THE FOREST ECOSYSTEM - BETWEEN STABILITY AND THE RISK OF DEGRADATION

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ABSTRACT. The forest ecosystem - between stability and the risk of degradation. The following paper is constructed as an essay created in the context of current challenges resulted from the irrational exploitation of Romanian forests for the sole purpose of influential characters to obtain personal benefits. In this respect we will present the structure, the importance, the functions and the needs of the forest ecosystem by starting to define and characterise the biocoenosis and biotopes populations which, together, make up the ecosystem. Finally, we will present the living conditions in an ecosystem and we will highlight its auto-regulation function but also the situations that might lead to the ecosystem's disruption, thus indicating the need to apply the precautionary principle in order to preserve the forest ecosystem.

Key-words: forest ecosystem, stability, risk, disorder, precautionary principle.

1. Introduction

This essay is part of a series of works that are designed to pull a warning signal in order to stop the degradation of forests, the main source of oxygen on the planet, in a post revolutionary context characterized by lack of interest towards the community's good and by selfish concern. In this respect we will present the structure, the importance, the functions and the needs of the forest ecosystem by starting to define and characterise the biocoenosis and biotopes populations which, together, make up the ecosystem. We will highlight the auto-regulation function of the ecosystem and we will show that this function is necessary but not sufficient, indicating the need to apply the precautionary principle in order to preserve the forest ecosystem.

2. Results and debates

The main element of biocenosis is represented by the population of plants and animals, consisting of a multitude of individuals more or less similar in terms of genetic inheritance and adaptation to the biotope and it is characterized by: density, fluctuation, age, longevity, birth rate, mortality rate, distribution in space, ecological niche, etc.

The population density is the number of individuals per unit, which may be an area (m2, ha), a tree, a biosphere (bark, foliage, heap). It varies significantly, depending on the species, the intraspecific and interspecific relationships (especially competition for food), the environmental conditions, the evolution of climatic conditions and elements. Thus, in a forest where the population consists mainly of trees, the density represents the number of trees per hectare. In this case the density varies according to species, age, soil bonitation etc. Two distinct aspects must be considered: the real effective density reflecting the actual situation of biocoenosis and an optimal density, when the resort's opportunities to provide unrestricted food are taken into consideration, at a minimum level of competition between individuals or populations.

For an optimal use of the biological potential of the resort, it was established through calculations, for the trees for example, the necessary number of trees needed per hectare of forest, per species (groups) of forest, per age and per soil bonitation value. For spruce, regulations in force establish the optimal density at 2800 trees per hectare at the age 20 years and at 560 species per hectare at 90 years; respectively for the same ages the established numbers for beech are 3700 and 450 trees per hectare, as for oak a number of 3300 and 430 trees per hectare are required. Therefore, it is noticeable the gradual reduction of the number of trees from one stage to another, as their volume develops, simultaneously with the natural elimination of other weaker trees. Among the populations of animals, arthropods and vertebrates, the insects are the largest group. Their density is regularly calculated by reference to buds, branches, trees or surface. The population density of insects registers considerable fluctuations from one period of time to another, or from one development cycle to another, the latter being based on species, available food, intraspecific and interspecific relationships and the evolution of climatic conditions. In the case of defoliator insects such as *Lymantria dispar*, there are mass propagations (gradations) on large surfaces that can succeed every 3-5 years or 20-30 years. Significant gradations of this defoliator were registered in 1954-1956, when the attacks affected 600 000 hectares, which represented half of the area occupied by cvercinee species in Romania. A recurrence of similar magnitude occurred in 1986-1988. An important role in the production of these unusual propagations of *Lymantria dispar* was played by a sequence of drought years during the mentioned periods. In the defoliator of deciduous trees group, especially of Oak, *Tortrix viridana*, *Geometridae sp.*, *Malacosoma Neustr* are also mentionable, and *Euproctis chrysorrhoea, Drymonia ruficornis* in a lower percentage, these species periodically infest considerable areas of forest.

Lymantria monacha for spruce, *Choristoneura murinana* and *Semana rufimitrana* for fir tree are endangering, at high densities, the existence of the attacked forests. For these tree stands, another important pest control issue is represented by the insects that attack the trunk, known as secondary pests. Moreover, these problems are intractable in case of overgrowth, when species like *Ips typographus, Pityogenes chalcographus, Ips amitinus* etc. for spruce and for fir tree *Pitioktoines curvidens, Cryphalus piceae* etc. turn into primary pests, able to attack healthy trees. Other insects attack the roots of seedlings and endanger crops, insects such as beetles (*Melolontha sp.),* wireworms (*Agriotes sp., Selatosomus sp., Lacon murinus,* etc.), darkling beetles (*Opatrum sabulosum*), soil caterpillars (*Agrostis sp.),* pine weevil (*Hylobius abietis*) etc. From the group of insects that attack the trunk of seedlings and trees and therefore contribute to their technical damage the following are mentionable: the willow weevil (*Cryptorrhyncus lapathi*), the small poplar longhorn beetle (*Saperda populnea*), the goat moth (*Cossus cossus*), great capricorn beetle (*Cerambyx cerdo*), the striped ambrosia beetle (*Trypodendron lineatum*). The seeds and the fruits are often attacked by the tortricid moth (*Laspeyresia strobilella*), the spruce cornworm (*Dioryctria abietella*) and the acorn weevil (*Balanius glandium*). In soil and in the forest litter there are various invertebrate populations.

The existence of any forest biocoenosis is conditioned by the presence decomposers: fungi, bacteria and other microorganisms. On the other hand they can also have negative effects. For example, under the action of parasitic fungi on plants the photosynthesis intensity decreases while the breathing intensifies, thus decreasing the net primary production. Resistant phenotypes survive but the weak ones are eliminated. There are also microorganisms with positive role. Widespread are the mycorrhizal fungi, which in symbiosis with the plant roots contribute to filling the need for water and nutrients, situations encountered especially at acacia, oak, holm, etc.

Depending on the structure and environmental conditions, the forest biocoenosis is also populated by birds and mammals. Most birds have a positive role, being known as insectivorous. Their presence in the food chain and the activities they carry out are of great importance for cenosis homeostasis and for the stability of the ecological balance of the ecosystem.

The mammals populations represented by game species, in addition to being one of the major wealth of the forest, also exercise a positive biological role for the biocoenosis they live in. Some of these, such as the Cervidae family (Carpathian stag, roe deer, deer), rabbits, wild boar, squirrel, parse etc. are phytophagous (first-order consumers), their food is herbaceous, leaves, bark, seeds, fruit trees, etc. Others, including the wolf, the bear, the lynx, the marten, the wild cat, the fox, etc. are carnivores (second and third order consumers).

The density of birds and mammals is reported to the surface, depending on the species and on the bonitation conditions of the forest biocoenosis.

The age and longevity of plants and animals is one of the chief characteristics of their populations. Thus, trees usually exceed 100 years. Taking into consideration the maximum accumulation of biomass and the efficiency of the protection functions, harvesting is allowed at the ages: 120-160 years for oak, 120 years for beech, 110 years for spruce, 120 years for fir tree.

In general, the populations of animals from a biocoenosis are younger, especially if we refer to woody plants. The average age depends on the species and its way of living. When it comes to insects, their life cycle may be of several months to a year, two or three, while for mammals the bear can reach 30 years, the deer and the wild boar 20 years, the wolf and the marten 15 years. Birds also do not reach too high ages: the goldfinch and the nightingale reach up to 12 years.

The breeding capacities have a particular importance in the dynamics of a population. The population is increasing when the number of individuals grows from one generation to another or it decreases when their number drops.

Birth rate and mortality rate are influenced by the internal characteristics of the species but also by the local environmental factors (climate, soil, etc.). One important element is fecundity, the reproductive capacity of the species. The proportion between the sexes is very important: when females predominate there is a tendency to increase the herd population. The carnivores represent the repressive regulatory factors. Any population in an ecosystem occupies a certain part of the biotope, which is her place of residence or ecological niche. Moreover, it fulfills a certain role in the transfer of matter and energy in the ecosystem (the trophic pyramid), with a specialized function in this regard. A population consumes a certain kind of food and it also represents a food source for other populations of other species (Botnariuc, Vădineanu, 1982). In the case of insects, several ecological niches can be destroyed depending on their development stages (egg, larva, pupa, adult), but within the same ecological niche can coexist two or more populations with interdependent functions.

Biocoenosis can be defined as a community of vegetable and animal organisms, established through a long process of evolution under the influence of environmental factors (Simionescu, 1977). Since 1877, when Mobius defined biocoenosis as a community of organisms adapted to the environment from a given territory, and up to present, several opinions were formed regarding this term. Thus, Odum (1971) considered biocoenosis as a set of populations living in a particular territory and operating as an organized unit. Botnariuc, Vădineanu, (1982) view biocoenosis as "a supra-individual system, representing a level of organization of living matter, composed of territorial populations (therefore sympathetic) and functionally interdependent populations." Doniţă et al., (1978) state that "forest biocoenosis is the supra-individual biological system in which, among producers, trees populations have the most important role."

Within a biocoenosis, a complex of functions between the component organisms is created, leading to the creation of a circuit of the organic matter. As a structure, biocoenosis consists of functional groups formed by primary producers, consumers and decomposers.

The producers group includes primarily green plants, which, by chlorophyll, synthesize organic matter from inorganic elements, using solar energy and performing the process of photosynthesis, followed by photosynthesizing bacteria and chemosynthesizing bacteria.

The basic component of the forest biocoenosis is the populations of trees, shrubs, undergrowth, accompanying herbaceous stratum, but also mosses and lichens. As a result of their physiological processes, primarily of the tree species photosynthesis, gross primary production is achieved, which decreased the energy used for respiration net primary production is obtained. Organic accumulation on a given area and at a certain date forms the plant biomass. This includes increasing the wood of trees accumulated over time, the shrubs, the volume of leaves, flowers, the amount of seeds, fruits, the the grasses of the herbaceous layer etc. Biomass size depends on the intensity of photosynthesis, which at its turn depends on the tree stand composition, age and productivity, and on the other hand on the availability of light, air temperature, soil water, carbon dioxide content in air and other nutrients. At the same time, it must be kept in mind that the decrease in intensity of the breathing process, as in disassimilation, diminishes the gross primary production. The forest’s biomass is composed of leaf production as a result of the assimilation and of wood accumulated each year as growth in height and diameter of trees, which is expressed by weight (tons/ha) or volume (m3/ha) and varies depending on the species, on the stationary conditions in which the stand vegetates and on the evolution of that period's climate. In the calculation of wood biomass, in addition to the tree trunk, its main component, the bark, the branches and the roots are included. The shrub biomass is also estimated and it varies depending on the stand's growth. Part of biomass is taken by consumers and another part, resulting from the rotten leaves and branches fallen on the ground but also from the dry trees, constitutes the necromass that re-enters the energetic cycle of the ecosystem. In the trophic pyramid, the producers that are situated at the base are followed by consumers, represented by the first-order phytophagous and by the secondary, tertiary and quaternary order zoophagous.

In the phytophagous category we can distinguish the populations of phyllophagous, rhizophagous, xylophagous, clethrophagous, etc. The phyllophagous populations are feeding on foliage of trees, shrubs, undergrowth, and herbaceous stratum. This group includes the defoliator insects that both through larvae, for defoliator caterpillars, and also as adults and larvae, for defoliator beetles, feed on leaves of trees, shrubs, undergrowth. Xylophagous insects eat wood. Rhizophagous populations are made of beetles larvae, wire larvae, soil caterpillars, Hylobius abietis, Hylaste sp adults, etc.and feed on the roots of seedlings or parts of them. Herbaceous stratum is highly sought-after by herbivorous mammals. The damaging of seeds and fruits is caused by the clethrophagous populations consisting mainly of insects like Balaninus glandium (acorn weevil), or Laspeyresia strobilella and Dioryctris abietella that harm the spruce cones.

The secondary, tertiary and quaternary consumer category, zoophagous represents a large group. Predators, parasites or nematodes live and feed on phytophagous. Some may be hyperparasites, case in which they belong to the third order.

Insectivorous birds and mammals that eat the insects in various stages of development represent the secondary, tertiary, or quaternary consumers. The same situation applies to mammals. Some of them feed on green plants while others that are carnivores live on plant feeders and so on.

The consumer category can also include the detritophagus (earthworms, molluscs, insects, etc.), which feed on organic material fragments derived from decomposing plants, named organic detritus .

The third important element of biocoenosis are the decomposers, represented by fungi, bacteria, insects and other microorganisms that convert organic substances from corpses, waste, litter, trees, shrubs or parts of them into simple compounds. Thus, such elements are reused by autotrophic plants, after the end of the mineralization process of cellulose, hemicelluloses, lignin, etc.

Among the categories of primary producers, consumers and decomposers, representing stages of the same process, the dependency relationships concerning food and life create the food chains (the trophic levels). The relationship between these trophic levels must be balanced for the ecological stability of biocoenosis. In fact, biocoenosis is characterized by the possibility of self-regulation, due to the mutual connections between the belonging species. The more complex the biocoenosis, the greater the stability, and trophic networks are formed inside it as a result of the overlapping of food chains. However, energy transfer takes place in a biocoenosis, the source energy being a solar one. A complete biocoenosis is characterized by its capacity to function as an indestructible complex.

The unity composed of biocoenosis and biotope constitutes the ecosystem. The biotope is the place where a biocoenosis is found. The biotope is characterized by geographical, geological, mechanical, climatic, chemical factors.

The geographical factors are the longitude, the latitude, the altitude, the landform and the exhibition. The longitude and the latitude indicate the geographic position of the ecosystem on the world map and therefore its main climatic features. The altitude plays the same role but in vertical plan and in Romania is reported to the Black Sea level. The exhibition is defined as the direction of inclination of a place from the cardinal points. According to the Sun, it can be sunny, shaded or intermediate. These positions are particularly important for the forest vegetation, some species growing better on sunny exhibitions, others on the shaded ones and some on the intermediate exhibitions.

The geological factors are represented by nature, by the mineralogical composition of the geological substrate and by soil itself. The soil is created due to the disintegration of rocks under the action of atmospheric factors and living organisms. Due to the phenomena of physical, chemical and biochemical alteration, organic matter (humus) is formed. It is decomposed under the influence of microorganisms, and the various resulting compounds become assimilable through water, being then taken in the process of nutrition.

The mechanical factors are represented by the air (also a climatic factor) and water movement, and also by the movement of the tectonic substrate. The air masses movement (wind) from one place to another takes place due to the differences in atmospheric pressure. The wind direction is from higher pressure areas to lower pressure areas and this direction can be altered by the land's orography. The ecological effects of wind on the ecosystem can be of the most varied. Uprooting can occur or trees can be broken due to some intense winds and this process has a serious influence on the forest. The operation and use of these trees requires the creation of new forest crops, which are not always similar to the previous ones. In this way, biocoenosis, and implicitly the forest ecosystem with all its components, is highly affected. Other effects of wind on the forest ecosystem should be considered. On one hand it can have positive effects by helping to spread seeds and to pollinate plants, but on the other hand it can carry caterpillars from one forest to another (for example the caterpillars Lymantria dispar), phenomenon facilitated by the existence of spiny bristles on their body.

Water movement, both for running and infiltration water, contributes to the transport of solutes and microorganisms.

Rarely, tectonic movements can appear in some regions, producing great disturbance on the ecosystem.

The climate influences the forest ecosystem through temperature, light, solar radiation, precipitation and humidity. Their influence on the biocoenosis, respectively on the ecosystem, is extremely important.

The temperature is one of the most important factors of life on Earth. Both plants and animals need a certain temperature for their development. In this sense, even if the temperature varies they fit within the limits of tolerance, having certain minimum and maximum temperature thresholds. In general, the temperature tolerance limits of a population are restricted. Some experts indicate that for the survival of insect populations the maximum temperature is 55^0C and the minimum is -5^0C (Boughey, 1968). The optimum temperature for a population allows a normal metabolic process, with a maximum biological efficiency. Generally, each species, vegetable or animal, is adapted to a particular temperature and its fluctuations. The agreement in forestry was to consider the annual average temperature and the sum of actual temperatures higher than 10^0C. For spruce, the annual average temperature of 2 to 4^0C is considered as the minimum and the sum of actual temperatures over 10^0C at a 500^0C level, while for the pedunculate oak these thresholds are of 6 to 10^0C and of $1000\text{-}2000^0$C.

Light, especially its intensity, and solar radiation have a great influence on the life of a population. Radiation energy is used by plants in the biosynthesis of organic matter. For animals, the colour and the motion perception determine their adaptation to the environment.

Necessary light conditions vary from one species to another. Thus, it is assumed that the pedunculate oak, the ash, the larch, the poplar, the pine, etc. are more demanding while the spruce, the maple, the beech, the hornbeam, etc. are less demanding, especially compared to the fir tree, the yew, etc., who prefer penumbras. Such a classification is not considered absolute, as other elements are involved, such as latitude, longitude, altitude, exhibition, etc. Just like plants, insects can be considered *photophilic*, requiring light (beetles), *photothermophilic,* requiring light and heat (*Tortrix viridana, Lymantria dispar, Malacosoma Neustr etc*.) or *photophobic*, bearing little light (larvae of *Ips typographus, Ips amitinus etc*.).

The water derived from precipitations like rain or snow, has a leading role in a biotope. Within the metabolic processes, it performs a series of functions. Water has a large share in the structure of plant and animal organisms. It helps with the dissolving of a significant number of substances and with their assimilation in the course of metabolic processes.

For any forest system, the annual amount of precipitations, and their distribution in time are determined both in terms of structure and forest productivity. Since in Romania the average annual rainfall regime is between 400 and 1600 mm, the types of vegetation are varied, their upper limit being decisive. This explains the existence of xerophyte species in this country, which form the low productivity stands (rainfall below 600 mm / year). In exchange, in areas with precipitation between 600 and 1000 mm we find forests of oak, beech, spruce and fir of high productivity, with a complex and rich biocoenosis and with a high environmental stability. Besides precipitation, air humidity, which means the amount of water vapour in the atmosphere, plays an important role in the life of biocoenosis. This influences the plant's processes of evaporation, sweating or breathing.

The lack of water in soil, which helps to reduce the water supply for plants, produces serious disturbances on vegetation, often leading to isolated or mass desiccation of trees. The plants' and animals' adaptation to drought can be morphological, physiological and behavioral. Beldie, Chiriţă, (1967) established the following groups of plants as soil moisture indicators for the Romanian forests: xerophytes, mezo xerophytes, mesophiles, mezohygrophites, hygrophites, ultrahygrophites, euriphytes. Some species such as alder, ash, poplar, willow, etc. manifest higher requirements than the soil's water content, others such as fir, spruce, beech, pedunculate oak or maple have medium water requirements, while the downy oak and others vegetate in conditions of low water level in soil. Animals are adapted to the hydric regime to. Some of these get their water directly from food, but others use water sources existing in the ecosystem. The hydrophilic insects, adapted to high humidity conditions are: *Lymantria monacha, Blastophagus piniperda, Tripodendron sp*. etc., and most of the soil insects. The photothermophilic species that can withstand high humidity variations but require more light and heat are *Lymantria dispar* and the buprestidae.

Among the chemical factors, we mention the ionic composition, the salinity, the oxygen, the concentration of hydrogen ions (pH), etc. The ionic composition of the soil environment mainly affects the structure of biocoenosis by conditioning the flora and fauna distribution. The salinity (3 ‰) is an important element for the aquatic ecosystems' biocoenosis. The oxygen makes the development of all organisms that inhabit the planet. However, some creatures require a greater consumption of oxygen. The soil's hydrogen ion concentration (pH) also has a great influence on the development of biocoenosis. The solution's H + and OH- ions concentration ratio determines whether the soil is acid, alkaline or neutral. Its reaction is expressed in pH, which differs from one soil to another and depends on the content of CO2 in the atmosphere and in the soil solution, but also on the presence of certain easily oxidizable substances and salts. The flora and fauna are adapted to that soil's characterizing pH.

All these factors, which form the biotope and whose influence in the installation and development of vegetable and animal organisms is important, are included in the ecologic sphere. Mutual influence relationships are created between biotopes, defining the ecosystem as a standalone unit.

The ecosystem performs the following functions: energetic function, information transmission, program development, movement of matter and energy, self-regulation, etc. In fact, the ecosystem, as an open biological system, has all the attributes of cybernetics. According to Botnariuc and Vădineanu (1982) "the ecosystem's functioning results from the interaction of populations that compose it, and from their interaction with the abiotic components (biotope)."The vegetable and animal organisms, basic components of the ecosystem, need energy in order to develop. The main source of energy is the solar radiation and, to a lesser extent, the chemical energy produced by some substances. This energy insures the development and maintenance of the essential processes of vegetable and animal organisms, the accumulation of plant biomass as organic matter occurring at the same time.

The forest ecosystem is characterized by the fact that, both at the individual (tree, animal)/population and biocoenosis level, the messaging in the form of information is done by using energy. Following the principle of cybernetics, the communication is achieved through a direct connection, the upper system controlling the lower system and through a reverse connection, the higher system being informed of the lower system. In the open biological systems, the program constitutes one of the features.

The self-regulation function of the ecosystem is realised by maintaining its ecological balance. All components of biocoenosis concur in achieving this requirement. As previously shown, the more numerous the trophic chains, the greater the number of connections involved in the self-regulation function.

As a result of exercising the self-regulation function, the natural elimination of the weaker species and strengthening of others takes place in a forest, until it reaches the exploitation level.

However, certain natural phenomena like the destructive action of winds, snow, fire, excessive humidity, flooding or the too low or too high temperatures can seriously affect the forest ecosystem and lead to its disruption. In this respect, human intervention can restore the affected biocoenosis by reforesting the area and by ensuring favourable conditions for the installation and development of useful fauna and entomofauna. A considerable proportion of forests composed of indigenous species of great value and productivity, such as beechwood, spruce, fir tree, holm, are of great ecological stability.

The stability should not be understood as absolute but as relative, taking into consideration the fluctuations. In this case, the energy transfer at the trophic levels takes place without lowering the net production, respectively the biomass, the biomass' activity at normal parameters being ensured at the same time. This is what we call cenosis homeostasis.

3. Conclusions

As a result of the analysis which has been conducted, the following simple conclusion, prefaced in the introduction and detailed in a recent study (Mahara et al., 2011), can be drawn: the precautionary principle used by ecologists needs to be respect. This principle shows that the humanity would benefit from adopting a more cautious behaviour towards the forest ecosystem, whose stability should be of primary concern, as reflected very well in a folk saying:

Because of a bolt, the horseshoe was lost;
Because of the horseshoe, the horse was lost;

Because of the horse, the rider was lost;
Because of the rider, the battle was lost;
Because of a battle, the kingdom was lost.

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