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Exploring ecosystem-change and society through a landscape lens: recent progress in European landscape research

*Tobias Plieninger*¹, *Thanasis Kizos*², *Claudia Bieling*³, *Laurence Le Dü-Blayo*⁴, *Marie-Alice Budniok*⁵, *Matthias Bürgi*⁶, *Carole L. Crumley*⁷, *Geneviève Girod*⁸, *Pip Howard*⁹, *Jan Kolen*¹⁰, *Tobias Kuemmerle*¹¹, *Grega Milcinski*¹², *Hannes Palang*¹³, *Kathrin Trommler*¹¹ and *Peter H. Verburg*¹⁴

ABSTRACT. Landscapes are closely linked to human well-being, but they are undergoing rapid and fundamental change. Understanding the societal transformation underlying these landscape changes, as well as the ecological and societal outcomes of landscape transformations across scales are prime areas for landscape research. We review and synthesize findings from six important areas of landscape research in Europe and discuss how these findings may advance the study of ecosystem change and society and its thematic key priorities. These six areas are: (1) linkages between people and the environment in landscapes, (2) landscape structure and land-use intensity, (3) long-term landscape history, (4) driving forces, processes, and actors of landscape change, (5) landscape values and meanings, and (6) landscape stewardship. We propose that these knowledge areas can contribute to the study of ecosystem change and society, considering nested multiscale dynamics of social-ecological systems; the stewardship of these systems and their ecosystem services; and the relationships between ecosystem services, human well-being, wealth, and poverty. Our synthesis highlights that knowledge about past and current landscape patterns, processes, and dynamics provides guidance for developing visions to support the sustainable stewardship of social-ecological systems under future conditions.

Key Words: *ecosystem services; European Landscape Convention; landscape governance; landscape stewardship; landscape values; multiscale landscape modeling; social-ecological systems*

INTRODUCTION

Research on environmental change is characterized by striking contrasts in spatial scales. Global-scale data and increasingly sophisticated quantitative methods allow the assessment of such issues as planetary boundaries (Steffen et al. 2015), food security (West et al. 2014), or future land use (Schmitz et al. 2014), often in a top-down style (Verburg et al. 2013). A complementary view emphasizes that, to acknowledge the complexities of current sustainability challenges, among others, profound alterations of ecosystems and the services they provide, we additionally need to connect global to regional and local scales through place-based approaches, thereby taking context, meaning, and real-world relevance into consideration (Fischer et al. 2011). The Program on Ecosystem Change and Society (PECS) has been established within the International Council for Science (ICSU) global change programs to strengthen such place-based research through comparative and collaborative approaches, thus facilitating insight into three focal areas: (1) the nested multiscale dynamics of social-ecological systems, (2) the stewardship of these systems and their ecosystem services, and (3) the relationships between ecosystem services, human well-being, wealth, and poverty (Carpenter et al. 2012).

The Program on Ecosystem Change and Society builds heavily on the concepts of social-ecological systems, which have paved the way for the increased recognition of the dependence of humanity on ecosystems in science and policy. Among the existing frameworks to describe social-ecological systems (Binder et al. 2013), the ecosystem services concept appears to be prominent. This concept suggests that human well-being depends on

ecosystem services and that assessment and acknowledgement of these services leads to more sustainable ecosystem management (Raymond et al. 2013). In the ecosystem services concept, the social system is understood to comprise humans acting as users of the ecological system and as valuing agents. The ecological system is conceptualized to focus on ecosystem integrity and functions that ensure the continued availability of ecosystem services (Binder et al. 2013). Despite a wealth of research on social-ecological systems and ecosystem services, the approach still needs advancement in terms of understanding and governance of social-ecological interactions between regions; attention to long-term drivers; understanding of the interactions among power relations, justice, and ecosystem stewardship; and development of a stronger science-society interface (Fischer et al. 2015).

One research project endorsed by PECS is specifically dedicated to the study of landscapes and their role in European culture and societies (<http://www.hercules-landscapes.eu>). This project has a particular focus on dynamics, actors, and cultural values around landscapes. In general, landscape research seeks to draw connections among people, between people and places, and between societies in their environment at the landscape scale (ESF 2010). In Europe, landscape research has received broad attention since the adoption of the European Landscape Convention (CE 2000). More recently, landscape approaches have found substantial resonance also outside Europe (Sayer et al. 2013). We review and synthesize findings from six important areas of landscape research in Europe and discuss how these findings may advance the study of ecosystem change and society.

¹University of Copenhagen, ²University of the Aegean, ³University of Hohenheim, ⁴Université Rennes 2, ⁵European Landowners' Organization, ⁶Swiss Federal Research Institute WSL, ⁷Uppsala University, ⁸CIME, ⁹Forest Communication Network Ltd., ¹⁰Leiden University, ¹¹Humboldt-Universität zu Berlin, ¹²SINERGISE, ¹³Tallinn University, ¹⁴VU University Amsterdam

LANDSCAPE RESEARCH: CONCEPTS AND HISTORY

The European Landscape Convention has defined landscape as “an area, as perceived by people, whose character is the result of action and interaction of natural and/or human factors” (EC 2000:3). The convention has been powerful in raising awareness among scientists, policymakers, and the general public for the cultural, ecological, environmental, and social values of landscapes, and through this for the importance of landscapes for individual and societal well-being (Jones et al. 2007). Defining landscape as a central arena for sustainable development, the convention has become the governing document steering both landscape management and, inadvertently, landscape research in Europe. The European Landscape Convention has influenced landscape research substantially in the past 10 years, in particular through expanding its scope to include all dimensions and types of landscapes, through an increased emphasis on public participation, through a focus on designing measures appropriate for different contexts and scales, and through the encouragement of support for capacity-building (Conrad et al. 2011a). However, its impact on the operational levels of landscape assessment, planning, and policy has remained limited (Conrad et al. 2011b, Butler and Berglund 2012, De Montis 2014).

Landscapes are the interface of nature and society and express a tight interplay of physical features of the human environment with social structures and human ideas (Selman 2012). Emphasizing the cultural dimension of such coupled systems implies a holistic view, not the least through the frequently used term “cultural landscapes” (Plieninger and Bieling 2012), in which humans perceive and value the existence of landscapes and, at the same time, interact with them and even create them (Naveh 1995). With this, landscapes not only integrate the natural and the human realm, but are also at the nexus of material and immaterial, perception-based dimensions (Widgren 2004).

The term “landscape” has deep roots particularly in Central and Northern Europe (Olwig 1996). Ever since Carl Sauer (1925) postulated that the aim of humankind is to turn nature into cultural landscapes, there has been discussion on where exactly nature ends and cultural landscape starts and how culture should be understood, whether it is human material input, valued environment, or something more. Today, the scientific discourse mainly revolves around four distinct concepts: (1) landscape as purely natural phenomenon, i.e., a biophysical interpretation, (2) landscape as nature with human artifacts, i.e., anthropogenic interpretation, (3) landscape as cognitive representation of a space, i.e., intangible interpretation, and (4) landscape as totality including both material natural and cultural dimensions, i.e., coupled social-ecological interpretation (Angelstam et al. 2013a).

The history of landscape studies can be traced in two broad fields of inquiry: (1) geographical research and (2) art and landscape painting, which make the landscape itself an object worthy of aesthetic admiration (Howard et al. 2012). In geography, the term landscape was initially used as a “regional synthesis” (Antrop 2008:30). In the twentieth century, new tools and concepts enriched and diverted this approach into a wide array of disciplines. On the one hand, a broader geographical and anthropological branch of landscape studies has considered land and the interactions between human activities and physical geography. On the other hand, cultural geography has

incorporated aesthetic and symbolic readings of the landscape with the geographical and art traditions. More recently, social geography has filled the gap between regional studies, i.e., landscape assessment, and cultural geography, i.e., landscape perception, by exploring the question of social and individual well-being (Luginbühl 2006). This line of inquiry has demonstrated how the study of day-to-day practices and relationships, whether professional or not, are essential for the understanding of landscape dynamics. Increasing computational power and new developments in GIS, geostatistics, and visualization tools have paved the way for quantitative analyses of spatial patterns in landscapes and the dynamics in these patterns in a range of fields, including ecology, archaeology, history, land-use planning, and policy evaluation. The art tradition was joined with garden architecture and the cultural component of geographical analysis resulting in landscape architecture and landscape planning. It has also been enhanced by philosophy and postmodernist theories to study the intangible dimensions of landscapes, such as texts, signs, repositories of meanings, ideas, and place attachment (Howard et al. 2012). This abbreviated family tree of landscape studies illustrates that landscapes are boundary objects and meeting points for different disciplines, theories, concepts, analytical tools, and scales. Therefore, a landscape approach can be deemed particularly useful for the highly complex research field on society-ecosystem interactions in the context of sustainability.

RECENT PROGRESS IN LANDSCAPE RESEARCH

We take up this hypothesis and explore current progress in six areas of landscape research that are derived from the characteristics of the landscape approach (Angelstam et al. 2013a, Sayer et al. 2013):

1. Landscapes are shaped by the connections and disconnections between people and their environment;
2. Landscapes exhibit important biophysical structures and land use intensities;
3. Landscapes have experienced long-term histories, which have left land-use legacies that critically determine the functions and values of many contemporary landscapes;
4. Landscapes are undergoing change at different rates, with a multiplicity of driving forces, processes, actors, and outcomes;
5. Landscapes entail broad and diverse sets of values and meanings for people; and
6. Landscape governance can follow a preservation or a stewardship approach, with the latter becoming increasingly influential.

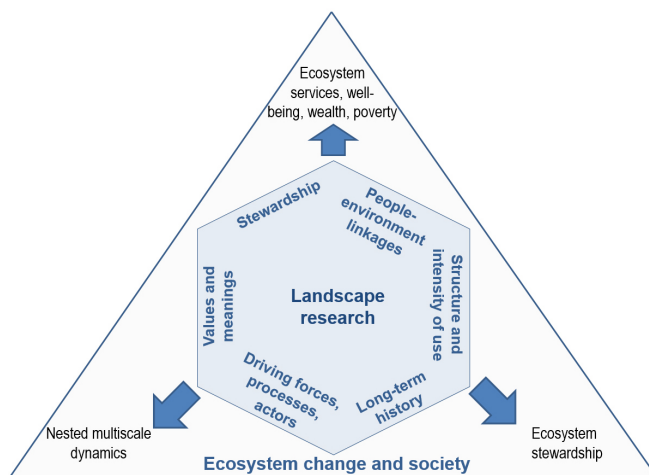
It is important to note that these six areas are partly overlapping and interconnected, but each one has a particular research focus (Fig. 1).

Linkages between people and the environment in landscapes

Our review starts with the most important property of landscapes: they are linked systems of people and their environment. The intensity of the linkage between people and the environment varies from person to person and from landscape to landscape, with consequences for the structures, functions, and societal

values of landscapes (Selman 2012). People and the environment have been tightly linked in landscapes historically, because people have shaped the landscapes they inhabit through their activities, and these landscapes have provided people with a variety of goods and services (Fischer et al. 2012). A number of drivers though have led toward a fundamental decoupling, including agricultural industrialization, urbanization, and land abandonment. Although agricultural industrialization and urbanization have been the dominant drivers of the decoupling phenomenon in the more productive areas of Europe, the more marginal rural areas, i.e., those affected by physical constraints in terms of soils, topography, climate, and remoteness, have been affected by decoupling through competitive disadvantages of farming leading to widespread land abandonment, which has been further exacerbated through rural outmigration and other demographic and structural changes (Plieninger and Bieling 2013).

Fig. 1. Schematic summary of six areas of recent progress in landscape research that can contribute to the three focal areas of ecosystem change and society.



Selman and Knight (2006) have analyzed existing or missing linkages within landscapes and have found that these lead to practical consequences. The study established the idea of “vicious” and “virtuous” circles, linking people and nature in landscapes, and their effects in diminishing or accumulating valued attributes. The latter may be harnessed for a “transformation strategy,” which could reinstate meaningful, virtuous circles between social and ecological systems within landscapes. Consideration of the complexities of social-ecological feedback loops in landscapes is also important for the study of ecosystem services, because many of these services are not only a function of natural processes but also the result of human interaction with the environment. Thinking of such services as linked social-ecological services can be useful in the design of programs that encourage ecosystem services provision (Huntsinger and Oviedo 2013), with increased reliance on local food resources being a frequently cited pathway to tighten social-ecological linkages in landscapes (Sundkvist et al. 2005).

Landscape structure and land-use intensity

Landscape characterization and assessment methods began to be developed in the UK and France in the early 1990s and then spread out all over Europe, following the call of the European Landscape Convention to identify the diversity of landscapes (Butler and Berglund 2012). Much progress is currently being made regarding the continental-scale quantification of biophysical landscape patterns, for example of climate, topography, soils, and land-cover composition. Examples are the European Landscape Map (Mücher et al. 2010) and the Environmental Stratification of Europe (Hazeu et al. 2011). Two additional types of biophysical information have been incorporated at Pan-European scale very recently, namely landscape structure and land-use intensity.

Information on landscape structure, e.g., parcel size and shape, or the position of landscape elements, such as hedgerows and solitary trees, in space, is crucial to characterizing landscapes and their societal values, with a broad variety of metrics being used (Uuemaa et al. 2013). Inventories of landscape elements are available for a few study regions (Deckers et al. 2005, Meyer et al. 2012, Plieninger et al. 2012) and, in some cases, at the national scale (Barr and Gillespie 2000, Grashof-Bokdam et al. 2009). An important step forward has been the recent creation of a European Union-wide map of landscape elements (van der Zanden et al. 2013).

Land-use intensity is typically conceptualized as the degree of yield amplification caused by human activities and measured with the use of input-output analyses and by quantifying changes in system properties (Erb et al. 2013), e.g., in fertilizer applied, grazing intensity, people engaged, or numbers of tourists and houses in a landscape. It is an important factor, as most processes transforming landscapes occur along gradients of land-use intensity (Rounsevell et al. 2012, Kuemmerle et al. 2013). Land-cover maps, such as the CORINE maps of the European Commission, are, in general, particularly poor in capturing farmland abandonment as well as intensification and disintensification processes. Fortunately, new land-use intensity datasets for Europe have been or are currently produced, including livestock grazing intensity (Neumann et al. 2009, 2011), fertilizer application (Temme and Verburg 2011), forest harvesting intensity (Levers et al. 2014), and cropping intensity (S. Estel, T. Kuemmerle, C. Alcántara, C. Levers, A. Prishchepov, and P. Hostert, *unpublished manuscript*), offering potential for uptake in more comprehensive landscape characterizations.

Long-term landscape history

To explore differences in long-term historical landscape development is another important strand of landscape research. The legacies of historical interactions of humans with their biophysical environments are often visible in present-day landscapes, as expressed, for example, in established land-tenure structures; infrastructure characteristics, e.g., drainage and transport; soil modifications, e.g., adding organic matter or removal of peat; and establishment of landscape elements, e.g., hedgerows, stone walls (Foster et al. 2003). More recent processes have modified these structures and often adapted landscapes to modern practices and needs. In some cases, policies, planning, and voluntary incentives have aimed to protect landscape structures and elements that originated through historical interaction (Schleyer and Plieninger 2011); in other cases, large-

scale land consolidation has been implemented to adapt landscapes to the current needs of their managers. New datasets on land-use history, ranging from decades (Fuchs et al. 2012) to centuries (Kaplan et al. 2009, Kaplan 2012) in span, have recently become available and because of their quantitative nature hold much promise for better characterizing landscapes.

In parallel with that, new approaches are currently emerging for the study of long-term landscape history, with landscape biographies and historical ecology being of particular relevance. Landscape biography studies long-term transformations in landscapes, preferably from prehistory to the present, viewing landscape at each point in time as a complex interplay between social and economic developments, culturally specific perceptions of the environment, histories of institutions and political formations, and ecological dynamics (Roymans et al. 2009, Palang et al. 2011). It particularly acknowledges that landscapes have their own temporalities and rhythms, in relation to but distinctive from individual and community life cycles (Ingold 1993, Kolen et al. 2015). Landscape biography views landscapes as palimpsests that are transforming continuously, both through conscious interaction by people with the material past in the environment and through less conscious forms of agency. This indicates that landscapes cannot simply be seen as the outcomes of drivers, but that landscapes themselves are also drivers of social, political, and economic change. Historical ecology is another holistic, ethical, and place-based framework of concepts and methods for studying the past and future of the relationship between people and their environments (Crumley 2015). Particularly rich sources of data are found at the landscape scale, in which human activity and cognition interact with biophysical systems, and in which records from many disciplines are plentiful. Historical ecology provides tools to construct an evidence-validated, open-ended narrative of the evolution and transformation of specific landscapes. Historical ecology aims to contribute toward preserving cultural heritage in ecosystems and landscapes, understanding long-term historical trajectories of patterns and processes in ecosystems and landscapes, and informing ecosystem and landscape management (Crumley 2012).

Driving forces, processes, and actors of landscape change

The interwoven linkages between people and the environment in landscapes and their inherently dynamic nature raise the issue of investigating the processes that change them, the actors involved, and the rates of change, both short and long term (Schneeberger et al. 2007). Five major types of driving forces that affect cultural landscapes have been distinguished: socioeconomic, political, technological, natural, and cultural (Brandt et al. 1999, Bürgi et al. 2004). Among these drivers, there can be strong linkages, dependencies, and feedback loops over several temporal and spatial levels and with different rates of change. A useful conceptual distinction is to separate direct and indirect, as well as, intrinsic and extrinsic driving forces, because driving forces characteristically have to be interpreted in nested scales of explanation. However, most of these driving forces do not have an impact on landscapes directly but rather through actors (Hersperger et al. 2010). Whereas land use and land cover can also be analyzed at large scales, landscapes are closely linked to actors and their land-use practices (Bieling et al. 2013). In particular, land users and landowners are sculptors of landscape development, as can be read, for example, in the composition and

structure of forests (Schaich and Plieninger 2013, Rendenieks et al. 2015).

Promising progress in assessing the interplay between driving forces, processes, and actors of landscape change has been made through landscape modelling. Broad-scale models can foster understanding of how changes in driving forces such as demography, the global economy, technological change, and EU policies may affect the pressures that landscapes are facing. Most of the current simulation models used at the European scale translate national-scale macroeconomic outcomes to land-cover change patterns as part of either scenario or ex-ante policy assessments (Verburg et al. 2010). At regional scales, models have focused on either simulating changes in agricultural practices and crop rotations or on simulating land-cover change (Happe et al. 2006). Novel techniques allow for explicit modeling of changes in the abundance of landscape elements and landscape structures. For example, a model of changes in a heritage landscape as result of farmers' decisions to remove or restore hedgerows showed how global or regional level driving forces may, through influencing the decision making of actors, either separate or connect agriculture and seminatural areas (Valbuena et al. 2010). Another landscape model demonstrated that adding a stronger consideration of the ecological and spatial context of payments would increase the resilience of farmland biodiversity (Schouten et al. 2013).

Landscape values and meanings

Landscapes exhibit diversified and interconnected types of values ranging, for instance, from intangible features such as spiritual values and outdoor recreation through water and climate regulation to the provision of food (Termorshuizen and Opdam 2009). Landscape research into such services is typically focused on how different types of landscapes provide different services, and how different parts of society value them, depending on the cultural background, scarcity, and accessibility of the services provided. Precise understanding of the complexity of assigning values to landscapes is important for decision making on the protection or development of cultural landscapes, in particular for evaluating trade-offs around alternative trajectories of landscape change.

Some landscape values are well investigated, such as landscape aesthetics (Daniel 2001), recreational values and touristic values (Bell et al. 2007), or sense of place (Manzo and Devine-Wright 2013). One important insight from studies of landscape values is that, although landscape values are closely connected to landscape patterns, intensity of use, and structure, they cannot be assessed in terms of purely material site attributes (Stedman 2003, Stephenson 2008). Rather, they possibly evolve from human interaction with sites in the course of a cultural process of acquiring a sense for them, resulting in the creation of meaning and knowledge (see the example of heritage values, Smith 2006). Although the process of how people create values, both intellectually and emotionally, out of material landscape structures is still poorly understood, studies point to the central importance of being able to experience landscapes and engage with them in the course of landscape-related practices (Stephenson 2008, Research Box and Minter 2009, Bieling et al. 2014). Several studies have made the point that ecosystem management has to expand its focus beyond the best-possible

conservation of physical manifestations of values, i.e., sites being important in terms of heritage, tourism, or scenery. It may be more relevant to foster possibilities for a broad and increasingly differentiated public to experience these sites and to acquire memories, meaning, values, and knowledge, for instance, in the course of community walking initiatives or storytelling (Clark et al. 2003, Dobson 2011, Evans and Jones 2011).

Landscape stewardship

Finally, the topic of landscape stewardship, which aims to foster particular landscape values, is currently emerging in the literature (Ode Sang and Tveit 2013, Penker et al. 2013). Landscape governance has most typically followed a preservation approach throughout the 19th and 20th centuries (Guttinger 2007), comprising the designation of special sites. This approach has been directed toward the preservation of landscape features that are not allowed to change. When such a definition of preservation has been applied at a large scale, it has led to a disruption between protected landscapes and surrounding landscapes that undergo changes and pressures. Just like nature reserves, protected landscapes have often been accompanied by spatial and social imbalance, as their establishment and management usually followed strong top-down decision-making rules (Roberts 2010). Cultural landscapes protected through the World Heritage Convention fall into this category. The preservation approach has more recently been complemented by a landscape stewardship approach, understood as an inclusive notion for all collaborative efforts toward landscape sustainability (Ode Sang and Tveit 2013). It has been adopted because of the liaison of two overarching developments: (1) an increasing demand for high-quality amenity landscapes, in particular in industrialized countries and (2) a general trend toward decentralized landscape planning and policy (Termorshuizen and Opdam 2009). Landscape stewardship is centered on everyday, often periurban, landscapes that are exposed to multiple societal demands, whether for infrastructure purposes, urbanization, agricultural-land uses, or outdoor recreation. Here, decision making involves many stakeholders, ranging from farmers through local residents to tourists and nature conservationists.

Innovative models of landscape stewardship have been studied in many everyday landscapes in Europe and around the world (Prager 2012, Estrada-Carmona et al. 2014, Milder et al. 2014). There is some evidence about the ecological importance of collaborative landscape stewardship. For example, well-designed collaborative landscape-scale schemes were found to be more beneficial than farm-scale schemes for a small but significant number of key farmland species and ecosystem services, although unlikely to harm species operating at smaller scales (McKenzie et al. 2013). Landscape stewardship is also important for understanding cultures, landholder practices, and the politics of land (Gill 2014). It has been shown that landscape stewardship is closely related to place attachment, thus affecting people's attitudes toward conservation and planning (Lokocz et al. 2011). Some of the factors for the success of landscape stewardship partnership, such as, leadership, long-term vision, and building on existing success, were identified as important (Southern et al. 2011). Also, consideration of experience-based knowledge held by local land users has a role to play, particularly in times of change and uncertainty (Hernández-Morcillo et al. 2014). A clear understanding of the aspirations of local people regarding

particular landscape features, for example through eliciting joint landscape quality objectives, as proposed in the European Landscape Convention, is another requirement for success (Loupa Ramos 2010).

CONTRIBUTIONS OF LANDSCAPE RESEARCH TO THE STUDY OF ECOSYSTEM CHANGE AND SOCIETY

We propose that it is useful to study ecosystem change interactions with society through the perspective of landscape research. We reflect, for each of the six themes reviewed in this synthesis, on how they can contribute to the study of ecosystem change and society.

Several studies have pointed out that people and the environment are linked in landscapes. The particular strength of a landscape perspective is that it considers humans as integral elements of landscapes, whereas other models tend to see humans as impartial observers, external drivers of ecosystems, or mere beneficiaries of ecosystem services (Matthews and Selman 2006). Landscape research can thus identify options for recoupling social and ecological subsystems, both at the practitioner and policy levels.

The sketched advances in quantifying and mapping landscape structure and land-use intensity have been mainly driven by improved availability, processing, and analysis options of large and consistent sets of high-resolution spatial data, e.g., satellite images or ground survey data. They have the potential for the study of ecosystem change, because they enable fine-grained, but large-scale quantification of ecosystem change processes. By this, they may dissolve the distinction between presumably big data-driven global-scale and presumably descriptive place-based research, allowing for enhanced insight into the nested multiscale dynamics of social-ecological systems.

Consideration of long-term landscape history in the study of ecosystem change and society is important, because the capacity of an ecosystem to provide services and the realization and recognition of key ecosystem services through society evolve over time, with some ecosystem services waning, others being persistent, and others having been discovered only recently. Therefore, awareness of historical variation is a basis for accurately projecting ecosystem services into the future (Bürgi et al. 2015). The reviewed developments in landscape history can provide tools, theories, and methods that allow such integration of an historical perspective into ecosystem studies. For example, landscape biography and historical ecology can provide detailed chronologies of land-use practices and landscape features with the broader regional economic development and thus facilitate understanding of social-ecological interactions between regions and across large distances, as well as the links between local landscapes and the global economic system in history.

Frameworks, methods, and modeling tools for assessing drivers, processes, and actors of landscape change are also relevant for ecosystem change and society, allowing analysis of the in-depth dynamics of local and regional social-ecological systems. In particular, they may facilitate better understanding of the largely unexplored feedbacks between distant places (Liu et al. 2013). Knowledge of the actors in landscapes is also a precondition for sketching future landscape developments, especially for accommodating new land uses, e.g., wind turbines or photovoltaic plants, in landscapes (Le Dü-Blay 2011).

Research on landscape values and meanings has shown that the relationship between ecosystem services and human well-being is a complex one. Categories and frameworks of ecosystem services have been made by experts, but people may have different understandings of a landscape's contributions to their well-being (Bieling et al. 2014). The research reviewed has also pointed to the social complexities of ecosystem services, especially to the visible and invisible conflicts around them. Surveys and stakeholder consultations can be used to generate place-based understanding of landscape values, supplemented by detailed spatial data of landscape changes and values. By this, research can address the various, stakeholder-specific and often contested, views on landscape values (Setten et al. 2012) and the ways in which policies are affecting local landscape evolution.

The emerging issue of landscape stewardship shows some basic principles that are informative for the study of ecosystem change and society. Landscape stewardship as a normative concept rivets onto the simultaneous improvement of food production, biodiversity or ecosystem conservation, cultural heritage preservation, and human well-being, rather than on the maximized production of an individual ecosystem good or service (Laven et al. 2012, Milder et al. 2014). Landscape stewardship can inform on the successful intersectorial coordination or alignment of activities, policies, or investments at the level of citizens, NGOs, community organizations, government agencies, and/or the private sector. In addition to that, landscape stewardship offers lessons in self-organization of communities and stakeholder participation, including people not only as variables affecting landscapes but also as stewards of those landscapes, supporting adaptive, collaborative management within a social learning framework. Landscape stewardship can further add a diversity of perspectives and ways of knowing, including local and traditional knowledge of landscapes and natural resources. The ability to perform landscape stewardship firmly depends on questions of power.

CONCLUSIONS

Landscape approaches have been advocated as important components of sustainability science (Angelstam et al. 2013b, Wu 2013). Indeed, landscape is a boundary object, which is useful for studying the complex interactions between human activities, social structures, and physical features concerned with land. We emphasize that recent progress in six core areas of landscape research, i.e., linkages between people and the environment in landscapes; landscape structure and land-use intensity; long-term landscape history; driving forces, processes, and actors of landscape change; landscape values and meanings; and landscape stewardship can improve the understanding of the multiple dimensions of ecosystem change and society. Our synthesis highlights that knowledge about past and current landscape patterns, processes, and dynamics provides guidance for developing visions to support the sustainable stewardship of social-ecological systems under future conditions. However, landscape research is not a panacea, and some important research priorities of the ecosystem change and society agenda remain unaddressed. For example, questions of power relations and environmental justice have not been exhaustively considered in European landscape research, and stronger consideration of, for example, social stratification, control of labor, and access to land remains a desideratum (Widgren 2012). Therefore, we suggest that

landscape research and studies of ecosystem change and society are complementary, and bidirectional exchange between them has the potential to create a truly integrated social-ecological perspective on ecosystems and landscapes.

Responses to this article can be read online at:

<http://www.ecologyandsociety.org/issues/responses.php/7443>

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