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ROLE OF ECO-INFORMATION IN MONITORING: *PRO ET CONTRA*

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Abstract. The author examines a number of concepts and laws that came to ecology from informatics and became widespread due to their deep semantic content. Although the importance of information processes for the implementation of ecological functions is widely recognized today, the fundamental principles of information theory are not sufficiently reflected in theoretical ecology. True, some general theoretical problems in the light of information theory (hierarchy, stability, interspecies interactions, classification of ecosystems, etc.) are discussed by specialists. The author examines attempts to create new scientific directions - "environmental informatics" and "information ecology". The "informational approach" in the study of certain properties of ecosystems should be perceived only as a method. The conclusion is made that "informational ecology", "ecological informatics" do not have the right to pretend to a new and original direction. Synecology focuses on the relationship of populations with each other; in this case, information theory can be applied in a very natural way to the study of interrelated processes. Two aspects of information are discussed: syntactic and semiotic information. It is hoped that, as a result of the methodological successes, the "informatization" of ecology will not take much time, as it might seem. However, it seems that this task in its difficulty exceeds the limits of any individually planned program. The "information" approach is applicable in ecology only within the framework of analogies that can "lead" the thought of environmental researchers to the formulation of new approaches and directions for the search for new laws and patterns.
Key words: information, geoinformation monitoring, information field.

Dedicated to the memory of Doctor of Physical and Mathematical Sciences,
Professor Vladimir F. Krapivin (1936–2021).
Посвящается памяти доктора физико-математических наук,
профессора Владимира Федоровича Крапивина (1936–2021).

Information is not knowledge and knowledge is not wisdom.
Информация – ещё не знание, знание – ещё не мудрость.
James Gleick; born 1954 – American writer,
journalist (Gleick, 2011, p. 380).

Introduction

We all live in an information society and the modern world is no longer able to do without information technologies, since every day they are being introduced more and more into our daily life. Computer science – «the science of the methods and processes of collecting, storing, processing, transferring, analyzing and evaluating information using computer technologies that provide the possibility of using it for decision-making» [Zhuravlev, Gurevich, 2008, p. 481] – for more than half a century has been one of the most important scientific and applied directions, forcing us to keep pace with the times along the path of human progress. Even Wiener in 1948 noted: «Information is in-

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formation, neither a matter and nor energy. Materialism which does not recognize this cannot be viable at the present time» [Wiener, 1948, p. 66].

At the same time, nature conservation, rational use of its resources and ecosystem services today can no longer be imagined without strictly quantitative research methods and mathematical modeling of ecosystems. Therefore, inevitably, «there was a need to develop an interdisciplinary direction of science, which would combine GIS, global modeling, GIMS (*geoinformation monitoring systems. – Author's note*), expert systems and would take into account the socio-economic aspects of human nature conservation. Ecoinformatics has become such a direction» [Krapivin, 2011, p. 29].

Ecological (environmental) informatics

Thus, environmental informatics (ecoinformatics) combines environmental and information sciences. In its most general terms, it is the science of applying mathematical modeling and computing techniques to the study of the functioning of ecosystems. «Environmental informatics (ecoinformatics) is a section of applied informatics associated with the development and application of methods, procedures and ICT *(information and communication technologies. – Author's note*) for environmental research, including the acquisition, processing and analysis of environmental data, the development of measures for protection of the environment, a description of the links between the OS (*environment. – Author's note*.) and man-made systems, including industrial enterprises. <...> Applying the methods of ecoinformatics for collecting, processing and analyzing environmental data, methods of modeling ecological systems (ecosystems) and decision support systems (DSS) for various tasks of environmental analysis, it is possible to obtain the results of assessing the current state and to predict the characteristics of the operating system, which make it possible to explain and solve many environmental problems. The object of research in ecoinformatics is various ecological systems and arrays of ecological data that characterize the state of the environment. The subject of research in ecoinformatics is the processes of collecting, processing and storing environmental data. Methods of ecoinformatics are methods of mathematical statistics for processing ecological data, methods for analyzing temporal characteristics of the environment (time series), methods of ecological modeling, methods of development and methodology for using DSS for managing environmental protection» [Meshalkin et al., 2020].

Information is structurally heterogeneous and includes syntactic (form), semantic (meaning) and pragmatic (value) components, described by three corresponding sections of semiotics - the general theory of sign systems [Kull, 1999; Knyazeva, 2018]. Biosemiotics, as a branch of semiotics, examines the properties of signs and sign systems (sign processes) in living systems. Distinguish between phyto-semiotics (studies sign processes in plants [Krampen, 1981; Kull, 2000]) and zoosemiotics (studies biocommunication of animals – the transfer of information from one individual to another – from the standpoint of the content of their communicative actions [Naumov, 1973; Mozgovoi, 2005; Nikolsky, 2013; Kull, 2014].

Biodiversity

Biodiversity is a form of information; it is information stored in genes, morphology, behavior, reflecting the ecological and evolutionary history of the life of organisms on Earth. Ecology is still not able to fully understand the consequences of the loss of this information (biodiversity) for its reading (processing) and control of the flows of matter and energy with its help. Although some concepts and methods for assessing biodiversity are not poorly developed, they are not yet embedded in the frameworks of theoretical ecology (general relationships between information and flows of matter and energy). For the sake of fairness, I note that some general theoretical problems in the light of information theory (hierarchy, stability, interspecies interactions, classification of ecosystems, etc.) are discussed by specialists (see, for example, [Ulanowicz, 2002]). Thus, while it is generally accepted that biodiversity is being lost (valuable information is irrevocably lost), we do not have basic principles to guide our understanding of the impact of this threat. At the same time, anthropogenic activity can destroy the integrity of information networks and their ability to adapt even before they become the subject of study in the framework of environmental science [O'Connor et al., 2019, p. 2].

In recent years, more and more articles have begun to appear in which the foundations of a new scientific direction – «information ecology» are discussed in all seriousness [Davenport, Prusak, 1997; Mizintseva et al., 2000]. I think this is superfluous, for a number of reasons [Rozenberg, 2011], among which there is such an argument: the «information approach» in the study of certain properties of ecosystems should be perceived only as a method (if you have carried out a study of microorganisms using a microscope, then it would not occur to you to defend this work in physics [optics], but rather you will defend in microbiology. The situation is a bit like trying to «hijack» a resounding domain on the Internet, so that if you are lucky, make it a subject of bargaining). Thus, information theory (as well as mathematical modeling, automatic control, etc.) makes it possible to see some analogies in the description of ecosystems and apply (with a clear understanding of possible limitations) the corresponding apparatus; and this is not a new science.

This can be attributed to the emerging «environmental informatics»; the question of the need for «environmental informatics» can be reformulated as follows: «Is it necessary for informatics?» or «What new

can this give to the general laws of information transfer?». Information theory in environmental research, so far, has been reduced only to measuring information ecologists has not yet been attracted by the main limiting ratios for data transmission systems, which constitute its essence. Thus, it seems that, as with «information ecology», «environmental informatics» does not have the right to claim a new and original direction. The natural process of the interpenetration of various sciences has not yet gained «critical mass» here.

Today, it seems very likely that the study of ecology will be conducted in at least two separate areas – aut- and demecology, on the one hand, and synecology, on the other, which will apply the methodology of information theory in different ways [Ulanowicz, 2002]. Information theory «professes» a relational approach [Bateson, 1972], according to which it is impossible to say that people, animals or other organisms enter into communication (informational approach) or participate in it (interactional approach), since they are already an integral part of this process whether they like it or not, part of both local and global relationships. This approach conflicts with the methods of aut- and demecological studies (emphasis on the size and composition of the population, and relations with other populations remain secondary). Indeed, in such a situation, many information approaches lose their meaning (an exception is the analysis of information fields [Naumov, 1973; Mozgovoi, 2005]). Synecology, on the contrary, focuses on the relationship of populations with each other; in this case, information theory can be applied in a very natural way to the study of interrelated processes.

One hopes that as a result of methodological successes, as well as experience gained in other areas of knowledge, "informatization" of ecology will not take much time, as it might seem. However, it seems that this task in its difficulty exceeds the limits of any individually planned program. Moreover, the process of mathematizing the introduction of information theory into ecology is not at all trivial (more precisely, it is little, or not at all, is still used in this process [Krapivin, Potapov, 2002; Burkov, Krapivin, 2009; Krapivin, Shutko, 2012].

Conclusions

In conclusion, I note that the feeling of dissatisfaction with mathematical interpretations of the application of information theory in ecology is largely due to the fact that they often give (confirm) statements that using an entropy indicator. But information theory is not a theory of measuring information (more precisely, it is far from only measuring information); the attention of are no better than the same statements expressed in verbal form. John von Neumann and Oskar Morgenstern [1944] came up with the following idea, regarding the use of game theory in economics: there is no evidence because the mathematical apparatus is applied to those areas that are so vast and complex that for a long time – until more empirical facts are accumulated – hardly whether serious progress can be expected from an increase in the dose of mathematics alone. The fact that these areas are attacked in this way only shows that the difficulties accompanying this process are underestimated. In reality, these difficulties are enormous, and we do not feel prepared enough to overcome them.

It remains to emphasize once again that the «information» approach is applicable in ecology only within the framework of analogies that can «lead» the thought of environmental researchers to formulate new approaches and directions of searching for new laws and patterns. Moreover, success should be expected not in the direct use of information measures to assess biodiversity or ecosystem similarity, but in deep penetration and ecological interpretation of the limiting cybernetic laws of the potential effectiveness of complex systems.

I'd like to finish the article with the words of Shannon from the short note in Bandwagon: «What can be done to inject a note of moderation in this situation? In the first place, workers in other fields should realize that the basic results of the subject are aimed in a very specific direction, a direction that is not necessarily relevant to such fields as psychology, economics, and other social sciences (*biology and ecology can be added to this list. – Author's note*.). <…> but the establishing of such applications is not a trivial matter of translating words to a new domain, but rather the slow tedious process of hypothesis and experimental verification. <…> Secondly, we must keep our own house in first class order. The subject of information theory has certainly been sold, if not oversold. <…> Only by maintaining a thoroughly scientific attitude can we achieve real progress in communication theory and consolidate our present position» [Shannon, 1956].

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РОЛЬ ЭКОИНФОРМАЦИИ В МОНИТОРИНГЕ: *ЗА И ПРОТИВ*

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Аннотация. Автор рассматривает ряд понятий и законов, пришедших в экологию из информатики и получивших широкое распространение благодаря своему глубокому смысловому содержанию. Хотя важность информационных процессов для реализации экологических функций сегодня общепризнана, фундаментальные положения теории информации недостаточно отражены в теоретической экологии. Правда, некоторые общетеоретические проблемы в свете теории информации (иерархия, устойчивость, межвидовые взаимодействия, классификация экосистем и др.) обсуждаются специалистами. Автор рассматривает попытки создания новых научных направлений – «экологическая информатика» и «информационная экология». «Информационный подход» в изучении тех или иных свойств экосистем следует воспринимать только как метод. Делается вывод о том, что «информационная экология», «экологическая информатика» не имеют права претендовать на новое и оригинальное направление. Синэкология фокусируется на отношениях популяций друг с другом; в этом случае теория информации естественным образом может быть применена к изучению взаимосвязанных процессов. Обсуждаются два аспекта информации: синтаксическая и семиотическая информация. Есть надежда, что в результате методологических успехов «информатизация» экологии не займет много времени, как может показаться. Однако кажется, что эта задача по своей сложности выходит за пределы любой индивидуально спланированной программы. «Информационный» подход применим в экологии лишь в рамках аналогий, способных «подвести» мысль исследователей-экологов к формулировке новых подходов и направлений поиска новых законов и закономерностей.
Ключевые слова: информация, геоинформационный мониторинг, информационное поле.