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Principles of General Ecology†

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Abstract: Ecological systems are studied in many areas. There are different ecological areas: plant ecology, animal ecology, natural ecology, human ecology, industrial ecology, information ecology, ecology of mind, knowledge ecology and so on. Here we develop a unifying approach to ecological studies developing general ecology, which encompasses and organizes different directions on a reliable foundation. Information ecology as one of the basic areas in ecological studies is placed in a resourceful environment allowing its accelerated development and advanced expansion.

Keywords: information, system, ecology, ecological system, world, component, technology

1. Introduction: A historical perspective

The term *ecology* (*Ökologie* in German) was coined in 1866 by the German scientist Ernst Haeckel (1834–1919) from two Greek words *oikos*, which means *house*, or more generally, *habitat* or place of living and logos, which was used in ancient Greece denoting such concepts as *order*, *meaning*, *foundation* or *mind* [1]. Haeckel's initiative instigated an approach, where European botanists investigated plant communities related to definite territories and their interdependencies, giving rise to the science of ecology, which was dealing not only with plants but also with other living beings.

In the contemporary science, ecology is a holistic study of living systems in relation to their environment by explicating patterns of, processes in and relationships between these systems.

At the same time, ecology as a whole contains such subdisciplines as plant ecology and animal ecology.

Plant ecology studies the distribution and abundance of plants, the effects of environmental factors upon the abundance of plants, and the interactions among and between plants and other organisms [2].

Animal ecology is the scientific study of animals and how they related to and interact with each other, as well as with their environment, determining the distribution and abundance of organisms.

Together these two areas form *natural ecology*, whereas researchers also created other ecological fields. One of them is *human ecology*, which is an interdisciplinary and transdisciplinary study of the relationships between humans and their natural, social, and technological environments involving a variety of disciplines: geography, sociology, psychology, anthropology, zoology, epidemiology, public health, home economics, and natural ecology, among others [3].

While ecology has traditionally dealt only with natural systems, the new field of *industrial ecology* studies industrial products as part of larger systems and processes including industrial behavior and biogeochemical cycles as a part of a system and aiming at reduction of the environmental impacts of production, consumption, and disposal.

Chinese scientist Yixin Zhong initiated *information ecology* [4,5]. This discipline is essentially important for information studies as a holistic approach to the existence and functioning of information processing systems, as well as for better understanding of information processes in all spheres of reality. If ecology of plants studies structures and processes in systems of plants,

information ecology studies structures and processes in organizations of information processing systems and formations.
One more ecological area is *ecology of mind* suggested by Bateson [6].
Researchers also study *knowledge ecology* [7,8], which is an approach to knowledge management aimed at fostering the dynamic evolution of knowledge interactions between systems to advance decision-making and innovation by means of enhanced evolutionary networks of collaboration. In contrast to purely instructional management, which attempts either to manage or to direct outcomes, knowledge ecosystems advocate that knowledge strategies should focus more on enabling flexible self-organization and self-improvement in response to changing environments.
In addition, American anarchist and libertarian socialist author Murray Bookchin introduced *social ecology* as a critical study of society [9].

2. Principles and structures of general ecology

Existence of different ecological disciplines needs a common foundation and presented in this work *general ecology* provides such a unifying foundation for all ecological studies.
The concept of *ecosystem* proposed by the English ecologist Arthur Tansley is central for different ecological disciplines. That is why we start our exposition with defining this concept in the most general context. To do this, we describe how the global structure of the world affects the organization of ecosystems.
The large-scale structure of the world is represented by the *Existential Triad* [10], which is presented in Figure 1.

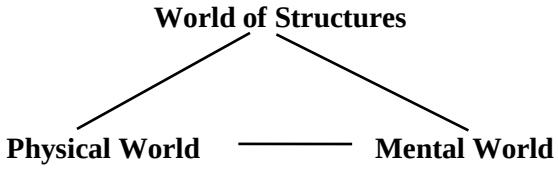

Figure1. The Existential Triad of the World

The three worlds from the Existential Triad are not separate realities: they interact and intersect. Individual mentality is based on the brain, which is a material thing, while in the opinion of many physicists mentality influences physical world (cf., for example, [11]). At the same time, our knowledge of the physical world largely depends on interaction between mental and material worlds.
Note that not only people but also all information processing systems have their mentality. Let us look at a computer. The content of the computer's memory can be naturally treated as the mentality of this computer. For instance, the operating system is a part of the mentality of the computer.
The World of Structures consists of various forms and types of structures perfectly matching to Plato's World of Ideas/Forms because ideas or forms are correctly associated with structures. Structures exist like material things, such as tables, chairs, or buildings do, and form the *structural level* of the world. When it is necessary to learn or to create a system or to start a process, it is done, as a rule, by means of knowledge of the corresponding structure. Structures mold things in their being and comprehension.
The global structure of the world induces three types of ecosystems:

- *Physical ecosystem* includes physical systems and processes as its elements and components
- *Mental ecosystem* includes mental systems and processes as its elements and components
- *Structural ecosystem* includes physical systems and processes as its elements and components

When all three components of the world stratification are combined in one system, we have a *total ecosystem*. Such a total ecosystem has three constituents:

- The physical constituent of the ecological system and its environment
- The structural constituent of the ecological system and its environment
- The mental constituent of the ecological system and its environment

An ecosystem is delineated by three parameters:

- A region in the space, i.e., it is assumed that all elements and components of an ecological system belong to a definite region in the space
- The primary types of its elements/components, i.e., it is determined what elements and components of given ecological system are considered the most important from the point of view of ecological studies
- The basic types of connections between its elements/components including processes as dynamic connections, i.e., it is determined what connections, ties and processes in given ecological system are considered the most important from the point of view of ecological studies

For instance, in a natural ecosystem, living organisms form the primary type of elements and a chosen area on the Earth shapes the region in the space. In this context, a natural ecosystem is composed of the dynamically interacting parts including all living organisms in a given area, which interact with each other and with their non-living environment.

In an information ecosystem, information processing systems form the primary type of elements and a chosen area on the Earth (may be the whole Earth) shapes the region in the space in which information processing systems are interacting with each other, and also with their environments. In addition, studies of information ecosystems concentrates on information processes going in the system.

Note that there are different kinds of information processing systems: technical information processing systems, living information processing systems, human information processing systems and so on.

Three grades of (types of) elements/components:

- Primary or leading elements/components
- Secondary or auxiliary elements/components
- Tertiary or background elements/components

Ecological studies are aimed at understanding existence and functioning of the primary elements/components of ecosystems, as well as basic connections, ties and processes in these ecosystems.

A physical ecosystem contains parts, elements and components of three kinds:

- Natural parts, elements and components, which include physical systems and processes in nature
- Technological parts, elements and components, which include technological systems and processes
- Social parts, elements and components, which include social systems and processes

In a physical ecosystem, it is possible to consider only physical processes or also to take into account mental and information processes.

A mental ecosystem contains parts, elements and components of three kinds:

- Natural parts, elements and components, which include and comprise mentality and its components of living beings
- Technological parts, elements and components, which include and comprise mentality and its components of technical devices
- Social parts, elements and components, which include and comprise mentality and its components of groups, communities and societies of living beings and technical devices

In a mental ecosystem, it is possible to consider only mental processes or also to take into account information processes.

A structural ecosystem contains parts, elements and components of three kinds:

- Natural parts, elements and components, which include structures of physical systems and processes
- Technological parts, elements and components, which include structures of technological systems and processes
- Social parts, elements and components, which include structures of social systems and processes

4. Conclusion

The general ecology standpoint shows that it is possible to study information ecosystems either as physical ecosystems or as mental ecosystems or as structural ecosystems. It gives three perspectives at information ecosystems allowing researchers to obtain better knowledge and understanding of these systems. One more possibility is to study total information ecosystems combining all three perspectives in one model.

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