotic factors. In the 1970s–1980s German landscape ecology ideas were often tied to planning, even landscape architecture. The 1984 book, *Landscape Ecology,* by Z. Naveh and A. Lieberman seems to be in part a transition from the German geography approach to a somewhat more modern ecology one for landscape ecologists. Moss (2000), Bastian (2001), and Wu and Hobbs (2007) offer additional insights on these varied perspectives.

In my decades of interacting with landscape ecologists and many others in Europe, only once did someone volunteer firsthand information about C. Troll. Based on being briefly introduced, the British scientist reported that Troll was quite cordial. Perhaps landscape ecology will have to await scholarly histories by German historians.

2. The Dutch land mosaic approach of Paul Opdam and many research colleagues in the early 1980s focused on an agricultural landscape(s) with dispersed wooded patches. A 1981 paper uses the term "ecotope" (seldom used in later papers), but focuses on relating birds and other ecological attributes to landscape pattern/structure/arrangement. The scientists analyzed the ecological effects of patch size, patch arrangement, hedges/ditches/linear features, species diversity patterns, animal movement patterns, and much more.

Considering the preceding work in Europe, this represents no less than a new paradigm. Little evidence exists, based on perusing the text and literature cited in the articles, that this work is mainly building on the Troll or German geography concepts. Likewise, little evidence exists that the work was largely building on the early landscape ecology work emerging in North America. Rather, key background literature seems to emphasize individual articles from a wide scatter of researchers, such as R. MacArthur and E. Wilson (United States), L. Hansson (Sweden), C. Margules (Australia), G. Merriam (Canada), I. Hanski (Finland), M. Soule (United States), and F.

Burel and J. Baudry (France). An experimental study in Germany by H. Mader in 1981–1984 dovetails nicely with this Dutch landscape ecology approach.

I regret that I have never talked this through with Opdam, but trust that the researchers will write their own history. I would like to learn.

3. The North American land mosaic approach of John Wiens, Gray Merriam, Lenore Fahrig, Steward Pickett, Richard Forman, Larry Harris, David Sharpe, Paul Risser, Reed Noss, Mark McDonnell, and others is documented in the preceding timelines. The early steps were basically taken without knowledge of the two European approaches above (though after learning about them in 1981, both were recognized and cited). Again, the land mosaic work in North America represents a paradigm developed de novo.

The roots and foundations underlying the initial steps of the timeline in North America are encapsulated elsewhere (Forman and Godron 1986; Forman 1995). The following seem to be the main roots: (1) Island biogeography theory; (2) gradient analysis; (3) succession, disturbance, and patch dynamics; (4) physical geography (especially North American); (5) early spatial models of the land or landscape (from Europe); (6) vegetation geography; (7) zoogeography; (8) ecosystem concept; (9) spatially focused vegetation methodology; (10) agricultural hedgerow studies; and (11) quantitative geography (mainly from the UK). While these seem to me the key roots, I am reminded of an insight from landscape ecologist, Robert O'Neill, who commented that his list of giant shoulders stood on might well be quite different from mine.

In brief, landscape ecology effectively originated independently three times. The first manifestation seems to have somewhat faded in landscape ecology, with modest or minimal effect on the following two. The second and third manifestations developed almost concurrently and are essentially the same. Together, they represent the core of "modern" landscape ecology today. In this context, the contrast often mentioned between European and North American landscape ecology has a grain of truth. But overall, it is misleading.

Finally, it is interesting to note that in Australia, Denis A. Saunders, Richard J. Hobbs, and many research collaborators working in the Western Australia Wheat Belt have effectively accomplished a fourth, relatively independent discovery of landscape ecology (see Chap. 9). Their large-area, long-term, multi-investigator, multidimensional work conceptually is nearly identical to those in the Dutch and North American landscapes. Perusing the literature cited in Sanders et al. (1987) (some by foreign researchers) suggests that the main intellectual roots were island biogeography (e.g., MacArthur and Wilson 1976; J. Terborgh 1974–1983; Diamond 1975; Simberloff 1976), gradient analysis (e.g., Curtis and Cottam 1956–1971; Whittaker 1970), vegetation dynamics (e.g., Watt 1947; White 1979; Shugart and West 1980), and hedgerows (e.g., Arnold 1982; Baudry 1984). The Troll geography approach apparently is not cited. The Opdam and colleagues approach is cited about five times. And the North American approach is cited about 18 times (Four for G. Merriam, L. Fahrig, and colleagues; 14 for R. Burgess, D. Sharpe, L. Harris, S. Pickett, P. White, P. Risser, M. McDonnell, R. Forman, and colleagues). The Australian

Wheat Belt work was followed by analogous impressive studies of wooded Australian landscapes by D. Lindenmayer and colleagues, 1990 to the present.

In effect, landscape ecology now has a solid broad international footing for the future.

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Chapter 3
Right Time at the Right Place in History

Gary W. Barrett

Introduction

From 1980 to 1981, I served as a panel member for the initial program for Long-Term Ecological Research (LTER); I was the ecology program director within the National Science Foundation (NSF) from 1981 to 1983. During my term with NSF, I was appointed to administer funds for the best proposals with a significant applied component, a requirement in the charter of NSF. This administrative challenge was most rewarding to me because of my interest in applied ecology, that is, the need to wed basic with applied ecology (Barrett 1984a, b, 1987). I considered those 3 years of service to be one of the most inspiring and worthwhile years of my professional career. Guidelines, such as "conflict of interest," "confidentially," and "peer review," were (and I assume remain) hallmarks of the NSF. As a young ecologist, I was impressed that less than 5 percent of the NSF appropriation each year was directed at program administration (>95 percent going toward supporting excellent research by Principal Investigators (PIs)).

In those days previous to NSF, I also was concerned with regard to how best to encompass humankind into the ecosystem concept. My earlier challenges to this integration need included integrative fields of study, such as stress ecology (Barrett et al. 1976; Barrett 1981; Barrett and Rosenberg 1981); interdisciplinary fields of research, such as environmental science (Barrett and Puchy 1977); and an integrative approach to research, such as a problem-solving algorithm (Baldwin et al. 1975; Barrett 1985). One might wonder why I chose the above title for this chapter—permit me to explain. "Right time at the right place," refers to NSF (1981–1983). NSF in those days was located at 1800 G Street NW, Washington DC. Opportunities and challenges while serving at NSF were numerous. For example, I recommended funding and attended a team-research expedition following the eruption of Mount

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Saint Helens on 18 May 1980. The experience of NSF Program Director frequently provides opportunity to gain insights into new fields of study. I recall when William Jordan III visited NSF and discussed with several individuals *Ecological Restoration*, which is now recognized as a vital emerging field of study (Jordan et al. 1987; Jordan 2003), and when Richard Forman invited me to Rutgers University to provide me with an onsite clear understanding of landscape ecology.

Other site visits included the Konza Prairie, located near Manhattan, Kansas; University of Minnesota, where I saw Cedar Lake Bog and reflected on the contribution of Ray Lindeman to the trophic-dynamic aspect of ecology; and Tall Timbers Research Station and Land Conservancy, in proximity to Tallahassee, Florida, where fire ecology is almost a religion. After two wonderful and challenging years at NSF, I became increasingly interested in holistic science, especially after being trained by Eugene P. Odum in ecosystem science at the University of Georgia (Barrett and Barrett 2001b). Thus, the opportunity to recommend funding for Allerton Park Workshop on landscape ecology from 25 to 27 April 1983 was most exciting.

One day during my stay at NSF, Bob Woodmansee, then director of the NSF ecosystem studies program, showed a color slide of a grassland community (likely the Pawnee Grassland Site where Bob had conducted research) during an internal NSF seminar. The Pawnee Grassland site was a major component of the International Biological Program (IBP) Grassland Biome Program at that time (Coleman 2010). In the background of this image was evidenced a ranch with trees, buildings, cattle, and human activity. At that instance, I recognized that human systems should be reintegrated into our decipher of natural systems at the "landscape scale."

During my early years, I became interested regarding the relationship between human and natural systems (Baldwin et al. 1975; Barrett 1981). I have maintained an association with that relationship throughout my academic career (Barrett et al. 1999, 2009; Barrett and Barrett 2001a). Recently (5 July 2013), on the cover of *Science* appeared an aerial view of the relationship of farmland to the city of London. The accompanying article to this image (Bateman et al. 2013) shows how ecosystem services are best quantified at the landscape scale. This image afforded me the opportunity to reflect on my early and evolving career as a landscape ecologist.

On 7 December 1982, a grant proposal (#83-04762) was logged into the NSF network entitled "Landscape Ecology Workshop," submitted by Paul G. Risser, James R. Karr, and Richard T. T. Forman Fig. 3.1 (a–c). Workshop proposals are typically mailed to peer reviewers, and do not go to an NSF panel for review. I selected 10 ad hoc reviewers, and, as I recall, 6 responded. I should note that the NSF Program Director makes the recommended final decision regarding funding of proposals. During my 2-year NSF tenure, this was the only proposal that I intended to recommend for funding regardless of ad hoc review. Fortunately, all six outside reviews strongly recommended funding. I also should mention that if a program director goes against the panel or ad hoc recommendation, her or his decision must be justified to the division director to whom she/he reports. NSF division directors during my tenure were John L. Brooks and W. Frank Harris, two outstanding division administrators.

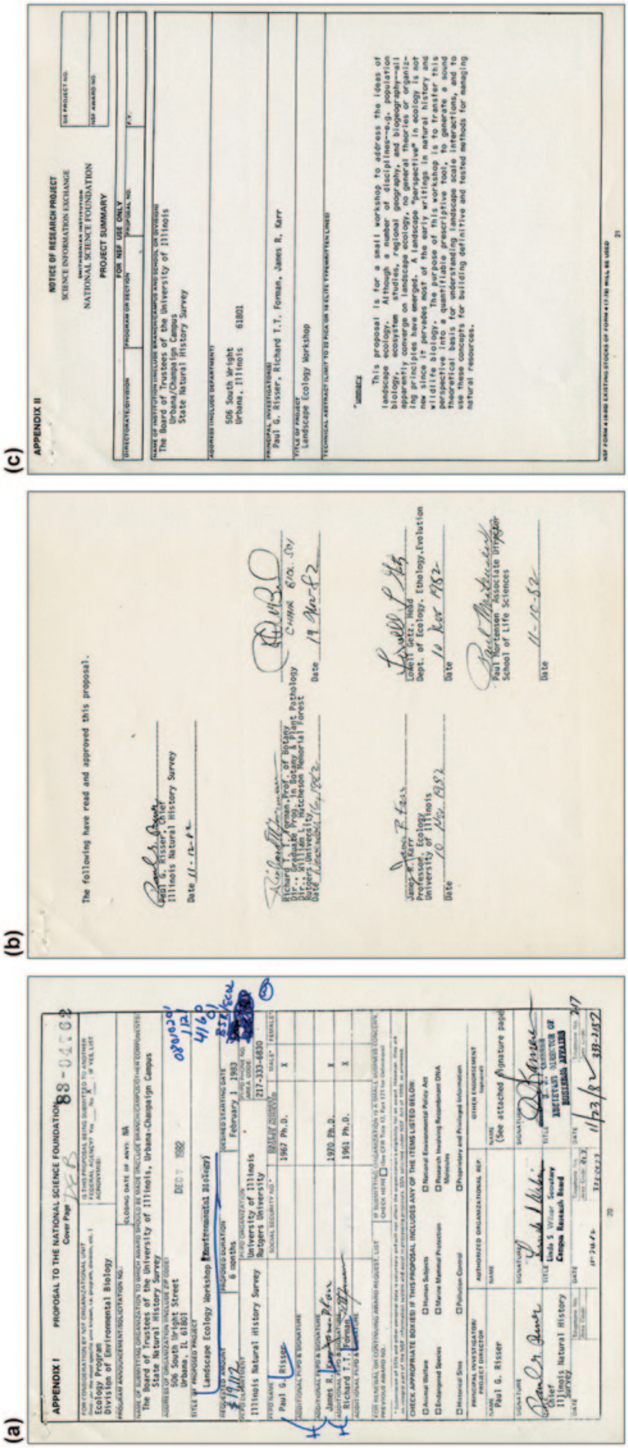

Fig. 3.1 **(a)** Cover page, **(b)** signature, and **(c)** project summary of the proposed project entitled *Landscape Ecology Workshop*, to be considered by National Science Foundation Unit—Ecology Program, Division of Environmental Biology, submitted on 7 December 1982

It is interesting and worthwhile to revisit the original NSF proposal by Risser, Karr, and Forman. The summary abstract is as follows:

> This proposal is for a small workshop to address the ideas of landscape ecology. Although a number of disciplines—e.g., population biology, ecosystem studies, regional geography, and biogeography—all apparently converge on landscape ecology, no general theories or organizing principles have emerged. A landscape 'perspective' in ecology is not new science it pervades most of the early writings in natural history and wildlife biology. The purpose of this workshop is to transfer this perspective into a quantifiable prescriptive tool, to generate a sound theoretical basis for understanding landscape scale interactions, and to use these concepts for building definitive and tested methods for managing natural resources.

I should mention that the cost of this workshop was $19,112—not a bad investment concerning the development of a new paradigm!

Authors of the proposal note that the ecosystem concept focuses on a relatively homogeneous area or community, while the landscape concept focuses on a heterogeneous area that includes several relatively homogeneous ecosystems. They additionally note that when spatial or topographic, geographic, and edaphic heterogeneities combine with temporal pattern, environmental mosaics of extraordinary complexity are produced in natural and human-induced landscapes. As an example, they describe how temporal changes in the physical environment may force species to migrate; such migration varies from very short distances to between continents. Clearly, much knowledge is to be gained by addressing population processes that govern an organism's ability to survive in various regional landscapes.

Wisely, they note that the landscape perspective is embodied in *A Sand County Almanac, And Sketches Here and There* (Leopold 1949), and many earlier writings in natural history and wildlife biology. The PIs of this proposal sought to transfer this perspective into a quantifiable tool, generate a sound theoretical basis for understanding landscape scale interactions, and use the concepts for building defining methods for managing natural resources. They clearly recognized that landscape ecology had the potential to transcend the classical divisions between basic and applied ecology and between population and ecosystem ecology.

They also noted that most past research had ignored the spatial scale of landscape ecology. Such discussion was not the case during the workshop held at Allerton Park, Piatt County, Illinois, 25–27 April 1983. John Wiens, who attended this organizational workshop, reflected 25 years later (Wiens 2008) that heterogeneity, scale, and dynamics were threads that ran throughout the discussion at this workshop. Indeed in the NSF proposal, it was noted that ecosystem science had progressed from the single watershed input–output context to studies designed to investigate mechanisms and processes, which might be informative at the landscape spatial scale (Sharpe et al. 1980; Bormann and Likens 1981; Burgess and Sharpe 1981; Shugart and West 1981).

Returning to the logistics of the Allerton Park Workshop, participants from a number of disciplines agreed that no uniform theory or principles had been identified in landscape ecology at that time. To move the discussion forward, 10 fundamental questions were posed (abbreviated below):

1. Is it possible to define a bona fide area of science termed landscape ecology?

2. Are there emergent properties at the landscape scale that are not simply additive properties of the included ecosystem units?
3. Is the study of landscape ecology useful only when major attention is paid to the relevant cultural, sociological, economical, and political considerations?
4. What is the nature of landscape change through time, and how are these temporal changes related to spatial scale?
5. How are the fluxes of organisms, materials, and energy related to the structure of the landscape?
6. Is it possible to predict landscape pattern that is resistant or resilient to climate variations, productive in terms of biotic diversity, or efficient in nutrient retention or capture of energy?
7. Can population structure or biotic diversity be predicted from characteristics of the patches and intervening mosaic?
8. Are theories of population biology applicable to the development of concepts and hypotheses related to landscape patterns?
9. Is our understanding of mathematical spatial models adequate to enhance our concept of landscape ecology?
10. Are concepts of landscape ecology mandatory for adequate resource management?

Participants at this 1983 Allerton Park Workshop are pictured in Fig. 3.2. Robert Woodmansee, as Director of Ecosystem Studies, and I, as Director of Ecology, represented NSF. It was noted by Wiens (2008) that no women participants were among the 25 present; he suggested that this unfortunate oversight was "a sign of the times."

The proceeding of this essential workshop was published in 1984 (Risser et al. 1984) in a report entitled "Landscape ecology: Directions and Approaches." The conclusions (abbreviated below) were as follows:

1. There is a need for a set of coherent principles about the ecological characteristics and behavior of landscape units because no unifying theory has been developed and communicated;
2. Landscape ecology is not a distinct discipline or simply a branch of ecology, but rather is the synthetic intersection of many disciplines that focus on the spatial–temporal pattern of the landscape (I will return to this definition later in this chapter);
3. Conceptually, landscape ecology considers the development and maintenance of spatial heterogeneity, spatial and temporal interactions and exchanges across heterogeneous landscapes, influence of heterogeneity on biotic and abiotic processes, and management of that heterogeneity;
4. The process of redistribution of organisms, materials, and energy among landscape components is thus an essential feature of landscape ecology;
5. A special need exists for research in numerous aspects of spatial patterning and its effects on redistribution processes;
6. Many fundamental questions in both basic ecology and resource management issues require understanding and application of a landscape perspective;

Fig. 3.2 Participants in the Allerton Park Workshop, Piatt County, Illinios, 25–27 April 1983. (*Left* to *right*): R. V. O'Neill, J. R. Karr, P. G. Risser, M. Wiley, S. A. Levin, W. G. Ruesink, M. Godron, H. H. Shugart, R. L. Rabb, F. B. Golley, R. Woodmansee, R. Costanza, J. A. Wiens, C. Steinitz, G. W. Barrett (*Back row*); T. Hoekstra (*Middle row*); W. J. Parton (*Middle row*); D. B. Botkin (*Front row*); J. W. Thomas (*Back row*); G. Merriam, D. M. Sharpe, L. R. Iverson, G. C. Sanderson, C. Becker, R. T. T. Forman

7. Quantitative methods provide many of the analytical tools necessary for progress in landscape ecology;
8. Principles of landscape ecology will catalyze a convergence of developing methodology and theory that will provide practical improvement in existing methodologies;
9. Addressing issues in landscape ecology will result in critical consideration of several conventional and restrictive assumptions, such as homogeneity and equilibrium;
10. Principles of landscape ecology will be identified in part by intellectual exchanges, such as exemplified by the Allerton Park Workshop; and
11. Improvements in the conceptual base of landscape ecology will assist in the communication of ideas between and among groups that now suffer from the absence of a common framework.

The Risser et al. (1984) report (Fig. 3.3), based on the Allerton Park Workshop, made numerous recommendations to NSF and the *Ecological Society of America*,

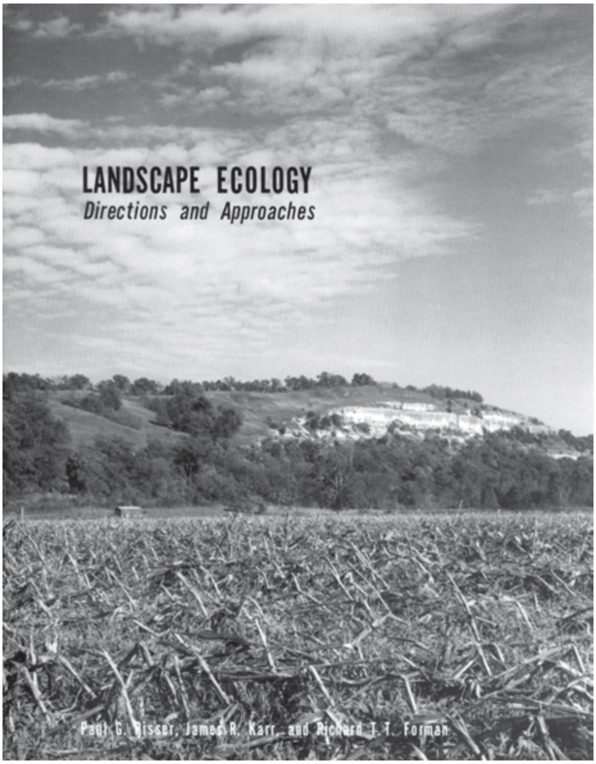

Fig. 3.3 Front cover page of the 1984 Allerton Park Report, "Landscape Ecology: Directions and Approaches," authored by P. G. Risser, J. R. Karr, and R. T. T. Forman

including recognizing the interdisciplinary nature of landscape ecology, increased funding for high-quality basic research, curricula and training programs within colleges and universities, and encouraging the intellectual development of landscape ecology through symposia and journal review guidelines. The report also noted that because personnel in landscape ecology address questions that transcend boundaries of agencies and disciplines, and have direct application to regional issues, land management agencies cooperate with supportive programs in landscape ecology.

Returning to the definition and concept of landscape ecology in the Allerton Park Report, the following definition for this interdisciplinary field of study was described specifically as, "landscape ecology considers the development and dynamics of spatial heterogeneity, spatial and temporal interactions and exchanges across heterogeneous landscapes, influences of spatial heterogeneity on biotic and abiotic processes, and management of spatial heterogeneity." In other publications, I have noted that landscape ecology is an integrative paradigm that helps to wed ecological theory with practical application (Barrett and Bohlen 1991; Barrett and Peles 1994; Barrett and Farina 2000; Barrett and Odum 2000).

Interestingly, one of the recommendations in the Allerton Park Report was to expedite development of landscape ecology by encouraging colleges and universities to contemplate the scope of curricular training required to educate landscape ecologists. One of the most effective means to educate college and university students is to select ecology textbooks that include chapters or sections specifically devoted to the subject of landscape ecology.

At the time of the Workshop Report (1984), few textbooks even mentioned landscape ecology, let alone devote a chapter to this new paradigm. Today most ecology textbooks (Odum and Barrett 2005; Molles 2008; Krebs 2008; Cain et al. 2011) contribute major chapters to landscape ecology; these chapters also provide an excellent service in integrating ecological theory with landscape management (i.e., integrating basic science with its application).

The Allerton Park Workshop Report has also been a catalyst for a quality array of benchmark books focused on landscape ecology, including Burgess and Sharpe (1981), viewing the dynamics of forest islands in human-dominate landscapes; Naveh and Lieberman (1984), focusing on theory and application; Turner (1987), reviewing landscape heterogeneity and disturbance; Hansen and di Castri (1992), discussing the relationship of landscape boundaries to biotic diversity and ecological flows; Turner and Gardner (1991), describing quantitative methods in landscape ecology; Forman (1997), discussing and describing landscape mosaics; Barrett and Peles (1999), reviewing investigations focused on a model taxonomic group, namely small mammals; Klopatek and Gardner (1999), outlining application of landscape ecology methodologies to management issues; Turner et al. (2001), integrating landscape theory with practice and application; Liu and Taylor (2002), integrating landscape ecology with natural resource management; Benson and Roe (2007), discussing sections on sustainable landscape development; Wu and Hobbs (2007), discussing key topics in landscape ecology; and Collinge (2009), addressing the ecology of fragmented landscapes; I would be remiss not to mention what I consider to be the first textbook in landscape ecology, namely, the classic book *Landscape Ecology*, coauthored by Forman and Godron (1986).

I should mention that the Allerton Park Report to NSF did not view landscape ecology as a distinct discipline (Risser et al. 1984), but rather the intersection of many related disciplines that focus on the spatial–temporal pattern of the landscape. Troll (1966) also indicated that landscape ecology was not a new science, but rather a special viewpoint in understanding complex natural phenomena. However, Zonneveld (1988) argued that landscape ecology is a science, rather than a mix of social activities, a state of mind, or human attitude. One of the earlier meanings of landscape, especially in fields such as landscape architecture and landscape planning, clearly contains an aesthetic element (Zonneveld 1990). More recently, Barrett et al. (2009) position the aesthetic landscape as an economy of nature. Other early perspectives of landscape ecology include the chronological aspect (i.e., a conglomerate of land units used for mapping patterns of the landscape), landscape as an ecosystem, and the total human ecosystem (Naveh 1982; Zonneveld 1990). Because the study of land requires many disciplines, Naveh and Liberman (1984) noted that it was paramount to recognize landscape ecology as a "transdisciplinary" science.

Thus, with the involvement of numerous disciplines focusing on the landscape, and with the rapid development of landscape approaches in Europe, the science of landscape ecology generated considerable interest in the United States. Also, an increase in American attendance in European symposia contributed to the establishment of the International Association for Landscape Ecology (IALE) in 1982 (Forman 1990 regarding early history of IALE).

In summary, the "stage was set" for the establishment of the United States regional Association for Landscape Ecology (USIALE) within IALE. The Landscape Ecology Workshop, funded by NSF, held at Allerton Park, Illinois, 25–27 April 1983, was the catalyst for the formal articulation of the landscape ecology emerging in North America. This book captures this evolutionary process during the previous 30 years; may the next 30 years be equally creative and productive.

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Chapter 4
Twenty-Five Years of United States Landscape Ecology: Looking Back and Forging Ahead

Monica G. Turner

Introduction

Looking Back

Landscape ecology is now a mature discipline, and I have been privileged to watch it grow and flourish in the United States during my professional career. It is hard for me to believe that more than 25 years have passed since the first United States Landscape Ecology Symposium was convened in January 1986 at the Institute of Ecology, University of Georgia (UGA). At that time, Ronald Reagan was president, the Soviet Union was intact, incidents including Chernobyl and Challenger were in the news, and world population was a mere 4.8 billion people. Landscape ecology concepts were only emerging, and the technology was nascent. There were relatively few landscape ecology publications (e.g., Forman and Godron 1981; Risser et al. 1984; Naveh and Lieberman 1984; Forman and Godron 1986) and no commercial geographic information systems or digital spatial pattern analysis programs were available. Yellowstone National Park had not yet burned, the oil tanker, Exxon Valdez, had not yet spilled its oil, and most ecologists had heard little about the northern spotted owl (*Strix occidentalis caurina*). Time has indeed marched on, and those earlier days when landscape ecology was little known and not widely accepted seem distant. A quarter century later, it is appropriate to reflect on how landscape ecology and the United States Regional Association of the International Association for Landscape Ecology (USIALE) developed in the United States. In this chapter, I describe how and why the first United States Landscape Ecology Symposium came about, and how it helped to catalyze subsequent progress in the field. Next, I reflect on USIALE during the 2 years (1994–1996) that I chaired the executive committee. Finally, in the spirit of looking forward, I offer a set of questions drawn from active areas of contemporary landscape ecology where I see potential for continued

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progress. This chapter was developed from oral presentations that I delivered at the 2010 25th USIALE Anniversary Symposium, "Is What Humans Do Natural?" held in Athens, Georgia, UGA.

The First United States Landscape Ecology Symposium "The Role of Landscape Heterogeneity in the Spread of Disturbance"

Dr. Frank B. Golley (1930–2006) and I organized that first symposium in 1986, about six months after I completed my PhD in Ecology at UGA under his guidance. Sadly, Frank died in 2006 from illness contracted during his years of fieldwork in the tropics (see Turner et al. 2007), and he was deeply missed at the 25th USIALE Anniversary Symposium. Frank was among a small handful of ecologists representing the United States who were crossing the Atlantic Ocean periodically to participate in landscape ecology meetings in Europe during the early 1980s. He was also among the attendees at the Allerton Park workshop (Risser et al. 1984), who explored the relevance of these new ideas for ecology in the United States. Upon returning from such trips, Frank always shared the new ideas and thinking with students and faculty at the Institute of Ecology. As a young scientist and graduate student, I was intrigued by the new directions that were emerging—notions about spatial pattern in the environment and why it might be important, and about ecological patterns and processes at large scales. These ideas made sense to me and seemed to open a range of new ecological questions waiting to be explored. My graduate training was in ecosystem ecology, not landscape ecology, and I was studying the consequences of interacting disturbances (fire along with grazing and trampling by feral horses) in a salt marsh on Cumberland Island National Seashore, Georgia. Perhaps because disturbances are inherently spatial, or large organisms conspicuously navigate heterogeneous environments and use multiple habitats, the emerging ideas of landscape ecology were appealing to me.

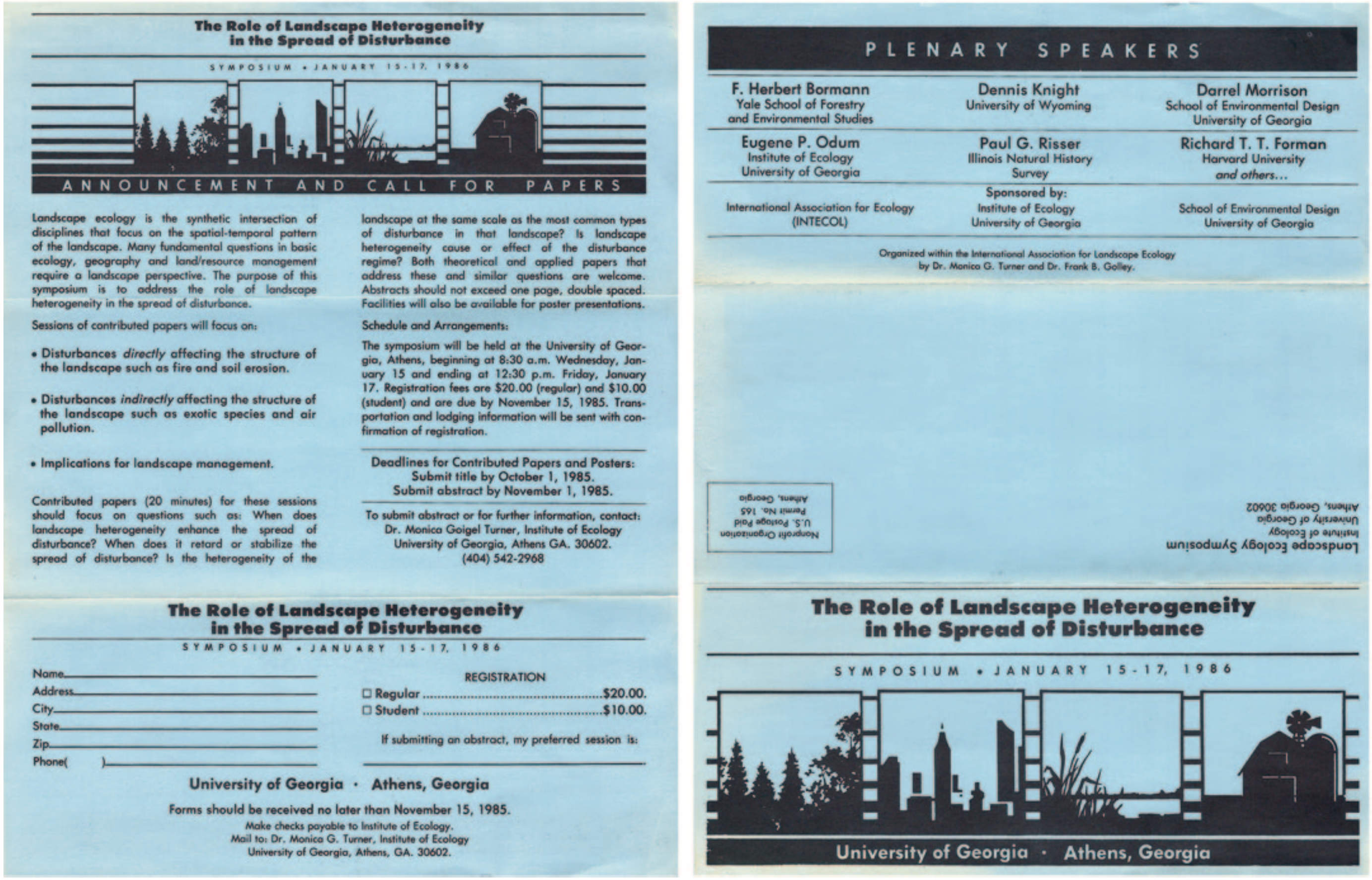
So how did the 1986 symposium develop? As I was completing my PhD in 1985, Dr. Eugene P. Odum (eminent ecologist and a member of my doctoral advisory committee) offered me a 2-year postdoctoral position on an interdisciplinary project focused on understanding social and environmental changes in the state of Georgia. Although relieved to have a position, I was worried about remaining at the same institution and discussed these concerns with Frank. Always the mentor, Frank helped me strategize ways in which to make the most of the opportunity. Given my budding interest in landscape ecology, Frank suggested that remaining at UGA could provide the chance to do something extra—such as organizing a symposium on landscape ecology for United States scientists. Interest in landscape ecology was growing but diffuse, and the time seemed ripe to explore the ideas in an open venue. This seemed like a terrific professional opportunity for me (and it was), though I was completely ignorant about how to proceed. With guidance from Frank and support from Gene Odum, we went about organizing a symposium; there was no a priori plan for it to be an annual event. Frank coached me through the process but allowed me the freedom (and responsibility) to do it, and we began planning in the late spring of 1985.

The first challenge was to select a theme for the symposium. From my doctoral research, I had a strong interest in disturbance dynamics, and "How does landscape heterogeneity affect the spread of disturbance?" was among the primary research questions identified at the Allerton Park workshop (Risser et al. 1984). Further, there was growing interest in disturbance within ecology, fueled by concepts of the steady-state mosaic (Bormann and Likens 1979), patch dynamics (Paine and Levin 1981), and landscape diversity (Romme and Knight 1982). Disturbance was (and remains) an ideal focal topic in landscape ecology because disturbances both create and respond to landscape heterogeneity. We settled on "The Role of Landscape Heterogeneity in the Spread of Disturbance," as the theme and began to plan in earnest.

Six plenary speakers were invited to the meeting—two from UGA and four from other institutions—and all agreed to attend. I vividly recall sitting at my desk, in front of my phone, gathering my notes and my nerve before calling potential plenary speakers. My own students find it mildly humorous that I was so nervous about contacting these people. However, these were luminaries in ecology—Herb Bormann, Dennis Knight, Paul Risser, and Richard Forman—and I was an unknown 26-year-old just finishing her PhD. Why was each invited? Herb Bormann (Yale University) had originated the steady-state mosaic concept in collaboration with Gene Likens and was a leading thinker in ecosystem ecology. Dennis Knight (University of Wyoming) studied disturbances in western forests and had developed ideas of landscape diversity with his PhD student, Bill Romme. Paul Risser (then at the University of New Mexico) was a leader of the Allerton Park workshop. Richard Forman (then at Rutgers University) was already beginning to conceptualize the discipline. From the UGA campus, Daryl Morrison was head of the School of Environmental Design and working to bridge landscape architecture and ecology, and Gene Odum was an especially holistic-thinking ecologist. To a person, they were gracious to a young scientist and enthusiastic about the symposium.

With speakers lined up, we proceeded to announce the meeting and arrange the logistics. We had no targeted funding, and my husband Michael Turner, a graphic designer, developed the logo and flyer for the meeting (Fig. 4.1). Ultimately, we hosted a 2.5-day conference that included plenary talks (Table 4.1), commentaries on each plenary talk, contributed papers and posters, and a reception at the UGA Botanical Gardens. Frank's secretary liked to do catering on the side, and she prepared the hors d'oeuvres for the reception (though we admittedly underestimated the amount of food that hungry landscape ecologists could consume!). About 90 individuals attended the symposium, representing academic, federal, and state agency scientists. Attendees were from varied disciplines, including landscape architecture, geography, ecology, wildlife, and forestry and included empiricists and modelers. We all fit in one auditorium, there were no concurrent sessions, and there was a wide exchange of ideas. Notably, young scientists (relatively new PhD fellows) were well represented at the meeting, and I think this was key to the rapid subsequent development of the field.

A number of consistent themes emerged during the presentations, and many of those themes remain relevant. For example, disturbance interactions, resilience, and



The Role of Landscape Heterogeneity
in the Spread of Disturbance

SYMPOSIUM • JANUARY 15-17, 1986

ANNOUNCEMENT AND CALL FOR PAPERS

Landscape ecology is the synthetic intersection of disciplines that focus on the spatial-temporal pattern of the landscape. Many fundamental questions in basic ecology, geography and land/resource management require a landscape perspective. The purpose of this symposium is to address the role of landscape heterogeneity in the spread of disturbance.

Sessions of contributed papers will focus on:

- Disturbances *directly* affecting the structure of the landscape such as fire and soil erosion.
- Disturbances *indirectly* affecting the structure of the landscape such as exotic species and air pollution.
- Implications for landscape management.

Contributed papers (20 minutes) for these sessions should focus on questions such as: When does landscape heterogeneity enhance the spread of disturbance? When does it retard or stabilize the spread of disturbance? Is the heterogeneity of the landscape at the same scale as the most common types of disturbance in that landscape? Is landscape heterogeneity cause or effect of the disturbance regime? Both theoretical and applied papers that address these and similar questions are welcome. Abstracts should not exceed one page, double spaced. Facilities will also be available for poster presentations.

Schedule and Arrangements:

The symposium will be held at the University of Georgia, Athens, beginning at 8:30 a.m. Wednesday, January 15 and ending at 12:30 p.m. Friday, January 17. Registration fees are $20.00 (regular) and $10.00 (student) and are due by November 15, 1985. Transportation and lodging information will be sent with confirmation of registration.

Deadlines for Contributed Papers and Posters:
Submit title by October 1, 1985.
Submit abstract by November 1, 1985.

To submit abstract or for further information, contact:
Dr. Monica Goigel Turner, Institute of Ecology
University of Georgia, Athens GA. 30602.
(404) 542-2968

The Role of Landscape Heterogeneity
in the Spread of Disturbance

SYMPOSIUM • JANUARY 15-17, 1986

Name
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City
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REGISTRATION
☐ Regular .... $20.00.
☐ Student .... $10.00.

If submitting an abstract, my preferred session is:

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Forms should be received no later than November 15, 1985.
Make checks payable to Institute of Ecology.
Mail to: Dr. Monica G. Turner, Institute of Ecology
University of Georgia, Athens, GA. 30602.

PLENARY SPEAKERS

F. Herbert Bormann
Yale School of Forestry
and Environmental Studies

Dennis Knight
University of Wyoming

Darrel Morrison
School of Environmental Design
University of Georgia

Eugene P. Odum
Institute of Ecology
University of Georgia

Paul G. Risser
Illinois Natural History
Survey

Richard T. T. Forman
Harvard University
and others...

Sponsored by:
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Organized within the International Association for Landscape Ecology
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Fig. 4.1 First United States Landscape Ecology Symposium, *The Role of Landscape Heterogeneity in the Spread of Disturbance*, University of Georgia, Athens, Georgia, 1986 Program with logo designed by Michael Turner

Table 4.1 Plenary talks delivered at the first United States Landscape Ecology Symposium held in Athens, Georgia, in January 1986

Plenary speaker	Presentation title
Paul Risser	Landscape Ecology: Sate of the Art
Herb Bormann	Regional Air Pollution and Landscape Heterogeneity
Dennis Knight	Parasites, Lightning and the Vegetation Mosaic in Wilderness Landscapes
Gene Odum	Soil Erosion as Both Input and Output Disturbance
Darrel Morrison	Landscape Restoration in Response to Previous Disturbance
Richard Forman	Landscape Ecology, Disturbance, and the Ethics of Isolation

cumulative effects were considered in detail. Issues of spatial and temporal scale and challenges of extrapolation emerged in a number of presentations. Several presenters addressed water quality, riparian buffers, and nutrient pathways in human-dominated landscapes. Others considered species diversity in fragmented forests, or organisms as agents of spatial pattern. Two studies that subsequently led to very highly cited publications were first presented at the symposium. Jerry Franklin presented the heuristic model for how forest cutting patterns would influence the spread of subsequent disturbances, using Pacific Northwest conifer forests as an example (Franklin and Forman 1987, cited 409 times in ISI Web of Science as of April 2010), and Osvaldo Sala described regional patterns of net primary production in the Great Plains (Sala et al. 1988, cited 359 times as of April 2010). There was a tremendous shared sense of excitement for new ideas, and many hallway conversations focused on questions and methods for tackling more.

The primary product from the symposium was an edited book (Turner 1987; Fig. 4.2); once again, I am indebted to Frank Golley for suggesting the idea and for

Fig. 4.2 Monica G. Turner upon presentation by Terry L. Barrett of the book, *Landscape Heterogeneity and Disturbance*, containing her original inscription, gifted to Eugene P. Odum in 1987. This book was presented to her during the 2010 25th Anniversary Symposium of the United States Regional Association of the International Association for Landscape Ecology, University of Georgia, Athens, Georgia. (Photography by Wingate Downs Photo Courtesy of Terry Barrett)

coaching me through it. Ever the strategic thinker, Frank thought it would be advantageous both to have a product from the symposium and for me to learn how to edit a book (after all, he said, that would be a professional expectation up the road). Always one to embrace a challenge, I eagerly agreed to edit a book. This required developing a prospectus, securing a publisher, inviting contributors, and overseeing the review process. The resulting volume was published by Springer in 2007 and included chapters from each plenary speaker and several additional attendees. The chapter authored by Vern Meentemeyer and Elgene Box on scale effects in landscape ecology was especially influential (Meentemeyer and Box 1987).

Another key outcome from the 1986 symposium was the organizational meeting that led to formation of USIALE. In Europe, IALE had already been organized into regional associations by country, and we followed that model. The inaugural executive committee included Chair David Sharpe, Program Chair Monica Turner; Secretary Joan Nassauer; Treasurer Bill Romme; and Councilors-at-Large John Wiens, Jerry Franklin, and Paul Risser. There was a conscious effort to make the society reflect the interdisciplinary character of the discipline, and thus the officers included representatives from ecology, geography, and landscape architecture. It was also agreed that USIALE symposia would continue annually, and plans began for a 1987 meeting to be held at the University of Virginia in Charlottesville, with Bill Odum serving as local host. Around this same time, Frank Golley had agreed to serve as the first editor-in-chief of the new journal, *Landscape Ecology*, which launched in 1987.

Aside from the birth of USIALE, perhaps the most enduring legacy of the 1986 symposium was the networking, friendships, and collaborations that owe their genesis to that meeting. Cohorts of researchers developed long-term professional relationships that began at the symposium. For me personally, it was at this conference that my long-time collaborator, Bill Romme, and I became acquainted, and where I met the landscape ecology group from Oak Ridge National Laboratory, which I subsequently joined in 1987. Because landscape ecology was not represented at any other professional society meetings, the annual landscape ecology symposia were the best (perhaps only) way to stay abreast of the most innovative research in United States landscape ecology for at least 10 more years.

USIALE from 1994–1996: Reflections of a Past President

After serving USIALE as program chair for 4 years, I was subsequently elected as chair of the executive committee from 1994 to 1996. At that time, we faced three key challenges: membership, institutional memory, and maintaining cutting-edge meetings. I summarize those next, then conclude this section with three recommendations for future presidents of USIALE.

Membership

That first decade of USIALE encompassed a time of rapid growth and high interest in the field of landscape ecology. There was substantial progress in research and a heightened need for interfacing with resource management and planning. However, USIALE experienced relatively slow growth in membership, with low member retention and consequently high turnover. Thus, a USIALE ad hoc membership committee was formed to recommend (1) specific ongoing activities that should be pursued by the executive committee, (2) services or opportunities to enhance the benefits of membership, and (3) targeted one-time activities to enhance membership. The membership committee was chaired by Dave Mladenoff and included Tom Crow, Kathy Freemark, and Joan Nassauer. The committee made a set of excellent recommendations. Recommended ongoing activities included developing a consistent timeline, developing an identity and promotional schedule for the annual symposia (advertise early, widely, and often); a formal guide for the meetings in which the responsibilities of the local host and program chair were clearly demarcated; considering hiring a permanent staff person to facilitate society bookkeeping; and developing mechanisms to ensure inclusion of senior and junior members of the executive committee. All of these were implemented. For member services, the committee recommended development of a USIALE list serve and Web page, and publication of a membership directory; both of these were also implemented. For targeted activities, the committee recommended compiling a membership profile, which was completed by Mike Demers and Louis Iverson, and surveying members for desired services and activities, which also was accomplished.

The membership survey was mailed in the fall of 1994 and distributed at the 1995 symposium, and Eric Gustafson tallied the 82 responses that were received. The most valued aspects of USIALE membership were the personal contacts with colleagues, the newsletter, staying abreast of trends and developments in the field, the annual meetings, and providing a forum for exchanging ideas. Numerous suggestions about the annual symposium were also provided by members, including adding topical workshops; striving to maintain interdisciplinarity; improving professionalism, communication, and organization; minimizing concurrent sessions (no more than three); retaining the mid-meeting field trips; developing more mechanisms to encourage and support student attendees; adding a separate student award for Best Poster; and even adding live music and dancing at the banquet. Many of these suggestions influenced the planning for subsequent meetings and are clearly in evidence today.

Institutional Memory

Another challenge was to maintain institutional memory within USIALE as time passed and executive committee members rotated on and off. USALE operated under bylaws, but there was little continuity of knowledge and no formalized mechanism for transitioning from one officer to the next. We had no repository for USIALE policy, procedures, responsibilities, or history, and as a result, new officers often felt like they were reinventing the wheel. To address this need, the executive committee produced a handbook to facilitate the workings of USIALE and prevent loss of information as officers changed. In addition, the bylaws (passed initially in 1986) were updated to reflect operational changes that were in place.

Maintaining Cutting-Edge Meetings

The third challenge was to keep the quality of the annual landscape ecology symposia at a high level. During the early years, these symposia were "the" place for the current science; the work presented was creative, novel, and not found at other professional meetings. As time went on, landscape ecology was increasingly represented in other venues, and we recognized the need to avoid just having more of the "same old stuff" presented at USIALE symposia. To some extent, this remains a work in progress because landscape ecology has permeated so extensively within the other disciplines. However, meetings were structured to include symposia or organized sessions that could focus on cutting-edge topics and potentially draw in a new group of attendees. Along with affordability and early advertising, however, these challenges persist and require vigilance from the executive committee.

Recommendations to Future USIALE Presidents

As USIALE sets the course for its second quarter century, I suggest three areas of emphasis. First, the unique niche of USIALE should be enhanced—in the big scheme, we should play to our strengths, particularly with respect to the annual symposia. We have a culture of smallish, friendly, and highly interactive meetings, and we should maintain this strength. The interdisciplinarity and cutting-edge nature of the symposia require ongoing and active planning. Maintaining a strong website is also a must, and the membership survey should be repeated to help position the society to serve its members effectively in the future. Second, we should continue the strong emphasis on and support for student involvement in USIALE. Through the work of many people, USIALE has become one of the best organizations for involving graduate students in many ways. Jack Liu deserves special credit for this, as his long-term commitment to student participation and development through annual awards sponsored by the National Aeronautics and Space Administration (NASA)—Michigan State University (MSU) has made a lasting positive difference for dozens of students. No other society seems so welcoming to students as does ours—USIALE provides an excellent venue for networking, professional development, and linkages between basic and applied landscape ecology. Student involvement should remain a hallmark of the society. Third, USIALE should be a key player in the research and policy issues surrounding sustainability. Tremendous challenges and opportunities that face our society overlap with landscape ecology. As an interdisciplinary science as well as the branch of ecology that strives to understanding the causes and consequences of spatial heterogeneity, landscape ecology should be "at the table" helping to define our collective future.

Forging Ahead: The Next 25 Years of United States Landscape Ecology

In the 1980s, landscape ecology was sometimes disparaged as a pseudoscience. Some ecologists were skeptical about the rigor of studies conducted over large areas, and some thought landscape ecology largely entailed playing with maps. Twenty-five years later, landscape ecology is mainstream (Turner 2005a, b). Its concepts permeate ecological research across most levels and scales, the methods receive widespread use, approaches are incorporated widely in land management, and landscape ecology is even applied in aquatic and marine ecosystems. In contrast to the ecology of the 1980s, spatial variability and pattern can no longer be ignored; although not requisite in all studies, a conscious rationale and choice about whether to consider space explicitly is expected, and the potential consequences of spatial autocorrelation must be considered in data analyses. The effects of scale are now recognized, even if they are not fully understood, and scaling up and down remain significant challenges. So, what lies ahead?

Contemporary landscape ecology has continued to build on many of the themes touched on at the 1986 symposium, but many interesting questions remain to be answered. Using general phrasing, I list an illustrative set of questions that represent, to me, some of the current frontiers in landscape ecology research (Table 4.2). These questions fall into several general themes. (1) Landscape patterns result from multivariate causes operating over many scales, and they can still be difficult to predict. Much progress has been made in understanding the consequences of single drivers, but elucidating interacting drivers remains a challenge. (2) Disturbance has been a prominent theme in landscape ecology for 25 years, and much has been learned. However, disturbance regimes are changing, and understanding the consequences of such regime shifts is increasingly important. (3) Similarly, much has been learned about the dynamics of single species in heterogeneous landscapes. However, the interactions among species in heterogeneous landscapes, and how spatial patterns influence biotic communities remains a frontier. Landscape genetics also offers exciting new directions for examining within-species variation and bridging to evolution. (4) Despite early representation of ecosystem ecology within landscape ecology, explaining and predicting heterogeneity in ecosystem processes across landscapes remains a challenge. In part, this is because of scaling challenges; many ecosystem processes constitute microbial mediation and operate at very fine scales, yet we may wish to predict the broad scale patterns that result. At the other end of the spectrum, global-scale models do not incorporate the regional variation that is often at the core of landscape studies. (5) Humans have always been recog-

Table 4.2 An illustrative set of research questions that represent some of the current frontiers in landscape ecology

Theme	Questions
Interactions among multiple drivers	What is the relative importance of different factors in producing landscape patterns? How well can we explain the patterns we observe?
	How do relationships among drivers vary with scale?
	How do different causes of pattern (abiotic template, climate, biotic interactions, disturbance, human land use) interact?
Changing disturbance regimes	How will changing disturbance regimes affect landscape patterns and processes? Where are surprises likely?
	How do altered landscapes influence disturbance regimes?
	How will post-disturbance trajectories in the future differ from those of the past?
	How should management anticipate changes in disturbance regimes? Where will changes be of greatest magnitude? How can landscapes be designed or managed to alter susceptibility to disturbance?
Multispecies interactions and within-species variation	How does landscape heterogeneity influence interactions between species? What components of species interactions (e.g., detections, encounter, chase, escape) are affected by pattern?
	Do some landscapes disrupt species interactions?
	How does spatial heterogeneity influence entire biotic communities? How are changes in species assemblages affected by landscape heterogeneity?
	What landscapes promote homogenization versus diversification of community structure?
	How does spatial heterogeneity contribute to microevolution, and what are the implications of rapid changes in landscape pattern for adaptive genetic variation?
Ecosystem processes	How do rates of ecosystem processes vary over space and at different spatial scales, and what controls this variation?
	When must spatial contingencies be considered?
	How can landscape/regional dynamics be captured in global models?
	How can/should models be scaled up or scaled down?
Spatial aspects of social–ecological systems	What spatial patterns enhance resilience in social–ecological systems?
	How do today's land-use decisions constrain future patterns, processes, and options?
	What events or conditions elicit societal (or individual) responses? Do people respond in time to prevent undesirable of irreversible change?
Ecosystem services and sustainability	How does landscape heterogeneity influence the quantity and quality of ecosystem services?
	How can landscapes be designed to sustain production of ecosystem services?

nized in landscape ecology as important components of the system. The emergence of widespread interest in social–ecological systems should provide an opportunity for landscape ecology to contribute in meaningful ways. (6) Ecosystem services, the benefits that people obtain from ecosystems, are often affected by spatial heterogeneity. Again, landscape ecology has an opportunity to make important contributions to ongoing research in sustainability science. Thus, while landscape ecology has clearly matured, many exciting challenges and opportunities lie ahead.

Conclusion

The 1986 Landscape Ecology Symposium highlighted the interaction between spatial heterogeneity and disturbance. Twenty-five years later, the reciprocal interactions between landscape heterogeneity and disturbance are still numerous, interesting, complex, sometimes long lasting, reasonably well studied, uncertain in the future, relevant for management, and great topics for continued research (Turner 2010). The 1986 Landscape Ecology Symposium did not provide definitive answers, but rather it opened a new door into a rich area of inquiry. Looking ahead, the many drivers of global change will produce new spatial patterns and new landscape trajectories, and important questions must be addressed (Table 4.2). In the coming 25 years, landscape ecology should refine knowledge of when spatial heterogeneity is fundamentally important, rigorously test the generality of its concepts, and push the frontier of pattern–process interactions. Let us all forge ahead to keep landscape ecology a vibrant and exciting field.

Acknowledgments I am deeply grateful to my PhD advisor, Dr. Frank B. Golley, for having provided such tremendous guidance, encouragement, and support to me as a young scientist, for co-organizing that first United States Landscape Ecology Symposium with me, and for his numerous contributions to the field of landscape ecology. I am also grateful to all who served on the USIALE executive committee during my tenure as chair between 1994 and 1996: Mike Demers (secretary, 1994–1996), Louis Iverson (treasurer, 1993–1995), Sandra Turner (treasurer, 1995–1997), Eric Gustafson (councilor, 1993–1995), Dave Mladenoff (councilor, 1993–1995), Kathy Freemark (councilor, 1994–1996), Marie-José Fortin (councilor, 1995–1997), Joe Means (councilor, 1995–1997), Jeff Klopatek (program chair, 1994–1996), Joan Nassauer (local host 1995, Minneapolis), and Bob Coulson and Robert Giordano (local hosts 1996, Galveston).

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Chapter 5
History and Evolution of the Journal *Landscape Ecology*

Jianguo Wu

Introduction

Since their first appearance in the seventeenth century, peer-reviewed journals have played an instrumental role in advancing science (Meadows 1985; Day 1989; Wu 2011). To paraphrase Day and Gastel (2006), a scientific study is not completed before its results have been published in a peer-reviewed outlet. When a new field of study is emerging, it may be difficult for the researchers to find a place to publish their results. Thus, whether a discipline has a well-established journal is often considered an important indicator for assessing its maturity. Landscape ecologists had their days when finding a mainstream journal to publish their results was challenging, but to their credit those days are gone. Today, landscape ecologists have a well-established journal of their own, *Landscape Ecology*. For 25 years, the journal has documented what landscape ecologists do, how they do it, and what they find. The pages of the journal, therefore, are an important part in recording the development of this field.

The dominant intellectual environment at the time usually facilitates the establishment of a new field of study or its flagship journal. What was the academic environment that promoted the "globalization" of landscape ecology and the launching of the journal *Landscape Ecology*? Several fascinating personal accounts of the early developments of landscape ecology in North America are found elsewhere in this book (see Chaps. 2, 3, and 4). Here, I would like to briefly discuss some of the important historical developments in ecology that have profoundly shaped my (and, I am sure, many others') understanding of landscape ecology during the past few decades.

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The early 1980s was an intriguing and somewhat perplexing period in the history of ecology, characterized by rapidly mounting evidence refuting some long-held ecological theories, heated debates on fundamental ecological principles and methodologies, and groundbreaking ideas that profoundly reshaped ecological thinking. The ecological historian and scientist McIntosh (1987) described the state of ecology in the early 1980s as follows:

> Ecologists are in a period of retrenchment, soul searching, "extraordinary introspection" (Shapiro 1985), or "presenting introspective examinations at an alarming rate" (Lehman 1986). This follows on nearly three decades of heady belief on the part of some ecologists, newly ventured into the maze of community ecology, that communities are structured in an orderly predictable manner, and of others that Information Theory, systems analysis, and mathematical models would transform ecology into a "hard" science.

In the 1950s and 1960s, a dominant view in ecology was that there were general or universal patterns among biological populations and communities regardless of their abiotic and biotic environments and history. Although different views had always existed, skepticism and criticisms became heightened in the late 1970s and early 1980s, subsequently leading to a shift in ecological thinking (McIntosh 1987; Wu and Loucks 1995). It became increasingly clear to ecologists that mathematically elegant equilibrium theories and models have little realism because nonlinearities, transient processes, and historical legacies frequently play key roles in real ecosystems. Universal laws are few, if any, in ecology because spatial heterogeneity and idiosyncratic system properties are often found to be essential to meaningful generalizations. This does not mean that searching for generalities in ecology should be discouraged, but rather generalities ought to be understood in a place-based context, which often takes the form of a landscape.

In the 1980s, patch dynamics, a perspective that emphasizes transient dynamics and disturbances in ecological systems, became widely accepted (Levin and Pain 1974; Levin 1976; Wiens 1976; Pickett and Thompson 1978; Pickett and White 1985; Turner 1987; Levin et al. 1993). The theory of island biogeography was widely (and only heuristically in many cases) applied in studying the effects of landscape fragmentation on biodiversity and ecological processes (Forman et al. 1976; Burgess and Sharpe 1981; Harris 1984). Ecologists began to realize that "[we] also need to erase from our minds the concept of a pristine world in static equilibrium, and recognize that biological changes and human interactions have been an ongoing process" (Golley 1987). At the same time, "an ecology of the landscape," with the patch–corridor–matrix model as a "spatial language," was developed to understand "the spatial heterogeneity of energy, nutrients, water, plants, and animals at the level of a landscape" (Forman 1981, 1983; Forman and Godron 1981, 1986).

Once spatial heterogeneity is emphasized, scale matters. The hierarchy theory, especially through the publications of Tim Allen, Bob O'Neill, and their affiliates (Allen and Starr 1982; O'Neill et al. 1986), increased ecologists' awareness of the importance of scale in space and time, as well as the necessity of linking pattern and process across multiple organizational levels of ecological systems. Different forms of patchiness from within local ecosystems to broad-scale watersheds manifest themselves on a range of scales and interact with each other, begetting a hierarchical perspective on the patterns and processes of ecological systems (Pickett et al. 1987; Urban et al. 1987; Levin 1992; Wu and Loucks 1995). For example, to fully understand the structure, function, and significance of an ecosystem, its interactions with neighboring ecosystems and the landscape matrix must be explicitly considered (e.g., Golley 1987). Remote sensing data and geographic information systems (GIS), indispensable for analyzing spatial patterns on broad scales, also became widely accessible to ecologists (Iverson 2007). Many of these new ideas were brought together at the historic Allerton Park Workshop in 1983 (Risser et al. 1984; Risser 1995), which "established something of a 'new paradigm' for landscape ecology" (Wiens 2008).

All of the abovementioned developments in ecology together created an intellectual environment that made it possible for landscape ecology—a field of study that had been practiced in central Europe since 1939—to take roots and take off in North America and across the rest of the world in the 1980s. The earlier European perspectives were focused heavily on land surveying and mapping, land-use planning and management, and human–land relationships. The modern landscape ecology was born in the 1980s as the new conceptual developments in ecology (particularly those related to spatial heterogeneity) and technological advances in computation (especially remote sensing and GIS) were incorporated into the field. In this new phase, landscape ecology was rejuvenated and characterized by a series of new concepts and theories (e.g., the patch–corridor–matrix model, patch dynamics, boundary dynamics, metapopulations, percolation theory, and hierarchy theory), as well as quantitative methods (e.g., pattern metrics and spatial models).

Founding of the Journal Landscape Ecology

As the ideas of heterogeneity and the techniques of spatial pattern analysis became increasingly widespread in ecology and related fields, the 1980s turned into a golden era for the development of landscape ecology. The International Association for Landscape Ecology (IALE) was established in 1982, primarily a result of the concerted efforts by European ecologists and geographers. A historic workshop was held in Allerton Park, IL, United States in 1983, which produced a spatial heterogeneity-oriented blueprint for modern landscape ecology. Two classic books—*Landscape Ecology: Theory and Application* coauthored by Naveh and Lieberman (1984) and *Landscape Ecology* coauthored by Forman and Godron (1986)—were then published. Also in 1986, the First United States Landscape Ecology Symposium was held in Athens, University of Georgia (see Chap. 4).

In July 1987, the journal *Landscape Ecology* was launched by SPB Academic Publishing with founding editor in chief Frank B. Golley (Fig. 5.1). This was undoubtedly an important milestone in the history of the field. As Monica Turner recalls, "Scientifically, *Landscape Ecology* provided the first outlet for papers in this area, at a time when such papers were receiving resounding rejections from other mainstream journals in ecology" (personal communication). As a world-renowned

Editor-in-Chief: Frank B. Golley

Editorial Board
R. T. T. Forman, M. Godron, G. Haase, W. Haber, S. A. Levin, E. van der Maarel, G. Merriam, Z. Naveh, M. Numata, A.F. Ramos, P. G. Risser, R.Tosswall, M.Ruzicka, K. F. Schreiber, H. H.Shugart, C. Steinitz, I. S. Zonneveld, E. H. Zube

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Fig. 5.1 Journal cover of the inaugural issue of *Landscape Ecology* published in July 1987. The first editorial board consisted of 18 members, and the first issue included 7 articles, including the editorial by the Editor-In-Chief

ecosystem ecologist, and then president of International Association for Ecology (INTECOL, 1986–1990), Frank Golley provided leadership essential in the founding of the journal. It was his vision that ensured the journal to be interdisciplinary and global from its very beginning.

Since 1987, *Landscape Ecology* has been the flagship journal of IALE. In his inaugural editorial, Golley (1987) described the aims and scope of the journal as:

> IALE membership includes landscape designers, architects, and planners, as well as soil scientists, geographers, modelers, and those biologists who call themselves ecologists. The journal is intended to be the official voice of IALE and to represent these various disciplines' interests and research on the landscape. Landscape sets the scale and orientation of the journal. Ecology indicates its breadth and holistic approach…. The task of correcting biospheric disorder is a universal activity, requiring information and insight from all. We intend that *Landscape Ecology* have this broad objective and that it be relevant to the problems that face [humankind] at the end of the twentieth century.

The guidelines are in line with the original vision of Troll (1939, 1971), which called for landscape ecology to be "the study of the main complex causal relationships between the life communities and their environment…expressed regionally in a definite distribution pattern (landscape mosaic, landscape pattern)" (Troll 1971).

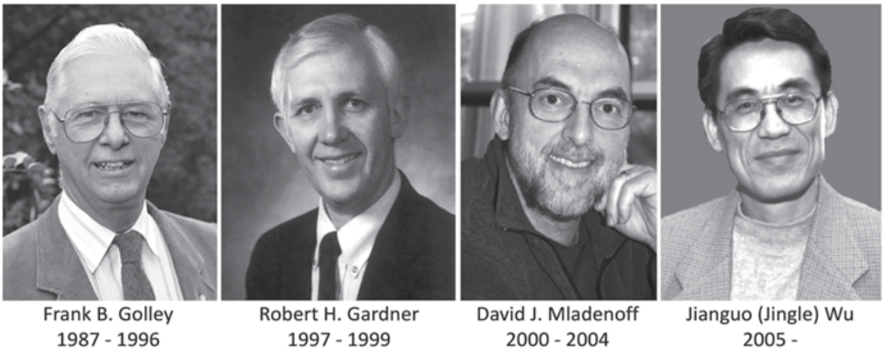


Fig. 5.2 Editors-In-Chief of the journal *Landscape Ecology* from 1987 to present

The emphasis on the ecological effects of landscape patterning, interdisciplinarity, and broad spatial scales has been a salient characteristic of the journal since its founding in 1987.

Succession of Editors and Publishers

Since 1987, *Landscape Ecology* has flourished with a steady increase in the quantity and quality of published articles, with a succession of editors, publishers, and reviewers. The journal has had four editors in chief in its 25-year history (Fig. 5.2). After serving as the founding editor in chief for 10 years, Frank Golley handed over the reins to Robert Gardner in 1997 (Gardner 1996; Golley 1996). Three years later, David Mladenoff succeeded Bob Gardner in 2000 (Mladenoff 2000). Since the beginning of 2005, Jianguo (Jingle) Wu has been the editor in chief of the journal (Wu 2005). Golley and Gardner played an instrumental role in the early development of landscape ecology in North America. David Mladenoff did an outstanding job as the editor in chief for 5 years, and improved the journal in a number of ways by working closely with the publishing staff and editorial board members. Under the leadership of David, the number of manuscript submissions and the rejection rate increased substantially, resulting in a considerable improvement in the overall quality of published articles in the journal. All four editors in chief have been honored with the Distinguished Landscape Ecologist Award by US Regional Association of the International Association for Landscape Ecology (USIALE; Golley in 1991, Gardner in 1994, Wu in 2010, Mladenoff in 2012).

With the growth of the journal and changes in editorship, the size and composition of the editorial board have also changed substantially over the years. The first editorial board established in 1987 consisted of 18 people from 10 countries (Fig. 5.1). Today, the board comprises 48 scientists from 14 countries (Fig. 5.3). Between 1987 and 2012, a total of 136 scientists have served on the editorial board of the journal for different durations. Among them, 16 people served the journal

Fig. 5.3 Members of the Editorial Board of *Landscape Ecology* who were at the 2007 World Congress in Wageningen, the Netherlands. From left to right: J. D. Wickham, J. A. G. Jaeger, K. Riitters, T. Wiegand, M. Antrop, H. Wagner, J. Ahern, A. Farina, J. Wu, J. Niemelä, T. Esplin (Springer), J. Breuste, C. Cotton (Springer), U. Mander, J. Ludwig, F. Kienast, J. Baudry, P. Opdam, R. Jongman, and J. P. Metzger

Fig. 5.4 Changes in the journal cover of *Landscape Ecology*. The current photo-mosaic format was adopted in 2005, and the nine photos comprising the mosaic have been replaced each year since 2007

for 10 or more years, and about 50 people served for 5–9 years, as of May 2012. In addition to the editorial board, the advisory board of the journal was first established in 1998, dissolved by the end of 1999, and reestablished in 2007. The dedication and diligent work of all the members of the editorial board and the editorial office at the publisher, as well as a greater number of reviewers and readers, have been instrumental to the growth and success of the journal.

Since 1987, the journal has had three different publishers, and these transitions were complex, and negatively affected the production of the journal for several months or longer. From 1987 to 1997, the journal was published by SPB Academic Publishing, which was succeeded by Kluwer Academic Publishers in 2000. Following the merger of Kluwer with Springer in 2005, the journal has been published by Springer ever since. With each change of publishers, the printed version of the journal cover has also changed (Fig. 5.4). Bob Gardner "deserves great credit for guiding the journal through complex transitions" during his tenure as the editor in chief for 3 years between 1997 and 1999 (Mladenoff 2000). Of course, Bob also was one of the key players who helped establish modern landscape ecology. David Mladenoff did a marvelous job of guiding the journal successfully in the aftermath of the transition from SPB to Kluwer, and the unpredictable foreshocks of the Kluwer and Springer merger. As paper submissions were only eliminated around 2004, all three former editors in chief had to deal with hard-copy manuscripts.

Performance of the Journal by Numbers

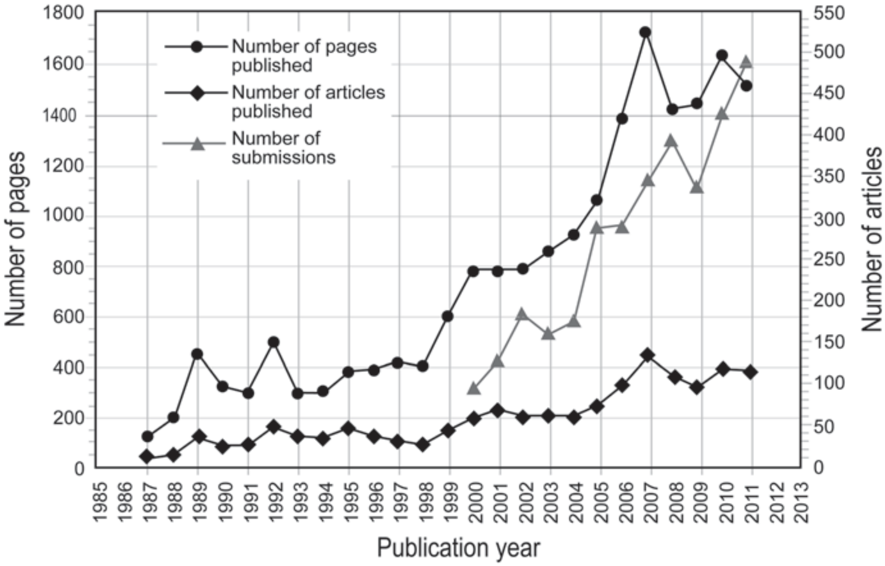
The journal has grown substantially in terms of the numbers of published articles and pages each year since 1987. *Landscape Ecology* started with one volume with four issues a year in 1987. The number of issues per year increased to six in 1995, eight in 2000, and ten in 2007. As the total number of manuscript submissions per year increased from about 97 in 2000 to 486 in 2011, the total numbers of articles and pages published each year also increased rapidly (Fig. 5.5).

The average number of articles published per year was 33 for the period of 1987–1996, 52 for the period of 1997–2004, and 106 for the period of 2005–2011. The average number of published pages per year increased from 325 for the period of 1987–1996 to 688 for the period of 1997–2004 and 1444 for the period of 2005–2011. The rate of increase in the number of manuscript submissions far exceeded the rate of increase in the number of the published articles on an annual basis (Fig. 5.5). This resulted in a continuously decreasing acceptance rate for the journal in recent years, although the total number of pages published each year increased substantially.

Given the history and recent developments of landscape ecology, it is not surprising that most manuscripts submitted to the journal have come from North America and Europe. For example, of all the submitted manuscripts during the period of 2005–2011, about 34 percent were from the United States, 23.4 percent from six European countries (Spain, Germany, France, UK, the Netherlands, and Italy, each contributing about 3–5 percent), 9 percent from China, 8 percent from Canada, and 6 percent from Australia (Fig. 5.6). Of the published articles in *Landscape Ecology* from 1987 to April 2012, about 50 percent came from the United States, 10 percent from Canada, and 5.4 percent from Australia. The leading European countries in this category include France, the Netherlands, Germany, Spain, UK, Sweden, Switzerland, Belgium, and Italy, each contributing about 2–7 percent to the total number of published papers (Fig. 5.6). The apparent geographic imbalance in the number of papers submitted to and published in *Landscape Ecology* is, to some extent, reflective of the uneven development of the science in different parts of the world. The good news is that this geographic imbalance has appeared to decline in recent years. This trend is likely to continue into the future.

The academic standing and influence of the journal can be assessed, in part, by comparison with other journals in ecology and related fields. One metric that has been used frequently for such a purpose is the journal impact factor published each year in Journal Citation Reports® by Thomson Reuters (http://apps.webofknowledge.com/;

(a)



(b)

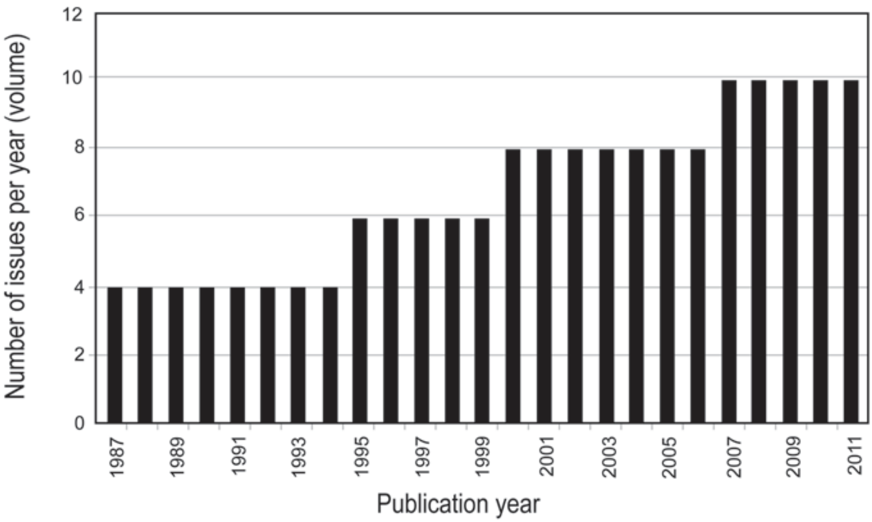


Fig. 5.5 (**a**) Numbers of published of pages, articles, and manuscript submissions per year. (**b**) Growth trend of the journal *Landscape Ecology* between 1987 and 2011, in terms of the number of issues per volume

formerly Institute for Scientific Information, ISI). The journal impact factor, like all metrics and indicators in landscape ecology, is useful but not perfect. The *Landscape Ecology* impact factor and ranking among related journals have increased steadily since it was first included into the ISI database in 1997 (Fig. 5.7). The impact factor of the journal was 1.3 in 1997, and exceeded 2 in 2004 and 3 in 2009 (Fig. 5.7a). Its overall ranking has been consistently strong and trending upward

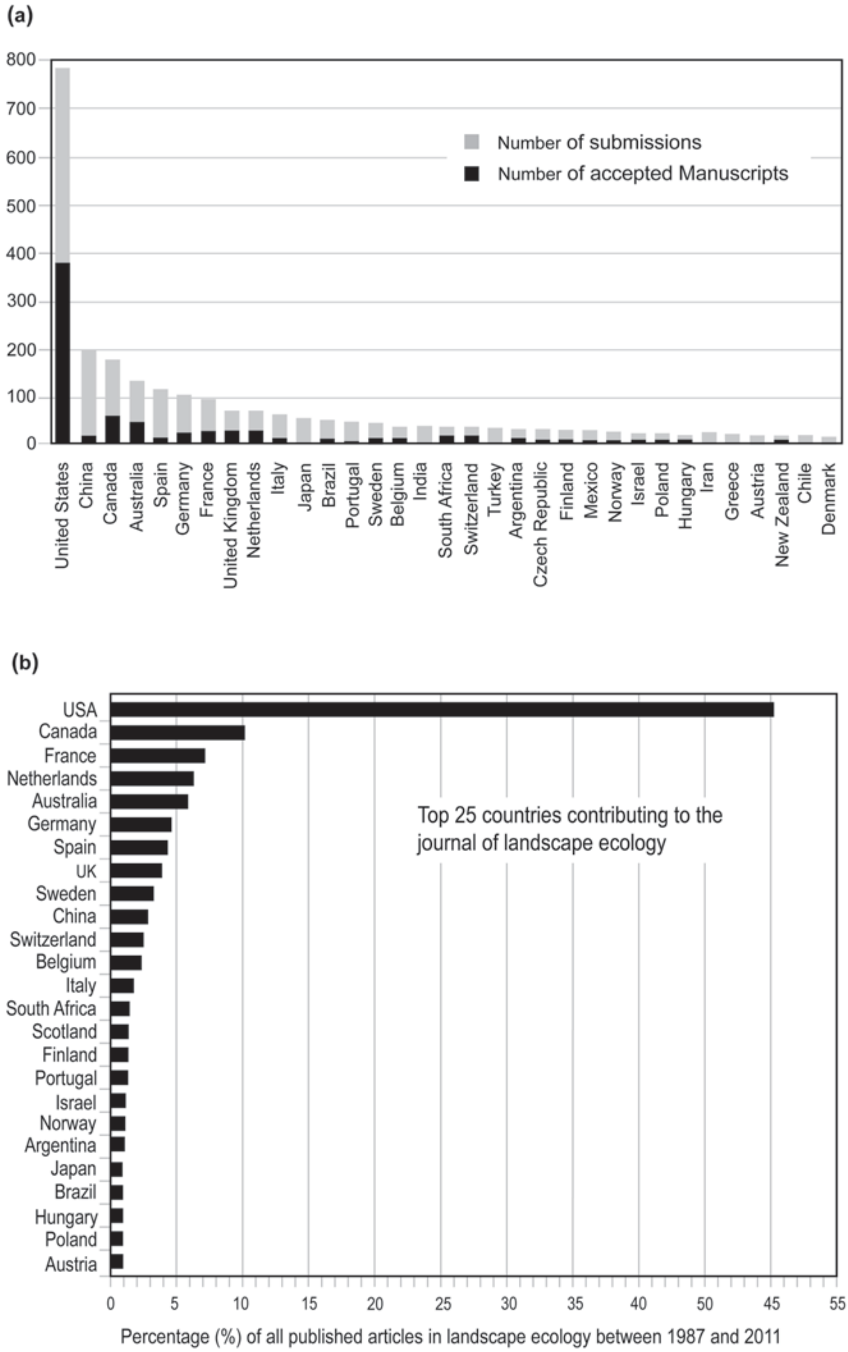


Fig. 5.6 (**a**) Numbers of manuscripts submitted to and accepted by *Landscape Ecology* each year by country, based on data between January 1, 2005, and December 31, 2011, that included only countries with 20 or more submissions. (**b**) Ranking of the top 25 countries according to the number of published articles between 2005 and 2011

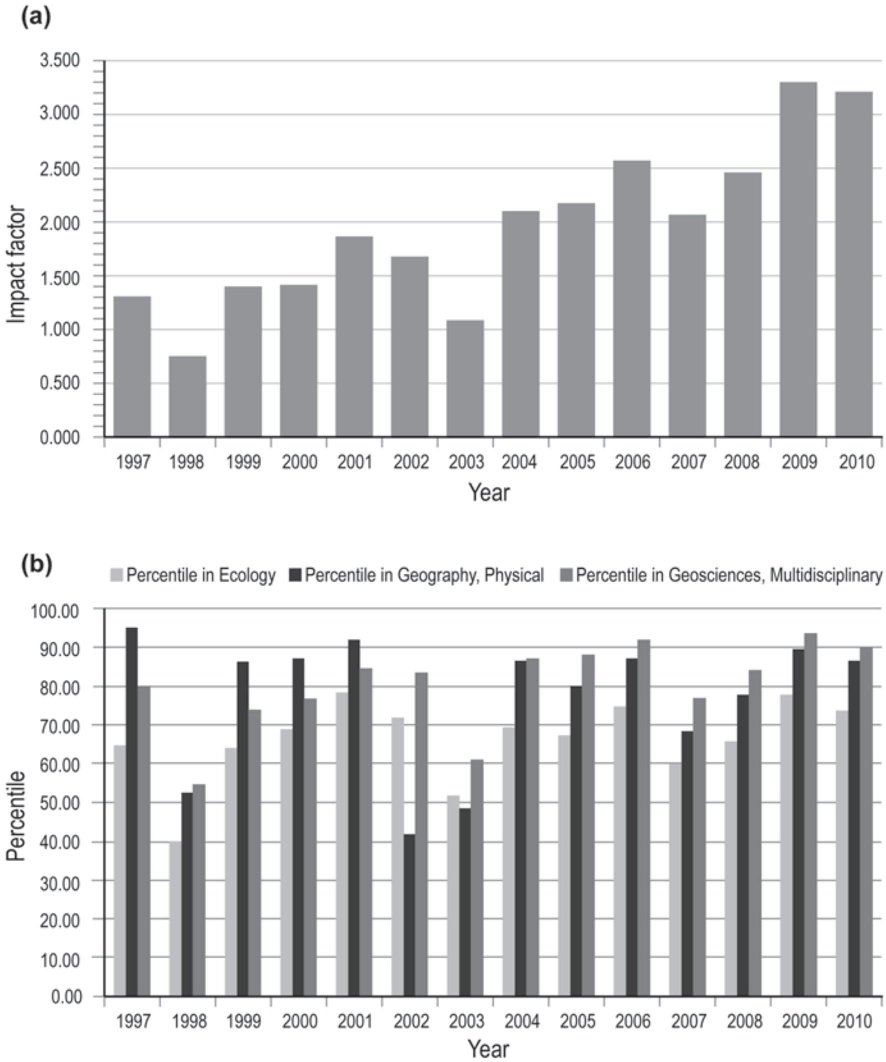


Fig. 5.7 (**a**) Impact factor of *Landscape Ecology* and (**b**) its ranking among related journals. (Data from Thomson Reuters' Web of Science)

(Fig. 5.7b). In 2009, it was ranked 4th among 36 physical geography journals, 11th among 155 multidisciplinary geosciences journals, and the 30th among 129 ecology journals. These numbers remained at similar levels in 2010 and 2011.

Research Trends Observed from the Journal

Golley (1987) pointed out that "[a] central task of the editor and editorial board is to set the boundaries of the subject matter contained in the journal." This is generally true, but the exact extent to which the editor in chief and the editorial board should (and can) define the scope and direction of the journal may be difficult to gauge. It is certain, however, that the main themes and specific research topics in the published papers of *Landscape Ecology* have continued to evolve since 1987, documenting the rapid developments of the field. It is also true that these changes have been influenced, to a significant degree, by the vision and perspectives of the editors as well as the reviewers.

Several research trends may be identified from the published pages of the journal in the past 25 years. Some of these trends were revealed by three consecutive analyses of the publications in *Landscape Ecology,* in terms of the subject focus, scale of study, level of ecological organization, research methods, and "hot" topics (Wiens 1992; Hobbs 1997; Andersen 2008). First, research themes and topics that have continued to dominate the journal pages include landscape pattern analysis, land use/land cover change, and effects of landscape fragmentation on biodiversity. The top 25 most cited papers published in the journal since 1987 (Table 5.1) seem to capture some of the key topics that have originated and persisted in the field: landscape disturbance dynamics (Franklin and Forman 1987; Andow et al. 1990; Turner et al. 1993; Turner and Romme 1994), landscape pattern quantification and interpretation (O'Neill et al. 1988; Turner 1990; Gustafson and Parker 1992; Li and Reynolds 1993; Plotnick et al. 1993; Riitters et al. 1995; Hargis et al. 1998; Li and Wu 2004), scale effects and scaling (O'Neill et al. 1989; Turner et al. 1989; Wiens and Milne 1989; Jelinski and Wu 1996; Wu 2004), neutral landscape models and critical thresholds (Gardner et al. 1987; Johnson et al. 1992), and ecological effects of landscape fragmentation (Van Dorp and Opdam 1987; Opdam 1991). In the first decade of the journal, relatively more papers dealt with conceptual issues and landscape pattern analysis. During the past decade, however, purely descriptive studies have become increasingly difficult to get into the journal. On the topics of land-use change and landscape fragmentation, increasing emphasis has been placed on the driving processes and ecological impacts. Urbanization, as the most extreme form of land use and land cover change, has become a frequent subject matter in the published studies in the journal since the late 1990s. A clear articulation of the relationship between landscape pattern and ecological processes is now generally expected in each paper published by the journal. Consequently, the relative abundance of studies focusing on ecological processes and landscape functioning has been increasing.

Second, most landscape ecological studies have been conducted on broad scales—that is, human landscapes of hundreds to thousands of square kilometers in area—although the essential ideas of landscape ecology can be applied essentially to any scale. With increasing needs for scaling up ecological information and for integrating human and environmental systems, this trend is most likely to continue.

Table 5.1 Top 25 most cited papers published in *Landscape Ecology* since 1987 (data from Web of Science; accessed on April 25, 2012). The number of 25 was picked in honor of the 25th anniversary of the journal *Landscape Ecology*

Rank	Author	Year	Article title	Volume	Start page	Total cites	Cites/year
1	O'Neill, R; Krummel, J; Gardner, R; Sugihara, G; Jackson, B; Deangelis, D; Milne, B; Turner, M; Zygmunt, B; Christensen, S; Dale, V; Graham, R;	1988	Indices of landscape pattern	1	153	581	25.26
2	Franklin, J; Forman, R	1987	Creating landscape patterns by forest cutting: Ecological consequences and principles	1	5	446	18.58
3	Riitters, KH; O'Neill, RV; Hunsaker, CT; Wickham, JD; Yankee, DH; Timmins, SP; Jones, KB; Jackson, B	1995	A factor analysis of landscape pattern and structure metrics	10	23	362	22.63
4	Roth, NE; Allan, JD; Erickson, D	1996	Landscape influences on stream biotic integrity assessed at multiple spatial scales	11	141	358	23.87
5	Gardner, RH; Milne, BT; Turner, MG; O'Neill, RV	1987	Neutral models for the analysis of broad-scale landscape pattern	1	19	341	14.21
6	Turner, MG.; O'Neill, RV; Gardner, RH; Milne, BT	1989	Effects of changing spatial scale on the analysis of landscape pattern	3	153	337	15.32
7	Wu, J; Hobbs, R	2002	Key issues and research priorities in landscape ecology: an idiosyncratic synthesis	17	355	236	26.22
8	Turner, MG; Romme, WH	1994	Landscape dynamics in crown fire ecosystems	9	59	229	13.47
9	Hargis, CD; Bissonette, JA; David, JL	1998	The behavior of landscape metrics commonly used in the study of habitat fragmentation	13	167	225	17.31
10	Gustafson, EJ; Parker, GR	1992	Relationships between landcover proportion and indexes of landscape spatial pattern	7	101	221	11.63
11	Wiens, JA; Milne, BT	1989	Scaling of "Landscapes" in landscape ecology, or, landscape ecology from a beetle's perspective	3	87	216	9.82

Table 5.1 (continued)

Rank	Author	Year	Article title	Volume	Start page	Total cites	Cites/year
12	Andow, DA; Kareiva, PM; Levin, SA; Okubo, A	1990	Spread of invading organisms	4	177	215	10.24
13	Wu, J	2004	Effects of changing scale on landscape pattern analysis: Scaling relations	19	125	202	28.86
14	Turner, MG	1990	Spatial and temporal analysis of landscape patterns	4	21	197	9.38
15	Van Dorp, D; Opdam, P	1987	Effects of patch size, isolation and regional abundance on forest bird communities	1	59	196	8.17
16	Li, H; Wu, J	2004	Use and misuse of landscape indices	19	389	192	27.43
17	Ludwig, JA; Tongway, DJ	1995	Spatial-organization of landscapes and its function in semiarid woodlands, Australia	10	51	180	11.25
18	Opdam, P	1991	Metapopulation theory and habitat fragmentation: A Review of holarctic breeding bird studies	5	93	175	8.75
19	Jelinski, DE; Wu, J	1996	The modifiable areal unit problem and implications for landscape ecology	11	129	174	11.60
20	Johnson, AR; Wiens, JA; Milne, BT; Crist, TO	1992	Animal movements and population-dynamics in heterogeneous landscapes	7	63	167	8.79
21	Turner, MG; Romme, WH; Gardner, RH; O'Neill, RV; Kratz, TK	1993	A revised concept of landscape equilibrium: Disturbance and stability on scaled landscapes	8	213	164	9.11
22	Pielke, RA; Avissar, R	1990	Influence of landscape structure on local and regional climate	4	133	163	7.76
23	O'Neill, RV; Johnson, AR; King, AW	1989	A hierarchical framework for the analysis of scale	3	193	162	7.36
24	Plotnick, RE; Gardner, RH; O'Neill, RV	1993	Lacunarity indexes as measures of landscape texture	8	201	161	8.94
25	Li, H; Reynolds, JF	1993	A new contagion index to quantify spatial patterns of landscapes	8	155	153	8.50

Third, the levels of ecological organization at which landscape ecological questions have been most frequently addressed include the populations of single or multiple species and the entire landscape. Studies on the structure and function of communities and ecosystems in a landscape context have been increasing slowly but steadily in the recent decade.

Fourth, in terms of ecosystem or landscape types studied, there have been an increasing number of "wet" papers that deal with rivers, lakes, and different types of wetlands. However, forests have been by far the most studied, whereas deserts and grasslands have been seriously underrepresented, considering that arid and semiarid regions cover more than 40 percent of the land area of Earth and are home to more than 35 percent of the global population.

Fifth, landscape ecological studies have relied increasingly on the use of remotely sensed data and GIS, and multiple-scale approaches have become increasingly the norm in data acquisition and analysis. Problems of spatial accuracy and uncertainty have been recognized, but little genuine progress has been made, and studies on these topics are seriously lacking.

Sixth, field manipulative experiments at the landscape scale are still relatively rare because of their conceptual and logistic challenges. However, the number of landscape-scale studies has been increasing. With heightened recognition in the roles of landscape design within landscape ecology (Nassauer and Opdam 2008), more experimental studies are expected to appear in the journal from now on, although many landscape experiments will never strictly meet the criteria of "controlled experimentation" prescribed by classic scientific inquiry. The problems of pseudo-replication and internal validity of experiments at the landscape scale need to be faced but not feared, however.

Finally, several "hot" and new topics have emerged through the pages of the journal. For example, behavioral landscape ecology—the study of the relationship between landscape pattern and behavioral processes of organisms—has remained a vibrant area for several decades. The spatiotemporal patterns and ecological effects of land use and land cover change have continued to gain new insights and momentum. In the past decade, one of the most rapidly developing areas has been landscape genetics that integrates landscape pattern analysis with population genetics (Holderegger and Wagner 2006; Balkenhol et al. 2009). Studies in this area not only contribute significantly to our basic understanding of pattern-process relations but also to the conservation of biodiversity in fragmented landscapes. Another new area of research is soundscape ecology, which integrates landscape ecology with acoustics to understand the importance of biological, geophysical, and anthropogenic sounds to landscapes as coupled human–environment systems (Pijanowski et al. 2011; Truax and Barrett 2011). In addition, with the rapid development of sustainability science since the early 2000s, the topic of landscape sustainability has received increasing attention from landscape ecologists worldwide (Wu 2006; Naveh 2007; Fu et al. 2008; Musacchio 2009; McAlpine et al. 2010; Cumming et al. 2013; Turner et al. 2013).

Conclusion

The process of scientific publishing has been essential to the advancement of science. A true test of the success of a journal is its real impacts on the development of the related science (Monica Turner, personal communication). As the flagship journal of the international association for the field, *Landscape Ecology* has served as an effective and premier forum for landscape scientists for 25 years. While many were skeptical about the legitimacy and future success of the field of landscape ecology just a few decades ago, there is little doubt that landscape ecology today is a well-established interdisciplinary field cutting across ecology, geography, and landscape architecture. Some have argued that landscape ecology now has come of age or "matured" (Turner 2005). I am less certain about the degree of maturity of the field, as its core concepts and methodology are still rapidly evolving. I am sure, however, that the journal has been not only an incubator but also an indicator, of the growth and success of the field. Its instrumental role in promoting the science is overwhelmingly evident.

With its well-established reputation as a mainstream journal in ecological and geographical sciences, *Landscape Ecology* has a bright future. In the increasingly competitive publishing world in which publishers and authors seem to be forced to chase journal impact factors, however, our journal must continue to improve to better serve landscape science, its researchers and practitioners, and society as a whole. Toward this end, I would like to conclude this chapter by discussing some of the major challenges ahead.

First, landscape ecology has become increasingly integrative and interdisciplinary, demanding broader perspectives and expertise from the editors and reviewers. As Golley (1987) pointed out at the launching of the journal, the ultimate goal of landscape ecology would be "to create landscapes which are beautiful, as well as productive of goods and services required by humans and natural creatures and to contribute to a system of values where landscapes can be assessed and protected for their intrinsic qualities and not only their economic worth." To achieve this goal, "we must form teams with historians, landscape architects, archeologists, anthropologists and other social scientists to explore these relationships" (Golley 1996). Meanwhile, the journal needs to have an identifiable scientific core. The relationship between spatial pattern and ecological processes across scales has emerged as the most central idea that this scientific core hinges upon. To embrace pluralism and maintain an identity at the same time is much harder done than said. To meet this challenge, the editor and the editorial board need to be acutely cognizant of the central theme of landscape ecology, collectively help to define the boundary, and guide the overall direction, of the field.

Second, to facilitate the development of a scientific core for landscape ecology, review and synthesis papers are critically important. The details of the core will continue to be developed and refined by the scientific community as a whole, but the guiding theme seems clear, as mentioned above. Key research questions in the field ought to be examined periodically across taxa, systems, and scales. For example, how does spatial heterogeneity affect biodiversity? How does spatial heterogeneity affect ecological processes within and between populations, communities, and ecosystems in landscapes? How does spatial heterogeneity affect ecosystem services and the sustainability of landscapes? How can landscape ecological principles be used in, and derived from, the practice of biodiversity conservation, land design and planning, and sustainable development? After publishing more than 1500 articles in the past 25 years, *Landscape Ecology* now welcomes reviews and syntheses on both specific topics and broad themes.

Third, we need to continue our push for more papers on "landscape ecology in practice," as the ultimate goal of our science is to help achieve sustainable landscapes, even if understanding how landscapes work in and of itself is a worthy academic goal. In other words, we must make our science more "actionable" through promoting publications that demonstrate how landscape ecological knowledge is actually translated and applied on the ground (Opdam et al. 2009; Opdam 2010). As used in the field of action research or organizational learning (Argyris 1996), "actionable" means being able to be implemented or acted on by the intended users (not giving sufficient reason to take legal action!). Actionable science is "science that is motivated to serve society," which "has the potential to inform decisions (in government, business, and the household), improve the design or implementation of public policies, or influence public- or private-sector strategies, planning and behaviors that affect the environment" (Palmer 2012). Landscape is arguably the most operational spatial scale, between a study plot and the entire biosphere, for sustainability research and practice, and landscape ecology ought to be an actionable science. The "landscape ecology in practice" articles published by our journal so far have not been among the most cited, but their importance far exceeds what can be measured by any journal performance metric based solely on citations.

Finally and very importantly, the journal of *Landscape Ecology* is an important performance barometer of the field as a whole. To a large extent, the articles published in the journal reflect what landscape ecologists do and how well they do it. It is hard to image a well-established landscape ecologist today who has not published any influential papers in the flagship journal. A close scrutiny of all the published issues of the journal in the past 25 years certainly would support this claim. Thus, all of us who call ourselves landscape ecologists are obligated to contribute to the immediate improvements and long-term success of our own journal by enhancing its influence in academia and on real landscapes. A straightforward first step toward this end is to submit your best papers to *Landscape Ecology*!

Greater success will come from greater efforts from all our editors, publisher, authors, reviewers, and readers of the journal. I feel the pressure and the excitement, and look forward to working with all the parties to turn future challenges into exciting opportunities.

Acknowledgments I am enormously grateful to my predecessors—the three former editors in chief, Frank Golley, Bob Gardner, and David Mladenoff—for their outstanding contributions to the journal. Former Associate Editor Marc Antrop, Associate Editor Paul Opdam, editorial board and advisory board members, Senior Publishing Editor Catherine Cotton at Springer, and staff at the *Landscape Ecology* editorial office are acknowledged for their excellent service. I thank Monica Turner, David Mladenoff, and Paul Opdam for providing valuable comments on an earlier version of this paper. I am privileged to dedicate this chapter to the memory of Founding Editor in Chief Frank B. Golley (1930–2006).

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Chapter 6
Historical Perspectives from Former Presidents of USIALE

Gary W. Barrett

Introduction

All presidents of United States Regional Association of the International Association for Landscape Ecology (USIALE) during the past 30 years were invited to reflect on their challenges and accomplishments during their tenure as president of USIALE. Following a second invitation, six of the past USIALE presidents shared their perspectives regarding this important office. Although a tentative outline was suggested encouraging a similar format, most elected to comment independently regarding administrative changes and key accomplishments during their respective tenure as president. Their comments provide an interesting historical perspective of USIALE from conception (1983) to present (2014). It is rare to gain an evolutionary insight into the challenges faced during the development of a new integrative paradigm.

An award was presented to each president during the 2010 USIALE 25th Anniversary Symposium (Fig. 6.1). This symposium initiated a new Editor Award for distinguished service to the journal *Landscape Ecology* (Figs. 6.2 and 6.3).

Chronologically ordered below are comments, as written and expressed, by each respective USIALE president (Fig. 6.4):

David M. Sharpe 1986–1988

It is a pleasure to help celebrate the first 25 years of USIALE. But I have a question: Why isn't this the 50th anniversary; why wasn't IALE organized in 1960 rather than 1983, and USIALE in 1986? What was special about the mid-1980s that led to this new scientific organization? What converged in 1986 that didn't come together in

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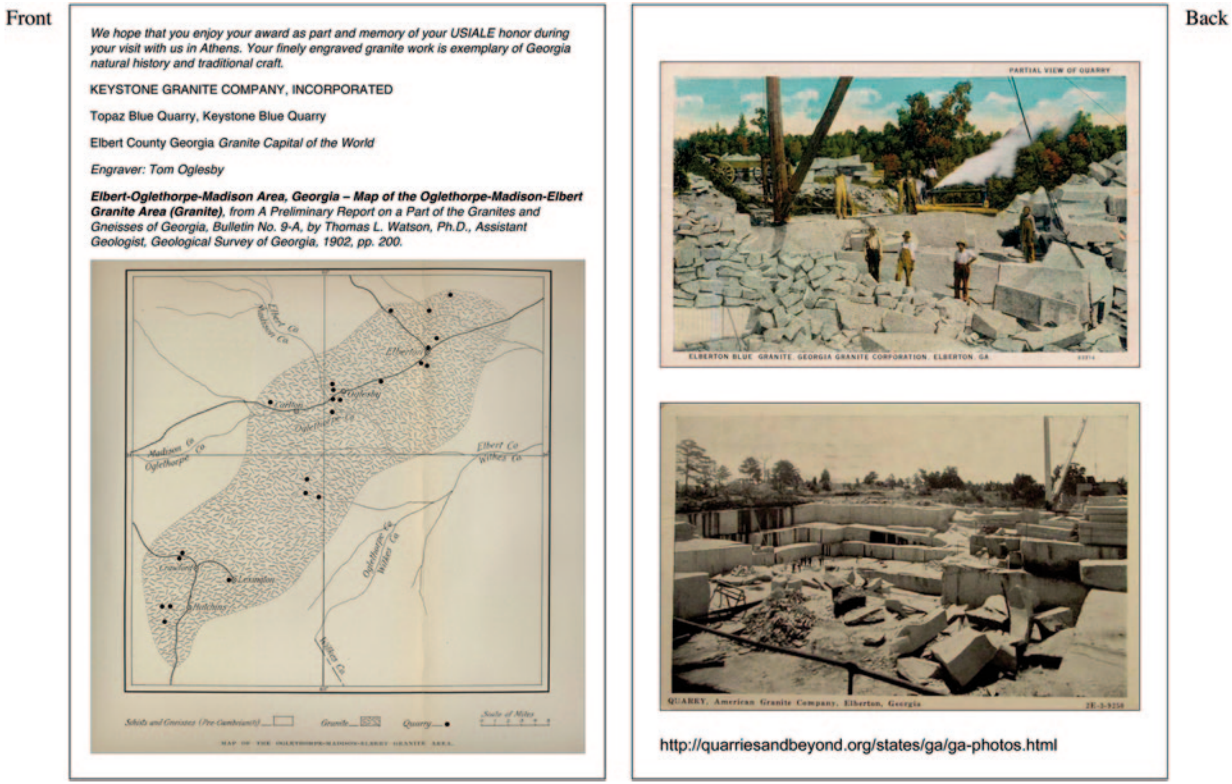


Fig. 6.1 Description of the USIALE Award presented to each president at the 2010 USIALE 25th Anniversary Symposium, University of Georgia, Athens, Georgia

Fig. 6.2 Gary W. Barrett presenting Pricilla Golley with the 2010 Frank B. Golley Founding Editor Award of the journal *Landscape Ecology*. Note: Robert H. Gardner, Editor 1997–1999 and David J. Mladenoff, Editor 2000–2004 (not in attendance), were recognized during this presentation. 2010 Editor Awards were subsequently shipped to them. (Photography by Wingate Downs Photo Courtesy of Terry Barrett)

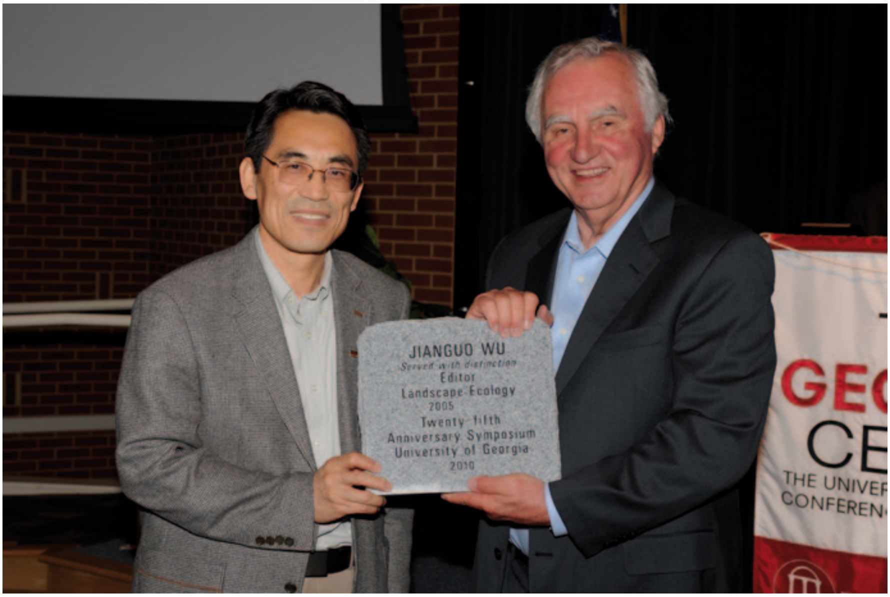


Fig. 6.3 Jianguo (Jingle) Wu, current editor of *Landscape Ecology,* receiving the 2010 Editor Award for serving with distinction. (Photography by Wingate Downs Photo Courtesy of Terry Barrett)

1960? After all, ecology was well established as a discipline. The Ecological Society of America (ESA) had been founded in 1915; in 1960, the journal *Ecology* was in its 40th volume. And Carl Troll had defined "landschaftsökologie" in 1939. Why did it take two more generations?

I am not a historian of science, so let me draw upon my own experience. I remember being captivated by the definition of ecology in my first botany class. It was 1956, and I was a freshman at the New York State College of Forestry (now SUNY College of Environmental Science and Forestry—another indication of changing times). I found the definition of ecology, but no mention of landscape ecology. In 1956, the term "landscape" was associated with the department one floor above the auditorium where I sat—landscape architecture, which had a different agenda at that time.

Two years later, at forestry summer camp in the Adirondacks, we were assigned to map the campus. We used a plane table, sighted through the alidade to the range rod held by a partner standing at a corner of a bunkhouse. By moving the plane table around the campus, we were able to map the buildings and locate the shore of Cranberry Lake. We were using a 400-year-old technology, an invention of the 1500s.

Fig. 6.4 Presentation of the 2010 USIALE Distinguished Presidents' Award: David M. Sharpe. (Photography by Wingate Downs Photo Courtesy of Terry Barrett)

Then, two more years as a junior forester in the United States Forest Service (USFS), I was on a crew installing CFI—Continuous Forest Inventory—plots on the Mount Hood National Forest. For each plot, we were given an aerial photo with a pinhole in it, circled on the back with a plot number. Our assignment—walk to that pinhole—a mile or miles from the nearest road, using compass, topography, and vegetation patterns for guidance, then mark and measure the trees. No, the times, the emphases, the technologies were not propitious for landscape ecology.

In a book review in an issue of *American Scientist,* Marvalee Wake, a professor at Berkeley, asks: "What constitutes a new field in science? Must it be the consequence of a new synthesis? Does it need to take research in a new direction based on new ideas or new techniques? Or is it something that we recognize after the fact as a paradigm change?" She is referring to ecological developmental biology in a review of a book of the same title, and finds that "eco-devo" fulfills all these criteria. A new synthesis, new directions for research, use of new techniques, perhaps a paradigm shift.

Could she be considering landscape ecology as well? Does landscape ecology involve a new synthesis of formerly discrete fields? Certainly. Has it taken ecologic research in new directions; has it stimulated new directions for environmental planning, as well? Certainly. Has it been enabled by new techniques? Unequivocally.

So, what changed in those 25 years? I think we could all tell the story, or our take on it. Here is mine.

I focus on two powerful trends in science. One, certainly, is the globalization of science. Remember, landscape ecology had been gestating in Europe for decades. A number of countries had their own ecological societies. How did IALE become a global scientific association in the 1980s? One precursor was the growth of international science and the expectations and communications that resulted. Big science, international science, included the International Geophysical Year (IGY); the International Hydrological Decade (IHD); and most relevant to us, the International Biological Program (IBP) from 1964 to 1974. Many of the scientists in the United States who would later help found USIALE had contributed to projects in IBP. And each of these projects drew in researchers from a variety of disciplines. They were inherently interdisciplinary. For me, working in the Eastern Deciduous Forest Biome (EDFB) project at Oak Ridge is where "landscape" became attached to ecology. In fact, this is where it became clear to me that ecology without landscape was truncated.

And landscape ecology needed a whole new tool kit for spatial analysis. My first experience with Geographic Information System (GIS) was with MAP (Map Analysis Package) developed by Dana Tomlin. Environmental Systems Research Institute (ESRI) released ArcInfo in 1982. Earth Resources Data Analysis System (ERDAS) was developed in the 1970s, and linked to ArcInfo in the 1980s. It is important to note that one institution, Harvard Graduate School of Design, is the birthplace of all these tools, is where all the people who developed them either worked or earned advanced degrees.

As just suggested, people drive change, and landscape ecology has several other notable people. Dr. I. S. Zonneveld organized the first international conference on landscape ecology at Veldhoven in 1981, where the idea of IALE was planted. It blossomed at the Bratislava symposium on landscape ecology in 1982 where Dr. Zonneveld was elected the first president of IALE.

The United States was well represented at these meetings. Richard Forman, then of Rutgers, later the Practical Assessment Exploration System (PAES) Professor of Landscape Ecology at Harvard Graduate School of Design, was elected Vice President of IALE.

Landscape ecology came back to the United States when Paul Risser, chief of the Illinois Natural History Survey, Richard Forman, and Jim Karr, University of Illinois, organized a workshop on landscape ecology for American ecologists on the spring of 1983. I think that this was where the full potential of landscape ecology in the United States was realized.

And, Frank Golley played several pivotal roles. As president of the International Association for Ecology (INTECOL) when IALE was being considered, he provided guidance on structure. And, as director of the Institute of Ecology, University of Georgia, he hosted the first United States symposium on landscape ecology in January 1986, where he and Monica Turner organized a special meeting to establish the United States region of IALE. The 70 people attending the meeting concurred, and USIALE was established.

So, to me, it's obvious why USIALE is celebrating its 25th anniversary at the University of Georgia in 2010, not its 50th. Landscape ecology relies upon permeable boundaries between disciplines. International cooperation in science must be the norm. It needed the new computer tools we take for granted. And it needed farsighted colleagues to assure that landscape ecology was recognized among the sciences. All of this converged in the 1980s as the United States Regional Association of the International Association for Landscape Ecology USIALE. Much of this came together at the University of Georgia following the workshop held at Allerton Park in April 1983.

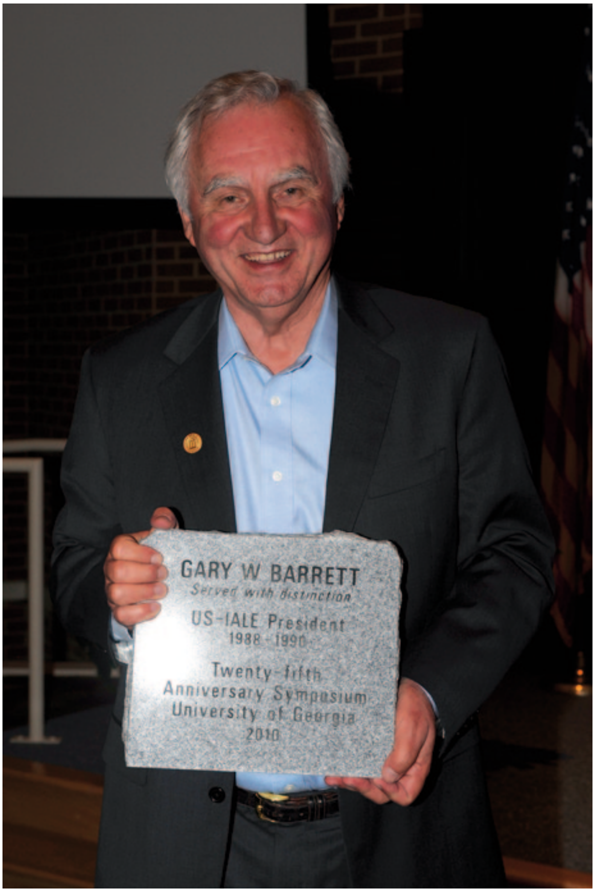


Fig. 6.5 Presentation of the 2010 USIALE Distinguished Presidents' Award: Gary W. Barrett. (Photography by Wingate Downs Photo Courtesy of Terry Barrett)

Gary W. Barrett 1988–1990

I was honored to serve as the second president of USIALE from 1988 to 1990 (Fig. 6.5). David Sharpe was the first president of USIALE. John L. Vankat and I served as local hosts of the 1990 Annual Symposium held, 21–24 March 1990, at Miami University, Oxford, Ohio. The theme of the 1990 Annual Symposium was, "The Role of Landscape Ecology in Public-Policy-Making and Land-Use Management." Plenary speakers were Gene E. Likens, Donald L. Hey, Joan I. Nassauer, Ben W. Breedlove, Robert P. McIntosh, and Lynton K. Caldwell. Officers during my term as president were James F. Thorne, program chair; Joan I. Nassauer, secretary; Bruce T. Milne, treasurer; Thoms R. Crow, Vern G. Meentemeyer, and Robert V. O'Neill, councilors-at-large. The registration fees for this symposium were (regular) \$25 and (student) \$10.

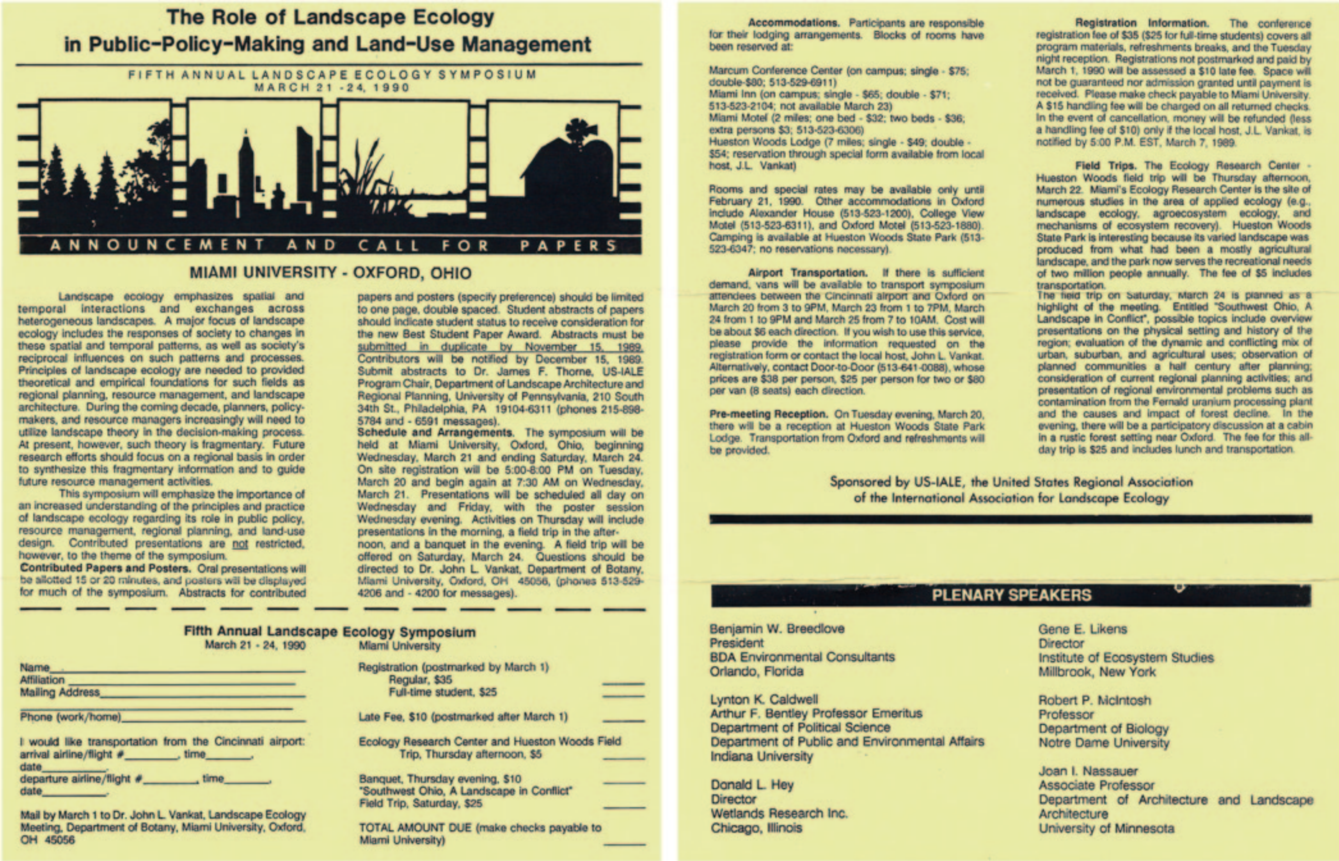
Fig. 6.6 Participants in touring the Miami University Ecology Research Center (ERC) by tractor hayride during the 1990 USIALE Annual Symposium. Note: Richard T. T. Forman (*left*) and Gene E. Likens (*right*). (Photo Courtesy of Gary Barrett)

Orie Loucks led a bus fieldtrip north to the prairie at Wright–Patterson Air Force Base, and east to the treeless prairie of south Clinton County. The group of about 20 next visited the Hopewell Ceremonial Earthworks, Fort Ancient, located within Warren County, Ohio. I organized a tractor hayride at the Ecology Research Center near campus, and on to Hueston Woods State Park (Fig. 6.6).

I appointed the first USIALE Awards Committee, and awarded the first Distinguished Landscape Ecologist Award to Frank B. Golley in 1990 at the USIALE Awards Dinner at Miami University. Robert V. O'Neill, chair of the Awards Committee in 1991, forgot that Frank had already received this award and made the same recommendation at the 1991 Annual Symposium held in Toronto, Canada. For many years, USIALE records showed that Frank B. Golley only received the Distinguished Landscape Ecologist Award in 1991!

The costs for the 1990 Annual Symposium were paid from the Distinguished Professorship of Ecology account held by me, and personal funds from Terry L. Barrett. Miami University provided a unique meeting site and quality accommodations (Fig. 6.7).

At that time, I recognized the need for a permanent administrative structure for this fledgling organization (standing committees, annual meeting sites, bylaws). Needless to say, USIALE has come a long way in achieving this administrative stability.



The Role of Landscape Ecology in Public-Policy-Making and Land-Use Management

FIFTH ANNUAL LANDSCAPE ECOLOGY SYMPOSIUM
MARCH 21 - 24, 1990

ANNOUNCEMENT AND CALL FOR PAPERS

MIAMI UNIVERSITY - OXFORD, OHIO

Landscape ecology emphasizes spatial and temporal interactions and exchanges across heterogeneous landscapes. A major focus of landscape ecology includes the responses of society to changes in these spatial and temporal patterns, as well as society's reciprocal influences on such patterns and processes. Principles of landscape ecology are needed to provided theoretical and empirical foundations for such fields as regional planning, resource management, and landscape architecture. During the coming decade, planners, policy-makers, and resource managers increasingly will need to utilize landscape theory in the decision-making process. At present, however, such theory is fragmentary. Future research efforts should focus on a regional basis in order to synthesize this fragmentary information and to guide future resource management activities.

This symposium will emphasize the importance of an increased understanding of the principles and practice of landscape ecology regarding its role in public policy, resource management, regional planning, and land-use design. Contributed presentations are not restricted, however, to the theme of the symposium.

Contributed Papers and Posters. Oral presentations will be allotted 15 or 20 minutes, and posters will be displayed for much of the symposium. Abstracts for contributed papers and posters (specify preference) should be limited to one page, double spaced. Student abstracts of papers should indicate student status to receive consideration for the new Best Student Paper Award. Abstracts must be submitted in duplicate by November 15, 1989. Contributors will be notified by December 15, 1989. Submit abstracts to Dr. James F. Thorne, US-IALE Program Chair, Department of Landscape Architecture and Regional Planning, University of Pennsylvania, 210 South 34th St., Philadelphia, PA 19104-6311 (phones 215-898-5784 and - 6591 messages).

Schedule and Arrangements. The symposium will be held at Miami University, Oxford, Ohio, beginning Wednesday, March 21 and ending Saturday, March 24. On site registration will be 5:00-8:00 PM on Tuesday, March 20 and begin again at 7:30 AM on Wednesday, March 21. Presentations will be scheduled all day on Wednesday and Friday, with the poster session Wednesday evening. Activities on Thursday will include presentations in the morning, a field trip in the afternoon, and a banquet in the evening. A field trip will be offered on Saturday, March 24. Questions should be directed to Dr. John L. Vankat, Department of Botany, Miami University, Oxford, OH 45056, (phones 513-529-4206 and - 4200 for messages).

Fifth Annual Landscape Ecology Symposium
March 21 - 24, 1990 Miami University

Name________
Affiliation________
Mailing Address________

Phone (work/home)________

I would like transportation from the Cincinnati airport:
arrival airline/flight #______, time______, date______.
departure airline/flight #______, time______, date______.

Mail by March 1 to Dr. John L. Vankat, Landscape Ecology Meeting, Department of Botany, Miami University, Oxford, OH 45056

Registration (postmarked by March 1)
Regular, $35 ______
Full-time student, $25 ______

Late Fee, $10 (postmarked after March 1) ______

Ecology Research Center and Hueston Woods Field Trip, Thursday afternoon, $5 ______

Banquet, Thursday evening, $10 ______
"Southwest Ohio, A Landscape in Conflict" Field Trip, Saturday, $25 ______

TOTAL AMOUNT DUE (make checks payable to Miami University) ______

Accommodations. Participants are responsible for their lodging arrangements. Blocks of rooms have been reserved at:

Marcum Conference Center (on campus; single - $75; double-$80; 513-529-6911)
Miami Inn (on campus; single - $65; double - $71; 513-523-2104; not available March 23)
Miami Motel (2 miles; one bed - $32; two beds - $36; extra persons $3; 513-523-6306)
Hueston Woods Lodge (7 miles; single - $49; double - $54; reservation through special form available from local host, J.L. Vankat)

Rooms and special rates may be available only until February 21, 1990. Other accommodations in Oxford include Alexander House (513-523-1200), College View Motel (513-523-6311), and Oxford Motel (513-523-1880). Camping is available at Hueston Woods State Park (513-523-6347; no reservations necessary).

Airport Transportation. If there is sufficient demand, vans will be available to transport symposium attendees between the Cincinnati airport and Oxford on March 20 from 3 to 9PM, March 23 from 1 to 7PM, March 24 from 1 to 9PM and March 25 from 7 to 10AM. Cost will be about $6 each direction. If you wish to use this service, please provide the information requested on the registration form or contact the local host, John L. Vankat. Alternatively, contact Door-to-Door (513-641-0088), whose prices are $38 per person, $25 per person for two or $80 per van (8 seats) each direction.

Pre-meeting Reception. On Tuesday evening, March 20, there will be a reception at Hueston Woods State Park Lodge. Transportation from Oxford and refreshments will be provided.

Registration Information. The conference registration fee of $35 ($25 for full-time students) covers all program materials, refreshments breaks, and the Tuesday night reception. Registrations not postmarked and paid by March 1, 1990 will be assessed a $10 late fee. Space will not be guaranteed nor admission granted until payment is received. Please make check payable to Miami University. A $15 handling fee will be charged on all returned checks. In the event of cancellation, money will be refunded (less a handling fee of $10) only if the local host, J.L. Vankat, is notified by 5:00 P.M. EST, March 7, 1989.

Field Trips. The Ecology Research Center - Hueston Woods field trip will be Thursday afternoon, March 22. Miami's Ecology Research Center is the site of numerous studies in the area of applied ecology (e.g., landscape ecology, agroecosystem ecology, and mechanisms of ecosystem recovery). Hueston Woods State Park is interesting because its varied landscape was produced from what had been a mostly agricultural landscape, and the park now serves the recreational needs of two million people annually. The fee of $5 includes transportation.
The field trip on Saturday, March 24 is planned as a highlight of the meeting. Entitled "Southwest Ohio, A Landscape in Conflict", possible topics include overview presentations on the physical setting and history of the region; evaluation of the dynamic and conflicting mix of urban, suburban, and agricultural uses; observation of planned communities a half century after planning; consideration of current regional planning activities; and presentation of regional environmental problems such as contamination from the Fernald uranium processing plant and the causes and impact of forest decline. In the evening, there will be a participatory discussion at a cabin in a rustic forest setting near Oxford. The fee for this all-day trip is $25 and includes lunch and transportation.

Sponsored by US-IALE, the United States Regional Association of the International Association for Landscape Ecology

PLENARY SPEAKERS

Benjamin W. Breedlove
President
BDA Environmental Consultants
Orlando, Florida

Lynton K. Caldwell
Arthur F. Bentley Professor Emeritus
Department of Political Science
Department of Public and Environmental Affairs
Indiana University

Donald L. Hey
Director
Wetlands Research Inc.
Chicago, Illinois

Gene E. Likens
Director
Institute of Ecosystem Studies
Millbrook, New York

Robert P. McIntosh
Professor
Department of Biology
Notre Dame University

Joan I. Nassauer
Associate Professor
Department of Architecture and Landscape Architecture
University of Minnesota

Fig. 6.7 USIALE Annual Symposium Program, *The Role of Landscape Ecology in Public-Policy-Making and Land-Use Management*, 21–24 March 1990, Miami University, Oxford, Ohio

Joan I. Nassauer 1990–1992

I was elected president at the March 1990 annual meeting in Oxford, Ohio, Miami University. Subsequent annual meetings were: 1991, in which USIALE's annual meeting was held in concert with the World Congress of Landscape Ecology in Ottawa, Ontario; 1992, Corvallis, Oregon.

A challenge I addressed During My Term As President

Engaging landscape ecologists and employing landscape ecology to influence policy—Perhaps the biggest challenge we faced during my term was consideration of the question of whether IALE should be involved in policy making. At the 1990 membership meeting, Frank Golley advocated for landscape ecologists to influence environmental policy, and I appointed a Landscape Policy Scoping Committee to study if and how USIALE might do this. After a vigorous discussion of this issue during the 1991 annual meeting in Ottawa, the Scoping Committee conducted a survey of members. Citing member concerns about diluting the resources of a small organization IALE and about the danger of undermining scientific legitimacy by attempting to influence policy, the Scoping Committee ultimately recommended that USIALE *not* be in involved in policy making at this time. *Note:* Leaping ahead in the history of IALE, in 2009 President Jack Liu appointed a policy task force to study if and how IALE should be involved in policy making. I chaired that task force, and at the 2010 annual meeting in Athens, Georgia, we delivered a report enthusiastically recommending that IALE work to influence environmental policy and suggesting appropriate and efficient means to do this. In 2012, the current president Kurt Riitters and the immediate past president Dean Urban have implemented this recommendation.

Most Significant Accomplishments During My Term As President

During my term as president, our aim was to build the interdisciplinary science and practice of landscape ecology. We engineered the structure of USIALE annual meetings to be settings for interdisciplinary discovery, for interaction between science and practice, and for sharing of knowledge between American landscape ecologists and foreign scholars, especially scholars whose national currencies or economies made travel to America difficult at that time. Some specific elements of our engineering were:

Organization of sessions around interdisciplinary themes—In those years, USIALE annual meetings grew too large to be entirely plenary sessions, so we were careful to identify session topics and assign papers in the multiple parallel sessions in a way that challenged participants to learn different perspectives or methods related to the topic.

This is quite different from sessions organized around similar research methods or similar disciplinary teams.

Embracing landscape ecology practice as important to the evolution of landscape ecology science—We established a new award, Distinguished Landscape Ecology Practitioner, to accompany the Distinguished Landscape Ecologist Award, which emphasized accomplishment in science. In 1991, the Philadelphia, Pennsylvania, ecological design firm, Andropogon Associates, was the first recipient of the Landscape Ecology Practitioner Award. Over time, this award has elevated the essential contributions of integrative designers, planners, conservationists, community leaders, and nontraditional scientists.

Continued emphasis on the value of exchanging information with foreign scholars—Thanks to the hard work of Frank Golley and Gary Barrett in the founding years of USIALE, we clearly recognized the importance of support for foreign scholars who otherwise would have been unable to participate in USIALE meetings. Several scientists who have now become world renowned participated in our annual meetings as a result of this support. During my term as president, we developed tactics to raise funds to support these scholars. Ideas that we put into action included the annual book auction.

In addition, we established an endowment to sponsor student participation in the USIALE annual meetings. We also continued a valuable tradition begun at the 1990 Oxford, Ohio meeting—inviting representatives of peoples who are indigenous to the regions that are the site of the annual meeting to participate. Participation by indigenous peoples took many forms under subsequent presidents and program chairs—all these interactions were meaningful and enlightening.

Most Significant Challenges that Landscape Ecologists Must Address over the Next 25 Years

In my view, the most significant challenge ahead for landscape ecologists is to assert and build confidently, credibly, and legitimately the significance of our work for science and practice. This challenge is significant, not so much because it affects landscape ecology as a field, but because it could be so significant for action in the world and on the ground. It is no small challenge. It requires that we individual landscape ecologists and USIALE as a whole adopt ways of working that empower us to draw upon the many methods and programs that fall within what has become our transdisciplinary field. We can celebrate the work of many leading landscape ecologists, which exemplifies this transdisciplinary capacity to conduct actionable science. Their work suggests how we as a scientific organization can more purposefully position landscape ecology's longtime commitment to building meaningful and actionable knowledge of landscape pattern, process, and design for broader critical examination.

I would argue that, since its inception at the 1986 Athens, Georgia symposium, landscape ecology in America has aspired to achieve the very integration of environmental and social science knowledge toward action on the ground that much of science has only recently come to see as a pressing need. Our challenge over the next 5 years is to characterize and catalyze the science and practice we have already achieved and the new discoveries that we can see from where we stand to boost the advance of actionable socio-environmental science. Over the next 25 years, we should aim to have repeatedly demonstrated how new socio-environmental scientific discoveries about landscapes have real influence on environmental change.

Fig. 6.8 Presentation of the 2010 USIALE Distinguish Presidents' Award: Monica G. Turner. (Photography by Wingate Downs Photo Courtesy of Terry Barrett)

Monica G. Turner 1994–1996

For USIALE President Monica G. Turner contribution, see Chap. 4 in this volume (Fig. 6.8).

Fig. 6.9 Presentation of the 2010 USIALE Distinguished Presidents' Award: Louis R. Iverson. (Photography by Wingate Downs Photo Courtesy of Terry Barrett)

Louis R. Iverson 1996–1998

Annual meetings were at Duke University (1997, Dean Urban local host), and Michigan State University (1998, Jack Liu and William Taylor local hosts) (Fig. 6.9)

Significant challenges

1. *Landscape Ecology Journal* issues—SPB Publishing bought out by Kluwer. Bob Gardner takes over as Editor-In-Chief from Frank Golley. What is the relationship of the society to the journal?
2. What is the role of landscape ecology in general and USIALE in particular in shaping management of our landscapes? How can we get the word out that we are the right people to help in this arena? What are the long-range plans for the society?

Three significant accomplishments

1. Hired part-time membership secretary (Nancy Castro) with membership management software for tracking members and dues payments.
2. Initiated website for USIALE and for the individual host annual meeting sites, along with USIALE list serve. Other publicity efforts included initiating a brochure and a poster board set up on the value of USIALE.

3. Established first Strategic Planning Committee (Forman, Nassauer, Crow, With) to conduct long-range planning for the society. The strategic goals formulated and adopted were five:

    a. Promote high-quality research and scholarship in landscape ecology.
    b. Catalyze new knowledge and further develop the body of theory using the interdisciplinary expertise in landscape ecology.
    c. Improve communication among members and with international colleagues in landscape ecology, and among members, practitioners, and policy makers.
    d. Advance the application of landscape ecology principles in natural resource management, land planning and design, conservation, and public policy.
    e. Enhance the effectiveness of USIALE for its members.

One unusual event

1. IALE raised dues for members from $10 to $20. This raised a fuss. Fortunately, it is still an unusual event.

Two most significant landscape ecology advances

1. Improved engagement and long-term involvement into the landscape ecology field by and for students. First National Aeronautics and Space Administration–Michigan State University (NASA–MSU) grants for students (by Jack Liu)—still continues today to bring students to the meetings and gets them engaged in the society.
2. Also the first student representative, Sam Riffel, joined the Executive Committee to ensure student needs were addressed in all society actions.

Three most significant challenges facing landscape ecology in next 25 years

1. Making the science and tools more relevant for the big questions—How to deal with climate change? How to deal with human poverty and the landscape controls on human well-being? How to deal with biodiversity loss and invasive species? How to deal with population increases, urban sprawl, wildland–urban interface, in the face of many other challenges?
2. Getting the public (and especially public officials) educated on the value of and need for support of landscape ecology-based analysis and management for the above issues.
3. Because landscape ecology is a great integrator among disciplines, how to keep all the advances in related disciplines, especially those with socioeconomic dimensions, actively integrated and current for landscape ecology researchers and practitioners?

Fig. 6.10 Presentation of the 2010 USIALE Distinguished Presidents' Award: Virginia Dale. (Photography by Wingate Downs Photo Courtesy of Terry Barrett)

Virginia Dale 2000–2002

Term when I was president of USIALE (Fig. 6.10), including the sites of the annual meeting each year

Annual meetings:
2001—Tempe, Arizona
2002—Lincoln, Nebraska

Three greatest challenges I addressed during my term as president

- Establishing a protocol for running the annual meetings
- Transitioning the web page management to a more permanent status
- Continuing outreach and engagement of students

Three most significant ecological concepts, principles, or methodologies that changed the direction of landscape ecology during my tenure as president

Trends

- In how information is used in decision making
  - More complex view of world
  - Environmental pressures are increasing
  - Awareness of environmental pressures increasing
  - World is becoming networked
  - Globalization of economy
  - Stakeholders more educated and more actively involved
- The amount of effective biosphere per person on the earth (e.g., the world's population is growing and the area of land not in some sort of development is decreasing)
- Everyone wants answers now!
  - Seeking a technology "fix"
  - Society resists change
  - Happens incrementally
  - Results following disaster
  - Policy incentives, mandates and restrictions are viewed with caution
  - The process of scientific investigation is not understood

Gaps in knowledge and tools

- Addressing appropriate scale of issue
- Available data and use
  - Need to be at appropriate temporal and spatial scales
  - Need to relate to phenomenon of interest, e.g., land cover ≠ land use
  - Need to be affected by process of concern
- Experiments that include key drivers and appropriate scales
- Models that include key processes at appropriate scales and that are well documented
- Key indicators and how to measure them
- Comparison tools
- Linking ecosystem function to services
- Quantifying monetary and nonmonetary values of ecosystem services
- Determinates of behavioral response
- Considering all components of sustainability

- Comparing across options
  - Some energy options (fossil fuel-based energy, natural gas, coal, renewable-based energy, bioenergy, wind, solar, geothermal, nuclear-based energy
  - Activities that have potential effects (e.g., exploration and development, extraction, processing, transport, storage, and dealing with waste products)

Solutions offered by landscape ecology

- Using research for resource management
  - Acknowledge full scope of problem within a systems perspective
  - Explore diversity of approaches
  - Use long-term vision to direct research
  - Explore alternative futures
  - Engage the people affected by the resource uses
- Tools that address problems in appropriate manner
  - Including human drivers and responses
  - Dealing with spatial and temporal dynamics
  - Considering interactions and trade-offs
  - Quantifying uncertainties and sensitivities
- Collaboration between scientists and decision makers
  - Collaboration
  - Iterative process to build consensus
  - Set goals that reward collaboration
  - Technology transfer
  - Presenting information in an understandable manner
  - Designing research in terms of management design (see the end at the beginning)
  - Dealing directly with risk
  - Define uncertainties
  - Communicate risk

One unusual event that occurred during my presidency that impacted my career as a landscape ecologist

The US-IALE 2002 Symposium in Lincoln, Nebraska , featured a staged debate between a contemporary landscape ecologist and an impersonator of Julius Sterling Morton (1832–1902), a Nebraska journalist and politician, who instigated the first Arbor Day celebration on 10 April 1872 in Nebraska. The debate centered on ideas for and against planting trees in the prairie. It illustrated how far modern ecological thinking has come in terms of realizing the importance of place in interpreting theories and implementing management practices.

Fig. 6.11 Presentation of the 2010 USIALE Distinguished Presidents' Award: Eric J. Gustafson. (Photography by Wingate Downs Photo Courtesy of Terry Barrett)

Eric J. Gustafson 2002–2004

I was the first person to hold the office of chair-elect of USIALE, an office created in 2001 (Fig. 6.11). My role as chair-elect effectively oriented me to the business of the society over the course of a year; and I believe that extra time contributed greatly to the success we had during my administration in advancing the society on a number of fronts. My formal term as chair began in 2003 at the Lincoln, Nebraska annual meeting when the outgoing chair Virginia Dale handed me a rolled-up Lincoln Street map as an off-the-cuff symbol of the transfer of power in a society that values maps! We had a lot of fun in that moment, but I resolved to procure a better symbol to hand to my own successor. Some may argue that the cherrywood gavel that is now passed to all incoming chairs is the crowning achievement of my administration!

Focus Areas

The Executive Committee and I agreed on three major focus areas during my term as chair:

1. Advancing the society into the digital age. Although it seems indispensable today, the Internet was not really used by the society prior to 2002 except for

e-mail. In response to rapidly increasing demand to accept online payments, we spent a good deal of time and resources to develop a useful Web presence. With leadership by Rebecca Kennedy Hess, we hired a webmaster (Matt Gregory) and made substantive improvements to our website, including online membership registration and dues payment, member networking services (including job postings), and enhanced website content (including course syllabi and photo gallery).

2. Improving the administration and organization of our annual meetings. Another perennial issue at that time was the enormous task of organizing the annual meeting, which had become a barrier to recruiting people to organize meetings. Two volunteer members who functioned as program chair and local host traditionally handled this task. The stress and exhaustion resulting from organizing a meeting depended in some measure on the organization and delegation skills of those volunteers, but it was a grueling task for even the most gifted of administrators. It also was apparent that the quality of the meetings was sometimes uneven because of the magnitude of the task. The primary enhancements we made were to begin using the services of a meeting organizer (an idea advanced by Virginia Dale) and to develop a Memorandum Of Understanding (MOU) template to use with annual meeting host organizations to specify responsibilities and fiscal arrangements. Nita Tallent-Halsell and Bruce Jones first used the services of a meeting consultant to organize the Las Vegas meeting of 2004, and although all subsequent meeting planners have not used such services, it has become a standard practice that significantly reduces the magnitude of the job of organizing the annual meeting.
3. Strategic and tactical planning and implementation. The Executive Committee charged the chair-elect (Pete August) to form a committee to revise the 1998 strategic plan, providing his administration with a ready-made blueprint for action. Concurrently, we developed a list of strategic initiatives that would improve the value and effectiveness of the society for its members. We also had a fairly lengthy laundry list of more tactical items that would incrementally improve the functioning of the society. To implement our solutions to these needs, we formed several ad hoc committees and assigned action items to Executive Committee members. Progress was encouraged by holding regular teleconferences to monitor progress. The items we worked on included financial planning and budgeting (Phil Townsend), producing a USIALE brochure and poster (Nita Tallent-Halsell), amending the bylaws to allow online voting, an outreach and promotion plan (Nancy McIntyre), formalizing an MOU to be used with institutions hosting meetings, and continual website improvement (Rebecca Kennedy Hess). We also focused a great deal of time and energy on brainstorming and implementing tactical plans to increase membership, improve services to our members, advance the relevance of the society to the landscape ecology scientific enterprise, and improve the administration of the society.

Challenges for the Future

I see three challenges for the future, all related to the fundamental and rapid changes occurring in how people communicate and interact:

1. I believe that the most important task for the leaders of USIALE is to sustain and improve our core strength—our annual meeting. This seems to be the service that the members of USIALE most value. The most commonly cited things that people like about our meetings are their relatively small size, the midweek field trips, and the opportunity for quality networking and socializing. Our traditional format will likely need revision to adapt to the times and technology, but these core strengths should not be forgotten. Perhaps we will one day offer videoconferencing options for those who cannot travel, but I believe that the face-to-face experience of our meetings will remain a core value of the society.
2. I believe that there is almost unlimited potential for the society to exploit the Internet to help landscape ecologists get information, to connect and network with each other, and to create and disseminate knowledge. I pose this question to the leadership of USIALE: "If we are not relevant on the Web, will we be relevant anywhere?" I commend the society for the advances that have been made in this regard, primarily via the USIALE website, which has a number of very useful features. But I believe there is still much untapped potential for connecting landscape ecologists to each other, and to connect landscape ecology knowledge to those who need it. I recommend that the society leadership invest aggressive and intentional energy to advance us rapidly in this arena.
3. How do we maintain the relevance of our scientific society in the face of instant global access to information and people? This is both a challenge and a great opportunity. People are rapidly relating to others almost exclusively through electronic media. To what extent should we embrace this, and how can we create an essential niche to enhance the interpersonal networking that will make our society critical for the advancement of our science? For example, should we establish an aggressive Facebook or LinkedIn or Twitter presence to help our members connect with each other and to reach new members? Should we promote landscape ecology bulletin boards or chat forums? We could provide a service to connect first-world landscape ecologists with scientists in less-developed countries, using Skype, to mentor colleagues anywhere in the world. Should we promote blogging and twittering from our meetings? Many of these are technological challenges, and a small society may be better able to pioneer such technology because the scale is more manageable.

Conclusion

The steps my administration took 10 years ago to bring USIALE into the digital age seem distant and miniscule today. But they seem to have produced useful and even necessary value to our society over the past decade. Yet the promise and challenge of the digital age remains as large as ever. I look forward to seeing how this promise is harnessed over the coming decade to advance the study and application of landscape ecology.

Peter August 2004–2006

Annual meeting sites

2003—Banff, Alerta, Canada
2004—Las Vegas, Nevada
2005—Syracuse, New York
2006—San Diego, California

Three Greatest Challenges

The three greatest challenges that I addressed during my term were (1) creating value for membership in USIALE, (2) maintaining the strong portfolio of activities USIALE has evolved to support student development, and (3) navigating some unforeseen and delicate issues that emerged with international chapters of IALE.

1. The membership of USIALE is its greatest asset. Landscape ecologists participate in USIALE for many reasons, but whatever the reason, they feel they receive value and return for the cost of their membership. The organization must ensure that it continues to provide value to its members. During my term as chair, the officers and counselors-at-large made enhancing USIALE web services a priority activity with the goal of increasing value for being a member in the organization. Our work is described in the accomplishments section of this chapter. Other important activities that provide value to USIALE members include the annual meeting, the newsletter, the support it provides students and foreign landscape ecologists, and advancing scholarship through the journal and symposia. Related to the issue of value is the oft-asked question—What is the optimal size of the organization? The Society for Conservation Biology (SCB) and the Ecological

Society America (ESA) are an order of magnitude larger than USIALE. Of the discussions that I have been party to on the question "should we grow USIALE to be as large as ESA or SCB?," the answer is invariably no; our members value the intimacy of USIALE and the ability to have meaningful interpersonal interactions at the annual meeting.

2. USIALE excels in providing support and mentoring to the next generation of landscape ecologists—students and young scientists early in their careers. This is accomplished in many ways, notably: support for student activities at the annual meeting, feedback on student presentations, awards for best student paper and posters, networking events with senior landscape ecologists, and the successful NASA–MSU travel scholarship program led by Dr. Jack Liu. USIALE must continue these flagship activities. This is achieved by ensuring adequate financial support for these programs in the annual budget of the organization, providing time and space at the annual meeting for student events, and supporting the work of the NASA–MSU awards program and the USIALE Awards Committee that handles the logistics of reviewing student presentations and making the annual awards.
3. A simple inquiry that came to USIALE during my term as chair quickly spiraled into an awkward international incident. Canadian landscape ecologists were debating the pros and cons of forming a Canadian chapter of IALE, or alternatively, merging with USIALE to create a larger entity called the North American chapter of IALE. We were asked if USIALE would be supportive of such a merger. To respond to this inquiry from our colleagues to the north, I formed a small committee chaired by the councilor-at-large Kurt Ritters to look into the issue and identify the opportunities and pitfalls that such a merger might have. The charge of the committee was expanded to include Mexico when we were informed by IALE that Latin American landscape ecologists also were entertaining the idea of a merger with the United States chapter. In the period of a few months, rumors spread that the USIALE and Canada had formed an alliance and had made an offer to Mexican landscape ecologists to join with Canada and the United States. This false rumor apparently spawned a rift within the Latin American landscape ecology community, which resulted in the resignation of the leadership team that was supposed to create a Latin American chapter of IALE. When this news reached us, we immediately sent a clear statement to our colleagues in Canada and Mexico that USIALE would be delighted to explore mergers, but had no interest in leading the initiative. We also suspended the work of the committee that was formed to study the matter. In the end, there were no permanently ruffled feathers, and our colleagues to the north and south continue to explore developing their own communities of landscape ecologists. The lesson learned for USIALE was tread carefully on matters of mergers and international alliances; rumors and misconceptions can arise out of the blue and create awkward problems.

Three Most Significant Accomplishments

The three most significant accomplishments I contributed to as chair of USIALE were (1) providing support and guidance to many individuals who enhanced the USIALE website, (2) laying the foundation for a system to ensure inter-year organizational and logistic continuity in running the annual meeting of USIALE, and (3) delivering a strong organization to the chair that followed me, Bob Gardner.

1. Many people worked hard to make the USIALE website more informative and useful to the membership during my term. Rebecca Kennedy, Matt Gregory, and Jack Liu were particularly active in enhancing the website. A “Members Only” section of the USIALE was created that held documents and information of interest to the membership. This included copies of USIALE and IALE newsletters, committee documents, and the USIALE Handbook. A glaring omission in the USIALE website was basic information on what landscape ecology is. Someone outside the discipline would have had a hard time learning what landscape ecology is from the website alone. Jack Liu, a councilor-at-large at the time, took on the task of creating content for a “What is Landscape Ecology?” section on the opening page of the USIALE website. Jack collected short squibs from eminent landscape ecologists who personalized their passion for the discipline. Another enhancement of the USIALE website was creation of an online voting system that allowed all members to vote for officers of the society. Previously, only members attending the annual meeting were able to vote. In its inaugural year, the online system increased participation in voting for officers by a factor of three—from 30 votes cast in 2004 to over 90 in 2005. These initiatives in enhancing web services and content were part of our larger effort to provide value to USIALE members for the annual dues.
2. Landscape ecologists are truly a clever lot. Over the years, I have discovered that they possess many interesting skills and talents—they are excellent statisticians, accomplished photographers, hikers, naturalists, and, as we sometimes learn at the annual meeting, talented singers on the karaoke stage. Unfortunately, profound business acumen is rarely a skill that emerges among a room full of landscape ecologists. This becomes a practical problem for the organization because some of its activities, the annual meeting for example, can become incredibly complex in terms of financial modeling, handling large sums of money, negotiating contracts with hotels, and managing complex databases on registrations, and papers/abstracts. For the 2006 meetings in San Diego, we hired a professional meeting planner, Cindy Delaney of Delaney Meeting and Management (DMM), who handled all the business aspects of the conference. This allowed the local host, Janet Franklin, to focus on the program, field trips, and plenary speakers. We have continued to use DMM when local hosts do not have capacity to perform the complex logistics of coordinating a meeting of 250–350 people. DMM will assist USIALE in meeting management for 2011 and 2012. By contracting

out meeting management to professionals, the responsibilities of organizing a meeting are significantly easier for the local host. Having a single meeting manager provides year-to-year logistic continuity for many aspects of the annual meeting.

3. Discovery is typically a bottom-up process. Advancement of the science and application of landscape ecology begins with ideas, insights, and creativity among individual scientists. The role of USIALE in the discovery process is to provide a fertile setting for scientific exchange, sharing of ideas, fostering collaboration, and communicating new advances in the discipline. USIALE does this very well through its annual meeting, newsletters, LISTSERV, and contributions to the journal *Landscape Ecology*. It is the responsibility of the chair to ensure that the organization continues to be successful in providing a setting where landscape ecology grows and advances as a science, and the insights of the science are used to address pressing environmental management challenges of the day. My term as chair was sandwiched between two extremely capable chairs of great scientific record and management skill. I inherited a strong organization from Eric Gustafson and was able deliver to Bob Gardner a strong USIALE. This was certainly not my accomplishment alone, but represented considerable effort during my term by the other officers of the society, the councilors-at-large, the student representatives, and committee chairs and members.

One Unusual Event…

The Indonesian tsunami of 2004 occurred during my term as chair. It spawned discussion and scholarly research by our community on the role of landscapes in the dynamics of natural disasters. Landscape ecologists are preadapted to have informed insights on the topic; the discipline has long studied the nature of movement across the land, for example the spread of fire, disease, pollutants, and species. In the case of the Indonesian tsunami, the driving factor was the flow of water over coastal landscapes. Sadly, this theme was repeated in Hurricane Katrina. Landscape ecologists brought their scholarship to bear on understanding the dynamics of flooding, property loss, and habitat damage in the tsunami of 2004 (Iverson and Prasad 2007). An international group of landscape ecologists have recently challenged their peers to use the knowledge and methods of landscape ecology to address issues of poverty in the world (Pijanowski et al. 2010).

The loss of people and property from the Indonesian tsunami of 2004 has brought indescribable suffering to many. It also spawned an increased awareness that landscape ecologists have much to offer the scientific assessment of disaster mitigation and relief. Hopefully, the USIALE will continue to acknowledge and support the importance of this “grand challenge.”

Two Concepts to Change Direction…

The two most exciting concepts that enriched the science and application of landscape ecology during my term were (1) the formal demonstration that the principles of landscape ecology that were conceived in terrestrial ecosystems could be extended into marine environments, and (2) advances made in translating the science of landscape ecology into terms and concepts that planners and resource managers can adopt.

1. Most of the research that has given rise to the core principles of landscape ecology was developed in terrestrial ecosystems. This is not surprising because the tools and technologies used to measure landscape pattern were first developed for mapping land systems. Air photo acquisition and interpretation, satellite image processing, and GIS are examples of such tools. Under the leadership of Elizabeth Hinchey, Matt Nicholson, Roman Zajac, and Elizabeth Irlandi, a special symposium was held at the 2004 USIALE meetings in Las Vegas that explored the application of the principles landscape ecology to marine and coastal environments. The results of symposium were published in a special edition of the journal *Landscape Ecology* (Hinchey et al. 2008). The contributors clearly showed how the concepts of landscape ecology apply well to submerged environments. In the past few years, there has been a resounding call for "Marine Spatial Planning (MSP)" as a means to manage our oceans as we do our terrestrial environments (The White House Council on Environmental Quality 2009). The symposium and publication by Hinchey et al. (2008) set the stage nicely for the development methods and protocols for MSP.
2. Much of the excitement of landscape ecology stems from the bridging the principles and discoveries of the science with the information needs of planners and resource managers. For 30 years, USIALE has remained committed to ensuring a seamless continuum from discovery to application. The 2006 publication "Measuring Landscapes: A Planner's Handbook" by André Botequilha-Leitão, Joseph Miller, Jack Ahern, and Kevin McGarigal was an important ratification of the importance of extending the science of landscape ecology to the desk of the decision maker. A fundamental principle of our science is landscapes have pattern; pattern can be measured, and pattern influences process. The software tool FRAGSTATS has made it possible to easily measure landscape pattern and evaluate how those patterns affect process. Much of this research sits on the basic science side of the discover–application continuum. Leitão's publication is aimed at making the measurement of landscape pattern useful and relevant to planners and decision makers. It is publications like this that makes landscape ecology such an exciting discipline.

Three Challenges

The great challenges facing USIALE for the next 25 years include:

1. The future of the science landscape ecology and the USIALE rests in the work of the next generation of landscape ecologists. USIALE must continue, and even expand, its programs to support students and provide for them a professional setting that is exciting, welcoming, and fosters collaboration. The current portfolio of student activities works well. Evidence of this is the excellent research and application of landscape ecology by young professionals who were nurtured by the organization in their early years. The NASA–MSU awards have been exceptionally successful in making it possible for large numbers of students to attend the annual meetings. It would be prudent to begin work now to make this program a secure and permanent one. This might take the form of a modest endowment that would produce an annual dividend to continue the NASA–MSU student awards that has proven so successful.
2. USIALE is unique in its support for basic science and the application of the knowledge that the science produces. If USIALE loses its commitment to the planning, design, and resource management community, it will not be much different from organizations such as the ESA. Furthermore, if USIALE loses its commitment to discovery science of landscape pattern and process, it will not be much different from the American Planning Association. The challenge for USIALE for the next 25 years is to maintain a fertile environment where scientists and resource managers can interact in a respectful and stimulating manner.
3. The vast majority of students I see in my classes are enthusiastic about their science, and are passionate that their scholarship serves society. When I was a graduate student three decades ago, there was a strong feeling that applied science played second fiddle to basic science. The emergence of disciplines such as landscape ecology and conservation biology sent young scientists a clear message that applied science is relevant and important. It is now clear that the science of landscape ecology can play a key role in designing sustainable communities, planning for smart growth, developing ecosystems resilient to climate change impacts, preserving biodiversity, and addressing the relationships between ecosystem condition and poverty. It is incumbent on USIALE to continually reinforce this message, especially to young professionals just starting their careers. Philosopher Thomas Kuhn noted in his essay on the structure of scientific revolutions that paradigm changes happen, in part, when the senior statesmen and stateswomen of science and society declare the new paradigm to be good. USIALE must play an active role in providing this blessing of applied research to young scientists.

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Jianguo Liu 2008–2010

Jianguo Liu was serving as USIALE president at the time of the 2010 USIALE 25th Anniversary Symposium (Fig. 6.12).

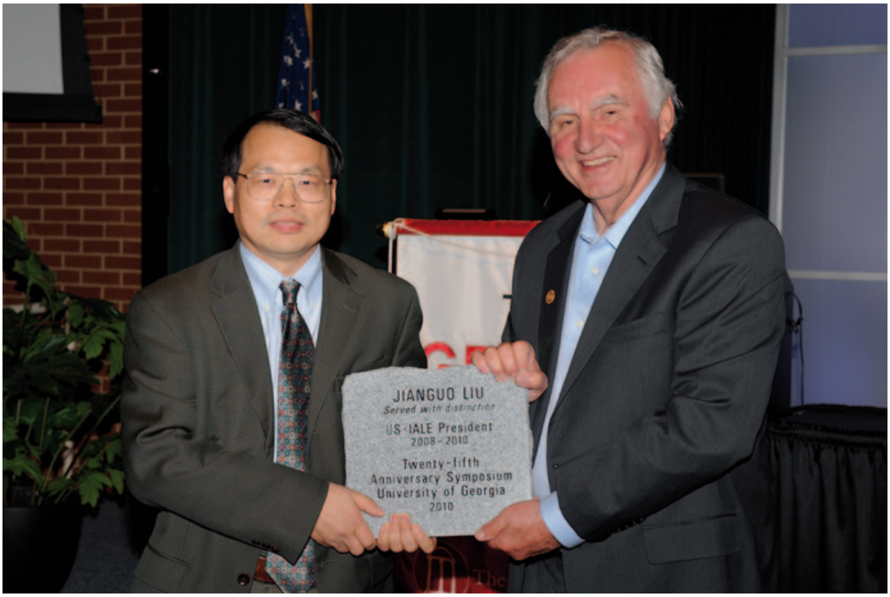

Fig. 6.12 Presentation of the 2010 USIALE Distinguished Presidents' Award: Jianguo (Jack) Lui. (Photography by Wingate Downs Photo Courtesy of Terry Barrett)

Concluding Remarks by G. W. Barrett

I found it interesting that earlier former presidents of USIALE were the ones who accepted our invitation to provide perspectives on their tenure as chair. For example, seven of the presidents, 1986–2006, provided excellent overviews regarding their challenges and achievements while in office, whereas no past presidents following 2006 accepted our invitation. Perhaps recent presidents of USIALE discovered that most problems had been solved and few administrative achievements remained to be accomplished!

At any rate, these early perspectives provide a historical glimpse of a developing paradigm during these past three decades of growth, development, and stature. Chapter 11 will attempt to provide suggestions of challenges that may face future presidents of USIALE.

Acknowledgments I sincerely thank those early presidents who shared their challenges and accomplishments, thereby providing an overview of how USIALE became such a successful and vibrant new transdisciplinary field of study.

Chapter 7
Significant Theories, Principles, and Approaches that Emerged Within Landscape Ecology During the Previous Thirty Years

Gary W. Barrett and Herman H. Shugart

Introduction

What is landscape ecology?

As with the science of ecology, several individuals are frequently mentioned during recorded antecedents as pioneers to this emerging field of science or paradigm. For example, German zoologist, Ernst Haeckel (1869), coined the term "ecology." In his first edition, *On the Origin of Species*, Charles Darwin outlined the theory of natural selection (which Haeckel termed "the struggle for existence") that remains a mainspring of ecology (Darwin 1859). The writings of Hippocrates, Aristotle, and other philosophers of ancient time also clearly contain references to ecological topics.

Sauer (1925) defined landscape as a unit concept in geography, while describing the areal features and morphology of the landscape. For example, Harper et al. (1993) investigated how the geometry of landscape patches influences small mammal (*Microtus pennsylvanicus*) home-range size and shape. He also noted distinction between natural and cultural landscape.

Tansley (1935) was the first to define the term "ecosystem" as an intrinsically self-coherent entity of a living community and environmental factors. Troll (1939) was the first to define the term "landscape ecology" as the harmonic interplay of climate, soil, and vegetation, including the equally important interconnectedness of animal life, parasites, and soil fauna. Turner (2005) noted that landscape ecology offers a spatially explicit perspective focusing on the relationships between ecological pattern and process that can be applied across a range of scales. Most defini-

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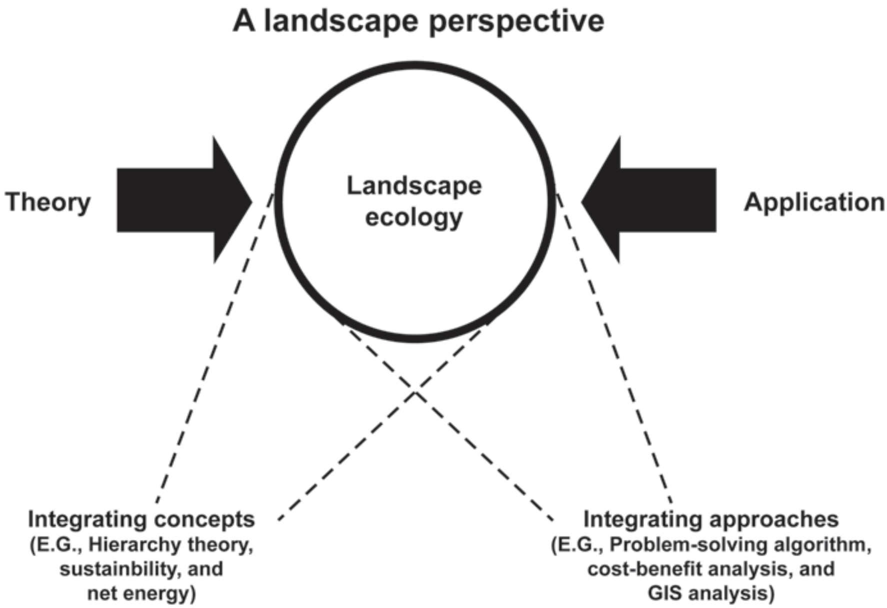

Fig. 7.1 Landscape ecology as an integrative paradigm wedding ecological theory with practical application

tions of landscape ecology share the explicit focus on the importance of spatial heterogeneity on ecological processes—processes that transcend across all levels of organization.

Originators of landscape ecology include German biogeographer, Carl Troll (1939), who coined the term, “landscape ecology,” and Karl Friedrich Schreiber (1990), who described the early history of landscape ecology in Europe—a field of study that developed in close association with land-use planning. Originating from this rich European tradition, landscape ecology in North America, especially in the United States, is now a well-established field of study, nationally and internationally. The concepts of landscape ecology (patch dynamics, metapopulation theory, and hierarchical theory), its tools (Geographical Information Systems (GIS), remote sensing, spatial modeling), and transdisciplinary approaches (problem-solving algorithms, cost-benefit analyses, and scaling) are now widely used in most ecological and related disciplines, such as forestry, wildlife biology, conservation, and resource management (Barrett 1985; Fortin and Agrawal 2005; Turner 2005). Landscape ecology also provides an excellent venue to integrate basic and applied science (Barrett and Bohlen 1991). Landscape ecology is an integrative paradigm that weds ecological theory with practical application (Fig. 7.1).

In this chapter, we focus on significant theories, principles, concepts, and approaches that emerged within landscape ecology during the previous 30 years. Emphasis will be placed on the United States Regional Association of the International Association for Landscape Ecology (USIALE) where appropriate.

Description and Importance of Landscape Components or Elements

It is now widely accepted that the three basic elements of landscape ecology are patches, corridors, and the landscape matrix. Forman and Godron (1986) described how patches differ fundamentally in origin and dynamics, also noting that patch size, shape, and spatial configuration are important. They organized four types of corridors in landscapes: line corridors, strip corridors, stream corridors, and network corridors. Later, Odum and Barrett (2005) defined five types of corridors: remnant (e.g., corridors connecting virgin patches of timbered forest); disturbance (e.g., power line cutting through a forest habitat); planted (e.g., trees established during the Shelter Belt project in the 1930s); resource (e.g., stream meandering through a watershed); and regenerated (e.g., fencerow in secondary succession). Earlier, Pickett and Thompson (1978) discussed patch dynamics in context with the design of natural reserves. They build on the Island Biogeography Theory (MacArthur and Wilson 1967) describing how population confined in small areas such as "islands" is more prone to extinction due to internal dynamics of the small area; that is, small areas increase the probability of extinction principally due to reduced population size (Simberloff 1974).

Wiens (1976), building on the concept of resource availability (low and high), expressed how spatially defined social organization is a function of the expense to defend these resources, ranging from territoriality and home range to refuge and herds or flocks of organisms. In essence, he was one of the first landscape ecologists to describe population responses to patchy environments.

Several investigators, early on, described the relationship of landscape corridors or connectivity to population survival and patterns of movement. For example, Wegner and Merriam (1979) monitored movements of birds and small mammals in farmland habitat, showing how fencerows, which connect woods within the surrounding agricultural mosaic, concentrate the activity of avian and small mammal species into the habitat corridor, thus relieving the isolating effect of the farmland surrounding the wooded forest habitat. Later, Pulliam (1988) described how high-quality patches serve as a reservoir of reproductive surpluses from "source habitats" to maintain populations in "sink habitats," where local reproductive success fails to keep pace with local mortality. Also, Lefkovitch and Fahrig (1985) described how populations of *Peromyscus leucopus* in isolated patches have lower survival probabilities than those populations that are connected to other forest patches.

Much research also has been focused on how the "edge" of landscape patches and edge habitats influence plant and animal interactions, such as predation, nesting and foraging behavior, and changes in abiotic factors. Leopold (1933) in his classic book, *Game Management*, perhaps, was the first to bring attention to the concept of "edge effect" or "edge species." Pratt and Barrett (2012) described how two species of small mammals, the golden mouse (*Ochrotomys nuttalli*) and white-footed mouse (*P. leucopus*), are considered edge species because both species are most abundant in forest-edge habitats. Pratt and Barrett (2012) also scaled the edge concept to the regional biome level, describing how a latitudinal mean annual temperature isotherm, within the eastern deciduous forest biome, defines a switch in reproductive strategies for northern versus southern populations of *O. nuttalli* and *P. leucopus*. Corridor presence and width also play a major role regarding the use and movement of interior versus edge species (Lapolla and Barrett 1993; Haddad and Baum 1999; Haddad et al. 2003).

The Importance of Understanding Temporal and Spatial Scales

Landscape carries with it an intrinsic spatial implication. Accordingly, in the initial development of landscape ecology, a great deal of effort was devoted in attempts to define landscapes and their extent in time and space. There were large implications in exactly how the time and space domains of a landscape were determined, and which phenomena would best incorporate the pattern and dynamics of a landscape. As a prelude to discussing some of these issues, a brief history of temporal scale in ecological systems seems appropriate.

Time and Space Scales and the Ecosystem Concept

In an issue of *Ecology* to Henry Chandler Cowles, Tansley (1935) defined a concept that he called the "ecosystem" as a contrasting alternative to the views of Phillips (1934, 1935a, b) and Clements (1916) on ecological succession as the supra-organismic development of a community. There is little doubt as to what Tansley meant with the word, ecosystem. The term "ecosystem" was first printed in a sentence that also was its definition,

> …the more fundamental conception is, as it seems to me, the whole system (in the sense of physics), including not only the organism-complex, but also the whole complex of physical factors forming what we call the environment of the biome—the habitat factors in the widest sense. Though the organisms may claim our primary interest, when we are trying to think fundamentally we cannot separate them from their special environment, with which they form one physical system.
> It is these systems so formed which, from the point of view of the ecologist, are the basic units of nature on the face of the earth [Earth]. Our natural human prejudices force us to consider the organisms (in the sense of the biologist) as the most important parts of these systems, but certainly the inorganic "factors" are also parts—there could be no systems without them, and there is constant interchange of the most various kinds within each system, not only between the organisms but between the organic and the inorganic. These ecosystems, as we may call them, are of the most various kinds and sizes. They form one category of the multitudinous physical systems from the universe as a whole down to the atom. (Tansley 1935, p. 299)

Tansley emphasized that ecosystems "were of the most various kinds and sizes" and essentially defined an ecosystem as what a systems scientist would term "system of definition"—an arbitrary system defined by the specific considerations for a particular application. Ecosystem as defined by Tansley often conforms well to more mathematical, interactive systems concepts in other sciences. His systems-oriented definition requires the consideration of time and space scales found in other sciences, particularly physical-based sciences.

So how might scale and systems-of-definition come together in the modern ecosystem concept? Figure 7.2 displays the Delcourt et al. (1983) conceptualization of the time and space scales of external inputs (disturbances), the internal ecological processes that are excited by these inputs, and the resultant patterns (e.g., associations, formations) for forest ecosystems. For purposes of example, we have designated two of a possible myriad of forest ecosystems. One indicated by the blue circles in Fig. 7.2 defines a forest ecosystem that is driven by climate variations operating on processes of forest succession to produce changes in subtypes of forests; the other (red circles) denotes a second forest ecosystem responding to glacial cycles and plate tectonics, which operate on evolution and diversity change to produce the global pattern of vegetational formations (e.g., rainforests, deciduous forests, dry forests). Each of these could be called a "forest ecosystem." Each considers inputs, processes, and patterns that are not in the domain of the other. Both are forest ecosystems in the Tansley construct. With the Tansley ecosystem, the questions of which disturbances are most important in an ecosystem depend on the time and space domains over which the scales are defined.

Discussions on the Time and Space Domains of Landscapes

If the time and space scales are a prerequisite to knowing how to formulate the concept of an ecosystem, then this is no less true in the case of landscape. For mosaics of different ecological systems on landscapes, even if these patches are noninteractive but of different ages of the same sort of ecosystem, it is fairly easy to demonstrate that the dynamics of the individual patches can be very different from the dynamics of the landscape summation of the patches. This simplest case of landscape dynamics is a classic concept in forest ecology.

Dynamics of Forest Landscapes with Noninteractive Patches

Understanding the noninteractive dynamics of mosaic systems has deep roots in the ecological literature. Watt (1947) developed a classic paper that is the wellspring for subsequent ideas and extensions of the basic concept that the structure of a mature forest (at the scale of several hectares) is a heterogeneous mixture of patches in different phases or stages of gap-phase replacement. The mature forest should have patches with all stages of gap-phase dynamics and the proportions of each should reflect the proportional duration of the different gap replacement stages.

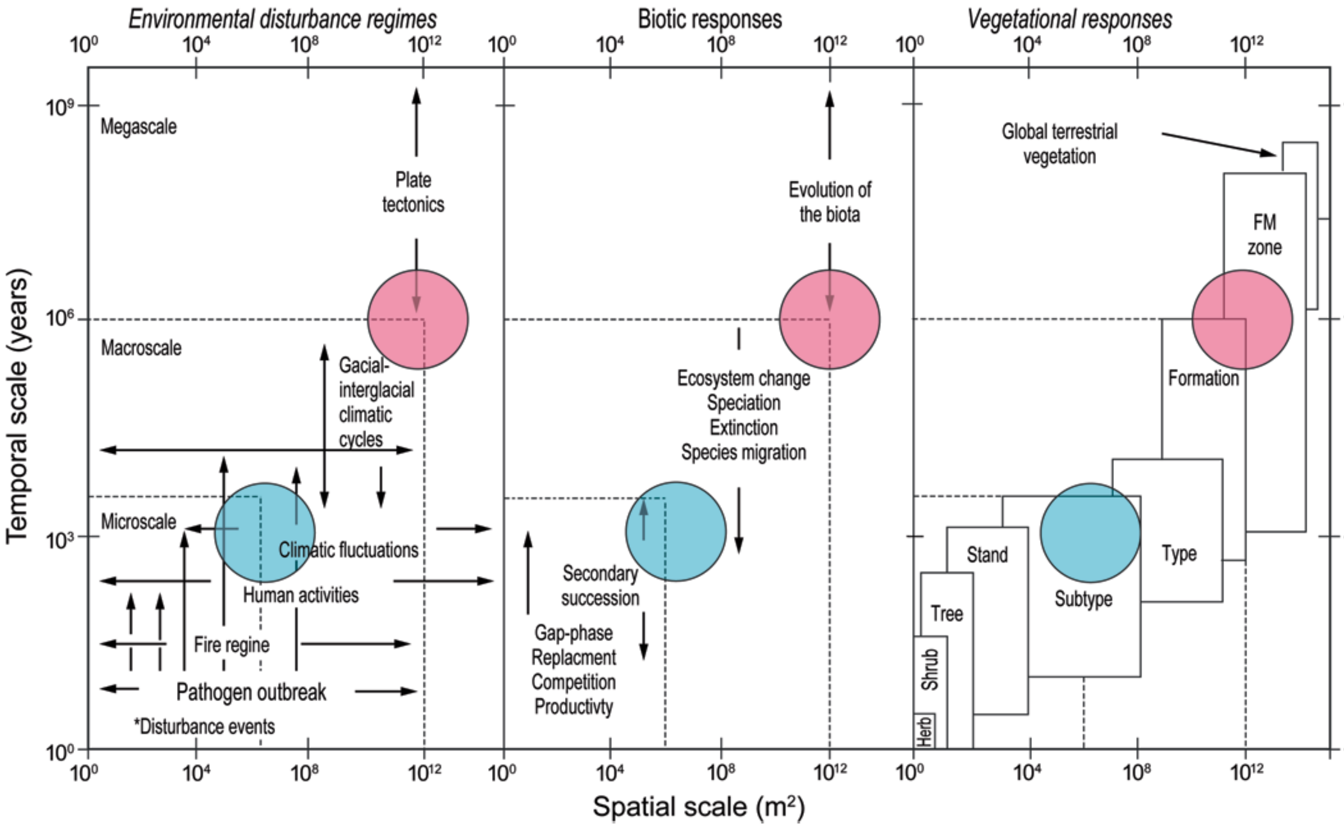

Fig. 7.2 Environmental disturbance regimes, biotic responses, and vegetational patterns viewed in the context of time and space domains in which the scale for each process or pattern reflects the sampling intervals required to observe it. The timescale for the vegetational patterns is the time interval required to record their dynamics. The vegetational units are mapped as a nested series. *Blue circles* denote an ecosystem involving climate variations operating on forest succession to produce changes in subtypes of forests; *red circles* mark a second ecosystem involving glacial cycles and plate tectonics operating on evolution and ecosystems change to produce the global pattern of vegetational formations (rainforests, tundra, deserts). (After Delcourt et al. 1983)

This has significant implications for the apparent dynamics of forests when viewed at different spatial resolutions. The biomass dynamics for a single canopy-sized piece of a forest (Fig. 7.3a) is quasi-cyclical or in the form of a saw-toothed curve (Shugart 1998). The spaces between the "teeth" in the saw-toothed, small-scale biomass curve are determined by how long a particular tree lives, and for how much time growing is required for a new tree to dominate a canopy gap. After a clear-cutting or forest fire, for example, the summation of several of these biomass curves can be summed to predict the biomass change for a forest landscape. The result is the expected change from deforested land being restored to a forest condition in an effort to increase the regional storage of organic carbon.

This landscape scale biomass dynamic is a simple statistical consequence of summing the dynamics of the parts of the mosaic. If there has been a synchronizing event, such as a clear-cutting, one would expect the mosaic biomass curve to rise as all of the parts are simultaneously covered with growing trees (I in Fig. 7.3b). Eventually, some patches produce trees of sufficient size to dominate the local area; and there is a point in the forest development when the local drops in biomass are balanced by the continued growth of large trees at other locations leveling out the mosaic biomass curve (II in Fig. 7.3b). If the trees over the area have relatively similar longevities, there is also a subsequent period when several (perhaps the majority) of the pieces that comprise the forest mosaic all have deaths of the canopy dominant trees (III in Fig. 7.3b). Over time, the local biomass dynamics becomes desynchronized and the biomass curve varies about an equilibrium biomass value (IV in Fig. 7.3b).

The occurrence of such patterns has been documented for several different mature forest systems. For example, patches of shade-intolerant trees present within mature undisturbed forest are but one observation consistent with the mosaic dynamics of mature forests. The scales of the mosaics in many natural forests are somewhat larger than one would expect from gap filling of a single tree gap, indicating an importance of phenomena that cause multiple tree replacements. Also, the relatively long records (*circa* 40 years in most cases) that are available for forests indicate a tendency for the forest composition to fluctuate with species showing periods of relatively weak recruitment of individuals to replace large trees and strong recruitment in other periods (Jones 1945; Rackham 1992). The carbon storage dynamic (Fig. 7.3) implies that carbon taken up by reforestation and growth of trees may be partially released back into the atmosphere in the future.

When disturbances are sufficiently small or frequent, they are incorporated into the environment of the ecosystem; when sufficiently large and infrequent, they are catastrophic (Fig. 7.4a). There is an intermediate scale of extent and occurrence at which disturbance enforces a mosaic pattern to the ecological landscape. In this case, the landscape pattern is a mosaic of patches, each patch with an internal homogeneity of recent disturbance history different from the surrounding patches.

The mosaic landscape is a statistical assemblage of patches. As in any sampled system, when the number of such patches is small, the variability is relatively large with related increased unpredictability (Fig. 7.4a). If the number of patches making up a landscape is large, the landscape dynamics will become more predictable. Large-scale environmental change, human land-use changes, and natural or

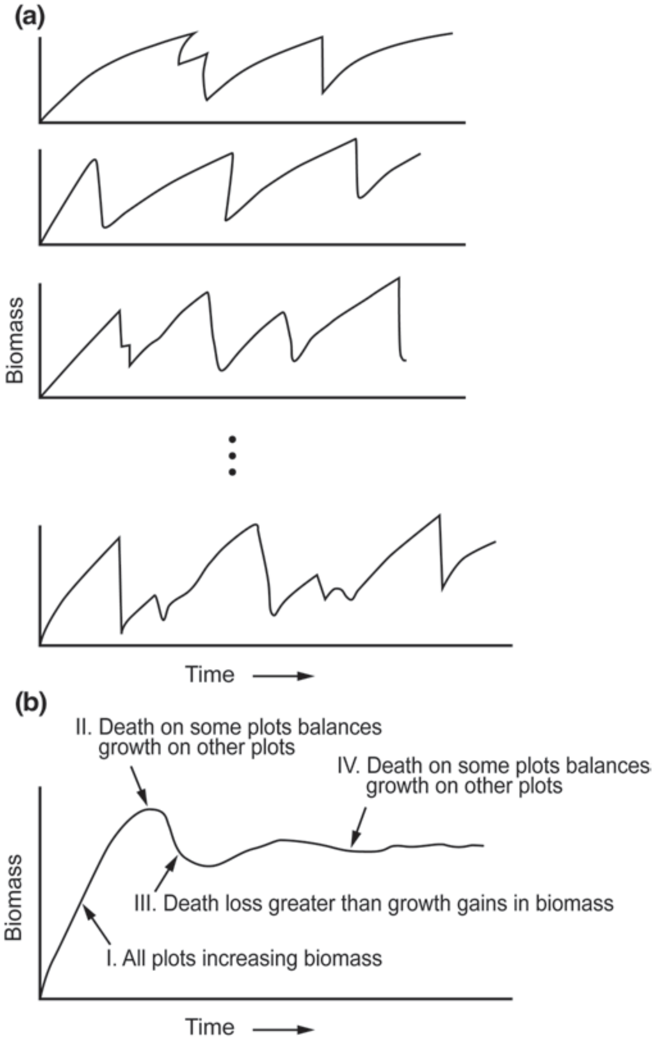

Fig. 7.3 Biomass dynamics for an idealized landscape. The response is from a relatively large, homogeneous area composed of small patches with gap-phase biomass dynamics. (**a**) Individual dynamics of the patches that are summed to produce the landscape biomass dynamics. (**b**) Sections of the landscape biomass dynamics curve are: (I) increasing landscape biomass curve rising as all of the patches are simultaneously covered with growing trees; (II) local drops in biomass are balanced by the continued growth of large trees at other locations (landscape biomass curve levels out); (III) if the trees have relatively similar longevities, there is a period when several (perhaps the majority) of the patches that comprise the forest mosaic all contain deaths of the canopy-dominant trees; and (IV) local biomass dynamics become desynchronized and the landscape biomass curve varies about an equilibrium biomass value

human-induced changes in the climate can alter the spatial and temporal domain of disturbances, and thus change the degree to which we predict landscape behavior. Climate change and human land-use changes tend to increase the size and synchronization of disturbances and make landscape dynamics less predictable.

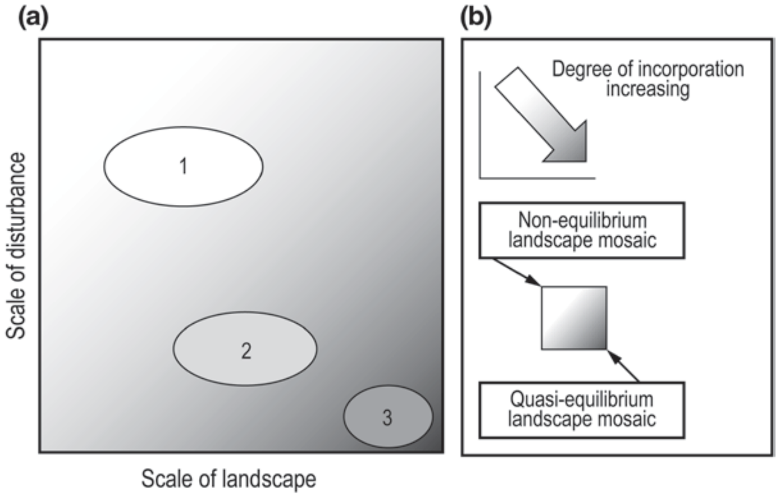

Fig. 7.4 Landscape and disturbance scales. (**a**) The relationship between the size range of disturbances and of the landscapes on which they operate can be used to categorize landscape dynamic behavior. *1* Indicates a disturbance regime whose spatial scale extent is so large that it could be termed a catastrophe; *2* indicates a disturbance regime whose spatial scale is smaller and is a disturbance in the usual sense of the word; and *3* indicates a disturbance regime whose spatial scale is so small with respect to the landscape that it would normally be considered an internal landscape process. (**b**) Quasi-equilibrium landscapes are much larger than the disturbances that drive them and the average behavior of these landscapes is relatively more predictable. When the disturbance scale is relatively large with respect to a given landscape system, the resultant landscape is effectively a nonequilibrium system and is predictable only when the disturbance history is known. The relatively smaller a disturbance, the greater is the degree of incorporation into the functioning of the landscape

The characterization of a forested landscape as a dynamic mosaic of changing patches was well expressed by Bormann and Likens (1979) in what they call the "shifting mosaic steady-state concept of ecosystem dynamics," which is derived from Watt (1947). Exemplified in the paragraphs above, this is an old concept in ecology (Aubréville 1932, 1938; Watt 1947; Whittaker and Levin 1977). In a landscape composed of many patches, the proportion of patches in a given successional state should be relatively constant, and the resulting landscape should contain a mixture of patches of different successional ages of a quasi-equilibrium landscape (Shugart 1998; Fig. 7.4b). In small landscapes (or landscapes composed of relatively few patches), the stabilizing aspect of averaging large numbers is lost. The dynamics of the landscape and the proportion of patches in differing states making up the landscape also become increasingly subject to chance variation. If a landscape is small, it takes on many of the attributes of the dynamically changing mosaic patches that make it an effectively nonequilibrium landscape (Shugart 1998).

In Fig. 7.5, landscape area is plotted along the vertical axis; typical disturbance area for each landscape type is plotted along the horizontal axis. The 1/50 ratio of disturbance area to landscape area is shown as a line. The 1/50 ratio was derived (Shugart and West 1981) from using individual-based tree models (Shugart 1998) to determine the needed number of samples of simulated plots to be averaged for a statistically reliable estimate of landscape biomass. Approximately 50 plots, taken

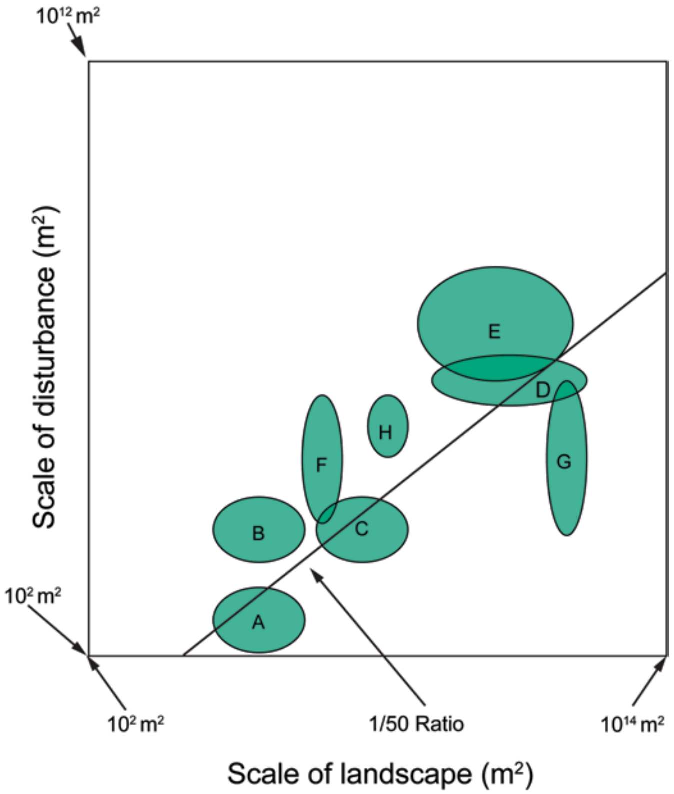

Fig. 7.5 Examples of quasi-equilibrium and effectively nonequilibrium landscapes. **A** Tree fall size versus size of watershed of first-order streams in the Appalachian region of the United States. **B** Wildfire size versus size of watershed of first-order streams in the Appalachian region of the United States. **C** Wildfire size versus size of national parks in the Appalachian region of the United States. **D** Wildfire size versus spatial extent of the species ranges for commercial Australian *Eucalyptus* species. **E** Size of hurricanes versus spatial area of islands in Caribbean. **F** Size of wildfires in Siberia versus size of a forest stand. **G** Size of wildfires in Siberia versus land area of Siberia. **H** Size of floods versus size of floodplain forests

on average, tend to produce a fairly predictable landscape level biomass response, and are used as an arbitrary delineation between quasi-equilibrium and effectively nonequilibrium landscapes. Please note that the comments that follow would hold if this ratio were 1/10 or 1/200.

For example, in Australia, the amount of land burned each year by fires approaches the size of the actual species ranges of a large number of the commercial tree species (Fig. 7.5D). Entire species populations do not have stable age distributions over the entire continent. Some overrepresented tree ages are of individuals regenerated in a particular fire and not subsequently destroyed by later fires. *Eucalyptus delegatensis* tree populations in Australia were disturbed in a tremendous set of forest fires in 1939 that burned over the species' range. For this reason, there are fewer trees than expected that are older than 60 years. A large number of trees regenerated following the 1939 fire; this cohort is overrepresented continentally. There were other fires that also created big mortality events followed by big birth events since 1939 (notably in 1984). Thus, for *E. delegatensis* throughout southeast Australia, most of the trees are only of a few age classes. This situation has important consequences. One of these is that several species of animals that require old *E. delegatensis* trees, as habitat, are now considered endangered species. Many of the Australian forests dominated by *Eucalyptus* species are effectively nonequilibrium landscapes with respect to their biomass dynamics.

If the fall of the tree is the disturbance of interest (gap-scale disturbances), then watersheds of first-order streams in the Appalachian mountains (Fig. 7.5A) would be quasi-equilibrium landscapes. However, if Appalachian wildfires are the focal disturbance (Fig. 7.5B), these same watersheds are relatively too small, and the dynamics of their biomass would be unpredictable without knowing the fire history (as for an effectively nonequilibrium landscape). Indeed, only in the largest parks within the Appalachian region of the United States (Fig. 7.5C) are landscapes large enough to average away the effects on biomass dynamics of the disturbance from typical-sized forest fires. Similarly, forest fires in Russia are large enough to make Siberian forest stands effectively nonequilibrium landscapes (Fig. 7.5F), but Siberia as a whole may be large enough to average away these variations to qualify as a quasi-equilibrium landscape (Fig. 7.5G).

In some cases, the entire biota may inhabit effectively nonequilibrium landscapes. Continental-scale examples have been discussed concerning *Eucalyptus* forest biomass dynamics under the Australian fire disturbance regime (Fig. 7.5D) and Siberian forests (Fig. 7.5F). As further example, the size of hurricanes, which disturb forests of the West Indies, is large when compared with the size of the islands in the Caribbean (Fig. 7.5E). The Caribbean islands are small with respect to the spatial scale of a major climatologic feature that disturbs them, and for this reason, might effectively function as nonequilibrium landscapes. A similar example would be the spatial extent of floodplain forests and floods in large rivers (Fig. 7.5H).

Time and Space as a Fundamental Issue Initially Concerning Landscape Ecology

The discussion of landscape scale developed among ecologists and others who already had ideas of important factors, including external drivers, processes, and patterns that conformed to their particular idea of a landscape. The word landscape itself appears to be appropriated from art history. Landscape as an English word derives from the Dutch word *landschap* from Dutch landscape painting or *landsschappen* (Zonneveld 1990). Certainly, the origins of the fine arts in landscape lend credulity to issues of beauty in landscape as scenery, a topic that is often found in the early issues of *Landscape Ecology*. This is an early interpretation of landscape, traditionally found within landscape architecture, that includes, although has moved beyond, simply the aestheticism of land surfaces (Cramer et al. 1984; Barrett and Barrett 2008; Barrett et al. 2009).

If to some a landscape is what you pay for when you go to a restaurant with a view, others saw landscapes as having heterogeneous patterns as an intrinsic feature. Combinations of geological, ecological, or hydrological spatial data sets produce spatial patterns of landscapes. These combinations create patches of landscape with different rates of responses and ecological functions. In many systems, these patches and their arrangement repeat in a way that implies a unity of processes. When one flies down the eastern coast of New South Wales, there are rock headlands covered with shrubby, protean heathlands that yield to crescent beaches with dune vegetation, then to *Eucalyptus* forests behind the dunes. Such landscape ecosystems form dynamic repeating patterns and interact to reform these patterns after major disturbances.

Along with different points of view as to what a landscape actually was, there were also other important developments that influenced the appropriate scale to consider in landscape ecology. Ecologists have had a long tradition of studying relatively pristine systems with the idea that in remote areas with mature systems, the complications of the human impact on these systems could be controlled quasi-experimentally. At about the time of the emergence of landscape ecology, the realization that human influence was everywhere on the planet was producing a refocusing of study sites to locations that somehow incorporated human impacts. The importance of including humankind meant the scale of human systems somehow should be included (Naveh and Lieberman 1984). An increasing capability of satellite remote sensing focused attention upon landscape scales that matched the spatial resolution and orbital revisit intervals of the satellites (Frohn 1988). The increasing capability and application of spatial statistics mitigated for particular sampling regimes (Dale and Fortin 2002). The advent and innovation of modern GIS represented a growing technological capacity to manipulate, display, and interact with complex spatial data (Haines-Young et al. 1993).

Thus, when the United States National Science Foundation (NSF) sponsored workshop met at Allerton Park, Illinois, during April 1983, to formulate a basis for landscape ecology, the discussions defining a landscape were extended and vigorous. In retrospect, these discussions carried a significant subtext of important process, the issue of whether humans could be considered in landscape or not, remote sensing and spatial resolution application, sampling structures, and spatial statistics. The importance of these issues has been elucidated more sharply as landscape ecology has progressed as a discipline.

Emergence of a Hierarchical Perspective for Understanding Landscape Ecology

Particular phenomena emerge as being more or less important at different scales in time and space. Hence, understanding space and time scales in ecological systems is a necessary preamble to understanding how ecosystems will respond to large-scale environmental change (O'Neill 1988). The experience in building interdisciplinary research teams indicates that an attention to space and time scales may not guarantee success—but to not do so seems to enhance the likelihood of failure (Shugart and Urban 1988). This attention to scale is highlighted in the development of the Hierarchy Theory in ecology (Allen and Starr 1982; O'Neill et al. 1986; O'Neill 1988).

For landscape ecology, the Hierarchy Theory represented a substantial reinforcement of the ecosystem concept as originally formulated by Tansley (1935). Schneider (2001) reviewed the use of the word "scale" in the ecological literature. He found the frequency of "spatial scale" in *Ecology* and *Ecological Monographs* increased approximately 18 percent per year from 1972 to 1991 starting with papers by Marten (1972) and Wiens (1973). Time and space diagrams first appeared in Steele (1978). These diagrams essentially delineate time and space scales at which different factors control the dynamics of ecosystems. The Hierarchy Theory has sometimes been summarized as, "scale matters" (Wiens 1999) in the context of landscape ecology. It is clear that scale and its formalization as Hierarchy Theory are components of the philosophical underpinnings of landscape ecology.

Scaling-Up Landscape Models for Smaller Scale Empirical Investigations

If 25 years ago, landscape ecology synthesized themes of remote sensing, spatial statistics, and awareness of scale in ecology, it also sprung from an era in which ecological models were becoming a part of the fabric of ecology. Starting in the 1960s and continuing to the present, several different scientific disciplines (astronomy, ecology, physics) independently began to apply computers to the tasks of "bookkeeping" the changes and interactions of individual entities. Early versions of these models in ecology, developed by population ecologists interested in including animal behavior in population models, led to a diverse array of applications for fish, insects, and birds (Holling 1961, 1964; Rohlf and Davenport 1969). Exemplary of these applications was the use of Individual-Based Models (IBMs) to represent forests by simulating the trees.

A second and more recent development has been the implementation of complex models that transcend several scales to combine plant geography, physiology, and demography to interact with the current suite of General Circulation Models (GCMs) of the planet's climate, and Dynamic Global Vegetation Models (DGVMs). The need in the development of DGVMs was for models that could represent the canopy processes that linked the ground surface into the commodities simulated by the climate models. The importance of the terrestrial surface in the decades to century storage and release of carbon also implied a representation of the carbon budget of vegetation.

Individual Based Models (IBM) of Forest Dynamics, Particularly Gap Models

IBMs are models examining vegetation dynamics at a spatial scale corresponding to the area occupied by a small number of mature individuals, approximately the size of a plot or quadrant used for vegetation sampling. Among the earliest IBMs in ecology were IBMs of forest succession based on the growth of the individual trees. These models were developed by quantitatively oriented foresters and were focused toward practical issues in production forestry (Shugart et al. 1992).

There are several, rather different, modeling approaches that produce IBMs. Indeed, many of the models developed for element cycling and carbon metabolism in ecosystems (notably the developments during the International Biological Program (IBP) of the 1960s and 1970s) were developed to duplicate experimental or observational results from a relatively small tract of land. The principal feature of IBMs was their emphasis on the dynamics of ecosystems at relatively small spatial scales. The initial reasons for this emphasis lay with a need to model at the spatial scale at which data are collected and with the necessity to assume a degree of spatial homogeneity in the model formulation. Recently, recognition of the importance of treating phenomena that do not "scale-up" easily to larger spatial scales has reinforced an interest in individual-based modeling.

Computer models that simulate the dynamics of a forest by following the fates of each individual tree in a forest stand were developed initially in the mid-1960s. The earliest model was developed by Newnham (1964) and followed by similar developments at several schools of forestry. The models predicted change in a small patch of forest using a digital computer to dynamically change a map of the sizes and positions of each tree in a forest. These early individual tree-based simulators took what was known from yield tables and other data sets and developed a more flexible, quantitative methodology for prediction. Some of the earliest attempts to apply such models were very successful and produced results of surprising detail.

An important subcategory of individual organism-based IBMs that has been widely used in ecology (as opposed to traditional forestry applications) is the term "gap" models (Shugart and West 1980). The first such model was the JABOWA model (Botkin et al. 1972) developed for forests in New England. Over the past 20 years, gap models have been developed for a wide variety of forest ecosystems, from boreal to tropical, and the general approach has been extended to nonforested ecosystems such as grasslands, shrub lands, and savannas.

Dynamic Global Vegetation Models

The factors involved in the development of DGVMs originated in the interests of global climate modelers, who realized that surprisingly there were significant feedbacks between the atmosphere and terrestrial surface. They had by this time begun to wrestle with the most significant atmosphere/earth surface feedbacks; ocean currents transport a significant amount of heat. The freezing of seas is one of the largest changes in the surface albedo. Seawater absorbs much of the solar radiation that strikes it; ice reflects much of the same radiation. These factors lead climate modelers to consider the atmosphere/ocean interactions as a high priority, but the surface changes in vegetation increasingly were seen as significant with the development of climate models. This trend continues today. One of the natural model elements in the synthesis to develop DGVMs was the canopy process model. These also are called Soil Vegetation Atmosphere Transfer (SVAT) models in the current global climate formulations (Bonan 2008). The aim in developing DGVMs was to maximize the use of mechanistic models (Whitmore 1982). The primary example of such models is that of photosynthesis, which drives the carbon cycle. The Farquhar et al. (1980) formulation, a biochemical model of photosynthesis designed to simulate the net photosynthetic effects of changes in CO_2 or light, has been tested in a range of situations and proven most effective in DGVMs.

Another aspect of many early DGVMs was a fusion of physiological models with biogeographical algorithms to understand the changes in physical structure (leaf areas, heights, amount of biomass) that go with changes in vegetation types, as well as differences in the ecosystem functioning of these vegetations. Early precursors to the modern DGVMs comprised a model developed by Woodward (1987) that was "rule based" with broad functional types of plants categorized, but their low temperature limits to survival and growth were based on the ranges of required growing season lengths, warmth, and the degree of their water requirements were met through precipitation. An early fusion of hydrology and plant canopy function was the Forest BGC model (Running and Coughlan 1988; Running and Nemani 1988; Running et al. 1989; Running and Gower 1991). Forest BGC (hydrology and plant canopy function) has been melded to an individual tree-based forest model providing a capability to dynamically simulate the change in forest structure over time (Friend et al. 1993).

In 1997, an asynchronously coupled GCM and DGVM were found to produce relatively small and positive feedbacks on climate (Betts et al. 1997). Asynchronous coupling indicates that one model is run for a period of time, then its results are fed into the second model, which is also run based on these inputs, and then the second models' results are fed into the first model, and so on. Just a few years later, a fully coupled GCM called "TRIFFID" (Cox et al. 2000) produced quite alarming results—under a future-warming scenario, the terrestrial biosphere turned from a sink of anthropogenic CO_2 at 2050 to a source by 2100. The source strength was so strong that atmospheric CO_2 concentrations were 250 parts per million (ppm) greater by 2100, with an associated 1.5 °C extra warming above the 4 °C case that occurred when the vegetation and atmosphere were not coupled. This effect has been speculated about in the past as the runaway greenhouse effect in which change begets more change. More recently, 11 coupled GCMs (Friedlingstein et al. 2006) were compared to investigate differences in future simulations of the global carbon cycle. The differences in land uptake of carbon considerably differ from large uptakes to large releases up to the end of the century. It is interesting to note that the TRIFFID DGVM, coupled within the Hadley Centre GCM that was used in the initial coupled simulation (Cox et al. 2000), had the largest changes in vegetation activity over the twenty-first century.

In the case of both gap models or IBMs and the DGVMs, there is a direct attempt to scale processes up to the global levels by a synthesis of processes normally considered in landscape ecology. How successful was this leap of several quanta in scale remains a challenge for landscape ecology theory and theory testing.

Landscape Boundaries and Connectivity

A landscape boundary may be *physical*, such as the edge of a watershed, *political*, such as the jurisdiction of a natural reserve (Schonewald-Cox 1988), *ecological*, such as an isolated forest patch in an agricultural landscape matrix, or *functional*, such as home-range size of a small mammal. Several publications have focused on landscape boundaries during the past 30 years (Lefkovitch and Fahrig 1985; Opdam et al. 1985; Wiens et al. 1985; Holland et al. 1991). Barrett (1985) described the importance of defining boundaries (i.e., a defined universe) when using a problem-solving approach to resource management. Boundaries define watersheds, home-range size, and experimental landscape patches. Defining the experimental universe is essential for estimating such parameters as biotic diversity, species abundance, and resource availability.

Fahrig and Merriam (1985) were among the first to investigate connectivity in the study of population survivorship. They viewed connectivity as a model that measures the difference in survivorship of populations in patches that are interconnected at the landscape scale. Forman and Godron (1986) defined "connectivity" as a measure of how spatially continuous a corridor or matrix exists. The greater the number of connections between landscape patches, the greater the connectivity of the patch in the landscape. Forman and Godron (1986) pointed out that landscape corridors also may function as physical or biotic barriers.

Landscape connectivity plays a major role in local–regional plant species diversity (Damschen and Brudvig 2012), seed predation (Orrock and Damschen 2005), survivorship of small mammal species (Fahrig and Merriam 1985), and metapopulation source–sink dynamics (Pulliam 1988). Haddad et al. (2003), for example, investigated ten different species, including butterflies, small mammals, and bird-dispersed plants, resulting in higher movement between connected than between unconnected landscape patches; their findings show that movements of disparate taxa with different life histories and functional roles are directed by corridors.

Thus, landscape ecologists have gained increased understanding regarding the structure and function of spatial heterogeneity, and how the application of landscape ecology will broaden our scope in natural resource management (Turner 2005). We will next discuss how the field of landscape ecology has emerged as a new paradigm (i.e., a new "level of ecological organization" or "level of integration").

Viewing Landscape as a Level-of-Organization Concept

The evolution of the level-of-organization concept has a long and rich history (Sears 1949; Wright 1959; Rowe 1961) during which the concept has been challenged as well (Guttman 1976). MacMahon et al. (1978) advanced the concept, focusing on an organism-centered approach. Earlier ecology textbooks omitted the landscape as an emerging and valid level of organization. Interestingly, as alluded to earlier in this volume, most recent editions of ecology textbooks now include a chapter devoted to landscape ecology (Cain et al. 2008; Molles 2008; Ricklefs 2008; Smith and Smith

2012), and some textbooks specifically identify the landscape as a level-of-organization (Odum and Barrett 2005) or level-of-integration (Krebs 2008) concept. Barrett et al. (1997) described how 7 major processes (behavior, development, diversity, energetics, evolution, integration, and regulation) transcend 11 ecological levels of organization, ranging from the ecosphere to the cell, including the landscape level. Barrett et al. (2009) introduced aesthetics as an eighth transcending process through these selected 11 ecological levels of organization. An understanding of aesthetics as economy (energetic efficiency) of survivorship allows the integration of nonmarket (i.e., ecosystem services) and market (i.e., monetary currency) values (Fig. 7.6).

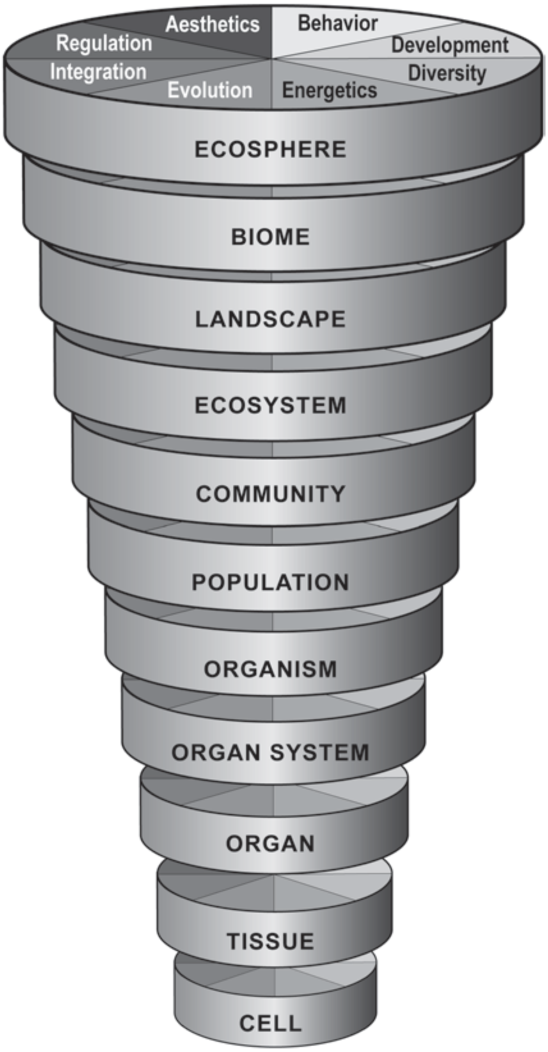

Fig. 7.6 Eight major processes through 11 selected ecological levels of organization. (After Odum and Barrett 2005; Barrett et al. 2009)

Thus, during the past half century, landscape ecology has become a cornerstone of ecological research, learning, and resource management. Although landscape ecology is typically referred to as a subdiscipline of ecology (Cain et al. 2008), much like decades ago when ecology was considered a subdiscipline of biology (Barrett 2001), we now recognize landscape ecology as an emerging paradigm or standalone interdisciplinary field of study. Perhaps landscape ecology is best defined as the study of the relationship between spatial pattern and ecological process over a range of scales (Wu and Hobbs 2006), or perhaps as a pertinent example of a transdisciplinary, integrative science for future generations of problem solvers and resource managers (Barrett 1985, 2001).

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Chapter 8
Transforming Fields of Study in Landscape Ecology

Terry L. Barrett and Gary W. Barrett

Introduction

Primack and Abrams (2006) considered,

> …that the physical size of human beings is roughly midway on the logarithmic scale between the so-called Planck length—the smallest meaningful increment of distance, about 10 to the minus 33 centimeters, and the distance to the edge of the visible universe, the largest meaningful distance, about 10 to the 28 centimeters. Much smaller creatures than we are could not develop the complexity necessary for intelligence; much larger ones would be limited by the time it takes information to travel across their brains… [Also] Earth happens to occupy a privileged niche of habitability—neither too close to the Sun nor too far, protected by Jupiter's gravity from collisions with comets, locked by the Moon into a stable orientation that provides predictable seasons. If our solar system were very much closer to the center of our galaxy, cosmic rays from nearby stars might have made life impossible; very much farther out on the edge, and the heavy elements that makeup Earth (and living creatures) might have been too sparse. (Adler 2006, p. 74)

Joel Primack, cosmologist at the University of California Santa Cruz, is one of the pioneers of the "cold dark matter" theory accounting for the invisible mass whose gravity holds galaxies together. Nancy Abrams is a writer and musician (Adler 2006). Together, they have written a book entitled *The View from the Center of the Universe* (Primack and Abrams 2006). The premise of this work is that most people have difficulty relating to discovery in dimensions outside the "macroscopic, earthbound realm of human perception." Therefore, a deeper appreciation of their situation and circumstance is for the most part lost in a mélange of conjecture. Human behavior appears to oscillate in unison with comprehension; in other words, humans behave commensurate with their

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knowledge. For example, as transpired during 2011, Egyptian protesters commandeered social media or Internet-based applications as an essential tool for globally informing their political agenda. Subsequently, self-organizing overt demonstrations within Tahrer Square led to the resignation of President Hosni Mubarak, and contribution in part to the *Arab Spring*. This process is comparable to the French and American revolutions that were spurred by the printed word, which emanated from the preexistent oral culture of the British (McLuhan 1964). Knowledge gleaned from evolving technology expands human dimensions not only through social, political, and economic networks but also through biological systems. Drew Endy, biological engineer at Stanford University, explains, "…even though we do not understand everything, in fact most things, about the natural world, we are beginning—through technology standardization and powerful paintbrushes, like DNA synthesis—to create, to construct. And so we are implementing a collapse, basically, of the decoupling; we are starting to participate, and systematically design biological systems." (Endy and Sagmeister 2010, p. 71)

If, as Primack and Abrams (2006) suggest, most people have difficulty relating to discovery in dimensions outside the macroscopic, earthbound realm of human perception, a "refreshed thinking" is required (Ulanowicz 1997). As the realm of landscape is biologically the human dimension, landscape ecology is a logistically sound marker for this wellspring of refreshed thinking to transpire (Allen and Hoekstra 1992b). Previous and present canons, for the most part, leverage landscape as an object (Lorsch 1983; Willis et al. 2004; Barrett and Barrett 2008). Through technology, dynamic dimensions of landscape have revealed themselves, inviting a culture of "changing minds" regarding many earlier expectations.

A modern experiment that synthesizes a micro-/macro-spectrum in landscape thought has been purposed in the Large Hadron Collider (LHC), a project of global scientific cooperation. CERN (*Conseil Européen pour la Recherche Nucléaire*), since 1954 named European Organization for Nuclear Research, of which the United States received observer status in 1997, accesses an intercontinental LHC computer grid with the eventuality of a worldwide synchronization of data through their Oracle Streams Program (Fleischer et al. 2009). Located 100 m underground in proximity to Geneva, Switzerland, the LHC tunnel allows views of particle collision from seven different technologies (Boisot 2011).

A recent experiment during 2012 detected a subatomic particle appearing consistent with the Higgs boson or "W and Z particle" that unifies the weak and electromagnetic interactions, implicit in a mechanism by which fundamental particles acquire mass (Englert and Brout 1964; Guralnik et al. 1964; Higgs 1964). Although in 1993, Lederman termed the Higgs boson as "The God Particle," in the popular book "*The God Particle: If the Universe is the Answer, What is the Question?*" authored by Lederman and Teresi (1993), inferring a *Rosetta stone* importance in deciphering the nature of matter concerning inner and outer spaces.

Navigating

After the death of Nicolaus Copernicus, his book was published in 1543 entitled, *De Revolutionibus Orbium Coelestium Libri VI* (Six Books Concerning the Revolutions of the Celestial Spheres) based on the thesis of Aristarchus of Samos, 250 BC. His heliocentric model of our solar system in which Earth spins on its axis and orbits the Sun made possible his extrapolation of the celestial sphere—concentric with Earth, and rotating upon the same axis. This virtual celestial coordinate system quantifies the direction of natural objects in the sky, such as constellations, for navigators and astronomers.

Improvements in the telescope by Galileo, making possible an affirmation of a heliocentric model of our solar system, conflicted with a predominant belief system of the era. "The Catholic Church, perhaps receiving its first strong and unwelcome whiff of the power of scientific theory in shaping opinion, began to mobilize against these heretical ideas. Galileo was formally charged by the Inquisition, forced to recant and kept under house arrest for the rest of his life." (Gooley 2010, p. 74)

New universes are being observed through the Hubble telescope (Weiler and Jacobs 2010). Exchange within universes is claimed by some investigators, such as the seamless panning of the skies to listen for intelligent signals that are improbable in natural sequence (Horowitz et al. 1992). Breakthroughs such as wormholes hypothetically serve as portals allowing interchange of different dimensions of time–space between universes (Sagan 1980; Hawkins 1983; Primack and Abrams 2006; Greene 2011; Wallace 2012). Numerous belief systems also mediate parallel universes; exemplary is Dante's portrayal of a hellish universe of spiraling levels of punishment commensurate with a committed sin.

Mapping

One of the oldest epic poems in Western literature, that of *The Odyssey*, weaves the navigational concepts of the relationships between the Sun, the horizon, and east and west. Possibly the earliest literature connecting knowing direction with knowing where you are (Gooley 2010).

Along with the accompanying technosphere of satellites and transmission lines, other grids map the virtual networks familiar to cartography—the longitudinal and latitudinal degrees that lattice Earth, such as, the Tropic of Cancer, equator, Tropic of Capricorn, North and South Poles, and the International Date Line, which provides Coordinated Universal Time (UTC). Referencing these delineations of the globe, the March and September Equinox and June and December Solstice calibrate the clocks and configure the calendars of cultural environments.

When Henry David Thoreau returned to Walden Pond 5 or 6 years after living there, he lamented that visitors had worn his path to the pond without venturing a different way. In his opinion, had they done so, perhaps it may have led to their own unique experience of the landscape. Skirting the issue of efficiency, his philosophical protest rather was, "The surface of the earth is soft and impressible by the feet of men; and so with the paths which the mind travels. How worn and dusty, then, must be the highways of the world, how deep the ruts of tradition and conformity!" (Horan 1973, p. 183)

Humans do trust cues of continuous human habitation for survivorship, such as, environmental footprints, that reveal a history of successive settlement (Mumford 1961; Sanderson et al. 2002; Willis et al. 2004). Paths are the essence of human mapping—the traces of previous navigation, for example, the 1800-m Sweet Track (4000 BC) of the Neolithic period that is found in the lowlands of Somerset Levels within southeastern England. This road of hewn 400-year-old oaks up to a meter in diameter, ashes, elms, and lindens was crafted to connect two islands (Coles 1989). However, in the important book *Road Ecology: Science and Solutions,* Forman et al. (2003) address the conundrum, "The road system ties the land together for us yet slices nature into pieces" (Forman et al. 2003, p. xiii).

Wildlife corridors follow the contours of the land, sea, and sky in seasoned wisdoms that satisfy hunger, thirst, and alleviate exposure. The overlay of human movement upon these migrations of wildlife lends a cultural significance to essential natural resources (Brown 2011). Case in point, Jim Carrier traced the commercial overfishing of shrimp for half a century, "Down below in the channel… was a kind of 'fishing' that was nothing short of marine clear-cutting… Shrimpers killed ten pounds of sea life for every pound of harvested shrimp—waste that reached one billion pounds a year in the Gulf." (Carrier 2010, p. 166) United States restrictions on the shrimp catch led alternatively to numerous international shrimp farms. "Transshipment" is the relabeling of shrimp from a country, which is under penalty of tax for carcinogens or other anthropogenic agents found in their shrimp, to a country in good standing (e.g., "farm raised in Indonesia" maybe from China; Carrier 2010). Technology economizes and expedites harvest by accurately mapping sea life location with yield (e.g., the mature shrimp is found in salty waters).

Along these wildlife corridors, humans have settled, only to traverse these same paths in order to efficiently align those communities (e.g., the Silk Road AD 150), as well as natural features, and human-built forms, from ancient monuments and megaliths to modern networks of commerce (Morris 1967; Lippard 1983). Forman et al. (2003) attribute degradation of landscape connectivity—the degree to which the landscape facilitates animal movement and other ecological flows—to the interruptions inherent in this dimension of human–nature duplexity.

Framework

Landscape Profiles

Within the monoculture of utilitarian purpose, as Nietzsche suggested a falsification of the world exists, that is our "…failure to see that our senses" and our "categories of reason" involve "the adjustment of the World for utilitarian ends."

In effect, an "anthropocentric idiosyncrasy" was taken as a measure of all things. (Stack 2005; Barrett and Barrett 2008, p. 196) Under the resolve of survivorship, humans gradually have objectified wilderness into territories of individual wealth (Daly and Townsend 1993). Subsequently, these territories are investigated readily by landscape pattern, which is configured by these fluctuating borders and boundaries (Forman and Godron 1986; O'Neill 1999).

Within the United States, in the past half century, landscape has been recognized as a biotic as well as geologic level of organization (Forman and Godron 1986; Forman 1995; Ulanowicz 1997). Although life zone (Merriam 1894), biomes (Shelford 1913), biotic provinces (Dice 1943), patterns of global plant formations (Whittaker 1975), and ecoregion (Bailey 1998) have been described for decades, Landscape Ecology, as a transforming field of study, broadens function and structure to encompass a human–nature duplexity (Odum 1971; Barrett and Odum 2000; Barrett et al. 2009a, b). Processes such as biotic diversity (Hanski 1982), sustainability (Goodland 1995), ecosystem services (Daily 1997), and natural capital (Kareiva et al. 2007) are inherent in landscape scale. It has only been in recent decades that the plant/animal/human triumvirate has made major contributions to landscape ecology.

Landscape Ecology was first introduced as an independent chapter within the ecology textbook *Fundaments of Ecology, Fifth Edition* (Odum and Barrett 2005). Encompassed as an ecological component within the ecological level-of-organization concept, fragmented landscape level accompaniments did appear throughout the manuscript during the rewriting process. However, after many discussions during working vacations at the Fripp Island house of Martha and Gene Odum, Gene was persuaded in the importance of formalizing Landscape Ecology as a chapter. Many modern ecology textbooks now include the subject of landscape ecology (see Chap. 3).

Allen and Hoekstra (1992a) within their book, *Toward a Unified Ecology*, include landscape within their "layer cake." This concept offers a conical model in which the element of scale transcends a horizontal cross section of ecological criteria, namely, organism, population, community, ecosystem, landscape, and biome. This allows each ecological criterion to be subsequently contextualized along an abacus of scale, and concurrently considered between and among the horizontal cross section of ecological criteria. While recognizing landscape as not always essential in viewing ecosystems, Allen and Hoekstra (1992b) also find landscape "… the most obvious and most tractable ecological type…. Because it is unequivocally ecological, we employ the landscape criterion as the point of departure." (Allen and Hoekstra 1992b, p. 54)

Landscape Ecology Principles in Landscape Architecture and Land-Use Planning, by Dramstad et al. (1996), is important in the ordering of essential principles of this sensible landscape, as patch, edge, corridor, and matrix, which forms a simple lexicon with which to begin landscape dialogue. Dramstad et al. (1996) also appreciate these ecological principles at macro-, meso-, and microscales.

Negotiating—Technoecosystem

These landscape elements, earlier described by Forman (1995) in *Land Mosaics: The Ecology of Landscapes and Regions*, were compounded by the technoecosystem created of high technology (Neveh 1982). Simulating the natural ecosystem, as H. T. Odum (1971) termed "cities of nature" by his analogy with an oyster reef, these human-built cities disproportionally require the inflow of food and fuel, and outflow of waste and heat transpiring within their surrounding environment (Odum 1971; Odum and Barrett 2005). Wackernagel and Rees (1996) defined this area outside a city, which is required to support that city, as the "ecological footprint." Barrett et al. (1999) evolved this ecological footprint (i.e., city, suburb, and exurb) to encompass a reciprocal process from the centralized urban dynamic, to the peripheral suburban and exurban growth that surrounds the diminished vitality of an "oxbow city." The footprint concept allowed Luck et al. (2001) to find differences in the ability of a matrix environment to provide goods and services, in their comparison of water and food footprints of cities in the United States (Odum and Barrett 2005).

Odum and Barrett (2005) organized the technoecosystem within the major ecosystem types of the biosphere (i.e., marine, freshwater, terrestrial, domesticated ecosystems) under domesticated ecosystem—agroecosystem, plantation forest and agroforest systems, rural technoecosystems (transportation corridors, small towns, industries), and urban industrial technoecosystems (metropolitan districts).

Influences such as social (belief systems), economic (human-made and natural resources), political (organization of systems), and security (methods of capture and possession) make up the urban ecosystem as a multidimensional network of cultural values and manifestations of historical decisions. In Fig. 8.1, ancient city origins of this classic concentric pattern of human settlement (Mumford 1961) have evolved "…into urban systems that encompass a modern field of technological networks (e.g., Internet), and systems traditionally attached to urban functions (e.g., telecommunications) [see Fig. 11.6 in this Volume]. Computerized devices create a Virtualsphere (i.e., cyberspace) that allows for parallel virtual- and real-environments (Barrett and Barrett 2008; Barrett et al. 2009a). Understanding the function and structure of the technoecosystem as a synthesis of virtual and real systems contributes to the survival of modern global citizenry." (Barrett 2011, p. 125)

> Virtuality now vies with materiality. Travel is no longer the only way to go, and human intelligence is augmented on a vast scale, by the silicon/software partnership. As a result, familiar urban patterns have lost their inevitability. (Mitchell 2000, p. 147)

The cityscape unit of urban, suburban, and exurban is fading—into a loose configuration of electronic cottages, and digital and intelligent cities organized upon social and creative capital, and planned environments that are shaped with energy efficient dwellings that reconfigure landscape (Florida 2002, 2005). The centralized power of the urban core has been bypassed by way of suburbia, leaving "oxbow cities" deplete of energy and resources (Rusk 1995; Barrett et al. 1999). Fields of study anticipating the logical progression of the cityscape, as concentric rings of agrarian

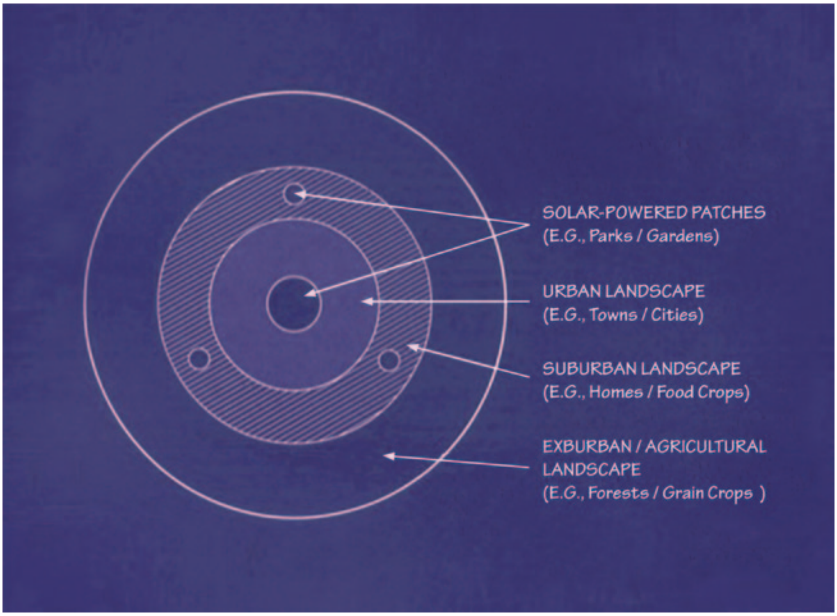

Fig. 8.1 Model of an iconic pattern of landscape—cityscape of urban, suburban, and exurban—determined by urban systems. (After Barrett 2011)

and industrial trade, currently are shape shifting (Forman 2010). The Silk Road, with caravans and maritime trading vessels, is an ancient interpretation contrasting the impending sky of the commercial drone.

Combining architecture, politics, and science, the *vertical farm concept* (e.g., urban farming spaced in "farmscrapers") offers the possibilities of local employment, reliable source of organic foods, and elimination of storage and shipping—a solution to the inequities of distribution of fresh produce caused by intermittent transportation gaps. Additionally, recycled water and renewable energy sources create independence from the utility grid and allow additional geothermal, wind, and solar power to be harvested from these systems. These structural designs maximize the amount of space to growing crops and predictably protect plants by a controlled environment (Despommier 2010).

Mitchell (2000) in his book, *e-topia: "Urban Life, Jim—But Not As We Know It,"* presents five summary points that may apply to design and planning on multiple scales: (a) dematerialization—tasks completed electronically typically require less material and space for the same function; (b) demobilization—introduction of live/work neighborhoods with electronic distribution services; (c) mass customization—in place of standardization and repetition, computer-controlled production machinery; (d) intelligent operation—energy efficiency by the use of technological management, such as sensors; and (e) soft infrastructure—with the refinement of digital telecommunication, retrofitting existing urban structures and spaces, and networking newly planned cities is environmentally less obtrusive than conventional forms of infrastructure (Mitchell 2000).

To understand the essence of city (new and old), a new science termed “quantitative urbanism” explores cityscape through mathematical formulas involving such aspects as human proportion comparatives to urban architecture or human movement along urban corridors. This scientific methodology recognizes that cities at their core are universal inventions (Adler 2013).

Summary

Alan Lightman comments, “Especially in the Twentieth Century, science has gotten so far beyond human sensory perception that we are really talking about very abstract things—subatomic particles and wavelengths of light, which we cannot see; the Big Bang, which we cannot experience; and distant galaxies, which we really cannot touch. And yet when we talk about phenomena, even in these inaccessible domains, we have to use language. Because that is all we have. I think one of the things that art helps provide scientists with is the language—and the metaphors and the images—to describe what scientists are so desperately trying to understand. Our instruments tell us that these totally unimaginable phenomena are happening; yet we have no intuitive understanding of them. So we grope for language and pictures, and I think art provides some of these for us.” (Lightman and Colton 2010, p. 55) The artist Carl Andre was influenced by ancient sites, such as Stonehenge and the Ohio Indian Mounds, Taoist principles, and Japanese gardens in sculpturing his Earthworks of the 1960s and 1970s. He explains

> Abstraction arose in Neolithic times, after Paleolithic representation, for the same reason that we are doing it now. The culture requires significant blankness because the emblems, symbols and signs, which were adequate for the former method of organizing production, are no longer efficient in carrying out the cultural roles that we assign to them. You just need some *tabula rasa*, or a sense that there is a space to add significance… Perhaps abstract art has occurred in human history every time there has been a total technological change in the organization of society. (Lippard 1983, p. 125)

This needed “sense that there is space to add significance” that Ardre shares is an important human consideration (Lippard 1983). The space need not be eternal to be immortal. For example, the Burning Man festival held yearly in Black Rock City, Nevada, is a gathering of approximately 50,000 participators in the arts, dance, and music for the purpose of expression and inspiration. Black Rock City is a series of concentric semicircles of streets organized around a giant effigy of a man to be traditionally set ablaze at the closing of the festival. The life of Black Rock City, planned by landscape designer, Rod Garrett, is 7 days. Yet, this city is replete with residential neighborhoods, a park area, and an amenity named Center Camp for living necessities and services. Each year, this event transforms the landscape of the Nevada dessert into a cityscape (Bernstein 2011). Aspects of landscape design and community, given this ecological and social footprint, could be one of many models for temporal events, or makeshift crises (e.g., increasing numbers crossing political borders in search of temporary refuge from their homeland chaos).

The famous architect Lebbeus Woods (1992) in his book of futuristic drawings, *The New City,* designs geometrical neighborhoods and dwellings that interconnect as free space structures. Each floating unit will be customized to the individual or community. Woods' premise is that there is no ideal creative individual; therefore, there is no ideal city. His futuristic structures are in response to the mobility that global networking has provided possibility to live and work anywhere on the planet and access the comfort of urban life (Modrcin 1991).

Within the Virtualsphere, human beings also have created the address of cyberspace. This space has allowed room for different views of subject and process that have transformed fields of study.

The information management system, termed the World Wide Web (WWW), addresses an Internet culture that is infused with its own canon of principles and mores, and lexicon. Echoing from a previous generation of modernism, "the medium is the message" (McLuhan 1964), in which media eclipses content as the greater societal influence. This is evidenced by the assertion of Sir Tim Berners-Lee, Founders Chair of Computer Science and Artificial Intelligence Laboratory, Massachusetts Institute of Technology, that "net neutrality" is a basic human right requiring openness, accountability, and transparency from traditional institutions such as government, religion, and commerce (O'Regan 2013).

Deussen (2003) has developed methodology in the simulation of organic forms that are able to realize information that differ from photorealistic images. This proposed methodology can generate interactive walkthroughs that visually will make clear landscape scenarios for fields of study such as landscape architecture and urban planning.

R. Buckminster Fuller worked extensively on "Dymaxion" and copyrighted the map in 1946 (McGonigal 2011). His map is construed from the World Grid, which is patterned by tracing the gravity and energy of Earth. The creation of such simulation allowed Fuller to develop *World Game*. The educational game is played in virtual space on the Dymaxion map. The stated objective of the game is to make the world work for 100 % of humanity in the shortest possible time through spontaneous cooperation without ecological damage or disadvantage to anyone (Marks 1973; see Chap. 11 for gaming possibilities afforded individual and community).

Presently, Landscape Ecology is a statement of explanation for the dynamics through which landscape exists. With Earth as marker, landscape ecologists have dutifully and purposely fulfilled the task of coding the globe with information based on scientific methodology. The data through interpretation and application have made and will make possible major changes in the quality of life. An indicator of directional shifts in Landscape Ecology is the selected themes of USIALE Symposia (see Chap. 1, Table 1.2, Timetable of USIALE Symposia from 1986 to 2013; Fig. 8.2). Additionally, changing interpretations of landscape

Fig. 8.2 Program of the 2010 USIALE Twenty-fifth Anniversary Symposium, *Is What Humans Do Natural?* 5–9 April 2010, University of Georgia, Athens, Georgia. Cover: Terry L. Barrett, *Fermentation*, 1994. Pastel/ pencil on paper, 6.75 in × 8.50 in

are present in the subject titles of invited speakers who are selected by the program committee each year (Fig. 8.3a–g). Landscape Ecology as a field of study needs to lose its self-defining, self-referential, and self-critical foci to become a "supercollaborator" to which McGonigal (2011) attributes qualities as high-level perspective for the bigger picture, openness to unplanned opportunities for collaboration in new communities, and willingness to bypass old goals if more epic goals present themselves. Transforming Landscape Ecology as fields of study, does and will rely on the ability to (a) *navigate* through discoveries of Earth, and those of heavenly bodies with their unique properties, proportions, and rhythms, and (b) *negotiate* beyond the regional and global institutional forums (e.g., telecommunication) to integrate the expression of cyberspace (i.e., Internet). This will require a honing of different methods of observation, and the lessening of preconceptions to trace the subtle ley lines of ancient cues (Sagan 1980), and to notice the barely visible shadows of parallel universes (Greene 2011).

Fig. 8.3 Invited speakers to the USIALE Twenty-fifth Anniversary Symposium and their selected subject titles: (**a**) Herman H Shugart, Awards Dinner Address, "Landscape Ecology and Global Environmental Change"; (**b**) Gary W. Barrett, Plenary Talk, "Right Place, Right Time"; (**c**) Carol Brewer, Plenary Talk, "Linking Renaissance Ecologists with Citizen Scientists to Advance Scientific Research and Literacy"; (**d**) Richard T. T. Forman, Plenary Talk, "Origin and Trajectories of Landscape Ecology Internationally, and the United States' Role"; (**e**) Simon A. Levin, Plenary Talk, "On the Evolution of Ecosystem Patterns"; (**f**) Joseph A. Tainter, "Collapse and Sustainability: Lessons from History;" and (**g**) Monica G. Turner, "Twenty-five Years of United States' Landscape Ecology: Looking Back and Forging Ahead." Complete listing of Plenary Speakers and their subject titles may be accessed in the USIALE Executive Committee Handbook. (Photography by Wingate Downs Courtesy of Terry Barrett)

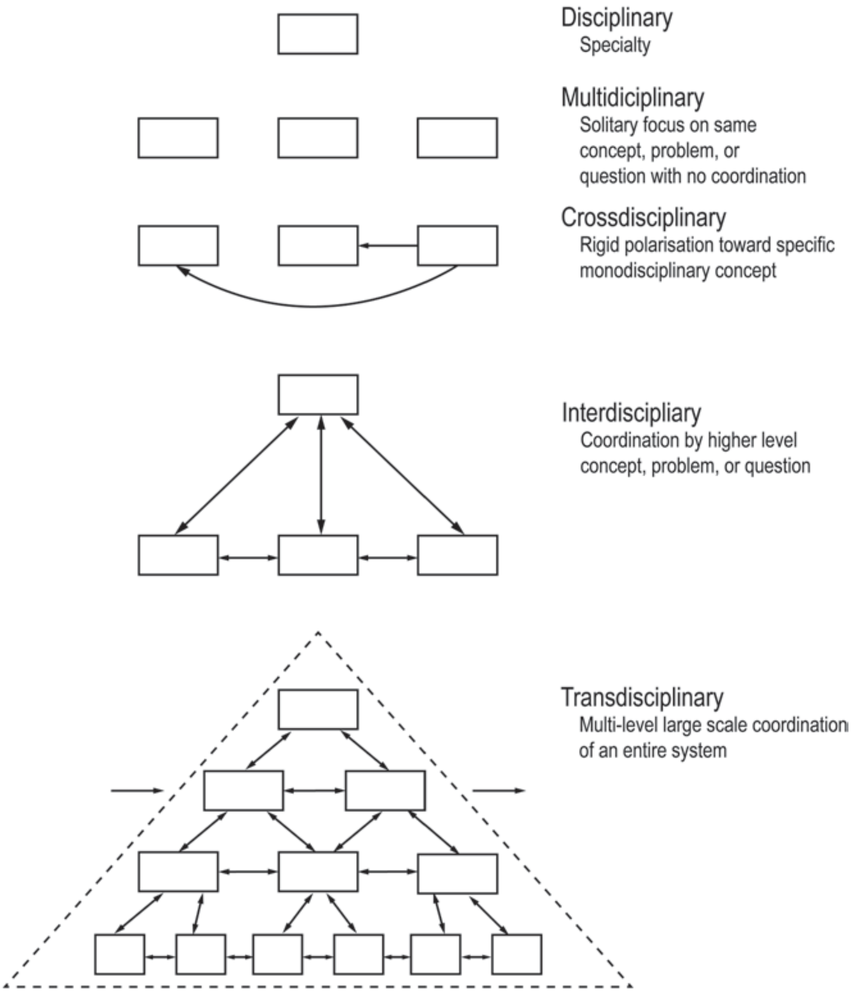

Fig. 8.4 Levels of complexity in organizational relationships from disciplinary to transdisciplinary. (After Jantsch 1972)

Transdisciplinary organization

Most undergraduates, upon entering college, are asked which discipline they planned to select as a major (Fig. 8.4). Such was *disciplinary* education for decades; the environmental movement of the late 1960s and 1970s (The Decade of the Environment) changed that academic philosophy. Ecologists recognized that events, such as the Santa Barbara Oil Spill, among others, required at least a *multidisciplinary* approach to address and solve such problems.

About this time, major grants were being awarded to disciplines, centers, or institutes to focus on challenges—such was the recognition that well-organized centers or institutes, such as the Institute of Ecology at the University of Georgia, had a capacity to conduct research in a *cross-disciplinary* manner.

A cross-disciplinary approach, however, frequently lacked coordination by a higher-level concept. Exemplary of such a higher-level concept was the research conducted at the Savannah River Ecology Laboratory (SREL) focusing on secondary succession or ecosystem development (Odum 1969, 1977). Colleges and universities quickly recognized the need for an *interdisciplinary* research agenda in order to efficiently and effectively coordinate research and academic programs in a cost-effective manner.

In recent decades, scholars have attempted to develop entire centers in a *transdisciplinary* manner. Academic centers, such as Evergreen State University and University of Wisconsin-Green Bay, have attempted a multilevel, entire-center transdisciplinary approach with limited success. The Institute of Environmental Sciences (IES) at Miami University, Oxford, Ohio, organized on a problem-solving algorithm (Barrett and Puchy 1977, Barrett 1985), is an example of an interdisciplinary training model. Although a very successful interdisciplinary training model, the lack of understanding by higher administration kept the IES problem-solving structure from reaching a transdisciplinary level of success. Perhaps coming decades will witness successful transdisciplinary teaching, research, and service centers organized in a coordinated, multilevel structure (e.g., organization in this holistic systems approach is found in commerce and the military). Programs focusing on the concept of sustainability represent a major step in this transdisciplinary direction.

In Fig. 8.5a–b, a three-dimensional interpretation of a transdisciplinary approach as a large-scale coordination of an entire system of transdisciplinary groups interacting around a concept, problem, or question is illustrated. Each triangle represents an individual group or program within the total hierarchy with a team of participants at the base of each triangle and the expert or executive committee at the apex of each triangle. By pulling the apex of each individual triangle from the margin to the position closest to the center sphere (representing the concept, problem, or question), as many experts are optional from the fields of study as appropriate to the solution. The base teams of participants support at the outer margin with direct access to shared information simultaneously.

The model is interchangeable when the solution calls for teams of participants and a few experts. The base team of participants remains in place with their respective supporting expert, as a field expert represented by an apex of another group may be positioned closer to the center (Barrett and Barrett 2001b).

A New Historical Perspective on Landscape Ecology

Most ecologists are familiar with Eugene P. Odum as a leader and pioneer in the field of ecosystem ecology (Barrett and Likens 2002; Barrett 2003, 2005). Odum was the first director and founder of the Sapelo Marine Biological Laboratory in

(a) (b)

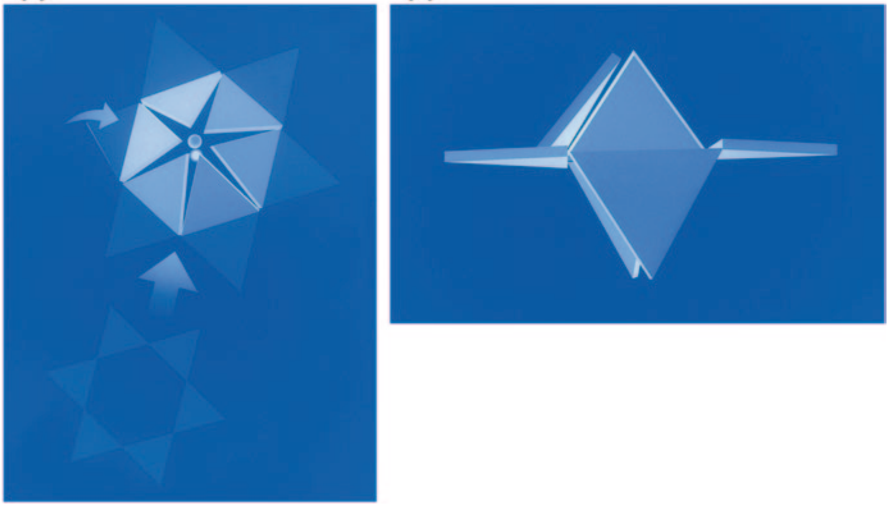

Fig. 8.5 **(a)** The *Multi-faced Levelscape Model* is transformed to the *Multilayered Point Model*. **(b)** Profile of the transformation. Illustration of a three-dimensional model to meet future challenges by providing the organization with multiple possibilities and flexibility to seek solutions determined by the complexity of a concept, problem, or question. (After Barrett and Barrett 2001b)

1954, which became the Institute of Radiation Ecology in 1958; The Institute of Radiation Ecology became the Institute of Ecology in 1967 (Barrett and Barrett 2001a). Most ecologists also are aware that the Institute of Ecology was recognized as a national and international ecological research center for decades.

In 1994, the new mission of the Institute of Ecology also was to develop this facility as a center for academic training with a B.S., M.S., and Ph.D. in Ecology—this mission was achieved during the tenure of Gary Barrett as director of the "new" Institute of Ecology. One of the seminal goals of Gene Odum was to invest ecology as a stand-alone discipline (paradigm), not just a subdiscipline of biology, which is still the case regarding most centers of higher learning in the United States.

What is less understood is that the Institute of Ecology was evolving as a center for landscape ecology during that time as well. For example, the Institute of Ecology was recognized as a center of ecosystem ecology during those formative years with numerous distinguished professors (David Coleman, Dac Crossley, Frank Golley, Carl Jordon, Judy Meyer, Bernard Pattern, and Richard Wiegert). What is lesser known is because of the holistic approach to ecology manifested by these faculty members at the Institute of Ecology, Landscape Ecology was influenced by a new integrative science as well (Barrett 2001). For example, graduate students and an undergraduate student, Ron Pulliam, trained by these faculty later were recognized as Distinguished Landscape Ecologists—these include Gary Barrett, Ron Pulliam, Hank Shugart, Monica Turner, Jianguo Liu, and Jianguo Wu.

Interestingly, the Institute of Ecology became the first stand-alone School of Ecology in 2007. Unfortunately, within the new School of Ecology, Landscape Ecology is increasingly becoming a disregarded discipline due to the attrition of landscape ecologists over the past decade. However, other institutions of higher learning will train the next generation of landscape ecologists. Arizona State University with its School of Life Sciences and Global Institute of Sustainability is a step in this direction.

As exemplary within this chapter, the transforming fields of study are not considered necessarily Landscape Ecology per se. However, Landscape Ecology influences the direction and form of many of these inquiries. Perhaps the dissemination of Landscape Ecology, signified by transdisciplinary science, will allow a continuum of study with landscape as referent of an integrative science.

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Chapter 9
A Tale of Two Continents: The Growth and Maturation of Landscape Ecology in North America and Australia

John A. Wiens and Richard J. Hobbs

Introduction

The historical trajectory of a discipline is determined by the initial conditions of its emergence and by what happens along the way. There may be strong founder effects when a discipline is given impetus by a few individuals, whose interests, perspectives, and personalities influence the course of development. There may also be geographical effects, as the environmental and cultural settings influence the questions that are asked and define the problems that need solutions. As a discipline develops, its growth may be more vigorous on some pathways than on others, driven by funding opportunities, new technologies, the development of nuclei of graduate training, and public perceptions of what is relevant.

Landscape ecology is a young science, still showing the effects of these forces. Although its identity may be a bit more certain than when Hobbs (1994) labeled it a "science in search of itself" two decades ago, landscape ecology has yet to develop a central conceptual framework or core set of guiding principles, several attempts notwithstanding (e.g., Forman 1995, Farina 1998, Wiens 2002). In part, this reflects the mixed parentage of landscape ecology, stemming from the humanistic focus of Europeans and the ecological emphasis of North Americans (Wu and Hobbs 2007).

Our goal in this chapter is to explore how initial conditions and environmental and cultural settings have influenced how landscape ecology has developed in

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North America over the past quarter of a century. What better way to do this than by comparing this ontogeny with that of landscape ecology in Australia, where things are indeed different (Dodson and Westoby 1985, Hobbs and Wiens 2011) and landscape ecology had a later start than in North America? Specifically, our objectives are to:

- Describe how landscape ecology emerged as a scientific discipline on the two continents
- Consider what factors influenced the directions of development in the two regions
- Discuss what we see as the current and future foci of landscape ecology

The Emergence of Landscape Ecology

North America

Several contributions to this volume describe the early glimmerings of landscape ecology in North America. Two somewhat independent threads were involved. One was the exposure of a few North American scientists to the landscape ecology that had developed in Europe, particularly in the Netherlands. By the early 1970s, conferences and meetings were being held, opening the eyes and minds of those who attended to the potential of this new discipline to integrate disparate themes. Reflecting the highly modified character of the European landscapes and the strong sociological leanings of some of its progenitors, the European perspective was human centered and holistic. Humans and landscapes were regarded as inseparable—people were part of landscapes and landscapes were part of people. This was the version of landscape ecology that was carried back to North America in the early 1980s.

The other thread came from ecology. Ecology, of course, became well established (if not well defined) in North America by the 1930s (McIntosh 1985, Kingsland 2005). From its beginnings, there was a strong conceptual thrust, exemplified by the development of Clements' thinking about ecological succession and Gleason's countering individualistic concept (McIntosh 1975). The conceptual flowering of ecology in the 1950s, led by Evelyn Hutchinson, Gene Odum, Robert MacArthur, Robert Whittaker, and others, dominated North American ecology for decades and, in a transformed state, still does. During the 1960s and 1970s, some ecologists began to incorporate an explicit recognition of the importance of spatial patterns and relationships into their work. For example, island biogeography theory (MacArthur and Wilson 1967) incorporated landscape features such as island (patch) size and isolation, and its subsequent application to terrestrial situations (e.g., Wilson and Willis 1975, Diamond 1975) tightened the linkage. Patch dynamics (Pickett and Thompson 1978) coupled ecological succession with island biography. By and large, however, ecologists were unaware of the landscape ecology developing in Europe, and they rarely associated the word "landscape" with what they were describing. Instead, they saw their work being relevant to disciplines such as mainstream ecology or conservation. Thus, although ecology itself was becoming spatially explicit (e.g., Tilman and Kareiva 1997), the connection to landscape ecology was not apparent.

Although multiple factors were involved in the emergence of landscape ecology as a recognizable discipline in North America, a single consolidating event stands out. The two threads—the landscape ecology imported from Europe and the developing emphasis on spatial relationships in North American ecology—coalesced at a workshop held in Allerton Park, IL, USA, 25–27 April 1983 (Risser et al. 1984). The goal of the workshop was to define the core issues and themes that would launch a cohesive, empirical, and rigorous discipline of landscape ecology in North America. The participants identified four central questions:

- How are flows of organisms, materials, and energy affected by landscape structure?
- What processes create landscape patterns?
- How does heterogeneity affect the spread of disturbances?
- How can the concepts and findings of landscape ecology be applied to natural resource management?

Underlying these questions and themes was a strong focus on spatial heterogeneity, scale, and dynamics (Wiens 2008).

Although the European perspective was represented at the workshop, these themes were clearly ecological, not humanistic. The emphasis was on the "ecology" part of landscape ecology, on the ways in which spatial patterns might affect the processes of interest to ecologists (Turner 1989). Concerns about disturbances in ecological systems emphasized how landscape structure might facilitate or constrain their spread (e.g., Turner 1987, Turner et al. 1989). Applications of island biogeography theory to the design of nature reserves became the cornerstone of a broader consideration of the effects of habitat fragmentation and patch dynamics in resource management and conservation (Burgess and Sharpe 1981, Bissonette and Storch 2003), leading to the incorporation of landscape ecology into the organization and practices of governmental agencies, such as the United States Forest Service, United States Geological Survey, and Environmental Protection Agency.

In many ways, the trajectory of development of landscape ecology in North America was determined by what transpired at the Allerton Park workshop. Many of the participants went on to redefine themselves as landscape ecologists. Their thinking was shaped or catalyzed by the discussions at Allerton Park. Several of them played important roles in influencing how the field developed in North America and internationally, through their involvement in the International Association for Landscape Ecology (IALE), the development of graduate programs in landscape ecology, publication of papers and books, organization of conferences, and so on.

We return in the next section to consider the forces that may have set landscape ecology on this trajectory in North America. First, however, let us review how the discipline developed in Australia.

Australia

Unlike North America, there was no particular event that could be said to mark the start of the emergence of landscape ecology in Australia. Indeed, one could legitimately question whether landscape ecology as a separate enterprise has ever emerged there. Ecology in general is considerably younger in Australia. The Ecological Society of Australia, for example, began when a small band of mostly Canberra-based scientists established the society in 1961. In contrast, the Ecological Society of America was established in 1915. Australia itself only became a federated country at the turn of the twentieth century. Ecology developed along with the new country as society tried to understand the array of organisms that inhabited the continent, and the ecosystems they comprised. Many of the early investigations related to attempts to subdue and utilize the ecosystems across the country and control the sometimes-unruly biota that stood in the way of human enterprise. Some of the biota in question was not Australian, but had been introduced by European settlers.

From the start, many of the ecological questions being tackled in Australia had strong spatial elements. Understanding and managing disturbance regimes, particularly fire, were (and remain) a priority. Examining and, where possible, halting or controlling the spread of invasive organisms were also early preoccupations of Australian ecologists (Groves and Burdon 1986). Trying to understand the reasons behind the widespread extinction of medium-sized mammals that unfolded in the twentieth century (unlike anything seen in North America) also became a priority (Burbidge and McKenzie 1989). In addition, the patchy nature of scarce resources, such as water and nutrients in the Australian environment, meant that ecologists could scarcely avoid considering the spatial and temporal distribution of these resources and how the biota responded to and used them. This was equally relevant in the extensive arid and semiarid zones and in the more temperate regions of the south. Indigenous Australians had a strong awareness of these spatial and temporal variations and crafted their own movements and management practices around them. As European patterns were imposed on the continent, the need to understand the implications of the newly created patterns increased, particularly in relation to the fragmentation and modification of the systems that had been there before.

It could be argued, then, that a lot of the ecology that developed in Australia had landscape ecology at its core, even though few people would have called it that. Indeed, the word "landscape" appeared only sporadically in the titles of scientific articles from the 1960s, mostly in geography journals and in articles relating to landforms and geomorphology. Its use increased from the early 1990s and has been increasing steadily since (Fig. 9.1). This increase coincided with the development of a range of research programs across Australia specifically focusing on the ecology and management of Australian landscapes. For instance, the Commonwealth Scientific and Industrial Research Organization (CSIRO), Division of Wildlife and Ecology, had programs (coalescing in the 1980s from formerly separate entities) focusing on tropical savannas, rainforest, rangelands, and agricultural landscapes, all of which took a distinctly landscape ecological approach.

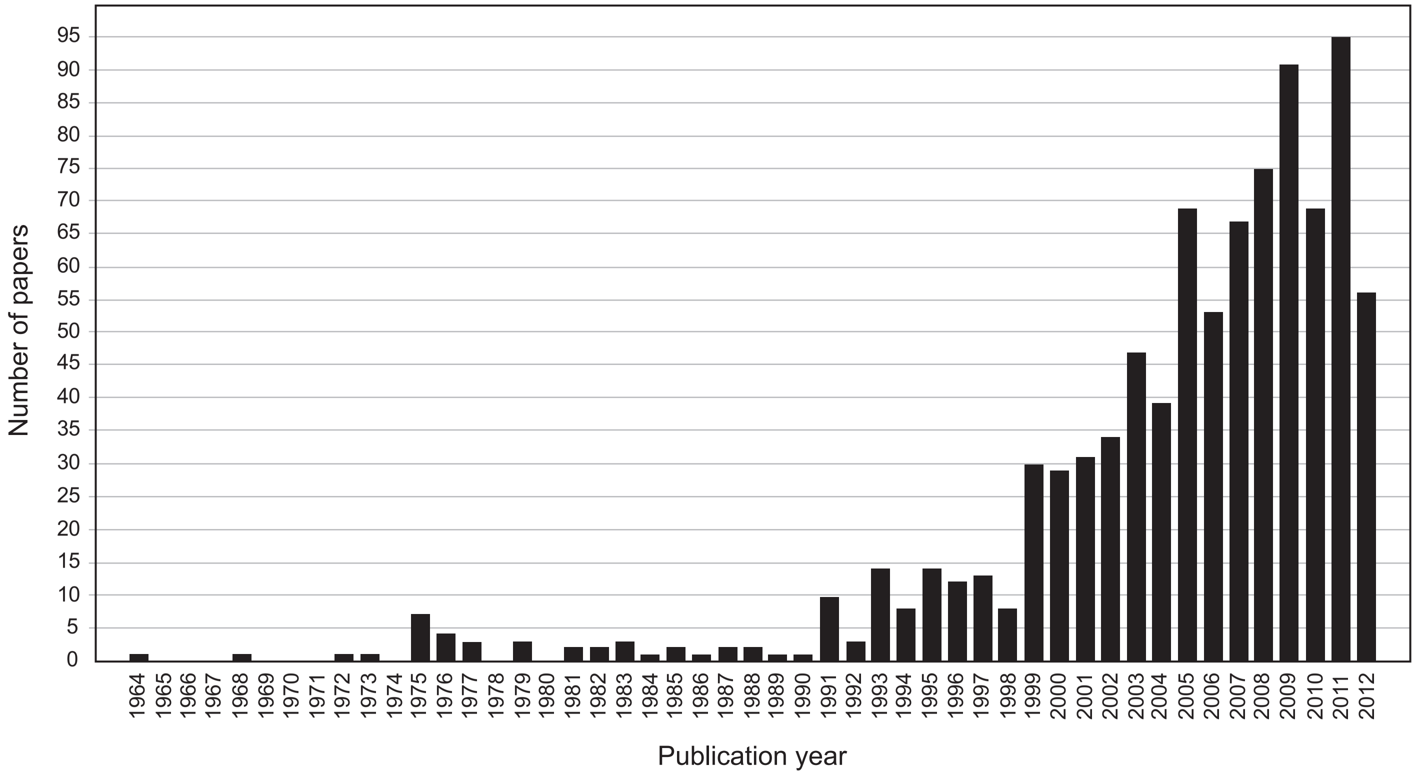

Fig. 9.1 Number of papers per year (1964–2012) with the word “landscape” in the title and “Australia” in “topic.” From ISI Web of Science. A similar analysis could not be conducted for North America because the “topic” entry could have been “North America,” the “United States,” or specific regions or states, each yielding different (and incomplete) results.

The landscape ecology that developed in these and other programs was a hybrid beast, incorporating the strongly ecological approach common in North America, but also increasingly considering the social, cultural, and economic aspects more commonly associated with the European approach. Several of the research groups that developed around these themes went on to make significant contributions to the international development of landscape ecology—for instance, the work of David Lindenmayer in the southern forests and agricultural area, Denis Saunders and Richard Hobbs in the Western Australian wheat belt, and David Tongway and John Ludwig in the rangelands.

Partially on the back of this work, the Sixth International Congress of IALE came to Australia in 2003, attracting some 600 participants to Darwin in the Northern Territory (the 1999 Fifth International Congress of IALE was held in Snowmass, CO, USA). An Australian association with IALE formed in advance of the Congress, continued for a few years afterward, but did not maintain momentum and mainly organized symposia as part of the annual conference of the Ecological Society of Australia. This reflects the degree to which landscape ecology is embedded within Australian ecology and is not necessarily seen as a separate or special enterprise. Indeed, the theme of the 2011 Ecological Society of Australia Conference was "Ecology in Changing Landscapes."

Summary

It is clear that landscape ecology developed along somewhat different pathways in North America and Australia. In both, the initial impetus was strongly rooted in ecology. In North America, however, ecology was a well-established discipline by the time landscape ecology materialized as a discipline, whereas in Australia ecology was new and there were fewer scientists involved. Consequently, the landscape perspective became embedded in ecology rather than being something separate. There were also differences in the sorts of ecology being done. In North America, ecology was largely driven by concepts and theories, and ecologists sought out appropriate places to test those notions, usually small, homogeneous areas in which the bothersome effects of spatial heterogeneity would be reduced. In Australia, ecology was more pragmatic and applied, seeking to understand the diversity of landscapes arrayed before them and past human influences on those landscapes. Finally, there was no single event to catalyze the emergence of landscape ecology in Australia as there was in North America. So, although ecologists in neither North America nor Australia initially associated what they were doing with landscape ecology, it eventually emerged as a defined, vigorous discipline in North America, but not to the same degree in Australia.

Whether or not it is formally recognized with the label "landscape ecology," however, the emphasis on spatial patterns, relationships, and processes is clearly part of ecology and resource management in both continents. There are differences, however, and both differ from the European foundation of landscape ecology. Why?

The Guiding Forces

The directions in which landscape ecology developed in North America and Australia—the questions asked, the dominant themes, and how the discipline was applied—were not random, nor were they direct outgrowths of the European roots of landscape ecology. What factors canalized development in particular directions? Although many forces were at work, we focus on four that have had particularly strong, nonrandom effects: people, places, procedures, and policies.

North America

People To the extent that the Allerton Park workshop set a direction for the development of landscape ecology in North America, it was largely a reflection of the backgrounds, interests, and expertise of the 25 people assembled there (as a regrettable sign of the times, all were white males). Although their perspectives varied, all recognized the importance of spatial pattern and heterogeneity and temporal dynamics, and all implicitly rejected the assumptions of spatial homogeneity and temporal equilibrium that dominated North American ecology through the 1960s and much of the 1970s (Wiens 1984, Wu and Loucks 1995). Beyond this, several individuals (e.g., Paul Risser, Frank Golley, Bob Woodmansee, John Wiens, Gary Barrett, Bill Parton) had been involved in ecosystem studies as part of the International Biological Program (IBP). With others (e.g., Bob O'Neill, Hank Shugart, Tom Hoekstra), they brought to the discussions a systems perspective, with an emphasis on processes and flows. Several people (e.g., Shugart, Barrett, Dan Botkin, Gray Merriam, David Sharpe) had emphasized disturbance or patch dynamics in their work, while others (e.g., Jack Ward Thomas, Louis Iverson, William Ruesink, Robert Rabb, Glen Sanderson) were directly involved in natural resource, wildlife, or agricultural management. Although other perspectives were also represented (e.g., ecological economics, Bob Costanza; landscape planning, Carl Steinitz; the European approach, Michel Godron), the summary that came out of the workshop highlighted the dominant themes of flows, processes, patch dynamics, scale, and disturbance and their relevance to resource management (Risser et al. 1984). A different assemblage of people, with different perspectives and expertise, would have likely emphasized different themes. The 1981 Veldhoven Conference held in the Netherlands, for example, produced a series of papers focused largely on agricultural landscapes and the relations between humans and the landscape, reflecting the interests of the participants (Tjallingii and de Veer 1982). Strong founder effects were at play.

While few of the participants in the conference would have previously identified themselves as landscape ecologists (although Frank Golley, Richard Forman, and David Sharpe had already been converted as a result of their earlier contacts with European colleagues; see Forman, this volume), most left with that identity firmly implanted. Awareness of the discipline spread. A journal, *Landscape Ecology*, was launched, a United States Regional Association of IALE was formed, conferences and workshops were held, and graduate programs established, all within a few years. In particular, a group of scientists at Oak Ridge National Laboratory (ORNL; Bob O'Neill, Bob Gardner, Monica Turner, Virginia Dale, and Tim Allen) played a pivotal role in advancing landscape ecology in North America over the next decade through their publications and their training programs. Not coincidentally, ORNL was also a center of ecosystem ecology and systems analysis.

Places People work in places, and the geographical and environmental settings of those places inevitably influence their interests and perspectives. In Europe, for example, human activities are closely interwoven into the landscape, so it is not surprising that European landscape ecology would develop with an emphasis on humans *in* the landscape. In contrast, in North America, the scale, diversity, and availability of extensive natural, seminatural, and agricultural landscapes allowed landscape ecology to be applied in a diversity of landscape types and exerted a strong ecological pull.

The interests of the participants in the Allerton Park workshop helped to set the stage. Several people (Botkin, Forman, Iverson, Sharpe, Shugart, Thomas) worked primarily in forests; others (Barrett, Parton, Risser, Wiens, Woodmansee) had conducted research in grasslands. Yet others (Merriam, Rabb, Ruesink, Sanderson) dealt with landscapes in which agriculture was a major element. These people brought different viewpoints about landscapes to the workshop. Fragmentation was a major concern of forest ecologists, and their thinking about landscapes incorporated ecological succession, patch dynamics, disturbance spread, and the application of island biogeography concepts in forest management. The grassland ecologists (all of whom had conducted research as part of the IBP) carried with them an affinity for systems thinking and modeling, while those who worked in agricultural settings were interested in how landscape structure might affect the movements of insect pests or the population dynamics of small mammals living in an agriculture-woodland mosaic. This breadth of interests and experiences and the variety and scale of landscapes available in North America provided a broad canvas to which the emerging concepts of landscape ecology could be applied.

Procedures Disciplines are often defined as much by their procedures and tools as by their concepts, and this is particularly true of landscape ecology. The very beginnings of the field, in the work of Carl Troll in Germany, were founded on the use of aerial photography to document landscape patterns (Troll 1950). By the time of the Allerton Park workshop, the tools of remote sensing were rapidly expanding in coverage, resolution, and the array of information generated. The use of geographic information systems (GIS) to analyze spatial data was gaining force, as was a growing arsenal of spatial statistics. Over the next two decades, the use of these tools became a central element of landscape ecology, producing an explosion of increasingly sophisticated and detailed analyses of landscape structure (Wiens

1992, Hobbs 1997, Andersen 2008). The initial products were often impressive and colorful GIS images of mosaic patterns, but attention quickly shifted from documentation of patterns to using this information in statistical analyses and modeling of fragmentation effects, disturbance spread, patch dynamics, and the like. Concurrently, advances in radio telemetry and the use of radioisotopes facilitated research on how materials and organisms moved through spatial mosaics—a focus on landscape processes.

Notwithstanding several notable exceptions (e.g., Holt and Debinski 2003, Ims 2005), the customary scales on which landscapes are considered (hectares to many square kilometers) have generally precluded the sorts of carefully replicated experiments that, together with hypothesis testing, had become central to ecological science and resource management by the 1980s. To be recognized as a legitimate scientific discipline, at least in the eyes of the prevailing scientific culture (and funding agencies) in North America, landscape ecology needed something to demonstrate that it had come of age. Perhaps more than anything else, it was the availability of these tools and the analytical and statistical rigor they fostered that enhanced the standing of landscape ecology among other scientists and promoted the incorporation of landscape perspectives and approaches into multiple areas of ecology, wildlife management, and conservation. People asked the questions and landscapes provided the settings that gave landscape ecology its North American identity, but the tools and the analytical power they provided pulled the discipline from the scientific fringes into the mainstream.

Policy Although the landscape ecology that developed in North America had a strong underpinning of basic ecology, it was always, at its core, a discipline with obvious applications. Although several of the Allerton Park participants (e.g., Ruesink, Rabb, Sanderson) were directly involved in applied research and two (Thomas, Iverson) were with the United States Forest Service, most were academics. In the years following the workshop, they incorporated landscape ecology into their teaching and research, and their contributions helped to advance the conceptual, empirical, and methodological content of the discipline. At the same time, however, landscape ecology was spreading into federal agencies. During the late 1980s and 1990s, landscape ecology units were established in the United States Forest Service and Environmental Protection Agency, a program to use remote sensing to catalog and analyze land-use change was initiated within the United States Geological Survey, and landscape fragmentation and connectivity became central to refuge management in the United States Fish and Wildlife Service. "Landscape" began to appear in the planning documents and regulations of these agencies. The explicit incorporation of a landscape perspective, concepts, and tools into the structure and policies of these agencies (and, in turn, their funding of landscape research) contributed greatly to the development and recognition of landscape ecology in North America.

Australia

People and places The people who contributed to the development of a landscape perspective in Australia were inseparable from the places in which they worked. Landscape thinking in Australia initially developed from work based in the geomorphological realm or geographic/cultural arena. Landform analysis was an important enterprise for understanding land capability and hydrologic flows, with various investigators across the country leading the way—for instance, Morris Mulcahy and Eric Bettenay in Western Australia (Bettenay and Mulcahy 1972). Other researchers (e.g., Lesley Head, Sylvia Hallam) considered Aboriginal knowledge and use of Australian landscapes, while George Seddon pioneered a truly integrated landscape perspective involving biophysical and socio-cultural elements in his classic 1972 work *Sense of Place*, focused on the Swan Coastal Plain in Western Australia (Seddon 1972).

The emergence and flowering of Australian landscape ecological work continued with various groups across the country from the 1980s onward. In the arid rangelands, the Alice Springs group, including Geoff Pickup, Marg Friedel, Barney Foran, and later Steve Morton, Mark Stafford Smith, and others, started using the new possibilities afforded by remote sensing and spatial analysis to develop spatially oriented approaches to understanding arid landscapes. This included studies relating to distribution and dynamics of native biota in relation to patchy resource availability and fire regimes, as well as a focus on patterns of primary production for rangeland use (Morton et al. 1995, 2011). These studies related to the patterning of plant growth in relation to landscape flows of water, and modification of these patterns by various grazing regimes involving domestic stock and feral animals such as rabbits. Elsewhere in the rangelands, John Ludwig and David Tongway developed strongly process-oriented approaches to assessing landscape health and devising management techniques for preventing or correcting degradation, focusing particularly on how landscape structure affected the flows of water and materials and, consequently, the patchiness of vegetation (Ludwig et al. 1997, 2000). In northern Australia, researchers in Darwin, including Pat Werner, Alan Anderson, Jeremy Russell-Smith, Dave Bowman, and others, examined savanna landscapes and the impacts of fire-regime change and invasive species, an enterprise that continued and expanded with the formation of a Tropical Savannas Cooperative Research Center. The ecology of fragmented agricultural and forest landscapes attracted considerable attention on several fronts, including southeastern Australia, with work initiated by Chris Margules, David Lindenmayer, Andrew Bennett, and Ralph Mac Nally. In Western Australia, Denis Saunders, Richard Hobbs, and the CSIRO group worked in the agricultural landscapes of the wheat belt, along with others including Bert and Barbara Main (Hobbs and Saunders 1993, Hobbs et al. 1993). In tropical Queensland, an array of researchers including Francis Crome worked on tropical forest fragments, leading to the development of various incarnations of research centers devoted to rainforest ecology. In both these latter cases, the initial focus was on the conservation and management of remnant patches, but gradually developed a strong landscape focus relating to the movements of biota and, in the case of the wheat belt, hydrological processes driving system change.

As time progressed, some people moved around these various nodes. For instance, Denis Saunders moved east and Chris Margules moved to tropical Queensland. At the same time, the focus of the research developed and in some cases moved on, although several long-term studies continued, including the experimental work of David Lindenmayer in forest and agricultural landscapes (Lindenmayer 2009).

Procedures As in North America, the development of new technologies such as remote sensing and GIS greatly enhanced the ability to examine Australian landscapes effectively. The strength of Australian landscape ecology, however, may derive more from the effective use of the landscapes themselves as experimental and observational test beds. The work in the Western Australian wheat belt, for example, led to a rapid development of concepts and ideas concerning fragmented landscapes, rather than the ideas and concepts determining the focus on particular landscapes. In eastern Australia, the effective use of managed landscapes by Lindenmayer, Bennett, Margules, and others to provide replicated examples and experimental treatments has greatly enhanced the quantitative rigor of landscape studies. The establishment of long-term research sites has also been a major contributor to increased understanding of landscape processes and biotic responses, as well as the development of effective measurement and monitoring approaches (Lindenmayer et al. 2012).

Policies Perhaps more so than in North America, the landscape ecology that developed in Australia was linked from the start to management and policy. The programs initiated in CSIRO had a mandate to be relevant to the practical issues faced by those dealing with the various issues in conservation and management of production landscapes. Research projects were often conducted jointly with the relevant management agency and, increasingly, with nongovernmental organizations (NGOs). Partly, this was due to a genuine desire to make the research relevant, but it was also due to the fact that the research was only possible because of the active involvement of the management agency (for instance, in carrying out experimental fire, logging, or revegetation programs).

At the same time, the research actively informed management in ways that led to changes in management focus from simple patch-based management to more landscape and regional approaches. Government funding programs were developed with a distinctly landscape- or region-based approach. The infusion of landscape perspectives into management and policy continues; the federal government has recently embraced "landscape management" for biodiversity, as well as initiating programs focusing on enhancing landscape connectivity.

Summary

Although there are parallels in the ways in which people, places, procedures, and policies influenced the development of landscape ecology in North America and Australia, the differences illustrate the power of these influences. Clearly, the environmental settings affected the questions that were asked, but the linkages between people and places were much tighter in Australia than North America. Consequently, the landscapes, and the challenges in managing and using these landscapes, dictated how scientists approached their work: landscape driven, rather than concept driven. Australian landscape research was also more pragmatic than that in North America from the outset; the emphasis on practical outcomes allowed Australian landscape investigations to feed directly into management and policy issues. Finally, there were matters of scale. A few key individuals got landscape thinking going in Australia, and they were widely scattered in a few geographic and environmental nodes, whereas the impetus for North American landscape ecology rapidly spread (both geographically and numerically) well beyond the participants in the Allerton Park workshop. In addition, since the nuclei for much of the landscape research in Australia were in various CSIRO laboratories rather than within universities, there were fewer graduate students being trained in landscape ecology.

Subsequent Developments in Landscape Ecology

Although the factors that gave North American and Australian (and European) landscape ecology their distinctive flavors are still at play, the distinctions have become blurred as the discipline has undergone globalization. The expansion and strengthening of IALE and landscape ecology journals, frequent regional and international conferences, and increasing collaborations among individuals and sharing of students among continents have all contributed to a cross-fertilization of perspectives and approaches.

How might landscape ecology continue to develop in the two continents in the future? One way to gauge this is by revisiting the list of key issues and research topics in landscape ecology that emerged from discussions at a landscape ecology conference in 2001, nearly 20 years after the Allerton Park workshop (summarized by Wu and Hobbs 2002). The six issues identified by Wu and Hobbs (Table 9.1) are less issues to be addressed through research than they are challenges to the continuing development of landscape ecology as a scientific discipline. For the most part, these challenges all relate to the need for broader communication among the disciplines that deal with landscapes and the integration of basic research into practical applications. These needs were recognized at the Allerton Park workshop and they were part of Australian landscape ecology from the outset. Considerable progress has been made, largely due to the growth and greater visibility of the discipline and its incorporation into the agendas of government agencies in both continents. Given the diversity of approaches, the inherent complexity of landscapes, and the multiple ways in which landscapes are used, however, the challenges are likely to remain with us for some time.

The research topics that Wu and Hobbs identified are more directly relevant to our discussion here (Table 9.2). Are these simply extensions of the trajectories of development we described earlier, or do they represent new directions? Did the seeds sown in the early beginnings of North American and Australian landscape

Table 9.1 Key issues in landscape ecology (Wu and Hobbs 2002), and how they relate to the current status of landscape ecology in North America and Australia

Key issue	Current status
1. Greater interdisciplinary is needed	Linkages with landscape planners and designers and conservation biologists are strong; closer integration with basic ecologists and human geographers needed
2. Basic research and application should be integrated	Good progress, but barriers still exist; see issue 4
3. Enhanced conceptual and theoretical development	Basic concepts are well developed and widely applied; further theoretical development should be related to particular needs
4. Greater attention to education and training	Many programs in North America now train students in integrated landscape ecology; explicit training programs are less well-established in Australia
5. Enhanced communication and collaboration	There is broader participation in conferences, but needs improvement to realize the synergistic effects of combining perspectives and disciplines
6. Greater outreach and communication with public and decision makers	There is greater communication among scientists, but conveying the messages of landscape ecology to other audiences remains a challenge, although there is some evidence of increased interchange in Australia

ecology bear fruit, or were they transformed or replaced as new questions gained favor?

Several of the themes that were recognized in the Allerton Park workshop continue to be major areas of research in landscape ecology, particularly as it has become integrated more closely into mainstream ecology. Research on how landscape structure, pattern, and heterogeneity affect ecological flows, for example, has become a central part of population ecology and conservation through its incorporation into modeling and analysis of metapopulation dynamics (McCullough 1996, Hanski and Gaggiotti 2004), source–sink processes (Liu et al. 2011), and the spread of invasive species (Mooney and Hobbs 2000). Scale continues to be at the core of landscape ecology (Wu et al. 2006, Wiens et al. 2012), although the challenge of understanding how processes are translated across scales remains unresolved. The need for quantitative measures of landscape patterns was widely recognized in the Allerton Park discussions, and recent technological developments have enabled landscape ecologists to measure more things about landscape structure and patterns with greater precision. Spatially explicit modeling and the use of spatial statistics were just beginning to be applied in landscape ecology at the time of the workshop, and both have expanded tremendously in diversity, power, and applicability since then. The real interest at Allerton Park, however, was in how patterns influenced ecological processes (and vice versa); this emphasis was also evident in some of the initial landscape work in Australia—for example, in the rangeland studies of Ludwig and Tongway (Ludwig et al. 1997, 2000). Although ways of detecting, measuring, and analyzing landscape patterns have proliferated, progress in developing landscape metrics that reveal much about processes has been slow.

Table 9.2 Major research topics for landscape ecology summarized by Wu and Hobbs (2002), and their relations to the themes that characterized North American and Australian landscape ecology early in their development

Research topic	Status
1. Ecological flows in mosaics	Highlighted at AP and recognized early in Australia; continues to be a major theme of ecological landscape ecology
2. Dynamics of land cover change	Developed from landscape pattern description, facilitated by remote sensing and GIS technologies and developing linkages with geography and sociology
3. Nonlinear dynamics and landscape complexity	An outgrowth of bringing theories of hierarchies, complex adaptive systems, chaos, fractals, and similar concepts into landscape ecology starting in the mid-1980s
4. Scaling	An important undercurrent at AP; often mentioned and multiscale investigations more frequent, but challenge of extrapolating or translating among scales remains
5. Methodological development	The emphasis on spatial modeling and spatial statistics at AP has continued to grow and diversify
6. Linking landscape metrics to ecological processes	Metrics of landscape pattern have proliferated, but linkages to processes remain largely inferential
7. Integrating people and their activities into landscape ecology	Not a major theme at AP, but developed quickly as geographers, social scientists, and landscape planners became more active in landscape ecology; now recognized as an integral part of landscape ecology in both North America and Australia
8. Optimization of landscape patterns	A new area of landscape research, not mentioned at AP nor yet well developed, but an area of active research in Australia
9. Landscape conservation and sustainability	Neither an explicit theme at AP; application to conservation coincided with emergence of conservation biology as a discipline in mid-1980s; focus on landscape sustainability is more recent
10. Data acquisition and accuracy	Importance of data recognized at AP; data management and quality assessment developed as technologies generated more spatial data; challenge is to understand and interpret data

AP allerton park, *GIS* geographic information systems

Other topics listed by Wu and Hobbs (2002) did not have clear precursors in the discussions at Allerton Park or in Australia. The emergence of an emphasis on land-cover change came only after the remote sensing and analytical technologies had developed sufficiently to enable high-resolution tracking of land cover over large areas, and the application of landscape ecology concepts and approaches to conservation issues increased after conservation biology became a recognized discipline in the mid-1980s. Discussions of landscape sustainability are even more recent (Musacchio 2009), reflecting the rise of sustainability science as a new discipline in the early 2000s (Kates et al. 2001, Wiens 2012). All of these developing topics relate to the increasing integration of people and their activities into landscape ecology, a theme that was largely in the background at Allerton Park but was central to

Australian approaches from the beginning. Although the increased recognition of humans as part of landscapes in North America resulted in part from the infusion of the European landscape ecology perspective, it was largely due to the involvement of geographers, landscape planners, sociologists, landscape architects, urban planners, and the like—people who shared the affinity of landscape ecologists for spatial patterns and processes but whose work dealt with humans and their activities rather than ecological systems.

Yet others of the key research topics were not to jell until later. Although O'Neill and his colleagues were beginning to formulate their ideas about hierarchy theory at the time of the Allerton Park workshop (O'Neill et al. 1986), this and the rich array of theory dealing with complex adaptive systems, chaos, fractals, self-organization, and other aspects of complex, nonlinear systems did not inculcate landscape ecology in North America until some years later (e.g., Milne 1991, Milne et al. 1992), although they were already surfacing in Australia in the late 1980s (Westoby et al. 1989). Ideas about using spatial optimization approaches (Hof and Bevers 1998, 2002; Moilanen et al. 2009) to move management and design of landscapes beyond patches and corridors to deal with entire mosaics as integrated entities, noted as a key area for research by Wu and Hobbs, has yet to gain traction in landscape ecology.

Whither Landscape Ecology?

Landscape ecology has matured differently in North America and Australia. In North America, it has become an established discipline with a separate identity. Annual conferences of USIALE regularly attract 300–400 attendees; for many, this is the primary (or only) scientific conference they attend. By contrast, in Australia, the brief flurry of organizational activity associated with the Sixth IALE Congress did not last. Perhaps there were too few people too widely scattered to maintain a separate organization. But landscape ecology was already embedded in Australian ecology, and the more pragmatic nature of Australian ecology allowed the landscape perspective to grow within that setting.

Landscape ecology as an endeavor, if not an organized discipline, still bears the imprints of its founders and the environmental settings in North America and Australia. In both regions, the landscape perspective has grown and diversified by capitalizing on new technologies, incorporating theory and practices from other disciplines, attracting scientists and practitioners with an array of backgrounds and expertise, and (less so in Australia) training generations of students who bring fresh thinking and renewed vigor. The recognition of spatial heterogeneity and dynamics and the power of spatial analyses have been infused into other disciplines as diverse as restoration, architecture, urban planning, and conservation. What is left?

Quite a lot is left, actually. The themes, topics, and questions that were part of the foundations and that have developed over the past decades will continue to drive research and applications. But there are other challenges, some persisting from the past, others emerging as we write. Dealing with scale in other than a descriptive way, for example, seems still beyond our grasp. Are scaling effects continuous or discontinuous, and are there generalities to be drawn in how patterns and processes scale in different systems? Are there predictable ways in which ecological processes change with scale transitions? How does one deal with a system in which different components function on different scales of time or space? How can an understanding of thresholds or state-and-transition dynamics, or of complexity or chaos theory, or of resiliency, contribute to the development of a theory of scaling?

Landscape ecology has also become important within the growing field of urban ecology. Cities are among the most dynamic and rapidly changing environments, with complex spatial and temporal patterns (Ramalho and Hobbs 2012). Ecologists all but ignored cities as a valid topic for research until recently, but the field has expanded rapidly, with a strong recognition of the importance of the spatial distribution of human infrastructure, remnant ecosystems, parklands, and so on (McDonnell et al. 2009, Niemela 2011). Some of this work harkens back decades to studies in human geography (e.g., Haggett et al. 1977), a discipline that has yet to be fully integrated with landscape ecology.

Landscape ecology has dealt with dynamics and change since its beginnings, mostly in the context of ecological succession and land-use change. Yet the changes in the environment of Earth now under way due to global climate change will push these systems into novel configurations—no-analog communities, ecosystems, and landscapes (Hobbs et al. 2009, Stralberg et al. 2009). Will the questions we have asked in the past or the concepts and tools that have fueled the emergence of landscape ecology as a rigorous scientific discipline still be appropriate, or will new approaches be needed? How can the structure of landscape mosaics be managed to ensure the persistence of species by considering the functional connectivity that will enable species to shift distributions in response to climate change? How should protected areas be integrated into landscapes to provide refugia from the effects of climate change or new places to absorb species as their distributions shift? How can landscapes be managed to forestall or slow the spread of invasive plants and animals? What features of landscapes should be monitored to provide early warnings of changes that may render current land-management practices ineffective? How can spatial prioritization or optimization be used to design landscapes for nature *and* for people, and what criteria should determine the priorities?

So there are plenty of questions and challenges left. To answer the questions and address the challenges will require landscape ecologists to build on their understanding of the structure and function of past and present landscapes to peer into the future, uncertain as it may be. Every landscape on Earth will undergo change: some rapidly and some slowly; some massively and some scarcely at all; some driven by changes in temperature, precipitation, or sea level; and some by more immediate changes in land use or urbanization. While biological systems—populations, communities, and ecosystems—and the ways in which people use these systems or derive goods and services from them will all change as well, these changes will occur within the overarching context of landscapes. Landscape ecology is poised to play a leading role in informing people what to expect and how to deal with it.

To do so will require an even greater integration of disparate disciplines. Landscape ecology must continue to draw from its distinctive roots in Europe, North America, Australia, and elsewhere, but it must also grow beyond these foundations to become a cohesive global enterprise.

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Chapter 10
Landscape Ecology at Oak Ridge National Laboratory

Robert V. O'Neill

Introduction

This chapter attempts to capture the excitement of landscape ecology at Oak Ridge National Laboratory from the early explorations (~1970) until the author's retirement in 2000. The period was remarkable for a number of reasons. I would like to highlight two:

First, the period was remarkable for its productivity. Over that quarter century, researchers at Oak Ridge produced about 100 articles, chapters, and books. During the most intense period, approximately a dozen publications were produced each year. The productivity was so varied and rich that it defies summary into a single chapter. I will leave the task of listing all of the publications to a future bibliophile.

Second, the period is remarkable because of the number of participants. The scientists at Oak Ridge operating, sometimes independently, sometimes in close collaboration, established a surprising number of collaborations. Collaborators during this period number about 100 and were drawn from other disciplines at Oak Ridge, academia, and government laboratories.

As a result, this period generated many creative ideas and went in many diverse directions. The image that often occurs to my mind is the Lernaean Hydra. The Hydra was a mythical sea creature with many heads. The heads could operate in concert to present a formidable force. But, the heads also could operate independently, facing in many simultaneous directions. The application here is to point out the complexity of this history with individuals sometimes operating as one, sometimes in parallel, and sometimes diverging into new directions. As a result of the complexity, I will not attempt to draw out the details of each development. Most

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of the developments deserve a chapter, or a book, of their own. I can only scan the many directions briefly in this history.

Because of the complexity of the developments at Oak Ridge, I find it difficult, if not impossible to untangle the knot. I can only endeavor valiantly to describe the excitement in a semilinear order as required by writing a chapter, one paragraph following another. The inevitable result is that this, like any history, is inescapably personal. The many actors that will emerge from the wings as the play unfolds would necessarily have different recollections, different priorities, and different dialogues would result.

The material is organized into two parts. First, there is an attempt at an historical reconstruction of ideas. Second, there is an analysis of the factors that may account for this remarkable development at this place over this period.

Historical Development

Phase 1: Preparing the Ground

There was much that preceded the developments at Oak Ridge. Although it is largely personal, I would like to record another nexus that contributed in various ways to the evolution of landscape ecology. The centroid of this nexus is the campus of the University of Illinois in Champaign Urbana and the personage of S. Charles Kendeigh, my major professor. Allerton Park is only 28 miles from the Illinois campus and was quite familiar to me from Kendeigh's frequent field trips.

Kendeigh's first PhD graduate in 1939 was Eugene Odum. Odum's main contribution to later developments was in encouraging brilliant students like Hank Shugart and Monica Turner to go to Oak Ridge. Both Shugart, and a close associate at the University of Georgia, Frank Golley, were at the Allerton Park workshop.

In 1948, Kendeigh graduated another student, Bob Whittaker, with a thesis on the vegetation of the Great Smoky Mountains. The Great Smoky Mountains are only 75 miles from Oak Ridge. A yellowed and dog-eared copy of his publication (Whittaker 1956) accompanied me on numerous hikes over the decades. I count Whittaker's publication as a primary influence on me personally. The paper caused me to look at larger dimensions and become intrigued by the complexity of the landscape pattern and its influence on ecological processes.

The final strange confluence involved Jim Karr. Jim is best known for his development and application of the innovative index of biotic integrity (Karr 1981). The connection here is that Jim and I were officemates at Illinois; and both attended the Allerton Park workshop.

Perhaps the nexus described here is to be expected in any closely knit group of scholars. Perhaps it is a small world after all. But, I find the number of interconnections to be surprising and worth recording for posterity.

Phase 2: Planting the Seed

The history of landscape ecology at Oak Ridge National Laboratory began more than a decade before the historic meeting at Allerton Park. During the International Biological Program, the Deciduous Forest Biome program at Oak Ridge (Auerbach et al. 1977) initiated a think-tank project called regional ecology. The project was headed by Bob Burgess and allowed Glen Goff, Dave Sharpe, and Paul Baxter to explore how large-scale spatial patterns could be quantified and how these patterns constrained ecosystem processes. The basic insight integrated the ecosystem paradigm with earlier insights into vegetative biogeography. It was pointed out that ecosystem modeling presupposes a spatial context (Goff et al. 1971). In human-dominated landscapes, it was often the altered spatial pattern that constrained ecosystem processes (Burgess and Sharpe 1981). These early explorations developed a spatial mindset that foreshadowed much that followed.

Another early influence was the development of individual-based tree models by Hank Shugart and Daryl West (Shugart and West 1980). Although not operating at the scale of landscapes, these probabilistic models provide a mechanistic explanation for patterns such as ecotones, which appear on the landscape. This added an interesting new wrinkle to the landscape story. Not only does spatial pattern constrain ecosystem process but simple ecological processes such as plant competition also can generate spatial pattern.

For many of us, landscape ecology is a terrestrial discipline. But, of course, the real point is that space and scale alter ecosystem processes. So, there is another early project that shaped the receptivity of Oak Ridge researchers to the importance of spatial influences. The initial insight was that spatial heterogeneity influenced how nutrients were recycled down the length of a stream (O'Neill et al. 1979). The subsequent research was dubbed "stream spiraling" (Elwood et al. 1981). On flat terrain, the critical measure is the "time" for an average molecule of nutrient to recycle. In a landscape context, the crucial measure is the "distance" that the nutrient moves downstream before becoming available. This was another brick in the edifice of spatial ecology.

Following early explorations in regional ecology, the enthusiasm for large-scale spatial ecology was alive, even rich, and stimulating, at Oak Ridge. This period permitted a few, including Jeff Klopatek, John Krummel, and J. B. Mankin to explore. This interaction resulted in a number of ventures into landscape ecology (Krummel et al. 1980, 1984; Mankin et al. 1981; Klopatek et al. 1983). These publications opened new and exciting possibilities at least within the minds of the Oak Ridge researchers.

Phase 3: The Flowering

Following the Allerton Park workshop, there was a flowering of landscape ecology at Oak Ridge. My personal candidate for a turning point was the collaboration of

Hank Shugart with an exceptional student, Dean Urban. This interaction resulted in a publication in *BioScience* summarizing landscape ecology as a new paradigm (Urban et al. 1987). Beyond that, I am at a loss to analyze the eruption of creativity that occurred at Oak Ridge. But, for the purposes of this chapter, I will attempt to impose some semblance of linearity to what ensued.

Percolation Theory

One direction developed from Bob Gardner's intuition into the relevance of percolation theory (Gardner et al. 1989, 1990; Plotnick et al. 1993). A key aspect of percolation theory is that simulated landscapes, randomly filled with units of habitat, become highly connected when only about 60 percent of the landscape contains habitat (Gardner et al. 1987). Although actual landscapes are not random, natural landscapes have many similarities to those considered by percolation theory (Gardner et al. 1991a). Perhaps the most important influence of percolation theory was the demonstration that landscape ecology could be a quantitative predictive theory and not simply a qualitative and subjective evaluation of pattern. This was always a critical, perhaps, *the* critical element of Oak Ridge's contribution to landscape ecology. Quantification became a primary goal that influenced much that followed (Turner and Gardner 1991).

It is hard to delimit the contribution of Bob Gardner to landscape ecology and its flowering at Oak Ridge (Gardner and O'Neill 1991). One of the most interesting contributions involved the interaction of Bob with Sandra Lavorel. Together, they combined a hierarchically structured landscape with the dispersal strategy of an annual plant. You may disagree, but to me that is one to the hallmarks of the pattern/process paradigm that underlies landscape ecology (Lavorel et al. 1993, 1994, 1995).

Disturbance Theory

Another research direction followed the arrival of Monica Turner (Turner et al. 1995). Perhaps the unique contribution of Monica Turner was the application of a landscape perspective to the propagation of disturbances (Turner et al. 1988, 1989a, 1993a; O'Neill et al. 1992a, b). She may be best known for work on the combination of fire and large ungulates in shaping the Greater Yellowstone landscape (Turner et al. 1993c; Turner and Romme 1994). Monica contributed many of the theoretical developments such as the application of landscape ecology to global change (Turner et al. 1991a), and implications of habitat fragmentation (Gardner et al. 1993; Pearson et al. 1996).

Landscapes and Hierarchy Theory

Though it is not appropriate to make a wide diverticulum into the details of hierarchy theory, it should be made clear that scale matters! It became clear that changing the scale of observation changed the perceived landscape pattern (Turner et al. 1989b). Landscape pattern determined the scale at which organisms must operate to extract resources (O'Neill et al. 1988b; Turner et al. 1993a, b; Wallace et al. 1995).

But perhaps the most important aspect of the interface between hierarchy theory and landscape ecology was an actual test of hierarchy theory. Largely through the stimulation of Sandra Turner, a group of plant ecologists with fine-scaled and spatially extensive datasets assembled. Using a series of spatial analysis methods (Turner et al. 1991b), the team of researchers determined that between four and nine discrete hierarchical levels of organization could be seen in the data from all landscapes (O'Neill et al. 1991).

Another aspect of theory development during this period involved the continued attempt to quantify spatial pattern. One study proposed a small number of statistically independent axes on which one could arrange landscape pattern. Using these axes as indices permit correlation of pattern with processes measured on the landscapes (O'Neill et al. 1988a).

Rhondonia Project

Another major development involved Virginia Dale's project on deforestation in Brazil. Brazil began building roads into the province of Rhondonia to encourage farmers to migrate from overcrowded cities back onto the Amazonian lands. Dale's insight into the associated problems led to two important developments.

The first resulted in land conversion models (Southworth et al. 1991; Dale et al. 1993a, b, 1994a) that simulated the land use changes associated with the slash-and-burn agriculture and the associated addition of carbon dioxide to the atmosphere. The project also investigated the impact of the landscape changes on biodiversity (Dale et al. 1994b) as well as the specific impact on tropical forest fauna that depend on a continuous canopy (Offerman et al. 1995). Simply put, changing landscape pattern disrupts spatial adaptations that have evolved within an undisturbed community and can significantly reduce biodiversity.

The second development of the Rhondonia project was a productive interaction with an economist, Don Jones. Considering only the papers immediately relevant to landscape ecology, the research considered the economics of agricultural land use change and environmental degradation across a region (Jones and O'Neill 1992a, b), and the linked ecological and economic consequences of development policies such as those adopted in Brazil (Jones and O'Neill 1994, 1995).

Phase 4: The Harvest

Although many of the studies discussed above considered management and assessment applications, a shift of emphasis occurred when the Environmental Protection Agency (EPA) entered the mix. Specifically, a connection developed with Bruce Jones and the landscape ecology program at the EPA Las Vegas laboratory.

As a result of this connection, yet another direction developed under the leadership of Carolyn Hunsaker. The emphasis was on applying larger spatial scale analysis for regional risk assessment (Hunsaker et al. 1989, 1990; Graham et al. 1991; O'Neill et al. 1997). The project pointed out the problems of sampling landscape pattern at the regional scale (Hunsaker et al. 1994; O'Neill et al. 1996). Hunsaker also contributed in the effort to assess water quality using landscape pattern (Hunsaker et al. 1992; Wickham et al. 2000a).

Another direction involved the leadership of Bruce Jones. The work was done in close collaboration with Kurt Riitters and Jim Wickham at the Tennessee Valley Authority and later at the EPA. The research covered such a broad range of topics that it is difficult to arrange it into a simple order.

One line of thought continued the idea of quantifying indices of landscape pattern (Riitters et al. 1995, 1996; Wickham et al. 1996; O'Neill et al. 1999). Another continued the effort to assess water quality using landscape pattern (Wickham et al. 2002, 2003; Jones et al. 2001). Another considered the potential error introduced into landscape ecology applications that might be caused by small error in misclassifying remote imagery (Wickham et al. 1997).

There also was research into the diversity of ecological communities (Wickham et al. 1995) and developing methods for quantifying and interpreting forest fragmentation (Wickham et al. 1999, 2000b, c; Riitters et al. 1997, 2000, 2002). One development that I think deserves special acknowledgement was a study that related landscape pattern, specifically intact forest patches, to breeding bird richness (Jones et al. 2000).

The final stage of this research directly applied landscape principles to assessing environmental quality over a region. This exploratory effort resulted in an assessment of the Mid-Atlantic region (O'Neill et al. 1994; Kepner et al. 1995; Jones et al. 1997).

The success of this initial exploration led to yet another initiative in the form of the EPA program in regional vulnerability assessment (ReVA) under the leadership of Betsy Smith (Boughton et al. 1999; Smith et al. 2000, 2004, Wickham et al. 1999a, b). The major contribution of Oak Ridge landscape ecology to the ReVA program was the development of set of integration methods to combine large numbers of spatial databases into an integrated assessment of the Mid-Atlantic region (Locantore et al. 2004; Tran et al. 2002, 2004).

Phase 5: The Synthesis

Toward the end of my tenure at Oak Ridge, there were some attempts at synthesis. The attempt was to emphasize the need to consider space and pattern in ecological theory (O'Neill 1999, 2000). By far the most important and influential of these syntheses was a landscape ecology textbook (Turner et al. 2001). For the purposes of this personal history, these syntheses form an end bracket to the development that began with the Urban et al. (1987) publication in *BioScience*.

Analysis of the Phenomenon

I do not have any overarching conclusions to draw from this history. One can only ask why this development proceeded so fruitfully at Oak Ridge National Laboratory. I would like to point out five factors that may have contributed.

Professional Managers and Full-Time Research

At the National Laboratory, we never had to confront faculty committees and were never distracted by teaching duties. We were free to explore. We had excellent professional managers such as Stan Auerbach, Dave Reichle, and Bob Van Hook. They never micromanaged; they always defended freedom of thought. Many of the contributors discussed above might not list management as a critical ingredient in the environment at Oak Ridge. But, within my mind, it is that very lack of awareness that goes to the core. The management was efficient and invisible and that was a key. As another factor, there never was an administrative unit called "landscape ecology" and nobody was in charge. Everyone was free to move in new directions with no constraints on what "ought" to be done. The result was chaotic, but very productive.

Interdisciplinary Research

The National Laboratory, particularly under the enlightened directorship of Alvin Weinberg, understood and encouraged interdisciplinary team research. Perhaps the best way to explain the importance of this paradigm is to describe the "war room." For a number of years, my "office" was moved into a large conference room—my desk and file cabinet in the far corner. The room was an array of tables and chairs with white boards along walls. People wandered in and out all day—no ideas were too wild—nobody excluded—everything explored. The researchers that wandered in were from computer science, physics, control theory, economics, among others. Most of Oak Ridge's contributions to landscape ecology were generated in that freewheeling environment.

Team Research

Paging through the citations in the text, it is apparent that the greatest single contributor to landscape ecology at Oak Ridge was the anonymous "et al." Al was a critical contributor because at Oak Ridge there was never a nineteenth-century (my bias) emphasis on the individual scientist toiling alone over his/her laboratory bench under the light of a beeswax candle. Instead, groups of people with various talents and technical expertise worked together on a problem. No one person had to acquire all the needed skills.

Volatility

Brilliant minds kept coming and going. There was a continuous influx of new talent and new ideas. Like the mythical Hydra, if you cut off a head, two would grow in its place. In many environments, such volatility might lead to instability. Instead, the core research program kept developing in unexpected directions while many of the contributors simply moved on to productive and distinguished careers in universities.

Conclusion

Perhaps the most pervasive and unifying theme that runs through the many dimensions of landscape ecology at Oak Ridge National Laboratory was the emphasis on quantification. From early explorations with simulation modeling (Krummel et al. 1986) to the development of percolation theory (Gardner et al. 1989) to epidemiology theory (O'Neill et al. 1992b) to landscape pattern indices (O'Neill et al. 1999), the emphasis on quantification was pervasive. It can only be hoped that this emphasis proves a lasting legacy of landscape ecology at Oak Ridge.

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Chapter 11
A Future for USIALE

Gary W. Barrett, Terry L. Barrett and Jianguo Wu

Introduction

In preparing Chap. 11 regarding the future of the United States Regional Association of the International Association for Landscape Ecology (USIALE), we suggest that the book entitled, *The Tipping Point: How Little Things Can Make a Big Difference* (Gladwell 2000), might provide a future scenario for economic, educational, physical, political, and social trends at the landscape and global scales. Gladwell notes that a little thing can make a big difference in determining threshold concerning aesthetics, communication, ecological/environmental health, and human behavior. For example, his "Rule of 150" explains that 150 individuals appear to be the optimum size for a cohesive group dynamic without division or alienation—important in military and business strategies. He emphasizes the need for persons versed as connectors (communication), mavens (information), and salespersons (persuasion) to provide a contagious effort for change in political or socioeconomic events.

We suggest that the number 400 parts per million (ppm) CO_2 in the atmosphere may result in economic, physical, political, and social shifts concerning global climate change. We emphasize ecosystem, landscape, and global change, *not just global warming* (see Schuldt et al. 2011 discussing this distinction). The climatic records set for drought, winter cold and snowfall, and weather turbulence in 2013–2014 hopefully will provide a tipping point of recognition for the need to plan accordingly for a changing environment in the decades ahead.

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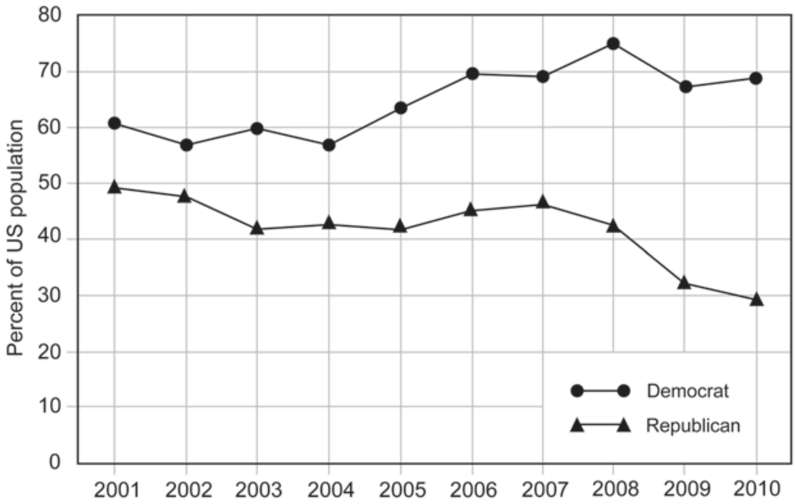

Fig. 11.1 Percentage of Americans who believe in global change according to their political party identification, 2001–2010. (After McCright and Dunlap 2011)

For over 45 years of teaching undergraduate ecology, Gary Barrett began his introductory lecture by pointing out that most colleges and universities have a Department of History; however, few have a Department of Future. The need has never been greater than now for personnel trained in energy dynamics, landscape management, social behavior, and transdisciplinary research. Therefore, the precursor of curricula that emphasize problem solving, critical thinking, sustainability, and socioeconomic management is paramount to future solutions. As Edward O. Wilson (2013) noted in his book entitled, *Letters to a Young Scientist,* "The world needs you—badly." The same goes for training young scientists in landscape ecology—we need you!

Presently in 2014, societies are dealing with an incomplete knowledge of ecology, meteorology, and landscape science. In addition, because the 113th United States Congress has failed to recognize and provide funding for global climate change, in part due to ideological divide within and between political parties, there exists a serious gap between understanding atmospheric science and political science. To make matters worse, there exist well-paid "merchants of doubt" (Oreskes and Conway 2010), obscuring the facts on the issue of climate change. More recently, the "merchants of doubt" concept has entered the political arena regarding a growing partisan divide between political parties in the United States (Hoffman 2012) (Fig. 11.1).

In the past, literary works such as *Uncle Tom's Cabin; or, Life Among the Lowly* (Stowe 1852), *The Grapes of Wrath* (Steinbeck 1939), or *Silent Spring* (Carson 1962), were each an exemplary tipping point towards abolition of slavery, congressional legislation benefiting farmworkers, and the contemporary environmental protection movement, respectively. Will the 400 ppm CO_2 be the tipping point in global change? How will landscapes be changed by, or adapt to, altered climate regimes beyond the tipping point? Such essential questions open understanding of an uncertain future facing humans. Thus, let us next turn to the role and importance of the concept of sustainability.

Quantifying Landscape Sustainability

Much has been written on the topic of sustainability (Lubchenco et al. 1991). A special section (11 chapters) of the *Annual Review of Ecology and Systematics* (Fautin et al. 1995) was devoted to this concept. "Sustain" is defined as to keep in existence or to supply with necessities or nourishment to prevent from falling below a given threshold of health or vitality (Barrett 1989). Goodland (1995) defined "sustainability" as maintaining natural capital and resources. There is also a wealth of information on ecosystem services (Costanza et al. 1997; Daily et al. 1997) and natural capital (Daily 1997; Kareiva et al. 2011). However, it only has been recently that landscape sustainability has been addressed at the landscape scale within the field of landscape ecology (Wu 2006, 2013, Wu and Hobbs 2007; Barrett et al. 2009b; Jackson and Fahrig 2012; Musacchio 2013).

Although not intended to minimize the role and importance of the concept of ecosystem services, we suggest that natural capital at the landscape scale (i.e., landscape services; Dramstad and Fjellstad 2013; Bastian et al. 2014) is an analytical and a comprehensive approach to quantifying pattern and processes such as abiotic diversity (typically referred to as gamma diversity), carbon sequestration, cultural vitality, energy resource management, food productivity, nutrient retention and recycling, and pollution abatement. To accomplish the goal of landscape sustainability will require a transdisciplinary approach to learning, an interactive approach to resource management, and a problem-solving approach to environmental planning and policy making (at all levels of education and government). To achieve a sustainable society, citizens will require clear understanding of ecological concepts such as optimum carrying capacity, maximum sustained yield, Integrative Pest Management (IPM), net energy, market and nonmarket value, ecological facilitation, intellectual and social capital, and ecological footprint. We believe that the landscape is the most efficient level-of-organization to address these concepts and challenges. There exists a dire need for a new holistic integrative science during the coming decades (Barrett 2001).

Landscape Replication

Ecologists, especially population, community, and ecosystem ecologists recognize the importance of replication if we are to distinguish measurable difference between, or among, treatments. Although difficult, ecosystem ecologists use scale (microcosms, mesocosms, and macrocosms) to achieve systems replication to quantity significant difference in probability, whether it is at the ($p=0.001$, 0.01, or seldom used 0.1) levels of probability. There exists an abundance of literature recognizing the challenge to replicate ecosystems (Hurlbert 1984; Odum 1984; Barrett 1988; Tuckfield 2005).

Can landscape ecologists successfully replicate real landscapes? The answer is likely "no." Although there are numerous outstanding papers dealing with watersheds at sites such as Hubbard Brook Experimental Forest in the White Mountains of New Hampshire and Coweeta Hydrologic Laboratory of North Carolina located in Coweeta basin, the design, findings, and discussion typically emphasize an ecosystem approach. Thus, large landscapes (larger than watersheds) likely are not replicate systems from an experimental perspective. Such landscapes, however, are ideal systems for deductive observations and sites for studies at numerous levels of organization ranging from organism to ecosystem levels of study.

Monitoring Changes in Landscape

In anticipation of mounting environmental challenges, monitoring changes in landscape is essential. The National Ecological Observatory Network (NEON) is a continental scale research instrument consisting of geographically distributed infrastructure, networked by means of cybertechnology into an integrated platform of ecological ratio from regional to continental scale. NEON, in addition to the United States Department of the Interior Climate Science Centers (DOI CSC), provides landscape ecologists with the data and forecasting capability to monitor events and changes such as planetary disturbance, tropical diseases, a magnitude of climatic catastrophes, and changes in population dynamics of numerous plant and animal species, including *Homo sapiens*. We predict that these changes and events will increase in frequency and intensity during the decades ahead.

Scientists and engineers will use NEON to construct real-time ecological studies spanning all levels of biological/ecological organization and temporal and geographic scales. NEON will provide a platform for nationally networked research, communication, and information of collaborative, interdisciplinary experiments at regional, landscape, and continental scales. Landscape ecologists should play a major part in this agenda.

Organizational Reform

In her work, *The Dinner Party*, Judy Chicago provides a symbolic view of the levels of history with place settings that hold in time and context each of 39 feminine icons of Western civilization. For example, the place settings, of plate on woven runner, personify the accomplishment of Caroline Herschel, eighteenth-century astronomer, and the scholarship and patronage to the arts of Isabella d'Este during the Renaissance. The architecture of the piece consists of three long tables forming an

Fig. 11.2 Chicago, Judy (b. 1939) © ARS, NY. *The Dinner Party* installed in its permanent home at the Elizabeth A. Sackler Center for Feminist Art, at the Brooklyn Museum, Brooklyn, NY. 1979. Mixed media. 36 in. × 576 in. × 576 in. (Photo: © Donald Woodman Photo courtesy of Judy Chicago/Art Resource, NY)

equilateral triangle that is positioned on a floor of 2300 handcrafted porcelain tiles inscribed with 999 names of women noted for their accomplishment or unique situation (Chicago 1979; Fig. 11.2).

> *The Dinner Party* takes on a tour of Western civilization, a tour that bypasses what we have been taught to think of as the main road. Yet it is a new world-view, one that acknowledges the history of both the powerful and the powerless peoples of the world…History has been written from the point of view of those who have been in power. (Chicago 1979, p. 56)

The science of ecology offers a transdisciplinary approach to holism that effectively addresses societal problems in an efficient manner. Landscape Ecology as an integrative science captures the essence of this emerging challenge, while maintaining an understanding of the ecological principles, concepts, and natural laws, which underpin integration of not only biological, physical, and social sciences, but the humanities (e.g., ethics) as well (Hardin 1968; Turner 1991; Capra 2010).

In Fig. 11.3, the triangle (a) shows "values and ethics" as a culmination of a factual basis, with subsequent "concepts, principles, and laws." While valid within traditional logic, the intrinsic question remains, *who selects the universe of facts that*

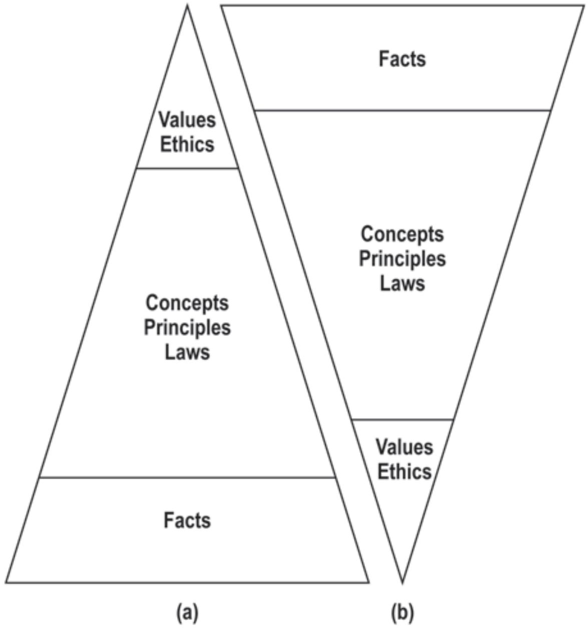

Fig. 11.3 Concept for landscape ecology studies of community values and ethics derived from facts (**a**), and facts discerned from community values and ethics (**b**)

support a set of values and ethics (Norenzayan 2011)? Inverting the triangle opens a more complete investigation of landscape. The inverted triangle (b) complements the picture by encompassing community organization of concepts, principles, and laws prefaced by oral histories or mores, which also illuminate that which is accepted as fact in a given time or place (Harris 1977; Campbell 1986). After completing *The Dinner Party*, Chicago wrote, "If we have found so much information on women in Western civilization during the duration of this project, how much more is there still? Moreover, what about all the other civilizations on Earth?" (Chicago 1979, p. 55). In redefining environmental literacy, USIALE could be significant to opening possibilities for those in power and those not currently invited to the table.

Integrative science encompasses the human relationship with and influence on natural and socioeconomic systems, based on ecological theory and knowledge, for societal benefit and survival. In order to explore and attempt to understand the totality of relationships among organisms, including humans, and their environments, emerging fields of study in the ecological sciences (e.g., agroecosystem ecology, conservation biology, landscape ecology, and restoration ecology) will interact with the humanities (i.e., learning or literature concerned with human dynamics) as integrative science.

In Fig. 11.4, the number of authors in their respective fields of study who have published in *Landscape Ecology* from 2004 to 2013 is shown. (also see Anderson 2008 for diversity in types of research published in *Landscape Ecology* from 1987 to 2005 based on six criteria developed by Wiens 1992).

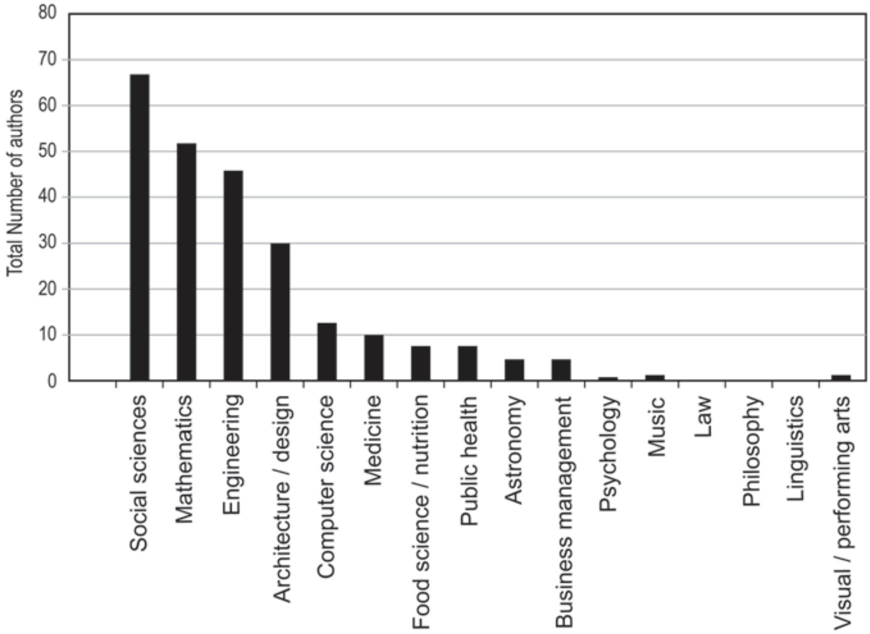

Fig. 11.4 Number of authors (including coauthors) in their respective fields of study whose work was published in *Landscape Ecology* during 2004 through 2013. (Computation of data courtesy of Yuyang Bao and Qun Ma)

USIALE and the International Association for Landscape Ecology (IALE) Europe have played a particularly important role in promoting the research and applications of landscape ecology during the past decades. For several decades, contributions from scientists in the United States, Canada, Australia, the Netherlands, Germany, France, and Spain have dominated the peer-reviewed literature in landscape ecology. In recent decades, several regional chapters in Africa, Asia, and South America have become increasingly visible in both research outcome and scholarly activities. As has the active IALE China Regional Association had an increasing quantity and quality of publications.

However, the development of landscape ecological research remains geographically uneven across the globe. Most of the developing countries facing severe environmental problems due to economic development and land use changes often lag in the science and application of landscape ecology. As a leading professional organization, USIALE could help in at least two ways. First, USIALE could work closely with IALE and other regional associations to promote the science of landscape ecology through, for example, joint conferences and other scholarly activities. Second, USIALE could promote collaborations between North American landscape ecologists and those in developing countries working on research projects and publications. Such collaborations can advance this field of study on a global scale and improve the scientific quality of landscape ecology in these regions.

USIALE as Marker for Transdisciplinary Scholarship

Tristan Gooley (2010) writes in his book entitled, *The Natural Navigator,*

> Perspective is vital. The most common mistake that newcomers to the art of natural navigation make is to look up at a tree from one angle, trying to read it before they have taken time to walk around it. (Gooley 2010, p. 47)

Scholarship requires a like appreciated perspective from a multifaceted approach—a refreshed thinking. Collaboration among schools of thought that experience World (i.e., the human dynamic such as institutions and societies) and Earth (i.e., the dynamic of nature such as tides and seasons) through different prisms, interfaced systems which are mature and complete within themselves—a sophistication of thought to problem solving. Genuine engagement with global citizenry effects regional aesthetic influences, which delineate boundaries (e.g., political borders), encrypt space (e.g., architecture), and sequence events (e.g., ritual) (Barrett et al. 2009b).

The affluent of each culture live differently than a larger percentage of a population within that culture. Their monetary wealth has placed them within a tight community, which has established its own ethos concerning privileges and responsibilities. Their ambassadors have changed and continue to change World and Earth (Florida 2002; Chin and Culotta 2014).

> Noted inventor Alfred Ely Beach, the founder and one-time editor of *Scientific American* magazine, built a subway in 1870 and it ran for only a few weeks before New York's infamous Mayor Boss Tweed shut it down…Beach's is the only one of several experimental subway lines uncovered, so far as known. One of its features, a waiting room furnished with a crystal chandelier and grand piano, was found intact when the line was rediscovered. (Toth 1993, p. 45)

Underground tunnel dwellers inhabit these abandoned subway stations and vacant railways of New York City. No formal census of this underground community, including children, has been taken, however, its population is estimated in the thousands (Toth 1993). Their survivorship has changed and changes the dimension of cityscape (Chin and Culotta 2014).

Figure 11.5 offers a model of selected challenges and principles as a continuum or gradualism (Barrett et al. 2009b). The difference or "the-in-between" of the ecological–societal gap can be viewed as a gradience, which allows for contrasting comparisons as analog (e.g., Uninformed and Informed is the fine-grain variation in education)—an important equation for future problem solving.

Possibilities in Structuring the Viability of USIALE

> You never change things by fighting the existing reality. To change something, build a new model that makes the existing model obsolete. (R. Buckminster Fuller, ubiquitous quotation)

What is required of humans to prosper? We hypothesize that the path of human awareness persists toward survival through economy. Therefore, the confluence of

Fig. 11.5 Challenges and principles modeled as a continuum with ecological–societal gaps viewed as gradience between analogies. (After Barrett et al. 2009b)

culture-sustained vitality and ecological sustainability is essential to the health of living beings. The separation of culture with nature from paradisiacal unity is legendry. Under the auspices of such early movements as Humanism, an influential portion of humanity formalized its position to the center of an ecological board game. In doing so, a type of egoism developed that allowed investigation and exploration to move beyond utility to acquisition. As World and Earth become recognized as a Pangaea of virtual and real networks, global citizens will require knowledge of ecology and an understanding of aesthetics as economy for survival (Mitchell 2003).

Barrett (1985) recognized the noösphere concept after Vernadsky (1945) as a model unit of study in integrating biological, physical, and socioeconomic param-

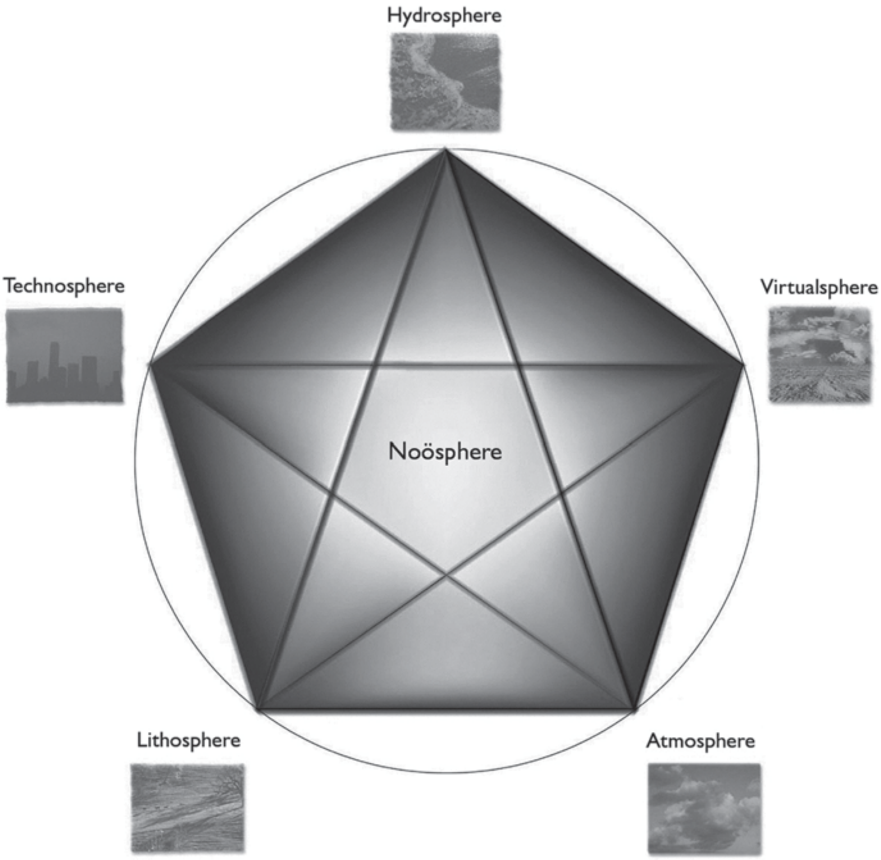

Fig. 11.6 Noösphere within the golden mean, inclusive of the modern Technosphere and Virtualsphere. (After Barrett et al. 2009a)

eters within a holistic, systems framework (Barrett et al. 2009a). Tress and Tress (2001) modeled a transdisciplinary approach to landscape study incorporating five dimensions (spatial entity, mental entity, temporal dimension, nexus of nature and culture, and complex system). One of the aforementioned, the mental entity, associates as the noösphere, and is an equal component in a triad of geo-, bio-, and noöspheres. Barrett et al. (2009a) structured the noösphere within a golden mean of human nature duality. Five integrated spheres: the traditional spheres of ecological science, atmosphere, hydrosphere, and lithosphere; and the modern spheres, technosphere (i.e., human-built systems, such as telecommunications) and virtualsphere (i.e., as focus of a system forming images that simulate an environment, such as cyberspace or mathematical abstractions) were included (Fig. 11.6). The techno-ecosystem, as the synthesis of real and virtual systems, has changed and changes survival of modern global citizenry (Odum 1971; Mitchell 2003; Florida 2005; Odum and Barrett 2005; McGonigal 2011). "Smart cities" such as Tsuhuba, Ibaraki, Japan and Masdar City, Abu Dhabi, United Arab Emirates are organized for aesthetic value and ecological efficiency. These types of cityscape, which are purposed for research institutions and clean companies, model cultural-sustained vitality and ecosystem–landscape health (Florida 2002, 2005).

To expand our dialogue with the future, we combine the opportunities of historic context and present technology. Jane McGonigal (2011) writes of the superpower of "extraordinary collaborators" who develop their skills through participating within the virtualsphere of gaming. Exemplary is the game of *Spore,* created by Will Wright in 2008. *Spore* has allowed collaborators from 33 countries to simulate an ecosystem from complex civilizations to planet-designing megacivilizations. Other games such as EVOKE, allow gamers to literally bridge virtual innovation and real world application to need (McGonigal 2011). She concludes, "In the decades to come, there will be many more challenges for us to tackle together as crowds [crowdsourcing]: more citizen journalism investigations, more collective intelligence projects, more humanitarian efforts, more citizen science research, [as NEON, previously mentioned within this Chapter]." (McGonigal 2011, p. 242)

Modern scholars, such as Haraway (1997), have argued there is an artificially created distinction where no real difference exists or in other words a distinction without a difference. She reasons because "…technonature, including its invented and copyrighted organisms, inhabits the borderland—totally natural and totally cultural simultaneously—thus making it impossible to define nature in opposition to culture, human activity, or technological interventions anymore." (Kull 2001, p. 52) For the first time in the history of technology, humans are increasingly able to reference their World and Earth from the perspective of the *Chandler* telescopic lens and a rapid progression of robotic rovers such as *Curiosity,* engaging the questions of cosmic life and colonization, such as on Mars, with unique ecologies and topographies. This blurred shape-shift from global to cosmic assimilation also offers unique possibilities of collaborations for landscape ecology.

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