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Geo-Ecological Analysis of Forest Potential Predkamie (North Region) of the Republic of Tatarstan from 1940 to 2013.

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ABSTRACT

This paper deals with the comparative geo-ecological analysis of forest potential of Predkamie (North region) of the Republic of Tatarstan from 1940 to 2013 using six criteria. These criteria were adopted in the frameworks of the Sustainable Forestry Montreal Process: 1) the relative area of native forests, 2) the distribution by dominant species, 3) the distribution of plants by age groups, 4) the relative area of native mature and over mature forests of the total area of this age group, 3) the relative total area of maturing, mature and over mature forests, 5) the coefficient of species composition change, and 6) the coefficient of human-induced transformation. We have studied the landscape area features for the growth of forest vegetation. We characterized the forested areas of environmental stress and disturbed species composition of forestry enterprises of Predkamie from 1940 to 2013. We have studied the influence of anthropogenic impact on the conservation of species diversity of trees and shrubs of this region.We revealed that intensive deforestation of Predkamie in the prewar and postwar periods until the second half of the 1960s, changed dramatically a qualitative forest productivity, which is defined by species composition, age structure and biodiversity of plantations. Earlier, conifers used to dominate in Predkamie, but today about 45% of the forest plantations is represented by soft-wooded species such as aspen, birch, etc. Therefore, the poorly preserved forest areas consisting of native, most valuable species such as spruce, pine and oak now take on special significance in Predkamie and the Republic of Tatarstan.

Keywords: geo-ecology, trees and shrubs, forest potential forest area, forestry enterprise, human-induced transformation, sustainable forest management.

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RELEVANCE OF THE STUDY

The forestry development strategy of the Republic of Tatarstan for the period until 2018, developed in accordance with the order of the President of the Republic of Tatarstan, and approved by the Cabinet of Ministers of the Republic of Tatarstan of October 2, 2009 No 1241-r, stresses that the preservation of the resource and environmental potential of forests, improvement of their quality and biodiversity, increase of forest areas in the territory of the republic by improving the forestation process are one of the priorities of the Government of the Republic of Tatarstan that ensure high and sustainable economic growth rates.

Natural and climatic conditions of the Republic of Tatarstan are generally favorable for forest vegetation. Nowadays, however, Tatarstan is considered one of sparsely wooded regions of Russia. In 2013, the forest cover area of the republic was 17.5%, which is insufficient for the full implementation of biosphere, resource and water regulating and improving function by the forests of the Republic of Tatarstan.

Peculiarity of the forests is that they are renewable, unlike many other natural resources, which allows their sustainable use. Therefore, it is of particular relevance to organize a sustainable forest management to address primarily the problems of quality of life of future generations.

Objective of this study

Is to perform a geo-ecological analysis of forest potential of Predkamie (North region) of the Republic of Tatarstan from 1940 to 2013.

MATERIALS AND RESEARCH TECHNIQUE

To evaluate the geo-ecological state of forest potential for 1940 and 2013, we have chosen seven criteria adopted in the frameworks of the Sustainable Forestry Montreal Process [7]: 1) the relative area of native forests; 2) the distribution by dominant species; 3) the distribution of plants by age groups; 4) the relative area of native mature and over mature forests of the total area of this age group; 5) the relative total area of maturing, mature and over mature forests; 6) the coefficient of species composition change; and 7) the coefficient of human-induced transformation.

Materials of forest inventory for 1940 and 2013 of the forestry enterprises operating in the territory of the Republic of Tatarstan were taken as original information for this study.

RESULTS AND DISCUSSION

Predkamie occupies the territory of the Republic of Tatarstan, which is located to the east of the Volga River and to the north of the Kama River. Predkamie, in turn, consists of Western and Eastern parts with a boundary line along the Viatka River. Predkamie occupies about one-third (32.5%) of the territory of the republic. This region is represented by two naturally historic districts such as northern and southern regions of mixed forests. In contrast to the Northern region, the Southern one has an insignificant area occupied by spruces, and a large area of forests represented by oak plantations, which is due to highly rich soil [6].

According to vegetation map of the European part of the USSR (1930) [1], Predkamie has a zone of deciduous forests lying near Kazan, going from the right to the left bank of the Volga river and stretching to Arsk, then to the north of Mamadysh and displacing along the valley of the Viatka River to its mouth, where it stretches along the right bank of the Kama River to the mouth of the Belaia River and further along its left bank.

The landscape-zoning map of the Republic of Tatarstan [4] defines two landscape zones in Predkamie such as boreal and northern sub-boreal semi-humid zones. The latter is located in the south-west of Predkamie and is represented by a deciduous landscape subzone. The greater part of Predkamie is located in the boreal landscape zone consisting of southern taiga and sub-taiga landscape subzones.

The forestry-based zoning of the Republic of Tatarstan refers Predkamie to the first forestry area of coniferous and mixed coniferous-deciduous forests. This area covers 34% of forests. Its boundary passes along the Kama River, crossing it to south near the city of Naberezhnye Chelny, and covers the Kzyl-Tau forestry [2].

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The first of the above criteria is the relative area of native plants obtained from converting a scale of zones of both environmental emergency and ecological disaster [5] to the scale of zones of environmental stress of forested areas (Table. 1).

Table 1: Scale of environmental stress areas

Criteria	standard	Area of environmental stress			Area of ecological risk
		low	average	high	
Relative area of native forests, %	≥ 60	59-53	52-47	46-40	39-20

In 1940, the native (coniferous and hardwood) forests of Predkamie having the relative area of 60% or more occupied 24% of the total forested area of the region, while the remaining area was a zone of ecological stress with 40% area of low stress, and 19% area of high stress. In 2013, the area of native forests with the relative area of 60% or more in the forestry enterprises of Predkamie was 15.6% of the total forested area of the region. The forested area with low and high level of environmental stress was 45.7% and 8%, respectively, of the total forested area.

At the same time, we should take into account that the areas of Predkamie for 1940 and 2013 being compared are not identical, namely the area of forestry enterprises in 1940 was 410 102 ha of the total forest recourses, which forested area was 359,024 ha. In 2013, the area of this territory was 461,089 ha of the total forest resources within the forestry enterprises, and forested area was 406,373 ha.

Thus, the forested area corresponding to the standard of environmental assessment was 1.5 times higher in 1940 than in 2013. At the same time, in 1940, the most favorable ecological situation on this criterion was observed in the forestry enterprises such as Lubyansk, Elabuga, Raifa, and Isleitar forestry enterprises, and in 2013 - in the National Park “Nizhniaia Kama”, as well as Arsk and Isleitar forestry enterprises.

According to the second criterion, the forest species composition of Predkamie was heavily changed because of long-term human activity; in 1940, for example, there were mostly coniferous forests represented by pine, spruce, and fir, which accounted for over 30% of all plants. Hard-wooded forests accounted for a quarter of the plantations, and the remaining part included soft-wooded plants mostly represented by birch, basswood and aspen.

In 2013, the plantations of pine occupied 26.4%, birch - 17.9%, linden - 15.1%, oak - 12.5%, fir - 12.2%, and aspen - 9.3% (Fig. 1).

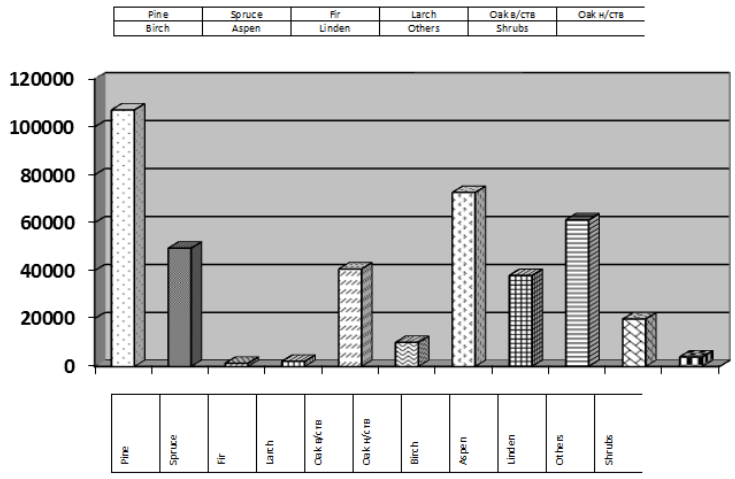

Figure 1: Distribution of forested area by the dominant species in hectares, for 2013

Analysis of the third criterion - the age structure - has shown that in 1940 the dominant plants were young stands, mature and over-mature plantations, which accounted for 65% of the total forested area in the

region [9], and in 2013 there were the middle-aged and young stands accounting for 68.3% of the total forested area of Predkamie [3], which, of course, resulted directly from the massive deforestation (Table. 2, 3).

Table 2: Age composition of plantations of Predkamie of the Republic of Tatarstan as of 01.01.1940 (%)

Groups of species	Age groups				
	Young stands	Middle-aged	Maturing	Mature and over-mature	Total
Conifers	32	12	18	38	31
Hard-wooded	37	18	16	29	24
Soft-wooded	33	25	16	26	45
Total	35	19	16	30	100

Table 3: Age composition of plantations of Predkamie of the Republic of Tatarstan as of 01.01.2013 (%)

Groups of species	Age groups				
	Young stands	Middle-aged	Maturing	Mature and over-mature	Total
Conifers	47.1	36.4	11	5.5	39.4
Hard-wooded	25.3	62.7	7.4	4.6	14.4
Soft-wooded	12.8	36.9	20	30.3	45.2
Shrubs	10.7	7.2	0	82.1	1
Total	28.1	40.2	14.4	17.3	100

The fourth criterion characterizing the ratio of native mature and over-mature plantations to the total area of mature and over-mature plantations (hereinafter - NMO) was chosen to characterize a disturbance level of the species composition. NMO is an indicator of safety of natural biodiversity and ecological balance, typical of this natural area [8] (Table 4).

Table 4: Natural species disturbance scale (%)

NMO values	Natural species disturbance characteristics
≤ 32.53	Severe disturbance
32.54 - 61.36	Moderate disturbance
≥ 61.37	Light disturbance

According to the figures in Table 4, in 1940 there was an "average disturbance" of the species composition of Predkamie forests with NMO equal to 61%. The "severe disturbance" is observed only in Laishev forestry (25.9%), while “light disturbance" is mostly common to Lubianka and Agryz forestry enterprises (90% and 89%, respectively). In 2013, soft-wooded plantations became dominant in all forestry enterprises with mature and over-mature stands, which resulted generally in severe disturbance of species composition in Predkamie, with NMO equal to 16.4%.

The fifth criterion characterizing the ratio of maturing, mature and over-mature stands to the total forested area (hereinafter - MMO) shows that the adult plants have the highest ecological and environment-forming influence on the maintenance of natural ecological balance (Table 5).

Table 5: Abundance ratio scale (%)

MMO values	Abundance ratio
≤ 32.67	low
32.68 – 53.84	average
≥ 53.85	high

In 1940, this criterion was 46% for Predkamie. We should note that the high MMO level was in the Lubianka (75%), Raifa (61%), Sabinskii (61%), Bersut (56%), and Kzyl-Iulduz (54%) forestry enterprises. No forestry enterprises with low MMO abundance rate were registered. In 2013, the MMO ratio in Predkamie decreased and was equal to 31.7%. Forestry enterprises with a high level of MMO abundance include the

Volga-Kama State Nature Biosphere Reserve. At the same time, the lowest level was observed in the National Park “Nizhniaia Kama" (11.5%).

The sixth criterion is a coefficient of species succession - C_{ss} - calculated by formula:

$$C_{ss}=P_y/P_m$$

where P_y is a percentage of soft-wooded species in the total area of young plants of all species, and P_m is a percentage of soft-wooded species in the total area of mature and over-mature plantation (Table 6) [11].

Table 6: Species succession ratio scale

C_{ss} value	Species succession characteristics
2.0 and more	Rapid degradation
1.9 – 1.3	Average degradation
1.2 – 1.1	Slow degradation
1.0 – 0.9	Slow improvement
0.8 – 0.6	Average improvement
0.5 and less	Rapid improvement

Analysis of species succession C_{ss} has shown that in 1940 there was an average degradation of species succession in Predkamie. The species succession leading to the "rapid degradation" of species composition was common to Agryz, Lubyansk and Sabinskii forestry enterprises with young stands of soft-wooded species dominating (59%, 53% and 75% of the total number of young stands in these forestry enterprises, respectively). A less intensive “rapid improvement" of the species composition was common only to Raifa forestry. In 2013, all the forestry enterprises showed "rapid improvement" of species succession, which was expressed in the increased ratio of young stands of native species to the total number of young trees, reached by artificial forestation of conifers (pine, spruce).

The seventh criterion is a coefficient of anthropogenic transformation - C_{at} - calculated by formula:

$$C_{at}=\sum(r_i p_i q)/100,$$

where r_i – a rank of anthropogenic transformation of the landscape with an “i” type of nature use, p_i - area of the territory with the given transformation rank (% of the entire studied area), and q - index of the landscape transformation level [10].

Rank of anthropogenic transformation increases together with the degree of landscape transformation. Index of the landscape transformation level (i.e. the importance ration of each type of nature use) is determined by examination.

We transformed the table of the anthropogenic transformation rank and index of landscape transformation, suggested by P.G. Shishchenko for the assessment of the degree of their anthropogenic variability in 5 km zone of influence of the Kalininskaia NPS, to apply it to the forested area (Table 7).

Table 7: Value of anthropogenic transformation rank and landscape transformation level index

Forested area by types of nature use	Transformation rank	Transformation level index
Coniferous and hard-wooded forests	1	1.05
Soft-wooded forests and shrubs	2	1.10
Open-growing forest plantation and forest nurseries	3	1.15
Non-forested areas (open stands, burnt areas, logged areas, glades and wastelands)	4	1.20

SUMMARY

Based on the assessment of forest area conducted for 73 years, we can conclude that the environmental situation has changed in the direction of the minimum transformation level equal to 11%. In 1940, the minimum anthropogenic transformation was common to Lubianka forestry, and in 2013 - to Arsk, Zelenodolsk, Isleitar and Prigorodnyi forestry enterprises and National Park “Nizhniaia Kama". In 1940, there was a significant anthropogenic transformation observed in Agryz, Arsk, Krasnobor, Isleitar, Laishev, Sabinskii and Tulbinskii forestry enterprises, while in 2013 there were no forestry enterprises with a high level of

human-induced transformation. A prosperous environmental situation in the modern forests of Predkamie is a consequence of the terminated large-scale deforestation.

Finally, we should note that intensive deforestation of Predkamie in the prewar and postwar periods until the second half of the 1960s, changed dramatically a qualitative forest productivity, which is defined by species composition, age structure and biodiversity of plantations. Earlier, conifers used to dominate in Predkamie, but today about 45% of the forest plantations is represented by soft-wooded species such as aspen, birch, etc. Therefore, the poorly preserved forest areas consisting of most valuable species such as spruce, pine and oak now take on special significance in Predkamie and the Republic of Tatarstan.

Thus, Predkamie is a strategic region of the republic in terms of forest potential, which must be maintained, restored and increased using the tree species common to this natural landscape.

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