Monitoring of the current state of tugai ecosystems in the conditions of the southern Aral Sea region

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Abstract. This article presents the results of monitoring the current state of the tugai in the South Aral Sea region. Over the past decades, as a result of a sharp increase in anthropogenic pressure on tugai forest ecosystems, there has been a catastrophic reduction in their areas, a violation of the ecological stability of ecosystems. The main area of distribution of tugai vegetation in the territory of Karakalpakstan is the lower reaches of the Amu Darya. Considering that tugai forests are a complex biological system with a long reproduction period, it is important to comprehensively know the influence of climatic and soil conditions on their formation and development. Tugai massifs are a unique type of ecosystems. They should be considered as a natural reserve of unique flora and fauna. During the formation and development of tugai communities, the ecological conditions of habitats change, which, in turn, affect communities. This mutual influence occurs during the entire period of their existence, being reflected in the accumulation of biological mass. In this connection, it is extremely interesting to consider the dynamics of changes in the productivity of tugai communities in the Amudarya delta. It is shown that as a result of a sharp increase in anthropogenic pressure on tugai forest ecosystems, their areas have sharply decreased, and the ecological stability of tugai ecosystems has been violated. Currently, in the tugai massifs of the lower reaches of the Amudarya, there are 55 species of tugai plants belonging to 21 families and 47 genera.
Keywords. Tugai massifs, dynamics, monitoring, anthropogenic impact, Aral Sea.

1 Introduction

The current ecological situation in the Aral Sea region is characterized by intensive processes of desertification and aridization of the territory, associated with a drop in the level of the Aral Sea and changes in hydrological conditions in the lower reaches of the Amu Darya. The

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destabilization of the ecological situation in this region had an ambiguous effect on various ecological types of vegetation. The most significant changes occurred in the vegetation of the tugai type [1, 2].

Over the past decades, as a result of a sharp increase in anthropogenic pressure on tugai forest ecosystems, there has been a catastrophic reduction in their areas, a violation of the ecological stability of ecosystems [3, 4].

Tugai massifs are a unique type of ecosystems. They should be considered as a natural reserve of unique flora and fauna. In this regard, and also taking into account the environment-forming and water-protecting role of the tugai, they are subject to mandatory protection [5]. At the same time, the development of an effective scientifically based program of rational nature management in tugai, which includes issues of protection, restoration, environmental monitoring and management of natural processes, will become especially relevant [6].

The main area of distribution of tugai vegetation in the territory of Karakalpakstan is the lower reaches of the Amu Darya [7]. Considering that tugai forests are a complex biological system with a long reproduction period, it is important to comprehensively know the influence of climatic and soil conditions on their formation and development. Therefore, we considered it appropriate to give a brief description of the current natural conditions of the lower reaches of the Amu Darya [8].

According to climatic conditions, the region belongs to the northern region of the desert zone with a sharply continental temperature regime. Aridity is determined by the amount of precipitation, which is equal to 100 mm per year and huge insolation, leading to an excess of evaporation over precipitation by 15-20 times [9]. An important climatic factor here is frequent winds of a predominantly northeasterly direction. The climate is sharply continental. Tugai soils are close to meadow soils, where the abundant annual leaf fall, together with the grassy mass, leads to the fact that a large amount of organic matter accumulates on the surface every year [10]. Therefore, on such soils, the supply of nutrients is quite significant, and they themselves are the most fertile.

At present, the change in hydrological conditions in the lower reaches of the Amu Darya, caused by the drying up of the Aral Sea, directly affected the current state of the vegetation cover, which led to a violation of the ecological stability of phytocenoses and the development of anthropogenic desertification processes, a decrease in the biomass of vegetation and wildlife. These factors led to the transformation of the structure and functioning of ecosystems [11].

Violations affected all ecological types of vegetation presented in the Amudarya delta. The vegetation of the tugai type has undergone the most significant changes. For the period from 1978-1985. The composition and structure of tugai communities changed radically, successional changes took place [12].

During the formation and development of tugai communities, the ecological conditions of habitats change, which, in turn, affect communities. This mutual influence occurs during the entire period of their existence, being reflected in the accumulation of biological mass. In this connection, it seems extremely interesting to consider the dynamics of changes in the productivity of tugai communities in the Amudarya delta.

Tugai complexes of the 50s of the last century were characterized by well-developed turanga forests with an admixture of oleaster *(Eleagnus angistifolia)* and willow species *(Salix songarica*), (*S. Wilhelmsiana*), as well as coastal aquatic plants . The main massifs of tugai massifs were confined to the valley and delta of the Amu Darya and were located along its main channel. Until 1961, their area was about 300 thousand hectares, and 260 thousand hectares were located in the delta [13]. In addition to the arboreal tugai forests inhabiting the fore-delta and flooded areas, on the dried-up channels grew tree-shrub vegetation composed

of species of comb, licorice, karabarak, and wolfberry. Reeds and reed grass, and on the banks - kendyr, bitter, abash, azhrek, kermek, parnolistnik, annual saltworts, yantak [1].

The anthropogenic impact on the vegetation of the lower reaches of the Amu Darya, which continued in the 1980s and 1990s, led to the degradation of forest vegetation over a large area. From 300 thousand hectares of tugai areas by 1984, no more than 50 thousand hectares remained [14].

In the 1990s, the natural formation of young tugai communities on the floodplain terraces of the river ceased. Studies carried out in these years [6] revealed that the primary colonization by trees and shrubs occurs only occasionally. The species composition of tugai pioneers has been significantly reduced. Seedlings of previously common kendyr (*Apocynum scabrum*), licorice (*Glycyrrhiza glabra*), chingil (*Halimodendron halodendron*), wolfberry (*Lycium ruthenicum*). Extremely rare single specimens of willow (*Salix songarica*) and parnophyllum (*Zygophyllum oxyanum*). *Quinoa* species (Atriplex *tatarica*, *A. dimorphostegia*) and saltworts (*Salsola paulsenii*, *S. micranthera*, *S. foliosa*). Common early pioneers are reed and reed species (*Calamagrostis epigeios*, *C. pseudophragmites*) met occasionally.

2 Material and Methods

In 2011, on the basis of the reserve and additional territories, the Nizhne-Amudarya State Biosphere Reserve was created with an area of 68,717.8 ha, of which the protected area is 11,568.3 ha [2]. The goals of the reserve are the protection of tugai forests in the Amudarya delta, scientific research, the protection of cultural values, and the socio-economic development of the region [8].

The main tugai species, the comb (*Tamarix ramosyssima*), proved to be more resistant than the turanga (*Populus ariana*). At the same time, it was established that in the Amudarya delta, the following row of plant communities can be traced in the direction from the riverbank to the interchannel descending: turanga tugai - comb tugai - comb-karabarak tugai - annual hodgepodges. In lower, more humid places, there are reed thickets [6, 7].

Thus, with the change in the hydro regime of the Amudarya and the lowering of the Aral Sea level, the tugai phytocenoses of the Amudarya delta have changed. The cessation of floods, a decrease in the level of groundwater, an increase in their mineralization, and salinization of soils contributed to the degradation of tugai: their territory began to be occupied by drought- and salt-tolerant phytocenoses [9].

Currently, in the tugai massifs of the lower reaches of the Amudarya, there are 55 species of tugai plants belonging to 21 families and 47 genera. Of these, the most representative are the haze and Compositae families. All woody edificators belong to the families of willows (5 species) and oleasters (1 species), accounting for 11% of the tugai flora [6, 7]. About 26 species (40%) of the flora are herbaceous, perennials, which usually form the basis of the grass cover of the tugai. Annual and biennial herbs (37%), as a rule, are rare in the composition of communities and do not have a large abundance. The classification of tugai trees and shrubs in the lower reaches of the Amudarya was compiled on the basis of the typology and nomenclature of K.Z. Zakirov and P.K. Zakirov [4], which are most convenient for characterizing and deciphering succession shifts. Based on them, A. B. Bakhiev compiled a classification of the vegetation of the lower reaches of the Amudarya with the allocation of taxa of the first order - climatypes - in accordance with special hydrothermal conditions [1, 3, 4].

3 Results and discussion

In the modern vegetation cover of the tugai of Central Asia, turanga communities occupy the largest areas. In the lower reaches of the Amudarya, two turanga formations were noted: gray-leaved poplar and mixed-leaved poplar [2, 5, 6]. Since in the lower reaches of the Amu Darya *turanga sizolifolia* is very rare, and tree tugai consist mainly of poplar variegated, then in the classification only the turanga formation from variegated poplar is distinguished [3].

In recent years, due to the regional anthropogenic impact, there has been a steady reduction in the areas occupied by the comb (*Tamarix*) in both the ancient and modern Amudarya delta, mainly due to the destruction and degradation of tree and shrub tugai. Comb tugai are one of the stages of vegetation change during the transition of the floodplain hydromorphic regime [7].

Fluctuations in the total phytomass in tugai communities are largely due to changes in the environmental conditions of their habitats. So, with the deterioration of water supply, accompanied by an increase in soil salinity, the share of root mass in shrub and halophyte-shrub tugai increases to 64-67% and, on the contrary, the abundance of moisture gives a significant increase in above-ground phytomass in tree and shrub tugai, thereby confirming the fact that soil conditions are the most important environmental factors influencing the entire course of formation and development of tugai vegetation. Tugais are the most highly productive (Table 1).

Table 1. Productivity of tugai communities in the lower reaches of the Amu Darya.

Index	Wood tugai	Shrub tugai	Herbal tugai
Phytomass , t/ha	60.7	44.2	16.0
Green part, %	15.3	11.9	21.3
Wood, %	23.4	19.9	21.0
Roots, %	56.2	68.0	54.6

It can be seen from Table 1 that the average amount of phytomass in arboreal tugai of the lower reaches of the Amudarya is 60.7 t/ha, of which 56% is for the root system. Anthropogenic interference has a huge impact on the productivity of tugai.

The dynamics of the watering of the delta has led to the fact that the areas of the tugai type of vegetation in the Amudarya valley, which occupied 300 thousand hectares in the 60s, Currently do not exceed 25 thousand hectares (Figure 1). Of the 10 types of pasture communities described in the Amudarya delta in 2006, only 3 were found, with the dominance of reed, azhrek and camel's thorn [6, 7].

The exponential trend indicates a reduction in the areas of tugai vegetation in the lower reaches of the Amu Darya, in our opinion, this is primarily due to the large anthropogenic pressure on the ecosystem, as well as the processes of desertification and aridization. The rate of reduction in the areas of tugai thickets is 4 thousand hectares per year.

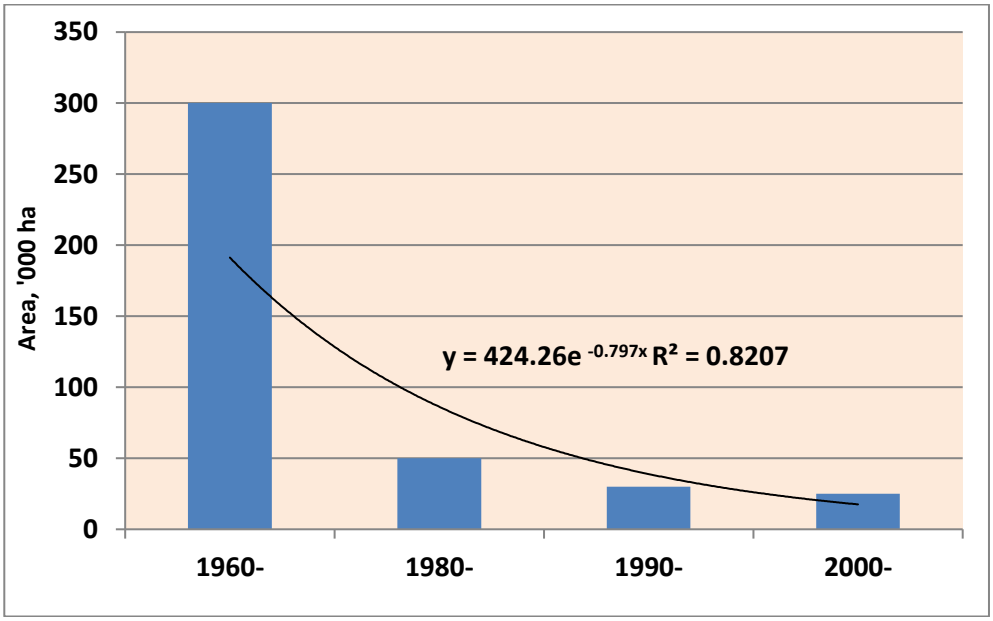

Figure 1. Dynamics of areas of tugai vegetation.

The predicted impact of climate change on the water resources of Central Asia can lead to a reduction in the water content of rivers by 20-40%, which will increase the drying of modern floodplain territories, with the activation of the solonchak formation process in soils, which in an extremely short time can lead to a complete loss of tugai in Central Asia [6, 7]. In order not to completely lose the tugai type of vegetation under the conditions of climate change, it is necessary to develop new approaches to the conservation and stabilization of these ecosystems in the absence of floods. First of all, we must not allow the complete loss of vegetation and the formation of open solonchaks in place of the former tugai alluvial soils of slightly or moderately saline.

4 Conclusions

Change in the hydrogeological regime of the territory leads to a radical change in the species composition of communities, which, in turn, affects the productivity of tugai in the conditions of the lower reaches of the Amudarya.

At present, the main direction of forestry activities in tugai communities is the protection of forests from fires and damage, reforestation , sanitary felling, thinning for the purpose of natural regeneration of the forest, reconstruction of low-value plantations, collection of medicinal plants, use of tugai plants as honey plants. A necessary condition for improving management in tugai forests is to bring the current tasks of the industry in line with the current state of forests and their potential.

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