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MATHEMATICAL METHODS IN ECOLOGY (ON THE EXAMPLE OF TIME SERIES ANALYSIS)

Математические методы в экологии (на примере временных рядов анализ)

Аннотация: математические методы применяются не только в соответствующих науках и дисциплинах, но и являются составляющей междисциплинарной методологии. В статье рассматривается применение математических методов в экологии. Автор берез за пример использование и анализ временных рядов, которые становятся все более популярными в экологии, поскольку делают доступным автоматический расчет оценки и учета перемен окружающей среды.

Firstly we understood ecology as the science which describes relationships of organisms and the environment. Human is a part of the Biosphere with all the rest of its parts. Today ecology has explored its subject of research and more it wanted to change the world within people favor. But for this purpose the human has nothing except the brain given by the nature. Ecology is also a diverse discipline.

Modern ecology is the doctrine of ecosystems revealing the patterns of their composition, structure, functioning and evolution for the study of which it is necessary to apply to mathematical methods. The most widespread use of mathematical models is the development of information technology and modeling methodology This is necessary to represent a biosphere development future image and to study the conditions for the joint humanity and environment evolution or degradation.

The role of mathematics is difficult to overestimate, because it is the best tool for studying abstract relations and is applicable to any sciences. Regardless of the nature of the phenomenon being studied, mathematics can accurately and clearly formulate a scientific problem. This leads to a diversification of the possibilities of analyzing any problem using mathematical methods.

If in the beginning the questions and results of mathematical modeling in ecology were exclusively abstract theoretical interest then in the future. There is a specificity with its inherent practical character. Thus the development of mathematical and ecological models can be traced to the evolution of scientific and applied problems solved by them. Obviously these issues have become more complex as the environment develops and the modeling methodology improves.

Let us emphasize that mathematical modeling can`t replace experimental ecological studies. On the contrary mathematical modeling stimulates the accumulation of factual material and refines the direction of the experiments. The Mathematical modeling development is necessary for constructing predictions of real objects dynamics and for scientifically based quantitative various impacts on the objects under study consequences predictions. Especially important place they occupy in the study of natural ecosystems, experiments with which are very difficult and often unacceptable.

Traditional forecasting is expressed in the choice of a single and better predictor and its operation. Environmental prediction specificity in the context of globalization lies in fact that same phenomenon study occurs through a variety of different and observance of the principle of multiplicity of models.

Ecosystems are considered a variety of large systems and function and develop in time and space under the influence of internal determinism and inertia. When modeling ecosystems their structure is taken into account. In this structure, the physical and biological and temporal structures are distinguished. Analysis allows us to identify the main elements of the system, its quantitative characteristics, which should be included in the mathematical model. The links between ecosystem elements and the environment are determined by the circulation of matter, energy and information [3].

Studied ecosystem states prediction is possible only if there is a sufficient amount of observational data. In those cases where this data is lacking the only way is to collect the missing information. Otherwise, the mathematical apparatus and information technologies are meaningless.

Existing objective trends in system parameters changes are preserved to a certain extent for a certain period. In addition real large systems elements are under constant influence of external acting unpredictably random factors and under the extremely complex interlacing of internal interrelations. It follows that the prediction of the behavior of ecosystems makes sense only within the framework of probabilistic categories. At the same time, only the probabilities of their occurrence can be indicated for the expected events, and in the cases of the values of certain quantities it is necessary to be within the laws of their distribution or other probability characteristics.

Numerical data characterizing processes that are in constant change and motion form a series of dynamics. Most often dynamic series are understood as temporal sequences, although the dynamics includes not only a change in time, but also any other change in state under the influence of external conditions, for example, in space.

Time series analysis theoretical grounds are contained in the theory of random processes. Random processes are a family of random functions $\boldsymbol{X}(\boldsymbol{t})$ that depend on a single parameter which in most cases is time. Modern method of random processes statistical analysis is based on the dynamic trajectory continuity postulate. However in practice in order to overcome computational difficulties, a continuous series is presented in tabular form in the form of discrete numerical sequences (even if a continuous recording of a change in the phenomenon was made using mechanical or electronic devices) [1].

The choice of strategy and methods for the preliminary processing and time series analysis depends on the ultimate researcher goal. However as a rule the first step is to estimate the trend of the time series.

Any series of time can be divided into three components:

$$x(t) = f(t) + g(t) + h$$

f(***t***) means a deterministic component as an analytic function expressing a tendency in a series of dynamics;

g(***t***) is a stochastic component that simulates the character of the periodic variation of the phenomenon under study;

h is a random component / White Gaussian Noise [2].

The example demonstrates the types of components that may appear in a time series. These are:

1. a trend component, such that there is a long-term tendency for the values in the series to increase or decrease (as for the sandwich tern);
2. a seasonal component for series with repeated measurements within calendar years, such that observations at certain times of the year tend to be higher or lower than those at certain other times of the year (as for the water temperatures in Dunedin);
3. a cyclic component that is not related to the seasons of the year (as for sunspot numbers);
4. a component of excursions above or below the long-term mean or trend that is not associated with the calendar year (as for global temperatures); and
5. a random component affecting individual observations (as in all the examples).

Time series use and analysis is increasingly popular in ecology, especially as equipment becomes available to automatically measure and record environmental variables. The paper illustrates just the only feature of the mathematical modeling process in environmental sciences. In conclusion of this article the author notes that methodology for constructing models can only be mastered as a result of one's own practice. This is determined by the decision of the cases, by turning to alternative scenarios and developing the skills of modern mathematical thinking.

References

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