Change and Transformation: A Synthesis

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Global biophysical and socio-economic changes and technological advances manifest themselves in changing land-use and altering landscape properties and functions. The industrial revolution in the nineteenth century was such an example, followed by the age of almost unlimited mobility starting in the twentieth century. Meanwhile, the last decade of the twentieth century has seen an astonishing development in information technology affecting almost every facet of the society. Easy and nearly unlimited access to computers, satellites and communications systems has also affected the way landscape research is done today. Data are obtained in massive amounts and data mining is now an issue. Also in the biological sciences, modern methods such as molecular genetics have revolutionized our understanding of ecology and evolution and how these interact with the environment. Following modern trends in science, landscape research has become computationally intensive, with strong theoretical components. Now, information is quantified, hypotheses are tested and scientific inference is formal.

Landscape research is an interdisciplinary science. It deals with complex environmental processes at multiple spatial and temporal scales. While the interdisciplinary nature and the focus on space-time processes are shared with other fields as well (cf. spatial ecology or bio-geochemistry), the subject of interest – "landscape" – is unique to landscape research. Popularly, "landscape" is understood as a portion of land or territory that the eye can capture at a single glance. Translated into scientific terms landscape can be considered a fraction of the globe's surface, that has been shaped by natural and human driving forces yielding specific qualities for the life of its inhabitants.

Some of the important events in the course of the history of landscape research include, the promotion of the terms landscape architecture in 1828 (Frederick Law Olmsted, designer of Central Park in the city of New York), landscape ecology in the 1930s, and the founding of the International Association for Landscape Ecology in the 1980s. Today, landscape research is the result of several evolutionary lines that are not contradictory but differ in emphasis. Two of these may be called "European" (which is also represented in the United States and elsewhere), and "American" (which is also common in Australia and Canada). They address different value systems and this is reflected in the diversity of coexisting definitions of landscape research and particularly of landscape ecology. Europeans, with their continent's long history of dense human inhabitation, traditionally envision the landscape to include a strong human component. The term landscape has Latin roots reaching back to the term "regio" which eventually evolved into the old German term "lantscaf". "Scaf" gave rise to the English term "shape" and the german term "schaben" or "schaffen". Thus "Landschaft" means land that was shaped by similar human land-use, and so it is not generally thought to be a natural area sensu stricto that is void of human influence. A detailed linguistic analysis can be found in Haber (2002)[1]. On the other hand, North Americans and Australians often view the landscape to be free of human influences, or else they consider such influences to be of less importance. Just

[1] Haber W. 2002. Kulturlandschaft zwischen Bild und Wirklichkeit. Schweiz. Akademie der Geistes- und Sozialwissenschaften, Bern.

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as the British ecologist Arthur Tansley (1935)[2] spoke of "anthropogenic" plant climaxes, while American ecologist Frederic Clements (1936)[3] focused on "natural" climaxes, so do Forman (American) and Naveh (Isreali) reflect these transatlantic differences in seeing human activities as either external or else integral to landscape research. Within Europe itself, the southern countries that refer to paysage, paesaggio, and paisaje – with etymological origins in pagus (village/town/ country) – seem to envisage an even stronger human presence in shaping land than the northern countries that refer to landshap, landschaft, landscape, and their derivatives. We also recognize that the worldwide spread of landscape-related research after 1980 challenges and complements the "European" and "American" paradigms of landscape research. We see emerging research centers in Asia, South America and Africa that voice their views about landscape values and will contribute to a wider understanding of space, place and changes in time.

This book has three sections that show new avenues for landscape research. These are (1) value systems and sociological aspects; (2) ecological observations, data management and ecological methods to identify processes such as migration and dispersal; and (3) concepts for landscape pattern recognition, statistical analysis of landscape and environmental time series data analysis and dynamic ecological modeling.

Value Systems – Major Drivers of Landscape Dynamics

Value systems determine which landscapes are worth preserving and which goods and services of landscapes shall be used or maintained. While values may form the core components of the most influential action theories, currently there is little empirical knowledge about the role of values in landscape research. This is the starting point of "Value systems: drivers of human-landscape interactions" by Buchecker *et al.* Based on two empirical studies, these authors discuss people-landscape interactions and highlight the potential of value-based landscape research.

A more practical perspective on how planning (e.g., biodiversity action plans) is driven by value systems is in "The role of value systems in biodiversity research" by Duelli *et al.* These authors suggest that a transparent discourse about value systems and corresponding indicators is needed. Rather than attempting to reconcile different value systems, their simultaneous relevance must be recognized while different indicator-sets are developed to account for the diverging objectives.

"The meaning of 'landscape' – an exegesis of Swiss government texts" by Longatti and Dalang presents a semantic analysis of the word "landscape" as it has occurred in a number of Swiss government documents over the last 40 years. The authors highlight how altering social value systems are mirrored in the altered use of the term landscape.

In "Space and place – two aspects of the human-landscape relationship", Hunziker *et al.* identify three recently developed concepts dealing with the human dimension of landscapes. First they elaborate on the concept of perceiving the physical space. In a second phase they compile theories dealing with landscape perceived as place. Finally they discuss the effect of landscapes on psychological restoration.

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2 Tansley A.G. 1935. The Use and Abuse of Vegetational Concepts and Terms. Ecology 16: 286–289, 303–307.

3 Clements F.E. 1936. Nature and Structure of the Climax. The Journal of Ecology 24: 252–284.

Ecological Observations and Processes

Due to the rapid technological achievements in remote sensing, since the 1990s, a wealth of data on land cover characteristics over large geographical regions have become available. "Modern remote sensing for environmental monitoring of landscape states and trajectories" by Zimmermann *et al.* is an introduction to aspects of remote sensing that are relevant for landscape research. The emphasis of this article is on ecological applications rather than on data-processing. The authors demonstrate a wide range of possibilities for using such data, and show the benefits and the difficulties of combining remotely sensed data with field observations. In "A large-scale, long-term view on collecting and sharing landscape data", Lanz *et al.* discuss accessing data from widely distributed repositories based on open standards and illustrate the important role of metadata for long-term monitoring and data reliability.

Careful interpretation of past land use and land cover helps to reconstruct patterns and processes within historic landscapes. Historical considerations also contribute to public discussions about the past and the future of landscapes. This is presented in the article by Bürgi *et al.* titled "Using the past to understand the present land use and land cover".

Proxy data originating from tree rings provide information on longer term regional and large-scale climate history. In their paper, "On selected issues and challenges in dendroclimatology", Esper *et al.* discuss quantification of climatic signals retained in certain tree ring parameters, and low frequency variations in long-term temperature reconstruction.

Paradigms and theories play important roles in understanding ecological processes. A prominent example is the theory of "island biogeography", already well-known in landscape management, e.g., in reconnecting isolated habitat patches. However, most landscape theories still await confirmation with empirical data. Modern methods, e.g., molecular biology, or satellite imagery, have the potential to rigorously question these paradigms. Testing of paradigms with genetic methods is the concern of the two articles "Integrating population genetics with landscape ecology to infer spatio-temporal processes" by Holderegger *et al.* and "Landscape permeability: from individual dispersal to population persistence" by Suter *et al.* The article by Holderegger *et al.* sets the scene for an emerging field in landscape research: landscape genetics. These authors show how beneficial molecular techniques can be for analyzing migration pattern, dispersal and gene flow. Suter *et al.* use capercaillie (*Tetrao urogallus;* Aves; Tetraonidae) as an example, to illustrate how relating spatial population patterns to landscape structure is limited by the lack of empirical data, and how genetic analysis may help to understand dispersal patterns.

Spatial Pattern Recognition, Time Series Analysis and Dynamic Modeling

This section is about principles, models and methods for quantitative analysis of landscape data. It starts with the article "Identifying and quantifying landscape patterns in space and time" by Bolliger *et al.* This is an overview of various indicators to assess landscape patterns. "Essay on the study of the vegetation process" by Wildi and Orlóci is about governing principles in vegetation analysis. In this essay, the authors discuss nonlinearity, scales, randomness, and other notions such as chaos. To understand why such notions are relevant, consider a chaotic system. In some situations, even very simple deterministic dynamic systems may be chaotic, with a behavior so complex that it mimics randomness. Why is chaos an issue? It is important because it may hamper the prediction of the state of a system, an important concern of ecologists. An emerging conclusion from these two papers is that the analysis of complex landscape data requires highly specialized statistical methods.

A landscape may be viewed as the realization of a space-time stochastic process. In "Statistical analysis of landscape data: space-for-time, probability surfaces and discovering species", Ghosh and Wildi present novel methods for analyzing landscape data in three different contexts. They explain the hypothesis of space for time substitution, nonparametric probability and quantile surface estimation, and the role of self-similarity in extrapolating hyperbolic species-area relations. A second article with rigorous statistical treatment is "Memory, non-stationarity and trend: analysis of environmental time series". The authors Ghosh *et al.* discuss models for changing seasonality, long-memory or slowly decaying autocorrelations, deterministic trend versus stochastic trend-like behavior, non-stationary and non-Gaussian stochastic processes and introduce wavelets and nonparametric curve estimation. Long-term time series observations from a number of regions illustrate the methods.

Handling different scales simultaneously is a key skill for understanding and managing landscapes. This is the topic of "Model up-scaling in landscape research" by Lischke *et al.* It is an overview of up-scaling techniques and considers hierarchy theory as an ideal frame-work for successful up-scaling. Hierarchy theory leads to a general formulation of the up-scaling process, which consists of (a) aggregating source scale variables to target scale variables and (b) deriving the associated target scale model functions. Properly integrating space and time plays a crucial role in predictive modeling. This is shown in the second article by Lischke *et al.* titled "Dynamic spatio-temporal landscape models". The authors claim that modeling at the landscape scale is most effective with the new generation of dynamic regionalized and spatially linked spatio-temporal (SLST) models taking into account both local dynamics and spatial interactions. The authors discuss various SLST models for landscape research.

In conclusion we note an acceleration of progress in landscape research as the methods, the availability of data resources and the awareness of public interests are concerned. It may be a coincidence that this goes parallel to the observed accelerated change of the landscape due to the ongoing globalization of interactions as well as climate- and land use change. The society is expecting solutions to newly emerging problems. We are convinced that our joint contributions from natural and social sciences will be well received by the readers of this book.