

# Principles and Methods in Landscape Ecology

Towards a Science of Landscape



*by*

Almo Farina



 Springer

Landscape Series

# PRINCIPLES AND METHODS IN LANDSCAPE ECOLOGY

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**Almo Farina**

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 Springer

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# PRINCIPLES AND METHODS IN LANDSCAPE ECOLOGY

# Landscape Series

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VOLUME 3

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## Aims & Scope:

Springer's innovative Landscape Series is committed to publishing high quality manuscripts that approach the concept of landscape from a broad range of perspectives. Encouraging contributions on theory development, as well as more applied studies, the series attracts outstanding research from the natural and social sciences, and from the humanities and the arts. It also provides a leading forum for publications from interdisciplinary and transdisciplinary teams.

Drawing on, and synthesising, this integrative approach the Springer Landscape Series aims to add new and innovative insights into the multidimensional nature of landscapes. Landscapes provide homes and livelihoods to diverse peoples; they house historic – and prehistoric – artefacts; and they comprise complex physical, chemical and biological systems. They are also shaped and governed by human societies who base their existence on the use of the natural resources; people enjoy the aesthetic qualities and recreational facilities of landscapes, and people design new landscapes.

As interested in identifying best practice as it is in progressing landscape theory, the Landscape Series particularly welcomes problem-solving approaches and contributions to landscape management and planning. The ultimate goal is to facilitate both the application of landscape research to practice, and the feed back from practice into research.

## Foreword by the series editors

*Principles and Methods in Landscape Ecology* is already a classic among the books published around the world on the topic. In the foreword of the first edition, Zev Naveh wrote: “I am confident that this book will serve very well as both a textbook and as a handbook for those involved in landscape ecological study, research and education, as well as for many others from closely related fields of natural and human sciences dealing with land use”. Two years later, in the foreword of the other book of Almo Farina – *Landscape Ecology in Action* – Frank Golley wrote about *Principles and Methods*: “My students like this text especially well because it is direct, to the point and comprehensive. ‘Farina’ is on loan much of the time”.

It appears that the book is so successful that a new version is now necessary, and it is a real pleasure to include it in our Springer Landscape Series. The aim of the series is to highlight the diversity of landscapes and approaches used in their study. While the multiplicity of relevant academic disciplines and approaches is characteristic of landscape research, we also aim to provide a place where the synthesis and integration of different knowledge cultures is common practice. Such aims are possible only if principles and methods of Landscape Ecology are clearly understood by students and practitioners in the field.

Almo Farina was particularly qualified to write such a book. First, because of his personal involvement in education and in research and second, because of his intelligence of the needs of the international community: Almo served as the secretary of IALE, the International Association of Landscape Ecology as well as the general secretary of INTECOL, the International Association of Ecology for which he organized a memorable VII World Congress in 1998 in the city of Florence, Italy. In addition, what gives this book its strength and unique character is the deep involvement of its author in the issue of the future on landscapes around the Mediterranean Basin – a hotspot for biodiversity and for the natural and societal impacts of global environmental change.

*Principles and Methods in Landscape Ecology* clearly summarizes the best theories, concepts, principles and methods in landscape ecology. It is an important tool not only for classrooms, but also for a broad range of scientists and practitioners, particularly in the first decade of this new Millennium, when unprecedented digital representations of the Earth revolutionize spatial

thinking and when, at the same time, landscapes experience drastic transformations triggered by unprecedented natural and societal changes everywhere in the world.

Toulouse and Aberdeen, February 2006

Henri Décamps  
Bärbel Tress  
Gunther Tress

## Preface to the 2nd edition

Landscape ecology has greatly gained reputation and scientific visibility as theoretical and applied science as well, since “Principles and Methods in Landscape Ecology” was firstly published in 1998. Ecologists and practitioners have widely applied the principles of the landscape ecology to model and to manage disturbed landscapes and menaced pristine areas as well.

A revision and an integration of the contents of the former edition have been carried out with the aim to update epistemological concepts and theoretical contents, and to include updates of the recent relevant literature. A new sentence “Toward a science of the landscape” has been added to the title “Principles and methods in landscape ecology” in order to better figure out and to stress the tremendous progresses achieved by this discipline in ecological as well as in social and economic realms.

In this new edition a special emphasis has been reserved to the “bio-complexity” paradigm relocating the landscape processes into the family of non linear and self-organizing phenomena. In particular, the first and the second chapter have been deeply integrated by new arguments dealing with the perception of the landscape.

The cognitive component of the landscape has been discussed in detail considering the different theories developed about the cognition and the environmental psychology. The paradigm of the eco-field, the bio-semiotic approach and the information theory, have been new arguments added to the original version.

Special attention has been reserved how landscapes behave and develop - the landscape ontogenesis hypothesis - incorporating the uncertainty and the hierarchical structure into the landscape paradigm.

Finally, a relevant goal of this new edition is create confidence in the new generations of students and practitioners to considering the ecological systems as the result of the integration between ecosystemic (non spatial) and landscape (spatial) patterns and processes.



# Preface

Currently considered bridge between basic and applied ecology landscape ecology occupies a new important “niche” in ecology representing a new star in the “galaxy” of the ecological sciences.

But the broad spectrum of his conceptual and methodological approaches has created a non-focused science strongly influenced by the more dominant disciplines like landscape planning and restoration, forest management, landscape architecture, etc.

The uncertain position of the landscape ecology among the ecological disciplines is in contradiction with the general reconnaissance that landscape dimension is a spatial scale in which important ecological processes occur. And the landscape is becoming very popular in many ecological related fields from plant disease to animal behavior.

Actually a consistent literature covers most of the landscape ecology themes and the theoretical frameworks are enough convincing to delineate new approaches and interpretations of the ecological complexity.

The available literature is growing very fast representing the different approaches by which the landscape ecology issues are addressed. But as in many other pioneering disciplines a general framework common to all users is lacking and the topics often are moving from a human oriented landscape ecology to simply large scale ecology.

In fact two souls are living in the landscape ecology the first is connected to the European culture and longer-time experience in landscape ecology especially in the field of landscape evaluation, management and restoration. A second soul is grown in the North America in the last two decades, characterized by theoretical basis and sophisticate methodologies producing formidable schools to study complexity beyond the ecosystem scale.

The presence of these two approaches in some measure is positive and allows the interchange of experience and point of views that found in exciting international meetings the main occasion.

In fact in the last decade landscape ecology has found a flowering of cultural initiatives aggregated around the International Association for Landscape Ecology (IALE) and a multitude of working groups in local Ecological Societies and in other NGO organizations have been successfully established.

Two possibilities exist to expand the landscape ecology, one consists in developing new researches, the last to develop a good educational framework. Both are important and non in conflict. With this spirit I have prepared this book aimed to summarize the best theory, concept, principles and methods in landscape ecology. An attempt to reinforce the landscape ecology approach in the ecological research perspective, to consolidate principles and methods, in validating procedures and to riconciliate different positions including geobotanic, animal and human perspectives.

The conceptual scheme is very simple. The direct address by which I move dealing with the landscape ecological issues is necessary to reduce the “fringes” that often characterize some compartments of this discipline.

I have no ambition to present new ideas and theories, I have worked to wrap up a tool spendable mainly in classrooms but also for orienting a broad range of scientists and practitioners dealing with the landscape complexity and related problems.

The selection of a simple and contemporarily enough “objective” conceptual path is full of risks due to a personal interpretation of this discipline. Theoretical basis, the contribution of other disciplines, emerging processes and patterns, managing applications and methods are the main steps that I have utilized in this exciting journey.

The book is not comprehensive neither for topic nor for references, but this has not been my goal.

I have tried to maintain a good balance between the relevant literature offered but often my background of “naturalist” has prevailed. In any way the percentage of literature for the different topics has been respected and it is not a surprise that animal studies are dominant in landscape ecology.

The references are not comprehensive but essential to “cover” the argument taken into consideration. In some cases has not be easy to make the best choice either for the great number of studies (f.i. on the effect of fragmentation on animal populations) in other cases for too few studies available (soil landscape and flux of nutrients in the landscape).

Some comments are necessary to explain the general project of the book with the sincere hope to do not bore the reader from the beginning .

In the short introduction to the landscape ecology I have avoided too “long historical perspectives” focusing more on the real object of the landscape ecology and on good definitions.

I have underlined the contribution of other related ecological disciplines in the creation of a strong conceptual framework.

The description of new theories as percolation, metapopulation, hierarchy, etc. have preceded the scaling approach.

Emerging processes (fragmentation and disturbance, connectivity and ecological fluxes) and patterns (heterogeneity and ecotones) occupy the central part of the book.

Landscape dynamic, management and nature conservation at landscape scale have been extensively described.

The last chapter is fully devoted to methods. Special importance has been maintained to indices describing the structure of the landscape mosaic from Euclidean to fractal geometry. GIS and GPS procedures have been included as indispensable tools. Remote sensing procedures and spatial explicit models occupy the final part of the book. In addition very simple routines to measure landscape structure and complexity are presented. These routines may be improved and incorporated in more sophisticated programs. I have tried to encourage people to measure the landscape by using simple tools aware of the frustration felt by people reading about huge, expensive and powerful computation and remote sensing facilities of super-specialized advanced research centers.

I am perfectly aware about the limit of this book, I am conscious that many perspectives have not been discussed like the socio-economical implications.

Most of the pictures and examples are from my preferred study area (Northern Apennines, Italy). The environmental and cultural complexity of this region, like most of Mediterranean basin is an exciting field to test and apply landscape principles and methodologies and an inexhaustible source of scientific creativity.

I am in debt with many people and in particular to Zev Naveh for his invaluable encouragement. I am grateful also to Francesco Di Castri for his friendship and the support during the preparation of this book.

# Foreword

Landscape ecology has its roots in the long tradition of central and eastern European geobotanists, ecologists, geographers, landscape planners and architects who were not content with the present state of their sciences and profession.

They strived to present their rich and heterogeneous landscapes in more holistic ways, as the spatial and functional integration of nature, humans and land, so that their studies could be of practical value in landscape appraisal, planning, management, conservation and restoration.

However, chiefly because of language and cultural barrier it remained a rather restrict “continental” science until it was joined more than twenty years ago by the “second generation” of a large group of far-sighted - and chiefly North American - ecologists and geographers. These realized the theoretical and methodological relevance of landscape ecology and the need for broadening the spatial scales of ecosystem ecology for the study of the ordered complexity of natural and cultural landscapes.

The two groups joined together and founded the International Association of Landscape Ecology (IALE). Fortunately these developments coincided with the dramatic advances in remote sensing and satellite imaging with finer and finer resolutions over larger and larger areas and with the progress in processing larger masses of data in smaller and cheaper computers with more sophisticated and comprehensive modelling methods. Since then landscape ecology has spread its wings all over the world both in industrialized and developing countries as one of the youngest and most dynamic branches of contemporary environmental science.

The author of this book, Dr. Almo Farina, is the first of the “third generation” who not only followed the footsteps of both these founder groups but contributed a new milestone to its further development and especially to the education of the next generation of landscape ecologists, academicians and professionals. He took upon himself the challenge to provide a meaningful synthesis of what he consider to be the “best theory, concept, principles and methods” which are presently applied in a multitude of landscape-ecological studies and are published in the journal “Landscape Ecology” and in many other journals and scientific publications.

Presenting in a lucid way some of the most relevant new ideas, theories and paradigms, he succeeds also in reconciling the diverse geological, biological and human perspectives. At the same time he provides his own original

well-versed and well-balanced contribution to contemporary landscape ecology as a holistic, quantitative and problem-solving oriented science for the promotion of sustainable, healthy and productive landscapes.

Although dealing in a systematic way with a large body of rather complex scientific information, such as fractal dimensions, numerical and spatial data processing and geographic information systems, this book is far from being dry, technical and detached from reality. On the contrary it is very lively with many fine illustrations and with many practical examples. While reading through its chapters I could sense that it was written by one who is eager to communicate not only his own knowledge and holistic perception of landscapes as a hybrid nature-culture gestalt systems, but also his close personal attachment to the biological and cultural assets of his Apennine mountain and rural landscapes in which he grew up, and lives and works, and where he carries out his own research.

A great advantage, in my opinion, is the fact that this book was not written by a purely academic scientist, spending most of his time sitting in an office behind a computer, trying to publish as many possible "scholarly" works to further his own reputation. Dr. Farina started his professional career as a high school teacher in biology and is still very active in public education as Director of the Lunigiana Museum of Natural History at Aulla, Italy (Which was established and is maintained thanks to his initiative to preserve one of the most outstanding historical landscape monuments of this region). He started his research as an enthusiastic ornithologist but very soon realized the great potentials of landscape ecology, which fitted very well with his deeply ingrained perception of the landscape as a whole, and his intellectual abilities for acquiring the most advanced methods available and to turn these into practical tools for the study, management and conservation of landscapes. Dr. Farina is not only active in these local issues but is also deeply involved in the broader issues of the future of Mediterranean landscapes in Italy and in the Mediterranean Basin. He also served for four years as secretary of IALE.

I am confident that this book will serve very well as both a textbook and as a handbook for those involved in landscape ecological studies, research and education, as well as for many others from closely related fields of natural and human sciences dealing with land use. I am also hopeful that it will help to bridge the gaps between these different fields so that landscape ecology can be realized as one of the most important integrative environmental sciences in this crucial transition period from the industrial to the information age.

Zev Naveh  
Haifa, Israel

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