

Key concepts and research priorities for landscape sustainability

Laura R. Musacchio

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Origins of key concepts and research priorities in landscape ecology

A recurrent question in landscape ecology has been: What is at the cutting-edge of research and application? The most thought-provoking debates and contributions in landscape ecology have occurred when scientists have mixed things up by crossing boundaries through interdisciplinary and transdisciplinary activities including discussions and collaborations. One of the main outcomes of these activities is the debate about which issues are critical to the evolution of landscape ecology's epistemology and its future research and application agenda (e.g., Tress and Tress 2001; Tress et al. 2001; Wu and Hobbs 2002; Potschin and Haines-Young 2006; Wu 2006, 2008, 2010; Nassauer and Opdam 2008; Musacchio 2009, 2011). For example, the debate about key concepts and research priorities have played an important role in shaping its future research and application agenda, and this approach can be traced at least to the days of Allerton workshop (see Risser and Iverson 2013) when landscape ecology was new on the scientific horizons much like sustainability science today. More recently, articles about key concepts and research

priorities have provided motivation for greater interdisciplinary integration in landscape ecology (Brandt 1998) and developed a top ten research agenda for the new millennium (Wu and Hobbs 2002). These efforts have created the dynamic, intellectual tension in landscape ecology that has come to characterize and differentiate it from other disciplines in the biophysical, social, and design sciences. This tension has major symbiotic benefits for what is perceived to be the intellectual core of the discipline as well as its intellectual margins—with the discipline's core and margins constantly refreshed and reinvigorated by the debate among landscape ecologists.

Landscape sustainability is an example of a key concept and research priority that will play an important role in helping to redefine the debate about relationships among landscapes, ecosystem services, and human well-being. As a focus of study, it has become more prominent as landscape ecologists included it more often as a key concept and research priority in landscape ecology (e.g., Wu and Hobbs 2002; Wu 2006, 2008, 2013a; Musacchio 2009, 2011). The years 2009 and 2010 stand out as important points of intellectual convergence because two special issues of this journal were published about landscape ecology and sustainability (e.g., Musacchio 2009; Pearson and McAlpine 2010). Building on this foundation, this special issue presents the diverse perspectives of scientists that represent the state-of-the-science in Europe, Pacific Rim, Africa, and North America. The authors' perspectives provide important insights into

L. R. Musacchio (✉)
Department of Landscape Architecture, University
of Minnesota, 89 Church St. SE, Minneapolis,
MN 55455, USA
e-mail: musac003@umn.edu

the different theoretical, empirical, and applied developments that coexist in the intellectual niches of landscape ecology and facilitate comparison of the different mental models of landscape, sustainability, and resilience that coexist in the discipline today. The diversity of perspectives demonstrates the breadth of studies about landscape sustainability that is inherent in this body of knowledge. Among the authors, some aspects resonate and converge toward agreement while at times there is divergence and contradiction. These similarities and differences represent the intellectual tensions that are present in landscape ecology today.

An ad-hoc list of key concepts and research priorities for landscape sustainability

From the articles, a number of key concepts and research priorities for landscape sustainability have emerged to provide road map for future research and application in landscape ecology. This ad-hoc list highlights these items and connects them to the appropriate articles in this special issue:

(1) *The emergence of landscape sustainability science*

The first theme is extending the paradigm of landscape ecology into what Wu calls *landscape sustainability science* (Wu 2013b). His article highlights the important role the landscape perspective plays in this emerging branch of sustainability science, which “is the study of how to maintain and improve the dynamic relationship between landscape services and human well-being in changing social, economic, and environmental conditions” (Wu 2013b). His perspective provides an important rationale why key concepts about landscape such as *landscape services* (Ter-morshuizen and Opdam 2009) and *land architecture* (Turner 2010; Turner BL et al. 2013a) need further conceptual development, empirical study, and professional application.

(2) *The cultural dimension of biodiversity, ecosystem services, and human well-being in landscapes*

Musacchio (2013) introduces *cultivating deep care* as a key concept and research priorities for landscape sustainability.

(3) *Thought-provoking questions about the role of landscape sustainability in landscape ecology*

The two articles by Dramstad and Fjellstad (2013) as well as Wiens (2013) ask thought-provoking questions about the role of sustainability in landscape ecology. Dramstad and Fjellstad (2013) reflect on the state of landscape ecology, identify the key challenges of scale and communication, and emphasize landscape services as a key research priority. The next article by Wiens (2013) explores the usefulness of landscape sustainability as a management goal for ecosystem services when landscapes are always changing.

(4) *The assessments of landscapes: from the scale of place to the scale of the globe*

Potschin and Haines-Young (2013) examine how the strengths and limitations of three major assessment frameworks can inform knowledge about ecosystem services and advocate for the importance of a place-based approach for the sustainability of landscapes. Verburg et al. (2013) critique the state of the science for representing landscapes in global assessments and suggest new directions for landscape ecology to contribute to research activities.

(5) *The sustainability of managed landscapes*

MG Turner et al. (2013b) investigate how the key drivers of climate, disturbance regimes, and land use might affect the sustainability of ecosystem services in forests landscapes of the United States. Lindenmayer and Cunningham (2013) present six principles for sustainable forest landscape management based on research and practical experiences in southeastern Australia. In contrast, Dale et al. (2013) examine how landscape ecology can contribute theory and methods for moving toward more sustainable agriculture and practices. Brandt et al. (2013) assess how the concept of carrying capacity can be used as an example of landscape sustainability in their case study of sustainable tourism in the Baltic region in Europe.

(6) *The connection between landscape sustainability to systems theory and resilience*

Cumming et al. (2013) contend that the goal of *landscape resilience* will be shaped by flexible institutions that not only can adapt to changing

circumstances but also can act at the appropriate scales to plan and manage ecosystem services in landscapes through deliberate experimentation and social learning. Lee et al. (2013) propose two principles for landscape sustainability based on energetic hierarchies in landscape systems. Petrosillo et al. (2013) analyze order and disorder in social-ecological landscapes in their case study of spatio-temporal analysis of landscape change in a region of Italy.

(7) *The extension of the landscape ecology paradigm into the design sciences*

Building on the theme connecting science and design, Jones et al. (2013) propose four focus areas for research about how landscape patterns can be monitored, managed, and designed for environmental targets and ecosystem services. Swaffield (2013) reviews how design science can help inform local governance and values for a wetlands and waterways strategy in Christchurch, New Zealand. Ahern (2013) explores five strategies for urban landscape sustainability that build resilience capacity, and he asks key research questions to inspire landscape ecologists, designers, and planners. Standish et al. (2013) discuss how people's preferences and values can reshape traditional conservation and restoration goals in cities and provide four restoration options for better human-nature interactions in urban landscapes.

Some concluding thoughts: How does this ad-hoc list of key concepts and research priorities advance knowledge about landscape sustainability?

The articles in this special issue are the beginning point of a broader dialogue about how landscape sustainability can extend the landscape ecology paradigm into new frontiers of research and application. As proposed by Wu (2013b), full integration of landscape sustainability into the landscape ecology paradigm will spawn a new field of knowledge: *landscape sustainability science*.

Landscape sustainability science will provide new opportunities to redefine the theory of landscape ecology that centers on the exploration of the relationships between landscape patterns, landscapes

processes, and scale. For example, a critical area of future inquiry will be assessments of landscapes that take on the challenge of scaling from local to global landscapes and how changing drivers influence landscape sustainability. Managed landscapes and their ecosystem services will be continue to an important focus for empirical research and modeling studies, and landscape ecologists will be instrumental in developing principles for more sustainable and resilient management of natural resources. Another research priority will be exploring how landscape sustainability influences emerging approaches and methods that connect the monitoring of ecosystem services in designed landscapes and social-ecological systems. In particular, the conservation and restoration of urban landscapes will be the nexus for cross-disciplinary inquiry about the interconnections among biodiversity, ecosystem services, and human well-being. For example, new interpretations of resilience thinking, adaptive management, and governance will be the impetus for new approaches to mainstream ecosystem services into the design and planning of urban landscape sites and infrastructure. To close, all of the key concepts and research priorities in this ad-hoc list represent how landscape ecologists are making important strides in the integration of sustainability and resilience sciences into their research and practices, but they are only a beginning point for what could happen in the coming decade.

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