Principle of the free choice of the Nature in forest ecosystems

Y Arefiev¹, I Kornev¹, V Garnaga¹, T Paramonova²

¹Department of Ecology, Forest Protection and Forest Hunting, Voronezh State University of Forestry and Technologies named after G F Morozov, 8 Timiryazeva Street, Voronezh 394087, Russian Federation
²Department of Forestry, Ulyanovsk State University, 108 Embankment of the Sviyagi River Street, Ulyanovsk432000, Russian Federation

¹E-mail: arefiev_yf@mail.ru

Abstract. The free choice of the Nature is understood here as formation of forest ecosystems under action of natural mechanisms of biotic autoregulation. The methodology of researches is based on uniform of ecological and genetics analysis of a condition of forest ecosystems and assessment of a role of key adaptive mechanisms in regulation of pathogenic processes in forest ecosystems. The primary factor that causing the long-term changes in forests tree mortality, tree growth and recruitment is interspecific and intraspecific competition. Competition among tree species is most important. Natural selection is a key mechanism of adaptation, the change in the heritable traits characteristic of a population over generations. Survival and reproduction of individual due to differences in phenotype. Variation exists within all populations of organisms. Offspring inherits mutations of parents. Inbreeding influences a condition of populations in forest ecosystems. Sexual reproduction of offspring can lead to a decreased biological fitness of a population. Inbreeding depression is especially dangerous in relative small populations. Ability of forest populations to survive and reproduce is dynamic. Sometimes it leads to epidemics of parasitic organisms. Allelic drift may reduce genetic variation in forest populations by disappear gene variants. The relevant problem is in providing freedom of action of natural mechanisms of biotic regulation in forest ecosystems. This problem is solved through formation of high-heterogeneous mosaic forest plantings. Such plantings are capable to long sustainable development without use of chemical and biological pesticides in the conditions of the changing global and local conditions. The long approbation of innovative forest plantings took place in conditions of the Central Russian forest-steppe. Ecosystem regulation of pathogenesis was successful.

1. Introduction

The problem of strengthening of natural adaptive mechanisms in forest ecosystems directly or indirectly is rather actively discussed in special literature in recent years. For improvement of quality of river waters by means of ecological regulation of the environment was rout [1-5]. The regulation principle of pathogenesis in chaotic forest ecosystems on the basis of transformation of ecosystems according to calculation of well-founded equation was offered for formation of the forest plantings capable to sustainable development [6-8]. Integration processes for managing sustainable development of forest plantings has to be based on strengthening of natural adaptive actions [4]. Preference for forest ecosystems of natural development of pathogenesis in a number of works [9-12]. The short review of sources allows to carry an ultimate goal of the conducted
researches – effective protection of the wood against pathogenic organisms – without use of chemical and biological pesticides.

While modern forest management have increasingly focused on environmental issues, since Rio Earth summit in 1992, social and ecological aspects of forestry concerning how really to improve the state of forest health as the basis of its ecological and social importance [1-3]. There are a number of convincing reasons for investigating of natural forest protection and these include: the central importance of forests for people's lives (1), as part of the ground of sustainability (2), ethical and social equity issue related to the environment (3).

The aim of the research therefore was to explore, describe and provide greater understanding and solving the problem of freedom action of natural mechanisms for biotic regulation in forest ecosystems [4, 5]. This problem is solved through formation of high-heterogeneous mosaic forest plantings.

The investigation is based on a comparison of values of the studied parameters in various conditions – at spontaneous and artificial cultivation of forest plantings. These researches were carried out permanently. Intensive long-term work began in about 2001. The region of researches is the Central Russian Upland, mainly in Shipov Oak Forest, Khrenovsky Pine Forest, Usmansky forest. The general for these mainly man-made forests is insufficiency of natural renewal of the main forest forming breeds. Pure stands composed of essentially a single species dominate.

2. Methods and Materials
A qualitative and quantitative methods where used for a research of a viability of trees, heterogeneity of plantings, natural renewal of the breed of the main forest forming breeds.

The basic formulas of the conducted quantitative researches are the following:

\[ IH = - \sum_{i=1}^{n} p_i \log_2 p_i \]  

where \( IH \) is index of heterogeneity, \( i \) is various of elements of a heterogeneity biodiversity, \( p_i \) is the probability of any element, \( n \) is number of groups of the studied elements.

\[ D = \frac{\sum (n \cdot b)}{N \cdot B} \cdot 100\% \]  

where \( D \) is development of disease (%), \( N \) is total of the considered objects, \( B \) is the highest point on the accepted scale, \( n \) is number of individuals of this or that point, \( b \) is concrete point of this or that individual.

The inbreeding depression was measured on phenotypical level. Phenotypical coefficient of inbreeding can be expressed by means of the following formula:

\[ ID_{ph} = \frac{d_1 - d_2}{d_1} \]  

where \( ID_{ph} \) – index of inbreeding depression (phenotypical), \( d_1 \) – development of a diseases in the conditions of open sites of plantings, \( d_2 \) – development of a diseases in the conditions of ecologically isolated sites of plantings.

Model objects: ascomycete *Erysiphe alphitoides* (pathogen of oak *Quercus robur*) & basidiomycete *Heterobasidion annosum* (pathogen of pine *Pinus sylvestris*). *E. alphitoides* causes powdery mildew on oak trees. Today oak powdery mildew is one of the most common diseases in the explored region and in European forests. The pathogen weakens adult oak trees and kills oak seedlings. Oak powdery mildewis in forests in the Europe, America. Pathogen kills trees of different species and is the most economically important forest pathogenic fungus.

The scale of assessment of viability of trees and plantings: 5 (healthy trees), 4 (foliage coloration is used as a criterion for vitality), 3 (trees sick to the 1st degree, recovery of health of a tree is possible), 2 (trees sick to the 2st degree, recovery of health of a tree is improbable), 1 (the dying-off trees, separate elements of life still remain), 0 (the died-off trees, without signs of life).
Statistical analysis: The comparison of the studied parameters of competition, natural selection and inbreeding were determined significant. Only significant data were used for discussion. The comparisons were determined with the least significant difference test at a significance level of 0.05.

3. Results and discussion
In development of populations of fungi for wood plants, alternation of sexual and asexual cycles is of great importance. For a pathogen *E. alphitoides* the initiating value has sexual reproduction, but mass distribution of a pathogen results from asexual reproduction.

As a result of researches it was established, that forest monocultures favor intensive asexual reproduction also suppresses sexual reproduction of the wood pathogens (Figure 1). This conclusion is of great importance for practical regulation of pathogenesis in forest ecosystems.

![Figure 1](image.png)

**Figure 1.** Comparative dynamics of abundance of *Microsphaera alphitoides* sporocarps (dark line) and distribution of diseases (red line).

Domination of an asexual cycle of reproduction of invasive pathogens is a real threat for host forest ecosystems. Forest monocultures are intensively damaged by harmful organisms, their invasive types are especially active. Forest monocultures act against the Nature. The great part of our modern plantings are forest monocultures and it continuous threat for the environment made. Many examples of mass dying off of monocultures of a pine, oak, forest belts of an ash-trees show it. Globalization of the problem of forest monocultures increasingly allow our interaction in the field of the world ecology.

Contrary to linear forest monocultures we recommend high-heterogeneous mosaic plantings (Figure 2) with the high level of bioreistance.

Transformation of the plant complexes in the pathogen (*H.*) center in result of free competition is presented in Table 1.

**Table 1.** Heterogeneity of the plant complexes in the center of the pathogen (*Heterobasidion annosum*) under the influence of free competition and of monocultures of the pine (*Pinus sylvestris*)

| Resulting plantings | Foreststand | Subgrowth | Underbrush | Grassy cover | General heterogeneity, bit |
|---------------------|-------------|-----------|------------|--------------|--------------------------|
| Natural overgrowing | 1.68        | 1.84      | 1.91       | 1.36         | 6.97                     |
| of mixed plants     |             |           |            |              |                          |
| Monocultures of     | 0.72        | 0         | 0          | 0.92         | 1.64                     |
| the pine (*P. sylvestris*) |          |           |            |              |                          |
As a result of natural overgrowing of the center planting with higher level of heterogeneity is formed (Table 2). Such plantings have high resilience to adverse factors. In essence, in them are formed the plantings close to the natural woods. Natural integration process in such plantings are rather active. Internal adaptive mechanisms freely act.

The mosaic structure of plantings has to become a basis of a modern forest protection. Free choice of the Nature is reached through formation of mosaic plantings.

Mosaic forest ecosystems are the new type of forest stands. Such forest stands are not favorable for development of forest pathogen populations. Smaller patches of tree cohorts create a basis of the resistant, beautiful, handmade mosaics.

Populations of pathogenic organisms in the conditions of mosaic plantings are suppressed. As an example, key parameters of the *M. alphitoides* population in the conditions of mosaic planting and linear oak monocultures in Table 2 are presented.

Table 2. Key parameters of the *Microsphaera alphitoides* population in the conditions of mosaic planting and linear oak monocultures

| Conditions             | Sizes of konidiya, µm | Parameters of cleistothecia |
|------------------------|-----------------------|-----------------------------|
|                        | Length | Width | Diameter, µm | Frequency, n/sm² |
| Linear oak monocultures | 33     | 19    | 98           | 69               |
| Mosaic oak planting    | 25     | 12    | 72           | 6                |

As appears from table 2 pathogen depression is observed in the conditions of mosaic planting. It is the result of researches of the long-term researches in the oak and pine forests of the Central Russian Upland. Inbreeding, as the reproduction from the mating of genetically related parents, is usual in the wild nature. As purposeful process, inbreeding is widely applied in selection of plants and animals. Inbreeding results in increased homozygosity. Homozygosity can increase the chances of offspring being affected by recessive or deleterious traits.

The homozygosity of offspring usually rises, because the number of identical alleles in their genomes of the subsequent individuals increases [6, 7]. Homozygosity reduces fitness of population, weakens it, that is causes inbreeding depression.

The important purpose of the given work is to use the factor of the inbreeding depressions for suppression of pathogenic populations in forest ecosystems. Inbreeding in the ecosystems is reached as a result of reproductive isolation of pathogenic organisms. Inbreeding leads to a decreased fitness of a population. The researches were spent in the Central Russian forest-steppe. Modelling test objects were the economically significant and well-known fungi *M. alphitoides* and *Heterobasidion annosum*.

Management of self-regulating pathogenic processes in forest plantings consists in formation of highly heterogeneous forest mosaic ecosystems (Figure 2).

![Figure 2. Scheme of mosaic high-heterogeneous planting.](image-url)
This research suggest that inbreeding in pathogenic populations of forest ecosystems leads to a decreased fitness of pathogen. In terms of the practical management of forest ecosystems the complex scheme of forest plantings is offered (Figure 3).

Figure 3. The scheme of complex oak-pine-birch planting.

The scheme of complex oak-pine-birch forest creates conditions for development of inbreeding in pathogenic populations, for development in forest ecosystem autoregulation mechanisms. In such forest plantings the populations of the most dangerous pathogen weaken.

Populations of pathogenic organisms in the conditions of mosaic plantings are suppressed. As an example, key parameters of the *M. alphitoides* population in the conditions of mosaic planting and linear oak monocultures in table 2 are presented.

The mosaic structure is typical for the natural woods. In the natural woods, mosaic is formed on the basis of various factors among which key value are soil conditions, pathogenic fungi, insects, weather factors. In natural virgin woods quantitative ratios in biocenoses were regulated automatically on the basis of biotic laws of the nature. In the mosaic artificially created woods, conditions for automatic regulation of the biotic relations are also created.

Inbreeding depression of *E. alphitoides* populations in mosaic highly heterogeneous forest plantings reached 78-83 %. It is a real way of radical disposal of oak plantings of the pathogen. Mosaic highly heterogeneous forest plantings.

Conclusion

Our investigations as well as analyses of data from the literature yielded the following conclusion. Ecosystem regulation of pathogenic processes in forest plantings in essence according the principle of the free choice of the Nature in forest ecosystems. It means formation of plantings close to natural forests. It does not mean that it is necessary to copy forest plantings of last centuries, but it is necessary to give freedom of action to natural mechanisms of formation when forming modern forest plantings. The created forest plantings have to be auto adjustable, rich and vital. There are three main reasons for that: namely biological, economical and ethical reasons. This research suggests that there is a significant relationship between the structure and composition of forest plantings on the one
hand and their state of health on the other hand. In terms of the practical management the relationship of woodlands and artificial forests must be they have to be ecologically reasonable and have to correspond to the principles of natural long development. They have to be widely adopted in Europe.

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