

Creation of artificial phytocenoses with controlled properties as a tool for managing cultural ecosystems and landscapes

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Abstract. The main purpose of the article was to update the fundamental component in the creation of phytocenoses with controlled properties in the feasibility of ensuring the stability of the structure, composition and condition of such communities. This direction plays an important role in ecological and economic activity, in modern nature management. The key aspects of the management of artificial phytocenoses which form the functional core of cultural ecosystems and landscapes are presented. Crop production, as well as botany and plant ecology as its overall fundamental basis, should implement the goals of strategic and territorial planning in this key. Designing and monitoring the efficiency of phytocenoses of the corresponding economic groups allows ensuring the productivity and sustainability of ecosystems and landscapes. In this case biology, ecology and geography of plants make it possible to determine the fundamental mechanisms of management of artificial biosystems in the corresponding territories. Ensuring a labile balance between potential and real opportunities in biological productivity and environmental sustainability of artificial plant communities is the scientific basis of ecological and economic activity. Phytocenoses of landscaping purposes have significant scientific and practical interest: decorative, protective, environmental, planning. Due to the fact that the phytocenoses of landscaping structures are initially mainly artificial biotic formations, the ecological, landscape-stabilizing and economic characteristics of the ecosystems of cities and villages, first of all, depend on the species and varietal composition of the plants used. Also, these biotic communities strongly depend on the possibility of realizing the biological potential of these plants in such non-specific environmental conditions.

1. Introduction

Modern economic activity, as before, is largely focused on the efficiency of environmental management. Integrated land use plays a special role among strategic resources [1-3]. Moreover, this applies to both land resources in agricultural objects [4, 5], and land in forestry [6], urban-economic complexes [7, 8]. In the world, the problems of conservation and restoration are solved comprehensively. A certain role in this context is assigned not only to environmental protection and restoration works. The creation of biocenoses for various economic purposes is of great importance. First of all, the primary role is assigned to phytocenoses of various composition, structure and purpose, both in Russia [9, 10] and abroad [11, 12].



Currently, one of the leading global environmental, organizational, demographic and economic problems is the loss of opportunities to provide life-sustaining biological resources and, including, food in a number of regions of the world [13, 14]. Another significant problem is the deterioration of the ecological situation, especially in large settlements with a high concentration of population. Technogenic chemical [15, 16], physical and biological factors [17] initiate the redistribution of the masses of substances and energy in cycles which are unusual for the natural environment [18]. As a result, irreversible changes occur very often, both in biocenoses and in landscapes. These processes are especially evident within modern cities, industrial and transport complexes. This applies to many regions of Russia: Voronezh, Saratov [19], Moscow [20], Penza [21], Orel [22] regions and others [23]. Accordingly, the phytocenoses created on the basis of plants that are useful for each of the strategic national, regional and local economic tasks allow them to be successfully solved. Of course, the priority of economic and production tasks are being implemented in many territories. This can be seen in Europe [24], North America [25], Asia, and Africa [26] and in some other parts of the world.

Some achievements in the design and maintenance of economic functionality of plant communities were also made in Russia at different historical stages [27, 28]. Unfortunately, the last decades of crisis have had a negative impact on the fundamental field of crop production and in practical terms. As a result, many branches of modern nature management remain in a decadent state as it was before. There is a certain incompatibility between scientific and theoretical achievements in the field of correction of the composition and structure of artificial phytocenoses, their control and management.

Such problems are especially evident in recreational, protective, decorative gardening, in various areas of forestry, in food and fodder crop production. Unfortunately, urban planners and many specialists in the sectors of urban economy do not realize the real ecological, landscape-planning and landscape-stabilizing purposes of phytocenoses during landscaping works. Mainly economic activity is not focused on the greening of applied technologies and construction projects, the biologization of the arrangement of living spaces and working areas of people, the achievement of sanitary and hygienic standards through the biological improvement of populated areas, areas of placement of technosphere objects.

Such problems actualized a whole layer of problems of economic, economic-planning, organizational and managerial nature. They are complex, systemic in nature in a number of regions of Asia, Europe, and Russia. In general, obvious conflicts in the systems 'natural resources – society', 'productivity of autotrophic components-exploited ecosystems', 'nature management – environmental engineering' are not resolved. This applies to both Russia and many other territories.

Planning and implementation of activities for the formation of plant communities from representatives of useful plants is a comprehensive solution to the life-supporting and environmental goals. At the same time, its implementation allows you to solve a variety of strategic and economic tasks, depending on the biology and ecology of the species, forms and varieties of plants used.

2. Material and methods

Crop production in general (broad) representation is understood as a system of economically sound and technologically competent cultivation of plants in certain territories [29]. These can be both cultivated plants (crops of ornamental, forest, technical, agricultural plants) and wild species. Representatives from the local natural flora (native species) can be used as wild plants. In addition, introduced plants are often used as wild plants. Their use should be regulated by regulatory documents, economic and scientific expediency (that is, the fundamental basis for the geography, biology and ecology of these species).

From the scientific (general- biological) point of view, crop production should be considered as a coherent and sustainable system of providing resources for net primary and gross primary production. This production is obtained by forming populations of individual species [30] and varieties of plant organisms and even entire plant communities, depending on the goals set [3]. This is precisely the unity of economic tasks and scientific achievements in the field of plant biology, ecology of organisms and populations, ecological landscape studies, biologization and rationalization of resource consumption.

3. Theory

When building a system of food and environmental security, the following territorial branches of nature management come to the fore: land use, water use, and consumption of biological resources. Strategic planning in the world and in Russia is based on the real and long-term needs of the productive forces of society. However, strategic planning does not take into account much knowledge in the field of biology of the plants used for economic purposes, their associations and cenoses. Serious gaps in strategic and territorial planning have been identified while ignoring the landscape structure and features of the exploited ecosystems. The sphere of rational consumption of ecosystem services and their renewal is not developed yet. These circumstances are a serious problem for Russia and for neighbouring countries in the system plan now.

Therefore, in the full sense of ecological and economic activity, we can only speak conditionally, if in the case of food security, the main vector of economic and environmental problems is localized in agriculture, processing and food industry. That is why, in terms of ensuring environmental safety, the problems are more multiple, diverse and often difficult to solve. They are explained in interdepartmental inconsistency and in the absence of a fundamental basis for resource management. In the scientific sense, the ideas of food and environmental security should be guided by general biological laws and landscape-ecological knowledge in the planning and implementation of nature management, including the consumption of resources of economic phytocenoses.

In the black earth region and the Volga region, in particular, the ecological frameworks of settlements are formed on the basis of natural and artificial ecosystems. Creating and maintaining the stability and functionality of artificial ecosystems in cities is a mandatory regulatory condition for the effectiveness of the planning framework, regulatory decisions in territorial urban planning and environmental management [31]. In turn, artificial ecosystems of settlements transport and industrial areas, as a rule, are based on green spaces of different types and corresponding target categories [32]. These categories determine the order and specifics of their use and are intended to ensure the ecological functionality of the created biotic communities. Actually, ecological frameworks, being a mandatory and at the same time the most labile part of planning frameworks, are designed to create biogeochemical and diverse environmental conditions, acceptable conditions for environmentally optimal life and safe work of the population.

4. Results and discussion

Everything that has been said about green spaces primarily refers to the planting of woody plants. The fact is that tree plantations are the basis of terrestrial and coastal-aquatic ecosystems. It is expressed in the functions of creation and long-term sustainability of the species, genetic and ecological structure of plant communities, and a set of artificial ecosystems. On the one hand, tree plantations are an important element of the planning framework; on the other hand, they represent a unique means for forming the appropriate landscape and architectural appearance of urban and rural settlements. On the third hand, tree plantations are an instrument of biological improvement of urban and agricultural landscapes, provided by nature itself, the very evolution of woody plants in all their species, physiological and ecological diversity [15].

Actually, the planting of woody plants of the corresponding types determines the appearance of landscaping structures. With the help of linear plantings, alleys, various buffer-dividing and protective landscaping structures are organized in streets, along transport routes, near enterprises and energy facilities. Often linear tree stands can be seen as part of landscaping 'rings' and 'half-rings' at the borders of cities (in the Black earth region, the Volga region and in a number of other sub-regions). Areal plantings of woody plants have different purposes. Traditionally, these are recreational facilities, urban gardens, landscaping of adjacent territories to large public-business and social institutions, and many intra-quarter landscaping areas in urban settlements.

Elements of the terrestrial ecological framework are determined by the occupied areas of linear, area and inset ('green wedges') plantings of woody (and related) plants. By the way, ecological frameworks in the materials of territorial planning in many municipalities are often called 'natural-landscape

frameworks'. From the fundamental positions of ecology of organisms, synecology, biogeocenology and landscape studies, such formations cannot be natural (that is, of natural origin) objects in the planning structure of a settlement. It is more correct to consider ecological frameworks as natural and economic systems with the corresponding ecological, landscape-optimization and economic potential.

Also, the plantings of woody plants largely contain (in their species composition, genetic, physiological and ecological diversity) internal biological properties that leave a significant imprint on the establishment of biogeocenotic relations between different constituent elements in urban and suburban natural and anthropogenic complexes. Tree stands allow providing a mobile balance between natural and artificial elements of the environment in different territories [33]. At the same time, biogeocenoses formed on the basis of woody plants of certain species, forms and varieties have certain biological and resource qualities. This is shown by the example of Florida [34], London [35], Madrid [36], Rome [37], Moscow [38], the Orel region [39] and other settlements in Russia.

The initial composition of tree plantations and their implementation of natural-biological and landscape-ecological-and practical (resource) potential should be strictly controlled by gardeners [33]. The creation of tree stands, the control of their condition and the development of effective methods of care for them and the complexity of their protection means can effectively manage artificial phytocenoses only in unity in modern settlements [40].

So, in this complex form of management of the composition and structure of tree plantations, ensuring ecological and protective functionality and the possibility of developing a greening system in specific abiotic, biotic and anthropogenic-technogenic environmental conditions as one of the main properties of terrestrial ecological frameworks in modern settlements is realized. It is important to understand that the implementation of these functions is based on the natural properties of the plants themselves: on the ability to create ecologically and biogeochemically optimal conditions for communities (in natural places of growth, as well as in culture), on providing a variety of biocenotic connections, on the implementation of environment-forming properties.

Of course, the artificial selection of the planting range from the number of woody plants at the organizational, varietal and species levels also has a certain, and in many ways a decisive role in the creation of plantings, ensuring their economic and environmental efficiency. Artificial selection in this case is a fundamental basis for identifying and fixing bioecological features which are necessary in specific climatic, ecological and economic conditions in new varieties and hybrids of woody plants. In territorial planning and in the planning of landscaping works, it is advisable to provide for the possibility of selecting high-quality planting material. It should primarily be focused on the resources of native tree and shrub species, which by default are available for cultivation in urban and rural areas.

The selection of a planting assortment of woody plants from among introduced species, especially species from geographical areas with a similar climate and other natural landscape conditions is of great importance. Undoubtedly, the introduction into the culture of tree species should be carried out with the fulfillment of a number of mandatory conditions of bioecological, agrotechnical, and planning, landscape-architectural and other nature. Including with the specified conditions, great importance belongs to the constant monitoring of the behaviour of introduced species at all stages of cultivation, acclimatization and complication of biocenotic relationships (especially in the context of harmful relations to specimens of species that are desirable from an ecological and economic point of view).

A special role on the part of scientists and responsible workers of the relevant institutions for gardening and caring for green spaces is assigned to the identification and control of invasive and potentially invasive qualities of trees and shrubs. This applies to new species and to species that are traditionally used in protective, decorative and recreational plant growing and which are determined to be introduced into culture as promising. It is advisable to provide control over the implementation of bioecological potential, landscape optimization, climate-regulating and economic qualities, as well as invasive properties, firstly, at the organizational (departmental) level with the involvement of specialists and scientists, secondly, on an ongoing basis, thirdly, with taking into account local meteoroclimatic, orographic, hydrographic, soil-ecological and anthropogenic-technogenic environmental factors.

For example, if there is a wide list of tree species classified as having invasiveness in Central Russia, then this list will be shorter in the conditions of the southeast and south of our country. The fact is that the continentality and aridity of the climate and the intense wind regime in a number of regions of the Volga region, especially in the steppes of the Lower Volga region and partly within the steppe zone of the Middle Volga region, in the steppe zone in the south and southeast of the Black earth region, generally limits the formation and development of forest, meadow-forest and forest-steppe plant formations. It has been noticed that many potentially invasive species of trees and shrubs are either present in natural communities as individual specimens and in small populations (it is usually important near settlements, economic facilities, and in waste areas). Or (often) they are absent in the surviving ecosystems, inhabiting only artificial ones and transformed due to the constantly implemented economic activity and its consequences. In this case, one should clearly understand the process of introducing woody invasive and potentially invasive species into natural communities in suburban areas in arid regions. For example, in the steppe and semi-desert Lower Volga region against the background of essentially harsh weather conditions in the summer months (abnormal heat for many tree species, dry winds, drying up the east, south, southeast and east winds), as well as under limiting conditions in the winter months and in early spring, the potential invasiveness of many species of woody plants tends to a minimum.

Our reality clearly testifies to the need to improve work in the field of selection of fruit and ornamental crops, selection of high-quality planting material from woody plants. In this case, taking into account the accumulated experience and knowledge in the field of ecology and biochemistry of woody plants in the urban environment, the inclusion of both native woody species into urban ecosystems and the introduction of introduced species into the composition of such natural-anthropogenic ecosystems should take place.

At the same time, the introduction of woody introduced species should be combined with accurate information about their biology and ecology in natural habitats. Consideration of climatic, orographic, edaphic, hydroecological, ecological-geological and planning conditions in the relevant area is of great importance in such an urgent work in all respects [41]. It is useful that the developed projects of urban planning and modernization of planning structures, the adopted regulatory documents regarding territorial planning and, in particular, the placement of ground elements of the ecological frame are based on fundamental information about the biology of woody plants, or at least combined with them, about the ability of tree plantations to implement the ecosystem, landscape-optimizing and economic functions assigned to them [16-42]. Some information about the biology and state of woody plants during landscaping will allow obtaining all the necessary environmental effects to ensure a favourable environmental situation and protecting plantings, and develop the most optimal urban planning solutions on an ecosystem basis [33, 43, 44]. This also applies to both the Black earth and the Volga regions [45], and other regions of Russia and the world.

Landscape planning plays an extremely positive role in creating optimal conditions for the functioning of tree plantations and, in general, ecological frameworks in urban and rural settlements. Unfortunately, such an activity in our country has not acquired a universal and, most importantly, normative character yet. It is useful for landscape planning to be harmoniously introduced into the planning of landscaping structures and the modernization of the elements of the planning framework of settlements, as well as individual economic objects - forestry, agricultural, water management - even at a distance from the urban systems themselves.

5. Conclusion

Ensuring a labile balance between potential and real opportunities in biological productivity and environmental sustainability of artificial plant communities is the scientific basis of ecological and economic activity. This is the primary basis for the life support of peoples and countries in all occupied territories. Moreover, it has been formed for thousands of years. However, now our civilization is faced with a lack of harmony of relations between economic tasks and the natural possibilities of consumed and reproduced biological resources.

The introduction of ideas and tools, practical and fundamental developments in the field of landscape planning of settlements in landscaping work will make it possible to solve more successfully a set of environmental problems, as well as to directly implement resource and economic goals in relation to the exploited components of landscapes and resources of landscaping structures.

Ecological frameworks with a trend towards sustainable development should be optimally integrated into the planning frameworks of modern settlements, especially those located in harsh climatic conditions. Rationalization in ensuring the harmony of structures of different types of landscaping (street, exterior, interior, etc.) and the achievement of ecological functionality can be provided on an ecosystem basis.

In turn, the solution of gardening tasks is necessary only on the basis of scientific data on the resource capabilities of phytocenoses of the corresponding economic purpose. It should be manifested in the following: the complexity of biocenotic relations that are useful to society and ensure the optimum life of individual specimens of woody plants and populations created from them; the initiation of the normal functioning of the created phytocenoses in urban and rural areas. Accounting for weather-climatic, edaphic, structural and landscape features of the area, biocenotic relations, ecological situation and planning decisions is a cumulative matrix in practical terms when creating and ensuring the economic efficiency of plant communities. Ecological and economic activities can be implemented on the principles of sustainable development only taking into account fundamental knowledge about phytocenoses and cultivated species, forms and varieties of plants, depending on the tasks set.

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