UDK 544.313.:[581.522.4+581.95]

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THERMODYNAMICAL ASPECTS OF THE INTRODUCTION PROCESSES

The theoretical component of the introductory process from the standpoint of the laws of thermodynamics is determined. At the ecosystem level, vegetation groups with specific environmental conditions characteristic of each species have been analyzed. The information resource approach is proposed as a biotechnical analogue for the study of the structural and functional organization of ecosystems of different levels of the hierarchy and ten basic characteristics are determined from their evaluation.

Key words: introduction, laws of thermodynamics, main characteristics of ecosystem assessment, information and resource modeling.

During many decades on the territory of M.M. Gryshko National Botanical Garden due to the unique principle of representing live plants in botanical and geographic areas artificial phytocoenoses close to natural with stable homeostatic introducing populations have been formed. In accordance with the laws of thermodynamics, any ecosystem consists of living organisms that are independent of each other, with the environmental conditions characteristic of each of them. At the same time, each organism is directly involved in the constant transfer of energy and mass, which occurs in a condition of a balanced or unbalanced state. Therefore, only thermodynamics provides a quantitative definition of the organization or disorganization of the ecosystem.

Ecosystems of any level of the hierarchy (from living cells to biogeocoenoses) can be described within the framework of a conceptual structural model that reproduces the general principles of life, adaptation and evolution. In this case, the conceptual model as a biotechnical analogue of systems of this complexity level includes two subsystems — resource and information.

Resource substructure, according to the theory of V.I. Vernadsky, describes the dynamics of the balance of material and energy resources and their ecological and physiological transformations in the process of plant life. Life activity should be considered as a process of regulation aimed at either structuring (in the presence of sufficient resources) or maintaining the existing structure (with a limited amount of resources).

Information substructure reproduces the information flows at different hierarchical levels for the formation of a structured knowledge base. In the process of plant life, the implementation of functional information is continuously carried out in the form of regression or adaptation, while structural information is only partially avaibalbe for external observation.

Our studies of the structural and functional organization of ecosystems at the botanical and geographical expositions made it possible to develop conceptual models of natural and artificial biogeocoenoses from the standpoint of the laws of thermodynamics and to determine the sequence of their synthesis for climatic changes; to identify the goals and criteria for identifying ecosystems; to construct conceptual models of the structure of an object, in which each subsystem corresponds to an information model and an adequate state parameter; to establish the rank of the information matrix of the state parameter and its orthogonality; to get the primary information and to process it at the current time scale; to check the system performance.

In particular, the first law is based on the fact that ecosystems of different hierarchical levels

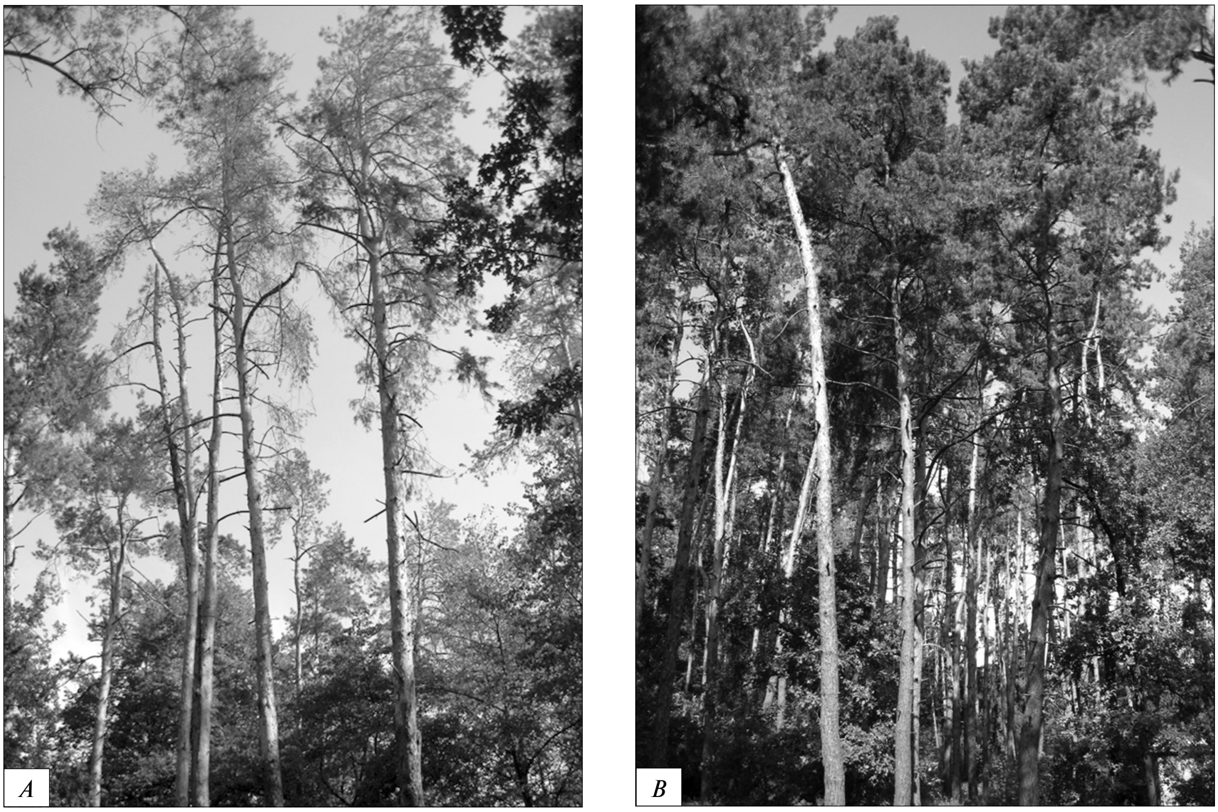

Fig. 1. State of pine plants on the botanical-geographical area "Forests of Ukrainian Plain": *A* — corrupted, drying plants; *B* — healthy plants

function due to their internal energy and external energy source. As an example, the etiology of drying out is a poorly understood and unclear section of forest pathology. The one-sidedness of interpretations of causal relationships is generally characterized by a rather simplistic approach, which explains the root cause of any factor that is understandable by an expert. The drying of trees of one or more species, especially at different stages of the ontogeny, is stretched in time and space, and a lot of factors influence the process. Taking into consideration that those ecosystems are the most complex biological complexes in the organic world, the pathological process is always the interaction of big number of organisms of different taxonomic groups. Therefore, the problem of massive drying of pine trees must be considered from the standpoint of synecology and biogeocenology, given that pests and phytopathogenic microorganisms cause death of plants at the final stage. Our recent studies have proved that one of the primary causes of pine-tree depletion, not only in Ukraine, but also in Europe, is the consolidation of forest litter, it's very rapid destruction, which results in the accumulation of large volumes of ammonium nitrogen in the soil (Fig. 1). The forest floor can be viewed as a mixture of organic substances (cellulose, proteins, resins, etc.), which performs many protective functions, one of the main of which is preventing soil compaction, preservation of entomophagous insects and microorganisms that inhibit the development of pathogenic organisms, supporting the biological balance of the forest ecosystem. The main reasons for the accumulation of ammoniac forms of nitrogen in the soil under pine plantations are:

• consolidation of soil as a result of rapid destruction of forest litter and short-term showers;

• lighting of the forest, development of grassy vegetation, accumulation of organic matter, formation of humic acids in aerobic conditions, synthesis of water-soluble ammonia compounds and their penetration under drought conditions into anaerobic zone;

• lack of moisture due to reduced rainfall and more intensive aerobiosis during drought 3; the continuous accumulation of mineral salts in the turf horizon;

• ammonium salts, which are always present in rainwater;

• high temperatures, which leads to overheating of soil due to the rapid destruction of forest litter;

• low content of potassium and calcium soils;

• inhibition of nitrification processes due to high acidity of the soil.

Consequently, accumulation of ammonia nitrogen and soil consolidation occurs in the conditions of destruction of forest litter, which leads to the physiological weakening of pine plants and makes them favorable for the settlement of insects, phytophagous and phytopathogenic microorganisms. Reduction of the negative effects of ammonia nitrogen on the root system of pine plants can be achieved by adding of potassium and calcium salts. It is possible to radically solve the problem of protection of plants of pine trees against drying out by managing the processes of soil microbiote development with the help of nitrification inhibitors, as well as siliceous mixtures that change the composition and ratio of microorganism populations, however, it requires additional research. In addition, it is necessary to optimize the species composition of plants in pine plantations through the mandatory formation and conservation of the leveling, and in the case of overall cuttings other wood species should be planted.

The second law indicates the irreversibility of macroscopic processes that occur at a certain speed. Thus, in a closed isolated ecological system, the entropy either remains unchanged, or increases and in equilibrium reaches the maximum bearings. As an example of the second law of thermodynamics could serve integrated studies of varying degrees of complexity of organisms that are in an active physiological state under conditions of a hermetic volume, and which enable the discovery of the versatile effects of stress factors, including microgravity on the vital functions and the development of living systems (Fig. 2). In a series of cosmic and laboratory experiments that model to some extent the influence of individual factors of the orbital flight, one can determine the nature of the changes occurring in different objects under the influence of physical stress factors depending on the nature and duration of the factor, the degree of complexity and physiological state plants [1].

Fig. 2. Japanese Garden of M.M. Gryshko National Botanical Garden. Development of closed ecosystem

The third law of thermodynamics, or the Nerst theorem, proves that the entropy of physico-chemical processes within the ecosystem in the state of thermodynamic equilibrium in the direction of temperature parameters to absolute values remains unchanged. According to the general principles of the reliability of the functioning of biological systems, the coordination of plant life processes is carried out by several independent regulatory systems, in particular electrophysiological. Agitation, which spreads in the leading tissues, is probably the first and the most urgent type of connection between all organs of plants, as long as the slower regulatory channels enter into force. The exceptional importance of bioelectric processes in the implementation of self-regulation, adaptation and evolution of living organisms requires a detailed study of bioelectric potentials. The manifestation of the third law is the very stable indicators of the surface biological potentials of the

Fig. 3. The manifestation of the third law. Blooming of *Vanda hybrida*

flower, especially its reproductive organs, which remain unchanged in all parameters of the environment (Fig. 3).

The fourth temporary law, or the concept of Prigozhyn, is based on the concept of dissipative structures, that is, living organisms maintain themselves in a state of distant from equilibrium. As an example, there are many metabolic processes that occur in living organisms and the chemical and thermal equilibrium when these processes are stopped. The principles of life cycle discretization in the range of different durability allow us to consider the plant as a purposeful system in conjunction with the local environment within the framework of the planetary system and a global source of solar energy resources. In this case, the genotype is presented as a purposeful system of a higher level of hierarchy, under the control of which is the structure formation and the choice of the strategy of life. The phenotype is a collection of not only morphological features, but also products of the exchange of physiological and biochemical processes (Fig. 4).

Thus, the system for managing the processes of structure formation and plant life has a complex organization, hierarchical in terms of functional goals and mode of existence, which are laid down in the basis of genetic knowledge.

Currently, there are two principles of thermodynamics that can be used to describe equilibrium ecosystems of introductive populations. The first principle is valid for isolated ecosystems, that is, entropy always increases with time and approaches to the maximum values in a state of equilibrium. The second principle is for the open ecosystems, in particular agrarian ones, namely: entropy decreases over time and approaches to the minimum values in a state of equilibrium.

Based on the above we can list ten basic characteristics to describe ecosystems of any hierarchical level of complexity:

1 — the principle of maximum energy accumulation [2]: the systems will be controlled provided the maximum amount of energy is available;

2 — the principle of maximum energy conservation [3]: accumulation of biomass;

3, 4 — maximum correspondence and realization [4]: different type of carbon fixation in plants;

Fig. 4. Destruction processes of forest ecosystem

5 — maximum improvement of the system [5]: optimization of agrophysical and agrochemical parameters of the soil;

6 — maximum bifurcation [6]: high adaptive potential of plants;

7 — the principle of cyclicity [7], or far-from-equelibrium: ontogenetic development of plants;

8 — hour principle [8]: the term of self-renewal of the ecosystem;

9 — minimal bifurcation [9]: genetically programmed processes in plants;

10 —minimal responsibility and implementation [10]: sensitivity of plants to stress factors.

Conclusions

Thus, the analysis of the introduction process from the standpoint of the laws of thermodynamics makes it possible to analyze natural and artificial ecosystems interaction with the external environment as an adaptive, purposefully developed system, taking into account that the soil and plant groups are adapted to certain biological, geological coenoses and difficult to be approximated. The information resource approach to the estimation of natural biological, geological coenoses makes it possible to identify parametrically the processes of their functioning and structure formation using the existing modeling theory.

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Recommended by P.E. Bulakh
Received 15.11.2018

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АСПЕКТИ ТЕРМОДИНАМІКИ В ПРОЦЕСАХ ІНТРОДУКЦІЇ

Визначено теоретичну складову інтродукційного процесу з позиції законів термодинаміки. На екосистемному рівні проаналізовано рослинні угруповання з характерними для кожного виду умовами довкілля. Запропоновано інформаційно-ресурсний підхід як біотехнічний аналог для дослідження структурно-функціональної організації екосистем різного рівня ієрархії та визначено 10 основних показників для їх оцінки.

Ключові слова: інтродукція, закони термодинаміки, основні показники для оцінки екосистем, інформаційно-ресурсне моделювання.

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АСПЕКТЫ ТЕРМОДИНАМИКИ В ПРОЦЕСАХ ИНТРОДУКЦИИ

Определена теоретическая составляющая интродукционного процесса с позиции законов термодинамики. На экосистемном уровне проанализированы растительные сообщества с характерными для каждого вида условиями внешней среды. Предложен информационно-ресурсный подход как биотехнический аналог для исследования структурно-функциональной организации экосистем разного уровня иерархии и определены 10 основных показателей для их оценки.

Ключевые слова: интродукция, законы термодинамики, основные показатели для оценки экосистем, информационно-ресурсное моделирование.