

## Challenges concerning terminology and methodology in forest sciences\*\*

Tomasz J. Wodzicki

Forest Research Institute, Part-time Doctoral Studies (NSD), Sękocin Stary, ul. Braci Leśnej 3, 05-090 Raszyn, Poland

Tel. +48 22 7150561, e-mail: [tomasz.wodzicki@wp.pl](mailto:tomasz.wodzicki@wp.pl)

**Abstract.** Commonly used scientific terms and their specific meaning in the context of forest sciences and services were the focus of this article. Special attention was devoted to analyzing the meaning of ecological terminology such as "niche", "homeostasis", "natural" and "succession" in order to better understand problems related to the interaction between and within complex biological structures such as forest multi population ecosystems and the human population. Especially the role of *Homo sapiens* occupying an ecological niche in forest ecosystems, as well as in the Earth's biosphere, formed the core in this discussion. One important challenge in terms of terminology and methodology concerns the considerable progress and interaction between achievements in the general sciences such as biology, physics, physiology, mathematics, sociology and economy as compared to forest sciences. Challenges are obviously accompanying the development in scientific terminology and are thus an important factor when conveying knowledge to the future doctors of forest sciences.

**Keywords:** forest ecosystem homeostasis, human forest niche, forest ecosystem evolution

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### 1. Introduction

The specificity of the problem in forest sciences results from the complex interaction of two of the terrestrial biological geophysical systems, which – mutually – constitute an element of the living environment of each of them. One is the collective system of many populations related to the specialisation of trophic processes, the other concerns only a single genetic population, but which is equipped with the ability to accumulate knowledge and the mental potential for consciously choosing criteria in using the resources of the environment of its own existence. At present, through the course of evolution, both systems have achieved the highest level of complexity of their functional structure. In order to maintain stability and further develop the interaction of both systems, forest management requires scientific research that takes into account the progress in knowledge of the basic sciences. The scientific circles of foresters should particularly take note of the problems of research methodology and progress in knowledge of the fields of genetics, physics, ecology, economics and sociology. By using the methodology of studying basic problems, the progress of knowledge in the field of forest sciences provides the opportunity to mobilise the reserves of development potential, both in forest ecosystems as

well as in the human population. In both cases, this potential is determined by the natural laws of evolutionary processes.

### 2. The niche relationship between forest ecosystems and the human population

Discussion on the essence of the relationship between the processes of forest ecosystem development and the human population requires the concept of niche to be elaborated. This concept, introduced in parallel with distinguishing an ecological research methodology, referred to the structure of the interdependence of biological systems and environments in the ecosystem. Today, it concerns not only the conditions of the abiotic environment but also the interdependence of the development of genetic populations (capable of reproduction) as an important component of the living environment for each of them in the process of specialising in the manner of obtaining food and acting as a host in the food chain of complex biological systems. In other words, an ecological niche means the location of genetic populations (and even an individual organism in the population) or their functional groups in processes conditioning reproduction, not only of their own kind in the ecosystem but also of ecosystems as units of the evolution of various structural

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forms of biogeocenosis. Although each genetic population in the collective structure of the relationship between life and the abiotic environment occupies its own ecological niche (even representing a similar functional specialization), it is also an element of the living environment of each of the other populations. In forest sciences, the concept of ecological niche refers not only to the individual and group developmental interdependence of species but also to the lives of entities of multi-species formations: autotrophs, herbivores, predators, reducers, parasites, symbionts and even functionally different, distinguished populations or individuals relative to their entire environment if they are a reproductive element of each biotope (on the scale of the global biosphere of planet Earth).

### **3. Homeostasis – processes of balancing forest development in forest management**

The niche structure of both the ecosystem and the biosphere is always the result of the functional specialisation of the genetic population, manifesting itself primarily in morphological diversity, because at every level of the organisation of life, morphogenetic development processes are realised, thanks to homeostasis. The success of natural selection in the niche structure of forest ecosystems is also the result of the evolution of homeostatic processes in phylogeny, which determines the specialisation of both the morphology and physiological properties of genetic populations (taxonomic units). The concepts of homeostasis, niche and evolution also apply to the nature of the natural relationship between structural changes in forest ecosystems and the activities of human life, that is, the relationship between forest ecology and forestry economics. These concepts, although they characterise the natural mechanism for the implementation of the basic laws of nature, have not yet been often used in discussions and the development of research programmes in the forest sciences. These terms are important when studying the relationship of the problems of forest sciences with the progress in other fields of specialised knowledge.

The first of the three aforementioned terms is the concept of homeostasis, which in forestry practice is equated with the concept of balance as a measure of immutability, that is, the state of the structure. This is due to the fact that observations and measurements generally relate to the state of the object only at the time of their performance. In studies of all life formations – and in this case, these are two complex life forms in the Earth's biosphere – the mechanism of creating a state of equilibrium in the system, that is, negative feedback processes, is important as a manifestation of all balancing mechanisms and their variability in subsequent stages of the development of biological systems. The currently measured state of equilibrium of the structure's elements is only the result of these mechanisms. In forest ecosystems, these are mainly the feedback loops of changes in the structure of the trophic interdependence of many populations, whereas in the economy, these are mainly the feedback loops of

changes in the principles of economic balancing, usually as a result of the development of the concept of forest use. All processes of stimulating or inhibiting the development (homeostasis) in forest ecosystems finally are realised at the level of the relationship between the metabolism of organisms and the expression of the reproductive potential of the population (and thus the laws of genetics and physiology) and, in the case of the human population, also with the mental choice of management methods. This choice involves the use of knowledge retained in the neuronal system of memory and the creative potential of the brain's imagination. The basic processes of homeostasis in the development of both the above-mentioned biological formations occur at the subcellular, cellular and tissue levels of organisms, but their expression in forest ecosystems is manifested in changes in the number and structure of the spatial distribution of a population. And these are realised in the processes of reproduction and the forces of the interdependence of life, which usually leads to a change in the form of trophic interactions. The higher the level of balancing development processes, controlled by the current state of homeostasis at increasingly higher levels of the organisation of the structure of life, the more effectively the function of reducing the sunlight's photon energy (in the succession of photosynthesis and respiration) is implemented. This is especially manifested in the forest, as a negative feedback loop (homeostasis) of a number of trophic interdependencies, from the photosynthesis of autotrophs to the mineralisation of organic matter in the succession of herbivores, predators and decomposers and, therefore, also in the use of the forest environment by humans. Unfortunately, the possibilities of studying the development of the niche situation of various populations in forest biocenosis are still very limited. This is due to the fact that the individual diversity of tree populations (perennial plants) in terms of the expression of growth processes in different development phases is also determined by the individual variability in the expression of the homeostasis of growth processes. This means that trees growing slowly in their youth may reach high growth rates at maturity or vice versa. The variability of stand structure in the ecosystem is a result of changes in the expression of homeostasis in different periods of individual tree development, or also of the methods of controlling homeostasis, established by humans in a forest management plan. However, regardless of whether it is homeostasis controlled by its own factors of the structure of the forest ecosystem or by humans, this process is controlled by physiological developmental changes in the mechanisms regulating the annual growth rate – which differs in the juvenile and mature phases of trees, and in old age is limited only to bud development and reduced cambium activity. This variability of the mechanism regulating physiological growth is the result of developmental changes in the feedback loop of the expression of the plant growth stimulator, auxins and substances limiting growth – growth inhibitors. This is also connected to changes in the level of the expression of cell polarity in the meristematic tissues of shoot tips and cambium, which always means a change in the gene expression in cytogenesis and the energy metabolism level

in the organism, depending also on the variability of environmental conditions. These issues were the subject of research in the Department of Forest Botany of the Warsaw University of Life Sciences – SGGW in the research project ‘Procesy starzenia się na poziomie organizmu i populacji głównych gatunków drzew leśnych’ [Ageing processes at the level of the organism and populations of the main forest tree species] in 1995–1999, commissioned by the General Directorate of State Forests. The results of these studies proved the dependence of hormonal mechanisms and the expression of polarity discussed above in the process of the growth regulation of pine and spruce on both the development phase and the conditions of the abiotic environment, but they were developed only as a final report deposited in the General Directorate. Unfortunately, further research was abandoned because the topic was classified as a basic research.

Any developmental changes in homeostasis (in both individual development and phylogeny) are a manifestation of changes in the molecular processes of the expression of information encoded in the DNA nucleotide sequence, that is, epigenesis. The mechanisms of gene expression control processes in cytogenesis and organogenesis have only recently become the subject of intensive research. They usually take place in meristematic cells at the level of the regulation of ion transport through the system of cytoplasmic membranes. The mechanisms of this level of homeostasis regulation are currently being studied in quantum biology. As far as knowledge about processes at the molecular level is concerned, an example is the result of research on the place and time of the occurrence of hydrolysis enzyme protein activity, specifically active in the process of the protoplast autolysis of wood cells conducting water in the pine trunk, that is, the differentiation of wood cells (research programme also conducted by scientists from the Department of Forest Botany at the Warsaw University of Life Sciences). It turns out that the activity of this protein is closely related only to the period of the division of cambium meristem cells and successively localised in the vacuolar system of cells differentiating into tracheids during their growth and cell wall formation. This protein is a protease, so after its release from the vacuolar sap, which is a consequence of the degradation of the structure of the tonoplast membrane (i.e. the vacuolar membrane), it hydrolyses the protoplast proteins, implementing a programme of controlled cell death, apoptosis in xylogenesis. During the winter rest period, the expression of the gene encoding this protein is not stimulated (or is inhibited), but the molecular mechanism of this inhibition process is unknown. All the more so, the mechanism determining the variability of the factors of shoot growth rate expression in the different developmental phases of forest trees is not better known. Therefore, for example, the measurements of the height and thickness of the main stem of seedlings in the nursery will only be a reliable indicator of their breeding value if they are confirmed by the results of growth measurements of the trees developing from them over the next several decades. Thus, forest breeding differs from that in agriculture, where based on observing the growth or the number of seeds and fruits of annual plants or perennials, it

was possible to select and promote more productive genotypes, which a long time ago decided the subordination of biological production in agriculture to man. Gardeners were managed in other ways, using the procedure of grafting selected genotypes of fruit trees. For the moment, foresters have been left with either the selection and thinning of tree stands according to a specific key for the characteristics of their morphological development after successive years of cultivation or the study (measurement) of the growth of offspring from the seeds of mother trees, which also requires many years. In addition, there remains, undoubtedly, forward-looking pioneering laboratory work to search for a method of offspring selection, after explaining the many mechanisms of molecular changes in the developmental expression of epigenesis in the ontogenesis of trees.

In conclusion, in the terminology of the sciences, which mainly study the developmental processes of ecosystems or human societies and also in forest sciences, the concept of homeostasis means the feedback loop (negative) of the stimulation and inhibition of developmental processes at the level of biological populations that also depend on the variability of environmental conditions and on the progress of human civilisation. In other words, the state of developmental balance in forest ecosystems has the right to be variable, because it depends on the expression of the genetic potential of all populations constituting the biocoenosis, that is, also on humans, whose participation is manifested in breeding, protection and various forms of use in the process of managing the natural resources in forestry. Therefore, the development of human culture (and also the knowledge of foresters) determines the possibility of choosing methods of controlling the homeostasis of forest ecosystems in order to activate not only the production potential reserves of the photosynthesis of solar energy, accumulated in various forms as products of the organic mass of practically all forms of biotic life, but also other valuable uses (e.g. recreational) of the forest. This indicates the importance of analysing the methods of planning and improving forest management through the use of the mental ability of foresters to balance natural and economic values. It should always be remembered that the collapse of homeostasis means the destruction of the stability of the entire trophic structure of the ecosystem (e.g. through the gradation of insects, overabundance of phytophages and degradation of forest soil microflora), that is, an ecological catastrophe and a return to the initial stage of development of stand succession.

To supplement this summary, a short description of the concept of homeostasis is presented by Ewa Bartnik, a biologist and professor at the University of Warsaw: ‘Homeostasis is a process that secures the sustainability, but also the evolution of biological systems in the face of the variability of environmental conditions during their existence on earth. It is achieved by reproducing the properties of the feedback loop between metabolism and energy at all levels of the organization of biological systems. It is a process of compensating for the deviations of the structural units of life from the state of the evolutionary norm. Homeostasis does not mean equilibrium but the proper balancing of the processes

of stimulating and inhibiting growth or development. It manifests itself as oscillations of the system, generating wave fields, and is one of the fundamental laws of physics as a process of restoring the symmetry of energy distribution at all levels of the organization of matter – equilibrium determines the state, homeostasis – the process securing the sustainability and evolution of biological systems against the variability of the environmental conditions during their existence on earth. It is achieved by reproducing the properties of the feedback loop of metabolism and energy at all levels of the organization of biological systems.'

#### **4. The evolutionary variability of the system's structural properties: forest ecosystem – human population**

The variability of the level and forms of feedback in the processes stimulating and inhibiting nature development as a condition of the structural properties of the systems evolution (not only biological). It also reveals the possibility of changing the system of processes determining the maintenance of the sustainable development of forest ecosystems by human intervention as an element of the natural set of factors in forest homeostasis. Planning research tasks, as well as interpreting research results aimed at finding ways to take advantage of the use potential of forest ecosystems for human needs (including the developmental problems of ecology, economics and environmental protection), also require the notions of time and memory to be explained, because the evolution of any process means changes in the structure of properties over time. After all, every plan is the result of transferring information collected in the past (and recorded in memory) to the future in the form of the predicted effect of its use. The notions of time, memory and information have been the subject of the discussions of scientists and philosophers for many years, but for the purposes of this article, the only assumption made was that they constitute the essence of the meaning of the notion of process, regardless of what it concerns.

The link between the development of both biological formations – forest and human – has a long history. The forest is an environment whose structural properties evolved over millions of years to improve the processes of transforming the structure of sunlight on the surface of the Earth, that is, to accelerate the process of its scattering in space, as a reduction of the potential of solar energy on the processes of life is many times greater than the analogous properties of the structure of mineral substances. Probably, one of the main reasons for the evolution of life on Earth is the possibility of achieving, in a huge number of forms of the interdependent existence of organisms through trophic speciation, an increasingly higher efficiency of the metabolism of energy. The evolution of life has achieved success by favouring the mechanisms of mutual trophic dependencies in the biogenesis of many populations of organisms, from autotrophs and herbivores through a series of heterotrophic populations that

successively condition their existence, and, in humans, through the progressive development of mind and consciousness.

Generally speaking, evolution is one of the most common natural progressive processes of structural change in the universe. Physicists define this process as a way of restoring symmetry in the emergent system of the universe, in which asymmetry arises as a result of the disintegration of vacuum quanta. This means that the essence of evolution is a constant process of reducing chaos (randomness) by creating ever more efficient structural forms of energy transformation. The evolution of the structural properties of both ecosystems and human population is realised by modifying the expression of genetic information constituting the essence of homeostatic processes, thus concerning mechanisms at the level of the morphogenesis of organisms and population variability.

Natural selection (as Darwin put it) "... is an unavoidable consequence of the competitive reproduction of organisms that have access to limited resources."

Charles Darwin's theory of evolution has received hundreds of comments and discussions, thousands of objections and as much apologetic literature. Paradoxically, the theory of evolution is still evolving. Owing to the seriousness of the discourse on the processes of evolution in the scientific community (and not only), it is worth presenting two published statements by a cosmologist and theologian, a member of the Pontifical Academy, Rev. Prof. Michał Heller: 'Man is genetically connected with the universe, his roots stem from the history of the universe' and 'In the face of the latest documents of the Holy See, it is obvious that the scientific theory of evolution is not contrary to any truth of the Christian faith' (Heller 2018).

The theory of evolution emerged as a result of the rational interpretation of the results of a huge number of observations and experimental research in various functional areas of the universe. Although this issue concerns still little known laws of the structure of the vacuum and the infinity of being, evolution means the succession of processes that enable the improvement (by favouring the most efficient and eliminating the less efficient) of the mechanisms transforming a part of primary free energy (speed of light) into the potential energy bonding the structure of matter. This means the ability to successively deposit the high potential of energy in nuclear, atomic and molecular bonds and then in ever more complex structures of the organisation of biological systems and the products of mental creation. The evolution of the ecosystem means changes in trophic interdependencies between populations of organisms, constituting a niche structure of the metabolic system under specific environmental conditions, which increases the efficiency of processing the solar spectrum assimilated in photosynthesis by autotrophs into heat. The improvement of the ways energy binds in the process of structural evolution also means the evolution of the level of informational complexity and homeostatic mechanisms. The highest level of life's evolution has been achieved through the development of the human mind and the possibility of using this property in planning and selecting methods that provide living conditions at dif-

ferent levels of organisation, from family to tribal, national and so on. Human evolution in social formations has also enabled functional specialisation within one's own human genetic population, that is, the evolution of personality, free will and culture.

In the context of the evolution of the interdependence of two biological systems, evolution is the process of the adaptation of organisms to changing environmental conditions, and its essential elements are variability, resulting from mutations and re-combinations of traits and natural selection. Thanks to selection, individuals whose genotype determines the highest number of offspring and the best adaptation to current living conditions predominate. It should be added that the variability of genetic populations in question concerns the information on the processes of the expression of organisms' morphogenetic traits, coded in the order of the nucleotides in DNA. Thus, evolution in biology concerns the morphogenetic differentiation of systems capable of acquiring, processing and releasing the energy of the environment, which in general means: ways of acquiring food as well as reproducing and defending the genotype. The realisation of these processes is always connected with the specialisation of autotrophic and heterotrophic organogenesis, which means that the genetic structure of both these forms of populations in different ecosystems is shaped by the interaction of morphological and behavioural factors.

The evolution of life on Earth manifests itself in a huge number of variants, but its most effective variant, as mentioned earlier, concerns the evolution of human culture as a process of promoting relationships that favour progressive changes in the structure of the social conditions of humanity. The property of the development of the human mind is the formation of a mental system of neural processes, which are capable of consciously choosing the direction of organising sensual information in the imagination. Through the hierarchisation of the expression of symmetry on successive levels of the organisation of reality, the evolution of culture is a 'multi-storied' process. This means that, taking into account the progress of knowledge and the development of imagination, the principles of the homeostasis of human and environmental social existence are described on an ever higher level of moral principles in the code of civil rights – criteria of aesthetics and utilitarian value. There are three aspects of human creativity in which the process of cultural evolution is realised: (1) scientific creativity, which is based on the interpretation of facts, that is, on the ordering of observations or measurements of phenomena collected in the past in order to create theories explaining the laws of nature; (2) technological creativity (engineering), transforming theoretical knowledge into systems of perfecting the conditions of human existence now and in the near future; (3) artistic creativity, that is, the creation of abstract systems, which represent the individuality of the creator, in which different variants of the elements of the structure of reality constitute an artistic work also in the future.

The evolution of intelligence in human consciousness as a factor of improving living conditions is one of the derivative processes of the evolution of niche biocoenosis of forest ecosystems. Thanks to human specialisation in organising the production of

metabolic goods produced in forests, supernatural population growth has been enabled. Human niche evolution means the loss in the past of the process of the continuous development of forest use, where it was one of the important factors in the metabolism of solar energy in the ecosystem – not only as a herbivore and hunter but also as a processor of organic matter – wood and mulch in construction, animal furs and plant materials in the production of clothing, and especially fuel to sustain fire. At that time, man also used the forest as a producer of natural healthcare products, as well as a shelter for the family and raising offspring. These conditions, thanks to the evolution of the mind, that is, consciousness and memory, or the ways of storing knowledge and developing communication, enabled the further niche development of man to the function of a farmer and animal breeder. Thanks to the use of the fertility of forest soils, centuries old human niche development gradually became the factor of the devastating exploitation of forest ecosystems. The use of knowledge in forest management brought an end (hopefully permanent) to this only in the recent decades. The development of civilisation, which manifests itself in the change of the structure of forest use, is, therefore, also a feature of the evolution of man's ecological niche, contributing to the protection of forest functions as a factor of the sustainability of all elements of the biosphere.

Learning about the potential possibilities of using the as yet unknown values of the forest and planning the modification of natural homeostasis without compromising the sustainability of the ecosystem provides the chance of satisfying various human developmental needs. How great these reserves are is shown by the successes of some of the implemented forest management programmes, which were presented in more detail in a separate study in 2014 (e.g. the success of the beech forest in the habitat of the crooked beech forest ecosystem in Wolin or the successes in genetic engineering of American foresters) (Wodzicki 2014). Research in the field of forest sciences, which provides the opportunity to activate the reserves of the potential development of 'forest – human' interactions, should take into account the possibility of interference in the conditions of the homeostasis of this relationship, in the sense of ensuring a dynamic balance in achieving the objectives of forest management by appropriately educated foresters. This is possible, thanks to both research on the scope of the interference in the developmental processes of forest ecosystems and the normalisation of privileges and civil rights, taking into account the principles of nature conservation – that is, the acquisition of knowledge and scientific creativity in various forms of forest use and forestry economics. Scientific research is a way to learn about these opportunities – mainly thanks to the employees of research institutions whose natural sponsors are government units implementing forest management programmes.

## **5. Developing the content of certain concepts used in forestry**

In practice, a number of terms such as 'balance' or 'natural' are commonly used today in the traditional sense, that

is, reality is divided into what is natural and human, which basically means placing these two components of Earth's nature in opposition. This practice should be respected, but corrections are needed in the meaning of concepts towards the direction of the unity of nature, which is proven in the recent decades. This indicates a course of action, especially for those who themselves contribute to the blurring of conceptual barriers through the results of their research in fields explaining the mechanisms of natural evolution. Only in this way it will be possible to finally define the term 'natural' and also to use the evolution of human awareness to protect the unity and development of the entire biosphere on Earth.

Creativity is a process that generates new information – an essential factor of communication and understanding. On Earth, the progress of knowledge and its use in the processes of natural resources management is possible only through the use of the conscious creativity of *Homo sapiens*. The questions to which working hypotheses are formulated in scientific research in forestry concern the existence of forest ecosystems in an environment dominated by human awareness. In one sentence, the point is to 'reconcile non-thinking nature with thinking nature – this is the most important direction of the evolution of life and the only way for earthly life to survive in the cosmos; making people aware of this thesis is a task of education in general, but foresters have a pioneering opportunity to prove it in practice today'.

## 6. The meaning of certain concepts

Concepts are evolving (some since their formulation in antiquity), so they can also be the subject of discussion today not only amongst linguists:

- Epigenetics – the science of the mechanisms of controlling the sequence of transcribing genetic information in ontogenesis (the individual development of organisms).
- Awareness – the process of recognition by the biological system of the developmental potential of its environment (according to psychologist Jean Piaget, Université de Paris).
- Intelligence – the ability to solve puzzles, thanks to the discovery of a new underlying principle (both concepts are at the core of operating with logic and building symbols – according to the neurobiologist Horace Barlow, Cambridge University, United Kingdom).
- Concept – a mental object (it emerges 'as it were' from brain function).
- Thinking – searching for questions, problems in the depths of one's consciousness and finding answers. Thoughts appear as a result of activating concepts in a conceptual network, caused by autonomous brain activity – they exist as spatial-temporal patterns of brain activity and each represents an object, an action, a theory or an abstraction. Thinking means changing the state of energy from a chemical form into a creative one – in this process, the physical

potential of energy binds the impressions acquired by the senses (physiological stimuli) to information acquired through education and, thanks to imagination, creates a concept of hypothetical relationships (Młodinow 2019).

- Creation – the highest level of our intelligence and awareness. The material in scientific creation is knowledge collected in all cognitive acts and transformed in the consciousness of the creator into information about the interaction of elements of the work so that it fulfils its assumed functional purpose.
  - Knowledge – rationally justified conclusions resulting from sensory observations and experiments as the sum of reliable information about the actual structure of systems and laws of nature. In other words, the current state of 'information' as a factor of nature.
  - Nature (an ambiguous concept) – objective reality; a world accessible to scientific cognition; the whole of things, phenomena and processes forming the universe including humans (some people exclude humans from the notion of 'nature', as a separate entity, which, however, does not find widespread acceptance today, even in religious communities).
- Science – a way of searching for the truth about the real structure and laws of nature by the scientific method, thus ensuring a high level of credibility of the conclusions formulated in the form of theories.

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