Assessment of environmental value of specially protected natural territories of Saratov region

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Abstract. The creation of specially protected natural areas is one of the main means in solving many environmental problems of our time. Over time, protected areas are transformed, while losing their environmental value. It necessitates a systematic assessment of the state of protected areas in order to predict negative changes. Maintaining an ecological balance is relevant for a region with high anthropogenic pressures, such as the Saratov Region.

1. Introduction

At present, the system of specially protected natural areas (SPNAs) formed in the Russian Federation is recognized as one of the best in the world. However, to answer the question of how good and perfect this system is quite difficult. A network of SPNAs has been created for many decades, but the system of priorities in selecting territories for special protection has changed repeatedly. The stages of rapid development of protected areas were replaced by periods when their area was reduced several times, and the boundaries of individual protected areas changed beyond recognition. At present, the borders of many territories reflect not so much an environmental idea as the result of a compromise with various economic interests. On the scale of the vast territory of the Russian Federation with its diversity of natural zones, as well as smaller administrative units that are no less diverse in terms of natural resource potential. The maximum environmental protection effect from protected areas can only be achieved if their organization was observed main criteria of representativeness: the value of biodiversity indicators, the status of rare and endangered taxa as indicators of anthropogenic stress, flora representativeness, nature of the boundaries of protected areas, environmental functions in the natural region, the presence of environmental risk, an increase in the number of limiting factors, the degree of threats from various types of nature management, communication interconnections between protected areas [1–7].

The need to improve and develop the system of specially protected natural territories of the Saratov region, its organization and increase the efficiency of functioning determines the relevance of the study. The purpose of the study is to assess the conservation value of specially protected natural areas of the Saratov region.

In this connection, the objectives of our research were to determine the degree of optimality of the forms of plots, indicators of ecological permeability of borders and the area of buffer zones of specially protected natural territories of the Saratov region.

2. Methods and materials

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Studies on the assessment of the conservation value of SPNAs were carried out in different areas of the Saratov region. The subjects of the study were 12 protected areas of regional significance in the Saratov region (Table 1).

The determination of the degree of optimality of the forms of areas of SPNAs was carried out according to the method of V.E. Sokolova [8].

To determine the size of SPNAs, the degree of permeability of the territory, the degree of ecological optimality of the territory, the theory of island biogeocenology was used [9]. The area of the buffer zone was calculated according to the method of V.V. Sukhanov [10].

3. Results

The degree of optimality of the shape of a territory is an important criterion in determining the anthropogenic load that affects the biological diversity and conservation value of SPNTs.

The most optimal form of SPNAs is a territory in the form of a circle, with the same area having the smallest perimeter. This reduces the length of boundaries of protected areas and reduces the number of points of contact with adjacent natural and man-made landscapes. In addition, the shape of circle minimizes the distance when moving inside SPNAs.

Table 1. Objects of research

| Name                                                                 | Abbreviation                      | Profile                      |
|----------------------------------------------------------------------|-----------------------------------|------------------------------|
| Finaykinsky tulip steppe of the Aleksandrov-Gaysky district          | Finaykinsky tulip steppe          | Landscape Botanical          |
| The tract Zaton near the Ozernoye village of the Atkarskogo District | The tract Zaton                   | Landscape                    |
| Grachevskaya Lesnaya Dacha, Balakovoo District                       | Grachevskaya Lesnaya Dacha        | Landscape Botanical          |
| Lake Rasskazan of Balashov district                                 | Lake Rasskazan                   | Landscape                    |
| The tract Mukhin dol Volsky district                                | The tract Mukhin dol              | Landscape Botanical          |
| Bolshie i Malye sosniaki of Dukhovnitsky district                   | Bolshie i Malye sosniaki         | Landscape                    |
| Novozivsevskaya tulip steppe of Derzhavsky district                  | Novozivsevskaya tulip steppe     | Landscape Botanical          |
| Mud springs of the Chapaevsky resort of the Ershov district          | Mud springs of the Chapaevsky resort | Balneological               |
| The tract Vavilov dol of Ivanteyevsky district                       | The tract Vavilov dol             | Landscape Botanical          |
| Novouzensky stumps of Novouzensky district                           | Novouzensky stumps               | Landscape Botanical          |
| Burkinskiy forest of Saratov region                                 | Burkinskiy forest                | Landscape Botanical          |
| Pobochinsky forest cottage of the Tatischevskiy district             | Pobochinsky forest cottage        | Landscape                    |

Rectangular areas are also less susceptible to human impact. As the criterion for the degree of ecological optimality of borders decreases, SPNAs acquire greater environmental instability.

In the process of determining the degree of optimality of the shapes of the areas of the studied territories, it was revealed that out of all 12 SPNAs of the Saratov Region, 7 is dominated by an elongated rectangle (Table 2). These are territories located in Atkarsky, Balakovovsky, Balashovsky, Volsky, Ershovsky, Saratov and Tatischevsky districts. The ribbon shape is typical for the protected areas of the Aleksandrovo-Gaysky, Ivanteyevsky and Novouzensky districts. The rectangular shape is usual for protected areas of the Dukhovnitsky and Dergachevsky districts. SPNTs of a round form have not been identified.

It has been established that in most cases there is an increase in the length of boundaries of protected areas and an increase in the number of points of contact with adjacent natural and
anthropogenic landscapes. At the same time, the shape of the rectangle maximizes the distance during movements within SPNAs, which can negatively affect the immigration of species.

Having determined the values of the shape indices of the territory of SPNAs of the Saratov region, we calculated the indicators of ecological permeability of borders and established the degree of ecological optimality of the territory (Table 3).

**Table 2. Indicators of the optimum degree of the form of the sites of the research territories**

| Name of SPNAs                  | Index of form of territory | Degree of optimality of forms of SPNTs |
|--------------------------------|-----------------------------|----------------------------------------|
| Finaykinsky tulip steppe       | 2.1                         | Tape form                              |
| The tract Zaton                | 1.6                         | Elongated rectangle                    |
| Grachevskaya Lesnaya Dacha     | 1.7                         | Elongated rectangle                    |
| Lake Rasskazan                 | 1.7                         | Elongated rectangle                    |
| The tract Mukhin dol           | 1.6                         | Elongated rectangle                    |
| Bolshie i Malye sosniaki       | 1.2                         | Rectangular shape                      |
| Novozizevskaya tulip steppe    | 1.1                         | Rectangular shape                      |
| Mud springs of the Chapaevsky resort | 1.5     | Elongated rectangle                    |
| The tract Vavilov dol          | 2.1                         | Tape form                              |
| Novouzensky stumps             | 1.9                         | Tape form                              |
| Burkinskiy forest              | 1.4                         | Elongated rectangle                    |
| Pobochinsky forest cottage     | 1.4                         | Elongated rectangle                    |

Based on calculations of environmental permeability and the degree of ecological optimality of the borders, it was revealed that the higher the indicator of environmental permeability of the territory, the lower the degree of environmental optimality of protected areas.

According to the shape of the territory, conventionally assigned to an elongated rectangle, prevailing in the Saratov region have a fairly low permeability of borders and a degree of ecological optimality of territories (less than 1), which indicates sufficient instability of specially protected natural territories (The tract Zaton, Grachevskaya Lesnaya Dacha, Lake Rasskazan, The tract Mukhin dol, Mud springs of the Chapaevsky resort, Burkinskiy forest, Pobochinsky forest cottage).

Territories having a rectangular shape (Bolshie i Malye sosniaki, Novozizevskaya tulip steppe) are less susceptible to anthropogenic influences.

As the ratio of the degree of ecological optimality of the territory increases, the protected natural complexes become more environmentally sustainable by moving the central part away from the peripheral, i.e. from external borders.

**Table 3. Indicators characterizing the landscape-geographic organization of the specially protected natural territories of the Saratov region**

| Name of SPNAs                  | Index of form of territory | Environmental Permeability Borders | The degree of Ecological Optimality of the Territory |
|--------------------------------|-----------------------------|-----------------------------------|----------------------------------------------------|
| Finaykinsky tulip steppe       | 2.1                         | 3.3                               | 0.3                                                |
| The tract Zaton                | 1.6                         | 3.3                               | 0.2                                                |
| Grachevskaya Lesnaya Dacha     | 1.7                         | 1.7                               | 0.6                                                |
| Lake Rasskazan                 | 1.7                         | 4.5                               | 0.2                                                |
| The tract Mukhin dol           | 1.6                         | 1.7                               | 0.6                                                |
| Bolshie i Malye sosniaki       | 1.2                         | 1.8                               | 0.6                                                |
| Novozizevskaya tulip steppe    | 1.1                         | 1.9                               | 0.5                                                |
| Mud springs of the Chapaevsky resort | 1.5     | 4.3                               | 0.2                                                |
| The tract Vavilov dol          | 2.1                         | 6.8                               | 0.1                                                |
| Novouzensky stumps             | 1.9                         | 3.1                               | 0.3                                                |
| Burkinskiy forest              | 1.4                         | 0.7                               | 1.5                                                |
| Pobochinsky forest cottage     | 1.4                         | 1.9                               | 0.5                                                |
As the degree of ecological optimality of the territory decreases, the protected natural systems acquire greater environmental instability, which entails the need to strengthen protection and develop a set of measures to optimize the territory by changing its configuration. Complicated borders, the presence of corners and protrusions resembling a peninsula, the highly elongated form of protected areas make it possible to clearly judge the strong insecurity of their internal parts.

Specially protected natural territories with low indicators of the degree of ecological optimality of the territory (The tract Zaton, Lake Rasskazan, Mud springs of the Chapaevsky resort, The tract Vavilov dol and Novouzensky stumps) differ from other territories by a small distance from any internal point to borders of protected areas. This indicates the instability of natural systems to external influences, and the preserved biota is largely affected by various accidents.

The higher the degree of ecological optimality of a territory, the greater the priority of a particular territory in the hierarchical series of protected areas.

High indicators of the degree of ecological optimality of the territory were observed in the Burkinskiy forest (Saratov District), Grachevskaya Lesnaya Dacha (Balakovo District), Bolshie i Malye sosniaki (Dukhovnitsky District), which reflects more favorable conditions for the existence of animal species populations.

As the criterion for the degree of ecological optimality of borders decreases, specially protected natural territories acquire greater environmental instability. The most unstable protected areas have been identified in the Ivanteyevsky district (The tract Vavilov dol).

The most stable territory in terms of environmental optimality is located in the Saratov region ("Burkino forest"), since the degree of environmental permeability of this territory with the lowest rate indicates a stable protection of the site from natural and anthropogenic impact.

Such specially protected natural territories as the “Finaykinsky Tulip Steppe” (Aleksandrovo-Gaysky District), the tract “Mukhin Dol” (Volsky District) and the “Novozizevskaya Tulip Steppe” (Dergachevsky District) possess the most stable permeability and optimality of the territory.

In order to minimize the effect of isolation and adverse anthropogenic impact on SPNAs, ecological corridors are organized on adjacent land plots and water bodies and buffer zones are created.

The regime of special protection of SPNAs is as follows: it is forbidden to lay communications, grazing, haying, plowing the territory, picking tulips, arranging landfills and littering the territory, driving and parking automobile and tracked vehicles outside the existing road network, except for special equipment, other types economic activity and nature management that impede the conservation, restoration and reproduction of natural complexes and their components. It is forbidden to carry out all types of logging, except for forest care and sanitary and recreational activities, travel outside the main routes, the construction of capital facilities, other types of economic activity and nature management that impede the conservation, restoration and reproduction of natural complexes and their components.

Data on the areas of reserves of SPNAs and buffer zones with a description of the boundaries of protected areas are shown in Table 4.

Studies have shown that the tract Zaton, Grachevskaya Lesnaya Dacha, Novozizevskaya Tulip Steppe, Novozizevskaya tulip steppe, Burkinskiy forest and Pobochinsky forest cottage were characterized by a small buffer zone, while having large areas of protected areas.

The largest ratio of areas has Lake Rasskazan of the Balashov district, which indicates the most protected territory of the reserve. The higher the isolation of the specially protected natural area from external factors and influences, the higher the environmental protection of the territory and the minimal impact on the natural environment of the area.

More even correlations between the areas of protected areas and buffer zones were observed at Finaykinsky tulip steppe, the tract Mukhin dol, Bolshie i Malye sosniaki, Mud springs of the Chapaevsky resort and the tract Vavilov dol.
Table 4. Areas and boundaries of zones of special protection of specially protected natural territories of regional value in the Saratov region

| Name of SPNAs                        | Area of protected areas / Buffer Square Zones, ha | Description of the boundaries of protected areas                                                                                                                                                                                                                                                                                                                                 |
|--------------------------------------|-----------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Finaykinsky tulip steppe             | 539.6 / 104.0                                 | A northern border was drawn along the irrigation canal and field road 1300 m southwest of the Finaykina Balka pasture. The northern boundary of the tract coincides with the boundary of the Lake Forestry of the Atkar Forestry; the eastern and southern boundaries pass along the left bank of the river Medveditsa 50 m from the water edge; western – on the right bank of the tract of the river Medveditsa. |
| The tract Zaton                       | 322.6 / 32.4                                  | The tract coincides with the border of the Balakovo forestry until it intersects with a small beam, it bends around the arable land, passing along a field road along the forest.                                                                                                                                                                                   |
| Grachevskaya Lesnaya Dacha            | 1384.0 / 68.0                                 | The northern border crosses the Kulikovo forestry of the Volsky forestry from west to east, 300 m from their southern border; the borders coincide with the boundaries of arable land and virgin steppe plots. The northern boundary of the tract runs along the edge of the swampy coastal areas of nearby lakes.                                                                                                     |
| Lake Rasskan                         | 177.9 / 176.6                                 | The northern boundary of the tract runs along the edge of the forest; southeast – along a field road 150 m southeast of the lake and further southwest along the edge of the forest; south and southwest along the dam 200 m from the banks of the Volga; eastern – along a field road along the edge of arable land and further north-east along a field road 130–150 m from the border of the forest. |
| The tract Mukhino dol                | 1256.0 / 127.0                                | The northern border of the tulip steppe runs along the edge of the field, the eastern and western borders along the field roads; southern border – from west to east along the old coastline of a dry pond.                                                                                                                                                                                                   |
| Bolshie i Malye sosniaki             | 671.4 / 155.0                                 | The northern boundary of the site runs along the country road in the direction from the northwest to the southeast, the eastern, southern and western borders are laid on the left slope of the river. Bolshoi Kushum is drawn along the field roads along the edge of arable land, along the edge of the forest and along the edge of the left side of the river valley. Bolshoi Uzen from west to east. The southern border runs along the arable land, and further west along a dirt road. |
| Novozizevskaya tulip steppe          | 429.1 / 73.0                                  | The northern boundary of the tract runs along the edge of the arable land, along the right side of the ravine in the direction from the southeast to the north-west, western – along the mouth of the nameless beam, eastern – along the bottom of the ravine.                                                                                                                      |
| Mud springs of the Chapaevskiy resort| 141.4 / 10.9                                  | The northern boundary of the tract runs along the edge of the arable land, and further west along a dirt road. The northern border is drawn along field roads along the edge of arable land, along the edge of the forest and along the edge of the left side of the river valley. Bolshoi Uzen from west to east. The southern border runs along the arable land, and further west along a dirt road. |
| The tract Vavilov dol                | 115.7 / 34.0                                  | The northern boundary of the tract runs along the edge of the arable land, along the edge of the forest and along the edge of the left side of the river valley. Bolshoi Uzen from west to east. The southern border runs along the arable land, and further west along a dirt road.                                                                                                                      |
| Novozizevskaya tulip steppe          | 429.1 / 73.0                                  | The northern boundary of the tract runs along the edge of the arable land, along the edge of the forest and along the edge of the left side of the river valley. Bolshoi Uzen from west to east. The southern border runs along the arable land, and further west along a dirt road.                                                                                                                      |
| Novozizevskaya tulip steppe          | 429.1 / 73.0                                  | The northern boundary of the tract runs along the edge of the arable land, along the edge of the forest and along the edge of the left side of the river valley. Bolshoi Uzen from west to east. The southern border runs along the arable land, and further west along a dirt road.                                                                                                                      |
| Novozizevskaya tulip steppe          | 429.1 / 73.0                                  | The northern boundary of the tract runs along the edge of the arable land, along the edge of the forest and along the edge of the left side of the river valley. Bolshoi Uzen from west to east. The southern border runs along the arable land, and further west along a dirt road.                                                                                                                      |
| Novozizevskaya tulip steppe          | 429.1 / 73.0                                  | The northern boundary of the tract runs along the edge of the arable land, along the edge of the forest and along the edge of the left side of the river valley. Bolshoi Uzen from west to east. The southern border runs along the arable land, and further west along a dirt road.                                                                                                                      |
| Novozizevskaya tulip steppe          | 429.1 / 73.0                                  | The northern boundary of the tract runs along the edge of the arable land, along the edge of the forest and along the edge of the left side of the river valley. Bolshoi Uzen from west to east. The southern border runs along the arable land, and further west along a dirt road.                                                                                                                      |
| Novozizevskaya tulip steppe          | 429.1 / 73.0                                  | The northern boundary of the tract runs along the edge of the arable land, along the edge of the forest and along the edge of the left side of the river valley. Bolshoi Uzen from west to east. The southern border runs along the arable land, and further west along a dirt road.                                                                                                                      |
| Novozizevskaya tulip steppe          | 429.1 / 73.0                                  | The northern boundary of the tract runs along the edge of the arable land, along the edge of the forest and along the edge of the left side of the river valley. Bolshoi Uzen from west to east. The southern border runs along the arable land, and further west along a dirt road.                                                                                                                      |

4. Conclusion

During the assessing of the conservation value of the SPNAs of the Saratov region, we revealed that the most optimal form of protected areas is the rectangular shape of the territory, as less susceptible to anthropogenic influences (Bolshie i Malye sosniaki, Novozizevskaya tulip steppe). The tract Vavilov dol (Ivanteyevsky district) has the lowest indicator of ecological optimality of territory, which indicates the instability of these protected areas to external anthropogenic impacts. At the same time, the tract has the highest indicator of environmental permeability, which characterizes the transparency of the borders. The highest indicator of environmental optimality is characteristic of the Burkinskiy forest.
forest, but this SPNA has the lowest indicator of environmental permeability of borders, which characterizes the least interaction with adjacent territories. The higher the isolation of a specially protected natural area from external factors and influences, the higher the ecological security of the territory and the minimal impact on the natural environment of the area. The maximum ratio of protected areas and buffer zones is possessed by the Lake Rasskazan of the Balashov district, which indicates the most protected territory of the reserve.

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