Book Review

A review on the book, *Ecological Modeling*

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Abstract
The book, *Ecological Modeling*, edited by WenJun Zhang and published by Nova Science Publishers, USA, was briefly reviewed in present report.

Keywords network biology; book; review.

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1 Introduction

Ecological modelling is a fast growing science. It is a powerful tool to handle complex ecological problems. More and more innovative methodologies and theories on ecological modelling are emerging around the world. Most of them have been published on interantional journals. Due to less page limitations, however, some quality papers may also be published in a careful planned book. The book, *Ecological Modelling*, is published to reflect recent achievements of scientists in ecological modelling. This book includes a lot of models, methods and theories on ecological modelling, for example, artificial neural networks, individual-based modelling, ecological nich models, landscape and GIS modelling, population dynamics, nutritional ecology, remote sensing, decision support systems, etc.

Articles in this book are contributed by nearly 40 ecologists, geo-scientists, physicist and mathematicians from the United States, Canada, China, Australia, Austria, Brazil, Russia, Greece, Italy, Spain, Portugal and Tunis, etc. It will provide researchers with diverse aspects of the latest advances in ecological modelling. It is a valuable reference for the scientists, university teachers and graduate students in ecology, environmental sciences, geography and computational science.

2 Contents

The book covered such contens as follows

Chapter 1 (Zhang and Liu, 2012): Probability distribution functions have been widely used to model the spatial distribution of arthropods. Aggregation types (i.e., randomly distributed, uniformly distributed, aggregately distributed, etc.) of arthropods can be detected based on probability distribution functions, but the abundance at given location is not able to be predicted by them. This study aimed to present an artificial neural network to simulate spatial distribution of arthropods. Response surface model and spline function were compared and evaluated against the neural network model for their simulation performance. The results showed that the artificial neural network exhibited good simulation performance. Simulated spatial distribution was highly in accordant with the observed one. Overall the neural network performed better in the case of lower total abundance of arthropods. Response surface model could fit the spatial distribution of arthropods but the simulation performance was worse than neural network. Cross validation revealed that neural network performed better than response surface model and spline function in predicting spatial distribution of arthropods. Confidence interval of predicted abundance could be obtained using randomized submission of quadrate sequences in the neural network simulation. It is concluded that artificial neural network is a valuable model to simulate the spatial distribution of arthropods.

Chapter 2 (Petropoulos et al., 2012): Remote sensing has generally demonstrated a great potential in mapping spatial patterns of vegetation. By employing the amount of reflected radiation at particular regions of the electromagnetic spectrum, it is possible to make estimates on certain characteristic of vegetation. The use of radiometric vegetation indices is a fast and efficient method for vegetation monitoring, explotiting information acquired from remote sensing data. These indices are dimensionless, radiometric measures that function as indicators of relative abundance and activity of green vegetation. Throughout the years, a large number of multispectral vegetation indices have been formulated. Each has variable degree of efficiency in estimating one or more vegetation parameters such as, health status, nutrient or water deficiency, crop yield, vegetation cover fraction, leaf area index, absorbed photosynthetically active radiation, net primary production and above-ground biomass. Additionally some of them also consider atmospheric effects and/ or the soil background for an enhanced retrieval. The present chapter aims in providing an overview on the use of radiometric vegetation indices developed over the last few decades utilizing spectral information acquired from multispectral remote sensing sensors. Before that, an introduction to some important principles of remote sensing relevant to the vegetation spectral response is made available, as this was considered necessary to better understand the context of the present overview.

Chapter 3 (Altartouri et al., 2012): According to the Water Framework Directive (WFD, 2000/60/EC), Integrated River Basin Management Plans (RBMP) are required at different scales, in order to prevent amongst other things, water resource deterioration and ensure water pollution reduction. An integrated river basin management approach underpins a risk-based land management framework for all activities within a spatial land-use planning framework. To this end, a risk assessment methodology is required to identify water pollution hazards in order to set appropriate environmental objectives and in turn design suitable mitigation measures. Surface water pollution as a result of Olive Mill Waste (OMW) discharge is a serious hazard in the olive oil producing regions of the Mediterranean. However, there is no standardised method to assess the risk of water pollution from olive mill waste for any given river basin. The present chapter shows the results from a study conducted addressing the above issue by designing a detailed risk assessment methodology, which utilises GIS modelling to classify within a watershed individual sub-catchment risk of water pollution occurring from olive mill waste discharges. The chapter presents the proposed criteria and calculations required to estimate sub-catchment risk significance and comments on the methods potential for wider application. It combines elements from risk assessment frameworks, Multi Criteria Analysis (MCA), and Geographic Information Systems (GIS). MCA is used to aggregate different aspects and elements associated with this environmental problem, while GIS modeling tools helped in obtaining many criterion values and providing insight into how different objects interact in nature and how these interactions influence risk at the watershed level. The proposed method was trialled in the Keritis watershed in Crete, Greece and the results indicated that this method has the potential to be a useful guide to prioritise risk management actions and mitigation measures which can subsequently be incorporated in river basin management plans.

Chapter 4 (Nedorezov, 2012): Publication is devoted to the problem of population time series analysis with various discrete time models of population dynamics. Applications of various statistical criterions, which are normally used for determination of mathematical model parameters, are under the discussion. With a particular example on green oak leaf roller (*Tortrix viridana* L.) population fluctuations, which had been presented in publications by Rubtsov (1992), and Korzukhin and Semevskiy (1992) for three different locations in Europe, the possibilities of considering approach to the analysis of population dynamics are demonstrated. For approximations of empirical datasets the well-known models of population dynamics with a discrete time (Kostitzin model, Skellam model, Moran – Ricker model, Morris – Varley – Gradwell model, and discrete logistic model) were applied. For every model the final decision about the possibility to use the concrete model for approximation of datasets are based on analyses of deviations between theoretical (model) and empirical trajectories: the correspondence of distribution of deviations to Normal distribution with zero average was checked with Kolmogorov – Smirnov and Shapiro – Wilk tests, and existence/absence of serial correlation was determined with Durbin – Watson criteria. It was shown that for two experimental trajectories Kostitzin model and discrete logistic model give good approximations; it means that population dynamics can be explained as a result of influence of intra-population self-regulative mechanisms only. The third considering empirical trajectory needs in use more complicated mathematical models for fitting.

Chapter 5 (Cianelli et al., 2012): In the last decades, numerical modelling has gained increasing consensus in the scientific world, and particularly in the framework of behavioural and population ecology. Through numerical models it is possible to reconstruct what is observed in the environment or in the laboratory and to get a more in-depth comprehension of the factors regulating the phenomena under examination.
Numerous approaches have been developed in this framework, but probably one of the most promising is the individual-based modelling. With this type of approach it is relatively straightforward to investigate aspects related to the ecology of a population starting from the characterisation of processes taking place at the scale of the individual organism. This contribution is intended to provide a general view of the main features of the individual-based models and of their peculiarities in comparison to other modelling strategies. Special emphasis will be given to applications in the field of phyto- and zooplankton ecology and behaviour, and results from the available literature on this topic will be used as examples.

Chapter 6 (Watts et al., 2012): The larval phase of most blowfly species is considered a critical developmental period in which intense limitation of feeding resources frequently occurs. Furthermore, such a period is characterised by complex ecological processes occurring at both individual and population levels. These processes have been analysed by means of traditional statistical techniques such as simple and multiple linear regression models. Nonetheless, it has been suggested that some important explanatory variables could well introduce non-linearity into the modelling of the nutritional ecology of blowflies. In this context, dynamic aspects of the life history of blowflies could be clarified and detailed by the deployment of machine learning approaches such as artificial neural networks (ANNs), which are mathematical tools widely applied to the resolution of complex problems. A distinguishing feature of neural network models is that their effective implementation is not precluded by the theoretical distribution of the data used. Therefore, the principal aim of this investigation was to use neural network models (namely multi-layer perceptrons and fuzzy neural networks) in order to ascertain whether these tools would be able to outperform a general quadratic model (that is, a second-order regression model with three predictor variables) in predicting pupal weight values (output) of experimental populations of *Chrysomya megacephala* (F.) (Diptera: Calliphoridae), using initial larval density (number of larvae), amount of available food, and pupal size as input variables. These input variables may have generated non-linear variation in the output values, and fuzzy neural networks provided more accurate outcomes than the general quadratic model (i.e. the statistical model). The superiority of fuzzy neural networks over a regression-based statistical method does represent an important fact, because more accurate models may well clarify several intricate aspects regarding the nutritional ecology of blowflies. Additionally, the extraction of fuzzy rules from the fuzzy neural networks provided an easily comprehensible way of describing what the networks had learned.

Chapter 7 (Newton, 2012): An ecological-based decision-support system and corresponding algorithmic analogue for managing natural black spruce (*Picea mariana* (Mill) BSP.) and jack pine (*Pinus banksiana* Lamb.) mixed stands was developed. The integrated hierarchical system consisted of six sequentially-linked estimation modules. The first module consisted of a key set of empirical yield-density relationships and theoretically-based functions derived from allometry and self-thinning theory that was used to describe overall stand dynamics including temporal size-density interrelationships and expected stand development trajectories. The second module was comprised of a Weibull-based parameter prediction equation system and an accompanying composite height-diameter function which was used to recover diameter and height distributions. The third module included a set of species-specific composite taper equations which was used to derive log product distributions and volumetric yields. The fourth module was composed of a set of species-specific allometric-based composite biomass equations which was used to estimate mass distributions and associated carbon-based equivalents for each above-ground component (bark, stem, branch and foliage). The fifth module incorporated a set of species-specific end-product and value equations which was used to predict chip and lumber volumes and associated monetary equivalents by sawmill type (stud and randomized length mill configurations). The sixth module encompassed a set of species-specific composite equations that was used to derive wood and log quality metrics (specific gravity and mean maximum branch diameter, respectively). The stand dynamic and structural recovery modules were developed employing 382 stand-level measurements derived from 155 permanent and temporary sample plots situated throughout the central portion of the Canadian Boreal Forest Region, the taper and end-product modules were developed employing published results from taper and sawmill simulation studies, and the biomass and fibre attribute modules were developed using data from density control experiments. The potential of the system in facilitating the transformative change towards the production of higher value end-products and a broader array of ecosystem services was exemplified by simultaneously contrasting the consequences of density management regimes involving commercial thinning treatments, in terms of overall productivity, end-product yields, economic efficiency, and ecological impact. This integration of quantitative relationships derived from applied ecology, plant population biology and forest science into a common analytical platform, illustrates the synergy that can be realized through a multi-disciplinary approach to forest modeling.

Chapter 8 (Barbosa et al., 2012): The authors present a review of the concepts and methods associated to ecological niche modeling illustrated with the published works on amphibians and reptiles of the Mediterranean Basin, one of the world's biodiversity hotspots for conservation priorities. The authors start by introducing ecological niche models, analyzing the various concepts of niche and the modeling methods associated to each of them. The authors list some conceptual and practical steps that should be followed when modeling, and highlight the pitfalls that should be avoided. The authors then outline the history of ecological modeling of Mediterranean amphibians and reptiles, including a variety of aspects: identification of the ecological niche; detection of common distribution areas (chorotypes) and other biogeographical patterns; analysis and prediction of species richness patterns; analysis of the expansion of native and invasive species; integration of molecular data with spatial modeling; identification of contact zones between related *taxa*; assessment of species' conservation status; and prediction of future conservation problems, including the effects of global change. The authors conclude this review with a discussion of the research that still needs to be developed in this area.

Chapter 9 (Krivtsov and Jago, 2012): Numerical techniques (e.g. correlation, multiple regression and factor analysis, path analysis, methods of network analysis, and, in particular, simulation modelling) may be very helpful in investigations of indirect relationships in aquatic ecosystems. Here the authors give a brief overview of some examples of the relevant studies, and focus on 1) a case study of a freshwater eutrophic lake, where statistical analysis of the datasets obtained within a comprehensive monitoring programme, and sensitivity analysis by a mathematical model 'Rostherne', helped to reveal the previously overlooked relationships between Si and P biogeochemical cycles coupled through the dynamics of primary producers, and 2) give an overview of how the coupling of physical, chemical, and biological processes in the marine ecosystem models offers a basis for investigations of indirect interactions in continental shelf seas. Complex aquatic ecosystem models provide a numerical simulation of biogeochemical fluxes underpinned by coupling physical forcing functions with definitions simulating biological and chemical processes, and offer a potential for quantitative interpretation of sediment proxies in the stratigraphic record. Combination of models and sediment proxies, calibrated by training sets, can provide information on water column structure, surface heating, mixing, and water depth, thus providing a basis for reconstruction of the past, and predicting the future environmental dynamics.

Chapter 10 (Schmickl et al., 2012): In the evolution of social insects, the colony and not the (often sterile) individual worker should be considered the major unit of selection. Thus, social insect colonies are considered to be 'super-organisms', which have – like all other organisms – to perform behaviors which affect their outside environment and which alter their own future internal status. The way these behaviors are coordinated is by means of communication, which is either direct or indirect and which involves information exchange either by transmitting signals or by exploiting cues. Therefore, social insect colonies perform information processing in a rather similar way as multicellular organisms do, where behaviors result from the exchange of information among their sub-modules (cells). In many cases, self-organization allows a colony to evaluate massive amounts of information in parallel and to decide about the colony's future behavioral responses. Many feedback systems that govern self-organization of workers have been investigated empirically and theoretically. Here, the authors discuss models which have been proposed to explain division of labor and task selection in social insects. The authors demonstrate how the collective regulation of labor in eusocial insect colonies is studied by means of top-down modeling and by bottom-up models, often analyzed with multi-agent computer simulations.

Chapter 11 (Gamez, 2012): The paper is a review of a research line initiated two decades ago. At the beginning the research was concentrated on basic qualitative properties of ecological and population-genetic models, such as observability and controllability. For population system, o*bservability* means that, e.g. from partial observation of the system (observing only certain indicator species), in principle the whole state process can be recovered. Recently, for different ecosystems, the so-called observer system (or state estimators) have been constructed that enables us to effectively estimate the whole state process from the observation. The methodology of observer design can be also applied to estimate unknown changes in ecological parameters of the system. Clearly, both observation (i.e. monitoring) and control are important issues in conservation ecology. For an ecological system, in an appropriate setting, *controllability* implies that a disturbed ecosystem can be steered beck to an equilibrium state by an abiotic human intervention. Recent research concern the effective calculation of such control functions. While the considered *ecological models* are *density-dependent*, observability and controllability problems also naturally arise in *frequency-dependent models* of *population genetics*. As for the frequency-dependent case, observation systems typically occur in case of phenotypic observation of genetic processes; control systems can be used to model e.g. artificial selection. In this survey, in addition to the basic methodology and its applications, the recent developments of the field are also reported.

Chapter 12 (Spagnolo et al., 2012): The authors analyse the effects of environmental noise in three different biological systems: (i) mating behaviour of individuals of Nezara viridula; (ii) polymer translocation in crowded solution; (iii) an ecosystem described by a Verhulst model with a multiplicative L´evy noise. Specifically, the authors report on experiments on the behavioural response of N. viridula individuals to sub-threshold deterministic signals in the presence of noise. The authors analyse the insect response by directionality tests performed on a group of male individuals at different noise intensities. The percentage of insects which react to the sub-threshold signal shows a non-monotonic behavior, characterized by the presence of a maximum, for increasing values of the noise intensity. This is the signature of the non-dynamical stochastic resonance phenomenon. By using a ”hard” threshold model the authors find that the maximum of the output cross correlation occurs in the same range of noise intensity values for which the behavioral activation shows a maximum. In the second system, the noise driven translocation of short polymers in crowded solutions is analyzed. An improved version of the Rouse model for a flexible polymer has been adopted to mimic the molecular dynamics, by taking into account both the interactions between adjacent monomers and introducing a Lennard-Jones potential between non-adjacent beads. A bending recoil torque has also been included in our model. The polymer dynamics is simulated in a two-dimensional domain by numerically solving the Langevin equations of motion. Thermal fluctuations are taken into account by introducing a Gaussian uncorrelated noise. The mean first translocation time of the polymer centre of inertia shows a minimum as a function of the frequency of the oscillating forcing field. In the third ecosystem, the transient dynamics of the Verhulst model perturbed by arbitrary non-Gaussian white noise is investigated. Based on the infinitely divisible distribution of the L´evy process the authors study the nonlinear relaxation of the population density for three cases of white non-Gaussian noise: (i) shot noise, (ii) noise with a probability density of increments expressed in terms of Gamma function, and (iii) Cauchy stable noise. The authors obtain exact results for the probability distribution of the population density in all cases, and for Cauchy stable noise the exact expression of the nonlinear relaxation time is derived. Moreover starting from an initial delta function distribution, the authors find a transition induced by the multiplicative L´evy noise, from a trimodal probability distribution to a bimodal probability distribution in asymptotics. Finally the authors find a nonmonotonic behavior of the nonlinear relaxation time as a function of the Cauchy stable noise intensity.

Chapter 13 (Ferrarini, 2012): Landscape modelling is founded on the idea that the patterning of landscape elements strongly influences ecological characteristics, thus the ability to quantify landscape structure is a prerequisite to the study of landscape function and change over time as well. For this reason, much emphasis has been placed until now on developing methods to quantify landscape structure. Unfortunately, on one side landscape (i.e., landcover or landuse) and vegetation maps are very complex mosaics of thousands of patches, and this makes the interpretation of their structure very challenging. On the other side, methods developed so far to quantify landscape structure just return numerical results, that are not linked to cartographic outputs. Last, landscape pattern indices are numerous, and the need for a synthetic representation is more and more impelling. The author provide here the description and application of a novel approach to landscape structural modelling based on the combined use of GIS (Geographical Information Systems) and multivariate statistics. First, landscape structure of the study area (Ceno valley, Italy) is analyzed through 5 patch-based, non-redundant indicators (area, isolation, compactness, shape complexity, interspersion) with indirect link to functional aspects. Second, PCA (principal component analysis) is used in order to synthesize structural indicators, and cartographic output is given. Third, KCA (k-means cluster analysis) is applied in order to group landscape patches into homogeneous clusters, and again GIS output is supplied. Last, LDA (linear discriminant analysis) is employed to provide evidence for the differences among clusters. This modelling approach provides the chance for a deep and cost-effective exegesis of landscape structure, with promising consequences on conjecture formulation about functional aspects as well.

Chapter 14 (Sellami, 2012): Our days, the climatic change, manifested by strong and brutal precipitation, violent wind and long drought, has as direct consequence to damage the plant canopies (forests, sylviculture, oasis, pastoral lands and agricultural fields) so menacing the human feeding either from plants or animals (caprine, ovine, bovine, cameline..), exhausting the water resources, increasing the need for energy in buildings used for all activities (industrial, agricultural and services). Which solution the ecological modelling is capable to participate with, at short and long dated, in order to buffer the climatic change effect and to assume the need of food and clean energy for human? In this chapter the authors present the basic concepts to model the plant architecture (species, densities, positions and orientation) the most adaptable to the sudden calamity, the energy use efficiency in building (material of construction, isolation system, organisation of accessories and apparatus), and the produce of clean energy from the wind velocity (founding wind sources and evaluating regional wind potential offshore and inshore, conceptualising wind turbine and testing their efficiencies

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